

PlayStation Specifications

- psx-spx

None

None

None

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1. Home

1.1 IMPORTANT UPDATE

On the 20th of August 2022, Martin surprisingly released a new version of this documentation. While this fork will try to incorporate the changes, one important footnote that got added is the following:

I am homeless in [Hamburg](#), please help me out!

The authors of this fork thought that this deserves more than a footnote, hence this notice here.

1.2 Home

This is a conversion/edition of Martin "nocash" Korth's Playstation specs document originally hosted at <https://problemkaputt.de/psx-spx.htm>. See <https://github.com/psx-spx/psx-spx.github.io#readme> for more details.

You can also download this website as a [single-page pdf](#).

Martin is a difficult individual to reach (see <https://problemkaputt.de/email.htm>, especially the part about gmail), and so far, any attempt at contacting him about collaborating on this document failed.

Therefore, no copyright or license have been properly acquired to republish and alter this document. However, since this repository will accept and proceed to issue corrections, amendments, and additions to the original work, the [fair use and derivative work doctrine](#) is believed to be applicable in this case.

An important detail to know about this current document, as well as the original from Martin, is that it isn't a clean room reverse engineering project, as some people may seem to believe or repeat. A good chunk of the original document has been either directly copy/pasted from the confidential code and documentation from Sony, or summarized and rephrased. As this document isn't clean room, any work derived from it shouldn't be considered clean, and anyone saying otherwise is misguided at best. The reference source material, code, and documentation used to make this document can be found at <https://psx.arthus.net/sdk/Psy-Q/>

To discuss the contents of this document, or hang out with likely minded people on development, hacking, and reverse engineering of Sony's first console, feel free to [join the PSX.Dev Discord Server](#).

[Memory Map](#)

[I/O Map](#)

[Graphics Processing Unit \(GPU\)](#)

[Geometry Transformation Engine \(GTE\)](#)

[Macroblock Decoder \(MDEC\)](#)

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[CDROM Video CDs \(VCD\)](#)

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2. Memory Map

Memory Map

KUSEG	KSEG0	KSEG1		
00000000h	80000000h	A0000000h	2048K	Main RAM (first 64K reserved for BIOS)
1F000000h	9F000000h	BF000000h	8192K	Expansion Region 1 (ROM/RAM)
1F800000h	9F800000h	--	1K	Scratchpad (D-Cache used as Fast RAM)
1F801000h	9F801000h	BF801000h	4K	I/O Ports
1F802000h	9F802000h	BF802000h	8K	Expansion Region 2 (I/O Ports)
1FA00000h	9FA00000h	BFA00000h	2048K	Expansion Region 3 (SRAM BIOS region for DTL cards)
1FC00000h	9FC00000h	BFC00000h	512K	BIOS ROM (Kernel) (4096K max)
	FFFE0000h (in KSEG2)		0.5K	Internal CPU control registers (Cache Control)

Additionally, there are a number of memory mirrors.

Additional Memory (not mapped to the CPU bus)

1024K	VRAM (Framebuffers, Textures, Palettes) (with 2KB Texture Cache)
512K	Sound RAM (Capture Buffers, ADPCM Data, Reverb Workspace)
0.5K	CDROM controller RAM (see CDROM Test commands)
16.5K	CDROM controller ROM (Firmware and Bootstrap for MC68HC05 cpu)
32K	CDROM Buffer (IC303) (32Kx8) (BUG: only two sectors accessible?)
128K	External Memory Card(s) (EEPROMs)

KUSEG,KSEG0,KSEG1,KSEG2 Memory Regions

Address	Name	i-Cache	Write-Queue
00000000h	KUSEG	Yes	Yes
80000000h	KSEG0	Yes	Yes
A0000000h	KSEG1	No	No
C0000000h	KSEG2	(No code)	No

Kernel Memory: KSEG1 is the normal physical memory (uncached), KSEG0 is a mirror thereof (but with cache enabled). KSEG2 is usually intended to contain virtual kernel memory, but in the PSX it's containing Cache Control hardware registers.

User Memory: KUSEG is intended to contain 2GB virtual memory (on extended MIPS processors), the PSX doesn't support virtual memory, and KUSEG simply contains a mirror of KSEG0/KSEG1 (in the first 512MB) (trying to access memory in the remaining 1.5GB causes an exception).

i-Cache

The i-Cache can hold 4096 bytes, or 1024 instructions.

It is only active in the cached regions (KUSEG and KSEG0).

There are reportedly some restrictions... not sure there... eventually it is using the LSBs of the address as cache-line number... so, for example, it couldn't simultaneously memorize opcodes at BOTH address 80001234h, AND at address 800F1234h (?)

Scratchpad

MIPS CPUs usually have a d-Cache, but, in the PSX, Sony has assigned it as what's referenced as the "Scratchpad", mapped to a fixed memory location at 1F800000h.. 1F8003FFh, ie. it's used as Fast RAM, rather than as cache.

There *might* be a way to disable that behavior (via Port FFFE0130h or so), but, the Kernel is accessing I/O ports via KUSEG, so activating Data Cache would cause the Kernel to access cached I/O ports.

The purpose of the scratchpad is to have a more flexible cache system available to the programmer. Neither the kernel nor the Sony libraries will try to make use of it, so it is therefore completely up for grabs to the programmer. A good example would be if you were to write a piece of code that's doing a lot of CRC computation, to use the 1KB scratchpad to initially load the CRC lookup tables, which incidentally, is exactly 1KB large. Doing this will relieve SDRAM page changes overhead while reading the data to checksum linearly, while also keeping the whole CRC code in the i-Cache, hence being more optimal than what you'd get with an automatic d-Cache system.

Memory Mirrors

As described above, the 512Mbyte KUSEG, KSEG0, and KSEG1 regions are mirrors of each other. Additional mirrors within these 512MB regions are:

```
2MB RAM can be mirrored to the first 8MB (strangely, enabled by default)
512K BIOS ROM can be mirrored to the last 4MB (disabled by default)
Expansion hardware (if any) may be mirrored within expansion region
The seven DMA Control Registers at 1F8010x8h are mirrored to 1F8010xCh
```

The size of the RAM, BIOS, Expansion regions can be configured by software, for Expansion Region it's also possible to change base address, see:

Memory Control

The Scratchpad is mirrored only in KUSEG and KSEG0, but not in KSEG1.

Memory Exceptions

```
Memory Error -----> Misalignments
                        (and probably also KSEG access in User mode)
Bus Error      -----> Unused Memory Regions (including Gaps in I/O Region)
                        (unless RAM/BIOS/Expansion mirrors are mapped to "unused" area)
```

Write queue

The MIPS CPU has a 4-words deep pass-through write queue, in order to relieve some bus contention when writing to memory. If reading the same memory location that just got written into the write queue, it will first be flushed before being read back from memory.

It is important to realize that the write queue's mechanism is only viable for normal memory attached to the main CPU, and that any hardware register state machine will get messed up by it.

The typical example is the typical JEDEC standard to access flash, which usually does the following sequence to read the ID of a flash chip:

```
base[0xAAA] = 0xAA;
base[0x555] = 0x55;
base[0xAAA] = 0x90;
uint8_t mnfctrID = base[0x000];
uint8_t deviceId = base[0x002];
```

In this example above, if `base` is located in a memory segment that has the write queue enabled, even if the low level assembly code will do the first 3 stores before doing 2 loads, the physical signals sent to that device through the CPU bus will be seen in the sequence:

```
store(0xaaa, 0xaa)
load(0x000)
store(0x555, 0x55)
load(0x002)
store(0xaaa, 0x90)
```

Therefore, using KSEG1 that disables the write queue is the only way to ensure that the operations are done in the proper way.

The above is valid for most of the hardware connected to the main CPU, such as the CDROM controller, exp1, exp2, the SPU, or the GPU. Therefore, using BF80180xh to access the CDROM registers is more correct than using 1F80180xh.

It is noteworthy that the Sony code will still incorrectly use KUSEG as the memory map for all hardware registers, and they then spend a lot of time writing 4 dummy values somewhere, in order to ensure the write queue has been flushed.

The SN debugger in contrast is properly using the KSEG1 memory map for all the hardware registers, nullifying the need to flush the write queue when accessing it.

It's also noteworthy that doing ANY KSEG1 access (read OR write) will automatically stall the CPU in order to flush the whole write queue before proceeding with the operation. Therefore, all BIOS ROM operations will naturally and effectively have the write queue disabled, as this code requires the CPU to read from KSEG1 constantly.

This also means that if using KUSEG for the hardware registers, another method to flush the write queue, albeit potentially slightly less efficient, would be to simply read the first byte located at BFC00000h. The latter is what is effectively described as the official method to flush the write queue in the MIPS handbook. This could be potentially useful to flush the write queue all at once, instead of flushing it word by word.

More Memory Info

For Info on Exception vectors, Unused/Garbage memory locations, I/O Ports, Expansion ROM Headers, and Memory Waitstate Control, etc. see:

[I/O Map](#)

[Memory Control](#)

[EXP1 Expansion ROM Header](#)

[BIOS Memory Map](#)

[BIOS Memory Allocation](#)

[COP0 - Exception Handling](#)

[Unpredictable Things](#)

3. I/O Map

Expansion Region 1

```
1F000000h 80000h Expansion Region (default 512 Kbytes, max 8 MBytes)
1F000000h 100h   Expansion ROM Header (IDs and Entrypoints)
```

Scratchpad

```
1F800000h 400h Scratchpad (1K Fast RAM) (Data Cache mapped to fixed address)
```

Memory Control 1

```
1F801000h 4      Expansion 1 Base Address (usually 1F000000h)
1F801004h 4      Expansion 2 Base Address (usually 1F802000h)
1F801008h 4      Expansion 1 Delay/Size (usually 0013243Fh; 512Kbytes 8bit-bus)
1F80100Ch 4      Expansion 3 Delay/Size (usually 00003022h; 1 byte)
1F801010h 4      BIOS ROM Delay/Size (usually 0013243Fh; 512Kbytes 8bit-bus)
1F801014h 4      SPU_DELAY Delay/Size (usually 200931E1h)
1F801018h 4      CDROM_DELAY Delay/Size (usually 00020843h or 00020943h)
1F80101Ch 4      Expansion 2 Delay/Size (usually 00070777h; 128-bytes 8bit-bus)
1F801020h 4      COM_DELAY / COMMON_DELAY (00031125h or 0000132Ch or 00001325h)
```

Peripheral I/O Ports

```
1F801040h 1/4    JOY_DATA Joypad/Memory Card Data (R/W)
1F801044h 4      JOY_STAT Joypad/Memory Card Status (R)
1F801048h 2      JOY_MODE Joypad/Memory Card Mode (R/W)
1F80104Ah 2      JOY_CTRL Joypad/Memory Card Control (R/W)
1F80104Eh 2      JOY_BAUD Joypad/Memory Card Baudrate (R/W)
1F801050h 1/4    SIO_DATA Serial Port Data (R/W)
1F801054h 4      SIO_STAT Serial Port Status (R)
1F801058h 2      SIO_MODE Serial Port Mode (R/W)
1F80105Ah 2      SIO_CTRL Serial Port Control (R/W)
1F80105Ch 2      SIO_MISC Serial Port Internal Register (R/W)
1F80105Eh 2      SIO_BAUD Serial Port Baudrate (R/W)
```

Memory Control 2

```
1F801060h 4/2    RAM_SIZE (usually 00000B88h; 2MB RAM mirrored in first 8MB)
```

Interrupt Control

1F801070h 2	I_STAT - Interrupt status register
1F801074h 2	I_MASK - Interrupt mask register

DMA Registers

1F80108xh	DMA0 channel 0 - MDECin
1F80109xh	DMA1 channel 1 - MDECout
1F8010Axh	DMA2 channel 2 - GPU (lists + image data)
1F8010Bxh	DMA3 channel 3 - CDROM
1F8010Cxh	DMA4 channel 4 - SPU
1F8010Dxh	DMA5 channel 5 - PIO (Expansion Port)
1F8010Exh	DMA6 channel 6 - OTC (reverse clear OT) (GPU related)
1F8010F0h	DPCR - DMA Control register
1F8010F4h	DICR - DMA Interrupt register
1F8010F8h	unknown
1F8010FCh	unknown

Timers (aka Root counters)

1F80110xh	Timer 0 Dotclock
1F80111xh	Timer 1 Horizontal Retrace
1F80112xh	Timer 2 1/8 system clock

CDROM Registers (Address.Read/Write.Index)

1F801800h.x.x	1	CD Index/Status Register (Bit0-1 R/W, Bit2-7 Read Only)
1F801801h.R.x	1	CD Response Fifo (R) (usually with Index1)
1F801802h.R.x	1/2	CD Data Fifo - 8bit/16bit (R) (usually with Index0..1)
1F801803h.R.0	1	CD Interrupt Enable Register (R)
1F801803h.R.1	1	CD Interrupt Flag Register (R/W)
1F801803h.R.2	1	CD Interrupt Enable Register (R) (Mirror)
1F801803h.R.3	1	CD Interrupt Flag Register (R/W) (Mirror)
1F801801h.W.0	1	CD Command Register (W)
1F801802h.W.0	1	CD Parameter Fifo (W)
1F801803h.W.0	1	CD Request Register (W)
1F801801h.W.1	1	Unknown/unused
1F801802h.W.1	1	CD Interrupt Enable Register (W)
1F801803h.W.1	1	CD Interrupt Flag Register (R/W)
1F801801h.W.2	1	Unknown/unused
1F801802h.W.2	1	CD Audio Volume for Left-CD-Out to Left-SPU-Input (W)
1F801803h.W.2	1	CD Audio Volume for Left-CD-Out to Right-SPU-Input (W)
1F801801h.W.3	1	CD Audio Volume for Right-CD-Out to Right-SPU-Input (W)
1F801802h.W.3	1	CD Audio Volume for Right-CD-Out to Left-SPU-Input (W)
1F801803h.W.3	1	CD Audio Volume Apply Changes (by writing bit5=1)

GPU Registers

```
1F801810h.Write 4   GP0 Send GP0 Commands/Packets (Rendering and VRAM Access)
1F801814h.Write 4   GP1 Send GP1 Commands (Display Control)
1F801810h.Read  4   GPUREAD Read responses to GP0(C0h) and GP1(10h) commands
1F801814h.Read  4   GPUSTAT Read GPU Status Register
```

MDEC Registers

```
1F801820h.Write 4   MDEC Command/Parameter Register (W)
1F801820h.Read  4   MDEC Data/Response Register (R)
1F801824h.Write 4   MDEC Control/Reset Register (W)
1F801824h.Read  4   MDEC Status Register (R)
```

SPU Voice 0..23 Registers

```
1F801C00h+N*10h 4   Voice 0..23 Volume Left/Right
1F801C04h+N*10h 2   Voice 0..23 ADPCM Sample Rate
1F801C06h+N*10h 2   Voice 0..23 ADPCM Start Address
1F801C08h+N*10h 4   Voice 0..23 ADSR Attack/Decay/Sustain/Release
1F801C0Ch+N*10h 2   Voice 0..23 ADSR Current Volume
1F801C0Eh+N*10h 2   Voice 0..23 ADPCM Repeat Address
```

SPU Control Registers

```
1F801D80h 4   Main Volume Left/Right
1F801D84h 4   Reverb Output Volume Left/Right
1F801D88h 4   Voice 0..23 Key ON (Start Attack/Decay/Sustain) (W)
1F801D8Ch 4   Voice 0..23 Key OFF (Start Release) (W)
1F801D90h 4   Voice 0..23 Channel FM (pitch lfo) mode (R/W)
1F801D94h 4   Voice 0..23 Channel Noise mode (R/W)
1F801D98h 4   Voice 0..23 Channel Reverb mode (R/W)
1F801D9Ch 4   Voice 0..23 Channel ON/OFF (status) (R)
1F801DA0h 2   Unknown? (R) or (W)
1F801DA2h 2   Sound RAM Reverb Work Area Start Address
1F801DA4h 2   Sound RAM IRQ Address
1F801DA6h 2   Sound RAM Data Transfer Address
1F801DA8h 2   Sound RAM Data Transfer Fifo
1F801DAAh 2   SPU Control Register (SPUCNT)
1F801DACH 2   Sound RAM Data Transfer Control
1F801DAEh 2   SPU Status Register (SPUSTAT) (R)
1F801DB0h 4   CD Volume Left/Right
1F801DB4h 4   Extern Volume Left/Right
1F801DB8h 4   Current Main Volume Left/Right
1F801DBCh 4   Unknown? (R/W)
```

SPU Reverb Configuration Area

```

1F801DC0h 2 dAPF1 Reverb APF Offset 1
1F801DC2h 2 dAPF2 Reverb APF Offset 2
1F801DC4h 2 vIIR Reverb Reflection Volume 1
1F801DC6h 2 vCOMB1 Reverb Comb Volume 1
1F801DC8h 2 vCOMB2 Reverb Comb Volume 2
1F801DCAh 2 vCOMB3 Reverb Comb Volume 3
1F801DCCh 2 vCOMB4 Reverb Comb Volume 4
1F801DCEh 2 vWALL Reverb Reflection Volume 2
1F801DD0h 2 vAPF1 Reverb APF Volume 1
1F801DD2h 2 vAPF2 Reverb APF Volume 2
1F801DD4h 4 mSAME Reverb Same Side Reflection Address 1 Left/Right
1F801DD8h 4 mCOMB1 Reverb Comb Address 1 Left/Right
1F801DDCh 4 mCOMB2 Reverb Comb Address 2 Left/Right
1F801DE0h 4 dSAME Reverb Same Side Reflection Address 2 Left/Right
1F801DE4h 4 mDIFF Reverb Different Side Reflection Address 1 Left/Right
1F801DE8h 4 mCOMB3 Reverb Comb Address 3 Left/Right
1F801DECh 4 mCOMB4 Reverb Comb Address 4 Left/Right
1F801DF0h 4 dDIFF Reverb Different Side Reflection Address 2 Left/Right
1F801DF4h 4 mAPF1 Reverb APF Address 1 Left/Right
1F801DF8h 4 mAPF2 Reverb APF Address 2 Left/Right
1F801DFCh 4 vIN Reverb Input Volume Left/Right

```

SPU Internal Registers

```

1F801E00h+N*04h 4 Voice 0..23 Current Volume Left/Right
1F801E60h      20h Unknown? (R/W)
1F801E80h      180h Unknown? (Read: FFh-filled) (Unused or Write only?)

```

Expansion Region 2 (default 128 bytes, max 8 KBytes)

```

1F802000h      80h Expansion Region (8bit data bus, crashes on 16bit access?)

```

Expansion Region 2 - Dual Serial Port (for TTY Debug Terminal)

```

1F802020h/1st   DUART Mode Register 1.A (R/W)
1F802020h/2nd   DUART Mode Register 2.A (R/W)
1F802021h/Read   DUART Status Register A (R)
1F802021h/Write  DUART Clock Select Register A (W)
1F802022h/Read   DUART Toggle Baud Rate Generator Test Mode (Read=Strobe)
1F802022h/Write  DUART Command Register A (W)
1F802023h/Read   DUART Rx Holding Register A (FIFO) (R)
1F802023h/Write  DUART Tx Holding Register A (W)
1F802024h/Read   DUART Input Port Change Register (R)
1F802024h/Write  DUART Aux. Control Register (W)
1F802025h/Read   DUART Interrupt Status Register (R)
1F802025h/Write  DUART Interrupt Mask Register (W)

```

```

1F802026h/Read   DUART Counter/Timer Current Value, Upper/Bit15-8 (R)
1F802026h/Write  DUART Counter/Timer Reload Value, Upper/Bit15-8 (W)
1F802027h/Read   DUART Counter/Timer Current Value, Lower/Bit7-0 (R)
1F802027h/Write  DUART Counter/Timer Reload Value, Lower/Bit7-0 (W)
1F802028h/1st    DUART Mode Register 1.B (R/W)
1F802028h/2nd    DUART Mode Register 2.B (R/W)
1F802029h/Read   DUART Status Register B (R)
1F802029h/Write  DUART Clock Select Register B (W)
1F80202Ah/Read   DUART Toggle 1X/16X Test Mode (Read=Strobe)
1F80202Ah/Write  DUART Command Register B (W)
1F80202Bh/Read   DUART Rx Holding Register B (FIFO) (R)
1F80202Bh/Write  DUART Tx Holding Register B (W)
1F80202Ch/None   DUART Reserved Register (neither R nor W)
1F80202Dh/Read   DUART Input Port (R)
1F80202Dh/Write  DUART Output Port Configuration Register (W)
1F80202Eh/Read   DUART Start Counter Command (Read=Strobe)
1F80202Eh/Write  DUART Set Output Port Bits Command (Set means Out=LOW)
1F80202Fh/Read   DUART Stop Counter Command (Read=Strobe)
1F80202Fh/Write  DUART Reset Output Port Bits Command (Reset means Out=HIGH)

```

Expansion Region 2 - Int/Dip/Post

```

1F802000h 1 DTL-H2000: ATCONS STAT (R)
1F802002h 1 DTL-H2000: ATCONS DATA (R and W)
1F802004h 2 DTL-H2000: Whatever 16bit data ?
1F802030h 1/4 DTL-H2000: Secondary IRQ10 Flags
1F802032h 1 DTL-H2000: Whatever IRQ Control ?
1F802040h 1 DTL-H2000: Bootmode "Dip switches" (R)
1F802041h 1 PSX: POST (external 7 segment display, indicate BIOS boot status)
1F802042h 1 DTL-H2000: POST/LED (similar to POST) (other addr, 2-digit wide)
1F802070h 1 PS2: POST2 (similar to POST, but PS2 BIOS uses this address)

```

Expansion Region 2 - Nocash Emulation Expansion

```

1F802060h Emu-Expansion ID1 "E" (R)
1F802061h Emu-Expansion ID2 "X" (R)
1F802062h Emu-Expansion ID3 "P" (R)
1F802063h Emu-Expansion Version (01h) (R)
1F802064h Emu-Expansion Enable1 "O" (R/W)
1F802065h Emu-Expansion Enable2 "N" (R/W)
1F802066h Emu-Expansion Halt (R)
1F802067h Emu-Expansion Turbo Mode Flags (R/W)

```

Expansion Region 2 - PCSX-Redux Emulation Expansion

```

1F802080h 4 Redux-Expansion ID "PCSX" (R)
1F802080h 1 Redux-Expansion Console putchar (W)
1F802081h 1 Redux-Expansion Debug break (W)

```

```
1F802082h 1 Redux-Expansion Exit code (W)
1F802084h 4 Redux-Expansion Notification message pointer (W)
```

Expansion Region 3 (default 1 byte, max 2 MBytes)

```
1FA00000h - Not used by BIOS or any PSX games
1FA00000h - POST3 (similar to POST, but PS2 BIOS uses this address)
```

BIOS Region (default 512 Kbytes, max 4 MBytes)

```
1FC00000h 80000h BIOS ROM (512Kbytes) (Reset Entrypoint at BFC00000h)
```

Memory Control 3 (Cache Control)

```
FFFE0130h 4 Cache Control
```

Coprocessor Registers

```
COP0 System Control Coprocessor - 32 registers (not all used)
COP1 N/A
COP2 Geometry Transformation Engine (GTE) - 64 registers (most are used)
COP3 N/A
```


4. Graphics Processing Unit (GPU)

The GPU can render Polygons, Lines, or Rectangles to the Drawing Buffer, and sends the Display Buffer to the Television Set. Polygons are useful for 3D graphics (or rotated/scaled 2D graphics), Rectangles are useful for 2D graphics and Text output.

GPU I/O Ports, DMA Channels, Commands, VRAM

GPU Render Polygon Commands

GPU Render Line Commands

GPU Render Rectangle Commands

GPU Rendering Attributes

GPU Memory Transfer Commands

GPU Other Commands

GPU Display Control Commands (GP1)

GPU Status Register

GPU Versions

GPU Depth Ordering

GPU Video Memory (VRAM)

GPU Texture Caching

GPU Timings

GPU (MISC)

4.1 GPU I/O Ports, DMA Channels, Commands, VRAM

GPU I/O Ports (1F801810h and 1F801814h in Read/Write Directions)

Port	Name	Expl.
1F801810h-Write	GP0	Send GP0 Commands/Packets (Rendering and VRAM Access)
1F801814h-Write	GP1	Send GP1 Commands (Display Control) (and DMA Control)
1F801810h-Read	GPUREAD	Receive responses to GP0(C0h) and GP1(10h) commands
1F801814h-Read	GPUSTAT	Receive GPU Status Register

It (=GP0 only?) has a 64-byte (16-word) command FIFO buffer.

Optionally, Port 1F801810h (Read/Write) can be also accessed via DMA2.

The communication between the CPU and the GPU is a 32-bits data-only bus called the VBUS. Aside from address line 2 being connected, in order to make the difference

between port 0 and 1, there are no other address line between the two chips.
Thus the GPU can be seen as a blackbox that executes 32 bits commands.

GPU Timers / Synchronization

Most of the Timers are bound to GPU timings, see

[Timers](#)

[Interrupts](#)

GPU-related DMA Channels (DMA2 and DMA6)

Channel	Recommended for
DMA2 in Linked Mode	- Sending rendering commands ;GP0 (20h..7Fh,E1h..E6h)
DMA2 in Continuous Mode	- VRAM transfers to/from GPU ;GP0 (A0h,C0h)
DMA6	- Initializing the Link List ;Main RAM

Note: Before using DMA2, set up the DMA Direction in GP1(04h).

DMA2 is equivalent to accessing Port 1F801810h (GP0/GPUREAD) by software.

DMA6 just initializes data in Main RAM (not physically connected to the GPU).

GPU Command Summary

While it is probably more simple for the MIPS software to see GPU commands as a collection of bytes, the GPU will only see 32 bits words being sent to it. Therefore, while the Sony libraries will fill up structures to send to the GPU using byte-level granularity, it is much more simple to see these as bitmasks from the GPU's point of view.

So when processing commands on GP0, the GPU will first inspect the top 3 bits of the 32 bits command being sent. Depending on the value of these 3 bits, further decoding of the other bits can be done.

Commands sent to GP1 are more simple in nature to decode.

Top 3 bits of a GP0 command:

0 (000)	Misc commands
1 (001)	Polygon primitive
2 (010)	Line primitive
3 (011)	Rectangle primitive
4 (100)	VRAM-to-VRAM blit
5 (101)	CPU-to-VRAM blit
6 (110)	VRAM-to-CPU blit
7 (111)	Environment commands

Some GP0 commands require additional parameters, which are written (following the initial command) as further 32bit values to GP0. The execution of the command starts when all parameters have been received (or, in case of Polygon/Line commands, when the first 3/2 vertices have been received).

The astute reader will realize that there are shared bits between primitives, such as the gouraud shading flag.

Unlike all the others, the environment commands are more clear to be seen as a single 8 bits command, therefore the rest of the document will refer to them by their full 8 bits value.

Clear Cache

1st	Command	(01000000h)
-----	---------	-------------

The GPU has a small texture cache, in order to reduce VRAM access. This command flushes it, when mutating the VRAM, similar to how the CPU i-cache must be flushed after writing new code and before executing it.

Note that it is possible to abuse the texture cache by changing pixels in VRAM that the GPU loaded in its cache, therefore creating weird drawing effects, but this is only seen in some demos, and never in actual games.

Quick Rectangle Fill

1st	Color+Command	(02BbGgRrh)	;24bit RGB value (see note)
2nd	Top Left Corner	(YyyyXxxxh)	;Xpos counted in halfwords, steps of 10h
3rd	Width+Height	(YsizXsizh)	;Xsiz counted in halfwords, steps of 10h

Fills the area in the frame buffer with the value in RGB. Horizontally the filling is done in 16-pixel (32-bytes) units (see below masking/rounding).

The "Color" parameter is a 24bit RGB value, however, the actual fill data is 16bit: The hardware linearly converts the 24bit RGB value to 15bit RGB by dropping the lower 3 bits of each color value and additionally sets the mask bit (bit15) to 0.

Rectangle filling is not affected by the GP0(E6h) mask setting, acting as if GP0(E6h).0 and GP0(E6h).1 are both zero.

This command is typically used to do a quick clear, as it'll be faster to run than an equivalent Render Rectangle command.

VRAM Overview / VRAM Addressing

VRAM can be 1 MB or 2 MB (not mapped to the CPU bus) (it can be read/written only via I/O or DMA). The memory is used for:

```
Framebuffer(s)      ;Usually 2 buffers (Drawing Area, and Display Area)
Texture Page(s)     ;Required when using Textures
Texture Palette(s)  ;Required when using 4bit/8bit Textures
```

1 MB VRAM is laid out as 512 lines of 2048 bytes each. 2 MB VRAM (only present on some arcade boards, not on consoles) is laid out as 1024 lines instead. It is accessed via coordinates, ranging from (0,0)=Upper-Left to (N,1023)=Lower-Right.

```
Unit   = 4bit   8bit   16bit   24bit   Halfwords   | Unit   = Lines
Width  = 4096   2048   1024    682.66  1024         | Height = 512/1024
```

The horizontal coordinates are addressing memory in 4bit/8bit/16bit/24bit/halfword units (depending on what data formats you are using) (or a mixup thereof, eg. a halfword-base address, plus a 4bit texture coordinate).

4.2 GPU Render Polygon Commands

When the upper 3 bits of the first GP0 command are set to 1 (001), then the command can be decoded using the following bitfield:

bit number	value	meaning
31-29	001	polygon render
28	1/0	gouraud / flat shading
27	1/0	4 / 3 vertices
26	1/0	textured / untextured
25	1/0	semi-transparent / opaque
24	1/0	raw texture / modulation
23-0	rgb	first color value.

Subsequent data sent to GP0 to complete this command will be the vertex data for the command. The meaning and count of these words will be altered by the initial flags sent in the first command.

If doing flat rendering, no further color will be sent. If doing gouraud shading, there will be one more color per vertex sent, and the initial color will be the one for vertex 0.

If doing textured rendering, each vertex sent will also have a U/V texture coordinate attached to it, as well as a CLUT index.

So each vertex data can be seen as the following set of words:

Color	xxBBGGRR	- optional, only present for gouraud shading
Vertex	YYYYXXXX	- required, two signed 16 bits values
UV	ClutVVUU or PageVVUU	- optional, only present for textured polygons

The upper 16 bits of the first two UV words contain extra information. The first word holds the [Clut index](#). The second word contains [texture page information](#). Any further clut/page bits should be set to 0.

So for example, a solid flat blue triangle of coordinate (10, 20), (30, 40), (50, 60) will be drawn using the following draw call data:

```
200000FF
00100020
00300040
00500060
```

And a quad with gouraud shading texture-blend will have the following structure:

```
2CR1G1B1
Yyy1Xxx1
ClutV1U1
00R2G2B2
Yyy2Xxx2
PageV2U2
00R3G3B3
Yyy3Xxx3
0000V3U3
00R4G4B4
Yyy4Xxx4
0000V4U4
```

Some combination of these flags can be seen as nonsense however, but it's important to realize that the GPU will still process them properly. For instance, specifying gouraud shading without modulation will force the user to send the colors for each vertex to satisfy the GPU's state machine, without them being actually used for the rendering.

Notes

Polygons are displayed up to \<excluding> their lower-right coordinates.

Quads are internally processed as two triangles, the first consisting of vertices 1,2,3, and the second of vertices 2,3,4. This is an important detail, as splitting the quad into triangles affects the way colours are interpolated.

Within the triangle, the ordering of the vertices doesn't matter on the GPU side (a front-back check, based on clockwise or anti-clockwise ordering, can be implemented at the GTE side).

Dither enable (in Texpage command) affects ONLY polygons that do use gouraud shading or modulation.

4.3 GPU Render Line Commands

When the upper 3 bits of the first GP0 command are set to 2 (010), then the command can be decoded using the following bitfield:

bit number	value	meaning
31-29	010	line render
28	1/0	gouraud / flat shading
27	1/0	polyline / single line
25	1/0	semi-transparent / opaque
23-0	rgb	first color value.

So each vertex can be seen as the following list of words:

Color	xxBBGGRR	- optional, only present for gouraud shading
Vertex	YYYYXXXX	- required, two signed 16 bits values

When polyline mode is active, at least two vertices must be sent to the GPU. The vertex list is terminated by the bits 12-15 and 28-31 equaling `0x5` , or

`(word & 0xF000F000) == 0x50005000` . The terminator value occurs on the first word of the vertex (i.e. the color word if it's a gouraud shaded).

If the 2 vertices in a line overlap, then the GPU will draw a 1x1 rectangle in the location of the 2 vertices using the colour of the first vertex.

Note

Lines are displayed up to \<including> their lower-right coordinates (ie. unlike as for polygons, the lower-right coordinate is not excluded).

If dithering is enabled (via Texpage command), then both monochrome and shaded lines are drawn with dithering (this differs from monochrome polygons and monochrome rectangles).

Wire-Frame

Poly-Lines can be used (among others) to create Wire-Frame polygons (by setting the last Vertex equal to Vertex 1).

4.4 GPU Render Rectangle Commands

Rectangles are drawn much faster than polygons. Unlike polygons, gouraud shading is not possible, dithering isn't applied, the rectangle must forcefully have horizontal and vertical edges, textures cannot be rotated or scaled, and, of course, the GPU does render Rectangles as a single entity, without splitting them into two triangles.

The Rectangle command can be decoded using the following bitfield:

bit number	value	meaning
31-29	011	rectangle render
28-27	sss	rectangle size
26	1/0	textured / untextured
25	1/0	semi-transparent / opaque
24	1/0	raw texture / modulation
23-0	rgb	first color value.

The `size` parameter can be seen as the following enum:

0 (00)	variable size
1 (01)	single pixel (1x1)
2 (10)	8x8 sprite
3 (11)	16x16 sprite

Therefore, the whole draw call can be seen as the following sequence of words:

Color	ccBBGGRR	- command + color; color is ignored when textured
Vertex1	YYYYXXXX	- required, indicates the upper left corner to render
UV	ClutVVUU	- optional, only present for textured rectangles
Width+Height	YsizXsiz	- optional, dimensions for variable sized rectangles (max 1023x511)

Unlike for Textured-Polygons, the "Texpage" must be set up separately for Rectangles, via GP0(E1h). Width and Height can be up to 1023x511, however, the maximum size of the texture window is 256x256 (so the source data will be repeated when trying to use sizes larger than 256x256).

Texture Origin and X/Y-Flip

Vertex & Texcoord specify the upper-left edge of the rectangle. And, normally, screen coords and texture coords are both incremented during rendering the rectangle pixels. Optionally, X/Y-Flip bits can be set in Texpage.Bit12/13, these bits cause the texture coordinates to be decremented (instead of incremented). The X/Y-Flip bits do affect only Rectangles (not Polygons, nor VRAM Transfers).

Caution: Reportedly, the X/Y-Flip feature isn't supported on old PSX consoles (unknown which ones exactly, maybe such with PU-7 mainboards, and unknown how to detect flipping support; except of course by reading VRAM).

Note

There are also two VRAM Transfer commands which work similar to GP0(60h) and GP0(65h). Eventually, that commands might be even faster... although not sure if they do use the Texture Cache?

The difference is that VRAM Transfers do not clip to the Drawig Area boundary, do not support fully-transparent nor semi-transparent texture pixels, and do not convert color depths (eg. without 4bit texture to 16bit framebuffer conversion).

4.5 GPU Rendering Attributes

Vertex (Parameter for Polygon, Line, Rectangle commands)

```
0-10   X-coordinate (signed, -1024..+1023)
11-15  Not used (usually sign-extension, but ignored by hardware)
16-26  Y-coordinate (signed, -1024..+1023)
26-31  Not used (usually sign-extension, but ignored by hardware)
```

Size Restriction: The maximum distance between two vertices is 1023 horizontally, and 511 vertically. Polygons and lines that are exceeding that dimensions are NOT rendered. For example, a line from Y1=-300 to Y2=+300 is NOT rendered, a line from Y1=-100 to Y2=+400 is rendered (as far as it is within the drawing area).

If portions of the polygon/line/rectangle are located outside of the drawing area, then the hardware renders only the portion that is inside of the drawing area. Not sure if the hardware is skipping all clipped pixels at once (within a single clock cycle), or if it's (slowly) processing them pixel by pixel?

Color Attribute (Parameter for all Rendering commands, except Raw Texture)


```

0-7    Red    (0..FFh)
8-15   Green  (0..FFh)
16-23  Blue   (0..FFh)
24-31  Command (in first paramter) (don't care in further parameters)

```

Caution: For untextured graphics, 8bit RGB values of FFh are brightest. However, for modulation, 8bit values of 80h are brightest (values 81h..FFh are "brighter than bright" allowing to make textures about twice as bright as than they were originally stored in memory; of course the results can't exceed the maximum brightness, ie. the 5bit values written to the framebuffer are saturated to max 1Fh).

Texpage Attribute (Parameter for Textured-Polygons commands)

```

0-8    Same as GP0(E1h).Bit0-8 (see there)
9-10   Unused (does NOT change GP0(E1h).Bit9-10)
11     Same as GP0(E1h).Bit11 (see there)
12-13  Unused (does NOT change GP0(E1h).Bit12-13)
14-15  Unused (should be 0)

```

This attribute is used in all Textured-Polygons commands.

Clut Attribute (Color Lookup Table, aka Palette)

This attribute is used in all Textured Polygon/Rectangle commands. Of course, it's relevant only for 4bit/8bit textures (don't care for 15bit textures).

```

0-5    X coordinate X/16 (ie. in 16-halfword steps)
6-14   Y coordinate 0-511 (ie. in 1-line steps) ;\on v0 GPU (max 1 MB VRAM)
15     Unused (should be 0) ;/
6-15   Y coordinate 0-1023 (ie. in 1-line steps) ;on v2 GPU (max 2 MB VRAM)

```

Specifies the location of the CLUT data within VRAM.

GP0(E1h) - Draw Mode setting (aka "Texpage")

```

0-3    Texture page X Base (N*64) (ie. in 64-halfword steps) ;GPUSTAT.0-3
4      Texture page Y Base 1 (N*256) (ie. 0, 256, 512 or 768) ;GPUSTAT.4
5-6    Semi-transparency (0=B/2+F/2, 1=B+F, 2=B-F, 3=B+F/4) ;GPUSTAT.5-6
7-8    Texture page colors (0=4bit, 1=8bit, 2=15bit, 3=Reserved);GPUSTAT.7-8
9      Dither 24bit to 15bit (0=Off/strip LSBs, 1=Dither Enabled) ;GPUSTAT.9
10     Drawing to display area (0=Prohibited, 1=Allowed) ;GPUSTAT.10
11     Texture page Y Base 2 (N*512) (only for 2 MB VRAM) ;GPUSTAT.15
12     Textured Rectangle X-Flip (BIOS does set this bit on power-up...?)
13     Textured Rectangle Y-Flip (BIOS does set it equal to GPUSTAT.13...?)

```

```
14-23 Not used (should be 0)
24-31 Command (E1h)
```

The GP0(E1h) command is required only for Lines, Rectangle, and Untextured-Polygons (for Textured-Polygons, the data is specified in form of the Texpage attribute; except that, Bits 9-10 can be changed only via GP0(E1h), not via the Texpage attribute).

Texture page colors setting 3 (reserved) is same as setting 2 (15bit).

Bits 4 and 11 are the LSB and MSB of the 2-bit texture page Y coordinate. Normally only bit 4 is used as retail consoles only have 1 MB VRAM. Setting bit 11 ($Y \geq 512$) on a retail console with a v2 GPU will result in textures disappearing if 2 MB VRAM support was previously enabled using GP1(09h), as the VRAM chip select will no longer be active. Bit 11 is always ignored by v0 GPUs that do not support 2 MB VRAM.

Note: GP0(00h) seems to be often inserted between Texpage and Rectangle commands, maybe it acts as a NOP, which may be required between that commands, for timing reasons...?

GP0(E2h) - Texture Window setting

```
0-4   Texture window Mask X   (in 8 pixel steps)
5-9   Texture window Mask Y   (in 8 pixel steps)
10-14 Texture window Offset X (in 8 pixel steps)
15-19 Texture window Offset Y (in 8 pixel steps)
20-23 Not used (zero)
24-31 Command (E2h)
```

Mask specifies the bits that are to be manipulated, and Offset contains the new values for these bits, ie. texture X/Y coordinates are adjusted as so:

```
Texcoord = (Texcoord AND (NOT (Mask * 8))) OR ((Offset AND Mask) * 8)
```

The area within a texture window is repeated throughout the texture page. The data is not actually stored all over the texture page but the GPU reads the repeated patterns as if they were there. Considering all possible regular tilings of UV coordinates for powers of two, the texture window primitive can be constructed as follows using a desired set of parameters of `tiling_x`, `tiling_y`, `window_pos_x`, `window_pos_y`, `u`, `v` and `color_mode`:

```
x_tiling_factor = {8: 0b11111, 16: 0b11110, 32: 0b11100, 64: 0b11000, 128: 0b10000, 256: 0b00000}[tiling_x]
y_tiling_factor = {8: 0b11111, 16: 0b11110, 32: 0b11100, 64: 0b11000, 128: 0b10000, 256: 0b00000}[tiling_y]
x_offset = u & 0b11111
x_offset <= {15: 0, 8: 1, 4: 2}[color_mode]
```

```
x_offset >>= 3;
y_offset = v & 0b11111
y_offset >>= 3
texture_window_prim = (0xE20 << 20) | (y_offset << 15) | (x_offset << 10) |
(y_tiling_factor << 5) | x_tiling_factor
```

GP0(E3h) - Set Drawing Area top left (X1,Y1)

GP0(E4h) - Set Drawing Area bottom right (X2,Y2)

```
0-9      X-coordinate (0..1023)
10-18    Y-coordinate (0..511)      ;\on v0 GPU (max 1 MB VRAM)
19-23    Not used (zero)            ;/
10-19    Y-coordinate (0..1023)     ;\on v2 GPU (max 2 MB VRAM)
20-23    Not used (zero)            ;/
24-31    Command (E4h)
```

Sets the drawing area corners. The Render commands GP0(20h..7Fh) are automatically clipping any pixels that are outside of this region.

GP0(E5h) - Set Drawing Offset (X,Y)

```
0-10     X-offset (-1024..+1023) (usually within X1,X2 of Drawing Area)
11-21    Y-offset (-1024..+1023) (usually within Y1,Y2 of Drawing Area)
22-23    Not used (zero)
24-31    Command (E5h)
```

If you have configured the GTE to produce vertices with coordinate "0,0" being located in the center of the drawing area, then the Drawing Offset must be " $X1+(X2-X1)/2$, $Y1+(Y2-Y1)/2$ ". Or, if coordinate "0,0" shall be the upper-left of the Drawing Area, then Drawing Offset should be " $X1,Y1$ ". Where $X1,Y1,X2,Y2$ are the values defined with GP0(E3h-E4h).

GP0(E6h) - Mask Bit Setting

```
0        Set mask while drawing (0=TextureBit15, 1=ForceBit15=1)      ;GPUSTAT.11
1        Check mask before draw (0=Draw Always, 1=Draw if Bit15=0) ;GPUSTAT.12
2-23     Not used (zero)
24-31    Command (E6h)
```

When bit0 is off, the upper bit of the data written to the framebuffer is equal to bit15 of the texture color (ie. it is set for colors that are marked as "semi-transparent") (for untextured polygons, bit15 is set to zero).

When bit1 is on, any (old) pixels in the framebuffer with bit15=1 are write-protected, and cannot be overwritten by (new) rendering commands.

The mask setting affects all rendering commands, as well as CPU-to-VRAM and VRAM-to-VRAM transfer commands (where it acts on the separate halfwords, ie. as for 15bit textures). However, Mask does NOT affect the Fill-VRAM command.

This setting is used in games such as Metal Gear Solid and Silent Hill.

Note

GP0(E3h..E5h) do not take up space in the FIFO, so they are probably executed immediately (even if there're still other commands in the FIFO). Best use them only if you are sure that the FIFO is empty (otherwise the new Drawing Area settings might accidentally affect older Rendering Commands in the FIFO).

4.6 GPU Memory Transfer Commands

The next three commands being described are when the high 3 bits are set to the values 4 (100), 5 (101), and 6 (110). For them, the remaining 29 bits are ignored, and can be set to any arbitrary value.

VRAM to VRAM blitting - command 4 (100)

```
1st  Command
2nd  Source Coord      (YyyyXxxxh) ;Xpos counted in halfwords
3rd  Destination Coord (YyyyXxxxh) ;Xpos counted in halfwords
4th  Width+Height      (YsizXsizh) ;Xsiz counted in halfwords
```

Copies data within framebuffer. The transfer is affected by Mask setting.

CPU to VRAM blitting - command 5 (101)

```
1st  Command
2nd  Destination Coord (YyyyXxxxh) ;Xpos counted in halfwords
3rd  Width+Height      (YsizXsizh) ;Xsiz counted in halfwords
...  Data               (...)      <--- usually transferred via DMA
```

Transfers data from CPU to frame buffer. If the number of halfwords to be sent is odd, an extra halfword should be sent, as packets consist of 32bits words. The transfer is affected by Mask setting.

VRAM to CPU blitting - command 6 (110)

```

1st  Command                ;\
2nd  Source Coord            (YyyyXxxxh) ; write to GP0 port (as usually)
3rd  Width+Height            (YsizXsizh) ;/
...   Data                    (...)      ;<--- read from GPUREAD port (or via DMA)

```

Transfers data from frame buffer to CPU. Wait for bit27 of the status register to be set before reading the image data. When the number of halfwords is odd, an extra halfword is added at the end, as packets consist of 32bits words.

Masking and Rounding for FILL Command parameters

```

Xpos=(Xpos AND 3F0h)                ;range 0..3F0h, in steps of 10h
Ypos=(Ypos AND 1FFh)                ;range 0..1FFh
Xsiz=((Xsiz AND 3FFh)+0Fh) AND (NOT 0Fh) ;range 0..400h, in steps of 10h
Ysiz=((Ysiz AND 1FFh))              ;range 0..1FFh

```

Fill does NOT occur when Xsiz=0 or Ysiz=0 (unlike as for Copy commands). Xsiz=400h works only indirectly: Param=400h is handled as Xsiz=0, however, Param=3F1h..3FFh is rounded-up and handled as Xsiz=400h.

Note that because of the height (Ysiz) masking, a maximum of 511 rows can be filled in a single command. Calling a fill with a full VRAM height of 512 rows will be ineffective as the height will be masked to 0.

Masking for COPY Commands parameters

```

Xpos=(Xpos AND 3FFh)                ;range 0..3FFh
Ypos=(Ypos AND 1FFh)                ;range 0..1FFh
Xsiz=((Xsiz-1) AND 3FFh)+1          ;range 1..400h
Ysiz=((Ysiz-1) AND 1FFh)+1          ;range 1..200h

```

Parameters are just clipped to 10bit/9bit range, the only special case is that Size=0 is handled as Size=max.

Notes

The coordinates for the above VRAM transfer commands are absolute framebuffer addresses (not relative to Draw Offset, and not clipped to Draw Area).

Non-DMA transfers seem to be working at any time, but GPU-DMA Transfers seem to be working ONLY during V-Blank (outside of V-Blank, portions of the data appear to be skipped, and the following words arrive at wrong addresses), unknown if it's possible to change that by whatever configuration settings...? That problem appears ONLY for

continuous DMA aka VRAM transfers (linked-list DMA aka Ordering Table works even outside V-Blank).

Wrapping

If the Source/Dest starting points plus the width/height value exceed the 1024x512 pixel VRAM size, then the Copy/Fill operations wrap to the opposite memory edge (without any carry-out from X to Y, nor from Y to X).

4.7 GPU Other Commands

GP0(1Fh) - Interrupt Request (IRQ1)

1st Command	(Cc000000h)	;GPUSTAT.24
-------------	-------------	-------------

Requests IRQ1. Can be acknowledged via GP1(02h). This feature is rarely used.

Note: The command is used by Blaze'n'Blade, but the game doesn't have IRQ1 enabled, and the written value (1F801810h) looks more like an I/O address, rather than like a command, so not sure if it's done intentionally, or if it is just a bug.

GP0(03h) - Unknown?

Unknown. Doesn't seem to be used by any games. Unlike the "NOP" commands, GP0(03h) does take up space in FIFO, so it is apparently not a NOP.

GP0(00h) - NOP (?)

This command doesn't take up space in the FIFO (eg. even if a VRAM-to-VRAM transfer is still busy, one can send dozens of GP0(00h) commands, without the command FIFO becoming full. So, either the command is ignored (or, if it has a function, it is executed immediately, even while the transfer is busy).

...

GP0(00h) unknown, used with parameter = 08A16Ch... or rather 08FDBCh ... the written value seems to be a bios/ram memory address, anded with 00FFFFFFh... maybe a bios bug?

GP0(00h) seems to be often inserted between Texpage and Rectangle commands, maybe it acts as a NOP, which may be required between that commands, for timing reasons...?

GP0(04h..1Eh,E0h,E7h..EFh) - Mirrors of GP0(00h) - NOP (?)

Like GP0(00h), these commands don't take up space in the FIFO. So, maybe, they are same as GP0(00h), however, the Drawing Area/Offset commands GP0(E3h..E5h) don't take up FIFO space either, so not taking up FIFO space doesn't necessarily mean that the command has no function.

4.8 GPU Display Control Commands (GP1)

GP1 Display Control Commands are sent by writing the 8bit Command number (MSBs), and 24bit parameter (LSBs) to Port 1F801814h. Unlike GP0 commands, GP1 commands are passed directly to the GPU (ie. they can be sent even when the FIFO is full).

GP1(00h) - Reset GPU

```
0-23  Not used (zero)
```

Resets the GPU to the following values:

```
GP1(01h)      ;clear fifo
GP1(02h)      ;ack irq (0)
GP1(03h)      ;display off (1)
GP1(04h)      ;dma off (0)
GP1(05h)      ;display address (0)
GP1(06h)      ;display x1,x2 (x1=200h, x2=200h+256*10)
GP1(07h)      ;display y1,y2 (y1=010h, y2=010h+240)
GP1(08h)      ;display mode 320x200 NTSC (0)
GP0(E1h..E6h) ;rendering attributes (0)
```

Accordingly, GPUSTAT becomes 14802000h. The x1,y1 values are too small, ie. the upper-left edge isn't visible. Note that GP1(09h) is NOT affected by the reset command.

GP1(01h) - Reset Command Buffer

```
0-23  Not used (zero)
```

Resets the command buffer and CLUT cache.

GP1(02h) - Acknowledge GPU Interrupt (IRQ1)

```
0-23  Not used (zero)
```

```
;GPUSTAT.24
```

Resets the IRQ flag in GPUSTAT.24. The flag can be set via GP0(1Fh).

GP1(03h) - Display Enable

0	Display On/Off	(0=On, 1=Off)	;GPUSTAT.23
1-23	Not used (zero)		

Turns display on/off. "Note that a turned off screen still gives the flicker of NTSC on a PAL screen if NTSC mode is selected."

The "Off" settings displays a black picture (and still sends /SYNC signals to the television set). (Unknown if it still generates vblank IRQs though?)

GP1(04h) - DMA Direction / Data Request

0-1	DMA Direction	(0=Off, 1=FIFO, 2=CPUtoGP0, 3=GPUREADtoCPU)	;GPUSTAT.29-30
2-23	Not used (zero)		

Notes: Manually sending/reading data by software (non-DMA) is ALWAYS possible, regardless of the GP1(04h) setting. The GP1(04h) setting does affect the meaning of GPUSTAT.25.

Display start/end

Specifies where the display area is positioned on the screen, and how much data gets sent to the screen. The screen sizes of the display area are valid only if the horizontal/vertical start/end values are default. By changing these you can get bigger/smaller display screens. On most TV's there is some black around the edge, which can be utilised by setting the start of the screen earlier and the end later. The size of the pixels is NOT changed with these settings, the GPU simply sends more data to the screen. Some monitors/TVs have a smaller display area and the extended size might not be visible on those sets. "(Mine is capable of about 330 pixels horizontal, and 272 vertical in 320*240 mode)"

GP1(05h) - Start of Display area (in VRAM)

0-9	X (0-1023)	(halfword address in VRAM)	(relative to begin of VRAM)
10-18	Y (0-511)	(scanline number in VRAM)	(relative to begin of VRAM)
19-23	Not used (zero)		

Upper/left Display source address in VRAM. The size and target position on screen is set via Display Range registers; target=X1,Y2; size=(X2-X1/cycles_per_pix), (Y2-Y1). Unknown if using Y values in 512-1023 range is supported (with 2 MB VRAM).

GP1(06h) - Horizontal Display range (on Screen)

```
0-11  X1 (260h+0)      ;12bit      ;\counted in video clock units,
12-23 X2 (260h+320*8) ;12bit      ;/relative to HSYNC
```

Specifies the horizontal range within which the display area is displayed. For resolutions other than 320 pixels it may be necessary to fine adjust the value to obtain an exact match (eg. $X2 = X1 + \text{pixels} * \text{cycles_per_pix}$).

The number of displayed pixels per line is " $((X2 - X1) / \text{cycles_per_pix} + 2)$ AND NOT 3" (ie. the hardware is rounding the width up/down to a multiple of 4 pixels).

Most games are using a width equal to the horizontal resolution (ie. 256, 320, 368, 512, 640 pixels). A few games are using slightly smaller widths (probably due to programming bugs). Pandemonium 2 is using a bigger "overscan" width (ensuring an intact picture without borders even on mis-calibrated TV sets).

The 260h value is the first visible pixel on normal TV Sets, this value is used by MOST NTSC games, and SOME PAL games (see below notes on Mis-Centered PAL games).

Video clock unit used depends on console region, regardless of NTSC/PAL video mode set by GP1(08h).3; see section on [nominal video clocks](#) for values.

GP1(07h) - Vertical Display range (on Screen)

```
0-9    Y1 (NTSC=88h-(240/2), (PAL=A3h-(288/2))) ;\scanline numbers on screen,
10-19 Y2 (NTSC=88h+(240/2), (PAL=A3h+(288/2))) ;/relative to VSYNC
20-23 Not used (zero)
```

Specifies the vertical range within which the display area is displayed. The number of lines is Y2-Y1 (unlike as for the width, there's no rounding applied to the height). If Y2 is set to a much too large value, then the hardware stops to generate vblank interrupts (IRQ0).

The 88h/A3h values are the middle-scanlines on normal TV Sets, these values are used by MOST NTSC games, and SOME PAL games (see below notes on Mis-Centered PAL games).

The 240/288 values are for fullscreen pictures. Many NTSC games display 240 lines, but on most analog television sets, only 224 lines are visible (8 lines of overscan on top and 8 lines of overscan on bottom). Many PAL games display only 256 lines (underscan with black borders).

Some games such as Chrono Cross will occasionally adjust these values to create a

screen shake effect, so proper emulation of this command is necessary for those particular cases.

GP1(08h) - Display mode

0-1	Horizontal Resolution 1	(0=256, 1=320, 2=512, 3=640)	;GPUSTAT.17-18
2	Vertical Resolution	(0=240, 1=480, when Bit5=1)	;GPUSTAT.19
3	Video Mode	(0=NTSC/60Hz, 1=PAL/50Hz)	;GPUSTAT.20
4	Display Area Color Depth	(0=15bit, 1=24bit)	;GPUSTAT.21
5	Vertical Interlace	(0=Off, 1=On)	;GPUSTAT.22
6	Horizontal Resolution 2	(0=256/320/512/640, 1=368)	;GPUSTAT.16
7	Flip screen horizontally	(0=Off, 1=On, v1 only)	;GPUSTAT.14
8-23	Not used (zero)		

Note: Interlace must be enabled to see all lines in 480-lines mode (interlace causes ugly flickering, so a non-interlaced low resolution image typically has better quality than a high resolution interlaced image, a pretty bad example is the intro screens shown by the BIOS). The Display Area Color Depth bit does NOT affect GP0 draw commands, which always draw in 15 bit. However, the Vertical Interlace flag DOES affect GP0 draw commands.

Bit 7 is known as "reverseflag" and can reportedly be used on (v1?) arcade/prototype GPUs to flip the screen horizontally. On a v2 GPU setting this bit corrupts the display output, possibly due to leftovers of the v1 GPU's screen flipping circuitry still being present.

GP1(10h) - Read GPU internal register

GP1(11h..1Fh) - Mirrors of GP1(10h), Read GPU internal register

After sending the command, the result can be read (immediately) from GPUREAD register (there's no NOP or other delay required) (namely GPUSTAT.Bit27 is used only for VRAM reads, but NOT for register reads, so do not try to wait for that flag).

0-23 Register index (via following GPUREAD)

On v0 GPUs, the following indices are supported:

```

00h-01h = Returns Nothing (old value in GPUREAD remains unchanged)
02h      = Read Texture Window setting ;GP0 (E2h) ;20bit/MSBs=Nothing
03h      = Read Draw area top left     ;GP0 (E3h) ;19bit/MSBs=Nothing
04h      = Read Draw area bottom right ;GP0 (E4h) ;19bit/MSBs=Nothing
05h      = Read Draw offset             ;GP0 (E5h) ;22bit

```

```
06h-07h = Returns Nothing (old value in GPUREAD remains unchanged)
08h-FFFFFFh = Mirrors of 00h..07h
```

On v2 (and v1?) GPUs, the following indices are supported:

```
00h-01h = Returns Nothing (old value in GPUREAD remains unchanged)
02h      = Read Texture Window setting   ;GP0(E2h) ;20bit/MSBs=Nothing
03h      = Read Draw area top left       ;GP0(E3h) ;20bit/MSBs=Nothing
04h      = Read Draw area bottom right   ;GP0(E4h) ;20bit/MSBs=Nothing
05h      = Read Draw offset               ;GP0(E5h) ;22bit
06h      = Returns Nothing (old value in GPUREAD remains unchanged)
07h      = Read GPU version (1 or 2)
08h      = Unknown (Returns 00000000h) (lightgun? VRAM size set via GP1(09h)?)
09h-0Fh = Returns Nothing (old value in GPUREAD remains unchanged)
10h-FFFFFFh = Mirrors of 00h..0Fh
```

The selected data is latched in GPUREAD, the same/latched value can be read multiple times, but, the latch isn't automatically updated when changing GP0 registers.

GP1(09h) - Set VRAM size (v2)

```
0      Allow Y coordinates in 512-1023 range (0=No/wrap to 0-511, 1=Yes)
1-23   Unknown (seems to have no effect)
```

Controls whether or not GP0(E1h).bit11 can be used to reference textures in the second half of VRAM on systems with 2 MB VRAM (possibly affects drawing/display area commands and DMA transfers as well). The GPU has two separate chip select outputs for the first and second half; on a retail console only the first output is used, so enabling this feature will result in textures disappearing if GP0(E1h).bit11 is also set.

GP1(09h) is supported only on v2 GPUs; v0 GPUs don't support 2 MB VRAM at all and v1 seems to use command GP1(20h) instead.

GP1(20h) - Set VRAM size (v1)

```
0-23   Unknown (501h=1 MB, 504h=2 MB, or so?)
```

Seems to be used only on v1 arcade/prototype GPUs. Regular v2 GPUs use GP1(09h) instead of GP1(20h).

GP1(0Bh) - Unknown/Internal?

```
0-10   Unknown (GPU crashes after a while when set to 274h..7FFh)
11-23  Unknown (seems to have no effect)
```

The register doesn't seem to be used by any games.

GP1(0Ah,0Ch..0Fh,21h..3Fh) - N/A

Not used?

GP1(40h..FFh) - N/A (Mirrors)

Mirrors of GP1(00h..3Fh).

Mis-Centered PAL Games (wrong GP1(06h)/GP1(07h) settings)

NTSC games are typically well centered (using $X1=260h$, and $Y1/Y2=88h+/-N$).

PAL games should be centered as $X1=260h$, and $Y1/Y2=A3h+/-N$ - these values would be looking well on a Philips Philetta TV Set, and do also match up with other common picture positions (eg. as used by Nintendo's SNES console).

However, most PAL games are using completely different "random" centering values (maybe caused by different developers trying to match the centering to the different TV Sets) (although it looks more as if the PAL developers just went amok: Many PAL games are even using different centerings for their Intro, Movie, and actual Game sequences). In result, most PAL games are looking like crap when playing them on a real PSX. For PSX emulators it may be recommended to ignore the GP1(06h)/GP1(07h) centering, and instead, apply auto-centering to PAL games.

For PAL game developers, it may be recommended to add a screen centering option (as found in Tomb Raider 3, for example). Unknown if this is really required... or if $X1=260h$, and $Y1/Y2=A3h+/-N$ would work fine on most or all PAL TV Sets?

4.9 GPU Status Register

1F801814h - GPUSTAT - GPU Status Register (R)

0-3	Texture page X Base	(N*64)	;GP0(E1h).0-3
4	Texture page Y Base 1	(N*256) (ie. 0, 256, 512 or 768)	;GP0(E1h).4
5-6	Semi-transparency	(0=B/2+F/2, 1=B+F, 2=B-F, 3=B+F/4)	;GP0(E1h).5-6
7-8	Texture page colors	(0=4bit, 1=8bit, 2=15bit, 3=Reserved)	GP0(E1h).7-8
9	Dither 24bit to 15bit	(0=Off/strip LSBs, 1=Dither Enabled)	;GP0(E1h).9
10	Drawing to display area	(0=Prohibited, 1=Allowed)	;GP0(E1h).10
11	Set Mask-bit when drawing pixels	(0=No, 1=Yes/Mask)	;GP0(E6h).0
12	Draw Pixels	(0=Always, 1=Not to Masked areas)	;GP0(E6h).1
13	Interlace Field	(or, always 1 when GP1(08h).5=0)	
14	Flip screen horizontally	(0=Off, 1=On, v1 only)	;GP1(08h).7
15	Texture page Y Base 2	(N*512) (only for 2 MB VRAM)	;GP0(E1h).11

16	Horizontal Resolution 2	(0=256/320/512/640, 1=368)	;GP1(08h).6
17-18	Horizontal Resolution 1	(0=256, 1=320, 2=512, 3=640)	;GP1(08h).0-1
19	Vertical Resolution	(0=240, 1=480, when Bit22=1)	;GP1(08h).2
20	Video Mode	(0=NTSC/60Hz, 1=PAL/50Hz)	;GP1(08h).3
21	Display Area Color Depth	(0=15bit, 1=24bit)	;GP1(08h).4
22	Vertical Interlace	(0=Off, 1=On)	;GP1(08h).5
23	Display Enable	(0=Enabled, 1=Disabled)	;GP1(03h).0
24	Interrupt Request (IRQ1)	(0=Off, 1=IRQ)	;GP0(1Fh)/GP1(02h)
25	DMA / Data Request, meaning depends on GP1(04h) DMA Direction:		
	When GP1(04h)=0 ---> Always zero (0)		
	When GP1(04h)=1 ---> FIFO State (0=Full, 1=Not Full)		
	When GP1(04h)=2 ---> Same as GPUSTAT.28		
	When GP1(04h)=3 ---> Same as GPUSTAT.27		
26	Ready to receive Cmd Word	(0=No, 1=Ready)	;GP0(...) ;via GP0
27	Ready to send VRAM to CPU	(0=No, 1=Ready)	;GP0(C0h) ;via GPUREAD
28	Ready to receive DMA Block	(0=No, 1=Ready)	;GP0(...) ;via GP0
29-30	DMA Direction (0=Off, 1=?, 2=CPUtoGP0, 3=GPUREADtoCPU)		;GP1(04h).0-1
31	Drawing even/odd lines in interlace mode (0=Even or Vblank, 1=Odd)		

In 480-lines mode, bit31 changes per frame. And in 240-lines mode, the bit changes per scanline. The bit is always zero during Vblank (vertical retrace and upper/lower screen border).

Note

Further GPU status information can be retrieved via GP1(10h) and GP0(C0h).

Ready Bits

Bit28: Normally, this bit gets cleared when the command execution is busy (ie. once when the command and all of its parameters are received), however, for Polygon and Line Rendering commands, the bit gets cleared immediately after receiving the command word (ie. before receiving the vertex parameters). The bit is used as DMA request in DMA Mode 2, accordingly, the DMA would probably hang if the Polygon/Line parameters are transferred in a separate DMA block (ie. the DMA probably starts ONLY on command words).

Bit27: Gets set after sending GP0(C0h) and its parameters, and stays set until all data words are received; used as DMA request in DMA Mode 3.

Bit26: Gets set when the GPU wants to receive a command. If the bit is cleared, then the GPU does either want to receive data, or it is busy with a command execution (and doesn't want to receive anything).

Bit25: This is the DMA Request bit, however, the bit is also useful for non-DMA transfers, especially in the FIFO State mode.

4.10 GPU Versions

Summary of GPU Differences

Differences...	v0 (160-pin)	v1 (208-pin prototype)	v2 (208-pin)
GPU Chip	CXD8514Q	CXD8538Q	CXD8561Q/BQ/CQ/CXD9500Q
Mainboard and up	EARLY-PU-8 and below	Arcade boards only	LATE-PU-8
Memory Type	Dual-ported VRAM	Dual-ported VRAM?	Normal
GPUSTAT.13 when interlace=off	always 0	unknown	always 1
GPUSTAT.14	always 0	screen flip	
nonfunctional screen flip			
GPUSTAT.15	always 0	always 0?	bit1 of
texpage Y base			
GP1(10h:index3..4)	19-bit (1 MB VRAM)	22-bit (2 MB VRAM)	20-bit (2 MB VRAM)
GP1(10h:index7)	N/A	00000001h version	00000002h
version			
GP1(10h:index8)	mirror of index0	00000000h zero	00000000h
zero			
GP1(10h:index9..F)	mirror of index1..7	unknown	N/A
GP1(09h)	N/A	N/A	VRAM size
GP1(20h)	N/A	VRAM size/settings	N/A
GP0(E1h).bit11	N/A	N/A	bit1 of
texpage Y base			
GP0(E1h).bit12/13	without x/y-flip	without x/y-flip	with x/y-flip
flip			
GP0(03h)	N/A (no stored in fifo)	unknown	unknown/
unused command			
Shaded Textures	((color/8)*texel)/2	unknown	
(color*texel)/16			
GP0(02h) FillVram	xpos.bit0-3=0Fh=bugged	unknown	
xpos.bit0-3=ignored			
dma-to-vram: doesn't work with blksiz>10h (v2 gpu works with blksiz=8C0h!) dma-to-vram: MAYBE also needs extra software-handshake to confirm DMA done? 320*224 pix = 11800h pix = 8C00h words			

The CXD8538Q (v1) GPU was only ever used in some arcade boards. Among other things, this GPU seems to use completely different drawing commands and has some additional functionality not available on v0/v2 GPUs (reportedly GP1(08h).bit7 can be used to flip the screen horizontally?). It may however have a smaller texture cache or no cache at all, which would explain why the screen flipping feature had to be removed from v2 to make room on the die for the cache.

There is another arcade-only GPU revision, the CXD8654Q (v2b). It seems to use the

same commands as regular v2 GPUs, but the differences between v2b and v2 are currently unknown.

Shaded Textures

The v0 GPU crops 8:8:8 bit gouraud shading color to 5:5:5 bit before multiplying it with the texture color, resulting in rather poor graphics. For example, the snow scene in the first level of Tomb Raider I looks a lot smoother on v2 GPUs. This bug was presumably already fixed on the v1 prototype GPU (unconfirmed).

The cropped colors are looking a bit as if dithering would be disabled (although, technically dithering works fine, but due to the crippled color input, it's always using the same dither pattern per 8 intensities, instead of using 8 different dither patterns).

Memory/Rendering Timings

The v0 GPU uses two Dual-ported VRAM chips (each with two 16bit databusses, one for CPU/DMA/rendering access, and one for output to the video DAC). The New GPU uses a normal DRAM chip (with single 32bit databus).

The exact timing differences are unknown, but the different memory types should result in quite different timings:

The v0 GPU might perform better on non-32bit aligned accesses, and on memory accesses performed simultaneously with DAC output.

On the other hand, the v2 GPU's DRAM seems to be faster in some cases (for example, during Vblank, it's fast enough to perform DMA's with blksiz>10h, which exceeds the GPU's FIFO size, and causes lost data on v0 GPUs).

X/Y-Flip and PSone 2 MB VRAM

The X/Y-flipping feature may be used by arcade games (provided that the arcade board is fitted with v2 GPUs). The flipping feature does also work on retail consoles with v2 GPUs, but PSX games should never use that feature (for maintaining compatibility with older PSX consoles).

Some PSone consoles seem to be fitted with 2 MB VRAM chips (maybe because smaller chips had not been in production anymore), but only the first 1 MB region is accessible. However, as all PSone models use a v2 GPU which supports 2 MB VRAM, it should be possible to rewire the chip selects to make the upper half accessible.

GPU Detection (and optional VRAM size switching)

Below is slightly customized GPU Detection function taken from Perfect Assassin (the index7 latching works ONLY on v1/v2 GPUs, whilst v0 GPUs would leave the latched value unchanged; as a workaround, the index4 latching is used to ensure that the latch won't contain 000002h on v0 GPUs, assuming that index4 is never set to 000002h).

```
[1F801814h]=10000004h      ;GP1(10h).index4 (latch draw area bottom right)
[1F801814h]=10000007h      ;GP1(10h).index7 (latch GPU version, if any)
if ([1F801810h] AND 00FFFFFFh)=00000002h then goto @@gpu_v2
[1F801810h]=([1F801814h] AND 3FFFh) OR E1001000h ;change GPUSTAT via GP0(E1h)
dummy=[1F801810h]          ;dummy read (unknown purpose)
if ([1F801814h] AND 00001000h) then goto @@gpu_v1 else goto @@gpu_v0
;---
@@gpu_v0:
return 0
;---
@@gpu_v1:
if want_2mb_vram then [1F801814h]=20000504h ;GP1(20h)
return 1
;---
@@gpu_v2:
if want_2mb_vram then [1F801814h]=09000001h ;GP1(09h)
return 2
```

GP0(02h) FillVram

The FillVram command does normally ignore the lower 4bit of the x-coordinate (and software should always set those bits to zero). However, if the 4bits are all set, then the old v0 GPU does write each 2nd pixel to wrong memory address. For example, a 32x4 pixel fill produces following results for x=0..1Fh:

0h	10h	20h	30h	40h
#####	#####	#####	#####	;\x=00h..0Eh
#####	#####	#####	#####	; and, x=0Fh
#####	#####	#####	#####	; on v2 GPU
#####	#####	#####	#####	;/
# # # # # # # ##### # # # # # # #	#####	#####	#####	;\
# # # # # # # ##### # # # # # # #	#####	#####	#####	; x=0Fh
# # # # # # # ##### # # # # # # #	#####	#####	#####	; on v0 GPU
# # # # # # # ##### # # # # # # #	#####	#####	#####	;/
	#####	#####	#####	;\x=10h..1Eh
	#####	#####	#####	; and, x=1Fh
	#####	#####	#####	; on v2 GPU
	#####	#####	#####	;/
	# # # # # # # ##### # # # # # # #	#####	#####	;\
	# # # # # # # ##### # # # # # # #	#####	#####	; x=1Fh


```
# # # # # # # ##### # # # # # # # ; on v0 GPU
# # # # # # # ##### # # # # # # # ;/
```

4.11 GPU Depth Ordering

Absent Depth Buffer

The PlayStation's GPU stores only RGB colors in the framebuffer (ie. unlike modern 3D processors, it's NOT buffering Depth values; leaving apart the Mask bit, which could be considered as a tiny 1bit "Depth" or "Priority" value). In fact, the GPU supports only X,Y coordinates, and it's totally unaware of Z coordinates. So, when rendering a polygon, the hardware CANNOT determine which of the new pixels are in front/behind of the old pixels in the buffer.

Simple Ordering

The rendering simply takes place in the ordering as the data is sent to the GPU (ie. the most distant objects should be sent first). For 2D graphics, it's fairly easy follow that order (eg. even multi-layer 2D graphics can be using DMA2-continous mode).

Depth Ordering Table (OT)

For 3D graphics, the ordering of the polygons may change more or less randomly (eg. when rotating/moving the camera). To solve that problem, the whole rendering data is usually first stored in a Depth Ordering Table (OT) in Main RAM, and, once when all polygons have been stored in the OT, the OT is sent to the GPU via "DMA2-linked-list" mode.

Initializing an empty OT (via DMA6)

DMA channel 6 can be used to set up an empty linked list, in which each entry points to the previous:

```
DPCR      - enable bits                      ;Example=x8xxxxxxh
D6_MADR    - pointer to the LAST table entry  ;Example=8012300Ch
D6_BCR     - number of list entries           ;Example=00000004h
D6_CHCR    - control bits (should be 11000002h) ;Example=11000002h
```

Each entry has a size of 00h words (upper 8bit), and a pointer to the previous entry (lower 24bit). With the above Example values, the generated table would look like so:

```
[80123000h]=00FFFFFFh ;1st entry, points to end code (xxFFFFFFh)
[80123004h]=00123000h ;2nd entry, points to 1st entry
[80123008h]=00123004h ;3rd entry, points to 2nd entry
[8012300Ch]=00123008h ;last entry, points to 3rd entry (table entriypoint)
```

Inserting Entries (Passing GTE data to the OT) (by software)

The GTE commands AVSZ3 and AVSZ4 can be used to calculate the Average Z coordinates of a polygon (based on its three or four Z coordinates). The result is returned as a 16bit Z value in GTE register OTZ, the commands do also allow to divide the result, to make it less than 16bit (the full 16bit would require an OT of 256KBytes - for the EMPTY table, which would be a waste of memory, and which would slowdown the DMA2/DMA6 operations) (on the other hand, a smaller table means less depth resolution).

```
[PacketAddr+0]      = [80123000h+OTZ*4] + (N SHL 24)  <--internal link chain
[PacketAddr+4..N*4] = GP0 Command(s) and Parameters  <--data (send to GP0)
[80123000h+OTZ*4]   = PacketAddr AND FFFFFFFh         <--internal link chain
```

If there's been already an entry (at the same OTZ index), then the new polygon will be processed first (ie. it will appear "behind" of the old entry).

Not sure if the packet size must be limited to max N=16 words (ie. as for the DMA2-continous block size) (due to GP0 FIFO size limits)?

Sending the OT to the GPU (via DMA2-linked-list mode)

```
1 - Wait until GPU is ready to receive commands ;GPUSTAT.28
2 - Enable DMA channel 2                        ;DPCR
3 - Set GPU to DMA cpu->gpu mode                ;[GP1]=04000002h aka GP1(04h)
3 - Set D2_MADR to the start of the list        ;(LAST Entry) ;Example=80123010h
4 - Set D2_BCR to zero                          ;(length unused, end at END-CODE)
5 - Set D2_CHCR to link mode, mem->GPU and dma enable ;=01000401h
```

4.12 GPU Video Memory (VRAM)

Framebuffer

The framebuffer contains the image that is to be output to the Television Set. The GPU supports 10 resolutions, with 16bit or 24bit per pixel.

Resolution	16bit	24bit		Resolution	16bit	24bit
256x240	120Kbytes	180Kbytes		256x480	240Kbytes	360Kbytes
320x240	150Kbytes	225Kbytes		320x480	300Kbytes	450Kbytes
368x240	xx0Kbytes	xx0Kbytes		368x480	xx0Kbytes	xx0Kbytes
512x240	240Kbytes	360Kbytes		512x480	480Kbytes	720Kbytes
640x240	300Kbytes	450Kbytes		640x480	600Kbytes	900Kbytes

Note: In most cases, you'll need TWO framebuffers (one being displayed, and used as rendering target) (unless you are able to draw the whole new image during vblank, or unless when using single-layer 2D graphics). So, resolutions that occupy more than 512K would exceed the available 1MB VRAM when using 2 buffers. Also, high resolutions mean higher rendering load, and less texture memory.

```
<B> 15bit Direct Display (default) (works with polygons, lines, rectangles)</B>
0-4   Red      (0..31)
5-9   Green    (0..31)
10-14 Blue     (0..31)
15    Mask flag (0=Normal, 1=Do not allow to overwrite this pixel)
<B> 24bit Direct Display (works ONLY with direct vram transfers)</B>
0-7   Red      (0..255)
8-15  Green    (0..255)
16-23 Blue     (0..255)
```

Note: The 24bit pixels occupy 3 bytes (not 4 bytes with unused MSBs), so each 6 bytes contain two 24bit pixels. The 24bit display mode works only with VRAM transfer commands like GP0(A0h); the rendering commands GP0(20h..7Fh) cannot output 24bit data. Ie. 24bit mode is used mostly for MDEC videos (and some 2D games like Heart of Darkness).

Texture Bitmaps

A texture is an image put on a polygon or sprite. The data of a texture can be stored in 3 different modes:

```
<B> 16bit Texture (Direct Color) ;(One 256x256 page = 128Kbytes)</B>
0-4   Red      (0..31)          ;\Color 0000h          = Fully-transparent
5-9   Green    (0..31)          ; Color 0001h..7FFFh = Non-transparent
10-14 Blue     (0..31)          ; Color 8000h..FFFFh = Semi-transparent (*)
15    Semi-transparency Flag    ;/(*) or Non-transparent for opaque commands
<B> 8bit Texture (256 Color Palette) ;(One 256x256 page = 64Kbytes)</B>
0-7   Palette index for 1st pixel (left)
8-15  Palette index for 2nd pixel (right)
<B> 4bit Texture (16 Color Palette) ;(One 256x256 page = 32Kbytes)</B>
0-3   Palette index for 1st pixel (left)
4-7   Palette index for 2nd pixel (middle/left)
```

```

8-11 Palette index for 3rd pixel (middle/right)
12-15 Palette index for 4th pixel (right)

```

A Texture Page is a 256x256 texel region in VRAM (the Polygon rendering commands are using Texcoords with 8bit X,Y coordinates, so polygons cannot use textures bigger than 256x256) (the Rectangle rendering commands with width/height parameters could theoretically use larger textures, but the hardware clips their texture coordinates to 8bit, too).

The GP0(E2h) Texture Window (aka Texture Repeat) command can be used to reduce the texture size to less than 256x256 texels.

The Texture Pages can be located in the frame buffer on X multiples of 64 halfwords and Y multiples of 256 lines.

Texture Palettes - CLUT (Color Lookup Table)

The clut is a the table where the colors are stored for the image data in the CLUT modes. The pixels of those images are used as indexes to this table. The clut is arranged in the frame buffer as a 256x1 image for the 8bit clut mode, and a 16x1 image for the 4bit clut mode.

0-4	Red	(0..31)	;\Color 0000h	= Fully-transparent
5-9	Green	(0..31)	; Color 0001h..7FFFh	= Non-transparent
10-14	Blue	(0..31)	; Color 8000h..FFFFh	= Semi-transparent (*)
15	Semi-transparency Flag		;/(*) or Non-transparent for opaque commands	

The clut data can be arranged in the frame buffer at X multiples of 16 (X=0,16,32,48,etc) and anywhere in the Y range of 0-511 (0-1023 if 2 MB VRAM is present).

Texture Color Black Limitations

On the PSX, texture color 0000h is fully-transparent, that means textures cannot contain Black pixels. However, in some cases, Color 8000h (Black with semi-transparent flag) can be used, depending on the rendering command:

opaque command, eg. GP0(24h)	--> 8000h = Non-Transparent Black
semi-transp command, eg. GP0(26h)	--> 8000h = Semi-Transparent Black

So, with semi-transparent rendering commands, it isn't possible to use Non-Transparent Black pixels in textures, the only workaround is to use colors like 0001h (dark red) or 0400h (dark blue). However, on some monitors with particularly high gamma, these colors might be clearly visible to be brighter than black.

4.13 GPU Texture Caching

The GPU has 2 Kbyte Texture Cache

There is also a CLUT cache that is preserved between GPU drawing commands. The CLUT cache is invalidated when different CLUT index values are used or when GP0(01h) is issued.

If polygons with texture are displayed, the GPU needs to read these from the frame buffer. This slows down the drawing process, and as a result the number of polygons that can be drawn in a given timespan. To speed up this process the GPU is equipped with a texture cache, so a given piece of texture needs not to be read multiple times in succession.

The texture cache size depends on the color mode used for the textures.

In 4 bit CLUT mode it has a size of 64x64, in 8 bit CLUT it's 32x64 and in 15bitDirect is 32x32. A general speed up can be achieved by setting up textures according to these sizes. For further speed gain a more precise knowledge of how the cache works is necessary.

Cache blocks

The texture page is divided into non-overlapping cache blocks, each of a unit size according to color mode. These cache blocks are tiled within the texture page.

```
+-----+-----+-----+---
|cache|      |      |
|block|      |
|  0|  1|  2|  ..
+-----+-----+---
|..  |      |
```

Cache entries

Each cache block is divided into 256 cache entries, which are numbered sequentially, and are 8 bytes wide. So a cache entry holds 16 4bit clut pixels 8 8bit clut pixels, or 4 15bitdirect pixels.

4bit and 8bit clut:	15bitdirect:
+-----+-----+-----+-----+	+-----+-----+-----+-----+-----+
0 1 2 3	0 1 2 3 4 5 6 7
+-----+-----+-----+-----+	+-----+-----+-----+-----+-----+
4 5 6 7	8 9 a b c d e f
+-----+-----+-----+-----+	+-----+-----+-----+-----+-----+
8 9 ..	10 11 ..
+-----+-----+-----+-----+	+-----+-----+-----+-----+-----+

```

|  c|  ..|          | 18|  ..|
+----+---          +----+---
|  ..              |  ..

```

The cache can hold only one cache entry by the same number, so if f.e. a piece of texture spans multiple cache blocks and it has data on entry 9 of block 1, but also on entry 9 of block 2, these cannot be in the cache at once.

4.14 GPU Timings

Nominal Video Clock

```

NTSC video clock = 53.693175 MHz
PAL video clock  = 53.203425 MHz

```

Consoles will always use the video clock for its region, regardless of the GPU being configured in NTSC or PAL output mode, because an NTSC console lacks a PAL reference clock and vice versa. Without modifications for an additional oscillator for the other region, consoles may experience drift over time when playing content from a different video region. See vertical refresh rates below.

Vertical Video Timings

```

263 scanlines per field for NTSC non-interlaced
262.5 scanlines per field for NTSC interlaced

314 scanlines per field for PAL non-interlaced
312.5 scanlines per field for PAL interlaced

```

Horizontal blanking and vertical blanking signals occur on the video output side as expected for NTSC/PAL signals. These are not necessarily the same as the timer/interrupt HBLANK and VBLANK.

Vertical Refresh Rates

```

NTSC mode on NTSC video clock
Interlaced:      59.940 Hz
Non-interlaced: 59.826 Hz

PAL mode on PAL video clock
Interlaced:      50.000 Hz
Non-interlaced: 49.761 Hz

```

```
NTSC mode on PAL video clock
Interlaced:      59.393 Hz
Non-interlaced: 59.280 Hz
```

```
PAL mode on NTSC video clock
Interlaced:      50.460 Hz
Non-interlaced: 50.219 Hz
```

For emulation purposes, it's recommended to use an NTSC video clock when running NTSC content (or in NTSC mode) and a PAL clock when running PAL content (or in PAL mode).

TODO: Derivations for vertical refresh rates; horizontal timing notes

Nocash's original GPU Timings notes:

Video Clock

The PSone/PAL video clock is the cpu clock multiplied by 11/7.

```
CPU Clock    = 33.868800MHz (44100Hz*300h)
Video Clock  = 53.222400MHz (44100Hz*300h*11/7)
```

For other PSX/PSone PAL/NTSC variants, see:

[Pinouts - CLK Pinouts](#)

Vertical Timings

```
PAL:  314 scanlines per frame (13Ah)
NTSC: 263 scanlines per frame (107h)
```

Timer1 can use the hblank signal as input, allowing to count scanlines (unless the display is configured to 0 pixels width, which would cause an endless hblank). The hblank signal is generated even during vertical blanking/retrace.

Horizontal Timings

```
PAL:  3406 video cycles per scanline (or 3406.1 or so?)
NTSC: 3413 video cycles per scanline (or 3413.6 or so?)
```

Dotclocks:

```
PSX.256-pix Dotclock = 5.322240MHz (44100Hz*300h*11/7/10)
PSX.320-pix Dotclock = 6.652800MHz (44100Hz*300h*11/7/8)
PSX.368-pix Dotclock = 7.603200MHz (44100Hz*300h*11/7/7)
```

```
PSX.512-pix Dotclock = 10.644480MHz (44100Hz*300h*11/7/5)
PSX.640-pix Dotclock = 13.305600MHz (44100Hz*300h*11/7/4)
Namco GunCon 385-pix = 8.000000MHz (from 8.00MHz on lightgun PCB)
```

Dots per scanline are, depending on horizontal resolution, and on PAL/NTSC:

```
320pix/PAL: 3406/8 = 425.75 dots      320pix/NTSC: 3413/8 = 426.625 dots
640pix/PAL: 3406/4 = 851.5 dots       640pix/NTSC: 3413/4 = 853.25 dots
256pix/PAL: 3406/10 = 340.6 dots      256pix/NTSC: 3413/10 = 341.3 dots
512pix/PAL: 3406/5 = 681.2 dots       512pix/NTSC: 3413/5 = 682.6 dots
368pix/PAL: 3406/7 = 486.5714 dots    368pix/NTSC: 3413/7 = 487.5714 dots
```

Timer0 can use the dotclock as input, however, the Timer0 input "ignores" the fractional portions (in most cases, the values are rounded down, ie. with 340.6 dots/line, the timer increments only 340 times/line; the only value that is rounded up is 425.75 dots/line) (for example, due to the rounding, the timer isn't running exactly twice as fast in 512pix/PAL mode than in 256pix/PAL mode). The dotclock signal is generated even during horizontal/vertical blanking/retrace.

Frame Rates

```
PAL: 53.222400MHz/314/3406 = ca. 49.76 Hz (ie. almost 50Hz)
NTSC: 53.222400MHz/263/3413 = ca. 59.29 Hz (ie. almost 60Hz)
```

Note

Above values include "hidden" dots and scanlines (during horizontal and vertical blanking/retrace).

4.15 GPU (MISC)

GP0(20h..7Fh) - Render Command Bits

0-23	Color for (first) Vertex	(Not for Raw-Texture)
24	Texture Mode (0=Blended, 1=Raw)	(Textured-Polygon/Rect only)
25	Semi-transparency (0=Off, 1=On)	(All Render Types)
26	Texture Mapping (0=Off, 1=On)	(Polygon/Rectangle only)
27-28	Rect Size (0=Var, 1=1x1, 2=8x8, 3=16x16)	(Rectangle only)
27	Num Vertices (0=Triple, 1=Quad)	(Polygon only)
27	Num Lines (0=Single, 1=Poly)	(Line only)
28	Shading (0=Flat, 1=Gouroud)	(Polygon/Line only)
29-31	Primitive Type (1=Polygon, 2=Line, 3=Rectangle)	

Perspective (in-)correct Rendering

The PSX doesn't support perspective correct rendering: Assume a polygon to be rotated so that it's right half becomes more distant to the camera, and it's left half becomes closer. Due to the GTE's perspective division, the right half should appear smaller than the left half.

The GPU supports only linear interpolations for rendering - that is correct concerning the X and Y screen coordinates (which are still linear to each other, even after perspective division, since both are divided by the same value).

However, texture coordinates (and Gouraud shaded colors) are NOT linear to the screen coordinates, and so, the linear interpolated PSX graphics are often looking rather distorted, that especially for textures that contain straight lines. For color shading the problem is less obvious (since shading is kinda blurry anyways).

Perspective correct Rendering

For perspective correct rendering, the polygon's Z-coordinates would be needed to be passed from the GTE to the GPU, and, the GPU would then need to use that Z-coordinates to "undo" the perspective division for each pixel (that'd require some additional memory, and especially a powerful division unit, which isn't implemented in the hardware).

As a workaround, you can try to reduce the size of your polygons (the interpolation errors increase in the center region of larger polygons). Reducing the size would be only required for polygons that occupy a larger screen region (which may vary depending on the distance to the camera).

Ie. you may check the size AFTER perspective division, if it's too large, then break it into smaller parts (using the original coordinates, NOT the screen coordinates), and then pass the fragments to the GTE another time.

Again, perspective correction would be relevant only for certain textures (not for randomly dithered textures like sand, water, fire, grass, and not for untextured polygons, and of course not for 2D graphics, so you may exclude those from size reduction).

24bit RGB to 15bit RGB Dithering (enabled in Texpage attribute)

For dithering, VRAM is broken to 4x4 pixel blocks, depending on the location in that 4x4 pixel region, the corresponding dither offset is added to the 8bit R/G/B values, the result is saturated to +00h..+FFh, and then divided by 8, resulting in the final 5bit R/G/B values.

```

-4  +0  -3  +1  ;\dither offsets for first two scanlines
+2  -2  +3  -1  ;/
-3  +1  -4  +0  ;\dither offsets for next two scanlines
+3  -1  +2  -2  ;/(same as above, but shifted two pixels horizontally)

```

POLYGONS (triangles/quads) are dithered ONLY if they do use gouraud shading or modulation.

LINEs are dithered (no matter if they are mono or do use gouraud shading).

RECTs are NOT dithered (no matter if they do use modulation or not).

Shading

The GPU has a shading function, which will scale the color of a primitive to a specified brightness. There are 2 shading modes: Flat shading, and gouraud shading. Flat shading is the mode in which one brightness value is specified for the entire primitive. In Gouraud shading mode, a different brightness value can be given for each vertex of a primitive, and the brightness between these points is automatically interpolated.

Semi-transparency

When semi-transparency is set for a pixel, the GPU first reads the pixel it wants to write to, and then calculates the color it will write from the 2 pixels according to the semi-transparency mode selected. Processing speed is lower in this mode because additional reading and calculating are necessary. There are 4 semi-transparency modes in the GPU.

```

B=Back (the old pixel read from the frame buffer)
F=Front (the new semi-transparent pixel)
* 0.5 x B + 0.5 x F      ;aka B/2+F/2
* 1.0 x B + 1.0 x F      ;aka B+F
* 1.0 x B - 1.0 x F      ;aka B-F
* 1.0 x B +0.25 x F      ;aka B+F/4

```

For textured primitives using 4-bit or 8-bit textures, bit 15 of each CLUT entry acts as a semi-transparency flag and determines whether to apply semi-transparency to the pixel or not. If the semi-transparency flag is off, the new pixel is written to VRAM as-is.

When using additive blending, if a channel's intensity is greater than 255, it gets clamped to 255 rather than being masked. Similarly, if using subtractive blending and a channel's intensity ends up being < 0 , it's clamped to 0.

Modulation (also known as Texture Blending)

Modulation is a colour effect that can be applied to textured primitives. For each pixel of the primitive it combines every colour channel of the fetched texel with the corresponding channel of the interpolated vertex colour according to this formula (Assuming all channels are 8-bit).

```
finalChannel.rgb = (texel.rgb * vertexColour.rgb) / vec3(128.0)
```

Using modulation, one can either decrease (if the vertex colour channel value is < 128) or increase (if it's > 128) the intensity of each colour channel of the texel, which is helpful for implementing things such as brightness effects.

Using a vertex colour of 0x808080 (ie all channels set to 128) is equivalent to not applying modulation to the primitive, as shown by the above formula.

"Texture blending" is not meant to be confused with normal blending, ie an operation that merges the backbuffer colour with the incoming pixel and draws the resulting colour to the backbuffer. The PS1 has this capability to an extent, using semi-transparency.

Draw to display enable

This will enable/disable any drawing to the area that is currently displayed. Not sure yet WHY one should want to disable that?

Also not sure HOW and IF it works... the SIZE of the display area is implied by the screen size - which is horizontally counted in CLOCK CYCLES, so, to obtain the size in PIXELS, the hardware would require to divide that value by the number of cycles per pixel, depending on the current resolution...?

5. Geometry Transformation Engine (GTE)

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[GTE Division Inaccuracy](#)

5.1 GTE Overview

GTE Operation

The GTE doesn't have any memory or I/O ports mapped to the CPU memory bus, instead, it's solely accessed via coprocessor opcodes:

```
mov  cop0r12,rt          ; -enable/disable COP2 (GTE) via COP0 status register
mov  cop2r0-63,rt        ; \write parameters to GTE registers
mov  cop2r0-31,[rs+imm]  ; /
mov  cop2cmd,imm25       ; -issue GTE command
mov  rt,cop2r0-63        ; \read results from GTE registers
mov  [rs+imm],cop2r0-31  ; /
jt   cop2flg,dest        ; -jump never ; \implemented (no exception), but,
jf   cop2flg,dest        ; -jump always ; /flag seems to be always "false"
```

GTE Load Delay Slots

Using CFC2/MFC2 has a delay of 1 instruction until the GPR is loaded with its new value. Certain games are sensitive to this, with the notable example of Tekken 2 which will be filled with broken geometry on emulators which don't emulate this properly.

GTE (memory-?) load and store instructions have a delay of 2 instructions, for any GTE commands or operations accessing that register. Any? That's wrong!

GTE instructions and functions should not be used in

- Delay slots of jumps and branches
- Event handlers or interrupts (sounds like nonsense?) (need push/pop though)

If an instruction that reads a GTE register or a GTE command is executed before the current GTE command is finished, the CPU will hold until the instruction has finished. The number of cycles each GTE instruction takes is shown in the command list.

GTE Command Encoding (COP2 imm25 opcodes)

```

31-25 Must be 0100101b for "COP2 imm25" instructions
20-24 Fake GTE Command Number (00h..1Fh) (ignored by hardware)
19    sf - Shift Fraction in IR registers (0=No fraction, 1=12bit fraction)
17-18 MVMVA Multiply Matrix      (0=Rotation, 1=Light, 2=Color, 3=Reserved)
15-16 MVMVA Multiply Vector      (0=V0, 1=V1, 2=V2, 3=IR/long)
13-14 MVMVA Translation Vector   (0=TR, 1=BK, 2=FC/Bugged, 3=None)
11-12 Always zero                (ignored by hardware)
10    lm - Saturate IR1,IR2,IR3 result (0=To -8000h..+7FFFh, 1=To 0..+7FFFh)
6-9   Always zero                (ignored by hardware)
0-5   Real GTE Command Number (00h..3Fh) (used by hardware)

```

The MVMVA bits are used only by the MVMVA opcode (the bits are zero for all other opcodes).

The "sf" and "lm" bits are usually fixed (either set, or cleared, depending on the command) (for MVMVA, the bits are variable) (also, "sf" can be changed for some commands like SQR) (although they are usually fixed for most other opcodes, changing them might have some effect on some/all opcodes)?

GTE Data Register Summary (cop2r0-31)

cop2r0-1	3xS16 VXY0,VZ0	Vector 0 (X,Y,Z)
cop2r2-3	3xS16 VXY1,VZ1	Vector 1 (X,Y,Z)
cop2r4-5	3xS16 VXY2,VZ2	Vector 2 (X,Y,Z)
cop2r6	4xU8 RGBC	Color/code value
cop2r7	1xU16 OTZ	Average Z value (for Ordering Table)
cop2r8	1xS16 IR0	16bit Accumulator (Interpolate)
cop2r9-11	3xS16 IR1,IR2,IR3	16bit Accumulator (Vector)
cop2r12-15	6xS16 SXY0,SXY1,SXY2,SXYP	Screen XY-coordinate FIFO (3 stages)
cop2r16-19	4xU16 SZ0,SZ1,SZ2,SZ3	Screen Z-coordinate FIFO (4 stages)
cop2r20-22	12xU8 RGB0,RGB1,RGB2	Color CRGB-code/color FIFO (3 stages)
cop2r23	4xU8 (RES1)	Prohibited
cop2r24	1xS32 MAC0	32bit Maths Accumulators (Value)
cop2r25-27	3xS32 MAC1,MAC2,MAC3	32bit Maths Accumulators (Vector)
cop2r28-29	1xU15 IRGB,ORGB	Convert RGB Color (48bit vs 15bit)
cop2r30-31	2xS32 LZCS,LZCR	Count Leading-Zeroes/Ones (sign bits)

GTE Control Register Summary (cop2r32-63)

cop2r32-36	9xS16 RT11RT12,...,RT33	Rotation matrix	(3x3)	;cnt0-4
cop2r37-39	3x 32 TRX,TRY,TRZ	Translation vector	(X,Y,Z)	;cnt5-7

cop2r40-44	9xS16	L11L12,...,L33	Light source matrix (3x3)	;cnt8-12
cop2r45-47	3x 32	RBK,GBK,BBK	Background color (R,G,B)	;cnt13-15
cop2r48-52	9xS16	LR1LR2,...,LB3	Light color matrix source (3x3)	;cnt16-20
cop2r53-55	3x 32	RFC,GFC,BFC	Far color (R,G,B)	;cnt21-23
cop2r56-57	2x 32	OFX,OFY	Screen offset (X,Y)	;cnt24-25
cop2r58	BuggyU16	H	Projection plane distance.	;cnt26
cop2r59	S16	DQA	Depth queing parameter A (coeff)	;cnt27
cop2r60	32	DQB	Depth queing parameter B (offset)	;cnt28
cop2r61-62	2xS16	ZSF3,ZSF4	Average Z scale factors	;cnt29-30
cop2r63	U20	FLAG	Returns any calculation errors	;cnt31

5.2 GTE Registers

Note in some functions format is different from the one that's given here.

Matrix Registers

Rotation matrix (RT)	Light matrix (LLM)	Light Color matrix (LCM)
cop2r32.lsb=RT11	cop2r40.lsb=L11	cop2r48.lsb=LR1
cop2r32.msb=RT12	cop2r40.msb=L12	cop2r48.msb=LR2
cop2r33.lsb=RT13	cop2r41.lsb=L13	cop2r49.lsb=LR3
cop2r33.msb=RT21	cop2r41.msb=L21	cop2r49.msb=LG1
cop2r34.lsb=RT22	cop2r42.lsb=L22	cop2r50.lsb=LG2
cop2r34.msb=RT23	cop2r42.msb=L23	cop2r50.msb=LG3
cop2r35.lsb=RT31	cop2r43.lsb=L31	cop2r51.lsb=LB1
cop2r35.msb=RT32	cop2r43.msb=L32	cop2r51.msb=LB2
cop2r36 =RT33	cop2r44 =L33	cop2r52 =LB3

Each element is 16bit (1bit sign, 3bit integer, 12bit fraction). Reading the last elements (RT33,L33,LB3) returns the 16bit value sign-expanded to 32bit.

Translation Vector (TR) (Input, R/W?)

```
cop2r37 (cnt5) - TRX - Translation vector X (R/W?)
cop2r38 (cnt6) - TRY - Translation vector Y (R/W?)
cop2r39 (cnt7) - TRZ - Translation vector Z (R/W?)
```

Each element is 32bit (1bit sign, 31bit integer).

Used only for MVMVA, RTPS, RTPT commands.

Background Color (BK) (Input?, R/W?)

```
cop2r45 (cnt13) - RBK - Background color red component
cop2r46 (cnt14) - GBK - Background color green component
cop2r47 (cnt15) - BBK - Background color blue component
```

Each element is 32bit (1bit sign, 19bit integer, 12bit fraction).

Far Color (FC) (Input?) (R/W?)

```
cop2r53 (cnt21) - RFC - Far color red component
cop2r54 (cnt22) - GFC - Far color green component
cop2r55 (cnt23) - BFC - Far color blue component
```

Each element is 32bit (1bit sign, 27bit integer, 4bit fraction).

Screen Offset and Distance (Input, R/W?)

```
cop2r56 (cnt24) - OFX - Screen offset X
cop2r57 (cnt25) - OFY - Screen offset Y
cop2r58 (cnt26) - H   - Projection plane distance
cop2r59 (cnt27) - DQA - Depth queing parameter A.(coeff.)
cop2r60 (cnt28) - DQB - Depth queing parameter B.(offset.)
```

The X and Y values are each 32bit (1bit sign, 15bit integer, 16bit fraction).

The H value is 16bit unsigned (0bit sign, 16bit integer, 0bit fraction). BUG: When reading the H register, the hardware does accidentally \<sign-expand> the \<unsigned> 16bit value (ie. values +8000h..+FFFFh are returned as FFFF8000h..FFFFFFFFh) (this bug applies only to "mov rd,cop2r58" opcodes; the actual calculations via RTPS/RTPT opcodes are working okay).

The DQA value is only 16bit (1bit sign, 7bit integer, 8bit fraction).

The DQB value is 32bit (1bit sign, 7bit integer, 24bit? fraction).

Used only for RTPS/RTPT commands.

Average Z Registers (ZSF3/ZSF4=Input, R/W?) (OTZ=Result, R)

```
cop2r61 (cnt29) ZSF3 | 0|ZSF3 1,3,12| Z3 average scale factor (normally 1/3)
cop2r62 (cnt30) ZSF4 | 0|ZSF4 1,3,12| Z4 average scale factor (normally 1/4)
cop2r7      OTZ  (R) | |OTZ 0,15, 0| Average Z value (for Ordering Table)
```

Used only for AVSZ3/AVSZ4 commands.

Screen XYZ Coordinate FIFOs

```
cop2r12 - SXY0  rw|SY0 1,15, 0|SX0 1,15, 0| Screen XY fifo (older)
cop2r13 - SXY1  rw|SY1 1,15, 0|SX1 1,15, 0| Screen XY fifo (old)
cop2r14 - SXY2  rw|SY2 1,15, 0|SX2 1,15, 0| Screen XY fifo (new)
cop2r15 - SXYP  rw|SYP 1,15, 0|SXP 1,15, 0| SXY2-mirror with move-on-write
cop2r16 - SZ0   rw|      0|SZ0 0,16, 0| Screen Z fifo (oldest)
cop2r17 - SZ1   rw|      0|SZ1 0,16, 0| Screen Z fifo (older)
```

```

cop2r18 - SZ2   rw|          0|SZ2 0,16, 0| Screen Z fifo (old)
cop2r19 - SZ3   rw|          0|SZ3 0,16, 0| Screen Z fifo (new)

```

SX,SY,SZ are used as Output for RTPS/RTPT. Additionally, SX,SY are used as Input for NCLIP, and SZ is used as Input for AVSZ3/AVSZ4.

The SZn Fifo has 4 stages (required for AVSZ4 command), the SXYn Fifo has only 3 stages, and a special mirrored register: SXYP is a mirror of SXY2, the difference is that writing to SXYP moves SXY2/SXY1 to SXY1/SXY0, whilst writing to SXY2 (or any other SXYn or SZn registers) changes only the written register, but doesn't move any other Fifo entries.

16bit Vectors (R/W)

Vector 0 (V0)	Vector 1 (V1)	Vector 2 (V2)	Vector 3 (IR)
cop2r0.lsbs - VX0	cop2r2.lsbs - VX1	cop2r4.lsbs - VX2	cop2r9 - IR1
cop2r0.msbs - VY0	cop2r2.msbs - VY1	cop2r4.msbs - VY2	cop2r10 - IR2
cop2r1 - VZ0	cop2r3 - VZ1	cop2r5 - VZ2	cop2r11 - IR3

All elements are signed 16bit. The IRn and VZn elements occupy a whole 32bit register, reading these registers returns the 16bit value sign-expanded to 32bit. Note: IRn can be also indirectly accessed via IRGB/ORGB registers.

Color Register and Color FIFO

cop2r6 - RGBC	rw CODE	B	G	R	Color/code
cop2r20 - RGB0	rw CD0	B0	G0	R0	Characteristic color fifo.
cop2r21 - RGB1	rw CD1	B1	G1	R1	
cop2r22 - RGB2	rw CD2	B2	G2	R2	
cop2r23 - (RES1)					Prohibited

RES1 seems to be unused... looks like an unused Fifo stage... RES1 is read/write-able... unlike SXYP (for SXYn Fifo) it does not mirror to RGB2, nor does it have a move-on-write function...

Interpolation Factor

```

cop2r8   IR0   rw|Sign   |IR0 1, 3,12| Intermediate value 0.

```

Used as Output for RTPS/RTPT, and as Input for various commands.

XX...


```
cop2r24  MAC0  rw|MAC0 1,31,0          | Sum of products value 0
```

XX...

```
cop2r25  MAC1  rw|MAC1 1,31,0          | Sum of products value 1
cop2r26  MAC2  rw|MAC2 1,31,0          | Sum of products value 2
cop2r27  MAC3  rw|MAC3 1,31,0          | Sum of products value 3
```

cop2r28 - IRGB - Color conversion Input (R/W)

Expands 5:5:5 bit RGB (range 0..1Fh) to 16:16:16 bit RGB (range 0000h..0F80h).

```
0-4      Red    (0..1Fh) (R/W)  ;multiplied by 80h, and written to IR1
5-9      Green  (0..1Fh) (R/W)  ;multiplied by 80h, and written to IR2
10-14    Blue   (0..1Fh) (R/W)  ;multiplied by 80h, and written to IR3
15-31    Not used (always zero) (Read only)
```

After writing to IRGB, the result can be read from IR3 after TWO nop's, and from IR1,IR2 after THREE nop's (for uncached code, ONE nop would work). When using IR1,IR2,IR3 as parameters for GTE commands, similar timing restrictions might apply... depending on when the specific commands use the parameters?

cop2r29 - ORGB - Color conversion Output (R)

Collapses 16:16:16 bit RGB (range 0000h..0F80h) to 5:5:5 bit RGB (range 0..1Fh). Negative values (8000h..FFFFh/80h) are saturated to 00h, large positive values (1000h..7FFFh/80h) are saturated to 1Fh, there are no overflow or saturation flags set in cop2r63 though.

```
0-4      Red    (0..1Fh) (R)    ;IR1 divided by 80h, saturated to +00h..+1Fh
5-9      Green  (0..1Fh) (R)    ;IR2 divided by 80h, saturated to +00h..+1Fh
10-14    Blue   (0..1Fh) (R)    ;IR3 divided by 80h, saturated to +00h..+1Fh
15-31    Not used (always zero) (Read only)
```

Any changes to IR1,IR2,IR3 are reflected to this register (and, actually also to IRGB) (ie. ORGB is simply a read-only mirror of IRGB).

cop2r30 - LZCS - Count Leading Bits Source data (R/W)**cop2r31 - LZCR - Count Leading Bits Result (R)**

Reading LZCR returns the leading 0 count of LZCS if LZCS is positive and the leading 1 count of LZCS if LZCS is negative. The results are in range 1..32.

cop2r63 (cnt31) - FLAG - Returns any calculation errors.

See GTE Saturation chapter.

5.3 GTE Saturation

Maths overflows are indicated in FLAG register. In most cases, the result is saturated to MIN/MAX values (except MAC0,MAC1,MAC2,MAC3 which aren't saturated). For IR1,IR2,IR3 many commands allow to select the MIN value via "lm" bit of the GTE opcode (though not all commands, RTPS/RTPT always act as if lm=0).

cop2r63 (cnt31) - FLAG - Returns any calculation errors.

```

31  Error Flag (Bit30..23, and 18..13 ORed together) (Read only)
30  MAC1 Result larger than 43 bits and positive
29  MAC2 Result larger than 43 bits and positive
28  MAC3 Result larger than 43 bits and positive
27  MAC1 Result larger than 43 bits and negative
26  MAC2 Result larger than 43 bits and negative
25  MAC3 Result larger than 43 bits and negative
24  IR1 saturated to +0000h..+7FFFh (lm=1) or to -8000h..+7FFFh (lm=0)
23  IR2 saturated to +0000h..+7FFFh (lm=1) or to -8000h..+7FFFh (lm=0)
22  IR3 saturated to +0000h..+7FFFh (lm=1) or to -8000h..+7FFFh (lm=0)
21  Color-FIFO-R saturated to +00h..+FFh
20  Color-FIFO-G saturated to +00h..+FFh
19  Color-FIFO-B saturated to +00h..+FFh
18  SZ3 or OTZ saturated to +0000h..+FFFFh
17  Divide overflow. RTPS/RTPT division result saturated to max=1FFFFh
16  MAC0 Result larger than 31 bits and positive
15  MAC0 Result larger than 31 bits and negative
14  SX2 saturated to -0400h..+03FFh
13  SY2 saturated to -0400h..+03FFh
12  IR0 saturated to +0000h..+1000h
0-11 Not used (always zero) (Read only)

```

Bit30-12 are read/write-able, ie. they can be set/reset by software, however, that's normally not required - all bits are automatically reset at the begin of a new GTE command.

Bit31 is apparently intended for RTPS/RTPT commands, since it triggers only on flags that are affected by these two commands, but even for that commands it's totally useless since one could as well check if FLAG is nonzero.

Note: Writing 32bit values to 16bit GTE registers by software does not trigger any overflow/saturation flags (and does not do any saturation), eg. writing 12008900h (positive 32bit) to a signed 16bit register sets that register to FFFF8900h (negative 16bit).

5.4 GTE Opcode Summary

GTE Command Summary (sorted by Real Opcode bits) (bit0-5)

Opc	Name	Clk	Expl.
00h	-		N/A (modifies similar registers than RTPS...)
01h	RTPS	15	Perspective Transformation single
0xh	-		N/A
06h	NCLIP	8	Normal clipping
0xh	-		N/A
0Ch	OP(sf)	6	Cross product of 2 vectors
0xh	-		N/A
10h	DPCS	8	Depth Cueing single
11h	INTPL	8	Interpolation of a vector and far color vector
12h	MVMVA	8	Multiply vector by matrix and add vector (see below)
13h	NCDS	19	Normal color depth cue single vector
14h	CDP	13	Color Depth Que
15h	-		N/A
16h	NCDT	44	Normal color depth cue triple vectors
1xh	-		N/A
1Bh	NCCS	17	Normal Color Color single vector
1Ch	CC	11	Color Color
1Dh	-		N/A
1Eh	NCS	14	Normal color single
1Fh	-		N/A
20h	NCT	30	Normal color triple
2xh	-		N/A
28h	SQR(sf)	5	Square of vector IR
29h	DCPL	8	Depth Cue Color light
2Ah	DPCT	17	Depth Cueing triple (should be fake=08h, but isn't)
2xh	-		N/A
2Dh	AVSZ3	5	Average of three Z values
2Eh	AVSZ4	6	Average of four Z values
2Fh	-		N/A
30h	RTPT	23	Perspective Transformation triple
3xh	-		N/A
3Dh	GPF(sf)	5	General purpose interpolation
3Eh	GPL(sf)	5	General purpose interpolation with base
3Fh	NCCT	39	Normal Color Color triple vector

Unknown if/what happens when using the "N/A" opcodes?

GTE Command Summary (sorted by Fake Opcode bits) (bit20-24)

The fake opcode number in bit20-24 has absolutely no effect on the hardware, it seems to be solely used to (or not to) confuse developers. Having the opcodes sorted by their fake numbers gives a more or less well arranged list:

Fake	Name	Clk	Expl.
00h	-		N/A
01h	RTPS	15	Perspective Transformation single
02h	RTPT	23	Perspective Transformation triple
03h	-		N/A
04h	MVMVA	8	Multiply vector by matrix and add vector (see below)
05h	-		N/A
06h	DCPL	8	Depth Cue Color light
07h	DPCS	8	Depth Cueing single
08h	DPCT	17	Depth Cueing triple (should be fake=08h, but isn't)
09h	INTPL	8	Interpolation of a vector and far color vector
0Ah	SQR(sf)	5	Square of vector IR
0Bh	-		N/A
0Ch	NCS	14	Normal color single
0Dh	NCT	30	Normal color triple
0Eh	NCDS	19	Normal color depth cue single vector
0Fh	NCDT	44	Normal color depth cue triple vectors
10h	NCCS	17	Normal Color Color single vector
11h	NCCT	39	Normal Color Color triple vector
12h	CDP	13	Color Depth Que
13h	CC	11	Color Color
14h	NCLIP	8	Normal clipping
15h	AVSZ3	5	Average of three Z values
16h	AVSZ4	6	Average of four Z values
17h	OP(sf)	6	Cross product of 2 vectors
18h	-		N/A
19h	GPF(sf)	5	General purpose interpolation
1Ah	GPL(sf)	5	General purpose interpolation with base
1Bh	-		N/A
1Ch	-		N/A
1Dh	-		N/A
1Eh	-		N/A
1Fh	-		N/A

For the sort-effect, DCPT should use fake=08h, but Sony seems to have accidentally numbered it fake=0Fh in their devkit (giving it the same fake number as for NCDT). Also, "Wipeout 2097" accidentally uses 0140006h (fake=01h and distorted bit18) instead of 1400006h (fake=14h) for NCLIP.

Additional Functions

The LZCS/LZCR registers offer a Count-Leading-Zeroes/Leading-Ones function. The IRGB/ORGB registers allow to convert between 48bit and 15bit RGB colors. These registers work without needing to send any COP2 commands. However, unlike for commands (which do automatically halt the CPU when needed), one must insert dummy opcodes between writing and reading the registers.

5.5 GTE Coordinate Calculation Commands

COP2 0180001h - 15 Cycles - RTPS - Perspective Transformation (single)

COP2 0280030h - 23 Cycles - RTPT - Perspective Transformation (triple)

RTPS performs final Rotate, translate and perspective transformation on vertex V0. Before writing to the FIFOs, the older entries are moved one stage down. RTPT is same as RTPS, but repeats for V1 and V2. The "sf" bit should be usually set.

```
IR1 = MAC1 = (TRX*1000h + RT11*VX0 + RT12*VY0 + RT13*VZ0) SAR (sf*12)
IR2 = MAC2 = (TRY*1000h + RT21*VX0 + RT22*VY0 + RT23*VZ0) SAR (sf*12)
IR3 = MAC3 = (TRZ*1000h + RT31*VX0 + RT32*VY0 + RT33*VZ0) SAR (sf*12)
SZ3 = MAC3 SAR ((1-sf)*12) ;ScreenZ FIFO 0..+FFFFh
MAC0=(( (H*20000h/SZ3)+1)/2)*IR1+OFX, SX2=MAC0/10000h ;ScrX FIFO -400h..+3FFh
MAC0=(( (H*20000h/SZ3)+1)/2)*IR2+OFY, SY2=MAC0/10000h ;ScrY FIFO -400h..+3FFh
MAC0=(( (H*20000h/SZ3)+1)/2)*DQA+DQB, IR0=MAC0/1000h ;Depth cueing 0..+1000h
```

If the result of the " $((H*20000h/SZ3)+1)/2$ " division is greater than 1FFFFh, then the division result is saturated to +1FFFFh, and the divide overflow bit in the FLAG register gets set; that happens if the vertex is exceeding the "near clip plane", ie. if it is very close to the camera ($SZ3 \leq H/2$), exactly at the camera position ($SZ3=0$), or behind the camera (negative Z coordinates are saturated to $SZ3=0$). For details on the division, see: [GTE Division Inaccuracy](#)

For "far plane clipping", one can use the SZ3 saturation flag ($MaxZ=FFFFh$), or the IR3 saturation flag ($MaxZ=7FFFh$) (eg. used by Wipeout 2097), or one can compare the SZ3 value with any desired MaxZ value by software.

Note: The command does saturate IR1,IR2,IR3 to -8000h..+7FFFh (regardless of 1m bit). When using RTP with $sf=0$, then the IR3 saturation flag (FLAG.22) gets set <only> if "MAC3 SAR 12" exceeds -8000h..+7FFFh (although IR3 is saturated when "MAC3" exceeds -8000h..+7FFFh).

COP2 1400006h - 8 Cycles - NCLIP - Normal clipping

```
MAC0 = SX0*SY1 + SX1*SY2 + SX2*SY0 - SX0*SY2 - SX1*SY0 - SX2*SY1
```

The sign of the result indicates whether the polygon coordinates are arranged clockwise or anticlockwise (ie. whether the front side or backside is visible). If the result is zero, then it's neither one (ie. the vertices are all arranged in a straight line). Note: The GPU probably renders straight lines as invisible 0 pixel width lines?

COP2 158002Dh - 5 Cycles - AVSZ3 - Average of three Z values (for Triangles)**COP2 168002Eh - 6 Cycles - AVSZ4 - Average of four Z values (for Quads)**

```
MAC0 = ZSF3*(SZ1+SZ2+SZ3)      ;for AVSZ3
MAC0 = ZSF4*(SZ0+SZ1+SZ2+SZ3)  ;for AVSZ4
OTZ  = MAC0/1000h              ;for both (saturated to 0..FFFFh)
```

Adds three or four Z values together and multiplies them by a fixed point value. The result can be used as index in the GPU's Ordering Table (OT).

GPU Depth Ordering

The scaling factors would be usually ZSF3=N/30h and ZSF4=N/40h, where "N" is the number of entries in the OT (max 10000h). SZn and OTZ are unsigned 16bit values, for whatever reason ZSFn registers are signed 16bit values (negative values would allow a negative result in MAC0, but would saturate OTZ to zero).

5.6 GTE General Purpose Calculation Commands

COP2 0400012h - 8 Cycles - MVMVA(sf,mx,v,cv,lm)

Multiply vector by matrix and vector addition.

```
Mx = matrix specified by mx ;RT/LLM/LCM - Rotation, light or color matrix
Vx = vector specified by v ;V0, V1, V2, or [IR1,IR2,IR3]
Tx = translation vector specified by cv ;TR or BK or Bugged/FC, or None
```

Calculation:

```
MAC1 = (Tx1*1000h + Mx11*Vx1 + Mx12*Vx2 + Mx13*Vx3) SAR (sf*12)
MAC2 = (Tx2*1000h + Mx21*Vx1 + Mx22*Vx2 + Mx23*Vx3) SAR (sf*12)
MAC3 = (Tx3*1000h + Mx31*Vx1 + Mx32*Vx2 + Mx33*Vx3) SAR (sf*12)
[IR1,IR2,IR3] = [MAC1,MAC2,MAC3]
```

Multiplies a vector with either the rotation matrix, the light matrix or the color matrix and then adds the translation vector or background color vector.

The GTE also allows selection of the far color vector (FC), but this vector is not added correctly by the hardware: The return values are reduced to the last portion of the formula, ie. $MAC1 = (Mx13 * Vx3) \text{ SAR } (sf * 12)$, and similar for MAC2 and MAC3, nevertheless, some bits in the FLAG register seem to be adjusted as if the full operation would have been executed. Setting $Mx=3$ selects a garbage matrix (with elements -60h, +60h, IR0, RT13, RT13, RT13, RT22, RT22, RT22).

COP2 0A00428h+sf*80000h - 5 Cycles - SQR(sf) - Square vector

```
[MAC1,MAC2,MAC3] = [IR1*IR1,IR2*IR2,IR3*IR3] SHR (sf*12)
[IR1,IR2,IR3]    = [MAC1,MAC2,MAC3]      ;IR1,IR2,IR3 saturated to max 7FFFh
```

Calculates the square of a vector. The result is, of course, always positive, so the "Im" flag for negative saturation has no effect.

COP2 170000Ch+sf*80000h - 6 Cycles - OP(sf,Im) - Cross product of 2 vectors

```
[MAC1,MAC2,MAC3] = [IR3*D2-IR2*D3, IR1*D3-IR3*D1, IR2*D1-IR1*D2] SAR (sf*12)
[IR1,IR2,IR3]    = [MAC1,MAC2,MAC3]                        ;copy result
```

Calculates the cross product of two signed 16bit vectors. Note: D1,D2,D3 are meant to be the RT11,RT22,RT33 elements of the RT matrix "misused" as vector. Im should be usually zero.

The official Sony documentation refers to this opcode as the Outer Product, but this is likely the result of a bad translation from Japanese: " - gaiseiki" can be translated to "cross product", "vector product", or "outer product".

LZCS/LZCR registers - ? Cycles - Count-Leading-Zeroes/Leading-Ones

The LZCS/LZCR registers offer a Count-Leading-Zeroes/Leading-Ones function.

5.7 GTE Color Calculation Commands

COP2 0C8041Eh - 14 Cycles - NCS - Normal color (single)

COP2 0D80420h - 30 Cycles - NCT - Normal color (triple)

COP2 108041Bh - 17 Cycles - NCCS - Normal Color Color (single vector)

COP2 118043Fh - 39 Cycles - NCCT - Normal Color Color (triple vector)

COP2 0E80413h - 19 Cycles - NCDS - Normal color depth cue (single vector)

COP2 0F80416h - 44 Cycles - NCDT - Normal color depth cue (triple vectors)

In: V0=Normal vector (for triple variants repeated with V1 and V2), BK=Background color, RGBC=Primary color/code, LLM=Light matrix, LCM=Color matrix, IR0=Interpolation value.

```
[IR1,IR2,IR3] = [MAC1,MAC2,MAC3] = (LLM*V0) SAR (sf*12)
[IR1,IR2,IR3] = [MAC1,MAC2,MAC3] = (BK*1000h + LCM*IR) SAR (sf*12)
[MAC1,MAC2,MAC3] = [R*IR1,G*IR2,B*IR3] SHL 4 ;<--- for NCDx/NCCx
[MAC1,MAC2,MAC3] = MAC+(FC-MAC)*IR0 ;<--- for NCDx only
[MAC1,MAC2,MAC3] = [MAC1,MAC2,MAC3] SAR (sf*12) ;<--- for NCDx/NCCx
Color FIFO = [MAC1/16,MAC2/16,MAC3/16,CODE], [IR1,IR2,IR3] = [MAC1,MAC2,MAC3]
```

COP2 138041Ch - 11 Cycles - CC(lm=1) - Color Color

COP2 1280414h - 13 Cycles - CDP(...) - Color Depth Que

In: [IR1,IR2,IR3]=Vector, RGBC=Primary color/code, LCM=Color matrix, BK=Background color, and, for CDP, IR0=Interpolation value, FC=Far color.

```
[IR1,IR2,IR3] = [MAC1,MAC2,MAC3] = (BK*1000h + LCM*IR) SAR (sf*12)
[MAC1,MAC2,MAC3] = [R*IR1,G*IR2,B*IR3] SHL 4
[MAC1,MAC2,MAC3] = MAC+(FC-MAC)*IR0 ;<--- for CDP only
[MAC1,MAC2,MAC3] = [MAC1,MAC2,MAC3] SAR (sf*12)
Color FIFO = [MAC1/16,MAC2/16,MAC3/16,CODE], [IR1,IR2,IR3] = [MAC1,MAC2,MAC3]
```


COP2 0680029h - 8 Cycles - DCPL - Depth Cue Color light**COP2 0780010h - 8 Cycles - DPCS - Depth Cueing (single)****COP2 0x8002Ah - 17 Cycles - DPCT - Depth Cueing (triple)****COP2 0980011h - 8 Cycles - INTPL - Interpolation of a vector and far color**

In: [IR1,IR2,IR3]=Vector, FC=Far Color, IR0=Interpolation value, CODE=MSB of RGBC, and, for DCPL, R,G,B=LSBs of RGBC.

```
[MAC1,MAC2,MAC3] = [R*IR1,G*IR2,B*IR3] SHL 4      ;<--- for DCPL only
[MAC1,MAC2,MAC3] = [IR1,IR2,IR3] SHL 12           ;<--- for INTPL only
[MAC1,MAC2,MAC3] = [R,G,B] SHL 16                 ;<--- for DPCS/DPCT
[MAC1,MAC2,MAC3] = MAC+(FC-MAC)*IR0
[MAC1,MAC2,MAC3] = [MAC1,MAC2,MAC3] SAR (sf*12)
Color FIFO = [MAC1/16,MAC2/16,MAC3/16,CODE], [IR1,IR2,IR3] = [MAC1,MAC2,MAC3]
```

DPCT executes thrice, and reads the R,G,B values from RGB0 (ie. reads from the Bottom of the Color FIFO, instead of from the RGBC register) (the CODE value is kept read from RGBC as usually), so, after DPCT execution, the RGB0,RGB1,RGB2 Fifo entries are modified.

COP2 190003Dh - 5 Cycles - GPF(sf,Im) - General purpose Interpolation**COP2 1A0003Eh - 5 Cycles - GPL(sf,?) - General Interpolation with base**

```
[MAC1,MAC2,MAC3] = [0,0,0]                        ;<--- for GPF only
[MAC1,MAC2,MAC3] = [MAC1,MAC2,MAC3] SHL (sf*12)   ;<--- for GPL only
[MAC1,MAC2,MAC3] = (([IR1,IR2,IR3] * IR0) + [MAC1,MAC2,MAC3]) SAR (sf*12)
Color FIFO = [MAC1/16,MAC2/16,MAC3/16,CODE], [IR1,IR2,IR3] = [MAC1,MAC2,MAC3]
```

Note: Although the SHL in GPL is theoretically undone by the SAR, 44bit overflows can occur internally when sf=1.

Details on "MAC+(FC-MAC)*IR0"

```
[IR1,IR2,IR3] = (([RFC,GFC,BFC] SHL 12) - [MAC1,MAC2,MAC3]) SAR (sf*12)
[MAC1,MAC2,MAC3] = (([IR1,IR2,IR3] * IR0) + [MAC1,MAC2,MAC3])
```

Note: Above "[IR1,IR2,IR3]=(FC-MAC)" is saturated to -8000h..+7FFFh (ie. as if Im=0), anyways, further writes to [IR1,IR2,IR3] (within the same command) are saturated as usually (ie. depening on Im setting).

Details on "(LLM*V0) SAR (sf*12)" and "(BK*1000h + LCM*IR) SAR (sf*12)"

Works like MVMVA command (see there), but with fixed Tx/Vx/Mx parameters, the sf/lm bits can be changed and do affect the results (although normally both bits should be set for use with color matrices).

Notes

The 8bit RGB values written to the top of Color Fifo are the 32bit MACn values divided by 16, and saturated to +00h..+FFh, and of course, the older Fifo entries are moved downwards. Note that, at the GPU side, the meaning of the RGB values depends on whether or not texture blending is used (for untextured polygons FFh is max brightness) (for texture blending FFh is double brightness and 80h is normal brightness).

The 8bit CODE value is intended to contain a GP0(20h..7Fh) Rendering command, allowing to automatically merge the 8bit command number, with the 24bit color value. The IRGB/ORGB registers allow to convert between 48bit and 15bit RGB colors. Although the result of the commands in this chapter is written to the Color FIFO, some commands like GPF/GPL may be also used for other purposes (eg. to scale or scale/translate single vertices).

5.8 GTE Division Inaccuracy

GTE Division Inaccuracy (for RTPS/RTPT commands)

Basically, the GTE division does (attempt to) work as so (using 33bit maths):

```
n = ((H*20000h/SZ3)+1)/2)
```

alternatly, below would give (almost) the same result (using 32bit maths):

```
n = ((H*10000h+SZ3/2)/SZ3)
```

in both cases, the result is saturated about as so:

```
if n>1FFFFh or division_by_zero then n=1FFFFh, FLAG.Bit17=1, FLAG.Bit31=1
```

However, the real GTE hardware is using a fast, but less accurate division mechanism (based on Unsigned Newton-Raphson (UNR) algorithm):

```

if (H < SZ3*2) then                                ;check if overflow
  z = count_leading_zeroes(SZ3)                    ;z=0..0Fh (for 16bit SZ3)
  n = (H SHL z)                                     ;n=0..7FFF8000h
  d = (SZ3 SHL z)                                   ;d=8000h..FFFFh
  u = unr_table[(d-7FC0h) SHR 7] + 101h            ;u=200h..101h
  d = ((2000080h - (d * u)) SHR 8)                  ;d=10000h..0FF01h
  d = ((0000080h + (d * u)) SHR 8)                  ;d=20000h..10000h
  n = min(1FFFFh, ((n*d) + 8000h) SHR 16))          ;n=0..1FFFFh
else n = 1FFFFh, FLAG.Bit17=1, FLAG.Bit31=1        ;n=1FFFFh plus overflow flag

```

the GTE's unr_table[000h..100h] consists of following values:

```

FFh,FDh,FBh,F9h,F7h,F5h,F3h,F1h,EFh,EEh,ECh,EAh,E8h,E6h,E4h,E3h ;\
E1h,DFh,DDh,DCh,DAh,D8h,D6h,D5h,D3h,D1h,D0h,CEh,CDh,CBh,C9h,C8h ; 00h..3Fh
C6h,C5h,C3h,C1h,C0h,BEh,BDh,BBh,BAh,B8h,B7h,B5h,B4h,B2h,B1h,B0h ;
AEh,ADh,ABh,AAh,A9h,A7h,A6h,A4h,A3h,A2h,A0h,9Fh,9Eh,9Ch,9Bh,9Ah ;/
99h,97h,96h,95h,94h,92h,91h,90h,8Fh,8Dh,8Ch,8Bh,8Ah,89h,87h,86h ;\
85h,84h,83h,82h,81h,7Fh,7Eh,7Dh,7Ch,7Bh,7Ah,79h,78h,77h,75h,74h ; 40h..7Fh
73h,72h,71h,70h,6Fh,6Eh,6Dh,6Ch,6Bh,6Ah,69h,68h,67h,66h,65h,64h ;
63h,62h,61h,60h,5Fh,5Eh,5Dh,5Ch,5Bh,5Ah,59h,58h,57h,56h,55h ;/
54h,53h,52h,51h,50h,4Fh,4Eh,4Dh,4Ch,4Bh,4Ah,49h,48h,47h ;\
47h,46h,45h,44h,43h,42h,41h,40h,3Fh,3Eh,3Dh,3Ch,3Bh,3Ah,39h,38h,37h,36h,35h,34h,33h,32h,31h,30h,2Fh ;
2Eh,2Dh,2Ch,2Bh,2Ah,29h,28h,27h,26h,25h,24h ;/
24h,23h,22h,21h,20h,1Fh,1Eh,1Dh,1Ch,1Bh,1Ah ;\
19h,18h,17h,16h,15h,14h,13h,12h,11h,10h ; C0h..FFh
0Fh,0Eh,0Dh,0Ch,0Bh,0Ah,09h,08h,07h,06h,05h,04h,03h,02h,01h,00h ;/
00h ;<-- one extra table entry (for "(d-7FC0h)/80h"=100h) ; -100h

```

Above can be generated as "unr_table[i]=min(0,(40000h/(i+100h)+1)/2-101h)".

Some special cases: NNNNh/0001h uses a big multiplier (d=20000h), in practice, this can occur only for 0000h/0001h and 0001h/0001h (due to the $H < SZ3 * 2$ overflow check).

The min(1FFFFh) limit is needed for cases like FE3Fh/7F20h, F015h/780Bh, etc. (these do produce UNR result 20000h, and are saturated to 1FFFFh, but without setting overflow FLAG bits).

6. Macroblock Decoder (MDEC)

The MDEC is a JPEG-style Macroblock Decoder, that can decompress pictures (or a series of pictures, for being displayed as a movie).

[MDEC I/O Ports](#)

[MDEC Commands](#)

[MDEC Decompression](#)

[MDEC Data Format](#)

6.1 MDEC I/O Ports

1F801820h - MDEC0 - MDEC Command/Parameter Register (W)

```
31-0  Command or Parameters
```

Used to send command word, followed by parameter words to the MDEC (usually, only the command word is written to this register, and the parameter words are transferred via DMA0).

1F801820h.Read - MDEC Data/Response Register (R)

```
31-0  Macroblock Data (or Garbage if there's no data available)
```

The data is always output as a 8x8 pixel bitmap, so, when manually reading from this register and using colored 16x16 pixel macroblocks, the data from four 8x8 blocks must be re-ordered accordingly (usually, the data is received via DMA1, which is doing the re-ordering automatically). For monochrome 8x8 macroblocks, no re-ordering is needed (that works with DMA1 too).

1F801824h - MDEC1 - MDEC Status Register (R)

```
31    Data-Out Fifo Empty (0=No, 1=Empty)
30    Data-In Fifo Full   (0=No, 1=Full, or Last word received)
29    Command Busy      (0=Ready, 1=Busy receiving or processing parameters)
28    Data-In Request    (set when DMA0 enabled and ready to receive data)
27    Data-Out Request   (set when DMA1 enabled and ready to send data)
26-25 Data Output Depth (0=4bit, 1=8bit, 2=24bit, 3=15bit)      ;CMD.28-27
```

```

24    Data Output Signed (0=Unsigned, 1=Signed)                ;CMD.26
23    Data Output Bit15 (0=Clear, 1=Set) (for 15bit depth only) ;CMD.25
22-19 Not used (seems to be always zero)
18-16 Current Block (0..3=Y1..Y4, 4=Cr, 5=Cb) (or for mono: always 4=Y)
15-0  Number of Parameter Words remaining minus 1 (FFFFh=None) ;CMD.Bit0-15

```

If there's data in the output fifo, then the Current Block bits are always set to the current output block number (ie. Y1..Y4; or Y for mono) (this information is apparently passed to the DMA1 controller, so that it knows if and how it must re-order the data in RAM). If the output fifo is empty, then the bits indicate the currently processed incoming block (ie. Cr,Cb,Y1..Y4; or Y for mono).

1F801824h - MDEC1 - MDEC Control/Reset Register (W)

```

31    Reset MDEC (0=No change, 1=Abort any command, and set status=80040000h)
30    Enable Data-In Request (0=Disable, 1=Enable DMA0 and Status.bit28)
29    Enable Data-Out Request (0=Disable, 1=Enable DMA1 and Status.bit27)
28-0  Unknown/Not used - usually zero

```

The data requests are required to be enabled for using DMA (and for reading the request status flags by software). The Data-Out request acts a bit strange: It gets set when a block is available, but, it gets cleared after reading the first some words of that block (nevertheless, one can keep reading the whole block, until the fifo-empty flag gets set).

DMA

MDEC decompression uses a lot of DMA channels,

- 1) DMA3 (CDROM) to send compressed data from CDROM to RAM
- 2) DMA0 (MDEC.In) to send compressed data from RAM to MDEC
- 3) DMA1 (MDEC.Out) to send uncompressed macroblocks from MDEC to RAM
- 4) DMA2 (GPU) to send uncompressed macroblocks from RAM to GPU

DMA0 and DMA1 should be usually used with a blocksize of 20h words. If necessary, the parameters for the MDEC(1) command should be padded with FE00h halfwords to match the 20h words (40h halfwords) DMA blocksize.

6.2 MDEC Commands

MDEC(1) - Decode Macroblock(s)

```

31-29 Command (1=decode_macroblock)
28-27 Data Output Depth (0=4bit, 1=8bit, 2=24bit, 3=15bit) ;STAT.26-25
26 Data Output Signed (0=Unsigned, 1=Signed) ;STAT.24
25 Data Output Bit15 (0=Clear, 1=Set) (for 15bit depth only) ;STAT.23
24-16 Not used (should be zero)
15-0 Number of Parameter Words (size of compressed data)

```

This command is followed by one or more Macroblock parameters (usually, all macroblocks for the whole image are sent at once).

MDEC(2) - Set Quant Table(s)

```

31-29 Command (2=set_iqtab)
28-1 Not used (should be zero) ;Bit25-28 are copied to STAT.23-26 though
0 Color (0=Luminance only, 1=Luminance and Color)

```

The command word is followed by 64 unsigned parameter bytes for the Luminance Quant Table (used for Y1..Y4), and if Command.Bit0 was set, by another 64 unsigned parameter bytes for the Color Quant Table (used for Cb and Cr).

MDEC(3) - Set Scale Table

```

31-29 Command (3=set_scale)
28-0 Not used (should be zero) ;Bit25-28 are copied to STAT.23-26 though

```

The command is followed by 64 signed halfwords with 14bit fractional part, the values should be usually/always the same values (based on the standard JPEG constants, although, MDEC(3) allows to use other values than that constants).

MDEC(0) - No function

This command has no function. Command bits 25-28 are reflected to Status bits 23-26 as usually. Command bits 0-15 are reflected to Status bits 0-15 (similar as the "number of parameter words" for MDEC(1), but without the "minus 1" effect, and without actually expecting any parameters).

MDEC(4..7) - Invalid

These commands act identical as MDEC(0).

6.3 MDEC Decompression

decode_colored_macroblock ;MDEC(1) command (at 15bpp or 24bpp depth)

```
rl_decode_block(Crblk,src,iq_uv)           ;Cr (low resolution)
rl_decode_block(Cbblk,src,iq_uv)           ;Cb (low resolution)
rl_decode_block(Yblk,src,iq_y), yuv_to_rgb(0,0) ;Y1 (and upper-left Cr,Cb)
rl_decode_block(Yblk,src,iq_y), yuv_to_rgb(0,8) ;Y2 (and upper-right Cr,Cb)
rl_decode_block(Yblk,src,iq_y), yuv_to_rgb(8,0) ;Y3 (and lower-left Cr,Cb)
rl_decode_block(Yblk,src,iq_y), yuv_to_rgb(8,8) ;Y4 (and lower-right Cr,Cb)
```

decode_monochrome_macroblock ;MDEC(1) command (at 4bpp or 8bpp depth)

```
rl_decode_block(Yblk,src,iq_y), y_to_mono ;Y
```

rl_decode_block(blk,src,qt)

```
for i=0 to 63, blk[i]=0, next i ;initially zerofill all entries (for skip)
@@skip:
n=[src], src=src+2, k=0 ;get first entry, init dest addr k=0
if n=FE00h then @@skip ;ignore padding (FE00h as first halfword)
q_scale=(n SHR 10) AND 3Fh ;contains scale value (not "skip" value)
val=signed10bit(n AND 3FFh)*qt[k] ;calc first value (without q_scale/8) (?)
@@lop:
if q_scale=0 then val=signed10bit(n AND 3FFh)*2 ;special mode without qt[k]
val=minmax(val,-400h,+3FFh) ;saturate to signed 11bit range
val=val*scalezag[i] ;<-- for "fast_idct_core" only
if q_scale>0 then blk[zagzig[k]]=val ;store entry (normal case)
if q_scale=0 then blk[k]=val ;store entry (special, no zigzag)
n=[src], src=src+2 ;get next entry (or FE00h end code)
k=k+((n SHR 10) AND 3Fh)+1 ;skip zerofilled entries
val=(signed10bit(n AND 3FFh)*qt[k]*q_scale+4)/8 ;calc value for next entry
if k<=63 then jump @@lop ;should end with n=FE00h (that sets k>63)
idct_core(blk)
return (with "src" address advanced)
```

fast_idct_core(blk) ;fast "idct_core" version

Fast code with only 80 multiplications, works only if the scaletable from MDEC(3) command contains standard values (which is the case for all known PSX games).

```
src=blk, dst=temp_buffer
for pass=0 to 1
  for i=0 to 7
    if src[(1..7)*8+i]=0 then ;when src[(1..7)*8+i] are all zero:
      dst[i*8+(0..7)]=src[0*8+i] ;quick fill by src[0*8+i]
```

```

else
    z10=src[0*8+i]+src[4*8+i], z11=src[0*8+i]-src[4*8+i]
    z13=src[2*8+i]+src[6*8+i], z12=src[2*8+i]-src[6*8+i]
    z12=(1.414213562*z12)-z13          ;=sqrt(2)
    tmp0=z10+z13, tmp3=z10-z13, tmp1=z11+z12, tmp2=z11-z12
    z13=src[3*8+i]+src[5*8+i], z10=src[3*8+i]-src[5*8+i]
    z11=src[1*8+i]+src[7*8+i], z12=src[1*8+i]-src[7*8+i]
    z5  =(1.847759065*(z12-z10))      ;=sqrt(2)*scalefactor[2]
    tmp7=z11+z13
    tmp6=(2.613125930*(z10))+z5-tmp7   ;=scalefactor[2]*2
    tmp5=(1.414213562*(z11-z13))-tmp6  ;=sqrt(2)
    tmp4=(1.082392200*(z12))-z5+tmp5   ;=sqrt(2)/scalefactor[2]
    dst[i*8+0]=tmp0+tmp7, dst[i*8+7]=tmp0-tmp7
    dst[i*8+1]=tmp1+tmp6, dst[i*8+6]=tmp1-tmp6
    dst[i*8+2]=tmp2+tmp5, dst[i*8+5]=tmp2-tmp5
    dst[i*8+4]=tmp3+tmp4, dst[i*8+3]=tmp3-tmp4
endif
next i
swap(src,dst)
next pass

```

real_idct_core(blk) ;low level "idct_core" version

Low level code with 1024 multiplications, using the scaletable from the MDEC(3) command. Computes $\text{dst}=\text{src}*\text{scaletable}$ (using normal matrix maths, but with "src" being diagonally mirrored, ie. the matrices are processed column by column, instead of row by column), repeated with src/dst exchanged.

```

src=blk, dst=temp_buffer
for pass=0 to 1
    for x=0 to 7
        for y=0 to 7
            sum=0
            for z=0 to 7
                sum=sum+src[y+z*8]*(scaletable[x+z*8]/8)
            next z
            dst[x+y*8]=(sum+0fffh)/2000h          ;<-- or so?
        next y
    next x
    swap(src,dst)
next pass

```

The "(sum+0fffh)/2000h" part is meant to strip fractional bits, and to round-up the result if the fraction was BIGGER than 0.5. The hardware appears to be working roughly like that, still the results aren't perfect.

Maybe the real hardware is doing further roundings in other places, possibly stripping some fractional bits before summing up "sum", possibly stripping different amounts of

bits in the two "pass" cycles, and possibly keeping a final fraction passed on to the y_to_mono stage.

yuv_to_rgb(xx,yy)

```

for y=0 to 7
  for x=0 to 7
    R=[Crblk+((x+xx)/2)+((y+yy)/2)*8], B=[Cbblk+((x+xx)/2)+((y+yy)/2)*8]
    G=(-0.3437*B)+(-0.7143*R), R=(1.402*R), B=(1.772*B)
    Y=[Yblk+(x)+(y)*8]
    R=MinMax(-128,127,(Y+R))
    G=MinMax(-128,127,(Y+G))
    B=MinMax(-128,127,(Y+B))
    if unsigned then BGR=BGR xor 808080h ;aka add 128 to the R,G,B values
    dst[(x+xx)+(y+yy)*16]=BGR
  next x
next y

```

Note: The exact fixed point resolution for "yuv_to_rgb" is unknown. And, there's probably also some 9bit limit (similar as in "y_to_mono").

y_to_mono

```

for i=0 to 63
  Y=[Yblk+i]
  Y=Y AND 1FFh ;clip to signed 9bit range
  Y=MinMax(-128,127,Y) ;saturate from 9bit to signed 8bit range
  if unsigned then Y=Y xor 80h ;aka add 128 to the Y value
  dst[i]=Y
next i

```

set_iqtab ;MDEC(2) command

```

iqtab_core(iq_y,src), src=src+64 ;luminance quant table
if command_word.bit0=1
  iqtab_core(iq_uv,src), src=src+64 ;color quant table (optional)
endif

```

iqtab_core(iq,src) ;src = 64 unsigned paramter bytes

```

for i=0 to 63, iq[i]=src[i], next i

```

Note: For "fast_idct_core" one could precalc "iq[i]=src[i]*scalezag[i]", but that would conflict with the RLE saturation/rounding steps (though those steps aren't actually required, so a very-fast decoder could omit them).

scalefactor[0..7] = cos((0..7)*90/8) ;for [1..7]: multiplied by sqrt(2)

```
1.000000000, 1.387039845, 1.306562965, 1.175875602,
1.000000000, 0.785694958, 0.541196100, 0.275899379
```

zigzag[0..63] =

```
0 , 1 , 5 , 6 , 14, 15, 27, 28,
2 , 4 , 7 , 13, 16, 26, 29, 42,
3 , 8 , 12, 17, 25, 30, 41, 43,
9 , 11, 18, 24, 31, 40, 44, 53,
10, 19, 23, 32, 39, 45, 52, 54,
20, 22, 33, 38, 46, 51, 55, 60,
21, 34, 37, 47, 50, 56, 59, 61,
35, 36, 48, 49, 57, 58, 62, 63
```

scalezag[0..63] (precalulated factors, for "fast_idct_core")

```
for y=0 to 7
  for x=0 to 7
    scalezag[zigzag[x+y*8]] = scalefactor[x] * scalefactor[y] / 8
  next x
next y
```

zagzig[0..63] (reversed zigzag table)

```
for i=0 to 63, zagzig[zigzag[i]]=i, next i
```

set_scale_table: ;MDEC(3) command

This command defines the IDCT scale matrix, which should be usually/always:

```
5A82 5A82 5A82 5A82 5A82 5A82 5A82 5A82
7D8A 6A6D 471C 18F8 E707 B8E3 9592 8275
7641 30FB CF04 89BE 89BE CF04 30FB 7641
6A6D E707 8275 B8E3 471C 7D8A 18F8 9592
5A82 A57D A57D 5A82 5A82 A57D A57D 5A82
471C 8275 18F8 6A6D 9592 E707 7D8A B8E3
30FB 89BE 7641 CF04 CF04 7641 89BE 30FB
18F8 B8E3 6A6D 8275 7D8A 9592 471C E707
```

Note that the hardware does actually use only the upper 13bit of those 16bit values. The values are choosen like so,

```

+s0 +s0 +s0 +s0 +s0 +s0 +s0 +s0
+s1 +s3 +s5 +s7 -s7 -s5 -s3 -s1
+s2 +s6 -s6 -s2 -s2 -s6 +s6 +s2
+s3 -s7 -s1 -s5 +s5 +s1 +s7 -s3
+s4 -s4 -s4 +s4 +s4 -s4 -s4 +s4
+s5 -s1 +s7 +s3 -s3 -s7 +s1 -s5
+s6 -s2 +s2 -s6 -s6 +s2 -s2 +s6
+s7 -s5 +s3 -s1 +s1 -s3 +s5 -s7

```

whereas, $s0..s7 = \text{scalefactor}[0..7]$, multiplied by $\sqrt{2}$ (ie. by 1.414), and multiplied by 4000h (ie. with 14bit fractional part).

6.4 MDEC Data Format

Colored Macroblocks (16x16 pixels) (in 15bpp or 24bpp depth mode)

Each macroblock consists of six blocks: Two low-resolution blocks with color information (Cr,Cb) and four full-resolution blocks with luminance (grayscale) information (Y1,Y2,Y3,Y4). The color blocks are zoomed from 8x8 to 16x16 pixel size, merged with the luminance blocks, and then converted from YUV to RGB format.

```

.---.      .---.      .---.      .---.
|  |      |  |      |Y1|Y2|      |  |
| Cr |    +   | Cb |    +   |--+--|    ----> | RGB |
|  |      |  |      |Y3|Y4|      |  |
'---'      '---'      '---'      '---'

```

Native PSX files are usually containing vertically arranged Macroblocks (eg. allowing to send them to the GPU as 16x240 portion) (JPEG-style horizontally arranged Macroblocks would require to send the data in 16x16 pixel portions to the GPU) (something like 320x16 won't work, since that'd require to wrap from the bottom of the first macroblock to the top of the next macroblock).

Monochrome Macroblocks (8x8 pixel) (in 4bpp or 8bpp depth mode)

Each macroblock consist of only one block: with luminance (grayscale) information (Y), the data comes out as such (it isn't converted to RGB).

```

.---.      .---.
| Y |    ----> | Y |
'---'      '---'

```

The output is an 8x8 bitmap (not 16x16), so it'd be send to the GPU as 8x8 pixel rectangle, or multiple blocks at once as 8x240 pixel rectangle. Since the data isn't RGB, it should be written to Texture memory (and then it can be forwarded to the frame buffer in form of a texture with monochrome 15bit palette with 32 grayscales). Alternately, one could convert the 8bpp image to 24bpp by software (this would allow to use 256 grayscales).

Blocks (8x8 pixels)

An (uncompressed) block consists of 64 values, representing 8x8 pixels. The first (upper-left) value is an absolute value (called "DC" value), the remaining 63 values are relative to the DC value (called "AC" values). After decompression and zig-zag reordering, the data in unfiltered horizontally and vertically (IDCT conversion, ie. the relative "AC" values are converted to absolute "DC" values).

.STR Files

PSX Video files are usually having file extension .STR (for "Streaming").

MDEC vs JPEG

The MDEC data format is very similar to the JPEG file format, the main difference is that JPEG uses Huffman compressed blocks, whilst MDEC uses Run-Length (RL) compressed blocks.

The (uncompressed) blocks are same as in JPEGs, using the same zigzag ordering, AC to DC conversion, and YUV to RGB conversion (ie. the MDEC hardware can be also used to decompress JPEGs, when handling the file header and huffman decompression by software).

Some other differences are that MDEC has only 2 fixed-purpose quant tables, whilst JPEGs \<can> use up to 4 general-purpose quant tables. Also, JPEGs \<can> use other color resolutions than the 8x8 color info for 16x16 pixels. Whereas, JPEGs \<can> do that stuff, but most standard JPEG files aren't actually using 4 quant tables, nor higher color resolution.

Run-Length compressed Blocks

Within each block the DCT information and RLE compressed data is stored:

```
DCT                ;1 halfword
RLE,RLE,RLE,etc.   ;0..63 halfwords
EOB                ;1 halfword
```

DCT (1st value)

DCT data has the quantization factor and the Direct Current (DC) reference.

```
15-10 Q    Quantization factor (6 bits, unsigned)
9-0  DC    Direct Current reference (10 bits, signed)
```

Contains the absolute DC value (the upper-left value of the 8x8 block).

RLE (Run length data, for 2nd through 64th value)

```
15-10 LEN  Number of zero AC values to be inserted (6 bits, unsigned)
9-0  AC    Relative AC value (10 bits, signed)
```

Example: AC values "000h,000h,123h" would be compressed as "(2 shl 10)+123h".

EOB (End Of Block)

Indicates the end of a 8x8 pixel block, causing the rest of the block to be padded with zero AC values.

```
15-0  End-code (Fixed, FE00h)
```

EOB isn't required if the block was already fully defined (up to including blk[63]), however, most games seem to append EOB to all blocks (although it's just acting as dummy/padding value in case of fully defined blocks).

Dummy halfwords

Data is sent in units of words (or, when using DMA, even in units of 32-words), which is making it necessary to send some dummy halfwords (unless the compressed data size should match up the transfer unit). The value FE00h can be used as dummy value: When FE00h appears at the begin of a new block, or after the end of block, then it is simply ignored by the hardware (if it occurs elsewhere, then it acts as EOB end code, as described above).

7. Sound Processing Unit (SPU)

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[SPU Unknown Registers](#)

[SPU Internal State Machine from SPU RAM Timing](#)

7.1 SPU Overview

SPU I/O Port Summary

```
1F801C00h..1F801D7Fh - Voice 0..23 Registers (eight 16bit regs per voice)
1F801D80h..1F801D87h - SPU Control (volume)
1F801D88h..1F801D9Fh - Voice 0..23 Flags (six 1bit flags per voice)
1F801DA2h..1F801DBFh - SPU Control (memory, control, etc.)
1F801DC0h..1F801DFFh - Reverb configuration area
1F801E00h..1F801E5Fh - Voice 0..23 Internal Registers
1F801E60h..1F801E7Fh - Unknown?
1F801E80h..1F801FFFh - Unused?
```

SPU Memory layout (512Kbyte RAM)

```
00000h-003FFh  CD Audio left   (1Kbyte) ;\CD Audio before Volume processing
00400h-007FFh  CD Audio right (1Kbyte) ;/signed 16bit samples at 44.1kHz
00800h-00BFFh  Voice 1 mono   (1Kbyte) ;\Voice 1 and 3 after ADSR processing
00C00h-00FFFh  Voice 3 mono   (1Kbyte) ;/signed 16bit samples at 44.1kHz
01000h-xxxxxh  ADPCM Samples  (first 16bytes usually contain a Sine wave)
xxxxxh-7FFFFh  Reverb work area
```

As shown above, the first 4Kbytes are used as special capture buffers, and, if desired, one can also use the Reverb hardware to capture output from other voice(s).

The SPU memory is not mapped to the CPU bus, it can be accessed only via I/O, or via DMA transfers (DMA4).

Voices

The SPU has 24 hardware voices. These voices can be used to reproduce sample data, noise or can be used as frequency modulator on the next voice. Each voice has its own programmable ADSR envelope filter. The main volume can be programmed independently for left and right output.

Voice Capabilities

All 24 voices are having exactly the same capabilities(?), with the exception that Voice 1 and 3 are having a special Capture feature (see SPU Memory map).

There seems to be no way to produce square waves (without storing a square waveform in memory... although, since SPU RAM isn't connected to the CPU bus, the "useless" DMA for square wave data wouldn't slowdown the CPU bus)?

Additional Sound Inputs

External Audio can be input (from the Expansion Port?), and the CDROM drive can be commanded to playback normal Audio CDs (via Play command), or XA-ADPCM sectors (via Read command), and to pass that data to the SPU.

Mono/Stereo Audio Output

The standard PSX Audio cables have separate Left/Right signals, that is good for stereo TVs, but, when using a normal mono TV, only one of the two audio signals (Left or Right) can be connected. PSX programs should thus offer an option to disable stereo effects, and to output an equal volume to both cables.

Unstable and Delayed I/O

The SPU occasionally seems to "miss" 32bit I/O writes (not sure if that can be fixed by any Memory Control settings?), a stable workaround is to split each 32bit write into two 16bit writes. The SPU seems to process written values at 44100Hz rate (so it may take 1/44100 seconds (300h clock cycles) until it has actually realized the new value).

SPU Bus-Width

The SPU is connected to a 16bit databus. 8bit/16bit/32bit reads and 16bit writes are implemented; 32bit writes are also supported but seem to be particularly unstable (see above). However, 8bit writes are NOT implemented: 8bit writes to ODD addresses are simply ignored (without causing any exceptions), 8bit writes to EVEN addresses are executed as 16bit writes (e.g. `li v0, 12345678h; sb v0, spu_port` will write 5678h instead of 78h).

7.2 SPU ADPCM Samples

The SPU supports only ADPCM compressed samples (uncompressed samples seem to be totally unsupported; leaving apart that one can write uncompressed 16bit PCM samples to the Reverb Buffer, which can be then output at 22050Hz, as long as they aren't overwritten by the hardware).

1F801C06h+N*10h - Voice 0..23 ADPCM Start Address (R/W)

This register holds the sample start address (not the current address, ie. the register doesn't increment during playback).

```
15-0   Startaddress of sound in Sound buffer (in 8-byte units)
```

Writing to this register has no effect on the currently playing voice.

The start address is copied to the current address upon Key On.

1F801C0Eh+N*10h - Voice 0..23 ADPCM Repeat Address (R/W)

If the hardware finds an ADPCM header with Loop-Start-Bit, then it copies the current address to the repeat addresss register.

If the hardware finds an ADPCM header with Loop-Stop-Bit, then it copies the repeat addresss register setting to the current address; that, \<after> playing the current ADPCM block.

```
15-0   Address sample loops to at end (in 8-byte units)
```

Normally, repeat works automatically via the above start/stop bits, and software doesn't need to deal with the Repeat Address Register. However, reading from it may be useful to sense if the hardware has reached a start bit, and writing may be also useful in some

cases, eg. to redirect a one-shot sample (with stop-bit, but without any start-bits) to a silent-loop located elsewhere in memory.

Sample Data (SPU-ADPCM)

Samples consist of one or more 16-byte blocks:

```
00h      Shift/Filter (reportedly same as for CD-XA) (see there)
01h      Flag Bits (see below)
02h      Compressed Data (LSBs=1st Sample, MSBs=2nd Sample)
03h      Compressed Data (LSBs=3rd Sample, MSBs=4th Sample)
04h      Compressed Data (LSBs=5th Sample, MSBs=6th Sample)
...      ...
0Fh      Compressed Data (LSBs=27th Sample, MSBs=28th Sample)
```

Flag Bits (in 2nd byte of ADPCM Header)

```
0  Loop End      (0=No change, 1=Set ENDX flag and Jump to [1F801C0Eh+N*10h])
1  Loop Repeat  (0=Force Release and set ADSR Level to Zero; only if Bit0=1)
2  Loop Start   (0=No change, 1=Copy current address to [1F801C0Eh+N*10h])
3-7 Unknown     (usually 0)
```

Possible combinations for Bit0-1 are:

```
Code 0 = Normal      (continue at next 16-byte block)
Code 1 = End+Mute     (jump to Loop-address, set ENDX flag, Release, Env=0000h)
Code 2 = Ignored      (same as Code 0)
Code 3 = End+Repeat   (jump to Loop-address, set ENDX flag)
```

Looped and One-shot Samples

The Loop Start/End flags in the ADPCM Header allow to play one or more sample block(s) in a loop, that can be either all block(s) endlessly repeated, or only the last some block(s) of the sample.

There's no way to stop the output, so a one-shot sample must be followed by dummy block (with Loop Start/End flags both set, and all data nibbles set to zero; so that the block gets endlessly repeated, but doesn't produce any sound).

SPU-ADPCM vs XA-ADPCM

The PSX supports two ADPCM formats: SPU-ADPCM (as described above), and XA-ADPCM. XA-ADPCM is decompressed by the CDROM Controller, and sent directly to the sound mixer, without needing to store the data in SPU RAM, nor needing to use a Voice

channel.

The actual decompression algorithm is the same for both formats. However, the XA nibbles are arranged in different order, and XA uses 2x28 nibbles per block (instead of 2x14), XA blocks can contain mono or stereo data, XA supports only two sample rates, and, XA doesn't support looping.

7.3 SPU ADPCM Pitch

1F801C04h+N*10h - Voice 0..23 ADPCM Sample Rate (R/W) (VxPitch)

```
0-15 Sample rate (0=stop, 4000h=fastest, 4001h..FFFFh=usually same as 4000h)
```

Defines the ADPCM sample rate (1000h = 44100Hz). This register (and PMON) does affect only the ADPCM sample frequency (but not on the Noise frequency, which is defined - and shared for all voices - in the SPUCNT register).

1F801D90h - Voice 0..23 Pitch Modulation Enable Flags (PMON)

Pitch modulation allows to generate "Frequency Sweep" effects by mis-using the amplitude from channel (x-1) as pitch factor for channel (x).

```
0      Unknown... Unused?
1-23   Flags for Voice 1..23 (0=Normal, 1=Modulate by Voice 0..22)
24-31  Not used
```

For example, output a very loud 1Hz sine-wave on channel 4 (with ADSR volume 4000h, and with Left/Right volume=0; unless you actually want to output it to the speaker). Then additionally output a 2kHz sine wave on channel 5 with PMON.Bit5 set. The "2kHz" sound should then repeatedly sweep within 1kHz..3kHz range (or, for a more decent sweep in 1.8kHz..2.2kHz range, drop the ADSR volume of channel 4).

Pitch Counter

The pitch counter is adjusted at 44100Hz rate as follows:

```
Step = VxPitch                ;range +0000h..+FFFFh (0...705.6 kHz)
IF PMON.Bit(x)=1 AND (x>0)    ;pitch modulation enable
    Factor = VxOUTX(x-1)      ;range -8000h..+7FFFh (prev voice amplitude)
    Factor = Factor+8000h      ;range +0000h..+FFFFh (factor = 0.00 .. 1.99)
    Step=SignExpand16to32(Step) ;hardware glitch on VxPitch>7FFFh, make sign
    Step = (Step * Factor) SAR 15 ;range 0..1FFFFh (glitchy if VxPitch>7FFFh)
```

```

Step=Step AND 0000FFFFh      ;hardware glitch on VxPitch>7FFFh, kill sign
IF Step>3FFFh then Step=4000h ;range +0000h..+3FFFh (0.. 176.4kHz)
Counter = Counter + Step

```

Counter.Bit12 and up indicates the current sample (within a ADPCM block).

Counter.Bit4..11 are used as 8bit gaussian interpolation index.

Maximum Sound Frequency

The Mixer and DAC supports a 44.1kHz output rate (allowing to produce max 22.1kHz tones). The Reverb unit supports only half the frequency.

The pitch counter supports sample rates up to 176.4kHz. However, exceeding the 44.1kHz limit causes the hardware to skip samples (or actually: to apply incomplete interpolation on the 'skipped' samples).

VxPitch can be theoretically 0..FFFFh (max 705.6kHz), normally 4000h..FFFFh are simply clipped to max=4000h (176.4kHz). Except, 4000h..FFFFh could be used with pitch modulation (as they are multiplied by 0.00..1.99 before clipping; in practice this works only for 4000h..7FFFh; as values 8000h..FFFFh are mistaken as signed values).

4-Point Gaussian Interpolation

Interpolation is applied on the 4 most recent 16bit ADPCM samples (new,old,older,oldest), using bit4-11 of the pitch counter as 8bit interpolation index (i=00h..FFh):

```

out =      ((gauss[0FFh-i] * oldest) SAR 15)
out = out + ((gauss[1FFh-i] * older)  SAR 15)
out = out + ((gauss[100h+i] * old)    SAR 15)
out = out + ((gauss[000h+i] * new)    SAR 15)

```

The Gauss table contains the following values (in hex):

```

-001h,-001h,-001h,-001h,-001h,-001h,-001h,-001h ;\
-001h,-001h,-001h,-001h,-001h,-001h,-001h,-001h ;
0000h,0000h,0000h,0000h,0000h,0000h,0000h,0001h ;
0001h,0001h,0001h,0002h,0002h,0002h,0003h,0003h ;
0003h,0004h,0004h,0005h,0005h,0006h,0007h,0007h ;
0008h,0009h,0009h,000Ah,000Bh,000Ch,000Dh,000Eh ;
000Fh,0010h,0011h,0012h,0013h,0015h,0016h,0018h ; entry
0019h,001Bh,001Ch,001Eh,0020h,0021h,0023h,0025h ; 000h..07Fh
0027h,0029h,002Ch,002Eh,0030h,0033h,0035h,0038h ;
003Ah,003Dh,0040h,0043h,0046h,0049h,004Dh,0050h ;
0054h,0057h,005Bh,005Fh,0063h,0067h,006Bh,006Fh ;
0074h,0078h,007Dh,0082h,0087h,008Ch,0091h,0096h ;
009Ch,00A1h,00A7h,00ADh,00B3h,00BAh,00C0h,00C7h ;

```

```

00CDh,00D4h,00DBh,00E3h,00EAh,00F2h,00FAh,0101h ;
010Ah,0112h,011Bh,0123h,012Ch,0135h,013Fh,0148h ;
0152h,015Ch,0166h,0171h,017Bh,0186h,0191h,019Ch ;/
01A8h,01B4h,01C0h,01CCh,01D9h,01E5h,01F2h,0200h ;\
020Dh,021Bh,0229h,0237h,0246h,0255h,0264h,0273h ;
0283h,0293h,02A3h,02B4h,02C4h,02D6h,02E7h,02F9h ;
030Bh,031Dh,0330h,0343h,0356h,036Ah,037Eh,0392h ;
03A7h,03BCh,03D1h,03E7h,03FCh,0413h,042Ah,0441h ;
0458h,0470h,0488h,04A0h,04B9h,04D2h,04ECh,0506h ;
0520h,053Bh,0556h,0572h,058Eh,05AAh,05C7h,05E4h ; entry
0601h,061Fh,063Eh,065Ch,067Ch,069Bh,06BBh,06DCh ; 080h..0FFh
06FDh,071Eh,0740h,0762h,0784h,07A7h,07CBh,07EFh ;
0813h,0838h,085Dh,0883h,08A9h,08D0h,08F7h,091Eh ;
0946h,096Fh,0998h,09C1h,09EBh,0A16h,0A40h,0A6Ch ;
0A98h,0AC4h,0AF1h,0B1Eh,0B4Ch,0B7Ah,0BA9h,0BD8h ;
0C07h,0C38h,0C68h,0C99h,0CCBh,0CFDh,0D30h,0D63h ;
0D97h,0DCBh,0E00h,0E35h,0E6Bh,0EA1h,0ED7h,0F0Fh ;
0F46h,0F7Fh,0FB7h,0FF1h,102Ah,1065h,109Fh,10DBh ;
1116h,1153h,118Fh,11CDh,120Bh,1249h,1288h,12C7h ;/
1307h,1347h,1388h,13C9h,140Bh,144Dh,1490h,14D4h ;\
1517h,155Ch,15A0h,15E6h,162Ch,1672h,16B9h,1700h ;
1747h,1790h,17D8h,1821h,186Bh,18B5h,1900h,194Bh ;
1996h,19E2h,1A2Eh,1A7Bh,1AC8h,1B16h,1B64h,1BB3h ;
1C02h,1C51h,1CA1h,1CF1h,1D42h,1D93h,1DE5h,1E37h ;
1E89h,1EDCh,1F2Fh,1F82h,1FD6h,202Ah,207Fh,20D4h ;
2129h,217Fh,21D5h,222Ch,2282h,22DAh,2331h,2389h ; entry
23E1h,2439h,2492h,24EBh,2545h,259Eh,25F8h,2653h ; 100h..17Fh
26ADh,2708h,2763h,27BEh,281Ah,2876h,28D2h,292Eh ;
298Bh,29E7h,2A44h,2AA1h,2AFFh,2B5Ch,2BBAh,2C18h ;
2C76h,2CD4h,2D33h,2D91h,2DF0h,2E4Fh,2EAEh,2F0Dh ;
2F6Ch,2FCCCh,302Bh,308Bh,30EAh,314Ah,31AAh,3209h ;
3269h,32C9h,3329h,3389h,33E9h,3449h,34A9h,3509h ;
3569h,35C9h,3629h,3689h,36E8h,3748h,37A8h,3807h ;
3867h,38C6h,3926h,3985h,39E4h,3A43h,3AA2h,3B00h ;
3B5Fh,3BBDh,3C1Bh,3C79h,3CD7h,3D35h,3D92h,3DEFh ;/
3E4Ch,3EA9h,3F05h,3F62h,3FBDh,4019h,4074h,40D0h ;\
412Ah,4185h,41DFh,4239h,4292h,42EBh,4344h,439Ch ;
43F4h,444Ch,44A3h,44FAh,4550h,45A6h,45FCh,4651h ;
46A6h,46FAh,474Eh,47A1h,47F4h,4846h,4898h,48E9h ;
493Ah,498Ah,49D9h,4A29h,4A77h,4AC5h,4B13h,4B5Fh ;
4BACH,4BF7h,4C42h,4C8Dh,4CD7h,4D20h,4D68h,4DB0h ;
4DF7h,4E3Eh,4E84h,4EC9h,4F0Eh,4F52h,4F95h,4FD7h ; entry
5019h,505Ah,509Ah,50DAh,5118h,5156h,5194h,51D0h ; 180h..1FFh
520Ch,5247h,5281h,52BAh,52F3h,532Ah,5361h,5397h ;
53CCh,5401h,5434h,5467h,5499h,54CAh,54FAh,5529h ;
5558h,5585h,55B2h,55DEh,5609h,5632h,565Bh,5684h ;
56ABh,56D1h,56F6h,571Bh,573Eh,5761h,5782h,57A3h ;
57C3h,57E2h,57FFh,581Ch,5838h,5853h,586Dh,5886h ;
589Eh,58B5h,58CBh,58E0h,58F4h,5907h,5919h,592Ah ;
593Ah,5949h,5958h,5965h,5971h,597Ch,5986h,598Fh ;
5997h,599Eh,59A4h,59A9h,59ADh,59B0h,59B2h,59B3h ;/





```

The PSX table is a bit different as the SNES table: Values up to 3569h are smaller as on SNES, the remaining values are bigger as on SNES, and the width of the PSX table entries is 4bit higher as on SNES.

The PSX table is slightly bugged: Theoretically, each four values (gauss[000h+i], gauss[0FFh-i], gauss[100h+i], gauss[1FFh-i]) should sum up to 8000h, but in practice they do sum up to 7F7Fh..7F81h (fortunately the PSX sum doesn't exceed the 8000h limit; meaning that the PSX interpolations won't overflow, which has been a hardware glitch on the SNES).

Waveform Examples

Incoming ADPCM Data ---> Interpolated Data

	---> 	Nibbles=79797979, Filter=0 HALF-volume ZIGZAG-wave
	---> 	Nibbles=77997799, Filter=0 FULL-volume SINE-wave
	---> 	Nibbles=77779999, Filter=0 SQUARE wave (with rounded edges)
	---> 	Nibbles=7777CC44, Filter=0 CUSTOM wave-form
	---> 	Nibbles=77DE9HZK, Filter=V SOLAR STORM wave-form

7.4 SPU Volume and ADSR Generator

1F801C08h+N*10h - Voice 0..23 Attack/Decay/Sustain/Release (ADSR) (32bit)

lower 16bit (at 1F801C08h+N*10h)		
15	Attack Mode	(0=Linear, 1=Exponential)
-	Attack Direction	(Fixed, always Increase) (until Level 7FFFh)
14-10	Attack Shift	(0..1Fh = Fast..Slow)
9-8	Attack Step	(0..3 = "+7,+6,+5,+4")
-	Decay Mode	(Fixed, always Exponential)
-	Decay Direction	(Fixed, always Decrease) (until Sustain Level)
7-4	Decay Shift	(0..0Fh = Fast..Slow)
-	Decay Step	(Fixed, always "-8")

3-0	Sustain Level	(0..0Fh) ;Level=(N+1)*800h _____upper 16bit (at 1F801C0Ah+N*10h)
31	Sustain Mode	(0=Linear, 1=Exponential)
30	Sustain Direction	(0=Increase, 1=Decrease) (until Key OFF flag)
29	Not used?	(should be zero)
28-24	Sustain Shift	(0..1Fh = Fast..Slow)
23-22	Sustain Step	(0..3 = "+7,+6,+5,+4" or "-8,-7,-6,-5") (inc/dec)
21	Release Mode	(0=Linear, 1=Exponential)
-	Release Direction	(Fixed, always Decrease) (until Level 0000h)
20-16	Release Shift	(0..1Fh = Fast..Slow)
-	Release Step	(Fixed, always "-8")

The Attack phase gets started when the software sets the voice ON flag (see below), the hardware does then automatically go through Attack/Decay/Sustain, and switches from Sustain to Release when the software sets the Key OFF flag.

1F801D80h - Mainvolume left

1F801D82h - Mainvolume right

1F801C00h+N*10h - Voice 0..23 Volume Left

1F801C02h+N*10h - Voice 0..23 Volume Right

Fixed Volume Mode (when Bit15=0):

15	Must be zero	(0=Volume Mode)
0-14	Voice volume/2	(-4000h..+3FFFh = Volume -8000h..+7FFEh)

Sweep Volume Mode (when Bit15=1):

15	Must be set	(1=Sweep Mode)
14	Sweep Mode	(0=Linear, 1=Exponential)
13	Sweep Direction	(0=Increase, 1=Decrease)
12	Sweep Phase	(0=Positive, 1=Negative)
7-11	Not used?	(should be zero)
6-2	Sweep Shift	(0..1Fh = Fast..Slow)
1-0	Sweep Step	(0..3 = "+7,+6,+5,+4" or "-8,-7,-6,-5") (inc/dec)

Sweep is another Volume envelope, additionally to the ADSR volume envelope (unlike ADSR, sweep can be used for stereo effects, such like blending from left to right). Sweep starts at the current volume (which can be set via Bit15=0, however, caution - the Bit15=0 setting isn't applied until the next 44.1kHz cycle; so setting the initial level with Bit15=0, followed by the sweep parameter with Bit15=1 works only if there's a suitable delay between the two operations). Once when sweep is started, the current volume level

increases to +7FFFh, or decreases to 0000h.

Sweep Phase should be equal to the sign of the current volume (not yet tested, in the negative mode it does probably "increase" to -7FFFh?). The Phase bit seems to have no effect in Exponential Decrease mode.

1F801DB0h - CD Audio Input Volume (for normal CD-DA, and compressed XA-ADPCM)

1F801DB4h - External Audio Input Volume

```
0-15  Volume Left    (-8000h..+7FFFh)
16-31 Volume Right   (-8000h..+7FFFh)
```

Note: The CDROM controller supports additional CD volume control (including ability to convert stereo CD output to mono, or to swap left/right channels).

Envelope Operation depending on Shift/Step/Mode/Direction

```
; Precalculation, can be cached on phase begin.
AdsrStep = 7 - StepValue
IF Decreasing XOR PhaseNegative THEN
    AdsrStep = NOT AdsrStep ; +7,+6,+5,+4 => -8,-7,-6,-5
AdsrStep = AdsrStep SHL Max(0,11-ShiftValue)
CounterIncrement = 8000h SHR Max(0,ShiftValue-11)
IF exponential AND increase AND AdsrLevel>6000h THEN
    IF ShiftValue < 10 THEN
        AdsrStep /= 4 ; SHR 2
    ELSE IF ShiftValue >= 11 THEN
        CounterIncrement /= 4 ; SHR 2
    ELSE
        AdsrStep /= 4 ; SHR 2
        CounterIncrement /= 4 ; SHR 2
ELSE IF exponential AND decrease THEN
    AdsrStep=AdsrStep*AdsrLevel/8000h

IF (StepValue | (ShiftValue SHL 2)) != ALL_BITS THEN
    CounterIncrement = MAX(CounterIncrement, 1)

; Runs once per 44.1kHz clock.
Counter += CounterIncrement
IF (Counter & 8000h) == 0 THEN
    RETURN ; No step this cycle.

; Saturate depending on mode.
AdsrLevel = AdsrLevel + AdsrStep
IF NOT decreasing THEN
    AdsrLevel = CLAMP(AdsrLevel, -8000h..+7FFFh)
ELSE IF PhaseNegative THEN
    AdsrLevel = CLAMP(AdsrLevel, -8000h..0h)
```

```
ELSE ; decreasing
    AdsrLevel = MAX(AdsrLevel, 0)
```

Exponential Increase is a fake (simply changes to a slower linear increase rate at higher volume levels).

Phase invert cause the step to be positive in decreasing mode, otherwise negative.

Using a step value of all-ones causes the volume to never step, and additionally never saturate. i.e. 0x7f, or 0x1f for decay/release.

The step counter has very strange behaviour. Initially this was documented as

`AdsrCycles = 1 SHL Max(0, ShiftValue-11)`, however, this is incorrect for shift values above 26. Hardware tests show that a rate of 0x76 behaves like 0x6A, seems it's dependent on the Bit15=1.

Phase invert acts very strange. If the volume is positive, it will decrease to zero, then increase back to maximum negative (inverted) volume. Except when decrementing, then it snaps straight to zero. Simply clamping to int16 range will be fine for incrementing, because the volume never decreases past zero. If the volume was negative, and is incrementing, hardware tests show that it only clamps to max, not 0.

Phase inversion is commonly used in "Dolby Surround" for simulating sound effects that should play through the rear speakers. There are also some cases where it is incorrectly used, such as Wipeout 3, where it sets a positive volume with an inverted sweep, but since all the rate bits are set to 1, the volume never steps, and it stays positive. If the rate had any bits clear, then the volume would slowly decrease to zero, then up to -8000h, growing louder but with phase inversion.

1F801C0Ch+N*10h - Voice 0..23 Current ADSR volume (R/W)

```
15-0 Current ADSR Volume (0..+7FFFh) (or -8000h..+7FFFh on manual write)
```

Reportedly Release can go down to -1 (FFFFh), but that isn't true; and release ends at 0... or does THAT depend on an END flag found in the sample-data?

The register is read/writeable, writing allows to let the ADSR generator to "jump" to a specific volume level. But, ACTUALLY, the ADSR generator does overwrite the setting (from another internal register) whenever applying a new Step?!

1F801DB8h - Current Main Volume Left/Right**1F801E00h+voice*04h - Voice 0..23 Current Volume Left/Right**

```
0-15  Current Volume Left  (-8000h..+7FFFh)
16-31 Current Volume Right (-8000h..+7FFFh)
```

These are internal registers, normally not used by software (the Volume settings are usually set via Ports 1F801D80h and 1F801C00h+N*10h).

Note

Negative volumes are phase inverted, otherwise same as positive.

7.5 SPU Voice Flags

1F801D88h - Voice 0..23 Key ON (Start Attack/Decay/Sustain) (KON) (W)

```
0-23  Voice 0..23 On  (0=No change, 1=Start Attack/Decay/Sustain)
24-31 Not used
```

Starts the ADSR Envelope, and automatically initializes ADSR Volume to zero, and copies Voice Start Address to Voice Repeat Address.

1F801D8Ch - Voice 0..23 Key OFF (Start Release) (KOFF) (W)

```
0-23  Voice 0..23 Off (0=No change, 1=Start Release)
24-31 Not used
```

For a full ADSR pattern, OFF would be usually issued in the Sustain period, however, it can be issued at any time (eg. to abort Attack, skip the Decay and Sustain periods, and switch immediately to Release).

1F801D9Ch - Voice 0..23 ON/OFF (status) (ENDX) (R)

```
0-23  Voice 0..23 Status (0=Newly Keyed On, 1=Reached LOOP-END)
24-31 Not used
```

The bits get CLEARED when setting the corresponding KEY ON bits.

The bits get SET when reaching an LOOP-END flag in ADPCM header.bit0.

R/W

Key On and Key Off should be treated as write-only (although, reading returns the most recently 32bit value, this doesn't provide any status information about whether sound is on or off).

The on/off (status) (ENDX) register should be treated read-only (writing is possible in so far that the written value can be read-back for a short moment, however, thereafter the hardware is overwriting that value).

7.6 SPU Noise Generator

1F801D94h - Voice 0..23 Noise mode enable (NON)

```
0-23  Voice 0..23 Noise (0=ADPCM, 1=Noise)
24-31 Not used
```

SPU Noise Generator

The signed 16bit output Level is calculated as so (repeated at 44.1kHz clock):

```
Wait(1 cycle)          ;at 44.1kHz clock
Timer=Timer-NoiseStep  ;subtract Step (4..7)
ParityBit = NoiseLevel.Bit15 xor Bit12 xor Bit11 xor Bit10 xor 1
IF Timer<0 then NoiseLevel = NoiseLevel*2 + ParityBit
IF Timer<0 then Timer=Timer+(20000h SHR NoiseShift) ;reload timer once
IF Timer<0 then Timer=Timer+(20000h SHR NoiseShift) ;reload again if needed
```

Note that the Noise frequency is solely controlled by the Shift/Step values in SPUCNT register (the ADPCM Sample Rate has absolutely no effect on noise), so when using noise for multiple voices, all of them are forcefully having the same frequency; the only workaround is to store a random ADPCM pattern in SPU RAM, which can be then used with any desired sample rate(s).

7.7 SPU Control and Status Register

1F801DAAh - SPU Control Register (SPUCNT)

```
15    SPU Enable          (0=Off, 1=On)          (Don't care for CD Audio)
14    Mute SPU            (0=Mute, 1=Unmute)     (Don't care for CD Audio)
13-10 Noise Frequency Shift (0..0Fh = Low .. High Frequency)
```

9-8	Noise Frequency Step	(0..03h = Step "4,5,6,7")
7	Reverb Master Enable	(0=Disabled, 1=Enabled)
6	IRQ9 Enable	(0=Disabled/Acknowledge, 1=Enabled; only when Bit15=1)
5-4	Sound RAM Transfer Mode	(0=Stop, 1=ManualWrite, 2=DMAwrite, 3=DMAread)
3	External Audio Reverb	(0=Off, 1=On)
2	CD Audio Reverb	(0=Off, 1=On) (for CD-DA and XA-ADPCM)
1	External Audio Enable	(0=Off, 1=On)
0	CD Audio Enable	(0=Off, 1=On) (for CD-DA and XA-ADPCM)

Changes to bit0-5 aren't applied immediately; after writing to SPUCNT, it'd be usually recommended to wait until the LSBs of SPUSTAT are updated accordingly. Before setting a new Transfer Mode, it'd be recommended first to set the "Stop" mode (and, again, wait until Stop is applied in SPUSTAT).

1F801DAEh - SPU Status Register (SPUSTAT) (R)

15-12	Unknown/Unused (seems to be usually zero)	
11	Writing to First/Second half of Capture Buffers	(0=First, 1=Second)
10	Data Transfer Busy Flag	(0=Ready, 1=Busy)
9	Data Transfer DMA Read Request	(0=No, 1=Yes)
8	Data Transfer DMA Write Request	(0=No, 1=Yes)
7	Data Transfer DMA Read/Write Request	;seems to be same as SPUCNT.Bit5
6	IRQ9 Flag	(0=No, 1=Interrupt Request)
5-0	Current SPU Mode	(same as SPUCNT.Bit5-0, but, applied a bit delayed)

When switching SPUCNT to DMA-read mode, status bit9 and bit7 aren't set immediately (apparently the SPU is first internally collecting the data in the Fifo, before transferring it).

Bit11 indicates if data is currently written to the first or second half of the four 1K-byte capture buffers (for CD Audio left/right, and voice 1/3). Note: Bit11 works only if Bit2 and/or Bit3 of Port 1F801DACH are set.

The SPUSTAT register should be treated read-only (writing is possible in so far that the written value can be read-back for a short moment, however, thereafter the hardware is overwriting that value).

7.8 SPU Memory Access

1F801DA6h - Sound RAM Data Transfer Address

15-0	Address in sound buffer divided by eight
------	--

Used for manual write and DMA read/write SPU memory. Writing to this registers stores the written value in 1F801DA6h, and does additional store the value (multiplied by 8) in another internal "current address" register (that internal register does increment during transfers, whilst the 1F801DA6h value DOESN'T increment).

1F801DA8h - Sound RAM Data Transfer Fifo

15-0 Data (max 32 halfwords)

Used for manual-write. Not sure if it can be also used for manual read?

1F801DACH - Sound RAM Data Transfer Control (should be 0004h)

15-4	Unknown/no effect?	(should be zero)
3-1	Sound RAM Data Transfer Type (see below)	(should be 2)
0	Unknown/no effect?	(should be zero)

The Transfer Type selects how data is forwarded from Fifo to SPU RAM:

Transfer Type	Halfwords in Fifo	Halfwords written to SPU RAM
0,1,6,7 Fill	A,B,C,D,E,F,G,H,...,X	X,X,X,X,X,X,X,X...
2 Normal	A,B,C,D,E,F,G,H,...,X	A,B,C,D,E,F,G,H...
3 Rep2	A,B,C,D,E,F,G,H,...,X	A,A,C,C,E,E,G,G...
4 Rep4	A,B,C,D,E,F,G,H,...,X	A,A,A,A,E,E,E,E...
5 Rep8	A,B,C,D,E,F,G,H,...,X	H,H,H,H,H,H,H,H...

Rep2 skips the 2nd halfword, Rep4 skips 2nd..4th, Rep8 skips 1st..7th.

Fill uses only the LAST halfword in Fifo, that might be useful for memfill purposes, although, the length is probably determined by the number of writes to the Fifo (?) so one must still issue writes for ALL halfwords...?

Note:

The above rather bizarre results apply to WRITE mode. In READ mode, the register causes the same halfword to be read 2/4/8 times (for rep2/4/8).

SPU RAM Manual Write

- Be sure that [1F801DACH] is set to 0004h
- Set SPUCNT to "Stop" (and wait until it is applied in SPUSTAT)
- Set the transfer address
- Write 1..32 halfword(s) to the Fifo
- Set SPUCNT to "Manual Write" (and wait until it is applied in SPUSTAT)

- Wait until Transfer Busy in SPUSTAT goes off (that, AFTER above apply-wait)
For multi-block transfers: Repeat the above last three steps (that is rarely done by any games, but it is done by the BIOS intro; observe that waiting for SPUCNT writes being applied in SPUSTAT won't work in that case (since SPUCNT was already in manual write mode from previous block), so one must instead use some hardcoded delay of at least 300h cycles; the BIOS is using a much longer bizarre delay though).

SPU RAM DMA-Write

- Be sure that [1F801DACH] is set to 0004h
- Set SPUCNT to "Stop" (and wait until it is applied in SPUSTAT)
- Set the transfer address
- Set SPUCNT to "DMA Write" (and wait until it is applied in SPUSTAT)
- Start DMA4 at CPU Side (blocksize=10h, control=01000201h)
- Wait until DMA4 finishes (at CPU side)

SPU RAM Manual-Read

As by now, there's no known method for reading SPU RAM without using DMA.

SPU RAM DMA-Read (stable reading, with [1F801014h].bit24-27 = nonzero)

- Be sure that [1F801014h] is set to 220931E1h (bit24-27 MUST be nonzero)
- Be sure that [1F801DACH] is set to 0004h
- Set SPUCNT to "Stop" (and wait until it is applied in SPUSTAT)
- Set the transfer address
- Set SPUCNT to "DMA Read" (and wait until it is applied in SPUSTAT)
- Start DMA4 at CPU Side (blocksize=10h, control=01000200h)
- Wait until DMA4 finishes (at CPU side)

SPU RAM DMA-Read (unstable reading, with [1F801014h].bit24-27 = zero)

Below describes some dirt effects and some trickery to get around those dirt effects.

Below problems (and workarounds) apply ONLY if [1F801014h].bit24-27 = zero.
Ie. below info describes what happens when [1F801014h] is mis-initialized.
Normally one should set [1F801014h]=220931E1h (and can ignore below info).

With [1F801014h].bit24-27=zero, reading SPU RAM via DMA works glitchy:
The first received halfword within each block is FFFFh. So with a DMA blocksize of 10h words (=20h halfwords), the following is received:

```
1st block:  FFFFh, halfwords[00h..1Eh]
2nd block:  FFFFh, halfwords[20h..3Eh]
etc.
```

that'd theoretically match the SPU Fifo Size, but, because of the inserted FFFFh value, the last Fifo entry isn't received, ie. halfword[1Fh,3Fh] are lost. As a workaround, one can increase the DMA blocksize to 11h words, and then the following is received:

```
1st block:  FFFFh, halfwords[00h..1Eh], twice halfword[1Fh]
2nd block:  FFFFh, halfwords[20h..3Eh], twice halfword[3Fh]
etc.
```

this time, all data is received, but after the transfer one must still remove the FFFFh values, and the duplicated halfwords by software. Aside from the <inserted> FFFFh values there are occasionally some unstable halfwords ORed by FFFFh (or ORed by other garbage values), this can be fixed by using "rep2" mode, which does then receive:

```
1st block:  FFFFh, halfwords[00h,00h,..0Eh,0Eh], triple halfword[0Fh]
2nd block:  FFFFh, halfwords[10h,10h,..1Eh,1Eh], triple halfword[1Fh]
etc.
```

again, remove the first halfword (FFFFh) and the last halfword, and, take the duplicated halfwords ANDed together. Unstable values occur only every 32 halfwords or so (probably when the SPU is simultaneously reading ADPCM data), but do never occur on two continuous halfwords, so, even if one halfword was ORed by garbage, the other halfword is always correct, and the result of the ANDed halfwords is 100% stable.

Note: The unstable reading does NOT occur always, when resetting the PSX a couple of times it does occasionally boot-up with totally stable reading, since there is no known way to activate the stable "mode" via I/O ports, the stable/unstable behaviour does eventually depend on internal clock dividers/multipliers, and whether they are starting in sync with the CPU or not.

Caution: The "rep2" trick cannot be used in combination with reverb (reverb seems to be using the Port 1F801DACH Sound RAM Data Transfer Control, too).

7.9 SPU Interrupt

1F801DA4h - Sound RAM IRQ Address (IRQ9)

15-0 Address in sound buffer divided by eight

See also: SPUCNT (IRQ enable/disable/acknowledge) and SPUSTAT (IRQ flag).

Voice Interrupt

Triggers an IRQ when a voice reads ADPCM data from the IRQ address.

Mind that ADPCM cannot be stopped (uh, except, probably they CAN be stopped, by setting the sample rate to zero?), all voices are permanently reading data from SPU RAM - even in Noise mode, even if the Voice Volume is zero, and even if the ADSR pattern has finished the Release period - so even inaudible voices can trigger IRQs. To prevent unwanted IRQs, best set all unused voices to an endless looped dummy ADPCM block. For stable IRQs, the IRQ address should be aligned to the 16-byte ADPCM blocks. If the IRQ address is in the middle of a 16-byte ADPCM block, then the IRQ doesn't seem to trigger always (unknown why, but it seems to occasionally miss IRQs, even if the block gets repeated several times).

Capture Interrupt

Setting the IRQ address to 0000h..01FFh (aka byte address 00000h..00FFFh) will trigger IRQs on writes to the four capture buffers. Each of the four buffers contains 400h bytes (=200h samples), so the IRQ rate will be around 86.13Hz (44100Hz/200h).

CD-Audio capture is always active (even CD-Audio output is disabled in SPUCNT, and even if the drive door is open). Voice capture is (probably) also always active (even if the corresponding voice is off).

Capture IRQs do NOT occur if 1F801DACH.bit3-2 are both zero.

Reverb Interrupt

Reverb is also triggering interrupts if the IRQ address is located in the reverb buffer area. Unknown \<which> of the various reverb read(s) and/or reverb write(s) are triggering interrupts.

Data Transfers

Data Transfers (usually via DMA4) to/from SPU-RAM do also trap SPU interrupts.

Note

The IRQ Address is used in the following games (not exhaustive): Metal Gear Solid: Dialogue and Konami intro. Legend of Mana Hercules: the memory card loading screen's lip sync. Tokimeki Memorial 2 Crash Team Racing: Lip sync, requires capture buffers. The Misadventures of Tron Bonne: Dialogues. Need For Speed 3: (somewhat?).

7.10 SPU Reverb Registers

Reverb Volume and Address Registers (R/W)

Port	Reg	Name	Type	Expl.
1F801D84h	spu	vLOUT	volume	Reverb Output Volume Left
1F801D86h	spu	vROUT	volume	Reverb Output Volume Right
1F801DA2h	spu	mBASE	base	Reverb Work Area Start Address in Sound RAM
1F801DC0h	rev00	dAPF1	disp	Reverb APF Offset 1
1F801DC2h	rev01	dAPF2	disp	Reverb APF Offset 2
1F801DC4h	rev02	viIR	volume	Reverb Reflection Volume 1
1F801DC6h	rev03	vCOMB1	volume	Reverb Comb Volume 1
1F801DC8h	rev04	vCOMB2	volume	Reverb Comb Volume 2
1F801DCAh	rev05	vCOMB3	volume	Reverb Comb Volume 3
1F801DCCh	rev06	vCOMB4	volume	Reverb Comb Volume 4
1F801DCEh	rev07	vWALL	volume	Reverb Reflection Volume 2
1F801DD0h	rev08	vAPF1	volume	Reverb APF Volume 1
1F801DD2h	rev09	vAPF2	volume	Reverb APF Volume 2
1F801DD4h	rev0A	mLSAME	src/dst	Reverb Same Side Reflection Address 1 Left
1F801DD6h	rev0B	mRSAME	src/dst	Reverb Same Side Reflection Address 1 Right
1F801DD8h	rev0C	mLCOMB1	src	Reverb Comb Address 1 Left
1F801DDAh	rev0D	mRCOMB1	src	Reverb Comb Address 1 Right
1F801DDCh	rev0E	mLCOMB2	src	Reverb Comb Address 2 Left
1F801DDEh	rev0F	mRCOMB2	src	Reverb Comb Address 2 Right
1F801DE0h	rev10	dLSAME	src	Reverb Same Side Reflection Address 2 Left
1F801DE2h	rev11	dRSAME	src	Reverb Same Side Reflection Address 2 Right
1F801DE4h	rev12	mLDIFF	src/dst	Reverb Different Side Reflect Address 1 Left
1F801DE6h	rev13	mRDIFF	src/dst	Reverb Different Side Reflect Address 1 Right
1F801DE8h	rev14	mLCOMB3	src	Reverb Comb Address 3 Left
1F801DEAh	rev15	mRCOMB3	src	Reverb Comb Address 3 Right
1F801DECh	rev16	mLCOMB4	src	Reverb Comb Address 4 Left
1F801DEEh	rev17	mRCOMB4	src	Reverb Comb Address 4 Right
1F801DF0h	rev18	dLDIFF	src	Reverb Different Side Reflect Address 2 Left
1F801DF2h	rev19	dRDIFF	src	Reverb Different Side Reflect Address 2 Right
1F801DF4h	rev1A	mLAPF1	src/dst	Reverb APF Address 1 Left
1F801DF6h	rev1B	mRAPF1	src/dst	Reverb APF Address 1 Right
1F801DF8h	rev1C	mLAPF2	src/dst	Reverb APF Address 2 Left
1F801DFAh	rev1D	mRAPF2	src/dst	Reverb APF Address 2 Right
1F801DFCh	rev1E	vLIN	volume	Reverb Input Volume Left
1F801DFEh	rev1F	vRIN	volume	Reverb Input Volume Right

All volume registers are signed 16bit (range -8000h..+7FFFh).

All src/dst/disp/base registers are addresses in SPU memory (divided by 8), src/dst are relative to the current buffer address, the disp registers are relative to src registers, the base register defines the start address of the reverb buffer (the end address is fixed, at 7FFFEh). Writing a value to mBASE does additionally set the current buffer address to that value.

1F801D98h - Voice 0..23 Reverb mode aka Echo On (EON) (R/W)

```
0-23  Voice 0..23 Destination (0=To Mixer, 1=To Mixer and to Reverb)
24-31 Not used
```

Sets reverb for the channel. As soon as the sample ends, the reverb for that channel is turned off... that's fine, but WHEN does it end?

In Reverb mode, the voice seems to output BOTH normal (immediately) AND via Reverb (delayed).

Reverb Bits in SPUCNT Register (R/W)

The SPUCNT register contains a Reverb Master Enable flag, and Reverb Enable flags for External Audio input and CD Audio input.

When the Reverb Master Enable flag is cleared, the SPU stops to write any data to the Reverb buffer (that is useful when zero-filling the reverb buffer; ensuring that already-zero values aren't overwritten by still-nonzero values).

However, the Reverb Master Enable flag does not disable output from Reverb buffer to the speakers (that might be useful to output uncompressed 22050Hz samples) (otherwise, to disable the buffer output, set the Reverb Output volume to zero and/or zerofill the reverb buffer).

7.11 SPU Reverb Formula

Reverb Formula

```
____Input from Mixer (Input volume multiplied with incoming data)____
Lin = vLIN * LeftInput      ;from any channels that have Reverb enabled
Rin = vRIN * RightInput     ;from any channels that have Reverb enabled
____Same Side Reflection (left-to-left and right-to-right)____
[mLSAME] = (Lin + [dLSAME]*vWALL - [mLSAME-2])*vIIR + [mLSAME-2] ;L-to-L
[mRSAME] = (Rin + [dRSAME]*vWALL - [mRSAME-2])*vIIR + [mRSAME-2] ;R-to-R
____Different Side Reflection (left-to-right and right-to-left)____
[mLDIFF] = (Lin + [dRDIFF]*vWALL - [mLDIFF-2])*vIIR + [mLDIFF-2] ;R-to-L
```

```

[mRDIFF] = (Rin + [dLDIFF]*vWALL - [mRDIFF-2])*vIIR + [mRDIFF-2] ;L-to-R
____Early Echo (Comb Filter, with input from buffer)____
Lout=vCOMB1*[mLCOMB1]+vCOMB2*[mLCOMB2]+vCOMB3*[mLCOMB3]+vCOMB4*[mLCOMB4]
Rout=vCOMB1*[mRCOMB1]+vCOMB2*[mRCOMB2]+vCOMB3*[mRCOMB3]+vCOMB4*[mRCOMB4]
____Late Reverb APF1 (All Pass Filter 1, with input from COMB)____
Lout=Lout-vAPF1*[mLAPF1-dAPF1], [mLAPF1]=Lout, Lout=Lout*vAPF1+[mLAPF1-dAPF1]
Rout=Rout-vAPF1*[mRAPF1-dAPF1], [mRAPF1]=Rout, Rout=Rout*vAPF1+[mRAPF1-dAPF1]
____Late Reverb APF2 (All Pass Filter 2, with input from APF1)____
Lout=Lout-vAPF2*[mLAPF2-dAPF2], [mLAPF2]=Lout, Lout=Lout*vAPF2+[mLAPF2-dAPF2]
Rout=Rout-vAPF2*[mRAPF2-dAPF2], [mRAPF2]=Rout, Rout=Rout*vAPF2+[mRAPF2-dAPF2]
____Output to Mixer (Output volume multiplied with input from APF2)____
LeftOutput = Lout*vLOUT
RightOutput = Rout*vROUT
____Finally, before repeating the above steps____
BufferAddress = MAX(mBASE, (BufferAddress+2) AND 7FFFEh)
Wait one 22050Hz cycle, then repeat the above stuff

```

Notes

The values written to memory are saturated to -8000h..+7FFFh.

The multiplication results are divided by +8000h, to fit them to 16bit range.

All memory addresses are relative to the current BufferAddress, and wrapped within mBASE..7FFFEh when exceeding that region.

All data in the Reverb buffer consists of signed 16bit samples. The Left and Right Reverb Buffer addresses should be choosen so that one half of the buffer contains Left samples, and the other half Right samples (ie. the data is L,L,L,L,... R,R,R,R,...; it is NOT interlaced like L,R,L,R,...), during operation, when the buffer address increases, the Left half will overwrite the older samples of the Right half, and vice-versa.

The reverb hardware spends one 44100h cycle on left calculations, and the next 44100h cycle on right calculations (unlike as shown in the above formula, where left/right are shown simultaneously at 22050Hz).

Reverb Disable

SPUCNT.bit7 disables writes to reverb buffer, but reads from reverb buffer do still occur. If vAPF2 is zero then it does simply read "Lout=[mLAPF2-dAPF2]" and "Rout=[mRAPF2-dAPF2]". If vAPF2 is nonzero then it does additionally use data from APF1, if vAPF1 and vAPF2 are both nonzero then it's also using data from COMB. However, the SAME/DIFF stages aren't used when reverb is disabled.

Bug

vIIR works only in range -7FFFh..+7FFFh. When set to -8000h, the multiplication by -8000h is still done correctly, but, the final result (the value written to memory) gets

negated (this is a pretty strange feature, it is NOT a simple overflow bug, it does affect the "+[mLSAME-2]" addition; although that part normally shouldn't be affected by the "*vIIR" multiplication). Similar effects might (?) occur on some other volume registers when they are set to -8000h.

Speed of Sound

The speed of sound is circa 340 meters per second (in dry air, at room temperature). For example, a voice that travels to a wall at 17 meters distance, and back to its origin, should have a delay of 0.1 seconds.

Reverb Buffer Resampling

Input and output to/from the reverb unit is resampled using a 39-tap FIR filter with the following coefficients.

```
-0001h, 0000h, 0002h, 0000h, -000Ah, 0000h, 0023h, 0000h,
-0067h, 0000h, 010Ah, 0000h, -0268h, 0000h, 0534h, 0000h,
-0B90h, 0000h, 2806h, 4000h, 2806h, 0000h, -0B90h, 0000h,
0534h, 0000h, -0268h, 0000h, 010Ah, 0000h, -0067h, 0000h,
0023h, 0000h, -000Ah, 0000h, 0002h, 0000h, -0001h,
```

7.12 SPU Reverb Examples

Reverb Examples

Below are some Reverb examples, showing the required memory size (ie. set Port 1F801DA2h to "(80000h-size)/8"), and the Reverb register settings for Port 1F801DC0h..1F801DFFh, ie. arranged like so:

```
dAPF1 dAPF2 vIIR vCOMB1 vCOMB2 vCOMB3 vCOMB4 vWALL ;1F801DC0h..CEh
vAPF1 vAPF2 mLSAME mRSAME mLCOMB1 mRCOMB1 mLCOMB2 mRCOMB2 ;1F801DD0h..DEh
dLSAME dRSAME mLDIFF mRDIFF mLCOMB3 mRCOMB3 mLCOMB4 mRCOMB4 ;1F801DE0h..EEh
dLDIFF dRDIFF mLAPF1 mRAPF1 mLAPF2 mRAPF2 vLIN vRIN ;1F801DF0h..FEh
```

Also, don't forget to initialize Port 1F801D84h, 1F801D86h, 1F801D98h, and SPUCNT, and to zerofill the Reverb Buffer (so that no garbage values are output when activating reverb). For whatever reason, one MUST also initialize Port 1F801DACH (otherwise reverb stays off).

Room (size=26C0h bytes)

```
007Dh,005Bh,6D80h,54B8h,BED0h,0000h,0000h,BA80h
5800h,5300h,04D6h,0333h,03F0h,0227h,0374h,01EFh
0334h,01B5h,0000h,0000h,0000h,0000h,0000h,0000h
0000h,0000h,01B4h,0136h,00B8h,005Ch,8000h,8000h
```

Studio Small (size=1F40h bytes)

```
0033h,0025h,70F0h,4FA8h,BCE0h,4410h,C0F0h,9C00h
5280h,4EC0h,03E4h,031Bh,03A4h,02AFh,0372h,0266h
031Ch,025Dh,025Ch,018Eh,022Fh,0135h,01D2h,00B7h
018Fh,00B5h,00B4h,0080h,004Ch,0026h,8000h,8000h
```

Studio Medium (size=4840h bytes)

```
00B1h,007Fh,70F0h,4FA8h,BCE0h,4510h,BEF0h,B4C0h
5280h,4EC0h,0904h,076Bh,0824h,065Fh,07A2h,0616h
076Ch,05EDh,05ECh,042Eh,050Fh,0305h,0462h,02B7h
042Fh,0265h,0264h,01B2h,0100h,0080h,8000h,8000h
```

Studio Large (size=6FE0h bytes)

```
00E3h,00A9h,6F60h,4FA8h,BCE0h,4510h,BEF0h,A680h
5680h,52C0h,0DFBh,0B58h,0D09h,0A3Ch,0BD9h,0973h
0B59h,08DAh,08D9h,05E9h,07ECh,04B0h,06EFh,03D2h
05EAh,031Dh,031Ch,0238h,0154h,00AAh,8000h,8000h
```

Hall (size=ADE0h bytes)

```
01A5h,0139h,6000h,5000h,4C00h,B800h,BC00h,C000h
6000h,5C00h,15BAh,11BBh,14C2h,10BDh,11BCh,0DC1h
11C0h,0DC3h,0DC0h,09C1h,0BC4h,07C1h,0A00h,06CDh
09C2h,05C1h,05C0h,041Ah,0274h,013Ah,8000h,8000h
```

Half Echo (size=3C00h bytes)

```
0017h,0013h,70F0h,4FA8h,BCE0h,4510h,BEF0h,8500h
5F80h,54C0h,0371h,02AFh,02E5h,01DFh,02B0h,01D7h
0358h,026Ah,01D6h,011Eh,012Dh,00B1h,011Fh,0059h
01A0h,00E3h,0058h,0040h,0028h,0014h,8000h,8000h
```

Space Echo (size=F6C0h bytes)

```
033Dh, 0231h, 7E00h, 5000h, B400h, B000h, 4C00h, B000h
6000h, 5400h, 1ED6h, 1A31h, 1D14h, 183Bh, 1BC2h, 16B2h
1A32h, 15EFh, 15EEh, 1055h, 1334h, 0F2Dh, 11F6h, 0C5Dh
1056h, 0AE1h, 0AE0h, 07A2h, 0464h, 0232h, 8000h, 8000h
```

Chaos Echo (almost infinite) (size=18040h bytes)

```
0001h, 0001h, 7FFFh, 7FFFh, 0000h, 0000h, 0000h, 8100h
0000h, 0000h, 1FFFh, 0FFFh, 1005h, 0005h, 0000h, 0000h
1005h, 0005h, 0000h, 0000h, 0000h, 0000h, 0000h, 0000h
0000h, 0000h, 1004h, 1002h, 0004h, 0002h, 8000h, 8000h
```

Delay (one-shot echo) (size=18040h bytes)

```
0001h, 0001h, 7FFFh, 7FFFh, 0000h, 0000h, 0000h, 0000h
0000h, 0000h, 1FFFh, 0FFFh, 1005h, 0005h, 0000h, 0000h
1005h, 0005h, 0000h, 0000h, 0000h, 0000h, 0000h, 0000h
0000h, 0000h, 1004h, 1002h, 0004h, 0002h, 8000h, 8000h
```

Reverb off (size=10h dummy bytes)

```
0000h, 0000h, 0000h, 0000h, 0000h, 0000h, 0000h, 0000h
0000h, 0000h, 0001h, 0001h, 0001h, 0001h, 0001h, 0001h
0000h, 0000h, 0001h, 0001h, 0001h, 0001h, 0001h, 0001h
0000h, 0000h, 0001h, 0001h, 0001h, 0001h, 0000h, 0000h
```

Note that the memory offsets should be 0001h here (not 0000h), otherwise zerofilling the reverb buffer seems to fail (maybe because zero memory offsets somehow cause the fill-value to mixed with the old value or so; that appears even when reverb master enable is zero). Also, when not using reverb, Port 1F801D84h, 1F801D86h, 1F801D98h, and the SPUCNT reverb bits should be set to zero.

7.13 SPU Unknown Registers

1F801DA0h - Some kind of a read-only status register.. or just garbage..?

```
0-15 Unknown?
```

Usually 9D78h, occasionally changes to 17DAh or 108Eh for a short moment.

Other day: Usually 9CF8h, or occasionally 9CFAh.

Another day: Usually 0000h, or occasionally 4000h.

1F801DBCh - 4 bytes - Unknown? (R/W)

```
80 21 4B DF
```

Other day (dots = same as above):

```
.. 31 .. ..
```

1F801E60h - 32 bytes - Unknown? (R/W)

```
7E 61 A9 96 47 39 F9 1E E1 E1 80 DD E8 17 7F FB
FB BF 1D 6C 8F EC F3 04 06 23 89 45 C1 6D 31 82
```

Other day (dots = same as above):

```
.. .. .. .. .. .. .. .. .. .. .. .. 7B ..
.. .. .. .. .. .. .. .. 04 .. .. .. .. .. .. 86
```

The bytes at 1F801DBCh and 1F801E60h usually have the above values on cold-boot. The registers are read/write-able, although writing any values to them doesn't seem to have any effect on sound output. Also, the SPU doesn't seem to modify the registers at any time during sound output, nor reverb calculations, nor activated external audio input... the registers seem to be just some kind of general-purpose RAM.

7.14 SPU Internal State Machine from SPU RAM Timing

7.14.1 Introduction

The 33.8 Mhz clock of the PSX is a well chosen value. It is exactly $768 \times 44.1 \text{ Khz}$ = For each audio sample in CD quality, there are 768 cycles of system clock. So, the state machine has to repeat its complete cycle every 768 system clock cycles.

Now the full job to do within those 768 cycles: - 24 channels to process. - Reverb to compute and write back. - Write back to voice 1 / 3, audio CD L/R. - Do transfer from/to CPU bus of SPU RAM data if asked.

7.14.2 First look at the data from logic analyzer.

By looking at the signal of the SPU RAM chip, it is possible to figure out what it is reading and writing. - A read or a write to the SPU Ram is happening in 8 clock cycles. (Did not check in detail, but probably allow refresh and everything) - Each channel is using 24 cycles. (3 operations of 8 cycles) - Has TWO read for the current ADPCM block : one to the header of the currently played ADPCM block, one to the current 16 bit of the ADPCM. - A unrelated READ (see later) - 8 Cycle for each operation : WRITE CD Left, WRITE CD Right, Voice 1 WRITE, Voice 3 WRITE. - Reverb operations : 14 memory operations of 8 cycles.

7.14.3 Sequence of work

When doing the analysis from data, it is possible to figure out what are the operations, in what order they are done. But it is not possible to figure out what is the FIRST operation in the loop. So we arbitrarily decide to start the loop at 'Voice 1' (voice being from 1 to 24).

- Voice 1
- Write CD Left
- Write CD Right
- Write Voice 1
- Write Voice 3
- Reverb
- Voice 2
- Voice 3
- Voice 4
- ...
- ...
- Voice 23
- Voice 24

As written earlier, each Voice is 3x RAM access (one unrelated), reverb is 14x RAM access, then 4x RAM access for the all write.

7.14.4 What we can guess from those information.

- If system wants to keep reverb done in the end, and write in sync against Voice 1 and 3, then the loop would most likely start at Voice 2.
- ADPCM decoder has to keep ADPCM decoder internal state about the samples. As the algorithm depends on the previous value inside a block, it can't do a direct access to a given sample in the block.
- We also understand how reverb is using 22 Khz because of the lack of bandwidth to do everything in 768 cycles if done at 44.1 Khz.
- Even when voices are not active, they always read something. It is possible to guess that the sample is simply ignored at some point in the data path (volume set to zero internally or mux not selecting the value). Interestingly, it may be possible if garbage is introduced in those read, to know how it is cancelled (enabling suddenly the channel and reading the sample out of the channel 1 or 3) -> DSP keeps history of sample for Gaussian Interpolation.

7.14.5 Reverb Computation Order

	[Left Side]	[Right Side]	
READ REVERB	dLSame	dRSame	
READ REVERB	mLSame-1	mRSame-1	
READ REVERB	dRDiff	dLDiff	
XXXX REVERB	mLSame	mRSame	<-- WRITE becomes READ if REVERB
DISABLED.			
READ REVERB	mLDiff-1	mRDiff-1	
READ REVERB	mLComb1	mRComb1	
XXXX REVERB	mLDiff	mRDiff	<-- WRITE becomes READ if REVERB
DISABLED.			
READ REVERB	mLComb2	mRComb2	
READ REVERB	mLComb3	mRComb3	
READ REVERB	mLComb4	mRComb4	
READ REVERB	mLAPF1 - dAPF1	mRAPF1 - dAPF1	
READ REVERB	mLAPF2 - dAPF2	mRAPF2 - dAPF2	
XXXX REVERB	mLAPF1	mRAPF1	<-- WRITE becomes READ if REVERB
DISABLED.			
XXXX REVERB	mLAPF2	mRAPF2	<-- WRITE becomes READ if REVERB
DISABLED.			

We anticipate that the easiest way in hardware to disable/enable the REVERB function would be to switch those WRITE into READ.

7.14.6 Voices

```
Read Header word in current ADPCM block.  
Read Current Sample 16 bit word in current ADPCM block.  
Read [UNRELATED ADR ? Not related to current block...]
```

7.14.7 Notes

- Remaining cycles.
- With $24 \times 8 + 4 \times 8 + 14 \times 8 = 720$ cycles out of 768 cycles.
- That would mean 6 READ/WRITE should still be possible.
- UNRELATED READ in voices : probably used for transfer from [CPU->SPU RAM] or [SPU RAM->CPU]
- That would equate to a transfer performance of $24 \times 2 \text{ byte} \times 44100 \text{ Khz} = 2,116,800$ bytes/sec
- The fixed READ timing would explain also why CPU can't read directly SPU RAM. As the SPU need to be the master to push the data.
- It only works with DMA waiting for the data to be sent.

Everything is not fully clear yet, testing of SPU with proper tests to validate/invalidate various assumption. Our finding are based on a logic analyzer log using the PSX boot sounds, knowing the values of the registers thanks to emulators.

8. Interrupts

1F801070h I_STAT - Interrupt status register (R=Status, W=Acknowledge)

1F801074h I_MASK - Interrupt mask register (R/W)

Status: Read I_STAT (0=No IRQ, 1=IRQ)

Acknowledge: Write I_STAT (0=Clear Bit, 1=No change)

Mask: Read/Write I_MASK (0=Disabled, 1=Enabled)

```

0      IRQ0 VBLANK (PAL=50Hz, NTSC=60Hz)
1      IRQ1 GPU    Can be requested via GP0(1Fh) command (rarely used)
2      IRQ2 CDROM
3      IRQ3 DMA
4      IRQ4 TMR0   Timer 0 aka Root Counter 0 (Sysclk or Dotclk)
5      IRQ5 TMR1   Timer 1 aka Root Counter 1 (Sysclk or H-blank)
6      IRQ6 TMR2   Timer 2 aka Root Counter 2 (Sysclk or Sysclk/8)
7      IRQ7 Controller and Memory Card - Byte Received Interrupt
8      IRQ8 SIO
9      IRQ9 SPU
10     IRQ10 Controller - Lightpen Interrupt. Also shared by PIO and DTL cards.
11-15  Not used (always zero)
16-31  Garbage

```

Secondary IRQ10 Controller (Port 1F802030h)

[EXP2 DTL-H2000 I/O Ports](#)

Interrupt Request / Execution

The interrupt request bits in I_STAT are edge-triggered, ie. they get set ONLY if the corresponding interrupt source changes from "false to true".

If one or more interrupts are requested and enabled, ie. if "(I_STAT AND I_MASK)≠nonzero", then cop0r13.bit10 gets set, and when cop0r12.bit10 and cop0r12.bit0 are set, too, then the interrupt gets executed.

Interrupt Acknowledge

To acknowledge an interrupt, write a "0" to the corresponding bit in I_STAT. Most interrupts (except IRQ0,4,5,6) must be additionally acknowledged at the I/O port that has caused them (eg. JOY_CTRL.bit4).

Observe that the I_STAT bits are edge-triggered (they get set only on High-to-Low, or False-to-True edges). The correct acknowledge order is:

```
First, acknowledge I_STAT          (eg. I_STAT.bit7=0)
Then, acknowledge corresponding I/O port (eg. JOY_CTRL.bit4=1)
```

When doing it vice-versa, the hardware may miss further IRQs (eg. when first setting JOY_CTRL.4=1, then a new IRQ may occur in JOY_STAT.4 within a single clock cycle, thereafter, setting I_STAT.7=0 would successfully reset I_STAT.7, but, since JOY_STAT.4 is already set, there'll be no further edge, so I_STAT.7 won't be ever set in future).

COP0 Interrupt Handling

Relevant COP0 registers are cop0r13 (CAUSE, reason flags), and cop0r12 (SR, control flags), and cop0r14 (EPC, return address), and, cop0cmd=10h (aka RFE opcode) is used to prepare the return from interrupts. For more info, see

[COP0 - Exception Handling](#)

PSX specific COP0 Notes

COP0 has six hardware interrupt bits, of which, the PSX uses only cop0r13.bit10 (the other ones, cop0r13.bit11-15 are always zero). cop0r13.bit10 is NOT a latch, ie. it gets automatically cleared as soon as "(I_STAT AND I_MASK)=zero", so there's no need to do an acknowledge at the cop0 side. COP0 additionally has two software interrupt bits, cop0r13.bit8-9, which do exist in the PSX, too, these bits are read/write-able latches which can be set/cleared manually to request/acknowledge exceptions by software.

PS2 IOP interrupts

The PS2's IOP has the same interrupt controller as the PS1 but with more channels. For more details, see:

[ps2tek - IOP Interrupts](#)

9. DMA Channels

DMA Register Summary

```

1F80108xh DMA0 channel 0 MDECin (RAM to MDEC)
1F80109xh DMA1 channel 1 MDECout (MDEC to RAM)
1F8010Axh DMA2 channel 2 GPU (lists + image data)
1F8010Bxh DMA3 channel 3 CDROM (CDROM to RAM)
1F8010Cxh DMA4 channel 4 SPU
1F8010Dxh DMA5 channel 5 PIO (Expansion Port)
1F8010Exh DMA6 channel 6 OTC (reverse clear OT) (GPU related)
1F8010F0h DPCR - DMA Control register
1F8010F4h DICR - DMA Interrupt register

```

These ports control DMA at the CPU-side. In most cases, you'll additionally need to initialize an address (and transfer direction, transfer enabled, etc.) at the remote-side (eg. at the GPU-side for DMA2).

1F801080h+N*10h - D#_MADR - DMA base address (Channel 0..6) (R/W)

```

0-23 Memory Address where the DMA will start reading from/writing to
24-31 Not used (always zero)

```

In SyncMode=0, the hardware doesn't update the MADR registers (it will contain the start address even during and after the transfer) (unless Chopping is enabled, in that case it does update MADR, same does probably also happen when getting interrupted by a higher priority DMA channel).

In SyncMode=1 and SyncMode=2, the hardware does update MADR (it will contain the start address of the currently transferred block; at transfer end, it'll hold the end-address in SyncMode=1, or the end marker in SyncMode=2)

Notes: Address bits 0-1 are writeable, but any updated current/end addresses are word-aligned with bits 0-1 forced to zero.

The address counter wraps around when counting down from 000000h to FFFFFCh, leading to words after wraparound not being written to RAM (as FFFFFCh is past the default 8 MB main RAM region).

1F801084h+N*10h - D#_BCR - DMA Block Control (Channel 0..6) (R/W)

For SyncMode=0 (ie. for OTC and CDROM):

0-15	BC	Number of words (0001h..FFFFh) (or 0=10000h words)
16-31	0	Not used (usually 0 for OTC, or 1 ("one block") for CDROM)

For SyncMode=1 (ie. for MDEC, SPU, and GPU-vram-data):

0-15	BS	Blocksize (words) ;for GPU/SPU max 10h, for MDEC max 20h
16-31	BA	Amount of blocks ;ie. total length = BS*BA words

For SyncMode=2 (ie. for GPU-command-lists):

0-31	0	Not used (should be zero) (transfer ends at END-CODE in list)
------	---	---

BC/BS/BA can be in range 0001h..FFFFh (or 0=10000h). For BS, take care not to set the blocksize larger than the buffer of the corresponding unit can hold. (GPU and SPU both have a 16-word buffer). A larger blocksize means faster transfer.

SyncMode=1 decrements BA to zero, SyncMode=0 with chopping enabled decrements BC to zero (aside from that two cases, D#_BCR isn't changed during/after transfer).

1F801088h+N*10h - D#_CHCR - DMA Channel Control (Channel 0..6) (R/W)

0	Transfer direction (0=device to RAM, 1=RAM to device)
1	MADR increment per step (0=+4, 1=-4)
2-7	Unused
8	When 1:
	-Burst mode: enable "chopping" (cycle stealing by CPU)
	-Slice mode: Causes DMA to hang
	-Linked-list mode: Transfer header before data?
9-10	Transfer mode (SyncMode)
	0=Burst (transfer data all at once after DREQ is first asserted)
	1=Slice (split data into blocks, transfer next block whenever DREQ is asserted)
	2=Linked-list mode
	3=Reserved
11-15	Unused
16-18	Chopping DMA window size (1 << N words)
19	Unused
20-22	Chopping CPU window size (1 << N cycles)
23	Unused
24	Start transfer (0=stopped/completed, 1=start/busy)
25-27	Unused
28	Force transfer start without waiting for DREQ
29	In forced-burst mode, pauses transfer while set. In other modes, stops bit 28 from being cleared after a slice is transferred. No effect when transfer was caused by a DREQ.
30	Perform bus snooping (allows DMA to read from -nonexistent- cache?)
31	Unused

Bit 28 is automatically cleared upon BEGIN of the transfer, this bit needs to be set only in SyncMode=0 (setting it in other SyncModes would force the first block to be transferred instantly without DREQ, which isn't desired).

Bit 24 is automatically cleared upon COMPLETION of the transfer, this bit must be always set for all SyncModes when starting a transfer.

For DMA6/OTC there are some restrictions, D6_CHCR has only three read/writeable bits: 24,28,30. All other bits are read-only: bit 1 is always 1 (increment=-4), and the other bits are always 0.

1F8010F0h - DPCR - DMA Control Register (R/W)

0-2	DMA0, MDECin	Priority	(0..7; 0=Highest, 7=Lowest)
3	DMA0, MDECin	Master Enable	(0=Disable, 1=Enable)
4-6	DMA1, MDECout	Priority	(0..7; 0=Highest, 7=Lowest)
7	DMA1, MDECout	Master Enable	(0=Disable, 1=Enable)
8-10	DMA2, GPU	Priority	(0..7; 0=Highest, 7=Lowest)
11	DMA2, GPU	Master Enable	(0=Disable, 1=Enable)
12-14	DMA3, CDROM	Priority	(0..7; 0=Highest, 7=Lowest)
15	DMA3, CDROM	Master Enable	(0=Disable, 1=Enable)
16-18	DMA4, SPU	Priority	(0..7; 0=Highest, 7=Lowest)
19	DMA4, SPU	Master Enable	(0=Disable, 1=Enable)
20-22	DMA5, PIO	Priority	(0..7; 0=Highest, 7=Lowest)
23	DMA5, PIO	Master Enable	(0=Disable, 1=Enable)
24-26	DMA6, OTC	Priority	(0..7; 0=Highest, 7=Lowest)
27	DMA6, OTC	Master Enable	(0=Disable, 1=Enable)
28-30	CPU memory access	priority	(0..7; 0=Highest, 7=Lowest)
31	No effect, should be CPU memory access enable (R/W)		

Initial value on reset is 07654321h. If two or more channels have the same priority setting, then the priority is determined by the channel number (DMA0=Lowest, DMA6=Highest, CPU=higher than DMA6?).

1F8010F4h - DICR - DMA Interrupt Register (R/W)

0-6	Controls channel 0-6 completion interrupts in bits 24-30. When 0, an interrupt only occurs when the entire transfer completes. When 1, interrupts can occur for every slice and linked-list transfer. No effect if the interrupt is masked by bits 16-22.		
7-14	Unused		
15	Bus error flag. Raised when transferring to/from an address outside of RAM. Forces bit 31. (R/W)		
16-22	Channel 0-6 interrupt mask. If enabled, channels cause interrupts as per bits 0-6.		
23	Master channel interrupt enable.		
24-30	Channel 0-6 interrupt flags. (R, write 1 to reset)		
31	Master interrupt flag (R)		

IRQ flags in bit (24+n) are set upon DMA_n completion - but caution - they are set ONLY if enabled in bit (16+n) (unlike interrupt flags in I_STAT, which are always set regardless of whether the respective IRQ is masked).

Bit 31 is a simple readonly flag that follows the following rules:

```
IF b15=1 OR (b23=1 AND (b16-22 AND b24-30)>0) THEN b31=1 ELSE b31=0
```

Upon 0-to-1 transition of Bit 31, the IRQ3 flag in I_STAT gets set.

Bits 24-30 are acknowledged (reset to zero) when writing a "1" to that bits (and additionally, IRQ3 must be acknowledged via I_STAT).

1F8010F8h (usually 7FFAC68Bh? or 0BFAC688h)

```
(changes to 7FE358D1h after DMA transfer)
```

1F8010FCh (usually 00FFFFFFh) (...maybe OTC fill-value)

```
(stays so even after DMA transfer)
```

Contains strange read-only values (but not the usual "Garbage").

Not yet tested during transfer, might be remaining length and address?

Commonly used DMA Control Register values for starting DMA transfers

```
DMA0 MDEC.IN  01000201h (always)
DMA1 MDEC.OUT 01000200h (always)
DMA2 GPU      01000200h (VramRead), 01000201h (VramWrite), 01000401h (List)
DMA3 CDROM    11000000h (normal), 11400100h (chopped, rarely used)
DMA4 SPU      01000201h (write), 01000200h (read, rarely used)
DMA5 PIO      11150100h (System 573 ATAPI read), ? (System 573 ATAPI write)
DMA6 OTC      11000002h (always)
```

XXX: DMA2 values 01000201h (VramWrite), 01000401h (List) aren't 100% confirmed to be used by ALL existing games. All other values are always used as listed above.

Linked List DMA

GPU commands are usually sent from RAM to GP0 using DMA2 in linked list mode. In this mode, the DMA controller transfers words in "nodes", with the first node starting in the address indicated by D2_MADR.

Each node is composed of a header word (the very first word in the node) and some

extra words to be DMA'd before moving on to the next node. The node header is formatted like this:

```
0-23  Address of the next node (or end marker)
24-31 Number of extra words to transfer for this node
```

The transfer is stopped once an end marker is reached. On some (earlier?) CPU revisions any address with bit 23 set will be interpreted as an end marker, while on other revisions all bits must be set (i.e. the address must be FFFFFFFF). This change was probably necessary as later CPU versions added support for up to 16 MB RAM addressing, which made addresses in the 800000-FFFFFFC range valid.

DMA Transfer Rates

```
DMA0 MDEC.IN      1 clk/word   ;0110h clks per 100h words ;\plus whatever
DMA1 MDEC.OUT      1 clk/word   ;0110h clks per 100h words ;/decompression time
DMA2 GPU           1 clk/word   ;0110h clks per 100h words ;-plus ...
DMA3 CDROM/BIOS    24 clks/word ;1800h clks per 100h words ;\plus single/double
DMA3 CDROM/GAMES   40 clks/word ;2800h clks per 100h words ;/speed sector rate
DMA4 SPU           4 clks/word   ;0420h clks per 100h words ;-plus ...
DMA5 PIO           20 clks/word ;1400h clks per 100h words ;-not actually used
DMA6 OTC           1 clk/word   ;0110h clks per 100h words ;-plus nothing
```

MDEC decompression time is still unknown (may vary on RLE and color/mono).

GPU polygon rendering time is unknown (may be quite slow for large polys).

GPU vram read/write time is unknown (may vary on horizontal screen resolution).

CDROM BIOS default is 24 clks, for some reason most games change it to 40 clks.

SPU transfer is unknown (may have some extra delays).

XXX is SPU really only 4 clks (theoretically SPU access should be slower)?

PIO is only used on some arcade systems (and configured with different timings).

OTC is just writing to RAM without extra overload.

CDROM/SPU/PIO timings can be configured via Memory Control registers.

DRAM Hyper Page mode

DMA is using DRAM Hyper Page mode, allowing it to access DRAM rows at 1 clock cycle per word (effectively around 17 clks per 16 words, due to required row address loading, probably plus some further minimal overload due to refresh cycles). This is making DMA much faster than CPU memory accesses (CPU DRAM access takes 1 opcode cycle plus 6 waitstates, ie. 7 cycles in total)

CPU Operation during DMA

CPU is running during DMA within very strict rules. It can be kept running when accessing only cache, scratchpad, COP0 and GTE.

It can also make use of the 4 entry Write queue for both RAM and I/O registers, see:

[Write queue](#)

Any read access from RAM or I/O registers or filling more than 4 entries into the write queue will stall the CPU until the DMA is finished.

Additionally, the CPU operation resumes during periods when DMA gets interrupted (ie. after SyncMode 1 blocks, after SyncMode 2 list entries) (or in SyncMode 0 with Chopping enabled).

PS2 IOP DMA

The PS2's IOP has an extended DMA unit with more channels, new control registers and an additional chain mode (SyncMode=3). For more details, see:

[ps2tek - IOP DMA](#)

10. Timers

1F801100h+N*10h - Timer 0..2 Current Counter Value (R/W)

```
0-15  Current Counter value (incrementing)
16-31 Garbage
```

This register is automatically incrementing. It is write-able (allowing to set it to any value). It gets forcefully reset to 0000h on any write to the Counter Mode register and when reaching counter overflow condition (either when reaching FFFFh, or when reaching the selected target value).

Writing a Current value larger than the Target value will not trigger the condition of Mode Bit4, but make the counter run until FFFFh and wrap around to 0000h once, before using the target value.

1F801104h+N*10h - Timer 0..2 Counter Mode (R/W)

```
0      Synchronization Enable (0=Free Run, 1=Synchronize via Bit1-2)
1-2    Synchronization Mode (0-3, see lists below)
        Synchronization Modes for Counter 0:
            0 = Pause counter during Hblank(s)
            1 = Reset counter to 0000h at Hblank(s)
            2 = Reset counter to 0000h at Hblank(s) and pause outside of Hblank
            3 = Pause until Hblank occurs once, then switch to Free Run
        Synchronization Modes for Counter 1:
            Same as above, but using Vblank instead of Hblank
        Synchronization Modes for Counter 2:
            0 or 3 = Stop counter at current value (forever, no h/v-blank start)
            1 or 2 = Free Run (same as when Synchronization Disabled)
3      Reset counter to 0000h (0=After Counter=FFFFh, 1=After Counter=Target)
4      IRQ when Counter=Target (0=Disable, 1=Enable)
5      IRQ when Counter=FFFFh (0=Disable, 1=Enable)
6      IRQ Once/Repeat Mode (0=One-shot, 1=Repeatedly)
7      IRQ Pulse/Toggle Mode (0=Short Bit10=0 Pulse, 1=Toggle Bit10 on/off)
8-9    Clock Source (0-3, see list below)
        Counter 0: 0 or 2 = System Clock, 1 or 3 = Dotclock
        Counter 1: 0 or 2 = System Clock, 1 or 3 = Hblank
        Counter 2: 0 or 1 = System Clock, 2 or 3 = System Clock/8
10     Interrupt Request (0=Yes, 1=No) (Set after Writing) (W=1) (R)
11     Reached Target Value (0=No, 1=Yes) (Reset after Reading) (R)
12     Reached FFFFh Value (0=No, 1=Yes) (Reset after Reading) (R)
13-15  Unknown (seems to be always zero)
16-31  Garbage (next opcode)
```

In one-shot mode, the IRQ is pulsed/toggled only once (one-shot mode doesn't stop the counter, it just suppresses any further IRQs until a new write to the Mode register occurs; if both IRQ conditions are enabled in Bit4-5, then one-shot mode triggers only one of those conditions; whichever occurs first).

Normally, Pulse mode should be used (Bit10 is permanently set, except for a few clock cycles when an IRQ occurs). In Toggle mode, Bit10 is set after writing to the Mode register, and becomes inverted on each IRQ (in one-shot mode, it remains zero after the IRQ) (in repeat mode it inverts Bit10 on each IRQ, so IRQ4/5/6 are triggered only each 2nd time, ie. when Bit10 changes from 1 to 0).

The "free run" mode is simply saying that the counter will not reset at a given threshold value.

1F801108h+N*10h - Timer 0..2 Counter Target Value (R/W)

```
0-15  Counter Target value
16-31 Garbage
```

When the Target flag is set (Bit3 of the Control register), the counter increments up to (including) the selected target value, and does then restart at 0000h.

Dotclock/Hblank

For more info on dotclock and hblank timings, see:

[GPU Timings](#)

Caution: Reading the Current Counter Value can be a little unstable (when using dotclk or hblank as clock source); the GPU clock isn't in sync with the CPU clock, so the timer may get changed during the CPU read cycle. As a workaround: repeat reading the timer until the received value is the same (or slightly bigger) than the previous value.

Reset and Wrap

When resetting the Counter by writing the Mode register, it will stay at 0000h for 2 clock cycles before counting up.

When writing the Current value, it will stay at the written value for 2 clock cycles before counting up or checking against Target overflows.

When wrapping around at FFFFh (Mode Bit3 not set), it will stay at 0000h for only 1 clock cycle.

When being reset to 0000h by reaching the Target value (Mode Bit3 set), it will stay at

0000h for 2 clock cycles.

Example behavior with Target Value of 0001h and Mode Bit3 set:

```
clock cycle 0 - Counter Value = 0000h
clock cycle 1 - Counter Value = 0000h
clock cycle 2 - Counter Value = 0001h
clock cycle 3 - Counter Value = 0000h
clock cycle 4 - Counter Value = 0000h
clock cycle 5 - Counter Value = 0001h
```

11. CDROM Drive

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11.1 CDROM Controller I/O Ports

The CD-ROM drive is made up of several chips. The CPU only has direct access to the sector buffer/decoder chip's "host" interface, which provides mailboxes to communicate with the drive's microcontroller, a data port for reading sectors and audio configuration

registers. The interface is bank switched and consists of four banks of four 8-bit registers each.

The following registers are available when reading:

Bank	0x1f801800	0x1f801801	0x1f801802	0x1f801803
0, 2	HSTS	RESULT	RDDATA	HINTMSK
1, 3	HSTS	RESULT	RDDATA	HINTSTS

The following registers are available when writing:

Bank	0x1f801800	0x1f801801	0x1f801802	0x1f801803
0	ADDRESS	COMMAND	PARAMETER	HCHPCTL
1	ADDRESS	WRDATA	HINTMSK	HCLRCTL
2	ADDRESS	CI	ATV0	ATV1
3	ADDRESS	ATV2	ATV3	ADPCTL

Official documentation for these registers is available in the "host interface" section of the CXD1199 decoder's datasheet. Later console revisions use different decoders, however they all seem to be variants of the CXD1199 (just merged with other CD-ROM chips, and possibly trimmed down by removing unused features such as the sound map functionality).

0x1f801800 (read, all banks): HSTS

0x1f801800 (write, all banks): ADDRESS

```

0-1 RA      Current register bank (R/W)
2  ADPBUSY  ADPCM busy              (R, 1=playing XA-ADPCM)
3  PRMEMPT  Parameter empty         (R, 1=parameter FIFO empty)
4  PRMWRDY  Parameter write ready   (R, 1=parameter FIFO not full)
5  RSLRRDY  Result read ready       (R, 1=result FIFO not empty)
6  DRQSTS   Data request             (R, 1=one or more RDDATA reads or WRDATA writes
pending)
7  BUSYSTS  Busy status              (R, 1=HC05 busy acknowledging command)
```

0x1f801801 (write, bank 0): COMMAND

```

0-7  Command Byte
```

Writing to this address sends the command byte to the HC05, which will proceed to drain the parameter FIFO, process the command, push any return values into the result FIFO and fire INT3 (or INT5 if an error occurs).

Command/Parameter processing is indicated by BUSYSTS.

When that bit gets zero, the response can be read immediately (immediately for MOST commands, but not ALL commands; so better wait for the IRQ).

Alternately, you can wait for an IRQ (which seems to take place MUCH later), and then read the response.

If there are any pending cdrom interrupts, these MUST be acknowledged before sending the command (otherwise BUSYSTS will stay set forever).

0x1f801802 (write, bank 0): PARAMETER

0-7 Parameter Byte(s) to be used for next Command

Before sending a command, write any parameter byte(s) to this address. The FIFO can hold up to 16 bytes; once full, the decoder will clear the PRMWRDY flag.

Note: the CXD1199 datasheet incorrectly states the parameter FIFO is 8 bytes deep, however the longest CD-ROM command has a 13-byte parameter.

0x1f801803 (write, bank 0): HCHPCTL

0-4	-	Reserved	(should be 0)
5		SMEN Sound map (manual XA-ADPCM playback) enable	
6		BFWR Request sector buffer write	(1=prepare for writes to WRDATA)
7		BFRD Request sector buffer read	(1=prepare for reads from RDDATA)

Note: in the original nocash documentation, SMEN is described as "Want Command Start Interrupt on Next Command". This is actually a side effect to the decoder firing the BFWRDY interrupt, not an intended feature.

0x1f801802 (read, all banks): RDDATA

After ReadS/ReadN commands have generated INT1, software must set the BFRD flag, then wait until DRQSTS is set, the datablock (disk sector) can be then read from this register.

0-7 Data 8bit (one byte), or alternately,
0-15 Data 16bit (LSB=First byte, MSB=Second byte)

The PSX hardware allows to read 800h-byte or 924h-byte sectors, indexed as [000h..7FFh] or [000h..923h], when trying to read further bytes, then the PSX will repeat the byte at index [800h-8] or [924h-4] as padding value.

RDDATA can be accessed with 8bit or 16bit reads (ie. to read a 2048-byte sector, one can use 2048 load-byte opcodes, or 1024 load halfword opcodes, or, more conventionally, a 512 word DMA transfer; the actual CDROM databus is only 8bits wide, so the CPU's bus interface handles splitting the reads).

0x1f801801 (read, all banks): RESULT

0-7 Response Byte(s) received after sending a Command

The result FIFO can hold up to 16 bytes (most or all responses are less than 16 bytes). The decoder clears RSLRRDY after the last byte of the HC05's response is read from this register.

When reading further bytes: The buffer is padded with 00h's to the end of the 16-bytes, and does then restart at the first response byte (that, without receiving a new response, so it'll always return the same 16 bytes, until a new command/response has been sent/received).

0x1f801803 (read, banks 1 and 3): HINTSTS

0-2 INTSTS Interrupt "flags" from HC05
 3 BFEMPT Sound map XA-ADPCM buffer empty (1=decoder ran out of sectors to play)
 4 BFWRDY Sound map XA-ADPCM buffer write ready (1=decoder is ready for next sector)
 5-7 - Reserved (always 1)

Bits 0-2 are supposed to be used as three separate IRQ flags, however the HC05 misuses them as a single 3-bit "interrupt type" value, which always assumes one of the following values:

INT0 NoIntr No interrupt pending
 INT1 DataReady New sector (ReadN/ReadS) or report packet (Play) available
 INT2 Complete Command finished processing (some commands, after INT3 is fired)
 INT3 Acknowledge Command received and acknowledged (all commands)
 INT4 DataEnd Reached end of disc (or end of track if auto-pause enabled)
 INT5 DiskError Command error, read error, license string error or lid opened
 INT6 -
 INT7 -

The response interrupts are queued, for example, if the 1st response is INT3, and the second INT5, then INT3 is delivered first, and INT5 is not delivered until INT3 is

acknowledged (ie. the response interrupts are NOT ORed together to produce INT7 or so). BFEMPT and BFWRDY however can be ORed with the lower bits (i.e. BFWRDY + INT3 would give 13h).

All interrupts are always fired in response to a command with the exception of INT5, which may also be triggered at any time by opening the lid.

0x1f801803 (read, banks 0 and 2): HINTMSK

0x1f801802 (write, bank 1): HINTMSK

0-2	ENINT	Enable IRQ on respective INTSTS bits
3	ENBFEMPT	Enable IRQ on BFEMPT
4	ENBFWRDY	Enable IRQ on BFWRDY
5-7	-	Reserved (should be 0 when written, always 1 when read)

The CD-ROM drive fires an interrupt whenever (HINTMSK & HINTSTS) is non-zero. This register is typically set to 1Fh, allowing any of the flags to trigger an IRQ (even though BFEMPT and BFWRDY are never used).

0x1f801803 (write, bank 1): HCLRCTL

0-2	CLRINT	Acknowledge HC05 interrupt "flags" (0=no change, 1=clear)
3	CLRBEMPT	Acknowledge BFEMPT (0=no change, 1=clear)
4	CLRBFWRDY	Acknowledge BFBFWRDY (0=no change, 1=clear)
5	SMADPCLR	Clear sound map XA-ADPCM buffer (0=no change, 1=clear/stop playback)
6	CLRPRM	Clear parameter FIFO (0=no change, 1=clear)
7	CHPRST	Reset decoder chip (0=no change, 1=reset)

Setting bits 0-4 resets the corresponding flags in HINTSTS; normally one should write 07h to reset the HC05 interrupt flags, or 1Fh to acknowledge all IRQs. Acknowledging individual HC05 flags (e.g. writing 01h to change INT3 to INT2) is possible, if completely useless. After acknowledge, the result FIFO is drained and if there's been a pending command, then that command gets send to the controller.

Setting CHPRST will result in a complete reset of the decoder. Unclear if this also reboots the HC05 and CD-ROM DSP (the decoder has an "external reset" pin which is pulled low when setting CHPRST).

Caution - Unstable IRQ Flag polling

IRQ flag changes aren't synced with the MIPS CPU clock. If more than one bit gets set (and the CPU is reading at the same time) then the CPU does occasionally see only one

of the newly bits:

```
0 -----> 3 ;99.9% normal case INT3's
0 -----> 5 ;99%   normal case INT5's
0 ---> 1 ---> 3 ;0.1% glitch: occurs about once per thousands of INT3's
0 ---> 4 ---> 5 ;1%   glitch: occurs about once per hundreds of INT5's
```

As workaround, do something like:

```
@@polling_lop:
  irq_flags = [1F801803h] AND 07h      ;<-- 1st read (may be still unstable)
  if irq_flags = 00h then goto @@polling_lop
  irq_flags = [1F801803h] AND 07h      ;<-- 2nd read (should be stable now)
  handle irq_flags and acknowledge them
```

The problem applies only when manually polling the IRQ flags (an actual IRQ handler will get triggered when the flags get nonzero, and the flags will have stabilized once when the IRQ handler is reading them) (except, a combination of IRQ10h followed by IRQ3 can also have unstable LSBs within the IRQ handler).

The problem occurs only on older consoles (like LATE-PU-8), not on newer consoles (like PSone).

0x1f801802 (write, bank 2): ATV0 (L->L volume)

0x1f801803 (write, bank 2): ATV1 (L->R volume)

0x1f801801 (write, bank 3): ATV2 (R->R volume)

0x1f801802 (write, bank 3): ATV3 (R->L volume)

Allows to configure the CD for mono/stereo output (eg. values "80h,0,80h,0" produce normal stereo volume, values "40h,40h,40h,40h" produce mono output of equivalent volume).

When using bigger values, the hardware does have some incomplete saturation support; the saturation works up to double volume (eg. overflows that occur on "FFh,0,FFh,0" or "80h,80h,80h,80h" are clipped to min/max levels), however, the saturation does NOT work properly when exceeding double volume (eg. mono with quad-volume "FFh,FFh,FFh,FFh").

```
0-7 Volume Level (00h..FFh) (00h=Off, FFh=Max/Double, 80h=Default/Normal)
```

After changing these registers, the CHNGATV flag in ADPCTL must be set.

Unknown if any existing games are actually supporting mono output. Resident Evil 2 uses these ports to produce fade-in/fade-out effects (although, for that purpose, it should be much easier to use Port 1F801DB0h).

0x1f801803 (write, bank 3): ADPCTL

0	ADPMUTE	Mute XA-ADPCM	(1=mute)
1-4	-	Reserved	(should be 0)
5	CHNGATV	Apply ATV0-ATV3 changes	(0=no change, 1=apply)
6-7	-	Reserved	(should be 0)

0x1f801801 (write, bank 1): WRDATA

0-7 Data

Used to upload sectors to the decoder for sound map XA-ADPCM playback.

This register seems to be restricted to 8bit bus, unknown if/how the PSX DMA controller can write to it (it might support only 16bit data for CDROM).

0x1f801801 (write, bank 2): CI

0	S/M	Channel count	(0=mono, 1=stereo)
1	-	Reserved	(should be 0)
2	FS	Sample rate	(0=37800Hz, 1=18900Hz)
3	-	Reserved	(should be 0)
4	BITLNTH	Bits per sample	(0=4bit, 1=8bit)
5	-	Reserved	(should be 0)
6	EMPHASIS	Emphasis filter	(0=off, 1=on)
7	-	Reserved	(should be 0)

Used to configure the decoder for sound map XA-ADPCM playback (does not affect playback of XA-ADPCM sectors from the disc). Uses the same format as the "codinginfo" field in XA sector headers.

BUSYSTS flag

Indicates ready-to-send-new-command,

0=Ready to send a new command
1=Busy sending a command/parameters

Trying to send a new command in the Busy-phase causes malfunction (the older command seems to get lost, the newer command executes and returns its results and triggers an interrupt, but, thereafter, the controller seems to hang). So, always wait until BUSYSTS goes off before sending a command.

When BUSYSTS goes off, a new command can be send immediately (even if the response from the previous command wasn't received yet), however, the new command stays in the Busy-phase until the IRQ from the previous command is acknowledged, at that point the actual transmission of the new command starts, and BUSYSTS goes off (once when the transmission completes).

```
Pause -> Wait for INT3 IRQ -> clear IRQ (write 0x1f to HCLRCTL) -> SetMode/Pause/Stop/  
SetMode/SeekL/... <br/>  
ReadN/ReadS -> Wait for INT3 IRQ -> clear IRQ (write 0x1f to HCLRCTL) -> SetMode/  
SetLoc/... <br/>
```

Will not drop any of the two commands, thus execute sequentially.

```
Stop -> Wait for INT3 IRQ -> clear IRQ (write 0x1f to HCLRCTL) -> SetMode/Pause/...<br/>
```

Will drop the second response of Stop(), and then execute the next command.

Misc

Performing a 32-bit read from 1F801800h will return the HSTS register's value repeated four times, as the "auto increment" flag in the BIU configuration register for the CD-ROM (at 1F801018h) is disabled by default. Enabling it will restore the correct behavior but will also break CD-ROM DMA reads, which rely on the bus interface splitting each 32-bit word transfer into four sequential byte reads from RDDATA.

To init the CD

```
-Flush all IRQs  
-HCHPCTL=0  
-Com_Delay=4901 (=1325h) (Port 1F801020h) (means 16bit or 32bit write?)  
  (the write seems to be 32bit, clearing the upper16bit of the register)  
-Send two Nop commands  
-Send Command 0Ah (Init)  
-Demute
```

Seek-Busy Phase

Warning: most or all of the info in the sentence below appear to incorrect (either that, or I didn't understand that rather confusing sentence).

REPORTEDLY:

"You should not send some commands while the CD is seeking (ie. Nop returns with bit6 set). Thing is that stat only gets updated after a new command. I haven't tested this for other command, but for the play command (03h) you can just keep repeating the [which?] command and checking stat returned by that, for bit6 to go low (and bit7 to go high in this case). If you don't and try to do a getloc [GetlocP and/or GetlocL?] directly after the play command reports it's done [what done? meaning sending start-to-play was "done"? or meaning play reached end-of-disc?], the CD will stop. (I guess the CD can't get it's current location while it's seeking, so the logic stops the seek to get an exact fix, but never restarts..)"

Sound Map Flowchart

Sound Map mode allows to output XA-ADPCM from Main RAM (rather than from CDROM).

```
SPU: Init Master Volume Left/Right (Port 1F801D80h/1F801D82h)
SPU: Init CD Audio Volume Left/Right (Port 1F801DB0h/1F801DB2h)
SPU: Enable CD Audio (Port 1F801DAAh.Bit0=1)
CDROM/CMD: send Stop command (probably better to avoid conflicts)
CDROM/CMD: send Demute command (if muted) (but works only if disc inserted)
CDROM/HOST: init CI register with XA-ADPCM coding info
CDROM/HOST: enable ADPCM (ADPMUTE=0) ;probably needed?
... set dummy addr/len with DISHXFRC=1 ? <-- NOT required !
... set SMEN ... and dummy BFWR? <-- BOTH bits required ?
transfer 900h bytes (same format as ADPCM sectors) (WRDATA)
Note: Before sending a byte, one should wait for DRQSTS
Note: ADPCM output doesn't start until the last (900h'th) byte is transferred
```

Sound Map mode may be very useful for testing XA-ADPCM directly from within an exe file (without needing a cdrom with ADPCM sectors). And, Sound Map supports both 4bit and 8bit compression (the SPU supports only 4bit).

Caution: If ADPCM wasn't playing, and one sends one 900h-byte block, then it will get stored in one of three 900h-byte slots in SRAM, and one would expect that slot to be played when the ADPCM output starts - however, actually, the hardware will more or less randomly play one of the three slots; not necessarily the slot that was updated most recently.

11.2 CDROM Controller Command Summary

Command Summary

Opcode	Command	Parameters	Acknowledge response	Completion
0x00	<i>Unused</i>		INT5: 0x11 , 0x40	
0x01	Nop		INT3: status	
0x02	Setloc	min, sec, frame	INT3: status	
0x03	Play	track (optional)	INT3: status	
0x04	Forward		INT3: status	
0x05	Backward		INT3: status	
0x06	ReadN		INT3: status	
0x07	Standby		INT3: status	INT2: status
0x08	Stop		INT3: status	INT2: status
0x09	Pause		INT3: status	INT2: status
0x0a	Init		INT3: status (late)	INT2: status
0x0b	Mute		INT3: status	
0x0c	Demute		INT3: status	
0x0d	Setfilter	file, channel	INT3: status	
0x0e	Setmode	mode	INT3: status	
0x0f	Getparam		INT3: status, mode, 0x00 , file, channel	
0x10	GetlocL		INT3: min, sec, frame, mode, file, channel, sm, ci	
0x11	GetlocP		INT3: track, index, rmin, rsec, rframe, min, sec, frame	
0x12	Setsession	session	INT3: status	INT2: status
0x13	GetTN		INT3: status, first, last	
0x14	GetTD	track	INT3: status, min, sec	
0x15	SeekL		INT3: status	INT2: status
0x16	SeekP		INT3: status	INT2: status
0x17-0x18	<i>Unused</i>		INT5: 0x11 , 0x40	
0x19	Test *	sub, ...	INT3: ...	
0x1a	GetID *		INT3: status	INT2/INT3: status
0x1b	ReadS		INT3: status	
0x1c	Reset		INT3: status	
0x1d	GetQ *	adr, point	INT3: status	INT2: status
0x1e	ReadTOC *		INT3: status (late)	INT2: status
0x1f	VideoCD *	sub, ...	INT3: status, ...	
0x20-0x4f	<i>Unused</i>		INT5: 0x11 , 0x40	
0x50	Unlock0 *		INT5: 0x11 , 0x40 (even when successful)	

Opcode	Command	Parameters	Acknowledge response	Completi
0x51	Unlock1 *	"Licensed by"	INT5: 0x11, 0x40 (even when successful)	
0x52	Unlock2 *	"Sony"	INT5: 0x11, 0x40 (even when successful)	
0x53	Unlock3 *	"Computer"	INT5: 0x11, 0x40 (even when successful)	
0x54	Unlock4 *	"Entertainment"	INT5: 0x11, 0x40 (even when successful)	
0x55	Unlock5 *	"<region>"	INT5: 0x11, 0x40 (even when successful)	
0x56	Unlock6 *		INT5: 0x11, 0x40 (even when successful)	
0x57	Lock *		INT5: 0x11, 0x40 (even when successful)	
0x58-0x5f	Unused			
0x60-0xff	Unused		INT5: 0x11, 0x40	

The following commands generate additional responses while reading:

Opcode	Command	Data responses
0x03	Play	INT1: status, track, index, (r)min, (r)sec, (r)frame, peakl, peakh
0x04	Forward	INT1: status, track, index, (r)min, (r)sec, (r)frame, peakl, peakh
0x05	Backward	INT1: status, track, index, (r)min, (r)sec, (r)frame, peakl, peakh
0x06	ReadN	INT1: status (sector data must be read separately via RDDATA or DMA)
0x1b	ReadS	INT1: status (sector data must be read separately via RDDATA or DMA)

* denotes commands that are not officially documented.

sub_function numbers (for command 19h)

Test commands are invoked with command number 19h, followed by a sub_function number as first parameter byte. The Kernel seems to be using only sub_function 20h (to detect the CDROM Controller version).

```

sub  params  response          ;Effect
00h    -    INT3(stat)         ;Force motor on, clockwise, even if door open
01h    -    INT3(stat)         ;Force motor on, anti-clockwise, super-fast
02h    -    INT3(stat)         ;Force motor on, anti-clockwise, super-fast
03h    -    INT3(stat)         ;Force motor off (ignored during spin-up)
04h    -    INT3(stat)         ;Start SCEx reading and reset counters
05h    -    INT3(total,success);Stop SCEx reading and get counters
06h *   n    INT3(old)  ;\early ;Adjust balance in RAM, send CX(30+n XOR 7)
07h *   n    INT3(old)  ; PSX   ;Adjust gain in RAM, send CX(38+n XOR 7)
08h *   n    INT3(old)  ;/only  ;Adjust balance in RAM only
06h..0Fh - INT5(11h,10h)      ;N/A (11h,20h when NONZERO number of params)
10h    -    INT3(stat) ;CX(..) ;Force motor on, anti-clockwise, super-fast
11h    -    INT3(stat) ;CX(03) ;Move Lens Up (leave parking position)

```


12h	-	INT3(stat)	;CX(02)	;Move Lens Down (enter parking position)
13h	-	INT3(stat)	;CX(28)	;Move Lens Outwards
14h	-	INT3(stat)	;CX(2C)	;Move Lens Inwards
15h	-	INT3(stat)	;CX(22)	;If motor on: Move outwards,inwards,motor off
16h	-	INT3(stat)	;CX(23)	;No effect?
17h	-	INT3(stat)	;CX(E8)	;Force motor on, clockwise, super-fast
18h	-	INT3(stat)	;CX(EA)	;Force motor on, anti-clockwise, super-fast
19h	-	INT3(stat)	;CX(25)	;No effect?
1Ah	-	INT3(stat)	;CX(21)	;No effect?
1Bh..1Fh	-	INT5(11h,10h)		;N/A (11h,20h when NONZERO number of params)
20h	-	INT3(yy,mm,dd,ver)		;Get cdrom BIOS date/version (yy,mm,dd,ver)
21h	-	INT3(n)		;Get Drive Switches (bit0=POS0, bit1=DOOR)
22h ***	-	INT3("for ...")		;Get Region ID String
23h ***	-	INT3("CXD...")		;Get Chip ID String for Servo Amplifier
24h ***	-	INT3("CXD...")		;Get Chip ID String for Signal Processor
25h ***	-	INT3("CXD...")		;Get Chip ID String for Decoder/FIFO
26h..2Fh	-	INT5(11h,10h)		;N/A (11h,20h when NONZERO number of params)
30h *	i,x,y	INT3(stat)		;Prototype/Debug stuff ;\supported on
31h *	x,y	INT3(stat)		;Prototype/Debug stuff ; early PSX only
4xh *	i	INT3(x,y)		;Prototype/Debug stuff ;/
30h..4Fh	..	INT5(11h,10h)		;N/A always 11h,10h (no matter of params)
50h	a[,b[,c]]	INT3(stat)		;Servo/Signal send CX(a:b:c)
51h **	39h,xx	INT3(stat,hi,lo)		;Servo/Signal send CX(39xx) with response
51h..5Fh	-	INT5(11h,10h)		;N/A
60h	lo,hi	INT3(databyte)		;HC05 SUB-CPU read RAM and I/O ports
61h..70h	-	INT5(11h,10h)		;N/A
71h ***	adr	INT3(databyte)		;Decoder Read one register
72h ***	adr,dat	INT3(stat)		;Decoder Write one register
73h ***	adr,len	INT3(databytes..)		;Decoder Read multiple registers, bugged
74h ***	adr,len,..	INT3(stat)		;Decoder Write multiple registers, bugged
75h ***	-	INT3(lo,hi,lo,hi)		;Decoder Get Host Xfer Info Remain/Addr
76h ***	a,b,c,d	INT3(stat)		;Decoder Prepare Transfer to/from SRAM
77h..FFh	-	INT5(11h,10h)		;N/A
80h..8Fh	a,b	?		;seem to do something on PS2

* sub_functions 06h..08h, 30h..31h, and 4xh are supported only in vC0 and vC1.

** sub_function 51h is supported only in BIOS version vC2 and up.

*** sub_functions 22h..25h, 71h..76h supported only in BIOS version vC1 and up.

Unsupported GetQ,VCD,SecretUnlock (command 1Dh,1Fh,5xh)

INT5 will be returned if the command is unsupported. That, WITHOUT removing the Parameters from the FIFO, so the parameters will be accidently passed to the NEXT command. To avoid that: clear the parameter FIFO by setting CLRPRM in HCLRCTL after receiving the INT5 error.

11.3 CDROM - Control Commands

Sync - Command 00h --> INTx(stat+1,40h) (?)

Reportedly "command does not succeed until all other commands complete. This can be used for synchronization - hence the name."

Uh, actually, returns error code 40h = Invalid Command...?

Setfilter - Command 0Dh,file,channel --> INT3(stat)

Automatic ADPCM (CD-ROM XA) filter ignores sectors except those which have the same channel and file numbers in their subheader. This is the mechanism used to select which of multiple songs in a single .XA file to play.

Setfilter does not affect actual reading (sector reads still occur for all sectors).

XXX err... that is... does not affect reading of non-ADPCM sectors (normal "data" sectors are kept received regardless of Setfilter).

Setmode - Command 0Eh,mode --> INT3(stat)

7	Speed	(0=Normal speed, 1=Double speed)
6	XA-ADPCM	(0=Off, 1=Send XA-ADPCM sectors to SPU Audio Input)
5	Sector Size	(0=800h=DataOnly, 1=924h=WholeSectorExceptSyncBytes)
4	Ignore Bit	(0=Normal, 1=Ignore Sector Size and Setloc position)
3	XA-Filter	(0=Off, 1=Process only XA-ADPCM sectors that match Setfilter)
2	Report	(0=Off, 1=Enable Report-Interrupts for Audio Play)
1	AutoPause	(0=Off, 1=Auto Pause upon End of Track) ;for Audio Play
0	CDDA	(0=Off, 1=Allow to Read CD-DA Sectors; ignore missing EDC)

The "Ignore Bit" does reportedly force a sector size of 2328 bytes (918h), however, that doesn't seem to be true. Instead, Bit4 seems to cause the controller to ignore the sector size in Bit5 (instead, the size is kept from the most recent Setmode command which didn't have Bit4 set). Also, Bit4 seems to cause the controller to ignore the \<exact> Setloc position (instead, data is randomly returned from the "Setloc position minus 0..3 sectors"). And, Bit4 causes INT1 to return status.Bit3=set (IdError). Purpose of Bit4 is unknown?

Init - Command 0Ah --> INT3(stat) --> INT2(stat)

Multiple effects at once. Sets mode=20h, activates drive motor, Standby, abort all commands.

Reset - Command 1Ch,(...) --> INT3(stat) --> Delay(1/8 seconds)

Caution: Not supported on DTL-H2000 (v01)

Resets the drive controller, reportedly, same as opening and closing the drive door. The command executes no matter if/how many parameters are used (tested with 0..7 params). INT3 indicates that the command was started, but there's no INT that would indicate when the command is finished, so, before sending any further commands, a delay of 1/8 seconds (or 400000h clock cycles) must be issued by software.

Note: Executing the command produces a click sound in the drive mechanics, maybe it's just a rapid motor on/off, but it might something more serious, like ignoring the /POS0 signal...?

MotorOn - Command 07h --> INT3(stat) --> INT2(stat)

Activates the drive motor, works ONLY if the motor was off (otherwise fails with INT5(stat,20h); that error code would normally indicate "wrong number of parameters", but means "motor already on" in this case).

Commands like Read, Seek, and Play are automatically starting the Motor when needed (which makes the MotorOn command rather useless, and it's rarely used by any games). Myth: Older homebrew docs are referring to MotorOn as "Standby", claiming that it would work similar as "Pause", that is wrong: the command does NOT pause anything (if the motor is on, then it does simply trigger INT5, but without pausing reading or playing).

Note: The game "Nightmare Creatures 2" does actually attempt to use MotorOn to "pause" after reading files, but the hardware does simply ignore that attempt (aside from doing the INT5 thing).

Stop - Command 08h --> INT3(stat) --> INT2(stat)

Stops motor with magnetic brakes (stops within a second or so) (unlike power-off where it'd keep spinning for about 10 seconds), and moves the drive head to the begin of the first track. Official way to restart is command 0Ah, but almost any command will restart it.

The first response returns the current status (this already with bit5 cleared), the second response returns the new status (with bit1 cleared).

Pause - Command 09h --> INT3(stat) --> INT2(stat)

Aborts Reading and Playing, the motor is kept spinning, and the drive head maintains the current location within reasonable error.

The first response returns the current status (still with bit5 set if a Read command was active), the second response returns the new status (with bit5 cleared).

Data/ADPCM Sector Filtering/Delivery

The PSX CDROM BIOS is first trying to send sectors to the ADPCM decoder, and, if that didn't work out, then it's trying to send them to the main CPU (and if that didn't work out either, then it's silently ignoring the sector).

```
try_deliver_as_adpcm_sector:
    reject if CD-DA AUDIO format
    reject if sector isn't MODE2 format
    reject if adpcm_disabled(setmode.6)
    reject if filter_enabled(setmode.3) AND selected file/channel doesn't match
    reject if submode isn't audio+realtime (bit2 and bit6 must be both set)
    deliver: send sector to xa-adpcm decoder when passing above cases
try_deliver_as_data_sector:
    reject data-delivery if "try_deliver_as_adpcm_sector" did do adpcm-delivery
    reject if filter_enabled(setmode.3) AND submode is audio+realtime (bit2+bit6)
    1st delivery attempt: send INT1+data, unless there's another INT pending
    delay, and retry at later time... but this time with file/channel checking!
    reject if filter_enabled(setmode.3) AND selected file/channel doesn't match
    2nd delivery attempt: send INT1+data, unless there's another INT pending
```

BUG: Note that the data delivery is done in two different attempts: The first one regardless of file/channel, and the second one only on matching file/channel (if filtering is enabled).

11.4 CDROM - Seek Commands

Setloc - Command 02h,amm,ass,asect --> INT3(stat)

Sets the seek target - but without yet starting the seek operation. The actual seek is invoked by certain commands: SeekL (Data) and SeekP (Audio) are doing plain seeks (and do Pause after completion). ReadN/ReadS are similar to SeekL (and do start reading data after the seek operation). Play is similar to SeekP (and does start playing audio after the seek operation).

The amm,ass,asect parameters refer to the entire disk (not to the current track). To

seek to a specific location within a specific track, use GetTD to get the start address of the track, and add the desired time offset to it.

SeekL - Command 15h --> INT3(stat) --> INT2(stat)

Seek to Setloc's location in data mode (using data sector header position data, which works/exists only on Data tracks, not on CD-DA Audio tracks).

After the seek, the disk stays on the sought location forever (namely: when seeking sector N, it does stay at around N-8..N-0 in single speed mode, or at around N-5..N+2 in double speed mode). This command will stop any current or pending ReadN or ReadS. Trying to use SeekL on Audio CDs passes okay on the first response, but (after two seconds or so) the second response will return an error (stat+4,04h), and stop the drive motor... that error doesn't appear ALWAYS though... works in some situations... such like when previously reading data sectors or so...?

SeekP - Command 16h --> INT3(stat) --> INT2(stat)

Seek to Setloc's location in audio mode (using the Subchannel Q position data, which works on both Audio on Data disks).

After the seek, the disk stays on the sought location forever (namely: when seeking sector N, it does stay at around N-9..N-1 in single speed mode, or at around N-2..N in double speed mode). This command will stop any current or pending ReadN or ReadS. Note: Some older docs claim that SeekP would recurse only "MM:SS" of the "MM:SS:FF" position from Setloc - that is wrong, it does seek to MM:SS:FF (verified on a PSone). After the seek, status is stat.bit7=0 (ie. audio playback off), until sending a new Play command (without parameters) to start playback at the sought location.

SetSession - Command 12h,session --> INT3(stat) --> INT2(stat)

Seeks to session (ie. moves the drive head to the session, with stat bit6 set during the seek phase).

When issued during active-play, the command returns error code 80h.

When issued during play-spin-up, play is aborted.

```

__Errors__
session = 00h causes error code 10h.          ;INT5(03h,10h), no 2nd/3rd response
__On a non-multisession-disk__
session = 01h passes okay.                    ;INT3(stat), and once INT2(stat)
session = 02h or higher cause seek error ;INT3(stat), and twice INT5(06h,40h)
__On a multisession-disk with N sessions__

```

```
session = 01h..N+1 passes okay ;where N+1 moves to the END of LAST session
session = N+2 or higher cause seek error ;2nd response = INT5(06h,20h)
```

after seek error --> disk stops spinning at 2nd response, then restarts spinning for 1 second or so, then stops spinning forever... and following gettn/gettd/getid/getloc/ getlocl fail with error 80h...

The command does automatically read the TOC of the new session. BUG: Older CD Firmwares (16 May 1995 and older) don't clear the old TOC when loading Session 1, in that case SetSession(1) may update some (not all) TOC entries; ending up with a mixup of old and new TOC entries.

There seems to be no way to determine the current sessions number (via Getparam or so), and more important, no way to determine if the disk is a multi-session disk or not... except by trial... which would stop the drive motor on seek errors on single-session disks...?

For setloc, one must probably specify minutes within the 1st track of the new session (the 1st track of 1st session usually/always starts at 00:02:00, but for other sessions one would need to use GetTD)...?

11.5 CDROM - Read Commands

ReadN - Command 06h --> INT3(stat) --> INT1(stat) --> datablock

Read with retry. The command responds once with "stat,INT3", and then it's repeatedly sending "stat,INT1 --> datablock", that is continued even after a successful read has occurred; use the Pause command to terminate the repeated INT1 responses.

Unknown which responses are sent in case of read errors?

====

ReadN and ReadS cause errors if you're trying to read an unlicensed CD or CD-R without a mod chip. Sectors on Audio CDs can be read only when CDDA is enabled via Setmode (otherwise error code 40h is returned).

====

Actually, Read seems to work on unlicensed CD-R's, but the returned data is the whole sector or so (the 2048 data bytes preceded by a 12byte header, and probably/maybe followed by error-correction info; in fact the total received data in the Data Fifo is 4096 bytes; the last some bytes probably being garbage) (however error correction is NOT performed by hardware, so the 2048 data bytes may be trashy) (however, if the error correction info IS received, then error correction could be performed by software) (also Setloc doesn't seem to work accurately on unlicensed CD-R's).

====

```
;Read occasionally returns 11h,40h ..? when TOC isn't loaded?
```

After receiving INT1, the Kernel does,

```
[1F801800h]=00h
00h=[1F801800h]
[1F801803h]=00h
00h=[1F801803h]
[1F801800h]=00h
[1F801803h]=80h
```

and then,

```
[1F801018h]=00020943h ;cdrom_delay
[1F801020h]=0000132Ch ;com_delay
```

then,

```
x=[1F8010F4h] AND 00FFFFFFh ;result is 00840000h
[1F8010F4h] = x OR 00880000h
[1F8010F0h] = [1F8010F0h] OR 00008000h
[1F8010B0h] = A0010000h ;addr
[1F8010B4h] = 00010200h ;LSBs=num words, MSBs=ignored/bullshit
[1F8010B4h] = 11000000h ;DMA control
```

thereafter,

```
[1F801800h]=01h
[1F801803h]=40h ;reset parameter fifo
[0]=00000000h
[0]=00000001h
[0]=00000002h
[0]=00000003h
[1F801800h]=00h
[1F801801h]=09h ;command9 (pause)
```

ReadS - Command 1Bh --> INT3(stat) --> INT1(stat) --> datablock

Read without automatic retry. Not sure what that means... does WHAT on errors? Maybe intended for continuous streaming video output (to skip bad frames, rather than to interrupt the stream by performing read-retrys).

ReadN/ReadS

Both ReadN/ReadS are reading data sequentially, starting at the sector specified with Setloc, and then automatically reading the following sectors.

CDROM Incoming Data / Buffer Overrun Timings

The Read commands are continuously receiving 75 sectors per second (or 150 sectors at double speed), and, basically, the software must be fast enough to process that amount of incoming data. However, the PSX hardware includes a buffer that can hold up to a handful (exact number is unknown?) of sectors, so, occasional delays of more than 1/75 seconds between processing two sectors aren't causing lost sectors, unless the delay(s) are summing up too much. The relevant steps for receiving data are:

```
Wait for Interrupt Request (INT1)      ;indicates that data is available
Send Data Request (BFRD=1)            ;accept data
Acknowledge INT1                       ;
Copy Data to Main RAM (via I/O or DMA) ;read data
```

The Data Request accepts the data for the currently pending interrupt, it should be usually issued between receiving/acknowledging INT1 (however, it can be also issued shortly after the acknowledge; even if there are further sectors in the buffer, there seems to be a small delay between the acknowledge and the next interrupt, and Data Requests during that period are still treated to belong to the old interrupt).

If a buffer overrun has occurred \<before> issuing the Data Request, then wrong data will be received, ie. some sectors will be skipped (the hardware doesn't seem to support a buffer-overrun error flag? Anyways, see GetlocL description for a possible way to detect buffer-overruns).

If a buffer overrun occurs \<after> issuing the Data Request, then the requested data can be still read via I/O or DMA intactly, ie. the requested data is "locked", and the overrun will affect only the following sectors.

ReadTOC - Command 1Eh --> INT3(stat) --> INT2(stat)

Caution: Supported only in BIOS version vC1 and up. Not supported in vC0.

Reread the Table of Contents of current session without reset. The command is rather slow, the second response appears after about 1 second delay. The command itself returns only status information (to get the actual TOC info, use GetTD and GetTN commands).

Note: The TOC contains information about the tracks on the disk (not file names or so, that kind of information is obtained via Read commands). The TOC is read automatically on power-up, when opening/closing the drive door, and when changing sessions (so, normally, it isn't required to use this command).

Setloc, Read, Pause

A normal CDROM access (such like reading a file) consists of three commands:

```
Setloc, Read, Pause
```

Normally one shouldn't mess up the ordering of those commands, but if one does, following rules do apply:

Setloc is memorizing the wanted target, and marks it as unprocessed, and has no other effect (it doesn't start reading or seeking, and doesn't interrupt or redirect any active reads).

If Read is issued with an unprocessed Setloc, then the drive is automatically seeking the Setloc location (and marks Setloc as processed).

If Read is issued without an unprocessed Setloc, the following happens: If reading is already in progress then it just continues reading. If Reading was Paused, then reading resumes at the most recently received sector (ie. returning that sector once another time).

11.6 CDROM - Status Commands

Status code (stat)

The 8bit status code is returned by Nop command (and many other commands), the meaning of the separate stat bits is:

7	Play	Playing CD-DA	;\only ONE of these bits can be set
6	Seek	Seeking	; at a time (ie. Read/Play won't get
5	Read	Reading data sectors	;/set until after Seek completion)
4	ShellOpen	Once shell open (0=Closed, 1=Is/was Open)	
3	IdError	(0=Okay, 1=GetID denied)	(also set when Setmode.Bit4=1)
2	SeekError	(0=Okay, 1=Seek error)	(followed by Error Byte)
1	Spindle Motor	(0=Motor off, or in spin-up phase, 1=Motor on)	
0	Error	Invalid Command/parameters	(followed by Error Byte)

If the shell is closed, then bit4 is automatically reset to zero after reading stat with the Nop command (most or all other commands do not reset that bit after reading). If stat

bit0 or bit2 is set, then the normal respons(es) and interrupt(s) are not send, and, instead, INT5 occurs, and an error-byte is send as second response byte, with the following values:

```

____These values appear in the FIRST response; with stat.bit0 set____
10h - Invalid Sub_function (for command 19h), or invalid parameter value
20h - Wrong number of parameters
40h - Invalid command
80h - Cannot respond yet (eg. required info was not yet read from disk yet)
      (namely, TOC not-yet-read or so)
      (also appears if no disk inserted at all)
____These values appear in the SECOND response; with stat.bit2 set____
04h - Seek failed (when trying to use SeekL on Audio CDs)
____These values appear even if no command was sent; with stat.bit2 set____
08h - Drive door became opened

```

80h appears on some commands (02h..09h, 0Bh..0Dh, 10h..16h, 1Ah, 1Bh?, and 1Dh) when the disk is missing, or when the drive unit is disconnected from the mainboard.

When the shell is opened, INT5 is triggered regardless of whether a command was executing or not. When this happens, all bits except shell open and error are cleared in the status register. The error byte in the INT5 is set to 08h.

Some games send a Stop command before changing discs, but others just wait for the user to open the shell, causing the disc to stop. The game can then send Nop commands, looping until bit 4 is cleared to detect when the new disc has been inserted.

Stat Seek/Play/Read bits

There's is only max ONE of the three Seek/Play/Read bits set at a time, ie. during Seek, ONLY the seek bit is set (and Read or Play doesn't get until seek completion), that is important for Gran Turismo 1, which checks for seek completion by waiting for READ getting set (rather than waiting for SEEK getting cleared).

Nop - Command 01h --> INT3(stat)

Returns stat (like many other commands), and additionally does reset the shell open flag (for the following commands; unless the shell is still opened). This is different as for most or all other commands (which may return stat, but which do not reset the shell open flag).

In official docs, the command is eventually referred to as "Nop", believing that it does nothing than returning stat (ignoring the fact that it's having the special shell open reset feature).

Getparam - Command 0Fh --> INT3(stat,mode,null,file,channel)

Returns stat (see Nop above), mode (see Setmode), a null byte (always 00h), and file/channel filter values (see Setfilter).

GetlocL - Command 10h --> INT3(amm,ass,asect,mode,file,channel,sm,ci)

Retrieves 4-byte sector header, plus 4-byte subheader of the current sector. GetlocL can be send during active Read commands (but, mind that the GetlocL-INT3-response can't be received until any pending Read-INT1's are acknowledged).

The PSX hardware can buffer a handful of sectors, the INT1 handler receives the \<oldest> buffered sector, the GetlocL command returns the header and subheader of the \<newest> buffered sector. Note: If the returned \<newest> sector number is much bigger than the expected \<oldest> sector number, then it's likely that a buffer overrun has occurred.

GetlocL fails (with error code 80h) when playing Audio CDs (or Audio Tracks on Data CDs). These errors occur because Audio sectors don't have any header/subheader (instead, equivalent data is stored in Subchannel Q, which can be read with GetlocP). GetlocL also fails (with error code 80h) when the drive is in Seek phase (such like shortly after a new ReadN/ReadS command). In that case one can retry issuing GetlocL (until it passes okay, ie. until the seek has completed). During Seek, the drive seems to decode only Subchannel position data (but no header/subheader data), accordingly GetlocL won't work during seek (however, GetlocP does work during Seek).

GetlocP - Command 11h - INT3(track,index,mm,ss,sect,amm,ass,asect)

Retrieves 8 bytes of position information from Subchannel Q with ADR=1. Mainly intended for displaying the current audio position during Play. All results are in BCD.

```
track: track number (AAh=Lead-out area) (FFh=unknown, toc, none?)
index: index number (Usually 01h)
mm:    minute number within track (00h and up)
ss:    second number within track (00h to 59h)
sect:  sector number within track (00h to 74h)
amm:   minute number on entire disk (00h and up)
ass:   second number on entire disk (00h to 59h)
asect: sector number on entire disk (00h to 74h)
```

Note: GetlocP is also used for reading the LibCrypt protection data:

[CDROM Protection - LibCrypt](#)

GetTN - Command 13h --> INT3(stat,first,last) ;BCD

Get first track number, and last track number in the TOC of the current Session. The number of tracks in the current session can be calculated as (last-first+1). The first track number is usually 01h in the first (or only) session, and "last track of previous session plus 1" in further sessions.

GetTD - Command 14h,track --> INT3(stat,mm,ss) ;BCD

For a disk with NN tracks, parameter values 01h..NNh return the start of the specified track, parameter value 00h returns the end of the last track, and parameter values bigger than NNh return error code 10h.

The GetTD values are relative to Index=1 and are rounded down to second boundaries (eg. if track=N Index=0 starts at 12:34:56, and Track=N Index=1 starts at 12:36:56, then GetTD(N) will return 12:36, ie. the sector number is truncated, and the Index=0 region is skipped).

GetQ - Command 1Dh,adr,point --> INT3(stat) --> INT2(10bytesSubQ,peak_lo)

Caution: Supported only in BIOS version vC1 and up. Not supported in vC0.
Caution: When unsupported, Parameter Fifo isn't cleared after the command.

Allows to read 10 bytes from Subchannel Q in Lead-In (see CDROM Subchannels chapter for details). Unlike GetTD, this command allows to receive the exact MM:SS:FF address of the point'ed Track (GetTD reads a memorized MM:SS value from RAM, whilst GetQ reads the full MM:SS:FF from the disk, which is slower than GetTD, due to the disk-access).

With ADR=1, point can be a any point number for ADR=1 in Lead-in (eg. 01h..99h=Track N, A2h=Lead-Out). The returned 10 bytes are raw SubQ data (starting with the ADR/Control value; of which the lower 4bits are always ADR=1).

The 11th returned byte is the Peak LSB (similar as in Play+Report, but in this case only the LSB is transferred, which is apparently a bug in CDROM BIOS, the programmer probably wanted to send 10 bytes without peak, or 12 bytes with full peak; although peak wouldn't be too useful, as it should always zero during Lead-In... but some discs do seem return non-zero values for whatever reason).

Aside from ADR=1, a value of ADR=5 can be used on multisession disks (eg. with point B0h, C0h). Not sure if any other ADR values can be used (ADR=3, ISRC is usually not in the Lead-In, ADR=2, EAN may be in the lead-in, but one may need to specify point equal to the first EAN byte).

If the ADR/Point combination isn't found, then a timeout occurs after circa 6 seconds (to

avoid this, use GetTN to see which tracks/points exist). After the timeout, the command starts playing track 1. If the controller wasn't already in audio mode before sending the command, then it does switch off the drive motor for a moment (that, after the timeout, and before starting playback).

In case of timeout, the normal INT3/INT2 responses are replaced by INT3/INT5/INT5 (INT3 at command start, 1st INT5 at timeout/stop, and 2nd INT5 at restart/play).

Note: GetQ sends scratch noise to the SPU while seeking to the Lead-In area.

GetID - Command 1Ah --> INT3(stat) --> INT2/5 (stat,flags,type,atip,"SCEX")

Drive Status	1st Response	2nd Response
Door Open	INT5 (11h,80h)	N/A
Spin-up	INT5 (01h,80h)	N/A
Detect busy	INT5 (03h,80h)	N/A
No Disk	INT3 (stat)	INT5 (08h,40h, 00h,00h, 00h,00h,00h,00h)
Audio Disk	INT3 (stat)	INT5 (0Ah,90h, 00h,00h, 00h,00h,00h,00h)
Unlicensed:Model	INT3 (stat)	INT5 (0Ah,80h, 00h,00h, 00h,00h,00h,00h)
Unlicensed:Mode2	INT3 (stat)	INT5 (0Ah,80h, 20h,00h, 00h,00h,00h,00h)
Unlicensed:Mode2+Audio	INT3 (stat)	INT5 (0Ah,90h, 20h,00h, 00h,00h,00h,00h)
Debug/Yaroze:Mode2	INT3 (stat)	INT2 (02h,00h, 20h,00h, 20h,20h,20h,20h)
Licensed:Mode2	INT3 (stat)	INT2 (02h,00h, 20h,00h, 53h,43h,45h,4xh)
Modchip:Audio/Model	INT3 (stat)	INT2 (02h,00h, 00h,00h, 53h,43h,45h,4xh)

The status byte (ie. the first byte in the responses), may differ in some cases; values shown above are typically received when issuing GetID shortly after power-up; however, shortly after the detect-busy phase, seek-busy flag (bit6) bit may be set, and, after issuing commands like Play/Read/Stop, bit7,6,5,1 may differ. The meaning of the separate 2nd response bytes is:

```
1st byte: stat (as usually, but with bit3 same as bit7 in 2nd byte)
2nd byte: flags (bit7=denied, bit4=audio... or reportedly import, uh?)
  bit7: Licensed (0=Licensed Data CD, 1=Denied Data CD or Audio CD)
  bit6: Missing (0=Disk Present, 1=Disk Missing)
  bit4: Audio CD (0=Data CD, 1=Audio CD) (always 0 when Modchip installed)
3rd byte: Disk type (from TOC Point=A0h) (eg. 00h=Audio or Model, 20h=Mode2)
4th byte: Usually 00h (or 8bit ATIP from Point=C0h, if session info exists)
  that 8bit ATIP value is taken from the middle 8bit of the 24bit ATIP value
5th-8th byte: SCEX region (eg. ASCII "SCEE" = Europe) (0,0,0,0 = Unlicensed)
```

The fourth letter of the "SCEX" string contains region information: "SCEI" (Japan/NTSC), "SCEA" (America/NTSC), "SCEE" (Europe/PAL). The "SCEX" string is displayed in the intro, and the PSX refuses to boot if it doesn't match up for the local region.

With a modchip installed, the same response is sent for Mode1 and Audio disks (except for Audio disks with very short TOCs (eg. singles) because SCEX reading is aborted immediately after reading all TOC entries on Audio disks); whether it is Audio or Mode1

can be checked by examining Subchannel Q ADR/Control.Bit6 (eg. via command 19h,60h,50h,00h).

Yaroze does return "SCEA" for SCEA discs, but, for SCEI,SCEE,SCEW discs it does return four ASCII spaces (20h).

11.7 CDROM - CD Audio Commands

To play CD-DA Audio CDs, init the following SPU Registers: CD Audio Volume, Main Volume, and SPU Control Bit0. Then send Demute command, and Play command.

Mute - Command 0Bh --> INT3(stat)

Turn off audio streaming to SPU (affects both CD-DA and XA-ADPCM).

Even when muted, the CDROM controller is internally processing audio sectors (as seen in 1F801800h.Bit2, which works as usually for XA-ADPCM), muting is just forcing the CD output volume to zero.

Mute is used by Dino Crisis 1 to mute noise during modchip detection.

Demute - Command 0Ch --> INT3(stat)

Turn on audio streaming to SPU (affects both CD-DA and XA-ADPCM). The Demute command is needed only if one has formerly used the Mute command (by default, the PSX is demuted after power-up (...and/or after Init command?), and is demuted after cdrom-booting).

Play - Command 03h (,track) --> INT3(stat) --> optional INT1(report bytes)

Starts CD Audio Playback. The parameter is optional, if there's no parameter given (or if it is 00h), then play either starts at Setloc position (if there was a pending unprocessed Setloc), or otherwise starts at the current location (eg. the last point seeked, or the current location of the current song; if it was already playing). For a disk with N songs, Parameters 1..N are starting the selected track. Parameters N+1..99h are restarting the begin of current track. The motor is switched off automatically when Play reaches the end of the disk, and INT4(stat) is generated (with stat.bit7 cleared).

The track parameter seems to be ignored when sending Play shortly after power-up (ie. when the drive hasn't yet read the TOC).

===

"Play is almost identical to CdIReadS, believe it or not. The main difference is that this does not trigger a completed read IRQ. CdIPlay may be used on data sectors. However,

all sectors from data tracks are treated as 00, so no sound is played. As CdIPlay is reading, the audio data appears in the sector buffer, but is not reliable. Game Shark "enhancement CDs" for the 2.x and 3.x versions used this to get around the PSX copy protection."

Hmmm, what/where is the sector buffer... in the SPU?

And, what/who are the 2.x and 3.x versions?

Forward - Command 04h --> INT3(stat) --> optional INT1(report bytes)

Backward - Command 05h --> INT3(stat) --> optional INT1(report bytes)

After sending the command, the drive is in fast forward/backward mode, skipping every some sectors. The skipping rate is fixed (it doesn't increase after some seconds) (however, it increases when (as long as) sending the command again and again). The sound becomes (obviously) non-continuous, and also rather very silent, muffled, and almost inaudible (that's making it rather useless; unless it's combined with a track/minute/second display). To terminate forward/backward, send a new Play command (with no parameters, so play starts at the "searched" location). Backward automatically switches to Play when reaching the begin of Track 1. Forward automatically Stops the drive motor with INT4(stat) when reaching the end of the last track.

Forward/Backwards work only if the drive was in Play state, and only if Play had already started (ie. not shortly/immediately after a Play command); if the drive was not in Play state, then INT5(stat+1,80h) occurs.

Setmode bits used for Play command

During Play, only bit 7,2,1 of Setmode are used, all other Setmode bits are ignored (that, including bit0, ie. during Play the drive is always in CD-DA mode, regardless of that bit).

Bit7 (double speed) should be usually off, although it can be used for a fast forward effect (with audible output). Bit2 (report) activates an optional interrupt for Play, Forward, and Backward commands (see below). Bit1 (autopause) pauses play at the end of the track.

Report --> INT1(stat,track,index,mm/amm,ss+80h/ass,sect/asect,peaklo,peakhi)

With report enabled via Setmode, the Play, Forward, and Backward commands do repeatedly generate INT1 interrupts, with eight bytes response length. The interrupt isn't generated on ALL sectors, and the response changes between absolute time, and

time within current track (the latter one indicated by bit7 of ss):

```
amm/ass/asect are returned on asect=00h,20h,40h,60h    ;-absolute time
mm/ss+80h/sect are returned on asect=10h,30h,50h,70h    ;-within current track
(or, in case of read errors, report may be returned on other asect's)
```

The last two response bytes (peaklo,peakhi) contain the Peak value, as received from the CXD2510Q Signal Processor. That is: An unsigned absolute peak level in lower 15bit, and an L/R flag in upper bit. The L/R bit is toggled after each SUBQ read, however the PSX Report mode does usually forward SUBQ only every 10 frames (but does read SUBQ in \<every> frame), so L/R will stay stuck in one setting (but may toggle after one second; ie. after 75 frames). And, peak is reset after each read, so 9 of the 10 frames are lost. Note: Report mode affects only CD Audio (not Data, nor XA-ADPCM sectors).

AutoPause --> INT4(stat)

Autopause can be enabled/disabled via Setmode.bit1:

```
Setmode.bit1=1: AutoPause=On  --> Issue INT4(stat) and PAUSE at end of TRACK
Setmode.bit1=0: AutoPause=Off --> Issue INT4(stat) and STOP at end of DISC
```

End of Track is determined by sensing a track number transition in SubQ position info. After autopause, the disc stays at the \<end> of the old track, NOT at the \<begin> of the next track (so trying to resume playing by sending a new Play command without new Seek/Setloc command will instantly pause again).

Caution: SubQ track transitions may pause instantly when accidentally starting to play at the end of the previous track rather than at begin of desired track (this \<might> happen due to seek inaccuracies, for example, GetTD does round down TOC entries from MM:SS:FF to MM:SS:00, which may be off by 0.99 seconds, although this error should be usually compensated by the leading 2-second pregap/index0 region at the begin of each track, unfortunately there are a few .CUE sheet files that do lack both PREGAP and INDEX 00 entries on audio tracks, which might cause problems with autopause).

AutoPause is used by Rayman and Tactics Ogre.

Playing XA-ADPCM Sectors (compressed audio data)

Aside from normal uncompressed CD Audio disks, the PSX can also play XA-ADPCM compressed sectors. XA-ADPCM sectors are organized in Files (not in tracks), and are "played" with Read command (not Play command).

To play XA-ADPCM, initialize the SPU for CD Audio input (as described above), enable

ADPCM via Setmode, then select the sector via Setloc, and issue a Read command (typically ReadS).

XA-ADPCM sectors are interleaved, ie. only each Nth sector should be played (where "N" depends on the Motor Speed, mono/stereo format, and sample rate). If the "other" sectors do contain XA-ADPCM data too, then the Setfilter command (and XA-Filter enable flag in Setmode) must be used to select the desired sectors. If the "other" sectors do contain code or data (eg. MDEC video data) which is wanted to be send to the CPU, then SetFilter isn't required to be enabled (although it shouldn't disturb reading even if it is enabled).

If XA-ADPCM (and/or XA-Filter) is enabled via Setmode, then INT1 is generated only for non-ADPCM sectors.

The Setmode sector-size selection is don't care for forwarding XA-ADPCM sectors to the SPU (the hardware does always decompress all 900h bytes).

11.8 CDROM - Test Commands

[CDROM - Test Commands - Version, Switches, Region, Chipset, SCEX](#)

[CDROM - Test Commands - Test Drive Mechanics](#)

[CDROM - Test Commands - Prototype Debug Transmission](#)

[CDROM - Test Commands - Read/Write Decoder RAM and I/O Ports](#)

[CDROM - Test Commands - Read HC05 SUB-CPU RAM and I/O Ports](#)

11.9 CDROM - Test Commands - Version, Switches, Region, Chipset, SCEX

19h,20h --> INT3(yy,mm,dd,ver)

Indicates the date (Year-month-day, in BCD format) and version of the HC05 CDROM controller BIOS. Known/existing values are:

(unknown)	;DTL-H2000 (with SPC700 instead HC05)	
94h,09h,19h,C0h	;PSX (PU-7)	19 Sep 1994, version vC0 (a)
94h,11h,18h,C0h	;PSX (PU-7)	18 Nov 1994, version vC0 (b)
94h,11h,28h,01h	;PSX (DTL-H2000)	28 Nov 1994, version v01 (debug)
95h,05h,16h,C1h	;PSX (LATE-PU-8)	16 May 1995, version vC1 (a)
95h,07h,24h,C1h	;PSX (LATE-PU-8)	24 Jul 1995, version vC1 (b)
95h,07h,24h,D1h	;PSX (LATE-PU-8, debug ver)	24 Jul 1995, version vD1 (debug)
96h,08h,15h,C2h	;PSX (PU-16, Video CD)	15 Aug 1996, version vC2 (VCD)
96h,08h,18h,C1h	;PSX (LATE-PU-8, yaroze)	18 Aug 1996, version vC1 (yaroze)

```

96h,09h,12h,C2h ;PSX (PU-18) (japan)      12 Sep 1996, version vC2 (a.jap)
97h,01h,10h,C2h ;PSX (PU-18) (us/eur)      10 Jan 1997, version vC2 (a)
97h,08h,14h,C2h ;PSX (PU-20)              14 Aug 1997, version vC2 (b)
98h,06h,10h,C3h ;PSX (PU-22)              10 Jun 1998, version vC3 (a)
99h,02h,01h,C3h ;PSX/PSone (PU-23, PM-41) 01 Feb 1999, version vC3 (b)
A1h,03h,06h,C3h ;PSone/late (PM-41(2))    06 Jun 2001, version vC3 (c)
(unknown)       ;PS2,   xx xxx xxxx, late PS2 models...?

```

19h,21h --> INT3(flags)

Returns the current status of the POS0 and DOOR switches.

```

Bit0   = HeadIsAtPos0 (0=No, 1=Pos0)
Bit1   = DoorIsOpen   (0=No, 1=Open)
Bit2   = EjectButtonOrOutSwOrSo? (DTL-H2000 only) (always 0 on retail)
Bit3-7 = AlwaysZero

```

19h,22h --> INT3("for Europe")

Caution: Supported only in BIOS version vC1 and up. Not supported in vC0.

Indicates the region that console is to be used in:

```

INT5(11h,10h)      --> NTSC, Japan (vC0)          --> requires "SCEI" discs
INT3("for Europe") --> PAL, Europe                --> requires "SCEE" discs
INT3("for U/C")     --> NTSC, North America        --> requires "SCEA" discs
INT3("for Japan")   --> NTSC, Japan / NTSC, Asia   --> requires "SCEI" discs
INT3("for NETNA")   --> Region-free yaroze version --> requires "SCEX" discs
INT3("for US/AEP")  --> Region-free debug version --> accepts unlicensed CDRs

```

The CDROMs must contain a matching SCEX string accordingly.

The string "for Europe" does also suggest 50Hz PAL/SECAM video hardware.

The Yaroze accepts any normal SCEE,SCEA,SCEI discs, plus special SCEW discs.

19h,23h --> INT3("CXD2940Q/CXD1817Q/CXD2545Q/CXD1782BR") ;Servo Amplifier**19h,24h --> INT3("CXD2940Q/CXD1817Q/CXD2545Q/CXD2510Q") ;Signal Processor****19h,25h --> INT3("CXD2940Q/CXD1817Q/CXD1815Q/CXD1199BQ") ;Decoder/FIFO**

Caution: Supported only in BIOS version vC1 and up. Not supported in vC0.

Indicates the chipset that the CDROM controller is intended to be used with. The strings aren't always precisely correct (CXD1782BR is actually CXA1782BR, ie. CXA, not CXD)

(and CXD1199BQ chips exist on PU-7 boards, but later PU-8 boards do actually use CXD1815Q) (and CXD1817Q is actually CXD1817R) (and newer PSones are using CXD2938Q or possibly CXD2941R chips, but nothing called CXD2940Q).

Note: Yaroze responds by CXD1815BQ instead of CXD1199BQ (but not by CXD1815Q).

19h,04h --> INT3(stat) ;Read SCEX string (and force motor on)

Resets the total/success counters to zero, and does then try to read the SCEX string from the current location (the SCEX is stored only in the Lead-In area, so, if the drive head is elsewhere, it will usually not find any strings, unless a modchip is permanently simulating SCEX strings).

This is a raw test command (the successful or unsuccessful results do not lock/unlock the disk). The results can be read with command 19h,05h (which will terminate the SCEX reading), or they can be read from RAM with command 19h,60h,lo,hi (which doesn't stop reading). Wait 1-2 seconds before expecting any results.

Note: Like 19h,00h, this command forces the drive motor to spin at standard speed (synchronized with the data on the disk), works even if the shell is open (but stops spinning after a while if the drive is empty).

19h,05h --> INT3(total,success) ;Get SCEX Counters

Returns the total number of "Sxxx" strings received (where at least the first byte did match), and the number of full "SCEX" strings (where all bytes did match). Typically, the values are "01h,01h" for Licensed PSX Data CDs, or "00h,00h" for disk missing, unlicensed data CDs, Audio CDs.

The counters are reset to zero, and SCEX receive mode is active for a few seconds after booting a new disk (on power up, on closing the drive door, on sending a Reset command, and on sub_function 04h). The disk is unlocked if the "success" counter is nonzero, the only exception is sub_function 04h which does update the counters, but does not lock/unlock the disk.

11.10 CDRom - Test Commands - Test Drive Mechanics

Signal Processor and Servo Amplifier

19h,50h,msb[,mid,[lsb[,xlo]]] --> INT3(stat)

Sends an 8bit/16bit/24bit command to the hardware, depending on number of parameters:

```
1 byte --> send CX(Xx)           ;short 8bit command
2 bytes --> send CX(Xxxx)        ;longer 16bit command
3 bytes --> send CX(Xxxxxx)      ;full 24bit command
4 bytes --> send CX(Xxxxxxxxx)    ;extended 32bit command (BIOS vC3 only)
4..15 bytes: acts same as max (3 or 4 bytes) (extra bytes are ignored)
0 bytes or more than 15 bytes: generates an error
```

19h,51h,msb[,mid,[lsb]] --> INT3(stat,hi,lo) ;BIOS vC2/vC3 only

Supported by newer CDROM BIOSes only (such that use CXD2545Q or newer chips).

Works same as 19h,50h, but does additionally receive a response.

The command is always sending a 24bit CX(Xxxxxx) command, but it doesn't verify the number of parameter bytes (when using more than 3 bytes: extra bytes are ignored, when using less than 3 bytes: garbage is appended, which is somewhat valid because 8bit/16bit commands can be padded to 24bit size by appending "don't care" bits).

The command can be used to send any CX(..) command, but actually it does make sense only for the get-status commands, see below "19h,51h,39h,xxh" description.

19h,51h,39h,xxh --> INT3(stat,hi,lo) ;BIOS vC2/vC3 only

Supported by newer CDROM BIOSes only (such that use CXD2545Q or newer chips).

Sends CX(39xx) to the hardware, and receives a response (the response.hi byte is usually 00h for 8bit responses, or 00h..01h for 9bit responses). For example, this can be used to dump the Coefficient RAM.

19h,03h --> INT3(stat) ;force motor off

Forces the motor to stop spinning (ignored during spin-up phase).

19h,17h --> INT3(stat) ;force motor on, clockwise, super-fast

19h,01h --> INT3(stat) ;force motor on, anti-clockwise, super-fast

19h,02h --> INT3(stat) ;force motor on, anti-clockwise, super-fast

19h,10h --> INT3(stat) ;force motor on, anti-clockwise, super-fast

19h,18h --> INT3(stat) ;force motor on, anti-clockwise, super-fast

Forces the drive motor to spin at maximum speed (which is much faster than normal or double speed), in normal (clockwise), or reversed (anti-clockwise) direction. The commands work even if the shell is open. The commands do not try to synchronize the motor with the data on the disk (and do thus work even if no disk is inserted).

19h,00h --> INT3(stat) ;force motor on, clockwise (even if shell open)

This command seems to have effect only if the drive motor was off. If it was off, it does FFh-fills the TOC entries in RAM, and seek to the begin of the TOC at 98:30:00 or so (where minute=98 means minus two). From that location, it follows the spiral on the disk, although it does occasionally jump back some seconds. After clearing the TOC, the command does not write new data to the TOC buffer in RAM.

Note: Like 19h,04h, this command forces the drive motor to spin at standard speed (synchronized with the data on the disk), works even if the shell is open (but stops spinning after a while if the drive is empty).

19h,11h --> INT3(stat) ;Move Lens Up (leave parking position)

19h,12h --> INT3(stat) ;Move Lens Down (enter parking position)

19h,13h --> INT3(stat) ;Move Lens Outwards (away from center of disk)

19h,14h --> INT3(stat) ;Move Lens Inwards (towards center of disk)

Moves the laser lens. The inwards/outwards commands do move ONLY the lens (ie. unlike as for Seek commands, the overall-laser-unit remains in place, only the lens is moved).

19h,15h - if motor on: move head outwards + inwards + motor off

Moves the drive head to outer-most and inner-most position. Note that the drive doesn't have a switch that'd tell the controller when it has reached the outer-most position (so it'll forcefully hit against the outer edge) (ie. using this command too often may destroy the drive mechanics).

Note: The same destructive hit-outer-edge effect happens when using Setloc/Seek with too large values (like minute=99h).

19h,16h --> INT3(stat) ;Unknown / makes some noise if motor is on**19h,19h --> INT3(stat) ;Unknown / no effect****19h,1Ah --> INT3(stat) ;Unknown / makes some noise if motor is on**

Seem to have no effect?

19h,16h seems to Move Lens Inwards, too.

19h,06h,new --> INT3(old) ;Adjust balance in RAM, and apply it via CX(30+n)**19h,07h,new --> INT3(old) ;Adjust gain in RAM, and apply it via CX(38+n)****19h,08h,new --> INT3(old) ;Adjust balance in RAM only**

These commands are supported only by older CDROM BIOS versions (those with CXA1782BR Servo Amplifier).

Later BIOSes will respond with INT5(11h,20h) when trying to use these commands (because CXD2545Q and later Servo Amplifiers don't support the CX(30/38+n) commands).

11.11 CDROM - Test Commands - Prototype Debug Transmission

Serial Debug Messages

Older CDROM BIOSes are supporting debug message transmission via serial bus, using lower 3bit of the HC05 "databus" combined with the so-called "ROMSEL" pin (which apparently doesn't refer to Read-Only-Memory, but rather something like Runtime-Output-Message, or whatever).

Data is transferred in 24bit units (8bit command/index from HC05, followed by 16bit

data to/from HC05), bigger messages are divided into multiple such 24bit snippets. There are no connectors for external debug hardware on any PSX mainboards, so the whole stuff seems to be dating back to prototypes. And it seems to be removed from later BIOSes (which appear to use "ROMSEL" as "SCLK"; for receiving status info from the new CXD2545Q chips).

19h,30h,index,dat1,dat2 --> INT3(stat) ;Prototype/Debug stuff

19h,31h,dat1,dat2 --> INT3(stat) ;Prototype/Debug stuff

19h,4xh,index --> INT3(dat1,dat2) ;Prototype/Debug stuff

These functions are supported on older CDROM BIOS only; later BIOSes respond by INT5(11h,10h).

The functions do not affect the CDROM operation (they do simple allow to transfer data between Main CPU and external debug hardware).

Sub functions 30h and 31h may fail with INT5(11h,80h) when receiving wrong signals on the serial input line.

Sub function "4xh" value can be 40h..4Fh (don't care).

INT5 Debug Messages

Alongsides to INT5 errors, the BIOS is usually also sending information via the above serial bus (the error info is divided into multiple 8bit+16bit snippets, and contains stat, error code, mode, current SubQ position, and most recently issued command).

11.12 CDROM - Test Commands - Read/Write Decoder RAM and I/O Ports

Caution: Below commands 19h,71h..76h are supported only in BIOS version vC1 and up. Not supported in vC0.

19h,71h,index --> INT3(databyte) ;Read single register

index can be 00h..1Fh, bigger values seem to be mirrored to "index AND 1Fh", with one exception: index 13h is NOT mirrored, instead, index 33h, 53h, 93h, B3h, D3h, F3h return INT5(stat+1,10h), and index 73h returns INT5(stat+1,20h).

Aside from returning a value, the commands seem to DO something (like moving the

drive head when a disk is inserted). Return values are usually:

index	value	
00h	04h	;04h=empty, 8Eh=licensed, 24h=audio
01h	[0B1h]	;DCh=empty/licensed, DDh=audio
02h	00h	
03h	00h	;or variable when disk inserted
04h	00h	
05h	80h	;or 86h or 89h when disk inserted
06h	C0h	
07h	02h	
08h	8Ah	
09h	C0h	
0Ah	00h	
0Bh	C0h	
0Ch	[1F2h]	
0Dh	[1F3h]	
0Eh	00h	;or 8Eh or E6h when disk inserted ;D4h/audio
0Fh	00h	;or sometimes 01h when disk inserted ;50h/audio
10h	C0h	
11h	E0h	
12h	71h	
13h	stat	
14h	FFh	
15h..1Fh	C0h-filled	;or 17h --> DEh

19h,72h,index,databyte --> INT3(stat) ;Write single register

```
;other response on param xx16h,xx18h with xx>00h
```

19h,73h,index,len --> INT3(databytes...) ;Read multiple registers (bugged)

19h,74h,index,len,databytes --> INT3(stat) ;Write multiple registers (bugged)

Same as read/write single register, but trying to transfer multiple registers at once.

BUG: The transfer should range from 00h to len-1, but the loop counter is left uninitialized (set to X=48h aka "command number 19h-minus-1-mul-2" instead of X=00h). Causing to the function to read/write garbage at index 48h..FFh, it does then wrap to 00h and do the correct intended transfer, but the preceeding bugged part may have smashed RAM or I/O ports.

19h,75h --> INT3(remain.lo,remain.hi,addr.lo,addr.hi) ;Get Host Xfer Info

Returns a 4-byte value. In my early tests, on the first day it returned B1h,CEh,4Ch,01h, on the next day 2Ch,E4h,95h,D5h, and on all following days 00h,C0h,00h,00h (no idea

why/where the earlier values came from).

The first byte seems to be always 00h; no matter of [1F0h].

The second byte seems to be always C0h; no matter of [1F1h].

The third,fourth bytes are [1F2h,1F3h].

That two bytes are 0Ch,08h after Read commands.

```
The first bytes are NOT affected by:
destroying [1F0h] via too-many-parameters in command-buffer,
changes to [1F1h] which may occur after read command (eg. may be 20h)
```

19h,76h,len_lo,len_hi,addr_lo,addr_hi --> INT3(stat) ;Prepare SRAM Transfer

Prepare Transfer to/from 32K SRAM.

After INT3, data can be read (same way as sector data after INT1).

11.13 CDROM - Test Commands - Read HC05 SUB-CPU RAM and I/O Ports

19h,60h,addr_lo,addr_hi --> INT3(data) ;Read one byte from Drive RAM or I/O

Reads one byte from the controller's RAM or I/O area, see the memory map below for more info. Among others, the command allows to read Subchannel Q data, eg. at [200h..209h], including ADR=2/UPC/EAN and ADR=3/ISRC values (which are suppressed by GetlocP). Eg. wait for ADR\<>2, then for ADR=2, then read the remaining 9 bytes (because of the delayed IRQs, this works only at single speed) (at double speed one can read only 5 bytes before the values get overwritten by new data). Unknown if older boards (with 4.00MHz oscillators) are fast enough to read all 10 SubQ bytes.

CDROM Controller I/O Area and RAM Memory Map

First 40h bytes are I/O ports (as in MC68HC05 datasheet):

```
000h 4      FF 7B 00 FF  (other when disk inserted)
004h 5      11 00 20 20 0C
009h 1      00 (when disk inserted: changes between 00 or 80)
00Ah 2      71 00
00Ch 1      00 (when disk inserted: changes between 00 or 80)
00Dh 3      20 20 20
010h 8      02 80 00 60 00 00 99(orBB) 98
018h 4      changes randomly (even when no disk inserted)
```

```

01Ch 3      40 00 41
01Fh 1      changes randomly (even when no disk inserted)
020h 30     20h-filled
03Eh 2      82h 20h

```

Next 200h bytes are RAM:

```

040h 4      08 00 00 00 ;or 98 07 xx 0B when disk inserted ;[40].Bit1=MUTE
044h 4      00h-filled
048h 3      40 20 00 ;or 58 71 0F when disk inserted
04Bh 1      changes randomly (nodisk: 00 or 80 / disk: BFh)
04Ch 1      Zero (or C0h)
04Dh 3      MM:SS:FF (begin of current track MM:SS:00h) (or increasing addr)
050h 10     Subchannel Q (adjusted position values)
05Ah 2      ...
05Ch 1      00h (or 64h)
05Dh 3      MM:SS:FF (current read address) (sticky address during pause)
060h 1      increments at circa 16Hz or so (or other rate when spinning)
061h 12     00h-filled ;or else when disk inserted
06Dh 1      01 ;or 0C when disk inserted
06Eh 2      SetFilter setting (file,channel)
070h 16     00h-filled ;or else when disk inserted
080h 8      00h-filled
088h 3      03:SS:FF (three, second, fraction)
08Bh 3      03:SS:FF (three, second, fraction)
08Eh 2      01 FF (or other values)
090h 1      00h (or 91h when disk inserted + spinning)
091h 13     Zero
09Eh 1      00h (or 01h when disk inserted + spinning)
09Fh 1      Zero
0A0h 1      Always 23h
0A1h 1      09h (5Dh when disk inserted)
0A2h 7      00h-filled
0A9h 1      40
0AAh 4      00h-filled
0AEh 1      00 (no disk) or 01 (disk) or so
0AFh 1      00 ;or 06 when disk inserted
0B0h 7      00 DC 00 02 00 E0 08 ;\or else when disk inserted
0B7h 1      20 ;Bit6+7=MUTE ;
0B8h 3      DE 00 00 ;/
0BBh 1      SetMode setting (mode)
0BCh 1      \ setting (stat)
0BDh 3      00h-filled
0C0h 6      FFh-filled ;stack... ;\
0C6h 1      Usually DFh ;sometimes [0EBh and up] are non-FFh, too
0C7h 15     FFh-filled ;(depending on disk or commands or so)
0D6h 1      Usually FDh (or FFh) ; ;
0D7h 24     FFh-filled ; stack
0EFh 4      on power-up FFh-filled, other once when disk read ;
0F3h 7      changes randomly (even when no disk inserted) ;
0FAh 6      2E 3C 2A D6 10 95 ;/
100h 2x99   TOC Entries for Start of Track 1..99 (MM:SS)
1C6h 1      TOC First Track number (usually 01h)

```

```

1C7h 1    TOC Last Track number (usually 01h or higher)
1C8h 3    TOC Entry for Start of Lead-Out (MM:SS:FF)
1CBh 2    Zero
1CDh 1    Depends on disk (01 or 02 or 06) (or 00 when no disk)
1CEh 1    Zero
1CFh 1    Depends on disk (NULL minus N*6) (or 00 when no disk)
           (maybe reflection level / laser intensity or so)
           [1CDh..1CFh]
           01 00 E8 --> licensed/metalgear/kain
           01 00 EE --> licensed/alone2
           06 00 E2 or 00 00 02 00 E8 --> licensed/wipeout
           02 00 DC --> unlicensed/elo
           02 00 D6 --> unlicensed/driver
           00 00 EE --> audio/lola
           00 00 FA --> audio/marilyn
           00 00 F4 --> audio/westen
           00 00 00 --> disk missing
           last byte is always in steps of 6

1D0h 4    SCEx String
1D4h 4    Zero
1D8h 2    SCEx Counters (total,success) ;for command 19h,05h
1DAh 6    00h-filled (or ... SS:FF)
1E0h 6    Command Buffer (usually 19h,60h,E2h,01h = Read RAM Command)
1E6h 7    00h-filled (unless destroyed by more-than-6-byte-commands)
1EDh 3    Setloc setting (MM:SS:FF)
1F0h 1    00h (unless destroyed by more-than-6-byte-commands)
1F1h 3    C0h 00h 00h ;or 20h,0Ch,50h or C0h,0Ch,08h ;for command(19h,75h)
           ;or 00h,00h,00h for audio
           ;or 80h,00h,00h for disk missing

1F4h 4    00h-filled ... or SCEx string
1F8h 1    00h
1F9h 1    Selected Target (parameter from Play and SetSession commands)
1FAh 5    00h-filled ;01 01 00 8B 00 00 ;or 01 02 8B 00 00
           01 00 8B 00 00 -- audio/unlicensed
           01 01 00 00 00 -- licensed

1FFh 1    00h-on power up, changes when disk inserted ;or 01 = Playing
1FDh 3    MM:SS:FF (only during command 19h,00h) (MM=98..99=TOC)
200h 10   Subchannel Q (real values)
20Ah 2    whatever
20Ch 1    Zero
20Dh 1    Desired Session (from SetSession command)
20Eh 1    Current Session (actual location of drive head)
20Fh 1    Zero
210h 10   Subchannel Q (adjusted position values)
21Ah 6    00h-filled
220h 4    Data Sector Header (MM:SS:FF:Mode)
224h 4    Data Sector CD-XA Subheader (file,channel,sm,ci)
228h 1    00h
229h 1    Usually 00h (shortly other value on power-up, and maybe on seek)
22Ah 1    10h (or 00h when no disk)
22Bh 3    00h-filled
22Eh 2    01,03 or 0A,00 or 03,01 (or else for other disk)
230h 3    00h-filled (or other during spin-up / read-toc or so)
233h 0Dh  00h-filled (unused RAM)

```

Other/invalid addresses are:

```
240h..2FFh - Invalid (00h-filled) (no ROM, RAM, or I/O mapped here)
300h..3FFh - Mirror of 200h..2FFh      ;\the BIOS is doing that
400h..FFFh - Mirrors of 000h..3FFh     ;/mirroring by software
```

DTL-H2000 Memory Map

This version allows to read the whole 64Kbyte memory space (withou mirroring everything to first 300h bytes). I/O Ports and Variables are at different locations:

```
000h..0DFh  RAM Part 1 (C0h bytes)
0E0h..0FFh  I/O Area
100h..1DFh  RAM Part 2 (C0h bytes)
1E0h..1FFh  I/O Area
200h..2DFh  RAM Part 3 (100h bytes)
2E0h..7FFFh Unknown
8000h-BFFFh Unknown (lower 16K of 32K EPROM) (or unused?)
C000h-FFFFh Firmware (upper 16K of 32K EPROM)
```

Writing to RAM

There is no command for writing to RAM. Except that, one can write to the command/parameter buffer at 1E0h and up. Normally, the longest known command should have 6 bytes (19h,76h,a,b,c,d), and longer commands results in "bad number of parameters" response - however, despite of that error message, the controller does still store ALL parameter bytes in RAM (at address 1E1h..2E0h, then wrapping back to 1E1h).

Whereas, writing more than 16 bytes (FIFO storage size) will mirror the FIFO content twice, and more than 32 bytes (FIFO counter size) will work only when feeding extra data into the FIFO during transmission. Anyways, writing to 1E1h and up doesn't allow to do interesting things (such like manipulating the stack and executing custom code on the CPU).

Subchannel Q Notes

The "adjusted position values" at 050h, 210h, 310h contain only position information (with ADR=1) (the PSX seems to check only the lower 2bit of the 4bit ADR value, so it also treats ADR=5 as ADR=1, too). Additionally, during Lead-In, bytes 7..9 are overwritten by the position value from bytes 3..5. The "real values" contain unadjusted data, including ADR=2 and ADR=3 etc.

11.14 CDROM - Secret Unlock Commands

SecretUnlockPart1 - Command 50h --> INT5(11h,40h)

SecretUnlockPart2 - Command 51h,"Licensed by" --> INT5(11h,40h)

SecretUnlockPart3 - Command 52h,"Sony" --> INT5(11h,40h)

SecretUnlockPart4 - Command 53h,"Computer" --> INT5(11h,40h)

SecretUnlockPart5 - Command 54h,"Entertainment" --> INT5(11h,40h)

SecretUnlockPart6 - Command 55h,\<region> --> INT5(11h,40h)

SecretUnlockPart7 - Command 56h --> INT5(11h,40h)

Caution: Supported only in BIOS version vC1 and up. Not supported in vC0.
 Caution: Supported only in Europe/USA. Nonfunctional in Japan/Asia.
 Caution: When unsupported, Parameter Fifo isn't cleared after the command.

Sending these commands with the correct strings (in order 50h through 56h) does disable the "SCEx" protection. The region can be detected via test command 19h,22h, and must be translated to the following \<region> string:

"of America"	;for NTSC/US	;\
"(Europe)"	;for PAL/Europe	; handled, and actually working
"World wide"	;for Yaroze	;/
"Inc."	;for NTSC/JP	;-non-functional

In the unlocked state, ReadN/ReadS are working for unlicensed CD-Rs, and for imported CDROMs from other regions (both without needing modchips). However there are some cases which may still cause problems: The GetID command (1Ah) does still identify the disc as being unlicensed, same for the Get SCEx Counters test command (19h,05h). And, if a game should happen to send the Reset command (1Ch) for some weird reason, then the BIOS would forget the unlocking, same for games that set the "HCRISD" I/O port bit. On the contrary, opening/closing the drive door does not affect the unlocking state. The commands have been discovered in September 2013, and appear to be supported by all CDROM BIOS versions (from old PSXes up to later PSones). Note that the commands do always respond with INT5 errors (even on successful unlocking).

Japanese consoles are internally containing code for processing the Secret Unlock commands, but they are not actually executing that code, and even if they would do so: they are ignoring the resulting unlocking flag, making the commands nonfunctional in Japan/Asia regions.

SecretLock - Command 57h --> INT5(11h,40h)

Undoes the unlocking and restores the normal locked state (same happens when sending the Unlocking commands in wrong order or with wrong parameters).

SecretCrash - Command 58h..5Fh --> Crash

Jumps to a data area and executes random code. Results are more or less unpredictable (as they involve executing undefined opcodes). Eventually the CPU might hit a RET opcode and recover from the crash.

11.15 CDROM - Video CD Commands

Caution: Supported only on SCPH-5903, not supported on any other consoles.
Caution: When unsupported, Parameter Fifo isn't cleared after the command.

1Fh VideoCD	sub,a,b,c,d,e	INT3(stat,a,b,c,d,e)	;<-- SCPH-5903 only
1Fh..4Fh -	-	INT5(11h,40h)	;-Unused/invalid

VideoCdSio - Cmd 1Fh,01h,JoyL,JoyH,State,Task,0 --> INT3(stat,req,mm,ss,ff,x)

The JoyL/JoyH bytes contain 16bit button (and drive door) bits:

0	Drive Door	(0=Open)	(from CDROM stat bit4)	;Open
1	Button /\	(0=Pressed)	(from PSX pad bit12)	;N/A ;PBC: Back/LevelUp
2	Button []	(0=Pressed)	(from PSX pad bit15)	;Enter Menu
3	Button ()	(0=Pressed)	(from PSX pad bit13)	;Leave Menu ;PBC: Confirm
4	Button ><	(0=Pressed)	(from PSX pad bit14)	;N/A
5	Start	(0=Pressed)	(from PSX pad bit3)	;Play/Pause
6	Select	(0=Pressed)	(from PSX pad bit0)	;Stop (prompt restart/resume)
7	Always 0	(0)	(fixed)	;N/A
8	DPAD Up	(0=Pressed)	(from PSX pad bit4)	;Menu Up ;PBC: +1
9	DPAD Right	(0=Pressed)	(from PSX pad bit5)	;Menu Right/change ;PBC: +10
10	DPAD Down	(0=Pressed)	(from PSX pad bit6)	;Menu Down ;PBC: -1
11	DPAD Left	(0=Pressed)	(from PSX pad bit7)	;Menu Left/change ;PBC: -10
12	Button R1	(0=Pressed)	(from PSX pad bit11)	;Prev Track/Restart Track
13	Button R2	(0=Pressed)	(from PSX pad bit9)	;Fast Forward (slowly)

```

14 Button L1    (0=Pressed) (from PSX pad bit10) ;Next Track (if any)
15 Button L2    (0=Pressed) (from PSX pad bit8)  ;Fast Backward (slowly)

```

The State byte can be:

```

00h Motor Off (or spin-up)    (when stat.bit1=0)
01h Playing                               (when stat.bit7=1)
02h Paused (and not seeking) (when stat.bit6=0)
(note: State remains unchanged when seeking)

```

The Task byte can be:

```

00h = Confirms that "Tocread" (aka setsession 1) request was processed
01h = Detect VCD Disc (used on power-up, and after door open) (after spin-up)
02h = Handshake (request ack response)
0Ah = Door opened during play (int5/door error)
80h = No disc
FFh = No change (nop)

```

The req byte in the INT3 response can be:

```

00h Normal (no special event occurred and no action requested)
01h Request CD to Seek_and_play (using mm:ss:ff response parameter bytes)
02h Request CD to Pause                ;cmd(09h)    -->int3(stat),int2(stat)
03h Request CD to Stop                  ;cmd(08h)    -->int3(stat),int2(stat)
04h Request CD to Tocread (setsession1);cmd(12h,01h)-->int3(stat),int2(stat)
05h Handshake Command was processed, and this is the "ack" response
06h Request CD to Fast Forward          ;cmd(04h)    -->int3(stat)
07h Request CD to Fast Backward         ;cmd(05h)    -->int3(stat)
80h Detect Command was processed, and disc was detected as VCD
81h Detect Command was processed, and disc was detected as Non-VCD

```

VideoCdSwitch - Cmd 1Fh,02h,flag,x,x,x,x --> INT3(stat,0,0,x,x,x)

```

00h      = Normal PSX Mode  (PortF.3=LOW)  (Audio/Video from GPU/SPU chips)
01h..FFh = Special VCD Mode (PortF.3=HIGH) (Audio/Video from MDEC/OSD chips)

```

Some findings on the SC430924 firmware...

The version/date is "15 Aug 1996, version C2h", although the "C2h" is misleading: The firmware is nearly identical to version "C1h" from PU-8 boards (the stuff added in normal "C2h" versions would be for PU-18 boards with different cdrom chipset).

Compared to the original C1h version, there are only a few changes: A initialization function for initializing port F on power-up. And new command (command 1Fh, inserted in the various command tables), with two subfunctions (01h and 02h):

- Command 1Fh,01h,a,b,c,d,e --> INT3(stat,a,b,c,d,e) Serial 5-byte read-write
- Command 1Fh,02h,v,x,x,x,x --> INT3(stat,0,0,x,x,x) Toggle 1bit (port F.bit3)

Whereas,

```
x = don't care/garbage
v = toggle state (00h=normal=PortF.3=LOW, 01h..FFh=special=PortF.3=HIGH)
    (toggle gpu vs mpeg maybe?)
a,b,c,d,e = five bytes sent serially, and five bytes response received
            serially (send/receive done simultaneously)
```

The Port F bits are:

```
Port F.Bit0 = Serial Data In
Port F.Bit1 = Serial Data Out
Port F.Bit2 = Serial Clock Out
Port F.Bit3 = Toggle (0=Normal, 1=Special)
```

And that's about all. Ie. essentially, the only change is that the new command controls Port F. There is no interaction with the remaining firmware (ie. reading, seeking, and everything is working as usually, without any video-cd related changes).

The SCEX stuff is also not affected (ie. Video CDs would be seen as unlicensed discs, so the PSX couldn't read anything from those discs, aside from Sub-Q position data, of course). The SCEX region is SCEI aka "Japan" (or actually for Asia in this case).

Note

The SPU MUTE Flag (SPUCNT.14) does also affect VCD Audio (mute is applied to the final analog audio amplifier). All other SPUCNT bits can be zero for VCD.

11.16 CDROM - Mainloop/Responses

SUB-CPU Mainloop

The SUB-CPU is running a mainloop that is handling hardware events (by simple polling, not by IRQs):

```
check for incoming sectors (from CDROM decoder)
check for incoming commands (from Main CPU)
do maintenance stuff on the drive mechanics
```


There is no fixed priority: if both incoming sector and incoming command are present, then the SUB-CPU may handle either one, depending on which portion of the mainloop it is currently executing.

There is no fixed timing: if the mainloop is just checking for a specific event, then a new event may be processed immediately, otherwise it may take whole mainloop cycle until the SUB-CPU sees the event.

Whereas, the mainloop cycle execution time isn't constant: It may vary depending on various details. Especially, some maintenance stuff is only handled approximately around 15 times per second (so there are 15 slow mainloop cycles per second).

The order of steps that happen when sending a command to the CD controller look roughly like this:

```
e.g. SetMode:
1. Command busy flag set immediately.
2. Response FIFO is populated.
3. Command is being processed.
4. Command busy flag is unset and parameter fifo is cleared.
5. Shortly after (around 1000-6000 cycles later), CDROM IRQ is fired.
```

Responses

The PSX can deliver one INT after another. Instead of using a real queue, it's merely using some flags that do indicate which INT(s) need to be delivered. Basically, there seem to be two flags: One for Second Response (INT2), and one for Data/Report Response (INT1). There is no flag for First Response (INT3); because that INT is generated immediately after executing a command.

The flag mechanism means that the SUB-CPU cannot hold more than one undelivered INT1. That, although the CDROM Decoder does notify the SUB-CPU about all newly received sectors, and it can hold up to eight sectors in the 32K SRAM. However, the SUB-CPU BIOS merely sets a sector-delivery-needed flag (instead of memorizing which/how many sectors need to be delivered, and, accordingly, the PSX can use only three of the available eight SRAM slots: One for currently pending INT1, one for undelivered INT1, and one for currently/incompletely received sector).

First Response (INT3) (or INT5 if failed)

The first response is sent immediately after processing a command. In detail: The mainloop checks for incoming commands once every some clock cycles, and executes commands under following condition:

Main CPU has sent a command, AND, there is no INT pending
 (if an INT is pending, then the command won't be executed yet, but will be
 executed in following mainloop cycles; once when INT got acknowledged)
 (even if no INT is pending, the mainloop may generate INT1/INT2 before
 executing the command, if so, as said above, the command won't execute yet)

Once when the command gets executed it will sent the first response immediately after the command execution (which may only take a few clock cycles, or some more cycles, for example Init/ReadTOC do include some time consuming initializations). Anyways, there will be no other INTs generated during command execution, so once when the command execution has started, it's guaranteed that the next INT will contain the first response.

Second Responses (INT2) (or INT5 if failed)

Some commands do send a second response after actual command execution:

07h MotorOn	E -	INT3(stat), INT2(stat)
08h Stop	E -	INT3(stat), INT2(stat)
09h Pause	E -	INT3(stat), INT2(stat)
0Ah Init	-	INT3(late-stat), INT2(stat)
12h SetSession	E session	INT3(stat), INT2(stat)
15h SeekL	E -	INT3(stat), INT2(stat) ;\use prior Setloc
16h SeekP	E -	INT3(stat), INT2(stat) ;/to set target
1Ah GetID	E -	INT3(stat), INT2/5(stat,flg,typ,atip,"SCEX")
1Dh GetQ	E adr,point	INT3(stat), INT2(10bytesSubQ,peak_lo)
1Eh ReadTOC	-	INT3(late-stat), INT2(stat)

In some cases (like seek or spin-up), it may take more than a second until the 2nd response is sent.

It should be highly recommended to WAIT until the second response is generated BEFORE sending a new command (it wouldn't make too much sense to send a new command between first and second response, and results would be unknown, and probably totally unpredictable).

Error Notes: If the command has been rejected (INT5 sent as 1st response) then the 2nd response isn't sent (eg. on wrong number of parameters, or if disc missing). If the command fails at a later stage (INT5 as 2nd response), then there are cases where another INT5 occurs as 3rd response (eg. on SetSession=02h on non-multisession-disk).

Data/Report Responses (INT1)

03h Play	E (track)	INT3(stat), optional INT1(report bytes)
04h Forward	E -	INT3(stat), optional INT1(report bytes)
05h Backward	E -	INT3(stat), optional INT1(report bytes)

06h ReadN	E -	INT3(stat), INT1(stat), datablock
1Bh ReadS	E?-	INT3(stat), INT1(stat), datablock

11.17 CDROM - Response Timings

Here are some response timings, measured in 33MHz units on a PAL PSone. The CDROM BIOSes mainloop is doing some maintenance stuff once and when, meaning that the response time will be higher in such mainloop cycles (max values), and less in normal cycles (min values). The maintenance timings do also depend on whether the motor is on or off (and probably on various other factors like seeking).

First Response

The First Response interrupt is sent almost immediately after processing the command (that is, when the mainloop sees a new command without any old interrupt pending). For Nop, timings are as so:

Command	Average	Min	Max
Nop (normal)	000c4e1h	0004a73h..003115bh	
Nop (when stopped)	0005cf4h	000483bh..00093f2h	

Timings for most other commands should be similar as above. One exception is the Init command, which is doing some initialization before sending the 1st response:

Init	0013cceh	000f820h..00xxxxxh	
------	----------	--------------------	--

The ReadTOC command is doing similar initialization, and should have similar timing as Init command. Some (rarely used) Test commands include things like serial data transfers, which may be also quite slow.

Second Response

Command	Average	Min	Max
GetID	0004a00h	0004922h..0004c2bh	
Pause (single speed)	021181ch	020eae1h..0216e3ch	;\time equal to
Pause (double speed)	010bd93h	010477Ah..011B302h	;/about 5 sectors
Pause (when paused)	0001df2h	0001d25h..0001f22h	
Stop (single speed)	0d38acah	0c3bc41h..0da554dh	
Stop (double speed)	18a6076h	184476bh..192b306h	
Stop (when stopped)	0001d7bh	0001ce8h..0001eefh	

Moreover, Seek/Play/Read/SetSession/MotorOn/Init/ReadTOC are sending second responses which depend on seek time (and spin-up time if the motor was off). The seek timings are still unknown, and they are probably quite complicated:

The CDROM BIOS seems to split seek distance somehow into coarse steps (eg. minutes) and fine steps (eg. seconds/sectors), so 1-minute seek distance may have completely different timings than 59-seconds distance.

The amount of data per spiral winding increases towards ends of the disc (so the drive head will need to be moved by shorter distance when moving from minute 59 to 60 as than moving from 00 to 01).

The CDROM BIOS contains some seek distance table, which is probably optimized for 72-minute discs (or whatever capacity is used on original PSX discs). 80-minute CDRs may have tighter spiral windings (the above seek table is probably causing the drive head to be moved too far on such discs, which will raise the seek time as the head needs to be moved backwards to compensate that error).

INT1 Rate

Command	Average	Min	Max
Read (single speed)	006e1cdh	00686dah..0072732h	
Read (double speed)	0036cd2h	00322dfh..003ab2bh	

The INT1 rate needs to be precise for CD-DA and CD-XA Audio streaming, exact clock cycle values should be: $\text{SystemClock} * 930h / 4 / 44100\text{Hz}$ for Single Speed (and half as much for Double Speed) (the "Average" values are AVERAGE values, not exact values).

11.18 CDROM - Response/Data Queueing

[Below are some older/outdated test cases]

Sector Buffer

The CDROM sector buffer is 32Kx8 SRAM (IC303). The buffer is apparently divided into 8 slots, theoretically allowing to buffer up to 8 sectors.

BUG: The drive controller seems to allow only 2 of those 8 sectors (the oldest sector, and the current/newest sector).

Ie. after processing the INT1 for the oldest sector, one would expect the controller to generate another INT1 for next newer sector - but instead it appears to jump directly to INT1 for the newest sector (skipping all other unprocessed sectors). There is no known way to get around that effect.

So far, the big 32Kbyte buffer is entirely useless (the two accessible sectors could have been as well stored in a 8Kbyte chip) (unless, maybe the 32Kbytes have been intended for some error-correction "read-ahead" purposes, rather than as "look-back" buffer for old sectors; one of the unused slots might be also used for XA-ADPCM sectors).

The bottom line is that one should process INT1's as soon as possible (ie. before the cdrom controller receives and skips further sectors). Otherwise sectors would be lost without notice (there appear to be absolutely no overrun status flags, nor overrun error interrupts).

Sector Buffer Test Cases

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Process INT1 --> receives sector header for 0:2:1
Process INT1 --> receives sector header for 0:2:2
Process INT1 --> receives sector header for 0:2:3
```

Above shows the normal flow when processing INT1's as they arise. Now, inserting delays (and not processing INT1's during that delays):

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
delay(1)
Process INT1 --> receives sector header for 0:2:1 (oldest sector)
Process INT1 --> receives sector header for 0:2:6 (newest sector)
Process INT1 --> receives sector header for 0:2:7 (next sector)
```

Above suggests that the CDROM buffer can hold max 2 sectors (the oldest and current one). However, using a longer delay:

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
delay(2)
Process INT1 --> receives sector header for 0:2:9 (oldest/overwritten)
Process INT1 --> receives sector header for 0:2:11 (newest sector)
Process INT1 --> receives sector header for 0:2:12 (next sector)
```

Above indicates that sector buffer can hold 8 sectors (as the sector 1 slot is overwritten by sector 9). And, another test with even longer delay:

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
delay(3)
Process INT1 --> receives sector header for 0:2:17 (currently received)
Process INT1 --> receives sector header for 0:2:16 (newest full sector)
```

```
Process INT1 --> receives sector header for 0:2:17 (next sector)
Process INT1 --> receives sector header for 0:2:18 (next sector)
```

Above is a special case where sector 17 appears twice; the first one is the sector 1 slot (which was overwritten by sector 9, and apparently then half overwritten by sector 17).

Sector Buffer VS GetlocL Response Tests

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
GetlocL
Process INT3 --> receives getloc info for 0:2:0
Process INT1 --> receives sector header for 0:2:1
Process INT1 --> receives sector header for 0:2:2
Process INT1 --> receives sector header for 0:2:3
```

Another test, with Delay BEFORE Getloc:

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Delay(1)
GetlocL
Process INT1 --> receives sector header for 0:2:1
Process INT3 --> receives getloc info for 0:2:6
Process INT1 --> receives sector header for 0:2:6
Process INT1 --> receives sector header for 0:2:7
```

Another test, with Delay AFTER Getloc:

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
GetlocL
Delay(1)
Process INT3 --> receives getloc info for 0:2:0
Process INT1 --> receives sector header for 0:2:5
Process INT1 --> receives sector header for 0:2:6
Process INT1 --> receives sector header for 0:2:7
```

Another test, with Delay BEFORE and AFTER Getloc:

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Delay(1)
GetlocL
Delay(1)
Process INT1 --> receives sector header for 0:2:9
Process INT1 --> receives sector header for 0:2:11
Process INT3 --> receives getloc info for 0:2:12
```

```
Process INT1 --> receives sector header for 0:2:12
Process INT1 --> receives sector header for 0:2:13
```

Sector Buffer VS Pause Response Tests

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Pause
Process INT3 --> receives stat=22h (first pause response)
Process INT2 --> receives stat=02h (second pause response)
```

Another test, with Delay BEFORE Pause:

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Delay(1)
Pause
Process INT1 --> receives sector header for 0:2:1 (oldest)
Process INT3 --> receives stat=22h (first pause response)
Process INT2 --> receives stat=02h (second pause response)
```

Another test, with Delay AFTER Pause:

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Pause
Delay(1)
Process INT3 --> receives stat=22h (first pause response)
Process INT2 --> receives stat=02h (second pause response)
```

Another test, with Delay BEFORE and AFTER Pause:

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Delay(1)
Pause
Delay(1)
Process INT1 --> receives sector header for 0:2:9 (oldest/overwritten)
Process INT3 --> receives stat=22h (first pause response)
Process INT2 --> receives stat=02h (second pause response)
```

For above: Note that, despite of Pause, the CDROM is still writing to the internal buffer (and overwrites slot 1 by sector 9) (this might be because the Pause command isn't processed at all until INT1 is processed).

Double Commands (Getloc then Pause)

```

Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
GetlocL
Pause
Process INT3 --> receives stat=22h (first pause response)
Process INT2 --> receives stat=02h (second pause response)

```

Another test,

```

Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Delay(1)
GetlocL
Pause
Process INT1 --> receives sector header for 0:2:1
Process INT1 --> receives sector header for 0:2:6
Process INT3 --> receives stat=22h (first pause response)
Process INT2 --> receives stat=02h (second pause response)

```

Another test,

```

Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
GetlocL
Delay(1)
Pause
Process INT3 --> receives getloc info for 0:2:0 (first getloc response)
Process INT3 --> receives stat=22h (first pause response)
Process INT2 --> receives stat=02h (second pause response)

```

Another test,

```

Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Delay(1)
GetlocL
Delay(1)
Pause
Process INT1 --> receives sector header for 0:2:9 (oldest/overwritten)
Process INT3 --> receives stat=22h (first pause response)
Process INT2 --> receives stat=02h (second pause response)

```

Double Commands (Pause then Getloc)

```

Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Pause
GetlocL
Process INT3 --> receives getloc info for 0:2:0 (first getloc response)

```



```
Process INT1 --> receives sector header for 0:2:1
Process INT1 --> receives sector header for 0:2:2
Process INT1 --> receives sector header for 0:2:3
```

Another test,

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Delay(1)
Pause
GetlocL
Process INT1 --> receives sector header for 0:2:1
Process INT3 --> receives getloc info for 0:2:6 (first getloc response)
Process INT1 --> receives sector header for 0:2:6
Process INT1 --> receives sector header for 0:2:7
```

Another test,

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Pause
Delay(1)
GetlocL
Process INT3 --> receives stat=22h (first pause response)
Process INT3 --> receives getloc info for 0:2:6 (first getloc response)
(No further INT's, ie. read is paused, but second-pause-response is lost).
```

Another test,

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Pause
Delay(1)
GetlocL
Delay(1)
Process INT3 --> receives stat=22h (first pause response)
Process INT3 --> receives getloc info for 0:2:6 (first getloc response)
Process INT2 --> receives stat=02h (second pause response)
```

Another test,

```
Setloc(0:2:0)+Read
Process INT1 --> receives sector header for 0:2:0
Delay(1)
Pause
Delay(1)
GetlocL
Process INT1 --> receives sector header for 0:2:9
Process INT1 --> receives sector header for 0:2:11
Process INT3 --> receives getloc info for 0:2:12 (first getloc response)
```

```
Process INT1 --> receives sector header for 0:2:12  
Process INT1 --> receives sector header for 0:2:13
```

12. CDROM Format

General CDROM Disk Format

- CDROM Disk Format
- CDROM Subchannels
- CDROM Sector Encoding
- CDROM Scrambling
- CDROM XA Subheader, File, Channel, Interleave
- CDROM XA Audio ADPCM Compression
- CDROM ISO Volume Descriptors
- CDROM ISO File and Directory Descriptors
- CDROM ISO Misc
- CDROM File Formats
- CDROM Video CDs (VCD)

Playstation CDROM Protection

- CDROM Protection - SCEX Strings
- CDROM Protection - Bypassing it
- CDROM Protection - Modchips
- CDROM Protection - Chipless Modchips
- CDROM Protection - LibCrypt

12.1 CDROM Disk Format

Overview

The PSX uses a ISO 9660 filesystem, with data stored on CD-XA (Mode2) Sectors. ISO 9660 is standard for CDROM disks, although newer CDROMs may use extended filesystems, allowing to use long filenames and lowercase filenames, the PSX Kernel doesn't support such stuff, and, in fact, it's putting some restrictions on the ISO standard: it's limiting file names to MSDOS-style 8.3 format, and it's allowing only a limited number of files and directories per disk.

CDROM Filesystem (ISO 9660 aka ECMA-119)

Originally intended for Mode1 Sectors (but is also used for CD-XA Mode2)
 Supports "FILENAME.EXT;VERSION" filenames (version is usually "1")
 Supports all-uppercase filenames and directory names (0-9, A-Z, underscore)
 For PSX: Max 8-character filenames with max 3-character extensions
 For PSX: Max 8-character directory names, without extension
 For PSX: Max one sector per directory (?)
 For PSX: Max one sector (or less?) per path table (?)

CDROM Extended Architecture (CD-ROM XA aka CD-XA)

Uses Mode2 Sectors (see Sector Encoding chapter)
 Allows 800h or 914h byte data per sector (with/without error correction)
 Allows to break interleaved data into separate files/channels
 Supports XA-ADPCM compressed audio data
 Stores "CD-XA001" at 400h Primary Volume Descriptor (?)
 Stores 14 extra bytes in System Use area (LEN_SU) of Directory Entries

Physical Audio/CDROM Disk Format (ISO/IEC 10149 aka ECMA-130)

Defines physical metrics of the CDROM and Audio disks
 Defines Sub-channels and Track.Index and Minute.Second.Fraction numbering
 Defines 14bit-per-byte encoding, and splits sectors into frames
 Defines ECC and EDC (error correction and error detection codes)

Available Documentation

ISO documents are commercial standards (not available for download), however, they are based on ECMA standards (which are free for download, however, the ECMA stuff is in PDF format, so one may treat it as commercial bullshit, too). CD-ROM XA is commercial only (not available for download), and, CD-XA doesn't seem to have become very popular outside of the PSX-world, so there's very little information available, portions of CD-XA are also used in the CD-i standard (which may be a little better or worse documented).

Stuff

sessions	one or more sessions per disk	
tracks	99 tracks per disk	(01h..99h) (usually only 01h on Data Disks)
index	99 indices per track	(01h..99h) (rarely used, usually always 01h)
minutes	74 minutes per disk	(00h..73h) (or more, with some restrictions)
seconds	60 seconds per minute	(00h..59h)
sectors	75 sectors per second	(00h..74h)
frames	98 frames per sector	

bytes	33 bytes per frame	(24+1+8 = data + subchannel + error correction)
bits	14 bits per byte	(256 valid combinations, and many invalid ones)

Track.Index (stored in subchannel, in BCD format)

Multiple Tracks are usually used only on Audio Disks (one track for each song, numbered 01h and up), a few Audio Disks may also split Tracks into separate fragments with different Index values (numbered 01h and up, but most tracks have only Index 01h). A simple Data Disk would usually contain only one Track (all sectors marked Track=01h and Index=01h), although some more complex Data Disks may have multiple Data tracks and/or Audio tracks.

Minute.Second.Sector (stored in subchannel, and in Data sectors, BCD format)

The sectors on CDROMs and CD Audio disks are numbered in Minutes, Seconds, and 1/75 fragments of a second (where a "second" is referring to single-speed drives, ie. the normal CD Audio playback speed).

Minute.Second.Sector is stored twice in the subchannel (once the "absolute" time, and once the "local" time).

The "absolute" sector number (counted from the begin of the disk) is mainly relevant for Seek purposes (telling the controller if the drive head is on the desired location, or if it needs to move the head backwards or forwards).

The "local" sector number (counted from the begin of the track) is mainly relevant for Audio Players, allowing to pass the data directly to the Minute:Second display, without needing to subtract the start address of the track.

Data disks are additionally storing the "absolute" values in their Data Areas, basically that's just the subchannel data duplicated, but more precisely assigned - the problem with the subchannel data is that the CD Audio standard seems to lack a clear definition that would assign the begin of the sub-channel block to the exact begin of a sector; so, when using only the subchannel data, some Drive Controllers may assign the begin of a new sector to another location as than other Controllers do, for Audio Disks that isn't too much of a problem, but for Data Disks it'd be fatal.

Subchannels

Each frame contains 8 subchannel bits (named P,Q,R,S,T,U,V,W). So, a sector (with 98 frames) contains 98 bits (12.25 bytes) for each subchannel.

[CDROM Subchannels](#)

Error Correction

Each Frame contains 8 bytes Error Correction information, which is mainly used for Audio Disks, but it isn't 100% fail-proof, for that reason, Data Disks are containing additional Error Correction in the 930h-byte data area (the audio correction is probably focusing on repairing the MSBs of the 16bit samples, and gives less priority on the LSBs). Error Correction is some kind of a huge complex checksum, which allows to detect the location of faulty bytes, and to fix them.

930h-Byte Sectors

The "user" area for each sector is 930h bytes (2352 bytes). That region is combined of the 24-byte data per frame (and excludes the 8-byte audio error correction info, and the 1-byte subchannel data).

Most CDROM Controllers are only giving access to this 930h-byte region (ie. there's no way to read the audio error correction info by software, and only limited access to the subchannel data, such like allowing to read only the Q-channel for showing track/minute/second in audio playback mode).

On Audio disks, the 930h bytes are plain data, on Data disks that bytes are containing headers, error correction, and usually only 800h bytes user data (for more info see Sector Encoding chapter).

Sessions

Multi-Sessions are mainly used on CDR's, allowing to append newer data at the end of the disk at a later time. First of, the old session must contain a flag indicating that there may be a newer session, telling the CDROM Controller to search if one such exists (and if that is equally flagged, to search for an even newer session, and so on until reaching the last and newest session).

Each session contains a complete new ISO Volume Descriptor, and may additionally contain new Path Tables, new Directories, and new Files. The Driver Controller is usually recursing only the Volume Descriptor of the newest session. However, the various Directory Records of the new session may refer to old files or old directories from previous sessions, allowing to "import" the older files, or to "rename" or "delete" them by assigning new names to that files, or by removing them from the directory.

The PSX is reportedly not supporting multi-session disks, but that doesn't seem to be correct, namely, the Setsession command is apparently intended for that purpose... though not sure if the PSX Kernel is automatically searching the newest session...

otherwise the boot executable in the first session would need to do that manually by software, and redirect control to the boot executable in the last session.

12.2 CDROM Subchannels

Subchannel P

Subchannel P contains some kind of a Pause flag (to indicate muted areas between Audio Tracks). This subchannel doesn't have any checksum, so the data cannot be trusted to be intact (unless when sensing a longer stream of all-one's, or all zero's). Theoretically, the 98 pause bits are somehow associated to the 98 audio frames (with 24 audio bytes each) of the sector. However, reportedly, Subchannel P does contain two sync bits, if that is true, then there'd be only 96 pause flags for 98 audio frames. Strange.

Note: Another way to indicate "paused" regions is to set Subchannel Q to ADR=1 and Index=00h.

Subchannel Q

contains the following information:

```
Bits Expl.
2   Sub-channel synchronization field
8   ADR/Control (see below)
72  Data (content depends on ADR)
16  CRC-16-CCITT error detection code (big-endian: bytes ordered MSB, LSB)
```

Possible values for the ADR/Control field are:

```
Bit0-3 ADR (0=No data, 1..3=see below, 4..0Fh=Reserved)
Bit4   Audio Preemphasis (0=No, 1=Yes) (Audio only, must be 0 for Data)
Bit5   Digital Copy (0=Prohibited, 1=Allowed)
Bit6   Data (0=Audio, 1=Data)
Bit7   Four-Channel Audio (0=Stereo, 1=Quad) (Audio only, must be 0 for Data)
```

The 72bit data regions are, depending on the ADR value...

Subchannel Q with ADR=1 during Lead-In -- Table of Contents (TOC)

```
8   Track number (fixed, must be 00h=Lead-in)
8   Point (01h..99h or A0h..A2h, see last three bytes for more info)
24  MSF address (incrementing address within the Lead-in area)
```

Note: On some disks, these values are chosen so that the lead-in
<starts> at 00:00:00, on other disks so that it <ends> at 99:59:74.

8	Reserved (00h)
---	----------------

When Point=01h..99h (Track 1..99) or Point=A2h (Lead-Out):

24	MSF address (absolute address, start address of the "Point" track)
----	--

When Point=A0h (First Track Number):

8	First Track number (BCD)
8	Disk Type Byte (00h=CD-DA or CD-ROM, 10h=CD-I, 20h=CD-ROM-XA)
8	Reserved (00h)

When Point=A1h (Last Track Number):

8	Last Track number (BCD)
16	Reserved (0000h)

ADR=1 should exist in 3 consecutive lead-in sectors.

Subchannel Q with ADR=1 in Data region -- Position

8	Track number (01h..99h=Track 1..99)
8	Index number (00h=Pause, 01h..99h=Index within Track)
24	Track relative MSF address (decreasing during Pause)
8	Reserved (00h)
24	Absolute MSF address

ADR=1 is required to exist in at least 9 out of 10 consecutive data sectors.

Subchannel Q with ADR=1 during Lead-Out -- Position

8	Track number (fixed, must be AAh=Lead-Out)
8	Index number (fixed, must be 01h) (there's no Index=00h in Lead-Out)
24	Track relative MSF address (increasing, 00:00:00 and up)
8	Reserved (00h)
24	Absolute MSF address

ADR=1 should exist in 3 consecutive lead-out sectors (and may then be followed by ADR=5 on multisession disks).

Subchannel Q with ADR=2 -- Catalogue number of the disc (UPC/EAN barcode)


```

52  EAN-13 barcode number (13-digit BCD)
12  Reserved (000h)
8   Absolute Sector number (BCD, 00h..74h) (always 00h during Lead-in)

```

If the first digit of the EAN-13 number is "0", then the remaining digits are a UPC-A barcode number. Either the 13-digit EAN-13 number, or the 12-digit UPC-A number should be printed as barcode on the rear-side of the CD package.

The first some digits contain a country code (EAN only, not UPC), followed by a manufacturer code, followed by a serial number. The last digit contains a checksum, which can be calculated as 250 minus the sum of the first 12 digits, minus twice the sum of each second digit, modulated by 10.

ADR=2 isn't included on all CDs, and, many CDs do have ADR=2, but the 13 digits are all zero. Most CDROM drives do not allow to read EAN/UPC numbers.

If present, ADR=2 should exist in at least 1 out of 100 consecutive sectors. ADR=2 may occur also in Lead-in.

Subchannel Q with ADR=3 -- ISRC number of the current track

(ISO 3901 and DIN-31-621):

```

12  Country Code      (two 6bit characters)  (ASCII minus 30h) ;eg. "US"
18  Owner Code       (three 6bit characters) (ASCII minus 30h)
2   Reserved         (zero)
8   Year of recording (2-digit BCD) ;eg. 82h for 1982
20  Serial number    (5-digit BCD) ;usually increments by 1 or 10 per track
4   Reserved         (zero)
8   Absolute Sector number (BCD, 00h..74h) (always 00h during Lead-in)

```

Most CDROM drives for PC's do not allow to read ISRC numbers (or even worse, they may accidently return the same ISRC number on every two tracks).

If present, ADR=3 should exist in at least 1 out of 100 consecutive sectors. However, reportedly, ADR=3 should not occur in Lead-in.

Subchannel Q with ADR=5 in Lead-in -- Multisession Lead-In Info

When Point=B0h:

```

8   Track number (fixed, must be 00h=Lead-in)
8   POINT = B0h (multi-session disc)
24  MM:SS:FF = the start time for the next possible session's program area,
      a final session is indicated by FFh:FFh:FFh,
      or when the ADR=5 / Point=B0h is absent.

```

```

8      Number of different Mode-5 pointers present.
24     MM:SS:FF = the maximum possible start time of the outermost Lead-out

```

When Point=C0h:

```

8      Track number (fixed, must be 00h=Lead-in)
8      POINT = C0h (Identifies a Multisession disc, together with POINT=B0h)
24     ATIP values from Special Information 1, ID=101
8      Reserved (must be 00h)
24     MM:SS:FF = Start time of the first Lead-in area of the disc

```

And, optionally, when Point=C1h:

```

8      Track number (fixed, must be 00h=Lead-in)
8      POINT=C1h
8x7    Copy of information from A1 point in ATIP

```

Subchannel Q with ADR=5 in Lead-Out -- Multisession Lead-Out Info

```

8      Track number (fixed, must be AAh=Lead-out)
8      POINT = D1h (Identifies a Multisession lead-out)
24     Usually zero (or maybe ATIP as in Lead-In with Point=C0h...?)
8      Seems to be the session number?
24     MM:SS:FF = Absolute address of the First data sector of the session

```

Present in 3 consecutive sectors (3x ADR=1, 3x ADR=5, 3x ADR=1, 3x ADR=5, etc).

Subchannel Q with ADR=5 in Lead-in -- CDR/CDRW Skip Info (Audio Only)

When Point=01h..40h:

```

8      Track number (fixed, must be 00h=Lead-in)
8      POINT=01h..40h (This identifies a specific playback skip interval)
24     MM:SS:FF Skip interval stop time in 6 BCD digits
8      Reserved (must be 00h)
24     MM:SS:FF Skip interval start time in 6 BCD digits

```

When Point=B1h:

```

8      Track number (fixed, must be 00h=Lead-in)
8      POINT=B1h (Audio only: This identifies the presence of skip intervals)
8x4    Reserved (must be 00h,00h,00h,00h)
8      the number of skip interval pointers in POINT=01h..40h
8      the number of skip track assignments in POINT=B2h..B4h
8      Reserved (must be 00h)

```

When Point=B2h,B3h,B4h:

```

8   Track number (fixed, must be 00h=Lead-in)
8   POINT=B2h,B3h,B4h (This identifies tracks that should be skipped)
8   1st Track number to skip upon playback (01h..99h, must be nonzero)
8   2nd Track number to skip upon playback (01h..99h, or 00h=None)
8   3rd Track number to skip upon playback (01h..99h, or 00h=None)
8   Reserved (must be 00h)... unclear... OR... 4th (of 7) skip info's...?
8   4th Track number to skip upon playback (01h..99h, or 00h=None)
8   5th Track number to skip upon playback (01h..99h, or 00h=None)
8   6th Track number to skip upon playback (01h..99h, or 00h=None)

```

Note: Skip intervals are seldom written by recorders and typically ignored by readers.

Subchannel R..W

Subchannels R..W are usually unused, except for some extended formats:

```

CD-TEXT in the Lead-In area (see below)
CD-TEXT in the Data area      (rarely used)
CD plus Graphics (CD+G)       (rarely used)

```

Most CDROM drives do not allow to read these subchannels. CD-TEXT was designed by Sony and Philips in 1997, so it should be found only on (some) newer discs. Most CD/DVD players don't support it (the only exception is that CD-TEXT seems to be popular for car hifi equipment). Most record labels don't support CD-TEXT, even Sony seems to have discontinued it on their own records after some years (so CD-TEXT is very rare on original disks, however, CDR software does often allow to write CD-TEXT on CDRs).

Subchannel R..W, when used for CD-TEXT in the Lead-In area

CD-TEXT is stored in the six Subchannels R..W. Of the 12.25 bytes (98 bits) per subchannel, only 12 bytes are used. Together, all 6 subchannels have a capacity of 72 bytes (6x12 bytes) per sector. These 72 bytes are divided into four CD-TEXT fragments (of 18 bytes each). The format of these 18 bytes is:

```

00h 1  Header Field ID1: Pack Type Indicator
01h 1  Header Field ID2: Track Number
02h 1  Header Field ID3: Sequence Number
03h 1  Header Field ID4: Block Number and Character Position Indicator
04h 12 Text/Data Field
10h 2  CRC-16-CCITT (big-endian) (across bytes 00h..0Fh)

```

ID1 - Pack Type Indicator:

80h	Titel	(TEXT)	
81h	Performer	(TEXT)	
82h	Songwriter	(TEXT)	
83h	Composer	(TEXT)	
84h	Arranger	(TEXT)	
85h	Message	(TEXT)	
86h	Disc ID	(TEXT?)	(content/format/purpose unknown?)
87h	Genre	(BINARY)	(ID codes unknown?)
88h	TOC	(BINARY)	(content/format/purpose unknown?)
89h	TOC2	(BINARY)	(content/format/purpose unknown?)
8Ah	Reserved for future		
8Bh	Reserved for future		
8Ch	Reserved for future		
8Dh	Reserved for "content provider" aka "closed information"		
8Eh	UPC/EAN and ISRC Codes	(TEXT)	(content/format/purpose unknown?)
8Fh	Blocksize	(BINARY)	(see below)

ID2 - Track Number:

00h	Title/Performer/etc. for the Disc
01h..63h	Title/Performer/etc. for Track 1..99 (Non-BCD) (Bit7=Extension)

ID3 - Sequence Number:

00h..FFh	Incrementing Number (00h=First 18-byte fragment, 01h=Second, etc.)
----------	--

ID4 - Block Number and Character Position Indicator:

Bit7	Character Set	(0=8bit, 1=16bit)
Bit6-4	Block Number	(0..7 = Language number, as set by "Blocksize")
Bit3-0	Character Position	(0..0Eh=Position, 0Fh=Append to prev fragment)

Example Data (generated with CDRWIN):

```

ID TR SQ CH <-----Text/Data-----> -CRC- <---Text--->
80 00 00 00 54 65 73 74 44 69 73 6B 54 69 74 6C E2 22 TestDiskTitl
80 00 01 0C 65 00 54 65 73 74 54 72 61 63 6B 54 C9 1B e.TestTrackT
80 01 02 0A 69 74 6C 65 31 00 54 65 73 74 54 72 40 3A itle1.TestTr
80 02 03 06 61 63 6B 54 69 74 6C 65 32 00 00 00 80 E3 ackTitle2...
81 00 04 00 54 65 73 74 44 69 73 6B 50 65 72 66 03 DF TestDiskPerf
81 00 05 0C 6F 72 6D 65 72 00 54 65 73 74 54 72 12 A5 ormer.TestTr
81 01 06 06 61 63 6B 50 65 72 66 6F 72 6D 65 72 BC 5B ackPerformer
81 01 07 0F 31 00 54 65 73 74 54 72 61 63 6B 50 AC 41 1.TestTrackP
81 02 08 0A 65 72 66 6F 72 6D 65 72 32 00 00 00 64 1A erformer2...
8F 00 09 00 01 01 02 00 04 05 00 00 00 00 00 00 6D E2 .....
8F 01 0A 00 00 00 00 00 00 00 00 03 0B 00 00 00 CD 0C .....
8F 02 0B 00 00 00 00 00 09 00 00 00 00 00 00 00 FC 8C .....
00 ;<--- for some reason, CDRWIN stores an ending 00h byte in .CDT files

```

Each Text string is terminated by a 00h byte (or 0000h for 16bit character set). If there's still room in the 12-byte data region, then first characters for the next Text string (for the next track) are appended after the 00h byte (if there's no further track, then the remaining bytes should be padded with 00h).

The "Blocksize" (ID1=8Fh) consists of three packs with 24h bytes of data (first 0Ch bytes stored with ID2=00h, next 0Ch bytes with ID2=01h, and last 0Ch bytes with ID2=02h):

```

00h 1 Character set (00h,01h,80h,81h,82h = see below)
01h 1 First track number (usually/always 01h)
02h 1 Last track number (01h..63h)
03h 1 1bit-cd-text-in-data-area-flag, 7bit-copy-protection-flags
04h 16 Number of 18-byte packs for ID1=80h..8Fh
14h 8 Last sequence number of block 0..7 (or 00h=none)
1Ch 8 Language codes for block 0..7 (definitions are unknown)

```

Character Set values (for ID1=8Fh, ID2=00h, DATA[0]=charset):

```

00h ISO 8859-1
01h ISO 646, ASCII
80h MS-JIS
81h Korean character code
82h Mandarin (standard) Chinese character code
Other = reserved

```

"In case the same character strings is used for consecutive tracks, character 09h (or 0909h for 16bit charset) may be used to indicate the same as previous track. It shall not be used for the first track."

adjust_crc_16_ccitt(addr,len) ;for CD-TEXT and Subchannel Q

```

lsb=00h, msb=00h      ; -initial value (zero for both CD-TEXT and Sub-Q)
for i=0 to len-1      ; -len (10h for CD-TEXT, 0Ah for Sub-Q)
  x = [addr+i] xor msb
  x = x xor (x shr 4)
  msb = lsb xor (x shr 3) xor (x shl 4)
  lsb = x xor (x shl 5)
next i
[addr+len+0]=msb xor FFh, [addr+len+1]=lsb xor FFh  ;inverted / big-endian

```

12.3 CDROM Sector Encoding

Audio

```
000h 930h Audio Data (2352 bytes) (LeftLsb,LeftMsb,RightLsb,RightMsb)
```

Mode0 (Empty)

```
000h 0Ch Sync (00h,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,00h)
00Ch 4 Header (Minute,Second,Sector,Mode=00h)
010h 920h Zerofilled
```

Mode1 (Original CDROM)

```
000h 0Ch Sync (00h,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,00h)
00Ch 4 Header (Minute,Second,Sector,Mode=01h)
010h 800h Data (2048 bytes)
810h 4 EDC (checksum across [000h..80Fh])
814h 8 Zerofilled
81Ch 114h ECC (error correction codes)
```

Mode2/Form1 (CD-XA)

```
000h 0Ch Sync (00h,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,00h)
00Ch 4 Header (Minute,Second,Sector,Mode=02h)
010h 4 Sub-Header (File, Channel, Submode AND DFh, Codinginfo)
014h 4 Copy of Sub-Header
018h 800h Data (2048 bytes)
818h 4 EDC (checksum across [010h..817h])
81Ch 114h ECC (error correction codes)
```

Mode2/Form2 (CD-XA)

```
000h 0Ch Sync (00h,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,00h)
00Ch 4 Header (Minute,Second,Sector,Mode=02h)
010h 4 Sub-Header (File, Channel, Submode OR 20h, Codinginfo)
014h 4 Copy of Sub-Header
018h 914h Data (2324 bytes)
92Ch 4 EDC (checksum across [010h..92Bh]) (or 00000000h if no EDC)
```

encode_sector

```
sector[000h]=00h,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh,00h
sector[00ch]=bcd(adr/75/60) ;0..7x
sector[00dh]=bcd(adr/75 MOD 60) ;0..59
sector[00eh]=bcd(adr MOD 75) ;0..74
sector[00fh]=mode
if mode=00h then
    sector[010h..92Fh]=zerofilled
```

```

if mode=01h then
    adjust_edc(sector+0, 800h+10h)
    sector[814h..817h]=00h,00h,00h,00h,00h,00h,00h,00h
    calc_p_parity(sector)
    calc_q_parity(sector)
if mode=02h and form=1
    sector[012h]=sector[012h] AND (NOT 20h) ;indicate not form2
    sector[014h..017h]=sector[010h..013h] ;copy of sub-header
    adjust_edc(sector+10h,800h+8)
    push sector[00ch] ;\temporarily clear header
    sector[00ch]=00000000h ;/
    calc_p_parity(sector)
    calc_q_parity(sector)
    pop sector[00ch] ;-restore header
if mode=02h and form=2
    sector[012h]=sector[012h] OR 20h ;indicate form2
    sector[014h..017h]=sector[010h..013h] ;copy of sub-header
    adjust_edc(sector+10h,914h+8) ;edc is optional for form2

```

calc_parity(sector,offs,len,j0,step1,step2)

```

src=00ch, dst=81ch+offs, srcmax=dst
for i=0 to len-1
    base=src, x=0000h, y=0000h
    for j=j0 to 42
        x=x xor GF8_PRODUCT[j,sector[src+0]]
        y=y xor GF8_PRODUCT[j,sector[src+1]]
        src=src+step1, if (step1=2*44) and (src>=srcmax) then src=src-2*1118
    sector[dst+2*len+0]=x AND 0FFh, [dst+0]=x SHR 8
    sector[dst+2*len+1]=y AND 0FFh, [dst+1]=y SHR 8
    dst=dst+2, src=base+step2

```

calc_p_parity(sector) = calc_parity(sector,0,43,19,2*43,2)

calc_q_parity(sector) = calc_parity(sector,43*4,26,0,2*44,2*43)

adjust_edc(addr,len)

```

x=00000000h
for i=0 to len-1
    x=x xor byte[addr+i], x=(x shr 8) xor edc_table[x and FFh]
word[addr+len]=x ;append EDC value (little endian)

```

init_tables

```

for i=0 to FFh
    x=i, for j=0 to 7, x=x shr 1, if carry then x=x xor D8018001h
    edc_table[i]=x
GF8_LOG[00h]=00h, GF8_ILOG[FFh]=00h, x=01h

```

```

for i=00h to FEh
  GF8_LOG[x]=i, GF8_ILOG[i]=x
  x=x SHL 1, if carry8bit then x=x xor 1dh
for j=0 to 42
  xx=GF8_ILOG[44-j], yy=subfunc(xx xor 1,19h)
  xx=subfunc(xx,01h), xx=subfunc(xx xor 1,18h)
  xx=GF8_LOG[xx], yy = GF8_LOG[yy]
  GF8_PRODUCT[j,0]=0000h
  for i=01h to FFh
    x=xx+GF8_LOG[i], if x>=255 then x=x-255
    y=yy+GF8_LOG[i], if y>=255 then y=y-255
    GF8_PRODUCT[j,i]=GF8_ILOG[x]+(GF8_ILOG[y] shl 8)

```

subfunc(a,b)

```

if a>0 then
  a=GF8_LOG[a]-b, if a<0 then a=a+255
  a=GF8_ILOG[a]
return(a)

```

12.4 CDROM Scrambling

Scrambling

Scrambling does XOR the data sectors with random values (done to avoid regular patterns). The scrambling is applied to Data sector bytes[00Ch..92Fh] (not to CD-DA audio sectors, and not to the leading 12-byte Sync mark in Data sectors).

The (de-)scrambling is done automatically by the CDROM controller, so disc images should usually contain unscrambled data (there are some exceptions such like CD-i discs that have audio and data sectors mixed inside of the same track; which may confuse the CDROM controller about whether or not to apply scrambling to which sectors; so one may need to manually XOR the faulty sectors in the disc image).

The scrambling pattern is derived from a 15bit polynomial counter (much like a noise generator in sound chips). The data bits are XORed with the counters low bit, and the counters lower 2bit are XORed with each other, and shifted in to the counters upper bit. To compute 8 bits and once, and store them in a 924h-byte table:

```

poly=0001h ;init 15bit polynomial counter
for i=0 to 924h-1
  scramble_table[i]=poly AND FFh
  poly=((poly XOR poly/2) AND 0FFh)*80h) XOR (poly/100h)
next i

```


The resulting table content should be:

```
01h, 80h, 00h, 60h, 00h, 28h, 00h, 1Eh, 80h, 08h, 60h, 06h, A8h, 02h, FEh, 81h,
80h, 60h, 60h, 28h, 28h, 1Eh, 9Eh, 88h, 68h, 66h, AEh, AAh, FCh, 7Fh, 01h, E0h,
etc.
```

After scrambling, the data is reportedly "shuffled and byte-swapped". Unknown what shuffling means. And unknown what/where/why byte-swapping is done (it does reportedly swap each two bytes in the whole(?) 930h-byte (data-?) sector; which might date back to different conventions for disc images to contain "16bit audio samples" in big- or little-endian format).

12.5 CDROM XA Subheader, File, Channel, Interleave

The Sub-Header for normal data sectors is usually 00h,00h,08h,00h (some PSX sectors have 09h instead 08h, indicating the end of "something" or so?

1st Subheader byte - File Number (FN)

```
0-7 File Number      (00h..FFh) (for Audio/Video Interleave, see below)
```

2nd Subheader byte - Channel Number (CN)

```
0-4 Channel Number (00h..1Fh) (for Audio/Video Interleave, see below)
5-7 Should be always zero
```

Whilst not officially allowed, PSX Ace Combat 3 Electrosphere does use Channel=FFh for unused gaps in interleaved streaming sectors.

3rd Subheader byte - Submode (SM)

```
0 End of Record (EOR) (all Volume Descriptors, and all sectors with EOF)
1 Video      ;\Sector Type (usually ONE of these bits should be set)
2 Audio      ; Note: PSX .STR files are declared as Data (not as Video)
3 Data       ;/
4 Trigger          (for application use)
5 Form2           (0=Form1/800h-byte data, 1=Form2, 914h-byte data)
6 Real Time (RT)
7 End of File (EOF) (or end of Directory/PathTable/VolumeTerminator)
```

The EOR bit is set in all Volume Descriptor sectors, the last sector (ie. the Volume Descriptor Terminator) additionally has the EOF bit set. Moreover, EOR and EOF are set in

the last sector of each Path Table, and last sector of each Directory, and last sector of each File.

4th Subheader byte - Codinginfo (CI)

When used for Data sectors:

```
0-7 Reserved (00h)
```

When used for XA-ADPCM audio sectors:

```
0-1 Mono/Stereo      (0=Mono, 1=Stereo, 2-3=Reserved)
2-2 Sample Rate      (0=37800Hz, 1=18900Hz, 2-3=Reserved)
4-5 Bits per Sample  (0=Normal/4bit, 1=8bit, 2-3=Reserved)
6   Emphasis         (0=Normal/Off, 1=Emphasis)
7   Reserved         (0)
```

Audio/Video Interleave (Multiple Files/Channels)

The CDROM drive mechanics are working best when continuously following the data spiral on the disk, that works fine for uncompressed Audio Data at normal speed, but compressed Audio Data the disk is spinning much too fast. To avoid the drive to need to pause reading or to do permanent backwards seeking, CD-XA allows to store data interleaved in separate files/channels. With common interleave values like so:

```
Interleave  Data Format
1/1 (none)  44100Hz Stereo CD Audio at normal speed
1/8         37800Hz Stereo ADPCM compressed Audio at double speed
1/16        18900Hz Stereo ADPCM compressed Audio at double speed
1/16        37800Hz Mono   ADPCM compressed Audio at double speed
1/32        18900Hz Mono   ADPCM compressed Audio at double speed
7/8         15fps 320x224 pixel MDEC compressed Videos at double speed
Unknown if 1/16 and 1/32 interleaves are actually possible (the PSX cdrom
controller seems to overwrite the IC303 sector buffer entries once every
eight sectors, so ADPCM data may get destroyed on interleaves above 1/8).
(Crash Team Racing uses 37800Hz Mono at Double speed, so 1/16 must work).
```

For example, 1/8 means that the controller processes only each 8th sector (each having the same File Number and Channel Number), and ignores the next 7 sectors (which must have other File Number and/or other Channel Number). There are various ways to arrange multiple files or channels, for example,

```
one file with eight 1/8 audio channels
one file with one 1/8 audio channels, plus one 7/8 video channel (*)
one file with one 1/8 audio channels, plus 7 unused channels
```

```
eight different files with one 1/8 audio channel each
etc.
```

(*) If the Audio and Video data belongs together then both should use the SAME channel.
 Note: Above interleave values are assuming that PSX Game Disks are always running at double speed (that's fastest for normal data files, and ADPCM files are usually using the same speed; otherwise it'd be necessary to change the drive speed everytime when switching between Data to ADPCM modes).

Note: The file/channel numbers can be somehow selected with the Setfilter command. No idea if the controller is automatically switching to the next channel or so when reaching the end of the file?

Unused sectors in Interleave

There are different ways to mark unused sectors in interleaved streams. Ace Combat 3 uses Channel=FFh=Invalid. Tron Bonne uses Submode=00h=Nothing (notably, that game has a 74Mbyte XA file that leaves about 75% unused).

```
Subheader bytes: 01h,FFh,64h,01h ;Ace Combat 3 Electrosphere
Subheader bytes: 01h,00h,00h,00h ;Misadventures of Tron Bonne (XA\*.XA)
```

Real Time Streaming

With the above Interleave, files can be played continuously at real time - that, unless read-errors do occur. In that case the drive controller would usually perform time-consuming error-correction and/or read-retries. For video/audio streaming the resulting delay would be tendencially more annoying as than processing or skipping the incorrect data.

In such cases the drive controller is allowed to ignore read errors; that probably on sectors that have the Real Time (RT) flag set in their subheaders. The controller is probably doing some read-ahead buffering (so, if it has buffered enough data, then it may still perform read retries and/or error correction, as long as it doesn't affect real time playback).

12.6 CDROM XA Audio ADPCM Compression

CD-ROM XA ADPCM is used for Audio data compression. Each 16bit sample is encoded in 4bit nibbles; so the compression rate is almost 1:4 (only almost 1:4 because there are

16 header bytes within each 128-byte portion). The data is usually/always stored on 914h-byte sectors (without error correction).

Subheader

The Subheader (see previous chapter) contains important info for ADPCM: The file/channel numbers for Interleaved data, and the codinginfo flags: mono/stereo flag, 37800Hz/18900Hz sampling rate, 4bit/8bit format, and emphasis.

ADPCM Sectors

Each sector consists of 12h 128-byte portions (=900h bytes) (the remaining 14h bytes of the sectors 914h-byte data region are 00h filled).

The separate 128-byte portions consist of a 16-byte header,

```
00h..03h  Copy of below 4 bytes (at 04h..07h)
04h       Header for 1st Block/Mono, or 1st Block/Left
05h       Header for 2nd Block/Mono, or 1st Block/Right
06h       Header for 3rd Block/Mono, or 2nd Block/Left
07h       Header for 4th Block/Mono, or 2nd Block/Right
08h       Header for 5th Block/Mono, or 3rd Block/Left ; \unknown/unused
09h       Header for 6th Block/Mono, or 3rd Block/Right ; for 8bit ADPCM
0Ah       Header for 7th Block/Mono, or 4th Block/Left ; (maybe 0, or maybe
0Bh       Header for 8th Block/Mono, or 4th Block/Right ; /copy of above)
0Ch..0Fh  Copy of above 4 bytes (at 08h..0Bh)
```

followed by twentyeight data words (4x28-bytes),

```
10h..13h  1st Data Word (packed 1st samples for 2-8 blocks)
14h..17h  2nd Data Word (packed 2nd samples for 2-8 blocks)
18h..1Bh  3rd Data Word (packed 3rd samples for 2-8 blocks)
...       Nth Data Word (packed Nth samples for 2-8 blocks)
7Ch..7Fh  28th Data Word (packed 28th samples for 2-8 blocks)
```

and then followed by the next 128-byte portion.

The "Copy" bytes are allowing to repair faulty headers (ie. if the CDROM controller has sensed a read-error in the header then it can eventually replace it by the copy of the header).

XA-ADPCM Header Bytes

```
0-3  Shift  (0..12) (0=Loudest) (13..15=Reserved/Same as 9)
4-5  Filter (0..3) (only four filters, unlike SPU-ADPCM which has five)
6-7  Unused (should be 0)
```

Note: The 4bit (or 8bit) samples are expanded to 16bit by left-shifting them by 12 (or 8), that 16bit value is then right-shifted by the selected 'shift' amount. For 8bit ADPCM shift should be 0..8 (values 9..12 will cut-off the LSB(s) of the 8bit value, this works, but isn't useful). For both 4bit and 8bit ADPCM, reserved shift values 13..15 will act same as shift=9).

XA-ADPCM Data Words (32bit, little endian)

```

0-3   Nibble for 1st Block/Mono, or 1st Block/Left   (-8h..+7h)
4-7   Nibble for 2nd Block/Mono, or 1st Block/Right (-8h..+7h)
8-11  Nibble for 3rd Block/Mono, or 2nd Block/Left   (-8h..+7h)
12-15 Nibble for 4th Block/Mono, or 2nd Block/Right (-8h..+7h)
16-19 Nibble for 5th Block/Mono, or 3rd Block/Left   (-8h..+7h)
20-23 Nibble for 6th Block/Mono, or 3rd Block/Right (-8h..+7h)
24-27 Nibble for 7th Block/Mono, or 4th Block/Left   (-8h..+7h)
28-31 Nibble for 8th Block/Mono, or 4th Block/Right (-8h..+7h)

```

or, for 8bit ADPCM format:

```

0-7   Byte for 1st Block/Mono, or 1st Block/Left     (-80h..+7Fh)
8-15  Byte for 2nd Block/Mono, or 1st Block/Right    (-80h..+7Fh)
16-23 Byte for 3rd Block/Mono, or 2nd Block/Left     (-80h..+7Fh)
24-31 Byte for 4th Block/Mono, or 2nd Block/Right    (-80h..+7Fh)

```

decode_sector(src)

```

src=src+12+4+8    ;skip sync,header,subheader
for i=0 to 11h
  for blk=0 to 3
    IF stereo ;left-samples (LO-nibbles), plus right-samples (HI-nibbles)
      decode_28_nibbles(src,blk,0,dst_left,old_left,older_left)
      decode_28_nibbles(src,blk,1,dst_right,old_right,older_right)
    ELSE      ;first 28 samples (LO-nibbles), plus next 28 samples (HI-nibbles)
      decode_28_nibbles(src,blk,0,dst_mono,old_mono,older_mono)
      decode_28_nibbles(src,blk,1,dst_mono,old_mono,older_mono)
    ENDIF
  next blk
  src=src+128
next i
src=src+14h+4     ;skip padding,edc

```

decode_28_nibbles(src,blk,nibble,dst,old,older)

```

shift  = 12 - (src[4+blk*2+nibble] AND 0Fh)
filter =      (src[4+blk*2+nibble] AND 30h) SHR 4
f0 = pos_xa_adpcm_table[filter]

```

```

f1 = neg_xa_adpcm_table[filter]
for j=0 to 27
  t = signed4bit((src[16+blk+j*4] SHR (nibble*4)) AND 0Fh)
  s = (t SHL shift) + ((old*f0 + older*f1+32)/64);
  s = MinMax(s,-8000h,+7FFFh)
  halfword[dst]=s, dst=dst+2, older=old, old=s
next j

```

Pos/neg Tables

```

pos_xa_adpcm_table[0..4] = (0, +60, +115, +98, +122)
neg_xa_adpcm_table[0..4] = (0, 0, -52, -55, -60)

```

Note: XA-ADPCM supports only four filters (0..3), unlike SPU-ADPCM which supports five filters (0..4).

Old/Older Values

The incoming old/older values are usually that from the previous part, or garbage (in case of decoding errors in the previous part), or whatever (in case there was no previous part) (ie. maybe zero on power-up?) (and maybe there's also a way to reset the values to zero at the begin of a new file, or *maybe* it's silently done automatically when issuing seek commands?).

25-point Zigzag Interpolation

The CDROM decoder is applying some weird 25-point zigzag interpolation when resampling the 37800Hz XA-ADPCM output to 44100Hz. This part is different from SPU-ADPCM (which uses 4-point gaussian pitch interpolations). For example, XA-ADPCM interpolation applied to a square wave looks like this:



The zigzagging does produce some (inaudible) 22050Hz noise, and does produce some low-pass (?) filtering ("sinc filter"). The effect can be reproduced somewhat like so:

```
<B> Output37800Hz(sample):</B>
ringbuf[p AND 1Fh]=sample, p=p+1, sixstep=sixstep-1
if sixstep=0
    sixstep=6
    Ouput44100Hz(ZigZagInterpolate(p,Table1))
    Ouput44100Hz(ZigZagInterpolate(p,Table2))
    Ouput44100Hz(ZigZagInterpolate(p,Table3))
    Ouput44100Hz(ZigZagInterpolate(p,Table4))
    Ouput44100Hz(ZigZagInterpolate(p,Table5))
    Ouput44100Hz(ZigZagInterpolate(p,Table6))
    Ouput44100Hz(ZigZagInterpolate(p,Table7))
endif
<B> ZigZagInterpolate(p,TableX):</B>
sum=0
for i=1 to 29, sum=sum+(ringbuf[(p-i) AND 1Fh]*TableX[i])/8000h, next i
return MinMax(sum,-8000h,+7FFFh)
<B> Table1, Table2, Table3, Table4, Table5, Table6, Table7 ;Index</B>
0      , 0      , 0      , 0      , -0001h, +0002h, -0005h ;1
0      , 0      , 0      , -0001h, +0003h, -0008h, +0011h ;2
0      , 0      , -0001h, +0003h, -0008h, +0010h, -0023h ;3
0      , -0002h, +0003h, -0008h, +0011h, -0023h, +0046h ;4
0      , 0      , -0002h, +0006h, -0010h, +002Bh, -0017h ;5
-0002h, +0003h, -0005h, +0005h, +000Ah, +001Ah, -0044h ;6
+000Ah, -0013h, +001Fh, -001Bh, +006Bh, -00EBh, +015Bh ;7
-0022h, +003Ch, -004Ah, +00A6h, -016Dh, +027Bh, -0347h ;8
+0041h, -004Bh, +00B3h, -01A8h, +0350h, -0548h, +080Eh ;9
-0054h, +00A2h, -0192h, +0372h, -0623h, +0AFAh, -1249h ;10
+0034h, -00E3h, +02B1h, -05BFh, +0BCDh, -16FAh, +3C07h ;11
+0009h, +0132h, -039Eh, +09B8h, -1780h, +53E0h, +53E0h ;12
-010Ah, -0043h, +04F8h, -11B4h, +6794h, +3C07h, -16FAh ;13
+0400h, -0267h, -05A6h, +74BBh, +234Ch, -1249h, +0AFAh ;14
-0A78h, +0C9Dh, +7939h, +0C9Dh, -0A78h, +080Eh, -0548h ;15
+234Ch, +74BBh, -05A6h, -0267h, +0400h, -0347h, +027Bh ;16
+6794h, -11B4h, +04F8h, -0043h, -010Ah, +015Bh, -00EBh ;17
-1780h, +09B8h, -039Eh, +0132h, +0009h, -0044h, +001Ah ;18
+0BCDh, -05BFh, +02B1h, -00E3h, +0034h, -0017h, +002Bh ;19
-0623h, +0372h, -0192h, +00A2h, -0054h, +0046h, -0023h ;20
+0350h, -01A8h, +00B3h, -004Bh, +0041h, -0023h, +0010h ;21
-016Dh, +00A6h, -004Ah, +003Ch, -0022h, +0011h, -0008h ;22
+006Bh, -001Bh, +001Fh, -0013h, +000Ah, -0005h, +0002h ;23
+000Ah, +0005h, -0005h, +0003h, -0001h, 0      , 0      ;24
-0010h, +0006h, -0002h, 0      , 0      , 0      , 0      ;25
+0011h, -0008h, +0003h, -0002h, +0001h, 0      , 0      ;26
-0008h, +0003h, -0001h, 0      , 0      , 0      , 0      ;27
+0003h, -0001h, 0      , 0      , 0      , 0      , 0      ;28
-0001h, 0      , 0      , 0      , 0      , 0      , 0      ;29
```

The above formula/table gives nearly correct results, but with small rounding errors in some cases - possibly due to actual rounding issues, or due to factors with bigger

fractional portions, or due to a completely different formula...

Probably, the hardware does actually do the above stuff in two steps: first, applying a zig-zag filter (with only around 21-points) to the 37800Hz output, and then doing 44100Hz interpolation (2-point linear or 4-point gaussian or whatever) in a second step.

That two-step theory would also match well for 18900Hz resampling (which has lower-pitch zigzag, and gets spread across about fifty 44100Hz samples).

XA-ADPCM Emphasis

With XA-Emphasis enabled in Sub-header, output will appear as so:



The exact XA-Emphasis formula is unknown (maybe it's just same as for CD-DA's SUBQ emphasis). Additionally, zig-zag interpolation is applied (somewhere before or after applying the emphasis stuff).

Note: The Emphasis feature isn't used by any known PSX games.

Uninitialized Six-step Counter

The hardware does contain some six-step counter (for interpolating 37800Hz to 44100Hz, ie. to insert one extra sample after each six samples). The 900h-byte sectors contain a multiple of six samples, so the counter will be always same before & after playing a sector. However, the initial counter value on power-up is uninitialized random (and the counter will fallback to that initial random setting after each 900h-byte sector).

RIFF Headers (on PCs)

When reading files that consist of 914h-byte sectors on a PC, the PC seems to automatically insert a 2Ch-byte RIFF fileheader. Like so, for ADPCM audio files:

```
00h 4  "RIFF"
04h 4  Total Filesize (minus 8)
08h 8  "CDXAfmt "
10h 4  Size of below stuff (10h)
14h 14 Stuff (looks like the "LEN_SU" region from XA-Directory Record)
22h 2  Zero (probably just dummy padding for 32bit alignment)
```



```

24h 4    "data"
28h 4    Size of following data (usually N*930h)

```

That RIFF stuff isn't stored on the CDROM (at least not in the file area) (however, some of that info, like the "=UXA" stuff, is stored in the directory area of the CDROM).

After the RIFF header, the normal sector data is appended, that, with the full 930h bytes per sector (ie. the 914h data bytes preceded by sync bytes, header, subheader, and followed by the EDC value).

The Channel Interleave doesn't seem to be resolved, ie. the Channels are kept arranged as how they are stored on the CDROM. However, File Interleave \<should> be resolved, ie. other Files that "overlap" the file shouldn't be included in the file.

12.7 CDROM ISO Volume Descriptors

System Area (prior to Volume Descriptors)

The first 16 sectors on the first track are the system area, for a Playstation disk, it contains the following:

```

Sector 0..3    - Zerofilled (Mode2/Form1, 4x800h bytes, plus ECC/EDC)
Sector 4       - Licence String
Sector 5..11   - Playstation Logo (3278h bytes) (remaining bytes FFh-filled)
Sector 12..15  - Zerofilled (Mode2/Form2, 4x914h bytes, plus EDC)

```

Of which, the Licence String in sector 4 is,

```

000h 32      Line 1      ("          Licensed by          ")
020h 32+6    Line 2 (EU) ("Sony Computer Entertainment Euro", " pe  ") ;\either
020h 32+1    Line 2 (JP) ("Sony Computer Entertainment Inc.",0Ah)      ; one of
020h 32+6    Line 2 (US) ("Sony Computer Entertainment Amer", " ica ") ;/these
041h 1983    Empty (JP)   (filled by repeating pattern 62x30h,1x0Ah, 1x30h)
046h 1978    Empty (EU/US) (filled by 00h-bytes)

```

The Playstation Logo in sectors 5..11 contains data like so,

```

0000h ..    41h,00h,00h,00h,00h,00h,00h,00h,01h,00h,00h,00h,1Ch,23h,00h,00h
0010h ..    51h,01h,00h,00h,A4h,2Dh,00h,00h,99h,00h,00h,00h,1Ch,00h,00h,00h
0020h ..    ...
3278h 588h  FF-filled (remaining bytes on sector 11)

```

the Logo contains a .TMD header, polygons, vertices and normals for the "PS" logo (which is displayed when booting from CDROM). Some BIOS versions are comparing these 3278h bytes against an identical copy in ROM, and refuse to boot if the data isn't 1:1 the same:

- NTSC US/ASIA BIOS always accepts changed logos.
 - PAL EU BIOS accepts changed logos up to v3.0E (and refuses in v4.0E and up).
 - NTSC JP BIOS never accepts changed logos (and/or changed license strings?).
- Note: A region-patch-modchip causes PAL BIOS to behave same as US/ASIA BIOS.

Volume Descriptors (Sector 16 and up)

Playstation disks usually have only two Volume Descriptors,

```
Sector 16    - Primary Volume Descriptor
Sector 17    - Volume Descriptor Set Terminator
```

Primary Volume Descriptor (sector 16 on PSX disks)

000h 1	Volume Descriptor Type	(01h=Primary Volume Descriptor)
001h 5	Standard Identifier	("CD001")
006h 1	Volume Descriptor Version	(01h=Standard)
007h 1	Reserved	(00h)
008h 32	System Identifier	(a-characters) ("PLAYSTATION")
028h 32	Volume Identifier	(d-characters) (max 8 chars for PSX?)
048h 8	Reserved	(00h)
050h 8	Volume Space Size	(2x32bit, number of logical blocks)
058h 32	Reserved	(00h)
078h 4	Volume Set Size	(2x16bit) (usually 0001h)
07Ch 4	Volume Sequence Number	(2x16bit) (usually 0001h)
080h 4	Logical Block Size in Bytes	(2x16bit) (usually 0800h) (1 sector)
084h 8	Path Table Size in Bytes	(2x32bit) (max 800h for PSX)
08Ch 4	Path Table 1 Block Number	(32bit little-endian)
090h 4	Path Table 2 Block Number	(32bit little-endian) (or 0=None)
094h 4	Path Table 3 Block Number	(32bit big-endian)
098h 4	Path Table 4 Block Number	(32bit big-endian) (or 0=None)
09Ch 34	Root Directory Record	(see next chapter)
0BEh 128	Volume Set Identifier	(d-characters) (usually empty)
13Eh 128	Publisher Identifier	(a-characters) (company name)
1BEh 128	Data Preparer Identifier	(a-characters) (empty or other)
23Eh 128	Application Identifier	(a-characters) ("PLAYSTATION")
2BEh 37	Copyright Filename	("FILENAME.EXT;VER") (empty or text)
2E3h 37	Abstract Filename	("FILENAME.EXT;VER") (empty)
308h 37	Bibliographic Filename	("FILENAME.EXT;VER") (empty)
32Dh 17	Volume Creation Timestamp	("YYYYMMDDHHMMSSFF", timezone)
33Eh 17	Volume Modification Timestamp	("0000000000000000", 00h)
34Fh 17	Volume Expiration Timestamp	("0000000000000000", 00h)
360h 17	Volume Effective Timestamp	("0000000000000000", 00h)
371h 1	File Structure Version	(01h=Standard)
372h 1	Reserved for future	(00h-filled)
373h 141	Application Use Area	(00h-filled for PSX and VCD)
400h 8	CD-XA Identifying Signature	("CD-XA001" for PSX and VCD)
408h 2	CD-XA Flags (unknown purpose)	(00h-filled for PSX and VCD)
40Ah 8	CD-XA Startup Directory	(00h-filled for PSX and VCD)

412h 8	CD-XA Reserved	(00h-filled for PSX and VCD)
41Ah 345	Application Use Area	(00h-filled for PSX and VCD)
573h 653	Reserved for future	(00h-filled)

Volume Descriptor Set Terminator (sector 17 on PSX disks)

000h 1	Volume Descriptor Type	(FFh=Terminator)
001h 5	Standard Identifier	("CD001")
006h 1	Terminator Version	(01h=Standard)
007h 2041	Reserved	(00h-filled)

Boot Record (none such on PSX disks)

000h 1	Volume Descriptor Type	(00h=Boot Record)
001h 5	Standard Identifier	("CD001")
006h 1	Boot Record Version	(01h=Standard)
007h 32	Boot System Identifier	(a-characters)
027h 32	Boot Identifier	(a-characters)
047h 1977	Boot System Use	(not specified content)

Supplementary Volume Descriptor (none such on PSX disks)

000h 1	Volume Descriptor Type	(02h=Supplementary Volume Descriptor)
001h ..	Same as for Primary Volume Descriptor	(see there)
007h 1	Volume Flags	(8bit)
008h ..	Same as for Primary Volume Descriptor	(see there)
058h 32	Escape Sequences	(32 bytes)
078h ..	Same as for Primary Volume Descriptor	(see there)

In practice, this is used for Joliet:

CDROM Extension Joliet

Volume Partition Descriptor (none such on PSX disks)

000h 1	Volume Descriptor Type	(03h=Volume Partition Descriptor)
001h 5	Standard Identifier	("CD001")
006h 1	Volume Partition Version	(01h=Standard)
007h 1	Reserved	(00h)
008h 32	System Identifier	(a-characters) (32 bytes)
028h 32	Volume Partition Identifier	(d-characters) (32 bytes)
048h 8	Volume Partition Location	(2x32bit) Logical Block Number
050h 8	Volume Partition Size	(2x32bit) Number of Logical Blocks
058h 1960	System Use	(not specified content)

Reserved Volume Descriptors (none such on PSX disks)

```
000h 1      Volume Descriptor Type      (04h..FEh=Reserved, don't use)
001h 2047 Reserved                      (don't use)
```

12.8 CDROM ISO File and Directory Descriptors

The location of the Root Directory is described by a 34-byte Directory Record being located in Primary Volume Descriptor entries 09Ch..0BDh. The data therein is: Block Number (usually 22 on PSX disks), LEN_FI=01h, Name=00h, and, LEN_SU=00h (due to the 34-byte limit).

Format of a Directory Record

```
00h 1      Length of Directory Record (LEN_DR) (33+LEN_FI+pad+LEN_SU) (0=Pad)
01h 1      Extended Attribute Record Length (usually 00h)
02h 8      Data Logical Block Number (2x32bit)
0Ah 8      Data Size in Bytes          (2x32bit)
12h 7      Recording Timestamp         (yy-1900,mm,dd,hh,mm,ss,timezone)
19h 1      File Flags 8 bits           (usually 00h=File, or 02h=Directory)
1Ah 1      File Unit Size              (usually 00h)
1Bh 1      Interleave Gap Size         (usually 00h)
1Ch 4      Volume Sequence Number      (2x16bit, usually 0001h)
20h 1      Length of Name              (LEN_FI)
21h LEN_FI File/Directory Name ("FILENAME.EXT;1" or "DIR_NAME" or 00h or 01h)
xxh 0..1   Padding Field (00h) (only if LEN_FI is even)
xxh LEN_SU System Use (LEN_SU bytes) (see below for CD-XA disks)
```

LEN_SU can be calculated as "LEN_DR-(33+LEN_FI+Padding)". For CD-XA disks (as used in the PSX), LEN_SU is 14 bytes:

```
00h 2      Owner ID Group  (whatever, usually 0000h, big endian)
02h 2      Owner ID User   (whatever, usually 0000h, big endian)
04h 2      File Attributes (big endian):
           0  Owner Read    (usually 1)
           1  Reserved      (0)
           2  Owner Execute (usually 1)
           3  Reserved      (0)
           4  Group Read    (usually 1)
           5  Reserved      (0)
           6  Group Execute (usually 1)
           7  Reserved      (0)
           8  World Read    (usually 1)
           9  Reserved      (0)
          10  World Execute (usually 1)
          11  IS_MODE2      (0=MODE1 or CD-DA, 1=MODE2)
```

```

12 IS_MODE2_FORM2 (0=FORM1, 1=FORM2)
13 IS_INTERLEAVED (0=No, 1=Yes...?) (by file and/or channel?)
14 IS_CDDA (0=Data or ADPCM, 1=CD-DA Audio Track)
15 IS_DIRECTORY (0=File or CD-DA, 1=Directory Record)

```

Commonly used Attributes are:

```

0D55h=Normal Binary File (with 800h-byte sectors)
1555h=Uncommon (fade to black .DPS and .XA files)
2555h=Uncommon (wipeout .AV files) (MODE1 ??)
4555h=CD-DA Audio Track (wipeout .SWP files, alone .WAV file)
3D55h=Streaming File (ADPCM and/or MDEC or so)
8D55h=Directory Record (parent-, current-, or sub-directory)

06h 2 Signature ("XA")
08h 1 File Number (Must match Subheader's File Number)
09h 5 Reserved (00h-filled)

```

Directory sectors do usually have zeropadding at the end of each sector:

```

- Directory sizes are always rounded up to N*800h-bytes.
- Directory entries should not cross 800h-byte sector boundaries.
There may be further directory entries on the next sector after the padding.
To deal with that, skip 00h-bytes until finding a nonzero LEN_DR value (or
slightly faster, upon a 00h-byte, directly jump to next sector instead of
doing a slow byte-by-byte skip).
Note: Padding between sectors does rarely happen on PSX discs because the
PSX kernel supports max 800h bytes per directory (one exception is PSX Hot
Shots Golf 2, which has an ISO directory with more than 800h bytes; it does
use a lookup file instead of actually parsing the while ISO directory).

```

Names are alphabetically sorted, no matter if the names refer to files or directories (ie. SUBDIR would be inserted between STRFILE.EXT and SYSFILE.EXT). The first two entries (with non-ascii names 00h and 01h) are referring to current and parent directory.

Path Tables

The Path Table contain a summary of the directory names (the same information is also stored in the directory records, so programs may either use path tables or directory records; the path tables are allowing to read the whole directory tree quickly at once, without needing to seek from directory to directory).

Path Table 1 is in Little-Endian format, Path Table 3 contains the same data in Big-Endian format. Path Table 2 and 4 are optional copies of Table 1 and 3. The size and location of the tables is stored in Volume Descriptor entries 084h..09Bh. The format of the separate entries within a Path Table is,

```

00h 1 Length of Directory Name (LEN_DI) (01h..08h for PSX)
01h 1 Extended Attribute Record Length (usually 00h)
02h 4 Directory Logical Block Number
06h 2 Parent Directory Number (0001h and up)

```

```

08h LEN_DI  Directory Name (d-characters, dl-characters) (or 00h for Root)
xxh 0..1    Padding Field (00h) (only if LEN_FI is odd)

```

The first entry (directory number 0001h) is the root directory, the root doesn't have a name, nor a parent (the name field contains a 00h byte, rather than ASCII text, LEN_DI is 01h, and parent is 0001h, making the root it's own parent; ignoring the fact that incest is forbidden in many countries).

The next entries (directory number 0002h and up) (if any) are sub-directories within the root (sorted in alphabetical order, and all having parent=0001h). The next entries are sub-directories (if any) of the first sub-directory (also sorted in alphabetical order, and all having parent=0002h). And so on.

PSX disks usually contain all four tables (usually on sectors 18,19,20,21).

Format of an Extended Attribute Record (none such on PSX disks)

If present, an Extended Attribute Record shall be recorded over at least one Logical Block. It shall have the following contents.

```

00h 4      Owner Identification (numerical value)  ;\used only if
04h 4      Group Identification (numerical value)  ; File Flags Bit4=1
08h 2      Permission Flags (16bit, little-endian) ;/
0Ah 17     File Creation Timestamp      ("YYYYMMDDHHMMSSFF",timezone)
1Bh 17     File Modification Timestamp   ("0000000000000000",00h)
2Ch 17     File Expiration Timestamp     ("0000000000000000",00h)
3Dh 17     File Effective Timestamp      ("0000000000000000",00h)
4Eh 1      Record Format                  (numerical value)
4Fh 1      Record Attributes              (numerical value)
50h 4      Record Length                  (numerical value)
54h 32     System Identifier              (a-characters, al-characters)
74h 64     System Use                     (not specified content)
B4h 1      Extended Attribute Record Version (numerical value)
B5h 1      Length of Escape Sequences     (LEN_ESC)
B6h 64     Reserved for future standardization (00h-filled)
F6h 4      Length of Application Use      (LEN_AU)
FAh LEN_AU Application Use
xxh LEN_ESC Escape Sequences

```

Unknown WHERE that data is located... the Directory Records can specify the Extended Attribute Length, but not the location... maybe it's meant to be located in the first some bytes or blocks of the File or Directory...?

12.9 CDROM ISO Misc

Both Byte Order

All 16bit and 32bit numbers in the ISO region are stored twice, once in Little-Endian order, and then in Big-Endian Order. For example,

```
2x16bit value 1234h      ---> stored as 34h,12h,12h,34h
2x32bit value 12345678h ---> stored as 78h,56h,34h,12h,12h,34h,56h,78h
```

Exceptions are the 16bit Permission Flags which are stored only in Little-Endian format (although the flags are four 4bit groups, so that isn't a real 16bit number), and, the Path Tables are stored in both formats, but separately, ie. one table contains only Little-Endian numbers, and the other only Big-Endian numbers.

d-characters (Filenames)

```
"0..9", "A..Z", and "_"
```

a-characters

```
"0..9", "A..Z", SPACE, "!"%&'()*+,-./:;<=>?_"
```

Ie. all ASCII characters from 20h..5Fh except "#\$@[]^"

SEPARATOR 1 = 2Eh (aka ".") (extension; eg. "EXT")

SEPARATOR 2 = 3Bh (aka ";") (file version; "1".."32767")

Fixed Length Strings/Filenames

The Volume Descriptors contain a number fixed-length string/filename fields (unlike the Directory Records and Path Tables which have variable lengths). These fields should be padded with SPACE characters if they are empty, or if the string is shorter than the maximum length.

Filename fields in Volume Descriptors are referring to files in the Root Directory. On PSX disks, the filename fields are usually empty, but some disks are mis-using the Copyright Filename to store the Company Name (although no such file exists on the disk).

Volume Descriptor Timestamps

The various timestamps occupy 17 bytes each, in form of

```
"YYYYMMDDHHMMSSFF",timezone
"0000000000000000",00h      ;empty timestamp
```

The first 16 bytes are ASCII Date and Time digits (Year, Month, Day, Hour, Minute, Second, and 1/100 Seconds). The last byte is Offset from Greenwich Mean Time in number of 15-minute steps from -48 (West) to +52 (East); or actually: to +56 when recursing Kiribati's new timezone.

Note: PSX games manufactured in year 2000 were accidently marked to be created in year 0000.

Recording Timestamps

Occupy only 7 bytes, in non-ascii format

```
year-1900,month,day,hour,minute,second,timezone
00h,00h,00h,00h,00h,00h,00h      ;empty timestamp
```

The year ranges from 1900+0 to 1900+255.

File Flags

If this Directory Record identifies a directory then bit 2,3,7 shall be set to ZERO.

If no Extended Attribute Record is associated with the File Section identified by this Directory Record then bit positions 3 and 4 shall be set to ZERO.

```
0  Existence      (0=Normal, 1=Hidden)
1  Directory      (0=File, 1=Directory)
2  Associated File (0=Not an Associated File, 1=Associated File)
3  Record
    If set to ZERO, shall mean that the structure of the information in
    the file is not specified by the Record Format field of any associated
    Extended Attribute Record (see 9.5.8).
    If set to ONE, shall mean that the structure of the information in
    the file has a record format specified by a number other than zero in
    the Record Format Field of the Extended Attribute Record (see 9.5.8).
4  Restrictions   (0=None, 1=Restricted via Permission Flags)
5  Reserved      (0)
6  Reserved      (0)
7  Multi-Extent   (0=Final Directory Record for the file, 1=Not final)
```


Permission Flags (in Extended Attribute Records)

```
0-3   Permissions for upper-class owners
4-7   Permissions for normal owners
8-11  Permissions for upper-class users
12-15 Permissions for normal users
```

This is a bit bizarre, an upper-class owner is "an owner who is a member of a group of the System class of user". An upper-class user is "any user who is a member of the group specified by the Group Identification field". The separate 4bit permission codes are:

```
Bit0  Permission to read the file      (0=Yes, 1=No)
Bit1  Must be set (1)
Bit2  Permission to execute the file  (0=Yes, 1=No)
Bit3  Must be set (1)
```

12.10 CDROM Extension Joliet

Typical Joliet Disc Header

The discs contains two separate filesystems, the ISO one for backwards compatibility, and the Joliet one with longer filenames and Unicode characters.

```
Sector 16 - Primary Volume Descriptor (with 8bit uppercase ASCII ISO names)
Sector 17 - Secondary Volume Descriptor (with 16bit Unicode Joliet names)
Sector 18 - Volume Descriptor Set Terminator
Sector .. - Path Tables and Directory Records (for ISO)
Sector .. - Path Tables and Directory Records (for Joliet)
Sector .. - File Data Sectors (shared for ISO and Joliet)
```

There is no way to determine which ISO name belongs to which Joliet name (except, filenames do usually point to the same file data sectors, but that doesn't work for empty files, and doesn't work for folder names).

The ISO names can be max 31 chars (or shorter for compatibility with DOS short names: Nero does truncate them to max 14 chars "FILENAME.EXT;1", all uppercase, with underscores instead of spaces, and somehow assigning names like "FILENAMx.EXT;1" in case of duplicated short names).

Secondary Volume Descriptor (aka Supplementary Volume Descriptor)

This is using the same format as ISO Primary Volume Descriptor (but with some changed entries).

CDROM ISO Volume Descriptors

Changed entries are:

000h 1	Volume Descriptor Type	(02h=Supplementary instead of 01h=Primary)
007h 1	Volume Flags	(whatever, instead of Reserved)
008h 2x32	Identifier Strings	(16-char Unicode instead 32-char ASCII)
058h 32	Escape Sequences	(see below, instead of Reserved)
08Ch 4x4	Path Tables	(point to new tables with Unicode chars)
09Ch 34	Root Directory Record	(point to root with Unicode chars)
0BEh 4x128	Identifier Strings	(64-char Unicode instead 128-char ASCII)
2BEh 3x37	Filename Strings	(18-char Unicode instead 37-char ASCII)

The Escape Sequences entry contains three ASCII chars (plus 29-byte zeropadding), indicating the ISO 2022 Unicode charset:

%/�	UCS-2 Level 1
%/C	UCS-2 Level 2
%/E	UCS-2 Level 3

Directory Records and Path Tables

This is using the standard ISO format (but with 16bit Unicode characters instead of 8bit ASCII chars).

CDROM ISO File and Directory Descriptors

File and Directory Name Characters

All characters are stored in 16bit Big Endian format. The LEN_FI filename entry contains the length in bytes (ie. numchars*2). Characters 0000h/0001h are current/parent directory. Characters 0020h and up can be used for file/directory names, except six reserved characters: */:;?\

All names must be sorted by their character numbers, padded with zero (without attempting to merge uppercase, lowercase, or umlauts to nearby locations).

File and Directory Name Length

max 64 chars	according to original Joliet specs from 1995
max 110 chars	(on standard CDROMs, with LEN_SU=0)
max 103 chars	(on CD-XA discs, with LEN_SU=14)

Joliet Filenames include ISO-style version suffices (usually ";1", so the actual filename lengths are two chars less than shown above).

The original 64-char limit was perhaps intended to leave space for future extensions in

the LEN_SU region. The 64-char limit can cause problems with verbose names (eg. "Interprete - Title (version).mp3"). Microsoft later changed the limit to up to 110 chars. The 110/103-char limit is caused by the 8bit "LEN_DR=(33+LEN_FI+pad+LEN_SU)" entry in the Directory Records.

Joliet allows to exceed the 8-level ISO directory nesting limit, however, it doesn't allow to exceed the 240-byte (120-Unicode-char) limit in ISO 9660 section 6.8.2.1 for the total "path\filename" lengths.

Official Specs

Joliet Specification, CD-ROM Recording Spec ISO 9660:1988, Extensions for Unicode Version 1; May 22, 1995, Copyright 1995, Microsoft Corporation

<http://littlesvr.ca/isomaster/resources/JolietSpecification.html>

12.11 CDROM Protection - SCEX Strings

SCEX String

The heart of the PSX copy-protection is the four-letter "SCEX" string, encoded in the wobble signal of original PSX disks, which cannot be reproduced by normal CD writers. The last letter varies depending on the region:

```
"SCEI" for Japan
"SCEA" for America (and all other NTSC countries except Japan)
"SCEE" for Europe (and all other PAL countries like Australia)
```

If the string is missing (or if it doesn't match up for the local region) then the PSX refuses to boot. The verification is done by the Firmware inside of the CDROM Controller (not by the PSX BIOS, so there's no way to bypass it by patching the BIOS ROM chip).

Wobble Groove and Absolute Time in Pregroove (ATIP) on CD-R's

A "blank" CDR contains a pre-formatted spiral on it. The number of windings in the spiral varies depending on the number of minutes that can be recorded on the disk. The spiral isn't made of a straight line (-----), but rather a wobbled line (/V/V), which is used to adjust the rotation speed during recording; at normal drive speed, wobble should produce a 22050Hz sine wave.

Additionally, the CDR wobble is modulated to provide ATIP information, ATIP is used for

locating and positioning during recording, and contains information about the approximate laser power necessary for recording, the last possible time location that lead out can start, and the disc application code.

Wobble is commonly used only on (recordable) CDRs, ie. usually NOT on (readonly) CDROMs and Audio Disks. The copyprotected PSX CDROMs are having a short CDR-style wobble period in the first some seconds, which seems to contain the "SCEX" string instead of ATIP information.

Other Protections

Aside from the SCEX string, PSX disks are required to contain region and licence strings (in the ISO System Area, and in the .EXE file headers), and the "PS" logo (in the System Area, too). This data can be reproduced with normal CD writers, although it may be illegal to distribute unlicensed disks with licence strings.

12.12 CDROM Protection - Bypassing it

Modchips

A modchip is a small microcontroller which injects the "SCEX" signal to the mainboard, so the PSX can be booted even from CDRs which don't contain the "SCEX" string. Some modchips are additionally patching region checks contained in the BIOS ROM.

Note: Although regular PSX disks are black, the hardware doesn't verify the color of the disks, and works also with normal silver disks.

Disk-Swap-Trick

Once when the PSX has recognized a disk with the "SCEX" signal, it'll be satisfied until a new disk is inserted, which is sensed by the SHELL_OPEN switch. When having that switch blocked, it is possible to insert a CDR without the PSX noticing that the disk was changed.

Additionally, the trick requires some boot software that stops the drive motor (so the new disk can be inserted, despite of the PSX thinking that the drive door is still closed), and that does then start the boot executable on the new disk.

The boot software can be stored on a special boot-disk (that do have the "SCEX" string on it). Alternately, a regular PSX game disk could be used, with the boot software stored somewhere else (eg. on Expansion ROM, or BIOS ROM replacement, or Memory Card).

Booting via BIOS ROM or Expansion ROM

The PSX can be quite easily booted via Expansion ROM, or BIOS ROM replacements, allowing to execute code that is stored in the ROM, or that is received via whatever serial or parallel cable connection from a PC.

However, even with a BIOS replacement, the protection in the CDROM controller is still active, so the ROM can't read "clean" data from the CDROM Drive (unless the Disk-Swap trick is used).

Whereas, no "clean" data doesn't mean no data at all. The CDROM controller does still seem to output "raw" data (without removing the sector header, and without handling error correction, and with only limited accuracy on the sector position). So, eventually, a customized BIOS could convert the "raw" data to "clean" data.

Secret Unlock Commands

There is an "official" backdoor that allows to disable the SCEX protection by software via secret commands (for example, sending those commands can be done via BIOS patches, nocash BIOS clone, or Expansion ROMs).

[CDROM - Secret Unlock Commands](#)

Booting via Memory Card

Some games that load data from memory cards may get confused if the save data isn't formatted as how they expect it - with some fine tuning you can get them to "crash" in a manner that they do accidentally execute bootcode stored on the memory card. This is how tonyhax's game exploits and FreePSXBoot's BIOS shell exploit work.

Requires a tools to write to the memory card (eg. parallel port cable), and the memory card data customized for a specific game, and an original CDROM with that specific game. Once when the memory card code is booted, the Disk-Swap trick can be used.

12.13 CDROM Protection - Modchips

Modchip Source Code

The Old Crow mod chip source code works like so:

```
entrypoint:                                ;at power_up
    gate=input/highz
    data=input/highz
    wait 50 ms
```

```

data=output/low
wait 850 ms
gate=output/low
wait 314 ms
loop:
  wait 72 ms                ;pause (eighteen "l=low" bits)
  sendbyte("S")             ;1st letter
  sendbyte("C")             ;2nd letter
  sendbyte("E")             ;3rd letter
  sendbyte(...)             ;4th letter (A, E, or I, depending on region)
  goto loop
sendbyte(char):
  sendbit(0)                ;one start bit (0=highz)
  for i=0 to 7
    sendbit(char AND 1)     ;output data (LSB first)
    char=char/2
  next i
  sendbit(1)                ;1st stop bit (1=low)
  sendbit(1)                ;2nd stop bit (1=low)
  return
sendbit(bit):
  if bit=1 then data=output/low elseif bit=0 then data=input/highz
  wait 4 ms                 ;4ms per bit = 250 bits per second
  return

```

That is, 62 bits per transfer at 250bps = circa 4 transfers per second.

Connection for the data/gate/sync signals:

For older PSX boards (data/gate):

Board	data	gate	
PU-xx	unknown?	unknown?	;older PSX boards

For newer PSX and PSone boards (data/sync):

Board	data	sync	
PU-23, PM-41	CXD2938Q.Pin42	CXD2938Q.Pin5	;newer PSX and older PSone
PM-41 (2)	CXD2941R.Pin36	CXD2941R.Pin76	;newer PSone boards

On the mainboard should be a big SMD capacitor (connected to the "data" pin), and a big testpoint (connected to the "sync" pin); it's easier to connect the signals to that locations than to the tiny CXD-chip pins.

gate and data must be tristate outputs, or open-collector outputs (or normal high/low outputs passed through a diode).

Note on "data" pin (all boards)

Transfers the "SCEx" data. Note that the signal produced by the modchip is looking entirely different than the signal produced by original disks, the real signal would be modulated 22050Hz wobble, while the modchip is simply dragging the signal permanently LOW throughout "1" bits, and leaves it floating for "0" bits. Anyways the "faked" signal seems to be accurate enough to work.

Note on "gate" pin (older PSX boards only)

The "gate" pin needs to be LOW only for use with original licensed disks (reportedly otherwise the SCEx string on that disks would conflict with the SCEx string from the modchip).

At the mainboard side, the "gate" signal is an input, and "data" is an inverted output of the gate signal (so dragging gate to low, would cause data to go high).

Note on "sync" pin (newer PSX and PSone boards only)

The "sync" pin is a testpoint on the mainboard, which does (at single speed) output a frequency of circa 44.1kHz/6 (of which some clock pulses seem to be longer or shorter, probably to indicate adjustments to the rotation speed).

Some modchips are connected directly to "sync" (so they are apparently synchronizing the data output with that signal; which is not implemented in the above source code). Anyways, other modchips are using a more simplified connection: The modchip itself connects only to the "data" pin, and "sync" is required to be wired to IC723.Pin17.

Note on Multi-Region chips

Modchips that are designed to work in different regions are sending a different string (SCEA, SCEE, SCEI) in each loop cycle. Due to the slow 250bps transfer rate, it may take a while until the PSX has received the correct string, so this multi-region technique may cause a noticeable boot-delay.

Stealth (hidden modchip)

The Stealth connection is required for some newer games with anti-modchip protection, ie. games that refuse to run if they detect a modchip. The detection relies on the fact that the SCEx signal is normally received only when booting the disk, whilst older modchips were sending that signal permanently. Stealth modchips are sending the signal only on power-up (and when inserting a new disk, which can be sensed via

SHELL_OPEN signal).

Modchip detection reportedly works like so (not too sure if all commands are required, some seem to be rather offtopic):

```

1. Com 19h,20h ;Retrieve CDROM Controller timestamp
2. Com 01h      ;CdINop: Get CD status
3. Com 07h      ;CdIMotorOn: Make CD-ROM drive ready (blah?)
4. Com 02h,1,1,1 ;CdISetloc(01:01:01) (sector that does NOT have SCEX data)
5. Com 0Eh,1    ;CdISetmode: Turn on CD-DA read mode
6. Short Delay
7. Com 16h      ;CdISseekP: Seek to Setloc's parameters (4426)
8. Com 0Bh      ;CdIMute: Turn off sound so CdIPlay is inaudible
9. Com 03h      ;CdIPlay: Start playing CD-DA.
10. Com 19h,04h ;ResetSCEXInfo (reset GetSCEXInfo response to 0,0)
11. Long Delay  ;wait until the modchip (if any) has output SCEX data
12. Com 19h,05h ;GetSCEXInfo (returns total,succcess counters)
13. Com 09h     ;CdIPause: Stop command 19h.

```

If GetSCEXInfo returns nonzero values, then the console is equipped with a modchip, and if so, anti-modchip games would refuse to work (no matter if the disk is an illegal copy, or not).

NTSC-Boot BIOS Patch

Typically connects to two or three BIOS address/data lines, apparently watching that signals, and dragging a data line LOW at certain time, to skip software based region checks (eg. allowing to play NTSC games on PAL consoles).

Aside from the modchip connection, that additionally requires to adjust the video signal (in 60Hz NTSC mode, the PSX defaults to generate a NTSC video signal) (whilst most PAL screens can handle 60Hz refresh, they can't handle NTSC colors) (on PSone boards, this can be fixed simply by grounding the /PAL pin; IC502.Pin13) (on older PSX boards it seems to be required to install an external color clock generator).

MODCHIP Connection Example

Connection for 8pin "12C508" mod chip from fatcat.co.nz for a PAL PSone with PM-41 board (ie. with 208pin SPU CXD2938Q, and 52pin IC304 "C 3060, SC430943PB"):

```

1 3.5V          (supply)
2 IC304.Pin44   (unknown?) (XLAT)
3 BIOS.Pin15    (D2)
4 BIOS.Pin31    (A18)
5 SPU.Pin5      ("sync")
6 SPU.Pin42     ("data")

```



```
7 IC304.Pin19 (SHELL_OPEN)
8 GND        (supply)
```

The chip can be used in a Basic connection (with only pin1,5,6,8 connected), or Stealth and NTSC-Boot connection (additionally pin2,3,4,7 connected). Some other modchips (such without internal oscillator) are additionally connected to a 4MHz or 4.3MHz signal on the mainboard. Some early modchips also connected to a bunch of additional pins that were reportedly for power-on timings (whilst newer chips use hardcoded power-on delays).

Nocash BIOS "Modchip" Feature

The nocash PSX bios outputs the "data" signal on the A20 address line, so (aside from the BIOS chip) one only needs to install a 1N4148 diode and two wires to unlock the CDROM:

```
SPU.Pin42 "data" -----|>|----- CPU.Pin149 (A20)
SPU.Pin5  "sync" ----- IC723.Pin17
```

With the "sync" connection, the SCEX signal from the disk is disabled (ie. even original licensed disks are no longer recognized, unless SCEX is output via A20 by software). For more variants, see:

[CDROM Protection - Chipless Modchips](#)

12.14 CDROM Protection - Chipless Modchips

The nocash kernel clone outputs a SCEX signal via A20 and A21 address lines, (so one won't need a separate modchip/microprocessor):

```
A20 = the normal SCEX signal (inverted ASCII, eg. "A" = BEh) ;all boards
A21 = uninverted SCEX signal (uninverted ASCII, eg. "A" = 41h) ;PU-7..PU-20
A21 = always 1 during SCEX output ;PU-22 and up
```

When using the clone bios as internal ROM replacement, A20 can be used with simple wires/diodes. Doing that with external expansion ROMs would cause the console to stop working when unplugging the ROM, hence needing a slightly more complex circuit with transistors/logic chips.

External Expansion ROM version, for older boards (PU-7 through PU-20):

```

      .------.
GATE-----| C  NPN  | .   DATA-----| C  NPN  | .
A20--[10K]--| B  BC   | |   A21--[10K]--| B  BC   | |
GND-----| E  547  | '   GND-----| E  547  | '
      '-----'

```

External Expansion ROM version, for newer boards (PU-22):

```

      .------.
A21----| OE1, OE2      |
A20----| IN1   74HC126  OUT1 |--- DATA
WFCK---| IN2                OUT2 |--- SYNC
      '-----'

```

Internal Kernel ROM version, for older boards (PU-7 through PU-20):

```

GATE-----GND
DATA-----A20

```

Internal Kernel ROM version, for newer boards (PU-22 through PM-41(2)):

```

SYNC-----WFCK
DATA---|>|---A20

```

What pin is where...

```

GATE is IC703.Pin2  (?) (8pin chip with marking "082B")    ;PU-7? .. PU-16
GATE is IC706.Pin7/10 (16pin "118" (uPC5023GR-118))      ;PU-18 .. PU-20
SYNC is IC723.Pin17 (TEO) (20pin "SONY CXA2575N")         ;PU-22 .. PM-41(2)
DATA is IC???Pin7 (CG) (8pin chip with marking "2903")    ;PU-7? .. PU-16
DATA is IC706.Pin1 (CG) (16pin "118" (uPC5023GR-118))     ;PU-18 .. PU-20
DATA is HC05.Pin17 (CG) (52pin "SONY SC4309xxPB")         ;PU-7 .. EARLY-PU-8
DATA is HC05.Pin32 (CG) (80pin "SONY E35D, 4246xx 185")   ;LATE-PU-8 .. PU-20
DATA is SPU.Pin42 (CEI) (208pin "SONY CXD2938Q")          ;PU-22 .. PM-41
DATA is SPU.Pin36?(CEI) (176pin "SONY CXD2941R")          ;PM-41(2)
WFCK is SPU.Pin5 (WFCK) (208pin "SONY CXD2938Q")          ;PU-22 .. PM-41
WFCK is SPU.Pin84 (WFCK) (176pin "SONY CXD2941R")         ;PM-41(2)
A20  is CPU.Pin149(A20) (208-pin CPU CXD8530 or CXD8606)  ;PU-7 .. PM-41(2)
A20  is EXP.Pin28 (A20) (68-pin Expansion Port)           ;PU-7 .. PU-22
A21  is CPU.Pin150(A21) (208-pin CPU CXD8530 or CXD8606)  ;PU-7 .. PM-41(2)
A21  is EXP.Pin62 (A21) (68-pin Expansion Port)           ;PU-7 .. PU-22

```

GATE on PU-18 is usually IC706.Pin7 (but IC706.Pin10 reportedly works, too).

GATE on PU-20 is usually IC706.Pin10 (but IC706.Pin7 might work, too).

12.15 CDROM Protection - LibCrypt

LibCrypt is an additional copy-protection, used by about 100 PSX games. The protection uses a 16bit decryption key, which is stored as bad position data in Subchannel Q. The 16bit key is then used for a simple XOR-decryption on certain 800h-byte sectors.

Protected sectors generation schemas

There are some variants on how the Subchannel Q data is modified:

1. 2 bits from both MSFs are modified,
CRC-16 is recalculated and Xored with 0x0080.
Games: MediEvil (E).
2. 2 bits from both MSFs are modified,
original CRC-16 is Xored with 0x8001.
Games: CTR: Crash Team Racing (E) (No EDC), CTR: Crash Team Racing (E) (EDC), Dino Crisis (E), Eagle One: Harrier Attack (E) et al.
3. Either 2 bits or none from both MSFs are modified,
CRC-16 is recalculated and Xored with 0x0080.
Games: Ape Escape (S) et al.

Anyways, the relevant part is that the modified sectors have wrong CRCs (which means that the PSX cdrom controller will ignore them, and the GetlocP command will keep returning position data from the previous sector).

LibCrypt sectors

The modified sectors could be theoretically located anywhere on the disc, however, all known protected games are having them located on the same sectors:

No.	<----- Minute=03/Normal ----->				<----- Minute=09/Backup ----->			
Bit15	14105	(03:08:05)	14110	(03:08:10)	42045	(09:20:45)	42050	(09:20:50)
Bit14	14231	(03:09:56)	14236	(03:09:61)	42166	(09:22:16)	42171	(09:22:21)
Bit13	14485	(03:13:10)	14490	(03:13:15)	42432	(09:25:57)	42437	(09:25:62)
Bit12	14579	(03:14:29)	14584	(03:14:34)	42580	(09:27:55)	42585	(09:27:60)
Bit11	14649	(03:15:24)	14654	(03:15:29)	42671	(09:28:71)	42676	(09:29:01)
Bit10	14899	(03:18:49)	14904	(03:18:54)	42813	(09:30:63)	42818	(09:30:68)
Bit9	15056	(03:20:56)	15061	(03:20:61)	43012	(09:33:37)	43017	(09:33:42)
Bit8	15130	(03:21:55)	15135	(03:21:60)	43177	(09:35:52)	43182	(09:35:57)
Bit7	15242	(03:23:17)	15247	(03:23:22)	43289	(09:37:14)	43294	(09:37:19)
Bit6	15312	(03:24:12)	15317	(03:24:17)	43354	(09:38:04)	43359	(09:38:09)
Bit5	15378	(03:25:03)	15383	(03:25:08)	43408	(09:38:58)	43413	(09:38:63)
Bit4	15628	(03:28:28)	15633	(03:28:33)	43634	(09:41:59)	43639	(09:41:64)
Bit3	15919	(03:32:19)	15924	(03:32:24)	43963	(09:46:13)	43968	(09:46:18)
Bit2	16031	(03:33:56)	16036	(03:33:61)	44054	(09:47:29)	44059	(09:47:34)
Bit1	16101	(03:34:51)	16106	(03:34:56)	44159	(09:48:59)	44164	(09:48:64)
Bit0	16167	(03:35:42)	16172	(03:35:47)	44312	(09:50:62)	44317	(09:50:67)

Each bit is stored twice on Minute=03 (five sectors apart). For some reason, there is also a "backup copy" on Minute=09 (however, the libcrypt software doesn't actually support using that backup stuff, and, some discs don't have the backup at all (namely, discs with less than 10 minutes on track 1?)).

A modified sector means a "1" bit, an unmodified means a "0" bit. The 16bit keys of the existing games are always having eight "0" bits, and eight "1" bits (meaning that there are 16 modified sectors on Minute=03, and, if present, another 16 ones one Minute=09).

Example (Legacy of Kain)

Legacy of Kain (PAL) is reading the LibCrypt data during the title screen, and does then display GOT KEY!!! on TTY terminal (this, no matter if the correct 16bit key was received).

The actual protection jumps in a bit later (shortly after learning to glide, the game will hang when the first enemies appear if the key isn't okay). Thereafter, the 16bit key is kept used once and when to decrypt 800h-byte sector data via simple XORing.

The 16bit key (and some other related counters/variables) aren't stored in RAM, but rather in COP0 debug registers (which are mis-used as general-purpose storage in this case), for example, the 16bit key is stored in LSBs of the "cop0r3" register.

In particular, the encryption is used for some of the BIGFILE.DAT folder headers:

[CDROM File Archive BIGFILE.DAT \(Soul Reaver\)](#)

13. CDROM File Formats

Official PSX File Formats

[CDROM File Official Sony File Formats](#)

Executables

[CDROM File Playstation EXE and SYSTEM.CNF](#)

[CDROM File PsyQ .CPE Files \(Debug Executables\)](#)

[CDROM File PsyQ .SYM Files \(Debug Information\)](#)

Video Files

[CDROM File Video Texture Image TIM/PXL/CLT \(Sony\)](#)

[CDROM File Video Texture/Bitmap \(Other\)](#)

[CDROM File Video 2D Graphics CEL/BGD/TSQ/ANM/SDF \(Sony\)](#)

[CDROM File Video 3D Graphics TMD/PMD/TOD/HMD/RSD \(Sony\)](#)

[CDROM File Video STR Streaming and BS Picture Compression \(Sony\)](#)

Audio Files

[CDROM File Audio Single Samples VAG \(Sony\)](#)

[CDROM File Audio Sample Sets VAB and VH/VB \(Sony\)](#)

[CDROM File Audio Sequences SEQ/SEP \(Sony\)](#)

[CDROM File Audio Other Formats](#)

[CDROM File Audio Streaming XA-ADPCM](#)

[CDROM File Audio CD-DA Tracks](#)

Virtual Filesystem Archives

PSX titles are quite often using virtual filesystems, with numerous custom file archive formats.

[CDROM File Archives with Filename](#)

[CDROM File Archives with Offset and Size](#)

[CDROM File Archives with Offset](#)

[CDROM File Archives with Size](#)

[CDROM File Archives with Chunks](#)

[CDROM File Archives with Folders](#)

[CDROM File Archives in Hidden Sectors](#)

[More misc stuff...](#)

[CDROM File Archive HED/DAT/BNS/STR \(Ape Escape\)](#)

[CDROM File Archive WAD.WAD, BIG.BIN, JESTERS.PKG \(Crash/Herc/Pandemonium\)](#)

[CDROM File Archive BIGFILE.BIG \(Gex\)](#)

[CDROM File Archive BIGFILE.DAT \(Gex - Enter the Gecko\)](#)

[CDROM File Archive FF9 DB \(Final Fantasy IX\)](#)

[CDROM File Archive Ace Combat 2 and 3](#)

[CDROM File Archive NSD/NSF \(Crash Bandicoot 1-3\)](#)

[CDROM File Archive STAGE.DIR and *.DAT \(Metal Gear Solid\)](#)

[CDROM File Archive DRACULA.DAT \(Dracula\)](#)

[CDROM File Archive Croc 1 \(DIR, WAD, etc.\)](#)

[CDROM File Archive Croc 2 \(DIR, WAD, etc.\)](#)

[CDROM File Archive Headerless Archives](#)

Using archives can avoid issues with the PSX's poorly implemented ISO filesystem: The PSX kernel supports max 800h bytes per directory, and lacks proper caching for most recently accessed directories (additionally, some archives can load the whole file/directory tree from continuous sectors, which could be difficult in ISO filesystems).

Compression

[CDROM File Compression](#)

Misc

[CDROM File XYZ and Dummy/Null Files](#)

General CDROM Disk Images

[CDROM Disk Images CCD/IMG/SUB \(CloneCD\)](#)

[CDROM Disk Images CDI \(DiscJuggler\)](#)

[CDROM Disk Images CUE/BIN/CDT \(Cdrwin\)](#)

[CDROM Disk Images MDS/MDF \(Alcohol 120%\)](#)

[CDROM Disk Images NRG \(Nero\)](#)

[CDROM Disk Image/Containers CDZ](#)

[CDROM Disk Image/Containers ECM](#)

[CDROM Subchannel Images](#)

[CDROM Disk Images Other Formats](#)

FILENAME.EXT

The BIOS seems to support only (max) 8-letter filenames with 3-letter extension, typically all uppercase, eg. "FILENAME.EXT". Eventually, once when the executable has started, some programs might install drivers for long filenames(?)

The PSX uses the standard CDROM ISO9660 filesystem without any encryption (ie. you can put an original PSX CDROM into a DOS/Windows computer, and view the content of the files in text or hex editors without problems).

Note

MagDemoNN is short for "Official U.S. Playstation Magazine Demo Disc NN"

13.1 CDROM File Official Sony File Formats

Official Sony File Formats

<https://psx.arthus.net/sdk/Psy-Q/DOCS/Devrefs/Filefmt.pdf> - Sony 1998

File Formats	
(c) 1998 Sony Computer Entertainment Inc.	
Publication date: November 1998	
Chapter 1: Streaming Audio and Video Data	
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VAG: PS Single Waveform Data	4-5
VAB: PS Sound Source Data [VAB and VH/VB]	4-5

DA: CD-DA Data	4-7
Chapter 5: PDA and Memory Card	
FAT: Memory Card File System Specification	5-3

Most games are using their own custom file formats. However, VAG, VAB/VH(VB, STR/XA, and TIM are quite popular (because they are matched to the PSX low-level data encoding). Obviously, EXE is also very common (although not included in the above document).

13.2 CDROM File Playstation EXE and SYSTEM.CNF

SYSTEM.CNF

Contains boot info in ASCII/TXT format, similar to the CONFIG.SYS or AUTOEXEC.BAT files for MSDOS. A typical SYSTEM.CNF would look like so:

```
BOOT = cdrom:\abcd_123.45;1 arg ;boot exe (drive:\path\name.ext;version)
TCB = 4 ;HEX (=4 decimal) ;max number of threads
EVENT = 10 ;HEX (=16 decimal) ;max number of events
STACK = 801FFF00 ;HEX (=memtop-256)
```

The first line specifies the executable to load, from the "cdrom:" drive, "\" root directory, filename "abcd_123.45" (case-insensitive, the real name in the disk directory would be uppercase, ie. "ABCD_123.45"), and, finally ";1" is the file's version number (a rather strange ISO-filesystem specific feature) (the version number should be usually/always 1). Additionally, "arg" may contain an optional 128-byte command line argument string, which is copied to address 00000180h, where it may be interpreted by the executable (most or all games don't use that feature).

Each line in the file should be terminated by 0Dh,0Ah characters... not sure if it's also working with only 0Dh, or only 0Ah...?

ABCD_123.45

This is a normal executable (exactly as for the .EXE files, described below), however, the filename/extension is taken from the game code (the "ABCD-12345" text that is printed on the CD cover), but, with the minus replaced by an underscore, and due to the 8-letter filename limit, the last two characters are stored in the extension region.

That "XXXX_NNN.NN" naming convention seems to apply for all official licensed PSX games. Wild Arms does unconventionally have the file in a separate folder, "EXE\SCUS_946.06".

PSX.EXE (Boot-Executable) (default filename when SYSTEM.CNF doesn't exist)

XXXX_NNN.NN (Boot-Executable) (with filename as specified in SYSTEM.CNF)

FILENAME.EXE (General-Purpose Executable)

PSX executables are having an 800h-byte header, followed by the code/data.

```

000h-007h ASCII ID "PS-X EXE"
008h-00Fh Zerofilled
010h      Initial PC                      (usually 80010000h, or higher)
014h      Initial GP/R28                  (usually 0)
018h      Destination Address in RAM      (usually 80010000h, or higher)
01Ch      Filesize (must be N*800h)       (excluding 800h-byte header)
020h      Data section Start Address      (usually 0)
024h      Data Section Size in bytes      (usually 0)
028h      BSS section Start Address       (usually 0) (when below Size=None)
02Ch      BSS section Size in bytes       (usually 0) (0=None)
030h      Initial SP/R29 & FP/R30 Base    (usually 801FFFF0h) (or 0=None)
034h      Initial SP/R29 & FP/R30 Offs    (usually 0, added to above Base)
038h-04Bh Reserved for A(43h) Function    (should be zerofilled in exe file)
04Ch-xxxh ASCII marker
          "Sony Computer Entertainment Inc. for Japan area"
          "Sony Computer Entertainment Inc. for Europe area"
          "Sony Computer Entertainment Inc. for North America area"
          (or often zerofilled in some homebrew files)
          (the BIOS doesn't verify this string, and boots fine without it)
xxxh-7FFh Zerofilled
800h...   Code/Data                      (loaded to entry[018h] and up)

```

The code/data is simply loaded to the specified destination address, ie. unlike as in MSDOS .EXE files, there is no relocation info in the header.

Note: In bootfiles, SP is usually 801FFFF0h (ie. not 801FFF00h as in system.cnf). When SP is 0, the unmodified caller's stack is used. In most cases (except when manually calling DoExecute), the stack values in the exeheader seem to be ignored though (eg. replaced by the SYSTEM.CNF value).

The memfill region is zerofilled by a "relative" fast word-by-word fill (so address and size must be multiples of 4) (despite of the word-by-word filling, still it's SLOW because the memfill executes in uncached slow ROM).

The reserved region at [038h-04Bh] is internally used by the BIOS to memorize the caller's RA,SP,R30,R28,R16 registers (for some bizarre reason, this information is saved in the exe header, rather than on the caller's stack).

Additionally to the initial PC,R28,SP,R30 values that are contained in the header, two parameter values are passed to the executable (in R4 and R5 registers) (however, usually that values are simply R4=1 and R5=0).

Like normal functions, the executable can return control to the caller by jumping to the incoming RA address (provided that it hasn't destroyed the stack or other important memory locations, and that it has pushed/popped all registers) (returning works only for non-boot executables; if the boot executable returns to the BIOS, then the BIOS will simply lockup itself by calling the "SystemErrorBootOrDiskFailure" function).

Relocatable EXE

Fade to Black (CINE.EXR) contains ID "PS-X EXR" (instead "PS-X EXE") and string "PSX Relocable File - Delphine Software Int.", this is supposedly some custom relocatable exe file (unsupported by the PSX kernel).

MSDOS.EXE and WINDOWS.EXE Files

Some PSX discs contain DOS or Windows .EXE files (with "MZ" headers), eg. devkit leftovers, or demos/gimmicks.

13.3 CDROM File PsyQ .CPE Files (Debug Executables)

Fileheader

```
00h 4   File ID (01455043h aka "CPE", 01h)
```

Chunk 00h: End of File

```
00h 1   Chunk ID (00h)
```

Chunk 01h: Load Data

```
00h 1   Chunk ID (01h)
01h 4   Address (usually 80010000h and up)
05h 4   Size (LEN)
09h LEN Data (binary EXE code/data)
```

Theoretically, this could contain the whole EXE body in a single chunk. However, the PsyQ files are usually containing hundreds of small chunks (with each function and each data item in a separate chunk). For converting CPE to EXE, use "ExeOffset = (CpeAddress AND 1FFFFFFFh)-10000h+800h".

Chunk 02h: Run Address (whatever, optional, usually not used in CPE files)

```
00h 1   Chunk ID (02h)
01h 4   Address
```

Unknown what this is. It's not the entrypoint (which is set via chunk 03h). Maybe intended to change the default load address (usually 80010000h)?

Chunk 03h: Set Value 32bit (LEN=4) (used for entrypoint)**Chunk 04h: Set Value 16bit (LEN=2) (unused)****Chunk 05h: Set Value 8bit (LEN=1) (unused)****Chunk 06h: Set Value 24bit (LEN=3) (unused)**

```
00h 1   Chunk ID (03h..06h)
01h 2   Register (usually 0090h=Initial PC, aka Entrypoint)
03h LEN Value (8bit..32bit)
```

Chunk 07h: Select Workspace (whatever, optional, usually not used in CPE)

```
00h 1   Chunk ID (07h)
01h 4   Workspace number (usually 00000000h)
```

Chunk 08h: Select Unit (whatever, usually first chunk in CPE file)

```
00h 1   Chunk ID (08h)
01h 1   Unit (usually 00h)
```

Example from LameGuy's sample.cpe:

```
0000h 4   File ID ("CPE", 01h)
0004h 2   Select Unit 0 (08h, 00h)
0006h 7   Set Entrypoint 8001731Ch (03h, 0090h, 8001731Ch)
000Dh 0Dh Load (01h, 800195F8h, 00000004h, 0, 0, 0, 0)
001Ah .. Load (01h, 80010000h, 0000002Bh, ...)
004Eh .. Load (01h, 8001065Ch, 00000120h, ...)
0177h ... Load (01h, 8001077Ch, 0000012Ch, ...)
02ACh ... Load (01h, 800108A8h, 000000A4h, ...)
... .. Load (...)
98F4h ... Load (01h, 800195F0h, 00000008h, ...)
9905h 1   End (00h)
```

13.4 CDROM File PsyQ .SYM Files (Debug Information)

PsyQ .SYM Files contain debug info, usually bundled with PsyQ .MAP and Psy .CPE files. Those files are generated by PsyQ tools, which appear to be still in use for homebrew PSX titles.

The files are occasionally also found on PSX CDROMs:

```
Legacy of Kain PAL version (\DEGUG\NTSC\KAIN2.SYM+MAP+CPE)
RC Revenge (\RELEASE.SYM)
Twisted Metal: Small Brawl (MagDemo54: TMSB\TM.SYM)
Jackie Chan Stuntmaster (GAME_REL.SYM+CPE)
SnoCross Championship Racing (MagDemo37: SNOCROSS\SNOW.TOC\SNOW.MAP)
Sled Storm (MagDemo24: DEBUG\MAIN.MAP)
E.T. Interplanetary Mission (MagDemo54: MEGA\MEGA.CSH\* has SYM+CPE+MAP)
```

Fileheader .SYM

```
00h 4 File ID ("MND",01h)
04h 4 Whatever (0,0,0,0) ;TOMB5: 0,02h,0,0
08h .. Chunks (see below)
```

Symbol Chunks

CHUNK 01H: SYMBOL (IMMEDIATE, EG. MEMSIZE, OR MEMBASE)

CHUNK 02H: SYMBOL (FUNCTION ADDRESS FOR INTERNAL & EXTERNAL FUNCTIONS)

CHUNK 05H: SYMBOL (?)

CHUNK 06H: SYMBOL (?)

```
00h 4 Address/Value
04h 1 Chunk ID (01h/02h/05h/06h)
05h 1 Symbol Length (LEN)
06h LEN Symbol (eg. "VSync")
```

Source Code Line Chunks

CHUNK 80H: SOURCE CODE LINE NUMBERS: ADDRESS FOR 1 LINE

```
00h 4 Address (for 1 line, starting at current line)
04h 1 Chunk ID (80h)
```

CHUNK 82H: SOURCE CODE LINE NUMBERS: ADDRESS FOR N LINES (8BIT)

```

00h 4   Address (for N lines, starting at current line)
04h 1   Chunk ID (82h)
05h 1   Number of Lines (00h=None, or 02h and up?)

```

CHUNK 84H: SOURCE CODE LINE NUMBERS: ADDRESS FOR NN LINES (16BIT)

```

00h 4   Address (for N lines, starting at current line)
04h 1   Chunk ID (84h)
05h 2   Number of Lines (?)

```

CHUNK 86H: SOURCE CODE LINE NUMBERS: ADDRESS FOR LINE NNN (32BIT?)

```

00h 4   Address (for 1 line, starting at newly assigned current line)
04h 1   Chunk ID (84h)
05h 4   Absolute Line Number (rather than number of lines) (?)

```

CHUNK 88H: SOURCE CODE LINE NUMBERS: START WITH FILENAME

```

00h 4   Address (start address)
04h 1   Chunk ID (88h=Filename)
05h 4   First Line Number (after comments/definitions) (32bit?)
09h 1   Filename Length (LEN)
0Ah LEN Filename (eg. "C:\path\main.c")

```

CHUNK 8AH: SOURCE CODE LINE NUMBERS: END OF SOURCE CODE

```

00h 4   Address (end address)
04h 1   Chunk ID (8Ah)

```

Internal Function Chunks**CHUNK 8CH: INTERNAL FUNCTION: START WITH FILENAME**

```

00h 4   Address
04h 1   Chunk ID (8Ch)
05h 4   Whatever (1Eh,00h,20h,00h) ;or 1Eh,00h,18h,00h
09h 4   Whatever (00h,00h,1Fh,00h)
0Dh 4   Whatever (00h,00h,00h,C0h)
11h 4   Whatever (FCh,FFh,FFh,FFh) ;mask? neg.offset?
15h 4   Whatever (10h,00h,00h,00h) <-- line number (32bit?)
19h 1   Filename Length (LEN1)
1Ah LEN1 Filename (eg. "C:\path\main.c")
xxh 1   Symbol Length (LEN2)
xxh LEN2 Symbol (eg. "VSync")

```

CHUNK 8EH: INTERNAL FUNCTION: END OF FUNCTION (END OF CHUNK 8CH)

```

00h 4   Address
04h 1   Chunk ID (8Eh)
05h 4   Line Number                <-- line number (32bit?)

```

CHUNK 90H: INTERNAL FUNCTION:WHATEVER90H... FIRST INSTRUCTION IN MAIN FUNC?

CHUNK 92H: INTERNAL FUNCTION:WHATEVER92H... LAST INSTRUCTION IN MAIN FUNC?

Maybe line numbers? Or end of definitions for incoming parameters?

```

00h 4   Address
04h 1   Chunk ID (90h/92h)
05h 4   Whatever (1Fh,00h,00h,00h)  <-- line number relative to main.start?

```

Class/Type Chunks

CHUNK 94H: TYPE/SYMBOL (SIMPLE TYPES?)

```

00h 4   Offset (when used within a structure, or stack-N, or otherwise zero)
04h 1   Chunk ID (94h)
05h 2   Class (000Dh=Type.alias, 000Ah=Address, 0001h=Stack, 0002h=Addr)
07h 2   Type (XX = 8bit,16bit,signed,etc.?)
09h 4   Zero, or Size in Bytes (for "memblocks")
0xh 1   Symbol Name Length (LEN)
0xh LEN Symbol Name (eg. "size_t")

```

CHUNK 96H: TYPE/SYMBOL (COMPLEX STRUCTURES/ARRAYS?)

```

00h 4   Offset (when used within a structure, otherwise zero)
04h 1   Chunk ID (96h)
05h 2   Class (02h=Array,08h=RefToStruct,0Dh=DefineAlias,66h=StructEnd)
07h 2   Type (0xh=Small, 3xh=WithArrayStuff?) (same/similar as in chunk 94h)
09h 4   Struct Size in Bytes
0Dh 2   Array Dimensions (DIM) (0=none) ;eg. [3][4] --> 0002h
0Fh DIM*4 Array Entries per Dimension ;eg. [3][4] --> 00000003h,00000004h
xxh 1   Internal Fake Name Length (LEN1) (0=none)
xxh LEN1 Internal Fake Name (eg. ".1fake")
xxh 1   Symbol Name Length (LEN2)
xxh LEN2 Symbol Name (eg. "r")

```

Class/Type Values

CLASS DEFINITION (IN CHUNK 94H) (AND SOMEWHAT SAME/SIMILAR IN CHUNK 96H)

(looks same/similar as C_xxx class values in COFF files!)

```

0001h = Local variable          (with Offset = negative stack offset)
0002h = Global variable or Function (with Offset = address)
0008h = Item in Structure        (with Offser = offset within struct)
0009h = Incoming Function param  (with Offset = index; 0,4,8,etc.)
000Ah = Type address / struc start? (with Offset = zero)
000Dh = Type alias              (with Offset = zero)

```

TYPE DEFINITION (IN CHUNK 94H/96H)

(maybe lower 4bit=type, and next 4bit=usage/variant?)

(looks same/similar as T_xxx type values in COFF files!)

```

0000h =
0001h =
0002h =
0003h =          (16bit signed?)
0004h = int       (32bit signed?)
0005h =
0006h =
0007h =
0008h = (address)  (32bit unsigned?) (with Definition=000Ah)
0009h =
000Ah =
000Bh =
000Ch = u_char     (8bit unsigned?)
000Dh = u_short,ushort (16bit unsigned?)
000Eh = u_int      (32bit unsigned?)
000Fh = u_long     (64bit unsigned?) (or rather SAME as above?)
0021h = function with 0 params, and/or return="nothing"?
0024h = main function with 2 params, and/or return="int"?
0052h = argv       (string maybe?)
0038h = GsOT       (huh?)
00F8h = GsOT_TAG   (huh?)
00FCh = PACKET     (huh?)
??    = float,bool,string,ptr,packet, (un-)signed8/16/32/64bit,etc
??    = custom type/struct (using value 000xh plus "fake" name, or so?)

```

.MAP File

PSYQ .MAP FILE

The .SYM file is usually bundled with a .MAP file, which is containing a summary of the symbolic info as ASCII text (but without info on line numbers or data types). For example:

Start	Stop	Length	Obj	Group	Section name
80010000	80012D5B	00002D5C	80010000	text	.rdata
80012D5C	800C8417	000B56BC	80012D5C	text	.text
800C8418	800CDAB7	000056A0	800C8418	text	.data

```

800CDAB8 800CFB63 000020AC 800CDAB8 text          .sdata
800CFB64 800D5C07 000060A4 800CFB64 bss           .sbss
800D5C08 800DD33F 00007738 800D5C08 bss           .bss

```

```

Address  Names alphabetically
800CFE80 ACE_amount
800CFB94 AIMenu
800CDE5C AXIS_LENGTH
8005E28C AddClippedTri
8005DFEC AddVertex
...

```

```

Address  Names in address order
00000000 _cinemax_obj
00000000 _cinemax_header_org
00000000 _cinemax_org
00000000 _mcardx_sbss_size
00000000 _mcardx_org
...

```

13.5 CDROM File Video Texture Image TIM/PXL/CLT (Sony)

TIM/PXL/CLT are standard formats from Sony's devkit. TIM is used by many PSX games.

```

.TIM  contains Pixel data, and (optional) CLUT data  ;-all in one file
.PXL  contains Pixel data only                      ;\in two separate files
.CLT  contains CLUT data only (if any)               ;/

```

TIM Format

```

000h 1  File ID   (always 10h=TIM)
001h 1  Version   (always 00h)
002h 2  Reserved (always 0000h) (or 1 or 2 for Compressed TIM, see below)
004h 4  Flags (bit0-2=Type; see below, bit3=HasCLUT, bit4-31=Reserved/zero)
... .. Data Section for CLUT (Palette), only exists if Flags.bit3=1, HasCLUT
... .. Data Section for Pixels (Bitmap/Texture)

```

The Type in Flags.bit0-2 can be 0=4bpp, 1=8bpp, 2=16bpp, 3=24bpp, 4=Mixed.

NFL Blitz 2000 (MagDemo26: B2000\DATA\ARTD_G.BIN) does additionally use Type 5=8bit.

The Type value value is only a hint on how to view the Pixel data (the data is copied to VRAM regardless of the type; 4=Mixed is meant to indicate that the data contains different types, eg. both 4bpp & 8bpp textures).

Type 3=24bpp is quite rare, but does exist (eg. Colony Wars (MagDemo02: CWARS\GAME.RSC\DEMO.TIM)).

The format of the CLUT and Pixel Data Section(s) is:

```
000h 4  Size of Data Section (Xsiz*2*Ysiz+0Ch) ;maybe rounded to 4-byte?
004h 4  Destination Coord (YyyyXxxxh) ;Xpos counted in halfwords
008h 4  Width+Height (YsizXsizh) ;Xsiz counted in halfwords
00Ch .. VRAM Data (to be DMAed to frame buffer)
```

Note: Above is usually a multiple of 4 bytes, but not always:

Shadow Madness (MagDemo18: SHADOW\DATA\ANDY\LOADSAVE*.TIM) contains TIM bitmaps with 27x27 or 39x51 halfwords; those files have odd section size & odd total filesize. Gran Turismo 2 (GT2.VOL\arcade\arc_other.tim\0000) also has odd size.

Unknown if the CLUT can also have odd size (which would misalign the following Bitmap section).

Bust A Groove (MagDemo18: BUSTGR_A\G_COMMON.DFS\0005) has 0x0 pixel Bitmaps (with CLUT data).

PXL/CLT Format

PXL/CLT is very rare. And oddly, with swapped ID values (official specs say 11h=PXL, 12h=CLT, but the existing games do use 11h=CLT, 12h=PXL).

Used by Granstream Saga (MagDemo10 GS\)

Used by Bloody Roar 1 (MagDemo06: BL\)

Used by Bloody Roar 2 (MagDemo22: ASC,CMN,EFT,LON,SND,ST5,STU*)

CLT Format

```
000h 1  File ID ( 11h=CLT) (although Sony's doc says 12h)
001h 1  Version ( 00h)
002h 2  Reserved (always 0000h)
004h 4  Flags (bit0-1=Type=2; bit2-31=Reserved/zero)
... .. Data Section for CLUT (Palette)
```

The .CLT Type should be always 2 (meant to indicate 16bit CLUT entries).

PXL Format

```
000h 1  File ID (always 12h=PXL) (although Sony's doc says 11h)
001h 1  Version (always 00h)
002h 2  Reserved (always 0000h)
```

```
004h 4  Flags (bit0-?=Type; see below, bit?-31=Reserved/zero)
... .. Data Section for Pixels (Bitmap/Texture)
```

This does probably support the same 5 types as in .TIMs (though official Sony docs claim the .PXL type to be only 1bit wide, but nevertheless claim that PXL can be 4bpp, 8bpp, or 16bpp).

Compressed TIMs

Ape Escape (Sony 1999) is using a customized TIM format with 4bpp compression:

[CDROM File Compression TIM-RLE4/RLE8](#)

Other than that, TIMs can be compressed via generic compression functions (like LZSS, GZIP), or via bitmap dedicated compression formats (like BS, JPG, GIF).

Malformed Files

MALFORMED TIMS IN BIGFILE.DAT

```
Used by Legacy of Kain: Soul Reaver (eg. BIGFILE.DAT\folder04h\file13h)
Used by Gex - Enter the Gecko (eg. BIGFILE.DAT\file0Fh\LZcompressed)
```

Malformed TIMs contain texture data preceeded by a dummy 14h-byte TIM header with following constant values:

```
10 00 00 00 02 00 00 00 04 00 08 00 00 02 00 00 00 02 00 02 ;<-- this
10 00 00 00 02 00 00 00 04 00 08 00 00 00 00 00 00 02 00 02 ;<-- or this
```

The malformed entries include:

```
[04h]=Type should indicated the color depth, but it's always 02h=16bpp.
[08h]=Width*2*Height+0Ch should be 8000Ch, but malformed is 80004h.
Total filesize should be 80014h, but Gecko files are often MUCH smaller.
```

Also, destination yloc should be 0..1FFh, but PSX "Lemmings & Oh No! More Lemmings" (FILES\GFX*.TIM) has yloc=200h (that game also has vandalized .BMP headers with 2-byte alignment padding after ID "BM", whilst pretending that those extra bytes aren't there in data offset and total size entries).

OVERSIZED TIMS

```
Used by Pong (MagDemo24: LES02020\*\*.TIM)
```

Has 200x200h pix, but section size (and filesize) are +2 bigger than that:

```

10 00 00 00 02 00 00 00 0E 00 08 00 C0 01 00 00 02 00 02 ;Pong *.TIM
10 00 00 00 02 00 00 00 0E 00 07 00 00 02 00 00 C0 01 00 02 ;Pong WORLD.TIM
10 00 00 00 02 00 00 00 0E 80 03 00 00 02 00 01 C0 01 00 01 ;Pong ZONE*.TIM

```

MISCOMPUTED SECTION SIZE

NBA Basketball 2000 (MagDemo28: FOXBB\TIM*.TIM) has TIMs with section size "0Ch+Xsiz*Ysiz" instead of "0Ch+Xsiz*2*Ysiz".

NONTIMS IN BLOODY ROAR 1 AND 2

```

Bloody Roar 1 (CMN\INIT.DAT\000Eh)
Bloody Roar 2 (CMN\SE00.DAT, CMD\SEL00.DAT\0030h and CMN\VS\VS.DAT\0000h)

```

This looks somehow TIM-inspired, but has ID=13h.

```

13 00 00 00 02 00 00 00 0C 20 00 00 00 00 F8 01 00 01 10 00 ;Bloody Roar 1
13 00 00 00 02 00 00 00 0C 20 00 00 00 00 00 00 01 10 00 ;Bloody Roar 2

```

OTHER UNCOMMON/MALFORMED TIM VARIANTS

And, Heart of Darkness has a TIM with Size entry set to Xsiz*2*Ysiz+0Eh (instead of +0Ch) (that malformed TIM is found inside of the RNC compressed IMAGES\US.TIM file).

Also, NFL Gameday '99 (MagDemo17: GAMEDAY\PHOTOS.FIL) contains a TIM cropped to 800h-byte size (containing only the upper quarter of the photo).

Also, not directly malformed, but uncommon: Final Fantasy IX contains 14h-byte 0x0 pixel TIMs (eg. FF9.IMG\dir04\file0046\1B-0000\04-0001).

Klonoa (MagDemo08: KLONOA\FILE.IDX\3\2\0..1) has 0x0pix TIM (plus palette).

MALFORMED CLTS

```

Used by Secret of Mana, WM\WEFF\*.CLT

```

ID is 10h=TIM, Flags=10101009h (should be ID=12h, Flags=02h).

13.6 CDROM File Video Texture/Bitmap (Other)

Apart from Sony's TIM (and PXL/CLT) format, there are a bunch of other texture/bitmap formats:

Compressed Bitmaps

```
.BS used by several games (and also in most .STR videos)
.GIF used by Lightspan Online Connection CD
.JPG used by Lightspan Online Connection CD
.BMP with RLE4 used by Lightspan Online Connection CD (MONOFONT, PROPFONT)
.BMP with RLE8+Delta also used by Online Connection CD (PROPFONT\ARIA6.BMP)
.PCX with RLE used by Jampack Vol. 1 (MDK\CD.HED\*.pcx)
```

Uncompressed Bitmaps

```
.BMP
.BMP used by Mat Hoffman's Pro BMX (MagDemo39: BMX\BMXCD.HED\*)
.BMP used by Mat Hoffman's Pro BMX (MagDemo48: MHPB\BMXCD.HED\*)
.BMP used by Thrasher: Skate and Destroy (MagDemo27: SKATE\ASSETS\*.ZAL)
.BMP used by Dave Mirra Freestyle BMX (MagDemo36,46: BMX\ASSETS\*.ZAL)
.VRM .IMG .TEX .TIM .RAW .256 .COL .4B .15B .R16 .TPG - raw VRAM data
"SC" memory card icons
```

Targa TGA and Paintbrush PCX

[CDROM File Video Texture/Bitmap \(TGA\)](#)

[CDROM File Video Texture/Bitmap \(PCX\)](#)

PSI bitmap - Power Spike (MagDemo43: POWER\GAME.IDX\B/Z\PSI)

```
000h 10h  Name 1 ("FILENAME.BMP", zeropadded)
010h 10h  Name 2 ("FILENAME.PSI", zeropadded)
020h 4     Bits per pixel (usually 4, 8, or 16)
024h 2     Bitmap VRAM Dest.X ?
026h 2     Bitmap VRAM Dest.Y ?
028h 2     Bitmap Width in pixels
02Ah 2     Bitmap Height in pixels
02Ch 2     Palette VRAM Dest.X ?    ;\zero for 16bpp
02Eh 2     Palette VRAM Dest.Y ?    ;/
030h 2     Bitmap Width in Halfwords (PixelWidth*bpp/16)
032h 2     Palette Size in Halfwords (0, 10h, 100h for 16bpp,4npp,8bpp)
034h 4     Maybe Bitmap present flag (always 1)
038h 4     Maybe Palette present flag (0=16bpp, 1=4bpp/8bpp)
03Ch ..    Bitmap pixels
... ..    Palette (if any, for 4bpp: 16x16bit, for 8bpp: 256x16bit)
```

JumpStart Wildlife Safari Field Trip (MagDemo52: DEMO\DATA.DAT*.DAT+*.PSX)

This game does use two different (but nearly identical) bitmap formats (with either palette or bitmap data stored first).

```

000h 4      Total Filesize (Width*Height+20Ch)
004h 2      Bitmap Width
006h 2      Bitmap Height
008h 4      Unknown, always 1 (maybe 1=8bpp?)
In .DAT files (512x192 or 256x64 pix), palette first:
00Ch 200h   Palette data
20Ch ..     Bitmap data
In .PSX files (64x64 pix), bitmap first:
00Ch ..     Bitmap data
... 200h    Palette data

```

To detect the "palette first" format, check for these conditions(s):

```

Filename extension is ".DAT"
Bitmap Width<>Height (non-square)
[00Ch..20Bh] has AllMSBs>=80h, and SomeLSBs<80h

```

Note: The bitmaps are vertically mirrored (starting with bottom-most scanline).

WxH Bitmap (Width*Height)

Used by Alone in the Dark The New Nightmare (FAT.BIN\BOOK,DOC,INTRO,MENU\)

Used by Rayman (RAY\JUN,MON,MUS\) (but seems to contain map data, not pixels)

```

000h 2      Width  (W)      ;\usually 320x240 (or 512x240 or 80x13)
002h 2      Height (H)      ;/
004h ..     Bitmap 16bpp (W*H*2 bytes)

```

RAWP Bitmap

Used by Championship Motocross (MagDemo25: SMX\RESHAD.BIN*) ("RAWP")

```

000h 4      ID "RAWP" (this variant has BIG-ENDIAN width/height!)
004h 2      Width  (usually 280h=640pix or 140h=320pix) (big-endian!!!)
006h 2      Height (usually 1E0h=480pix or F0h=240pix) (big-endian!!!)
008h ..     Bitmap data, 16bpp (width*height*2 bytes)

```

XYWH Bitmap/Palette (X,Y,Width*Height) (.BIT and .CLT)

Used by CART World Series (MagDemo04: CART*.BIT and *.BIN*)

Used by NFL Gameday '98 (MagDemo04: GAMEDAY\BUILD\GRBA.FIL\)

*Used by NFL Gameday '99 (MagDemo17: GAMEDAY\.*BIT and **.FIL\)*

*Used by NFL Gameday 2000 (MagDemo27: GAMEDAY\.*BIT)

Used by NCAA Gamebreaker '98 (MagDemo05: GBREAKER*.BIT and UFLA.BIN*)

Used by NCAA Gamebreaker 2000 (MagDemo27: GBREAKER*.BIT and *.FIL*)

Used by Twisted Metal 4 (MagDemo30: TM4DATA*.MR, *.IMG\.*bit,**.clt*)

```
000h 2   VRAM.X           (X) (0..3FFh)
002h 2   VRAM.X           (Y) (0..1FFh)
004h 2   Width in halfwords (W) (1..400h)
006h 2   Height           (H) (1..200h)
008h ..   Bitmap or Palette data (W*H*2 bytes)
```

Doom (PSXDOOM\ABIN\PSXDOOM.WAD\)

```
000h 2   Hotspot X (signed) (usually 0)
002h 2   Hotspot Y (signed) (usually 0)
004h 2   Width in bytes
006h 2   Height
008h ..   Bitmap 8bpp (Width*Height bytes)
```

Most files have Hotspot X=0,Y=0, WAD\LOADING has X=FF80h,Y=FF8Ah, and WAD\S* has X=0..Width, Y=0..Height+1Ah (eg. S\BKEY*, S\BFG*, S\PISFA0 have large Y).

The files do not contain any palette info... maybe 2800h-byte PLAYPAL does contain the palette(s)?

Lemmings & Oh No! More Lemmings (FILES\GFX\BOB, FILES\SMLMAPS\BOB)

```
000h 2   Width
002h 2   Height
004h 100h*3   Palette 24bit RGB888
304h ..   Bitmap 8bpp (Width*Height bytes)
.. (1700h)   Unknown (only in SMLMAPS\*.BOB, not in GFX\*.BOB)
```

Apart from .BOB, the FILES\GFX folder also has vandalized .BMP (with ID "BM",00h,00h) and corrupted .TIM (with VRAM.Y=200h).

Perfect Assassin (DATA.JFS\DATA*.BM)

```

000h 4      Format 1 (0=8bpp, 1=16bpp)
004h 4      Format 2 (1=8bpp, 2=16bpp)
008h 4      Width in pixels
00Ch 4      Height in pixels
010h ..     Bitmap Data
... (300h) Palette 18bit RGB666 (R,G,B range 00h..3Fh) (only if format 8bpp)

```

One (DIRFILE.BIN*.VCF)

```

000h 4      Unknown (always 1)
004h 4      Unknown (always 8)
008h 4      Unknown (always 2) (maybe 2=16bpp?)
00Ch 4      Width in pixels (3Ah, 140h, or 280h)
010h 4      Height          (3Ah, or F0h)
014h ..     Bitmap 16bpp (Width*Height*2 bytes)

```

One (DIRFILE.BIN*.VCK and DIRFILE.BIN\w*\sect*.bin\TEXTURE 001)

```

000h 2      Number if Files (N)
002h 2      Number of VRAM.Slots (less or equal than Number of Files)
004h 4      ID "BLK0"
008h N*10h File List
... ..     1st File Bitmap
... ..     1st File Palette (20h/200h/0 bytes for 4bpp/8bpp/16bpp)
... ..     2nd File Bitmap
... ..     2nd File Palette (only if PaletteID=FileNo=1)
... ..     3rd File Bitmap
... ..     3rd File Palette (only if PaletteID=FileNo=2)
... ..     etc.

```

File List entries:

```

000h 2      VRAM.X in halfwords (0..1Fh, +bit15=Blank) ;\within current
002h 2      VRAM.Y              (0..3Fh)                ;/VRAM.Slot
004h 2      Width in pixels (max 80h/40h/20h for 4bpp/8bpp/16bpp)
006h 2      Height              (max 40h)
008h 2      VRAM.Slot           (0,1,2,3,...,NumSlots-1)
00Ah 2      Unknown             (0,1,2,4 in *.vck, 4 in sect*.bin)
00Ch 2      Color Depth         (0=4bpp, 1=8bpp, 2=16bpp)
00Eh 2      Palette ID          (0..FileNo-1=Old, FileNo=New, FFFFh=None/16bpp)
NumFiles-1, or ID of already used palette)

```

Note: VRAM.Slots are 20h*40h halfwords.

Bitmaps can either have newly defined palettes (when PaletteID=FileNo), or re-use previously defined "old" palettes (when PaletteID\<FileNo).

The Blank flag allows to define a blank region (for whatever purpose), the file doesn't contain any bitmap/palette data for such blank regions.

BMR Bitmaps

These are 16bpp bitmaps, stored either in uncompressed .BMR files, or in compressed .RLE files:

[CDROM File Compression RLE_16](#)

```
Apocalypse (MagDemo16: APOC\CD.HED\*.RLE and *.BMR)
Spider-Man 1 older version (MagDemo31: SPIDEY\CD.HED\*.RLE)
Spider-Man 1 newer version (MagDemo40: SPIDEY\CD.HED\*.RLE and .BMR)
Spider-Man 2 (MagDemo50: HARNESS\CD.HED\*.RLE)
Tony Hawk's Pro Skater (MagDemo22: PROSKATE\CD.HED\*.BMR)
```

The width/height for known filesizes are:

```
33408h bytes --> 512x205pix, 16bpp (Apocalypse warning.rle)
3C008h bytes --> 512x240pix, 16bpp (most common)
96008h bytes --> 640x480pix, 16bpp (tony hawk's pro skater)
```

Most of the older BMR files (in Apocalypse) have valid 8-byte headers:

```
000h 2      Unknown (FFA0h) (ID for files with valid headers?)
002h 2      Dest.Y (usually 0) (11h=(240-205)/2 in Apocalypse warning.rle)
004h 2      Width (usually 200h=512pix)
006h 2      Height (usually F0h=240pix) (CDh=205pix in Apocalypse warning.rle)
008h ..     Bitmap data, 16bpp (width*height*2 bytes)
```

Most or all newer BMR files (in Apocalypse "loadlogo.rle", and in all files in Spider-Man 1, Spider-Man-2, Tony Hawk's Pro Skater) have the 8-byte header replaced by unused 8-byte at end of file:

```
000h ..     Bitmap data, 16bpp (width*height*2 bytes)
.. 8        Unused (garbage or extra pixels, not transferred to VRAM)
```

BUG: The bitmaps in all .BMR files (both with/without header) are distorted: The last 4-byte (rightmost 2pix) of each scanline should be actually located at the begin of the scanline, and the last scanline is shifted by an odd amount of bytes (resulting in nonsense 16bpp pixel colors); Spider-Man is actually displaying the bitmap in that distorted form (although it does mask off some glitches: one of the two bad rightmost pixels is replaced by a bad black leftmost pixel, and glitches in upper/lower lines aren't visible on 224-line NTSC screens).

Croc 1 (retail: *.IMG) (retail only, not in MagDemo02 demo version)

Croc 2 (MagDemo22: CROC2\CROCI.DIR*.IMG)

Disney's The Emperor's New Groove (MagDemo39: ENG\KINGDOM.DIR*.IMG)

Disney's Aladdin in Nasira's Rev. (MagDemo46: ALADDIN\ALADDIN.DIR*.IMG)

Contains raw 16bpp bitmaps, with following sizes:

```
25800h bytes = 12C00h pixels (320x240) ;Croc 1 (retail version)
3C000h bytes = 1E000h pixels (512x240)
96000h bytes = 4B000h pixels (640x480)
```

Note: The .IMG format is about same as .BMR files (but without the 8-byte header, and without distorted scanlines).

Mat Hoffman's Pro BMX (MagDemo39: BMX\FE.WAD+STR*.BIN) (Activision)

Mat Hoffman's Pro BMX (MagDemo48: MHPB\FE.WAD+STR*.BIN) (Shaba/Activision)

```
000h 2      Bits per pixel (4 or 8)
002h 2      Bitmap Width in pixels
004h 2      Bitmap Height in pixels
006h 2      Zero
008h N*2    Palette (with N=(1 SHL bpp))
... ..     Bitmap (with Width*Height*bpp/8 bytes)
... (..)    Zeropadding to 4-byte boundary (old version only)
```

The trailing alignment padding exists only in old demo version (eg. size of 78x49x8bpp "coreypp.bin" is old=10F8h, new=10F6h).

E.T. Interplanetary Mission (MagDemo54: MEGA\MEGA.CSH*)

```
000h 2      Type (0=4bpp, 1=8bpp, 2=16bpp)
002h 2      Unknown (usually 0000h, or sometimes CCCCh)
004h 2      Bitmap Width in pixels
006h 2      Bitmap Height in pixels
008h 200h   Palette (always 200h-byte, even for 4bpp or 16bpp)
208h ..     Bitmap (Width*Height*bpp/8 bytes)
```

Palette is 00h-or-CCh-padded when 4bpp, or CCh-filled when 16bpp.

Note: Some files contain two or more such bitmaps (of same or different sizes) badged together.

EA Sports: Madden NFL '98 (MagDemo02: TIBURON\DAT\)**EA Sports: Madden NFL 2000 (MagDemo27: MADN00\DAT\)****EA Sports: Madden NFL 2001 (MagDemo39: MADN01\DAT\)**

This format is used in various EA Sports Madden .DAT archives, it contains standard TIMs with extra Headers/Footers.

```

000h 4      Offset to TIM (1Ch) (Hdr size)      (1Ch)          ;\
004h 4      Offset to Footer      (Hdr+TIM size) (123Ch,1A3Ch,1830h) ;
008h 2      Bitmap Width in pixels      (40h or 60h or 30h)      ;
00Ah 2      Bitmap Height in pixels      (40h)                  ;
00Ch 4      Unknown, always 01h          (01h)                  ; Header
010h 4      Unknown, always 23h          (23h)                  ; 1Ch bytes
014h 2      Unknown, always 0101h        (101h)                 ;
016h 1      Bitmap Width in pixels      (40h or 60h or 30h)      ;
017h 1      Bitmap Height in pixels      (40h)                  ;
018h 4      Unknown, always 00h          (0)                    ;/
01Ch ..     TIM (Texture, can be 4bpp, 8bpp, 16bpp)              ;-TIM
... 4      Unknown, always C0000222h     (C0000222h)           ;\
... 2      Unknown, always 0001h         (0001h)               ;
... 1      Bitmap Width in pixels      (40h or 60h or 30h)      ; Footer
... 1      Bitmap Height in pixels      (40h)                  ; 12h bytes
... 4      Unknown, always 78000000h     (78000000h)           ;
... 6      Unknown                      (0,0,80h,0,0,0)         ;/

```

Purpose is unknown; the 8bit Width/Height entries might be TexCoords.

The PORTRAITS.DAT archives are a special case:

```

Madden NFL '98 (MagDemo02: TIBURON\PORTRAIT.DAT) (48x64, 16bpp)
Madden NFL 2000 (MagDemo27: MADN00\PORTRAIT.DAT) (96x64, 8bpp plus palette)
Madden NFL 2001 (MagDemo39: MADN01\PORTRAIT.DAT) (64x64, 8bpp plus palette)

```

Those PORTRAITS.DAT don't have any archive header, instead they do contain several images in the above format, each one zeropadded to 2000h-byte size.

989 Sports: NHL Faceoff '99 (MagDemo17: FO99\KGB\TEX)**989 Sports: NHL Faceoff 2000 (MagDemo28: FO2000*.TEX)****989 Sports: NCAA Final Four 2000 (MagDemo30: FF00*.TEX)**

```

000h 0Ch    ID "TEX PSX ",01h,00h,00h,00h      ;used in 989 Sports games
00Ch 4      Number of Textures
010h 4      Total Filesize

```

```

014h 4    Common Palette Size      (0=200h, 1=None, 2=20h)
018h (..) Common Palette, if any (0,20h,200h bytes)
... ..   Texture(s)
Texture format:
000h 10h  Filename (eg. "light1", max 16 chars, zeropadded if shorter)
010h 4    Width in pixels  (eg. 40h)
014h 4    Height           (eg. 20h or 40h)
018h 4    Unknown          (always 0)
01Ch 4    Number of Colors (eg. 10h, 20h or 100h)
020h ..   Bitmap (4bpp when NumColors<=10h, 8bpp when NumColors>10h)
... (..) Palette (NumColors*2 bytes, only present if Common Palette=None)

```

The .TEX files may be in ISO folders, KGB archives, DOTLESS archives. And, some are stored in headerless .DAT/.CAT archives (which start with ID "TEX PSX ", but seem to have further files appended thereafter).

Electronic Arts .PSH (SHPP)

FIFA - Road to World Cup 98 (with chunk C0h/C1h = RefPack compression)

NCAA March Madness 2000 (MagDemo32: MM2K\.*PSH*)

Need for Speed 3 Hot Pursuit (*.PSH, ZLOAD*.QPS\RefPack.PSH)

ReBoot (DATA\.*PSH*) (with chunk 6Bh)

Sled Storm (MagDemo24: DEBUG,ART,ART2,ART3,SOUND\.*PSH*) (*with Comment, Mipmap*)

WCW Mayhem (MagDemo28: WCWDEMO\.*BIG**.PSH) (with chunk C0h/C1h = RefPack)

```

000h 4    ID "SHPP"
004h 4    Total Filesize (or Filesize-0Ch, eg. FIFA'98 ZLEG*.PSH)
008h 4    Number of Textures (N)
00Ch 4    ID "GIMX"
010h N*8  File List
... ..   Data (each File contains a Bitmap chunk, and Palette chunk, if any)
File List entries:
000h 4    Name (ascii) (Mipmaps use the same name for each mipmap level)
004h 4    Offset from begin of archive to first Chunk of file
Caution: Most PSH files do have the above offsets sorted in increasing order,
but some have UNSORTED offsets, eg. Sled Storm (MagDemo24: ART3\LOAD1.PSH),
so one cannot easily compute sizes as NextOffset-CurrOffset.
Note: Mipmap textures consist of two files with same name and different
resolution, eg. in Sled Storm (MagDemo24: ART\WORLD0x.PSH)
Bitmap Chunk:
000h 1    Chunk Type (40h=PSX/4bpp, 41h=PSX/8bpp, 42h=PSX/16bpp)
001h 3    Offset from current chunk to next chunk (000000h=None)
004h 2    Bitmap Width in pixels (can be odd, pad lines to 2-byte boundary)
006h 2    Bitmap Height
008h 2    Center X      (whatever that is)
00Ah 2    Center Y      (whatever that is)
00Ch 2    Position X (whatever that is, plus bit12-15=flags?)
00Eh 2    Position Y (whatever that is, plus bit12-15=flags?)

```

```

010h ..   Bitmap data (each scanline is padded to 2-byte boundary)
... ..   Padding to 8-byte boundary
Compressed Bitmap Chunk:
000h 1    Chunk Type (C0h=PSX/4bpp, C1h=PSX/8bpp, and probably C2h=PSX/16bpp)
001h 0Fh  Same as in Chunk 40h/41h/42h (see there)
010h ..   Compressed Bitmap data (usually/always with Method=10FBh)
... ..   Padding to 8-byte boundary
Palette Chunk (if any) (only for 4bpp/8bpp bitmaps, not for 16bpp):
000h 1    Chunk Type (23h=PSX/Palette)
001h 3    Offset from current chunk to next chunk (000000h=None)
004h 2    Palette Width in halfwords (10h or 100h)
006h 2    Palette Height (1)
008h 2    Unknown (usually same as Width) (or 80D0h or 9240h)
00Ah 2    Unknown (usually 0000h) (or 0001h or 0002h)
00Ch 2    Unknown (usually 0000h)
00Eh 2    Unknown (usually 00F0h)
010h ..   Palette data (16bit per color)
Note: The odd 80D0h,0001h values occur in Sled Storm ART\WORKD00.PSH\TBR1)
Unknown Chunk (eg. ReBoot (DATA\AREA15.PSH\sp*))
000h 1    Chunk Type (6Bh)
001h 3    Offset from current chunk to next chunk (000000h=None)
004h 8    Unknown (2C,00,00,3C,03,00,00,00)
00Ch -    For whatever reason, there is no 8-byte padding here
Comment Chunk (eg. Sled Storm (MagDemo24: ART\WORLD0x.PSH))
000h 1    Chunk Type (6Fh=PSX/Comment)
001h 3    Offset from current chunk to next chunk (000000h=None)
004h ..   Comment ("Saved in Photoshop Plugin made by PEE00751@...",00h)
... ..   Zeropadding to 8-byte boundary
Unknown Chunk (eg. Sled Storm (MagDemo24: ART\WORLD09.PSH\ADAA))
000h 1    Chunk Type (7Ch)
001h 3    Offset from current chunk to next chunk (000000h=None)
004h 2Ch  Unknown (reportedly Hot spot / Pix region, but differs on PSX?)

```

The whole .PSH file or the bitmap chunks can be compressed:

CDROM File Compression EA Methods

Variants of the .PSH format are also used on PC, PS2, PSP, XBOX (with other Chunk Types for other texture/palette formats, and for optional extra data). For details, see: http://wiki.xentax.com/index.php/EA_SSH_FSH_Image

Destruction Derby Raw (MagDemo35: DDRAW*.PCK,*.FNT,*.SPR)

This format can contain one single Bitmap, or a font with several small character bitmaps.

```

000h 2    ID "BC" ;\
002h 1    Color Depth (1=4bpp, 2=8bpp, 4=16bpp) ; Header
003h 1    Type (40h=Bitmap, C0h=Font) ;/
... (2)   Palette Unknown (0 or 1) ;\only if Bitmap
... (2)   Palette Unknown (1) ; 4bpp or 8bpp
... (...) Palette data (20h or 200h bytes for 4bpp/8bpp) ;/

```

```

... 2      Bitmap Number of Bitmaps-1 (N-1)          ;\
... 2      Bitmap Width in pixels                     ;
... 2      Bitmap Height in pixels                    ; Bitmap(s)
... N*1    Bitmap Tilenumbers (eg. "ABCDEFG..." for Fonts);
... N*1    Bitmap Proportional Font widths? (0xh or FFh) ;
... N*BMP  Bitmap(s) for all characters               ;/
... (20h)  Palette Data (20h bytes for 4bpp)          ;-only if Font/4bpp

```

All bitmap scanlines are padded to 2-byte boundary, eg. needed for:

```

INGAME1\BOWL2.PTH\SPRITES.PTH\ST.SPR    30x10x4bpp: 15 --> 16 bytes/line
INGAME1\BOWL2.PTH\SPRITES.PTH\STOPW.SPR 75x40x4bpp: 37.5 --> 38 bytes/line

```

The BC files are usually compressed (either in PCK file, or in the compressed DAT portion of a PTH+DAT archive).

Cool Boarders 2 (MagDemo02: CB2\DATA**.FBD)

```

000h 2      ID ("FB")                                ;\File Header
002h 2      Always 1 (version? 4bpp? num entries?)    ;/
004h 2      Palette VRAM Dest X (eg. 300h)            ;\
006h 2      Palette VRAM Dest Y (eg. 1CCh,1EDh,1FFh) ; Palette Header
008h 2      Palette Width in halfwords (eg. 100h)     ; (all zero when unused)
00Ah 2      Palette Height (eg. 1 or 0Dh)             ;/
00Ch 2      Bitmap VRAM Dest X (eg. 140h or 200h)    ;\
00Eh 2      Bitmap VRAM Dest Y (eg. 0 or 100h)       ; Bitmap Header
010h 2      Bitmap Width in halfwords                 ;
012h 2      Bitmap Height                             ;/
... ..      Palette Data (if any)                     ;-Palette Data
... ..      Bitmap Data                               ;-Bitmap Data

```

The bitmap data seems to be 4bpp and/or 8bpp, but it's hard to know the correct palette (some files have more than 16 or 256 palette colors, or don't have any palette at all).

13.7 CDROM File Video Texture/Bitmap (TGA)

Targa TGA

```

000h 1      Image ID Size (00h..FFh, usually 0=None) ;0
001h 1      Palette Present Flag (0=None, 1=Present) ;0          iv=1
002h 1      Data Type code (0,1,2,3,9,10,11,32,33)   ;NEBULA=2      iv=1
003h 2      Palette First Color (usually 0)          ;0             iv=0
005h 2      Palette Number of Colors (usually 100h) ;0             iv=100h
007h 1      Palette Bits per Color (16,24,32, usually 24) ;0             iv=18h
008h 2      Bitmap X origin (usually 0)              ;0
00Ah 2      Bitmap Y origin (usually 0)              ;0

```

```

00Ch 2   Bitmap Width                               ;NEBULA=20h LOGO=142h
00Eh 2   Bitmap Height                             ;NEBULA=20h
010h 1   Bitmap Bits per Pixel (8,16,24,32 exist?) ;NEBULA=18h   iv=8
011h 1   Image Descriptor (usually 0)              ;0
012h ..  Image ID Data (if any, len=[00h], usually 0=None)
... ..  Palette
... ..  Bitmap
... 1Ah Footer (8x00h, "TRUEVISION-XFILE.", 00h) (not present in iview)

```

Data Type [02h]:

```

00h = No image data included ; -Unknown purpose
01h = Color-mapped image     ; \
02h = RGB image              ; Uncompressed
03h = Black and white image  ; /
09h = Color-mapped image     ; \Runlength
0Ah = RGB image              ; /
0Bh = Black and white image  ; -Unknown compression method
20h = Color-mapped image     ; -Huffman+Delta+Runlength
21h = Color-mapped image     ; -Huffman+Delta+Runlength+FourPassQuadTree

```

The official specs do list the above 9 types, but do describe only 4 types in detail (type 01h,02h,09h,0Ah).

```

Type 01h and 09h lack details on supported bits per pixel (8bpp with 100h
  colors does exist; unknown if less (or more) than 8bpp are supported,
  and if so, in which bit order.
Type 02h and 0Ah are more or less well documented.
Type 03h has unknown bit-order, also unknown if/how it differs from type
  01h with 1bpp.
Type 0Bh, 20h, 21h lack any details on the compression method.

```

TGA's are used by a couple of PSX games/demos (all uncompressed):

```

16bpp: Tomb Raider 2 (MagDemo01: TOMBRAID\*.RAW)
24bpp: Tomb Raider 2 (MagDemo05: TOMB2\*.TGA)
24bpp: Colony Wars Venegance (MagDemo14: CWV\GAME.RSC\NEBULA*.TGA, *SKY.TGA)
24bpp: Colony Wars Red Sun (MagDemo31: CWREDSUN\GAME.RSC\000A\*)
16bpp: Colony Wars Venegance (MagDemo14: CWV\GAME.RSC\LOGO.DAT)
16bpp: X-Men: Mutant Academy (MagDemo50: XMEN2\*)
16bpp: Disney's Tarzan (MagDemo42: TARZAN\*)
8bpp+Wrong8bitAttr: SnoCross Championship Racing (MagDemo37: SNOCROSS\*.TGA)
16bpp+WrongYflip: SnoCross Championship Racing (MagDemo37: SNOCROSS\*.TGA)

```

For whatever reason, TGA is still in use on newer consoles:

```

32bpp: 3DS AR Games (RomFS:\i_ar\tex\hm*.lz77

```

13.8 CDROM File Video Texture/Bitmap (PCX)

PC Paintbrush .PCX files (ZSoft)

Default extension is .PCX (some tools did use .PCX for the "main" image, and .PCC for smaller snippets that were clipped/cropped/copied from from a large image).

```

000h 1   File ID (always 0Ah=PCX/ZSoft)
001h 1   Version (0,2,3,4,5)
002h 1   Compression (always 01h=RLE) (or inofficial: 00h=Uncompressed)
003h 1   Bits per Pixel (per Plane) (1, 2, 4, or 8)
004h 2   Window X1   ;\
006h 2   Window Y1   ; Width  = X2+1-X1
008h 2   Window X2   ; Height = Y2+1-Y1
00Ah 2   Window Y2   ;/
00Ch 2   Horizontal Resolution in DPI ;\often square, but can be also zero,
00Eh 2   Vertical Resolution in DPI   ;/or screen size, or other values
010h 30h EGA/VGA Palette (16 colors, 3-byte per color = R,G,B) (or garbage)
010h 1   CGA: Bit7-4=Background Color (supposedly IRGB1111 ?)
013h 1   CGA: Bit7:0=Color,1=Mono,Bit6:0=Yellow,1=White,Bit5:0=Dim,1=Bright
014h 1   Paintbrush IV: New CGA Color1 Green ;\weird new way to encode CGA
015h 1   Paintbrush IV: New CGA Color1 Red   ;/palette in these two bytes
040h 1   Reserved (00h) (but is 96h in animals.pcx)
041h 1   Number of color planes (1=Palette, 3=RGB, or 4=RGBI)
042h 2   Bytes per Line (per plane) (must be N*2) (=(Width*Bits+15)/16*2)
044h 2   PaletteInfo? (0000h/xxxxh=Normal, 0001h=Color/BW, 0002h=Grayscale)
046h 2   Horizontal screen size in pixels ;\New fields, found only
048h 2   Vertical screen size in pixels   ;/in Paintbrush IV/IV Plus
04Ah 36h Reserved (zerofilled) (or garbage in older files, custom in MGS)
080h ..  Bitmap data (RLE compressed)
... 1   VGA Palette ID (0Ch=256 colors) ;\when 8bpp
.. 300h VGA Palette (256 colors, 3-byte per color = R,G,B) ;/

```

Decoding PCX files is quite a hardcore exercise due to a vast amount of versions, revisions, corner cases, incomplete & bugged specifications, and inofficial third-party glitches.

PCX Versions

```

00h = Version 2.5 whatever ancient stuff
02h = Version 2.8 with custom 16-color palette
03h = Version 2.8 without palette (uses fixed CGA/EGA palette)
04h = Version ?? without palette (uses fixed CGA/EGA palette)
05h = Version 3.0 with custom 16-color or 256-color palette or truecolor

```

NOTE: Version[01h]=05h with PaletteInfo[44h]=0001h..0002h is Paintbrush IV?

Known PCX Color Depths

```
planes=1, bits=1  P1      ;1bit, HGC 2 color (iview and paint shop pro 2)
planes=1, bits=2  P2      ;2bit, CGA 4 color (with old/new palette info)
planes=3, bits=1  RGB111  ;3bit, EGA 8 color (official samples) ;\version
planes=4, bits=1  IRGB1111 ;4bit, EGA 16 color (paint shop pro 2) ;/03h..04h
planes=1, bits=4  P4      ;4bit, BMP 16 color (iview)
planes=1, bits=8  P8      ;8bit, VGA 256 color palette
planes=1, bits=8  I8      ;8bit, VGA 256 level grayscale (gmarbles.pcx)
planes=3, bits=8  BGR888  ;24bit, truecolor (this is official 24bit format)
;planes=1, bits=24 BGR888 ? ;24bit, reportedly exists? poor compression
;planes=4, bits=4  ABGR4444 ;16bit, wikipedia-myth? unlikely to exist
;planes=4, bits=8  ABGR8888 ;32bit, truecolor+alpha (used in abydos.dcx\*)
```

Width and Height

These are normally calculated as so:

```
Width  = X2+1-X1      ;width for normal files
Height = Y2+1-Y1      ;height for normal files
```

However, a few PCX files do accidentally want them to be calculated as so:

```
Width  = X2-X1        ;width for bugged files
Height = Y2-Y1        ;height for bugged files
```

Files with bugged width can be (sometimes) detected as so:

```
(Width*Bits+15)/16*2) > BytesPerLine
```

Files with bugged height can be detected during decompression:

```
BeginOfLastScanline >= Filesize (or Filesize-301h for files with palette)
```

Bugged sample files are SAMPLE.DCX, marbles.pcx and gmarbles.pcx. RLE decompression may crash when not taking care of such files.

Color Planes and Palettes

The official ZSoft PCX specs are - wrongly - describing planes as:

```
plane0 = red          ;\
plane1 = green        ; this is WRONG, NONSENSE, does NOT exist
plane2 = blue         ;
plane3 = intensity    ;/
```


The 8-color and 16-color EGA images are actually using plane0,1,2,(3) as bit0,1,2,(3) of the EGA color number; which implies plane0=blue (ie. red/blue are opposite of the ZSoft document).

The truecolor and truecolor+alpha formats have plane0..2=red,green,blue (as described by ZSoft), but they don't have any intensity plane (a few files are using plane3=alpha).

Mono 2-Color Palette

This format was intended for 640x200pix 2-color CGA graphics, it's also common for higher resolution FAX or print images. The general rule for these files is to use this colors:

```
color0=black
color1=white
```

There are rumours that color1 could be changed to any of the 16 CGA colors (supposedly via [10h].bit7-4, but most older & newer 2-color files have that byte set to 00h, so one would end up with black-on-black).

Some newer 2-color files contain RGB palette entries [10h]=000000h, [13h]=FFFFFFh (and [16h..3Fh]=00h-filled or FFh-filled).

Iview does often display 2-color images with color1=dark green (somewhat mysteriously; it's doing that even for files that don't contain any CGA color numbers or RGB palette values that could qualify as dark green).

4-Color Palettes

This format was intended for 320x200pix 4-color CGA graphics, and the palette is closely bound to colors available in CGA graphics modes. Color0 is defined in [10h], and Color1-3 were originally defined in [13h], and later in

```
color0=[10h].bit7-4 ; (Color0 IRGB) ; CGA Port 3D9h.bit3-0 (usually 0=black)
bright=[13h].bit5 ; CGA Port 3D9h.bit4 ; \
palette=[13h].bit6 ; CGA Port 3D9h.bit5 ; old method
if [13h].bit7 then palette=2 ; CGA Port 3D8h.bit2 ; /
if [01h]=05h and [44h]=0001h then ; \new "smart"
    if [14h]>200 or [15h]>200 then bright=1, else bright=0 ; method used in
    if [14h]>[15h] then palette=0 else palette=1 ; /Paintbrush IV
if palette=0 and bright=0 then color1..3=02h,04h,06h ; \green-red-yellow
if palette=0 and bright=1 then color1..3=0Ah,0Ch,0Eh ; /
if palette=1 and bright=0 then color1..3=03h,05h,07h ; \cyan-magenta-white
if palette=1 and bright=1 then color1..3=0Bh,0Dh,0Fh ; /
if palette=2 and bright=0 then color1..3=03h,04h,07h ; \cyan-red-white
if palette=2 and bright=1 then color1..3=0Bh,0Ch,0Fh ; /
```

Palette=2 uses some undocumented CGA glitch, it was somewhat intended to output grayscale by disabling color burst on CGA hardware with analog composite output, but actually most or all CGA hardware is having digital 4bit IRGB output, which outputs cyan-red-white.

The new "smart" method is apparently trying to detect if [13h-1Bh] contains RGB values with Color1=Green or Cyan, and to select the corresponding CGA palette; unfortunately such PCX files are merely setting 14h,15h to match up with the "smart" formula, without actually storing valid RGB values in [13h-1Bh].

8-Color and 16-Color, with fixed EGA Palettes (version=03h or 04h)

These images have 3 or 4 planes. Plane0-3 correspond to bit0-3 of the EGA color numbers (ie. blue=plane0, green=plane1, red=plane2, and either intensity=plane3 for 16-color, or intensity=0 for 8-color images).

Some 8-Color sample images (with version=03h and 04h) can be found bundled with PC Paintbrush Plus 1.22 for Windows. A 16-color sample called WINSCR.PCX can be found elsewhere in internet.

Caution 1: Official ZSoft specs are wrongly claiming plane0=red and plane2=blue; this is wrong (although Paint Shop Pro 2 is actually implementing it that way) (whilst MS Paint for Win95b can properly display them) (most other tools are trying to read a palette from [10h..3Fh], which is usually garbage filled in version=03h..04h).

Caution 2: The standard EGA palette is used for version=03h..04h (many docs claim it to be used for version=03h only).

16-Color, with custom EGA/VGA Palettes (version=02h or 05h)

These can have 1 plane with 4 bits, or 4 planes with 1 bit. Header[10h..3Fh] contains a custom 16-color RGB palette with 3x8bit per R,G,B.

Classic VGA hardware did only use the upper 6bit of the 8bit values.

Classic EGA hardware did only use the upper 2bit of the 8bit values (that, only when having a special EGA monitor with support for more than 16 colors).

256-Color VGA Palettes (version=05h)

These have 1 plane with 8 bits. And a 256-color RGB palette with 3x8bit per R,G,B appended at end of file.

The appended 256-color palette should normally exist only in 256-color images, some PCX tools are reportedly always appending the extra palette to all version=05h files (even for 2-color files).

256-Level Grayscale Images (version=05h and [44h]=0002h)

The most obvious and reliable way is to use a palette with grayscale RGB values. However, Paintbrush IV is explicitly implementing (or ignoring?) an obscure grayscale format with following settings:

```
[01h]=version=05h, and [44h]=0002h=grayscale
```

That settings are used in a file called gmarbles.pcx (which does contain a 256-color RGB palette with gray RGB values, ie. one can simply ignore the special settings, and display it as normal 256-color image).

Default 16-color CGA/EGA Palettes

Color	Name	IRGB1111	RGB222	RGB888	Windows
00h	dark black	0000	000	000000	000000
01h	dark blue	0001	002	0000AA	000080
02h	dark green	0010	020	00AA00	008000
03h	dark cyan	0011	022	00AAAA	008080
04h	dark red	0100	200	AA0000	800000
05h	dark magenta	0101	202	AA00AA	800080
06h	dark yellow (brown)	0110	210!!	AA5500!!	808000
07h	dark white (light gray)	0111	222	AAAAAA	C0C0C0!!
08h	bright black (dark gray)	1000	111	555555	808080!!
09h	bright blue	1001	113	5555FF	0000FF
0Ah	bright green	1010	131	55FF55	00FF00
0Bh	bright cyan	1011	133	55FFFF	00FFFF
0Ch	bright red	1100	311	FF5555	FF0000
0Dh	bright magenta	1101	313	FF55FF	FF00FF
0Eh	bright yellow	1110	331	FFFF55	FFFF00
0Fh	bright white	1111	333	FFFFFF	FFFFFF

Some notes on number of colors:

```
CGA supports 16 colors in text mode (but only max 4 colors in graphics mode).
EGA supports the same 16 colors as CGA in both text and graphics mode.
EGA-with-special-EGA-monitor supports 64 colors (but only max 16 at once).
VGA supports much colors (but can mimick CGA/EGA colors, or similar colors)
```

CGA is using a 4pin IRGB1111 signal for up to 16 colors in text mode (max 4 colors in graphics mode), and CGA monitors contain some circuitry to convert "dark yellow" to "brown" (though cheap CGA clones may display it as "dark yellow").

EGA can display CGA colors (with all 16 colors in graphics mode). EGA-with-special-EGA-monitor uses 6pin RGB222 signals for up to 64 colors (but not more than 16 colors at once).

Windows is also using those 16 standard colors (when not having any VGA driver installed, and also in 256-color VGA mode, in the latter case the 16 standard colors are held to always available (even if different tasks are trying to simultaneously display different images with different palettes).

However, Windows has dropped brown, and uses non-pastelized bright colors.

PCX files in PSX games

```
.PCX with RLE used by Jampack Vol. 1 (MDK\CD.HED\*.pcx)
.PCX with RLE used by Hot Wheels Extreme Racing (MagDemo52: US_01293\MISC\*)
.PCX with RLE used by Metal Gear Solid (slightly corrupted PCX files)
```

PCX files in PSX Metal Gear Solid (MGS)

MGS is storing some extra data at [4Ah..57h] (roughly resembling the info in TIM files).

```
04Ah 2    Custom MGS ID (always 3039h)
04Ch 2    Display Mode? (08h/18h=4bit, 09h/19h=8bit)
04Eh 2    Bitmap X-coordinate in VRAM (reportedly "divided by 2" ???)
050h 2    Bitmap Y-coordinate in VRAM
052h 2    Palette X-coordinate in VRAM
054h 2    Palette Y-coordinate in VRAM
056h 2    Palette number of actually used colors (can be less than 16/256)
058h 28h  Reserved (zerofilled)
080h ..   Bitmap data (RLE compressed)
... 1     VGA Palette ID (0Ch=256 colors)                ;\when 8bpp
.. 300h   VGA Palette (256 colors, 3-byte per color = R,G,B) ;/
.. ..    Padding to 4-byte boundary, ie. palette isn't at filesize-301h !!!
```

MGS has filesize padded to 4-byte boundary. That is causing problems for files with 256-color palette: The official way to find the palette is to stepback 301h bytes from end of file, which won't work with padding. To find the MGS palette, one must decompress the whole bitmap, and then expect the 301h-byte palette to be located after the compressed data.

As an extra oddity, MGS uses non-square ultra-high DPI values.

DCX Archives

DCX archives contain multiple PCX files (eg. multi-page FAX documents). The standard format is as so:

```
0000h 4    ID (3ADE68B1h) (987654321 decimal)
0004h 4000h File List (32bit offsets) (max 1023 files, plus 0=End of List)
1004h ..   File Data area (PCX files)
```

However, some files have the first PCX at offset 1000h (ie. the list is only 3FFCh bytes tall). Reportedly there are also files that start with yet smaller offsets (for saving space when the file list contains fewer entries).

The PCX filesize is next-curr offset (or total-curr for last file).

References

<https://www.fileformat.info/format/pcx/egff.htm>

13.9 CDROM File Video 2D Graphics CEL/BGD/TSQ/ANM/SDF (Sony)

CEL/BGD/TSQ/ANM/SDF

CEL: Cell Data (official format with 8bit header entries)

This does merely translate Tile Numbers to VRAM Addresses and Attributes (with the actual VRAM bitmap data usually being stored in .TIM files).

```
000h 1   File ID (22h)
001h 1   Version (3)
002h 2   Flag (bit15=WithAttr, bit14=AttrDataSize:0=8bit,1=16bit, bit13-0=0)
004h 2   Number of cell data items (in cell units) (N)
006h 1   Sprite Editor Display Window Width (in cell units)
007h 1   Sprite Editor Display Window Height (in cell units)
008h ..  Cell Data[N] (64bit entries)
... ..  Cell Attr[N] (0bit/8bit/16bit user data? depending on Flag)
```

Cell Data:

```
0-7   Tex Coord X (8bit)
8-15  Tex Coord Y (8bit)
16-21 Clut X      (6bit)
22-30 Clut X      (9bit)
31    Semi-transparency enable      ;-only in Version>=3
32    Vertical Reversal (Y-Flip)    ;\only in Version=0 and Version>=2
33    Horizontal Reversal (X-Flip)  ;/
34-47 Unused
48-52 Texture Page (5bit)
53-54 Semi Transparency (0=B/2+F/2, 1=B+F, 2=B-F, 3=B+F/4)
55-56 Texture page colors (0=4bit, 1=8bit, 2=15bit, 3=Reserved)
57-60 Sprite Editor Color Set Number ;\
61    Unused                      ; only in Version>=3
62-63 Sprite Editor TIM Bank      ;/ XXX else hardcoded?
```

This is used in R-Types, CG.1\file3Dh\file00h, but [6,7] are 16bit wide! And there are a LOT of ZEROes appended (plus FFh-padding due to CG.1 archive size units).

Used by R-Types (CG.1\file07h\file01h, size 08h*04h, with 8bit attr)

Used by R-Types (CG.1\file07h\file03h, size 10h*08h, with 16bit attr)

Used by R-Types (CG.1\file07h\file05h, size 04h*04h, with 16bit attr)

Used by Tiny Tank (MagDemo23: TINYTANK\TMD05.DSK*.CEL, size 08h*05h)

CEL16: Inofficial CEL hack with 16bit entries and more extra data (R-Types)

This is an inofficial hack used by R-Types, the game does use both the official CEL and inofficial CEL16 format.

```

000h 1  File ID (22h)          ;\same as in official CEL version
001h 1  Version (3)           ;/
002h 2  Flag (...unknown meaning in this case...?)           ;<-- ?
004h 2  Number of cell data items (in cell units) (N)
006h 2  Sprite Editor Display Window Width (in cell units)  ;<-- 16bit!
008h 2  Sprite Editor Display Window Height (in cell units) ;<-- 16bit!
00Ah .. Cell Data[N] (64bit entries)
... .. Cell Attr[N] (16bit/192bit user data, depending on Flag or so...?)

```

Used by R-Types (CG.1\file12h\file00h, size 0120h*000Fh with 192bit attr)

Used by R-Types (CG.1\file15h\file00h, size 0168h*000Fh with ? attr)

Used by R-Types (CG.1\file1Ch\file00h, size 00D8h*000Fh with ? attr)

BGD: BG Map Data (official format with 8bit header entries)

```

000h 1  File ID (23h)
001h 1  Version (0)
002h 2  Flag (bit15=WithAttr, bit14=AttrDataSize:0=8bit,1=16bit, bit13-0=0)
004h 1  BG Map Width (in cell units) (W)
005h 1  BG Map Height (in cell units) (H)
006h 1  Cell Width (in pixels)
007h 1  Cell Height (in pixels)
008h .. BG Map Data[W*H] (16bit cell numbers)
... .. BG Map Attr[W*H] (0bit/8bit/16bit user data? depending on Flag)

```

Used by R-Types (CG.1\file07h\file00h, official BGD format)

Used by Cardinal Syn (MagDemo03,09: SYN\SONY\KROLOGO.WAD\BGD)

Used by Tiny Tank (MagDemo23: TINYTANK\TMD05.DSK\BGD, with 8bit entries).

BGD16: Inofficial BGD hack with 16bit entries (R-Types)

This is an inofficial hack used by R-Types, the game does use both the official BGD and inofficial BGD16 format. Apparently invented to support bigger BG Map Widths for huge sidescrolling game maps.

```

000h 1  File ID (23h)          ;\same as in official BGD version
001h 1  Version (0)           ;/
002h 2  Flag (bit15=WithAttr, bit14=AttrDataSize:0=8bit,1=16bit, bit13-0=0)
004h 2  BG Map Width (in cell units) (W)                ;<-- 16bit!
006h 2  BG Map Height (in cell units) (H)               ;<-- 16bit!
008h 2  Cell Width (in pixels)                          ;<-- 16bit!
00Ah 2  Cell Height (in pixels)                         ;<-- 16bit!
00Ch .. BG Map Data[W*H] (16bit cell numbers)
... .. BG Map Attr[W*H] (0bit/8bit/16bit user data? depending on Flag)
... .. FFh-padding (in case being stored in R-Types' DOT1 archives)

```

Used by R-Types (CG.1\file3Ch\file00h, inofficial BGD16 format)

TSQ: Animation Time Sequence

```

000h 1  File ID (24h)
001h 1  Version (1)
002h 2  Number of Sequence data entries (N)
004h N*8 Sequence Data (64bit entries)

```

Sequence Data:

```

0-15  Sprite Group Number to be displayed
16-23 Display Time
24-27 Unused
28-31 Attribute (user defined) (only in Version>=1)
32-47 Hotspot X Coordinate
48-63 Hotspot Y Coordinate

```

There aren't any known games using .TSQ files.

ANM: Animation Information

```

000h 1  File ID (21h)
001h 1  Version (3=normal) (but see below notes on older versions)
002h 2  Flag (bit0-1=TPF, bit2-11=0, bit12-15=CLT)
        0-1   TPF PixFmt (0=4bpp, 1=8bpp, 2/3=Reserved) ;version>=2 only
        2-11  -   Reserved (0)
        12-15 CLT Number of CLUT Groups, for color animation
004h 2  Number of Sprites Groups
006h 2  Number of Sequences (N) (can be 0=None)
008h N*8 Sequence(s) (64bit per entry) ;Num=[004h]

```

```

... .. Sprite Group(s) ;Num=[006h]
... .. CLUT Group(s) ;Num=[002h].bit12-15

```

Sequence entries:

```

000h 2 Sprite Group Number to be displayed (range 0..AnimHdr[004h]-1)
002h 1 Display Time (can be 00h or 0Ah or whatever)
003h 1 Attribute (bit0-3=Unused/Zero, bit4-7=User defined) ;version>=3 only
004h 2 Hotspot X Coordinate (usually 0, or maybe can be +/-NN ?)
006h 2 Hotspot Y Coordinate (usually 0, or maybe can be +/-NN ?)

```

Sprite Group entries:

Each "Group" seems to represent one animation frame.
Each "Group" can contain one or more sprites (aka metatiles).
Below stuff is "4+N*14h" bytes, that seems to repeat "AnmHeader[004h] times"
XXX... actually below can be "4+N*10h" or "4+N*14h" bytes
XXX... so, maybe maybe some entries like width/height are optional?

```

000h 4 Number of Sprites in this Sprite Group ("sprites per metatile")
004h 14h*N Sprite(s) (see below)
Sprites:
000h 1 Tex Coord X (8bit)
001h 1 Tex Coord Y (8bit)
002h 1 Offset X from Hotspot within frame (maybe vertex x ?)
003h 1 Offset Y from Hotspot within frame (maybe vertex y ?)
004h 2 CBA Clut Base (bit0-5=ClutX, Bit6-14=ClutY, bit15=SemiTransp)
006h 2 FLAGS (bit0-4, bit5-6, bit7-8, bit9, bit10, bit11, bit12-15)
      0-4 TPN Texture Page Number
      5-6 ABR Semi-Transparency Rate
      7-8 TPF Pixel depth (0=4bpp, 1=8bpp, 2=16bpp)
      9 - Reserved
      10 RSZ Scaling (0=No, 1=Scaled)
      11 ROT Rotation (0=No, 1=Rotated)
      12-15 THW Texture Width/Height div8 (0=Other custom width/height)
008h (2) Texture Width "of optional size" (uh?) ;\only present if
00Ah (2) Texture Height "of optional size" (uh?) ;/FLAGS.bit12-15=0 ?)
00Ch 2 Angle of Rotation (in what units?)
00Eh 2 Sprite Editor info (bit0-7=Zero, bit8-13=ClutNo, bit14-15=TimBank)
010h 2 Scaling X (for Vertex?) (as whatever fixed point number) (eg. 1000h)
012h 2 Scaling Y (for Vertex?) (as whatever fixed point number) (eg. 1000h)

```

CLUT Group entries:

```

000h 4 CLUT size in bytes (Width*Height*2+0Ch)
004h 2 Clut X Coordinate
006h 2 Clut Y Coordinate
008h 2 Clut Width
00Ah 2 Clut Height
00Ch .. CLUT entries (16bit per entry, Width*Height*2 bytes)

```


Note: ALICE.PAC\MENU.PAC\CON00.ANM has NumSequences=0 and NumSpriteGroups=2Dh (unknown if/how that is animated, maybe it has 2Dh static groups? or the groups are played in order 0..2Ch with display time 1 frame each?). Used by Alice in Cyberland (ALICE.PAC*.ANM) (ANM v3)
Unknown if there are any other games are using that format.

SDF: Sprite Editor Project File

This is an ASCII text file for "artist boards" with following entries:

```
TIM0 file0.tim           ;\
TIM1 file1.pxl file1.clt ; four TIM banks (with TIM or PXL/CLT files)
TIM2                     ; (or no filename for empty banks)
TIM3                     ;/
CEL0 file0.cel           ;-one CEL (with CEL, or no filename if none)
MAP0 file0.bgd           ;\
MAP1 file1.bgd           ; four BG MAP banks (with BGD filenames)
MAP2                     ; (or no filename for empty banks)
MAP3                     ;/
ANM0 file0.anm           ;-one ANM (with ANM, or no filename if none)
DISPLAY n                ;0-3=256/320/512/640x240, 4-7=256/320/512/640x480
COLOR n                  ;0=4bpp, 1=8bpp ;docs are unclear, is it COLORn or COLOR n?
ADDR0 texX texY clutX clutY numColorSets ;\
ADDR1 texX texY clutX clutY numColorSets ; four texture/palette offsets
ADDR2 texX texY clutX clutY numColorSets ; for the corresponding TIM banks
ADDR3 texX texY clutX clutY numColorSets ;/ (or whatever for empty banks?)
```

13.10 CDROM File Video 3D Graphics TMD/PMD/TOD/HMD/RSD (Sony)

TMD - Modeling Data for OS Library

```
000h 4      ID (00000041h)
004h 4      Flags (bit0=FIXP, bit1-31=Reserved/zero)
008h 4      Number of Objects (N)          ;"integral value" uh?
00Ch N*1Ch Object List (1Ch-byte per entry)
... ..     Data (Vertices, Normals, Primitives)
```

Object List entries:

```
000h 4      Start address of a Vertex      ;\Address values depend on the
004h 4      Number of Vertices              ; file header's FIXP flag:
008h 4      Start address of a Normal      ; FIXP=0 Addr from begin of Object
00Ch 4      Number of Normals              ; FIXP=0 Addr from begin of TMD File
010h 4      Start address of a Primitive  ;
```

```

014h 4    Number of Primitives          ;/
018h 4    Scale (signed shift value, Pos=SHL, Neg=SHR) (not used by LIBGS)

```

Vertex entries (8-byte):

```

000h 2    Vertex X (signed 16bit)
002h 2    Vertex Y (signed 16bit)
004h 2    Vertex Z (signed 16bit)
006h 2    Unused

```

Normal entries (8-byte) (if any, needed only for computing light directions):

```

000h 2    Normal X (fixed point 1.3.12)
002h 2    Normal Y (fixed point 1.3.12)
004h 2    Normal Z (fixed point 1.3.12)
006h 2    Unused

```

Primitive entries (variable length):

```

000h 1    Output Size/4 of the GPU command (after GTE conversion)
001h 1    Input Size/4 of the Packet Data in the TMD file
002h 1    Flag
           0    Light source calculation (0=On, 1=Off)
           1    Clip Back (0=Clip, 1=Don't clip) (for Polygons only)
           2    Shading (0=Flat, 1=Gouraud)
               (Valid only for the polygon not textured,
               subjected to light source calculation)
           3-7 Reserved (0)
003h 1    Mode (20h..7Fh) (same as GP0 (20h..7Fh) command value in packet)
004h ..    Packet Data

```

Packet Data (for Polygons)

```

000h 4    GPU Command+Color for that packet (CcBbGgRrh), see GP0 (20h..3Fh)
... (4)   Texcoord1+Palette (ClutYyXxh)                ;\
... (4)   Texcoord2+Texpage (PageYyXxh)                ; only if Mode.bit2=1
... (4)   Texcoord3          (0000YyXxh)                ;
... (4)   Texcoord4          (0000YyXxh) ; -quad only   ;/
... (4)   Color2 (00BbGgRrh)                            ;\
... (4)   Color3 (00BbGgRrh)                            ; only if Flag.bit2=1
... (4)   Color4 (00BbGgRrh) ; -quad only                ;/
... (2)   Normal1 (index in Normal list?) ;always, unless Flag.bit0=1
... 2     Vertex1 (index in Vertex list?)
... (2)   Normal2 (index in Normal list?)                ; -only if Mode.bit4=1
... 2     Vertex2 (index in Vertex list?)
... (2)   Normal3 (index in Normal list?)                ; -only if Mode.bit4=1
... 2     Vertex3 (index in Vertex list?)
... (2)   Normal4 (index in Normal list?) ;\quad only ; -only if Mode.bit4=1
... 2     Vertex4 (index in Vertex list?) ;/
... (2)   Unused zeropadding (to 4-byte boundary)

```

Packet Data (for Lines)

```
000h 4 GPU Command+Color for that packet (CcBbGgRrh), see GP0(40h,50h)
... (4) Color2 (00BbGgRrh) ; -only if Mode.bit4=1
... 2 Vertex1 (index in Vertex list?)
... 2 Vertex2 (index in Vertex list?)
```

Packet Data (for Rectangle/Sprites)

```
000h 4 GPU Command+Color for that packet (CcBbGgRrh), see GP0(60h..7Fh)
... .. Unknown, reportedly "with 3-D coordinates and the drawing
      content is the same as a normal sprite."
```

Note: Objects should usually contain Primitives and Vertices (and optionally Normals), however, N2O\SHIP.TMD does contain some dummy Objects with Number of Vertices/ Normals/Primitives all set to zero.

Used by Playstation Logo (in sector 5..11 on all PSX discs, 3278h bytes)

Used by ...???model???... (MagDemo54: MODEL\BIN\TMD)

Used by Alice in Cyberland (ALICE.PAC\xxx_TM*.FA\TMD)

Used by Armored Core (MagDemo02: AC10DEMP\MS\MENU_TMD.T\)

Used by Bloody Roar 1 (MagDemo06: CMN\EFFECT.DAT\0005h)

Used by Deception III Dark Delusion (MagDemo33: DECEPT3\K3_DAT.BIN\056A,0725\)

Used by Gundam Battle Assault 2 (DATA\PA\)

Used by Hear It Now (Playstation Developer's Demo) (.TMD and FISH.DAT).*

Used by Jersey Devil (MagDemo10: JD\BZZ\)

Used by Klonoa (MagDemo08: KLONOA\FILE.IDX\)

Used by Legend of Dragoon (MagDemo34: LOD\DRAGN0.BIN\16xxh)

Used by Macross VF-X 2 (MagDemo23: VFX2\DATA01\TMD)

Used by Madden NFL '98 (MagDemo02: TIBURON\MODEL01.DAT\)

Used by No One Can Stop Mr. Domino (MagDemo18: DATA\TMD and DOT1\TMD)

Used by O.D.T. (MagDemo17: ODT\LNK\)

Used by Parappa (MagDemo01: PARAPPA\COMPO01.INT\3\TMD)

Used by Resident Evil 1 (PSX\ITEM_M1\DOR\0001)

Used by Starblade Alpha (FLT\SB2.DAT\ and TEX\SB2.DAT\)

Used by Tiny Tank (MagDemo23: TINYTANK\TMD.DSK\TMD)*

Used by WCW/nWo Thunder (MagDemo19: THUNDER\RING\TMD)

Used by Witch of Salzburg (the MODELS\MDL\TMD)

Used by Scooby Doo and the Cyber Chase (MagDemo54: MODEL)*

PMD - High-Speed Modeling Data

This is about same as TMD, with less features, intended to work faster.

```

000h 4    ID (00000042h)
004h 4    Offset to Primitives
008h 4    Offset to Shared Vertices (or 0=None)
00Ch 4    Number of Objects
010h ..   Objects          (4+N*4 bytes each, with offsets to Primitives)
... ..   Primitives
... ..   Shared Vertices (8-bytes each, if any)

```

Vertex entries (8-byte):

```

000h 2    Vertex X (signed 16bit)
002h 2    Vertex Y (signed 16bit)
004h 2    Vertex Z (signed 16bit)
006h 2    Unused

```

Objects:

```

000h 4    Number of Primitives
004h N*4  Offsets to Primitives ... maybe relative to hdr[004h] ?

```

Primitives:

```

000h 2    Number of Packets
002h 2    Type flags
          0    Polygon    (0=Triangle, 1=Quadrilateral)
          1    Shading    (0=Flat, 1=Gouraud)           ;uh, with ONE color?
          2    Texture    (0=Texture-On, 1=Texture-Off) ;uh, withoutTexCoord?
          3    Shared      (0=Independent vertex, 1=Shared vertex)
          4    Light source calculation (0=Off, 1=On)   ;uh, withoutNormal?
          5    Clip        (0=Back clip, 1=No back clip)
          6-15 Reserved for system
004h ...   Packet(s)

```

Packet entries, when Type.bit3=0 (independent vertex):

```

000h 4    GPU Command+Color for that packet (CcBbGgRrh), see GP0 (20h..7Fh)
004h 8    Vertex1 (Xxxxh,Yyyh,Zzzzh,0000h)
00Ch 8    Vertex2 (Xxxxh,Yyyh,Zzzzh,0000h)
014h 8    Vertex3 (Xxxxh,Yyyh,Zzzzh,0000h)
01Ch (8)  Vertex4 (Xxxxh,Yyyh,Zzzzh,0000h) ;<-- only when Type.bit0=1 (quad)

```

Packet entries, when Type.bit3=1 (shared vertex):

```

000h 4   GPU Command+Color for that packet (CcBbGgRrh), see GP0(20h..7Fh)
004h 4   Offset to Shared Vertex1      ;offsets are
008h 4   Offset to Shared Vertex2      ;"from the start of a row"
00Ch 4   Offset to Shared Vertex3      ;aka from "Packet+04h" ?
010h (4) Offset to Shared Vertex4      ;<-- only when Type.bit0=1(quad)

```

Unknown if/how Texture/Light is implemented... without TexCoords/Normals?

Unknown if/how Gouraud is implemented... with ONE color and without Normals?

Used only by a few games:

```

Cool Boarders 2 (MagDemo02: CB2\DATA3\*.PMD)
Cardinal Syn (MagDemo03,09: SYN\*\*.WAD\*.PMD)      (4-byte hdr plus PMD file)
Sesame Streets Sports (MagDemo52: SSS\LV*\*MRG\*) (4-byte hdr plus PMD file)

```

Unknown if/which other games are using the PMD format.

TOD - Animation Data

```

000h 1   ID (50h)
001h 1   Version (0)
002h 2   Resolution (time per frame in 60Hz units, can be 0) (60Hz on PAL?)
004h 4   Number of Frames
008h ..   Frame1
... ..   Frame2
... ..   Frame3
... ..   etc.

```

Frames:

```

000h 2   Frame Size in words (ie. size/4)
002h 2   Number of Packets (can be 0=None, ie. do nothing this frame)
004h 4   Frame Number (increasing 0,1,2,3,..)
008h ...   Packet(s)

```

Packet:

```

000h 2   Object ID
002h 1   Type/Flag (bit0-3=Type, bit4-7=Flags)
003h 1   Packet Size ("in words (4 bytes)")
004h ...   Packet Data

```

XXX... in Sony's doc.

Used by Witch of Salzburg (ANIM\ANM0\ANM0.TOD) (oddly with [02h]=0000h)

Used by Parappa (MagDemo01: PARAPPA\COMPO01.INT\3\TOD)

Used by Macross VF-X 2 (MagDemo23: VFX2\DATA01\TOD and *.TOX)

Used by Alice in Cyberland (ALICE.PAC\xxx_T*.FA*.TOD)

Unknown if/which other games are using the TOD format.

HMD - Hierarchical 3D Model, Animation and Other Data

```

000h 4    ID (00000050h)    ;same as in TOD, which CAN ALSO have MSBs=zero(!)
004h 4    MAP FLAG (0 or 1, set when mapped via GsMapUnit() function)
008h 4    Primitive Header Section pointer (whut?)
00Ch 4    Number of Blocks
010h 4*N  Pointers to Blocks
...       Primitive Header section    (required)
...       Coordinate section          (optional)
...       Primitive section           (required)

```

This format is very complicated, see Sony's "File Formats" document for details.

.HMD used by Brunswick Bowling (MagDemo13: THQBOWL\).

.HMD used by Soul of the Samurai (MagDemo22: RASETSU\0\OPT01T.BIN\0\0\)

.HMD used by Bloody Roar 2 (MagDemo22: LON\LON*.DAT*, ST5\ST*.DAT\02h..03h)

.HMD used by Ultimate Fighting Championship (MagDemo38: UFC\CU00.RBB\6Bh..EFh)

Unknown if/which games other are using the HMD format.

RSD Files (RSD,PLY,MAT,GRP,MSH,PVT,COD,MOT,OGP)

RSD files consist of a set of several files (RSD,PLY,MAT,etc). The files contain the "polygon source code" in ASCII text format, generated from Sony's "SCE 3D Graphics Tool". For use on actual hardware, the "RSDLINK" utility can be used to convert them to binary (TMD, PMD, TOD?, HMB?) files.

```

RSD Main project file
PLY Polygon Vertices (Vertices, Normals, Polygons)
MAT Polygon Material (Color, Blending, Texture)
GRP Polygon Grouping
MSH Polygon Linking                ;\
PVT Pivot Rotation center offsets   ; New Extended
COD Vertex Coordinate Attributes    ; (since RSD version 3)
MOT Animation Information           ;/
OGP Vertex Object Grouping          ; -Sub-extended

```

All of the above files are in ASCII text format. Each file is starting with a "@typYYMMDD" string in the first line of the file, eg. "@RSD970401" for RSD version 3. Vertices are defined as floating point values (as ASCII strings).

There's more info in Sony's "File Formats" document, but the RSD stuff isn't used on retail discs. Except:

RSD/GRP/MAT/PLY (and DXF=whatever?) used on Yaroze disc (DTL-S3035)

13.11 CDROM File Video STR Streaming and BS Picture Compression (Sony)

STR Files (movie streams)

[CDROM File Video Streaming STR \(Sony\)](#)

[CDROM File Video Streaming STR Variants](#)

[CDROM File Video Streaming Framerate](#)

[CDROM File Video Streaming Audio](#)

[CDROM File Video Streaming Chunk-based formats](#)

[CDROM File Video Streaming Mis-mastered files](#)

Apart from the 20h-byte STR headers, movies basically consist of a series of BS files (see below).

BS Files (Huffman compressed MDEC codes)

BS stands for bitstream, which might refer to the use in STR files, or to the Huffman bitstreams.

[CDROM File Video BS Compression Versions](#)

[CDROM File Video BS Compression Headers](#)

The header is followed by the bitstream...

```
v1/v2/v3/ea/iki --> first bit in bit15 of first halfword (good for psx)
v0              --> first bit in bit7 of first byte (not so good for psx)
(to use the same decoder for all version: swap each 2 bytes in v0)
```

For each block, the bitstream contains one DC value, up to 63 AC values, terminated by EOB (end of block).

[CDROM File Video BS Compression DC Values](#)

[CDROM File Video BS Compression AC Values](#)

Apart from being used in STR movies, BS can be also used to store single pictures:

[CDROM File Video BS Picture Files](#)

Wacvac (similar as BS, but with completely different Huffman codes)

[CDROM File Video Wacvac MDEC Streams](#)

Credits

Thanks to Michael Sabin for info on various STR and BS variants:

<https://github.com/m35/jpsxdec/>

13.12 CDROM File Video Streaming STR (Sony)

.STR Sectors (with 20h-byte headers) (for MDEC Movies, or User data)

```

000h 2    StStatus (0160h) (RV6Rh; R=Reserved=0, V=Version=1, 6=Fixed ID)
002h 2    StType (0000h..7FFFh=User Defined, 8000h..FFFFh=System; 8001h=MDEC)
004h 2    StSectorOffset (Sector number in the frame, 0=First)
006h 2    StSectorSize (Number of sectors in the frame) (eg. 4 or 5)
008h 4    StFrameNo (Frame number, 1=First) (except Viewpoint=0)
00Ch 4    StFrameSize (in bytes, in this frame, excluding headers/padding)
When StType=0000h..7FFFh:
010h 10h StUser (user defined data)
020h 7E0h User data (more user defined data)
When StType=8001h=MDEC (the only system defined type) (with StStatus=0160h):
010h 2    StMovieWidth (eg. 0140h)
012h 2    StMovieHeight (eg. 00F0h)
014h 4    StHeadM (reserved for system) (eg. 38000720h) ;\same as [020h-027h]
018h 4    StHeadV (reserved for system) (eg. 00020001h) ;/from 1st STR sector
01Ch 4    Unspecified (eg. 00000000h) (except Viewpoint<>0)
020h 7E0h Data (in BS format) (or padding, when image is smaller than frame)

```

The default file extension .STR is used by various games (though some games use other extensions, the .FMV files in Tomb Raider do also contain standard 20h-byte .STR sector headers).

Video Frames

The video frames consist of BS compressed images (that is, all sectors have STR headers at 000h..01Fh, and the first sector of each frame does additionally contain a standard BS fileheader at offset 020h..027h).

See "CDROM File Video BS Compression" chapters

Less common, there is also a format for streaming polygon animations instead of BS compressed bitmaps:

[CDROM File Video Polygon Streaming](#)

STR Resolution

The Width/Height entries are almost always multiples of 16 pixels. But there are a few exceptions:

```
Height=260 (104h) in Star Wars Rebel Assault II, NTSC (S1\L01_PLAY.STR)
Height=200 (0C8h) in Perfect Assassin (DATA.JFS\CDV\*.STR)
Height=40 (028h) in Gran Turismo 1 (TITLE.DAT\*, MagDemo10 and MagDemo15)
Width=232 (0E8h) in Gran Turismo 1 (TITLE.DAT\*, MagDemo10 only)
```

For such videos, the width/height of MDEC decompression buffer in RAM must be rounded up to multiples of 16 pixels (and the decompressed picture should be cropped to the STR header width/height before forwarding it to VRAM).

Note: The extra scanlines are usually padded with the bottom-most scanline (except, Gran Turismo 1 has gray-padding in lower/right pixels). Ideally, one would repeat the bottom-most pixels in zigzag order.

Subtitles

Metal Gear Solid MGS\ZMOVIE.STR contains subtitles as text strings: The first sector of the .STR file is something custom (without STR header), the remaining movie consists of STR sectors with StType=0001h for subtitles and StType=8001h for picture frames. Unknown if other games are using the same method, or other methods.

Obviously, subtitles could be also displayed as part of the compressed image, but text strings are much smaller, have better quality, and would also allow to support multiple languages.

13.13 CDROM File Video Streaming STR Variants

STR ID Values

2-byte	0160h	;Standard STR header
1-byte	01h	;Ace Combat 3 Electrosphere
4-byte	"SMJ",01h	;Final Fantasy 8, Video
4-byte	"SMN",01h	;Final Fantasy 8, Audio/left
4-byte	"SMR",01h	;Final Fantasy 8, Audio/right
4-byte	0000000xh	;Judge Dredd
4-byte	DDCCBBAAh	;Crusader: No Remorse, older Electronic Arts
4-byte	08895574h	;Chunk header in 1st sector only, Best Sports (demo)
4-byte	"VLC0"	;Chunk header in 1st sector only, newer Electronic Arts
4-byte	"VMNK"	;Chunk header in 1st sector only, Policenauts

```

4-byte  01h,"XSP"      ;Sentient header in 1st sector only
N-byre  zero(es)      ;Polygons? (in last 150Mbyte of PANEKIT.STR)

```

STR Type values (for videos that do have STR ID=0160h):

The official definition from Sony's File Formats document is as so;

```

0000h..7FFFh=User Defined
8000h..FFFFh=System (with 8001h=MDEC being the only officially defined type)

```

In practice, the following values are used (of which, 8001h is most common).

```

0000h=Polygon Video, Wacvac as Polygon Stream
0000h=Polygon Video?, Army Men Air Attack 2 (MagDemo40: AMAA2\*.PMB)
0000h=MDEC Video, Alice in Cyberland
0001h=MDEC Video, Ridge Racer Type 4 (PAL version, 320x176 pix)
0001h=Whatever extra data for XA-ADPCM streams (Bits Laboratory games)
0001h=Whatever non-audio waveform? (3D Baseball)
0001h=Subtitles, Metal Gear Solid MGS\ZMOVIE.STR
0002h=Software-rendered video (without using MDEC/GTE) (Cyberia)
0002h=MDEC Video, Wacvac with IntroTableSet
0003h=MDEC Video, Wacvac with EndingTableSet
0004h=MDEC Video, Final Fantasy 9 (MODE2/FORM2)
0008h=SPU-ADPCM, AKAO audio (Final Fantasy 9)
0000h=SPU-ADPCM, AKAO audio (Chrono Cross Disc 1, Legend of Mana)
0001h=SPU-ADPCM, AKAO audio (Chrono Cross Disc 1, Legend of Mana)
0100h=SPU-ADPCM, AKAO audio (Chrono Cross Disc 2)
0101h=SPU-ADPCM, AKAO audio (Chrono Cross Disc 2)
0000h=Whatever special, channel 0 header (Nightmare Project: Yakata)
0400h=Whatever special, channel 1 header (Nightmare Project: Yakata)
0001h=Whatever special, channel 0 data (Nightmare Project: Yakata)
0401h=Whatever special, channel 1 data (Nightmare Project: Yakata)
5349h=MDEC Video, Gran Turismo 1 and 2 (with BS iki)
0078h=MDEC Ending Dummy (Mat Hoffman's Pro BMX (MagDemo48: MHPB\SHORT.STR)
5673h=MDEC Leading Dummy (Mat Hoffman's Pro BMX (MagDemo48: MHPB\SHORT.STR)
8001h=MDEC Video, Standard MDEC (most common type value)
8001h=Polygon Video (Ape Escape) (same ID as standard MDEC)
8001h=Eagle One: Harrier Attack various types (MDEC and other data)
8001h=Dance series SPU-ADPCM streaming (with STR[1Ch]=DDCCBBAAh)
8101h=MDEC Video, Standard MDEC plus bit8=FlagDisc2 (Chrono Cross Disc 2)

```

Leading XA-ADPCM

Most movies start with STR video sectors. But a few games start with XA-ADPCM:

```

Ace Combat 3 Electrosphere (*.SPB)
Alice in Cyber Land (*.STR)
Judge Dredd (*.IXA) ;and very small 4-byte STR header
ReBoot (MOVIES\*.WXA)

```

Also, Aconcagua (Wacwac) has XA-ADPCM before Video (but, yet before that, it has 150 leading zerofilled sectors).

Also, Porsche Challenge (SRC\MENU\STREAM*.STR) starts with corrupted Subheaders, which may appear as leading XA-ADPCM (depending on how to interpret the corrupted header bits).

Leading SPU-ADPCM

```
EA videos      ;\
Crusader       ; chunks
Policenauts    ;/
AKAO videos
```

Metal Gear Solid (MGS\ZMOVIE.STR, 47Mbyte)

This is an archive dedicated to STR movies (with number of frames instead of filesize entries). Metal Gear Solid does also have cut-scenes with polygon animations (but those are supposedly stored elsewhere?).

```
000h 4      Number of entries (4)
004h N*8    File List
... ..     Zerofilled
```

File List entries:

```
000h 2      Unknown... decreasing values?
002h 2      Number of Frames (same as last frame number in STR header)
004h 4      Offset/800h (to begin of STR movie, with subtitles in 1st sector)
```

Disc 1 has four movies: The first one has a bit more than 12.5 sectors/frame, the other three have a bit more than 10 sectors/frame (eg. detecting the archive format could be done checking for entries with 8..16 sectors/frame).

Example, from Disc 1:

```
04 00 00 00
ED 97 9E 01 01 00 00 00 ;num sectors=1439h ;div19Eh=C.81h ;97EDh-6137h=36B6h
37 61 86 01 3A 14 00 00 ;num sectors=0F41h ;div186h=A.03h ;6137h-38D0h=2867h
D0 38 10 03 7B 23 00 00 ;num sectors=1EA1h ;div310h=A.00h ;38D0h-2302h=15CEh
02 23 73 02 1C 42 00 00 ;num sectors=1881h ;div273h=A.01h ;2302h-0000h=2302h
```

The files in the ZMOVIE.STR archive start with subtitles in 1st sector (this is usually/always only one single sector for the whole movie):

```

000h 2   STR ID      (0160h)                                ;\
002h 2   STR Type (0001h=Subtitles)                          ;
004h 2   Sector number within Subtitles (0)                  ; STR
006h 2   Number of Sectors with Subtitles (1)                ; header
008h 4   Frame number (1)                                    ;
00Ch 4   Data size counted in 4-byte units (same as [02Ch]/4) ;
010h 10h Zerofilled                                         ;/
020h 4   Unknown (2)                                        ;\
024h 4   Unknown (1AAh, 141h, or 204h)                       ; Data
028h 4   Unknown (00100000h)                                 ; part
02Ch 4   Size of all Subtitle entries in bytes plus 10h      ;
030h ..  Subtitle entries                                   ;/
... ..  Zeropadding to 800h-byte boundary                    ; -padding

```

Subtitle entries:

```

000h 4   Offset from current subtitle to next subtitle (or 0=Last subtitle)
004h 4   First Frame number when to display the subtitle?
008h 4   Number of frames when to display the subtitle?
00Ch 4   Zero
010h ..  Text string, terminated by 00h
... ..  Zeropadding to 4-byte boundary

```

The text strings are ASCII, with special 2-byte codes (80h,7Bh=Linebreak, 1Fh,20h=u-Umlaut, etc).

Customized STR Video Headers

VIEWPOINT (WITH SLIGHTLY MODIFIED STR HEADER)

```

008h 4   Frame number (0=First)                               ;<-- instead of 1=First
01Ch 2   Unknown (always D351h)                               ;<-- instead of zero
01Eh 2   Number of Frames in this STR file                    ;<-- instead of zero

```

CAPCOM GAMES

Resident Evil 2 (ZMOVIE\.*STR*, *PL0\ZMOVIE\.*STR)

Super Puzzle Fighter II Turbo (STR/CAPCOM15.STR)

```

01Ch 4   Sector number of 1st sector of current frame ;<-- instead of zero

```

CHRONO CROSS DISC 2 VIDEO

Chrono Cross Disc 1 does have normal STR headers, but Disc 2 has Type.bit8 toggled:

```

002h 2   STR Type (8101h=Disc 2)                             ;<-- instead of 8001h

```

And, the Chrono Cross "final movie" does reportedly have "additional properties". Unknown, what that means, it does probably refer to the last movie on Chrono Cross Disc 2, which is quite huge (90Mbyte), and has lower resolution (160x112), and might have whatever "additional properties"?

NEED FOR SPEED 3

Need for Speed 3 Hot Pursuit (MOVIES\XA, contains videos, not raw XA-ADPCM)
 Jackie Chan Stuntmaster (FE\MOVIES\STR)

With slightly modified STR headers:

```
014h 4    Number of Frames (..excluding last some frames?) ;-instead BS[0..3]
018h 4    Unlike the above modified entry, this is normal  ;-copy of BS[4..7]
```

REBOOT (MOVIES*.WXA)

This has leading XA-ADPCM, and customized STR header:

```
014h 2    Type (0000h=Normal, 01FFh=Empty frames at end of video)
016h 2    Number of Frames (excluding empty ones at end of video)
018h 8    Zerofilled
```

GRAN TURISMO 1 (230MBYTE STREAM.DAT) AND GRAN TURISMO 2 (330MBYTE STREAM.DAT)

These two games use BS iki format, and (unlike other iki videos) also special STR headers:

```
002h 2    STR Type (5349h) ("IS")                ;-special (instead 8001h)
010h 2    Total number of frames in video          ;-special (instead width)
012h 2    Flags (bit15=1st, bit14=last)            ;-special (instead height)
014h 8    Zero                                     ;-special (instead BS header copy)
020h 7E0h Data (in BS iki format)                 ;-BS iki header (with width/height)
```

Caution: The STR header values aren't constant throughout the frame:

```
Namely, flags in [012h] are toggled on first/last sector of each frame,
and of course [04h] does also increase per sector.
```

PGA TOUR 96, 97, 98 (VIDEO..\XA AND ZZBUFFER\STR)

Used by all movies in PGA Tour 96, 97 (and for the ZZBUFFER\BIGSPY.STR dummy padding movie in PGA Tour 98).

The videos have normal BS v2 data, but the Frame Size entry is 8 smaller than usually. As workaround, always load [0Ch]+8 for all movies with standard STR headers (unless

that would exceed [06h]*7E0h).

```
00Ch 4      Frame Size-8 (ie. excluding 8-byte BS header)  ;instead of Size-0
```

The padding videos in ZZBUFFER folder have additional oddities in STR header:

```
ZZBUFFER\SPY256.STR    [14h..1Fh]=normal copy of 8-byte BS v2 header and zero
ZZBUFFER\SPYGLASS.STR  [14h..1Fh]=zerofilled                      ;\BS v1
ZZBUFFER\SPYTEST.STR   [14h..1Fh]=00 00 10 00 00 00 00 09 00 00 07 EE ;/
ZZBUFFER\BIGSPY.STR    Used in PGA Tour 98 (instead of above three files)
```

SPYTEST.STR has nonsense quant values exceeding the 0000h..003Fh range (first frame has quant=00B1h, and later frames go as high as quant=FFxxh, that kind of junk is probably unrelated to BS fraquant). The oddities for SPYTEST.STR do also occur in some frames in PGA Tour 98 BIGSPY.STR. Anyways, those ZZBUFFER files seem to be only unused padding files.

ALICE IN CYBER LAND (*.STR)

Note: First sector contains XA-ADPCM audio (video starts in 2nd sector).

```
STR Sector Header:
002h 2      STR Type (0000h=Alice in Cyber Land video)           ;-special
008h 4      Frame number (1=First) (bit15 set in last frame, or FFFFh)
010h 10h    Zerofilled (instead width/height and BS header copy) ;-special
020h 7E0h   Data (in BS v2 format)
```

Frames are always 320x240.

The frame number of the last used frame of a movie has the bit15 set. After that last frame, there are some empty frame(s) with frame number FFFFh.

For some reason there are "extra audio sectors in between movies" (uh?).

Many of the movies have a variable frame rate. All movies contain frames sequences that match one of the following frame rates: 7.5 fps, 10 fps, 15 fps, 30 fps.

ENCRYPTED IKI (PANEKIT - INFINITIVE CRAFTING TOY CASE)

```
014h 8      Copy of decrypted BS header (instead of encrypted BS header)
```

PRINCESS MAKER: YUMEMIRU YOUSEI (PM3.STR)

PARAPPA (JAPANESE DEMO VERSION ONLY) (S0/GUIDE.STR)

These files do have BS ID=3000h (except, the first and last some frames have normal ID=3800h). The STR header is quite normal (apart from reflecting the odd BS ID):

```

016h 2    Copy of BS ID, 3000h in most frames (instead of 3800h)
020h 7E0h Data (in BS format, also with BS ID 3000h, instead of 3800h)

```

STARBLADE ALPHA AND GALAXIAN 3

These movies have Extra stuff in the data section. The STR header is quite normal (apart from reflecting the Extra stuff):

```

00Ch 4    Frame Size in bytes (=size of ExtraHeader + BsData + ExtraData)
014h 4    Copy of Extra Header          ;instead of BS[0..3]
018h 4    Copy of BS[0..3]              ;instead of BS[4..7]
020h 7E0h Data (ExtraHeader + BsData + ExtraData)

```

The data part looks as so:

```

000h 2    Size of BS Data area      (S1)          ;\Extra Header
002h 2    Size of Extra Data area   (S2)          ;/
004h S1    BS Data (in BS v3 format)              ;-BS Data
.. S2      Extra Data (unknown purpose)            ;-Extra Data

```

Note: Starblade Alpha does use that format for GAMEn.STR and NAME.STR in FLT and TEX folders (the other movies in that game are in normal STR format).

LARGO WINCH: COMMANDO SAR (FMVINSPIN_W.RNG)

This is a somewhat "normal" movie, without audio, and with the STR headers moved to the begin of the file:

```

000h Nx20h    STR Headers    ;size = filesize/800h*20h
... Nx7E0h    Data           ;size = filesize/800h*7E0h

```

Note: The movie contains the rotating "W" logo, which is looped in Start screen.

PLAYER MANAGER (1996, ANCO SOFTWARE) (FILMS\1..3*.STR)

```

006h 2    Number of Sectors in this Frame-1 (8..9 = 9..10 sectors)
00Ch 4    Frame Size in bytes                (8..9*7E0h = 3F00h or 46E0h)
010h 2    Bitmap Width                       (always F0h)
012h 2    Bitmap Width                       (always 50h)
014h 0Ch  Zerofilled (instead copy of BS header or copy of Extra header)
020h 7E0h Data (Extra Stuff, BS v2 data, plus Unused stuff)

```

The data part occupies 9-10 sectors, consisting of:

```

0000h Extra Stuff    (7E0h bytes, whatever, often starts with 00,FF,00,FF,..)
07E0h BS v2 data    (3720h or 3F00h bytes, including FFh-padding)
...   Unused Sector (7E0h bytes, same as in previous frame or zerofilled)

```

The compressor tries to match the picture quality to the number of sectors per frame, but it's accidentally leaving the last sector unused:

```

For 9 sectors:  Only 1..7 are used, sector 8 is same as in previous frame
For 10 sectors: Only 1..8 are used, sector 9 is zerofilled

```

Apart from the odd format in *FILMS\1..3\STR*, the game does also have normal videos in *FILMS\STR*.

CHIISANA KYOJIN MICROMAN (DAT\STAGE**.MV)

The .MV files have 5 sectors/frame: Either 5 video sectors without audio, or 4-5 video sectors plus XA-ADPCM audio (in the latter case, audio is in each 8th sector (07h,0Fh, 17h,1Fh,etc), hence having filesize rounded up to $N*8$ sectors):

```

Filesize = 800h*((NumberOfFrames*5))           ;5 sectors, no xa-adpcm
Filesize = 800h*((NumberOfFrames*5+7) AND not 7) ;4-5 sectors, plus xa-adpcm

```

Caution: The STR header values aren't constant throughout the frame:

```

Sector 0: [10h] = Number of Frames,    [12h]=Junk
Sector 1: [10h] = Junk,                 [12h]=0
Sector 2: [10h] = Junk,                 [12h]=Junk
Sector 3: [10h] = Junk,                 [12h]=Same as below (Bitmap Height)
Below ONLY when having 5 sectors per frame:
Sector 4: [10h] = Bitmap Width (140h) [12h]=Bitmap Height (D0h)
That is, frames with 4 sectors do NOT have any Bitmap Width entry
(the duplicated Height entry in sector 3 exists, so one could compute
Width=NumMacroBlocks*100h/Height, or assume fixed Width=320, Height=208).

```

The Junk values can be zero, or increase/decrease during the movie, some or all of them seem to be sign-expanded from 12bit (eg. increasing values can wrap from 07xxh to F8xxh).

Apart from the odd *DAT\STAGE**.MV* files, the game does also have .STR files with normal STR headers and more sectors per frame (*DAT\STAGE16,21,27\STR*, *DAT\OTHER\STR*, *DAT\OTHER\CM\STR*, and *MAT\DAT*.STR*).

BLACK SILENCE PADDING

Used by Bugriders: The Race of Kings (MOVIE\XB.STR)

Used by Rugrats Studio Tour (MagDemo32: RUGRATS\DATA\OPEN\B.STR)

```
Each movie file is followed by dummy padding file. For example, in Bugriders:
MOVIE\*XA.STR  Movie clip                (with correct size, 320x192)
MOVIE\*XB.STR  Black Silence padding      (wrong size 640x192, should be 320x192)
```

The names are sorted alphabetically and exist in pairs (eg. CHARMXA.STR and CHARMXB.STR), and the disc sectors are following the same sort order.

The padding files contain only black pixels and silent XA-ADPCM sectors, with following unique STR header entries, notably with wrong Width entry (the MDEC data contains only 320x192 pixels).

```
00Ch 4    Frame Size      (087Ch)
010h 2    Bitmap Width   (wrongly set to 640, should be 320)
012h 2    Bitmap Height  (192)
014h 2    MDEC Size      (05A0h)
016h 2    BS ID          (3800h)
018h 2    BS Quant       (0001h)
01Ah 2    BS Version     (0002h)
Filesize is always 44Fh sectors (about 2.2Mbyte per *XB.STR file)
```

The huge 7 second padding is a very crude way to avoid the next movie to be played when not immediately pausing the CDROM at end of current movie.

RIDGE RACER TYPE 4 (ONLY PAL VERSION) (R4.STR)

The 570Mbyte R4.STR file contains XA-ADPCM in first three quarters, and two STR movies in last quarter:

```
1st NTSC/US movie: 320x160 pix, 0F61h frames, 4-5 sectors/frame, normal STR
1st PAL/EUR movie: 320x176 pix, 0CD0h frames, 5-6 sectors/frame, special STR
2nd NTSC/US movie: 320x160 pix, 1D6Ah frames, 4-5 sectors/frame, normal STR
2nd PAL/EUR movie: 320x160 pix, 18B5h frames, 5-6 sectors/frame, normal STR
```

As seen above, the PAL movies have lower framerate. And, the 1st PAL movie has higher resolution, plus some other customized STR header entries:

```
002h 2    STR Type (0001h=Custom, 176pix PAL video)          ;instead of 8001h
006h 2    Number of Sectors in this Frame (always 5..6)
00Ch 4    Frame Size (always 2760h or 2F40h, aka 7E0h*5..6)
012h 2    Bitmap Height (00B0h, aka 176 pixels)              ;instead of 00A0h
014h 8    Zerofilled                                         ;instead BS[0..7]
020h 7E0h Data (in BS v3 format, plus FFh-padding)
```

That is, the special video is standard MDEC, the only problem is detecting it as such (despite of the custom STR Type entry).

MAT HOFFMAN'S PRO BMX (MAGDEMO48: MHPB\SHORT.STR)

This contains a normal MDEC movie, but with distorted "garbage" in first and last some sectors.

```
1st sector      STR Type 5673h (Leading Dummy)      ;\
2nd sector      STR Type 8001h (distorted/empty MDEC) ; junk
3rd..6th sector STR Type 8001h (distorted/garbage MDEC) ;/
7th sector and up STR Type 8001h (normal MDEC, with odd [01Ch]) ; -movie
Last 96h sectors STR Type 0078h (Ending Dummy)      ; -junk
```

1st Sector:

```
002h 2  STR Type (5673h=Leading Dummy)
004h 4  Whatever (0004000Ch)
008h 4  Whatever (0098967Fh)
00Ch 4  Frame Size (always 100h)
010h 7F0h EAh-filled
```

2nd Sector:

```
002h 2  STR Type (8001h=Normal MDEC ID, but content is empty)
004h 4  Whatever (0004000Ch) ;\
008h 4  Whatever (0098967Fh) ; same as in 1st sector
00Ch 4  Frame Size (always 100h) ; (but ID at [002h] differs)
010h 7F0h EAh-filled ;/
```

3rd-6th Sector:

```
002h 2  STR Type (8001h=Normal MDEC ID, but content is distorted)
004h 2  Sector number within current Frame (always 0)
006h 2  Number of Sectors in this Frame (always 1)
008h 4  Frame number (increasing, 1..4 for 3rd..6th sector)
00Ch 4  Frame Size (always 7D0h)
010h 10h EAh-filled
020h 7D0h Unknown (random/garbage?)
7F0h 10h EAh-filled
```

7th Sector and up (almost standard MDEC):

Caution: The STR header values aren't constant throughout the frame:
Entry entry [01Ch] is incremented per sector (or wraps to 0 in new section).

```
01Ch 4  Increasing sector number (within current movie section or so)
```

Last 96h Sectors:

```

002h 2    STR Type (0078h=Ending Dummy)
004h 2    Sector number within current Frame (always 0)
006h 2    Number of Sectors in this Frame (always 1)
008h 4    Frame number (increasing, in last 96h sectors)
00Ch 4    Frame Size (always 20h)
010h 2    Bitmap Width  (always 40h)
012h 2    Bitmap Height (always 40h)
014h 7ECh Zerofilled

```

FINAL FANTASY VII (FF7) (MOVIE\MOV AND MOVIE\STR)

These movies have Extra stuff in the data section. The STR header is quite normal (apart from reflecting the Extra stuff):

```

00Ch 4    Frame Size in bytes (including 28h-byte extra stuff)
014h 8    Copy of Extra data [0..7]          :-instead of BS header[0..7]
020h 7E0h Data (ExtraData + BsData)

```

The data part looks as so:

```

000h 28h  Extra data (unknown purpose, reportedly "Camera data" ... whut?)
028h ..   BS Data (in BS v1 format)

```

FINAL FANTASY IX (FF9) (*.STR AND *.MBG)

There are several customized STR header entries:

```

002h 2    STR Type (0004h=FF9/Video)          ;instead of 8001h
004h 2    Sector number within current Frame (02h..num-1) (2..9 for video)
006h 2    Total number of Audio+Video sectors in this frame (always 0Ah)
00Ch 4    Frame Size/4 (of BS data, excluding MBG extra) ;instead of Size/1
014h 8    Copy of BS[0..7] from 8th video sector    ;instead 1st sector
01Ch 2    Usually 0000h (or 0004h in some MBG sectors) ;inszead of 0000h
01Eh 2    Usually 0000h (or 3xxxh in some MBG sectors) ;inszead of 0000h
020h 8F4h Data (in BS v2 format, plus MBG extra data, if any)

```

Caution: The STR header values aren't constant throughout the frame:

```

Namely, entry [1Ch..1Fh]=nonzero occurs only on the sector that does contain
the end of BS data (=and begin of MBG extra data), and of course [04h] does
also increase per sector.

```

Sector ordering has BS data snippets arranged backwards, for example, if BS data does occupy 2.5 sectors:

```
[04h]=00h-01h 1st-2nd audio sector, SPU-ADPCM (see Audio streaming chapter)
[04h]=02h-06h 1st-5th video sector, unused, [020h..913h] is FFh-filled
[04h]=07h      6th video sector, contains end of BS data and MBG extra, if any
[04h]=08h      7th video sector, contains middle of BS data
[04h]=09h      8th video sector, contains begin of BS data
```

Sector type/size, very unusually with FORM2 sectors:

```
Audio sectors are MODE2/FORM1 (800h bytes, with error correction)
Video sectors are MODE2/FORM2 (914h bytes, without error correction)
```

Huffman codes are standard BS v2, with one odd exception: MDEC 001Eh/03E1h (run=0, level=+/-1Eh) should be usually encoded as 15bit Huffman codes, FF9 is doing that for 001Eh, but 03E1h is instead encoded as 22bit Escape code:

```
000000000100010      MDEC=001Eh (run=0, level=+1Eh) ; -normal (used)
000000000100011      MDEC=03E1h (run=0, level=-1Eh) ; -normal (not used)
0000010000001111100001 MDEC=03E1h (run=0, level=-1Eh) ; -escape (used)
```

There are two movie variants: *.STR and *.MBG. Most MBG files (except SEQ02\MBG102.MBG) contain extra MBG info in [01Ch..01Fh] and extra MBG data appended after the BS data. If present, the appended MBG data is often/always(?) just these 28h-bytes:

```
FF FF FF FF FE FF FE 41 AD AD AD AD AD AD AD AD
AD AD AD AD AD AD AD AD AD AD AD AD AD AD AD
AD AD AD AD AD AD AD AD
(followed by FF's, which might be padding, or part of the extra data)
```

Unknown if some sectors contain more/other MBG data, perhaps compressed BG pixel-depth values for drawing OBJs in front/behind BG pixels?

Non-standard STR Video Headers

FINAL FANTASY VIII (FF8)

Video frames are always 320x224. The video frames are preceeded by two SPU-ADPCM audio sectors.

```
000h 4      ID "SMJ", 01h=Video
004h 1      Sector number within current Frame (02h..num-1) (2..9 for video)
005h 1      Total number of Audio+Video sectors in this frame, minus 1 (9)
006h 2      Frame number (0=First)
008h 7F8h   Data (in BS v2 format)
```

ACE COMBAT 3 ELECTROSPHERE (IN 520MBYTE ACE.SPH/SPB ARCHIVE)

The videos start with one XA-ADPCM sector, followed by the first Video sector.

```
STR Sector Header:
000h 1    Always 01h
001h 1    Sector number within current Frame (00h..num-1) (8bit)
002h 2    Number of Sectors in this Frame
004h 2    Unknown (1 or 3)
006h 2    Frame number (decreasing, 0=Last)
008h 2    Bitmap Width in pixels    ;\130hxE0h or 140hxB0h or 80hx60h
00Ah 2    Bitmap Height in pixels  ;/
00Ch 4    Zero
010h 2    Zero, or decreasing timer (decreases approx every 2 sectors)
012h 2    Zero, or decreasing timer (decreases approx every 1 sector)
014h 3    Zero
017h 1    Zero, or increases with step 2 every some hundred sectors
018h 2    Zero, or Timer (increments when [1Ah] wraps from 04h to 01h)
01Ah 1    Zero, or Timer (increments when [1Bh] wraps from 5Fh to 00h)
01Bh 1    Zero, or Timer (increments approx every 1 sector)
01Ch 2    Zero, or Whatever (changes to whatever every many hundred sectors)
01Eh 2    Zero, or 0204h
020h 7E0h Data (in BS v3 format)
```

Caution: The STR header values aren't constant throughout the frame:

Namely, entry [10h..1Fh] can change within the frame (happens in japanese version), and of course [01h] does also increase per sector.

The Japanese version may be the only game that has two streaming videos running in parallel on different channels.

That means, non-japanese version is different...?

JUDGE DREDD (1998, GREMLIN) (CUTS*.IXA AND LEVELS*.IXA)

This is a lightgun-game with "interactive movies". The gameplay consists of running on a fixed path through a scene with pre-recorded background graphics, the only player interaction is aiming the gun at other people that show up in that movie scene. There are two movie types:

```
LEVELS\*\*.IXA    - Interactive gameplay movies
CUTS\*.IXA        - Non-interactive cut-scene movies
```

Both CUTS and LEVELS have unusually small 4-byte STR headers:

```
000h 4    Sector number within current Frame (LEVELS=0..8, or CUTS=0..9)
004h 7FCh Data (see below)
```

Data for CUTS is 320x240pix (10 sectors per frame):

```
Note: CUTS videos have 2 leading XA-ADPCM sectors
000h ..   BS Data (in BS v2/v3 format)                ;-BS picture
```

Data for LEVELS is 320x352pix plus extra stuff (9 sectors per frame):

```
Note: LEVELS videos have 1 leading XA-ADPCM sector
000h 4      Offset to BS Data (always 28h)              ;\
004h 4*6    Offsets to Extra Stuff 1..6                 ; extra header
01Ch 0Ch    Zerofilled                                   ;/
028h ..     BS Data (in BS v2/v3 format)                ;-BS picture
... ..     Extra Stuff 1..6                             ;-extra data
```

The unusual 320x352pix resolution contains a 320x240pix BG image, with additional 320x112pix texture data appended at the bottom.

Extra Stuff 1..6 does supposedly contain info for animating enemies and/or backgrounds.

iki

The .iki video format (found in files with .IKI or .IK2 extension) is used in several games made by Sony. iki movie sectors have some different properties:

- * There are only as many iki video sectors as needed to hold all the frame's data. Remaining sectors are null.
- * The first sector's Submode.Channel starts at zero, then increments for each sector after that, and resets to zero after an audio sector.
- * IK2 videos can also have variable frame rates that are very inconsistent.

13.14 CDROM File Video Streaming Framerate

According to Sony, BS encoded 320x240pix videos can be played at 30fps (with cdrom running at double speed).

STR Frame Rate

As a general rule, the frame rate is implied in CDROM rotation speed (150 or 75 sectors per second, minus the audio sectors, divided by the number of sectors per video frame).

Fixed/Variable Framerates

The frame can drop on video frames that contain more sectors than usually. Video frames that require fewer sectors than often padded with zerofilled sectors. However,

some games don't have that padding, so they could end up receiving up to 150 single-sector frames per second; the actual framerate is supposedly slowed down to 60Hz or less via Vblank timer (and with the CDROM reading getting paused when the read-ahead buffer gets full).

Audio Samplerate

XA-ADPCM audio contains samplerate info (in the FORM2 subheader), the samplerate versus amount of audio sectors can be used to compute the CDROM rotation speed. There are two exceptions: Some movies don't have any audio at all, and some movies use SPU-ADPCM instead of XA-ADPCM. In the latter case, the SPU Pitch (samplerate) may (or may not) be found somewhere in the audio sector headers.

CDROM Rotation speed

As said above, the speed can be often detected via audio sample rate. Otherwise, the general rule is that most PSX games are used 2x speed (150 sectors/second). But, there are a few games with 1x speed (see below).

CDROM Single speed (75 sectors/frame)

Here are probably most of the USA games with videos at 1x speed.

```
007 - The World Is Not Enough
1Xtreme
Arcade Party Pak
Atari Anniversary Edition Redux
Blast Radius
Blue's Clues - Blue's Big Musical
Chessmaster II
Chronicles of the Sword
Civilization II
Colin McRae Rally
Creatures - Raised in Space
Cyberia
Demolition Racer
Dune 2000
ESPN Extreme Games
FIFA Soccer 97
Fade to Black
Family Connection - A Guide to Lightspan
Fear Effect
Fox Hunt
Interactive CD Sampler Volume 1
Jade Cocoon - Story of the Tamamayu
Jeopardy! 2nd Edition
```

```

Juggernaut
Krazy Ivan
MTV Sports - Skateboarding featuring Andy Macdonald
MTV Sports - T.J. Lavin's Ultimate BMX
Medal of Honor
Medal of Honor - Underground
Official U.S. PlayStation Magazine Demo Disc 23
Planet of the Apes
PlayStation Underground Number 2
Shockwave Assault
Starblade Alpha
Starwinder - The Ultimate Space Race
Str.at.e.s. 1 - Match-A-Batch
Str.at.e.s. 5 - Parallel Lives!
Str.at.e.s. 7 - Riddle Roundup!
The X-Files
Top Gun - Fire at Will!
Um Jammer Lammy
Uprising X
Wheel of Fortune - 2nd Edition
Williams Arcade's Greatest Hits

```

13.15 CDROM File Video Streaming Audio

Audio Stream

STR movies are usually interleaved with XA-ADPCM sectors (the audio sectors are automatically decoded by the CDROM hardware and consist of raw ADPCM data without STR headers).

[CDROM File Audio Streaming XA-ADPCM](#)

However, there are also movies without audio. And a few movies with SPU-ADPCM audio.

SPU-ADPCM in Chunk-based formats

[CDROM File Video Streaming Chunk-based formats](#)

SPU-ADPCM in Chrono Cross/Legend of Mana Audio Sector

Chrono Cross Disc 1 (HiddenDirectory\1793h..17A6h)

Chrono Cross Disc 2 (HiddenDirectory\1793h..179Dh)

Legend of Mana (MOVIE*.STR, except some movies without audio)

```

000h 2    STR ID    (0160h)
002h 2    STR Type (0000h, 0001h, 0100h, or 0101h)

```



```

0000h=Legend of Mana, Audio normal sectors
0001h=Legend of Mana, Audio sectors near end of movie
0000h=Chrono Cross Disc 1, Audio.left?
0001h=Chrono Cross Disc 1, Audio.right?
0100h=Chrono Cross Disc 2, Audio.left?
0101h=Chrono Cross Disc 2, Audio.right?
004h 2    Sector number in Frame (0=Audio.left?, 1=Audio.right?)
006h 2    Number of Audio sectors in this frame (always 2)
008h 4    Frame number (1=First)
00Ch 4    Unused (Chrono: FFh-filled or Mana: 0000FC0h=2x7E0h=Framesize?)
010h 10h  Unused (Chrono: FFh-filled or Mana: 00h-filled)
020h 60h  Unused (FFh-filled)
080h 4    ID "AKAO"
084h 4    Frame number (0=First)
088h 8    Unused (zerofilled)
090h 4    Remaining Time (step 690h) (can get stuck at 0340h or 0B20h at end)
094h 4    Zero
098h 4    Unknown (11h)
09Ch 4    Pitch (1000h=44100Hz)
0A0h 4    Number of bytes of audio data (always 690h)
0A4h 2Ch  Unused (zerofilled)
0D0h 690h Audio (10h-byte SPU-ADPCM blocks) (1680 bytes)
760h A0h  Unused (10h-byte SPU-ADPCM blocks with flag=03h and other bytes=0)

```

Note: The Chrono/Mana STR files start with Audio frames in first sector (except, some Legend of Mana movies don't have any Audio, and do start with Video frames).

SPU-ADPCM in Final Fantasy VIII (FF8)

```

000h 4    ID "SMN",01h=Audio/left, "SMR",01h=Audio/right
004h 1    Sector number in Frame (0=Audio.left, 1=Audio.right)
005h 1    Total number of Audio+Video sectors in this frame, minus 1 (1 or 9)
006h 2    Frame number (0=First)
008h E8h  Unknown (camera data?) (232 bytes)
0F0h 6    Audio ID (usually "MORIYA", sometimes "SHUN.M")
0F6h 0Ah  Unknown (10 bytes) (reportedly 10 bytes at offset 250 = FAh ?????)
100h 4    ID "AKAO"
104h 4    Frame number (0=First)
108h 14h  Unknown (20 bytes)
11Ch 4    Pitch (1000h=44100Hz)
120h 4    Number of bytes of audio data (always 690h)
124h 2Ch  Unknown (44 bytes)
150h 20h  Unknown (32 bytes)
170h 690h SPU-ADPCM Audio data (690h bytes)

```

There is one special case on disc 1: a movie with no video. Each 'frame' consists of two sectors: the first is the left audio channel, the second is the right audio channel.

SPU-ADPCM in Final Fantasy IX (FF9) (*.STR and *.MBG)

The FF9 audio sectors are normal MODE2/FORM1 sectors (unlike the FF9 video sectors, which are MODE2/FORM2).

```

000h 2    STR ID    (0160h)
002h 2    STR Type (0008h=FF9/Audio)
004h 2    Sector number in Frame (0=Audio.left, 1=Audio.right)
006h 2    Total number of Audio+Video sectors in this frame (always 0Ah)
008h 4    Frame number (1=First)
00Ch 4    Zero
010h 1    Audio flag? (00h=No Audio, 01h=Audio)
011h 4Fh  Zerofilled --- XXX or whatever (when above is 00h)
060h 4    Number of Frames in this STR file
064h 1Ch  EEh-filled
Below 780h bytes are all zerofilled when [10h]=00h (no audio)
Below 780h bytes are reportedly all ABh-filled "in the last frame of a movie
on Disc 4" (unknown which movie, and if that occurs in other movies, too)
080h 4    ID "AKAO"
084h 4    Frame number (0=First)
088h 14h  Unknown (20 bytes)
09Ch 4    Pitch (116Ah=48000Hz) (or 1000h=44100Hz in final movie)
0A0h 4    Number of bytes of audio data (0, 720h, 730h, or 690h=final movie)
0A4h 2Ch  Unknown (44 bytes)
0D0h 730h SPU-ADPCM audio (plus leftover/padding when less than 730h bytes)

```

Dance series SPU-ADPCM streaming (bigben interactive, DATA.PAK\stream*.str)

This format is used for raw SPU-ADPCM streaming (without video).

SLES-04121 Dance: UK

SLES-04161 Dance: UK eXtra TraX

SLES-04129 Dance Europe

SLES-04162 All Music Dance! (Italy)

```

000h 2    STR ID    (0160h)
002h 2    STR Type (8001h, same as MDEC)
004h 2    Sector number within current Frame (0000h..num-1)
006h 2    Number of Sectors in this Frame (always 9)
008h 4    Frame number (0=First)
00Ch 4    Frame Size in bytes (always 4000h)
010h 4    Whatever (always 00A000A0h, would be width/height if it were video)
014h 8    Zerofilled
01Ch 4    Special ID (always DDCCBBAh for Dance audio)
020h 7E0h Data (in SPU-ADPCM format, mono, 22200Hz aka Pitch=07F5h)

```

Note: Sector 0..8 contain $9 \times 7E0h = 46E0h$ bytes data per frame, but only 4000h bytes are used (the last 6E0h bytes in sector 8 are same as in sector 7).

Raw SPU-ADPCM Streaming

Some games are using raw SPU-ADPCM for streaming. That is, the file is basically a normal .VB file, but it can be dozens of megabytes tall (ie. too large to be loaded into RAM all at once).

```
Disney's The Emperor's New Groove (MagDemo39: ENG\STREAM\*.CVS)
Disney's Aladdin in Nasira's Revenge (MagDemo46: ALADDIN\STREAM\*.CVS)
```

13.16 CDROM File Video Streaming Chunk-based formats

Newer Electronic Arts videos (EA)

EA videos are chunk based (instead of using 20h-byte .STR headers). The next chunk starts right at the end of the previous chunk (without padding to sector boundaries).

```
STR Sector Header:
No STR Sector header (first sector starts directly with "VLC0" chunk)
VLC0 Chunk (at begin of movie file):
000h 4      Chunk ID "VLC0"
004h 4      Chunk Size (always 1C8h)          (big-endian)
008h 1C0h   16bit MDEC values for E0h huffman AC codes (little-endian)
MDEC Chunks (video frames):
000h 4      Chunk ID "MDEC"                      ;\
004h 4      Chunk Size (...)                    (big-endian) ; custom chunk header,
008h 2      Bitmap Width in pixels              (big-endian) ; instead of STR header
00Ah 2      Bitmap Height in pixels            (big-endian) ;
00Ch 4      Frame Number (starting at 0) (big-endian) ;/
010h ..     Data (in BS v2 format, but using custom Huffman codes from VLC0)
... ..     Zeropadding to 4-byte boundary
Audio Chunks (au00/au01):
000h 4      Chunk ID ("au00"=normal, "au01"=last audio chunk)
004h 4      Chunk Size (...)                    (big-endian)
008h 4      Total number of 2x4bit samples in previous chunks (big-endian)
00Ch 2      Unknown (always 800h) (maybe Pitch: 800h=22050Hz) (big-endian)
00Eh 2      Unknown (always 200h)              (big-endian)
... ..     SPU-ADPCM audio data, left  (0Fh bytes per sample block)
... ..     SPU-ADPCM audio data, right (0Fh bytes per sample block)
... ..     Garbagepadding to 4-byte boundary
Note: SPU-ADPCM does normally have 10h-byte blocks, but in this case,
the 2nd byte (with loop flags) is omitted, hence only 0Fh-byte blocks.
Zero Chunk (zeropadding at end of file, exists only in some EA videos):
000h ..     Zeropadding
```

Older Electronic Arts videos

Crusader: No Remorse (1996 Origin Systems) (MOVIES*.STR)

Soviet Strike (1996 Electronic Arts)

Battle Stations (1997 Electronic Arts)

Andretti Racing (1996 Electronic Arts)

```
STR Sector Header:
000h 4    ID (DDCCBBAAh) (aka AABBCDDh big-endian)
004h 4    Sector number within STR file (0=First, up to Filesize/800h-1)
008h 7F8h Data (video and audio chunks, see below) (first chunk is "ad20")
Video Chunks (MDEC):
000h 4    Chunk ID "MDEC" ;\
004h 4    Chunk Size (...) (big-endian) ;
008h 2    Bitmap Width in pixels (big-endian) ; custom chunk header
00Ah 2    Bitmap Height in pixels (big-endian) ;
00Ch 4    Frame Number (starting at 0) (big-endian) ;/
010h ..   Data (in BS v2 format) ;--standard BS v2 data
Audio Chunks (ad20/ad21) (22050Hz stereo):
000h 4    Chunk ID ("ad20"=normal, "ad21"=last audio chunk)
004h 4    Chunk Size (1A50h or 1A70h) (big-endian)
008h 4    Total number of 2x4bit samples in previous chunks (big-endian)
00Ch 2    Unknown (always 800h) (maybe Pitch: 800h=22050Hz) (big-endian)
00Eh 2    Unknown (always 200h) (big-endian)
010h ..   SPU-ADPCM audio data, left (10h bytes per sample block)
... ..   SPU-ADPCM audio data, right (10h bytes per sample block)
Last STR Sector:
000h 18h  FFh-filled (aka 8-byte STR header and 10h-byte Chunk header)
018h -    Nothing (total STR filesize is N*800h+18h bytes)
```

Oldest Electronic Arts videos

Wing Commander III: Heart of the Tiger (MOVIES1.LIB*.wve) (1995, EA/Origin)

```
STR Sector Header:
No STR Sector header (first sector starts directly with "Ad10" chunk)
Video Chunks (MDEC):
000h 4    Chunk ID "MDEC" ;\
004h 4    Chunk Size (2xx0h) (big-endian) ;
008h 2    Bitmap Width in pixels (big-endian) ; custom chunk header
00Ah 2    Bitmap Height in pixels (big-endian) ;
00Ch 2    Unknown (7FFFh) (big-endian) ;
00Eh 2    Unknown (AD14h or AD24h) (big-endian) ;/
010h ..   Data (in BS v2 format) ;--standard BS v2 data
... ..   Padding, up to circa 20h bytes, FFh-filled
Audio Chunks (Ad10/Ad11) (22050Hz stereo):
000h 4    Chunk ID ("ad20"=normal, "ad21"=last audio chunk)
004h 4    Chunk Size (D38h or D28h) (or less in last chunk) (big-endian)
```

```

010h ..   SPU-ADPCM audio data, left  ? (10h bytes per sample block)
...  ..   SPU-ADPCM audio data, right ? (10h bytes per sample block)

```

Audio seems to be 22050Hz stereo, however, chunks with size=D38h have odd amounts of sampleblocks, so it isn't as simple as having left/right in first/second half.

Polcenauts (Japan, 1996 Konami) (NAUTS\MOVIE*.MOV)

```

STR Sector Header:
No STR Sector header (first sector starts directly with "VMNK" chunk)
First chunk (800h bytes):
000h 4      ID "VMNK" (aka KNMV backwards, maybe for Konami Video/Movie)
004h 4      Unknown (01h)
008h 4      Unknown (01h)
00Ch 4      Unknown (F0h)
010h 4      Size of KLBS chunks?          (40000h)
014h 4      Bitmap X1 (aka left border)?   (16pix, 10h)
018h 4      Bitmap Y1 (aka upper border)?  (16pix, 10h)
01Ch 4      Bitmap Width                   (288pix, 120h)
020h 4      Bitmap Height                  (144pix, 90h)
024h 7E4h   Zerofilled
Further chunks (40000h bytes, each):
000h 8      Zerofilled
008h 4      Chunk ID "KLBS" (aka SBLK backwards, maybe for Stream Block)
00Ch 4      Chunk Size (usually 40000h)
010h 4      Number of Name List entries
014h 4      Number of Name List entries (same as above)
018h 8      Zerofilled
020h N*30h  Name List
... ..      Data (referenced from Name List)
... ..      Zeropadding (to end of 40000h-byte chunk)

```

The Name List does resemble a file archive, however, the "filenames" are just Type IDs (eg. all picture frames do have the same name).

```

Name List entries:
000h 8      Zerofilled
008h 8      Data Type Name (eg. "SCIPPPTS")
010h 4      Time when to play/display the frame (0 and up)
014h 4      Time duration for that frame (usually 14h for Picture frames)
018h 4      Data Offset in bytes (from begin of chunk)
01Ch 4      Data Size in bytes
020h 10h    Zerofilled

```

Data Formats for the different Data Types...

```

Type "SDNSHPTS" aka SNDS,STDH - SoundStdHeader (Size=800h, Duration=0)
000h 4      Maybe Pitch? (800h)                (big-endian)
004h 4      Maybe Pitch? (800h)                (big-endian)
008h 4      Total SPU-ADPCM size in bytes (for whole .MOV) (big-endian)

```

```

00Ch 4      Unknown (FFFFFFFFh)                (whatever)
010h 4      Unknown (00007FFFh)                (big-endian)
014h 7ECh   Zerofilled
Type "SDNSSDTS" aka SNDS,STDS - SoundStdStream (Size=10h..4000h, Duration=9Ch)
000h 4000h SPU-ADPCM data in 10h-byte blocks (last chunk is less than 4000h)
Type "SCIPPDTS" aka PICS,STDP - PictureStdPicture (Size=3xxxh, Duration=14h)
000h 3xxxh Picture Frame (in BS v1 format)
Type "SCTELLE" aka ETCS,CELL - ExtraCells? (Size=0Ch, Duration=1)
000h ..     Maybe subtitle related...?
Type "SCTEGOLD" aka ETCS,DLOG - ExtraD-log? (Size=19h..31h, Duration=27h..44h)
000h ..     Maybe subtitle related...?

```

Note: Total number of 10h-byte SPU-ADPCM blocks can be odd (so the audio seems to be mono).

Apart from the .MOV files, there's also one standard .STR file for the Knnami Intro (with normal STR headers and BS v2 data).

Best Sports Games Ever (DD\ *VLC* and *MOVIES* *VLC*) (Powerline Demo Disc menu)

This format is used for still images with only frame, and for looping short animation sequences in the Demo Disc Menu. There's no audio.

```

Header Chunk:
000h 4      Fixed ID (74h,55h,89h,08h aka 08895574h)
004h 2      Bitmap Width          (140h)
006h 2      Bitmap Height         (100h)
008h 2      Video Frame Size/4     (17A0h or 13B0h)
00Ah 2      Number of Video Frames (01h or 32h)
00Ch 4      Frame End ID (eg. 62DCCACEh) (random?, but stays same within movie)
Video Frame Chunk(s):
... ..     Data (in BS v1/v2/v3 format)          ;\size = hdr[008h]*4
... ..     FFh-filled (padding to Frame Size)    ;/
... 4      Frame End ID (eg. 62DCCACEh)          ;-same value as in hdr[00Ch]

```

For random access, best is seeking "fpos=N*(Framesize+4)+10h", alternately one could search "fpos=LocationAfterFrameEndID".

Sentient (FILMS*.FXA)

This is having neither per-sector STR headers nor Chunk headers, instead it's having raw data with fixed size of 10 sectors per frame.

File Header (sector 0, 800h bytes):

```

000h 4      File ID (01h,"XSP") (aka PSX backwards)
004h 2      Unknown (0001h)
006h 2      Unknown (0040h) (this is used for something...)
008h 2      Bitmap Width (0140h)

```

```

00Ah 2    Bitmap Height (00F0h)
00Ch 4    Total number of video frames
010h 4    Number of video sectors per frame (always 8)
014h 4    Total number of video sectors, excluding audio/dummy (=NumFrames*8)
018h 1    Zero
019h 1    Sector List size (28h) (ie. each 4 frames) ;\or zerofilled when
01Ah 28h  Sector Types (2=Video, 1=Audio, 0=Dummy)    ;/not present
042h ..   Zerofilled
7xxh ..   Unknown, maybe just garbage ...?
... ..   Zerofilled

```

The frame rate is 15fps with 10 sectors per frame (8xVideo and either 2xAudio or 1xAudio+1xDummy). The Video/Audio/Dummy sector arrangement does repeat each 40 sectors (aka each 4 frames):

```

vVvvvvv--vvVvvv--vvvvVv--vvvvvv-Vvvvvvv- Video
-----A-----A-----A-----A-----A Audio
-----D-----D-----D-----D-----D Dummy

```

V = 1st sector of video frame

v = 2nd..8th sector of video frame (or fileheader in case of sector 0)

A = Audio (each 8th sector, ie. sector 07h,0Fh,17h,1Fh,etc.)

D = Dummy (occurs after some (not all) audio sectors)

Some files have that sector arrangement stored in header[019h..041h], but other files have that header entries zerofilled (despite of using the same arrangement).

Video frames are 8 sectors (4000h-byte), first and last 8 bytes are swapped:

```

0000h 8    Last 8 bytes of BS v1 bitstream    ;\or garbage padding
0008h 3FF0h First 3FF0h of BS v1 bitstream    ;/
3FF8h 8    Footer (64bit, with squeezed BS header and other info)

```

The footer bits are:

```

0-4    5bit   Quant (00h..1Fh) (only 5bit, not 6bit)
5-15   11bit  MDEC Size in 20h-word units (80h-byte units)
16-23  8bit   Unknown (lowbits are often same as bit48 and up?)
24-31  8bit   BS ID/100h (3800h/100h)
32-47  16bit  Frame Number (0=First)
48-63  16bit  Next Sector Number (start of next video frame)

```

To decrypt/convert the frame to standard BS v1 format:

```

x=[3FF8h]                                ;get footer
[3FF8h..3FFFh]=[0000h..0007h] ;last 8 bytes of bitstream
[0000h]=(x AND FF0FFE0h)    ;size and ID=3800h
[0004h]=(x AND 1Fh)+10000h  ;quant and version=v1

```

The next_sector number is usually current_sector+1 (or +2 if that would be audio), in last frame it does point to end of file.

Bitstreams smaller than 3FF8h are garbage padded (initially some 32bit garbage values, and in later frames leftovers from previous bitstream sectors).

Dummy sectors contain 800h bytes:

```

000h 4      Always FFFFFFFFh (unfortunately, this isn't a unique ID)
004h 7FCh  Garbage (zeroes, random, or even leaked ASM source code)
Dummy sectors have the same Subheader as video sectors, the leading FFFFFFFFh
could also occur in BS bitstreams or frames with garbage padding, so one must
use the sector arrangement pattern to identify dummy sectors.

```

Audio sectors are XA-ADPCM and can be filtered via Subheader, or via sector arrangement pattern.

13.17 CDROM File Video Streaming Mis-mastered files

Mis-mastered streaming files

There are several discs that have streaming data stored as partial CDROM images (instead of as real CDROM sectors).

Format	Content	Where
raw 920h-byte STR		K9.5 1 - Live in Airedale (ZZBUFFER.STR) ;\
raw 920h-byte STR		Need for Speed 3 (MOVIES\ZZZZZZZ*.PAD) ;
raw 920h-byte STR		3D Baseball (ZZZZZZZZ.ZZZ) ; intended
raw 920h-byte STR		Wing Commander III (DUMMY.DAT) ; padding
raw 920h-byte STR		R-Types (DMY\DUMMY.BIN) ;
raw 920h+junk STR+junk		Grand Slam (DUMMY.BIN) ;
raw 920h-byte XA-ADPCM		Spec Ops Airborne Commando (PADDING.NUL) ;
raw 920h-byte SW-STR		Cyberia (ENDFILL*.STR) (software render) ;
RIFFs/CDXAfmt STRs		Sonic Wings Special (SW00.DMY = two RIFFs);/
raw 920h-byte XA-ADPCM		Rugrats (MagDemo19: STREAMS\DB02.ISF) ;\nonsense
raw 920h-byte Data BABEH		Rugrats (MagDemo19: STREAMS\OPEN.BIN) ; dupes
raw ???-byte CDDA		Championship Surfer (MagDemo43: HWX\MUSIC);/
raw ???-byte CDDA		Twisted Metal 2 (MagDemo50: TM2\FRWYSUB.DA) ; -?
raw 920h-byte STR		Sonic Wings Special (MOV\MQ*.STR) ; -unused?
raw 920h-byte STR		Apocalypse (MagDemo16: APOC*.STR)
raw 920h-byte XA-ADPCM		Apocalypse (MagDemo16: APOC*.XA)
raw 920h-byte XA-ADPCM		NFL Xtreme (MagDemo13: NFLX\GAME\SOUND\2PLAYRNO.XA)
raw 920h-byte XA-ADPCM		Ace Combat 2 (MagDemo01: ACE2.STP)
raw 920h-byte XA-ADPCM		Colony Wars (MagDemo02: CWARS\DEMO.PAK)
raw 920h-byte XA-ADPCM		Best Sports demo (AH2\GAMEDATA\COM\MUSIC\MUSIC.IXA)
raw 920h-byte XA-ADPCM		Tomb Raider: Last Revelation (MagDemo29: TR4\XA1.XA)
raw 800h-byte XA-ADPCM		Croc 1 demo (MagDemo02: CROC\MAGMUS.STR) (FORM1)
RIFF/CDXAfmt XA-ADPCM		Best Sports demo (LOMUDEMO\SFX\COMMENT.STR)
RIFF/CDXAfmt ?+XA-ADPCM		Ace Combat 3 Electrosphere (MagDemo30: AC3*.SPB)
RIFF/CDXAfmt XA-ADPCM		Colony Wars Venegance (MagDemo14: CWV\SONYDEMO.PAK)
RIFF/WAVEfmt CDDA		T'ai Fu (MagDemo16: TAIFU\3_10.WAV, 2x16bit 44100Hz)
RIFF/WAVEfmt CDDA		Psalm69 (beta) FRONT\FIRE.TRK

The 920h-byte sectors exclude the leading Sync mark and MM:SS:FF:Mode2 value.


```

Data/movie sectors look as so:
000h 4      Sub-Header (File, Channel, Submode OR 20h, Codinginfo)
004h 4      Copy of Sub-Header
008h 800h Data (2048 bytes)                ;<-- contains STR movie sectors
808h 4      EDC (zerofilled)
80Ch 114h ECC (zerofilled)
And XA-ADPCM sectors look as so:
000h 4      Sub-Header (File, Channel, Submode OR 64h, Codinginfo)
004h 4      Copy of Sub-Header
008h 900h Data (18*128 bytes)              ;\contains XA-ADPCM audio sectors
908h 14h Data (zerofilled)                 ;/
91Ch 4      EDC (zerofilled)

```

The RIFF/CDXAfmt has a standard RIFF header, followed by 930h-byte sectors (same format as when opening CDROM streaming files in Windows). The RIFF/WAVEfmt is just a standard .WAV file.

In case of the ZZ*.* files on retail discs, the developers did intentionally append some non-functional dummy STR files (instead of appending zerofilled 30Mbyte at end of disc).

CDROM File XYZ and Dummy/Null Files

In case of the Demo Discs, the developers did probably have high hopes to release a demo version with working streaming data, just to find out that Sony had screwed up the data format (or maybe they had only accidentally included streaming data, without actually using it in demo version). Confusingly, the corrupted files were released on several discs (magazine demos, and other demo releases).

The Rugrats demo has intact files in RUGRATS\CINEMAT and RUGRATS\XA folders, plus nonsense copies of that files in 920h-byte format in STREAMS folder.

Partially mis-mastered files

Legend of Dragoon (MagDemo34: LOD\XA\LODXA00.XA has FIRST SECTOR mis-mastered (it has TWO sub-headers

(01,00,48,00,01,00,48,00,01,01,64,04,01,01,64,04), the remaining sectors are looking okay).

Porsche Challenge (USA) (SRC\MENU\STREAM*.STR)

The subheader and data of the 1st sector are accidentally overwritten by some ASCII string:

```

000h 4      Subheader          01 44 2D 52          ".D-R"      ;\distorted
004h 4      Subheader copy    01 4D 20 47          ".M G"      ;/"CD-ROM G"
008h 299h Data ASCII         65 6E 65 72 61 ...    "enerator for Windows"...
2A1h 567h Data BS bitstream (but lacks BS header and start of bitstream)

```

The 2nd sector and up are containing intact STR headers (for the 2nd-Nth sector of 1st frame, but the whole 1st frame is unusable due to missing 1st sector; however, the following frames are intact).

13.18 CDROM File Video BS Compression Versions

STR/BS Version Summary, with popularity in percents (roughly)

Version	.STR movies	.BS pictures	
BS v2	60%	6%	Most games
BS v3	20%	4%	Some newer games
BS v1	15%	0.1%	Old games
BS ea	2%	- (?)	Electronic Arts titles
BS iki	0.5%	0.1%	Several games
BS fraquant	0.2%	0.1%	Rare (X-Files, Eagle One)
BS v0	0.1%	-	Rare (Serial Experiments Lain)
BS v2/v3.crypt	0.2%	-	Rare (Star Wars games)
BS iki.encrypted	0.1%	-	Rare (Panekit)
Wacvac MDEC	0.1%	-	Rare (Aconcagua)
Polygon Streams	0.x% (?)	-	Some titles
Raw MDEC	-	-	Was never used in files?
MPEG1	-	-	VCD Video CDs
None	?% (?)	90%	No videos or BS pictures

Most games can decrypt v1/v2/v3 videos (no matter which of the three versions they are actually using), newer games do occasionally use v3 for picture compression, but often stick with v2 for video streaming (perhaps because v3 does require slightly more CPU load; unknown if the higher CPU load has been an actual issue, and if it has been solved in the later (more optimized) decompressor versions) (unknown if there are other benefits like v2 having better DC quality or better compression in some cases?).

BS v0 (used by only one known game)

v0 used by Serial Experiments Lain

This game is apparently using a very old and very unoptimized decoder (although it was released in 1997, when most or all other games did already have decoders with v1/v2/v3 support).

The v0 decoder has different header, lacks End of Frame codes, and uses Huffman codes with different AC values than v1/v2/v3/iki.

BS v1 (used by older games, some of them also having v2 videos)

```
v1 used by Wipeout 2097 (MAKE.AV, XTRO*.AV)
v1 used by Viewpoint (MOVIES\*.STR) (oddly with [08h]=FirstFrame=0 and
    [1Ch]=Unspecified=Nonzero) (the game also has ".str" files in
    VIEW.DIR\streams, but that isn't MDEC/STR stuff)
v1 used by Ridge Racer Revolution (MOVIE\*.STR)
v1 used by Policenauts
v1 used by Final Fantasy VII (FF7)
v1? used by Tekken 2
v1/v2 used by Final Fantasy Tactics (OPEN*.STR)
v1/v2 used by Project Horned Owl (*.STR)
v1/v2 used by Gex (*.FMV)
(and probably more)
```

v1 and v2 can be decoded with the same decompressor. The only difference is that v1 was generated with an older compressor (which did accidentally store nonsense 22bit escape codes with run=N, level=0 in the bitstream; whereas one could as well use run+N+1 in the next code, or omit it completely if next code is EOB).

BS v2 (most games)

```
v2 used by Gex - Enter the Gecko (*.STR)
v2 used by Tomb Raider (FMV\*.FMV)
v2 used by Alone (STR*\*.STR)
v2 used by Kain (*.STR)
v2 used by Fear Effect (BOOT.SID, LOGO.SID, ABGA\ABGA.FLX)
v2 used by Parasite Eve 2 (INTERx.STR, and in .CDF's eg. stage1\folder501)
v2 used by Witch of Salzburg (MOVIE\*.STR)
v2 used by Breath of Fire III (LOGO\*.STR)
v2 used by Hear it Now (MOVIE\*.STR)
v2 used by Legend of Mana (MOVIE\*.STR)
v2 used by Misadventures of Tron Bonne (STR\*.STR)
v2 used by Rayman (VIDEO\*.STR)
v2 used by Resident Evil 1 (PSX\MOVIE\*.STR) ;\although v3 is
v2 used by Resident Evil 2 (PL0\ZMOVIE\*.STR, ZMOVIE\*.STR) ;/used in *.BSS
v2 used by Tokimeki Memorial 2 (VX*.STR)
v2 used by Spider-Man (CINEMAS\*.STR)
v2 used by Perfect Assassin (CDV\*.STR)
v2 used by Pandemonium 2 (*.STR)
v2 used by Die Hard Trilogy 2 (MOVIE\*.STR)
v2 used by Need for Speed 3 (MOVIES\*.STR) (oddly with [14h,18h]<>[20h,24h])
v2 used by Wild Arms (STR\*.STR)
v2 used by Wild Arms 2 (STR\*.STR)
v2 used by Frogger (*.STR)
v2 used by Gundam Battle Assault (XA\*.STR)
v2 used by Alundra (MOVIE\*.MOV)
v2 used by Spec Ops (file 95h,96h within BIGFILE.CAT)
v2 used by Crash Team Racing (file 1E1h..1F8h,1FAh within BIGFILE.BIG)
(and many more)
```

Same as v1, but without the compressor bug.

BS v3 (used by some newer games, some of them also having v2 videos)

```
v2/v3 used by Lemmings Oh No More Lemmings (ANIMS\*.STR)
v2/v3 used by Castlevania (*.STR)
v3 used by Heart of Darkness (CINE\*.STR, SETUP\*.STR)
v3 used by R-Types (MV\*.STR)
v3 used by Black Matrix (MOVIE\*.STR)
v3 used by Nightmare Creatures II (INTRO\*.STR, LEVEL*\*.STR)
(and many more)
```

Same as v2, but using Huffman compressed DC values.

BS ea (Electronic Arts)

Used by many EA Sports titles and several other titles from Electronic Arts:

```
Castrol Honda Superbike Racing
EA Sports Supercross 2000, 2001
Future Cop - L.A.P.D. (retail and MagDemol4: FCOPLAPD\*.WVE and *.FSV)
Hot Wheels - Turbo Racing
Jampack Vol. 2
Knockout Kings 99, 2000, 2001
Madden NFL 99, 2000, 2001, 2002, 2003, 2004, 2005 (eg. MADN00\FMVIDEO.DAT\*)
NASCAR 98, 99, 2000, 2001 (and 98 Collector's Edition, and 99 Legacy)
NASCAR Thunder 2002, 2003, 2004 and NASCAR Rumble
Nuclear Strike
Official U.S. PlayStation Magazine Demo Disc 39 (...XXX which game?)
PlayStation Underground Jampack - Winter 2000
Road Rash Jailbreak, and Road Rash 3D
Tiger Woods PGA Tour Golf, and Tiger Woods USA Tour 2001
```

Uses VLC0 and MDEC chunks (instead of STR headers), the MDEC chunks contain standard BS v2 data, but using custom MDEC values from VLC0 chunk.

BS fraquant

```
X-Files (Fox Interactive/Hyperbole Studios, 1999)
Eagle One: Harrier Attack (Infogrames/Glass Ghost, 2000)
Blue's Clues: Blue's Big Musical (Mattel/Viacom/TerraGlyph, 2000)
```

This replaces the 6bit quant value by a 16bit fixed-point quant value (done by manipulating the Quant Table instead of using QuantDC, apart from that extra feature it's internally using normal BS v1/v2/v3 decoding).

BS iki

```
iki: Gran Turismo 1 (STREAM.DAT) ;\with uncommon STR header
iki: Gran Turismo 2 (STREAM.DAT) ;/
iki: Hot Shots Golf 2 / Everybody's Golf 2 (MagDemo31: HSG2\MINGOL2X.BIN)
iki: Legend of Legaia (MagDemo20: LEGAIA\MOV\MV2.STR)
iki: Legend of Dragoon (STR\*.IKI)
iki: Omega Boost (MOVIE\*.IKI)
iki: Um Jammer Lammy (MagDemo24: UJL\*.IKI) (retail: *\*.IKI and CM\*.IK2)
iki: plus a dozen of japanese-only titles
```

This might have been used between v2 and v3, iki is using uncommon BS headers and LZ compressed Quant/DC values (whilst v3 is using Huffman compressed DC values).

Encrypted iki

```
Panekit - Infinitive Crafting Toy Case (first 13Mbyte in PANEKIT.STR)
```

Same as normal iki, with some SWAP/ADD/XOR-encrytion in first 20h-bytes.

Encrypted v2/v3

```
v3.xor used by Star Wars Masters of Teras Kasi (MagDemo03: MASTERS\*.STR)
v2.xor supported (but not actually used) by Star Wars Masters (MagDemo03)
v3.swap used by Star Wars Rebel Assault II (*.STR, *.SED, Stills)
v2.swap used by Star Wars Rebel Assault II (*.STR)
v3.swap used by BallBlazer Champions (*.STR)
```

Same as normal v2/v3 with simple XOR-encryption or SWAP-encryption.

Wacwac MDEC

```
Aconcagua (JP) (2000 Sony/WACWAC!) (STR_01_00.STR and STR_09_01.STR)
```

Similar to v3, but uses completely different Huffman codes than BS video.

Polygon Streaming (instead of MDEC picture streaming)

```
Ape Escape (DEMO\*.STR, STR\*.STR, and KKIIDDZZ.HED\STR\0006h and up)
Aconcagua (most STRs are Polygon Streams, except two are Wacwac MDEC streams)
Panekit - Infinitive Crafting Toy Case (last 150Mbyte in PANEKIT.STR)
```

Polygon streams contain vertices (for textures that are stored elsewhere). Usually needing only one sector per frame. This can be useful for animations that were recorded

from real actors. Drawbacks are more edgy graphics and lower color depth (although that may fit in with the game engine).

CDROM File Video Polygon Streaming

MPEG1 (on VCD Video CDs)

MPEG1 uses I/P/B-Frames, the I-Frames may reach similar compression as BS files. However, P-Frames and B-Frames do compress much better than BS files.

CDROM Video CDs (VCD)

MPEG1 isn't used in any PSX games, but VCDs can be viewed on SCPH-5903 consoles (or via software decoder in nocash PSX kernel clone).

Titles without movies

Most PSX titles do include movies, exceptions are some early launch titles and educational titles:

```
Ridge Racer 1 (1994)
Lightspan Online Connection CD
```

13.19 CDROM File Video BS Compression Headers

There are several different BS headers. The File ID/Version entries can be used to detect the correct type. The MDEC Size entry contains the size after Huffman decompression (ie. the half-decompressed size before passing the data to the MDEC decompression hardware) (usually divided by 4 and rounded up to 80h/4 bytes).

BS v1/v2/v3 header

```
000h 2    MDEC Size/4 (after huffman decompression) (rounded to 80h/4 bytes)
002h 2    File ID (3800h)
004h 2    Quantization step/factor (0000h..003Fh, for MDEC "DCT.bit10-15")
006h 2    Version (1, 2, or 3) (2 is most common)
008h ...  Huffman compressed data blocks (Cr,Cb,Y1,Y2,Y3,Y4, Cr,Cb,Y1,Y2..)
```

Encrypted v2/v3

Encryption is used in Star Wars games, there are two encryption schemes (XOR and SWAP).

XOR-encrypt: Star Wars Masters of Teras Kasi (MagDemo03: MASTERS*.STR):

```

000h 2  MDEC Size/4 (rounded to 80h/4 bytes) (unencrypted) ;\same as normal
002h 2  File ID (3800h) (unencrypted) ; BS v1/v2/v3
004h 2  Quant (0..3Fh) (unencrypted) ;/
006h 2  Version (in bit15, plus random in LSBs):
        00xxh..7FFFh for v2 (unknown if this could include values 0..3)
        8000h..FFFFh for v3 (bit14-0=random, varies in each frame)
008h .. Encrypted bitstream
        (each halfword XORed by BE67h for v2, or XORed by E67Bh for v3)
... (2) Zeropadding to 4-byte boundary (unencrypted)
... .. Zeropadding to end of sector (unencrypted)

```

The XOR values BE67h/E67Bh are hardcoded in the Star Wars Masters of Teras Kasi .EXE (same XOR values for both retail and demo version), unknown if any other games are also using that kind of encryption (and if yes, if they are using the same XOR values).

SWAP-encrypt: BallBlazer Champions, Star Wars Rebel Assault II (*.STR, *.SED):

```

000h 2  MDEC Size/4 (rounded to 80h/4 bytes) ;\same as normal
002h 2  File ID (3800h) ; BS v1/v2/v3
004h 2  Quant (0..3Fh) ;/
006h 2  Version (random 16bit, 00xxh..FFFFh) ;-no meaningful version info
008h 2  Bitstream 2nd halfword ;\to "decrypt" the file,
00Ah 2  Bitstream 1st halfword ;/these must be swapped
00Ch .. Bitstream 3rd halfword and up ;-in normal order

```

Whilst XORing or SWAPping the halfwords is simple, the more difficult part is distinguishing between SWAP-v2/v3 and XOR-v2/v3 encryption. This can be done as so:

```

if header[06h]<=0003h then assume unencrypted v0/v1/v2/v3
if header[06h]>=0004h then strip any trailing 0 bits, and check EndOfFrame..
if last 10bit = 0111111111 then assume SWAP.v2
if last 10bit = 1111111111 then assume SWAP.v3
otherwise assume XOR.v2/v3 (and use header[06h].bit15 to distinguish v2/v3)

```

BS iki Header

IKI videos have a custom .BS header, including some GT-ZIP compressed data:

```

000h 2  MDEC Size/4 (rounded to 80h/4 bytes) ;\same as normal
002h 2  File ID (3800h) ;/BS v1/v2/v3
004h 2  Bitmap Width in pixels ;instead of Quant
006h 2  Bitmap Height in pixels ;instead of Version
008h 2  Size of GT-ZIP compressed data (plus 2-byte alignment padding)
00Ah .. GT-ZIP compressed DC/Quant values (plus 2-byte alignment padding)
... .. Huffman compressed AC data blocks (Cr,Cb,Y1,Y2,Y3,Y4, Cr,Cb,Y1,Y2..)

```

The number of blocks is $\text{NumBlocks} = (\text{Width} + 15) / 16 * (\text{height} + 15) / 16 * 6$. The size of the decompressed GT-ZIP data is $\text{NumBlocks} * 2$.

Encrypted iki

The first 20h byte of the iki header & data are encrypted. Among others, the ID 3800h is inverted (=C7FFh). To decrypt them:

```
[buf+00h]=[buf+00h] XOR FFFFFFFFh
[buf+04h] <--> [buf+08h]           ;exchange 2x32bit
[buf+0Ch] <--> [buf+0Eh]           ;exchange 2x16bit
[buf+10h]=[buf+10h]+FFFF6F7Bh
[buf+14h]=[buf+14h]+69140000h
[buf+18h]=[buf+18h]+FFFF7761h
[buf+1Ch]=[buf+1Ch]+6B040000h
```

Note: The .STR header's StHeadM/StHeadV fields contain a copy of the decrypted values. The PANEKIT.STR file is 170Mbyte tall, but only the first 13Mbyte contain movie data... the rest is unknown stuff... often with zeroes followed by 7B,44,F0,29,E0,28 unknown what for...?

BS fraquant

```
X-Files, GRAPHICS\*.STR,*.BIN, LOGOS\*.STR,*.BS
Eagle One: Harrier Attack (\*.STR, DATA*\*.STR) (leading zerofilled sectors)
Blue's Clues: Blue's Big Musical (*.STR) (has one leading zerofilled sector)
```

This has a normal BS v1/v2/v3 header, with special quant entry:

```
004h 2      Quant (0001h..0003h, or fixed-point 8000h..9xxxh)
```

The decoder is using the default_quant_table (02h,10h,10h,13h,...,53h) multiplied with a fixed point number:

```
quant=BsHeader[04h]    ;get fractional quant value
BsHeader[04h]=0001h    ;force quant=1 (for use in BS v1/v2/v3 decoder)
if quant<8000h then quant=quant*200h else quant=quant AND 7FFFh
quant[0]=default_quant_table[0]
for i=1 to 3Fh,
    x=(default_quant_table[i]*quant)/200h
    if x=00000000h then quant[i]=01h else quant[i]=(x AND FFh)
next i
use MDEC(2) command to apply quant[0..3Fh] to both Luma and Chroma tables
use normal BS v1/v2/v3 decoder to decompress the bitmap
```


BsHeader[04h] should be 0001h..0003h, or 8000h..862Bh (values outside that range would overflow the 8bit quant table entries). Values 0001h..0003h should give same results as for normal BS decoding, so only values 8000h and up do need special decoding.

Caution: Despite of the overflows, quant>862Bh is used (eg. X-Files GRAPHICS\GRAPHICS.BIN has quant=88C4h, Blue's Big Musical has quant=93E9h; those images do look okay, so the compressor seems to have recursed the overflows; or the overflow affects only a few pixels), however, very large with LSBs all zero (eg. 9000h) can cause 8bit table entries to become 00h (due to ANDing the result with FFh).

Note: X-Files LOGOS\POP*.STR have quant=8001h (=near zero), that files are only 60Kbyte and seem to be all black.

Note: The movie engine uses COP2 GPF opcodes to calculate quant values.

v0 Header (in STR files)

```
000h 1  Quant for Y1,Y2,Y3,Y4  (00h..3Fh)
001h 1  Quant for Cr,Cb        (00h..3Fh)
002h 2  File ID (3800h) (or Frame Number in ENDROLL1.STR on Disc 2)
004h 2  MDEC Size/2 (!), and without padding (!) (unlike v1/v2/v3/iki)
006h 2  BS Version (0) (actually MSBs of above Size, but it's always 0)
008h .. Huffman Bitstream, first bit in bit7 of first byte
```

v0 Header (in LAPKS.BIN chunks)

LAPKS.BIN contains several chunks, each chunk contains an animation sequence with picture frame(s), each frame starts with following header:

```
000h 2  Bitmap Width in pixels      ;\cropped to non-black screen area,
002h 2  Bitmap Height in pixels    ;/size can vary within the sequence
004h 2  Quant for Y1,Y2,Y3,Y4  (0000h..003Fh)
006h 2  Quant for Cr,Cb        (0000h..003Fh)
008h 4  Size of compressed BS Bitstream plus 4 ;Transparency at [008h]+0Ch
00Ch 2  Size/2 of MDEC data (after huffman decompression, without padding)
00Eh 2  BS Version (0) (actually MSBs of above Size, but it's always 0)
010h .. BS Bitstream with DC and AC values (Huffman compressed MDEC data)
... 4   Transparency Mask Decompressed Size (Width*Height*2/8) (=2bpp)
... .. Transparency Mask LZSS-compressed data
```

For decompressing the transparency mask:

[CDROM File Compression LZSS \(Serial Experiments Lain\)](#)

The Transparency Mask is stored as scanlines (not as macroblocks), the upper/left pixel is in bit7-6 of first byte, the 2bit alpha values are ranging from 0=Transparent to 3=Solid.

BS ea Headers (Electronic Arts)

EA videos are chunk based (instead of using 20h-byte .STR headers).

CDROM File Video Streaming Chunk-based formats

VLC0 Chunk: Custom MDEC values (to be assigned to normal BS v2 Huffman codes).

MDEC Chunks: Width/Height and BS v2 data (using MDEC values from VLC0 chunk).

Raw MDEC

There aren't any known pictures or movies in raw MDEC format. However, the Huffman decompression functions do usually output raw data in this format:

```
000h 2   MDEC Size/4 (after huffman decompression) (rounded to 80h/4 bytes)
002h 2   File ID (3800h)
004h ..  MDEC data (16bit DC/AC/EOB codes)
... ..  Padding (FE00h-filled to 80h-byte DMA transfer block size boundary)
```

The first 4 bytes are the MDEC(1) command, the "ID" is always 3800h (equivalent to selecting 16bpp output; for 24bpp this must be changed to 3000h before passing the command to the MDEC hardware). The remaining bytes are MDEC data (padded to 80h-byte boundary).

Macroblock Decoder (MDEC)

13.20 CDROM File Video BS Compression DC Values

DC v0

```
nnnnnnnnnn      DC Value (signed 10bit, -200h..+1FFh)
```

This is similar as v1/v2, except there is no End code for End of Frame, and the .BS header contains two separate quant values (for Cr/Cb and Y1-Y4).

```
If output_size=NumberOfMdecCodes*2 then EndOfFrame
If BlockIsCrCb then QuantDC=DC+QuantC*400h else QuantDC=DC+QuantY*400h
```

DC v1/v2/ea

```
nnnnnnnnnn      DC Value (signed 10bit, -200h..+1FEh)
0111111111      End of Frame (+1FFh, that, in place of Cr)
```

This is similar as v0, except there is only one Quant value for all blocks, and the header lacks info about the exact decompressed size, instead, compression end is indicated by a newly added end code:

```
If DC=+1FFh then EndOfFrame
QuantDC=DC+Quant*400h
```

DC v3

Similar as v1/v2, but DC values (and End code) are now Huffman compressed offsets relative to old DC, with different Huffman codes for Cr/Cb and Y1-Y4:

For Cr/Cb	For Y1..Y4	Offset (added to old DC of Y/Cr/Cb block)
00	100	+(00h) ; \
01s	00s	-(01h)*4 , +(01h)*4 ;
10sn	01sn	-(03h..02h)*4, +(02h..03h)*4 ; required
110snn	101snn	-(07h..04h)*4, +(04h..07h)*4 ; codes
1110snnn	110snnn	-(0Fh..08h)*4, +(08h..0Fh)*4 ; for 10bit
11110snnnn	1110snnnn	-(1Fh..10h)*4, +(10h..1Fh)*4 ; range
111110snnnnn	11110snnnnn	-(3Fh..20h)*4, +(20h..3Fh)*4 ;
1111110snnnnnn	111110snnnnnn	-(7Fh..40h)*4, +(40h..7Fh)*4 ; /
11111110snnnnnnn	1111110snnnnnnn	-(FFh..80h)*4, +(80h..FFh)*4 ; -11bit (!)
-	11111110	Unused ; \
111111110	111111110	Unused ; unused
1111111110	1111111110	Unused ; /
1111111111	1111111111	End of Frame ; -end code

Note: the "snnn" bits are indexing the values in right column, with s=0 for negative values, and s=1 for positive values.

The decoding works as so (with oldDcXxx=0 for first macroblock):

```
If bits=1111111111 then EndOfFrame
If BlockIsCr then DC=DecodeHuffman(HuffmanCodesCbCr)+oldDcCr, oldDcCr=DC
If BlockIsCb then DC=DecodeHuffman(HuffmanCodesCbCr)+oldDcCb, oldDcCb=DC
If BlockIsY1234 then DC=DecodeHuffman(HuffmanCodesY1234)+oldDcY, oldDcY=DC
If older_version AND DC>=0 then QuantDC=Quant*400h or (DC) ; \requires
If older_version AND DC<0 then QuantDC=Quant*400h or (DC+400h) ; /11bit
If newer_version then QuantDC=Quant*400h+(DC AND 3FFh) ; -wrap 10bit
```

Note: The offsets do cover signed 11bit range -3FCh..+3FCh. Older v3 decoders did require 11bit offsets (eg. add +3FCh to change DC from -200h to +1FCh). Newer v3 decoders can wrap within 10bit (eg. add -4 to wrap DC from -200h to +1FCh).

DC iki

The DC values (including Quant values for each block) are separately stored as GT-ZIP compressed data in the IKI .BS header.

CDROM File Compression GT-ZIP (Gran Turismo 1 and 2)

Calculate NumBlocks=(Width+15)/16*(height+15)/16*6, decompress the DC values (until DecompressedSize=NumBlocks*2). During Huffman decompression, read the DC values from the decompressed DC buffer (instead of from the Huffman bitstream):

```
If BlockNo>=NumBlocks then EndOfFrame
QuantDC = DCbuf[BlockNo]*100h + DCbuf[BlockNo+NumBlocks]
```

As shown above, the Hi- and Lo-bytes are stored in separate halves of the DC buffer (which may gain better compression).

13.21 CDROM File Video BS Compression AC Values

Below shows the huffman codes and corresponding 16bit MDEC values; the "xx" bits contain an index in the list of 16bit MDEC values, the "s" bit means to negate the AC level (in lower 10bit of the 16bit MDEC value) when s=1.

Huffman codes for AC values BS v1/v2/v3/iki

10	FE00h	;End of Block, EOB
11s	0001h	
011s	0401h	
010xs	0002h, 0801h	
0011xs	1001h, 0C01h	
00101s	0003h	
00100xxxs	3401h, 0006h, 3001h, 2C01h, 0C02h, 0403h, 0005h, 2801h	
0001xxs	1C01h, 1801h, 0402h, 1401h	
00001xxs	0802h, 2401h, 0004h, 2001h	
000001xxxxxxxxxxxxxxxx	0000h..FFFFh	;Escape code for raw 16bit values
000001xxxxxx0000000000	0000h..FC00h	;Escape nonsense level=0 (used in v1)
0000001xxxs	4001h, 1402h, 0007h, 0803h, 0404h, 3C01h, 3801h, 1002h	
00000001xxxs	000Bh, 2002h, 1003h, 000Ah, 0804h, 1C02h, 5401h, 5001h,	
	0009h, 4C01h, 4801h, 0405h, 0C03h, 0008h, 1802h, 4401h	
000000001xxxs	2802h, 2402h, 1403h, 0C04h, 0805h, 0407h, 0406h, 000Fh,	
	000Eh, 000Dh, 000Ch, 6801h, 6401h, 6001h, 5C01h, 5801h	
0000000001xxxs	001Fh, 001Eh, 001Dh, 001Ch, 001Bh, 001Ah, 0019h, 0018h,	
	0017h, 0016h, 0015h, 0014h, 0013h, 0012h, 0011h, 0010h	
00000000001xxxs	0028h, 0027h, 0026h, 0025h, 0024h, 0023h, 0022h, 0021h,	
	0020h, 040Eh, 040Dh, 040Ch, 040Bh, 040Ah, 0409h, 0408h	
000000000001xxxs	0412h, 0411h, 0410h, 040Fh, 1803h, 4002h, 3C02h, 3802h,	

000000000000	3402h, 3002h, 2C02h, 7C01h, 7801h, 7401h, 7001h, 6C01h
	Unused

Huffman codes for AC values BS v0 (Serial Experiments Lain)

10	FE00h	;End of Block, EOB
11s	0001h	
011s	0002h	
010xs	0401h, 0003h	
0011xs	0801h, 0005h	
00101s	0004h	
00100xxxs	000Ah, 000Bh, 0403h, 1801h, 000Ch, 000Dh, 1C01h, 000Eh	
0001xxs	0006h, 0C01h, 0402h, 0007h	
00001xxs	0008h, 1001h, 0009h, 1401h	
000001xxxxxx0xxxxxxx	0000h..FC00h+(+001h..+07Fh AND 3FFh)	; \
000001xxxxxx000000001xxxxxxx	0000h..FC00h+(+080h..+0FFh AND 3FFh)	; Escape
000001xxxxxx000000000xxxxxxx	Unused	; codes
000001xxxxxx1xxxxxxx	0000h..FC00h+(-080h..-001h AND 3FFh)	;
000001xxxxxx100000000xxxxxxx	0000h..FC00h+(-100h..-081h AND 3FFh)	;
000001xxxxxx100000001xxxxxxx	Unused	;/
0000001xxxs	000Fh, 0802h, 2001h, 0404h, 0010h, 0011h, 2401h, 0012h	
00000001xxxs	0013h, 0405h, 0014h, 2801h, 0015h, 0C02h, 3001h, 0017h,	
	0016h, 2C01h, 0018h, 001Ch, 0019h, 0406h, 0803h, 001Bh	
000000001xxxs	001Ah, 3401h, 001Dh, 0407h, 1002h, 001Fh, 001Eh, 3801h,	
	0020h, 0021h, 0408h, 0023h, 0022h, 1402h, 0024h, 0025h	
0000000001xxxs	0804h, 0409h, 0418h, 0026h, 3C01h, 0027h, 0C03h, 1C03h,	
	0028h, 0029h, 002Ah, 002Bh, 040Ah, 002Ch, 1802h, 002Dh	
00000000001xxxs	002Fh, 002Eh, 4001h, 0805h, 0030h, 040Bh, 0031h, 0033h,	
	0032h, 1C02h, 0034h, 1003h, 0035h, 4401h, 040Ch, 0037h	
000000000001xxxs	0036h, 0038h, 0039h, 5401h, 003Ah, 0C04h, 040Dh, 5C01h,	
	2002h, 003Bh, 0806h, 4C01h, 003Ch, 2402h, 6001h, 4801h	
000000000000	Unused	

Uses different 16bit MDEC values, and the Escape code is different: 8bit levels are 2bit shorter than v1/v2/v3, but 9bit levels are much longer, and 10bit levels are not supported at all (those v0 Escape codes are described in Sony's File Format documented; albeit accidentally because the doc was actually trying to describe v2/v3).

Huffman codes for AC values BS ea (Electronic Arts)

This is using custom MDEC values from VLC0 chunk, and assigns them to the standard Huffman codes. There are two special MDEC values:

FE00h	End of Block (EOB)
7C1Fh	Escape code (huffman code will be followed by v2-style 16bit value)

VLC0 chunk entries 00h..DFh are mapped to the following Huffman codes:

10	00
11x	01,02
011x	03,04
010xx	05,06,07,08
0011xx	0D,0E,0B,0C
00101x	09,0A
00100xxxx	2E,2F,22,23,2C,2D,2A,2B,26,27,24,25,20,21,28,29
0001xxx	15,16,13,14,0F,10,11,12
00001xxx	1A,1B,1E,1F,18,19,1C,1D
000001	17h
0000001xxxx	3E,3F,38,39,30,31,34,35,32,33,3C,3D,3A,3B,36,37
00000001xxxxx	46,47,54,55,4E,4F,44,45,4A,4B,52,53,5E,5F,5C,5D, 42,43,5A,5B,58,59,48,49,4C,4D,40,41,50,51,56,57
000000001xxxxxx	74,75,72,73,70,71,6E,6F,6C,6D,6A,6B,68,69,66,67, 64,65,62,63,60,61,7E,7F,7C,7D,7A,7B,78,79,76,77
0000000001xxxxxx	9E,9F,9C,9D,9A,9B,98,99,96,97,94,95,92,93,90,91, 8E,8F,8C,8D,8A,8B,88,89,86,87,84,85,82,83,80,81
00000000001xxxxxx	B0,B1,AE,AF,AC,AD,AA,AB,A8,A9,A6,A7,A4,A5,A2,A3, A0,A1,BE,BF,BC,BD,BA,BB,B8,B9,B6,B7,B4,B5,B2,B3
000000000001xxxxxx	C6,C7,C4,C5,C2,C3,C0,C1,C8,C9,D4,D5,D2,D3,D0,D1, CE,CF,CC,CD,CA,CB,DE,DF,DC,DD,DA,DB,D8,D9,D6,D7
000000000000	Unused

All codes can be freely assigned (Escape and EOB don't need to be at 10 and 000001, and the last huffman bit doesn't have to serve as sign bit).

Notes

All BS versions are using the same Huffman codes (the different BS versions do just assign different 16bit MDEC codes to them).

The huffman codes can be neatly decoded by "counting leading zeroes" (without needing bitwise node-by-node processing; this is done in IKI video decoders via GTE registers LZCS and LZCR). Sony's normal v2/v3 decoders are using a yet faster method: A large table to interpret the next 13bit of the bitstream, the table lookup can decode up to 3 huffman codes at once (if the 13bit contain several small huffman codes).

13.22 CDROM File Video BS Picture Files

BS Picture Files

A couple of games are storing single pictures in .BS files:

```
Alice in Cyberland (ALICE.PAC\*.BS)
BallBlazer Champions (BBX_EXTR.DAT\Pics\*) (SWAP-encrypted)
Bugriders: The Race of Kings (*.BS and STILL\*\*.BS\*)
```

```

Die Hard Trilogy 2 (DATA\*.DHB, DATA\DH*\L*\*.DHB, MOVIE\*.DHB)
Dino Crisis 2 (PSX\DATA\ST*.DBS\*)
Duke Nukem (MagDemo12: DN_TTK\*)
Final Fantasy VII (FF7) (MOVIE\FSHIP2*.BIN\*) (BS v1)
Gran Turismo 1 (retail TITLE.DAT\* and MagDemo10/15) (in BS iki format)
Jet Moto 2 (MagDemo03: JETMOTO2\*)
Mary-Kate and Ashley Crush Course (MagDemo52: CRUSH\SCRN\*.BS)
Mat Hoffman's Pro BMX (MagDemo48: MHPB\STILLS.BIN\*) (with width/height info)
NFL Gameday '99 (MagDemo17: GAMEDAY\FE\GD98DATA.DAT)
Official U.S. PlayStation Magazine Demo Disc 01-02 (MENU\DATA\*.BSS)
Official U.S. PlayStation Magazine Demo Disc 03-54 (MENU.FF\*)
Parasite Eve 2 (INIT.BS, and within .HED/.CDF archives)
Resident Evil 1 (PSX\STAGE*\*.BSS, headerless archive, 8000h-byte align)
Resident Evil 2 (COMMON\BSS\*.BSS, headerless archive, 10000h-byte align)
Rugrats (MagDemo19: RUGRATS\*)
Rugrats Studio Tour (MagDemo32: RUGRATS\DATA\RAW\*.BS)
Starwars Demolition (MagDemo39+MagDemo41: STARWARS\SHELL\*.BS+.TBL\*)
Star Wars Rebel Assault 2 (RESOURCE.000\Stills\*) (SWAP-encrypted)
Ultimate Fighting Championship (MagDemo38: UFC\CU00.RBB\390h..3E2h)
Vigilante 8 (MagDemo09: EXAMPLE\*)
Witch of Salzburg (PICT\PIC*\*.BS and DOT1 archives *.BSS, *.DAT, *.BIN)
X-Files (LOGOS\*.BS and GRAPHICS\GRAPHICS.BIN and GRAPHICS\PACKEDBS.BIN\*)
You Don't Know Jack 2 (MagDemo41: YDKJV2\RES\UI\*.BS)

```

Note: Those .BS files are usually hidden in custom file archives.

BS Picture Resolution

Movies have Width/Height entries (in the .STR header). Raw .BS picture files don't have any such information. However, there are ways to guess the correct resolution:

```

For BS iki format, use resolution from iki header (eg. Gran Turismo 1)
For MHPB\STILLS.BIN, there's width/height in chunk headers
Count the number of blocks (EOB codes) during Huffman decompression
Divide that number by 6 to get the number of Macroblocks
Search matches for Height=NumBlocks/Width with Width>=Height and Remainder=0
If Height=300..400, assume double H-resolution, repeat with Width/2>=Height
And/or use a list of known common resolutions (see below examples)
Search arrangements with many similar colors on adjacent macroblocks

```

Common resolutions are:

Blocks	Pixels	Example
F0h	256x240	any?
12Ch	320x240	Resident Evil 2 (COMMON\BSS*.BSS)
1E0h	512x240	Demo Disc 03-54 (MENU.FF*), Duke Nukem (MagDemo12)
1E0h	640x192	Less common than above (but used by Witch of Salzburg)
4B0h	640x480	Vigilante 8 (MagDemo09), Jet Moto 2 (MagDemo03)
var	random	Witch of Salzburg has various random resolutions
iki	ikihdr	Gran Turismo 1 has A0hxA0h and odd size (!) E8hx28h
?	?	Final Fantasy VII (FF7)

```

?      ?      Ultimate Fighting Championship (UFC\CU00.RBB\3B7h..3E2h)
118h   320x224 Alice in Cyberland (most files; or two such as panorama)
230h   ?      Alice in Cyberland (AD_115.BS and AD_123A.BS)

```

Some other possible, but rather unlikely results would be:

```

C8h    320x160 Unlikely for pictures (but used for STR videos, eg. Alone)
F0h    320x192 Unlikely for pictures (but used for STR videos, eg. Wipeout)
1E0h   384x320 Very unlikely to see that vertical resolution on PSX

```

Witch of Salzburg has many small .BS files with various uncommon resolutions (most of them are bundled with 16-byte .TXT files with resolution info).

Extended BS with Width/Height

Starwars Demolition (MagDemo39:

STARWARS\SHELL\DEMOLOGO.BS+RESOURCE.TBL\)

Starwars Demolition (MagDemo41:

STARWARS\SHELL\DEMOLOGO.BS+RESOURCE.TBL\)

```

000h 2   Width  (280h)          ;\extra header
002h 2   Height (1E0h)         ;/
004h 2   MDEC Size/4 (after huffman decompression) (rounded to 80h/4 bytes)
006h 2   File ID (3800h)
008h 2   Quantization step/factor (0000h..003Fh, for MDEC "DCT.bit10-15")
00Ah 2   Version (1, 2, or 3) (2 is most common)
00Ch ... Huffman compressed data blocks (Cr,Cb,Y1,Y2,Y3,Y4, Cr,Cb,Y1,Y2..)

```

13.23 CDROM File Video Wacvac MDEC Streams

Wacvac uses different Huffman codes than BS videos, the decoder has some promising ideas that might yield slightly better compression than BS v3. However, it is used by only one known game:

```
Aconcagua (JP) (2000 Sony/WACWAC!)
```

And even that game is only using it in two movies, and the movies are barely making any use of it: The 20Mbyte intro scene is a picture slide show (where the camera is zooming across twelve black and white images), the 50Mbyte ending scene is providing a more cinematic experience (the camera is scrolling through a text file with developer staff names).

Wacvac MDEC Stream Sectors

```

000h 2   STR ID      (0160h)
002h 2   STR Type WACWAC Tables (0002h=IntroTableSet, 0003h=EndingTableSet)
004h 2   Sector number within current Frame (0000h..num-1)
006h 2   Number of Sectors in this Frame
008h 4   Frame number (6 or 11 and up, because 1st some frames are Polygons)
00Ch 4   Frame Size in bytes
010h 2   Bitmap Width  (always 140h)  ;\always 320x208 (in fact, the
012h 2   Bitmap Height (always 0D0h)  ;/decoder is hardcoded as so)
014h 4   Quant (0..3Fh) (same for all sectors within the frame)
018h 8   Zerofilled
020h 7E0h Raw Bitstream data (without Quant or BS header) (garbage padded)

```

Aconcagua has dozens of STR files with Polygon Streams. MDEC Streams are found only in two STR files for Intro and Ending scenes:

Intro=Disc1:\ST01_01\STR_01_00.STR	Ending=Disc2:\ST09_01\STR_09_01.STR
Leading zeroes (150 sectors)	Leading zeroes (150 sectors)
Frame 0001h..0005h Polygon Frames	Frame 0001h..000Ah Polygon Frames
Frame 0006h..0545h MDEC Frames 20MB	Frame 000Bh..0D79h MDEC Frames 50MB
Frame 0546h..1874h Polygon Frames 48MB	

Audio is normal XA-ADPCM, with the first audio sector occurring before 1st frame (after the leading zeropadded 150 sectors).

Wacvac Huffman Bitstreams

Wacvac uses little-endian bitstreams (starting with low bit in bit0 of first byte). To decode the separate blocks in the bitstream:

```

Read Huffman code for DC, and output Quant*400h+(DC AND 3FFh)
Read Huffman code for Size, aka num1,num2,num3 values for below reads
Repeat num1 times: Read Huffman code for AC1, and output AC
Repeat num2 times: Read Huffman code for AC2, and output AC
Repeat num3 times: Read Huffman code for AC3, and output AC
Output EOB (end of block)

```

The header/data lacks info about MDEC size after Huffman decompression, the worst case size for 320x208pix would be:

```
14h*0Dh*6*41h*2+Align(80h)+Header(4) = 31880h+4 bytes
```

Note: The bitstream consists of separate 16x208pix slices (set DC for Cr,Cb,Y to zero at begin of each slice, and skip padding to 32bit-boundary at end of each slice).

Wacvac Huffman Table Sets

Aconcagua has two table sets, stored in PROGRAM.BIN (in compressed form, appearing as so: FF,90,16,2E,06,20,03,D6,etc). While watching the intro movie, the uncompressed sets can be found at these RAM locations:

```
80112AF8h (1690h bytes) ;Table Set for Intro Scene
80114188h (1B68h bytes) ;Table Set for Ending Scene
```

Each Table Set has a 38h-byte header, followed by five tables:

```
000h 4    Table Set size (1690h or 1B68h)
004h 4    Table Set exploded size (when allocating 16bit/DC, 32bit/Size/AC)
008h 2    Size Table max Huffman size in bits (0Ah or 09h) ;\Size
00Ah 2    Size Table number of entries (40h) ;/
00Ch 2    DC Table max Huffman size in bits (0Bh) ;\
00Eh 2    DC Table number of entries (100h) ; DC
010h 2    DC Huffman code Escape 10bit (non-relative 10bit DC value) ;
012h 2    DC Huffman size Escape 10bit (3 or 6, escape prefix size) ;/
014h 2    AC1 Table max Huffman size in bits (0Eh or 0Bh) ;\
016h 2    AC1 Table number of entries (0DAh or 100h) ;
018h 2    AC1 Huffman code Escape 7bit (run=0bit, level=signed7bit) ; AC1
01Ah 2    AC1 Huffman code Escape 16bit (run=6bit, level=10bit) ;
01Ch 2    AC1 Huffman size Escape 7bit (9 or 7, escape prefix size) ;
01Eh 2    AC1 Huffman size Escape 16bit (9 or 7, escape prefix size) ;/
020h 2    AC2 Table max Huffman size in bits (0Eh) ;\
022h 2    AC2 Table number of entries (AAh or F4h) ;
024h 2    AC2 Huffman code Escape 8bit (run=3bit, level=signed5bit) ; AC2
026h 2    AC2 Huffman code Escape 16bit (run=6bit, level=10bit) ;
028h 2    AC2 Huffman size Escape 8bit (10 or 9, escape prefix size) ;
02Ah 2    AC2 Huffman size Escape 16bit (10 or 9, escape prefix size) ;/
02Ch 2    AC3 Table max Huffman size in bits (0Eh) ;\
02Eh 2    AC3 Table number of entries (87h or B2h) ;
030h 2    AC3 Huffman code Escape 8bit (run=4bit, level=signed4bit) ; AC3
032h 2    AC3 Huffman code Escape 16bit (run=6bit, level=10bit) ;
034h 2    AC3 Huffman size Escape 8bit (10 or 9, escape prefix size) ;
036h 2    AC3 Huffman size Escape 16bit (10 or 9, escape prefix size) ;/
038h ..   Size Table (64bit per entry) ;\
... ..   DC Table (32bit per entry) ;
... ..   AC1 Table (64bit per entry) ; Tables
... ..   AC2 Table (64bit per entry) ;
... ..   AC3 Table (64bit per entry) ;/
```

Size Table entries (64bit):

```
0-1      Zero
2-31     Huffman code (10bit max)
32-39    Number of AC1 codes in this block ;\implies End of Block (EOB)
40-47    Number of AC2 codes in this block ; after those AC codes
```

```

48-55  Number of AC3 codes in this block  ;/
56-63  Huffman size (1..10 bits)

```

DC Table entries (32bit):

```

0-9    Relative DC Value (relative to old DC from memorized Cr,Cb,Y)
10-15  Huffman size (1..11 bits)
16-31  Huffman code (11bit max)

```

Notes: For the relative DC's, the decoder does memorize DC for Cr,Cb,Y upon decoding Cr,Cb,Y1,Y3 (but does NOT memorize DC when decoding Y2,Y4).

Initial DC for Cr,Cb,Y is zero at begin of each 16x208pix slice.

Obscurities: The decoder does accidentally use bit10 to sign-expand the DC value in bit0-9 (but does mask-off those bugged sign bits thereafter), and the decoder does uselessly memorize Y1 and Y3 separately (but uses only the most recently memorized value).

AC1/AC2/AC3 Table entries (64bit):

```

0-1    Zero
2-31   Huffman code (14bit max)
32-47  MDEC code (6bit run, and 10bit AC level)
48-63  Huffman size (1..14 bits)

```

The Escape codes are stored in the 38h-byte Table Set header (instead of in the tables), the init function uses that info for patching escape-related opcodes in the decoder function (that would allow to omit table lookups upon escape codes; the decoder doesn't actually omit such lookups though).

To simplify things, one could store the escape codes in the tables (eg. using special MDEC values like FC00h+35h for run=3bit, level=signed5bit).

13.24 CDROM File Video Polygon Streaming

Ape Escape - Polygon Streaming

Used by Ape Escape (Sony 1999) (DEMO\.*STR* and some *STR*\.*STR* files and KKIIDDZZ.HED\STR\0006h and up).

The files start with zerofilled sectors (without STR headers), followed by sectors with STR headers with [00h]=0160h, [02h]=8001h (same values as for MDEC), but with [10h..1Fh]=zero (without resolution/header info). And the data at [20h] starts with something like 14h,00h,03h,FFh,2Ah,02h,00h,00h.

That data seems to consist of polygon coordinates/attributes that are rendered as movie frames. The texture seems to be stored elsewhere (maybe in the .ALL files that are bundled with some .STR files).

Panekit - Polygon Streaming

Panekit STR seems to use Polygon Streaming (except 1st some Megabytes are MDEC).

Aconcagua - Polygon Streaming

Aconcagua STR does use Polygon Streaming (except first+last movie are MDEC).

Cyberia (1996) (TF\STR*.STR)

Cyberia is using Software-rendering for both movies and in-game graphics. That is, PSX hardware features like MDEC, GTE, and GPU-Polygons are left all unused, and the GPU is barely used for transferring data from CPU to VRAM.

The STR header for software-rendered movie frames looks as so:

```
000h 2    STR ID    (0160h)
002h 2    STR Type (0002h=Custom, Software rendering)
004h 2    Sector number within current Frame (0..num-1)
006h 2    Number of Sectors in this Frame    (varies)
008h 4    Frame Number (1=First)
00Ch 4    Frame Size in Bytes/4 (note: first frame in MAP*.STR is quite big)
010h 2    Rendering Width  (0140h)
012h 2    Rendering Height (00C0h)
014h 0Ch  Unknown (zerofilled or random garbage)
020h 7E0h Custom data for software rendering
```

Note: First sector of First frame does usually have byte[22h]=88h (except FINMUS.STR). The Custom data part is often have garbage padding (such like ASCII strings with "c2str" command line tool usage instructions).

Croc 1 (CUTS*.AN2)

Probably cut-scenes with polygon animations. The files seem to contain 2300h-byte data frames (plus XA-ADPCM sectors inserted here and there).

```
000h 4    Number of remaining frames
... 22FCh Unknown data (zeropadded if smaller)
```

```
_____ Unknown Streaming Data (Polygons or whatever) _____
```

Custom STR - 3D Baseball (BIGFILE.FOO)

This is used for several files in 3D Baseball (BIGFILE.FOO):

```
BIGFILE.FOO\0151h\0005h,0009h,000Fh,0017h,001Bh, 02E5h,02E9h,...,0344h,0348h
BIGFILE.FOO\0152h\0186h,018Ch,0192h,0198h)
BIGFILE.FOO\0153h\029Ah,02A0h,02A6h,02ACh)
```

The files contain some kind of custom streaming data, with custom STR header, and data containing increasing/decreasing bytes... maybe non-audio waveforms?

```
000h 2    STR ID    (0160h)
002h 2    STR Type (0001h=Custom)
004h 2    Sector number within current Frame (always 0)
006h 2    Number of Sectors in this Frame      (always 1)
008h 4    Frame Number (1=First)
00Ch 4    Frame Size (6FAh or 77Ah, sometimes 17Ah or 1FAh or 20Ah)
010h 2    Unknown (280h, or sometimes 300h or 340h)
012h 2    Frame Time (0=First, increases with step [19h], usually +5 or +7)
014h 2    Unknown (280h, or sometimes 300h or 3C0h, or 0)
016h 1    Frame Time (same as [012h] AND FFh)
017h 1    Unknown (0 or 1)
018h 1    Unknown (40h, or 80h, or C0h)
019h 1    Duration? (5 or 7, or sometimes less, step for Frame Time)
01Ah 1    Unknown (3, or less in last some frames)
01Bh 5    Zerofilled
020h 7E0h Data (increasing/decreasing bytes... maybe non-audio waveforms?)
```

Army Men Air Attack 2 (MagDemo40: AMAA2*.PMB)

```
000h 2    STR ID    (0160h)
002h 2    STR Type (0000h=Custom)
004h 2    Sector number within current Frame (0..2)
006h 2    Number of Sectors in this Frame      (always 4) (3xSTR + 1xADPCM)
008h 4    Frame Number (1=First)
00Ch 4    Frame Size? (800h, despite of having 3 sectors with 7E0h each?)
010h 2    Unknown (00h or 01h)
012h 2    Unknown (A3h or ABh ... 6Ch or 7Bh ... or 43h or 49h)
014h 2    Sector number within current Frame (0..2) (same as [004h])
016h 0Ah  Zerofilled
020h 7E0h Data (polygon streaming or so?)
```

Note: The .PMB file is bundled with a .PMH file, which might contain header info?

Bits Laboratory games (Charumera, and True Love Story series)

```
Charumera          ENDING.XA      (with dummy/zero data)
True Love Story    TLS\MULTI.XA   (with nonzero data)
True Love Story 2  TLS2\ENDING.STR and TLS2\MULTI.XA
True Love Story Fan Disc      ;\probably use that format, too
True Love Story: Remember My Heart ;/(not verified)
```

The STR headers have STR ID=0160h and STR Type=0001h, STR header[10h..1Fh] contains nonsense BS video info (with BS ID=3800h, although there isn't any BS data in the actual data part at offset 20h and up).

The files do mainly contain XA-ADPCM sectors, plus some STR sectors in non-MDEC format. Unknown if that STR sectors are separate channels, or if they are used in parallel with the XA-ADPCM channel(s).

Unknown what the STR sectors are used for (perhaps Polygon Streaming, audio subtitles, or simple garbage padding for unused audio sectors). In some files, the STR sectors appear to be just dummy padding (STR header plus zerofilled data area).

Nightmare Project: Yakata

This game has normal MDEC Streams, and Special Streams in non-MDEC format (eg. Disc1, File 0E9h-16Eh and 985h-B58h), perhaps containing Polygon Streams or whatever.

There are two channels (file=1/channel=00h-01h), each channel contains data that consists of 5 sectors per frame (1xHeader plus 4xData). The sectors have STR ID=0160h, and STR Type as follows:

```
0000h=Whatever special, channel 0 header (sector 0)
0400h=Whatever special, channel 1 header (sector 1)
0001h=Whatever special, channel 0 data (sector 2,4,6,8)
0401h=Whatever special, channel 1 data (sector 3,5,7,9)
```

Eagle One: Harrier Attack STR files

```
\*.STR          MDEC movies ;\BS fraquant (except, demo version
\DATA*\*.STR    MDEC movies ;/          on MagDemo31 uses normal BS v2)
\DATA*\M*\L*.STR Multi-language TXT files with STR header on each sector
\DATA*\M*\I*.STR unknown binary data (whatever and SPU-ADPCM)
\LANGN*.STR     unknown binary data (whatever)
```

All of the above have STR Type=8001h (but only the MDEC movies have BS ID 3800h; the MDEC movies start with 13 zerofilled sectors that are all zeroes without any STR/BS headers).

13.25 CDROM File Audio Single Samples VAG (Sony)

VAG audio samples

PSX Lightspan Online Connection CD, `cdrom:\CD.TOC:\UI*\VAG`

PSX Wipeout 2097, `cdrom:\WIPEOUT2\SOUND\SAMPLES.WAD:\.vag` (version=02h)

PSX Perfect Assassin, `DATA.JFS:\AUDIO\VAG and DATA.JFS:\SND\VAG`

```

000h 4    File ID (usually "VAGp")
004h 4    Version (usually 02h, or 20h) (big-endian)
008h 4    Reserved (0) (except when ID="VAGi") (big-endian)
00Ch 4    Channel Size (data size... per channel?) (big-endian)
010h 4    Sample Rate (in Hertz) (eg. 5622h=22050Hz) (big-endian)
014h 0Ch  Reserved (0) (except when version=2)
020h 10h  Name (ASCII, zeropadded)
... (..)  Optional ID string (eg. "STEREO" in upper/lowercase)
... (..)  Optional Padding to Data start
... ..    ADPCM Data for channel(s) (usually at offset 030h)

```

VAG files are used on PSX, PSP, PS2, PS3, PS4. The overall 1-channel mono format is same for consoles. But there are numerous different variants for interleaved 2-channel stereo data.

VAG Filename Extensions

```

.vag      default (eg. many PSX games)
.vig      2-channel with interleave=10h (eg. PS2 MX vs ATV Untamed)
.vas      2-channel with interleave=10h (eg. PS2 Kingdom Hearts II)
.swag     2-channel with interleave=filesize/2 (eg. PSP Frantix)
.l and .r 2-channel in l/r files (eg. PS2 Gradius V, PS2 Crash Nitro Kart)
.str      whatever (eg. P?? Ben10 Galactic Racing)
.abc      whatever (eg. PSP F1 2009 (v6), according to wiki.xentax.com)

```

VAG File IDs (header[000h])

```

"VAGp"    default (eg. many PSX games)
"VAG1"    1-channel (eg. PS2 Metal Gear Solid 3)
"VAG2"    2-channel (eg. PS2 Metal Gear Solid 3)
"VAGi"    2-channel interleaved (eg. ?)
"pGAV"    little endian with extended header (eg. PS2 Jak 3, PS2 Jak X)
"AAAp"    extra header, followed by "VAGp" header (eg. PS2 The Red Star)

```

VAG Versions (header[004h])

```

00000000h  v1.8 PC
00000002h  v1.3 Mac (eg. PSX Wipeout 2097, in SAMPLES.WAD)
00000003h  v1.6+ Mac
00000020h  v2.0 PC (most common, eg. PSX Perfect Assassin)
00000004h  ? (later games, uh when/which?)
00000006h  ? (vagconf, uh when/which?)
00020001h  v2.1 (vagconf2) ;\with HEVAG coding instead SPU-ADPCM
00030000h  v3.0 (vagconf2) ;/(eg. PS4/Vita)
40000000h  ? (eg. PS2 Killzone) (1-channel, little endian header)

```

Reserved Header entries for ID="VAGi"

```

008h 4  Interleave (little endian) (the other header entries are big endian)

```

Reserved Header entries for Version=00000002h (eg. PSX Wipeout 2097)

This does reportedly contain some default "base" settings for the PSX SPU:

```

014h 2  Volume left                4Eh,82h  ; -Port 1F801C00h
016h 2  Volume right               4Eh,82h  ; -Port 1F801C02h
018h 2  Pitch (includes fs modulation) A8h,88h  ; -Port 1F801C04h +extra bit?
01Ah 2  ADsr1                      00h,00h  ; -Port 1F801C08h
01Ch 2  ADsr2                      00h,E1h  ; -Port 1F801C0Ah
01Eh 2  ?                          A0h,23h  ; -Port 1F801C0xh maybe?

```

Reserved Header entries for Version=00000003h (according to wiki.xentax.com)

```

01Eh 1  Number of channels (0 or 1=Mono, 2=Stereo)

```

Reserved Header entries for Version=00020001h and Version=00030000h

```

01Ch 2  Zero                        ;if non-zero: force Mono
01Eh 1  Number of channels (0 or 1=Mono, 2=Stereo) ;if 10h..FFh: force Mono
01Fh 1  Zero                        ;if non-zero: force Mono

```

Unknown if the above "force Mono" stuff is really needed (maybe it was intended to avoid problems with Version=00000002h, and maybe never happens in Version=00000003h and up)?

VAG ADPCM Data

The ADPCM data uses PSX SPU-ADPCM encoding (even on PS2 and up, except PS4 with Version=00020001h or Version=00030000h, which do use HEVAG encoding).

SPU ADPCM Samples

The data does usually start at offset 0030h (except, some files have extra header data or padding at that location).

The first 10h-byte ADPCM block is usually all zero (used to initialize the SPU).

2-channel (stereo) files are usually interleaved in some way.

VAG Endiannes

The file header entries are almost always big-endian (even so when used on little endian consoles). There are a few exceptions:

ID="VAG1" has little endian [008h]=Interleave (remaining header is big-endian).

ID="pVAG" has (some?) header entries in little endian.

Version=40000000h has most or all header entries in little endian (perhaps including the version being meant to be 00000040h).

VAG Channels

VAGs can be 1-channel (mono) or 2-channel (stereo). There is no standardized way to detect the number of channels (it can be implied in the Filename Extension, Header ID, in Reserved Header entries, in the Name string at [020h..02Fh], in optional stuff at [030h], or in a separate VAG Header in the middle of the file).

VAG Interleave

```

None          default (for 1-channel mono) (and separate .l .r stereo files)
800h          when ID="VAG2"
[008h]        when ID="VAGi" (little-endian 32bit header[008h])
1000h         when ID="pGAV" and [020h]="Ster" and this or that
2000h         when ID="pGAV" and [020h]="Ster" and that or this
10h           when filename extension=".vig"
10h           when Version=0002001h or Version=00030000h (and channels=2)
filesize/2    when filename extension=".swag"
6000h         when [6000h]="VAGp" (eg. PSX The Simpsons Wrestling)
1000h         when [1000h]="VAGp" (eg. PS2 Sikigami no Shiro)
...

```

AAAp Header

```

000h 4        ID "AAAp"
004h 2        Interleave
006h 2        Number of Channels (can be 1 or 2?)
008h 30h*N    VAGp header(s) for each channel, with Version=00000020h
... ..       ADPCM Data (interleaved when multiple channels)

```

See also

<http://github.com/vgmstream/vgmstream/blob/master/src/meta/vag.c> ;very detailed
http://wiki.xentax.com/index.php/VAG_Audio ;rather incomplete and perhaps wrong

13.26 CDROM File Audio Sample Sets VAB and VH/VB (Sony)

VAB vs VH/VB

```
.VAB  contains VAB header, and ADPCM binaries    ;-all in one file
.VH   contains only the VAB header                ;\in two separate files
.VB   contains only the ADPCM binaries            ;/
```

PSX Perfect Assassin has some v7 .VH/.VB's (in \DATA.JFS:\SND\.*)

PSX Resident Evil 2, COMMON\DATA*.DIE (contains .TIM+.VAB badged together)

PSX Spider-Man, CD.HED\I2a1.vab is VAB v5 (other VABs in that game are v7)

PSX Tenchu 2 (MagDemo35: TENCHU2\VOLUME.DAT\5* has VAB v20h, maybe a typo)

VAB Header (VH)

```
0000h 4      File ID ("pBAV")
0004h 4      Version (usually 7) (reportedly 6 exists, too) (5, 20h exists)
0008h 4      VAB ID (usually 0)
000Ch 4      Total .VAB filesize in bytes (or sum of .VH and .VB file sizes)
0010h 2      Reserved (EEEEh)
0012h 2      Number of Programs, minus 1 (0000h..007Fh = 1..128 programs)
0014h 2      Number of Tones, minus? (max 0800h?) (aka max 10h per program)
0016h 2      Number of VAGs, minus? (max 00FEh)
0018h 1      Master Volume (usually 7Fh)
0019h 1      Master Pan (usually 40h)
001Ah 1      Bank Attribute 1 (user defined) (usually 00h)
001Bh 1      Bank Attribute 2 (user defined) (usually 00h)
001Ch 4      Reserved (FFFFFFFh)
0020h 800h   Program Attributes 10h-byte per Program 00h..7Fh (fixed size)
0820h P*200h Tone Attributes 200h-byte per Program 00h..P-1 (variable size)
xx20h 200h   16bit VAG Sizes (div8) for VAG 00h..FFh (fixed size)
xx20h (...)  ADPCM data (only in .VAB files, otherwise in separate .VB file)
```

Program Attributes (10h-byte per Program, max 80h programs)

```
000h 1      tones      Number of Tones in the Program (Yaroze: 4) (uh?)
001h 1      mvol       Master Volume (Yaroze: 0..127)
002h 1      prior      (Yaroze: N/A)
003h 1      mode       (Yaroze: N/A)
004h 1      mpan       Master Panning (Yaroze: 0..127)
005h 1      reserved0
```

006h	2	attr	(Yaroze: N/A)
008h	4	reserved1	
00Ch	4	reserved2	

Tone Attributes (20h-byte per Tone, max 10h tones per Program)

000h	1	prior	Tone Priority	(Yaroze: 0..127, 127=highest)
001h	1	mode	Mode	(Yaroze: 0=Normal, 4=Reverberation)
002h	1	vol	Tone Volume	(Yaroze: 0..127)
003h	1	pan	Tone Panning	(Yaroze: 0..127)
004h	1	center	Centre note (in semitone units)	(Yaroze: 0..127)
005h	1	shift	Centre note fine tuning	(Yaroze: 0..127)
006h	1	min	Note limit minimum value	(Yaroze: 0..127)
007h	1	max	Note limit maximum value	(Yaroze: 0..127)
008h	1	vibW		(Yaroze: N/A)
009h	1	vibT		(Yaroze: N/A)
00Ah	1	porW		(Yaroze: N/A)
00Bh	1	porT		(Yaroze: N/A)
00Ch	1	pbmin	Max? value for downwards pitchbend	(Yaroze: 0..127)
00Dh	1	pbmax	Max value for upwards pitchbend	(Yaroze: 0..127)
00Eh	1	reserved1		
00Fh	1	reserved2		
010h	2	ADSR1	Attack,Decay	(Yaroze: 0..127,0..15)
012h	2	ADSR2	Release,Sustain	(Yaroze: 0..127,0..31)
014h	2	prog	Program number that tone belongs to	(Yaroze: 0..127)
016h	2	vag	VAG number	(Yaroze: 0..254)
018h	8	reserved		

VAB Binary (VB) (ADPCM data) (to be loaded to SPU RAM)

This can contain max 254 "VAG files" (maybe because having two (?) reserved 8bit numbers?).

Sony wants the total size of the ADPCM data to be max 7E000h bytes (which would occupy most of the 512Kbyte SPU RAM, leaving little space for the echo buffer or additional effects).

Note: The "VAG files" inside of VAB/VB are actually raw SPU-ADPCM data, without any VAG file header. The first 10h-byte ADPCM block is usually zerofilled.

13.27 CDROM File Audio Sequences SEQ/SEP (Sony)

SEQ - Single Sequence

.SEQ contains MIDI-style sequences, the samples for the instruments can be stored in a separate .VAB file (or .VH and .VB files).

Used by Perfect Assassin, DATA.JFS:\SND*.SEQ (bundled with *.VH and *.VB)

Used by Croc (MagDemo02: CROC\CROCFILE.DIR\AMBI*.BIN, MAP*.BIN, JRHYTHM.BIN)
 Used by many other games.

```

000h 4  File ID "pQES"
004h 4  Version (1)                (big endian?)
008h 2  Resolution per quarter note (01h,80h)
00Ah 3  Tempo 24bit (8bit:16bit maybe?) (07h,27h,0Eh)
00Dh 2  Rhythm (NN/NN)             (04h,02h)
00Fh ... Score data, uh?           (with many MIDI KeyOn's: xx,9x,xx,xx)
... 3  End of SEQ (2Fh=End of Track) (FFh,2Fh,00h)

```

The "Score data" seems to be more or less same as in Standard Midi Format (.smf files), ie. containing timing values and MIDI commands/parameters.

SEP - Multi-Track Sequences

This is a simple "archive" with several SEQ-like sequences.

```

000h 4  File ID "pQES" ;same ID as in .SEQ files (!)
004h 2  Version (0)    ;value 0, and only 16bit, unlike .SEQ files
006h .. 1st Sequence
... .. 2nd Sequence
... .. etc.

```

Sequences:

```

000h 2  Sequence ID (0000h and up)    (big endian)      ; -ID number
002h 2  Resolution per quarter note   (01h,80h)        ; \
004h 3  Tempo 24bit                   (07h,27h,0Eh)     ; as in SEQ files
007h 2  Rhythm (NN/NN)                 (04h,02h)        ; /
009h 4  Data size (big endian, from 00Dh up to including End of SEQ(
00Dh ... Score data, uh?               (... )          ; \as in SEQ files
... 3  End of SEQ (2Fh=End of Track)   (FFh,2Fh,00h)    ; /

```

Used by Hear It Now (Playstation Developer's Demo) (RCUBE\RCUBE.SEP)

Used by Rayman (SND\BIGFIX.ALL\0002)

Used by Monster Rancher (MagDemo06, MR_DEMO\DATA\MF_DATA.OBJ\025B)

Used by Rugrats (MagDemo19: RUGRATS\DB02\SEP and MENU\SOUND\SEPS\SEP)

Used by Rugrats Studio Tour (MagDemo32: RUGRATS\DATA\SEPS*.SEP)

Used by Monkey Hero (MagDemo17: MONKEY\BIGFILE.PSX}*.SEP)

Used by Pitfall 3D

Used by Blue's Clues: Blue's Big Musical (SEPD chunks in *.TXD)

13.28 CDROM File Audio Other Formats

.SQ .HD .HD (SSsq/SShd)

This is a newer Sony format from 1999 (resembling the older .SEQ .VH .VB format). Used by Alundra 2, Ape Escape, Arc the Lad 3, Koukidou Gensou - Gunparade March, Omega Boost, PoPoLoCrois Monogatari II, The Legend of Dragoon, Wild Arms 2.

```
.SQ Sequence Data (with ID "SSsq")
.HD Voice Header (with ID "SShd")
.BD Voice Binary (raw SPU-ADPCM, same as .VB)
```

SEQUENCE DATA (*.SQ)

```
000h 2      Sequence Volume (0 .. 127, Always 64??)
002h 2      Ticks per Quarter Note (always 1E0h)
004h 2      Tempo
005h 6      Zerofilled
00Ch 4      ID "SSsq"
010h 10h*10h Channels
110h ..     Sequence
```

Channel

```
000h 1      UNKNOWN
001h 1      Channel Index
002h 1      Program Index
003h 1      Volume
004h 1      Pan (0 .. 127, 64 is center)
005h 4      UNKNOWN
009h 1      Modulation (Multiplier for "breath" control)
00Ah 1      Pitch Bend (0 .. 127, 64 is center)
00Bh 1      Priority
00Ch 1      Breath (0 .. 127 how quickly to loop over the breath wave)
00Dh 1      UNKNOWN
00Eh 1      Adjusted volume (combination of sequence volume and channel volume)
00Fh 1      UNKNOWN
```

VOICE HEADER (*.HD)

```
000h 4      Size of the .HD file itself
004h 4      Size of the corresponding .BD file
008h 4      Zero
00Ch 4      ID "SShd"
010h 1Ch*4  Offsets to data (or FFFFFFFFh=None)
080h ..     Data
```

Data 0 - Programs

```

Header
  000h 2      Program Upper bound (count - 1)
  002h 2*n    Program offsets (FFFFh=None, yes the count can be higher than actual program
count)
  ...  ...    Program data

```

```

Program
  000h 1      Type + Tone Upper bound (FF = SFX, if not, 1st bit allows the program to
play multiple tones per one KeyOn, rest is upper bound)
  001h 1      Volume (0 .. 127)
  002h 1      Pan (0 .. 127, 64 is center)
  003h 1      UNUSED
  004h 1      Pitch Bend multiplier
  005h 1      Breath wave index (7Fh=None)
  006h 1      SFX - Starting note
  007h 1      SFX - Tone count

```

```

Tone
  000h 1      Minimum note
  001h 1      Maximum note
  002h 1      Root key
  003h 1      Fine pitch adjustment (in 1/16 of a semitone)
  004h 2      ADPCM offset (*8)
  006h 4      ADSR
  00Ah 1      Volume override
  00Bh 1      Volume (0 .. 127)
  00Ch 1      Pan (0 .. 127, 64 is center)
  00Dh 1      Pitch Bend multiplier
  00Eh 1      Breath wave index (7Fh=None)
  00Fh 1      Flags (High priority, Noise, UNKNOWN, UNKNOWN, Pitch Bend from Program,
Modulation, Breath wave from Program, Reverb)

```

Data 1 - Velocity volumes

```

  000h 2      UNUSED
  002h 1*80h Velocity volumes

```

Data 2 - Breath waves

```

  000h 2      Beath wave upper bound
  002h 2*n    Breath wave offsets
  ...  40h*n Breath waves (Only 60 out of the 64 values are used. And each represents 1
step in a 1 sec cycle at the lowest breath speed)

```

Data 3 - Sequence set (Used for SFX, uses a slightly altered subset of commands)

```

000h 2      Sets upper bound
002h 2*n    Set Offsets
... 2      Sequence upper bound (Set 0)
... 2*m    Sequence offset (Set 0)
... ..
... ..     Sequences (Terminated with FF 2F 00 - End of Track command)

```

Data 4 - Embedded SSsq (Used for SFX)

```

000h 10h    SSsq header with just the volume
010h 18h*10h Channels
190h ...    Programs

```

VOICE BINARY (*.BD) (SAME AS .VB FILES)

```

000h ..     SPU-ADPCM data (usually starting with zerofilled 10h-byte block)

```

DNSa/PMSa/FNSa/FMSa

There are four four file types:

```

"DNSa" (aka SouND backwards)      ;sequence data
"PMSa" (aka SaMPles backwards)    ;samples with small header
"FMSa" (aka SaMPles-F... backwards) ;samples with bigger header ;\Legacy
"FNSa" (aka SouNd-F... backwards) ;whatever tiny file           ;/of Kain

```

Used by several games (usually inside of BIGFILE.DAT):

```

Akuji (MagDemo18: AKUJI\BIGFILE.DAT\*) (DNSa,PMSa)
Gex 2 (MagDemo08: GEX3D\BIGFILE.DAT\*) (DNSa)
Gex 3: Deep Cover Gecko (MagDemo20: G3\BIGFILE.DAT\*) (DNSa,PMSa)
Legacy of Kain 2 (MagDemo13: KAIN2\BIGFILE.DAT\*) (DNSa)
Legacy of Kain 2 (MagDemo26: KAIN2\BIGFILE.DAT\*) (DNSa,PMSa,FNSa,FMSa)
Walt Disney World Racing Tour (MagDemo35: GK\BIGFILE.DAT\*) (DNSa,PMSa)

```

Note: The exact file format does reportedly differ in each game.

"PMSa" (AKA SAMPLES BACKWAORDS)

```

000h 4      ID "PMSa"
004h 4      Total Filesize
008h 8      Zerofilled
010h ..     SPU-ADPCM data (usually starting with zerofilled 10h-byte block)

```

"DNSa" (AKA SOUND BACKWARDS)

```

000h 4      ID "DNSa"    ;aka SND backwards
004h 2      Offset from DNSa+4 to 8-byte entries (can be odd)
006h 1      Unknown (3)
007h 1      Number of 8-byte entries (N1)
008h 1?     Number of 10h-byte entries (N2)
... ..     Unknown (..)
... N1*8    Whatever 8-byte entries
... N2*10h  Whatever 10h-byte entries
... ..     ... circa 40h 4-byte entries...?
... ..     Unknown (..)
... ..     Several blocks with ID "QESa" or "QSMa" ;supposedly MIDI-style?

```

"FNSA" (AKA SOUND-F... BACKWARDS)

These are whatever tiny files (with filesize 1Ch or 2Ch).

```

000h 4      ID "FNSa"
... ..     Unknown

```

"FMSA" (AKA SAMPLES-F... BACKWARDS)

```

000h 4      ID "FMSa"
008h ..     Unknown..
... ..     SPU-ADPCM data (usually starting with zerofilled 10h-byte block)

```

AKAO

There are several games that have sound files with ID "AKAO".

```

XXX does that include different AKAO formats... for Samples and Midi?

```

AKAO is also used in several streaming movies:

[CDROM File Video Streaming Audio](#)

Others

Alone in the Dark IV has MIDB and DSND chunks (which contain sound files).

See also

The page below does mention several PSX sound formats, plus some open source & closed source tools for handling those files.

https://github.com/loveemu/vgmdocs/blob/master/Conversion_Tools_for_Video_Game_Music.md

13.29 CDROM File Audio Streaming XA-ADPCM

Audio Streaming (XA-ADPCM)

Audio streaming is usually done by interleaving the .STR or .BS file's Data sectors with XA-ADPCM audio sectors (the .STR/.BS headers don't contain any audio info; because XA-ADPCM sectors are automatically decoded by the CDROM controller).

Raw XA-ADPCM files (without video) are usually have .XA file extension.

13.30 CDROM File Audio CD-DA Tracks

The eleven .SWP files in Wipeout 2097 seem to be CD-DA audio tracks.

The one TRACK01.WAV in Alone in the Dark, too?

Other than that, tracks can be accessed via TOC instead of filenames.

13.31 CDROM File Archives with Filename

Entrysize=08h

WWF SMACKDOWN (MAGDEMO33: TAIL*.PAC)

```

000h 4      ID ("DPAC")                      ; \
004h 4      Unknown (100h)                   ;
008h 4      Number of files (N)              ;
00Ch 4      Directory Size (N*8)             ; Header
010h 4      File Data area size (SIZE = Totalsize-Headersize) ;
014h 4      Unknown (1)                     ;
018h 7E8h   Zerofilled (padding to 800h-byte boundary) ;
800h N*8     File List                       ;
... ..      Zerofilled (padding to 800h-byte boundary) ;/
... SIZE     File Data area                  ;-Data area
File List entries:
000h 8      Filename ("NAME")
004h 2      File Offset/800h (increasing)
006h 2      File Size/800h

```

The DPAC archives can contain generic files (eg .TIM) and child archives (in a separate archive format, with ID "PAC ").

Entrysize=10h**CHAMPIONSHIP MOTOCROSS (MAGDEMO25: SMX\RESHEAD.BIN AND RESBODY.BIN)****RESHEAD.BIN:**

```

000h N*10h  File List (220h bytes)
File List entries:
000h 8      Filename ("FILENAME", if shorter: terminated by 00h plus garbage)
008h 4      Filesize in bytes
00Ch 4      Offset/800h in RESBODY.BIN (increasing) (or FFFFFFFFh if Size=0)

```

RESBODY.BIN:

```

000h ..      File Data (referenced from RESHEAD.BIN)

```

ONE (DIRFILE.BIN\W*\SECT*.BIN)

```

000h N*10h  File List
... ..      File Data area
File List entries:
000h 0Ch    Filename (eg. "FILENAME 001")      ;for last entry: "END      000"
00Ch 4      Offset (increasing, N*10h and up) ;for last entry: zero

```

TRUE LOVE STORY 1 AND 2 (TLS*\MCD.DIR AND MCD.IMG)**MCD.DIR:**

```

000h N*10h  File List
... 10h     End marker (FFh-filled)
File List entries:
000h 8      Filename (zeropadded if less than 8 chars)
008h 2      Zero (0000h)
00Ah 2      Size/800h
00Ch 4      Offset/800h in MCD.IMG
Note: Filenames are truncated to 8 chars (eg. "FOREST.T" instead "FOREST.TIM")

```

MCD.IMG:

```

000h ..      File Data area (encrypted in True Love Story 2)

```

In True Love Story 2, the MCD.IMG data is encrypted as follows:

```

init_key_by_filename(name):      ;for MCD.IMG (using filenames from MCD.DIR)
i=0, key0=0001h, key1=0001h, key2=0001h
while i<8 and name[i]<>00h
    key0=(key0 XOR name[i])
    key1=(key1 * name[i]) AND FFFFh

```

```

    key2=(key2 + name[i]) AND FFFFh
ret
init_key_by_numeric_32bit_seed(seed): ;maybe for LINEAR.IMG and PICT.IMG ?
key0=(seed) AND FFFFh
key1=(seed - (seed*77975B9h/4000000000h)*89h) AND FFFFh
key2=(seed - (seed*9A1F7E9h/20000000000h)*3527h) AND FFFFh
ret
decrypt_data(addr,len):
for i=1 to len/2
    key2=key2/2 + (key0 AND 1)*8000h
    key0=key0/2 + (key1 AND 1)*8000h
    key1=key1/2 + ((key1/2 OR key0) AND 1)*8000h
    key0=(((key1+47h) AND FFFFh)/4) XOR key0)+key2+(((key1+47h)/2) AND 1)
    halfword[addr]=halfword[addr] XOR key0, addr=addr+2
ret

```

The MCD.* files don't contain any encryption flag. Below are some values that could be used to distinguish between encrypted and unencrypted MCD archives (though that may fail in case of any other games/versions with other values):

Item	Unencrypted	Encrypted
Parent Folder name	"TLS"	"TLS2"
First name in MCD.DIR	"BACKTILE"	"TEST.RPS"
First word in MCD.IMG	00000010h	074D4C8Ah

STAR WARS REBEL ASSAULT 2 (RESOURCE.*, AND NESTED THEREIN)

BALLBLAZER CHAMPIONS (*.DAT, AND NESTED THEREIN)

The Rebel RESOURCE.* files start with name "bigEx" or "fOFS", BallBlazer *.DAT start with "SFXbase" or "tpage", nested files start with whatever other names.

```

000h N*10h File List
... (4) CRC32 on above header (Top-level only, not in Nested archives)
... .. File Data area
... (..) Huge optional padding to xx000h-byte boundary (in BallBlazer .DAT)
File List entries in Top-level archives (with [0Ch].bit31=1):
000h 8 Filename (zeropadded if less than 8 chars)
008h 4 Decompressed Size (or 0=File isn't compressed)
00Ch 4 Offset, self-relative from current List entry (plus bit31=1)
File List entries in Nested archives (with [0Ch].bit31=0):
000h 0Ch Filename (zeropadded if less than 12 chars)
00Ch 4 Offset, self-relative from current List entry (plus bit31=0)
Last File List entry has [00h..0Bh]=zerofilled, and Offset to end of file.

```

Uncompressed Data Format (when List entry [08h]=0 or [0Ch].bit31=0):

```

000h .. Uncompressed Data
... .. CRC32 on above Data (Top-level only, not in Nested archives)

```

Compressed Data Format (when List entry [08h]>0 and [0Ch].bit31=1)::

```

000h 1      Compression Method (01h=LZ/16bit, 02h=LZ/24bit)
001h 3      Decompressed Size (big-endian)
004h ..     Compressed Data
... ..     Zeropadding to 4-byte boundary
... ..     CRC32 on above bytes (method, size, compressed data, padding)

```

CDROM File Compression RESOURCE (Star Wars Rebel Assault 2)

Entrysize=14h

FIGHTING FORCE (MAGDEMO01: FGHTFRCE*.WAD)

```

000h 4      Number of files                                (big endian)
004h N*14h  File List
... ..     File Data

```

File List entries:

```

000h 0Ch    Filename ("FILENAME.EXT", zeropadded if shorter than 12 chars)
00Ch 4      Filesize in bytes (can be odd)                  (big endian)
010h 4      Fileoffset in bytes (increasing, 4-byte aligned) (big endian)

```

PARAPPA (MAGDEMO01: PARAPPA*.INT)

UM JAMMER LAMMY (MAGDEMO24: UJL*.INT)

```

0000h 2000h Folder 1
2000h ..     File Data for Folder 1
... 2000h Folder 2
... ..     File Data for Folder 2
... 2000h Folder End marker (FFFFFFFFh, plus zeropadding)

```

Folder entries:

```

0000h 4      Folder ID (increasing, 1,2,3, or FFFFFFFFh=End)
0004h 4      Number of files (max 198h) (N)
0008h 4      File Data Area size/800h    (S)
000Ch 4      Zero (0)
0010h N*14h  File List
... ..     Zeropadding to 2000h
2000h S*800h File Data Area for this folder

```

File List entries:

```

000h 4      Filesize in bytes
004h 10h    Filename (FILENAME.EXT, zeropadded)

```

File Offsets are always 4-byte aligned (required for Um Jammer Lammy, which contains Filesizes that aren't multiples of 4).

Note: There can be more than one folder with same ID (ie. when having more than 198h TIM files, which won't fit into a single 2000h-byte folder).

GRAN TURISMO 1 (MAGDEMO10: GT\BG.DAT\, GTCOURSE.DAT\)

GRAN TURISMO 1 (MAGDEMO15: GT\BG.DAT\, GTCOURSE.DAT\)

JUMPSTART WILDLIFE SAFARI FIELD TRIP (MAGDEMO52: DEMO\DATA.DAT*.DAT)

These are child archives found inside of the main GT-ARC and DATA.DAT archives.

```

000h 4      Number of Files (eg. 26h) (usually at least 02h or higher)
004h N*14h  File List
... ..     File Data area
File List entries:
000h 10h    Filename ("FILENAME.EXT", zeropadded if shorter)
010h 4      Offset in bytes (increasing, 4-byte-aligned?)

```

CROC 2 (MAGDEMO22: CROC2\CROCII.DAT AND CROCII.DIR)

DISNEY'S THE EMPEROR'S NEW GROOVE (MAGDEMO39: ENG\KINGDOM.DIR+DAT)

DISNEY'S ALADDIN IN NASIRA'S REVENGE (MAGDEMO46: ALADDIN\ALADDIN.DIR+DAT)

```

DIR:
000h 4      Number of Entries (0Eh)
004h N*14h  File List
DAT:
000h ..     File Data (referenced from CROCII.DIR)

```

File List entries:

```

000h 0Ch    Filename ("FILENAME.EXT", zeropadded if shorter)
00Ch 4      File Size in bytes
010h 4      File Offset in .DAT file (800h-byte aligned, increasing)

```

ALICE IN CYBERLAND (ALICE.PAC, AND NESTED .PAC, .FA, .FA2 ARCHIVES)

```

000h N*14h  File List
... 14h     Zerofilled (File List end marker)
... ..     File Data area
File List entries:
000h 0Ch    Filename ("FILENAME.EXT", zeropadded if shorter)

```

```

00Ch 4      Offset (increasing, 4-byte aligned)
010h 4      Filesize in bytes (can be odd, eg. for .FA2 files)

```

PAC and FA are uncompressed, FA2 is compressed via some LZ5-variant:

CDROM File Compression LZ5 and LZ5-variants

INTERPLAY SPORTS BASEBALL 2000 (MAGDEMO22:BB2000\DATA\HOG.TOC\UNIFORMS*.UNI)

```

000h N*14h  File List (3Ch*14b bytes, unused entries are zeropadded)
4B0h ..      Data area (TIM files for player uniforms)
File List entries:
000h 10h     Filename ("FILENAME.EXT", zeropadded)
010h 4       Offset (zerobased, from begin of Data area, increasing)

```

Entrysize=18h

INVASION FROM BEYOND (MAGDEMO15: IFB*.CC)

```

000h 0Ch     Fixed ID (always "KotJCo01Dir ") (always that same string)
00Ch 4       Number of Files
010h N*18h   File List
... ..       File Data area

```

File List entries:

```

000h 10h     Filename ("FILENAME.EXT", zeropadded)
010h 4       Offset in bytes (increasing, 1-byte or 4-byte aligned)
014h 4       Filesize in bytes (can be odd)

```

Note: Alignment is optional: Files in IFB\HANGAR\CC and IFB\MAPS\CC use 4-byte aligned offsets (but may have odd filesizes). Files in IFB\INCBINS*.CC don't use any alignment/padding.

GHOST IN THE SHELL (MAGDEMO03: GITSDEMO\S01*.FAC)

```

000h N*18h   File List (18h-bytes each)
... 18h      File List end marker (zerofilled)
... ..       File Data

```

File List entries:

```

000h 1       Filename Checksum (sum of bytes at [001h..00Dh])
001h 1       Filename Length (excluding ending zeroes) (eg. 8, 9, 10, 12)
002h 0Ch     Filename ("FILENAME.EXT", zeropadded if less than 12 chars)
00Eh 2       Unknown (2000h) (maybe attr and/or ending zero for filename)

```

```

010h 4    Filesize in bytes (can be odd)
014h 4    Offset (increasing, 4-byte aligned)

```

ODDWORLD: ABE'S EXODUS (MAGDEMO17: ABE2*.LVL)

ODDWORLD: ABE'S EXODUS (MAGDEMO21: ABE2*.LVL AND NESTED .IDX FILES)

```

000h 4    Header Size in bytes (2800h) (can be MUCH bigger than needed)
004h 4    Zero
008h 4    ID "Indx"
00Ch 4    Zero
010h 4    Number of Files (N) (CEh) (can be zero=empty in .IDX files)
014h 4    Header Size/800h (05h)
018h 4    Zero
01Ch 4    Zero
020h N*18h File List
... ..    Zeropadding to end of Headersize
... ..    File Data area

```

File List entries (in .LVL files):

```

000h 0Ch   Filename ("FILENAME.EXT", zeropadded if shorter)
00Ch 4     Offset/800h
010h 4     File Size/800h
014h 4     File Size in bytes

```

File List entries (in .IDX files):

```

IDX files use the same File List entry format as LVL, but the offsets
seem to refer to an external file with corresponding name, for example:
  cdrom:\ABE2\CR.LVL\CR.IDX      ;directory info
  cdrom:\ABE2\CR.MOV             ;external data (the .MOV being a .STR video)
XXX: That's not tested/verified, and not implemented in no$psx file viewer.

```

MONKEY HERO (MAGDEMO17: MONKEY\BIGFILE.PSX AND NESTED .PSX FILES)

```

000h 4    Unknown (6)
004h 4    Total Filesize (1403800h)
008h 2    Unknown, Alignment? (800h)
00Ah 2    Number of Files, excluding zerofilled File List entries (ACh)
00Ch 4    Header Size (1800h)
010h 4    Unknown, Entrysize? (18h)
014h 4    Unknown, Entrysize? (18h)
018h N*18h File List (can contain unused zerofilled entries here and there!)
... ..    File Data area

```

File List entries:

```

000h 10h  Filename ("FILENAME.EXT", zeropadded)
010h 4     File Offset in bytes (800h-byte aligned, unsorted/not increasing)
014h 4     File Size in bytes

```

NHL FACEOFF '99 (MAGDEMO17: FO99*.KGB AND NESTED *.PRM *.TMP *.ZAM)

NHL FACEOFF 2000 (MAGDEMO28: FO2000*.KGB, Z.CAT, AND NESTED *.PRM AND *.TMP)

```

000h 4     ID "KGB", 00h
004h 4     Number of Files (N)
008h (4)   Number of Files negated (-N) ;<-- optional, not in LITESHOW.KGB
... N*18h  File List
... (...)  CBh-padding to alignment boundary (only if align=800h)
... ..     File Data area

```

File List entries:

```

000h 10h  Filename ("FILENAME.EXT", terminated by 00h, padded with CDh)
010h 4     File Size in bytes
014h 4     File Offset (800h-byte or 1/4-byte? aligned)

```

SYPHON FILTER 1 (MAGDEMO18: SYPHON\SUBWAY.FOG) (4MBYTE, NAMELEN=10H)

```

000h 4     Unknown (80000001h)
004h 4     Offset/800h to Final Padding area
008h 8     Zerofilled
010h N*18h File List
... (...)  CDh-padding to 800h-byte alignment boundary
... ..     File Data area
... 800h   Some text string talking about "last-sector bug"
... 40BEh  Final Padding area (CDh-filled)

```

File List entries:

```

000h 10h  Filename ("FILENAME.EXT", terminated by 00h, padded with CDh)
010h 4     File Offset/800h (increasing)
014h 4     File Size/800h

```

This is almost same as the newer v2 format in Syphon Filter 2 (see there for details).

CENTIPEDE (MAGDEMO23: ARTFILES*.ART)

```

000h 0Fh  ID ("Art", zeropadded) ;\
00Fh 1    Type or so ("?") ; sorts of File List entry
010h 4    Number of entries plus 1 (N+1) ; for root folder
014h 4    Total Size in bytes (can be odd) ;/
018h N*18h File List
... ..     File Data area
File List entries:

```



```

000h 0Fh  Filename ("FILENAME", zeropadded)
00Fh 1    Type/extension or so ("X" or "D")
010h 4    File Offset (unaligned, increasing)
014h 4    File Size in bytes (can be odd)

```

Note: COL7.ART includes zerofilled 18h-bytes as last File List entry, BONU.ART doesn't have any such zerofilled entry.

Unknown if this can have child folders (maybe in similar form as the root folder entry).

SHEEP RAIDER (MAGDEMO52: SDWDEMO*.SDW)

SHEEP RAIDER (MAGDEMO54: SDWDEMO*.SDW)

```

000h 4      Unknown (301h)
004h 4      Zero (0)
008h 4      Number of files (N)
00Ch N*18h  File List
... ..      Zeropadding to 800h-byte boundary
... ..      File Data area
File List entries:
000h 4      Offset (800h-byte aligned, increasing)
004h 4      Filesize in bytes
008h 1      Unknown (01h)
009h 0Fh    Filename ("FILENAME.EXT", 00h, plus garbage padding)

```

The SDW archive contains malformed 200h*1A4h pixel TIMs.

```

Texsize is 6900Eh, but should be 6900Ch = 200h*1A4h*2+0Ch
Filesize is 6A000h, but should be 69014h = 200h*1A4h*2+14h

```

WING COMMANDER III (*.LIB)

```

000h 2      Number of Files (C9h)
002h N*18h  File List
... (..)    Padding to 800h-byte boundary (if any, eg. in MOVIES.LIB)
... ..      File data area (800h-byte aligned, or unaligned)
File List entries:
000h 4      Filesize in bytes
004h 4      Offset (increasing, 800h-byte aligned, or unaligned)
008h 10h    Filename ("filename.ext", zeropadded)

```

LARGO WINCH - COMMANDO SAR (LEVELS*.DCF)

```

000h 4      ID "DCAT"
004h 4      Number of Entries
008h N*18h  File List
... ..      Zerofilled (padding to 800h-byte boundary)
... ..      File Data area
File List entries:

```

```

000h 10h  Filename ("FILENAME.EXT", terminated by 00h, plus garbage padding)
010h 4     Filesize in bytes
014h 4     Offset (increasing, 800h-byte aligned)

```

POLICENAUTS (NAUTS*.DPK)

```

000h 4     ID "FRID"
004h 4     Always E0000000h
008h 4     Always 800h (...maybe alignment)
00Ch 4     Number of Entries (N)
010h 4     Header Size (N*18h+20h, plus padding to 800h-byte boundary)
014h 4     Always 18h (...maybe entry size)
018h 8     Zerofilled
020h N*18h File List
... ..    Zerofilled (padding to 800h-byte boundary)
... ..    File Data area
File List entries:
000h 0Ch  Filename ("FILENAME.EXT", zeropadded if shorter)
00Ch 4     Offset (increasing, 800h-byte aligned)
010h 4     Filesize in bytes
014h 4     Unknown (checksum? random?)

```

ACTUA ICE HOCKEY 2 (BEST SPORTS GAMES EVER (DEMO), AH2\GAMEDATA*.MAD)

```

000h N*18h File List
... ..    File Data area (directly after File List, without end-code)
Note: There is no file-list end-marker (instead, the Offset in 1st File
      entry does imply the end of File List).
File List entries:
000h 10h  Filename ("FILENAME.EXT", zeropadded)
010h 4     Offset (increasing, 4-byte aligned, or unaligned for TXT files)
014h 4     Filesize in bytes (or weird nonsense in SFX.MAD)

```

There are several oddities in demo version (unknown if that's in retail, too):

```

SFX.MAD has nonsense Filesize entries (eg. 164h for a 15150h-byte file).
FACES.MAD contains only one TIM file... but as 3Mbyte junk appended?
RINKS.MAD and TEAMS.MAD start with 0Dh,0Ah,1Ah followed by 4Mbyte junk.
MISCFIE.MAD contains several nested .mad files.
MISCFIE.MAD\panfont.mad\*.txt --> starts with FF,FE --> that's 16bit Unicode?

```

MUPPET MONSTER ADVENTURE (MAGDEMO37: MMA\GAMEDATA+WORLDS*.INF+WAD)

```

INF:
  000h N*18h File List
WAD:
  000h ..    File Data area

```

File List entries:

```

000h 4      File Offset/800h in .WAD file
004h 4      File Size in bytes
008h 10h    Filename ("FILENAME.EXT", zeropadded)

```

ARMY MEN AIR ATTACK 2 (MAGDEMO40: AMAA2*.PCK)

```

000h 4      Number of entries (N)
004h N*18h  File List
... ..     Zeropadding to 800h-byte boundary
... ..     File Data area
File List entries:
000h 10h    Filename ("FILENAME.EXT", zeropadded)
010h 4      Fileoffset (800h-byte aligned, increasing)
014h 4      Filesize in bytes

```

MORT THE CHICKEN (MAGDEMO41: MORT*.PPF AND .TPF)

```

000h 2      Type (31h=TPF with TIMs, 32=PPF with PMDs)
002h 2      Number of entries (N) (can be 0=None, eg. STAGE*\MORT.PPF)
004h 4      File List Size (N*18h)
008h 4      Header Size (always 14h)
00Ch 4      Data area Size (Filesize-14h-N*18h)
010h 4      Data area Offset (14h+N*18h)
014h N*18h  File List
... ..     File Data area
File List entries:
000h 10h    Filename ("FILENAME.EXT", zeropadded)
010h 4      Filesize in bytes
014h 4      Fileoffset (from begin of Data area, increasing)

```

HOT WHEELS EXTREME RACING (MAGDEMO52: US_01293\VEHICLES*.CAB)

```

000h 4      ID "BACR" (aka RCAB backwards)
004h 4      Number of entries (N)
008h N*18h  File List
... ..     File Data area
File List entries:
000h 10h    Filename ("FILENAME.EXT", zeropadded)
020h 4      Offset (from begin of Data area, increasing, 4-byte aligned)
024h 4      Filesize in bytes (can be odd)

```

Entrysize=19h

WAD FORMAT (WIPEOUT 2097)

PSX Wipeout 2097, cdrom:\WIPEOUT2\SOUND\SAMPLES.WAD:\.vag

PSX Wipeout 2097, cdrom:\WIPEOUT2\TRACK*\TRACK.WAD:\.*

PSX Wipeout 3 (MagDemo25: WIPEOUT3*)

```
000h 2      Number of files
002h N*19h Directory Entries for all files
... ..     Data for all files (without any alignment, in same order as above)
```

Directory Entries

```
000h 10h Filename (ASCII, can be lowercase), terminated by 00h, plus garbage
010h 4      Filesize in bytes ;\maybe compressed/uncompressed, or rounded,
014h 4      Filesize in bytes ;/always both same
018h 1      Unknown (always 00h)
```

The filesize entry implies offset to next file.

Entrysize=1Ch

COMMAND & CONQUER, RED ALERT (MAGDEMO05: RA*) FAT/MIX/XA

```
000h 4      Number of entries with location 0=MIX (M=65h)
000h 4      Number of entries with location 1=XA (X=1)
008h M*1Ch File List for location 0=MIX
... X*1Ch File List for location 1=XA
```

File List entries:

```
000h 10h Filename (terminated by 00h, padded with garbage)
010h 4      Offset/800h in DATA.MIX or Offset/930h DATA.XA file (increasing)
014h 4      Filesize in bytes
018h 4      File Location (0=DATA.MIX, 1=DATA.XA)
```

SYPHON FILTER 2 (MAGDEMO30: SYPHON\TRAIN.FOG) (2.8MBYTE, NAMELEN=14H)

```
000h 4      Unknown (80000001h)
004h 4      Offset/800h to Final Padding area
008h 8      Zerofilled
010h N*1Ch File List
... (..) CDh-padding to 800h-byte alignment boundary
... ..     File Data area
... 3394h Final Padding area (CDh-filled)
```

File List entries:

```
000h 14h Filename ("FILENAME.EXT", terminated by 00h, padded with CDh)
014h 4      File Offset/800h (increasing)
018h 4      File Size/800h
```

This is almost same as the older v1 format in Syphon Filter 1:

```
v1 (Syphon Filter 1) has filename_len=10h (and filelist_entrysize=18h)
v2 (Syphon Filter 2) has filename_len=14h (and filelist_entrysize=1Ch)
```

To detect the version: Count the length of the "ASCII chars + 00h byte + CDh padding bytes" at offset 10h.

Note: The FOG archive in Syphon Filter 2 demo version does contain some empty dummy files (with intact filename, but with offset=0 and size=0).

Entrysize=20h

COLONY WARS (MAGDEMO02: CWARS\GAME.RSC)

COLONY WARS VENEGANCE (MAGDEMO14: CWW\GAME.RSC, 8MBYTE)

```
000h 4      Number of Files
004h N*20h  File List
... 10h     File List End: Name      (zerofilled)
... 4       File List End: Offset   (total filesize, aka end of last file)
... 0Ch     File List End: Padding  (zerofilled)
... ..      File Data area
```

File List entries:

```
000h 10h    Filename ("FILENAME.EXT", terminated by 00h, padded with garbage)
010h 4      File Offset in bytes (increasing, 4-byte aligned)
014h 0Ch    Padding (garbage) (usually 800F68A0h,800F68A0h,800F68A0h)
```

Note: Colony Wars Red Sun does also have a GAME.RSC file (but in different format, with folder structure).

WARGAMES (MAGDEMO14: WARGAMES*.DAT)

```
000h 4      Number of Files (1C3h)
004h N*20h  File List
... ..      Zeropadding to 800h-byte boundary
... ..      File Data area
```

File List entries:

```
000h 10h    Filename ("FILENAME.EXT", zeropadded, sorted alphabetically)
010h 4      File Offset/800h (unsorted, not increasing)
014h 4      File Size in bytes
018h 4      File Size/800h
01Ch 4      Zero
```

RUNNING WILD (MAGDEMO15: RUNWILD*.BIN)

```

000h N*20h File List
... 4      File List End Offset/800h (end of last file)
... 4      File List End Size (zero)
... 18h    File List End Name (zerofilled)
... ..    Padding to 800h-byte boundary (each 20h-byte: 01h, and 1Fh zeroes)
... ..    File Data

```

File List entries:

```

000h 4      Offset/800h (increasing)
004h 4      Filesize in bytes
008h 18h    Filename ("FILENAME.EXT" or ":NAME" or ":NAME:NAME", zeropadded)

```

Files with extension .z or .Z are compressed:

CDROM File Compression Z (Running Wild)**TEST DRIVE OFF-ROAD 3 (MAGDEMO27: TDOR3\TDOR3.DAT)**

About same as the other Test Drive games, but with shorter filenames.

```

000h N*20h File List (1920h bytes used; with padding: 5800h bytes in total)
... ..    Zeropadding to Headersize (5800h)
... ..    File Data area
File List entries:
000h 18h    Filename ("FILENAME.EXT" or "PATH\FILENAME.EXT", zeropadded)
018h 4      Filesize in bytes
01Ch 4      File (Offset-Headersize)/800h

```

TDOR3.DAT contains DOT1 child archives and many RNC compressed files: --> CDROM File Compression RNC (Rob Northen Compression)

TINY TANK (MAGDEMO23: TINYTANK*.DSK)

```

000h 4      ID ("TDSK") ;\
004h 4      Number of Files (1Bh) ; Directory
008h N*20h File List ;/
... 4      1st File Size (same as Size entry in File List) ;\File Data area
... ..    1st File Data ; (each file os
... 4      2nd File Size (same as Size entry in File List) ; preceded by
... ..    2nd File Data ; a size entry)
... ..    etc. ;/
File List entries:
000h 10h    Filename ("FILENAME.EXT", zeropadded)
010h 4      File Size in bytes
014h 4      Unknown (35xxxxxxh..372xxxxxxh)
018h 4      Unknown (3724xxxxh) (Timestamp maybe?)
01Ch 4      File Offset in bytes (increasing, 4-byte aligned)

```

Note: The File Offset points to a 32bit value containing a copy of the Filesize, and the actual file starts at Offset+4.

MAG 3 (MAGDEMO26: MAG3\MAG3.DAT, 7MBYTE)

```
000h N*20h  File List (B60h bytes)
... ..      Zeropadding to 800h-byte boundary
... ..      File Data area (files are AAh-padded to 800h-byte boundary)
File List entries:
000h 4       Filesize in bytes
004h 2       File Offset/800h (16bit) (increasing)
006h 1Ah     Filename ("FILENAME.EXT" or "PATH\FILENAME.EXT", zeropadded)
```

PLAY WITH THE TELETUBBIES (MAGDEMO35: TTUBBIES*.RES)

```
000h 2       Zero (0000h)
002h 2       Number of Files (N)
004h 4       Data Base (N*20h+10h)
008h 4       Unknown (20h)  ;-maybe File List entry size?
00Ch 2       Unknown (10h)  ;\maybe filename length and/or header size?
00Eh 2       Unknown (10h)  ;/
010h N*20h  File List
... ..      File Data area
```

File List entries:

```
000h 4       Zero
004h 4       File Offset (increasing, 4-byte aligned, relative to Data Base)
008h 4       File Size in bytes (can be odd)
00Ch 4       Zero
010h 10h     Filename ("FILENAME.EXT", zeropadded)
```

MAT HOFFMAN'S PRO BMX (OLD DEMO) (MAGDEMO39: BMX\FE.WAD+STR) (UNCOMPRESSED)

MAT HOFFMAN'S PRO BMX (NEW DEMO) (MAGDEMO48: MHPB\FE.WAD+STR) (COMPRESSED)

```
WAD:
000h N*20h  File List
STR:
000h ..     File Data (MagDemo39: 4.5Mbyte, MagDemo48: compressed/2.8Mbyte)
File List entries:
000h 14h     Filename ("FILENAME.EXT", zeropadded)
014h 4       Offset in bytes, 4-byte aligned, in STR file
018h 4       Filesize, compressed (always rounded to multiple of 4 bytes)
01Ch 4       Filesize, decompressed (zero when not compressed)
```

The decompressor is using an Inflate variant with slightly customized block headers:

- end flag is processed immediately (instead of after the block)
- blocktype is only 1bit wide (instead of 2bit)
- stored blocks have plain 16bit len (without additional 16bit inverse len)

Everything else is same as described here:

CDROM File Compression ZIP/GZIP/ZLIB (Inflate/Deflate)

Instead of "tinf_uncompress", use the function below:

```
bmx_tinf_style_uncompress(dst,src)
  tinf_init()                ;init constants (needed to be done only once)
@@lop:
  if tinf_getbit()=0 then goto @@done    ;end flag, 1bit
  if tinf_getbit()=0 then                ;blocktype, 1bit
    tinf_align_src_to_byte_boundary()
    len=LittleEndian16bit[src], src=src+2    ;get len (without inverse len)
    for i=0 to len-1, [dst]=[src], dst=dst+1, src=src+1, next i    ;uncompressed
  else
    tinf_decode_dynamic_trees(), tinf_inflate_compressed_block()    ;compressed
  gpto @@lop
@@done:
  ret
```

Note: Apart from the MHPB\FE.WAD archive, many MHPB*.BIN files seem to be also compressed (unknown if that's the same compression method; and, if so, they would lack decompressed size info).

Entrysize=28h

DEMO MENU, PLAYSTATION MAGAZINE DEMO DISC 03-54, MENU.FF

Used on most PlayStation Magazine Demo Discs (Disc 03-54, except Disc 01-02)

Used on PlayStation Underground 3.1 (and maybe other issues)

Used on Interactive CD Sampler Disc Volume 10 (maybe others, but not Vol 4,5)

```
000h 4      Number of entries (eg. 20h or 28h)
004h N*28h  File List
... ..     Garbage padding to 800h-byte boundary
... ..     File Data
... ..     Huge zeropadding to 200000h or 2EE000h (2048Kbyte or 3000Kbyte)
```

File List entries:

```
000h 20h    Filename (terminated by 00h, padded with... looks like garbage)
020h 4      Size/800h
024h 4      Offset/800h (increasing)
```


Contains .BS, .TIM, .TXT, .VH, .VB files. The size seems to be always(?) 2048Kbytes, 2992Kbytes, 2000Kbytes, or 3000Kbytes (often using only the first quarter, and having the remaining bytes zeropadded).

TEST DRIVE 4 (MAGDEMO03: TD4.DAT) (HEADERSIZE=2000H, USED=0...H)

TEST DRIVE 5 (MAGDEMO13: TD5.DAT) (HEADERSIZE=3000H, USED=1EF8H)

DEMOLITION RACER (MAGDEMO27: DRIDD.DAT) (HEADERSIZE=5000H, USED=2328H)

This is used by several games, with different Headersizes (2000h or 3000h or 5000h), with Offsets relative to the Headersize. To detect the Headersize, skip used entries, skip following zeropadding, then round-down to 800h-byte boundary (in case the 1st file contains some leading zeroes).

```
000h N*28h File List (less than 0C00h bytes used in TD4 demo)
... .. Zeropadding to Headersize (2000h or 3000h or 5000h)
... .. File Data
```

File List entries:

```
000h 20h Filename ("PATH\FILENAME.EXT", zeropadded)
020h 4 Size in bytes
024h 4 (Offset-Headersize)/800h (increasing)
```

TD5.DAT and DD.DAT contain DOT1 child archives and many RNC compressed files:
[CDROM File Compression RNC \(Rob Northern Compression\)](#)

GEKIDO (MAGDEMO31: GEKIDO\GLOBAL.CD)

```
0000h N*28h File List
21C0h ... Unknown random gibberish? (23h,E8h,0Ch,1Dh,79h,C5h,24h,...)
4000h ... File Data area
```

File List entries:

```
000h 1Ch Filename ("PATH\FILENAME.EXT;0", zeropadded)
01Ch 4 Filesize in bytes
020h 4 Fileoffset in bytes (4000h and up, increasing)
024h 4 Filechecksum (32bit sum of all bytes in the file)
```

There is no "number of files" entry, and no "file list end marker" (though the "random gibberish" might serve as end marker, as long it doesn't start with "\" backslash).

TEAM BUDDIES (MAGDEMO37: BUDDIES\BUDDIES.DAT* AND NESTED *.BND FILES)

```

000h 4      ID "BIND"
004h 4      Number of files (N)
008h N*28h  File List
... ..     File Data area

```

File List entries:

```

000h 20h    Filename ("\FILENAME.EXT", zeropadded)
020h 4      File Offset (increasing, 4-byte aligned)      ;\see note
024h 4      File Size in bytes (always a multiple of 4)  ;/

```

Note: There is a 4-byte gap between most files, that appears to be caused by weird/bugged alignment handling done as so:

```

size=((filesize+3) AND not 3)      ;size entry for curr file (plus 3)
offs=((filesize+4) AND not 3)+offs ;offs entry for next file (plus 4 !!!)

```

Namely, odd file sizes (eg. for TXT files in BUDDIES.DAT\00D2h..00D7h) are forcefully rounded-up to 4 bytes boundary. If that rounding has occurred then there is no additional 4-byte gap (but the 4-byte gap will appear if the original filesize was already 4-byte aligned).

JUMPSTART WILDLIFE SAFARI FIELD TRIP (MAGDEMO52: DEMO\DATA.DAT)

```

000h 4      Number of entries (N)
004h 4      Number of entries (same as above)
008h 4      Number of entries (same as above)
00Ch 4      Number of entries (same as above)
010h N*28   File List
... ..     Zeropadding to 800h-byte boundary
... ..     File Data area
File List entries:
000h 20h    Filename ("\PATH\FILENAME.EXT", zeropadded)
020h 4      Offset/800h, from begin of Data area (increasing)
024h 4      Filesize in bytes

```

Entrysize=34h

ARMY MEN: AIR ATTACK (MAGDEMO28: AMAA\PAK*.PAK)

```

000h 4      Number of Files
004h N*34h  File List
... ..     Zeropadding to 4000h
4000h ..    File Data area
File List entries:
000h 10h    Filename ("FILENAME.EXT", zeropadded)
010h 4      Filesize in bytes ;\always both same, always

```

```

014h 4      Filesize in bytes ;/both multiple of 800h
018h 4      Zero
01Ch 4      Type      (07h..1Ah)
020h 4      Subtype  (00h..01h)
024h 10h    Zero

```

The used Type.Subtype values are:

```

07h.0      .TIM  (*.TIM)
07h.01h    .TIM  (HUD_*.TIM)
08h.0      .TIM  (PSTART.TIM)
09h.0      .TIM  (FONT.TIM)
0Ah.0      .SFX
0Eh.0      .MBL
10h.0      .ATR
11h.0      .RLC
13h.0      .AST
15h.0      .SCD
16h.0      .TXT  (PAUSED.TXT)
17h.0      .TXT  (OBJECT*.TXT)
18h.0      .BIN
1Ah.0      Misc  (.3DO=TIM, .V=TXT, and TERRAIN.CLP .HI .LIT .MAP .PAT .POB .TER)

```

Entrysize=40h

NINJA (MAGDEMO13: NINJA\CUTSEQ\WAD AND NINJA\WADS\WAD)

```

000h 4      Number of Files (N)
004h 4      Size of File Data area (SIZ) (total filesize-8-N*40h)
008h N*40h  File List
... SIZ     File Data area
File List entries:
000h 4      Filesize in bytes
004h 4      Fileoffset in bytes (zerobased, from begin of File Data area)
008h 38h    Filename, zeropadded

```

YOU DON'T KNOW JACK (MAGDEMO23: YDKJ\RES*.GLU)

YOU DON'T KNOW JACK 2 (MAGDEMO41: YDKJV2*.GLU)

```

000h 4      ID ("GLUE")
004h 4      Unknown (always 400h)
008h 4      Number of Files (N)
00Ch 4      Header Size (40h+N*40h)
010h 30h    Zerofilled
040h N*40h  File List
... ..     Garbage padding to alignment boundary
... ..     File Data area
File List entries:
000h 20h    Filename ("FILENAME.EXT", zeropadded)
020h 4      File Offset in bytes (increasing, 800h-byte aligned)

```

```

024h 4      File Size in bytes
028h 2      File ID Number 1 (eg. 1-71 for C01.GLU-C71.GLU)
02Ah 2      Unknown (random, checksum, ?)
02Ch 4      File ID Number 2 (eg. increasing: 1, 2, 3)
030h 10h    Zerofilled

```

Most .GLU files are 800h-byte aligned (except SHORTY\GLU and THREEWAY\GLU which use 4-byte alignment).

The files do start on alignment boundaries, but there is no alignment padding after end of last file.

EntrySize=60h

ARMY MEN AIR ATTACK 2 (MAGDEMO40: AMAA2\PACK\PAK)

```

000h 4      Number of entries (N)
010h N*60h  File List
... ..     Zeropadding to 2000h
2000h ..    File Data area
File List entries:
000h 4      Timestamp? (BFxxxxh..C0xxxxh) (or zero, in first file)
004h 4      Unknown (always 421C91h)
008h 4      Unknown (200h or 60200h)
00Ch 4      Filesize (uncompressed)
010h 4      Filesize (compressed, or 0 when not compressed)
014h 4      File Checksum (sum of all bytes in uncompressed file data)
018h 4      Unknown (random 32bit value?)
01Ch 10h    Filename ("FILENAME.EXT", zeropadded)
02Ch 4      Zerofilled
030h 4      Unknown (0 or 1 or 8)
034h 4      File Type (see below)
038h 8      Zerofilled
040h 4      Offset MSBs (Fileoffset-2000h)/800h ;\increasing, 4-byte aligned
044h 4      Offset LSBs (Fileoffset AND 7FFh) ;/(or zero when filesize=0)
048h 18h    Zerofilled

```

File Type values are 07h=TIM, 0Ah=SFX, 0Eh=MBL, 10h=ATR, 13h=AST, 15h=SCD, 19h=VTB, 1Bh=DCS, 1Dh=DSS, 1Eh=STR, 1Fh=DSM, 20h=FNT, 21h=TER, 25h=PMH, 26h=Misc.

Most of the files are SCRATCH compressed:

CDROM File Compression LZ5 and LZ5-variants

There are also several uncompressed files (eg. VERSION.V, *.SFX, and many of the TERRAIN.* files).

Entrysize=90h**GRIND SESSION (MAGDEMO33: GRIND\SLIP.GRV)****GRIND SESSION (MAGDEMO36: GRIND\SLIP.GRV)****GRIND SESSION (MAGDEMO42: GRIND\SLIP.GRV)****GRIND SESSION (MAGDEMO45: GRIND\SLIP.GRV)**

```

000h 4      ID (A69AA69Ah)
004h 4      Number of files (N)
008h N*90h File List
... ..     File Data area
File List entries:
000h 80h    Filename ("DATA\FILENAME.EXT",00h, plus CDh-padding)
080h 4      File Offset in bytes (increasing, 4-byte aligned)
084h 4      File Size in bytes
088h 8      Unknown (random/checksum?)

```

Variable Entrysize**HED/WAD**

```

Used by Spider-Man (MagDemo31,40: SPIDEY\CD.HED and CD.WAD)
Used by Spider-Man 2 (MagDemo52: SPIDEY\CD.HED and CD.WAD)
Used by Tony Hawk's Pro Skater (MagDemo22: PROSKATE\CD.HED and CD.WAD)
Used by Apocalypse (MagDemo16: APOC\CD.HED and CD.WAD)           ;with PADBUG
Used by MDK (Jampack Vol. 1: MDK\CD.HED and CD.WAD)               ;without ENDCODE
Used by Mat Hoffman's Pro BMX (old demo) (MagDemo39: BMX\BMXCD.HED+WAD)

```

Format of the CD.HED file:

```

000h ..     File Entries (see below)
... (1) End code (FFh) (if any, not present in MDK)

```

File Entry format:

```

000h ..     Filename (ASCII, terminated by 00h, zeropadded to 4-byte boundary)
... 4       Offset in CD.WAD (in bytes, usually 800h-byte aligned)
... 4       Filesize (in bytes)

```

PADBUG: Apocalypse does append 1..800h bytes alignment padding (instead of 1..7FFh or 0 bytes).

DANCE UK (DATA.PAK)

```

000h 4      Number of Files (N) (1ADh)
004h 4      Unknown (7) (maybe HeaderSize/800h, same as first Offset/800h ?)
008h 4      Unknown (1430h = 14h+N*0Ch, same as first Name pointer)
00Ch 4      Unknown (1430h = 14h+N*0Ch, same as first Name pointer)
010h 4      Unknown (1430h = 14h+N*0Ch, same as first Name pointer)
014h N*4    Name List (pointers to name strings, 1430h and up) 6B4h bytes
... N*4     Size List (filesize in bytes) 6B4h bytes
... N*4     Offset List (Offset/800h) 6B4h bytes
... N*var   Name Strings (ASCII strings, "folder\filename.ext",00h)
... ..     Zerofilled (padding to 800h-byte boundary)
... ..     File Data area

```

KULA QUEST / KULA WORLD / ROLL AWAY (*.PAK)

```

000h 4      Number of Files (N)
004h N*8    File List (2x32bit entries: Offset, Size) (unaligned, can be odd)
... N*4     File Name Offsets
... N*var   File Name Strings ("FILE NN",0Ah,00h)
... ..     Garbage-padding to 4-byte boundary
... (4)     Optional extra garbage? ("MON " in ATLANTFI.PAK, MARSFI.PAK, etc.)
... ..     File Data area (ZLIB compressed, starting with big-endian 789Ch)

```

CDROM File Compression ZIP/GZIP/ZLIB (Inflate/Deflate)

LARGO WINCH - COMMANDO SAR (NTEXTURE\GRP AND LEVELS\DCF*.CAT AND *.GRP)

```

000h 4      ID (12h,34h,56h,78h) (aka 12345678h in big endian)
004h 4      Header Size (offset to File Data area)
008h 4      Number of Entries (can be 0=None, eg. LEVELS\LARGO07.DCF\Z16.CAT)
00Ch N*var  Name List (Filenames in form "FILENAME.EXT",00h)
... ..     Zeropadding to 4-byte boundary
... N*4     Size List (Filesizes in bytes)
... ..     File Data area

```

JACKIE CHAN STUNTMASER (RTARGET\GAME.GCF AND LEV*.LCF)

```

000h 4      Number of files (N) (3..EBh) (big-endian)
004h N*Var  File List (list size is implied in first file offset)
... ..     Zeropadding to 800h-byte boundary
... ..     File Data area
File List entries:
000h 4      File Type (ascii, .LLN .TXI .TPG .RCI .RCP .WDB .PCI .PCP .BLK)
004h 4      File Size (can be odd) (big-endian)
008h 4      File Offset (increasing, 800h-byte aligned) (big-endian)
00Ch 4      Extra Size (0 or 4 or 8) (big-endian)
010h ..     Extra Data (if any) (32bit number, or "TEXTURES")

```

SYPHON FILTER 1 (MAGDEMO18: SYPHON\HOG, SYPHON\SUBWAY.FOG\HOG,SLF.RFF)**SYPHON FILTER 2 (MAGDEMO30: SYPHON\HOG, SYPHON\TRAIN.FOG\HOG,SLF.RFF)**

```

000h 4      Timestamp? (36xxxxxxh=v1?, 38xxxxxxh=v2?, other=SLF.RFF)
004h 4      Number of Files          (N)
008h 4      Base for Offset List    (always 14h)
00Ch 4      Base for String Table (v1=N*4+14h, or v2=N*4+18h)
010h 4      Base for File Data (end of String Table plus align 4/800h/920h)
014h N*4    Offsets to File(s) (increasing, first=0, relative to above [010h])
... (4)     v2 only: End Offset for Last File (HOG filesize minus [010h])
... ..     String Table (filename list in form of "FILENAME.EXT",00h)
... ..     Zeropadding to 4-byte or 800h-byte boundary
... ..     File Data area

```

There are two versions: Syphon Filter 1 (v1) and Syphon Filter 2 (v2):

```

v1 has [0Ch]=N*4+14h (without end-of-last-file entry; use end=total_size)
v2 has [0Ch]=N*4+18h (and does have end-of-last-file entry)
v1 has STR files in ISO filesystem (not in HOG archives)
v2 has STR files in MOVIES.HOG (with [10h]=920h and [14h and up]=sectors)

```

Normally, the following is common for v1/v2:

```

v1/v2 has [10h]=data base, aligned to 4 or 800h
v1/v2 has [14h and up] in BYTE-offsets, relative to base=[10h]
v1/v2 uses HOG format in .HOG files also in SLF.RFF
v1/v2 has further .RFF files (but that aren't in HOG format)

```

There are several inconsistent special cases for some v2 files:

```

v2 MOVIE.HOG has [10h]=920h (which is meant to mean base="after 1st sector")
v2 MOVIE.HOG has [14h and up] in SECTOR-units, with base="after 1st sector"
v2 SLF.RFF does contain two HOG archives badged together (plus final padding)
v2 has some empty 0-byte .HOG files (at least so in demo version)

```

Danger: The special value 920h means that headersize is one 800h-byte sector (whereas 920h is dangerously close to REAL headersize, eg. v1 PCHAN.HOG has headersize=908h which means one 800h-byte sector plus 108h bytes) (the 920h thing should occur only in v2 though, since v1 has STR files stored in ISO filesystem instead of in HOG archives).

ELECTRONIC ARTS 32BIT BIGF ARCHIVES

```

000h 4      ID "BIGF" (normal case, all big-endian, 4-byte aligned)      ;\
          ID "BIGH" (with [04h]=little-endian instead big-endian)      ;
          ID "BIG4" (with 40h-byte alignment padding instead 4-byte)   ;
004h 4      Sum of Header+Filesizes (excluding Padding's!) (big-endian) ; Header
008h 4      Number of entries (N)                                     ;11h (big-endian) ;

```

```

00Ch 4   Size of Header (including File List)   ;11Fh   (big-endian) ;
010h ..  File List                               ;/
... ..  Padding to 1/4/8-byte boundary (optional, before each file) ;\Data   ... ..
File Data                                     ;/

```

File List entries (with variable length names, entries aren't 4-byte aligned):

```

000h 4   Offset in bytes (increasing, often 4/8-byte aligned)   (big-endian)
004h 4   Size in bytes (can be odd, but often rounded to 4-byte) (big-endian)
008h ..  Filename (ASCII, terminated by 00h) ;variable length
Note: Filenames can be empty ("",00h) (eg. in WCWDEMO\ZSOUND.BIG)

```

Used by PGA Tour 96, 97, 98 (*.VIV)

Used by FIFA - Road to World Cup 98 (MOP*.BK*, Z4TBLS.BIG\..t, ZMO*.BIG\..viv)

Used by Fifa 2000 (Best Sports demo: FIFADEMO\..BIG, *.SBK, and nested .viv)

Used by Need for Speed 3 Hot Pursuit (.VIV)*

Used by WCW Mayhem (MagDemo28: WCWDEMO\..BIG) (odd filesizes & nameless files)

This is reportedly also used for various other Electronic Arts games for PC, PSX, and PS2 (often with extension *.BIG, *.VIV).

Reportedly also "BIGH" and "BIG4" exist:

http://wiki.xentax.com/index.php/EA_BIG_BIGF_Archive

Other Electronic Arts file formats (used inside or alongside big archives):

[https://wiki.multimedia.cx/index.php/Electronic_Arts_Formats_\(2\)](https://wiki.multimedia.cx/index.php/Electronic_Arts_Formats_(2)) - BNK etc

ELECTRONIC ARTS 24BIT C0FB ARCHIVES

```

000h 2   ID C0FBh                               (C0h,FBh)   (big-endian)   ;\
002h 2   Size of Header-4                       (00h,15h)   (big-endian)   ; Header
004h 2   Number of Files                       (00h,01h)   (big-endian)   ;
006h ..  File List                               ;/
019h ..  Padding to 4-byte boundary?             ; -Padding
01Ch ..  File Data                               ; -Data
... 4    "CRCF"                                   ;\
... 4    Unknown (0C,00,00,00) (chunk-size little-endian?) ; Footer
... 4    Unknown (3B,2E,00,00) (checksum maybe?) ;/

```

File List entries (with variable length names, and unaligned 24bit values):

```

000h 3   Offset in bytes (increasing)           ; (big-endian, 24bit)
004h 3   Size in bytes                           ; (big-endian, 24bit)
008h ..  Filename (ASCII, terminated by 00h) ;variable length

```


Used by FIFA - Road to World Cup 98 (*.BIG)

Used by Sled Storm (MagDemo24: ART\ZZRIDER.UNI, with 8 files insides)

DESTRUCTION DERBY RAW (MAGDEMO35: DDRAW*.PTH+.DAT, AND NESTED THEREIN)

```
PTH File:
  000h N*var File List
DAT File:
  000h ..    File Data area
```

File List entries:

```
000h ..    Filename ("FILENAME.EXT",00h) (variable length)
...  4      File Size in bytes (can be odd)
...  4      File Offset in bytes in DAT file (increasing, unaligned)
```

Caution: Filenames in PTH archives aren't sorted alphabetically (so DAT isn't always guaranteed to be the previous entry from PTH, namely, that issue occurs in MagDemo35: DDRAW\INGAME\NCKCARS.PTH*.PTH+DAT).

Caution: The whole .DAT file can be compressed: If the sum of the filesizes in PTH file does exceed the size of the DAT file then assume compression to be used (normally, the top-level DATs are uncompressed, and nested DATs are compressed).

CDROM File Compression PCK (Destruction Derby Raw)

SNOCROSS CHAMPIONSHIP RACING (MAGDEMO37: SNOCROSS\SNOW.TOC+.IMG)

```
TOC:
  000h N*var File List
IMG:
  000h ..    File Data area
```

File List entries:

```
000h ..    Filename ("DATA\FILENAME.EXT",00h) (variable length)
...  4      File Offset (increasing, 800h-byte aligned, in .IMG file)
...  4      File Size in bytes
```

Resembles DDRAW*.PTH+.DAT (but Offset/Size are swapped, and uses 800h-align).

Note: The archive contains somewhat corrupted TGA's:

```
TGA[10h..11h] = 08h,08h  ;bpp=8 (okay) and attr=8 (nonsense)
TGA[10h..11h] = 10h,01h  ;bpp=16 (okay) and attr=1 (okay) but it's yflipped
```

13.32 CDROM File Archives with Offset and Size

Crash Team Racing (retail: BIGFILE.BIG, and MagDemo30/42: KART\SAMPLER.BIG)

```
000h 4      Zero
004h 4      Number of Files (260h)
010h N*8    File entries
... ..     Zeropadding to 800h byte boundary
... ..     File Data
```

File Entries:

```
000h 4      Fileoffset/800h (increasing)
004h 4      Filesize in bytes
```

Filetypes in the archive include...

```
MDEC v2 STR's  (file 1E1h..1F8h,1FAh)
TIM textures   (file 01FBh..0200h and others)
empty files    (file 01F9h and others)
small archives with named entries (file B5h,124h,125h,126h and others)
stuff with date string and names (file 253h,256h)
there seem to be no nested BIG files inside of the main BIG file
```

Black Matrix (*.DAT)

```
000h 4      Number of files (N) (eg. 196h)
004h 4      Unknown (always 0Bh) (maybe sector size shift?)
008h N*4    File List
... ..     Zeropadding to 800h-byte boudary
... ..     File Data
```

File List entries:

```
000h 2      Offset/800h (increasing)
002h 2      Size/800h (can be zero)
```

The "files" might actually contain small child folders? Or the whole stuff is just some kind of data structure, not an actual file system archive.

Charumera (*.CVF)

```
000h N*4    File List
... ..     Zeropadding to 800h-byte boundary
... ..     File Data area
```

File List entries:

```
000h 1      Size/800h      (8bit)
001h 3      Offset/800h (24bit, increasing)
```

Vs (MagDemo03: THQ*) has .CDB archives

```
000h N*8    File List
... ..      Zeropadding to 800h-byte boundary
... ..      File Data
... ..      Garbage padding (can be several megabytes tall)
```

File List entries:

```
000h 2      Offset/800h (increasing)
002h 2      Size/800h (same as below, rounded up to sector units)
004h 4      Size in bytes
```

Note: The files may consist of multiple smaller files badged together (eg. DISPLAY.CDB contains several TIMs per file).

Some CDB archives have garbage padding at end of file: BIN.CDB (2Kbyte), CSEL.CDB (80K), DISPLAY.CDB (70K), MOT.CDB (10648Kbyte). Maybe that's related to deleted files in the Vs demo version and/or to updating the CDB archives with newer/smaller content, but without truncating the CDB filesize accordingly.

Monster Rancher (MagDemo06: MR_DEMO*.OBJ)**Deception III Dark Delusion (MagDemo33: DECEPT3\K3_DAT.BIN)****Star Trek Invasion (MagDemo34: STARTREK\STARTREK.RES)**

Similar as .CDB archives (but with 32bit offset, and without duplicated size).

```
000h N*8    File List
... 4       File List end marker (00000000h)
... ..      Garbage padding to 800h-byte boundary
... ..      File Data
```

File List entries:

```
000h 4      Offset/800h (increasing)
004h 4      Size in bytes (often zero; for unused file numbers)
```

Note: Files are usually padded with 0..7FFh bytes to 800h-byte boundary, but STARTREK.RES does append additional 800h-byte padding after each file (ie. 800h..FFFh padding bytes in total).

Einhandler (MagDemo08: BININDEX.BIN/BINPACK0.BIN/BINPACK1.BIN)

```
000h X*4  File List for BINPACK0.BIN          ;\
... ..   Zeropadding                        ; BINPACK0
410h ..   Unknown (some/all of it looks like garbage) ;/
800h Y*4  File List for BINPACK1.BIN          ;\
... ..   Zeropadding                        ; BINPACK1
C10h ..   Unknown (some/all of it looks like garbage) ;/
```

File List entries:

```
000h 2      Offset/800h in BINPACK0.BIN or BINPACK1.BIN
002h 2      Size/800h
```

SO98 Archives (NBA Shootout '98, MagDemo10: SO98..*.MDL *.TEX *.ANI *.DAT)

Resembles .BZE (in terms of duplicated size entry).

```
000h 4      Number of Files
004h 4      Size of File Data area (total filesize-N*0Ch-8)
008h N*0Ch  File List
... ..      File Data area
```

File List entries:

```
000h 4      Offset (zerobased, from begin of File Data area)
004h 4      Size in bytes
008h 4      Size rounded to mutiple of 4-bytes
```

.DAT contains .TIM .SEQ .VB .VH and nested SO98 archives

.MDL contains whatever (and empty 0-byte files)

.TEX contains .TIM

.ANI contains whatever

Gran Turismo 1 (MagDemo10: GT*.DAT) GT-ARC

Gran Turismo 1 (MagDemo15: GT*.DAT) GT-ARC

Gran Turismo 2 (GT2.VOL\arcade\arc_fontinfo) GT-ARC

```

000h 0Ch   ID "@(#)GT-ARC", 00h, 00h
00Ch 2     Content Type (8001h=Compressed, 0001h=Uncompressed)
00Eh 2     Number of Files (eg. 0Fh)
010h N*0Ch File List
... ..    File Data area
File List entries:
000h 4     Offset in bytes (increasing, unaligned)
004h 4     Compressed File Size (can be odd)   ;\both same when uncompressed
008h 4     Decompressed File Size             ;/(ie. when [00Ch]=0001h)

```

MESSAGES.DAT, SOUND.DAT, TITLE.DAT which are completely uncompressed GT-ARC's. Most other GT-ARC's contain LZ compressed files. In case of CARINF.DAT it's vice-versa, the files are uncompressed, but the GT-ARC itself is LZ compressed (the fileheader contains 00h,"@(#)GT-A",00h,"RC",00h,00h; it can be detected via those bytes, but lacks info about decompressed size).

CDROM File Compression GT-ZIP (Gran Turismo 1 and 2)

O.D.T. (MagDemo17: ODT*.LNK and ODT\RSC\NTSC\ALLSOUND.SND and nested LNK's)

Barbie Explorer (MagDemo50: BARBIEX*.STR and nested therein)

```

000h 4     Number of Files (N)
004h N*8   File List
... ..    File Data area

```

File List entries:

```

000h 4     Offset in bytes (increasing, 1/4-byte? aligned)
004h 4     File Size in bytes (usually N*4, TXT's in ODT are padded as so)

```

Quirk: Instead of rounding only Offsets to N*4 byte boundary, all Sizes are rounded to N*4 bytes (eg. TXT files in ODT\RSC\NTSC\GFILES.LNK\01 with odd number of characters are zero padded to N*4 bytes).

Note: The PADBUG archives in Final Fantasy VIII (FF8) are very similar (but have a different alignment quirk).

Bust A Groove (MagDemo18: BUSTGR_A\DFS and BUSTGR_B\DFS) (DFS)

Bust-A-Groove 2 (MagDemo37: BUSTAGR2\BUST2.BIN*) (main=DF2 and child=DFS)

Same as in O.D.T. with extra "DFS_" ID at start of file.

```

000h 4      ID "DFS_" (with align 4) or "DF2_" (with align 800h)
004h 4      Number of Files (N)
008h N*8    File List
... ..     File Data area
File List entries:
000h 4      Fileoffset in bytes (4-byte or 800h-byte aligned, increasing)
004h 4      Filesize in bytes (can be odd, eg. in BUSTGR_A\SELECT.BPE\*)

```

The game does use uncompressed DFS archives (in .DFS files) and compressed DFS archives (in .BPE files):

CDROM File Compression BPE (Byte Pair Encoding)

The game does also use .DBI files (which contain filenames and other strings, whatever what for).

Monaco Grand Prix Racing Simulation 2 (MagDemo24: EXE\I.SUN)

Same as DFS, but with Total Filesize instead of "DFS_".

```

000h 4      Total used filesize (excluding zeropadding to 2EE000h)
004h 4      Number of Files (N)
008h N*8    File List
... ..     File Data area
... (..)    In some files: Zeropadding to 2EE000h (3072Kbytes)

```

File Entries:

```

000h 4      Offset (increasing, 4-byte aligned, see note)
004h 4      Filesize in bytes (can be odd in Monaco)

```

Note: The alignment in Monaco is a bit glitchy:

```

If (Size AND 3)=0 then NextOffset=Offset+Size           ;Align4
If (Size AND 3)>0 then NextOffset=Offset+Size+Align800h ;Align800h
Namely, Monaco has files with Size=3BC5h.

```

The first file starts with unknown 32bit value, followed by "pBAV".

Rollcage (MagDemo19: ROLLCAGE\SPEED.IMG) (2Mbyte)

Rollcage Stage II (MagDemo31: ROLLCAGE\SPEED.IDX+SPEED.IMG) (3Kbyte+9Mbyte)

Sydney 2000 (MagDemo37: OLY2000\DEMO.IDX+DEMO.IMG) (1Kbyte+2Mbyte)

```

Rollcage 1 uses a single IMG file that contains both directory and data:
000h 4      Header offset (0)                ;\
004h 4      Header size (10h+N*10h)          ; this seems to be a File List entry
008h 4      Header size (10h+N*10h)          ; for the header itself
00Ch 4      Zero                             ;/
010h N*10h  File List                        ;-File List for actual files
... ..     Zeropadding to 800h-byte boundary
... ..     File Data area
Number of files is "IMG[04h]/10h" (minus 1 for excluding the header itself)
The other titles have seaparate IDX and IMG files for directory and data:
SPEED.IDX = Directory (N*10h bytes File List with offsets into SPEED.IMG)
SPEED.IMG = File data
Number of files is "Filesize(SPEED.IDX)/10h"

```

File List entries:

```

000h 4      Fileoffset in bytes (800h-byte aligned, increasing)
004h 4      Filesize in bytes
008h 4      When compressed:   GT20 Header [004h] (decompressed size)
           When uncompressed: Same as filesize
00Ch 4      When compressed:   GT20 Header [008h] (overlap, usuallly 3, or 7)
           When uncompressed: Zero

```

The compression related entries allow to pre-allocated the decompression buffer (without needing to load the actual GT20 file header), and then load the comprssed file to the top of the decompression buffer.

CDROM File Compression GT20 and PreGT20

Ultimate 8 Ball (MagDemo23: POOL.DAT) (5.5Mbyte)

```

000h 4      Number of Entries
004h N*0Ch  File List
... ..     Zeropadding to 800h-byte boundary
... ..     File Data area
File List entries:
000h 4      Unknown (random/checksum?)
004h 4      File Offset (800h-byte aligned, increasing)
008h 4      File Size in bytes

```

Notes: The LAST file isn't zeropadded to 800h-byte boundary. The File List includes some unused entries (all 0Ch-bytes zerofilled).

BIGFOOL - 3D Baseball (BIGFILE.FOO)

```

000h N*0Ch  File List                                (154h entries)
...  N*4    Filename Checksums (?)                    (154h entries)

```

```
... .. Zerofilled (padding to 800h-byte boundary)
... .. File Data area
```

The 1st list entry describes the current directory itself, as so:

```
000h 4      Number of entries (including the 1st entry itself)
004h 4      Offset/800h (always 0, relative from begin of directory)
008h 4      Type              (always 3=Directory)
```

Further list entries are Files or Subdirectories, as so:

```
000h 4      For Files: Size in bytes, for Directories: Number of entries
004h 4      Offset/800h (from begin of current directory, increasing)
008h 4      Type              (0=File, 3=Directory)
```

Spec Ops - Airborne Commando (BIGFILE.CAT and nested CAT files therein)

```
000h 4      File ID                      (always 01h,02h,04h,08h)
004h 4      Maybe Version?                (always 01h,00h,01h,00h)
008h 4      Header Size (18h+N*8+ArchiveNameLength) ;eg. 4ECh
00Ch 4      Sector Alignment (can be 4 or 800h)
010h 4      Number of Files (N)           ;eg. 99h
014h 4      Length of Archive Name (including ending 00h)
018h N*8    File entries (see below)
... ..      Archive Name, ASCII, terminated by 00h ;eg. "bigfile.dir",00h
... ..      Zeropadding to Sector Alignment boundary
... ..      File Data
```

File Entries:

```
000h 4      Fileoffset (with above Sector Alignment) (increasing)
004h 4      Filesize in bytes
```

Filetypes in the archive include...

```
nested CAT archives (file 07h,0Ch,11h,16h,1Bh,20h,25h,etc)
empty files          (file 3Eh,5Ah-5Fh,62h-67h,etc)
MDEC v2 STR's        (file 95h-96h)
XA-ADPCM's           (inside of nested CAT, in file94h\file*)
```

There are "strings" in some files, are those filenames, eg. Icon_xxx etc?

Hot Shots Golf 2 (retail: DATA\F0000.BIN, MagDemo31/42: HSG2\MINGOL2.BIN)

The DATA directory is 13800h bytes tall. But, the PSX kernel supports max 800h bytes per ISO directory (so the kernel can only see the first 33 files in that directory). The

game isn't actually trying to parse the ISO directory entries, instead, it's using the 2800h-byte offset/size list in F0000.BIN to access the directory content:

```
0000h+N*4 1      Sector MM in BCD      ;\based at 00:06:00 for file 0
0001h+N*4 1      Sector SS in BCD      ; (unused files are set to 00:00:00)
0002h+N*4 1      Sector FF in BCD      ;/
0003h+N*4 1      Size MSB in hex (Size/800h/100h)
2000h+N 1        Size LSB in hex (Size/800h AND FFh)
2800h      (..)   Data area for file 001h..590h (demo version only)
```

Retail Version disc layout:

```
Sector 000ADh SCUS_944.76      ;exefile      ;\
Sector 00130h SYSTEM.CNF      ; iso root folder
Sector 00131h DATA (sub-folder, 27h sectors) ;/
Sector 00158h (padding)        ; -padding to 00:06:00
Sector 001C2h DATA\F0000.BIN  ;file 000h    ;\
Sector 001C7h DATA\F0001.BIN  ;file 001h    ;
...                               ; iso data folder
Sector 00B54h DATA\F0032.BIN  ;file 020h    ;
Sector 00B9Bh DATA\F0033.BIN  ;file 021h    ; ;\files exceeding the 800h
...                               ; ; directory size limit, not
Sector 1A0C9h DATA\F1907.BIN  ;file 773h    ;/ ;/accessible via PSX kernel
Sector 1AAF1h DUMMY.BIN        ; -iso root folder (padding)
```

Demo version in Playstation Magazine is a bit different: It has only two large .BIN files (instead of hundreds of smaller .BIN files). The directory is stored in first 2800h bytes of MINGOL2.BIN. The MM:SS:FF offsets are numbered as if they were located on sector 00:06:00 and up (to get the actual location: subtract 00:06:00 and then add the starting sector number of MINGOL2.BIN).

```
Sector 07148h HSG2\MINGOL2.BIN ;file 000h..590h ;demo binary files
Sector 0AC1Dh HSG2\MINGOL2X.BIN ;file 76Ch      ;demo streaming file(s)
Sector 0B032h HSG2\SCUS_944.95 ;exefile      ;demo exe file
```

Note: File 000h is a dummy entry referring to the 2800h-byte list itself (retail file 000h has offset=00:06:00 but size=0, demo file 000h has offset and size set to zero). File 001h is the first actual file (at offset=00:06:05, ie. after the 2800h-byte list)

Threads of Fate (MagDemo33: TOF\DEWPRISM.HED+.EXE+.IMG)

The demo version uses "Virtual Sectors" in HED+EXE+IMG files. Apart from that, the format is same as for the "Hidden Sectors" in retail version:

[CDROM File Archives in Hidden Sectors](#)

WWF Smackdown (MagDemo33: TAI\PAC\, and nested therein)

These "PAC " files are found in the main archives (which use a separate archive format, with ID "DPAC").

```

000h 4      ID ("PAC ")                      ;\
004h 4      Number of files (N)              ; Header
008h N*8    File List                        ;/
... ..     File Data area                    ;-Data area

```

File List entries:

```

000h 2      File ID (increasing, but may skip numbers, ie. non-linear)
002h 3      File Offset (increasing, relative to begin of Data area)
005h 3      File Size

```

Bug: TAI\C.PAC\EFFC\0001h has TWO entries with File ID=0002h.

Tyco R/C Racing (MagDemo36: TYCO\MAINRSRC.BFF)

```

000h 4      Unknown (1)
004h 4      Filelist Offset                  (800h)
008h 4      Filelist Size (N*8+4)           (7ACh)
... ..     Padding to 800h-byte boundary (see note)
800h 4      Number of files (N)              (F5h)
804h N*8    File List
... ..     Padding to 800h-byte boundary (see note)
... ..     File Data area

```

File List entries:

```

000h 4      File Offset in bytes (increasing, 800h-byte aligned)
004h 4      File Size in bytes

```

Padding Note: Padding after headers & files is weirdly done in two steps:

```

Step 1: Zeropadding to 200h-byte boundary    (first 0..1FFh bytes)
Step 2: Garbagepadding to 800h-byte boundary (last 0..600h bytes)

```

Team Buddies (MagDemo37: BUDDIES\BUDDIES.DAT)

```

000h 2      ID ("BD")
002h 2      Number of files (N)
004h N*8    File List
... ..     Zeropadding to 3000h
3000h ..    File Data area

```

File List entries:

```

000h 4      File Offset/800h (increasing)
004h 4      File Size in bytes

```

Gundam Battle Assault 2 (DATA*.PAC, and nested therein)

```

000h 4      ID ("add",00h)
004h 4      Fixed (4)
008h 4      Offset to File List (usually/always 20h)
00Ch 4      Number of Files (N)
010h 4      Fixed (10h)
014h 0Ch    Zerofilled
020h N*10h  File List
... ..     File Data area

```

File List entries:

```

000h 4      Offset (increasing, 4-byte aligned)  ;\or both zero
004h 4      Size (can be odd)                    ;/
008h 4      Unknown (0) (or 00h,10h,11h,20h,30h,40h when Offset/Size=0)
00Ch 4      Zero (0)

```

Incredible Crisis (MagDemo38: IC*.CDB)

```

000h 4      Number of files (N)
004h N*4    File List
... ..     Zeropadding to 800h-byte boundary

```

File List entries:

```

000h 2      File Offset/800h (increasing)
002h 2      File Size/800h

```

Ape Escape Sound Archive (MagDemo22:KIDZ\KKIIDDZZ.HED\DAT\1Bh-1Dh,49h-53h,..)**Ape Escape Sound Archive (MagDemo44:KIDZ\KKIIDDZZ.HED\DAT\1Bh-1Dh,4Fh-59h,..)**

```

000h 5*4    File Sizes (can be odd) (can be 0 for 2nd and 5th file)
014h 5*4    File Offsets (28h and up, increasing by sizes rounded to N*10h)
028h ..     File Data area (first file usually/always contains "SShd")

```

Ultimate Fighting Championship (MagDemo38: UFC\CU00.RBB)

```

0000h 4    ID "siff"                                ;\Header
0004h 4    Total Filesize (DADB1Ch)                 ;/
0008h 4    ID "RSRC"                                ;\
000Ch 4    String Size (70h)                        ; ASCII string
0010h 70h  String "RC ver1.0 Copyright",...,00h     ;/
0080h 4    ID "RIDX"                                ;\
0084h 4    File List Size      (1F78h) (3EFh*8)      ; Directory
0088h N*8  File List (Offset, Size1)                 ;/
2000h 4    ID "EXIX"                                ;\
2004h 4    Extended List Size (FBCh)  (3EFh*4)       ; Extended
2008h N*4  Extended List (Size2)                     ;/
2FC4h 4    ID "GAP0"                                ;\Alignment Padding
2FC8h 4    Padding Size (2Ch)                       ; (so that next chunk
2FCCh 2Ch  Padding (1Ah-filled)                     ;/starts at boundary-8)
2FF8h 4    ID "RBB0"                                ;\
2FFCh 4    File Data area Size (DAAB1Ch)            ; Data area
3000h ..   File Data area                           ;/

```

File List entries (RIDX):

```

000h 4      File Offset (increasing, 4-byte aligned, from ID "RBB0" plus 8)
004h 4      File Size in bytes (can be odd)

```

Extended List entries (EXIX):

```

000h 4      File Size in bytes (always the same size as in RIDX chunk)

```

Ultimate Fighting Championship (MagDemo38: UFC\CU00.RBB\183h,37Bh..3EBh)

```

000h 4    ID "OIFF"                                ;\Header
004h 4    Total Filesize                            ;/
008h 4    ID "TIMT" or "ANMT"                       ;\
00Ch 4    Size (N*4)                                ; Directory Table
010h N*4  File List (offsets from begin of Data ID+8);/
... 4     ID "TIMD" or "ANMD"                       ;\
... 4     Data Area size (SIZ) (Filesize-18h-N*4)    ; Data area
... SIZ   Data Area                                 ;/

```

E.T. Interplanetary Mission (MagDemo54: MEGA\MEGA.CSH+.BIN)

```

MEGA.CSH:
  000h N*0Ch File List
MEGA.BIN:
  000h ..   File Data area

```

File List entries:

```

000h 4      Offset (in MEGA.BIN file, 800h-byte aligned, increasing)
004h 4      Unknown (32bit id/random/checksum/whatever)
008h 4      Filesize in bytes

```

Driver 2 The Wheelman is Back (MagDemo40: DRIVER2\SOUND\I)

```

000h 4      Number of entries (1 or more)
004h N*10h File List
... ..     File Data area (.VB aka SPU-ADPCM)
File List entries:
000h 4      Offset from begin of Data area, increasing
004h 4      Filesize in bytes
008h 4      Unknown (0 or 1)
00Ch 4      Unknown (AC44h, 0FA0h, 2EE0h, 2710h, 2B11h, 3E80h, 1F40h, etc.)
Note: Above AC44h might 44100Hz, or just file number 44100 decimal?

```

Thrasher: Skate and Destroy (MagDemo27: SKATE\ASSETS*.ZAL) (Z-Axis)

Dave Mirra Freestyle BMX (MagDemo36: BMX\ASSETS*.ZAL) (Z-Axis)

Dave Mirra Freestyle BMX (MagDemo46: BMX\ASSETS*.ZAL) (Z-Axis)

```

000h 4      ID (always 2A81511Ch)
004h 0Ch    Zerofilled
010h 1      Unknown (1)
011h 1      Compression Flag for all files (00h=Uncompressed, 80h=Compressed)
012h 2      Number of files (bit0-13?=N, bit14=Unknown, can be set)
014h N*0Ch File List, 12 bytes/entry      ;<-- when [11h]=00h=uncompressed
014h N*10h File List, 16 bytes/entry      ;<-- when [11h]=80h=compressed
... ..     File Data area

```

File List entries (0Ch or 10h bytes per entry, depending on compression):

```

000h 4      File ID (usually 0=first, increasing) (or 0001h,7531h,7532h,...)
004h 4      Offset-10h in bytes (increasing, 4h-byte aligned)
008h 4      Filesize, uncompressed (can be odd)
00Ch (4)    Filesize, compressed (can be odd) ;<-- exists only if compressed

```

For decompression, see:

[CDROM File Compression ZAL \(Z-Axis\)](#)

Speed Punks (MagDemo32: SPUNKS*.GDF)

```

000h 4      ID "0FDG XSP" (aka PSX GDF0 backwards)
008h 4      Header Size (N*10h+10h)

```

```

00Ch 4      Number of files (N)
010h N*10h File List
... ..      Zeropadding to 800h-byte boundary
... ..      File Data area
File List entries:
000h 4      ID/Type ("MARV", "MARS", "MARD", "PMET", "COLR", "MROF")
004h 4      ID/Num (usually 1 SHL N, or all zero)
008h 4      Offset (800h-byte aligned, increasing)
00Ch 4      Size in bytes

```

Legend of Dragoon (MagDemo34: LOD\SECT*.BIN, and nested therein)

```

000h 4      ID "MRG",1Ah
004h 4      Number of Files (eg. 0, 1, 2, 193h, 2E7h, or 1DBBh)
008h N*8    File List
... ..      Padding to 800h-byte boundary (8Ch-filled) (not in nested MRG's)
... ..      File Data area
File List entries:
000h 4      Offset/800h, or 4-byte aligned Offset/1 (increasing)
004h 4      Size (can be odd, and can be zero)
Size oddities:
Empty files in demo version have Size=0 and Offset=0.
Empty files in retail version have Size=0 and Offset=OffsetOfNextFile.
MRG archives can start or end with Empty files.
All files can be empty (eg. retail DRAGN0.BIN\1190h).
NumFiles can be zero (eg. retail DRAGN0.BIN\1111h, demo DRAGN0.BIN\10E2h).
Offset oddities:
SECT\*.BIN have Offset/800h
Nested MRGs have 4-byte aligned Offset/1
The two variants can be detected as:
  if FirstOffset=(NumFiles*8+8) then NestedVariant
  if FirstOffset=(NumFiles*8+8+7FFh) AND NOT 7FFh then RootVariant
Whereas, FirstOffset is the first NONZERO offset in file list (important
for demo version, which has archives that start with ZERO offsets).

```

RC Revenge (MagDemo37: RV2\BB\3.BBK and Retail: BB*.BBK)

This does basically contain four large files (and four info blocks with info on the content of those files).

```

000h 4      Random/Checksum?
004h 4      Faded ID (FADED007h)
008h 4      Part 1 Offset (Sound)      (always E5Ch)
00Ch 4      Part 2 Offset (Texture)    (when Type=01h: Offset-E5Ch)
010h 4      Part 3 Offset (?)          (when Type=01h: Offset-E5Ch)
014h 4      Part 4 Offset (?)          (when Type=01h: Offset-E5Ch)
018h 4      Type (10h or 20h=Normal)   (or 01h=Special in BB\8\*.BBK)
01Ch B0Ch   Part 1 Info (Sound)        (when Type=01h: garbage-filled)
B28h 314h   Part 2 Info (Texture)
E3Ch 14h    Part 3 Info (?)

```

```

E50h 0Ch   Part 4 Info (?)
E5Ch ..    Part 1 Data (Sound, SPU-ADPCM data, if any)
... ..     Part 2 Data (Texture data) (starts with BDEF1222h or BDEF1111h)
... ..     Part 3 Data (?) ;\maybe map, models, and/or whatever
... ..     Part 4 Data (?) ;/

```

Part 1 Info (Sound info) (if any):

```

01Ch 4      Random/Checksum?
020h 4      Faded ID (FADED007h)
024h 4      Part 1 Size          (eg.7C7F0h)
028h 4      SPU Start Addr       (1010h) (for data from file offset E5Ch)
02Ch 4      SPU Middle Addr      (eg. 58F70h)
030h 4      SPU End Addr         (eg. 7D800h) (start+size)
034h 2      Middle entry number  (often 3Ch)
036h 2      Number of used entries-1 (eg. 50h means that 51h entries are used)
038h AF0h   Sample List (100 entries, unused ones are zerofilled)
914h 214h   Zerofilled (unused 1Ch-byte entries) (total is 1Ch*64h)
Sample List entries:
000h 4      SPU Offset (1010h and up) (SpuOffset=1010h is FileOffset=E5Ch)
004h 4      Sample Size in bytes
008h 4      Unknown (0)
00Ch 4      Unknown (0)
010h 4      Pitch   (400h=11025Hz, 800h=22050Hz, 2E7h=8000Hz, 8B5h=24000Hz)
014h 4      Unknown (0 or 1)
018h 4      File ID (00001F08h and up)

```

Part 2 Info (Texture info):

```

B28h 4      Random/Checksum?
B2Ch 4      Faded ID (FADED007h)
B30h 4      Part 2 Size          (N*16000h) ;Width=2C0h halfwords, Height=N*64
B34h 4      Zero                (0h)
B38h 4      Some RAM Address    (8010xxxxh)
B3Ch 4      Unknown            (eg. 195h or E3h) ;same as at [DA4h]
B40h 4+4    VRAM Address X,Y    (140h,0) ;maybe load target
B48h 4+4    VRAM Address X,Y    (140h,0) ;maybe palette base?
B50h 4+4    VRAM Address X,Y    (xx0h,Height-40h) ;often at/near end of used area
B58h 4      Unknown            (eg. 1D0h or 1E0h)
B5Ch 4      Unknown            (eg. 1Ah or 0Dh)
B60h 200h   Some halfwords?    (most are FFFFh, some are 0000h)
D60h 40h    Zerofilled         (0)
DA0h 4      Unknown            (eg. 185h or E2h)
DA4h 4      Unknown            (eg. 195h or E3h) ;same as at [B3Ch]
DA8h 9x10h  Special Texpages   (VramX,Y, SizeX,Y, StepX,Y, Flag/Type/Num or so?)
E38h 4      Some RAM Address    (800Axxxxh)

```

Part 3 Info:

```

E3Ch 4      Random/Checksum?
E40h 4      Faded ID (FADED007h)

```

E44h	4	Part 3 Size	(eg. A9728h or 51264h)
E48h	4	RAM End Address (start+size)	(eg. 801Fxxxxh) (near memtop)
E4Ch	4	RAM Start Address (end-size)	(eg. 801xxxxxh)

Part 4 Info:

E50h	4	Random/Checksum?
E54h	4	Faded ID (FADED007h)
E58h	4	Part 4 Size (usually 10CCCh) (or 105E0h in demo version)

Note: File CAT\RDS.CAT does also start with ID=FADED007h (but contains whatever different stuff).

13.33 CDROM File Archives with Offset

Below are archives that start with a simple Offset list. The DOT1 and DOTLESS types are "standard" archives used by many PSX games (although the "standard" was probably independently created by different developers).

DOT1 Archives (named after the ".1" extension in R-Types)

Used by various titles:

```
R-Types (CG.1, PR\PR.1, and nested inside CG.1)
Final Fantasy IX (nested inside FF9.IMG, FF9.IMG\DB, FF9.IMG\DB\DOT1)
Legend of Mana (*.EFF,*.SET,*.BTP(?) in folders SND*,SOUND,WM(?))
Witch of Salzburg (*.ANM/BIN/BSS/DAT/MDL/SCE)
Rayman (RAY\*.XXX, RAY\SND\*.ALL, and nested inside *.XXX)
Pandemonium II (JESTERS.PKG\0101\0008 and JESTERS.PKG\0101\000D)
Incredible Crisis (MagDemo38: IC\TAN_DAT.CDB\<DOTLESS>\<DOT1>\<SHIFTJIS>)
Various games on PlayStation Magazine Demo Discs (Disc 03-54)
```

DOT1 (in lack of a better name) is a simple archive format that contains Number of Entries and List with Increasing Offsets to File data.

000h	4	Number of Files (N)	(eg. 2..18)
004h	N*4	File List (offsets to each file, increasing, aligned)	
...	(4)	Optional: Total filesize (aka end-offset for last list entry)	
...	..	Optional: Zeropadding to alignment boundary (when alignment>4)	
...	..	File Data	

There are four variants with different alignment (and in some cases, with an extra entry with end-offset for last file):

Align800h, no extra entry	R-Types (CG.1 and PR\PR.1)
Align4, no extra entry	R-Types (nested in CG.1), FF9 (in IMG, IMG\DB)
Align2, no extra entry	Incredible Crisis (IC\TAN_DAT.CDB**)
Align800h, with extra entry	MLB 2000 (DATA.WAD)
Align10h, with extra entry	Witch of Salzburg (*.ANM/BIN/BSS/DAT/MDL/SCE)
Align4, with extra entry	Rayman (*.XXX, *.ALL)

The files can be detected by checking $[004h] = 4 + (N * 4)$, $4 + (N * 4) + \text{Align800h}$, $4 + (N * 4) + 4$, or $4 + (N * 4) + 4 + \text{Align10h}$, and checking that the offsets are increasing with correct alignment (Rayman has some empty files with same offset), and don't exceed the total filesize. And that the alignment space is zeropadded (in case of R-Types, only the header is 00h-padded, but files are FFh-padded).

The detection could go wrong, especially if the archive contains very few files, some of the nested DOT1's contain only one file (header "00000001h, 00000008h", without any further increasing offsets or padding). As workaround, accept such files only if they have a ".1" filename extension, or if they were found inside of a bigger DOT1, IMG, or DB archive.

Final Fantasy IX contains some DOT1's with fewer than few entries (the file being only 4-bytes tall, containing value NumEntries=00000000h).

NFL Gameday '98 (MagDemo04: GAMEDAY*.FIL) (32bit) (with nested FIL's)

NFL Gameday '99 (MagDemo17: GAMEDAY*.FIL) (32bit)

NFL Gameday 2000 (MagDemo27: GAMEDAY*.FIL) (16bit and 32bit)

NCAA Gamebreaker '98 (MagDemo05: GBREAKER*.FIL,*.BIN) (16bit and 32bit)

NCAA Gamebreaker 2000 (MagDemo27: GBREAKER*.FIL) (16bit and 32bit)

FIL/32bit (with $[02h] = \text{FFFFh}$):

000h 2	Number of Files (N)
002h 2	ID for 32bit version (FFFFh=32bit entries)
004h N*4	File List (offsets to each file, increasing, 4-byte aligned)
... ..	File Data

FIL/16bit (with $[02h] \neq \text{FFFFh}$, eg. FLAG*.FIL and VARS\STARTUP2.FIL\0*):

000h 2	Number of Files (N)
002h N*2	File List (offsets to each file, increasing, 4-byte aligned)

```
... .. Zeropadding to 4-byte boundary
... .. File Data
```

PreSizeDOT1 (Ace Combat 2) (retail and MagDemo01: ACE2.DAT*)

Like DOT1, but with Total Filesize being oddly stored at begin of file.

```
000h 4 Total Filesize (aka end-offset for last list entry)
004h 4 Number of Files (N)
008h N*4 File List (offsets to each file, increasing, 4-byte aligned)
... .. File Data
```

Note: Ace Combat 2 contains PreSizeDOT1 (ACE2.DAT\02h..1Dh,36h..B2h) and normal DOT1 archives (nested in PreSizeDOT1's and in ACE2.DAT\B3h..E1h).

DOT-T (somewhat same as DOT1, but with 16bit entries)

Armored Core (MagDemo02, AC10DEMP*.T)

```
000h 2 Number of Files
002h N*2 File List (Offset/800h to file data, increasing)
... 2 Total Size/800h (end-offset for last file)
... .. Zeropadding to 800h-byte boundary
... .. File Data
```

This can contain many empty 0-byte files (aka unused file numbers; though maybe those files exist in the retail version, but not in the demo version).

DOTLESS Archive

Hot Shots Golf (MagDemo07: HSG\DAT)

Hot Shots Golf 2 (retail: DATA\F0000.BIN\, MagDemo31/42: HSG2\MINGOL2.BIN\)

Starblade Alpha (FLT\DAT, TEX\DAT)

Incredible Crisis (MagDemo38: IC\TAN_DAT.CDB\<DOTLESS>)

```
000h N*4 Offsets to File data (increasing, usually 4-byte aligned)
... (4) Filesize (end-offset for last file) (only in Ape Escape)
... ... File Data
```

Like DOT1, but without Number of Files entry (instead, the first offset does imply the end of file list). There's no extra entry for end of last file (instead, that's implied in the total filesize). Most files have at least 5 entries, but HSG\TITLE0.DAT seems to contain only one entry (ie. the whole header contains only one value, 00000004h, followed by something that looks like raw bitmap data).

Also used by Ape Escape (*MINIGAME* included nested ones), the Ape Escape files do have an end-marker with last-offset (that will appear as an empty 0-byte file at end of list when not specifically handling it). *MINIGAME\MINI2\BXTIM.BIN* does also have several 0-byte files inside of the file list.

Twisted Metal: Small Brawl (MagDemo54: TMSB\SHL*.TMS)

```
000h 4      Size of Data Area (total filesize minus 0D0h)
004h 4      Number of files
008h N*4    File List (zerobased offsets from begin of Data Area)
... ..     Zeropadding to 0D0h
0D0h ..     File Data Area
```

This resembles DOT1, with an extra size entry and padding to 0D0h.

Ridge Racer Type 4 (MagDemo19: R4DEMO\R4.BIN, 39Mbyte)

Ridge Racer Type 4 (MagDemo21: R4DEMO\R4.BIN, 39Mbyte)

Basically, this is alike DOT1, but SECTOR numbers, and with extra entries...

```
000h 4      Number of Files (N) (3C9h)
004h N*4    File List (Offset/800h)
... 4      Total Size/800h                ;<-- last offset
... 4      Unknown (00,E8,82,2E)          ;<-- ??? maybe checksum*800h or so?
... ..     Zeropadding to 800h-byte boundary
... ..     File Data area
```

Legend of Legaia (MagDemo20: LEGAIA\PROT.DAT)

```
000h 4      Zero
004h 4      Number of Entries (4D3h)
008h N*4    File List (Offset/800h)
... 4      Total Size/800h (aka end Offset/800h of last file)
... ..     Zeropadding to 800h-byte boundary
... ..     File Data area
```

The PROT.DAT does not contain filenames, however, it's bundled with CDNAME.TXT, which appears to contain symbolic names for (some) indices:

```
#define init_data 0          ;for file 0000h
#define gameover_data 1      ;for file 0001h
#define town01 3             ;for file 0003h
#define town0b 12            ;for file 000Ch
...                          ;...
```

```
#define other6 1222      ;for file 04C6h
#define other7 1228      ;for file 04CCh
```

The DAT file contains many zerofilled "dummy" files with 800h-byte size.

Bloody Roar 1 (MagDemo06: BL*.DAT)

Bloody Roar 2 (MagDemo22: ASC,CMN,EFT,LON,SND,ST5,STU*.DAT)

```
000h 4      Number of Entries (N)
004h N*4    File List (Offset-(4+N*4), increasing) (or FFFFFFFFh=Unused entry)
... ..     File Data area
```

Most or all files in DAT archives are PreGT20 compressed.

CDROM File Compression GT20 and PreGT20

Note: Unused entries can occur anywhere, eg. Bloody Roar 2 CMN\SEL01.DAT does have both first and LAST entry marked as unused (FFFFFFFh). Also, there may be a lot of unused entries, eg. Bloady Roar 1 CMN\TITLE00.DAT uses only 5 of 41h entries).

Klonoa (MagDemo08: KLONOA\FILE.IDX*)

```
000h 4      ID "OA05"
004h N*4    Offset List (usually/always 5 used entries, plus zeropadding)
030h ..     File Data area (usually/always starting at offset 30h)
```

C - The Contra Adventure (DATA\SND*.SGG)

```
000h 4      ID "SEGG"
004h 4      Offset to .VH file
008h 4      Offset to .VB file
00Ch 4      Number of .SEQ files (N) (usually 6Eh, or 08h in MENU.SGG)
010h N*4    Offsets to .SEQ files (increasing, unaligned)
... ..     SEQ files
... ..     Padding to 4-byte boundary
... ..     VH file
... ..     VB file
```

Ninja (MagDemo13: NINJA\VRW*.VRW)

```
000h 8      ID "VRAM-WAD" (here as archive ID, although same as compress ID)
004h N*4    File List (offsets to Data) ;NumFiles=(FirstOffset-8)/4
... ..     Data (compressed .PAK files, which do ALSO have ID="VRAM-WAD")
```

The compressed .PAK files are using a LZ5-variant:

CDROM File Compression LZ5 and LZ5-variants

The Next Tetris (MagDemo22: TETRIS*) has PSX.BSE (and nested therein)

```
000h 4      Unknown (3)
004h 4      Total Size
008h 4      Number of Files (N) (max 40h, for max 40h*4 bytes in file list)
00Ch N*4    File List (increasing offsets, 800h-byte aligned)
... ..     Unknown (looks like garbage padding for unused File List entries)
10Ch 6F4h   42h-filled padding to 800h-byte boundary
800h ..     File Data area
```

Tactics Ogre (UBF*.BIN)

```
000h 8      Fixed (88h,0,0,0,0,0,0,0)
008h 4      Number of Files (eg. 1Dh or 585h, including last/end file)
00Ch N*4    File List (increasing offsets, 800h-byte aligned)
... ..     Zeropadding to 800h-byte boundary
... ..     File Data area
```

Note: The last file is a TXT file containing "LINK-FILE END....",0Dh,0Ah,1Ah, plus zeropadding to 800h-byte boundary.

Spyro the Dragon (MagDemo12: SPYRO\PETE.WAD)

```
000h 4      Total Filesize (3E800h in Spyro)
004h N*8    File List (1B0h bytes in Spyro)
... ..     Zeropadding to 800h-byte boundary
... ..     File Data (4-byte aligned, despite of above 800h-byte hdr padding)
```

File List entries:

```
000h 4      Fileoffset (increasing, 4-byte aligned)
004h 4      File ID? (unsorted, not increasing, used range is 000h..1FAh)
```

13.34 CDROM File Archives with Size

Disney-Pixar's Monsters, Inc. (MagDemo54: MINC*.BZE)

```
000h 4      Zero (0)
004h 4      Type/ID (27100h=160000, 2BF20h=180000, 30D40h=200000 decimal)
008h 4      Number of files
```

```

00Ch N*0Ch File List
... .. Zeropadding to 7FCh
7FCh 4 Checksum (32bit sum of SIGN-EXPANDED bytes at [000h..7FBh])
... .. File Data

```

File List entries:

```

000h 4 File Type/ID or so (roughly increasing, eg. 1,3,6,5,7,8,9,A,B)
004h 4 Filesize in bytes
008h 4 Filesize rounded up to multiple of 800h bytes

```

Bugs Bunny: Lost in Time (MagDemo25: BBLIT*.BZZ) (without extra entry)

The Grinch (MagDemo40: GRINCH*.BZZ) (with extra entry)

Resembles .BZE, but without the Type entry in Header.

```

000h 4 Fixed 1 (maybe version, or compression flag)
004h (4) Unknown (000xxxx0h) ;<-- Extra in The Grinch only (not Bunny)
... 4 Number of files
... N*0Ch File List
... .. Zeropadding to 7FCh
7FCh 4 Checksum (32bit sum of SIGN-EXPANDED bytes at [000h..7FBh])
... .. File Data

```

File List entries:

```

000h 4 File Type/ID or so (roughly increasing, eg. 1,2,3,6,5,7,8,9,A)
004h 4 Filesize in bytes (rounded to N*4 even if compressed data is less)
008h 4 Filesize rounded up to multiple of 800h bytes

```

Files are compressed, starting with 0Bh, same as in Jersey Devil...

CDROM File Compression BZZ

Note: The TIM files in Bugs Bunny and The Grinch BZZ archives consists of two TIMs badged together: A 4x4 pix dummy TIM, followed by the actual 512x125 pix TIM (in some cases followed some extra bytes at end of file?).

Jersey Devil .BZZ (MagDemo10: JD*.BZZ)

Resembles .BZE, but without the Type entries in Header and File List, and without Header checksum.

```

000h 4 Fixed 1 (maybe version, or compression flag)
004h 4 Number of files (4)
008h N*8 File List

```

```
... .. Zeropadding to 800h-byte boundary (without checksum, unlike .BZE)
... .. File Data
```

File List entries:

```
000h 4      Size in bytes
004h 4      Size rounded to multiple of 800h
```

Files are compressed, starting with 0Bh, same as in Bugs Bunny...

CDROM File Compression BZZ

Jackie Chan Stuntmaster (RCHARS*.RR)

NBA Basketball 2000 (MagDemo28: FOXBB*.RR)

```
000h 2      ID ("PX")
002h 2      Unknown (1 or 3)
004h 4      Header Size (eg. 80h, 7C0h, or 1730h) (N*8+8)
008h N*8    File List
... ..     Zeropadding to 800h-byte boundary
... ..     File Data area
File List entries:
000h 4      Offset (increasing, 800h-byte aligned)
004h 1      Zero
005h 3      Filesize in bytes (24bit) (can be odd)
```

Jackie Chan Stuntmaster does always have headersize=1730h (with many unused entries with size=0, both in the middle & at the end of File List).

Bomberman World (MagDemo15: BOMBER*.RC)

```
XXX detect this WITH extension=".RC" check before OBJ
      (else type=1 could be mistaken as offs=1) (eg RC1\BP0*.RC)
```

Resembles .OBJ but contains Filetype? instead of Offset.

```
000h N*8    File List
... 8      File List end (zerofilled)
... ..     Garbage padding to 800h-byte boundary
```

File List entries:

```
000h 4      Filetype (see below)
004h 4      Filesize in bytes
```

There can be several files with same type in one .RC archive. Type values are:

```

00h = End of File List (at least so when Type and Size are both zero)
01h = .TIM
02h = Unknown
03h = Unknown
05h = .VH
06h = .VB
09h = Unknown
0Ah = .TIM (left half of a larger image) (right half has type 01h)
0Bh = Unknown
0Ch = Unknown

```

Mat Hoffman's Pro BMX (new demo) (MagDemo48: MHPB\BMXCD.HED+WAD)

This format is used by the NEW demo version on MagDemp48 (the OLD demo version on MagDemo39 did use Spider-Man-style HED/WAD format with filenames).

```

HED:
  000h 2      Number of entries (N)
  002h N*6    File List
WAD:
  000h ...    File data (at 800h-byte aligned locations)

```

File List entries:

```

000h 3      File ID (24bit)
003h 3      File Size in bytes (21bit, max 2Mbyte) (upper 3bit=unused?)

```

Note: HED is processed at 80052AC0h in MagDemo48.

Madden NFL 2000 (MagDemo27: MADN00*.DAT and nested therein)

Madden NFL 2001 (MagDemo39: MADN01*.DAT and nested therein)

```

000h 4      Header Size (N*SectorSize) (xxh, 800h, 1000h, 4800h, or 920h)
004h 4      Sector Size (4=ChildArchive, 800h=MainArchive, 920h=FMV/MADN00)
008h 4      File List entrysize (0=32bit, 1=16bit/MADN00, 4=16bit/MADN01)
00Ch N*2/4  File List (16bit or 32bit filesize in bytes)
... ..     Zeropadding to SectorSize boundary
... ..     Files (with above sizes, each zeropadded to SectorSize boundary)

```

Dummy files have filesize=1 (but they do nethertheless occupy a whole data sector). Unknown why the FMV file in MADN00 is using SectorSize=920h (it appears to be FORM2 related, although the file seems to be stored in FORM1 sectors, but the STR movie appears to work okay despite of the odd size).

Croc 2 (MagDemo22: CROC2\CROCI.DIR\FESOUND.WAD)**Disney's The Emperor's New Groove (MagDemo39:ENG\KINGDOM.DIR\FESOUND.WAD)****Disney's Aladdin in Nasira's Rev. (MagDemo46:ALADDIN\ALADDIN.DIR\FESOUND.WAD)**

```

000h 4      Total Filesize-4
004h N*14h File List (2 entries in Croc2, 3 entries in Aladdin/Emperor)
... ..    File Data area (SPU-ADPCM( (.VB files with leading zeroes)
File List entries:                (Aladdin/Emperor) (Croc2)
000h 4      Sample Rate in Hertz (AC44h=44100Hz)   (5622h=22050Hz)
004h 2      Sample Rate Pitch    (1000h=44100Hz)   (0800h=22050Hz)
006h 2      Unknown              (7Fh)             (32h)
008h 4      Unknown              (1)                (8)
00Ch 4      Unknown              (1FC0001Fh)        (40008Fh)
010h 4      Filesize              (xxx0h)           (xxx0h)

```

The number of files is implied in sum of file sizes versus total size.

Dino Crisis 1 and 2 (PSX\DATA*.DAT and *.DBS and *.TEX) ("dummy header")

```

000h 800h File List (with 10h or 20h bytes per entry)
800h ..   File Data (each file is zeropadded to 800h-byte boundary)

```

File List entry size can be 10h or 20h bytes:

```

Dino Crisis 1 --> always size 10h
Dino Crisis 2 --> usually size 20h
Dino Crisis 2 --> sometimes size 10h (eg. SC24.DAT, SC48.DAT, WEP_*.DAT)

```

File List entries:

```

File List entries, type 0 and 7:
000h 4      Type (0=Data (or .BS pictures), 7=CompressedData)
004h 4      Size
008h 4      RAM Addresss (80000000h..801FFFFFh)
00Ch 4      Zero
010h (10h) Zerofilled
File List entries, type 1 and 2 and 8:
000h 4      Type (1=Bitmap, 2=Palette, 8=CompressedBitmap)
004h 4      Size (see below Size Notes)
008h 2      VRAM Address X      (0..3FFh)
00Ah 2      VRAM Address Y      (0..1FFh) (or 280h in Dino 2 ST703.DAT)
00Ch 2      Width in halfwords (1..400h)
00Eh 2      Height              (1..200h)
010h (10h) Zerofilled
File List entries, type 3 and 4:
000h 4      Type (3=VoiceHeader("Gian"), 4=VoiceData (SPU-ADPCM))

```

```

004h 4      Size
008h 4      SPU Address (0..7FFF0h)
00Ch 2      Unknown (0..7)  ;\usually both same (or val1=0, val2>0)
00Eh 2      Unknown (0..7)  ;/
010h (10h) Zerofilled
File List entries, type 5 (eg. ME*.DAT):
000h 4      Type (5=Unknown... maybe Midi-style or so)
004h 4      Size
008h 4      Load Address (0, or on next 4-byte boundary after previous file)
00Ch 2      Unknown (0..2)  ;\always both same
00Eh 2      Unknown (0..2)  ;/
010h (10h) Zerofilled
File List entries, type 6 and 9:
The EXE code does also accept type 6 and 9 (type 6 is handled same as
type 0, and type 9 is ignored), but the actual archives don't seem to
contain any files with those types.
File List entries, padding for unused entries:
000h 10h    Type ("dummy header  ")
010h (10h) Zerofilled

```

Size Notes:

```

Bitmaps and Palettes can have following sizes:
Width*Height*2                                ;normal case
Width*Height*2 + Align(1000h)                  ;eg. Dino Crisis 1 DOOR*.DAT
Width*Height*2 + Align(800h)                   ;eg. Dino Crisis 2 DOOR27.DAT
CompressedBitmaps can have following sizes in compressed form:
Less than Width*Height*2                      ;normal case
Less than Width*Height*2 + 1000h               ;eg. Dino Crisis 2 M_RESULT,ST002.DAT
CompressedBitmaps can have following sizes after decompression:
Width*Height*2 + 8                            ;normal case
Width*Height*2 + Align(1000h?) + 8             ;eg. Dino Crisis 2 M_RESULT,ST002.DAT

```

Note: Dino Crisis DEMO version (MagDemo28: DINO\TRIAL.DAT) does also contain "dummy header" DAT archives (but, unlike as in retail version, they are hidden somewhere inside of the headerless 14Mbyte TRIAL.DAT archive).

Type 7 and 8 are using LZSS compression:

[CDROM File Compression LZSS \(Dino Crisis 1 and 2\)](#)

Apart from LZSS, Type 4 is using SPU-ADPCM compression, and some Type 0 files contain .BS compressed pictures (eg. Dino Crisis 2 PSX\DATA\ST*.DBS*).

13.35 CDROM File Archives with Chunks

Chunk-based archives have chunk headers for each file, but don't have a central directory. That's mainly useful when loading the whole archive to memory.

Interchange File Format (IFF)

IFF has been invented by Electronic Arts in 1985 on Amiga (hence using 2-byte alignment and big-endian size values).

IFF does mainly define a standardized file structure for use with custom group/chunk types (it does also define some Amiga-specific standard audio/video types, but those are barely useful on PSX).

The files are starting with a Group Header, followed by Chunks:

```
Group Header:
000h 4      Group ID ("FORM") (or "LIST" or "CAT " or "PROP")
004h 4      Group Size-08h (SIZ) (filesize-8) (big-endian)
008h 4      Group Type (4-character ASCII) (should be an unique identifier)
00Ch SIZ-4  Chunk(s), and/or nested Group(s)
Chunk Format:
000h 4      Chunk Type (4-character ASCII) (meaning depends on Group Type)
004h 4      Chunk Size (SIZ) (big-endian)
00Ch SIZ    Data (eg. .TIM, .VB, .VH or custom data)
... ..     Zeropadding to 2-byte boundary
```

Used by Forsaken (MagDemo09: FORSAKEN\.\BND,MP,PCO)

Used by Perfect Assassin (DATA.JFS\DATA\SCREEN1.LBM)

Used by Star Wars Demolition (MagDemo39,41: STARWARS\.*EXP*)

Used by Turbo Prop Racing (MagDemo11: RRACER\IFF, except COURSE.IFF)

Used by Viewpoint (VIEW.DIR\.*VCF*,*.*VCS*,*.*ST**) - *some have wrong Size entry?*

Used by Vigilante 8 (MagDemo09: EXAMPLE\EXP)

Used by Wing Commander III (*.LIB\.*IFF*)

Bugs in Viewpoint: fonts\vcf have correct Groupsiz=Filesize-8, but screens\vcf have incorrect Groupsiz=Filesize-4, and streams\vcf have weirdest random Groupsiz=Filesize+(-04h,+08h,+14h,+5A0h).

Z-Axis little-endian IFF variant

Unlike real IFF, these are using little-endian, and don't have a Group Type entry. There seem to be no nested FORMs. Alignment is kept as 2-byte.

```
Group Header:
000h 4      Group ID ("FORM" or "BODY")
004h 4      Group Size-08h (SIZ) (little-endian)
008h SIZ    Chunk(s)
Chunk Format:
000h 4      Chunk Type (4-character ASCII)
004h 4      Chunk Size (SIZ) (little-endian)
```

```
00Ch SIZ    Data
... ..     Zeropadding to 2-byte boundary
```

ID "FORM" used by Thrasher: Skate and Destroy (MagDemo27: SKATE\ASSETS\ZAL\)

ID "FORM" used by Dave Mirra Freestyle BMX (MagDemo36,46: BMX\ASSETS\ZAL\)

ID "BODY" used by Colony Wars (MagDemo02: CWARS\GAME.RSC\BND)

ID "BODY" used by Colony Wars Venegance (MagDemo14: CWV\GAME.RSC\BND)

Alice in Cyberland little-endian IFF variant (.TPK)

Same as Z-Axis IFF variant, except Group IDs are different, and the Header sizes are included in the Group/Chunk sizes.

```
Group Header:
000h 4      Group ID ("hTIX","hFNT","hMBD","hHBS")
004h 4      Group Size (total filesize) (little-endian)
... (8)     Unknown extra (0,0,0,0,0Ch,0,0,0)    ;<-- only in "hHBS" files
... ..     Chunk(s)
Chunk Format:
000h 4      Chunk Type ("cCLT","cBIT","cSTR","cMAP","cIDX","cVAB","cSEQ")
004h 4      Chunk Size (SIZ) (little-endian)
00Ch SIZ-8  Data
... ..     Maybe Zeropadding to boundary? (Chunk Size is always N*4 anyways)
```

ID "hTIX" used by Alice in Cyberland (ALICE.PAC\alice.tpk, csel.tpk, etc.)

ID "hFNT" used by Alice in Cyberland (ALICE.PAC\alice.tpk, juri.tpk, etc.)

ID "hMBD" used by Alice in Cyberland (ALICE.PAC\FA2\MBD)

ID "hHBS" used by Alice in Cyberland (ALICE.PAC\0x_xx.HBS)

Touring Car Championship (MagDemo09: TCAR\GAME\BFX)

Jarret & LaBonte Stock Car Racing (MagDemo38: WTC\BFX)

Contains several simple chunks:

```
000h 4      Chunksize in bytes (SIZ) (usually a multiple of 4)
004h SIZ    Chunkdata (eg. .TIM file or other stuff)
```

There is no end-marker in last chunk (it simply ends at total filesize).

Colony Wars Venegance (MagDemo14: CWV\GAME.RSC\VAG.WAD)**Colony Wars Red Sun (MagDemo31: CWREDSUN\GAME.RSC\0002\VAG_WAD)**

Contains several simple chunks with filenames:

```
000h 0Ch  Chunk Filename ("filename.ext", zeropadded if shorter)
00Ch 4    Chunk Data Size in bytes (SIZ)
010h SIZ  Chunk Data (usually VAGp files, in VAG.WAD)
```

There is no end-marker in last chunk (it simply ends at total filesize).

Red Sun VAG_WAD is a bit odd: The "extension" is _WAD instead .WAD, the chunk names include prefix "RedSun\\", which leaves only 5 chars for the actual name, causing duplicated names like "RedSun\\laser" (which were supposedly meant to be named laser1, laser2, laser3 or the like), and many of the Red Dun VAG files contain damaged 30h-byte VAG header entries, eg. zero instead of ID "VAGp").

Mat Hoffman's Pro BMX (new demo) (MagDemo48: MHPB\STILLS.BIN)

Contains .BS files in several chunks:

```
000h ..    Chunk(s) (.BS files with extra header info)
... 4      End Marker (00000000h)
Chunk format:
000h 4      Chunk size (including whole chunk header)
004h 2      Bitmap Width  (eg. F0h)
006h 2      Bitmap Height (eg. 80h)
008h 2      Data Size/4 (same as (Chunksize-0Ch-filenameelen)/4)
00Ah 2      MDEC Size/4 (same as at Data[0])
00Ch ..     Filename (eg. "lsFact",00h or "bsRooftop1",00h)  ;\filename field
... ..     Filename Zeropadding to 4-byte boundary          ;/
... ..     Data (in BS v2 format) (MDEC Size/4, BS ID 3800h, etc.)
```

Note: STILLS.BIN exists in newer BMX demo in MagDemo48 only (not in MagDemo39).

Ridge Racer (TEX*.TMS)**Ridge Racer Revolution (BIG*.TMS)****Ridge Racer Type 4 (MagDemo19+21: R4DEMO\R4.BIN\I)**

```
000h 4      ID (100h)
004h ..     Chunk(s)
```

```
... 4      Zero (Chunk Size=0=End)
... ..     Optional zeropadding to 800h-byte boundary (in R4.BIN\*)
```

Chunk Format:

```
000h 4      Chunk Size (SIZ)
004h SIZ     Chunk Data (TIM file) (note: includes 0x0pix TIMs with palette)
```

Jet Moto 2 (MagDemo03: JETMOTO2*.TMS)

Twisted Metal 2 (MagDemo50: TM2*.TMS)

Contains a fileheader and .TIM files in several chunks:

```
000h 8      ID "TXSPC",0,0,0 (aka CPSXT backwards)
008h 4      Timestamp? (32A5C8xxh)
00Ch 4      Number of Chunks (N) (can be 0=None, eg. TM2\SCREEN\ARROWS.TMS)
010h N*4     Unknown
... N*var    Chunks
Chunk format:
000h 4      Chunk Size-4 (SIZ)
004h SIZ     Chunk Data (TIM file)
```

Princess Maker - Yumemiru Yousei (BDY*.BD and PM.*)

The BDY*.BD files do simply contain several chunks:

```
000h ..     Chunk(s)
```

The PM.* files do contain several "folders" with fixed size:

```
000h ..     Chunk(s) for 1st folder           ;\Foldersizes are:
... ..     Zeropadding to Foldersize-boundary ; 20000h (PM.DT0 and PM.PCC)
... ..     Chunk(s) for 2nd folder           ; 28000h (PM.MAP)
... ..     Zeropadding to Foldersize-boundary ; 42000h (PM.SD0)
... ..     etc.                             ;/
```

Chunk Format:

```
000h 4      Chunk ID (800000xxh)
004h 4      Chunk Size (size of Data part, excluding ID+Size)
008h ..     Data
```

The Data for different Chunk IDs does usually have a small header (often with w,h,x,y entries, aka width/height, vram.x/y) followed by the actual data body:

80000004h	x(2),y(2),width(2),height(2)	Bitmap 8bpp	; PM.PCC,MAP
80000005h	w(2),h(2),zero(4)	Array32bit(w,h)	; PM.MAP
80000006h	x(2),width(2)	Bitmap Palette	; PM.*
80000007h	x(2),y(2),w(1),h(1),zero(2)	Array8bit(w,h)	; PM.MAP
80000010h	width(2),height(2),x(2),y(2)	Bitmap 16bpp	; *.BD
80000012h	zero(0)	?	; *.BD
80000014h	x(2),y(2),width(2),height(2)	Bitmap 4bpp	; PM.DT0
80000016h	x(2),y(2),w(1),h(1),n(1),3Fh(1)	BitmapArray4bpp(n*2)	; PM.DT0
80000018h	...	?	; PM.PCC
8000001Ah	zero(8)	?	; PM.PCC
8000001Ch	x(2),y(2),width(2),height(2)	Bitmap 1bpp flags?	; *.BD
80000020h	zero(8)	Sound .SEQ file	; PM.SD0
80000021h	zero(8)	Sound .VH file	; PM.SD0
80000022h	zero(8)	Sound .VB file	; PM.SD0
80000024h	x(2),zero(6)	?	; PM.DT0\4\0
00000000h	Zeropadding to next folder	Zeropadding	; PM.*

Project Horned Owl (COMDATA.BIN, DEMODATA.BIN, ROLL.BIN, ST*DATA.BIN)

000h .. Chunks

Chunk Format:

000h 1	Chunk Type (see below)
001h 3	Unknown (some flags or file ID, or zero in many files)
004h 4	Chunk Size (SIZ)
008h SIZ	Chunk Data (eg. SEQ file)

Chunk Type values:

02h	unknown	ST*.BIN
05h	.TXT	ROLL.BIN
05h	LZ-compressed TIM	DEMODATA.BIN, ST*.BIN (except ST1*.BIN)
06h	DOT1 with stuff and TSQ??	ST*.BIN
07h	.TMD	DEMODATA.BIN, ST*.BIN (except ST1*.BIN)
08h	unknown	ST*.BIN
09h	"PRM:"	ST*.BIN
0Ah	unknown	ST*.BIN
0Bh	DOT1 with stuff	ST*.BIN (except ST1*.BIN) (odd: ST3*.BIN)
0Ch	.SEQ	ROLL.BIN, ST*.BIN
0Dh	unknown	COMDATA.BIN
0Eh	unknown	ST*.BIN
0Fh	DOT1 with LZ-compressed TIMs	ST*.BIN
10h	DEFLATE-compressed TIM	COMDATA.BIN, ROLL.BIN, ST*.BIN
11h	DOT1 with stuff	ST*.BIN

Note: Type=05h can be uncompressed TXT or compressed TIM.

For detection, the existing .BIN files start with following values:

```

07 00 00 00 xx xx 00 00 41 00 00 00 ..   TMD Model  ("A")
0C 00 00 00 xx xx 00 00 70 51 45 53 ..   SEQ Midi   ("pQES")
0E xx 00 00 08 00 00 00 xx xx xx xx ..   Whatever in ST7DATA.BIN (see note)
10 01 00 00 24 28 00 00 EC 9B 7F 70 ..   Deflated TIM in COMDATA.BIN
10 08 1A 00 30 0C 00 00 ED 58 4F 88 ..   Deflated TIM in ROLL.BIN
ST7DATA.BIN has 2 chunks with Type=0Eh, followed by SEQ chunk at offset=20h.

```

TIMs are compressed via HornedLZ (Type=05h,0Fh) or Deflate (Type=10h).

CDROM File Compression HornedLZ

CDROM File Compression ZIP/GZIP/ZLIB (Inflate/Deflate)

The game's Inflate function does ignore the 2bit blocktype: All blocks must have dynamic trees (fixed trees and uncompressed blocks aren't supported).

Blaster Master (DATA\IDX, DATA\DAT)

DATA\GRP.IDX, DATA\MAP.IDX, DATA\SEQ.IDX DATA\VAB.IDX:

```

000h N*2  Chunk List (16bit Offset/800h to Part-1-Chunks in .DAT files)
... ..   Zeropadding to 800h-byte boundary
Notes:
The Chunk List can contain zeroes (as first entry at offset 0, and as
unused entries; in VAB.IDX those can be followed by further USED entries).
For 2-part DAT files, the Chunk List contains offsets for Part 1 only.

```

DATA\SEQ.DAT:

```

000h 4    Chunksize/800h                               ;\
004h 4    Datasize in bytes                             ; Single
008h 4    Always 015A5A01h or 015A5A00h                ; Part
00Ch 4    Always 2803h                                  ; with
010h ..   Midi data .SEQ file                           ; 1 file
... ..   Zeropadding to 800h-byte boundary              ;/

```

DATA\VAB.DAT:

```

000h 4    Chunksize/800h                               ;\
004h 4    Size of .VH Voice Header in bytes              ; Single
008h 4    Size of .VB Voice Binary in bytes              ; Part
00Ch ..   Voice Header .VH file                          ; with
... ..   Zeropadding to 800h-byte boundary              ; 2 files
... ..   Voice Binary .VB file                           ;
... ..   Zeropadding to 800h-byte boundary              ;/

```

DATA\GRP.DAT and DATA\MAP.DAT:

```

000h 4    Part 1 Chunksize/800h                         ;\
004h 4    Size of all TIM files in bytes (can be 0=None) ; Part 1

```



```

008h .. Texture data (several TIMs appended after each other) ;
... .. Zeropadding to 800h-byte boundary ;/
... 4 Number of Files (N) ;\
... 4 Part 2 Chunksize/800h ;
... N*8 File List ; Part 2
... .. Garbage-padding to 800h-byte boundary? ;
... .. File Data area (each file Garbage-padded to 800h-byte) ;
File List entries: ;
000h 4 File Type/ID ;
004h 4 Size in bytes ;/

```

The DAT files are chunk-based (unfortunately, each DAT file is using its own chunk format, some of them are using 2-part chunks).

The DAT chunks can be parsed without using the IDX file (the IDX can be helpful for quick lookup, but even then, one will still need to parse the DAT chunk headers to find the actual contents like TIM, SEQ, VB, VH files).

See also

[CDROM File Archive Darkworks Chunks \(Alone in the Dark\)](#)

[CDROM File Archive Blue Chunks \(Blue's Clues\)](#)

[CDROM File Archive HED/CDF \(Parasite Eve 2\)](#)

[CDROM File Compression LZSS \(Serial Experiments Lain\)](#)

[CDROM File Compression SLZ/01Z \(chunk-based compressed archive\)](#)

13.36 CDROM File Archives with Folders

There are several ways to implement folder-like directory trees:

- Using multiple archive files nested within each other
- Using filenames with path string (eg. "path\filename.ext")

Other than that, below are special formats with dedicated folder structures.

Archives with Folders

[CDROM File Archive HUG/IDX/BIZ \(Power Spike\)](#)

[CDROM File Archive TOC/DAT/LAY](#)

[CDROM File Archive WAD \(Doom\)](#)

[CDROM File Archive WAD \(Cardinal Syn/Fear Effect\)](#)

[CDROM File Archive DIR/DAT \(One/Viewpoint\)](#)

[CDROM File Archive HED/CDF \(Parasite Eve 2\)](#)

[CDROM File Archive IND/WAD \(MTV Music Generator\)](#)
[CDROM File Archive GAME.RSC \(Colonly Wars Red Sun\)](#)
[CDROM File Archive BIGFILE.DAT \(Soul Reaver\)](#)
[CDROM File Archive FF8 IMG \(Final Fantasy VIII\)](#)
[CDROM File Archive FF9 IMG \(Final Fantasy IX\)](#)
[CDROM File Archive GTFS \(Gran Turismo 2\)](#)
[CDROM File Archive Nightmare Project: Yakata](#)
[CDROM File Archive FAdj0500 \(Klonoa\)](#)

See also: [PKG](#) (a WAD.WAD variant with folders)

Perfect Assassin (*.JFS)

Overall File Structure

```

JFS for root                                ;\
JFS for 1st folder    ;\these are duplicated,    ; header with complete list
JFS for 2nd folder    ; also stored in below    ; of all file/folder names
JFS for 3rd folder    ; data area                ;
etc.                  ;/                        ;/
JFS for 1st folder, plus data for files in that folder ;\
JFS for 2nd folder, plus data for files in that folder ; data area
JFS for 3rd folder, plus data for files in that folder ;
etc.                                                         ;/

```

JFS Headers (0Ch+N*14h bytes)

```

00h 4    ID "JFS",00h
04h 4    Size in bytes (for root: including nearby child JFS's)
08h 4    Number of file/folder entries in this folder (N)
0Ch N*14h File/Folder entries

```

File Entries (with [10h].bit31=0):

```

00h 12    "FILENAME.EXT" (or zeropadded if shorter)
0Ch 4     Offset from begin of JFS in data area (without any alignment)
10h 4     Size in bytes, plus 00000000h=File

```

Folder Entries (with [10h].bit31=1):

```

00h 12    "DIRNAME.EXT" (or zeropadded if shorter)
0Ch 4     Offset to child JFS in data area
10h 4     Offset to child JFS in header area, plus 80000000h=ChildFolder

```

The JFS format is almost certainly unrelated to IBM's "Journaled File System".

Alone in the Dark The New Nightmare (FAT.BIN=Directory, and DATA.BIN=Data)

```
FAT.BIN:
00h 2      Number of folders (X) (43h)
02h 2      Number of files   (Y) (8F0h)
04h 4      Unknown           (1000h)
08h X*10h Directory Entry 0000h..X-1 (entry 0000h is named "ROOT")
.. Y*10h File Entry 0000h..Y-1
DATA.BIN:
00h ..     File Data area
```

Directory Entries (10h bytes):

```
00h 8      Name (terminated by 00h if less than 8 chars)
08h 2      First Subdirectory number (0001h and up, 0000h would be root)
0Ah 2      Number of Subdirectories   (0000h=None, if so above is usually 00FFh)
0Ch 2      First File number        (0000h and up)
0Eh 2      Number of files           (0000h=None, if so above is usually 00FFh)
```

File Entries (10h bytes):

```
00h 8      Name (terminated by 00h if less than 8 chars)
08h 4      Offset/800h to DATA.BIN
0Ch 4      Size in bytes (when compressed: decompressed size+02000000h)
```

Compressed files (in LEVELS\\ with Size.bit25=1) can be decompressed as so:

[CDROM File Compression Darkworks](#)

The files include some TIM images, WxH images, binary files, and chunks:

[CDROM File Archive Darkworks Chunks \(Alone in the Dark\)](#)

Interplay Sports Baseball 2000 (MagDemo22: BB2000* HOG.DAT and HOG.TOC)

```
HOG.TOC:
000h N*14h Folder/File List (starting with root folder)
HOG.DAT:
000h ..     File Data (referenced from HOG.TOC)
```

Folder entries:

```
000h 1      Type           ("D"=Directory)
001h 8      Name           ("FILENAME", zeropadded if shorter) (or "\" for root)
009h 3      Extension      (usually zero for directories)
00Ch 4      Folder Offset/14h in .TOC file (aka 1st child file/folder index)
010h 4      Folder Size/14h                (aka number of child files/folders)
```

File entries:

```

000h 1      Type      ("F"=File)
001h 8      Name      ("FILENAME", zeropadded if shorter)
009h 3      Extension ("EXT", zeropadded if shorter)
00Ch 4      File Offset/800h in .DAT file (increasing)
010h 4      File Size in bytes

```

Tenchu 2 (MagDemo35: TENCHU2\VOLUME.DAT)

```

000h 4      Unknown (demo=A0409901h, us/retail=A0617023h)
004h 4      Unknown (0h)
008h 4      Number of files (F) (demo=B7h, us/retail=1294h)
00Ch 4      Number of folders (D) (demo=0Fh, us/retail=3Eh)
010h D*8    Folder List
... ..     Zerofilled (padding to 800h-byte boundary)
800h F*10h  File List
... ..     Zerofilled (padding to 800h-byte boundary)
... ..     File Data area

```

Folder List entries:

```

000h 4      Folder ID (Random, maybe folder name checksum?)
004h 4      First file number in this folder (0=first, increasing)

```

File List entries:

```

000h 4      File Offset/800h
004h 4      File Size in bytes
008h 4      Folder ID (same as Parent Folder ID in Folder List)
00Ch 4      File ID (Random, maybe file name checksum?)

```

Blasto (MagDemo10: BLASTO\BLASTO.DAT and BLASTO\BLASTO.LFS)

```

LFS:
  000h N*18h File/Folder List
DAT:
  000h ..    File data

```

File entries (with [10h]=Positive):

```

000h 10h    Filename ("FILENAME.EXT", zeropadded)
010h 4      Offset in bytes, in BLASTO.DAT
014h 4      Size in bytes

```

Folder entries (with [10h]=Negative):

```

000h 10h  Foldername ("DIRNAME", zeropadded)
010h 4     Index to first child (at Offset=(-Index)*18h in BLASTO.LFS)
014h 4     Zero

```

Folder end marker (with [00h]=00h or 80h):

```

000h 1     End marker, at end of root & child directories (00h or 80h)
001h 17h   Unknown

```

Twisted Metal 4 (MagDemo30: TM4DATA*.MR and *.IMG)

These are relative small archives with hundreds of tiny chunks (with registry style Symbol=Value assignments), and a few bigger chunks (with .mod .vab .bit .clt files).

```

000h 4     Fixed ID (CCCC0067h)
004h ..    Root Folder (with Name="Root", 00h, FDh, FDh, FDh)
Folder Chunk format:
000h 1     Length of Name (including 4-byte padding)
001h 1     Number of Child Folders
002h 2     Number of Child Files
004h ..    Name ("name", 00h, CDh-padded to 4-byte boundary; Root=FDh-padded)
... ..    Child File(s)
... ..    Child Folder(s)
File Chunk format:
000h 1     Length of filename (including 4-byte padding)
001h 1     Filetype (see below)
002h 2     Array Size (or FFFFh for non-array filetypes)
004h 4     Filesize (SIZ) (including 4-byte padding)
008h 4     Decompressed Size (or 0=Uncompressed)
00Ch ..    Filename/Symbol ("name.ext", 00h, CDh-padded to 4-byte boundary)
... SIZ    Data/Value (CDh-padded to 4-byte boundary)

```

Some filenames have trailing non-ascii characters, for example:

```

"AXEL.MR\display\resolution\r3\Groups\Combined_Polyset", 1Ah, 01h, 04h, 00h
"CALYPSO.MR\display\resolution\r3\Groups\Combined_Polyset", A8h, 00h, CDh, CDh

```

Filetypes:

```

Typ Size  Expl.
02h var   Text String (terminated by 00h, garbage-or-00h-padded to 4-byte)
03h 8     Misc (*.IMG\textures\*) ;\
03h 20h   Misc (*.MR\display\resolution\r*\Groups\*) ; these are all
03h var   Misc (*.MR\display\resolution\*List) ; filetype=03h
03h file  Misc (*.MR\display\*.bit) (same as type=0Ch) ;/
04h 4     Numeric 32bit
05h 8     Numeric 4x16bit point (X,Y,Z,CDCDh)
06h file  Model (*.mod) (DOTLESS archive with model data)

```

```

0Bh 4      Numeric 32bit repeat,light
0Ch file   XYWH Bitmap/Palette (*.bit, *.clt) (in GAME.IMG, MENU\menu)
0Dh 4      Numeric 32bit delay
0Eh 4      Numeric 32bit color (maybe 24bit RGB plus 00h-padding?)
0Fh 10h    Whatever 10h-byte "pos"
10h file   Sony .VAB file (*.vab)
12h N*1    Array? (with Arraysize=0014h)
16h N*??   Array Text Strings (with Arraysize=0001h) (in MAIN.MR\worlds)
1Ah N*10h  Array Guns,startpoints (RCCAR.MR\*, NEON.MR\world)
1Bh 4      Numeric 2x16bit (X,Y) (in MENU.MR)
1Ch N*4    Array lloc (in MENU.MR\menu\screens) (with Arraysize=04h or 1Fh)
25h 8      Whatever 8-byte (in GAME.MR\dualShock)
26h N*8    Array CollideArray (in GAME.MR\dualShock) (with Arraysize=4 or 6)

```

Compressed Data (when [008h]\<>0):

```

000h ..    ZLIB compressed data (usually starting with big-endian 789Ch)
           (compression is used for almost all files, except VERY small ones)

```

CDROM File Compression ZIP/GZIP/ZLIB (Inflate/Deflate)

13.37 CDROM File Archive HUG/IDX/BIZ (Power Spike)

Power Spike (MagDemo43: POWER\GAME.IDX and .HUG)

POWER\GAME.HUG

```

000h ..    File Data

```

POWER\GAME.IDX

```

000h 4      ID "HUGE"
004h 4      Checksum (sum of all bytes at [010h and up])
008h 4      Number of Folders (D) (87h)
00Ch 4      Number of Files (F) (F9h)
010h D*1Ch  Folder List (Folder 0..D-1)
... F*18h  File List (File 0..F-1)

```

Folder List entries:

```

000h 0Ch    Folder Name ("DIRNAME", zeropadded)
00Ch 4      First Child File (or FFFFFFFFh=None)
010h 4      Number of Child Files (or 00000000h=None)
014h 4      First Child Folder (or FFFFFFFFh=None)
018h 4      Next Sibling Folder (or FFFFFFFFh=None)

```

File List entries:

```
000h 0Ch   File Name ("FILENAME.EXT", zeropadded if shorter than 12)
00Ch 4     File Checksum (sum of all bytes in file added together)
010h 4     File Offset/800h in GAME.HUG
014h 4     File Size in bytes
```

The root entries are Folder 0 (and its siblings). That is, the root can contain only folders (not files).

The IDX/HUG archive contains many BIZ archives (and some TXT files).

Power Spike (MagDemo43: POWER\GAME.IDX*.BIZ) (BIZ nested in IDX/HUG)

```
000h 4     ID "BIG!"
004h 4     Number of entries (N)
008h N*1Ch File List
... ..    BIZ compressed File Data
```

File List entries

```
000h 10h   Filename (zeropadded)
010h 4     File Offset (increasing, unaligned, can be odd)
014h 4     File Size decompressed
018h 4     File Size compressed
```

All files in the BIZ archive are BIZ compressed (unknown if it does also support uncompressed files).

CDROM File Compression LZ5 and LZ5-variants

The BIZ archive seems to be solely containing PSI bitmaps (even files in GAME.IDX\SOUND\MUSIC*.BIZ do merely contain PSI bitmaps, not audio files).

13.38 CDROM File Archive TOC/DAT/LAY

Used in PSX Lightspan Online Connection CD (CD.TOC, CD.DAT, CD.LAY).

```
CD.TOC contains File/Folder entries
CD.DAT contains the actual File bodies
CD.LAY devkit leftover (list of filenames to be imported from PC to TOC/DAT)
```

The .TOC file doesn't have any file header, it does just start with the first File/Folder folder entry in root directory. The directory chains with file/folder entries are sorted alphabetically, each chain is terminated by a final entry which does point to parent directory.

File Entries

```

00h 4   Offset to next Sibling File/Folder/Final entry
04h 4   Filesize in bytes
08h 4   Filedata Offset/800h in CD.DAT
0Ch ..  Filename (ASCII, terminated by 00h)
... ..  Padding to 4-byte boundary (garbage)

```

Folder Entries (with Filesize=FFFFFFFFh)

```

00h 4   Offset to next Sibling File/Folder/Final entry
04h 4   Filesize (always FFFFFFFFh in Folder entries)
08h 4   Offset to first File/Folder in Child directory
0Ch ..  Name of Child directory (ASCII, terminated by 00h)
... ..  Padding to 4-byte boundary (garbage)

```

Final Entries (with Name="",00h and Filesize=FFFFFFFh)

```

00h 4   Offset to next Sibling entry (00000000h=None)
04h 4   Filesize (FFFFFFFFh in child folders, FFFFFFFEh in root folder)
08h 4   Offset to first File/Folder in Parent directory (or to self for root)
0Ch 1   Empty Name ("",00h)
0Dh 3   Padding to 4-byte boundary (garbage)

```

13.39 CDROM File Archive WAD (Doom)

Doom, PSXDOOM\ABIN\WAD and PSXDOOM\MAPDIR*.WAD)

The .WAD format is used by Doom (for DOS, Jaguar, PSX, etc), various homebrew Doom hacks, and some other developers have adopted the format and used .WAD in other game engines.

```

000h 4   ID "IWAD" (or "PWAD" for homebrew patches, or "PACK" in A.D. Cop)
004h 4   Number of File List entries (N) (including final ENDOFWAD entry)
008h 4   Offset to Directory Area (filesize-N*10h)
00Ch ..  File Data area
... N*10h File List

```

File List entries:

```

000h 4   Offset to file data (increasing by compressed size, 4-byte aligned)
004h 4   Filesize in bytes (uncompressed size) (zero in ENDOFWAD file)
008h 8   Filename (uppercase ASCII, zeropadded if less than 8 chars)

```


Folders

The directory can contain names like F_START, F_END, P1_START, P1_END with filesize=0 to mark begin/end of something; that stuff can be considered as subdirectories with 1- or 2-character names.

Notes: There are also regular files with underscores which are unrelated to folders (eg. F_SKY01). There are also 0-byte dummy files (eg. MAP17 in first entry MAP17.WAD). And there's a 0-byte dummy file with name ENDOFWAD in last file list entry (at least, it's present versions with compression support).

LZSS Decompression

Compression is indicated by Filename[0].bit7=1. The compressed size is NextFileOffset-FileOffset (that requires increasing offsets in File List, including valid offsets for 0-byte files like F_START, F_END, ENDOFWAD).

```

@@collect_more:
    flagbits=[src]+100h, src=src+1    ;8bit flags
@@decompress_lop:
    flagbits=flagbits SHR 1
    if zero then goto @@collect_more
    if carry=0 then
        [dst]=[src], dst=dst+1, src=src+1
    else
        disp=([src]*10h)+([src+1]/10h)+1, len=([src+1] AND 0Fh)+1, src=src+2
        if len=1 then goto @@decompress_done
        for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
    endif
    goto @@decompress_lop
@@decompress_done:
    ret

```

The game engine may insist on some files to be compressed or uncompressed (so compression may be required even if the uncompressed data would be smaller).

More info: <http://doomwiki.org/wiki/WAD>

13.40 CDROM File Archive WAD (Cardinal Syn/Fear Effect)

.WAD files (Cardinal Syn/Fear Effect)

This format exists in two version:

Old format: Without leading Header Size entry (Cardinal Syn MagDemo03: SYN*)
 New format: With leading Header Size entry (eg. Fear Effect)

Version detection could be done somewhat as so:

```
if [04h]*1Ch+8 >= [00h] then OLD version
```

For loading the Old Header, one must guess the max header size (4000h should work, in fact, most or all Old Headers seem to be max 800h), or load more data on the fly as needed.

```
000h (4) Header Size (including folder/type/file directories) (new version)
... 4   Number of Folders
... .. Folder List (root)
... .. Type Lists (for each folder)
... .. File Lists (for each folder\type)
... .. File Data (for each folder\type\file)
Folder List Entries:
000h 14h Folder name (ASCII, zeropadded)
014h 4   Offset to Type List
018h 4   Number of different Types in this folder
Type List Entries:
000h 4   Offset to file entries (of same type, eg. .TIM files)
004h 4   Number of file entries (of same type, eg. .TIM files)
008h 4   Sum of all Filesizes with that type
00Ch 4   Group Type (0000000xh)
File List entries (Files within Type list):
000h 14h Name (ASCII, terminated by 00h, plus garbage padding)
014h 4   Offset to File Data (seems 4-byte aligned... always?)
018h 4   File Type (000x00xxh)
01Ch 4   Filesize in bytes ;\maybe compressed/uncompressed, or rounded,
020h 4   Filesize in bytes ;/always both same
```

Note: The Type List for one folder can contain several entries with same Group Type, eg. Fear Effect GSHELLE.WAD\CREDIT has 5 type list entries (with 2xGroup0, 2xGroup1, 1xGroup2).

The Type List, Group Type and File Type stuff seems to have no function, apart from faster look up (the types are also implied in the filename extension). Except, Fear Effect .RMD .VB .VH have some unknown stuff encoded in File Type bit16-19.

Group Type is usually 0 (except for .TIM .VB .VH .MSG .SPU .OFF).

The .TIM .VB .VH .SEQ files are using standard Sony file formats. The .PMD file seems to be also Sony standard (except that it contains a 00000000h prefix, then followed by the 00000042h PMD format ID).

Cardinal Syn Types

```
.BGD FileType=00000001h
.ANM FileType=00000003h
.TIM FileType=00000004h (GroupType=1)
.SP2 FileType=00000005h
.PMD FileType=00000007h
.MOV FileType=00000008h
.SPR FileType=0000000Ch
.PVT FileType=0000000Dh
.DB  FileType=0000000Eh
.VH  FileType=00000010h (GroupType=1) ;only in OLDER demo version MagDemo03
.VB  FileType=00000011h (GroupType=1)
.MSG FileType=00000012h (GroupType=1) (actually, this is .TIM, too)
.KMD FileType=00000013h
.OC  FileType=00000018h
.EMD FileType=00000019h
.COL FileType=0000001Bh
.CF  FileType=0000001Ch
.CFB FileType=0000001Dh
.CL  FileType=0000001Eh
.SPU FileType=0000001Fh (GroupType=1) ;added in newer demo version MagDemo09
.OFF FileType=00000020h (GroupType=1) ;added in newer demo version MagDemo09
.RCT FileType=00000021h ;added in newer demo version MagDemo09
```

Fear Effect Types

```
.TIM FileType=00000000h (GroupType=1)
.RMD FileType=000x0001h
.DB  FileType=00000002h
.ANM FileType=00000003h
.SYM FileType=00000004h
.VB  FileType=000x0008h (GroupType=1)
.SEQ FileType=00000010h
.BIN FileType=00000012h
.SFX FileType=00000013h
.VH  FileType=000x0014h (GroupType=2)
.TM  FileType=00000015h
.NRM FileType=00000017h
.WPD FileType=00000018h
```

13.41 CDROM File Archive DIR/DAT (One/Viewpoint)

DIR/DAT (One/Viewpoint)

Used by One (DATAFILE.BIN and DIRFILE.BIN)
 Used by Viewpoint (VIEW.DAT and VIEW.DIR)

Format of the DIR file:

```
000h 60h Extension List (20h x 3-char ASCII, zeropadded if shorter than 3)
060h .. Root Directory (can contain folders and files)
... .. Child Directories (can contain files) (maybe also sub-folders?)
```

Extension List contains several uppercase 3-character ASCII extensions, in a hex editor this will appear as a continuous string of gibberish (dots=00h):

```
In Viewpoint: "...VCSVCFBINTXTVH.VB.STRST1ST2ST3.....//..."
In One:      "...VCTVCKSNDBINCPEINI.....//..."
```

Directory Entries contain bitstreams with ASCII characters squeezed into 6bit values:

```
000h 1 Length of Filename and Extension index
      bit7-3 File Extension Index (0..1Fh = Offset I*3 in DIR file)
      bit2-0 Filename Length-1 (0..7 = 1..8 chars)
001h .. Filename in 6bit chars (N*6+7/8 bytes = 1..6 bytes for 1..8 chars)
      bit7-2 1st character, whole 6bit ;\1st byte
      bit1-0 2nd character, upper 2bit (if any) ;/
      bit7-4 2nd character, lower 4bit (if any) ;\2nd byte (if any)
      bit3-0 3rd character, upper 4bit (if any) ;/
      bit7-6 3rd character, lower 2bit (if any) ;\3rd byte (if any)
      bit5-0 4th character, whole 6bit (if any) ;/
      bit7-2 5th character, whole 6bit (if any) ;\4th byte (if any)
      bit1-0 6th character, upper 2bit (if any) ;/
      bit7-4 6th character, lower 4bit (if any) ;\5th byte (if any)
      bit3-0 7th character, upper 4bit (if any) ;/
      bit7-6 7th character, lower 2bit (if any) ;\6th byte (if any)
      bit5-0 8th character, whole 6bit (if any) ;/
      bitN-0 Zeropadding in LSBs of last byte ;-zeropadding
The 6bit characters codes are:
      00h..09h="0..9", 0Ah..23h="a..z", 24h="_", 25h..3Fh=Unused
... 4 Filesize and End Flag
      bit31 End of Directory Flag (0=Not last entry, 1=Last entry)
      bit30-0 Filesize 31bit (or 0=Child Folder)
... 4 Offset and fixed bit
      bit31 Unknown (always 1)
      bit30-0 File Offset in DAT file (or Folder offset in DIR file)
```

13.42 CDROM File Archive Darkworks Chunks (Alone in the Dark)

Alone in the Dark The New Nightmare (FAT.BIN*)

The files in FAT.BIN are using a messy chunk format: There's no clear ID+Size structure. There are 7 different chunk types (DRAM, DSND, MIDB, G3DB, VRAM, WEAP, HAND), each type requires different efforts to compute the chunk size.

VRAM Chunks (Texture/Palette) (in various files)

```

000h 4      ID "VRAM"
004h 4      With Tags (0=No, 1=Yes) (or "DRAM" when empty 4-byte chunk)
008h (4)    Number of Tagged items (N) (0=None)  ;\only when [4]=1
00Ch N*10h Tagged Item(s)                        ;/(not so in LEVELS\*\VIEW*)
... ..     Scanline Rows(s)
... 4      End code (00000000h) (aka final Scanline Row with width=0)
Tagged Item(s) (IMG, LINE, GLOW, FLARE, BALLE, BLINK, COURIER7, BMP_***):
000h 8      Tag (ASCII, if less than 8 chars: terminate by 00h, pad by FDh)
008h 8      Data
Scanline Row(s) (bitmap scanlines and palette data):
000h 4      Header (bit0-8=Width, bit10-18=Y, bit20-29=X, bit9,19,30,31=?)
004h W*2    Data (Width*2 bytes, to be stored at VRAM(X,Y))

```

Empty VRAM chunks can be either 4 or 10h bytes tall. The 4-byte variant is directly followed by another chunk name (eg. "VRAMDRAM"), the 10h-byte variant contains four words ("VRAM",WithTags=1,NumTags=0,EndCode=0).

Note: Some files contain two VRAM chunks (eg. LEVELS*\VIEW*).

G3DB Chunks (Models) (in various files)

```

000h 4      ID "G3DB"
004h 4      Unknown (0, 1, or 2)
008h 4      Size of Data part (SIZ)
00Ch 4      Number of List entries (eg. 6 or 0Ah or 117Ch) (N)
010h SIZ    Data (supposedly LibGDX models in G3DB format)
... N*4 List

```

DRAM Chunks (Text and Binary data) (in various files)

```

000h 4      ID "DRAM"
004h 4      Size of Data part (SIZ) (can be odd)
008h 4      Number of List entries (N)
00Ch SIZ    Data (raw data, and/or tags TEXT, SPC, COURIER7)
... N*4 List

```

WEAP Chunks (Weapons) (in WEAPON\)

```

000h 4      ID "WEAP"
004h 4      Size-10h?
008h ..     Data

```

Followed by VRAM and DSND chunks.

HAND Chunks (Hands) (in LEFTHAND*HAND*)

```

000h 4   ID "HAND"
004h 4   Size-0Ch? (18h)
008h 8   Zerofilled
010h 4x4 Unknown (FFh, FF00h, xF0000h, FF3232h, FF6464h, FFDCDCh, FFFFFFFh, ..)
020h 4   Unknown (0, 1, 101h, or 201h)

```

Followed by VRAM and G3DB chunks.

MIDB Chunks (Music) (in MIDI\)

```

000h 4   ID "MIDB"
004h 1   Unknown (0 or 1)
005h 1   Number of SEQ blocks (1..4) (S)
006h 1   Number of Unknown 80h-byte blocks (1..2) (U)
007h U*80h Unknown Blocks (mostly FFh-filled)
... S*Var SEQ Block(s)
... .. VAB Block
SEQ Blocks:
Probably some MIDI sequence data, similar to Sony's .SEQ format.
000h 4   Size-0Ch (can be odd)
004h 8   Name (zeropadded if less than 8 chars)
00Ch 4   ID "DSEQ" ;\Size
010h .. Data ;/
VAB Blocks:
Apparently inspired on Sony's .VAB format (but the ID is spelled other way
around, Lists have variable size, and entries have different format).
000h 4   ID "VABp" (this is: not pBAV, unlike normal .VAB files)
004h 4   Unknown (0)
008h 4   Unknown (0)
00Ch 4   Size of all SPU-ADPCM samples (SIZ)
010h 2   Number of List 1 entries (N1)
012h 2   Number of List 2 entries (N2)
014h 2   Number of Samples (N3)
016h 6   Unused? (CCh-filled)
01Ch N1*10h List 1
... N2*10h List 2
... N3*2 Sample Size List (size of each SPU-ADPCM sample)
... SIZ SPU-ADPCM Sample(s)

```

DSND Chunks (Sounds) (in various files)

```

000h 4   ID "DSND"
004h 4   Unknown (0 or 2)
008h .. VAB Block (same as in MIDB chunks, see there)

```

Note

DRAM and MIDB chunks can have odd size; there isn't any alignment padding, so all following chunks can start at unaligned locations.

13.43 CDROM File Archive Blue Chunks (Blue's Clues)

Blue's Clues: Blue's Big Musical (*.TXD)

```

000h 4    Size of AUDD+SEPD+VABB chunks ;\for quick look-up only
004h 4    Size of all VRAM chunks      ; (can be ignored by chunk crawlers)
008h 4    Size of STGE+ANIM+FRAM chunks ;/(note: sum is total filesize-0Ch)
... ..   AUDD Chunk    (contains .VH)                ;\
... ..   SEPD Chunk(s) (contains .SEP)                ; sound
... ..   VABB Chunk    (contains .VB)                ;/
... (..) VRAM Chunk(s) (not in IN\FE2.TXD)            ;-textures/palettes
... (..) STGE Chunk    (if any, not in IN\FE*.TXD)     ;-stage data?
... (..) ANIM Chunk    (if any, not in IN\FE*.TXD)     ;\animation
... (..) FRAM Chunk(s) (if any, not in IN\FE*.TXD)     ;/
... (..) Further groups with ANIM+FRAM Chunks (if any) ;-more animation(s)

```

AUDD Chunks:

```

000h 4    Chunk ID ("AUDD")
004h 4    Chunk Size (of whole chunk from Chunk ID and up)
008h 4    Compression Flag (0=Uncompressed)
00Ch 4    Zero
010h ..   VH File (Sony Voice Header, starting with ID "pBAV")

```

SEPD Chunks:

```

000h 4    Chunk ID ("SEPD")
004h 4    Chunk Size (of whole chunk from Chunk ID and up)
008h 4    Compression Flag (0=Uncompressed)
00Ch 2    Zero
00Eh 2    Number of sequences (in the SEP sequence archive)
010h 4    Zero
014h ..   SEP File (Sony Sequence archive, starting with ID "pQES")
... ..   Zeropadding to 4-byte boundary

```

VABB Chunks:

```

000h 4    Chunk ID ("VABB")
004h 4    Chunk Size (of whole chunk from Chunk ID and up)
008h 4    Compression Flag (0=Uncompressed)
00Ch ..   VB File (Sony Voice Binary, with raw SPU-ADPCM samples)

```

VRAM Chunks:

```

000h 4    Chunk ID ("VRAM")
004h 4    Chunk Size (of whole chunk from Chunk ID and up)
008h 4    Compression Flag (1=Compressed)
00Ch 2    VRAM.X
00Eh 2    VRAM.Y
010h 2    Width in halfwords
012h 2    Height
014h 4    Decompressed Size (Width*Height*2) ;\Texture Bitmaps 8bpp
018h ..   Compressed Data                ; (or Palettes, in last VRAM

```

```

... .. Zeropadding to 4-byte boundary      ;/chunk)
STGE Chunks:
000h 4   Chunk ID ("STGE")
004h 4   Chunk Size (of whole chunk from Chunk ID and up)
008h 4   Compression Flag (0=Uncompressed)
00Ch ..  Unknown (stage data?)
ANIM Chunks:
000h 4   Chunk ID ("ANIM")
004h 4   Chunk Size (of whole chunk from Chunk ID and up)
008h 4   Compression Flag (0=Uncompressed)
00Ch ..  Unknown (animation sequence info?)
FRAM Chunks:
000h 4   Chunk ID ("FRAM")
004h 4   Chunk Size (of whole chunk from Chunk ID and up)
008h 4   Compression Flag (0=When Chunksize=14h, 1=When Chunksize>14h)
00Ch 1   Width in bytes
00Dh 1   Height
00Eh 6   Unknown, looks like three signed 16bit values (maybe X,Y,Z)?
014h (4) Decompressed Size (Width*Height*1)   ;\Animation Frame Bitmap 8bpp
018h (..) Compressed Data                      ; (only if Chunksize>14h)
... (..) Zeropadding to 4-byte boundary      ;/

```

VRAM and FRAM chunks with [08h]=1 (and Chunksize>14h) are compressed:

CDROM File Compression Blues

13.44 CDROM File Archive HED/CDF (Parasite Eve 2)

Crazy Data Format (CDF) is used by Parasite Eve 2, on Disc 1 and 2:

1: PE_Disk.01 Stage0.hed Stage0.cdf Stage1.cdf Stage2.cdf Stage3.cdf Inter0.str

2: PE_Disk.02 Stage0.hed Stage0.cdf Stage3.cdf Stage4.cdf Stage5.cdf Inter1.str

STAGE0.HED and STAGE0.CDF

This uses separate header/data files. The directory is stored in STAGE0.HED:

```

0000h 78h   Streaming List (03h entries, 28h-bytes each, all entries used)
0078h 1B00h File List (360h entries, 8 bytes each, all entries used)
1B78b 8     File List End Code (FFFFFFFFh,FFFFFFFFh)

```

The actual data for the files (and audio stream) is stored in STAGE0.CDF.

STAGE1.CDF .. STAGE5.CDF

```

0000h 800h  Root: Folder List (100h entries, 8-byte each, unused=zeropadded)
0800h ..    1st Folder (File/Streaming List and Data)

```



```
... .. 2nd Folder (File/Streaming List and Data)
... .. etc.
```

Folder List entries:

```
000h 4 Folder ID (usually N*100+1 decimal, increasing, eg. 101,201,301,etc.)
004h 4 Folder Size/800h (of whole folder, with File/Stream List and Data)
The Folder List ends with unused/zeropadded entries with ID/Size=00000000h.
```

Folder format:

```
0000h 510h File List (A2h entries, 8-bytes each, unused=zeropadded)
0510h 4 Zero (padding to decimally-minded offset 1300 aka 514h)
0514h 2D0h Streaming List (12h entries, 28h-bytes each, unused=zeropadded)
07E4h 1Ch Zero (padding to end of sector)
0800h ... Data (for Files, Audio streams, and sometimes also Movie streams)
```

File List entries (in STAGE0 and STAGE1-5)

```
000h 4 File ID (increasing, eg. 0,1,2,3,4,etc.) (or 99) (or N*100+x)
004h 4 File Offset/800h in in .CDF (from begin of current Folder)
```

For STAGE0, file list ends with ID/Offset=FFFFFFFFh at end of HED file. For STAGE1-5, file list ends with unused/zeropadded entries with ID/Offset=00000000h.

The filesize can be computed as "NextOffset-CurrOffset" (at 800h-byte resolution).

Whereas, "NextOffset" can be:

```
The offset of next File in File List (same as CurrOffset for 0-byte files)
The offset of next Audio stream in Streaming List
The offset of next Movie stream in Streaming List (if it's in .CDF, not .STR)
The size of the current Folder (for STAGE1-5)
The size of the whole .CDF file (for STAGE0)
```

For STAGE1-5, audio streams are usually stored at the end of folder (after the files). However, for STAGE0, audio streams are oddly inserted between file21000 and file30100.

File Chunks (for files within File List)

Most CDF files in STAGE0 and STAGE1-5 do contain one or more chunks with 10h-byte chunk headers (this can be considered as an additional filesystem layer, with the chunk data being the actual files).

```
000h 1 Chunk Type (see below)
001h 1 End Flag (01h=More Chunks follow, FFh=Last Chunk)
002h 2 Unknown (usually 800h, sometimes 500h or 600h)
```

```

        (eg. 500h in stage0\file30301\chunkX)
        (eg. 600h in stage1\folder1201\file0\chunkXYZ)
004h 4  Chunk Size/800h
008h 4  Unknown (usually zero) (or 80xxxx00h in Chunk Type 0 files?)
00Ch 4  Zero (0)
010h .. Data (Chunk Size-10h bytes)

```

Chunk Types:

```

00h=Room package          .pe2pkg
01h=Image                 .pe2img
02h=CLUT                  .pe2clut
04h=CAP2 Text             .pe2cap2
05h=Room backgrounds      .bs
06h=SPK/MPK music program .spk ;stereo/mono, sound/music, single/multiple?
07h=ASCII text            .txt (eg. stage0\20101..20132)
;Reportedly also (but wrong):
;60h=Sounds               .pe2snd (but nope, that's wrong, see below)
;60h is a MDEC movie from Streaming List (unrelated to File List chunks),
;60h is 20h-byte .STR header each 800h-bytes (occurs in "stage1\folder501")

```

There are some chunkless files:

```

stage0\40105...40198 are raw hMPK files without chunks
stage0\11000, 20213, 20214, 20300, ..., 660800 and 900000 are empty 0-byte

```

Streaming List Movie entries (stream type 1)

```

000h 2  Stream Type (0001h=Movie)
002h 2  Unknown (8000h or 0000h)
004h 4  Offset/800h in current Folder of .CDF file ;<-- used when [024h]=0
008h 4  Offset/800h in INTERx.STR file             ;<-- used when [024h]>0
00Ch 2  Unknown (0000h)
00Eh 2  Stream ID (increasing, usually starting at 64h aka 100 decimal)
010h 2  Stream sub.ID (usually 0, increases +1 upon multiple same IDs)
012h 2  Picture Width (0140h = 320 decimal)
014h 2  Picture Height (00F0h = 224 decimal)
016h 2  Unknown (0000h)
018h 2  Unknown (0000h or 0018h) maybe 24bpp or 24fps
01Ah 2  Unknown (73Ah or 359h or 3DCh) (Size? but it's slightly too large?)
01Ch 6  Unknown (zero)
022h 2  Unknown (0 or 1) (often 1 when [024h]>0, but not always)
024h 2  Movie number in INTERx.STR, 1 and up? (or 0=Movie is in STAGEx.CDF)
026h 2  Unknown (0 or 1)

```

The size of movie streams in .CDF can be computed in similar fashion as for File List entries (see there for details).

The size of movie streams in .STR cannot be computed easily (the next stream isn't necessarily stored at the next higher offset; even if it's within same folder). As

workaround, one could create a huge list with all streams from all Folders in all STAGEx.CDFs (or scan the MDEC .STR headers in .STR file; and check when the increasing frame number wraps to next stream).

The dual offsets are oddly computed as: [004h]=[008h]+EndOfLastFileInFolder (that gives the correct value in the used entry, and a nonsensical value in the other entry).

Streaming List Audio entries (stream type 2)

```

000h 2   Stream Type (0002h=Audio)
002h 2   Unknown (806Ah or increasing 0133h,0134h,0135h)
004h 4   Offset/800h in STAGEx.CDF file (increasing offsets)
008h 4   Unknown (0 or 13000h or E000h)
00Ch 2   Stage Number (0..5 = STAGE0-5)
00Eh 2   Stream ID (1, or increasing 3Ah,3Bh,3Ch)
010h 4   Stream sub.ID (usually 0Bh, increases +0Ah upon multiple same IDs)
014h 2   Unknown (0 or 2B0h or 3ADh or 398h) (Size/800h minus something?)
016h 2   Unknown (usually 20h, sometimes 0Fh)
018h 4   Unknown (2 or 1) ... maybe num channels ?
01Ch 2+2 Unknown (0,0 or 800h,800h)
020h 8   Unknown (0)

```

The size of audio streams can be computed in similar fashion as for File List entries (see there for details).

Audio Stream Data (stored alongsides with file data in STAGEx.CDF file)

This contains a 800h-byte header a list of 32bit indices:

```

000h 800h Whatever increasing 32bit index/timing values? FFFFFFFFh=special?
;That header exists in stage0\ and stage3\folder101\
;That header doesn't exist in all files (eg. not in stage1\folder301\)

```

then followed by several chunk-like STM blocks with 10h-byte headers:

```

000h 4   Chunk Index (increases each second chunk, from 0 and up)
004h 4   Number of Chunk Indices
008h 4   Fixed (02h,"STM") ;2-channel Stream?
00Ch 1   Chunk Subindex (toggles 00h or 01h per each chunk) ;ch left/right?
00Dh 1   Chunk Size/800h
00Eh 4   Unknown (can be 00h, 01h, 11h, 20h, 21h)
00Fh 4   Unknown (can be A0h or C0h)
010h .. Data (Chunk Size-10h bytes) (looks like SPU-ADPCM audio)

```

After the last STM chunk, there is more unknown stuff:

```

000h 0   Number of ADPCM blocks?           (eg. 28h   or 49h)
004h 4   Size of extra data block in bytes (eg. 13900h or 24200h)
008h 38h Zerofilled
040h 8   Zerofilled (maybe 1st sample of 1st SPU-ADPCM block)
048h ..  Looks like more SPU-ADPCM block(s), terminated by ADPCM end flag(s)
... ..  Zerofilled (padding to end of last 800h-byte sector)

```

Movie Stream Data (stored in .CDF, or in separate INTERx.STR file)

The movies are usually stored in INTERx.STR (except, some have them stored in STAGEx.CDF, eg. stage1\folder501, stage1\folder801, stage2\folder2101, stage2\folder3001).

The data consists of standard .STR files (with 20h-byte headers on each 800h-byte sector), with the MDEC data being in huffman .BS format (with .BS header... per frame?).

And, supposedly interleaved with XA-ADPCM audio sectors...?

PE_DISK.01 and PE_DISK.02

The presence of these files is probably used to detect which disc is inserted. The file content is unknown (looks like 800h-byte random values).

Note

Reportedly "Files inside archive may be compressed with custom LZSS compression" (unknown if/when/where/really/which files).

13.45 CDROM File Archive IND/WAD (MTV Music Generator)

MTV Music Generator (IND/WAD) (MagDemo30: JESTER\WADS\ECTS.IND and .WAD)

ECTS.IND contains FOLDER info:

```

0000h 20h   Name/ID ("Music 2", zeropadded)
0020h 4     Unknown (110000h)
0024h 4     Filesize-1000h (size excluding last 1000h-byte padding)
0028h 4     Unknown (17E0h)
002Ch 4     Unknown (5)
0030h N*10h Folder List, starting with Root in first 10h-byte
2CF0h 4     Small Padding (34h-filled)
2CF4h 1000h Final Padding (34h-filled)
Folder List entries that refer to Child Folders in ECTS.IND:
000h 8     Folder Name ("EXTRA*~*", zeropadded if less than 8) ("" for root)

```

```

008h 2      Self-relative Index to first Child folder (positive)
00Ah 2      Number of Child Folders (0..7FFFh)
00Ch 4      Always 0007FFFFh (19bit Offset=7FFFh, plus 13bit Size=0000h)
Folder List entries that refer to File Folders in ECTS.WAD:
000h 8      Folder Name ("EXTRA*~*", zeropadded if less than 8)
008h 2      Self-relative Index to Parent folder (negative)
00Ah 2      Number of Child Folders (always 8000h=None)
00Ch 4      Offset and Size in ECTS.WAD
The 32bit "Offset and Size" entry consists of:
0-18      19bit Offset/800h in ECTS.WAD
19-31     13bit Size/800h-1 in ECTS.WAD

```

ECTS.WAD contains FILE info and actual FILE data:

```

There are several File Folders (at the locations specified in ECTS.IND).
The separate File Folders look as so:
000h 4      Number of files (N)
004h N*10h  File List
... ..     34h-Padding to 800h-byte boundary
... ..     File Data area
File List entries:
000h 8      File Name ("NAMELIST", "ACIDWO~1", etc.) (00h-padded if shorter)
008h 4      Offset/800h (always from begin of WAD, not from begin of Folder)
00Ch 4      Filesize in bytes
The first file in each folder is called "NAMELIST" and contains this:
000h 20h    Long Name for Parent Folder (eg. "Backgrounds", zeropadded)
020h 20h    Long Name for this Folder (eg. "Extra 1", zeropadded)
040h N*20h  Long Names for all files in folder (except for NAMELIST itself)
For example, Long name for "ACIDWO~1" would be "Acidworld". Short names are
uppercase, max 8 chars, without spaces (with "~N" suffix if the long name
contains spaces or more than 8 chars). Many folder names are truncated to
one char (eg. "D" for Long name "DTeX"), in such cases short names CAN be
lowercase (eg. "z" for Long name "zTrans").
The Long Names are scattered around in the NAMELIST files in ECTS.WAD file,
so they aren't suitable for lookup (unless when loading all NAMELIST's).

```

13.46 CDROM File Archive GAME.RSC (Colony Wars Red Sun)

Colony Wars Red Sun (MagDemo31: CWREDSUN\GAME.RSC, 13Mbyte)

```

0000h 4      Offset to Bonkers List (2794h)
0004h F*8    Folder List (80h bytes, 10h entries)
0084h N*14h  File List(s) for each folder (2710h bytes, 1F4h entries)
2794h 4      Number of Bonkers (FE3h)
2798h B*8    Bonkers List (7F18h bytes, FE3h entries)
A6B0h 8      Unknown (zerofilled)
A6B8h ..     File Data area

```

Folder List entries:

```

000h 4      Offset to File List for this folder    ;\both zero when empty
004h 4      Number of Files in this folder        ;/

```

File List entries:

```

000h 10h    Filename ("FILENAME_EXT", zeropadded)
010h 3      Index (in Bonkers list) (000h..Fxxh)
013h 1      Folder Number where the file is stored (00h..0Fh)

```

Bonkers List entries:

```

000h 4      File Offset (to Data, increasing, 4-byte aligned, A6B8h and up)
004h 4      Folder Number where the file is stored (00h..0Fh)

```

Offsets/Indices in Folder/File list are unsorted (not increasing).

Offsets in Bonkers List are increasing (so file sizes can be computed as size=next-curr, except, the LAST file must be computed as size=total-curr).

There is no "number of folders entry" nor "folder list end marker", as workaround, while crawling the folder list, search the smallest file list offset, and treat that as folder list end offset.

In the demo version, all File List entries for Folder 5 are pointing to files with filesize=0, however, the Bonkers List has a lot more "hidden" entries that are marked to belong to Folder 5 with nonzero filesize.

Note: Older Colony Wars titles did also have a GAME.RSC file (but in different format, without folder structure).

13.47 CDROM File Archive BIGFILE.DAT (Soul Reaver)

Legacy of Kain: Soul Reaver - BIGFILE.DAT**Legacy of Kain: Soul Reaver (MagDemo26: KAIN2\BIGFILE.DAT)**

```

000h 2      Number of Folders (175h in retail, 0Ah in demo)
002h 2      Zero
004h N*8    Folder List (8-byte per Folder)
... ..     Zeropadding (to 800h-byte boundary)
... ..     1st Folder (with File List, and File Data for that folder)
... ..     2nd Folder (with File List, and File Data for that folder)
... ..     3rd Folder (with File List, and File Data for that folder)
... ..     etc.

```

Folder List entries:

```

000h 2      Unknown (somehow randomly increases from -8000h to +7E8Fh)
002h 2      Number of Files in this Folder (eg. 97h)
004h 4      Offset to Folder (usually 800h-aligned)

```

Folder format:

```

000h 2      Number of Files (same value as FolderistEntry[002h]) ;\encrypted
002h 2      Zero ; by 16bit
004h N*10h  File List (10h-byte per Folder) ; XOR value
... ..      Zeropadding (to 800h-byte boundary) ;/
... ..      File Data for this folder ;-unencrypted

```

File List entries:

```

000h 4      Unknown (random? filename hash? encrypted name?)
004h 4      File Size in bytes
008h 4      File Offset (usually 800h-aligned)
00Ch 4      Unknown (random? filename hash? encrypted name?)

```

Encryption:

The file header, the first some Folder headers (those in first quarter or so), and (all?) File Data is unencrypted (aka XORed with 0000h).

The Folder headers at higher offsets are encrypted with a 16bit XOR value. That XOR value is derived from Subchannel Q via LibCrypt:

CDROM Protection - LibCrypt

When not having the Subchannel data (or when not knowing which Folders are encrypted or unencrypted), one can simply obtain the encryption key from one of these entries (which will be key=0000h when unencrypted):

```

key = FileListEntry[000h] XOR FolderListEntry[002h] ;encrypted num entries
key = FileListEntry[002h] ;encrypted Zero
key = FileListEntry[zeropadding, if any] ;encrypted Zeropadding

```

LibCrypt seems to be used only in PAL games, unknown if the Soul Reaver NTSC version does also have some kind of encryption.

13.48 CDROM File Archive FF8 IMG (Final Fantasy VIII)

FF8 is quite a mess without clear directory structure. Apart from SYSTEM.CNF and boot EXE, there is only one huge IMG file. There are at least two central directories: The Root directory (usually at the start of the IMG file), and the Fields directory (hidden in a

compressed file that can be found in the Root directory). Moreover, there are files that exist in neither of the directories (most notably the Movies at the end of the IMG file).

IMG File

The IMG file doesn't have a unique file header, it can be best detected by checking the filename: FF8DISCn.IMG with n=1-4 for Disc 1-4 (or only FF8DISC1.IMG or FF8.EXE+FF8TRY.IMG for demo versions).

The directories contain ISO sector numbers (originated from begin of the ISO area at sector 00:02:00). Accordingly, it's best to extract data from the whole disc image (in CUE/BIN format or the like). When having only the raw IMG file, one must know/guess the starting sector number (eg. assume that the first Root File is located on the sector after the Root Directory, and convert sector numbers ISO-to-IMG accordingly).

Another oddity is that many files contain RAM addresses (80000000h-801FFFFFh), unknown how far that's relevant, and if there are cases where one would need to convert RAM addresses to IMG offsets.

Root Directory

The Root Directory is found at:

```
Offset 0000h in FF8DISCn.IMG in NTSC retail versions
Offset 2800h in FF8DISCn.IMG in PAL retail versions
Offset 0000h in FF8DISC1.IMG in french demo version
Offset ???h in FF8.EXE in MagDemo23 (...maybe offset 3357Ch ?)
Offset 33510h in FF8.EXE in japanese demo version ?
Offset 33584h in FF8.EXE in other demo versions ?
```

For detection:

```
if FF8DISCn.IMG starts with 000003xxh --> assume Root at IMG offset 0
if FF8DISCn.IMG starts with xxxxxxxxh --> assume Root at IMG offset 2800h
if FF8TRY.IMG starts with "SmCdReadCore" --> assume Root somewhere in EXE
```

File List:

```
000h N*8  File List entries
... ..   Zeropadding to end of 800h-byte sector
```

File List entries:

```
000h 4    ISO Sector Number (origin at 00:02:00) (unsorted, not increasing)
004h 4    Filesize in bytes
```


The file list does usually end with zeropadding (unknown if that applies to all versions; namely the Demo version might end with gibberish instead of having 800h-byte sector padding).

Fields Directory

The Fields Directory is located in Root file 0002h. First of, decompress that file, then search the following byte sequences to find the start/end of the directory:

```
retail.start      040005241800bf8f1400b18f1000b08f2000bd270800e00300000000
retail.end        0000010002000300
demo.start       76DF326F34A8D0B863C8C0EC4BE817F8
demo.end         00000000000000000000000000000000000000000000000000000000
```

The bytes between those start/end pattern contain the Directory, with entries in same format as Root directory:

```
000h 4      ISO Sector Number (origin at 00:02:00)
004h 4      Filesize in bytes
```

Notes: Root file 0002h is about 190Kbyte (decompressed), of which, the Fields Directory takes up about 8Kbytes, the remaining data contains other stuff.

The sector numbers in the Fields Directory refer to other locations in the IMG file (not to data in Root File 0002h).

Movie List

There is no known central directory for the movies (unknown if such a thing exists, or if the movie sector numbers are scattered around, stored in separate files). However, a movie list can be generated by crawling the movie headers, starting at end of IMG file:

```
sector = NumSectors(IMG file)
@@lop:
seek(sector-1), read(buf,08h bytes)
if first4byte[buf+0]="SMJ",01h, or ("SMN",01h) then
    num_sectors=(byte[buf+5]+1)*(halfword[buf+6]+1)
    sector=sector-num_sectors
    AddToMovieFileList(sector, num_sectors)
    goto @@lop
endif
```

That should cover all movies, which are all at the end of the IMG file (except, there's one more movie-like file elsewhere in the middle of IMG file, that file has only SMN/SMR audio sectors, without any SMJ video sectors).

PADBUG archives

PADBUG archives are used in Root files 001Eh..007Fh, most of them contain two AKAO files (except file 004Bh contains one AKAO and one TXT file).

```
000h 4      Number of Files (N) (usually 2)
004h N*8    File List
... ..     File Data area
```

File List entries:

```
000h 4      Offset in bytes (increasing, 4-byte aligned, see Quirk)
004h 4      File Size in bytes (can be odd)
```

Quirk: All files are zeropadded with 1-4 bytes to 4-byte boundary (ie. files that do end on a 4-byte boundary will be nethertheless padded with 4 zeroes).

Note: The PADBUG archives resemble LNK archives in O.D.T. (though those LNK archives have a different unique 4-byte padding quirk).

Compression

CDROM File Compression LZ5 and LZ5-variants

FF8 does reportedly also use GZIP (unknown in which files).

Known/unknown sectors for US version FF8DISC1.IMG

```
root sectors:      27CBh ;\
field sectors:     D466h ; total known sectors: 36D13h
movie sectors:     270E2h ;/
unknown sectors:   14F49h
total IMG sectors: 4BC5Ch
```

See also

<https://github.com/myst6re/deling/blob/master/FF8DiscArchive.cpp>

<https://ff7-mods.github.io/ff7-flat-wiki/FF8/PlaystationMedia.html>

13.49 CDROM File Archive FF9 IMG (Final Fantasy IX)

Final Fantasy IX (FF9.IMG, 320Mbyte) Overall format

```

000h Root Directory
800h 1st Child Folder
... 2nd Child Folder
... 3rd Child Folder
... ...
8000h ?      Last folder, with Type3, contains 1FFh x increasing 16bit numbers
... Data for files in 1st Child Folder
... Data for files in 2nd Child Folder
... Data for files in 3rd Child Folder
...

```

IMG Root Directory

```

000h 4      ID "FF9 "
004h 4      Unknown (06h on Disc 1 of 4) (maybe version, or disc id?)
008h 4      Number of Folder List entries (0Fh)
00Ch 4      Unknown (01h on Disc 1 of 4) (maybe version, or disc id?)
              (or Offset/800h to first file list?)
010h N*10h Folder List
... ..      Padding to 800h-byte boundary ("FF9 FF9 FF9 FF9 ")

```

Folder List entries:

```

000h 4      FolderType (2=Normal, 3=Special, 4=Last entry)
004h 4      Number of entries in File List (0..1FFh ?)
008h 4      Offset/800h to Child Folder with File List
00Ch 4      Offset/800h to File Data (same as 1st offs in File List) (0=Last)

```

IMG Child Folders (FolderType=2)

```

000h N*8    File List entries (N=Number of files, from Root directory)
N*8  8      File List END entry (ID=FFFFh, Attr=FFFFh, Offs=EndOfLastFile)
... ..      Zeropadding to 800h-byte boundary

```

File List entries:

```

000h 2      File ID (increasing, often decimal 0,10,100, or FFFFh=Last)
002h 2      Attr (unknown purpose, eg. 0,2,3,4,8,21h,28h,2Fh,44h,114h,FFFFh)
004h 4      Offset/800h to File Data (increasing, implies end of prev entry)

```

IMG Child Folders (FolderType=3)

```

000h N*2    File Offsets/800h, from File Data Offset in Root (or FFFFh=None)
N*2  2      End Offset for last file

```

The filesize can be computed as (NextOffs-CurrOffs)*800h, however, one must skip unused entries (FFFFh) to find NextOffs.

Nested Child Archives

Most of the files in FF9.IMG are DB archives, there are also some DOT1 archives.

CDROM File Archive FF9 DB (Final Fantasy IX)

There are various combinations of IMG, DB, DOT1 archives nested up to 4 levels deep:

```

IMG\DOT1      (eg. dir01\file003C)
IMG\DB        (eg. dir01\file2712)
IMG\DB\DOT1   (eg. dir01\file2712\00-0411)
IMG\DB\DOT1\DOT1 (eg. dir01\file2712\00-0443\*)
IMG\DB\DB     (eg. dir03\file2328\1B-000*)

```

Folders in Root directory

```

dir00 - Status/Menu/Battle/... -Text and random stuff.
dir01 - Misc Images (Logos, Fonts, World 'mini' Map images, etc).
dir02 - Dialog Text
dir03 - Map models (Mini-zidane, airships, save point moogles, tent...)
dir04 - Field models
dir05 - Monster Data (Part I, stats, names, etc).
dir06 - Location Data (Dungeon, Cities, etc).
dir07 - Monster Data (Part II, 3d models)
dir08 - Weapon Data (including models)
dir09 - Samplebanks and Sequencer Data (ie music).
dir0A - party members Data (including models)
dir0B - Sound effects
dir0C - World Map Data
dir0D - Special effects (magic, summons...)

```

See also

<https://ninjatoes.blogspot.com/2020/07/>

https://wiki.ffrtt.ru/index.php?title=Main_Page

13.50 CDROM File Archive GTFS (Gran Turismo 2)

Gran Turismo 2 (MagDemo27: GT2\GT2.VOL, GT2.VOL\arcade\arc_carlogo) - GTFS

```

000h 4      ID "GTFS"                                ; \
004h 4      Zero                                     ;

```

```

008h 2      Number of 4-byte File Offset List entries (N)          ; File(0)
00Ah 2      Number of 20h-byte File/Folder Name List entries (F)   ;
00Ch 4      Zero                                                  ;
010h N*4    File Offset List (see below)                          ;/
... ..     Zeropadding to 800h-byte boundary
... F*20h   File/Folder Name List (see below)                      ; -File(1)
... ..     Zeropadding to 800h-byte boundary
... ..     File Data                                              ; -File(2)
... ..     Zeropadding to 800h-byte boundary
... ..     File Data                                              ; -File(3)
... ..     ...
... ..     File Data                                              ; -File(N-2)
... ..     Zeropadding to 800h-byte boundary
EOF 0      End of File                                           ; -File(N-1)

```

That is, for N files, numbered File(0)..File(N-1):

```

File(0) and File(1) = Directory information
File(2)..File(N-2)  = Regular data files
File(N-1)           = Offset List entry points to the end of .VOL file

```

File Offset List entries, in File(0):

Contains information for all files, including File(0) and File(1), and including an entry for File(N-1), which contains the end offset for the last actual file, ie. for File(N-2).

```

Bit0-10    = Number of padding bytes in last sector of this file (0..7FFh)
Bit11-31   = Offset/800h to first sector of this file (increasing)
To compute the filesize: Size=(Entry[N+1] AND FFFFFFF800h)-Entry[N]

```

File/Folder Name List entries, in File(1):

Contains information for all files, except File(0), File(1), File(N-1), plus extra entries for Folders, plus ".." entries for links to Parent folders.

```

000h 4      Unknown (379xxxxxh) (maybe timestamp?)
004h 2      When Flags.bit0=0: Index of File in File Offset List (2 and up)
             When Flags.bit0=1: Index of first child in Name List, or...
             When Flags.bit0=1: Index of 1st? parent in Name List (Name="..")
006h 1      Flags (bit0:0=File, 1=Directory; bit7:1=Last Child entry)
007h 19h    Name (ASCII, zeropadded)

```

The game does use several archive formats: GTFS (including nested GTFS inside of main GTFS) and WAD.WAD and DOT1.

The game does use some GT-ZIP compressed files, and many GZIP compressed files (albeit with corrupted/zeropadded GZIP footers; due to DOT1 filesize 4-byte padding and (unnecessarily) GTFS 800h-byte padding).

[CDROM File Compression GT-ZIP \(Gran Turismo 1 and 2\)](#)

CDROM File Compression ZIP/GZIP/ZLIB (Inflate/Deflate)

To extract the decompressed size from the corrupted GZIP footers, one could compute the compressed "size" (excluding the GZIP header, footer, and padding), and search for a footer entry that is bigger than "size".

```
size=gz_filesize
size=size-GzipHeader(including ExtraHeader, Filename, Comment, HeaderCrc)
size=size-GzipFooter(8) ;initially assuming 8-byte footer (without padding)
i=gz_filesize-4
@@search_footer:
if buf[i]<size then i=i-1, size=size-1 goto @@search_footer
decompressed_size = buf[i]
```

Note: Above doesn't recurse the worst-case compression ratio, where compressed files could be slightly bigger than decompressed files.

13.51 CDROM File Archive Nightmare Project: Yakata

Nightmare Project: Yakata

ISO Files:

CD.IMG	550Mbyte	Contains file 004h..FFFh
CDRTBL.DAT	32Kbyte	Alias for file 000h (File List for file 000h..FFFh)
FDTBL.DAT	2Kbyte	Alias for file 001h (Folder List and Disc ID)
SLPS_010.4*	500Kbyte	Alias for file 003h (Boot EXE)
SYSTEM.CNF	72bytes	Alias for file 002h (Boot Info)
XXXXXXXX.	27Mbyte	Padding (zerofilled)

FDTBL.DAT (Folder List):

FDTBL.DAT seems to be used to divide the file list in CDRTBL.DAT into separate folders. The Folder List entries are containing the first file number for each folder. Empty folders have same file number as next entry. The last folder contains the specified file number plus all remaining files.

```
000h 56h*2 Folder List (16bit File Numbers, increasing from 0004h to 0xxxh)
0ACh 748h Zerofilled
7F4h 0Ah Game ID (ASCII "SLPS1045", 00h, 00h; always so on Disc 1..3)
7FEh 2 Disc ID (1..3 = Disc 1..3)
```

CDRTBL.DAT (File List):

```
000h 8000h File List (1000h x 8-byte entries)
File List entries:
000h 4 Sector (MM:SS:FF:00 in BCD, increasing) ;\all zero for
004h 2 Size1 (NumFramesCh1 or NumSectors) ; unused entries
```

```
006h 2   Size0   (NumFramesCh0 or Zero)           ;/
```

The meaning of the Size entries depends on the file type:

```
Normal binaries:  [004h]=NumSectors    [006h]=0           (1 channel)
XA-ADPCM streams: [004h]=NumSectors-50h [006h]=0           (16 channels)
MDEC streams:     [004h]=NumFrames      [006h]=0           (audio+video)
Special streams:  [004h]=NumFramesCh1   [006h]=NumFramesCh0 (2 channels)
```

To determine the actual filesize, one must compute the difference between sectors for current and next used file entry (or end of CD.IMG for last file; or alternately assume last file to be a Normal Binary with Size=NumSectors).

Normal Binaries:

Contains single files (file=0/channel=0). Filetypes include TIM, VB, VH, other/custom file formats, and DOT1 archives.

The DOT1 archives have 4-byte aligned offsets, but, unconventionally, with some offsets set to ZERO (usually the last entry, and sometimes also other entries):

```
SEQ files (Disc1:Dir08h\File173h)           ;with ZERO entries   (=uncommon)
SEQ files (Disc1:Dir09h\File176h..3D7h)      ;with ZERO entries   (=uncommon)
SEQ files (Disc1:Dir0Ah\File3DAh..3E6h)      ;with ZERO entries   (=uncommon)
TIM files (Disc1:Dir4Fh\File962h..983h)      ;with ZERO entries   (=uncommon)
TIM files (Disc1:Dir0Ch\File414h..426h)      ;without ZERO entries (=normal DOT1)
```

XA-ADPCM Streams (Disc1:Dir0Bh\File3E7h..413h):

These contain 16 audio streams (file=1/channel=00h-0Fh). The Size entry is set to total size in sectors for all streams, minus 50h (ie. there appears to be 50h sectors appended as padding before next file).

MDEC Streams (Disc1:Dir53h\FileBD1h..BEBh):

These are standard STR files with MDEC video (file=0/channel=1) and XA-ADPCM (file=1/channel=1). There are 10 sectors per frame (8-9 video sectors plus 1-2 audio sectors). The total filesize is NumFrames*10+Align(8) sectors; the Align(8) might be there to include one final audio sector.

Special Streams (Disc1:Dir07h\File0E9h-16Eh and Dir50h\File985h..B58h):

These are custom STR files (non-MDEC format), perhaps containing Polygon streams or whatever.

There are two channels (file=1/channel=00h-01h), each channel contains data that consists of 5 sectors per frame (1xHeader plus 4xData).

The sectors have STR ID=0160h, and STR Type as follows:

```
0000h=Whatever special, channel 0 header (sector 0)
0400h=Whatever special, channel 1 header (sector 1)
0001h=Whatever special, channel 0 data   (sector 2,4,6,8)
0401h=Whatever special, channel 1 data   (sector 3,5,7,9)
```

The File List size entries contain Number of Frames for each channel (either of these entries may be zero, or bigger/smaller/same than the other entry).

The smaller channel is padded to same size as bigger channel (ie. total filesize is "max(NumFramesCh0,NumFramesCh1)*10 sectors"; though that formula doesn't always hold true, for example, Disc1:Dir50h\FileA2Dh and FileB1Bh are bigger or smaller than expected).

13.52 CDROM File Archive FAdj0500 (Klonoa)

Klonoa (MagDemo08: KLONOA\FILE.IDX+FILE.BIN)

```

FILE.IDX
000h 8      ID "FAdj0500"
008h 38h    RAM addresses      (80xxxxxxh, 0Ch words)
038h 4      Zero
03Ch 4      RAM address        (80xxxxxxh)
040h N*10h  File List (including Folder start/end markers)
FILE.BIN
000h ..     File Data area (split into filesizes from FILE.IDX)

```

File List entries:

```

Type 0 (Folder End):
000h 4      Type (0=Folder End)
000h 4      Zero
008h 4      RAM address        (always 801EAF8Ch)
00Ch 4      Zero
Type 1.a (Folder Start):
000h 4      Type (1=Folder Start)
000h 4      Folder Offset/800h (offset of FIRST file in this Folder)
008h 4      RAM address        (always 801EAF8Ch)
00Ch 4      Folder Size/800h   (size of ALL files in this Folder)
Type 1.b (Force Offset, can occur between Files within a Folder):
000h 4      Type (1=Same as Folder Start)
000h 4      Folder Offset/800h (offset of NEXT file in this Folder)
008h 4      RAM address        (always 801EAF8Ch)
00Ch 4      Folder Size/800h   (zero for Force Offset)
Type 2 (File entries, within Folder Start/End):
000h 4      Type (2=File)
004h 4      Filesize in bytes   (4-byte aligned?)
008h 4      RAM address 1       (80xxxxxxh, or zero)
00Ch 4      RAM address 2       (80xxxxxxh)

```

File Offsets are usually 4-byte aligned (at offset+filesize from previous entry). Except, the first file after Folder Start (and Force Offset) is 800h-byte aligned.

The archive contains DOT1 archives, OA05 archives, Ulz compression, and TIM, TMD, VAB, SEQ, VB files.

13.53 CDROM File Archives in Hidden Sectors

Hidden Sector Overview

Xenogears, Chrono Cross, and Threads of Fate contain only two files in the ISO filesystem (SYSTEM.CNF and the boot executable). The CDROMs contain standard ISO data in Sector 10h-16h, followed by Hidden stuff in Sector 17h and up:


```

Sector 10h (00:02:16) Volume Descriptor (CD001)      ;\
Sector 11h (00:02:17) Volume Terminator (CD001)      ;
Sector 12h (00:02:18) Path Table 1                   ;
Sector 13h (00:02:19) Path Table 2                   ; standard ISO
Sector 14h (00:02:20) Path Table 3                   ;
Sector 15h (00:02:21) Path Table 4                   ;
Sector 16h (00:02:22) Root Directory                  ;/
Sector 17h (00:02:23) Hidden ID                      ;\
Sector 18h (00:02:24) Hidden Directory                ; hidden directory
Sector .. (00:02:xx) Hidden Unknown                  ;/
Sector .. (00:02:xx) Hidden Files... (referenced via Hidden Directory)

```

Note: Like normal files, all hidden entries have their last sector flagged as SM=89h (that applies to all three Hidden ID, Directory, Unknown entries, and to all Hidden Files). For details, see:

[CDROM XA Subheader, File, Channel, Interleave](#)

Xenogears (2 discs, 1998)

```

Sector 17h (Hidden.ID)
  000h 0Eh ID ("DS01_XENOGears"=Disc 1, or "DS02_XENOGears"=Disc 2)
  00Eh 7F2h Zerofilled
Sector 18h..27h
  000h N*7 File List entries
Sector 28h (Hidden.Unknown)
  Seems to contain a list of 16bit indices 0000h..1037h,FFFFh in File List
  (that, as raw list indices, regardless of the directory structure)
  000h      Unknown 0016 0018 FFFF FFFF 01A8 FFFF FFFF FFFF ;\
  010h      Unknown FFFF FFFF FFFF FFFF 0A35 0A3A 0D35 0AD3 ; as so on Disc 2
  020h      Unknown 0A22 0A2E 0A2F FFFF FFFF FFFF FFFF FFFF ; (values<>FFFFh
  030h      Unknown 0014 0001 0013 FFFF 0075 FFFF FFFF FFFF ; on Disc 1
  040h      Unknown 0C10 0C14 0C15 0C19 0F52 FFFF FFFF FFFF ; are 5 less, eg.
  050h      Unknown 0F4C 0B6E 0C4D 1037 0C09 0BAD FFFF FFFF ; 0011,0013,FFFF..)
  060h      Unknown 002E 0034 FFFF FFFF FFFF FFFF FFFF FFFF ;
  070h      Unknown FFFF FFFF FFFF FFFF ;/
  078h 2     Disc Number      (0001h=Disc 1, 0002h=Disc 2)
  07Ah 786h Zerofilled
Sector 29h 1st file

```

File List entries:

```

000h 3      24bit Offset (increasing sector number, or 0=special)
003h 4      32bit Size   (filesize in bytes, or negative or 0=special)

```

The Offset/Size can have following meanings:

```

offset=curr,  size=+N      file at sector=curr, size N bytes
offset=curr,  size=-N      begin of sub-directory, with N files
offset=curr,  size=0       empty file, size 0 bytes

```

```
offset=0,      size=0      unused file entry
offset=FFFFFFh, size=0      end of root-directory
```

Notes: The Hidden.Directory size seems to be hardcoded to 10h sectors (alternately, one could treat the sector of the 1st file entry as end of Hidden.Directory plus Hidden.Unknown).

Root entry 0004h and 0005h are aliases for ISO files SYSTEM.CNF and boot EXE. There seem to be no nested sub-directories (but there are several DOT1 child archives, in root- and sub-directories, eg. 00DCh\0000h*).

Chrono Cross (2 discs, 1999,2000)

Threads of Fate (aka Dewprism) (1 disc, 1999,2000)

```
Sector 17h (Hidden.ID)
000h 2      Disc Number      (0001h=Disc 1, 0002h=Disc 2)
002h 2      Number of Discs? (0002h) (always 2, even if only 1 disc)
004h 2+2    Sector and Size for Hidden.ID      (Sector=0017h, Size=002Ch)
008h 2+2    Sector and Size for Hidden.Directory (Sector=0018h, Size=60E0h)
00Ch 2+2    Sector and Size for Hidden.Unknown  (Sector=0025h, Size=0022h)
010h 10h    Zerofilled
020h 0Ch    Title ID ("CHRONOCROSS",00h)      ;Chrono Cross (retail)
          09h    Title ID ("DEWPRISM",00h)      ;Threads of Fate (retail)
          10h    Title ID ("DEWPRISM_TAIKEN",00h) ;Threads of Fate (demo)
0xxh 7xxh   Zerofilled (unused, since Hidden.ID has only Size=2Ch/29h/30h)
Sector 18h..24h (Hidden.Directory)
000h N*4    File List entries
... ..     Zeropadding (till Size=60E0h, aka 6200 entries)
... 720h   Zeropadding (till end of 800h-byte sector)
Sector 25h (Hidden.Unknown)
Seems to contain a list of 16bit indices 0000h..1791h,FFFFh in File List
(though many of the listed indices are unused file list entries)
000h 2      Disc Number      (0001h=Disc 1, 0002h=Disc 2)
002h 10h    Unknown 0000 1791 1777 1775 00ED 09DF FFFF 0002      ;\same on
012h 10h    Unknown 0025 0943 10E3 FFFF FFFF 0C77 0FD9 0FA3      ;/Disc 1+2
022h ..     Zerofilled (unused, since Hidden.ID has only Size=0022h)
Sector 26h 1st file (same as boot EXE in ISO)
```

File List entries:

```
0-22      Sector number
23        Flag (0=Normal, 1=Unused entry)
24-31     Number of unused bytes in last sector, div8 (0..FFh = 0..7F8h bytes)
```

The directory is just a huge list of root files (without any folder structure; many of the root files do contain DOT1 child archives though).

Root entry 0000h and 0001h are aliases for ISO files boot EXE and SYSTEM.CNF.

Filesizes can be computed as follows (that works for all entries including last used entry; which is followed by some unused entries with bit23=1):

```
filesize = ([addr+4]-[addr] AND 7FFFFFFh)*800h - ([addr+3] AND FFh)*8
```

Unused entries with bit23=1 have Sector pointing to end of previous file (needed for filesize calculation). There are some zeropadded entries at end of list (with whole 32bit zero). There are hundreds of dummy txt files (24-byte "It's CDMAKE Dummy!", 0Dh, 0Ah,, 0Dh, 0Ah, 20h and File08xxh: 8-byte "dummy", 0, 0, 0) although those are real used file entries, each occupying a whole separate 800h-byte sector.

Threads of Fate (demo version) (MagDemo33: TOF\DEWPRISM.HED+.EXE+.IMG)

The demo version is using the same directory format as retail version (but with Virtual Sector numbers in HED+EXE+IMG files instead of Hidden Sectors).

```
TOF\DEWPRISM.HED (6000h bytes)   VirtSector=1Ah,   PhysSector=A0A5h
TOF\DEWPRISM.EXE (97800h bytes)  VirtSector=26h,   PhysSector=A0B1h
TOF\DEWPRISM.IMG (19EA800h bytes) VirtSector=155h,  PhysSector=A1E0h
```

The demo's Virtual Sectors start at 1Ah (instead of 17h), to convert them to Physical Sectors: Subtract 1Ah, then add starting Sector Number of HED file. The HED file contains Hidden.ID, Hidden.Directory, and Hidden.Unknown.

13.54 CDROM File Archive HED/DAT/BNS/STR (Ape Escape)

Ape Escape KKIIDDZZ.HED/.DAT/.BNS/.STR

```
000h 52Ch List for .DAT file      ;value 0000h..6FFFh = sector 0..6FFFh in DAT
52Ch D4h  Zerofilled
600h C4h  List for .BNS file      ;value 7000h..71AFh = sector 0..1AFh in BNS
6C4h 3Ch  Zerofilled
700h 50h  List for .STR file(s) ;raw CDROM sector numbers from 00:02:00
750h B0h  Zerofilled
```

List entries, for all three lists (32bit values):

```
0-19   File Offset/800h (20bit)
20-31  File Size/800h   (12bit)
```

The sector numbers in DAT and BNS are basically counted from begin of the .DAT file (which has 7000h sectors in retail version, and the .BNS file does follow right thereafter

on the next sector) (the demo version (MagDemo22: KIDZ\)) *has only 105Ah sectors in .DAT, and the BNS entries at offset 600h start with 105Ah accordingly*).

There are 29 STR files in DEMO\STR and STR.STR, and 20 of them (?) are referenced in HED ?* There are also several .ALL files in above folders.

Note: Most of the STR files in Ape Escape contain polygon animation streams rather than BS compressed bitmaps. Ape Escape is (c)1999 by Sony.

```
.HED is 2048 bytes
.DAT is 58720256 bytes = 3800000h bytes ;div800h would be 7000h
.BNS is 884736 bytes = D8000h bytes ;div800h would be 1B0h
.STR's: 7D3Bh+150 = 7DD1h = sector for STR\LAB.STR
```

Some files contain RLE compressed TIMs:

[CDROM File Compression TIM-RLE4/RLE8](#)

Some files contain raw headerless SPU-ADPCM (eg. DAT file 00Ah).

13.55 CDROM File Archive WAD.WAD, BIG.BIN, JESTERS.PKG (Crash/Herc/Pandemonium)

Below are two slightly different formats. WAD.WAD has unused entries 00h-filled. The PKG format has them FFh-filled, and does additionally support Folders, and does have a trailing ASCII string. There's also a difference on whether or not to apply alignment to empty 0-byte files.

However, the formats can appear almost identical (unused entries, 0-byte files, and folders are optional, without them, the only difference would be the presence of the ASCII string; which does exist only in 800h-byte aligned PKG's though).

WAD.WAD (Crash/Crash)

Used by Crash Bandicoot 3 (DRAGON\WAD.WAD, plus nested WADs inside of WAD.WAD)

Used by Crash Team Racing (SPYR02\WAD.WAD, plus nested WADs inside of WAD.WAD)

Used by Madden NFL'98 (MagDemo02: TIBURON.DAT except
PORTRAIT,SPRITES,XA.DAT)

Used by N2O (MagDemo09, N2O\PSXMAP.TRM and N2O\PSXSND.SND)

Used by Speed Racer (MagDemo10: SPDRACER\ALL1.BIN, with 0-byte, unpadded eof)

Used by Gran Turismo 2 (MagDemo27: GT2\GT2.OVL = 128Kbyte WAD.WAD with
GZIP's)

Used by Jonah Lomu Rugby (LOMUDEMO\SFX\VBS, ENGLISH\VBS)

Used by Judge Dredd (*.CAP and *.MAD)

Used by Spyro 2 Ripto's Rage (SPYRO2\WAD.WAD, and nested WAD's therein)

Used by Spyro 3 Year of the Dragon (SPYRO3\WAD.WAD, and nested WAD's therein)

Used by Men: Mutant Academy (MagDemo33: PSXDATA\WAD.WAD*, childs in PWF)

```
000h N*8  File List
... ..   Zeropadding to 4-byte or 800h-byte boundary (or garbage padding)
... ..   File Data...
```

The File List can contain Files, and Unused entries:

```
000h 4      Offset in bytes (4- or 800h-byte aligned, increasing) ;\both zero
004h 4      Size in bytes (always multiples of 800h bytes)       ;/when Unused
```

The Offset in first entry implies size of the File List (the list has no end-marker other than the following zeropadding; which doesn't always exist, ie. not in 4-byte aligned files, and not in case of garbage padding).

The last entry has Offset+Size+Align = Total WAD filesize (except, Speed Racer doesn't have alignment padding after the last file).

The WAD.WAD format doesn't have folder entries, however, it is often used with nested WADs inside of the main WAD, which is about same as folders.

The alignment can be 4-byte or 800h-byte: N2O uses 4-byte for the main WADs. Madden NFL '98 uses 800h-byte for main WAD and 4-byte for child WADs (file 08h,0Ah,0Ch in TIBURON\MODEL01.DAT and file 76h in PIX01.DAT). Crash Bandicoot 3 and Crash Team Racing use 800h-byte for both main & child WADs (although with garbage padding instead of zeropadding in child WAD headers).

Unused entries have Offset=0, Size=0.

Empty 0-byte files (should) have Size=0 and Offset=PrevOffs+PrevSize+Align (except, Speed Racer has Offset=PrevOffs+PrevSize, ie. without Align for 0-byte files).

X-Men: Mutant Academy (MagDemo33,50: PSXDATA\WAD.WAD)

This does resemble standard WAD.WAD, but with leading 800h-byte extra stuff.

```
000h 4      ID ("PWF ") ;\
004h 4      Total Filesize (707800h) ;
008h 4      Unknown (1) ; extra stuff
00Ch 4      Number of files (N) ;
010h 7F0h  Zerofilled ;/
800h N*8  File List ;\
... ..   Zerofilled (padding to 800h-byte boundary) ; standard WAD.WAD
... ..   File Data area ;/
File List entries:
```

```
000h 4      File Offset in bytes (increasing, 800h-byte aligned)
004h 4      File Size in bytes
```

The archive contains child archives in DOT1 format, and in standard WAD.WAD format (without PWF header).

PKG (Herc/Pandemonium/UnholyWar)

Used by Pandemonium II (JESTERS.PKG, with Files+Folders+Unused entries)

Used by Herc's Adventure (BIG.BIN, with Files+Unused entries, without Folders)

Used by Unholy War (MagDemo12:CERBSAMP.PKG, with 0-byte files and nested PKG's)

Used by 102 Dalmatians (MagDemo40: PTTR\PSXDEMO.PKG)

```
000h N*8    File List
... ..     ASCII string (junk, but somewhat needed as nonzero end marker)
... ..     Zeropadding to 800h-byte boundary; not in 4-byte aligned nested PKG
... ..     File Data...
```

The File List can contain Files, Folders, and Unused entries. The overall format of the list entries is:

```
000h 4      Offset in bytes (increasing, or 0=First child) ;\both FFFFFFFFh
004h 4      Size in bytes (always nonzero)                ;/when Unused
```

Files and Folders do have exactly the same format, the only difference is that Folders will have Offset=00000000h in the NEXT list entry (in other words, the folder entry is followed by child entries, which start with Offset=0).

Offsets for Root entries are 800h-byte aligned, relative to begin of PKG file.

Offsets for Child entries are 4-byte aligned, relative to Parent Folder Offset.

The last Child entry has Offset+Size+Align(4) = Parent Folder Size.

The last Root entry has Offset+Size+Align(800h) = Total PKG filesize.

The last Root entry is usually followed by the ASCII string (which looks like junk, but it is useful because it equals to NextOffset=Nonzero=NoChlds).

```
<B> Example</B>
00003800h,00000666h ;root00h      (file 666h bytes, padded=800h)
00004000h,00000300h ;root01h\..    (folder 300h bytes, padded=800h)
00000000h,000000FDh ;root01h\child00h (file FDh bytes, padded=100h) ;\300h
FFFFFFFFh,FFFFFFFFh ;root01h\child01h (unused)                ; byte
00000100h,000001FDh ;root01h\child02h (file 1FDh bytes, padded=200h) ;/
00004800h,00001234h ;root02h      (file 1234h bytes, padded=1800h)
00006000h,00001234h ;root03h      (file 1234h bytes, padded=1800h)
FFFFFFFFh,FFFFFFFFh ;root04h      (unused)
```

```
00007800h,00001234h ;root05h      (file 1234h bytes, padded=1800h)
etc.
```

Notes: Unused entries can occur in both root and child folders (except, of course, not as first or last entry in child folders). Folders seem to occur only in root folder (although the format would allow nested folders).

Alternately, instead of Folders, one can use nested PKG's (the nested ones are using 4-byte align, without ASCII string and zeropadding in header).

13.56 CDROM File Archive BIGFILE.BIG (Gex)

Gex (GXDATA\BIGFILE.BIG and nested BIG files therein)

```
000h 4      Number of Files (eg. F4h)
004h 0Ch    Zero
010h N*10h  File entries
... 4      Archive ID (eg. 00000000h, FF53EC8Bh, or 83FFFFFFh)
... ..     Zeropadding to 800h byte boundary
... ..     File Data
```

File Entries:

```
000h 4      Archive ID (same value as in above header)
004h 4      Filename checksum or so (randomly ordered, not increasing)
008h 4      Filesize in bytes
00Ch 4      Fileoffset (800h-byte aligned) (increasing)
```

Filetypes in the archive include...

```
looks like a lot of raw data without meaningful file headers...
file C3h,ECh are raw SPU-ADPCM
file 08h,09h are nested BIG archives, but with FileEntry[00h]=FF53EC8Bh
file D9h,DAh are nested BIG archives, but with FileEntry[00h]=83FFFFFFh
```

FileEntry[04h] sometimes has similar continous values (maybe caused by similar filenames, and using a simple checksum, not CRC32).

13.57 CDROM File Archive BIGFILE.DAT (Gex - Enter the Gecko)

Gex - Enter the Gecko - BIGFILE.DAT

Used by Gex 2: Enter the Gecko (BIGFILE.DAT)

Used by Gex 3: Deep Cover Gecko (MagDemo20: G3\BIGFILE.DAT) -- UNSORTED

Used by Akuji (MagDemo18: AKUJI\BIGFILE.DAT)

Used by Walt Disney World Racing Tour (MagDemo35: GK\BIGFILE.DAT) -- UNSORTED

```
000h 4      Number of Files      (C0h)
004h N*18h  File entries
... ..     Zeropadding to 800h byte boundary
... ..     File Data
```

File Entries:

```
000h 4      Random
004h 4      Filesize in bytes (uncompressed size)
008h 4      Filesize in bytes (compressed size, or 0=uncompressed)
00Ch 4      Fileoffset (800h-byte aligned) (increasing, unless UNSORTED)
010h 4      Random
014h 4      Random (or ascii in 1st file)
```

LZ Decompression:

```
@@collect_more:
    flagbits=[src]+[src+1]*100h+10000h, src=src+2    ;16bit flags, unaligned
@@decompress_lop:
    if dst>=dst.end then goto @@decompress_done
    flagbits=flagbits SHR 1
    if zero then goto @@collect_more
    if carry=0 then
        [dst]=[src], dst=dst+1, src=src+1
    else
        len=([src] AND 0Fh)+1, disp=([src] AND 0F0h)*10h+[src+1], src=src+2
        if len=1 or disp=0 then goto invalid    ;weirdly, these are left unused
        for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
    endif
    goto @@decompress_lop
@@decompress_done:
    ret
```

Filetypes in the archive include...

```
standard TIM   (eg. file 01h,02h)
malformed TIM  (eg. file 0Fh,14h) (with [8]=2*cx*cy+4 instead 2*cx*cy+0Ch)
crippled VAB   (eg. file 0Eh,13h) (with hdr=filesize-4 plus raw ADPCM samples)
several DNSa   (eg. file 0Dh,12h,17h,BCh) SND sound? (also used by kain)
```



```
PMSa          (eg. Gex 3, World Racing) (SMP spu-adpcm samples)
there seem to be no nested DAT files inside of the main DAT file
```

Note: same malformed TIMs are also in Legacy of Kain (folder0004h\file0013h).

13.58 CDROM File Archive FF9 DB (Final Fantasy IX)

DB Archive

```
000h 1  ID (DBh)
001h 1  Number of Types
002h 2  Zero (0)
004h N*4 Type List
... .. File Lists & File Data for each Type
```

Type List entries:

```
000h 3  Offset to File List (self-relative, from current entry in Type List)
003h 1  Data Type (00h..1Fh)
```

File List:

```
000h 1  Data type (00h..1Fh) (same as in Type List)
001h 1  Number of Files
002h 2  Zero (0)
004h N*2 File ID List (unique ID per type) (different types may have same ID)
... .. Zeropadding to 4-byte boundary
... N*4 Offset List (self-relative, from current entry in Offset List)
... 4  End Offset (first-relative, from first entry in Offset List)
... .. File Data (referenced from above Offset List)
```

Data Types

```
00h  Misc (DOT1 Archives, or other files)
01h  Unused?
02h  Reportedly 3D Model data (vertices,quads,triangles,texcoords)
03h  Reportedly 3D Animation sequences
04h  TIM Texture
05h  Reportedly Scripts (hdr="EV") (eg. dir04\file32\1B-0001)
06h  ? (eg. dir02\file*)
07h  Sound "Sequencer Data" (hdr="AKAO") (eg. dir09\file*)
08h  Sound? tiny files (hdr="AKAO") (eg. dir04\file32\1B-0001)
09h  Sound Samples (hdr="AKAO") (eg. dir0B\file*)
0Ah  Reportedly Field Tiles and Field Camera parameters
0Bh  Reportedly Field Walkmesh (eg. dir04\file32\1B-0001)
0Ch  Reportedly Battle Scene geometry (eg. dir06\file*)
0Dh  ? (eg. dir01\file01)
```

```

0Eh Unused?
0Fh Unused?
10h ? (eg. dir05\file*)
11h ? (eg. dir05\file*)
12h Reportedly CLUT and TPage info for models (eg. dir04\file32\1B-0001)
13h Unused?
14h ? (eg. dir05\file*)
15h Unused?
16h ? (eg. dir04\file32\1B-0001)
17h ? (eg. dir04\file32\1B-0000)
18h Sound (hdr="AKAO") (eg. dir04\file32\1B-0001)
19h ? (eg. dir04\file32\1B-0001)
1Ah ? (eg. dir06\file*)
1Bh DB Archives (ie. further DB's nested inside of the parent DB archive)
1Ch ? (eg. dir04\file32\1B-0001)
1Dh ? (eg. dir03\file2328\1B-0001)
1Eh ? (eg. dir04\file32\1B-0001)
1Fh ? (eg. dir04\file32\1B-0001)
20h..FFh Unused?

```

13.59 CDROM File Archive Ace Combat 2 and 3

Ace Combat 2 (Namco 1997) (ACE2.DAT and ACE2.STH/STP)

There are two archives, stored in three files:

```

ACE2.DAT Directory for Data in ACE2.DAT itself ;normal binary data
ACE2.STH Directory for Data in separate ACE2.STP file ;streaming data

```

Directory Format:

```

000h 4 Unknown (1)
004h 4 Number of entries (N)
008h N*8 File List

```

File List entries (64bit):

```

0-27 28bit Size/N (DAT=Size/4, STP=Size/800h)
28-31 4bit Type or Channel Number (see below)
32-63 32bit Offset/800h in ACE2.STP or ACE2.DAT file

```

The files are interleaved depending on the Type/Channel number:

File	Bit28-31	Channel	Sector types...	Interleave	Notes
DAT	0	ch=0	DDDDDDDDDDDDDDDDDDDDDDDDDDDDDD	1:1	data (normal)
DAT	2	ch=0	DDDDDDDDDDDDDDDDDDDDDDDDDDDDDD	1:1	data (exe)
STH	0-6	ch=0-6	S.....S.....S.....S.....	1:8	stereo

```

STH      8      ch=1      vvvvvvvvSvvvvvvvvSvvvvvvvvSvvvvvvvS 1:1      video+stereo
Whereas D=data, S=Stereo/Audio, v=video, .=other channels

```

Note: The DAT file does additionally contain PreSizeDOT1 and DOT1 child archives.

Demo: The archives in demo version (MagDemo01: ACE2.*) contain only a handful of files; the two EXE files in demo DAT archive are only 800h-byte dummy files, and demo STP is corrupted: Recorded as CDROM image with 920h-byte sectors, instead of as actual CD-XA sectors).

Ace Combat 3 Electrosphere (Namco 1999) (ACE.BPH/BPB and ACE.SPH/SPB)

There are two archives, stored in four files:

```

ACE.BPH Directory for Data in separate ACE.BPB file ;normal binary data
ACE.SPH Directory for Data in separate ACE.SPB file ;streaming data

```

Directory Format:

```

000h 4      ID "AC3E" (=Ace Combat 3 Electrosphere)
004h 4      Type (BPH=3=Data?, SPH=1=Streaming?)
008h 2      BCD Month/Day?      (Japan=0427h, US=1130h)
00Ah 2      BCD Year (or zero) (SPH=1999h, BPH=0)
00Ch 4      Unknown (SPH=0, BPH/US=16CFh or BPH/JP=1484h)
010h 4      Number of entries (N)
014h N*8    File List

```

File List entries (64bit), when Bit31=1 (normal entries):

```

0-18      19bit Size/N      (BPH=Size/4, SPB=Size/800h)
19-23      5bit Channel Number (BPH=0, SPH=0..1Fh)
24-26      3bit Channel Interval (BPH=0, SPH=1 SHL N, eg. 3=Interval 1:8)
27         1bit Video Flag      (0=No, 1=Has Video sectors)
28         1bit Audio Flag      (0=No, 1=Has Audio sectors)
29         1bit Always 1 (except special entries with Bit31=0, see below)
30         1bit Unknown (US: Always 1, Japan: 0 or 1)
31         1bit Always 1 (except special entries with Bit31=0, see below)
32-63      32bit Offset/800h in ACE.BPB or ACE.SPB file (or 0 when bit31=0 ?)

```

File List entries (64bit), when Bit31=0:

For unknown purpose, the normal entries with Bit31=1 are occasionally followed by one or more entries with Bit31=0.

Unknown if those entries do affect the actual storage (like switching to different channel numbers, or jumping to non-continuous sector numbers).

That unknown stuff exists in Japanese version only, not in US version.

```

0-18      19bit Unknown (maybe some snippet size value in whatever units?)

```

```

19-23      5bit Always 0      (instead of Channel)

```

```

24-27      4bit Same as in most recent entry with Bit31=1

```

File	Bit24-31	Sector types...	Interval	Content
BPH.US	E0h	DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD	1:1	data
SPH.US	F8h	SvvvvvvvSvvvvvvvSvvvvvvvSvvvvvvv	1:1	stereo+video
SPH.US	FBh	S.....v.....S.....v.....	1:8	stereo+video
SPH.US	F3h	S.....S.....S.....S.....	1:8	stereo
SPH.US	F4h	S.....S.....S.....S.....	1:16	stereo
SPH.US	F5h	M.....M.....M.....M.....	1:32	mono
BPH.JAP	E0h	DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD	1:1	data
SPH.JAP	B8h,F8h	SvvvvvvvSvvvvvvvSvvvvvvvSvvvvvvv	1:1	stereo+video
SPH.JAP	B9h	Svvv....vvvv....Svvv....vvvv....	1:2 (4:8)	stereo+video
SPH.JAP	BAh,FAh	Mv.....vv.....vv.....vv.....	1:4 (2:8)	mono+video
SPH.JAP	BBh,FBh	S.....v.....S.....v.....	1:8	stereo+video
SPH.JAP	B3h,F3h	S.....S.....S.....S.....	1:8	stereo
SPH.JAP	B5h,F5h	M.....M.....M.....M.....	1:32	mono

Whereas D=data, S=Stereo/Audio, M=Mono/Audio, v=Video, .=Other channels

The Subheader's Channel number is specified in the above directory entries, Subheader's File number is fixed (0 for BPB, and 1 for SPB).

The SPB file is about 520Mbyte in both US and Japan, however, the Japanese version does reportedly contain more movies and some storyline that is missing in US/EU versions.

CDROM File Compression ULz/ULZ (Namco)

Demo: The archives do also exist on the demo version (MagDemo30: AC3*), but the .SPB file is corrupted: Recorded as a RIFF/CDXAfmt file, instead of as actual CD-XA sectors).

NSD/NSF versions

- 420/1136 -

```
v2 Crash Bandicoot 2      (MagDemo02: CRASH\S0\*.NSD and .NSF)
v3 Crash Bandicoot 3 Warped (MagDemo26,50: (S0\*.NSD and .NSF)
```

NSD

OVERALL NSD STRUCTURE (V0 CONTAINS ONLY THE LOOKUP ENTRIES)

```
0000h 100h*4 Lookup Table, using index=((Filename/8000h) AND FFh) ;\
0400h 4      Number of Chunks in .NSF file                      ; Lookup
0404h 4      Number of Files in Lookup File List (N)           ; /
0408h 4      Level Data Filename (eg. 4F26E8DFh="DATH.L")      ; -LevelDat
040Ch 4      Bitmap Number of Colors (100h) (P) (0=None)      ; \
0410h 4      Bitmap Width (200h or 1B0h) (X) (0=None)         ; Bitmap
0414h 4      Bitmap Height (0D8h or 090h) (Y) (0=None)        ; /
0418h 4      Compression: Offset/800h of first uncompressed chunk ; \
041Ch 4      Compression: Number of compressed chunks (0..40h) ; Compress
0420h 40h*4  Compression: Compressed Chunk List (0=unused entry) ; /
... N*8      Lookup File List                                  ; -Lookup
... ..       Level Data (size/format varies, see below)       ; -LevelDat
... P*2      Bitmap Palette (16bit values, 8000h..FFFFh)      ; \Bitmap
... X*Y      Bitmap Pixels (0D8h*200h)                        ; /
```

There are four .NSD versions, which can be distinguished via filesize:

```
v0 NSD Filesize=408h + N*8 ; -Lookup only
v1 NSD Filesize=520h + N*8 + P*2+X*Y + 210h ; \
v2 NSD Filesize=520h + N*8 + P*2+X*Y + 1DCh+S*18h ; with extra stuff
v3 NSD Filesize=520h + N*8 + P*2+X*Y + 2DCh+S*18h ; /
```

Note: v0 is mainly used by the Crash Bandicoot prototype, but the Crash Bandicoot 1 retail version does also have a few v0 files.

NSD LOOKUP

The lookup table allows to find files (by filenames) in the NSF files. It does merely contain the NSF chunk number, so one must load/decompress that chunk to find the file's exact size/location in that chunk.

One can create a complete file list by scanning the whole NSF file without using the NDS lookup table.

```
Lookup File List entries (indexed via Lookup Table):
00h 4      Chunk Number in .NSF file
04h 4      Filename (five 6bit characters)
```

Filenames:

```

0      Type (always 1=Filename) (as opposed to 0=Memory Pointer)
1-6    5th character ; -Extension ; \character set is:
7-12   4th character ; \          ; 00h..09h="0..9"
13-18  3rd character ; Name      ; 0Ah..23h="a..z"
19-24  2nd character ;          ; 24h..3Dh="A..Z"
25-30  1st character ; /        ; /3Eh..3Fh="_" and "!"
31     Always zero?

```

Special name: 6396347Fh="NONE.!"

NSD LEVEL DATA

Level Data exists in NSD v1-v3 (v0 does also have Level Data, but it's stored in NSF file "DAT*.L" instead of in the NSD file). There are two major versions:

```

Level Data in NSD v1 (or NSF v0 file DAT*.L):
000h  4      01h                                ; \
004h  4      Level Number (xxh) (same as xx in S00000xx.NSD/NSF) ;
008h  4      3807C8FBh = "s0_h.Z" ?                ; LevelDat
00Ch  4      Zero                                ; v1
010h  4      Zero                                ;
014h  L*4    Namelist (40h*4)                      ;
...    4      5Ah                                ;
...    F8h    Zerofilled                          ; /

Level Data in NSD v2-v3:
000h  4      Number of Spawn Points (S)              ; \
004h  4      Zero                                ;
008h  4      Level Number (xxh) (same as xx in S00000xx.NSD/NSF) ; LevelDat
00Ch  4      Number of Objects? (can be bigger than below list) ; v2/v3
          (eg. 1BDh or A5h or E4h)                  ;
010h  L*4    Namelist for Objects? (v2=40h*4, or v3=80h*4) ;
...    4      Unknown, always 5Ah (maybe just list end marker?) ;
...    C8h    Zerofilled                          ;
...    S*18h  Spawn Points                        ; /

```

NSD BITMAP

This bitmap is displayed while loading the level.

NSD COMPRESSION INFO

Compression is only used in v1 (v2-v3 do also have the compression entries at [418h..51Fh], but they are always zerofilled).

```

Compressed Chunk List entries at [420h..51Fh]:
0-5    Compressed Chunk Size/800h (1..1Fh=800h..F800h bytes, 20h..3Fh=Bad?)
6-31   Compressed Chunk Offset/800h

```

Note: Crash Bandicoot 1 retail does also have a few uncompressed files (either v0 files without compression info, or v1 files with zerofilled compression info).

NSF

NSF files consist of 64Kbyte chunks (compressed chunks are smaller, but will be 64Kbyte after decompression). Each chunk can contain one or more file(s). That implies that all files must be smaller than 64Kbyte (larger textures or ADPCM samples must be broken into multiple smaller files).

All files (except Textures) are NSF Child Archives which contain one or more smaller files/items.

NSF CHUNK TYPES

```
N*8Kbyte-Compressed-chunks:
000h 2    ID, always 1235h (instead of 1234h)
002h 2    Zero
004h 4    Decompressed Size (max 10000h) (usually 9xxxh..Fxxxh, often Fxxxh)
008h 4    Skip Size (max 40h or so, when last LZSS_len was 40h)
00Ch ..   Compressed data
... SK    Unused (Skip size)
... ..   Final uncompressed bytes (10000h-compressed_size-skip_size)

64Kbyte-Texture-chunks:
000h 2    ID, always 1234h
002h 2    Chunk Family (1=Texture)
004h 4    Filename (five 6bit characters)
008h 4    File Type (5=Texture)
00Ch 4    Checksum (sum of bytes ar [0..FFFFh], with initial [0Ch]=00000000h)
010h ...  Zerofilled
020h ...  Texture data (raw VRAM data, FFE0h bytes?)

64Kbyte-NonTexture-chunks:
000h 2    ID, always 1234h
002h 2    Chunk Family (0=Misc or 2..5=Sound)
004h 4    Chunk Number*2+1
008h 4    Number of Files (N) (can be 0, eg. prototype S0000003 chunk21h)
00Ch 4    Checksum (sum of bytes ar [0..FFFFh], with initial [0Ch]=00000000h)
010h N*4  File List (Offsets from ID=1234h to entries) (4-byte aligned)
... ..   Offset for end of last File
... ..   File Data (NSF Child Archives) (includes Type/Filename)
... ..   Padding to 10000h-byte boundary
```

NSF CHILD ARCHIVES

```
000h 4    ID, always 0100FFFFh
004h 4    Filename (five 6bit characters)
008h 4    File Type (01h..04h, or 06h..15h)
00Ch 4    Item Count (I)
010h I*4  Item List (Offsets from ID=0100FFFFh to items) (...unaligned?)
```

```
... .. Offset for end last item
... .. Data (Items)
```

NSF CHUNK LOADING AND DECOMPRESSION

The compression is a mixup of LZSS and RLE. Compressed chunks are max F800h bytes tall (10000h bytes after decompression).

```
dst=chunk_buffer_64kbyte
if chunksize is known (from NSD file)
    src=dest=dst+10000h-chunksize
    diskread(fpos,src,chunksize)
else (when parsing raw NSF file without NSD file)
    src=temp_buffer_64kbyte
    diskread(fpos,src,10000h)
dst_start=dst, src_start=src
if halfword[src+00h]<>1234h then ;check ID (1234h=raw, or 1235h=compressed)
    dst_end=dst+word[src+04h]
    skip_size=word[src+08h]
    src=src+0Ch
    while dst<dst_end
        x=[src], src=src+1
        if x<80h then
            for i=0 to x-1, [dst]=[src], dst=dst+1, src=src+1, next i ;uncompressed
        else
            x=(x AND 7Fh)*100h+[src], src=src+1
            disp=x/8, len=(x AND 7)+3, if len=0Ah then len=40h
            for i=0 to len-1, [dst]=[dst-disp], dst=dst+1, next i ;compressed
        src=src+src_skip
    if src<>dst then
        while dst<dst_start+10000h, [dst]=[src], dst=dst+1, src=src+1 ;uncompressed
    chunksize=src-src_start ;<-- compute (when chunksize was unknown)
    fpos=fpos+chunksize ;<-- fileposition of next chunk
```

As shown above, the chunk is intended to be loaded to the end of the decompression buffer, so trailing uncompressed bytes would be already in place without needing further relocation (despite of that intention, the actual game code is uselessly relocating src to dst, even when src=dst).

Note: All compressed files seem to have an uncompressed copy with same filename in another chunk (the NSD Lookup table does probably(?) point to the compressed variant, which should reduce CDROM loading time).

Filetypes

FILETYPE SUMMARY

Below shows File Type, Chunk Family, Extension (5th character of filename), the version where the type is used, 4-letter type names (as found in the EXE files), and a more

verbose description.

Typ	Family	Ext	Ver	Name	Description
00h	-	!	-	NONE	Nothing
01h	0	V	all	SVTX	Misc.Vertices
02h	0	G	all	TGEO	Misc.Model ;\changed format in v2-v3 ?
03h	0	W	all	WGEO	Misc.WorldScenery ;/
04h	0	S	all	SLST	Misc.UnknownSLST
05h	01h	T	all	TPAG	Texture.VRAM
06h	0	L	v0	LDAT	Misc.LevelData ;-stored in NSD in v1-v3
07h	0	Z	all	ZDAT	Misc.Entity ;-changed format in v2-v3 ?
08h	-	-	-	CPAT	Internal?
09h	-	-	-	BINF	Internal?
0Ah	-	-	-	OPAT	Internal?
0Bh	0	C	all	GOOL	Misc.GoolBytecode
0Ch	02h	A	v0	ADIO	OldSound.Adpcm ;\type 0Ch
0Ch	03h	A	all	ADIO	Sound.Adpcm ;/
0Dh	0	M	all	MIDI	Misc.MidiMusic ;-changed format in v1-v3 ?
0Eh	04h	N	all	INST	Sound.Instruments
0Fh	0	D	v0-1	IMAG	Misc.UnknownIMAG ;\type 0Fh
0Fh	0	X	v2-3	VCOL	Misc.UnknownVCOL ;/
10h	-	-	-	LINK	Internal?
11h	0	P	v0-1	MDAT	Misc.UnknownMDAT ;\type 11h
11h	0	R	v3	RAWD	Misc.UnknownRAWD ;/
12h	0	U	v0-1	IPAL	Misc.Unknown ;-Crash 1 only? (eg. S0000019.NSF)
13h	0	B	v1-3	PBAK	Misc.DemoPlayback ;-eg. in MagDemo02
14h	0	V	v0-1	CVTX	Misc.UnknownCVTX ;\type 14h
14h	05h	O	v2-3	SDIO	Speech.Adpcm ;/
15h	0	D	v2-3	VIDO	Misc.UnknownVIDO

As shown above, Type 0Ch is used with family 02h/03h, and Type 0Fh,11h,14h have two variants each (with different extensions). The Extensions do usually corresponding with the Types (although extension V,D are used for two different types each).

SEE ALSO:

<https://gist.github.com/ughman/3170834>

<https://dl.dropbox.com/s/fu29g6xn97sa4pl/crash2fileformat.html>

WEIRD NOTE

"Sound entries don't need to be aligned as strictly for most (all?) emulators."

What does that mean???

Is there a yet unknown 16-byte DMA alignment requirement on real hardware?

13.61 CDROM File Archive STAGE.DIR and *.DAT (Metal Gear Solid)

Metal Gear Solid (MagDemo13: MGS\)

Metal Gear Solid (MagDemo25: MGS\)

Metal Gear Solid (MagDemo44: MGS\) (*looks same as in MagDemo13*)

Metal Gear Solid (Retail: MGS\)

Summary of ISO files in MGS folder (with filesize for different releases)

File	MagDemo13/44	MagDemo25	Retail/PAL	
.EXE	9C000h	9C800h	9D800h	;-executable
STAGE.DIR	590800h	11A7800h	42AE000h	;-main archive
FACE.DAT	2CA000h	3Dh (txt)	358800h	;-face animation archive
ZMOVIE.STR	-	-	2D4E800h	;-movie archive
DEMO.DAT	149B000h	3Dh (txt)	EC20000h	;\DAT\SYM combos (the .SYM
DEMO.SYM	88h	-	-	; files were leaked in
VOX.DAT	14F2000h	9F800h	B054800h	; MagDemo13/MagDemo44 only)
VOX.SYM	988h	-	-	;/
BRF.DAT	-	66800h	575800h	;\whatever, unknown format(s)
RADIO.DAT	16CB8h	3Dh (txt)	1AA956h	;/

STAGE.DIR:

```

000h 4      Size of File List (N*0Ch)
004h N*0Ch Folder List
... ..     Zeropadding to 800h-byte boundary
... ..     Folder Data
Folder List entries:
000h 8      Foldername (zeropadded if less than 8 chars) ;nickname=stg
008h 4      Offset/800h to File List
Folder Data (per folder):
000h 2      Unknown (always 1) (maybe File List size/800h?)
002h 2      Folder Size/800h (of whole folder, with file list plus file data)
004h N*8    File List
...         Zeropadding to 800h-byte
800h       Data (for files in current folder)
File List entries:
000h 2      File ID (checksum on name)
002h 1      File Family (one of following chars: "cnrs")
003h 1      File Type (one of following chars: "abcdefghiklmoprswz",FFh)
004h 4      File Size (or File Offset, when File Family="c")

```

Combinations of Family/Type characters are:

```

.?a      ??? if any ??? (does NOT exist on PAL disc 1)      ;nickname=azm
.sb      MIPS binary code (leading)                          ;nickname=bin

```

.cc	Whatever	(eg. vr10*, s01a*)	;nickname=con
.nd	Texture Archive	(leading) (contains PCX files)	;nickname=dar
.rd	Misc Archive	(leading) (eg. init*)	;nickname=dar
.se	Sound Effects?	(trailing)	;nickname=efx
.cg	Whatever, reportedly bytecode functions		;nickname=gcx
.ch	Whatever		;nickname=hzm
.ci	Whatever	(eg. ending*, s01a*)	;nickname=img
.ck	Whatever, model? aka "pat_***" files		;nickname=kmd
.cl	Lights, first word = size/10h		;nickname=lit
.sm	Sound Music? Nested DOT1+DOTLESS Archives		;nickname=mt3
.co	Whatever "OARa"	(eg. d16e*, s00a*, s02c*)	;nickname=oar
.cp	PCX bitmap	(eg. init*)	;nickname=pcc
.cr	Whatever "sNRJlF"	(eg. roll*)	;nickname=rar
.cs	Whatever	(eg. d16e*, s01a*)	;nickname=sgt
.sw	Wave Archive	(trailing)	;nickname=vvx
.cz	Whatever "KMDa"	(eg. s11a, a11c, s14e, s15a)	;nickname=zmd
.c,FFh	End of Family="c" area		;nickname=dar?

Files are starting on 800h-byte boundaries. Files with Family="c" are special, they contain an Offset entries instead of a Size entries, that Offsets are 4-byte aligned (relative to the 800h-byte aligned offset of the first Family="c" entry), the list of Family="c" entries is terminated by an entry with Family="c" and Type=FFh (which contains the end-offset of the last c-Family entry, aka the size of all c-Family entries).

Note: The above 3-letter nicknames are used on some webpages (unknown why, maybe they are derived from MGS filename extensions in the PC version).

FACE.DAT (face animations for video calls):

This contains several large blocks (supposedly one per stage, each block having its own file list). There is no directory to find the begin of the separate blocks, but one can slowly crawl through the file:

```
NextBlock = CurrBlock + 4 + Offset(lastfile)+Size(lastfile) + Align800h
```

The content of each block is:

```
000h 4      Number of Files in this block (eg. 19h or 1Ch)
004h N*0Ch  File List for this block
... ..     File Data for this block
... ..     Zeropadding to 800h-byte boundary (followed by next block, if any)
File List entries:
000h 2      File Type (0=Main/Eye/Mouth frames, 1=All frames are full size)
002h 2      File ID (name checksum?)
004h 4      Filesize in bytes
008h 4      Offset in bytes, minus 4
```

Type 0 Files in FACE.DAT:

This type use a single palette for all frames, and only the first frame is full 52x89pix, the other frames contain only the update sections (eg. eyes).

```

000h 4      Offset to 200h-byte palette      (usually 20h)      ;\Main
004h 4      Offset to Main Bitmap (52x89pix) (usually 220h)    ;/
008h 4      Offset to 4th Bitmap  (usually xxxxh or 0=None)    ;\Eyes
00Ch 4      Offset to 5th Bitmap  (usually xxxxh or 0=None)    ;/
010h 4      Zero
014h 4      Offset to 2nd Bitmap  (usually 143Ch or 0=None)    ;\Mouth
018h 4      Offset to 3rd Bitmap  (usually xxxxh or 0=None)    ;/
01Ch 4      Zero
020h 200h   Palette (256 colors) ;\Main
220h 1218h  Main Bitmap                ;/
1438h 4      Zero
143Ch ..    2nd Bitmap (if any) ;\Mouth
... ..     3rd Bitmap (if any) ;/
... ..     4th Bitmap (if any) ;\Eyes
... ..     5th Bitmap (if any) ;/

```

Type 1 Files in FACE.DAT:

This type use separate palettes for each frame, all frames are full 52x89pix.

```

000h 4      Number of frames
004h N*0Ch  Frame List
... 200h    1st Frame Palette
... 1218h   1st Frame Bitmap (52x89pix)
... 4       ?
... 200h    2nd Frame Palette
... 1218h   2nd Frame Bitmap (52x89pix)
... 4       ?
... ..     3rd Frame ...

```

Frame List entries:

```

000h 4      Offset to Palette
004h 4      Offset to Bitmap (usually at Palette+200h)
008h 4      Unknown (often 000x000xh)

```

Bitmap Format (for both Type 0 and Type 1):

```

000h 1      Offset X (always 00h in Main Bitmap)
001h 1      Offset Y (always 00h in Main Bitmap)
002h 1      Width     (always 34h in Main Bitmap, or less in 2nd-5th bitmap)
003h 1      Height    (always 59h in Main Bitmap, or less in 2nd-5th bitmap)
004h ..     Bitmap Pixels at 8bpp (Width*Height bytes)

```

DEMO.DAT, DEMO.SYM**VOX.DAT, VOX.SYM**

The .DAT files contain several huge blocks, found on 800h-boundaries starting with:

```
10 08 00 00 0x 00 00 00 ..
```

The .SYM files (if present) contain Names and .DAT Offsets/800h for those huge blocks in text format:

```
"0xNNNNNNNN name", 0Ah
```

VOX.DAT does (among others) contain SPU-ADPCM chunks with 2004h bytes or less, that is, a 1+3 byte chunk header (01h=SPU-ADPCM, 002004h=Size), plus 2000h byte or less SPU-ADPCM data.

RADIO.DAT:

Whatever, contains chunks with text messages, chunks are about as so:

```
000h 4   Unknown      (eg. 36h,BFh,5Eh,00h)
004h 4   Unknown      (eg. 03h,13h,00h,00h)
008h 1   Unknown      (eg. 80h)
009h 2   Chunk Size   (eg. 0xh,xxh)           ;big-endian
.. ..   Chunk Data   (Chunk Size-2 bytes) (binary stuff, and text strings)
```

BRF.DAT:

Contains several "folders" in this format:

```
000h 4   Number of files in this folder
004h ..   File(s)
... ..   01h-padding to 800h-byte boundary
Files have this format:
000h ..   Filename ("name.pll",00h)
... ..   Zeropadding to 4-byte boundary (aligned to begin of BRF.DAT)
... 4     File data size (usually a multiple of 4)
... ..   File data
... 1     Zero (00h)
```

The above "folders" are then followed by several PCX files:

```
000h .. PCX file (starting with 0A,05,01,01 or 0A,05,01,08)
... .. 01h-padding to 800h-byte boundary
```

The first part with .pll files does contain some kind of chunk sizes that could be used to find the next entry (but that would be very slow).

The second part with .PCX files doesn't have any chunk sizes at all (though one could decompress the .PCX file to find the end of each file) (also one could guess/find them by looking for 0A,05,01,01/08 on 800h-byte boundaries).

ZMOVIE.STR (movie archive with several STR files with subtitles)

CDROM File Video Streaming STR Variants

STAGE.DIR\\sb - stage binary/header

This is the first file in most folders (except "init*" folders).

The file contains MIPS binary program code. And, there are ascii strings near end of .sb files, which include filenames, alike:

```
"name.c",00h + garbage-padding to 4-byte boundary ;<-- maybe source code?
"pat_lamp",00h + zero- padding to 4-byte boundary ;<-- name for File ID !
```

Those filenames do cover some (not all) of the name checksums in the STAGE.DIR folder.

STAGE.DIR\\cp, STAGE.DIR\\nd.p, BRF.DAT* - PCX bitmap files

MGS is using customized/corrupted PCX files as standard texture format (in STAGE.DIR\\cp, STAGE.DIR\\nd.p, and BRF.DAT\).

For details on PCX format (and MGS-specific customizations), see:

CDROM File Video Texture/Bitmap (PCX)

Apart from PCX, there's also custom texture format for animated bitmaps (in FACE.DAT), and a few TIM images (in STAGE.DIR\\init*\\.rd\\.r)

STAGE.DIR\\nd - texture archive (with .PCX files)

STAGE.DIR\\init*\\.rd - misc archive (with misc files)

These archives contain several chunks in following format:

```
000h 2      File ID (checksum on name?)
002h 1      File Type (one of following chars: "p" for .nd, or "kors" for .rd)
003h 1      Zero (00h)
```

```

004h 4      Chunk Size (rounded to 4-byte boundary)
008h ..     Chunk Data

```

The File Type can be:

```

.p      PCX bitmap                      ;-in *\*.nd archives
.k      Whatever                       ;\
.o      Whatever "OARa"                 ; in init*\*.rd archives
.a      Whatever                       ;
.r      Misc (TIM and other stuff)      ;/

```

There can be 1-2 texture archives per STAGE.DIR folder (both having File ID=0000h) (probably due to a memory size limit: the game does probably load one archive with max 300Kbytes, relocate its contents to VRAM, then load the next archive, if any).

STAGE.DIR\sw - wave archive

There can be one or more .sw files per stage folder (eg. two sw's in "vr**.sw").

```

000h 4      Unknown (800h or C00h)       ;big-endian
004h 4      Size of File List (N*10h)    ;big-endian
008h 8      Zerofilled
010h N*10h  File List (xx,xx,xx,00,00,00,00,7F,00,00,00,0F,00,19,0A,00)
... 4      Unknown (40000h or 60000h)   ;big-endian
... 4      Size of SPU-ADPCM Data area   ;big-endian
... 8      Zerofilled
... ..     SPU-ADPCM Data area (indexed from File List)
File List entries:
000h 4      Offset+Flags                  ;little-endian!
           bit0-16  Offset (from begin of SPU-ADPCM Data area)
           bit17    Unknown (0 or 1)
           bit18    Unknown (1)
           bit19-31 Unknown (0)
004h 12     Whatever (always 00,00,00,7F,00,00,00,0F,00,19,0A,00)

```

The unknown fields might contain volume, ADSR, pitch or the like?

STAGE.DIR\se - sound effects? maybe short midi-like sequences or so?

```

000h 80h*10h List (unused entries are 1x00000000h,3xFFFFFFFFh)
800h ..     Data (whatever, usually 14h or more bytes per list entry)
List entries:
000h 1      Unknown (eg. 01h,10h,20h,A0h,80h,FFh)    ;\
001h 1      Number of Voices? (1..3)                 ; all zero for
002h 1      Unknown (1 or 0)                          ; unused list entries
003h 1      Unknown (2 or 0 or 1)                     ;/
004h 4      Offset-800h for 1st Voice?                 ;-FFFFFFFFh=Unused
008h 4      Offset-800h for 2nd Voice? (if any)        ;-FFFFFFFFh=Unused

```

```
00Ch 4      Offset-800h for 3rd Voice? (if any)      ;-FFFFFFFFh=Unused
Data:
Seems to contain 4-byte entries (last entry being 00,00,FE,FF).
```

STAGE.DIR\sm - whatever nested archives - sound music? mide-like?

This does resemble a DOT1 Parent archive with 1-4 DOTLESS Child archives. Except, the offsets in Child archives are counted from begin of Parent archive.

```
Data:
Seems to contain 4-byte entries (last entry being 00,00,FE,FF).
```

File IDs

File IDs in STAGE.DIR (and maybe elsewhere, too) are computed as so:

```
sum=0,
for i=0 to len(filename)-1
    sum=sum*20h+filename[i]      ;\or so, 16bit overflows might be
    sum=(sum+sum/10000h) AND FFFFh ;/cropped slightly differently
```

Examples: "abst"=1706h, "selectvr"=8167h.

Some filenames are empty (name="", ID=0000h).

Some filenames do match up with the STAGE.DIR foldername.

Some filenames do match up with strings in .sb file of current folder.

Other filenames are unknown.

13.62 CDROM File Archive DRACULA.DAT (Dracula)

Dracula - The Resurrection - DRACULA.DAT (180Mbyte)

```
000h 4      Zero
004h 4      Number of Entries (503h)
008h 4      Zero
00Ch 4      Random
010h 10h    Zero
020h N*10h  File List
... ..     Zeropadding to 800h-byte boundary
... ..     Fild Data area
```

File List entries:


```

000h 4      Offset/800h
004h 4      Type (see below for info on different file types)
008h 4      Filesize in bytes
00Ch 4      Random (or 0 when Filesize=0)

```

Most of the .DAT file consists of groups of 3 files (with type 01h/40h, 20h and 400h; of which the files with type 20h and 400h may have Size=0=empty).

```

Type=00000001h Cubemap           ;\either one of these
Type=00000040h Cubemap.empty     ;/
Type=00000020h Cubemap.overlay?  ;\these have size=0 when unused
Type=00000400h Cubemap.sounds    ;/

```

There are some general purpose files with other types at end of .DAT file:

```

Type=00000000h Archive with TIMs      (Size=AB74h)  (" RSC3.1V")
Type=00000004h Unknown                 (Size=16164h) (00000064h)
Type=00000008h Related to DRACULA1.STR (Size=1000h)  (" RTS1.1V")
Type=00001000h Unknown                 (Size=2000h)  ("BXFS1.1V")
Type=00008000h Unknown                 (Size=71Dh)   (" CM1.1V")
Type=00020000h Unknown                 (Size=3B9h)   (" GSM0.1V")
Type=02000000h Unknown                 (Size=0h)     (empty)
Type=00000100h Related to DRACULA1.XA  (Size=1000h)  ("RAAX1.1V")
Type=00000010h Unknown                 (Size=450h)   (" HYP0.1V")
Type=00100000h Unknown                 (Size=4014h)  (" xFS1.1V") (x=A1h)
Type=00000080h Unknown                 (Size=258F4h) (00000010h)
Type=00000200h TIM (gui charset)        (Size=6E9Eh)  (TIM)
Type=00010000h TIM (gui buttons)        (Size=10220h) (TIM)
Type=00040000h Unknown                 (Size=2C4h)   (" TES0.1V")
Type=00002000h TIM (gui book pages)     (Size=1040h)  (TIM)
Type=00008000h Cubemap ;\as Type 01h,   (Size=4092Ch) (" RIV3.1V")
Type=00004000h Cubemap ;/but [10h,14h]=0 (Size=4092Ch) (" RIV3.1V", too)

```

Type 01h - Cubemap:

```

000h 8      Name, ASCII, padded with leading spaces (eg. " RIV3.1V")
008h 4      Something (0, 1 or 2) (unknown, this isn't number of list entries)
00Ch 4      Zero
010h 4      Offset to Ext data (ACh)                      ;\ext data
014h 4      Size of Ext data (eg. 0 or 84h)                ;/
018h 6*4    Offsets to Side 0-5                          ;\cubemap sides
030h 6*4    Sizes of Side 0-5 (0, 10220h, or 10820h)      ;/
048h 44h    Zerofilled
08Ch 20h    Name, ASCII (eg. "DEBUT0.VR", zeropadded)
0ACh ..     Ext Data (if any)
... ..     Cubemap TIM sides (if any)

```

Note: The cubemap TIMs have 100h or 400h colors (in the latter case: 100h colors for each quarter of the 8bpp bitmap).

Note: The TIMs can be arranged as 3D-cubemap with six sides, or as hires 2D-bitmap (composed of four TIMs, and 2 empty TIMs with size=0).

Type 40h - Empty Cubemap:

Same as Type 01h, but size is always 0ACh (and all seven Size entries are 0)

Type 400h - Sound VAG's:

```

000h 8      Name, ASCII, padded with leading spaces (eg. " XFS0.1V")
008h 4      Zero
00Ch 4      Number of Files (N) (max 10h)
010h N*10h File List (100h bytes, zeropadded when less than 10h files)
110h ..     File Data (VAG files)
File List entries:
000h 4      Unknown (55F0h, 255F0h or 20000h)
004h 4      File ID (01010000h, increasing, or other when above=2xxxxh)
008h 4      Offset in bytes                               ;\VAG files
00Ch 4      Filesize in bytes                             ;/

```

Type 20h - Cubemap overlays, polygons, effects or so?:

```

000h 8      Name, ASCII, padded with leading dot (eg. ".MNA4.1V")
008h 4      Zero
00Ch 4      Random
010h 4      Unknown 01h
014h 4      Total Number of 40h-byte blocks (01h..[018h]) (H)
018h 4      Total Number of 120h-byte blocks (eg. 1Fh,31h) (N)
01Ch 4      Total Number of 1Ch-byte blocks (eg. 1Eh, 50h, F7h) (M)
020h 4      Unknown 0 or 1 (in file 4EAh)
024h 4      Unknown 01h
028h 6*4    Offsets to Side 0-5 (at end of file and up) (or 0)  ;\cubemap
040h 6*4    Sizes of Side 0-5 (10220h, or 10820h) (or 0)  ;/sides
058h H*40h  40h-byte blocks
... N*120h  120h-byte blocks (related to offsets in 40h-byte blocks)
... M*1Ch   1Ch-byte blocks (related to offsets in 120h-byte blocks)
... ..     Unknown data (related to offsets in 1Ch-byte blocks)
... ..     Ext data (related to Ext offsets in 40h-byte blocks)

```

FILE DOES END HERE!

(below is allocated in above header, but not actually stored in the file)

(maybe allocated as rendering buffer?)

... - Cubemap TIM sides

The 40h-byte blocks are:

```

000h 20h    Name (eg. "FLAMMES", zeropadded)
020h 4      Unknown 01h or 00h
024h 4      Offset to 120h-byte blocks (usually 98h, or higher)
028h 4      Unknown 00h
02Ch 4      Number of 120h-byte blocks (01h..[018h])
030h 4      Unknown 01h
034h 4      Ext Offset                               ;\usually all zero
038h 4      Ext Size (3C000h)                         ; (except, nonzero in file 4EAh)
03Ch 4      Ext Random (checksum?)                    ;/

```

The 120h-byte blocks are:

```

000h 18h*4  List with Offsets to 1Ch-byte blocks (usually 4 entries nonzero)
060h 18h*4  List with Zeroes

```

```

0C0h 18h*4  List with Numbers of 1Ch-byte blocks (usually max 4 entries)
The 1Ch-byte blocks are:
000h 4      Unknown 04h
004h 4      Width   20h or 10h
008h 4      Height  20h or 10h or 30h
00Ch 4      Unknown 60h or 10h
010h 4      Unknown 00h or 30h
014h 4      Offset to Unknown Data
018h 4      Size of Unknown Data (Width*Height*1)

```

Type 00h - TIMs:

```

000h 8      Name (" RSC3.1V")
008h 8      Zerofilled
010h 4      Number of used entries (1Fh) (max 80h)
014h 80h*4  Offset List      (offsets to files) (A14h and up)
214h 80h*4  Zero List        (zerofilled)
414h 80h*4  Size List         (filesizes)
614h 80h*4  Width List        (0Ch,18h,34h,2Ch) (in pixels)
814h 80h*4  Height List       (0Ch,24h,34h,2Ch)
A14h ..     Data (TIM files, with mouse pointers)

```

13.63 CDROM File Archive Croc 1 (DIR, WAD, etc.)

Croc 1 (MagDemo02: CROC*) (plus more files in retail version)

CROCFILE.DIR and CROCFILE.1:

```

CROCFILE.DIR:
000h 4      Number of Entries (N)
004h N*18h  File List
... 4      Checksum (sum of all of the above bytes)
CROCFILE.1:
000h ..     File Data (referenced from .DIR)
File List entries:
000h 0Ch    Filename ("FILENAME.EXT", zeropadded if shorter)
00Ch 4      File Size in bytes (can be odd) (including 8 byte for size/chksum)
010h 4      File Offset in .1 file (unaligned, can be odd, increasing)
014h 4      Zero (0)

```

CROCFILE.DIR\MP*.MAP (and MAP files inside of MAP*.WAD and MP090-100_*.WAD):

```

000h 4      Size-8 of whole file (or Size-0 for those in MP*.WAD)
004h 4      Flags? (usually 0Ch or 14h)
008h 1      Filename length (including trailing 00h, if any)
009h ..     Filename ("P:\CROC\EDITOR\MAPS\..\*.MAP") (+00h in MAP05*.WAD)
... ..     Unknown
... 1      Description length

```

```

... .. Description (eg. "Default New Map")
... .. Unknown
... (4) Checksum of whole file (sum of all bytes) (not in MP*.WAD)

```

CROCFIELDIR\WAD:

```

MAP*.WAD:
000h 4   Size-8 of whole file
004h ..  MAP file(s) (each with size/checksum, same format as MP*.MAP)
... 4    Checksum of whole file (sum of all of the above bytes)
CROC.WAD, CROCSLID.WAD, EXCLUDE.WAD, MP*.WAD, OPTIONS.WAD, SWIMCROC.WAD:
000h 4   Size-8 of whole file
004h 4   Offset-8 to SPU-ADPCM data area
008h ..  Data File area (model.MOD anim.ANI, bytecode.BIN, header.CVG, etc.)
... ..  SPU-ADPCM data area (if any, note in CROCSLID.WAD and OPTIONS.WAD)
The Data File area contains several "files" but doesn't have any directory
with filename/offset/size. The only way to find the separate files seems to
be to detect the type/filesize of each file, and then advance to next file
(bytecode.BIN files start with a size entry, but files like .MOD or .ANI
require parsing their fileheader for computing filesize).
Note: The PC version reportedly has .WAD files bundled with .IDX file (that
makes it easier to find files and filenames).
Note: The STRAT.DIR file contains a list of filenames used in .WAD files
(but lacks info on offset/size, so it isn't really useful).

```

CROCFIELDIR\BIN:

```

Sound.BIN Files (CROCFIELDIR\AMBI*.BIN, MAP*.BIN, JRHYTHM.BIN, REVERB.BIN):
000h 4   Size of .SEQ file ;\if any (not in REVERB.BIN)
004h ..  SEQ file (starting with ID "pQES") ;/
... 4    Size of .VH file ;\always present
... ..  VH file (starting with ID "pBAV") ;/
... ..  VB file (sample data, SPU-ADPCM data, up to end of file)
Music.BIN files (MAGMUS.BIN, MUSIC.BIN):
000h 4   Size-8 of whole file (118h)
004h ..  Increasing 32bit values ;sector numbers in PACK*.STR files or so?
... 4    Unknown (2EEh or 258h) (aka 750 or 600 decimal)
... ..  Zeropadding
11Ch 4   Checksum (sum of all of the above bytes)
Note: MUSIC.BIN has an extra copy (without checksum) in EXCLUDE.WAD\MUSIC.BIN
Ascii.BIN files (CREDITS*.BIN, MNAME.BIN):
000h 4   Size-8 of whole file
004h (2) Type or so? (02h,01h) (only in CREDITS*.BIN, not in MNAME.BIN)
... ..  Ascii strings (each string is: len,"text string",unknown)
... 4    Checksum (sum of all of the above bytes)
Texture.BIN files (type 4) (STILLGO.BIN, STILLST.BIN, STILLTL.BIN):
000h 2   Type (4=Texture/uncompressed, with 0Eh-byte list entries)
002h 1   Zero (maybe Extra6byte as in type 5,6 Texture.BIN files)
003h 2   Number of List entries (N) (always 4B0h in all three files)
005h 2   Number of Texture Pages (usually 2)
007h 2   Zero (maybe Unknown/Animation as in type 5,6 Texture.BIN files)
009h N*0Eh Polygon List (?, ?, ?, ?, ?, ?, x1,y1, x2,y1, x1,y2, x2,y2)

```

```

... 40000h Texture Page uncompressed data (two pages, 20000h bytes each)
... 4      Checksum (sum of all of the above bytes)
Texture.BIN files (type 5,6) (ENDTEXT*.BIN, FONT.BIN, FRONTEND.BIN,
OUTRO.BIN, PUBLISH.BIN, STILL*.BIN, TB*.BIN, TK*.BIN, TPAGE213.BIN):
000h 4      Zero (0) (in TPAGE213.BIN: Size-8 of whole file)
004h 2      Type (6=Texture/RLE16) (in TPAGE213.BIN: 5=Texture/uncompressed)
006h 1      Extra6byte flag/size (0=None, 3=Extra6byte: TB*.BIN, TPAGE*.BIN)
... (6)     Extra6byte data (unknown purpose, only present when [006h]=3)
... 2      Number of Polygon List entries (N)
... 2      Number of Texture Pages (usually 1) (in TK*_ENM.BIN: usually 2)
... 2      Number of Unknown Blocks (0=None, or 1,2,4,8)
... (...)   Unknown Block(s), if any
... 2      Number of Animation Blocks (0=None)
... (...)   Animation Block(s), if any
... N*0Ch   Polygon List (?, ?, ?, ?, x1,y1, x2,y1, x1,y2, x2,y2) ;x,y or y,x?
... (4)     Texture Page compressed size (T1) ;\only when [004h]=Type=6
... (T1)    Texture Page compressed data ;/
... (4)     Texture Page compressed size (T2) ;\only when [004h]=Type=6
... (T2)    Texture Page compressed data ;/ and NumPages=2
... 20000h Texture Page uncompressed data ;-only when [004h]=Type=5
... 4      Checksum (sum of all of the above bytes)

```

Unknown Block(s):

(Unknown purpose, each Unknown Block has the format shown below)

```

000h 2      Unknown (looks like some index value, different for each entry)
002h 2      Number of Unknown Items (eg. 1 or 2 or 4)
004h ..     Unknown Items (NumItems*6 bytes) (three halfwords each?)

```

Animation Block(s):

(This is supposedly used to update portions of the Texture Page for animated textures, each Animation Block has the format shown below)

```

000h 2      Number of Bitmap Frames in this Animation (usually 8)
002h 2      Bitmap Width (in halfword units)
004h 2      Bitmap Height
006h 2      Unknown (1 or 3) ;\
008h 2      Unknown (C10h, CC8h, 1E8h, or xxxh) ; maybe vram X,Y address?
00Ah 2      Unknown (0) ;/
00Ch ..     Bitmap Frames (Width*2*Height*NumFrames bytes, uncompressed)

```

Croc 1 RLE16 compression:

This is using unsigned little-endian 16bit LEN/DATA pairs, LEN can be:

0000h..7FFFh --> Load one halfword, fill 1..8000h halfwords

8000h..FFFFh --> Copy 1..8000h uncompressed halfwords

BUG: Texture pages should be 20000h bytes (256x256 halfwords), but for whatever reason, the size of decompressed data can be 1FFEAh, 1FFF0h, 1FFFAh, 20000h, or 20002h.

Bytecode.BIN (inside of .WAD files):

```

000h 4      Size of whole file
004h ..     Whatever bytecode (starting with initial 16bit program counter?)

```

Unknown.BIN (last 1-2 file(s) in EXCLUDE.WAD file):

```

000h 4      Number of entries (N)
004h N*18h Whatever
... 4      Checksum (sum of above bytes)

```

Unknown purpose, retail version has one such file (with 0Ah entries), demo version has two such files (with 0Ah and 4Eh entries. The files start with:

0A,00,00,00,00,00,00,00,00,00,64,00,00,00,EB,FF,... ;demo+retail

4E,00,00,00,00,00,64,00,00,00,50,00,00,00,64,00,... ;demo

CROCFIELDIR.MOD

Demo version has one .MOD file in CROCFIELDIR (retail has more such files):

```

000h 2      Number of Models (N) (1 or more) (up to ECh exists)      ;\header
002h 2      Flags (0 or 1)                                           ;/
004h N*Var  SubHeadersWithData ;see below                            ;-data
... 4      Checksum (sum of all of the above bytes)                  ;-checksum
SubHeadersWithData(N*Var):
004h 4      Radius                                                  ;\
008h 48h    Bounding Box[9*8] (each 8byte are 4x16bit: X,Y,Z,0)      ; for each
050h 4      Number of Vertices (V)                                   ; model
054h V*8    Vectors (4x16bit: X,Y,Z,0)                               ;
... V*8    Normals (4x16bit: X,Y,Z,0)                                ;
... 4      Number of Faces (F) (aka Polygons?)                       ;
... F*14h   Faces (8x16bit+4x8bit: X,Y,Z,0,V1,V2,V3,V4, Tex/RGB)      ;
... 2      Number of collision info 1? (X)                           ;\
... 2      Number of collision info 2? (Y)                           ; only if
... X*2Ch   Collision info 1?                                         ; Flags.bit0=1
... Y*2Ch   Collision info 2?                                         ;/

```

There are further .MOD models inside of .WAD files, with slightly re-arranged entries (and additional reserved/garbage fields):

```

000h 2      Number of Models (N) (1 or more) (up to ECh exists)      ;\
002h 2      Flags (0 or 1)                                           ; header
004h 4      Reserved/garbage (usually 224460h) (or 22C9F4h/22DF54h) ;/
008h (4)    Number of Models WITH Data arrays (M)                   ;\
00Ch (M*2)  Model Numbers WITH Data arrays (increasing, 0..N-1)     ; ext.hdr
... (...)   Padding to 4-byte boundary (garbage, usually=M)         ;/
... N*68h   Subheader(s) ;see below                                  ;-part 1
... N*Var   dataArray(s) ;see below                                  ;-part 2
Subheaders(N*68h):
000h 4      Radius                                                  ;\
004h 48h    Bounding Box[9*8] (each 8byte are 4x16bit: X,Y,Z,0)      ; for each
04Ch 4      Number of Vertices (V)                                   ; model
050h 4      Reserved/garbage (usually 0022xxxxh)                    ;
054h 4      Reserved/garbage (usually 0022xxxxh)                    ;
058h 4      Number of Faces (F) (aka Polygons?)                     ;
05Ch 4      Reserved/garbage (usually 0022xxxxh)                    ;
060h 2      Number of collision info1? (X)                           ;
062h 2      Number of collision info2? (Y)                           ;
064h 4      Reserved/garbage (usually 0022xxxxh) or xxxxxxxxxh      ;/
DataArrays(N*Var) with sizes V,F,X,Y from corresponding Subheader:
(if ext.hdr is present, then below exists only for models listed in ext.hdr)
000h V*8    Vectors (4x16bit: X,Y,Z,0)                               ;\
... V*8    Normals (4x16bit: X,Y,Z,0)                                ; for each
... F*14h   Faces (8x16bit+4x8bit: X,Y,Z,0,V1,V2,V3,V4, Tex/RGB)      ; model
... X*2Ch   Collision info 1?                                         ;
... Y*2Ch   Collision info 2?                                         ;/

```

The ext.hdr mentioned above exists only in some .MOD files (usually in one of the last chunks of MP*.WAD). Files with ext.hdr have N>1, Flags=1 (but files without ext.hdr can also have those settings). Files with ext.hdr do usually have uncommon garbage values at hdr[4], which isn't too helpful for detection. The only way to detect models with ext.hdr seems to be to check if the ext.hdr contains valid increasing entries in range 0..N-1.

WAD's that do contain a model with ext.hdr do usually also contain an extra

100h-byte file, that file contains N bytes for model $0..N-1$ (plus zeropadding to 100h-byte size), the bytes are supposedly redirecting models without Data Arrays to some other data source.

The 100h-byte files don't have any header or checksum, they contain up to 9Ch entries (so there's always some zeropadding to 100h), the existing 100h-byte files contain following values in first 4 bytes (as 32bit value):

04141401h, 0C040017h, 01010101h, 09030503h, 0A0B0A0Bh, 03020102h, 0C060900h, 00060501h, 04040201h, 01010203h, 01030201h, 05000302h, 0C040317h, or Zero.

To distinguish from other files: BIN/MAP files start with a 4-byte aligned Size value; if $\text{Size}=0$ or $(\text{Size AND } 3)>0$ or $\text{Size}>\text{RemainingSize}$ then it's probably a 100h-byte file. Best also check if last some bytes are zeropadded.

Exceptions:

Retail MP090..MP100_*.WAD has model with ext.hdr, but no 100h-byte file

Demo MP041_00.WAD has model with ext.hdr, with zerofilled 100h-byte file

Note: Some models have ALL models listed in ext.hdr (which is about same as not having any ext.hdr at all; except, they ARE bundled with 100h-byte file).

CROCFILE.DIR\MP*.DEM

Some (not all) MP*.WAD files are bundled with MP*.DEM files, supposedly containing data for demonstration mode. There are two versions:

demo version: size 2584h (9604 decimal) (some files with partial checksum)

retail version: size 0E10h (3600 decimal) (without checksum)

CROCFILE.DIR\CROCWALK.ANI:

Animation data, there is only one such file in CROCFILE.DIR:

```
000h 2      Value (100h)
002h 2      Number of Triggers (T) (2)
004h (T*2)  Trigger List (with 2x8bit entries: FrameNo, TriggerID)
... ..     Probably, Padding to 4-byte boundary (when T=odd)
... 4      Number of entries 1 (X)
... X*18h   Whatever Array 1
... 4      Number of entries 2 (Y) (usually/always 64h)
... X*Y*4   Whatever Array 2
... 4      Number of entries 3 (Z) (usually/always 0Ah)
... X*Z*18h Whatever Array 3
```

There are further .ANI files inside of .WAD files:

```
000h 2      Value (100h or 200h) ;Animation Speed?
002h 2      Number of Triggers (T) (0, 1, 2, 3, 5, or 9)
004h 4      Garbage/Pointer (usually 224460h) (or zero)
008h 4      Number of entries 1 (X) (1 or more) ;Num Frames
00Ch 4      Garbage/Pointer (usually 22C9F4h) (or 224460h or 22DF54h)
010h 4      Number of entries 2 (Y) (usually 64h) (or 0) ;Num Vertices (?)
014h 4      Garbage/Pointer
018h 4      Number of entries 3 (Z) (usually 0Ah) (or 6 or 9)
01Ch 4      Garbage/Pointer
020h (T*2)  Trigger List (with 2x8bit entries: FrameNo, TriggerID)
... ..     Padding to 4-byte boundary (garbage, usually=X)
... X*18h   Whatever Array 1
... X*4     Garbage/Pointers (0021EE74h,0021EE74h,xxx,...)
... X*Y*4   Whatever Array 2 ;Vertex 3x10bit? ;only if Y>0
```

```
... (X*4) Garbage/Pointers (0021EE74h,0021EE74h,xxx,...) ;only if Y>0
... X*Z*18h Whatever Array 3
```

CROCFILE.DIR\TCLD.CVG:

There is only one such file in CROCFILE.DIR:

```
000h 4      Size-8 of whole file
004h 4      Unknown (0)
008h 4      Unknown (1)
00Ch ..    SPU-ADPCM data
... 4      Checksum (sum of all of the above bytes)
```

There are further .CVG files inside of .WAD files, these consist of two parts; 0Ch-byte Headers (in the data file area), and raw SPU-ADPCM data (in the spu-adpcm data area at end of the .WAD file):

Header(0Ch):

```
000h 4      Size+8 of data part
004h 4      Unknown (0)
008h 4      Unknown (0 or 1)
Data(xxxx0h):
000h ..    SPU-ADPCM data (starting with sixteen 00h bytes)
```

STRAT.DIR (in retail version with extra copy in CROCFILE.DIR\STRAT.DIR):

This file contains a list of filenames for files inside of .WAD files, but it does NOT tell where those files are (in which WAD at which offset).

```
000h 4      Number of Entries (N)
004h N*xxh File List (retail=14h bytes, or demo=18h bytes per entry)
... 4      Checksum (sum of all of the above bytes)
```

List entries are:

```
demo:  entrysize=18h ;Filename(0Ch)+Size(4)+Zeroes(8)
retail: entrysize=14h ;Filename(0Ch)+Zeroes(8)
```

The list contains hundreds of filenames, with following extensions:

```
*.BIN  byte-code strategies
*.MOD  models
*.ANI  animations
*.CVG  spu-adpcm voice data
```

These "filenames" seem to be actually solely used as "memory handle names":

```
MemoryHandle(#1) = LoadFile("FILENAME.BIN") ;<-- names NOT used like this
MemoryHandle("FILENAME.BIN") = LoadFile(#1) ;<-- names used like this
```

PACK*.STR (retail version only):

Huge files with XA-ADPCM audio data

MAGMUS.STR (demo version only):

Huge mis-mastered 24Mbyte file (contains several smaller XA-ADPCM blocks, accidentally stored in 800h-byte FORM1 data sectors, instead of 914h-byte FORM2 audio sectors).

ARGOLOGO.STR, FOXLOGO.STR

MDEC movies

COPYRIGHT.IMG, WARNING.IMG

Raw bitmaps (25800h bytes, uncompressed, 320x240x16bpp)

CUTS.AN2 (looks like cut-scenes with polygon-streaming):

CDROM File Video Polygon Streaming

Note: MOD/ANI files contain many Reserved/Garbage/Pointer entries which are replaced by pointers after loading (the initial values seem to have no purpose; they are often set to constants with value 002xxxxxh which could be useful for file type detection, but they vary in different game versions).

See also:

<https://github.com/vs49688/CrocUtils/> (for PC version, PSX support in progress)

13.64 CDROM File Archive Croc 2 (DIR, WAD, etc.)

Croc 2 (MagDemo22: CROC2\CROCII.DIR\T*.WAD+DEM)

Disney's The Emperor's New Groove (MagDemo39: ENG\KINGDOM.DIR\T*.WAD+DEM)

Disney's Aladdin in Nasira's Rev. (MagDemo46: ALADDIN\ALADDIN.DIR\T*.WAD+DEM)

Alien Resurrection, and Harry Potter 1 and 2 ... slightly different format?

Overall .WAD format:

```
000h 4      Total Filesize+/-xx (-4 or +800h or +1800h)
004h 4+4+.. XSPT Chunk          ;Textures
... 4+4+.. XSPS Chunk          ;SPU-ADPCM Sound (if any, not in all .WAD's)
... 4+4+.. XSPD Chunk          ;...whatever Data...?
... 4+4     DNE Chunk           ;End marker (in Harry Potter: with data!)
```

XSPT Chunk (Textures):

```
000h 4      Chunk Name "XSPT" (aka TPSX backwards)
004h 4      Chunk Size (excluding 8-byte Name+Size)
008h 4      Chunk Flags (02h or 06h or 0Eh) ;02h in Croc 2
00Ch (20h)  Name (eg. "Default new map", zeropadded) ;\if Flags bit2=1
... (804h)  Unknown ... SAME as in XSPD chunk !!! ;/
```

```

... 4      Number of List 1 entries (N1) (xxh..xxh) ;\
... 4      Number of Texture Pages (1..4)           ; List 1 and NumPages
... N1*0Ch  List 1 Whatever (6B 2F xx 00..)         ;/
... 4      Number of List 2 entries (N2) (0..xxh)   ;\
... 4      Unknown (2 or 7)                         ; List 2
... N2*04h  List 2 Whatever (halfwords?) (if N2>0) ;/
... (5*C00h) Whatever, 5*C00h, Palette+Stuff?      ;-if Flags bit3=1
... ..     RLE16 compressed Texture Pages          ;-Texture bitmap

```

RLE16 Texture notes:

Compressed data consists of signed little-endian 16bit LEN+DATA pairs:

LEN=0000h --> invalid/unused

LEN=0001h..7FFFh --> copy LEN halfwords from src

LEN=8000h..FFFFh --> load ONE halfword as fillvalue, fill -LEN halfwords

Compressed size is everything up to end of XSPT chunk

Decompressed size is 20000h*NumTexturePages (=20000h,40000h,60000h or 80000h)

That is: Width=256 halfwords, height 256*NumTexturePages lines. There seems to be only one RLE16 compression block for all Texture Pages, rather than one RLE16 block for each Page.

BUG #1: Decompressed data in Aladding/Emperor does often contain only 1FFFEh,3FFFEh,5FFFEh,7FFFEh bytes (the decompressed data has correct size when appending ONE halfword with random/zero value).

BUG #2: Compressed data in Croc 2 ends with a RLE16 length value (-LEN), but lacks the corresponding RLE16 filldata (the decompressed data is 7FFFEh when filling those LEN halfwords with random/zero values).

XSPS Chunk (SPU-ADPCM Sound) (if any, isn't present in all .WAD files):

```

000h 4      Chunk Name "XSPS" (aka SPSX backwards) ;\
004h 4      Chunk Size (excluding 8-byte Name+Size) ; header
008h 4      Chunk Flags (0 or 3 or 7)              ;/
00Ch 4      Number of Sounds (N1) (1..xxh)         ;\always present
010h N1*14h Sound List                             ;/
... (4)     VAB/VH Size                             ;\if Flags=3 or 7
... (..)    VAB/VH Header                           ;/ (bit0 or bit1?)
... (4)     Unknown (2 or 4)                         ;-if Flags=3 or 7
... (4)     Whut (N2)                               ;\if Flags.bit2=1
... (N2*10h) Whut List (4 words: xxh,10h,xxxx00h,xxxx0h);/
... 4      Size of all Part 1 Sound Data blocks      ;\always
... ..     SPU-ADPCM Sound Data (referenced from Sound List) ;/
... (4)     Size of all Part 2 Sound Data blocks (+8) ;\if Flags=
... (..)    SPU-ADPCM Sound Data (referenced from Sound List?) ; 3 or 7
... (8)     Zero                                     ;/

```

Sound List entries (as in FESOUND.WAD):

```

000h 4      Sample Rate in Hertz (AC44h=44100Hz, 5622h=22050Hz, 3E80h=16000Hz)
004h 2      Sample Rate Pitch (1000h=44100Hz, 0800h=22050Hz, 05CEh=16000Hz)
006h 2      Unknown (7Fh)
008h 4      Unknown (1) (1) (8)
00Ch 4      Unknown (42008Fh) (1FC0001Fh) (40008Fh)
010h 4      Filesize (xxx0h) (xxx0h)

```

XSPD Chunk:

```

000h 4      Chunk Name "XSPD" (aka DPSX backwards)
004h 4      Chunk Size (excluding 8-byte Name+Size)
008h 4      Flags-and/or-other stuff ? (eg. 00000094h or 0A801094h)
00Ch 804h   Unknown ... SAME as in XSPT chunk !!!
810h ..     Unknown ...

```

DNE Chunk (End marker):

```

000h 4      Chunk Name " DNE" (aka END backwards)
004h 4      Chunk Size (0) (except, in Harry Potter: nonzero)
... ..     Data (usually none such) (except, in Harry Potter: with data!)

```

Additional DEM files (always 1774h bytes) (if any, not all .WAD's have .DEM's):

```

000h 4      Number of entries (N) (always 2EEh, aka 750 decimal)
004h N*8    Whatever entries... maybe data for demonstration mode?

```

See also:

http://wiki.xentax.com/index.php/Argonaut_WAD

13.65 CDROM File Archive Headerless Archives

Headerless Archives

Some games use files that contain several files badged together. For example,

```

PSX Resident Evil 2, COMMON\DATA\*.DIE contains TIM+VAB badged together
PSX Resident Evil 2, COMMON\DATA\*.ITP contains 1000h-byte aligned TIMs
Blaster Master, DATA\MENU\*\*.PRT contains three smaller TIMs badged together
Blaster Master, DATA\MENU\*\*.BG contains three bigger TIMs badged together
Misadventures of Tron Bonne, KATWA\*.BIN contains headerless archives (with TIMs and
audio)
Headerless BSS files contain several BS files with huge padding inbetween

```

To some level one could detect & resolve such cases, eg. TIM contains information about the data block size(s), if the file is bigger, then there may be further file(s) appended. Some corner cases may be: Files with odd size may insert alignment padding before next file. Archives with 800h-byte filesize resolution will have zeropadding (or garbage) if the real size isn't a mutiple of 800h. Regardless of that two cases, archives may use zeropadding to 800h-byte or even 10000h-byte boundaries (as workaround one could skip zeroes until reaching a well-aligned nonzero word or double word (assuming that most files start with nonzero values; though not always, eg. raw ADPCM or raw bitmaps).

13.66 CDROM File Compression

Compressed Bitmaps

```
.BS used by several games (and also in most .STR videos)
.GIF used by Lightspan Online Connection CD
.JPG used by Lightspan Online Connection CD
.BMP with RLE4 used by Lightspan Online Connection CD (MONOFONT, PROPFONT)
.BMP with RLE8+Delta also used by Online Connection CD (PROPFONT\ARIA6.BMP)
.PCX with RLE used by Jampack Vol. 1 (MDK\CD.HED\*.pcx)
.PCX with RLE used by Hot Wheels Extreme Racing (MagDemo52: US_01293\MISC\*)
.PCX with RLE used by Metal Gear Solid (slightly corrupted PCX files)
```

Compressed Audio

```
.XA uses XA-ADPCM (and also used in .STR videos)
.VAG .VB .VAB uses SPU-ADPCM
```

Compressed Files

[CDROM File Compression LZSS \(Moto Racer 1 and 2\)](#)
[CDROM File Compression LZSS \(Dino Crisis 1 and 2\)](#)
[CDROM File Compression LZSS \(Serial Experiments Lain\)](#)
[CDROM File Compression ZOO/LZSS](#)
[CDROM File Compression Ulz/ULZ \(Namco\)](#)
[CDROM File Compression SLZ/01Z \(chunk-based compressed archive\)](#)
[CDROM File Compression LZ5 and LZ5-variants](#)
[CDROM File Compression PCK \(Destruction Derby Raw\)](#)
[CDROM File Compression GT-ZIP \(Gran Turismo 1 and 2\)](#)
[CDROM File Compression GT20 and PreGT20](#)
[CDROM File Compression HornedLZ](#)
[CDROM File Compression LZS \(Gundam Battle Assault 2\)](#)
[CDROM File Compression BZZ](#)
[CDROM File Compression RESOURCE \(Star Wars Rebel Assault 2\)](#)
[CDROM File Compression TIM-RLE4/RLE8](#)
[CDROM File Compression RLE_16](#)
[CDROM File Compression PIM/PRS \(Legend of Mana\)](#)
[CDROM File Compression BPE \(Byte Pair Encoding\)](#)
[CDROM File Compression RNC \(Rob Northen Compression\)](#)
[CDROM File Compression Darkworks](#)

[CDROM File Compression Blues](#)

[CDROM File Compression Z \(Running Wild\)](#)

[CDROM File Compression ZAL \(Z-Axis\)](#)

[CDROM File Compression EA Methods](#)

[CDROM File Compression ZIP/GZIP/ZLIB \(Inflate/Deflate\)](#)

[CDROM File Compression LArc/LHarc/LHA \(LZS/LZH\)](#)

[CDROM File Compression UPX](#)

[CDROM File Compression LZMA](#)

[CDROM File Compression FLAC audio](#)

Some other archvies that aren't used by any PSX games, but, anyways...

[CDROM File Compression ARJ](#)

[CDROM File Compression ARC](#)

[CDROM File Compression RAR](#)

[CDROM File Compression ZOO](#)

[CDROM File Compression nCompress.Z](#)

[CDROM File Compression Octal Oddities \(TAR, CPIO, RPM\)](#)

[CDROM File Compression MacBinary, BinHex, PackIt, StuffIt, Compact Pro](#)

Compressed Archives

Some Archives have "built-in" compression.

[CDROM File Archive WAD \(Doom\)](#)

[CDROM File Archive BIGFILE.DAT \(Gex - Enter the Gecko\)](#)

13.67 CDROM File Compression LZSS (Moto Racer 1 and 2)

Moto Racer 1 ("LZSS" with len+2) (MagDemo03: MRDEMO\IMG*.TIM)

Moto Racer 2 ("LZSS" with len+3) (MagDemo16: MR2DEMO\IMG*.TIM and .TPK)

000h 4	ID "LZSS"
004h 4	Decompressed Size
008h ..	Compressed Data

This LZSS variant is unusually using 6bit len and 10bit disp. And, there are two versions: Moto Racer 1 uses len+2, and Moto Racer 1 uses len+3. There is no version information in the header, one workaround is to decompress the whole file with len+2, and, if the resulting size is too small, retry with len+3. Observe that the attempt with len+2 may

cause page faults (eg. if the sum of len values is smaller than disp; so allocate some extra space at begin of compression buffer, or do error checks),

```

@@collect_more:
    flagbits=[src]+100h, src=src+1    ;8bit flags
@@decompress_lop:
    flagbits=flagbits SHR 1
    if zero then goto @@collect_more
    if carry=1 then
        [dst]=[src], dst=dst+1, src=src+1
    else
        disp=([src]+[src+1]*100h) AND 3FFh, len=([src+1]/4)+2_or_3, src=src+2
        if disp=0 then goto @@decompress_done
        for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
    endif
    goto @@decompress_lop
@@decompress_done:
    ret

```

13.68 CDROM File Compression LZSS (Dino Crisis 1 and 2)

Dino Crisis 1 and 2 (PSX\DATA*.DAT and *.DBS and *.TEX, File type 7,8)

Dino Crisis LZSS Decompression for files with type 7 and 8:

```

@@collect_more:
    flagbits=[src]+100h, src=src+1    ;8bit flags
@@decompress_lop:
    flagbits=flagbits SHR 1
    if zero then goto @@collect_more
    if carry=1 then
        [dst]=[src], dst=dst+1, src=src+1
    else
        disp=[src]+[src+1]*100h AND FFFh, len=[src+1]/10h+2, src=src+2
        if disp=0 then error
        for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
    endif
    if src<src_end then goto @@decompress_lop
    ret

```

The compressed file & archive header don't contain any info on the decompressed size (except, for compressed bitmaps, the archive header does contain width/height entries, nethertheless the decompressed file is usually BIGGER then width*height*2 (it can contain padding, plus 8 bytes).

13.69 CDROM File Compression LZSS (Serial Experiments Lain)

Serial Experiments Lain is using LZSS compression for TIMs (in SITEA.BIN, SITEN.BIN), and for Transparency Masks (in LAPKS.BIN).

Serial Experiments Lain (7MB SITEA.BIN on Disc 1, 5MB SITEB.BIN on Disc 2)

These are huge 5-7 Mbyte files with hundreds of chunks. Each chunk contains one compressed TIM.

```
Each chunk is having this format:
000h 4      Chunk ID "napk"
004h 4      Decompressed size
008h ..     LZSS compressed TIM data
... ..     Zeropadding to 800h-byte boundary
```

Unknown how the game is accessing chunks (there is no chunk size info, so one would need read the whole file (or at least first 4-byte of each 800h-byte sector) for finding chunks with ID="napk").

Serial Experiments Lain (LAPKS.BIN on Disc 1 and 2)

This a huge 14Mbyte file with 59 chunks. Each chunk contains one or more 24bpp .BS images with black background (the images in each chunk are forming a short animation sequence; width/height may vary because all images are cropped to rectangles containing non-black pixels).

```
Each chunk is having this format:
000h 4      Chunk ID "lapk"
004h 4      Chunk size (excluding 8-byte chunk header, excluding zeropadding)
008h 4      Number of Files in this Chunk (N)
00Ch N*0Ch  File List
... ..     File Data (bitmaps in .BS v0 format with uncommon headers)
... ..     Zeropadding to 800h-byte boundary
File List entries:
000h 4      Offset in bytes (zerobased, from begin of File Data area)
004h 2      Bitmap Width/2 + some 3bit value in LSBs?
006h 2      Bitmap Height
00Ch 4      Zero
File Data (bitmaps in .BS v0 format with uncommon headers):
000h 2      Bitmap Width
002h 2      Bitmap Height
004h 2      Quant for Y1,Y2,Y3,Y4
006h 2      Quant for Cr,Cb
008h 4      Size of compressed BS Bitstream plus 4 ;Transparency at [008h]+0Ch
00Ch 2      Size/2 of MDEC data (after huffman decompression, without padding)
```

```

00Eh 2      BS Version (0) (actually MSBs of above Size, but it's always 0)
010h ..     BS Bitstream with DC and AC values (Huffman compressed MDEC data)
... 4       Transparency Mask Decompressed Size (Width*Height*2/8) (=2bpp)
... ..      Transparency Mask LZSS-compressed data

```

BUG: The chunksize at C3A800h is set to 4C614h but should be 4D164h (the next chunk starts at C88000h).

Unknown how the game is accessing chunks (crawling all chunks would be exceptionally slow due to CDROM seek times, and won't work with the BUGGED chunksize).

Decompression function

This LZSS variant is unusually using 8bit len and 8bit disp.

```

dst_end=dst+[src], src=src+4      ;decompressed size
@@collect_more:
flagbits=([src] SHL 24)+800000h, src=src+1      ;8bit flags
@@decompress_lop:
if dst=dst_end then goto @@decompress_done
flagbits=flagbits SHL 1      ;32bit shift with carry-out/zeroflag
if zero then goto @@collect_more
if carry=0 then
    [dst]=[src], dst=dst+1, src=src+1
else
    disp=[src]+1, len=[src+1]+3, src=src+2
    for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
endif
goto @@decompress_lop
@@decompress_done:
ret

```

13.70 CDROM File Compression ZOO/LZSS

Jarret & LaBonte Stock Car Racing (MagDemo38: WTC*.ZOO)

```

0000h 4      Decompressed Size                ;\1st sector
0004h 7FCh   Garbage                          ;/
0800h 4      Decompressed Size (same as above) ;\2nd sector
0804h 7FCh   LZSS compressed data, part 1     ;/
1000h 800h   LZSS compressed data, part 2     ;-3rd sector
1800h 800h   LZSS compressed data, part 3     ;-4th sector
... ..      etc.

```

Note: The file format & compression method is unrelated to ZOO archives (to distinguish between the formats: ZOO archives have [0014h]=FDC4A7DCh, the ZOO/LZSS files have

[0014h]=Garbage).

The decompressed WTC*.ZOO files can contain large TIMs, or chunk-based archives (where each chunk can contain one or more small TIMs), or other stuff.

Decompression function

```
decompress_file:
    if LittleEndian32bit[src+14h]=FDC4A7DCh then goto error ;refuse ZOO archives
    if LittleEndian32bit[src]<>LittleEndian32bit[src+800h] then goto error
    curr=src+800h
    src=curr+4
@@sector_lop:
    call decompress_sector
    curr=curr+800h
    src=curr
    if src<src_end then goto @@sector_lop
    ret
;---
decompress_sector:
@@collect_more:
    flagbits=([src] SHL 24)+800000h, src=src+1 ;8bit flags
@@decompress_lop:
    flagbits=flagbits SHL 1 ;32bit shift with carry-out/zeroflag
    if zero then goto @@collect_more
    if carry=0 then
        [dst]=[src], dst=dst+1, src=src+1
    else
        disp=[src]*100h+[src+1], src=src+2
        if disp=FFFFh then goto @@decompress_done
        len=(disp/800h)+3, disp=(disp AND 7FFh)+1
        for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
    endif
    goto @@decompress_lop
@@decompress_done:
    ret
```

13.71 CDROM File Compression Ulz/ULZ (Namco)

Ulz/ULZ uses fairly normal LZSS compression, unusually with variable Len/Disp ratio, three separate data streams (flg/lz/dta), and rather weird end check in version=0.

Ulz Format (Ace Combat 3 Electrosphere, Namco)

Ulz Format (Klonoa, MagDemo08: KLONOA\FILE.IDX*)

```

000h 4    ID ("Ulz",1Ah) (parts lowercase)
004h 3    Decompressed Size in bytes
007h 1    Version (0 or 2)
008h 3    Offset to Uncompressed data  <-- reportedly can be 0 in version=0?
00Bh 1    Number of Disp bits (DispBits=N, LenBits=16-N) (usually 0Ah..0Dh)
00Ch 4    Offset to Compressed data
010h ..   Compression Flags    (32bit entries)
... ..   Uncompressed data    (8bit entries)
... ..   Zeropadding to 4-byte boundary
... ..   Compressed data      (16bit entries)

```

Most files use version=2 (eg. US:ACE.BPH\0006h\000Fh contains DOT1 with TIMs).

Some files use version=0 (eg. US:ACE.BPH\0048h\ contains TIMs).

ULZ Format (Time Crisis, Namco)

```

000h 4    ID ("ULZ",1Ah) (all uppercase)
004h 2    Zero
006h 1    Version (0 or 2)
007h 1    Number of Disp bits (DispBits=N, LenBits=16-N) (usually 0Ah..0Dh)
008h 4    Offset to Uncompressed data
00Ch 4    Offset to Compressed data
010h 4    Decompressed Size in bytes
014h ..   Compression Flags    (32bit entries)
... ..   Uncompressed data    (8bit entries)
... ..   Zeropadding to 4-byte boundary
... ..   Compressed data      (16bit entries)

```

Most files use version=2 (eg. EUR: AD*\TIM*.FHT*)

Some files use version=0 (eg. EUR: AD4\TIM0_0.FHT\0018h, 0019h)

Ulz/ULZ Decompression Function

```

if [src+00h]="Ulz",1Ah then
  version  = Byte[src+07h]
  disp_bits = Byte[src+0Bh]
  dst_end   = LittleEndian24bit[src+04h] + dst
  src_dta   = LittleEndian24bit[src+08h] + src
  src_lz    = LittleEndian32bit[src+0Ch] + src
  src_flg   = src + 10h
  add_len   = 3
  flg_1st   = 31 ;process flag bit31 first
if [src+00h]="ULZ",1Ah then
  version  = Byte[src+06h]
  disp_bits = Byte[src+07h]
  src_dta   = LittleEndian32bit[src+08h] + src
  src_lz    = LittleEndian32bit[src+0Ch] + src
  dst_end   = LittleEndian32bit[src+10h] + dst
  src_flg   = src + 14h

```

```

    add_len    = 2
    flg_1st    = 0    ;process flag bit0 first
    collected = 80000000h    ;initially empty, plus stop bit
@@decompress_loop:
    if version=2 AND dst=dst_end then goto @@decompress_done
    flag = collected AND 80000000h
    collected=collected*2
    if collected=0
        collected = LittleEndian32bit[src_flg], src_flg=src_flg+4
        if flg_1st=0 then ReverseBitOrder(collected)    ;or make custom/faster code
        flag = collected AND 80000000h
        if version=0 AND collected=0 then goto @@decompress_done
        if version=0 then collected=collected*2    ;<-- has implied stop bit
        if version=2 then collected=collected*2 + 1    ;<-- shift-in stop bit
    if flag=0    ;compressed
        disp = LittleEndian16bit[src_lz], src_lz=src_lz+2
        len = (disp SHR disp_bits) + add_len
        disp = (disp AND ((1 shl disp_bits)-1)) + 1
        for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
    else    ;uncompressed
        [dst]=[src_dta], dst=dst+1, src_dta=src_dta+1
    goto @@decompress_loop
@@decompress_done:
    ret

```

Note: Version=2 has 32 flags per 32bit. Version=0 has 31 flags and 1 stop bit per 32bit, plus 32 null bits at end of data (which is all rather wasteful, there's no good reason to use version=0).

13.72 CDROM File Compression SLZ/01Z (chunk-based compressed archive)

SLZ/01Z files are Chunk-based archives with one or more compressed chunk(s).

Used by Hot Shots Golf 2 (retail: DATA\F0000.BIN\ *MagDemo31/42:*

HSG2\MINGOL2.BIN)

SLZ/01Z chunk headers

The archive consists of Chunk(s) in following format:

000h 3	ID (either "01Z" or "SLZ", both are used)
003h 1	Method (00h=Uncompressed, 01h=LZSS, 02h=LZSS+FILL)
004h 4	Compressed size (SIZ) (same as decompressed when Method=0)
008h 4	Decompressed size
00Ch 4	Distance to next chunk, if any (SIZ+10h+Align4, or 0=None)
010h SIZ	Compressed data

SLZ/01Z decompression function:

```

method=byre[src+3]
len=word[src+8]
src=src+10h
if method=0 then
    for i=1 to len, [dst]=[src], dst=dst+1, src=src+1, next i
    goto @@decompress_done
dst_end = dst+len
@@collect_more:
flagbits=[src]+100h, src=src+1 ;8bit flags
@@decompress_lop:
if method=2 AND dst=dst_end then goto @@decompress_done
flagbits=flagbits SHR 1
if zero then goto @@collect_more
if carry=1 then
    [dst]=[src], dst=dst+1, src=src+1
else
    disp=([src]+[src+1]*100h) AND 0FFFh, len=([src+1]/10h)+3, src=src+2
    if method=1 AND disp=0 then goto @@decompress_done
    if method=2 AND len=12h then ;special fill mode...
        len=disp/100h+3, val=disp AND FFh ;len=3..12h
        if len=3 then len=val+13h, val=[src], src=src+1 ;len=13h..112h
        for i=1 to len, [dst]=val, dst=dst+1, next i ;len=4..112h
    else
        for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
    endif
    goto @@decompress_lop
@@decompress_done:
ret

```

13.73 CDROM File Compression LZ5 and LZ5-variants

Original LArc LZ5 (method "-lz5-")

LZ5 was used by LArc compression tool from 1988/1989, decompression is also supported by LHarc/LHA. LZ5 is basically LZSS compression, but with some oddities:

```

LZ5 is often implemented with a ringbuf (instead of actual sliding window)
LZ5 uses absolute ringbuf indices (instead of relative sliding dest indices)
LZ5 requires the ringbuf to be initially prefilled with constants
LZ5 ringbuf is 1000h bytes tall and starts with write index FEEh

```

LArc was discontinued in 1989, but LZ5-variants have been kept used on PSX and Nintendo DSi; those variants are just using the raw compression, without LArc archive headers.

DSi Dr. Mario (DSiware, Nintendo/Arika, 2008-2009)

```

INFO.DAT
  encrypted directory with filename, offset and compressed/uncompressed size
GAME.DAT
000h 4   ID "ALZ1"
004h ... ALZ1 Compressed data (with size as defined in INFO.DAT)
... 4   ID "ALZ1"
... ... ALZ1 Compressed data (with size as defined in INFO.DAT)
...

```

PSX Final Fantasy VII (FF7)

ALZ1 compression is used in various folders (ENEMY*, STAGE*, STARTUP, MAGIC, FIELD, MINI, MOVIE, WORLD) with various filename extensions (.LZS .BSX .DAT .MIM .TIZ .PRE .BSZ .TXZ).

```

000h 4   Compressed Size           ;=Filesize-4
004h ..  ALZ1 Compressed data (Filesize-4 bytes)

```

Detection can be more or less reliably done by checking [000h]=Filesize-4, one could also check the filename extensions, although .DAT doesn't qualify as unique extension. The file doesn't contain any info on the decompressed size, so one cannot know the decompression buffer size without first decompressing the file.

Note: For whatever reason, the game does also have one GZIP compressed file (BATTLE\TITLE.BIN).

PSX Final Fantasy VIII (FF8)

About same as FF7, but detection is less reliable because there are no filenames or extensions, and the file header is somewhat randomly set to [000h]=(Filesize-4)+0..7, unknown why, maybe it's allocating dummy bytes to last some compression flags.

```

000h 4   Compressed Size+0..7      ;=(Filesize-4)+0..7
004h ..  ALZ1 Compressed data (Filesize-4 bytes)

```

ALZ1 is used in four Root files (0001h,0002h,0017h,001Ah), and in many Field files, and maybe in further files elsewhere.

PSX Ultimate Fighting Championship (MagDemo38: UFC\CU00.RBB\383h*)

```

000h 8   ID "00zLATAD" (aka DATAz00 backwards)           ;\PreHeader
008h 4   Total Filesize excluding PreHeader+Padding (SIZ+0Ch) ;/

```

00Ch	4	Unknown (always 1000h)		;\
010h	4	Compressed data size	(SIZ)	; Header
014h	4	Decompressed data size		;/
018h	SIZ	zLATAD Compressed data		;-Data
...	..	Padding to 4-byte boundary		;-Padding

Ninja (MagDemo13: **NINJA\LOADPICS\PAK** and **NINJA\VRWFOREST.VRW**)

000h	8	ID "VRAM-WAD"	
008h	4	Compressed size (Filesize-Padding-10h)	
00Ch	4	Decompressed size	(18000h, 28000h, 40000h bytes)
010h	..	VRAMWAD Compressed data	(192x256, 320x256, 512x256 halfwords)
...	(..)	Padding to 4-byte boundary (if any, in files in .VRW archives)	

Observe that Ninja is using the same ID="VRAM-WAD" for .PAK files and .VRW archives (if [008h]=Filesize-Padding-10h then it's a compressed .PAK file, otherwise it's a .VRW archive; whereas, those .VRW archives do themselves contain several .PAK files).

PSX Power Spike (MagDemo43: **POWER\GAME.IDX*.BIZ**)

BIZ compression is used in BIZ archives (which are nested in IDX/HUG archive). The compressed & decompressed size is stored in the BIZ archive.

Note: Power Spike 20h-filled initial BIZ ringbuf is required for sky pixels in:

```
MagDemo43: POWER\GAME.IDX\PERSOS\PSX\CUSTOM\TEXTURE\NFIELD.BIZ\LPORJ.PSI
```

PSX Army Men Air Attack 2 (MagDemo40: **AMAA2\PCK\PAK**)

SCRATCH compression is used in PAK archives (which are nested in PCK archive). The compressed & decompressed size is stored in the PAK archive.

Note: The decompressor uses half of the 1Kbyte Scratchpad RAM at 1F800000h as ringbuf (hence the name and unusual small 200h-byte ringbuf size).

Alice in Cyberland (**ALICE.PAC*.FA2**)

000h	..	FA2 Compressed .FA archive
------	----	----------------------------

The decompressor is at 80093A3Ch (but the code isn't permanently in memory), and it's by far one of the worst decompression functions in compilerland.

Decompression

```

DEFAULT = ALZ1 or BIZ or LZ5
if DEFAULT then wr=0FEEh, mask=FFFh ;\
if VRAMWAD then wr=0FEEh, mask=FFFh ; initial ringbuf write index
if zLATAD then wr=0000h, mask=FFFh ; and ringbuf mask (size-1)
if SCRATCH then wr=01BEh, mask=1FFh ;
if FA2 then wr=00EFh, mask=0FFh ;/
if FA2 then len2=0
initialize_ringbuf_content (see below)
numbits=0
@@decompress_lop:
if dst>=dst.end then goto @@decompress_done
if numbits=0
    flagbits=[src], numbits=8, src=src+1 ;8bit flags
numbits=numbits-1
if VRAMWAD or FA2 then flagbits SHL 1, else flagbits=flagbits SHR 1
if carry=1 then
    dta=[src], [dst]=dta, ringbuf[wr AND mask]=dta
    dst=dst+1, wr=wr+1, src=src+1
else
    if DEFAULT then rd=[src]+([src+1]/10h)*100h, len=([src+1] AND 0Fh)+3
    if zLATAD then rd=[src]+([src+1] AND 0Fh)*100h, len=([src+1]/10h)+3
    if SCRATCH then rd=[src]+([src+1]/80h)*100h, len=([src+1] AND 7Fh)+3
    if VRAMWAD then rd=[src+1]+([src]/10h)*100h, len=([src] AND 0Fh)+3
    if FA2 then rd=[src], len=len2, len2=0, src=src+1
    if FA2 and len=0 then len=[src]/10h+2, len2=([src] AND 0Fh)+2, src=src+1
    if FA2=0 then src=src+2
    for i=1 to len ;read ringbuf[rd] (instead of relative [dst-rd])
        dta=ringbuf[rd AND mask], [dst]=dta, ringbuf[wr AND mask]=dta
        dst=dst+1, wr=wr+1, rd=rd+1
    next i
endif
goto @@decompress_lop
@@decompress_done:
ret

```

Initial Ringbuf Content

```

if ALZ1 or zLATAD then
    ringbuf[000h..FFFh]=(00h) ;zeroes
if VRAMWAD then
    ringbuf[000h..FEDh]=(00h) ;zeroes
    ringbuf[FEEh..FFFh]=(uninitialized) ;uninitialized, don't use
if BIZ then
    ringbuf[000h..FEDh]=(20h) ;ascii space
    ringbuf[FEEh..FFFh]=(uninitialized) ;uninitialized, don't use
if SCRATCH then
    ringbuf[000h..1BFh]=(00h) ;zeroes
    ringbuf[1C0h..1FFh]=(uninitialized) ;uninitialized, don't use
if FA2 then
    ringbuf[000h..0FFh]=(00h) ;zeroes
if LZ5 then
    ringbuf[000h..CFFh]=(000h..CFFh)/0Dh ;increasing, repeated 0Dh times each

```

```

ringbuf[D00h..DFFh]=(00h..FFh)      ;increasing
ringbuf[E00h..EFFh]=(FFh..00h)      ;decreasing
ringbuf[F00h..F7Fh]=(00h)           ;zeroes
ringbuf[F80h..FEDh]=(20h)           ;ascii space
ringbuf[FEEh..FFFh]=(should be 00h) ;see note, better don't use

```

Note: The last 12h bytes in LZ5 are 00h in LArC v3.33 (though unknown if that's intended and stable), LHarc source code did accidentally set them to 20h (which is reportedly fixed in later LHA versions).

13.74 CDROM File Compression PCK (Destruction Derby Raw)

Destruction Derby Raw (MagDemo35: DDRAW*.PCK,EXE,DAT)

```

000h 3      Decompressed size (24bit, little-endian)
003h 1      Unused (0)
004h ...    LZSS compressed data, starting with 30bit+2bit flags

```

The compression is used in some ISO files, which can be detected as:

```

[03h]=00h, [04h]=00h, [08h]="PS-X EXE"          ;DDRAW\*.EXE
[03h]=00h, [04h] AND FCh=00h, [08h]="BC",04h,40h,0,0 ;DDRAW\LDPICS\*.PCK

```

The compression is also used in nested PTH+DAT archives (where the whole DAT is compressed), which can be detected by checking if the sum of the PTH filesizes exceeds the DAT filesize.

Self-decompressing GUI code in PSX BIOS for SCPH-7000 and up

The PSX BIOS seems to use the same LZSS format for the self-decompressing GUI code (with GUI/decompression starting at 80030000h).

Decompression function

```

dst_end=dst+LittleEndian24bit[src], src=src+4
@@collect_more:
flagbits=BigEndian32bit([src]), src=src+4
dispbits=14-(flagbits AND 03h), flagbits=(flagbits OR 3)-1
dispmask=(1 SHL dispbits)-1
@@decompress_lop:
flagbits=flagbits SHL 1      ;32bit shift with carry-out/zero flag
if zero then goto @@collect_more
if carry=0 then
    [dst]=[src], dst=dst+1, src=src+1

```



```

else
    disp=BigEndian16bit[src], src=src+2
    len=(disp SHR dispbits)+3
    disp=(disp AND dispmask)+1
    for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
endif
id dst<dst_end then goto @@decompress_lop
@@decompress_done:
ret

```

13.75 CDROM File Compression GT-ZIP (Gran Turismo 1 and 2)

BS iki Video

IKI is a rather uncommon variant of the .STR video format (used by Gran Turismo 1 and 2, Legend of Legaia, Legend of Dragoon, Omega Boost, Um Jammer Lammy).

IKI videos have a custom .BS header, including some GT-ZIP compressed data:

```

000h 2  MDEC Size/4 (after huffman decompression) (rounded to 80h/4 bytes)
002h 2  File ID (3800h)
004h 2  Bitmap Width in pixels      ;instead quant
006h 2  Bitmap Height in pixels    ;instead version
008h 2  Size of GT-ZIP compressed data (plus 2-byte alignment padding)
00Ah .. GT-ZIP compressed DC/Quant values (plus 2-byte alignment padding)
... .. Huffman compressed AC data blocks (Cr,Cb,Y1,Y2,Y3,Y4, Cr,Cb,Y1,Y2..)

```

The number of blocks is $\text{NumBlocks} = (\text{Width} + 15) / 16 * (\text{height} + 15) / 16 * 6$. The size of the decompressed GT-ZIP data is $\text{NumBlocks} * 2$.

Gran Turismo 1 (MagDemo10: GT*.DAT) - headerless

Gran Turismo 1 (MagDemo15: GT*.DAT) - headerless

```

000h ..  Compressed Data (without header)

```

This is used for compressing files inside of GT-ARC archives (or in one case, for compressing the whole GT-ARC archive). The GT-ARC directory contains additional compression info, see GT-ARC description for details.

The file GT\GAMEFONT.DAT is also GT-ZIP compressed, but lacks any ID or info on decompressed size, and there are at least two GAMEFONT.DAT versions (in MagDemo10 va MagDemo15), both versions are 8000h byte when decompressed, and compressed data starts with 00,FF,FF,00,00,00,80,00,00,01,17,07.

Gran Turismo 2 (MagDemo27: GT2\GT2.VOL\arcade\arc_other.tim*) - with header

```

000h 0Ch   ID "@(#)GT-ZIP",0,0
00Ch 4     Decompressed Size
010h ..   Compressed Data (unknown compressed size due to below padding)
... ..    Zeropadding to 4-byte boundary (when stored in DOT1 archives)

```

This is used for compressing some files in one DOT1 archive (most other files in Gran Turismo 2 are using GZIP compression; with corrupted/zeropadded GZIP footers).

Decompression function

```

if [src]="@(#)GT-ZIP",0,0 then dst.end=dst+[src+0Ch], src=src+10h
@@collect_more:
  flagbits=[src]+100h, src=src+1      ;8bit flags
@@decompress_lop:
  if src>=src.end then goto @@decompress_done ;(when src.end is known)
  if dst>=dst.end then goto @@decompress_done ;(when dst.end is known)
  flagbits=flagbits SHR 1
  if zero then goto @@collect_more
  if carry=0 then
    [dst]=[src], dst=dst+1, src=src+1
  else
    len=[src], src=src+1, disp=[src], src=src+1      ;len, disp
    if disp>=80h then disp=(disp-80h)*100h+[src], src=src+1      ;longer disp
    for i=1 to (len+3), [dst]=[dst-(disp+1)], dst=dst+1, next i
  endif
  goto @@decompress_lop
@@decompress_done:
  ret

```

Notes

Depending on the source, only the compressed or decompressed size may be known:

Source	Compressed Size	Decompressed Size
Compressed GAMEFONT.DAT	In ISO Filesystem	Unknown (n/a)
Compressed GT-ARC	In ISO Filesystem	Unknown (n/a)
Files in GT-ARC	In GT-ARC	In GT-ARC
Files with GT-ZIP header	Unknown (due to padding)	In GT-ZIP
DC values in IKI videos	Unknown (due to padding)	From Width*Height

Gran Turismo 1 has ID "@(#)GT-ZIP" (and "@(#)G.T-ZIPB" whatever that is) stored in Main RAM (though unknown if/which/any files do have those IDs).

Gran Turismo 2 has ID "@(#)GT-ZIP" in "GT2\GT2.VOL\arcade\arc_other.tim*", apart from that, it does mainly use GZIP compressed files.

13.76 CDROM File Compression GT20 and PreGT20

GT20 Compressed Files

Used by Rollcage (MagDemo19: ROLLCAGE\SPEED.IMG*)

Used by Rollcage Stage II (MagDemo31: ROLLCAGE\SPEED.IDX*)

Used by Sydney 2000 (MagDemo37: OLY2000\DEMO.IDX* and OLY2000\GTO*.GTO)

Reportedly also Chill (PS1) (*.GTO)

Reportedly also Ducati World: Racing Challenge

Reportedly also Martian Gothic: Unification (PS1) (*.GT20)

```

000h 4      ID ("GT20"=Compressed) (or reportedly "NOGT"=Uncompressed)
004h 4      Size of decompressed data in bytes
008h 4      Overlap for in-situ decompression (usually 3, or sometimes 7)
00Ch 4      Size of Leading Zeropadding in bytes (0..7FFh)
010h ..     Leading Zeropadding (0..7FFh bytes)
... ..     Compressed Data

```

The Leading Zeropadding can be used to arrange the data to end on a sector boundary (useful when loading the file in units of whole sectors, and wanting to load it to the end of the decompression buffer).

```

DecompressGT20:
  src=src+word[src+0Ch]+10h      ;skip header and any leading zeropadding
  collected=00000001h ;end-bit
@@lop:
  if GetBit=0
    [dst]=[src], dst=dst+1, src=src+1      ;uncompressed byte
  else
    if GetBit=0
      disp=byte[src]-100h, src=src+1      ;disp=(-100h..-1)
      len=(GetBit*2)+(GetBit*1)+2      ;len=(2..5)
    else
      tmp=halfword[src], src=src+2
      disp=(tmp/8)-2000h      ;disp=(-2000h..-1)
      len=(tmp AND 7)+2      ;len=(2..9)
      if len=2
        tmp=byte[src], src=src+1
        if (tmp AND 80h) then disp=disp-2000h      ;disp=(-4000h..-1)
        len=(len AND 7Fh)+2      ;len=(2..81h)
        if len=3 then goto decompression_done
        if len=2 then len=halfword[src], src=src+2 ;len=(0..FFFFh)
      for i=1 to len, [dst]=[dst+disp], dst=dst+1, next i
    goto @@lop
;---
GetBit:
  collected=collected SHR 1

```

```
if zero then collected=(word[src] SHR 1)+80000000h, src=src+4
return carry (from shift right)
```

Note: Uncompressed files can reportedly contain "NOGT" in the header, however, Rollcage does have compressed files (with GT20 header), and raw uncompressed files (without any NOGT header).

<https://zenhax.com/viewtopic.php?t=13175> (specs)

See also: http://wiki.xentax.com/index.php/GT20_Archive (blurp)

Pre-GT20 Compressed Files

Used by Bloody Roar 1 (MagDemo06: BL\.*DAT*\)

Used by Bloody Roar 2 (MagDemo22: ASC,CMN,EFT,LON,SND,ST5,STU\.*DAT*\)

```
000h 4      Compression Method (0=None, 2=Compressed, Other=Invalid)
004h 4      Compressed Size (SIZ) (same as decompressed when method=0)
008h 4      Decompressed Size
00Ch SIZ    Compressed Data
... ..     Garbagepadding to 4-byte boundary (in 4-byte aligned DAT files)
```

This is apparently on older version of what was later called GT20. The PreGT20 decompression works as so:

```
DecompressPreGT20:
    src=src+0Ch                ;skip header
    collected=80h ;end-bit
@@lop:
    if GetBit=1
        [dst]=[src], dst=dst+1, src=src+1                ;uncompressed byte
    else
        if GetBit=0
            len=(GetBit*2)+(GetBit*1)+2                ;len=(2..5)
            disp=byte[src]-100h, src=src+1                ;disp=(-100h..-1)
        else
            tmp=bigendian_halfword[src], src=src+2
            disp=(tmp/8)-2000h                ;disp=(-2000h..-1)
            len=(tmp AND 7)+2                ;len=(2..9)
            if len=2
                len=byte[src]+1, src=src+1                ;len=(1..100h)
                if len=1 then goto decompression_done
            for i=1 to len, [dst]=[dst+disp], dst=dst+1, next i
            goto @@lop
    ;---
GetBit:
    collected=collected SHL 1    ;8bit shift
    if zero then collected=(byte[src] SHL 1)+01h, src=src+1
    return carry (from 8bit shift left)
```

Note: Uncompressed files with Method=0 exist in Bloody Roar 2 (CMN\SEL01.DAT).
 Bloody Roar 1 (MagDemo06) has decompressor at 8016DD64h (method 0 and 2).
 Bloody Roar 2 (MagDemo22) has decompressor at 8015C8C0h (method 0 and 2).

13.77 CDROM File Compression HornedLZ

Used by Project Horned Owl (*.BIN*) (and within self-decompressing EXE)

HornedLZ Detection

The easiest way to detect HornedLZ files is to check first 4 bytes:

```
B3 10 00 4F ..    Compressed TIM with TIM Type=00h (4bpp without CLUT)
DB 10 00 3F ..    Compressed TIM with TIM Type=08h,09h,etc.
```

Alternately, one could check the Chunktype (in the parent archive):

```
Type=05h can be uncompressed .TXT or HornedLZ-compressed .TIM
  (check if 2nd data byte is ASCII or 10h)
Type=0Fh is a DOT1 archive with HornedLZ-compressed .TIMs
  (parse the DOT1 archive and treat its contents as compressed .TIMs)
Type=10h contains Deflated TIMs
  (a completely different compression method)
```

DecompressHornedLZ:

```
collected=01h ;end-bit
@@lop:
if GetBit=1
  [dst]=[src], dst=dst+1, src=src+1 ;uncompressed byte
else
  if GetBit=1
    tmp=[src], src=src+1
    len=tmp/40h+2, disp=tmp or (-40h) ;len=(2..05h), disp=(-40h..-1)
  else
    tmp=[src]*100h+[src+1], src=src+2
    len=tmp/1000h+2, disp=tmp or (-1000h) ;len=(2..11h), disp=(-1000h..-1)
    if len=2 then
      len=[src]+2, src=src+1 ;len=(2..101h)
      if len=2 then goto decompression_done
    for i=1 to len, [dst]=[dst+disp], dst=dst+1, next i
  goto @@lop
;---
GetBit:
collected=collected SHR 1
```

```

if zero then collected=([src] SHR 1)+80h, src=src+1
return carry (from shift right)

```

Note: The end code has all bits zero, except, disp is don't care (it's usually FFFh).

13.78 CDROM File Compression LZS (Gundam Battle Assault 2)

Gundam Battle Assault 2 (DATA\PAC\, with ID="lzs")

000h	4	ID ("lzs",00h)
004h	4	Zerofilled
008h	4	Fixed (must be 1) (method/version?)
00Ch	14h	Zerofilled
020h	2	Fixed (must be 3) (method/version?)
022h	2	Offset to Compressed Data minus 20h (usually 38h-20h)
024h	4	Decompressed Size
028h	2	Flagsize (must be 08h, 10h, or 20h) (usually 20h=32bit)
02Ah	2	Lensize (must be 02h..07h) (usually 05h=5bit)
02Ch	4	Compressed Size (total filesize, including "lzs" header)
030h	8	Name? (always "000000",00h,00h)
038h	..	Compressed data (usually at offset 38h)

decompress_gundam_lzs:

```

dst_end = dst+littleendian32bit[src+24h]
flg_bits = littleendian16bit[src+28h] ;8,16,32
len_bits = littleendian16bit[src+2Ah] ;2..7
len_mask = (1 shl len_bits)-1 ;03h..7Fh
src=src+littleendian16bit[src+22h]+20h
collected_bits=0
@@collect_more:
for i=0 to flg_bits/8-1 ;read 8bit/16bit/32bit little-endian
    collected_bits=collected_bits+([src] SHL (i*8)), src=src+1
num_collected=flg_bits
@@decompress_lop:
if dst=dst_end then goto @@decompress_done
if num_collected=0 then goto @@collect_more
num_collected=num_collected-1
flagbits=flagbits SHR 1
if carry=1 then
    [dst]=[src], dst=dst+1, src=src+1
else
    temp=bigendian16bit[src], src=src+2
    len=(temp AND len_mask)+3
    disp=(temp SHR len_bits), if disp=0 then goto @@decompress_error
    for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
endif
goto @@decompress_lop

```

```

@@decompress_done:
    ret

```

13.79 CDROM File Compression BZZ

Used in .BZZ archives. Note that there are three slightly different .BZZ archive formats (they are all using the same BZZ compression, only the BZZ archive headers are different).

```

Jersey Devil .BZZ (MagDemo10: JD\*.BZZ)
Bugs Bunny: Lost in Time (MagDemo25: BBLIT\*.BZZ)
The Grinch (MagDemo40: GRINCH\*.BZZ)

```

Neither the file header nor the archive directory entries do contain any information about the decompressed size. Best workaround might be to decompress the file twice (without storing the output in 1st pass, to determine the size of the decompression buffer for 2nd pass).

BZZ Decompression

The compression is fairly standard LZSS, except that it supports non-linear length values, and it does support uncommon Len/Disp pairs like 7bitLen/9bitDisp (though usually, it does use standard 4bitLen/12bitDisp).

```

decompress_bzz:
    method=byte[src], src=src+1          ;method (00h..1Fh) ;usually/always 0Bh)
    shifter  = ((method/8) and 3)        ;00h..03h          ;usually 1
    len_bits = ((method and 7) xor 7)    ;07h..00h          ;usually 4
    len_mask = (1 shl len_bits)-1        ;7Fh..00h          ;usually 0Fh
    threshold=len_mask/2, if threshold>07h then threshold=13h ;usually 07h
    for i=0 to len_mask
        if i>threshold then len_table[i] = ((i-threshold) shl shifter)+threshold+3
        else len_table[i] = i+3 ;method=18h max=(7Fh-13h)*8+13h+3=376h=886 decimal
    next i                                ;method=0Fh max=(0Fh-07h)*2+07h+3=1Ah=26 decimal
    num_flags=bigendian24bit[src]+1, src=src+3 ;NUM24+1
@@collect_more:
    if src>=src_end then goto @@decompress_error
    flagbits=[src]+100h, src=src+1        ;8bit flags
@@decompress_lop:
    flagbits=flagbits SHR 1
    if zero then goto @@collect_more
    if carry=1 then
        if src>=src_end then goto @@decompress_error
        [dst]=[src], dst=dst+1, src=src+1
    else
        if src+1>=src_end then goto @@decompress_error

```

```

temp=bigendian16bit[src], src=src+2
len=len_table[temp AND len_mask]
disp=temp SHR len_bits, if disp=0 then goto @@decompress_error
for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
endif
num_flags=num_flags-1, if num_flags>0 then goto @@decompress_lop
@@decompress_error:
ret

```

Bug: Files can randomly contain NUM24 or NUM24+1 codes (that seems to be due to a compressor bug or different compressor versions; the two variants are unfortunately randomly mixed even within the same game).

And, compressed files are padded to 4-byte boundary (making it impossible to distinguish between "NUM24+1" and "NUM24+padding").

```

Case 1) source has NUM24+1 codes
    --> decode all NUM24+1 codes (otherwise output will be too small)
Case 2) source has NUM24 codes (and enough padding for another code)
    --> decode all NUM24+1 codes (for compatibility with case 1)
    --> output will have some constant garbage byte(s) appended
    --> exception: omit last code if it contains invalid disp=0
Case 3) source has NUM24 codes (and not enough padding for another code)
    --> decode only NUM24 codes (abort if NUM24+1 exceeds src_end)
    --> output should (probably) have correct size
    --> never exceed src_end which would be highly unstable

```

13.80 CDROM File Compression RESOURCE (Star Wars Rebel Assault 2)

Star Wars Rebel Assault 2 (RESOURCE.**)

BallBlazer Champions (*.DAT)

```

decompression function:
base=src, method=[src], dst_end=dst+BigEndian24bit[src+1], src=src+4
@@decompress_lop:
if dst>=dst_end then goto @@decompress_done
if [src] AND 80h then
    if method=01h then
        len=([src]-80h)/8+3, disp=(BigEndian16bit[src] AND 7FFh)+1, src=src+2
    else ;method=02h
        len=([src]-80h)+4, disp=(BigEndian16bit[src+1])+1, src=src+3
    for i=1 to len, [dst]=[dst-disp], dst=dst+1
else ;uncompressed
    len=[src]+1, src=src+1
    for i=1 to len, [dst]=[src], src=src+1, dst=dst+1

```



```

goto @@decompress_lop
@@decompress_done:
src=(src+3) AND NOT 3
if LittleEndian32bit[src]<>crc(base, src-base) then error
ret

```

Note: Compression is (normally) used only in Top-level RESOURCE.* and *.DAT archives (not in Nested archives). The Top-level archives do also contain some uncompressed files (which contain data that is compressed on its own: SPU-ADPCM audio, or encrypted BS bitmaps).

Special case for BallBlazer Champions

Normally only Top-level archives contain compression, however, there are also some Nested archives with compression in BallBlazer Champions:

```

STD_BBX.DAT\s*t\tp_a\*      ;\double compression, Top-level is ALSO compressed
BBX_INTR.DAT\data1\pics\* ;/
BBX_INTR.DAT\Stad\pics\*   ;\
BBX_INTR.DAT\Stad\wire\*   ; Nested archives with compression
BBX_INTR.DAT\Subtitl\*     ;
BBX_INTR.DAT\Subtitl\sub\* ;/

```

The Nested archives don't have any compression flag or decompressed size entries (so there's no good way for detecting compression in nested files).

13.81 CDROM File Compression TIM-RLE4/RLE8

Ape Escape (Sony 1999) (MagDemo22: KIDZ\) has several compressed and uncompressed TIMs in headerless archives, the archives can contain:

```

Compressed 4bpp RLE4-TIM with uncompressed CLUT ;\only 4bpp can be compressed
Compressed 4bpp RLE8-TIM with uncompressed CLUT ;/
Uncompressed 4bpp TIM with uncompressed CLUT   ;\only this type/combinations
Uncompressed 8bpp TIM with uncompressed CLUT   ; are allowed if uncompressed
Uncompressed 16pp TIM without CLUT             ;/
End code 00000000h (plus more zeropadding)     ; -end of headerless archive

```

The compression method is indicated by changing a reserved halfword in the TIM header:

```

hdr[02h]=Method (0000h=Uncompressed, 0001h=RLE4, 0002h=RLE8)

```

The rest of the bytes in TIM header and in CLUT section are same as for normal TIMs. The Bitmap section is as follows:

*Decompressed size must be computed as Width*Height*2. The Section Size entry contains Section header size, plus compressed size, plus padding to 4-byte boundary. Method=0001h (RLE4):*

```
@@decompress_lop:
  color=[src]/10h, len=([src] AND 0Fh)+1, src=src+1
  for i=1 to len, putpixel(color), next i          ;len=1..10h
  if numpixels<Width*Height*4 then goto @@decompress_lop
```

Method=0002h (RLE8):

```
@@decompress_lop:
  color1=[src]/10h, color2=[src] AND 0Fh, src=src+1
  if color1=color2
    len=[src]+2, src=src+1
    for i=1 to len, putpixel(color1), next i        ;len=2..101h
  else
    putpixel(color1), if numpixels<Width*Height*4 then putpixel(color2)
  for i=1 to len, putpixel(color)          ;len=1..10h
  if numpixels<Width*Height*4 then goto @@decompress_lop
```

The decompression functions in Ape Escape (MagDemo22: KIDZ\) are found at:

```
80078760h ape_escape_load_tim_archive
8007894Ch ape_escape_decompress_with_4bit_lengths
800789FCh ape_escape_decompress_with_8bit_lengths
```

Examples for compressed TIMs are found at:

```
RLE8: Ape Escape, MagDemo22: KIDZ\KKIIDDZZ.HED\DAT\file004h\1stTIM
RLE4: Ape Escape, MagDemo22: KIDZ\KKIIDDZZ.HED\DAT\file135h\1stTIM
RLE8: Ape Escape, MagDemo22: KIDZ\KKIIDDZZ.HED\DAT\file139h\1stTIM
```

Being made by Sony, this might be an official (but late) TIM format extension, unknown if there are any other games using that compression.

13.82 CDROM File Compression RLE_16

Apocalypse (MagDemo16: APOC\CD.HED*.RLE)

Spider-Man (MagDemo31,40: SPIDEY\CD.HED*.RLE)

Spider-Man 2 (MagDemo50: HARNESS\CD.HED*.RLE)

```

000h 8      ID "_RLE_16_"
008h 4      Decompressed Size (usually 3C008h) (33408h=Apocalypse warning.rle)
00Ch ..    RLE Compressed Data (usually a .BMR bitmap)

```

This is using simple RLE compression with 16bit len/data units (suitable for 16bpp VRAM data). The compression ratio ranges from not so bad to very bad.

Decompression

```

src=src+0Ch                                ;skip ID and size
@@decompress_lop:
len=halfword[src], src=src+2
if len=0000h then goto @@decompress_done    ;end-code
if (len AND 8000h)=0 then
    for i=1 to len, halfword[dst]=halfword[src], dst=dst+2, src=src+2, next i
else
    fillvalue=halfword[src], src=src+2
    for i=1 to len-8000h, halfword[dst]=fillvalue, dst=dst+2, next i
goto @@decompress_lop
@@decompress_done:
ret

```

Other RLE16 variants

A similar RLE16 variant is used in Croc 1, and another variant in Croc 2.

[CDROM File Archive Croc 1 \(DIR, WAD, etc.\)](#)

[CDROM File Archive Croc 2 \(DIR, WAD, etc.\)](#)

13.83 CDROM File Compression PIM/PRS (Legend of Mana)

Legend of Mana (.PIM/.PRS)

```

000h 1      Unknown (always 01h) (maybe File ID or Compression method)
001h ..    Compressed data ;for TIM: usually 00,10, F0,00, 00,0x, F0,00, ...

```

Compression codes are:

nn,data[nn+1]	;nn=00..EF	len=nn+1	[dst]=data[1]		; -uncompressed
F0,xn		len=n+3	[dst]=0x	;1x4bit	;\
F1,nn,xx		len=nn+4	[dst]=xx	;1x8bit	;
F2,nn,xy		len=nn+2	[dst]=0x,0y	;2x4bit	; RLE fill
F3,nn,xx,yy		len=nn+2	[dst]=xx,yy	;2x8bit	;
F4,nn,xx,yy,zz		len=nn+2	[dst]=xx,yy,zz	;3x8bit	;/
F5,nn,xx,data[nn+4]		len=nn+4	[dst]=xx,data[1]		;\interleaved
F6,nn,xx,yy,data[nn+3]		len=nn+3	[dst]=xx,yy,data[1]		; fill combo

```

F7,nn,xx,yy,zz,data[nn+2] len=nn+2 [dst]=xx,yy,zz,data[1] ;/
F8,nn,xx len=nn+4 [dst]=xx ;xx=xx+1 ;\
F9,nn,xx len=nn+4 [dst]=xx ;xx=xx-1 ; fill with
FA,nn,xx,ss len=nn+5 [dst]=xx ;xx=xx+ss ; signed step
FB,nn,xx,yy,ss ;ss=signed len=nn+3 [dst]=xx,yy ;yyxx=yyxx+ss ;/
FC,xx,ny len=n+4 [dst]=[dst-yxx-1] ;\
FD,xx,nn len=nn+14h [dst]=[dst-xx-1] ; LZ compress
FE,xn len=n+3 [dst]=[dst-x*8-8] ;/
FF len=0 end ; -end code

```

The compression is used for several files in Legend of Mana:

```

BIN\*.BIN ---> packed misc binary
MAP\*\FDATA.PRS ---> packed resource, whatever
MAP\*\MAP*.PRS ---> packed MPD resource, "SKmapDat"
WM\WMTIM\*.PIM ---> packed TIM image, 384x384x4bpp, bad compression ratio
WM\WMAP\*.PAT ---> packed loaddata
WM\WMAP\*.PIM ---> packed TIM image, 320x256x16bit, with UNCOMPRESSED dupe

```

13.84 CDROM File Compression BPE (Byte Pair Encoding)

Byte Pair Encoding (BPE) does replace the most common byte-pairs with bytes that don't occur in the data. That does work best if there are unused bytes (eg. ASCII text, or 8bpp bitmaps with less than 256 colors).

Bust A Groove (MagDemo18: BUSTGR_AI*.BPE)

Bust-A-Groove 2 (MagDemo37: BUSTAGR2\BUST2.BIN*)

```

000h 4 ID "BPE_"
004h 4 Total Filesize of compressed file including header (big-endian)
... .. Compression block(s)
Each compression block contains:
000h .. Dictionary info
... 2 Size of compressed data (big-endian)
... .. Compressed data

```

The decompression function in Bust A Groove (MagDemo18) is at 80023860h, the heap is in 1Kbyte Scratchpad RAM at 1F800208h, so heap size should be max 1F8h bytes (assuming that the remaining Scratchpad isn't used for something else). The fileheader lacks info about the decompressed size.

Legend of Dragoon (MagDemo34: LOD\OVL.OV_ and LOD\SECT.BIN*)

```

000h 4      Decompressed size (little-endian)
004h 4      ID "BPE",1Ah
008h ..     Compression block(s)
... ..     End code (00000000h) (aka last block with Blocksize=0)
Each compression block contains:
000h 4      Size of decompressed block (little-endian) (or 0=End code)
004h ..     Dictionary info
... ..     Compressed data
... ..     Padding to 4-byte boundary

```

Max nesting appears to be 2Ch, the decompression function allocates a 30h-byte heap on stack, and fetches source data in 32bit units (occupying 4 heap bytes), the decompressor does then remove 1 byte from heap, and adds 2 bytes in case of nested codes.

BPE Decompression for Bust-A-Groove and Legend of Dragoon

```

if [src+0]="BPE_" then type=GROOVE ;\
if [src+4]="BPE",1Ah then type=DRAGOON ;
if type=GROOVE then src_end = src+BigEndian32bit[src+4] ; hdr
if type=DRAGOON then dst_end = dst+LittleEndian32bit[src+0] ;
src=src+8 ;/
@@block_lop:
if type=DRAGOON then ;\blk
    dst_blk_end = dst+LittleEndian32bit[src]+4, src=src+4 ; len
    if dst=dst_blk_end then goto @@decompress_done ;/
for i=00h to FFh, dict1[i]=i, next i ;\
i=00h ;
@@dict_lop: ; dict
num=[src], src=src+1 ;
if num>7Fh then i=i+(num-7Fh), num=0, if i=100h then goto @@dict_done ;
for j=0 to num ;
    a=[src], src=src+1 ;
    if a>i then b=[src], src=src+1, dict1[i]=a, dict2[i]=a ;
    i=i+1 ;
if i<100h then goto @@dict_lop ;
@@dict_done: ;/
if type=GROOVE then ;\blk
    src_blk_end = src+BigEndian16bit[src]+2, src=src+2 ;/len
i=0 ;\
@@data_lop: ;
if i=0 then ;\ ; data
    if type=GROOVE and src=src_blk_end then goto @@data_done ; get data ;
    if type=DRAGOON and dst=dst_blk_end then goto @@data_done; from src ;
    x=[src], src=src+1 ; or heap ;
else ; ;
    i=i-1, x=heap[i] ;/ ;
a=dict1[x] ;-xlat ;
if a=x then ;\ ;
    [dst]=x, dst=dst+1 ; output data to ;
else ; dst or heap ;
    b=dict2[x], heap[i]=b, heap[i+1]=a, i=i+2 ;/ ;

```

```

goto @@data_lop                                ;
@@data_done:                                   ;/
if type=GROOVE and src<src_end then goto @@block_lop ;\next
if type=DRAGOON then src=(src+3) AND not 3, goto @@block_lop ;/blk
@@decompress_done:
if type=DRAGOON and dst<>dst_end then error
ret

```

Electronic Arts

Electronic Arts games support several compression methods, including a BPE variant. That BPE variant is a bit unusual: It does have only one compression block (with a single dictionary for the whole file), and uses escape codes for rarely used bytes.

[CDROM File Compression EA Methods](#)

13.85 CDROM File Compression RNC (Rob Northen Compression)

Rob Northen compression

Rob Northen compression (RNC) is a LZ/Huffman compression format used by various games for PC, Amiga, PSX, Mega Drive, Game Boy, SNES and Atari Lynx.

Most RNC compressed files come in a standard 12h-byte header:

```

000h 3  Signature ("RNC") (short for Rob Northen Computing compression)
003h 1  Compression Method (01h or 02h)
004h 4  Size of Uncompressed Data                                ;big-endian
008h 4  Size of Compressed Data (SIZ)                            ;big-endian
00Ch 2  CRC16 on Uncompressed Data (with initial value 0000h) ;big-endian
00Eh 2  CRC16 on Compressed Data (with initial value 0000h) ;big-endian
010h 1  Leeway (difference between compressed and uncompressed data in
        largest pack chunk, if larger than decompressed data)
011h 1  Number of pack chunks
012h SIZ Compressed Data
... (..) Zeropadding to 800h-byte boundary-4 ;\as so in PSX Heart of Darkness
... (4)  Unknown                                                ;/

```

The compressed data consists of interleaved bit- and byte-streams, the first 2 bits of the bit stream are ignored.

RNC Method 1 - with custom Huffman trees

The bit-stream is read in 16bit units (the 1st bit being in bit0 of 1st byte).

Each pack chunk contains the following:

- * 3 Huffman trees (one for literal data sizes, one for distance values, and one for length values) in the bit stream. These consist of:
 - o A 5 bit value for the amount of leaf nodes in the tree
 - o 4 bit values for each node representing their bit depth.
- * One 16 bit value in the bitstream for the amount of subchunks in the pack chunk.
- * The subchunk data, which contains for each subchunk:
 - o A Huffman code value from the first tree in the bit stream for the amount of literals in the byte stream.
 - o Literals from the byte stream.
 - o A Huffman code from the bit stream that represents the distance - 1 of a distance/length pair.
 - o A Huffman code from the bit stream that represents the length - 2 of a distance/length pair.

Unknown how that works exactly (see source code for details), unknown if method 1 was used on PSX.

RNC Method 2 - with hardcoded Huffman trees

The bit-stream is read in 8bit units (the 1st bit being in bit7).

0	+ Byte(DATA[1])	Copy 1 Byte from Source
1000	+ Dist + Byte(X)	Copy 4 Bytes from Dest-(Dist+X+1)
10010	+ Dist + Byte(X)	Copy 6 Bytes from Dest-(Dist+X+1)
10011	+ Dist + Byte(X)	Copy 7 Bytes from Dest-(Dist+X+1)
1010	+ Dist + Byte(X)	Copy 5 Bytes from Dest-(Dist+X+1)
10110	+ Dist + Byte(X)	Copy 8 Bytes from Dest-(Dist+X+1)
10111	+ nnnn + Byte(DATA[12..72])	Copy nnnn*4+12 Bytes from Source
110	+ Byte(X)	Copy 2 Bytes from Dest-(X+1)
1110	+ Dist + Byte(X)	Copy 3 bytes from Dest-(Dist+X+1)
1111	+ Byte(0) + 0 + zeropadding	End of last pack chunk
1111	+ Byte(0) + 1	End of non-last pack chunk
1111	+ Byte(L) + Dist + Byte(X)	Copy L+8 Bytes from Dest-(Dist+X+1) ;L>00h

Dist values:

0	= 0000h	1000	= 0200h
110	= 0100h	1001	= 0300h
111000	= 0C00h	101000	= 0800h
111001	= 0D00h	101001	= 0900h
11101	= 0600h	10101	= 0400h
111100	= 0E00h	101100	= 0A00h
111101	= 0F00h	101101	= 0B00h
11111	= 0700h	10111	= 0500h

The purpose of the pack chunks isn't quite clear, it might be related to memory restrictions on old CPUs. In PSX Heart of Darkness they are chosen so that the

decompressed data is max 3000h bytes per chunk. Unknown if the next chunk may copy data from previous chunk.

Links

http://aminet.net/package/util/pack/RNC_ProPack - official tool & source code

https://segaretro.org/Rob_Northen_compression - description (contains bugs)

RNC is used in a number of games by UK developers (notably Bullfrog and Traveller's Tales), including Sonic 3D: Flickies' Island, Blam! Machinehead, Dungeon Keeper 2, Magic Carpet, Syndicate and Syndicate Wars.

RNC in PSX Games

```
Method 2: Demolition Racer (MagDemo27: DR\DD.DAT\*.RNC)
Method 2: Heart of Darkness (IMAGES\US.TIM)
Method 2: Jonah Lomu Rugby (LOMUDEMO\GFX\*.PAK)
Method 2: NBA Jam: Tournament Edition (*.RNC, headerless .BIN/.GFX archives)
Method 2: Test Drive 5 (MagDemo13: TD5.DAT\*.RNC)
Method 2: Test Drive Off-Road 3 (MagDemo27: TDOR3\TDOR3.DAT\*.rnc)
```

RNC in Mega Drive games

```
3 Ninjas Kick Back
Addams Family
Addams Family Values
The Adventures of Mighty Max
Asterix and the Great Rescue
Asterix and the Power of the Gods
The Incredible Hulk
The Itchy & Scratchy Game (unreleased)
Marsupilami
Mortal Kombat
Mr. Nutz
Outlander
The Pagemaster
RoboCop 3
Spirou
Spot Goes to Hollywood
Stargate
Street Racer
Tinhead
Tintin in Tibet
World Championship Soccer II
```


13.86 CDROM File Compression Darkworks

Used by Alone in the Dark The New Nightmare (FAT.BIN\LEVELS*\chunks)

Decompression

The decompressor is designed to hook the sector loading function: It does decompress incoming sectors during loading, and forwards the decompressed data to the original sector loading function. The decompressed data is temporarily stored in two small Dict buffers (which do also serve as compression dictionary).

```
decompress:
    dictsize=1000h, dict0=alloc(dictsize), dict1=alloc(dictsize)
    src=load_next_800h_byte_sector ;load first sector
    dst=dict0                      ;temp dest in current dict
    dst_base=dst                  ;memorize start of newly decompressed data
@@decompress_lop:
    if [src]=00h then              ;\
        esc=[src+1], src=src+1    ;
        forward_to_actual_dest(source=dst_base, len=dst-dst_base) ; escape
        if esc=0 or esc>4 then esc=2 (or warn_invalid_escape_code) ;
        if esc=1 then goto @@decompress_done ;
        if esc=2 or esc=4 then src=load_next_800h_byte_sector ;
        if esc=3 or esc=4 then swap(dict0,dict1), dst=dict0 ;
        dst_base=dst              ;/
    elseif ([src] AND 03h)=0 then  ;\
        len=[src]/4+2, dat=[src+1], src=src+2 ; fill 8bit
        for i=1 to len, [dst]=dat, dst=dst+1 ;/
    elseif ([src] AND 03h)=1 then  ;\
        len=[src]/4+([src+2] AND 40h)+4 ;
        ptr=[src+1]+([src+2] AND 3Fh)*100h ; LZ compressed
        if ptr+len>dictsize then error (exceeds allocated dictsize) ;
        if ([src+2] AND 80h) then ptr=ptr=dict1 else ptr=ptr=dict0 ;
        src=src+3 ;
        for i=1 to len, [dst]=[ptr], ptr=ptr+1, dst=dst+1 ;/
    elseif ([src] AND 03h)=2 then  ;\
        len=[src]/4+3, dat0=[src+1], dat1=[src+2], src=src+3 ; fill 16bit
        for i=1 to len, [dst]=dat0, [dst+1]=dat1, dst=dst+2 ;/
    elseif ([src] AND 03h)=3 then  ;\
        len=[src]/4+1, src=src+1 ; uncompressed
        for i=1 to len, [dst]=[src], src=src+1, dst=dst+1 ;/
    goto @@decompress_lop
@@decompress_done:
    dealloc(dict0), dealloc(dict1)
    ret
```

There are one or more escape codes per sector (one to indicate the of the sector, plus further escape codes to swap the Dict buffers whenever the current Dict is full). The original decompressor is doing the forwarding in 800h-byte units, so Dict swapping

may be only done when dict0 contains a multiple of 800h bytes (aka dictsize bytes). For whatever reason, there are only 4Kbyte per Dict allocated (although the 14bit LZ indices could have addressed up to 16Kbyte per Dict).

13.87 CDROM File Compression Blues

Blue's Clues: Blue's Big Musical (VRAM and FRAM chunks in *.TXD)

Decompression function:

```

if LittleEndian32bit[src+08h]<>1 then error ;compression flag
dst_end=dst+LittleEndian32bit[src+14h], src=src+18h, num_collected=0
@@decompress_lop:
if GetBit=1 then
    [dst]=[src], src=src+1, dst=dst+1 ;code 1 uncompressed byte
elseif GetBit=1 then
    len=[src], src=src+1 ;code 01 fill or end code
    if len=00h then goto @@decompress_done
    len=len+1, fillvalue=[dst-1]
    for i=1 to len, [dst]=fillvalue, dst=dst+1
else
    len=GetBit*2+GetBit
    if len=0 then ;code 0000 long LZ range
        len=[src] AND 0Fh, disp=[src]/10h+[src+1]*10h-1000h, src=src+2
    else ;code 00xx short LZ range
        disp=[src]-100h, src=src+1
    len=len+1
    for i=1 to len, [dst]=[dst+disp], dst=dst+1
goto @@decompress_lop
@@decompress_done:
if dst<>dst_end then error
ret
;---
GetBit:
if num_collected=0 then collected=[src], src=src+1, num_collected=8
collected=collected*2
return (collected/100h) AND 1

```

13.88 CDROM File Compression Z (Running Wild)

Running Wild (MagDemo15: RUNWILD\B\W.Z and *.z)

```

decompress_z:
    src=src+4 ;skip 32bit decompressed size entry
@@reload_lop:

```

```

load_table1          ;table for first 9bits
load_table2          ;table for codes longer than 9bits
@@decompress_lop:
sym=get_symbol()
if sym<100h then [dst]=sym, dst=dst+1, goto @@decompress_lop
if sym=100h then goto @@escape
len=sym-0FCh          ;change 101h..140h to 05h..44h
disp=((get_symbol()-101h)*40h) ;change 101h..140h to 00h..3Fh*40h
disp=((get_symbol()-101h) or disp)+1 ;change 101h..140h to 00h..3Fh+above+1
copy len bytes from dst-disp to dst
goto @@decompress_lop
@@escape:
if GetBits(1)=0 then goto @@reload_lop
ret
;-----
load_table1:
t=0
@@load_lop:
x=GetBits(10h)
if x and 8000h then num=1 else num=(1 shl (9-(x/400h)))
for i=1 to num, table1[t]=x, t=t+1, next i
if t<200h then goto @@load_lop
ret
;-----
load_table2:
num=GetBits(9)*2      ;can be 0=none, max=3FEh
if num>0 then for i=0 to num-1, table2[i]=GetBits(9), next i
ret
;-----
get_symbol:
;returns a value in range 0..140h:
; 00h..FFh = data 00h..FFh (or unused for disp codes)
; 100h     = escape (or unused for disp codes)
; 101h..140h = length 05h..44h (or 6bit fraction of 12bit disp)
; 141h..3FFh = would be possible for short codes, but shouldn't be used
x=table1[PeekBits(9)]
if (x and 8000h)=0 then SkipBits(x/400h), return (x and 3FFh) ;-short code
SkipBits(9) ;skip first 9 bits, and process futher bit(s).. ;\
x=x-0C000h ;change C000h..C1FFh and up to 000h..1FFh ; long code
@@lop:
x=table2[x*2+GetBits(1)] ;branch node0/node1 ; (with more
if x>=141h then x=x-141h, goto @@lop ; than 9bit)
return x ;/

```

The bitstream is fetched in little endian 16bit units (the first bit is in bit7 of second byte). PeekBits returns the next some bits without discarding them, SkipBits does discard them, GetBits does combine PeekBits+SkipBits.

Note: The decompression function in Running Wild (MagDemo15) is at 80029D10h.

13.89 CDROM File Compression ZAL (Z-Axis)

Thrasher: Skate and Destroy (MagDemo27: SKATE\ASSETS*.ZAL) (Z-Axis)

Dave Mirra Freestyle BMX (MagDemo36: BMX\ASSETS*.ZAL) (Z-Axis)

Dave Mirra Freestyle BMX (MagDemo46: BMX\ASSETS*.ZAL) (Z-Axis)

ZAL compression is used in ZAL archives. The archive header contains compressed and decompressed size for each file (and a compression flag indicating whether the archive is compressed at all).

ZAL Decompression

```

if src_len=0 then goto @@decompress_done      ;empty (without end code)
lzlen=0, rawlen=0
if [src]=10h..FFh then                       ;\special handling
    rawlen=[src]-11h, src=src+1              ; for code=10h..FFh
    if rawlen<=0 then goto @@decompress_error ;/at begin of source
@@decompress_lop:
memcpy(dst-disp,dst,lzlen)    ;copy compressed bytes
memcpy(src,dst,rawlen)        ;copy uncompressed bytes
code=[src], src=src+1
if code=00h..0Fh then
    if rawlen=0      ;when OLD rawlen=0...
        lzlen=0, rawlen=code+3                ;\
        if rawlen=3 then                      ;
            while [src]=00h, rawlen=rawlen+FFh, src=src+1 ;
            rawlen=rawlen+[src]+0Fh, src=src+1    ;/
    else                ;when OLD rawlen>0, and depending on OLD lzlen...
        rawlen=code AND 03h
        disp=code/4+[src]*4, src=src+1
        if lzlen=0 then disp=disp+801h, lzlen=3, else then disp=disp+1h, lzlen=2
if code=10h..1Fh then
    lzlen=(code AND 07h)+2
    if lzlen=2 then
        while [src]=00h, lzlen=lzlen+FFh, src=src+1
        lzlen=lzlen+[src]+07h, src=src+1
    rawlen=[src] AND 03h, disp=[src]/4+[src+1]*40h+(code/8 AND 1)*4000h+4000h
    src=src+2
    if disp=4000h AND code=11h then goto @@decompress_done      ;end code
    if disp=4000h AND code<>11h then goto @@decompress_error
if code=20h..3Fh then
    lzlen=code-20h+2
    if lzlen=2 then
        while [src]=00h, lzlen=lzlen+FFh, src=src+1
        lzlen=lzlen+[src]+1Fh, src=src+1
    rawlen=[src] AND 03h, disp=[src]/4+[src+1]*40h+1, src=src+2
if code=40h..FFh then

```

```

rawlen=code AND 03h
lzlen=(code/20h)+1
disp=((code/4) AND 07h)+([src]*8)+1, src=src+1
goto @@decompress_lop
@@decompress_done:
ret

```

13.90 CDROM File Compression EA Methods

Electronic Arts Compression Headers

The files start with a 16bit big-endian Method value, with following bits:

0-7	ID (usually FBh) (or 31h for Method 4A31h with 16bit sizes)
8	Extended Header (usually 0) (or 1 for headers with extra entries)
9-14	Used to distinguish different methods
15	Extended Size (usually 0 for 24bit sizes) (or 1 for 32bit sizes)

The most common Method values are:

```

10FBh = LZSS Compression (RefPack)
90FBh = LZSS Compression (RefPack, with 32bit size) (not on PSX)
30FBh = Huffman Compression
32FBh = Huffman Compression with filter
34FBh = Huffman Compression with dual filter
46FBh = BPE Byte-Pair Encoding
4AFBh = RLE Run-Length Encoding
4A31h = RLE Run-Length Encoding, with 16bit size
C0FBh = File Archive (not a compression method)

```

Most or all PSX files have Bit8=0, but anyways, the decompressor does support skipping extra header entries in files with Bit8=1 (with all methods except RLE).

Most or all PSX files have Bit15=0, games for newer consoles can reportedly have Method=90FBh (unknown if anything like B2FBh or CAFBh does also exist).

Most or all PSX files have Bit0-7=FBh (supposedly short for Frank Barchard), the 16bit mode with Bit0-7=31h is supported for Method=4A31h only (the decompressor would also accept invalid methods like 1031h or 3431h, but doesn't actually support 16bit mode for those).

Compression Formats

[CDROM File Compression EA Methods \(LZSS RefPack\)](#)

[CDROM File Compression EA Methods \(Huffman\)](#)

CDROM File Compression EA Methods (BPE)

CDROM File Compression EA Methods (RLE)

Usage in PSX games

The compression can be used to compress whole files:

```
PGA Tour 96, 97, 98 (*.*) and *.VIV\*) (with method 10FBh)
Need for Speed 3 Hot Pursuit (*.Q* with method 10FBh, 30FBh, 32FBh)
```

Or to compress texture bitmaps inside of .PSH file chunks:

```
FIFA - Road to World Cup 98 (*.PSH chunk C0h/C1h with method 10FBh)
Sled Storm (MagDemo24: ART3\LOAD*.PSH chunk C0h/C1h with method 10FBh)
WCW Mayhem (MagDemo28: WCWDEMO\*.BIG\*.PSH with chunk C0h/C1h with 10FBh)
```

The decompressor supports further methods (like 34FBh, 46FBh, 4AFBh), but there aren't any files or chunks known to actually use those compression formats.

Note: Some compressed files are slightly larger than uncompressed files (eg. filesizes for PGA Tour 96, 97, 98 COURSES*.VIV*.mis are compressed=58h, uncompressed=50h).

See also

<http://wiki.niotso.org/RefPack> - LZ method

13.91 CDROM File Compression EA Methods (LZSS RefPack)

RefPack

```
000h 2      Method (10FBh, or 11FBh,90FBh,91FBh) (big-endian)
... (3/4) Compressed size (24bit or 32bit) (optional)
... 3/4 Uncompressed size (24bit or 32bit) (big-endoan)
... .. Compressed data
```

The compression is some kind of LZSS/LZH variant (similar to Z-Axis .ZAL files). The compressed data consists of a big-endian bit-stream (or byte-stream, as all codes are multiples of 8bits). The Compression codes are:

```
0ddzzzrrddddd          rawlen=r(2), lzlen=z(3)+3, disp=d(10)+1
10zzzzzzrrddddd          rawlen=r(2), lzlen=z(6)+4, disp=d(14)+1
```

```
110dzzrrdddddzzzzzzzz rawlen=r(2), lzlen=z(10)+5, disp=d(17)+1  
111rrrrr rawlen=r(5)*4+4, lzlen=0  
111111rr rawlen=r(2), lzlen=0, endflag=1
```

refpack_decompress:

```

method=BigEndian16Bit[src], src=src+2
if (method AND 100h)>0 then src=src+3+method/8000h ;compressed size, if any
if (method AND 8000h)=0 then dst_size=BigEndian24bit[src], src=src+3
if (method AND 8000h)>0 then dst_size=BigEndian32bit[src], src=src+4
endflag=0
@@decompress_lop:
if ([src] AND 80h)=0 then
    rawlen=[src] AND 03h
    lzlen=( [src] AND 1Fh)/4+3
    disp=( [src] AND 60h)*8+[src+1]+1
    src=src+2
elseif ([src] AND 40h)=0 then
    rawlen=[src+1]/40h
    lzlen=[src] AND 3Fh+4
    disp=( [src+1] AND 3Fh)*100h+[src+2]+1
    src=src+3
elseif ([src] AND 20h)=0 then
    rawlen=[src] AND 03h
    lzlen=( [src] AND 0Ch)*40h+[src+3]+5
    disp=( [src] AND 10h)*1000h+[src+1]*100h+[src+2]+1
    src=src+4
elseif ([src] AND FCh)=FCh then
    rawlen=[src] AND 03h
    lzlen=0
    src=src+1, endflag=1
else
    rawlen=( [src] AND 1Fh)*4+4
    lzlen=0
    src=src+1
for i=1 to rawlen, [dst]=[src], src=src+1, dst=dst+1, next i
for i=1 to lzlen, [dst]=[dst-disp], dst=dst+1, next i
if endflag=0 then goto @@decompress_lop
if (dst-dst_base)<>dst_size then error
ret

```

13.92 CDROM File Compression EA Methods (Huffman)

Huffman

```

000h 2   Method (30FBh..35FBh) (big-endian)
... (3)   Extra 3 bytes (only present if Method.bit8=1)
... 3     Decompressed Size      (big-endian)
... 1     Escape code

```

```

... .. Number of codes per width
... .. Data placement for each code
... .. Compressed Data

```

Huffman

```

decompress_ea_huffman:
method=GetBits(16)      ;3xFBh                ; -get method (30FBh..35FBh)
if method AND 100h then dummy=GetBits(24)      ; -skip extra (if any)
dst_size=GetBits(24)    ; -get uncompressed size
ESC=GetBits(8)          ; -get escape code
huffwidth=0, huffcode=0, totalnumcodes=0        ; \
while (huffcode shl (10h-huffwidth))<10000h    ;
    num=GetVarLenCode                ; get num codes per width
    huffwidth=huffwidth+1             ;
    numcodes_per_width[width]=num     ;
    totalnumcodes=totalnumcodes+num   ;
    huffcode=(huffcode*2)+num         ; /
for i=0 to FFh, data_defined_flags[i]=00h      ; \
dat=FFh, index=0                          ;
while index<totalnumcodes                  ;
    n=GetVarLenCode+1                  ; -          ; get/assign data values
    while n>0 ;search Nth notyet defined entry ;
        dat=(dat+1) AND FFh ;wrap in 8bit range! ;
        if data_defined_flags[dat]=0 then n=n-1 ;
        data_defined_flags[dat]=1             ;
        data_values[index]=dat, index=index+1 ; /
    huffcode=0000h, index=0              ; \
    InitEmptyHuffTree(data_tree)         ;
    for width=1 to huffwidth              ;
        for i=1 to numcodes_per_width[width] ; create huffman tree
            dat=data_values[index], index=index+1 ;
            CreateHuffCode(data_tree,dat,huffcode,width) ;
            huffcode=huffcode+(1 shl (10h-width)) ; /
@@decompress_lop:                          ; \
dat=GetHuffCode(data_tree)                 ;
if dat<>ESC                                ;
    [dst]=dat, dst=dst+1                    ; decompress
else                                         ;
    num=GetVarLenCode                       ;
    if num=0 then                           ;
        if GetBits(1)=1 then goto @@decompress_done ;
        [dst]=GetBits(8), dst=dst+1         ;
    else                                     ;
        dat=[dst-1]                         ;
        for i=0 to num-1, [dst]=dat, dst=dst+1 ;
    goto @@decompress_lop                  ; /
@@decompress_done:
if (dst-dst_base)<>dst_size then error        ; -error check
dst=dst_base, x=00h, y=00h                 ; \
if (method AND FEFFh)=32FBh                ; optional final
    for i=0 to dst_size-1, x=x+[dst+i], [dst+i]=x ; unfiltering
if (method AND FEFFh)=34FBh                ;

```



```

    for i=0 to dst_size-1, x=x+[dst+i], y=y+x, [dst+i]=y ;/
ret
;-----
GetVarLenCode:
    num=2
    while GetBits(1)=0, num=num+1
    return (GetBits(num)+(1 shl num)-4)
GetBits(num):
    return "num" bits, fetched from big-endian bitstream
GetHuffCode(data_tree):
    ...
InitEmptyHuffTree(data_tree):
    ...
CreateHuffCode(data_tree,dat,huffcode,width):
    ...
numcodes_per_width[10h]    ;9bit numcodes per width 0..15 (entry[0]=unused)
data_values[100h]          ;8bit data values for up to 100h huffman codes
data_defined_flags[100h]   ;1bit flags for data(00h..FFh)

```

13.93 CDROM File Compression EA Methods (BPE)

Byte-Pair Encoding

```

000h 2    Method (46FBh or 47FBh) (big-endian)
... (5)   Extra 5 bytes (only present if Method=47FBh)
... 3     Decompressed Size          (big-endian)
... 1     Escape code
... 1     Number of Dict entries (N)
... N*3   Dict (each 3 bytes: Index,Dat1,Dat2)
... ..    Compressed Data

```

decompress_bpe:

```

method=BigEndian16bit[src], src=src+2
if method=47FBh then src=src+5
dst_size=BigEndian24bit[src], src=src+3
esc=[src], src=src+1
num=[src], src=src+1
for i=0 to FFh, dict1[i]=i ;initially default=self (uncompressed bytes)
for i=1 to num, j=[src], dict1[j]=[src+1], dict2[j]=[src+2], src=src+3
@@decompress_lop:
x=[src], src=src+1
if x=dict1[x] then
    if x=esc then x=[src], src=src+1, if x=00h then goto @@decompress_done
    [dst]=x, dst=dst+1
else
    heap[0]=x, i=1
    while i>0
        i=i-1, x=heap[i], a=dict1[x]

```

```

        if a=x then [dst]=x, dst=dst+1           ;\output data to
        else b=dict2[x], heap[i]=b, heap[i+1]=a, i=i+2 ;/dst or heap
goto @@decompress_lop
@@decompress_done:
if (dst-dst_base)<>dst_size then error
ret

```

13.94 CDROM File Compression EA Methods (RLE)

Run-Length Encoding

```

000h 2      Method (4AFBh=24bit or 4A31h=16bit) (big-endian)
... 2/3     Decompressed Size (24bit or 16bit) (big-endian)
... ..     Compressed Data

```

Compression codes are:

```

00h..3Fh   Copy 0..3Fh uncompressed bytes
40h..7Fh   Load new fillbyte and fill 0..3Fh bytes
80h..BFh   Use old fillbyte and fill 0..3Fh bytes (initial fillbyte=00h)
C0h..FFh   Copy 0..3Fh bytes with constant value in upper 4bit

```

decompress_bpe:

```

method=BigEndian16bit[src], src=src+2
if (method AND 00FFh)=31h then dst_size=BigEndian16bit[src], src=src+2
if (method AND 00FFh)<>31h then dst_size=BigEndian24bit[src], src=src+3
fillbyte=00h ;initially zero
@@decompress_lop:
type=[src]/40h, len=[src] AND 3Fh, src=src+1, dst_size=dst_size-len
if type=0 then                                     ;\uncompressed bytes
    for i=1 to len, [dst]=[src], src=src+1, dst=dst+1 ;/
elseif type=1 then                                 ;\
    fillbyte=[src], src=src+1                       ; fill with new dat
    for i=1 to len, [dst]=fillbyte, dst=dst+1       ;/
elseif type=2 then                                 ;\fill with old dat
    for i=1 to len, [dst]=fillbyte, dst=dst+1       ;/
elseif type=3 then
    x=[src], [dst]=x, src=src+1, dst=dst+1, x=x AND F0h
    for i=2 to len ;<-- or so?
        if (i AND 1)=0 then [dst]=x+([src]/10h) dst=dst+1
        if (i AND 1)=1 then [dst]=x+([src] AND 0Fh), dst=dst+1, src=src+1
if dst_size<>0 then goto @@decompress_lop
ret

```

13.95 CDROM File Compression ZIP/GZIP/ZLIB (Inflate/Deflate)

Inflate/Deflate is a common (de-)compression algorithm, used by ZIP, ZLIB, and GZIP.

[Inflate - Core Functions](#)

[Inflate - Initialization & Tree Creation](#)

[Inflate - Headers and Checksums](#)

PSX Disk Images

In PSX cdrom-images, ZLIB is used by the .CDZ cdrom-image format:

[CDROM Disk Image/Containers CDZ](#)

In PSX cdrom-images, Inflate is used by .PBP and .CHD cdrom-image formats:

[CDROM Disk Images PBP \(Sony\)](#)

[CDROM Disk Images CHD \(MAME\)](#)

PSX Games

In PSX games, ZLIB is used by:

```
Twisted Metal 4 (MagDemo30: TM4DATA\*.MR\* and *.IMG\*)
Kula Quest / Kula World / Roll Away (*.PAK) (*.PAK\*)
(and probably more games... particular files starting with "x")
```

In PSX games, GZIP is used by:

```
Final Fantasy VII (FF7) (BATTLE\TITLE.BIN)
Gran Turismo 2 (MagDemo27: GT2\*) (with corrupted/zeropadded GZIP footers)
Mat Hoffman's Pro BMX (old demo) (MagDemo39: BMX\BMXCD.HED\TITLE_H.ZLB)
```

In PSX games, Inflate (with slightly customized block headers) is used by:

```
Mat Hoffman's Pro BMX (new demo) (MagDemo48: MHPB\FE.WAD+STR)
```

In PSX games, Inflate (with ignored block type, dynamic tree only) is used by:

```
Project Horned Owl (COMDATA.BIN, DEMODATA.BIN, ROLL.BIN, ST*DATA.BIN)
```

13.96 Inflate - Core Functions

tinfl_uncompress(dst,src)

```

tinfl_init()                ;init constants (needed to be done only once)
tinfl_align_src_to_byte_boundary()
repeat
    bfinal=tinfl_getbit()    ;read final block flag (1 bit)
    btype=tinfl_read_bits(2) ;read block type (2 bits)
    if btype=0 then tinfl_inflate_uncompressed_block()
    if btype=1 then tinfl_build_fixed_trees(), tinfl_inflate_compressed_block()
    if btype=2 then tinfl_decode_dynamic_trees(), tinfl_inflate_compressed_block()
    if btype=3 then ERROR    ;reserved
until bfinal=1
tinfl_align_src_to_byte_boundary()
ret

```

tinfl_inflate_uncompressed_block()

```

tinfl_align_src_to_byte_boundary()
len=LittleEndian16bit[src+0]                ;get len
if LittleEndian16bit[src+2]<>(len XOR FFFFh) then ERROR ;verify inverse len
src=src+4                                   ;skip len values
for i=0 to len-1, [dst]=[src], dst=dst+1, src=src+1, next i ;copy block
ret

```

tinfl_inflate_compressed_block()

```

repeat
    sym1=tinfl_decode_symbol(tinfl_len_tree)
    if sym1<256
        [dst]=sym1, dst=dst+1
    if sym1>256
        len = tinfl_read_bits(length_bits[sym1-257])+length_base[sym1-257]
        sym2 = tinfl_decode_symbol(tinfl_dist_tree)
        dist = tinfl_read_bits(dist_bits[sym2])+dist_base[sym2]
        for i=0 to len-1, [dst]=[dst-dist], dst=dst+1, next i
until sym1=256
ret

```

tinfl_decode_symbol(tree)

```

sum=0, cur=0, len=0
repeat                ;get more bits while code value is above sum
    cur=cur*2 + tinfl_getbit()
    len=len+1
sum=sum+tree.table[len]

```

```

    cur=cur-tree.table[len]
until cur<0
return tree.trans[sum+cur]

```

tinfl_read_bits(num) ;get N bits from source stream

```

val=0
for i=0 to num-1, val=val+(tinfl_getbit() shl i), next i
return val

```

tinfl_getbit() ;get one bit from source stream

```

bit=tag AND 01h, tag=tag/2
if tag=00h then tag=[src], src=src+1, bit=tag AND 01h, tag=tag/2+80h
return bit

```

tinfl_align_src_to_byte_boundary()

```

tag=01h    ;empty/end-bit (discard any bits, align src to byte-boundary)
ret

```

13.97 Inflate - Initialization & Tree Creation

tinfl_init()

```

tinfl_build_bits_base(length_bits, length_base, 4, 3)
length_bits[28]=0, length_base[28]=258
tinfl_build_bits_base(dist_bits, dist_base, 2, 1)
ret

```

tinfl_build_bits_base(bits,base,delta,base_val)

```

for i=0 to 29
    bits[i]=min(0,i-delta)/delta
    base[i]=base_val
    base_val=base_val+(1 shl bits[i])
ret

```

tinfl_build_fixed_trees()

```

for i=0 to 6, tinfl_len_tree.table[i]=0, next i      ;[0..6]=0    ;len tree...
tinfl_len_tree.table[7,8,9]=24,152,112              ;[7..9]=24,152,112

```

```

for i=0 to 23, tinf_len_tree.trans[i+0] =i+256, next i ;[0..23] =256..279
for i=0 to 143, tinf_len_tree.trans[i+24] =i+0, next i ;[24..167] =0..143
for i=0 to 7, tinf_len_tree.trans[i+168]=i+280, next i ;[168..175]=280..287
for i=0 to 111, tinf_len_tree.trans[i+176]=i+144, next i ;[176..287]=144..255
for i=0 to 4, tinf_dist_tree.table[i]=0, next i ;[0..4]=0,0,0,0,0 ;\dist
tinf_dist_tree.table[5]=32 ;[5]=32 ; tree
for i=0 to 31, tinf_dist_tree.trans[i]=i, next i ;[0..31]=0..31 ;/
ret

```

tinf_decode_dynamic_trees()

```

hlit = tinf_read_bits(5)+257 ;get 5 bits HLIT (257-286)
hdist = tinf_read_bits(5)+1 ;get 5 bits HDIST (1-32)
hclen = tinf_read_bits(4)+4 ;get 4 bits HCLEN (4-19)
for i=0 to 18, lengths[i]=0, next i
for i=0 to hclen-1 ;read lengths for code length alphabet
  lengths[clcidx[i]]=tinf_read_bits(3) ;get 3 bits code length (0-7)
tinf_build_tree(code_tree, lengths, 19) ;build code length tree
for num=0 to hlit+hdist-1 ;decode code lengths for dynamic trees
  sym = tinf_decode_symbol(code_tree)
  len=1, val=sym ;default (for sym=0..15)
  if sym=16 then len=tinf_read_bits(2)+3, val=lengths[num-1] ;3..6 previous
  if sym=17 then len=tinf_read_bits(3)+3, val=0 ;3..10 zeroes
  if sym=18 then len=tinf_read_bits(7)+11, val=0 ;11..138 zeroes
  for i=1 to len, lengths[num]=val, num=num+1, next i
tinf_build_tree(tinf_len_tree, 0, hlit) ;\build trees
tinf_build_tree(tinf_dist_tree, 0+hlit, hdist) ;/
ret

```

tinf_build_tree(tree, first, num)

```

for i=0 to 15, tree.table[i]=0, next i ;clear code length count table
;scan symbol lengths, and sum code length counts...
for i=0 to num-1, x=lengths[i+first], tree.table[x]=tree.table[x]+1, next i
tree.table[0]=0
sum=0 ;compute offset table for distribution sort
for i=0 to 15, offs[i]=sum, sum=sum+tree.table[i], next i
for i=0 to num-1 ;create code to symbol xlat table (symbols sorted by code)
  x=lengths[i+first], if x<>0 then tree.trans[offs[x]]=i, offs[x]=offs[x]+1
next i
ret

```

tinf_data

```

clcidx[0..18] = 16,17,18,0,8,7,9,6,10,5,11,4,12,3,13,2,14,1,15 ;constants

```

```
typedef struct TINF_TREE:
    unsigned short table[16]      ;table of code length counts
    unsigned short trans[288]     ;code to symbol translation table
```

```
TINF_TREE tinf_len_tree    ;length/symbol tree
TINF_TREE tinf_dist_tree   ;distance tree
TINF_TREE code_tree        ;temporary tree (for generating the dynamic trees)
unsigned char lengths[288+32] ;temporary 288+32 x 8bit ;\for dynamic tree
unsigned short offs[16]     ;temporary 16 x 16bit      ;/creation
```

```
unsigned char  length_bits[30]
unsigned short length_base[30]
unsigned char  dist_bits[30]
unsigned short dist_base[30]
```

13.98 Inflate - Headers and Checksums

tinf_gzip_uncompress(dst, destLen, src, sourceLen)

```
src_start=src, dst_start=dst                ;memorize start addresses
if (src[0]<>1fh or src[1]<>8Bh) then ERROR    ;check id bytes
if (src[2]<>08h) then ERROR                  ;check method is deflate
flg=src[3]                                  ;get flag byte
if (flg AND 0E0h) then ERROR                 ;verify reserved bits
src=src+10                                  ;skip base header
if (flg AND 04h) then src=src+2+LittleEndian16bit[src] ;skip extra data
if (flg AND 08h) then repeat, src=src+1, until [src-1]=00h ;skip file name
if (flg AND 10h) then repeat, src=src+1, until [src-1]=00h ;skip file comment
hcrc=(tinf_crc32(src_start, src-src_start) & 0000ffffh) ;calc header crc
if (flg AND 02h) then x=LittleEndian16bit[src], src=src+2 ;get header crc
if (flg AND 02h) then if x<>hcrc then ERROR    ;verify header
tinf_uncompress(dst, destLen, src, src_start+sourceLen-src-8) ;----> inflate
crc32=LittleEndian32bit[src], src=src+4       ;get crc32 of decompressed data
dlen=LittleEndian32bit[src], src=src+4        ;get decompressed length
if (dlen<>destLen) then ERROR                  ;verify dest len
if (crc32<>tinf_crc32(dst_start,dlen)) then ERROR ;verify crc32
ret
```

tinf_zlib_uncompress(dst, destLen, src, sourceLen)

```
src_start=src, dst_start=dst                ;memorize start addresses
hdr=BigEndian16bit[src], src=src+2          ;get header
if (hdr MOD 31)<>0 then ERROR                  ;check header checksum (modulo)
if (hdr AND 20h)>0 then ERROR                 ;check there is no preset dictionary
if (hdr AND 0F00h)<>0800h then ERROR          ;check method is deflate
if (had AND 0F000h)>7000h then ERROR         ;check window size is valid
```

```

tinf_uncompress(dst, destLen, src, sourceLen-6)      ;-----> inflate
chk=BigEndian32bit[src], src=src+4                  ;get data checksum
if src-src_start<>sourceLen then ERROR               ;verify src len
if dst-dst_start<>destLen then ERROR                 ;verify dst len
if a32<>tinf_adler32(dst_start,destLen)) then ERROR  ;verify data checksum
ret

```

tinf_adler32(src, length)

```

s1=1, s2=0
while (length>0)
  k=max(length,5552)      ;max length for avoiding 32bit overflow before mod
  for i=0 to k-1, s1=s1+[src], s2=s2+s1, src=src+1, next i
  s1=s1 mod 65521, s2=s2 mod 65521, length=length-k
return (s2*10000h+s1)

```

13.99 CDROM File Compression LArc/LHarc/LHA (LZS/LZH)

LHA (formerly LHarc) is an old DOS compression tool with backwards compatibility for LArc. LHA appears to have been particularly popular in Japan, and in the Amiga scene. LHA archives are used by at least one PSX game:

```

PSX Championship Surfer (MagDemo43: HWX\*.DAT)      ;method lh5

```

And, there are various PSX games with compression based on LArc's method lz5:

CDROM File Compression LZ5 and LZ5-variants

Overall File Format

Default archive filename extension is .LZH for LHarc/LHA (lh*-methods), or .LZS for LArc (lz*-methods).

Archives can contain multiple files, and are usually terminated by a 00h-byte:

```

LHA Header+Data for 1st file
LHA Header+Data for 2nd file
End Marker (00h)

```

There is no central directory, one must crawl all headers to create a list of files in the archive.

Caution: There is a hacky test file (larc333\initial.lzs) with missing end byte (it does just end at filesize).

LHA Header v2 Headersize=xx00h would conflict with End Byte (as workaround, insert a Nullbyte between Ext.Headers and Data to change Headersize to xx01h.

LHA Header v0 (with [14h]=00h)

```

00h    1    Header Size (Method up to including Extended Area) (=16h+F+E)
01h    1    Header Checksum, sum of bytes at [02h+(0..15h+F+E)]
02h    5    Compression Method (eg. "-lh0-"=Uncompressed)
07h    4    Compressed Size
0Bh    4    Uncompressed Size
0Fh    2    Last modified time (in MS-DOS format)
11h    2    Last modified date (in MS-DOS format)
13h    1    MS-DOS File attribute (usually 20h)
14h    1    Header level (must be 00h for v0)
15h    1    Path\Filename Length
16h    (F) Path\Filename (eg. "PATH\FILENAME.EXT")
        '\ ' may apper in the 2nd byte of Shift_JIS, processing
        of Shift_JIS is indispensable when you need full
        implementation of reading Pathname.
16h+F  2    CRC16 (with initial value 0000h) on uncompressed file
18h+F  (E) Extended area (used by UNIX in v0)
18h+F+E .. Compressed data

```

Note: Reportedly, old LArc files don't have CRC16 (unknown if that is true, the ONLY known version is LArc v3.33, which DOES have CRC16, if older versions didn't have that CRC then they did perhaps behave as if E=(-2)?).

LHA Header v1 (with [14h]=01h)

```

00h    1    Header Size (Method up to including 1st Ext Size) (=19h+F+E)
01h    1    Base Header Checksum, sum of bytes at [02h+(0..18h+F+E)]
02h    5    Compression Method (eg. "-lh0-"=Uncompressed)
07h    4    Skip size (size of all Extended Headers plus Uncompressed Size)
0Bh    4    Uncompressed Size
0Fh    2    Last modified time (in MS-DOS format)
11h    2    Last modified date (in MS-DOS format)
13h    1    Reserved      (must be 20h) (but is 02h on Amiga)
14h    1    Header level (must be 01h for v1)
15h    1    Length of Filename (or 00h when name is in Extended Header)
16h    (F) Filename (eg. "FILENAME.EXT; path (if any) is in Extended Header)
16h+F  2    CRC16 (with initial value 0000h) on uncompressed file
18h+F  1    Compression Tool OS ID (eg. "M"=MSDOS)
19h+F  (E) Extended area (unused in v1, use Ext Headers instead)
19h+F+E 2    Size of 1st Extended Header (0000h=None)
1Bh+F+E .. Extended Header(s) (optional stuff)
...    .. Compressed data

```

LHA Header v2 (with [14h]=02h)

00h	2	Header Size (whole Header including all Extended Headers)
02h	5	Compression Method (eg. "-lh0-"=Uncompressed)
07h	4	Compressed Size
0Bh	4	Uncompressed Size
0Fh	4	Last modified date and time (seconds since 1st Jan 1970 UTC)
13h	1	Reserved (must be 20h) (but is 02h on Amiga)
14h	1	Header level (must be 02h for v2)
15h	2	CRC16 (with initial value 0000h) on uncompressed file
17h	1	Compression Tool OS ID (eg. "M"=MSDOS)
18h	2	Size of first Extended Header (0000h=None)
1Ah	..	Extended Header(s) (filename and optional stuff)
...	0/1	Nullbyte (End-Marker conflict: change Headersize xx00h to xx01h)
...	..	Compressed data

LHA Header v3 (with [14h]=03h)

Kinda non-standard (supported only in late japanese LHA beta versions): Allows Header and Ext.Headers to exceed 64Kbyte, which is rather useless.

00h	2	Word size for 32bit Header entries (always 4=32bit)
02h	5	Compression Method (eg. "-lh0-"=Uncompressed)
07h	4	Compressed Size
0Bh	4	Uncompressed Size
0Fh	4	Last modified date and time (seconds since 1st Jan 1970 UTC)
13h	1	Reserved (must be 20h)
14h	1	Header level (must be 03h for v3)
15h	2	CRC16 (with initial value 0000h) on uncompressed file
17h	1	Compression Tool OS ID (eg. "M"=MSDOS)
18h	4	Header Size (whole Header including all Extended Headers)
1Ch	4	Size of first Extended Header (00000000h=None)
20h	..	Extended Header(s) (filename and optional stuff)
...	..	Compressed data

Compression Methods

Method	Len	Window		
-lz4-	-	-	LArc	Uncompressed File
-lh0-	-	-	LHA	Uncompressed File
-lhd-	-	-	LHA	Uncompressed Directory name entry
-lzs-	2..17	2Kbyte	LArc	LZSS-Compressed (rare, very-very old) ; -15bit
-lz5-	3..17	4Kbyte	LArc	LZSS-Compressed (LArc standard) ; -16bit
-lh1-	3..60	4Kbyte	LHA	LZHUF-Compressed (old LHA standard)
-lh2-	3..256	8Kbyte	LHA	Obscure test (used in self-extractor)
-lh3-	3..256	8Kbyte	LHA	Obscure test (experimental)
-lh4-	3..256	4Kbyte	LHA	AR002-Compressed (rare, for small RAM) ; \4bit
-lh5-	3..256	8Kbyte	LHA	AR002-Compressed (new LHA standard) ; /
-lh6-	3..256	32Kbyte	LHA	AR002-Compressed (rare) ; \

```

-lh7- 3..256 64Kbyte LHA AR002-Compressed (rare) ; 5bit
-lh8- 3..256 64Kbyte LHA AR002-Compressed (accidentally same as lh7) ;
-lh9- 3..256 128Kbyte LHA AR002-Compressed (unimplemented proposal) ;
-lha- 3..256 256Kbyte LHA AR002-Compressed (unimplemented proposal) ;
-lhb- 3..256 512Kbyte LHA AR002-Compressed (unimplemented proposal) ;
-lhc- 3..256 1Mbyte LHA AR002-Compressed (unimplemented proposal) ;
-lhe- 3..256 2Mbyte LHA AR002-Compressed (unimplemented proposal) ;
-lhx- 3..256 512Kbyte LHA AR002-Compressed (rare) ;/

```

Apart from above methods, there are various other custom hacks/extensions.

Extended Headers

```

00h    1    Extension Type (00h..FFh, eg. 01h=Filename)
01h    ..   Extension Data
...    2/4  Size of next Extended Header (0=None) (v1/v2=16bit, v3=32bit)

```

Extension Type values:

```

00h    CRC16 on whole Header with InitialValue=0000h and InitialCrcEntry=0000h
01h    Filename
02h    Directory name (with FFh instead of "\", and usually with trailing FFh)
3Fh    Comment (unspecified format/purpose)
40h    MS-DOS File attribute of MS-DOS format
41h    Windows FILETIME for last access, creation, and modification
42h    Filesize (uncompressed and compressed size, when exceeding 32bit)
50h    Unix Permission
51h    Unix User ID and Group ID
52h    Unix Group name
53h    Unix User name (owner)
54h    Unix Last modified time in time_t format
7Dh    Capsule offs/size (if the OS adds extra header/footer to the filebody)
7Eh    OS/2 Extended attribute
7Fh    Level 3 Attribute in Unix form and MS-DOS form
FFh    Level 3 Attribute in Unix form

```

Note: There appears to be no MAC specific format (instead, the LHA MAC version is including a MacBinary header in the compressed files).

See also

The site below has useful links with info about headers (see LHA Notes), source code, and test archives:

<http://fileformats.archiveteam.org/wiki/LHA>

13.100 CDROM File Compression UPX

UPX Compression (used in AmiDog's GTE test)

UPX is a tool for creating self-decompressing executables. It's most commonly used for DOS/Windows EXE files, but it does also support consoles like PSX. The PSX support was added in UPX version 1.90 beta (11 Nov 2002).

```

000h 88h      Standard PS-X EXE header
088h 20h      Unknown
0A8h 4        ASCII ID "UPX!"
0ACh 1Eh      Unknown
0CAh 9Ah      ASCII "$info: This file is ..."
164h 69Ch     Zerofilled
800h ..       Leading zeropadding (to make below end on 800h-byte boundary)
... ..       Decompression stub
... ..       Compressed data (ending on 800h-byte boundary)
```

13.101 CDROM File Compression LZMA

LZMA is combining LZ+Huffman+Probabilities. The LZ+Huffman bitstream is rather simple (using hardcoded huffman trees), the high compression ratio is reached by predicting probabilities for the bitstream values (that is, the final compressed data is smaller than the bitstream).

LZMA Bitstreams

```

000h 1        Ignored byte (usually 00h, unknown purpose)
001h ..       Bitstream with actual compression codes
... ..       EOS end code (end of stream) (optional)
... ..       Ignored byte (present in case of Normalization after last code)
... ..       Padding to byte-boundary
```

Apart from the bitstream, one must know several parameters (which may be hardcoded, or stored in custom file headers in front of the bitstream):

```

Three decompression parameters: lc, lp, pb
Decompressed size (required if the bitstream has no EOS end code)
Dictionary size (don't care when decompressing the whole file to memory)
Presence/Absence of EOS end code
```

.lzma files (LZMA_Alone format from LZMA SDK)

```

000h 1  Parameters (((pb*5)+lp)*9)+lc  (usually 5Dh)          ;\
001h 4  Dictionary Size in bytes      (usually 10000h)       ; Header
005h 8  Decompressed Size in bytes    (or -1=Unknown)        ;/
00Dh 1  LZMA ignored 1st byte of bitstream (00h)            ;\LZMA
00Eh .. LZMA bitstream (with optional EOS end code)         ;/

```

The files are often starting with 5Dh,00h,00h. However, there's no real File ID, and there's no CRC, the format is rather unsuitable for file sharing.

The end of the bitstream is indicated by EOS end code, or by Decompressed Size entry (or both).

.lz files (LZIP)

LZIP files can contain one or more "LZIP Members" plus optional extra data:

```

000h ..  LZIP Member(s)
... ..  Optional extra data (if any) (eg. zeropadding or some SHA checksum)

```

Whereas, a normal .lz file contains only one "Member", without extra data.

Each of the "LZIP Member(s)" is having following format:

```

000h 5  ID and version ("LZIP",01h)                          ;\LZIP Header
005h 1  Dictionary size (5bit+3bit code, see below)          ;/
006h .. LZMA bitstream (with lc=3, lp=0, pb=2) (with EOS end code)
... 4   CRC32 on uncompressed data                           ;\
... 8   Size of uncompressed data                             ; LZIP Footer
... 8   Size of compressed data (including header+footer)    ;/

```

The dictionary size should be 1000h..20000000h bytes, computed as so:

```

temp = 1 SHL (hdr[005h] AND 1Fh)
dict_size = temp - (temp/10h)*(hdr[005h]/20h)

```

The LZIP format doesn't really allow to determine the uncompressed size before decompression (one must either decompress the whole file to detect the size, or one could try to find the Footer at end of file; which requires weird heuristics because the LZIP manual is explicitly stating that it's valid to append extra data after the Footer).

http://www.nongnu.org/lzip/manual/lzip_manual.html#File-format

.chd (MAME compressed CDROM and HDD images)

The CHD format has its own headers and supports several compression methods including LZMA. Leaving apart the CHD specific headers, the raw LZMA bitstreams are

stored as so:

```
000h .. LZMA bitstream (with lc=3, lp=0, pb=2) (without EOS end code)
```

.xz files (XZ Utils)

This is a slightly overcomplicated format with LZMA2 compression and optional filters.

[CDROM File Compression XZ](#)

.7z files (7-Zip archives)

```
000h 6 ID ("7z", BCh, AFh, 27h, 1Ch)
... ..
```

The 7z format defines many compression methods. The ones normally used are LZMA2 (default for 7-Zip 9.30 alpha +), LZMA (default for 7-Zip prior to 9.30 alpha), PPMd, and bzip2.

<http://fileformats.archiveteam.org/wiki/7z>

LZMA2 (used in .7z and .xz files)

LZMA2 is a container format with LZMA chunks. The LZMA function is slightly customized: It can optionally skip some LZMA initialization steps (and thereby re-use the dictionary/state from previous chunks). The chunks are:

```
ChunkID=00h - Last chunk:
000h 1 Chunk ID (00h=End)
ChunkID=01h..02h - Uncompressed chunks:
000h 1 Chunk ID (01h=Uncompressed+ResetDictionary, 02h=Uncompressed)
001h 2 Uncompressed Data Size-1 (big-endian)
003h .. Uncompressed Data (to be copied to destination and dictionary)
Note: The uncompressed data is stored in LZMA dictionary, and
the last uncompressed byte is updating the LZMA prevbyte.
ChunkID=03h..7Fh - Invalid chunks:
000h 1 Chunk ID (03h..7Fh=Invalid)
ChunkID=80h..FFh - LZMA-compressed chunks:
000h 1 Chunk ID (80h/A0h/C0h/E0h + Upper5bit(UncompressedSize-1))
001h 2 LSBs(UncompressedSize-1) (big-endian)
003h 2 CompressedSize-1 (big-endian)
005h (1) Parameters (((pb*5)+lp)*9)+lc (only present if ChunkID=C0h..FFh)
... .. LZMA bitstream (without EOS end code)
```

LZMA status gets reset depending on the Chunk ID:

ChunkID	dict/prev	lc/lp/pb	state	dist[0-3]	probabilities	code/range
01h	reset	-	-	-	-	-
02h	-	-	-	-	-	-
80h+n	-	-	-	-	-	reset
A0h+n	-	-	reset	reset	reset	reset
C0h+n	-	reset	reset	reset	reset	reset
E0h+nn	reset	reset	reset	reset	reset	reset

(Note: Those resets occur before processing the chunk data)

Note: dict/prev reset means that previous byte is assumed to be 00h (and old dictionary content isn't used, somewhat allowing random access or multicore decompression).

Apart from the chunks, LZMA2 does usually contain a Dictionary Size byte:

```
Dictionary Size byte (00h..28h = 4K,6K,8K,12K,16K,24K,...,2G,3G,4G)
Which can be decoded as so:
if (param AND 1)=0 then dict_size=1000h shl (param/2)
if (param AND 1)=1 then dict_size=1800h shl (param/2)
if param=28h then dict_size=FFFFFFFFh ;4GB-1
if param>28h then error
In .xz files, that byte is stored alongsides with the Filter ID.
```

LZMA Source code

Compact LZMA decompression ASM code can be found here:

<https://github.com/ilyakurdyukov/micro-lzmadec>

Above code is for self-decompressing executables (for plain LZMA, ignore the stuff about EXE/ELF headers). The two "static" versions are size-optimized (they contain weird and poorly commented programming tricks, and do require additional initialization code from "test_static.c"). For normal purposes, it's probably better to port the 64bit fast version to 32bit (instead of dealing with the trickery in the 32bit static version).

13.102 CDROM File Compression XZ

Overall Structure of .xz File

```
000h .. Stream(s)
```

Note: To determine the total uncompressed size, one must process the file backwards, starting at footer of last stream.

Stream

```

000h 6   Header ID (FDh,"7zXZ",00h) (FDh,37h,7Ah,58h,5Ah,00h) ;\
006h 2   Checksum Type (0000h, 0100h, 0400h or 0A00h)           ; Header
008h 4   Header CRC32 on above 2 bytes                           ;/
00Ch ..   Compressed Block(s)                                   ;-Block(s)
... ..   Index List                                           ;-Index
... 4    Footer CRC32 on below 6 bytes                           ;\
... 4    Index List Size/4-1                                    ; Footer
... 2    Checksum Type (must be same as in Header)              ;
... 2    Footer ID ("YZ") (59h,5Ah)                             ;/
... ..   Optional Zeropadding (multiple of 4 bytes)            ;-Padding
Checksum Type (for Block checksums):
0000h=None
0100h=CRC32 (little-endian)
0400h=CRC64 (little-endian)
0A00h=SHA256 (big-endian)
Other=Reserved

```

Index List

```

000h 1   Index Indicator (00h) (as opposed to 01h..FFh in Block Headers)
001h VL  Number of Records (must be same as number of Blocks in Stream)
... ..   Index Record(s)
... ..   Zeropadding to 4-byte boundary
... 4    CRC32 on above bytes
Index Record:
000h VL  Unpadded Block Size (BlockHeader + CompressedData + 0 + Checksum)
... VL   Uncompressed Block Size

```

Compressed Block

```

000h 1   Block Header Size/4-1 (01h..FFh = 8..400h bytes)      ;\
001h 1   Block Flags                                           ;
002h (VL) Compressed Size      ;present if Flags.bit6 = 1      ; Header
... (VL) Uncompressed Size     ;present if Flags.bit7 = 1      ;
... ..   Filter Info 0 (LAST filter when DECOMPRESSING)        ;
... (..) Filter Info 1         ;present if Flags.bit0-1 = 1,2,3 ;
... (..) Filter Info 2         ;present if Flags.bit0-1 = 2,3  ;
... (..) Filter Info 3         ;present if Flags.bit0-1 = 3    ;
... ..   Zeropadding to 4-byte boundary                          ;
... (..) Optional Zeropadding (multiple of 4 bytes)            ;
... 4    CRC32 on above bytes                                    ;/
... ..   Compressed Data                                           ;-Data
... ..   Zeropadding to 4-byte boundary                          ;-Pad
... (..) Checksum on uncompressed Data (None/CRC32/CRC64/SHA256) ;-Check
Block Flags:
0-1  Number of filters-1          (0..3 = 1..4 filters)
2-5  Reserved (0)
6    Compressed Size field is present (0=No, 1=Present)

```



```

7      Uncompressed Size field is present (0=No, 1=Present)
Filter Info:
000h VL   Filter ID
...  VL   Size of Filter Properties
...  ..   Filter Properties
Filter IDs:
03h                        Delta Filter          (with 1 byte param)
04h..09h                   Executable Filters (with 0 or 4 byte param)
21h                        LZMA2 Compression   (with 1 byte param)
300h..4FFh                 Reserved to ease .7z compatibility
20000h..7FFFFh             Reserved to ease .7z compatibility
2000000h..7FFFFFFh         Reserved to ease .7z compatibility
xxxxxxxxxxxxxxxxxh         Custom Registered IDs (obtained from Lasse Collin)
3Frrrrrrrrrrriiih         Custom Random IDs (40bit random+16bit filterno)
4000000000000000h and up   Reserved for internal use (don't use in xz files)

```

Note: The first decompression filter must be LZMA2, which reads from compressed data stream, and writes to decompressed data (and also implies the size of compressed/decompressed data). The other filters (if any) are unfiltering the decompressed data.

Filter 21h: LZMA2 Compression Method

This "filter" is the actual compression method (XZ supports only one method). It can be combined with BCJ/Delta filters (whereas, LZMA2 must be always used as LAST compression filter, aka FIRST decompression filter).

```

The filter parameter is 1 byte tall:
Dictionary Size byte (00h..28h = 4K,6K,8K,12K,16K,24K,...,2G,3G,4G)
The compressed data contains:
LZMA2 chunks (with LZMA-compressed data and/or uncompressed data)

```

Filter 03h: Delta Filter

The filter parameter is 1 byte tall:

```

Distance-1 (00h..FFh = distance 1..100h)
<B> unfilter_delta(buf,len,param_byte):</B>
dist=byte(param)+1, i=dist    ;init dist and skip first some unfiltered bytes
while i<len, byte(buf[i]) = buf[i]+buf[i-dist], i=i+1

```

Filter 04h-09h: Executable Branch/Call/Jump (BCJ) Filters

These filters can replace relative jump addresses by absolute values.

ID	Parameters	Alignment	Description
04h	0 or 4 bytes	1 byte	80x86 filter (32bit or 64bit)

05h	0 or 4 bytes	4 bytes	PowerPC filter (big endian)
06h	0 or 4 bytes	16 bytes	IA64 filter
07h	0 or 4 bytes	4 bytes	ARM filter (little endian)
08h	0 or 4 bytes	2 bytes	ARM Thumb filter (little endian)
09h	0 or 4 bytes	4 bytes	SPARC filter
0Ah, 0Bh			Inofficial hacks/proposals for ARM64?

The filter parameter field can 0 or 4 bytes tall:

```

if param_size=0 then offset=00000000h
if param_size=4 then offset=LittleEndian32bit(param)
Nonzero offsets are intended for executables with multiple sections and
cross-section jumps. The offset shall/must match the filter's alignment.
<B> unfilter_bcj_x86(buf,len,offset):</B>
i=0, len=len-4, offset=offset+4
while i<len
  x=byte[buf+i], i=i+1
  if (x AND FEh)=E8h ;Opcode=E8h or E9h
    x=LittleEndian32bit[buf+i]
    if ((x+01000000h) AND FE000000h)=0 ;MSB=00h or FFh
      LittleEndian32bit[buf+i]=SignExpandLower25bit(x-i-offset)
    i=i+4
<B> unfilter_bcj_arm(buf,len,offset):</B>
i=0, len=len/4, offset=(offset+8)/4
while i<len
  x=LittleEndian32bit[buf+i*4]
  if (x AND FF000000h)=EB000000h
    LittleEndian32bit[buf+i*4]=((x-i-offset) and 00FFFFFFh)+EB000000h
  i=i+1
<B> unfilter_bcj_armthumb(buf,len,offset):</B>
i=0, len=len/2-1, offset=(offset+4)/2
while i<len
  x=LittleEndian32bit[buf+i*2]
  if (x AND F800F800h)=F800F000h
    msw=LittleEndian16bit[buf+i*2+0] AND 7FFh
    lsw=LittleEndian16bit[buf+i*2+2] AND 7FFh
    x=msw*800h+lsw-i-offset
    LittleEndian16bit[buf+i*2+0]=F000h+(7FFh and (x/800h))
    LittleEndian16bit[buf+i*2+2]=F800h+(7FFh and (x/1))
  i=i+1
<B> unfilter_bcj_sparc(buf,len,offset):</B>
i=0, len=len/4, offset=offset/4
while i<len
  x=BigEndian32bit[buf+i*4]
  if (x AND FFC00000h)=40000000h or (x AND FFC00000h)=7FC00000h
    x=SignExpandLower23bit(x-i-offset)
    BigEndian32bit[buf+i*4]=(x AND 3FFFFFFFh)+40000000h
  i=i+1
<B> unfilter_bcj_powerpc(buf,len,offset):</B>
i=0, len=len/4, offset=offset/4
while i<len
  x=BigEndian32bit[buf+i*4]
  if (x AND FC000003h)=48000001h

```

```

        BigEndian32bit[buf+i*4]=(((x/4-i-offset) AND 0FFFFFFh)*4)+48000001h
        i=i+1
<B> unfilter_bcj_ia64(buf,len,offset):</B>
        i=0, len=len/10h, offset=offset/10h
        xlat[0..1Fh]=0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,4,4,6,6,0,0,7,7,4,4,0,0,4,4,0,0
        while i<len
            flags=xlat[byte[buf] and 1Fh]          ;shared 5bit for three 41bit opcodes
            for slot=0 to 2
                if flags and (1 shl slot)          ;process three 41bit opcodes
                    bitbase=slot*41+5
                    hi=byte[buf+(bitbase+37)/8] shr ((bitbase+37) and 7) and 0Fh
                    lo=LittleEndian16bit[buf+(bitbase+9)/8] shr ((bitbase+9) and 7) and 07h
                    if hi=5 and lo=0
                        mid=LittleEndian32bit[buf+(bitbase+13)/8]
                        x=mid shr ((bitbase+13) and 7)
                        x=x and 8FFFFFFh, if (x and 800000h) then x=x-700000h
                        x=x-i-offset
                        x=x and 1FFFFFFh, if (x and 100000h) then x=x+700000h
                        mid=mid AND NOT (8FFFFFFh shl ((bitbase+13) and 7)) ;strip old
                        mid=mid OR x shl ((bitbase+13) and 7) ;place new
                        LittleEndian32bit[buf+(bitbase+13)/8]=mid ;apply
                    i=i+1, buf=buf+10h

```

Cyclic Redundancy Checks (CRCs)

CRC32 uses 32bit (with polynomial=EDB88320h). CRC64 does basically use the same function (with 64bit values and polynomial=C96C5795D7870F42h).

Endianness and Variable Length (VL) Integers

Little-endian is used for 16bit/32bit/64bit values (Flags, Sizes, CRCs).

Big-endian is used for 256bit SHA256 and for values within LZMA2 chunks.

Variable length integers (marked VL in above tables) are used for Sizes and IDs, these values may contain max 63bit, stored in 1-9 bytes:

```

decode_variable_len_integer:
    i=0, num=0
@@lop:
    x=[src], src=src+1, num=num+((x and 7Fh) shl i), i=i+7
    if x AND 80h then goto @@lop
    return num

```

Notes and References

XZ Utils for Windows is claimed to work on Win98 (that is, it will throw an error about missing MSVCRT.DLL:___mb_cur_max_func). XZ Utils for DOS does work on Win98.

Official XZ file format specs for can be found at:

<https://tukaani.org/xz/format.html>

The BCJ filters aren't documented in XZ specs, but are defined in XZ source code, see `src\liblzma\simple*.c`). There's also this mail thread about semi-official ARM64 filters:

<https://www.mail-archive.com/xz-devel@tukaani.org/msg00537.html>

13.103 CDROM File Compression FLAC audio

FLAC is a lossless audio compression format.

FLAC file format

```
000h 4   FLAC ID ("fLaC")
004h ..  Metadata block with STREAMINFO
... ..  Metadata block(s) with further info (optional)
... ..  FLAC Frame(s)
```

The whole file can be read as big-endian bitstream (although bitstream reading is mainly required for the Frame bodies) (the Frame header/footer and Metadata blocks are byte-aligned and can be read as byte-stream).

Metadata Block format:

```
1bit     Last Metadata block flag (1=Last, 0=More blocks follow)
7bit     Block Type (see below)
24bit    Size of following metadata in bytes (N)
N*8bit   Metadata (depending on Type)
```

Metadata Block Types:

```
00h = STREAMINFO
01h = PADDING
02h = APPLICATION
03h = SEEKTABLE
04h = VORBIS_COMMENT
05h = CUESHEET
06h = PICTURE
..  = Reserved
7Fh = Invalid (to avoid confusion with a frame sync code)
```

FLAC METADATA_BLOCK_STREAMINFO

```
16bit    Minimum Block size in samples (10h..FFFFh)  ;\min=max implies
16bit    Maximum Block size in samples (10h..FFFFh)  ;/fixed blocksize
```

```

24bit  Minimum Frame size in bytes (or 0=Unknown)
24bit  Maximum Frame size in bytes (or 0=Unknown)
20bit  Sample rate in Hertz (01h..9FFF6h = 1..655350 Hz)
3bit   Number of channels-1 (00h..07h = 1..8 channels)
5bit   Bits per sample-1      (03h..1Fh = 4..32 bits) (max 24bit implemented)
36bit  Total number of samples per channel (or 0=Unknown)
128bit MD5 on unencoded audio data (...in which format? endian/interleave?)

```

More info

The FLAC file format is documented here:

<https://xiph.org/flac/format.html>

Source code for a compact FLAC decoder can be found here:

<https://www.nayuki.io/page/simple-flac-implementation>

13.104 CDROM File Compression ARJ

ARJ archives contain several chunks

```

Main header chunk
Local file chunk(s)
Chapter chunk(s), backup related, exist only in newer archives
End Marker

```

ARJ main "comment" header, with [00Ah]=2

This is stored at the begin of the archive. The format is same as for local file header (but with file-related entries set to zero, or to global security settings).

```

000h 2  ARJ ID (EA60h, aka 60000 decimal)
002h 2  Header size (from 004h up to including Filename+Comment) (max 2600)
004h 1  Header size (from 004h up to including Extra Data) (1Eh+extra)
005h 1  Archiver version number (01h..0xh)
006h 1  Minimum archiver version to extract (usually 01h)
007h 1  Host OS
008h 1  ARJ Flags (bit0-7, see below)
009h 1  Security version (2 = current)
00Ah 1  File Type          (must be 2=ARJ Comment in main header)
00Bh 1  Reserved/Garbage (LSB of Archive creation Date/Time, same as [00Ch])
00Ch 4  Date/Time when archive was created
010h 4  Date/Time when archive was last modified
014h 4  Zero (or Secured Archive size, excluding Security and Protection)
018h 4  Zero (or Security envelope file position) (after End Marker)

```

```

01Ch 2   Zero   (or Filespec position in filename) (0) (what is that??)
01Eh 2   Zero   (or Security envelope size in bytes) (78h, if any)
020h 1   Zero   (or >2.50?: Encryption version, 0=Old, 2=New, 4=40bit GOST)
021h 1   Zero   (or >2.50?: Last chapter (eg. 4 when having chapter 1..4)
022h (1) Extra data: ARJ Protection factor                ;\extra,
023h (1) Extra data: ARJ Flags (bit0=ALTVOLNAME, bit1=ReservedBit) ; if any
024h (2) Extra data: Spare bytes                          ;/
... ..   Filename, max 500 bytes ("FILENAME.ARJ",00h)
... ..   Comment, max 2048 bytes ("ASCII Comment",00h)
... 4    CRC32 on Header (from 004h up to including Comment)
... 2    Size of 1st extended header (usually 0=none)
... (0)  Extended Header(s?) (usually none such)

```

ARJ local file header, with [00Ah]=0,1,3,4

This occurs at the begin of each file in the archive.

```

000h 2   ARJ ID (EA60h, aka 60000 decimal)
002h 2   Header size (from 004h up to including Filename+Comment) (max 2600)
004h 1   Header size (from 004h up to including Extra Data) (1Eh+extra)
005h 1   Archiver version number
006h 1   Minimum archiver version to extract (usually 01h)
007h 1   Host OS
008h 1   ARJ Flags (bit0,2-5)
009h 1   Method
00Ah 1   File Type (0=Binary, 1=Text, 3=Directory Name, 4=Volume Name)
00Bh 1   Reserved/Garbage (LSB of Archive update Date/Time?)
00Ch 4   Date/Time modified
010h 4   Filesize, compressed (max 7FFFFFFFh)
014h 4   Filesize, uncompressed
018h 4   CRC32 on uncompressed file data
01Ch 2   Zero   (or Filespec position in filename) (what is that??)
01Eh 2   File access mode (aka MSDOS file attribute) (20h=Normal)
020h 1   Zero   (or >2.50?: first chapter of file's lifespan)
021h 1   Zero   (or >2.50?: last chapter of file's lifespan)
022h (4) Extra data: Extended file position (maybe for split?) ;\extra,
026h (4) Extra data: Date/Time accessed                ;\ARJ ; 0,4 or 10h
03Ah (4) Extra data: Date/Time created                  ; 2.62 ; bytes
03Eh (4) Extra data: Original file size even for volumes ;/      ;/
... ..   Filename, max 500 bytes ("PATH/FILENAME.EXT",00h)
... ..   Comment, max 2048 bytes ("ASCII Comment",00h)
... 4    CRC32 on Header (from 004h up to including Comment)
... 2    Size of 1st extended header (usually 0=none)
... (0)  Extended Header(s?) (usually none such)
... ..   Compressed file data

```

Entry 3Eh might be meant to contain Original Size of TEXT files (with CR,LFs), however, the entry is just set to 00000000h in ARJ 2.75a. Or maybe it's meant to mean size of whole file (in split-volumes)?

ARJ backup "chapter" header (ARJ >2.50?) (exists in 2.75a), with [00Ah]=5

This is rarely used and supported only in newer ARJ versions. The format is same as for local file header (but with file-related entries being nonsense in TECHNOTE; in practice, those nonsense values seem to be zero).

```

000h 2  ARJ ID (EA60h, aka 60000 decimal)
002h 2  Header size (from 004h up to including Filename+Comment) (max 2600)
004h 1  Header size (from 004h up to including Extra Data) (1Eh+extra)
005h 1  Archiver version number (eg. 0Ah=2.75a)
006h 1  Minimum archiver version to extract (usually 01h)
007h 1  Host OS
008h 1  ARJ Flags (usually 00h)
009h 1  Method (usually 01h, although chapters have no data)  what file???
00Ah 1  File Type (must be 5=ARJ Chapter)
00Bh 1  Reserved/Garbage (LSB of Chapter Date/Time, same as [00Ch])
00Ch 4  Date/Time stamp created
010h 4  Zero (or reportedly, ?)                                what question?
014h 4  Zero (or reportedly, ?)                                what question?
018h 4  Zero (or reportedly, original file's CRC32)           what file???
01Ch 2  Zero (or reportedly, entryname position in filename)  what file???
01Eh 2  Zero (or reportedly, file access mode)                what file???
020h 1  Chapter range start (01h=First chapter?)              what range???
021h 1  Chapter range end (contains same value as above)      what range???
022h (4) Extra data: Extended file position (usually none such)what extra???
... .. Filename ("<<<001>>>",00h for First chapter)
... .. Comment ("",00h)
... 4   CRC32 on Header (from 004h up to including Comment)
... 2   Size of 1st extended header (usually 0=none)
... (0) Extended Header(s?) (usually none such)

```

ARJ End Marker (with [002h]=0000h)

This is stored at the end of the archive.

```

000h 2  ARJ ID (EA60h, aka 60000 decimal)
002h 2  Header size (0=End)

```

Note: The End Marker may be followed by PROTECT info and Security envelope.

ARJ Method [009h]

```

0 = stored (uncompressed)
1 = compressed most (default) (Window=6800h=26Kbyte, Chars=255, Tree=31744)
2 = compressed medium          (Window=5000h=20Kbyte, Chars=72, Tree=30720)
3 = compressed less            (Window=2000h=8Kbyte, Chars=32, Tree=30720)
4 = compressed least/fastest   (Window=6800h? or 8000h?)

```

```

8 = no data, no CRC ;\unknown if/where that is used (maybe only used
9 = no data ;/internally, and never stored in actual files?)

```

ARJ File Type [00Ah]

```

0 = binary file (default)
1 = text file (with converted line breaks, via -t1 switch)
2 = ARJ comment header (aka ARJ main file header)
3 = directory name
4 = volume label (aka disc name)
5 = ARJ chapter label (aka begin of newer backup sections)

```

ARJ Flags (in Main [008h])

```

0  GARBLED
1  OLD_SECURED    has old signature (with signature in Main Header?)
1  ANSIPAGE       ANSI codepage used by ARJ32 (for what? for "FILENAME.ARJ"?)
2  VOLUME         presence of succeeding volume
3  ARJPROT
4  PATHSYM        archive name translated ("\\" changed to "/")
5  BACKUP         obsolete
6  SECURED        has new signature (in security envelope?)
7  ALTNAME        dual-name archive

```

ARJ Flags (in Local [008h])

```

0  GARBLED        passworded file
1  NOT_USED
2  VOLUME         continued file to next volume (file is split)
3  EXTFILE        file starting position field (for split files)
4  PATHSYM        filename translated ("\\" changed to "/")
5  BACKUP_FLAG    obsolete

```

ARJ Flags (in Chapter [008h])

```

0  GARBLED ;\
1  RESERVED ;
2  VOLUME ; what does that mean in Chapters???
3  EXTFILE ;
4  PATHSYM ;/
5  BACKUP    obsolete < 2.50a ; -how can obsolete exist in Chapters???
6  RESERVED

```

Host OS [007h]


```

0=MSDOS, 1=PRIMOS, 2=UNIX, 3=AMIGA, 4=MACDOS (aka MAC-OS)
5=OS/2, 6=APPLE GS, 7=ATARI ST, 8=NEXT
9=VAX VMS, 10=WIN95, 11=WIN32 (aka WinNT or so?)

```

ARJ Method 1-3 (LHA/LZH compression)

These methods are same as LHA's "-lh6-" compression method (albeit the three ARJ methods are allocating slightly less memory for the sliding window).

ARJ Method 4 (custom fastest compression)

```

@@decompress_lop:
  if dst>=dst_end then goto @@decompress_done
  width=count_ones(max=7), len = get_bits(width) + (1 shl width)+1
  if len=2 then
    [dst]=get_bits(8), dst=dst+1
  else ;len>=3
    width=count_ones(max=4)+9, disp = get_bits(width) + (1 shl width)-1FFh
    for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
  goto @@decompress_lop
@@decompress_done:
  ret
;---
count_ones(max):
  num=0
@@lop:
  if get_bits(1)=1 then
    num=num+1, if num<max then goto @@lop
  return num

```

get_bits(N) is same as in method 1-3 (fetching N bits, MSB first, starting with bit7 of first byte).

ARJ Glossary & Oddities

BACKUPS seem to keep old files (instead overwrting them by newer files)

CHAPTERs seems to be a new backup type (instead of [008h].Bit5=Backup flag).

COMMENTS can be text... with ANSI.SYS style ANSI escape codes?

DATE/TIME stamps seem to be MSDOS format (16bit date plus 16bit time)

EXTENDED headers seem to be unused, somewhat inspired on LHA format but with CRC32 instead CRC16 (unknown if the "1st extended header" can be followed by 2nd, 3rd, and further extended headers in LHA fashion) (bug: older ARJ versions are reportedly treating the extended CRC32 as 16bit value).

GARBLED seems to refer to encrypted password protected archives.

PROTECTED seems to mean Error Correction added in newer ARJ archives.
 SECURED seems to mean archive with signature from registered manufacturers.
 SPLIT aka VOLUMES means large ARJ's stored in fragments on multiple disks.
 TEXT (aka [00Ah]=1 aka -t1 switch aka "C Text" aka "7-bit text") converts linebreaks from CR,LF to LF to save memory (the uncompressed size and uncompressed CRC32 entries refer to that converted LF format, not to the original CR,LF format; the official name "7-bit text" is nonsense: All characters are stored as 8bit values, not 7bit values).
 TIMEBOMB causes newer ARJ versions to refuse to work (and request the user to check for non-existing newer updates) (eg. ARJ 2.86 is no longer working, ARJ 2.75a does still work without timebomb).

See also

The various ARJ versions include .TXT or .DOC files (notably, ARJ.TXT is user manual, TECHNOTE.TXT contains hints on the ARJ file format). There's also an open source version.

13.105 CDROM File Compression ARC

ARC Archives

ARC is an old DOS and CP/M compression tool from 1985-1990. ARC files contain chunks in following format:

```

000h 1      Fixed ID (1Ah)
001h 1      Compression Method (00h..1Fh)
002h 13     Filename ("FILENAME.EXT",00h) (garbage-padded if shorter)
00Fh 4      Filesize, compressed
013h 4      File Timestamp in MSDOS format
017h 2      CRC16 with initial value 0000h on uncompressed/decrypted file
019h (4)    Filesize, uncompressed ;<-- not present for Method=1
... ..     Compressed file data (size as stored in [00Fh])

```

The chunksize depends on the Method:

```

Method 00h and 1Fh --> Chunksize=02h      (archive/subdir end markers)
Method 01h         --> Chunksize=19h+[0Fh] (old uncompressed ARC archives)
Others Methods     --> Chunksize=1Dh+[0Fh] (normal case)

```

Compression Methods (aka "header versions"):

```

00h      End-of-archive marker (1Ah,00h)
01h      ARC v?      Uncompressed (with short 19h-byte header)
02h      ARC v?      Uncompressed (with normal 1Dh-byte header)
03h      ARC v?      Packed      (RLE90)                        Used for small files
04h      ARC v?      Squeezed    (RLE90+Huffman)              Based on CP/M Squeeze
05h      ARC v4.00   Crunched    (OldRandomizedLZW)           Derived from LZWCOM
06h      ARC v4.10   Crunched    (RLE90+OldRandomizedLZW)     Alike CP/M Crunch v1.x
07h      ARC vBeta?  Crunched    (RLE90+NewRandomizedLZW)     Leaked beta version?
08h      ARC v5.00   Crunched    (RLE90+ClearGap12bitLZW)     Most common ARC method
09h      Inofficial  Squashed    (ClearGap13bitLZW)           Used by PKARC/PKPAK
0Ah      ARC v7.xx   Trimmed     (RLE90+LZHUF)                Based on LHArc 1h1
0Ah      Inofficial  Crushed     (RLE90+LZW/LZMW?)            PAK
0Bh      Inofficial  Distilled   (LZ77+Huffman)                PAK v2.0
14h-1Dh  ARC v6.0   Used/reserved for Information items:
14h      Archive info
15h      Extended File info (maybe a prefix(?) for actual file entries?)
16h      OS-specific info
1Eh-27h  ARC v6.0   Used/reserved for Control items:
1Eh      ARC v6.00  Subdir (nested ARC-like format, created by the "z" option)
1Fh      ARC v6.00  End-of-subdir marker (1Ah,1Fh)
48h      Not used in ARC ;\Hyper archives start with 1Ah,48h or 1Ah,53h
53h      Not used in ARC ;/(an unrelated format that also starts with 1Ah)
80h-xxh  Not used in ARC ;-Spark archives (ARC-like, with extended headers)

```

Information items use standard 1Dh-byte headers (with [002h]="",00h, [00Fh]=SizeOfAllItem(s), [019h]=Junk. The data part at offset 01Dh can contain one or more item(s) in following format:

```

000h 2      Item size (LEN)
002h 1      Item Subtype
003h ..     Item Data (LEN-3 bytes)

```

Information item types as used by ARC 6.0:

```

Method=14h, Subtype=0  Archive description      (eg. "Comment blah",00h)
Method=14h, Subtype=1  Archive creator program name (eg. "ARC 7.12 ...",00h)
Method=14h, Subtype=2  Archive modifier program name
Method=15h, Subtype=0  File description          (eg. "Comment blah",00h)
Method=15h, Subtype=1  File long filename (if not MS-DOS "8.3" filename)
Method=15h, Subtype=2  File extended date-time info (reserved)
Method=15h, Subtype=3  File Icon                  (reserved)
Method=15h, Subtype=4  File attributes (see below) (eg. "RWHSN",00h)
Method=16h, Subtype=.. Operating system info      (reserved)

```

File attributes can contain following uppercase chars:

```

R=ReadAccess, W=WriteAccess, H=HiddenFile, 1=SystemFile, N=NetworkShareable

```

Sub-directories

Sub-directories are implemented as nested ARC files - about same as when storing the sub-directory files in SUBDIR.ARC, and including that SUBDIR.ARC file in the main archive with Method 02h. Except that:

It's using Method 1Eh (instead Method 02h), with filename SUBDIR (instead SUBDIR.ARC), and with [019h]=Nonsense (instead uncompressed size), and the nested file ends with Method 1Fh (instead Method 00h).

RLE90 (run-length compression with value 90h used as escape code)

ARC does use raw RLE90 for small files (eg. 4-byte "aaaa"). ARC does also use RLE90 combined with other methods (perhaps because ARC wasn't very fast, compressing 100Kbytes could reportedly take several minutes; and without RLE90 pre-compression it might have been yet slower).

```

90h,00h      Output 90h, but DON'T change prevbyte      ;<-- ARC
90h,00h      Output 90h, and DO set prevbyte=90h        ;<-- BinHex
90h,00h      Output 90h, and UNKNOWN what to do         ;<-- StuffIt
90h,01h..03h Output prevbyte 00h..02h times (this is not useful)
90h,04h..FFh Output prevbyte 03h..FEh times (this does save memory)
xxh          Output xxh, and memorize prevbyte=xxh

arc_decompress_rle90:
  src_end = src+src_size
  prevbyte = <initially undefined in ARC source code>
@@decompress_lop:
  if src>=src_end then goto @@decompress_done
  x=[src], src=src+1
  if x<>90h then
    [dst]=x, dst=dst+1, prevbyte=x      ;output x, and memorize prevbyte=x
  else ;x=90h
    x=[src], src=src+1
    if x=00h then
      [dst]=90h, dst=dst+1              ;output 90h, but DO NOT change prevbyte
      if BinHex then prevbyte=90h      ;for BinHex, DO change prevbyte
    else
      for i=1 to x-1, [dst]=prevbyte, dst=dst+1, next i
  goto @@decompress_lop

```

RLE90 is used by ARC (and Spark and ArcFS), StuffIt, and BinHex (some of these may handle "prevbyte" differently; the handling in ARC is somewhat stupid as it cannot compress repeating 90h-bytes).

Squeeze

```

000h 2      Number of Tree entries (0..100h) (when 0, assume tree=FEFFh,FEFFh)
002h N*4    Tree entries (16bit node0, 16bit node1)
... ..     Huffman bitstream (starting in bit0 of first byte)
... ..     Maybe supposedly padding to byte boundary?
The 16bit nodes are:
0000h..00FFh  Next Tree index
0100h..FEFEh  Invalid
FEFFh         End of compressed data
FF00h..FFFFh  Data values FFh..00h (these are somewhat inverted/reversed)
arc_decumpress_squeeze:
if [src]=0000h then tree=empty_tree, else tree=src+2  ;--start tree
InitBitstreamLsbFirst(src+2+[src]*4)                ;--start bitstream
@@decompress_lop:
index=0000h                                         ;\
while index<FEFFh                                  ; huffman decode
    index=[tree+index*4+GetBits(1)*2]               ;/
if index>FEFFh then                                ;--check end code
    [dst]=(index XOR FFh) AND FFh, dst=dst+1         ;--store data
    goto @@decompress_lop
return
empty_tree dw FEFFh,FEFFh    ;upen empty tree, ARC defines two 1bit END codes

```

<http://fileformats.archiveteam.org/wiki/Squeeze>

Randomized LZW

```

arc_decompress_randomized_lzw:
num_free=1000h, stack=empty, oldcode=-1
for i=0 to FFFh, lzw_parent[i]=EEEEh    ;mark all codes as unused
for i=0 to FFh, create_code(FFFFh,i)    ;codes for 00h..FFh with parent=none
@@decompress_lop:
if src>=src_end then goto @@decompress_done
code=GetBitsMsbFirst(12), i=code
if lzw_parent[i]=EEEEh then i=oldcode, push(oldbyte) ;--for KwKwK strings
while lzw_parent[i]<>FFFFh, push(lzw_data[i]), i=lzw_parent[i]
oldbyte=lzw_data[i], [dst]=oldbyte, dst=dst+1
if oldcode<>-1 then create_code(oldcode,oldbyte)
oldcode=code
while stack<>empty, [dst]=pop(), dst=dst+1
goto @@decompress_lop
@@decompress_done:
ret
;---
create_code(parent,data):
if num_free=0 then goto @@no_further_codes, else num_free=num_free-1 ;--full
i=(parent+data) AND 0000FFFFh                                         ;\
if method=7 then i=(i*3AE1h) AND FFFh                                ; new "fast" randomizer ;
else i=(sqr(i OR 800h)/40h) AND FFFh                                  ; old "slow" randomizer ;
if lzw_parent[i]=EEEEh then goto @@found_free                         ; alloc
while lzw_sibling[i]>0000h, do i=lzw_sibling[i]                       ; find chain end ; code
e=i, i=(i+65h) AND FFFh                                               ; memorize chain end & do some random skip ;
while lzw_parent[i]<>EEEEh, do i=(i+1) AND FFFh                       ; find a free code ;

```

```

    lzw_sibling[e]=i      ;weirdly, i=0 will make it behave as sibling=none ;
@@found_free:           ;/
    lzw_data[i]=data, lzw_parent[i]=parent, lzw_sibling[i]=0000h      ;-apply
@@no_further_codes:
    ret

```

Codes are always 12bit (unlike normal LZW that often starts with 9bit codes).

There won't be any new codes created if the table is full, the existing codes can be kept used if they do match the remaining data (unfortunately this LZW variant has no Clear code for resetting the table when they don't match).

Instead of just using the first free entry, code allocation is using some weird pseudo-random-sibling logic (which is totally useless and will slowdown decompression, but compressed files do contain such randomized codes, so it must be reproduced here).

ClearGap LZW

This is more straight non-randomized LZW with Clear codes (and weird gaps after Clear codes). The compression (and gaps) are same as for nCompress (apart from different headers):

[CDROM File Compression nCompress.Z](#)

```

ARC Method 8 with 1-byte header (0Ch) --> nCompress 3-byte header 1Fh,9Dh,8Ch
ARC Method 9 without header           --> nCompress 3-byte header 1Fh,9Dh,8Dh

```

Method 8 does have 0Ch as first byte (indicating max 12bit codesize, this must be always 0Ch, the ARC decoder supports only that value). Method 9 uses max 13bit codesize (but doesn't have any leading codesize byte).

LZHUF

This is based on LHArc lh1. Like lh1, it does have 13Ah data/len codes, and 1000h distance codes. There are two differences:

Differences	LHArc method lh1	ARC method 0Ah
Data/len codes:	100h..139h=Len(3..3Ch)	100h=End, 101h..139h=Len(3..3Bh)
Initial dictionary:	20h-filled	Uninitialized

Notes

ARC file/directory names are alphabetically sorted, that does apply even when adding files to an existing archive (they are inserted at alphabetically sorted locations rather than being appended at end of archive).

ARC files can be encrypted/garbled with password (via "g" option), the chunk header doesn't contain any flags for indicating encrypted files (except, the CRC16 will be wrong when not supplying the correct password).

ARC end-marker (1Ah,00h) may be followed by additional padding bytes, or by additional information from third-party tools:

```
PKARC/PKPAK adds comments (starting with "PK",AAh,55h)
PAK adds extended records (described in PAK.DOC file in the v2.51)
```

See also

[http://fileformats.archiveteam.org/wiki/ARC_\(compression_format\)](http://fileformats.archiveteam.org/wiki/ARC_(compression_format))

<https://www.fileformat.info/format/arc/corion.htm>

<http://cd.textfiles.com/pcmedic/utils/compress/arc520s.zip> - source code

<https://github.com/ani6al/arc> - source code, upgraded with method 9 and 4

<https://entropymine.wordpress.com/2021/05/11/arcs-trimmed-compression-scheme/>

<http://www.textfiles.com/programming/FORMATS/arc-lbr.pro> - benchmarks

13.106 CDROM File Compression RAR

RAR is a compression format for enthusiastic users (who love to download the latest RAR version before being able to decompress those RAR files).

RAR v1.3 (March 1994, used only in RAR 1.402)

This format was only used by RAR 1.402, and discontinued after three months when RAR 1.5 got released.

```
File Header:
000h 4      ID "RE~^" (aka 52h,45h,7Eh,5Eh)
004h 2      Header Size (usually 0007h, or bigger when Comment/Ext1 exist)
006h 1      Archive Flags (80h or xxh)
... (2)     Archive Comment Size ;\Only present when ArchiveFlags.bit1=1
... (..)    Archive Comment Data ;/
... (2)     Ext1 Size ;\Only present when ArchiveFlags.bit5=1
... (..)    Ext1 Data ;/
... ..     Unknown (TECHNOTE hints sth can be here, when bigger HeaderSize?)
Archive Flags:
0 Volume (maybe related to split-volume on several floppies?)
```

```

1  Comment
2  Unknown? (non-english description is in 1.402's TECHNOTE.DOC)
3  Unknown? (non-english description is in 1.402's TECHNOTE.DOC)
4  Unknown? (non-english description is in 1.402's TECHNOTE.DOC)
5  EXT1
6  Unspecified (maybe unused)
7  Unspecified (maybe unused, but... it's usually 1)

```

File Data blocks:

```

000h 4  Filesize, compressed
004h 4  Filesize, uncompressed
008h 2  Checksum on uncompressed? file (sum=LeftRotatel6bit(sum+byte[i])
00Ah 2  Header Size (usually 0015h+FilenameLength)
00Ch 4  File Modification Timestamp in MSDOS format
010h 1  File Attribute in MSDOS format (20h=Normal)
011h 1  Flags
012h 1  Version (0=0.99, 1=1.00, 2=1.30) (always 2 in public version)
013h 1  Filename Length
014h 1  Method (00h=m0a=Stored, 03h=m3a=Default) (1..5 = fastest..best)
... (2) File Comment Length          ;\Only present if FileFlags.bit3=1
... (..) File Comment Data           ;/
... .. Filename ("PATH\FILENAME.EXT", without any end marker)
... .. Unknown (TECHNOTE hints sth can be here, when bigger HeaderSize?)
... .. Compressed file data

```

File Flags:

```

0  Unknown? (non-english description is in 1.402's TECHNOTE.DOC)
1  Unknown? (non-english description is in 1.402's TECHNOTE.DOC)
2  Unknown? (non-english description is in 1.402's TECHNOTE.DOC)
3  Comment (non-english description is in 1.402's TECHNOTE.DOC)
4-7 Unspecified (maybe unused)

```

RAR 1.5 (June 1994) and newer**Overall Chunk Format:**

```

000h 2  Chunk Header CRC; Lower 16bit of CRC32 on [002h..HdrSize-1 or less]
002h 1  Chunk Type (72h..7Ah)
003h 2  Chunk Flags
005h 2  Chunk Header Size
007h (4) Data block size      ;<-- Only present if Flags.bit15=1
... .. Header values (depending on Chunk Type and Chunk Header Size)
... .. Data block           ;<-- Only present if Flags.bit15=1

```

Chunk Types:

```

72h="r"=Marker block (with "r" being 3rd byte in ID "Rar!",1Ah)
73h="s"=Archive header
74h="t"=File header
75h="u"=Old style Comment header (nested within Type 73h/74h)
76h="v"=Old style Authenticity information
77h="w"=Old style Subblock
78h="x"=Old style Recovery record
79h="y"=Old style Authenticity information
7Ah="z"=Subblock

```

Chunk Flags:


```

0-13  Flags, meaning depends on Chunk Type
14    If set, older RAR versions (before 1.52 or so?) will ignore the
      block and remove it when the archive is updated. If clear, the
      block is copied to the new archive file when the archive is
      updated;
      or does "older" mean older than the "archiver version"?
15    Data Block present (0=No, 1=Yes, with size at [007h])

```

Type 72h, Marker Block (MARK_HEAD)

This 7-byte ID occurs at the begin of RAR files (or after the executable in case of self-extracting files).

```

000h 7      ID ("Rar!",1Ah,07h,00h) (or "Rar!",1Ah,07h,01h for RAR 5.0)
The above ID can be somewhat parsed as normal chunk header, as so:
000h 2      Faux CRC                (6152h, no actual valid CRC)
002h 1      Chunk Type              (72h)
003h 2      Faux Flags              (1A21h, no actual meaning)
005h 2      Chunk Header size (0007h)

```

Type 73h, Archive Header (MAIN_HEAD)

```

000h 2      CRC32 AND FFFFh of fields HEAD_TYPE to RESERVED2
002h 1      Chunk Type: 73h
003h 2      Archive HeaderFlags
005h 2      Header size (usually 000Dh) (plus Comment Block, if any)
007h 2      RESERVED1 (0000h)
009h 4      RESERVED2 (0000011Dh)
... (..)    Comment block ;<-- only present if Flags.bit1=1
... (..)    Reserved for additional blocks
Archive Header Chunk Flags:
0      Volume attribute (archive volume) (split-volume? volume-label? what?)
1      Archive comment present ;<-- used only before RAR 3.x
      RAR 3.x uses "the separate comment block" and does not set this flag.
2      Archive lock attribute
3      Solid attribute (solid archive)
4      New volume naming scheme (0=Old="name.???", 1=New="name.partN.rar")
5      Authenticity information present ;<-- used only before RAR 3.x
6      Recovery record present
7      Chunk headers are encrypted
8      First volume ;<-- set only by RAR 3.0 and later
9-13    Reserved for internal use
14-15    See overall Chunk Format

```

Type 74h, File Header (File in Archive)

```

000h 2      CRC32 AND FFFFh on HEAD_TYPE to FILEATTR and file name
002h 1      Header Type: 74h
003h 2      Bit Flags
005h 2      File header full size including file name and comments
007h 4      Compressed file size (can be bigger than uncompressed)

```

```

00Bh 4    Uncompressed file size
00Fh 1    Operating system used for archiving
010h 4    CRC32 on uncompressed file
014h 4    File Modification Timestamp in MSDOS format
018h 1    RAR version needed to extract file (Major*10+Minor) (min=0Fh=1.5)
019h 1    Compression Method (usually 35h in RAR 1.52)
01Ah 2    Filename size
01Ch 4    File Attribute in MSDOS format (20h=Normal, Upper24bit=whatever=0)
... (...) Comment block                ;--Only present if Flags.bit3=1
... (4)   MSBs of compressed file size    ;\Only present if Flags.Bit8=1
... (4)   MSBs of uncompressed file size  ;/
... ..   Filename ("PATH\FILENAME.EXT")
... (...) Filename extra fields (see Flags.bit9+bit11)
... (8)   Encryption SALT                ;--Only present if Flags.Bit10=1
... (...) Extended Time, variable size    ;--Only present if Flags.Bit12=1
... (...) * other new fields may appear here.
... ..   Compressed file data

```

File Chunk Flags:

```

0    File continued from previous volume
1    File continued in next volume
2    File encrypted with password
3    File comment present                ;<-- used only before RAR 3.x
      RAR 3.x uses the separate comment block and does not set this flag.
4    Information from previous files is used (solid flag) ;RAR 2.0 and later
5-7  Dictionary bits (for RAR 2.0 and later)
8    64bit Filesizes (for files "larger than 2Gb")
9    Unicode Filename, this can be in Dual or Single name form:
      Dual name:  "NormalName",00h,"UnicodeName"    ;<-- in UTF-8 or what?
      Single name: "UnicodeName"                    ;<-- in UTF-8
10   Header contains 8-byte Encryption SALT entry
11   Backup File (with version number ";n" appended to filename)
12   Extended Time field present
13-14 -
15   Data Block present (always 1=With 32bit size at [007h], or 64bit size)

```

Dictionary Bits (bit5-7)

```

00h=Dictionary Size 64 Kbyte
01h=Dictionary Size 128 Kbyte    ;\
02h=Dictionary Size 256 Kbyte    ; RAR 2.0 and up
03h=Dictionary Size 512 Kbyte    ;
04h=Dictionary Size 1024 Kbyte   ;/
05h=Dictionary Size 2048 Kbyte   ;\RAR ?? and up
06h=Dictionary Size 4096 Kbyte   ;/
07h=File is a directory          ;--RAR 2.0 and up

```

Operating System Indicators:

```

00h=MS DOS
01h=OS/2
02h=Windows
03h=Unix
04h=Mac OS
05h=BeOS
??h=Android?

```

Compression Method:

```

35h=Default in RAR 1.52 (used even when file is too small to be compressed)
xxh=Other methods (unknown values)

```

```
30h=Stored (RAR 2.00 supports uncompressed small files and -m0 switch)
N/A=Stored (RAR 1.52 simply ignores "-m0" switch, and enforces "-m1" or so)
```

Type 75h, Comment block:

```
000h 2    Header CRC of fields from HEAD_TYPE to COMM_CRC
002h 1    Chunk Type: 75h
003h 2    Chunk Flags (unknown if/which flags are used)
005h 2    Chunk Header size (0Eh+Compressed comment size)
007h 2    Uncompressed comment size
009h 1    RAR version needed to extract comment
00Ah 1    Packing Method
00Ch 2    Comment CRC
00Eh ..   Compressed comment data
```

Sub-formats

The RAR format is comprised of many sub-formats that have changed over the years. The different formats and their descriptions are as follows:

- * 1.3 (Does not have the RAR! signature)
 - o There is difficulty finding information regarding this sub-format.
- * 1.5
 - o Utilizes a proprietary compression method that is not public.
 - o Considered the root model of subsequent formats.
 - o A detailed list of information can be found [here](#).
- * 2.0
 - o Utilizes a proprietary compression method that is not public.
 - o Based off of version 1.5 of the RAR file format.
- * 3.0
 - o Utilizes the PPMII and Lempel-Ziv (LZSS) algorithms.
 - o Encryption now uses cipher block chaining (AES?-CBC) instead of AES
 - o Based off of version 1.5 of the RAR file format.

See also

Older RAR versions did include a TECHNOTE file describing the file format of those versions (TECHNOTE for 1.402 exist in unknown-language only, perhaps russian, and TECHNOTE was discontinued somewhere between 2.5 and 2.9).

There is official decompression source code for newer RAR versions.

13.107 CDROM File Compression ZOO

ZOO Archives

File Header:

```

000h 20   Text Message (usually "ZOO #.## Archive.",1Ah,00h,00h)
014h 4     ID (FDC4A7DCh) (use this ID for detection, and ignore above text)
018h 4     Offset to first Chunk (22h or 2Ah+commentsize?)
01Ch 4     Offset to first Chunk, negated (-22h or -2Ah-commentsize?)
020h 1+1   Version needed to extract (Major,Minor) (usually 1,01 or 2,00)
022h (1)   Archive Header Type (01h) ;\
023h (4)   Offset to Archive Comment (0=None) ; v2.00 and
027h (2)   Length of Archive Comment (0=None) ; up only
029h (1)   Version Data (01h or 03h) "HVDATA" ;/

```

File Chunks:

```

000h 4     ID (FDC4A7DCh)
004h 1     Type of directory entry (1=Old, 2=New, with extra entries)
005h 1     Compression method (0=Stored, 1=LZW/default, 2=LZH)
006h 4     Offset to next Chunk
00Ah 4     Offset to File Data
00Eh 4     File Modification Date/time in MSDOS format
012h 2     CRC16 on uncompressed file (with initial value 0000h)
014h 4     Filesize, uncompressed
018h 4     Filesize, compressed
01Ch 1+1   Version needed to extract (Major,Minor) (usually 1,00 or 2,01)
01Eh 1     Deleted flag (0=Normal, 1=Deleted)
01Fh 1     File structure (unknown purpose)
020h 4     Offset of comment field (0=None)
024h 2     Length of comment field (0=None)
026h 13    Short Filename ("FILENAME.EXT",00h, garbage padded if shorter)
033h (1)   Unknown (4Fh) (or 00h when with comment?) ; -Type=1
033h (2)   Length of 038h and up (0Ah+longname+dirname) ;\
035h (1)   Timezone (signed) (7Fh=Unknown) ;
036h (2)   CRC16 on Header (000h..037h+[033h], with [036h]=0000h) ;
038h (1)   Length of Long Filename (0=None, use Short Filename) ;
039h (1)   Length of Directory name (0=None) ; Type=2
03Ah (..)  Long Filename ("longfilename.ext",00h) (if any) ;
... (..)  Directory name ("/path",00h) (if any) ;
... (2)   System ID (0=Unix, 1=DOS, 2=Portable) (but for DOS=0) ;
... (3)   File Attributes (24bit) (but for DOS=0) ;
... (1)   Backup Flags (bit7=On, bit6=Last, bit0-3=Generation) ;
... (2)   Backup File Version Number (for backup copies) ;/
... 5     File Leader aka Fudge Factor ("@)#(",00h) ;\
... ..    File Data ; All types
... ..    File Comment (if any) (ASCII, "Text string",0Ah) ;/

```

Last Chunk:

```

000h 4     ID (FDC4A7DCh)
004h (30h) Zerofilled ; -Type 1
004h (1)   Fixed (02h) ;\
005h (31h) Zerofilled ; Tyoe 2
036h (2)   CRC16 on Header (with [036h]=0000h) (always 83FCh) ;/
... (..)  Comments may be stored here (if added after archive creation)
... (..)  Padding, if any (1Ah-filled in some files)

```

Notes:

Method LZW is quite straight, the bitstream is fetched LSB first, codesize is initially 9bit,

max 13bit, with two special codes (100h=Clear, 101h=Stop), there aren't any gaps after clear codes, the unusual part is that the bitstream does start with a clear code.

Method LZH is slower, requires Zoo 2.10, and is used only when specifying "h" option in commandline. LZH has 8Kbyte window, same as LHA's "lh5", with an extra end marker (blocksize=0000h=end).

Comments may be stored anywhere in the middle or at the end of the archive (even after the zerofilled last chunk) (depending on whether the comment or further files where last added to the archive).

Zoo is from 1986-1991, long filenames were supported only for OSes that did support them at that time (ie. not for DOS/Windows).

When adding new files, Zoo defaults to maintain backups of old files in the archive (older files are marked as "deleted" via [01Eh]=1, but are kept in the archive; until the user issues command "P" for repacking/removing deleted files) (Zoo 2.xx can additionally use a "generation" limit of 0..15, which means to keep 0..15 older copies).

All offsets are originated from begin of archive.

Zoo Tiny format (single-file) (commandline "z" option)

This format is called Tiny in Zoo source code, but isn't documented in the Zoo manual or Zoo help screen. Tiny can contain only a single file (alike gzip). The purpose appears to be using Tiny as temporary files when moving files from one archive to another (without needing to decompress & recompress the file), for example:

```
zoo xz source.zoo testfile.txt      ;extract to tiny/temp file testfile.tzt
zoo az dest.zoo   testfile.txt      ;import from tiny/temp file testfile.tzt
```

The tiny/temp file extensions have the middle character changed to "z" (eg. "tzt" instead of "txt").

Going by zoo source code, the format should look as so:

```
000h 2  Zoo Tiny ID (07FEh)
002h 1  Type (01h)
003h 1  Compression Method
004h 4  Date/time in MSDOS format
008h 2  CRC16 on uncompressed file, or what (?)
00Ah 4  Filesize, uncompressed
00Eh 4  Filesize, compressed
012h 1  Major_ver
013h 1  Minor_ver
014h 2  Comment size (0=None)
016h 13 Short Filename
023h .. File data      ... plus comment, if any?
```

But, files from Zoo DOS version are reportedly starting with 07h,01h (instead FEh,07h, 01h).

And, using Zoo DOS version with "z" option in Win98 does merely display "Zoo: FATAL: I/O error or disk full."

Zoo Filter format (for modem streaming) (commandline "f" command)

This command is documented in the Zoo manual, although it isn't actually supported in Zoo DOS version. The intended purpose is to use Zoo as a filter to speedup modem transfers.

Going by some information snippets, the transfer format appears to be somewhat as so:

```
000h 2   Zoo Filter ID (32h,5Ah)
... ..   Compressed data
... 2    CRC16 on uncompressed file, or what (?)
```

The transfer uses stdin/stdout instead of source/dest filenames (although, the OS commandline interface may allow to assign filenames via ">" and "<").

There is no compression method entry (so both sides must know whether they shall use LZW or LZH).

Unknown if there are any transfer size entries, or LZW/LZH end codes, or maybe the streaming is infinite (with CRCs inserted here or there)?

13.108 CDROM File Compression nCompress.Z

nCompress is some kind of a Gzip predecessor. The program was originally called "compress" and later renamed to "ncompress" (and sometimes called "(n)compress"). Compressed files have uppercase ".Z" attached to their original name.

nCompress.Z

The header is rather small and lacks info on decompressed size (ie. the one must process the whole bitstream to determine the size, and accordingly, the fileformat doesn't allow padding to be appended at end of file). To detect .Z files, examine the first three bytes, and best also check that the leading 9bit codes don't exceed num_codes (with num_codes increasing from 101h and up for each new code).

```
000h 2   ID (1Fh,9Dh)
002h 1   Mode (MaxBits(9..16) + bit7=WithClearCode) (usually 90h)
003h ..   ClearGap LZW compressed data (or raw LZW when mode.bit7=0)
```

Compression is relative straight LZW, resembling 8bit GIFs, with 9bit initial codesize, with preset codes 000h..0FFh=Data and (optional) 100h=Clear code (there is no End code). Codes are allocated from 101h and up (100h and up if without Clear code).

The bitstream is fetched LSB first (starting in bit0 of first byte). The decoder is prefetching groups of eight codes (N-bytes with eight N-bit codes), the odd part is that Clear codes are discarding those prefetched bytes (so Clear codes will be followed by Gaps with unused bytes).

ClearGap LZW is also used by ARC Method 8 and 9.

13.109 CDROM File Compression Octal Oddities (TAR, CPIO, RPM)

Below are file formats with unix/linux-style octal numbers (unknown if they are serious about using that formats, or if they do consider them as decently amusing, or whatever).

Compression

TAR and CPIO are uncompressed archives, however, they are usually enclosed in a compressed Gzip file (or some other compression format like nCompress, Bzip2).

TAR format (1979)

```
0000h ..      TAR Chunk(s)
...   400h    TAR End Marker (400h bytes zerofilled)
...   ..      Zerofilled (whatever further padding)
```

TAR Chunk format:

```
000h 100 text  Filename ("path/filename.ext",00h)
064h 8  octal  Mode Flags
06Ch 8  octal  User ID
074h 8  octal  Group ID
07Ch 12 octal  Filesize
088h 12 octal  File modification time (seconds since 01 Jan 1970)
094h 8  octal  Header Checksum (sum of byte[0..1F3h], with [94h..9Bh]=20h)
09Ch 1  text   Type (00h or "0" for normal files)
09Dh 100 text  Whatever link name
101h 8  text   Tar ID (6x00h or "ustar",00h,"00" or "ustar  ",00h)
109h 32 text   User Name (owner)
129h 32 text   Group Name
149h 8  octal  Device major  ;\device number (when Type="4")
151h 8  octal  Device minor  ;/
```

```

159h 155 ?      Whatever prefix      ; -when ID="ustar", 00h, "00" or 6x00h
159h 131 ?      Whatever prefix      ; \
1DCh 12  octal  File access time      ; when ID="ustar  ", 00h
1E8h 12  octal  File status-change time ; /
1F4h 12  -      Zeropadding to 200h-byte boundary
200h ..  -      File data (Filesize bytes)
... ..  -      Zeropadding to 200h-byte boundary

```

TAR numeric values are weirdly stored as octal ASCII strings, often decorated with leading or trailing spaces. For example, 8-byte octal value 123o (53h) can look as so (with "." meaning 00h end-byte):

```

"0000123." <-- normal weirdness, with leading zeroes and end-byte ( "."=00h)
" 123 . " <-- extra weird, leading/trailing spaces, mis-placed end-byte
" 123 " <-- extra weird, leading/trailing spaces, without end-byte

```

See also: https://www.gnu.org/software/tar/manual/html_node/Standard.html

CPIO Format (1977) (and MAC .PAX files)

```

0000h ..      CPIO Chunk(s) (with actual files)
... 57h      CPIO Chunk (with filename "TRAILER!!!", 00h)
... ..      Zeropadding to 200h-byte boundary (not always present)

```

The chunks are simple, but they do exist in five weirdly different variants:

```

Align 2, Binary, little-endian (but partial "big-endian" for 2x16bit pairs)
Align 2, Binary, big-endian
Align 1, Ascii, octal strings
Align 4, Ascii, hexadecimal lowercase strings, checksum=0)
Align 4, Ascii, hexadecimal lowercase strings, checksum=sum of bytes in file)

```

Binary, little-or-big-endian:

```

000h 2  binary 16bit ID (71C7h)      ; -little-or big endian
002h 2  binary 16bit dev              ; \
004h 2  binary 16bit ino              ; same
006h 2  binary 16bit mode             ; endianness
008h 2  binary 16bit uid              ; as in ID
00Ah 2  binary 16bit gid              ;
00Ch 2  binary 16bit nlink            ; (but be aware
00Eh 2  binary 16bit rdev             ; of the fixed
010h 2  binary 16bit File modification time, upper 16bit ; \ ; upper/lower
012h 2  binary 16bit File modification time, lower 16bit ; / ; 16bit order
014h 2  binary 16bit Filename size (including ending 00h) ; for time and
016h 2  binary 16bit Filesize, upper 16bit      ; \ ; filesize)
018h 2  binary 16bit Filesize, lower 16bit      ; / ; /
01Ah .. text  Filename, terminated by 00h ("path/filename", 00h)
... .. binary Zeropadding to 2-byte boundary

```



```
... .. binary File data (Filesize bytes)
... .. binary Zeropadding to 2-byte boundary
```

Ascii/octal CPIO Chunk format:

```
000h 6  octal  18bit ID "070707" (=71C7h)
006h 6  octal  18bit dev      ;\unique file id
00Ch 6  octal  18bit ino      ;/within archive
012h 6  octal  18bit Mode (file attributes)
018h 6  octal  18bit User ID of owner
01Eh 6  octal  18bit Group ID
024h 6  octal  18bit nlink (related to duplicated dev/ino?)
02Ah 6  octal  18bit rdev (system-defined info on char/blk devices)
030h 11 octal  33bit File modification time
03Bh 6  octal  18bit Filename size (including ending 00h)
041h 11 octal  33bit Filesize
04Ch .. text  Filename, terminated by 00h ("path/filename",00h)
... .. binary File data (Filesize bytes)
```

Ascii/hex CPIO Chunk format:

```
000h 6  hex    24bit ID "070701"=Without Checksum, or "070702"=With Checksum
006h 8  hex    32bit  ino (does that 32bit value include 16bit "dev"?)
00Eh 8  hex    32bit  mode
016h 8  hex    32bit  uid
01Eh 8  hex    32bit  gid
026h 8  hex    32bit  nlink
02Eh 8  hex    32bit  mtime
036h 8  hex    32bit  Filesize
03Eh 8  hex    32bit  devmajor
046h 8  hex    32bit  devminor
04Eh 8  hex    32bit  rdevmajor
056h 8  hex    32bit  rdevminor
05Eh 8  hex    32bit  Filename size (including ending 00h)
066h 8  hex    32bit  Checksum, sum of all bytes in file, zero when ID=070701
06Eh .. text  Filename, terminated by 00h ("path/filename",00h)
... .. binary Zeropadding to 4-byte boundary
... .. binary File data (Filesize bytes)
... .. binary Zeropadding to 4-byte boundary
```

CPIO numeric values are weird octal ASCII strings (eg. 6-byte "000123"), but, unlike TAR, without extra oddities like spaces or end-bytes.

<https://www.systutorials.com/docs/linux/man/5-cpio/>

RPM Format (1997) (BIG-ENDIAN)

RPM files contain Linux installation packages. The RPM does basically contain a CPIO archive bundled with additional header/records with installation information.

```

000h 60h File Header      (officially called "Lead" instead of "Header")
060h .. Signature Record (contains "Header Record" in "Signature format")
... .. Padding           (to 8-byte boundary)
... .. Info Record       (called "Header" and also uses "Signature format")
... .. Archive file      (usually a GZIP compressed CPIO) (called "Payload")

```

File Header (aka Lead) (60h bytes):

```

000h 4   File ID (EDh,ABh,EEh,DBh)      (aka octal string "\355\253\356\333")
004h 1   Major version (3)
005h 1   Minor version (0)
006h 2   Type (0=Binary Package, 1=Source Package)
008h 2   Architecture ID (defined in ISO/IEC 23360)
00Ah 66  Package name, terminated by 00h
04Ch 2   Operating System ID (1)
04Eh 2   Signature Type (5)
050h 16  Reserved space (officially undefined, usually zerofilled)

```

Signature/Info Records (10h+N*10h+SIZ bytes):

```

000h 4   Record ID (8Eh,ADh,E8h,01h)   (aka octal string "\216\255\350\001")
004h 4   Reserved (zerofilled)          (aka octal string "\000\000\000\000")
008h 4   Number of Item List entries    (N)
00Ch 4   Size of Item Data              (SIZ)
010h N*10h Item List (4x32bit each: Tag, Type, Offset, Size)
... SIZ  Item Data (referenced via Offset/Size entries in above list)

```

Item Type values:

```

00h=NULL      Not Implemented
01h=CHAR      Unknown, maybe unsigned 8bit      (unaligned)
02h=INT8      Unknown, maybe signed 8bit        (unaligned)
03h=INT16     Unknown, maybe signed 16bit       (align2)
04h=INT32     Unknown, maybe signed 323bit      (align4)
05h=INT64     Reserved, maybe signed 643bit    (maybe align8)
06h=STRING    Variable, NUL terminated string   (unaligned)
07h=BIN       Unknown, reportedly 1-byte size??? (unaligned)
08h=STRING_ARRAY Variable, Sequence of NUL terminated strings (unaligned)
09h=I18NSTRING Variable, Sequence of NUL terminated strings (unaligned)

```

Item Tag values:

There are dozens of required & optional tag values defined.

RPM source code packages are often bundled with a .spec file (inside of the CPIO archive), that .spec file contains source code in text format for creating the RPM header/records.

File Extensions

```

Basic extensions:
.cpio (CPIO)
.pax (CPIO for MAC)
.rpm (RPM installation package for RPM package manager)
.spec (RPM source file for creating RPM header/records)
.tar (TAR, tape archive)
Double extensions (and short forms like tgz):
.tgz short for .tar.gz (gzip)
.tbz short for .tar.bz2 (bzip2)
.txz short for .tar.xz (XZ)
.tlz short for .tar.lz (Lzip) or .tar.lzma (LZMA_Alone)
.tzst short for .tar.zst (zstandard)
.tsz short for .tar.sz (Sunzip)
.taz short for .tar.Z (nCompress or possibly some other compressed format)
.tz short for .tar.Z (nCompress or possibly some other compressed format)
.spm short for .src.rpm (RPM source code package)

```

13.110 CDROM File Compression MacBinary, BinHex, PackIt, StuffIt, Compact Pro

Below are related to MAC filesystems (where the file body consists of separate Data and Resource forks), and file type/creator values (resembling filename extensions).

MacBinary I,II,III format (v1,v2,v3)

MacBinary contains a single uncompressed file, used for transferring MAC files via network, or storing MAC files on non-MAC filesystems.

PackIt/StuffIt archives do often have leading MacBinary headers. MacBinary doesn't have any unique filename extension (.bin may be used, more often it's using the same extension as the enclosed file, eg. .sit if it contains a StuffIt archive).

Also, archives without explicit MAC support may use MacBinary format within compressed files (eg. LZH archives created with LHA MAC version).

```

000h 1  Old version number, must be kept at zero for compatibility
001h 1  Length of filename (1..63) (though v3 says 1..31)
002h 63  Filename (only "length" bytes are significant)
041h 4  File type (normally expressed as four characters)
045h 4  File creator (normally expressed as four characters)
049h 1  Finder flags, bit8-15 (see [065h] for bit0-7)
04Ah 1  Zero (must be 00h for compatibility)
04Bh 2  File Vertical position within its window
04Dh 2  File Horizontal position within its window
04Fh 2  File Window or folder ID

```

```

051h 1   Protected flag (bit0=Protected, whatever that is)
052h 1   Zero (must be 00h for compatibility)
053h 4   Filesize, Data Fork      (0=None)
057h 4   Filesize, Resource Fork (0=None)
05Bh 4   File Timestamp, creation
05Fh 4   File Timestamp, last modification
063h 27  v1:   Reserved (zerofilled)
063h 2   v2/v3: Length of Get Info comment (if any, usually 0000h)
065h 1   v2/v3: Finder Flags, bit0-7 (see [049h] for bit8-15)
066h 6   v2:   Reserved (zerofilled)
066h 4   v3:   ID ("mBIN"=MacBinary III)
06Ah 1   v3:   Script of file name (from fdScript field of an fxInfo record)
06Bh 1   v3:   Extended Finder flags (from fdXFlags field of fxInfo record)
06Ch 8   v2/v3: Reserved (zerofilled)
074h 4   v2/v3: Length of "total files" when "packed files are unpacked", uh?
078h 2   v2/v3: Extended Header size (reserved for future, always 0000h)
07Ah 1   v2/v3: MacBinary II uploader version      (81h=v2, 82h=v3)
07Bh 1   v2/v3: MacBinary II downloader minimum version (81h=v2)
07Ch 2   v2/v3: CRC16-XMODEM on [000h..07Bh]
07Eh 2   Reserved for computer type and OS ID (0000h)
... .. Extended Header (if any, maybe stored here? when [078h]>0)
... .. Padding to 80h-byte boundary
... .. Data Fork (if any)
... .. Padding to 80h-byte boundary
... .. Resource Fork (if any)
... .. Padding to 80h-byte boundary
... .. Get Info comment (if any, usually none)

```

CRC16-XMODEM: http://www.sunshine2k.de/coding/javascript/crc/crc_js.html

BinHex 4.0 (.hqx) (ASCII, RLE90, big-endian)

Decoding binhex files is done via following steps (in that order):

- 1) ASCII to BINARY conversion (similar to BASE64)
- 2) RLE90 decompression of whole file (header+data+resource+crc's)
- 3) Processing the header+data+resource from the decompressed binary
- 4) For Multipart files, repeat above steps for each part

ASCII to BINARY:

The file may start with some text message, comments, description. Skip any such text lines until reaching a line that contains this 45-byte ID string:

(This file must be converted with BinHex 4.0)

That line should be followed by following characters (each char representing 6bit binary value, MSB first, first char is bit7-2 of first byte):

```

! "# $ % & ' ( ) * + , -   char(21h..2Dh) --> bin(00h..0Ch)
0123456                   char(30h..36h) --> bin(0Dh..13h)
89                        char(38h..39h) --> bin(14h..15h)
@ABCDEFGHIJKLMN          char(40h..4Eh) --> bin(16h..24h)
PQRSTUVWXYZ              char(50h..56h) --> bin(25h..2Bh)

```

XYZ[char(58h..5Bh) --> bin(2Ch..2Fh)
`abcdef	char(60h..66h) --> bin(30h..36h)
hijklm	char(68h..6Dh) --> bin(37h..3Ch)
pqr	char(70h..72h) --> bin(3Dh..3Fh)
:	char(3Ah) --> start/end marker
CR/LF	char(0Dh/0Ah) --> linebreaks per 64 chars (CR and/or LF)
SPC/TAB	char(09h/20h) --> blanks (reportedly in some files)

RLE90 Decompression:

RLE90 decompression is same as in ARC files, except, code 90h,00h is handled differently: ARC keeps prevbyte=unchanged, BinHex sets prevbyte=90h.

RLE90 compression is somewhat optional: 90h must be encoded as 90h,00h, but many encoders don't bother to compress repeating bytes (eg. many files contain "!!!!!!!" chars aka uncompressed 00h-filled bytes).

There is no way to know the decompressed size before decompression (either decompress the whole file and allocate more memory as needed, or decompress only the header (filename+16h bytes) and then compute decompressed size as filename+16h+data+2+resource+2 bytes).

Decompressed Binary (big-endian):

The decompressed binary contains following data (similar as MacBinary):

00h	1	Length of Filename (1..63)
01h	..	Filename ("FILENAME.EXT")
01h+N	1	Version (00h)
02h+N	4	File Type
06h+N	4	File Creator
0Ah+N	2	Finder Flags
0Ch+N	4	Filesize, uncompressed, Data Fork
10h+N	4	Filesize, uncompressed, Resource Fork
14h+N	2	Header CRC16-XMODEM on uncompressed 14h+N bytes
16h+N	..	Data Fork
...	2	Data Fork CRC16-XMODEM on uncompressed Data Fork
...	..	Resource Fork
...	2	Resource Fork CRC16-XMODEM on uncompressed Resource Fork
...	..	Padding (might reportedly occur in some files)

Caution: There is a document that does claim that the CRC field should be be set to 0000h before CRC calculation, and that the CRC would be computed on Size+2 bytes (up to including the CRC field), that appears to be nonsense, the CRC is computed on Size+0 bytes, not Size+2.

Multipart files:

Emails or other text documents may contain multiple binhex files, if so, each part should be reportedly followed by a line containing:

```
--- end of part NN ---
```

Unknown if there are any .hqx files with such multipart stuff.

Unknown if the next part starts with "(This file must.." or just with ":".

Note: Many files with .hqx extension are actually raw .sit or .cpt files (maybe because somebody had removed the binhex encoding without altering the filename extension).

PackIt (.pit) (Macintosh) (1986) (big-endian)

MAC File Type,Creator IDs = "PIT ","PIT " \<-- normal (=uncompressed?)

MAC File Type,Creator IDs = "PIT ","UPIT" \<-- other (=compressed?)

```

Bitstream for Uncompressed File Entries:
 32bits   Uncompressed Header[000h..003h] (Method/Crypto="PMag")
 ..bits   Uncompressed Header[004h..061h] (uncompressed size = 5Eh)
 ..bits   Uncompressed Data+Resource+CRC   (uncompressed size = Data+Rsrc+2)
Bitstream for Compressed File Entries:
 32bits   Uncompressed Header[000h..003h] (Method/Crypto="PMA4")
 ..bits   Compressed Huffman Tree           (for decoding following bits)
 ..bits   Compressed Header[004h..061h]     (uncompressed size = 5Eh)
 ..bits   Compressed Data+Resource+CRC      (uncompressed size = Data+Rsrc+2)
 ..bits   Padding to 8bit-boundary          (byte align next File Entry)
Bitstream for Archive End Marker (after last file):
 32bits   Uncompressed Header[000h..003h] (Method/Crypto="PEnd")
File Entry Format:
000h 4    Method/Crypto (usually "PMag"=Uncompressed, "PMA4"=Huffman)
004h 1    Filename length
005h 63   Filename ("FILENAME", garbage padded)
044h 4    File Type
048h 4    File Creator
04Ch 2    Finder flags
04Eh 2    Locked?
050h 4    Filesize, uncompressed, Data fork
054h 4    Filesize, uncompressed, Resource fork
058h 4    Timestamp, creation
05Ch 4    Timestamp, modification
060h 2    CRC16-XMODEM on [004h..05Fh]
... ..   Data Fork
... ..   Resource Fork
... 2    CRC16-XMODEM on uncompressed Data+Resource forks
Method/Crypto:
"PEnd" = Archive End marker (4-byte end marker, without filename etc.)
"PMag" = Uncompressed
"PMa1" = Uncompressed, Encrypted Simple
"PMa2" = Uncompressed, Encrypted DES
"PMa3" = Uncompressed, Encrypted reserved
"PMa4" = Huffman
"PMa5" = Huffman, Encrypted Simple
"PMa6" = Huffman, Encrypted DES
"PMa7" = Huffman, Encrypted reserved
Decompression:      ;for PackIt (and also for StuffIt method 03h)
InitBitstreamMsbFirst(src)      ;-src is after "PMA4" PackIt ID
tree=GetMem(200h*4)             ;-alloc tree (probably less needed)
num_entries=0                   ;\init tree
root=GetTreeEntry               ;/
while dst<dst_end                ;-decompress, till end...

```

```

    index=root                ;\
    while index<FF00h         ; huffman decode
        index=[tree+index*4+GetBits(1)*2] ;/
        [dst]=index AND FFh, dst=dst+1    ;-store data
    return
;---
GetTreeEntry:
    if GetBits(1)=1 then
        return GetBits(8)+FF00h          ;-final data entry
    else
        index=num_entries                ;-current index
        num_entries=num_entries+1        ;-alloc next index
        [tree+index*4+0*2] = GetTreeEntry ;-recursive call for node0
        [tree+index*4+1*2] = GetTreeEntry ;-recursive call for node1
    return index

```

<http://www.network172.com/early-mac-software/packit-source-code/> - official

StuffIt (.sit) (Macintosh) (old format) (1987) (big-endian)

MAC File Type,Creator IDs = "SIT!","SIT!" (version=01h).

MAC File Type,Creator IDs = "SITD","SIT!" (version=02h).

MAC File Type,Creator IDs = "APPL","STi0" (whatever, with ID="ST65")

StuffIt Archive Header:

```

000h 4    ID ("SIT!", short for StuffIt)
          Reportedly, there are several alternate IDs:
          "SIT!","ST46","ST50","ST60","ST65","STin","STi2","STi3","STi4"
          Unknown why, and if some do differ somehow (ST65 appears to be
          same as SIT!) (for STi, the "i" might be short for it? installer?)
004h 2    Number of entries in root directory
006h 4    Total size of archive
00Ah 4    ID ("rLau", short for Raymond Lau)
00Eh 1    Version number (01h=v1.x-v1.5.x, 02h=v1.6-v4.5)
00Fh 7    Reserved (zerofilled)                ;-when version=01h
00Fh 1    Unknown (C6h or FFh)                  ;\
010h 4    Offset to first root entry (16h or elsewhere!) ; when version=02h
014h 2    Unknown (0001h or FFFFh)              ;/

```

File Entries:

```

000h 1    Compression method, Resource fork
001h 1    Compression method, Data fork
002h 1    Filename length (1..63 for version=01h, 1..31 for version=02h)
003h 1Fh  Filename ("FILENAME.EXT", garbage padding)
022h 20h  Filename further chars                ;-when version=01h
022h 2    Filename+size CRC                      ;\
024h 2    Unknown (always 0000h or 0986h?)       ; when version=02h
026h 4    Unknown Resource fork related          ;maybe window ;
02Ah 4    Unknown Data fork related              ;coords ?    ;
02Eh 1    Unknown Data fork related              ;
02Fh 1    Unknown Resource fork related          ;
030h 2    Number of child entries (excluding End marker) ;

```

```

032h 4    Offset to previous entry                ;
036h 4    Offset to next entry                    ;
03Ah 4    Offset to parent entry                  ;
03Eh 4    Offset to first child (or -1 for file entries) ;/
042h 4    File type      (eg. "APPL")
046h 4    File creator   (eg. "ACTA")
04Ah 2    Finder flags   (2100h)
04Ch 4    Creation date
050h 4    Modification date
054h 4    Filesize, uncompressed, Resource fork (0=None)
058h 4    Filesize, uncompressed, Data fork    (0=None)
05Ch 4    Filesize, compressed, Resource fork  (0=None)
060h 4    Filesize, compressed, Data fork      (0=None)
064h 2    CRC16 on uncompressed(?) Resource fork (0=None)
066h 2    CRC16 on uncompressed(?) Data fork   (0=None)
068h 1    Pad bytes for encrypted Resource? (00h)
069h 1    Pad bytes for encrypted Data?      (00h)
06Ah 2    Unknown Data fork related           (0000h, or 0004h=Encrypted?)
06Ch 2    Unknown Resource fork related       (0000h, or 0004h=Encrypted?)
06Eh 2    CRC16 on Header [000h..06Dh] with initial=0000h
070h ..   Compressed Data, Resource fork (if any) (size=[05Ch])
... ..   Compressed Data, Data fork          (if any) (size=[060h])
StuffIt Methods:
00h Uncompressed
01h RLE90      (same as... unknown if this is like BinHex, or like ARC)
02h ClearGap LZW (same as nCompress, 14bit, with Clear(+gap), no Stop code)
03h Huffman    (same as PackIt "PMA4" method)
05h LZHUF      (same as LHA "lh1" method)
06h Fixed Huffman Segmented. PackBits, then optional Huffman coding.
                The set of Huffman codes is predefined, but the meaning
                of a code can be different in each segment
08h MW (Miller-Wegman, presumably LZMW)
0Dh LZ+Huffman  (?)                                ;-StuffIt and StuffIt5
0Eh Installer   (uh?)
0Fh Arsenic     (BWT and arithmetic coding)        ;-StuffIt5 only?
1xh Encrypted methods (same as above, plus encryption)
20h Folder start                                ;\StuffIt (not StuffIt5)
21h Folder end                                   ;/

```

Common methods are 02h,03h,0Dh (rarely also 00h,01h,05h) (and 0Fh for StuffIt5). Folders have BOTH methods set to 20h. Uncompressed Data size is WHAT? (maybe sum of all decompressed files in that folder?) Compressed Data size is size in SIT file including 70h-byte folder end-marker. The Folder END marker has both methods set to 21h. The Folder END marker has NONSENSE data size entries?

When version=01h (eg. blackfor.sit), folder/file entries start at offset 16h, and are ordered as so:

```

Folder start
  Child entries
  Folder end
Folder start

```



```
Child entries
Folder end
```

When version=02h (eg. cabletron.sit), folder/file entries start at offset from archive header [010h] (which can be anywhere at offset 16h, or near end of archive), and are ordered as specified in file header entries [022h..041h].

StuffIt 5 (.sit) (Macintosh, Windows) (1997) (big-endian)

StuffIt Archive Header:

```
000h 82  ID "StuffIt (c)1997",...,"/StuffIt/",0Dh,0Ah,1Ah,00h)
052h 1    Version (always 05h)
053h 1    Flags (can be 00h, 10h, 80h) (bit4=what?, bit7=Encrypted)
054h 4    Total size of archive
058h 4    Offset to first entry in root directory (64h, plus Extra Data)
05Ch 2    Number of entries in root directory
05Eh 4    Same as [058h] (maybe one is 1st entry, and other is Header size)?
062h 2    Header CRC16 on [000h..[05xh]-1] with [062h]=0000h and initial=0
064h ..   Extra Data (see below)
... ..   File/Folder entries
```

Extra data can be:

```
None (when [58h]=64h) ;with Flags=00h
05h,76h,35h,B9h,87h,11h ;maybe 05h=Length? ;with Flags=80h=crypto
0Dh,A5h,A5h,"Reserved",A5h,A5h,00h) ;maybe 0Dh=Length? ;with Flags=10h=what?
```

File/Folder entries:

```
000h ..   Base Header
... ..   OS Header (depending on OS Type in Base Header)
... ..   Resource fork (if any) (MAC only, not Windows)
... ..   Data fork      (if any)
```

Base Header:

```
000h 4    ID (A5A5A5A5h) (or B4B4B4B4h=corrupted charset conversion maybe?)
004h 1    OS Type (1=Mac, 3=Windows)
005h 1    Unknown (0)
006h 2    Base Header size (41h) (30h+IV?+Filename+Comment)
008h 1    Unknown (0) (maybe Flags MSB?)
009h 1    Flags (bit3=Comment, bit6=Folder, bit5=Encrypted)
00Ah 4    Timestamp, Creation (Mac OS format, seconds since 1904)
00Eh 4    Timestamp, Modification (Mac OS format, seconds since 1904)
012h 4    Offset of previous entry (0=None)
016h 4    Offset of next entry (0=None)
01Ah 4    Offset of parent folder entry (0=None)
01Eh 2    Filename size (F)
020h 2    Base Header CRC-16 on [000h..[006h]-1]
022h (4)  Offset of first child entry in folder (FFFFFFFFh=End) ;\Folder
026h (4)  Size of complete directory ; (if Flags
02Ah (4)  Unknown ; bit6=1)
02Eh (2)  Number of child entries (excluding folder End marker) ;/
022h (4)  Data fork uncompressed size ;\
026h (4)  Data fork compressed size ;
02Ah (2)  Data fork CRC-16 (0 for method 0Fh) ; File
02Ch (2)  Data fork Unknown (0000h) ; (if Flags
02Eh (1)  Data fork compression method (00h,0Dh,0Fh) ; bit6=0)
```

```

02Fh (1)  Data fork Encryption IV? size                ;
...  (...) Data fork Encryption IV? data              ;/
...  ..   File/Folder name ("FILENAME.EXT")
...  (2)  Comment size (K)                            ;\Comment
...  (2)  Comment Unknown (0)                        ; (if Flags
...  (...) Comment data                              ;/bit3=1)
OS Header for Mac (OS=1):
000h 2      Flags2 (bit0=HasResource, bit4=same as archive header [053h] ?)
002h 2      CRC16 on OS Header (with [002h]=0000h, initial=0)
004h 4      Mac OS file type                          ;\
008h 4      Mac OS file creator                       ; as so for Files
00Ch 2      Mac OS Finder flags                      ; (seems to contain
00Eh 2      Mac OS Unknown                          ; other stfuff/junk
010h 4      Mac OS Unknown                          ; for Folders)
014h 4      Mac OS Unknown                          ;
018h 4      Mac OS Unknown                          ;
01Ch 4      Mac OS Unknown                          ;
020h 4      Mac OS Unknown                          ;/
024h (4)     Resource fork uncompressed size          ;\
028h (4)     Resource fork compressed size            ; only if
02Ch (2)     Resource fork CRC-16 (0 for method 0Fh)   ; Flags2
02Eh (2)     Resource fork Unknown                  ; bit0=1
030h (1)     Resource fork compression method        ;
031h (1)     Resource fork Encryption IV? size       ;
...  (...)   Resource fork Encryption IV? data       ;/
OS Header for Windows (OS=3):
000h 2      Flags 2 (bit4=same as archive header [053h] ?)
002h 2      CRC16 on OS Header (with [002h]=0000h, initial=0)
004h 4      Windows File Attribute (20h=Normal, 10h=Folder)
008h 08h    Windows Zerofilled
010h 4      Windows Timestamp last accessed?
014h 4      Windows Unknown (0005xxxxh)
018h 08h    Windows Zerofilled

```

StuffIt 5 seems to only use 00h, 0Dh and 0Fh. See "StuffItSpecs" for descriptions of the algorithms.

StuffIt X (.sitx) (Macintosh, Windows) (20xx?)

```

StuffIt Archive Header:
000h 8      ID "StuffIt!" (reportedly "StuffIt?" also exists)
008h ..     Unknown...

```

The StuffIt X headers are somehow compressed/compacted (there are very few 00h bytes even when filesize entries should have zeroes in MSBs).

<https://github.com/incbee/Unarchiver/blob/master/XADMaster/XADStuffItXParser.m>

Compact Pro aka Compactor (.cpt) (Macintosh) (1990s) (big-endian)

MAC File Type, Creator IDs = "PACT", "CPCT".

Compact Pro (originally called Compactor) was a MAC archiver competing with StuffIt. There's also a DOS tool (ExtractorPC) for extracting .cpt files on PCs (albeit released in .EXE.sit.hqx format, making it unlikely that PC users could have used it).

```

Archive header:
000h  1  File ID                (always 01h)
001h  1  Volume number          (01h for single-volume, Other=Unknown)
002h  2  Random Volume ID?      (...must be same in all split volume files?)
004h  4  Offset to Footer        (from begin of file)
008h  .. Compressed files        (resource+data fork pairs)
...    .. Footer                (directory information)
Footer format:
000h  4  CRC32 XOR FFFFFFFFh on following bytes
004h  2  Number of entries in root folder (including all child entries)
006h  1  Comment length (usually 00h=None)
007h  N  Comment
007h+N .. File/Folder entries
Folder entries, with [000h].bit=1:
000h  1  Foldername length (N), plus bit7=Type (1=Folder)
001h  N  Foldername ("FOLDERNAME")
001h+N 2  Number of entries in this folder (including all child entries)
File entries, with [000h].bit=0:
000h  1  Filename length (N), plus bit7=Type (0=File)
001h  N  Filename ("FILENAME.EXT")
001h+N 1  Volume number (01h for single-volume, Other=Unknown)
002h+N 4  Offset to compressed Resource (followed by compressed Data)
006h+N 4  File type
00Ah+N 4  File creator
00Eh+N 4  Timestamp, creation      (seconds since 1904)
012h+N 4  Timestamp, modification (seconds since 1904)
016h+N 2  Finder flags
018h+N 4  CRC32 XOR FFFFFFFFh on uncompressed Resource + Data forks
01Ch+N 2  Method/Flags (see below)
01Eh+N 4  Filesize, uncompressed, Resource fork
022h+N 4  Filesize, uncompressed, Data fork
026h+N 4  Filesize, compressed, Resource fork
02Ah+N 4  Filesize, compressed, Data fork
Method/Flags:
0      Encryption                (0=None, 1=Encrypted, unknown how)
1      Method for Resource fork  (0=RLE8182, 1=RLE8182+LZSSHUF)
2      Method for Data fork      (0=RLE8182, 1=RLE8182+LZSSHUF)
3-15   Unknown/unused           (0)
Note: RLE8182 and RLE8182+LZSSHUF are also used by Mac DiskDoubler.

```

RLE8182 Compression:

```

This is same as RLE90, with two-byte escape code (81h,82h instead of 90h):
81h,82h,00h      Output 81h,82h

```

```

81h,82h,01h..03h  Output prevbyte 00h..02h times (this is not useful)
81h,82h,04h      Output prevbyte 03h times (useful if prev=81h, next=82h)
81h,82h,05h..FFh Output prevbyte 04h..FEh times (this does save memory)
81h,xxh          Output 81h, and then process xxh
81h,padding      Output 81h, at end of file (with padding<>82h)
xxh              Output xxh (unless it is 81h)

```

Note: prevbyte is the previous output byte (ie. that stored at [dst-1]).

If the uncompressed file ends with 81h, then the compressed file MUST contain a dummy padding byte (the RLE decoder in macutils sets a prefix flag upon 81h, but doesn't output it to dst until receiving the padding byte, which could be 81h, or any value other than 82h).

LZSSHUF Compression:

This uses LZSS-style flag bits (to distinguish between data and len/disp), combined with three Huffman trees (for data, len, disp values). The sliding window is 2000h bytes (8Kbytes). The format appears to be a simplified variant or LHA compression (but gets complicated by inventing weird corner cases).

DecompressLzsshuf:

```

if uncompressed_size=0 then goto @@all_done  ; -empty (eg. for unused forks)
[dst+0000h..1FFCh]=uninitialized             ; \
[dst+1FFDh..1FFFh]=00h,00h,00h             ; prefill sliding window
dst+dst+2000h                               ; /
@@block_lop:
InitBitstreamMsbFirst(src)
GetLzsshufTree(data_tree,100h) ; tree for data=00h..FFh
GetLzsshufTree(len_tree,40h)   ; tree for len=00h..3Fh (0,1 usually unused)
GetLzsshufTree(disp_tree,80h)  ; tree for dispUpper7bit=00h..7Fh
block_org=src, blocksize=0     ; block origin (after above trees)
@@decompress_lop:
if src>=src_end then goto @@all_done ; <-- this may overshoot on padding bits
if out>=out_end then goto @@all_done ; <-- more precise; if RleOnTheFly
if blocksize>=1FFF0h AND type=CompactPro then goto @@block_done
if blocksize>=0FFF0h AND type=Disc Double then goto @@block_done
if GetBits(1)=1 then
    [dst]=GetHuffCode(data_tree), dst=dst+1, blocksize=blocksize+2
else
    len=GetHuffCode(len_tree)+0, blocksize=blocksize+3
    disp=GetHuffCode(disp_tree)*40h+GetBits(6), if disp=0000h then disp=2000h
    for i=1 to len, [dst]=[dst-disp], dst=dst+1, next i
if RleOnTheFly then forward above byte(s) to RLE (which advances "out" ptr)
goto @@decompress_lop
@@block_done:
; the decoder does prefetch data in 16bit units, and it does always have
; 16..31 bits prefetched, these bits are discarded at block end...
src=src+2+((src-block_org) AND 1) ; discard 16..31 bits (till 16bit-boundary)
goto @@block_lop                  ; start next block, with new trees
@@all_done:
ret

```

GetLzsshufTree(tree,max):

```

num=GetBits(8)*2, if num>max then goto error ;number of symbols (00h and up)
for i=0 to num-1, codesizes[i]=GetBits(4)      ;sizes (1..15 bits, or 0=unused)
lzh_explode_tree(tree,codesizes,num)          ;alike LHA trees
ret

```

Minor Corner cases:

```

Disp=0 acts as Disp=2000h (don't care when using ringbuf[index AND 1FFFh])
Len=0..1 could be defined in the len_tree (but are usually size=0bit=unused)
Unknown if disp_tree & len_tree can be empty (when using data_tree only)?
RLE ending with 81h,padding should only output 81h (see RLE8182 description)

```

Incomplete Trees

A few .cpt files (eg. ABC's-1.09.cpt.hqx\..\Colin's ABC's\Message.h) have incomplete trees (like only one disp code, "0"=DispUpper7bit=00h, without defining any further huffman codes like "1" or "1xxx"). This isn't much of a problem (except, one may need to remove incomplete tree error checking in the "lzh_explode_tree" function).

End of Last Block

End of Last Block is usually determined by forwarding the LZSSHUF output directly to the RLE8182 decompressor (which does then check if uncompressed size is reached) (marked "RleOnTheFly" in above sample code). Alternately, one could decompress in separate steps (LZSSHUF to tempbuf, and then tempbuf to RLE8182), but that requires to deal with padding bits.

- padding seems to be 16..31 bits (?) alike at end of blocksize
- padding bits are (always?) zeroes, which act as flag=0=compressed
- compressed data occupies at least flg(1),len(1),disp(1),displsbs(6)=9bits

That can lead to decoding a few extra codes (with lengths up to 3Fh each), so the tempbuf must have trailing space for writing that garbage padding. And, those padding bits tend to translate to disp=0000h (aka disp=2000h), which can cause reads from the whole sliding window, so tempbuf requires 2000h leading bytes to avoid page faults (not just the 3 initialized bytes).

See also:

<https://github.com/dgilman/macutils/blob/master/macunpack/cpt.c> - source code

<https://github.com/MacPaw/XADMaster/wiki/CompactProSpecs> - confused anti-specs

Self-Extracting Archives (SEA)

The abbreviation SEA (and extension .sea) is used for several self-extracting MAC archives. The Resource fork contains an executable (as indicated by Type="APPL") which

contains the decompressor, and the Data fork contains the archive.

```
MAC File Type,Creator IDs = "APPL","aust" (StuffIt).
MAC File Type,Creator IDs = "APPL","EXTR" (CompactPro).
MAC File Type,Creator IDs = "APPL","DSEA" (DiskDoubler).
```

There are some oddities for .sea files found in internet:

```
StuffIt .sea files: These are often raw StuffIt archives (apparently
    somebody had removed the MacBinary header and the resource fork with
    the decompressor).
CompactPro .sea files: These are often stored as MacBinary without 80h-byte
    padding appended to the Data and Resource forks.
    That applies to "Santa.sea" but other such files have OTHER corruptions,
    which may include wrong Size and/or garbage in reserved MacBinary fields?
```

Note: Not to be confused with ARC archives from System Enhancement Associates (SEA).

Mac OS Data forks

The Data fork contains the "normal data" part of the file (eg. anything like .TXT .DOC .GIF .JPG .WAV .ZIP .LZH .SIT .PIT .CPT etc).

Mac OS Resource forks

The Resource fork can contain executable code resources (similar to .EXE files; with File Type="APPL"), and various other resources (fonts, icons, text strings for dialog boxes, etc). Those resources are stored in a filesystem-style archive and can be accessed with IDs and/or name strings.

```
Resource fork Header:
000h 4    Offset to Resource Data section (from start of file) (100h)
004h 4    Offset to Resource Map section (from start of file) (100h+DataSiz)
008h 4    Size of Resource Data section (can be 0=None)
00Ch 4    Size of Resource Map section
010h F0h  Unknown (can contain filename/type.. MAYBE just garbage padding?)
100h ..   Resource Data section, contains Data Record(s)
... ..   Resource Map section
Data Record(s) in Resource Data section (usually at offset 100h and up):
000h 4    Size of Data for this record
004h ..   Data for this record
Resource Map section:
000h 4    Offset to Resource Data section (from start of file) ;\
004h 4    Offset to Resource Map section (from start of file) ; same as in
008h 4    Size of Resource Data section ; header
00Ch 4    Size of Resource Map section ;/
010h 4    Zero (internally used by Resource Manager, nextResourceMap)
```

```

014h 2    Zero (internally used by Resource Manager, fileRef)
016h 2    Map Attributes
          0-4  Zero (reserved)
          5    Zero (internally used by Resource Manager, changed)
          6    Zero (internally used by Resource Manager, need compression)
          7    Resource map is read-only
          8-15 Zero (reserved)
018h 2    Offset to Type List (from start of resource map) (usually 1Ch ?)
01Ah 2    Offset to Name List (from start of resource map)
... ..   Type List
... ..   Resource List (with one or more entry for each entry in Type List)
... ..   Name List (each name consists of 8bit NameLength, plus name string)
Type List follows the header and contains an array of resource type records.
000h 2    Number of Type Records, minus one (FFFFh=None, 0000h=One, etc.)
002h N*8  Type Records
Type Record format:
000h 4    Resource Type (four-character constant)
004h 2    Number of Resource List entries, minus one (0000h=One, etc.)
006h 2    Offset to first Resource List entry (from start of Type List)
Resource List entries:
000h 2    Resource ID (C000h..FFFFh=Special/Owned)
002h 2    Offset to Resource Name (from start of Name List) (FFFFh=None)
004h 1    Attributes
          0    Resource data is compressed                (0=No, 1=Compressed)
          1    Zero (internally used by Resource Manager, changed)
          2    Load Resource as soon as file is opened (0=No, 1=Preload)
          3    Resource is read-only                      (0=No, 1=Protected)
          4    Resource may not be moved in memory        (0=No, 1=Locked)
          5    Resource may be paged out of memory        (0=No, 1=Purgeable)
          6    Load Resource to                          (0=Application heap, 1=System Heap)
          7    Zero (reserved)
005h 3    Offset to Resource Data (from start of Resource Data section)
008h 4    Zero (internally used by Resource Manager, resourcePtr)
Note: Some (or all?) 16bit offsets are reportedly signed (max 32Kbyte), the
24bit offsets are reportedly unsigned (max 16Mbyte).

```

Compressed Resources (when Attributes.bit0=1)

Compressed resource have a standardized header, the decompression function(s) are supposed to be stored in separate "dmcp" resource (unknown if the OS is also providing standard decompression functions).

```

000h 4    ID (always A89F6572h for compressed resource)
004h 2    Always 0012h (maybe compression header size)
006h 1    Type (08h=Type8, 09h=Type9)
007h 1    Always 01h
008h 4    Uncompressed resource size
00Ch 1    For Type8: workingBufferFractionalSize          ;\
00Dh 1    For Type8: expansionBufferSize                  ; Type8
00Eh 2    For Type8: dcmpID (ID in "dmcp" decompress resource) ;
010h 2    For Type8: Zero (reserved?)                     ;/
00Ch 2    For Type9: dcmpID (ID in "dmcp" decompress resource) ;\Type9
00Eh 4    For Type9: decompressor_specific_parameters_with_io ;/
012h ..   Compressed Resource Data

```

http://formats.kaitai.io/compressed_resource/

Owned Resources (with Resource ID=C000h..FFFFh):

<https://github.com/kreativekorp/ksfl/wiki/Macintosh-Resource-File-Format>

The upper 5bit (mask F800h) indicate the resource type of the owner, the middle 6bit (mask 07E0h) indicate the resource id of the owner, and the lower 5bit (mask 001Fh) indicate the "sub-id" of the owned resource.

ID MSBs	Owner Type	Notes
C000h	DRVR	driver or desk accessory
C800h	WDEF	window definition: code to draw windows
D000h	MDEF	menu definition: code to draw menus
D800h	CDEF	control definition: code to draw UI widgets
E000h	PDEF	printer driver
E800h	PACK	utility code package/library used by the Mac OS
F000h	cdev	control panel; owner id is set to 1
F800h	reserved	reserved for future use

The Mac OS Resource Manager used this scheme to ensure that certain types of programs, themselves stored in resources, could find the other resources they needed even if the resources had to be renumbered to avoid conflicts. Utilities such as Font/DA Mover that were used to install and remove these programs used this scheme to ensure that all associated resources were installed or removed as well, and renumber the resources if necessary to avoid conflicts.

13.111 CDROM File XYZ and Dummy/Null Files

Dummy/Null Files

Most PSX discs have huge zerofilled dummy files with about 32Mbytes, using filenames like DUMMY, NUL, NULL, or ZNULL, this is probably done to tweak the disc to have valid sector numbers at the end of disc (to help the drive head to know which sector it is on). Of course, Sony could as well pad the discs with longer Lead-Out areas, but the dummy files may have been needed during development with CDRs (though burning such large files doesn't exactly speed up development).

There are different ways to make sure that the file is at end of the disc:

- Some CDROM burning tools may allow to specify which file is where
- Some games have the file alphabetically sorted as last file in last folder

- Some games have the file declared as audio track
- Some games (additionally) have large zeropadding at end of their archive file

XYZ Files

To reduce seek times, it can make sense to have the boot files & small files at the begin of the disc.

Some games seem to use alphabetically sorted file/folder names to tweak Movies and XA-audio to be located at the end of disc (eg. using ZMOVIE as folder name).

13.112 CDROM Disk Images CCD/IMG/SUB (CloneCD)

File.IMG - 2352 (930h) bytes per sector

Contains the sector data, recorded at 930h bytes per sector. Unknown if other sizes are also used/supported (like 800h bytes/sector, or even images with mixed sizes of 800h and 930h for different tracks).

File.SUB - 96 (60h) bytes per sector (subchannel P..W with 96 bits each)

Contains subchannel data, recorded at 60h bytes per sector.

```
00h..0Bh 12 Subchannel P (Pause-bits, usually all set, or all cleared)
0Ch..17h 12 Subchannel Q (ADR/Control, custom info, CRC-16-CCITT)
18h..5Fh .. Subchannel R..W (usually zero) (can be used for CD-TEXT)
```

Optionally, the .SUB file can be omitted (it's needed only for discs with non-standard subchannel data, such like copy-protected games). And, some CloneCD disc images are bundled with an empty 0-byte .SUB file (which is about same as completely omitting the .SUB file).

File.CCD - Lead-in info in text format

Contains Lead-in info in ASCII text format. Lines should be terminated by 0Dh,0Ah. The overall CCD filestructure is:

```
[CloneCD]      ;File ID and version
[Disc]         ;Overall Disc info
[CDText]       ;CD-TEXT (included only if present)
[Session N]    ;Session(s) (numbered 1 and up)
```

```
[Entry N]      ;Lead-in entries (numbered 0..."TocEntries-1")
[TRACK N]      ;Track info (numbered 1 and up)
```

Read on below for details on the separate sections.

[CloneCD]

```
Version=3      ;-version (usually 3) (rarely 2)
```

[Disc]

```
TocEntries=4      ;-number of [Entry N] fields (lead-in info blocks)
Sessions=1        ;-number of sessions (usually 1)
DataTracksScrambled=0 ;-unknown purpose (usually 0)
CDTextLength=0    ;-total size of 18-byte CD-TEXT chunks (usually 0)
CATALOG=NNNNNNNNNNNNN ;-13-digit EAN-13 barcode (included only if present)
```

[CDText]

```
Entries=N        ;number of following entries (CDTextLength/18) (not /16)
Entry 0=80 00 NN NN NN NN NN NN NN NN NN NN NN NN NN NN NN ;entry 0
Entry 1=80 NN NN NN NN NN NN NN NN NN NN NN NN NN NN NN NN ;entry 1
...
Entry XX=8f NN NN NN NN NN NN NN NN NN NN NN NN NN NN NN NN ;entry N-1
Note: Each entry contains 16 bytes (ie. "18-byte CD-TEXT" with CRC excluded)
"NN NN NN.." consists of 2-digit lowercase HEX numbers (without leading "0x")
```

[Session 1]

```
PreGapMode=2      ;-unknown purpose (usually 1 or 2) (or 0)
PreGapSubC=1      ;-unknown purpose (usually 0 or 1)
```

Above are unknown, PreGapMode might be 0=Audio, 1=Mode1, 2=Mode2 for pregap, though unknown for which pregap(s) of which track(s), presumably for first track?

[Entry 0]

[Entry 0..2] are usually containing Point A0h..A2h info. [Entry 3..N] are usually TOC info for Track 1 and up.

```
Session=1        ;-session number that this entry belongs to (usually 1)
Point=0xa0        ;-point (0..63h=Track, non-BCD!) (A0h..XXh=specials) Q2
ADR=0x01          ;-lower 4bit of ADR/Control (usually 1) Q0.1o
Control=0x04      ;-upper 4bit of ADR/Control (eg. 0=audio, 4=data) Q0.hi
```

```

TrackNo=0          ;-usually/always 0 (as [Entry N]'s are in Lead-in)   Q1
Amin=0             ;\current MSF address                               Q3
ASec=0             ; (dummy zero values) (actual content)              Q4
AFrame=0           ; would be current lead-in position)                Q5
ALBA=-150          ;/ALBA=((Amin*60+ASec)*75+AFrame)-PreGapSize
Zero=0             ;-probably reserved byte from Q channel             Q6
PMin=1             ;\referenced MSF address (non-BCD!), for certain     Q7
PSec=32            ; Point's, PMin may contain a Track number, and PSec Q8
PFrame=0           ; the disc type value (that without non-BCD-glitch) Q9
PLBA=6750          ;/PLBA=((PMin*60+PSec)*75+PFrame)-PreGapSize

```

[TRACK 1] ;-track number (non-BCD) (1..99)

```

MODE=2             ;-mode (0=Audio, 1=Model, 2=Mode2)
ISRC=XXXXXXXXXXXX  ;-12-letter/digit ISRC code (included only if present)
INDEX 0=N          ;-1st sector with index 0, missing EVEN if any?
INDEX 1=N          ;-1st sector with index 1, usually same as track's PLBA
INDEX 2=N          ;-1st sector with index 2, if any
etc.

```

Missing Sectors & Sector Size

The .CCD file doesn't define the "PreGapSize" (the number of missing sectors at begin of first track). It seems to be simply constant "PreGapSize=150". Unless one is supposed to calculate it as "PreGapSize=((PMin*60+PSec)*75+PFrame)-PLBA".

The SectorSize seems to be also constant, "SectorSize=930h".

Non-BCD Caution

All Min/Sec/Frame/Track/Index values are expressed in non-BCD, ie. they must be converted to BCD to get the correct values (as how they are stored on real CDs).

Exceptions are cases where those bytes have other meanings: For example, "PSec=32" does normally mean BcdSecond=32h, but for Point A0h it would mean DiscType=20h=CD-ROM-XA).

The Point value is also special, it is expressed in hex (0xNN), but nonetheless it is non-BCD, ie. Point 1..99 are specified as 0x01..0x63, whilst, Point A0h..FFh are specified as such (ie. as 0xA0..0xFF).

Versions

Version=1 doesn't seem to exist (or it is very rare). Version=2 is quite rare, and it seems to lack the [TRACK N] entries (meaning that there is no MODE and INDEX information, except that the INDEX 1 location can be assumed to be same as PLBA).

Version=3 is most common, this version includes [TRACK N] entries, but often only with INDEX=1 (and up, if more indices), but without INDEX 0 (on Track 1 it's probably missing due to pregap, on further Tracks it's missing without reason) (so, only ways to reproduce INDEX=0 would be to guess it being located 2 seconds before INDEX=1, or, to use the information from the separate .SUB file, if that file is present; note: presence of index 0 is absolutely required for some games like PSX Tomb Raider 2).

Entry & Points & Sessions

The [Entry N] fields are usually containing Point A0h,A1h,A2h, followed by Point 1..N (for N tracks). For multiple sessions: The session is terminated by Point B0h,C0h. The next session does then contain Point A0h,A1h,A2h, and Point N+1..X (for further tracks). The INDEX values in the [TRACK N] entries are originated at the begin of the corresponding session, whilst PLBA values in [Entry N] entries are always originated at the begin of the disk.

13.113 CDROM Disk Images CDI (DiscJuggler)

Overall Format

```

Sector Data (sector 00:00:00 and up)           ; -body
Number of Sessions (1 byte)      <--- located at "Filesize-Footersize"
Session Block for 1st session (15 bytes)       ; \
nnn-byte info for 1st track                ; 1st session
nnn-byte info for 2nd track (if any)          ;
etc.                                         ; /
Session Block for 2nd session (15 bytes)       ; \
nnn-byte info for 1st track                ; 2nd session (if any)
nnn-byte info for 2nd track (if any)          ;
etc.                                         ; /
etc.                                         ; -further sessions (if any)
Session Block for no-more-sessions (15 bytes) ; -end marker
nnn-byte Disc Info Block                ; -general disc info
Entrypoint (4 bytes)                   <--- located at "Filesize-4"
```

Sector Data

Contains Sector Data for sector 00:00:00 and up (ie. all sectors are stored in the file, there are no missing "pregap" sectors).

Sector Size can be 800h..990h bytes/sector (sector size may vary per track).

Number of Sessions (1 byte)

00h	1	Number of Sessions (usually 1)
-----	---	--------------------------------

Session Block (15-bytes)

00h	1	Unknown (00h)
01h	1	Number of Tracks in session (01h..63h) (or 00h=No More Sessions)
02h	7	Unknown (00h-filled)
09h	1	Unknown (01h)
0Ah	3	Unknown (00h-filled)
0Dh	2	Unknown (FFh,FFh)

Track/Disc Header (30h+F bytes) (used in Track Blocks and Disc Info Block)

00h	12	Unknown (FFh,FFh,00h,00h,01h,00h,00h,00h,FFh,FFh,FFh,FFh)
0Ch	3	Unknown (DAh,0Ah,D5h or 64h,05h,2Ah) (random/id/chksum?)
0Fh	1	Total Number of Tracks on Disc (00h..63h) (non-BCD)
10h	1	Length of below Path/Filename (F)
11h	(F)	Full Path/Filename (eg. "C:\folder\file.cdi")
11h+F	11	Unknown (00h-filled)
1Ch+F	1	Unknown (02h)
1Dh+F	10	Unknown (00h-filled)
27h+F	1	Unknown (80h)
28h+F	4	Unknown (00057E40h) (=360000 decimal) (disc capacity 80 minutes?)
2Ch+F	2	Unknown (00h,00h)
2Eh+F	2	Medium Type (0098h=CD-ROM, 0038h=DVD-ROM)

Track Block (E4h+F+I+T bytes)

00h	30h+F	Track/Disc Header (see above)
30h+F	02h	Number of Indices (usually 0002h) (I=Num*4)
32h+F	(I)	32bit Lengths (per index) (eg. 00000096h,00007044h)
32h+FI	04h	Number of CD-Text blocks (usually 0) (T=Num*18+VariableLen's)
36h+FI	(T)	CD-Text (if any) (see "mirage_parser_cdi_parse_cdtext")
36h+FIT	02h	Unknown (00h,00h)
38h+FIT	01h	Track Mode (0=Audio, 1=Model, 2=Mode2/Mixed)
39h+FIT	07h	Unknown (00h,00h,00h,00h,00h,00h,00h)
40h+FIT	04h	Session Number (starting at 0) (usually 00h)
44h+FIT	04h	Track Number (non-BCD, starting at 0) (00h..62h)
48h+FIT	04h	Track Start Address (eg. 00000000h)
4Ch+FIT	04h	Track Length (eg. 000070DAh)
50h+FIT	0Ch	Unknown (00h-filled)
5Ch+FIT	04h	Unknown (00000000h or 00000001h)
60h+FIT	04h	read_mode (0..4)
		0: Model, 800h, 2048
		1: Mode2, 920h, 2336
		2: Audio, 930h, 2352

```

        3: Raw+PQ,          940h, 2352+16 non-interleaved (P=only 1bit)
        4: Raw+PQRSTUVW, 990h, 2352+96 interleaved
64h+FIT 4   Control (Upper 4bit of ADR/Control, eg. 00000004h=Data)
68h+FIT 1   Unknown (00h)
69h+FIT 4   Track Length          (eg. 000070DAh) (same as above)
6Dh+FIT 4   Unknown (00h,00h,00h,00h)
71h+FIT 12  ISRC Code 12-letter/digit (ASCII?) string (00h-filled if none)
7Dh+FIT 4   ISRC Valid Flag (0=None, Other?=Yes?)
81h+FIT 1   Unknown (00h)
82h+FIT 8   Unknown (FFh,FFh,FFh,FFh,FFh,FFh,FFh,FFh)
8Ah+FIT 4   Unknown (00000001h)
8Eh+FIT 4   Unknown (00000080h)
92h+FIT 4   Unknown (00000002h)      (guess: maybe audio num channels??)
96h+FIT 4   Unknown (00000010h)      (guess: maybe audio bits/sample??)
9Ah+FIT 4   Unknown (0000AC44h) (44100 decimal, ie. audio sample rate?)
9Eh+FIT 2Ah Unknown (00h-filled)
C8h+FIT 4   Unknown (FFh,FFh,FFh,FFh)
CCh+FIT 12  Unknown (00h-filled)
D8h+FIT 1   session_type ONLY if last track of a session (else 0)
              (0=Audio/CD-DA, 1=Mode1/CD-ROM, 2=Mode2/CD-XA)
D9h+FIT 5   Unknown (00h-filled)
DEh+FIT 1   Not Last Track of Session Flag (0=Last Track, 1=Not Last)
DFh+FIT 1   Unknown (00h)
E0h+FIT 4   address for last track of a session? (otherwise 00,00,FF,FF)

```

Disc Info Block (5Fh+F+V+T bytes)

```

00h      30h+F Track/Disc Header (see above)
30h+F    4      Disc Size (total number of sectors)
34h+F    1      Volume ID Length (V) ;\from Primary Volume Descriptor[28h..47h]
35h+F    (V)    Volume ID String      ;/(ISO Data discs) (unknown for Audio)
35h+FV   1      Unknown (00h)
36h+FV   4      Unknown (01h,00h,00h,00h)
3Ah+FV   4      Unknown (01h,00h,00h,00h)
3Eh+FV   13     EAN-13 Code 13-digit (ASCII?) string (00h-filled if none)
4Bh+FV   4      EAN-13 Valid Flag (0=None, Other?=Yes?)
4Fh+FV   4      CD-Text Length in bytes (T=Num*1)
53h+FV   (T)    CD-Text (for Lead-in) (probably 18-byte units?)
53h+FVT   8      Unknown (00h-filled)
5Bh+FVT   4      Unknown (06h,00h,00h,80h)

```

Entrypoint (4 bytes) (located at "Filesize-4")

```

00h      4      Footer Size in bytes

```

13.114 CDROM Disk Images CUE/BIN/CDT (Cdrwin)

.CUE/.BIN (CDRWIN)

CDRWIN stores disk images in two separate files. The .BIN file contains the raw disk image, starting at sector 00:02:00, with 930h bytes per sector, but without any TOC or subchannel information. The .CUE file contains additional information about the separate track(s) on the disk, in ASCII format, for example:

```
FILE "PATH\FILENAME.BIN" BINARY
  TRACK 01 MODE2/2352
    INDEX 01 00:00:00          ;real address = 00:02:00  (+2 seconds)
  TRACK 02 AUDIO
    PREGAP 00:02:00           ;two missing seconds      (NOT stored in .BIN)
    INDEX 01 08:09:29          ;real address = 08:13:29  (+2 seconds +pregap)
  TRACK 03 AUDIO
    INDEX 00 14:00:29          ;real address = 14:04:29  (+2 seconds +pregap)
    INDEX 01 14:02:29          ;real address = 14:06:29  (+2 seconds +pregap)
  TRACK 04 AUDIO
    INDEX 00 18:30:20          ;real address = 18:34:20  (+2 seconds +pregap)
    INDEX 01 18:32:20          ;real address = 18:36:20  (+2 seconds +pregap)
```

The .BIN file does not contain ALL sectors, as said above, the first 2 seconds are not stored in the .BIN file. Moreover, there may be missing sectors somewhere in the middle of the file (indicated as PREGAP in the .CUE file; PREGAPS are usually found between Data and Audio Tracks).

The MM:SS:FF values in the .CUE file are logical addresses in the .BIN file, rather than physical addresses on real CDROMs. To convert the .CUE values back to real addresses, add 2 seconds to all MM:SS:FF addresses (to compensate the missing first 2 seconds), and, if the .CUE contains a PREGAP, then the pregap value must be additionally added to all following MM:SS:FF addresses.

The end address of the last track is not stored in the .CUE, instead, it can be only calculated by converting the .BIN filesize to MM:SS:FF format and adding 2 seconds (plus any PREGAP values) to it.

FILE <filename> BINARY|MOTOTOLA..or..MOTOROLA?|AIFF|WAVE|MP3

(must appear before any other commands, except CATALOG)
(uh, may also appear before further tracks)

FLAGS DCP 4CH PRE SCMS**INDEX NN MM:SS:FF****TRACK NN datatype**

AUDIO	;930h	;bytes 000h..92Fh
CDG	;?	;?
MODE1/2048	;800h	;bytes 010h..80Fh
MODE1/2352	;930h	;bytes 000h..92Fh
MODE2/2336	;920h	;bytes 010h..92Fh
MODE2/2352	;930h	;bytes 000h..92Fh
CDI/2336	;920h	;?
CDI/2352	;930h	;bytes 000h..92Fh

PREGAP MM:SS:FF**POSTGAP MM:SS:FF**

Duration of silence at the begin (PREGAP) or end (POSTGAP) of a track. Even if it isn't specified, the first track will always have a 2-second pregap.

The gaps are NOT stored in the BIN file.

REM comment

Allows to insert comments/remarks (which are usually ignored). Some third-party tools are mis-using REM to define additional information.

CATALOG 1234567890123**ISRC ABCDE1234567**

(ISRC must be after TRACK, and before INDEX)

PERFORMER "The Band"**SONGWRITER "The Writer"****TITLE "The Title"**

These entries allow to define basic CD-Text info directly in the .CUE file.

Some third-party utilites allow to define additional CD-Text info via REM lines, eg. "REM

GENRE Rock".

Alternately, more complex CD-Text data can be stored in a separate .CDT file.

CDTEXTFILE "C:\LONG FILENAME.CDT"

Specifies an optional file which may contain CD-TEXT. The .CDT file consists of raw 18-byte CD-TEXT fragments (which may include any type of information, including exotic one's like a "Message" from the producer). For whatever reason, there's a 00h-byte appended at the end of the file. Alternately to the .CDT file, the less exotic types of CD-TEXT can be defined by PERFORMER, TITLE, and SONGWRITER commands in the .CUE file.

Missing

Unknown if newer CUE/BIN versions do also support subchannel data.

Malformed .CUE files

Some .CCD files are bundled with uncommon/corrupted .CUE files, with entries as so:

```
TRACK 1 MODE2/2352 ;three spaces indent, and 1-digit track
INDEX 1 00:00:00 ;three spaces indent, and 1-digit index
```

Normally, that should look as so:

```
TRACK 01 MODE2/2352 ;two spaces indent, and 2-digit track
INDEX 01 00:00:00 ;four spaces indent, and 2-digit index
```

The purpose of the malformed .CUE might be unsuccessful compatibility, or tricking people into thinking that .CCD works better than .CUE.

13.115 CDROM Disk Images MDS/MDF (Alcohol 120%)

File.MDF - Contains sector data (optionally with sub-channel data)

Contains the sector data, recorded at 800h..930h bytes per sector, optionally followed by 60h bytes subchannel data (appended at the end of each sector). The stuff seems to be start on 00:02:00 (ie. the first 150 sectors are missing; at least it is like so when "Session Start Sector" is -150).

The subchannel data (if present) consists of 8 subchannels, stored in 96 bytes (each

byte containing one bit per subchannel).

```
Bit7..0 = Subchannel P..W (in that order, eg. Bit6=Subchannel Q)
```

The 96 bits (per subchannel) can be translated to bytes, as so:

```
1st..8th bit  = Bit7..Bit0 of 1st byte (in that order, ie. MSB/Bit7 first)
9st..16th bit = Bit7..Bit0 of 2nd byte ("")
17th..       = etc.
```

File.MDS - Contains disc/lead-in info (in binary format)

An MDS file's structure consists of the following stuff ...

```
Header           (58h bytes)
Session block(s) (usually one 18h byte entry)
Data blocks      (N*50h bytes)
Index blocks     (usually N*8 bytes)
Filename blocks(s) (usually one 10h byte entry)
Filename string(s) (usually one 6 byte string)
Read error(s)    (usually none such)
```

Header (58h bytes)

```
00h 16 File ID ("MEDIA DESCRIPTOR")
10h 2  Unknown (01h,03h or 01h,04h or 01h,05h) (Fileformat version?)
12h 2  Media Type (0=CD-ROM, 1=CD-R, 2=CD-RW, 10h=DVD-ROM, 12h=DCD-R)
14h 2  Number of sessions (usually 1)
16h 4  Unknown (02h,00h,00h,00h)
1Ah 2  Zero (for DVD: Length of BCA data)
1Ch 8  Zero
24h 4  Zero (for DVD: Offset to BCA data)
28h 18h Zero
40h 4  Zero (for DVD: Offset to Disc Structures) (from begin of .MDS file)
44h 0Ch Zero
50h 4  Offset to First Session-Block (usually 58h) (from begin of .MDS file)
54h 4  Offset to Read errors (usually 0=None) (from begin of .MDS file)
```

Session-Blocks (18h bytes)

```
00h 4  Session Start Sector (starting at FFFFFFF6Ah=-150 in first session)
04h 4  Session End Sector (XXX plus 150 ?)
08h 2  Session number (starting at 1) (non-BCD)
0Ah 1  Number of Data Blocks with any Point value (Total Data Blocks)
0Bh 1  Number of Data Blocks with Point>=A0h (Special Lead-In info)
0Ch 2  First Track Number in Session (01h..63h, non-BCD!)
0Eh 2  Last Track Number in Session (01h..63h, non-BCD!)
```

```

10h 4   Zero
14h 4   Offset to First Data-Block (usually 70h) (from begin of .MDS file)

```

Data-Blocks (50h bytes)

Block 0..2 are usually containing Point A0h..A2h info. Block 3..N are usually TOC info for Track 1 and up.

```

00h 1   Track mode (see below for details)
01h 1   Number of subchannels in .MDF file (0=None, 8=Sector has +60h bytes)
02h 1   ADR/Control (but with upper/lower 4bit swapped, ie. MSBs=ADR!)      Q0
03h 1   TrackNo (usually/always 00h; as this info is in Lead-in area)      Q1
04h 1   Point (Non-BCD!) (Track 01h..63h) (or A0h and up=Lead-in info)      Q2
05h 4   Zero (probably dummy MSF and reserved byte from Q channel)      Q3..Q6?
09h 1   Minute (Non-BCD!) ; \MM:SS:FF of Point'ed track                    Q7
0Ah 1   Second (Non-BCD!) ; (or disc/lead-out info when Point>=A0h)        Q8
0Bh 1   Frame (Non-BCD!) ; /                                              Q9

```

For Point>=A0h, below 44h bytes at [0Ch..4Fh] are zero-filled

```

0Ch 4   Offset to Index-block for this track (from begin of .MDS file)
10h 2   Sector size (800h..930h) (or 860h..990h if with subchannels)
12h 1   Unknown (02h) (maybe number of indices?)
13h 11h Zero
24h 4   Track start sector, PLBA (00000000h=00:02:00) (or 00000096h=00:02:00?)
28h 8   Track start offset (from begin of .MDF file)
30h 4   Number of Filenames for this track (usually 1)
34h 4   Offset to Filename Block for this track (from begin of .MDS file)
38h 18h Zero

```

Trackmode:

```

(upper 4bit seem to be meaningless?)
00h=None (used for entries with Point=A0h..FF)
A9h=AUDIO ;sector size = 2352 930h ;bytes 000h..92Fh
AAh=MODE1 ;sector size = 2048 800h ;bytes 010h..80Fh
ABh=MODE2 ;sector size = 2336 920h ;bytes 010h..92Fh
ACh=MODE2_FORM1 ;sector size = 2048 800h ;bytes 018h..817h (incomplete!)
ADh=MODE2_FORM2 ;sector size = 2324+0? 914h ;bytes 018h..91Bh (incomplete!)
ADh=MODE2_FORM2 ;sector size = 2324+4? 918h ;bytes ??..?? (contains what?)
ECh=MODE2 ;sector size = 2448 990h ;(930h+60h) (with subchannels)

```

Index Blocks (usually 8 bytes per track)

```

00h 4   Number of sectors with Index 0 (usually 96h or zero)
04h 4   Number of sectors with Index 1 (usually size of main-track area)

```

Index blocks are usually/always 8 bytes in size (two indices per track, even when recording a CD with more than 2 indices per track).

The MDS file does usually contain Index blocks for \<all> Data Blocks (ie. including unused dummy Index Blocks for Data Blocks with Point>=A0h).

Filename Blocks (10h bytes)

```
00h 4  Offset to Filename (from begin of .MDS file)
04h 1  Filename format (0=8bit, 1=16bit characters)
05h 11 Zero
```

Normally all tracks are sharing the same filename block (although theoretically the tracks could use separate filename blocks; with different filenames).

Filename Strings (usually 6 bytes)

```
00h 6  Filename, terminated by zero (usually "*.mdf", 00h)
```

Contains the filename of the of the sector data (usually "*.mdf", indicating to use the same name as for the .mds file, but with .mdf extension).

Read errors aka DPM data blocks (present if errors occurred during recording)

```
00h 4  Unknown (1)
04h 4  Offset to following stuff
08h 4  Unknown (2)
0Ch 4  Unknown (7)
10h 4  Unknown (1)
14h 4  Number of read errors (E)
18h E*4 LBA's for sectors with read errors (0 and up)
```

Instead of (or additionally to) read errors, there may be also hundreds of Kbytes of unknown stuff appended (text strings in 8bit or 16bit format, binary numbers, and huge zerofilled blocks).

Missing

Unknown if/how this format supports EAN-13, ISRC, CD-TEXT.

13.116 CDROM Disk Images NRG (Nero)

.NRG (NERO)

Nero is probably the most bloated and most popular CD recording software. The first part of the file contains the disk image, starting at sector 00:00:00, with 800h..930h bytes per sector. Additional chunk-based information is appended at the end of the file, usually consisting of only four chunks: CUES,DAOI,END!,NERO (in that order).

Chunk Entrypoint (in last 8/12 bytes of file)

```
4   File ID "NERO"/"NER5"
4/8 Fileoffset of first chunk
```

Cue Sheet (summary of the Table of Contents, TOC)

```
4   Chunk ID "CUES"/"CUEX"
4   Chunk size (bytes)
```

below EIGHT bytes repeated for each track/index,
of which, first FOUR bytes are same for both CUES and CUEX,

```
1   ADR/Control from TOC (usually LSBs=ADR=1=fixed, MSBs=Control=Variable)
1   Track   (BCD) (00h=Lead-in, 01h..99h=Track N, AAh=Lead-out)
1   Index   (BCD) (usually 00h=pregap, 01h=actual track)
1   Zero
```

next FOUR bytes for CUES,

```
1   Zero
1   Minute (BCD) ;starting at 00:00:00 = 2 seconds before ISO vol. descr.
1   Second (BCD)
1   Sector (BCD)
```

or, next FOUR four bytes for CUEX,

```
4   Logical Sector Number (HEX) ;starting at FFFFFFF6Ah (=00:00:00)
```

Caution: Above may contain two position 00:00:00 entries: one nonsense entry for Track 00 (lead-in), followed by a reasonable entry for Track 01, Index 00.

Disc at Once Information

```

4   Chunk ID "DAOI"/"DAOX"
4   Chunk size (bytes)
4   Garbage (usually same as above Chunk size)
13  EAN-13 Catalog Number (13-digit ASCII) (or 00h-filled if none/unknown)
1   Zero
1   Disk type (00h=Mode1 or Audio, 20h=XA/Mode2) (and probably 10h=CD-I?)
1   Unknown (01h)
1   First track (Non-BCD) (01h..63h)
1   Last track (Non-BCD) (01h..63h)

```

below repeated for each track,

```

12  ISRC in ASCII (eg. "USXYZ9912345") (or 00h-filled if none/unknown)
2   Sector size (usually 800h, 920h, or 930h) (see Mode entry for more info)
1   Mode:
    0=Mode1/800h ;raw model data (excluding sync+header+edc+errorinfo)
    3=Mode2/920h ;almost full sector (exluding first 16 bytes; sync+header)
    6=Mode2/930h ;full sector (including first 16 bytes; sync+header)
    7=Audio/930h ;full sector (plain audio data)
Mode values from wikipedia:
    00h for data                                Mode1/800h
    02h
    03h for Mode 2 Form 1 data   eh? FORM1???    Mode2/920h
    05h for raw data                                Mode1?/930h
    06h for raw Mode 2/form 1 data                Mode2/930h
    07h for audio                                Audio/930h
    0Fh for raw data with sub-channel            Mode1?/930h+WHAT?
    10h for audio with sub-channel                Audio/930h+WHAT?
    11h for raw Mode 2/form 1 data with sub-channel Mode2/WHAT?+WHAT?
Note: Some newer files do actually use different sector sizes for each
track (eg. 920h for the data track, and 930h for any following audio
tracks), older files were using the same sector size for all tracks
(eg. if the disk contained 930-byte Audio tracks, then Data tracks
were stored at the same size, rather than at 800h or 920h bytes).
3   Unknown (always 00h,00h,01h)
4/8 Fileoffset 1 (Start of Track's Pregap) (with Index=00h)
4/8 Fileoffset 2 (Start of actual Track) (with Index=01h and up)
4/8 Fileoffset 3 (End of Track) (aka begin of next track's pregap)

```

End of chain

```

4   Chunk ID "END!"
4   Chunk size (always zero)

```

Track Information (contained only in Track at Once images)

```

4   Chunk ID "TINF"/"ETNF"/"ETN2"
4   Chunk size (bytes)

```

below repeated for each track,

```
4/4/8 Track fileoffset      ;\32bit in TINF/ETNF chunks,
4/4/8 Track length (bytes)  ;/64bit in ETN2 chunks
4      Mode (should be same as in DAO chunks, see there) (implies sector size)
0/4/4 Start lba on disc     ;\only in ETNF/ETN2 chunks,
0/4/4 Unknown?             ;/not in TINF chunks
```

Unknown 1 (contained only in Track at Once images)

```
4      Chunk ID "RELO"
4      Chunk size (bytes)
4      Zero
```

Unknown 2 (contained only in Track at Once images)

```
4      Chunk ID "TOCT"
4      Chunk size (bytes)
1      Disk type (00h=Model or Audio, 20h=XA/Mode2) (and probably 10h=CD-I?)
1      Zero (00h)
```

Session Info (begin of a session) (contained only in multi-session images)

```
4      Chunk ID "SINF"
4      Chunk size (bytes)
4      Number of tracks in session
```

CD-Text (contained only in whatever images)

```
4      Chunk ID None/"CDTX"
4      Chunk size (bytes) (must be a multiple of 18 bytes)
```

below repeated for each fragment,

```
18      Raw 18-byte CD-text data fragments
```

Media Type? (contained only in whatever images)

```
4      Chunk ID "MTYP"
4      Chunk size (bytes)
4      Unknown? (00000001h for CDROM) (maybe other value for DVD)
```

Optional Filenames (names where the image was generated from?)

```

4   Chunk ID "AFNM"
4   Chunk size (bytes)
..  Track Filenames (eg. "Track1.wav",0,"Track2.wav",0)

```

Optional Volume name

```

4   Chunk ID "VOLUME"
4   Chunk size (bytes)
..  Name (eg. "Audio CD",00h)

```

Notes

Newer/older .NRG files may contain 32bit/64bit values (and use "OLD"/"NEW" chunk names) (as indicated by the "/" slashes).

CAUTION: All 16bit/32bit/64bit values are in big endian byte-order.

Missing

Unknown if newer NRG versions do also support subchannel data.

13.117 CDROM Disk Image/Containers CDZ

.CDZ is a compressed disk image container format (developed by pSX Author, and used only by the pSX emulator). The disk is split into 64kbyte blocks, which allows fast random access (without needing to decompress all preceeding sectors).

However, the compression ratio is surprisingly bad (despite of being specifically designed for cdrom compression, the format doesn't remove redundant sector headers, error correction information, and EDC checksums).

.CDZ File Structure

```

FileID ("CDZ",00h for cdztool v0/v1, or "CDZ",01h for cdztool v2 and up)
One or two Chunk(s)

```

.CDZ Chunk Format

Chunk Header in v0 (unreleased prototype):


```
4      32bit Decompressed Size (of all blocks) (must be other than "ZLIB")
```

Chunk Header in v1 (first released version):

```
4      ZLIB ID ("ZLIB")
8      64bit Decompressed Size (of all blocks)
```

Chunk Header in v2 and up (later versions):

```
4      Chunk ID (eg. "CUE",00h)
8      Chunk Size in bytes (starting at "ZLIB" up to including Footer, if any)
4      ZLIB ID ("ZLIB")
8      64bit Decompressed Size (of all blocks)
```

Chunk Body (same in all versions):

```
4      Number of Blocks (N)
4      Block 1 Compressed Size (CS.1)
4      Block 1 Decompressed Size (always 00010000h, except last block)
CS.1 Block 1 Compressed ZLIB Data (starting with 78h,9Ch)
...    ...                                ;\
4      Block N Compressed Size (CS.N)      ; further block(s)
4      Block N Decompressed Size           ; (if any)
CS.N Block N Compressed ZLIB Data         ;/
```

Chunk Footer in v0 (when above header didn't have the "ZLIB" ID):

```
4*N      Directory Entries for N blocks      ; -this ONLY for BIN chunk
```

Chunk Footer in v1 and up:

```
BPD*(N-1) Directory Entries for N-1 blocks ; \this ONLY for BIN chunk
1          Bytes per Directory Entry (BPD)  ; /(not for CUE/CCD/MDS)
```

The "Compressed ZLIB Data" parts contain Deflate'd data (starting with 2-byte ZLIB header, and ending with 4-byte ZLIB/ADLER checksum), for details see: [CDROM File Compression ZIP/GZIP/ZLIB \(Inflate/Deflate\)](#)

.CDZ Chunks / Content

The chunk(s) have following content:

```
noname+noname      --> .CUE+.BIN (cdztool v1 and below)
"BIN",0            --> .ISO      (cdztool v2? and up)
"CUE",0+"BIN",0    --> .CUE+.BIN (cdztool v2 and up)
"CCD",0+"BIN",0    --> .CCD+.IMG (cdztool v2 and up)
```

```
"CCD",0+"BIN",01h  --> .CCD+.IMG+.SUB (930h sectors, plus 60h subchannels)
"MDS",0+"BIN",0    --> .MDS+.MDF (cdztool v5 only)
```

Note: cdztool doesn't actually recognize files with .ISO extension (however, one can rename them to .BIN, and then compress them as CUE-less .BIN file).

Cdztool.exe Versions

```
cdztool.exe v0, unreleased prototype
cdztool.exe v1, 22 May 2005, CRC32=620dbb08, 102400 bytes, pSX v1.0-5
cdztool.exe v2, 02 Jul 2006, CRC32=bcb29c1e, 110592 bytes, pSX v1.6
cdztool.exe v3, 22 Jul 2006, CRC32=4062ba82, 110592 bytes, pSX v1.7
cdztool.exe v4, 13 Aug 2006, CRC32=7388dd3d, 118784 bytes, pSX v1.8-11
cdztool.exe v5, 22 Jul 2007, CRC32=f25c1659, 155648 bytes, pSX v1.12-13
```

Note: v0 wasn't ever released (it's only noteworthy because later versions do have backwards compatibility for decompressing old v0 files). v1 didn't work with all operating systems (on Win98 it just says "Error: Couldn't create \<output>" no matter what one is doing, however, v1 does work on later windows versions like WinXP or so?).

13.118 CDROM Disk Image/Containers ECM

ECM (Error Code Modeler by Neill Corlett) is a utility that removes unnecessary ECC error correction and EDC error detection values from CDROM-images. This is making the images a bit smaller, but the real size reduction isn't gained until subsequently compressing the images via tools like ZIP. Accordingly, these files are extremely uncomfortable to use: One must first UNZIP them, and then UNECM them.

.EXT.ECM - Double extension

ECM can be applied to various CDROM-image formats (like .BIN, .CDI, .IMG, .ISO, .MDF, .NRG), as indicated by the double-extension. Most commonly it's applied to .BIN files (hence using extension .BIN.ECM).

Example / File Structure

```
45 43 4D 00          ;FileID "ECM",00h
3C                  ;Type 0, Len=10h (aka 0Fh+1)
00 FF FF FF FF FF FF FF FF FF FF FF FF FF 00 00 02 00 02 ;16 data bytes
02                  ;Type 2, Len=1 (aka 00h+1)
00 00 08 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ;804h data bytes
3C                  ;Type 0, Len=10h (aka 0Fh+1)
00 FF FF FF FF FF FF FF FF FF FF FF FF FF 00 00 02 01 02 ;16 data bytes
```

```

02                                     ;Type 2, Len=1 (aka 00h+1)
00 00 08 00 00 00 00 00 00 00 00 00 ..... 00 00 00 ;804h data bytes
...
FC FF FF FF 3F                       ;End Code (Len=FFFFFFFFh+1)
NN NN NN NN                          ;EDC (on decompressed data)

```

Type/Length Byte(s)

Type/Length is encoded in 1..5 byte(s), with "More=1" indicating that further length byte(s) follow:

```
1st Byte: Bit7=More, Bit6-2=LengthBit4-0, Bit1-0=Type(0..3)
2nd Byte: Bit7=More, Bit6-0=LengthBit5-11
3rd Byte: Bit7=More, Bit6-0=LengthBit12-18
4th Byte: Bit7=More, Bit6-0=LengthBit19-25
5th Byte: Bit7-6=Reserved/Zero, Bit5-0=LengthBit26-31
```

Length=FFFFFFFFh=End Indicator

The actual decompression LEN is: "LEN=Length+1"

ECM Decompression

Below is repeated LEN times (with LEN being the Length value plus 1):

```
Type 0: load 1 byte, save 1 byte
Type 1: load 803h bytes [0Ch..0Eh,10h..80Fh], save 930h bytes [0..92Fh]
Type 2: load 804h bytes [14h..817h], save 920h bytes [10h..92Fh]
Type 3: load 918h bytes [14h..91Bh], save 920h bytes [10h..92Fh]
```

Type 1-3 are reconstructing the missing bytes before saving. Type 2-3 are saving only 920h bytes, so (if the original image contained full 930h byte sectors) the missing 10h bytes must be inserted via Type 0. Type 0 can be also used for copying whole sectors as-is (eg. Audio sectors, or Data sectors with invalid Sync/Header/ECC/EDC values). And, Type 0 can be used to store non-sector data (such like the chunks at the end of .NRG or .CDI files).

Central Mistakes

There's a lot of wrong with the ECM format. The two central problems are that it doesn't support data-compression (and needs external compression tools like zip/rar), and, that it doesn't contain a sector look-up table (meaning that random access isn't possible unless when scanning the whole file until reaching the desired sector).

Worst-case Scenario

As if ECM as such wouldn't be uncomfortable enough, you may expect typical ECM users to get more things messed up. For example:

```
A RAR file containing a 7Z file containing a ECM file containing a BIN file.
The BIN containing only Track 1, other tracks stored in APE files.
And, of course, the whole mess without including the required CUE file.
```

13.119 CDROM Subchannel Images

SBI (redump.org)

SBI Files start with a 4-byte FileID:

```
4 bytes FileID ("SBI",00h)
```

Then followed by entries as so:

```
3 bytes real absolute MM:SS:FF address where the sub q data was bad
1 byte Format: the format can be 1, 2 or 3:
Format 1: complete 10 bytes sub q data (Q0..Q9)
Format 2: 3 bytes wrong relative MM:SS:FF address (Q3..Q5)
Format 3: 3 bytes wrong absolute MM:SS:FF address (Q7..Q9)
```

Note: The PSX libcrypt protection relies on bad checksums (Q10..Q11), which will cause the PSX cdrom controller to ignore Q0..Q9 (and to keep returning position data from most recent sector with intact checksum).

Ironically, the SBI format cannot store the required Q10..Q11 checksum. The trick for using SBI files with libcrypted PSX discs is to ignore the useless Q0..Q9 data, and to assume that all sectors in the SBI file have wrong Q10..Q11 checksums.

M3S (Subchannel Q Data for Minute 3) (ePSXe)

M3S files are containing Subchannel Q data for all sectors on Minute=03 (the region where PSX libcrypt data is located) (there is no support for storing the (unused) libcrypt backup copy on Minute=09). The .M3S filesize is 72000 bytes (60 seconds * 75 sectors * 16 bytes). The 16 bytes per sector are:

```

Q0..Q9   Subchannel Q data (normally position data)
Q10..Q11 Subchannel Q checksum
Q12..Q15 Dummy/garbage/padding (usually 00000000h or FFFFFFFFh)

```

Unfortunately, there are at least 3 variants of the format:

1. With CRC (Q0..Q11 intact) (and Q12..Q15 randomly 00000000h or FFFFFFFFh)
2. Without CRC (only Q0..Q9 intact, but Q10..Q15 zerofilled)
3. Without anything (only Q0 intact, but Q1..Q15 zerofilled)

The third variant is definitely corrupt (and one should ignore such zerofilled entries). The second variant is corrupt, too (but one might attempt to repair them by guessing the missing checksum: if it contains normal position values assume correct crc, if it contains uncommon values assume a libcryptoed sector with bad crc).

The M3S format is intended for libcryptoed PSX games, but, people seem to have also recorded (corrupted) M3S files for unprotected PSX games (in so far, more than often, the M3S files might cause problems, instead of solving them).

Note: The odd 16-byte format with 4-byte padding does somehow resemble the "P and Q Sub-Channel" format 'defined' in MMC-drafts; if the .M3S format was based on the MMC stuff: then the 16th byte might contain a Subchannel P "pause" flag in bit7.

CDROM Images with Subchannel Data

Most CDROM-Image formats can (optionally) contain subchannel recordings. The downsides are: Storing all 8 subchannels for a full CDROM takes up about 20MBytes. And, some entries may contain 'wrong' data (read errors caused by scratches cannot be automatically repaired since subchannels do not contain error correction info). If present, the subchannel data is usually appended at the end of each sector in the main binary file (one exception is CloneCD, which stores it in a separate .SUB file instead of in the .IMG file).

CCD/IMG/SUB (CloneCD)	P-W	60h-bytes Non-interleaved (in separate .SUB file)
CDI (DiscJuggler)	P-Q	10h-bytes Non-interleaved (in .CDI file)
""	P-W	60h-bytes Interleaved (in .CDI file)
CUE/BIN/CDT (Cdrwin)	N/A	
ISO (single-track)	N/A	
MDS/MDF (Alcohol 120%)	P-W	60h-bytes Interleaved (in .MDF file)
NRG (Nero)	P-W	60h-bytes Interleaved (in .NRG file)

Interleaved Subchannel format (eg. Alcohol .MDF files):

00h-07h	80 C0 80 80 80 80 80 C0	;P=FFh, Q=41h=ADR/Control, R..W=00h
08h-0Fh	80 80 80 80 80 80 80 C0	;P=FFh, Q=01h=Track, R..W=00h

```

10h-17h  80 80 80 80 80 80 80 C0 ;P=FFh, Q=01h=Index, R..W=00h
18h-1Fh  80 80 80 80 80 80 80 80 ;P=FFh, Q=00h=RelMinute, R..W=00h
20h-27h  80 80 80 80 80 80 80 80 ;P=FFh, Q=00h=RelSecond, R..W=00h
28h-2Fh  80 80 80 80 80 80 80 80 ;P=FFh, Q=00h=RelSector, R..W=00h
30h-37h  80 80 80 80 80 80 80 80 ;P=FFh, Q=00h=Reserved, R..W=00h
38h-3Fh  80 80 80 80 80 80 80 80 ;P=FFh, Q=00h=AbsMinute, R..W=00h
40h-47h  80 80 80 80 80 80 C0 80 ;P=FFh, Q=02h=AbsSecond, R..W=00h
48h-4Fh  80 80 80 80 80 80 80 80 ;P=FFh, Q=00h=AbsSector, R..W=00h
50h-57h  80 80 C0 80 C0 80 80 80 ;P=FFh, Q=28h=ChecksumMsb, R..W=00h
58h-5Fh  80 80 C0 C0 80 80 C0 80 ;P=FFh, Q=32h=ChecksumLsb, R..W=00h

```

Non-Interleaved Subchannel format (eg. CloneCD .SUB files):

```

00h-0Bh  FF FF FF FF FF FF FF FF FF FF FF FF ;Subchannel P (Pause)
0Ch-17h  41 01 01 00 00 00 00 00 02 00 28 32 ;Subchannel Q (Position)
18h-23h  00 00 00 00 00 00 00 00 00 00 00 00 ;Subchannel R
24h-2Fh  00 00 00 00 00 00 00 00 00 00 00 00 ;Subchannel S
30h-3Bh  00 00 00 00 00 00 00 00 00 00 00 00 ;Subchannel T
3Ch-47h  00 00 00 00 00 00 00 00 00 00 00 00 ;Subchannel U
48h-53h  00 00 00 00 00 00 00 00 00 00 00 00 ;Subchannel V
54h-5Fh  00 00 00 00 00 00 00 00 00 00 00 00 ;Subchannel W

```

Non-Interleaved P-Q 10h-byte Subchannel format:

```

This is probably based on MMC protocol, which would be as crude as this:
The 96 pause bits are summarized in 1 bit. Pause/Checksum are optional.
00h-09h  41 01 01 00 00 00 00 00 02 00 ;Subchannel Q (Position)
0Ah-0Bh  28 32 ;<-- OPTIONAL, can be zero! ;Subchannel Q (Checksum)
0Ch-0Eh  00 00 00 ;Unused padding (zero)
0F       80 ;<-- OPTIONAL, can be zero! ;Subchannel P (Bit7=Pause)

```

13.120 CDROM Disk Images PBP (Sony)

.PBP

Sony's disc image format used on PSP. Can store multi-disc images in a single file. Supports deflate data compression and some yet unknown audio compression. A homebrew compressor can compress whole discs with deflate (which works, but it isn't very good to compress audio sectors that way).

PBP Format (rev-engineered from homebrew DBALL.PBP)

```

000000h 4 ID (00h, "PBP")
000004h 4 Version? (10000h) (but, reportedly "always 100h or 1000100h")
000008h 4 Offset of the file PARAM.SFO (28h)
00000Ch 4 Offset of the file ICON0.PNG (3D8h)

```

```

000010h 4   Offset of the file ICON1.PMF (3D8h) or ICON1.PNG
000014h 4   Offset of the file PIC0.PNG (3D8h) or UNKNOWN.PNG
000018h 4   Offset of the file PIC1.PNG (3D8h) or PICT1.PNG
00001Ch 4   Offset of the file SND0.AT3 (3D8h)
000020h 4   Offset of the file DATA.PSP (3D8h)
000024h 4   Offset of the file DATA.PSAR (10000h)
000028h ..  PARAM.SFO file (zerofilled in homebrew PBP)
0003D8h ..  PNG files etc (zerofilled in homebrew PBP)
010000h 0Ch  ID "PSISOIMG0000"
01000Ch 4   PBP Size-10000h (144740h)
010010h 4   PBP Size-6420h (???) (14E320h)
010014h ..  Zerofilled
010400h 0Bh  Game ID ("_SCUS_94476" for Hot Shots Golf 2)
01040Bh ..  Zerofilled
010800h A00h TOC List (0Ah-byte per entry) (unused entries are zerofilled)
011200h 20h  Zerofilled
011220h 4   PBP Size-D2CFh (???) (147471h)
011224h 4   Zero
011228h 4   Unknown (7FFh)
01122Ch 11h  Game Name ("Hot Shots Golf",C2h,AEh,"2")
01123Dh ..  Zerofilled
014000h ..  Sector List (20h-byte per entry) (unused entries are zerofilled)
... .. Zerofilled
110000h ..  Deflated sectors (9300h bytes after decompression)
15467Dh B8h  One extra compression block that is NOT in Sector List ???
154735h 0Bh  Weird padding with ASCII "000000000000"
154740h -    End of file

```

TOC List (Subchannel Q with ADR=1 during Lead-In):

```

000h 1   ADR/Control (eg. 41h=Data Track)
001h 1   Track (always 00h=Lead-in for all TOC List entries)
002h 1   Point (A0h, A1h, A2h, or Track 01h and up) (BCD?)
003h 3   Dummy MSF (usually 00:00:00 or weirdly 00:02:01) (BCD?)
006h 1   Reserved (00h)
007h 3   Actual MSF (or TOC info for Point=A0h,A1h) (BCD?)

```

Example TOC (DBALL.PBP):

```

41 00 A0 00 00 00 00 01 20 00 ;First Track (1) and Type (20h=CDROM-XA)
41 00 A1 00 00 00 00 01 00 00 ;Last Track Number (1)
41 00 A2 00 00 00 00 27 19 22 ;Lead-Out, uh at 27:19:22 in DBALL.PBP ???
41 00 01 00 02 01 00 00 02 00 ;Track 1 at 00:02:00
(remaining entries are zerofilled)

```

Example TOC (PSALM69.PBP):

```

01 00 01 00 02 00 00 00 00 00 ;Track 1 as audio <-- why that ???
01 00 02 02 37 44 00 00 00 00 ;Track 2 as audio
01 00 03 03 25 45 00 00 00 00 ;Track 3 as audio
41 00 01 00 02 01 00 00 02 00 ;Track 1 as data <-- listed last?
(remaining entries are zerofilled)
(weirdly, most MM:SS:FF values are stored in byte[3..5] instead [7..9])
(there are no point=A0h,A1h,A2h entries)

```

Example TOC (GOOGLE_AI_TTS.PBP):

```

01 00 01 00 02 00 00 00 00 00 ;Track 1 as audio
01 00 02 00 02 30 00 00 00 00 ;Track 2 as audio, but without pregap?
01 00 03 00 02 60 00 00 00 00 ;Track 3 as audio, but without pregap?
01 00 04 00 03 15 00 00 00 00 ;Track 4 as audio, but without pregap?
(remaining entries are zerofilled)

```

Sector List:

```

000h 4   Offset-110000h to Sector(N*10h)
004h 2   Compressed size of Sector(N*10h+(0..0Fh))    ;9300h=uncompressed?
006h 2   Zero (but, reportedly "usually 1... and 0 for the last entry")
008h 10h Zero (but, reportedly "first 10h bytes of SHA1 sum of 10h sectors")
018h 8   Zero (padding)

```

Data Compression is using raw Deflate (without any zlib headers or the like), and it's unfortunately just compressing the sectors as-is (without filtering out sector headers and ECC/EDC values).

CDROM File Compression ZIP/GZIP/ZLIB (Inflate/Deflate)

Audio Compression format is unknown:

?

Multi-disc format is unknown:

?

Retail files have "PGD" encryption:

?

13.121 CDROM Disk Images CHD (MAME)

All numbers are stored in Motorola (big-endian) byte ordering.

V1/V2 header (hdcomp):

V1/V2 contains harddisk related header entries (and apparently doesn't support cdroms).

```

000h 08h  ID "MComprHD" (MAME Compressed Hunks of Data)
008h 4    Header size    (4Ch=V1, 50h=V2)
00Ch 4    Header version (probably 01h=V1, 02h=V2)
010h 4    Flags (bit0=DriveHasParent, bit1=AllowWrites)
014h 4    Compression type (0=None, 1=ZLIB)
018h 4    Number of sectors per hunk
01Ch 4    Total number of hunks represented
020h 4    Number of cylinders on hard disk
024h 4    Number of heads on hard disk
028h 4    Number of sectors on hard disk
02Ch 10h  MD5 checksum on raw data
03Ch 10h  MD5 checksum on parent file
N/A -    V1: Uses fixed 200h-byte Sector size

```



```

04Ch (4)  V2: Number of bytes per sector
... ?     Supposedly followed by map and/or data at whatever locations

```

V3/V4 header (chdman):

V3/V4 are inventing new "metadata" for info about harddisks or cdroms.

```

000h 08h  ID "MComprHD" (MAME Compressed Hunks of Data)
008h 4     Header size      (78h=V3, 6Ch=V4)
00Ch 4     Header version (03h=V3, 04h=V4)
010h 4     Flags (bit0=DriveHasParent, bit1=AllowWrites)
014h 4     Compression type (0=None, 1=ZLIB, 2=ZLIB_PLUS) (V4: 3=AV)
018h 4     Total number of hunks represented      (N)      (92h)
01Ch 08h   Total size of all uncompressed hunks (N*2640h) (15D080h)
024h 08h   Offset to the first blob of metadata
02Ch 10h   V3: MD5 checksum on raw data           ;\
03Ch 10h   V3: MD5 checksum on parent file        ;
04Ch 4     V3: Number of bytes per hunk (2640h=990h*4) ; V3
050h 14h   V3: SHA1 checksum on raw data          ;
064h 14h   V3: SHA1 checksum on parent file       ;/
02Ch 4     V4: Number of bytes per hunk (2640h=990h*4) ;\
030h 14h   V4: SHA1 checksum on raw+meta          ; V4
044h 14h   V4: SHA1 checksum on raw+meta of parent ;
058h 14h   V4: SHA1 checksum on raw data          ;/
... N*10h  Map entries (for each hunk)
... 10h    Map end marker ("EndOfListCookie",00h)
... ..    Metadata Chunk(s)
... ..    Compressed Sectors (aka hunks)

```

V5 header (chdman):

```

000h 8     ID "MComprHD" (MAME Compressed Hunks of Data)
008h 4     Header size      (7Ch=V5)
00Ch 4     Header version (05h=V5)
010h 4     Compressor 0 (usually "cdlz"=cdrom/lzma)
014h 4     Compressor 1 (usually "cdzl"=cdrom/zlib)
018h 4     Compressor 2 (usually "cdf1"=cdrom/flac)
01Ch 4     Compressor 3 (usually 0=none)
020h 8     Total size of all uncompressed hunks      (N*4C80h-HunkPadding)
028h 8     Offset to Map                             (3D797h)
030h 8     Offset to first Metadata chunk            (7Ch)
038h 4     Number of bytes per hunk (512k maximum) (990h*8) (4C80h)
03Ch 4     Number of bytes per sector                (990h)  (30h+60h)
040h 14h   SHA1 on raw data
054h 14h   SHA1 on raw+meta
068h 14h   SHA1 on raw+meta of parent (0=No parent)
... ..    Metadata Chunk(s)
... ..    Padding to BytesPerHunk-boundary         ;\when uncompressed
... ..    Uncompressed Sectors (aka hunks)         ;/

```

```
... .. Compressed Sectors (aka hunks)      ;-when compressed
... .. Map
```

CHD Metadata

V3/V4/V5 METADATA

Overall Metadata chunk format:

```
000h 4   Chunk ID (aka Blob Tag) (eg. "CHT2" for each CDROM track)
004h 1   Flags (00h=V3, 01h=V4/V5)  ;maybe some kind of flag/type/version?
005h 3   Chunk Data Size (24bit)
008h 8   Offset to next Chunk (or 0=Last chunk)
010h ..  Chunk Data (eg. "TRACK:1 TYPE:MODE2_RAW ... POSTGAP:0",00h for CHT2)
```

There can be one or more chunks (eg. CHT2 chunk(s), one for each CDROM track).

Summary of Chunk IDs and corresponding Data entries:

ID	Data		
"GDDD"	"CYLS,HEADS,SECS,BPS"	;-hard disk standard info	;\
"IDNT"	?	;-hard disk identify info	; HDD
"KEY "	?	;-hard disk key info	;/
"CIS "	?	;-pcmcia CIS info	;-PCMCIA
"CHCD"	94Ch-byte binary (4+99*24 bytes)		;\
"CHTR"	"TRACK TYPE SUBTYPE FRAMES"		; CD-ROM
"CHT2"	"TRACK TYPE SUBTYPE FRAMES PREGAP PGTYPE PGSUB POSTGAP"		;/
"CHGT"	?		;\Sega
"CHGD"	"TRACK TYPE SUBTYPE FRAMES PAD PREGAP PGTYPE PGSUB POSTGAP"		;/GD-ROM
"AVAV"	"FPS WIDTH HEIGHT INTERLACED CHANNELS SAMPLERATE"		;\AV
"AVLD"	? (A/V Laserdisc frame)		;/

V3/V4/V5 METADATA IN ASCII FORMAT

The ASCII items are separated by spaces as shown above (or commas for GDDD). The last item in each chunk is terminated by 00h (at least so for CHTR/CHT2). Most items are followed by a colon and decimal string (eg. TRACK:1), except, TYPE,PGTYPE,SUBTYPE,PGSUB are followed by text strings (eg. TYPE:MODE2_RAW).

CYLS:#	Hard disc number of cylinders
HEADS:#	Hard disc number of heads
SECS:#	Hard disc number of sectors
BPS:#	Hard disc bytes per sector
TRACK:#	CDROM current track number (1..99)
TYPE:string	CDROM sector type/size
SUBTYPE:string	CDROM subchannel info (usually "NONE")
FRAMES:#	CDROM number of sectors per track (with/without pregap?)
PAD:#	Sega GDROM only: whatever pad value?
PREGAP:#	CDROM ... maybe number of pregap sectors? (can be HUGE !!??)
PGTYPE:string	CDROM ... whatever type? (usually "MODE1"??)

```
PGSUB:string      CDROM ... whatever subchannel          (usually "RW"??)
POSTGAP:#         CDROM ... maybe number of pstgap sectors? (usually 0)
FPS:#.#####     AV Video(?) -frames per second? with 6-digit fraction? (.avi?)
WIDTH:#          AV Width          (maybe in pixels?)
HEIGHT:#         AV Height         (maybe in pixels?) (with/without interlace?)
INTERLACED:#     AV Interlace     (maybe a flag that might be maybe 0 or 1?)
CHANNELS:#       AV Channels      (maybe audio mono/stereo or so?)
SAMPLERATE:#     AV Samplerate   (maybe audio samplerate, maybe in Hertz?)
```

For SUBTYPE and PGSUB:

```
"RW"           60h-byte interleaved ;normal "cooked" 96 bytes per sector
"RW_RAW"       60h-byte uninterleaved ;raw uninterleaved 96 bytes per sector
"NONE"        0-byte                ;no subcode data stored (default)
(unknown how RAW and RW_RAW differ, one format does probably store 8 bits
for 8 subchannels per byte... but unknown which format is doing so?)
```

For TYPE and PGTYPE (and CHCD numeric type 0..7):

```
"MODE1/2048" or "MODE1"           CHCD=0  800h-byte ;\Data Model
"MODE1/2352" or "MODE1_RAW"       CHCD=1  930h-byte ;/
"MODE2/2336" or "MODE2"           ;\dupe? CHCD=2  920h-byte ;\
"MODE2/2336" or "MODE2_FORM_MIX" ;/    CHCD=5  920h-byte ;
"MODE2/2048" or "MODE2_FORM1"     CHCD=3  800h-byte ; Data Mode2
"MODE2/2324" or "MODE2_FORM2"     CHCD=4  914h-byte ;
"MODE2/2352" or "MODE2_RAW" or "CDI/2352" CHCD=6  930h-byte ;/
"AUDIO" (stored as big-endian samples!!!) CHCD=7  930h-byte ; -Audio CD-DA
```

Caution:

AUDIO sectors are conventionally stored as 16bit little-endian samples, but CHD is storing them in big-endian (unlike formats like CUE/BIN).

Caution:

Older CHDMAN versions (eg. v0.146) did use nonsense "PGTYPE:MODE1" for all tracks (including audio tracks), later versions (eg. v0.246) did fix that issue; those newer files include a "V" prefix to indicate that the entry contains "valid" info (eg. "PGTYPE:VAUDIO") (except, Track 1 keeps using "PGTYPE:MODE1" without "V" and it's "MODE1" even on MODE2 discs).

CHCD METADATA (94CH BYTES, PLUS 10H-BYTE METADATA HEADER)

```
000h 4      Number of tracks (N) (1..99)
004h N*18h  Track entries
... ..     Zeropadding to 94Ch-byte size (when less than 99 tracks)
Track entries:
000h 4      Track Type          (0..7, CHCD=# in above table) (eg. 6=MODE2_RAW)
004h 4      Subchannel Type     (0=RW, 1=RW_RAW, 2=None)
008h 4      Sector Size        (800h, 914h, 920h or 930h)
00Ch 4      Subchannel Size     (0 or 60h)
010h 4      Number of Frames    (aka number of sectors)
014h 4      Padding Frames      (0..3) (to make Total Frames a multiple of 4)
```

CHD Maps

The Maps contain info (offset, size, compression method, etc.) for the separate compression blocks.

V1/V2 MAP FORMAT (64BIT ENTRIES WITH 44BIT+20BIT):

```
44bit    Offset to compressed data
20bit    Size of compressed data (or uncompressed data when size=hunksize)
```

Unknown if offset is in upper or lower 44bit.

V3/V4 MAP ENTRIES (PER HUNK):

```
000h 8    Offset to compressed data (64bit big-endian)
008h 4    CRC32 on uncompressed data (32bit big-endian)
00Ch 3    Size of compressed data (24bit mixed-endian: Mid, Low, High)
00Fh 1    Flags, indicating compression info (=whut? maybe below V34 stuff?)
```

V34_MAP_ENTRY_FLAG_TYPE_MASK = 0x0f; // what type of hunk

V34_MAP_ENTRY_FLAG_NO_CRC = 0x10; // no CRC is present (which CRC?)

V3-V4 entry types

```
V34_MAP_ENTRY_TYPE_INVALID      = 0  invalid type
V34_MAP_ENTRY_TYPE_COMPRESSED  = 1  standard compression
V34_MAP_ENTRY_TYPE_UNCOMPRESSED = 2  uncompressed data
V34_MAP_ENTRY_TYPE_MINI        = 3  mini: use offset as raw data
V34_MAP_ENTRY_TYPE_SELF_HUNK   = 4  same as another hunk in this file
V34_MAP_ENTRY_TYPE_PARENT_HUNK = 5  same as a hunk in the parent file
V34_MAP_ENTRY_TYPE_2ND_COMPRESSED = 6  compressed with secondary algorithm
```

Note: Secondary algorithm is NEVER used (it seems to have been intended for FLAC CDDA, but that was apparently never actually implemented in V3/V4).

Blurb: Secondary algorithm is "usually FLAC CDDA" (unknown where that is defined, and if one could also select other algorithms) ("usually FLAC" might mean "always FLAC" for cdroms, and "not used" elsewhere).

V5 MAP FORMATS

```
V5 uncompressed map format (when [filehdr+10h]=00000000h):
 000h N*4    Hunk List (32bit offsets: Offset/BytesPerHunk) (usually 1,2,3..)
V5 compressed map format (when [filehdr+10h]<>00000000h):
 000h 4      Length of compressed map
 004h 6      Offset of first block (48bit) (E4h, after meta)
 00Ah 2      CRC16 on decompressed map entries
 00Ch 1      bits used to encode complength
 00Dh 1      bits used to encode self-refs
```

```

00Eh 1    bits used to encode parent unit refs
00Fh 1    Reserved for future use (probably zero)
010h ..   Compressed Map entries (bitstream with Huffman/RLE encoding)

```

The decompressed map entries should look as shown below (one could store them differently, eg. as 32bit little endian values; however, they must be stored exactly as shown below when computing the CRC16 on decompressed map entries):

```

000h 1    Compression type (0..3=Codec0..3, 4=Uncompressed, 5=Self, 6=Parent)
001h 3    Compressed length (24bit big-endian)
004h 6    Offset to compressed data (48bit big-endian)
00Ah 2    CRC16 on decompressed data (big-endian)

```

V5 compression codecs:

```

0,0,0,0 = CHD_CODEC_NONE           ;-unused (when using less than 4 codecs)
"zlib" = CHD_CODEC_ZLIB             ;\
"lzma" = CHD_CODEC_LZMA             ; general codecs
"huff" = CHD_CODEC_HUFFMAN          ;
"flac" = CHD_CODEC_FLAC             ;/
"cdzl" = CHD_CODEC_CD_ZLIB          ;\
"cdlz" = CHD_CODEC_CD_LZMA          ; general codecs with CD frontend
"cdf1" = CHD_CODEC_CD_FLAC          ;/
"avhu" = CHD_CODEC_AVHUFF           ;-A/V codecs

```

UNCOMPRESSED V5 MAP LOADING (WHEN [FILEHDR+10H]=00000000H)

```

readfile(src,NumberOfHunks*4)           ;\
i=0                                     ; load uncomoreessed
while i<NumberOfHunks                   ; map (needed only
    ofs=bigendian32bit[src+i*4]*BytesPerHunk ; for uncompressed
    byte[map+i*0Ch+00h]=04h               ; files, which can
    bigendian24bit[map+i*0Ch+01h]=BytesPerHunk ; be created via
    bigendian48bit[map+i*0Ch+04h]=ofs       ; chdman commandline
    bigendian16bit[map+i*0Ch+0Ah]=none      ; options)
    ofs=ofs+len, i=i+1                   ;/

```

COMPRESSED V5 MAP LOADING (WHEN [FILEHDR+10H]<>00000000H)

```

readfile(hdr,10h)                       ;\read map hdr and
readfile(src,bigendian32bit[hdr+0])      ; compressed map
InitBitstream(src,BigEndianMsbFirst)    ;/
i=0                                     ;\
while i<10h                             ;
    val=GetBits(4), num=1                 ;
    if val=01h then                       ; read huffman tree
        val=GetBits(4)                   ;
        if val<>01h then num=GetBits(4)+3 ;
        for j=1 to num, codesizes[i]=val, i=i+1 ;
nonlzh_explode_tree(codetree,codesizes,10h) ;/
i=0, typ=0, num=0                       ;\
while i<NumberOfHunks                   ;
    if num=0                             ; load huffman coded
        x=GetHuffCode(codetree)          ; map type values
        if x=07h then                   ;
            num=GetHuffCode(codetree)+03h ;

```

```

        elseif x=08h then ;COMPRESSION_RLE_LARGE ;
            num=GetHuffCode(codetree)*10h ;
            num=GetHuffCode(codetree)+num+13h ;
        else typ=x, num=1 ;
        byte[map+i*0Ch+0]=typ, i=i+1, num=num-1 ;/
i=0, s=0, p=0 ;index,self,parent ;\
o=bigendian48bit[hdr+4] ;offset ; load other
while i<NumberOfHunks ; map items
    typ=byte[map+i*0Ch+00h], ofs=o, len=0, crc=0 ;
    if typ<04h then len=GetBits([hdr+0Ch]), crc=GetBits(16); ;Method 0..3
    elseif typ=04h then len=BytesPerHunk, crc=GetBits(16) ; ;Uncompressed
    elseif typ=05h then s=GetBits([hdr+0Dh]), ofs=s ; ;New Self
    elseif typ=06h then p=GetBits([hdr+0Eh]), ofs=p ; ;New Parent
    elseif typ=09h then typ=05h, ofs=s ; ;Old Self
    elseif typ=0Ah then typ=05h, s=s+1, ofs=s ; ;Old Self+1
    elseif typ=0Bh then typ=06h, p=i*SectorsPerHunk, ofs=p ; ;Direct Parent
    elseif typ=0Ch then typ=06h, ofs=p ; ;Old Parent
    elseif typ=0Dh then typ=06h, p=p+SectorsPerHunk, ofs=p ; ;Old Parent+1
    else goto error ;
    byte[map+i*0Ch+00h]=typ ;
    bigendian24bit[map+i*0Ch+01h]=len ;
    bigendian48bit[map+i*0Ch+04h]=ofs ;
    bigendian16bit[map+i*0Ch+0Ah]=crc ;
    o=o+len, i=i+1 ;/
if bigendian16bit[hdr+0Ah]<>noncrc16(map,i*0Ch) then error ; -final crc check

```

noncrc16: Uses the same polynomial as for CDROM subchannels, but with initial value FFFFh (instead 0) and with final value left un-inverted (instead of inverting it).

nonlzh_explode_tree: Uses the same concept as for LZH/ARJ huffman trees (it's storing only the number of bits per each codes, and the codes are then automatically assigned). But CHD is doing that backwards: It's starting with the biggest codes (instead of smallest codes). For example, if you have three codes with size 1, 2, 2. The traditional standard assignment would be 0, 10, 11. But CHD is instead assigning them as 00, 01, 1.

CHD Compression

COMPRESSION V1-V4 FORMAT 0 (UNCOMPRESSED)

COMPRESSION V5 0,0,0,0 (UNCOMPRESSED)

```
000h .. Uncompressed data
```

Uncompressed format can be selected in CHD Map entries (per hunk), and in CHD file header (per whole file).

COMPRESSION V1-V4 FORMAT 1 (ZLIB) (GENERIC DEFLATE)**COMPRESSION V1-V4 FORMAT 2 (ZLIB+) (GENERIC DEFLATE)****COMPRESSION V5 "ZLIB" (GENERIC DEFLATE)**

```
000h .. Deflate-compressed data
```

COMPRESSION V5 "LZMA" (GENERIC LZMA)

```
000h .. LZMA-compressed data (with lc=3, lp=0, pb=2) (without EOS end code)
```

COMPRESSION V5 "FLAC" (GENERIC FLAC)

```
000h 1   Output format for 16bit samples ("L"=Little-endian, "B"=Big-endian)
001h ..   FLAC-compressed data frame(s)
```

COMPRESSION V5 "HUFF" (GENERIC HUFFMAN)

```
000h .. Huffman-compressed data (small tree, large tree, plus data)
```

COMPRESSION V5 "CDZL" (CDROM DEFLATE+DEFLATE)

```
000h .. ECC Flags, (SectorsPerHunk+7)/8 bytes ;little-endian, bit0=1st flag
... 2/3 Size of compressed Data part (SIZ)      ;big-endian, 16bit or 24bit
... SIZ Deflate compressed Data part            ;uncompressed=930h*N bytes
... .. Deflate compressed Subchannel part       ;uncompressed=60h*N bytes
```

COMPRESSION V5 "CDLZ" (CDROM LZMA+DEFLATE)

```
000h .. ECC Flags, (SectorsPerHunk+7)/8 bytes ;little-endian, bit0=1st flag
... 2/3 Size of compressed Data part (SIZ)      ;big-endian, 16bit or 24bit
... SIZ LZMA compressed Data part              ;uncompressed=930h*N bytes
... .. Deflate compressed Subchannel part       ;uncompressed=60h*N bytes
```

COMPRESSION V5 "CDFL" (CDROM FLAC+DEFLATE)

```
000h .. FLAC-compressed Data Frame(s)          ;uncompressed=930h*N bytes
... .. Deflate compressed Subchannel part       ;uncompressed=60h*N bytes
```

COMPRESSION V5 "AVHU" (A/V MIXUP WITH HUFFMAN AND FLAC OR SO)

This isn't used on CDROMs and details are unknown/untested. It does reportedly exist in different versions, and does combine different compression methods for audio and video data.

COMPRESSION V4 FORMAT 3 (AV)

Unknown, maybe same/similar as "avhu".

COMPRESSION V3-V4 SECONDARY COMPRESSION METHOD (FLAC CDDA)

CHD source code claims that V3-V4 maps support "FLAC CDDA", but it doesn't actually seem to support that (audio discs compressed with chdman v0.145 are merely using Deflate).

CHD Compression for CDROMs

CDROM "CDZL" AND "CDLZ"

If the sector's ECC flag is set:

```
Fix the 0Ch-byte Sync mark at [000h..00Bh]
Fix the 114h-byte ECC data at [81Ch..92Fh] in relation to Mode at [00Fh]
Fixing just means to overwrite those values (there's no XOR-filter or so).
CHD doesn't filter EDC values, MM:SS:FF:Mode Sector headers, nor Subheaders.
```

The Size entry is 16bit (when $N \cdot 990h < 10000h$) or 24bit (when $N \cdot 990h \geq 10000h$), the size entry has no real purpose, however, it may be useful for:

```
decompressing the subchannel part without decompressing the whole data part,
and for using libraries that don't return the end of the compressed data part
```

CDROM "CDFL"

There are no ECC flags (since Audio sectors don't have ECC).

There is no size entry (one must decompress the whole FLAC part to find the begin of the Subchannel part).

The FLAC output is always stored in BIG-ENDIAN format (because CHD likes to use big-endian for audio sectors, unlike formats like CUE/BIN).

CDROM SUBCHANNEL DATA

The Data part and Subchannel part must be interleaved after decompression (to form 990h-byte sectors with 930h+60h bytes). The CHD map's CRC is then computed on that interleaved data.

Most CHD files use metadata SUBTYPE:NONE which means that the 60h-byte subchannel data is simply zerofilled and one must replace it by default Index/Position values (AFTER the above CRC check). The CHD metadata lacks accurate info about Index values; the PREGAP part is supposedly meant to have Index=0 and the remaining

sectors Index=1).

Although CHD files can contain subchannel data, CHDMAN has very limited support for creating such files (the most practical way seems to be to convert CCD/IMG/SUB to TOC/BIN and then convert that to CHD format).

CHD CDROM Sector Sizes

Decompressed CHD CDROM Sectors are always 990h bytes tall (930h+60h). However, the Metadata TYPE/SUBTYPE entries may specify smaller sizes (corresponding to the format of the original TOC/BIN or CUE/BIN image). CHD does arrange that data as so:

000h	Sector Data	(800h, 914h, 920h or 930h bytes)
...	Subchannel Data	(0 or 60h bytes)
...	Zeropadding to 990h-byte size	(0..190h bytes)

That is somewhat okay for V3/V4 files, but involves two design mistakes that conflict with the V5 format:

- The ECC-Filter works only for 930h-byte sectors (920h does also contain ECC, but CHD can't filter that, resulting in very bad compression ratio)
- The last 60h-byte are supposed to be Deflate-compressed Subchannel Data (but 800h..920h+60h sectors actually contain Zeropadding in that location)

Note: The CHD Map CRC checks are done on the above arrangement (including zeropadding, and any prior ECC-unfiltering).

After the CRC check, one must relocate the Sector/Subchannel parts to their actual locations (and replace zeropadding by actual Sync marks, header, sub-header, ECC/EDC, and Subchannel data as needed).

CHD Compression Methods

DEFLATE

This is raw Deflate (despite of being called "zlib" in chd headers and source code; there aren't any ZLIB headers nor Adler checksums). V1-V4 does distinguish between "zlib" and "zlib+" (both are using normal Deflate) (V3/V4 are always using "zlib+") (the "+" does probably just mean that file was compressed with improved compression ratio).

[CDROM File Compression ZIP/GZIP/ZLIB \(Inflate/Deflate\)](#)

LZMA

This contains a raw LZMA bitstream (without .lzma or .lz headers). The LZMA bitstream starts with 8 ignored bits, if Normalization occurs after last compression code, then it

will also end with 8 ignored bits (those ignored bits aren't CHD-specific, they do also occur in other LZMA-based formats).

CDROM File Compression LZMA

FLAC

The data consists of raw FLAC Frames (without FLAC file header or FLAC metadata blocks), the format is always signed 16bit/stereo (NumChannels=2 SampleDepth=16), the sample rate is don't care for compression purposes (the FLAC Frame headers have it set to 09h=44100Hz).

Each FLAC Frame starts with a 14bit Sync mark (3FFEh), and ends with 16bit CRC.

There are usually several FLAC frames per CHD hunk (one must decompress all FLAC frames, until reaching the decompressed hunk size).

Each FLAC Frame contains Left samples, followed by Right samples. After decompression, CHD does store them in interleaved form (L,R,L,R,etc.)

CDROM File Compression FLAC audio

HUFFMAN

This is using some custom CHD-specific Huffman compression.

```
decompress_chd_huffman_hunk:
    InitBitstream(src,BigEndianMsbFirst)                ;-init
    codesizes[0..17h]=00h                                ;initially all unused ;\
    codesizes[0]=GetBits(3)                               ;get first entry ;
    i=GetBits(3)+1                                         ;leading unused entries ; small
@@small_tree_lop:                                       ; tree
    val=GetBits(3)                                         ;
    if val=07h then goto @@small_tree_done                ;trailing unused entries ;
    codesizes[i]=val, i=i+1                               ;apply entry ;
    if i<18h then goto @@small_tree_lop                   ;
@@small_tree_done:                                     ;
    nonlzh_explode_tree(codetree,codesizes,18h)           ;/
    data=00h                                              ;\
@@large_tree_lop:                                       ;
    val=GetHuffCode(codetree)-1                           ;using small tree codes ; large
    if val>=00h then                                     ; tree
        data=val, codesizes[i]=data, i=i+1               ;
    else                                                 ;
        len=GetBits(3)+2                                  ;
        if len=7+2 then len=GetBits(8)+7+2              ;
        for n=1 to len, codesizes[i]=data1, i=i+1       ;
    if i<100h then goto @@large_tree_lop                 ;
    nonlzh_explode_tree(codetree,codesizes,100h)         ;/
    for n=1 to decompressed_size                         ;\data
        [dst]=GetHuffCode(codetree), dst=dst+1           ;using large tree codes ;/
    
```

CHD Notes

TRACK/HUNK PADDING AND MISSING INDEX0 SECTORS

A normal CDROM contains a series of sectors. The CHD format is violating that in several ways: It's removing Index0/Pregap sectors, and it's instead inserting dummy/padding sectors between tracks.

Track	<---- Track1----->			<---- Track2----->			<--End-->
Section	Index0	IndexN	TrackPad	Index0	IndexN	TrackPad	HunkPad
Real Disc	Yes	Yes	-	Yes	Yes	-	-
CHD Header	-	Yes	Yes	-	Yes	Yes	-
CHD Data	-	Yes	Yes	-	Yes	Yes	Yes

That is, the critical parts are:

```
Index0/pregap: Metadata PREGAP:sectors isn't stored in compressed data
Track padding: Metadata FRAMES:sectors is rounded up to N*4 sectors
Hunk padding:  The last hunk is additionally rounded up to hunksizes
```

Missing Index0 might be a problem if a disc contains nonzero data between tracks (like audio discs with applause in Index0 periods).

Track padding is total nonsense. The final hunk padding makes sense (but confusingly that extra padding isn't included in the uncompressed size entry in CHD header).

PARENT REFERENCES

Parent files are only used for writeable media like harddisks. The idea is to store the original installation and operating system in a readonly Parent file, and to store changes that file in a writeable Child file.

Unknown what determines which parent belongs to which child, and if parents can be nested with other grandparents. Anyways, Parents aren't needed for CDROMs (except, one could theoretically store CDROM patches in child files).

SELF REFERENCES

This can be used to reference to another identical hunk in the same file (eg. zero-filled sectors or other duplicated data). There are some restrictions for CDROMs: Data sector headers contain increasing sector numbers, so there won't be any identical sectors. However, Audio sectors can be identical (unless they are stored with subchannel info, which does also contain increasing sector numbers).

MINI

Mini is only used in V3/V4 maps. It does apparently store the "data" directly in the 8-byte Map offset field.

```
XXX Unknown what kind of "data" that is
(probably "normal compressed data", that happens to be 8 bytes or smaller).
```

Mini isn't used in V5 because the compressed V5 map doesn't contain any offset fields (and things like zerofilled sectors could be as well encoded as Self instead of Mini).

CHDMAN VERSIONS

CHD files can (cannot) be generated with the CHDMAN.EXE tool:

```
chdman hdr meta  features/requirements/bugs/quirks/failures...
v0.58  -  -  -  ; -CHD didn't exist in older MAME versions
v0.59  V1 -  -  -  ; \
v0.71  V2 -  -  -  ; supports harddisk CHD files only, not cdrom
v0.78  V3 xxxx -  -  ; /
v0.81  V3 CHCD bad ; -crashes after creating the CHD file header
v0.90  V3 CHCD ok  ; \
v0.110 V3 CHCD ok  ; requires cdrdao TOC/BIN as input (CUE/BIN does crash)
v0.111 V3 CHTR ok  ; (warning: BIN filenames may not contain space chars!)
v0.112 V3 CHTR bug ;      ; \works, but compression is somewhat bugged (files
v0.118 V3 CHTR bug ;      ; /are BIGGER instead of SMALLER after compression)
v0.120 V3 CHTR ok  ;
v0.130 V3 CHTR ok  ;
v0.131 V4 CHTR ok  ; /
v0.140 V4 CHT2 ok  ; \requires "unicows.dll" (=Quintessential Media Player)
v0.145 V4 CHT2 ok  ; /
v0.146 V5 CHT2 bad ; \says output file already exists (crashes on -f force)
v0.154 V5 CHT2 bad ; /
v0.155 V5 CHT2 bad ; \crashes instantly (shortly before CreateEventW)
v0.160 V5 CHT2 bad ; /
v0.161 V5 CHT2 bad ; \says output file already exists (crashes on -f force)
v0.169 V5 CHT2 bad ; /
v0.170 V5 CHT2 bad ; \missing KERNEL32.DLL:AddVectoredExceptionHandler
v0.217 V5 CHT2 bad ; /
v0.218 V5 CHT2 bad ; \requires "newer version of windows" (64bit)
v0.247 V5 CHT2 bad ; /
```

Note: The compression tool was originally called HDCOMP (V1/V2), and later renamed to CHDMAN (V3/V4/V5).

REFERENCES

CHD source code (see files cdrom.*, chd*.*, etc):

<https://github.com/mamedev/mame/tree/master/src/lib/util>

CHDMAN commandline tool for generating chd files:

<https://github.com/mamedev/mame/blob/master/src/tools/chdman.cpp>

CHD decompression clone with useful comments:

<https://github.com/SnowflakePowered/chd-rs/tree/master/chd-rs/src>

CHD format reverse-engineering thread:

<http://www.psxdev.net/forum/viewtopic.php?f=70&t=3980>

13.122 CDROM Disk Images Other Formats

.ISO - A raw ISO9660 image (can contain a single data track only)

Contains raw sectors without any sub-channel information (and thus it's restricted to the ISO filesystem region only, and cannot contain extras like additional audio tracks or additional sessions). The image should start at 00:02:00 (although I wouldn't be surprised if some \<might> start at 00:00:00 or so). Obviously, all sectors must have the same size, either 800h or 930h bytes (if the image contains only Mode1 or Mode2/Form1 sectors then 800h bytes would usually enough; if it contains one or more Mode2/Form2 sectors then all sectors should be 930h bytes).

Handling .ISO files does thus require to detect the image's sector size, and to search the sector that contains the first ISO Volume Descriptor. In case of 800h byte sectors it may be additionally required to detect if it is a Mode1 or Mode2/Form1 image; for PSX images (and any CD-XA images) it'd be Mode2.

.C2D

Something. Can contain compressed or uncompressed CDROM-images. Fileformat and compression ratio are unknown. Also unknown if it allows random-access.

Some info on (uncompressed) .C2D files can be found in libmirage source code.

.ISZ - compressed ISO file with 800h-byte sectors (UltraISO)

This contains a compressed ISO filesystem, without supporting any CD-specific features like Tracks, FORM2 sectors, or CD-DA Audio.

<http://www.ezbsystems.com/isz/iszspec.txt>

The format might be suitable for PC CDROMs, but it's useless for PSX CDROMs.

.MDX

Reportedly a "compressed" MDS/MDF file, supported by Daemon Tools.

Other info says that MDX is just MDS/MDF merged into a single file, without mentioning any kind of "compression" support.

Basically... Daemon Tools is Adware that can merge MDS+MDF into one MDX file... with additional Advertising?

However, the MDS+MDF format is completely different than MDX format:

```
000h 10h  ID ("MEDIA DESCRIPTOR") (weirdly, same as in Alcohol .MDS)
010h 2    Unknown (02h,01h) (maybe version or so)
012h 1Ah  Copyright string (A9h," 2000-2015 Disc Soft Ltd.")
02Ch 4    Unknown (FFFFFFFFh)
030h 4    Offset to Unknown Footer (322040h) (N*800h+40h)
034h 4    Unknown (0)
038h 4    Unknown (B0h)
03Ch 4    Unknown (0)
040h N*800h  Sector Data
322040h 270h Unknown (Advertising IDs? CRCs? Encrypted CUE sheet? Garbage?)
```

.CU2/.BIN

Custom format used by PSIO (an SD-card based CDROM-drive emulator connected to PSX expansion port). The .CU2 file is somewhat intended to be smaller and easier to parse than normal .CUE files, the drawback is that it's kinda non-standard, and doesn't support INDEX and ADSR information. A sample .CUE file looks as so:

```
ntracks 3
size      39:33:17
data1     00:02:00
track02   31:36:46
track03   36:03:17
;(insert 2 blanks lines here, and insert 1 leading space in next line)
trk end 39:37:17
```

All track numbers and MM:SS:FF values are decimal. The ASCII strings should be as shown above, but they are simple ignored by the PSIO firmware (eg. using "popcorn666" instead of "size" or "track02" should also work). The first track should be marked "data1", but PSIO ignores that string, too (it does always treat track 1 as data, and track 2-99 as audio; thus not supporting PSX games with multiple data tracks). The "trk end" value

should be equal to the "size" value plus 4 seconds (purpose is unknown, PSIO does just ignore the "trk end" value).

CU2 creation seems to require CDROM images in "CUE/BIN redump.org format" (with separate BIN files for each track), the CUE is then converted to a CU3 file (which is used only temporarily), until the whole stuff is finally converted to a CU2 file (and with all tracks in a single BIN file). Tools like RD2PSIO (aka redump2psio) or PSIO's own SYSCON.ZIP might help on doing some of those steps automatically.

Alongsides, PSIO uses a "multidisc.lst" file... for games that require more than one CDROM disc?

CD Image File Format (Xe - Multi System Emulator)

This is a rather crude file format, used only by the Xe Emulator. The files are meant to be generated by a utility called CDR (CD Image Ripper), which, in practice merely displays an "Unable to read TOC." error message.

The overall file structure is, according to "Xe User's Manual":

```
header: 200h bytes header (see below)
data:   990h bytes per sector (2352 Main, 96 Sub), 00:00:00->Lead Out
```

The header "definition" from the "Xe User's Manual" is as unclear as this:

```
000h  00
001h  00
002h  First Track
003h  Last Track
004h  Track 1 (ADR << 4) | CTRL      ;\
005h  Track 1 Start Minutes          ; Track 1
006h  Track 1 Start Seconds          ;
007h  Track 1 Start Frames           ;/
...      ...                        ; -Probably Further Tracks (?)
n+0     Last Track Start Minutes      ;\
n+1     Last Track Start Seconds      ; Last Track
n+2     Last Track Start Frames       ;
n+3     Last Track (ADR << 4) | CTRL   ;/
n+4     Lead-Out Track Start Minutes  ;\
n+5     Lead-Out Track Start Seconds  ; Lead-Out
n+6     Lead-Out Track Start Frames   ;
n+7     Lead-Out Track (ADR << 4) | CTRL ;/
...     00
1FFh    00
```

Unknown if MM:SS:FF values and/or First+Last Track numbers are BCD or non-BCD.

Unknown if Last track is separately defined even if there is only ONE track.

Unknown if Track 2 and up include ADR/Control (and if yes: where?).

Unknown if ADR/Control is really meant to be \<before> MM:SS:FF on Track 1.

Unknown if ADR/Control is really meant to be \<after> MM:SS:FF on Last+Lead-Out.

Unknown if this format does have a file extension (if yes: which?).

Unknown if subchannel data is meant to be interleaved or not.

The format supports only around max 62 tracks (in case each track is 4 bytes).

There is no support for "special" features like multi-sessions, cd-text.

14. Controllers and Memory Cards

Controllers/Memory Cards

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Controllers

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Memory Cards

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Pocketstation (Memory Card with built-in LCD screen and buttons)

[Pocketstation](#)

Pinouts

Pinouts - Controller Ports and Memory-Card Ports

14.1 Controller and Memory Card Overview

Controllers and memory cards connect to the console using a serial protocol and are accessed through SIO0 registers:

Serial Interfaces (SIO)

The protocol used is similar to standard SPI, with no start/stop bytes and no parity (even though SIO0 has support for it). Unlike typical SPI, only one byte is transferred at a time and a separate wire (/ACK) is used by the device to signal the PS1 that it is ready to exchange the next byte. For more details see:

Controller and Memory Card Signals

Device addressing

Each controller port and its respective memory card slot are wired in parallel, and the /CSn signals select both the controller and the memory card when asserted. This selection is narrowed down through a simple addressing scheme, where the first byte sent by the console after asserting /CSn is the address of the device that shall reply. All devices must keep the DAT line idle before receiving this byte. Once the address is sent, the device that was addressed shall pull /ACK low to signal its presence and start exchanging bytes.

The following addresses are known to be used:

Device	Address
Standard controller	01h
Yaroze Access Card	21h
PS2 multitap (incompatible with PS1)	21h
PS2 DVD remote receiver	61h
Memory card	81h

DSR (/ACK) Controller and Memory Card - Byte Received Interrupt

Gets set after receiving a data byte - that only if an /ACK has been received from the peripheral (ie. there will be no IRQ if the peripheral fails to send an /ACK, or if there's no peripheral connected at all).

Actually, DSR means "more-data-request", accordingly, it does NOT get triggered after receiving the LAST byte.

I_STAT.7 is edge triggered (that means it can be acknowledge before or after acknowledging SIO0_STAT.9). However, SIO0_STAT.9 is NOT edge triggered (that means it CANNOT be acknowledged while the external /IRQ input is still low; ie. one must first wait until SIO0_STAT.7=0, and then set SIO0_CTRL.4=1) (this is apparently a hardware glitch; note: the LOW duration is circa 100 clock cycles).

/IRQ10 (/IRQ) Controller - Lightpen Interrupt

Pin 8 on Controller Port. Routed directly to the Interrupt Controller (at 1F80107xh). There are no status/enable bits in the SIO0_registers (at 1F80104xh).

Plugging and Unplugging Cautions

During plugging and unplugging, the Serial Data line may be dragged LOW for a moment; this may also affect other connected devices because the same Data line is shared for all controllers and memory cards (for example, connecting a joypad in slot 1 may corrupt memory card accesses in slot 2).

Moreover, the Sony Mouse does power-up with /ACK=LOW, and stays stuck in that state until it is accessed at least once (by at least sending one 01h byte to its controller port); this will also affect other devices (as a workaround one should always access BOTH controller ports; even if a game uses only one controller, and, code that waits for /ACK=HIGH should use timeouts).

Emulation Note

After sending a byte, the Kernel waits 100 cycles or so, and does THEN acknowledge any old IRQ7, and does then wait for the new IRQ7. Due to that bizarre coding, emulators can't trigger IRQ7 immediately within 0 cycles after sending the byte.

BIOS Functions

Controllers can be probably accessed via InitPad and StartPad functions,

BIOS Joypad Functions

Memory cards can be accessed by the filesystem (with device names "bu00:" (slot1) and "bu10:" (slot2) or so). Before using that device names, it seems to be required to call InitCard, StartCard, and _bu_init (?).

Synchronous I/O

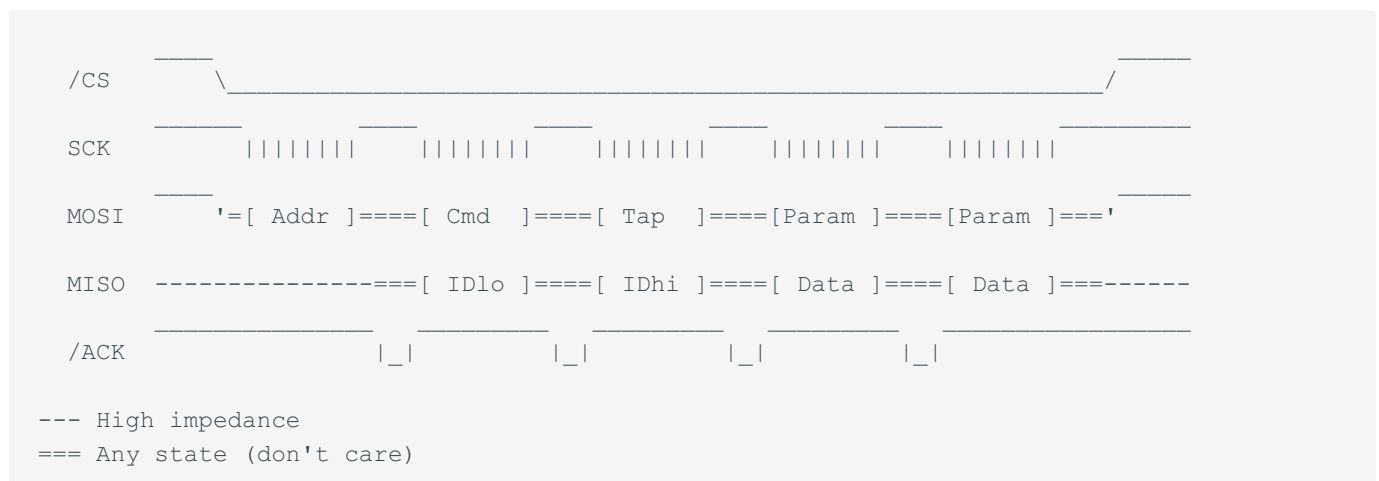
The data is transferred in units of bytes, via separate input and output lines. So, when sending byte, the hardware does simultaneously receive a response byte.

One exception is the address byte (which selects either the controller, or the memory card) until that byte has been sent, neither the controller nor memory card are selected (and so the first "response" byte should be ignored; probably containing more or less stable high-z levels).

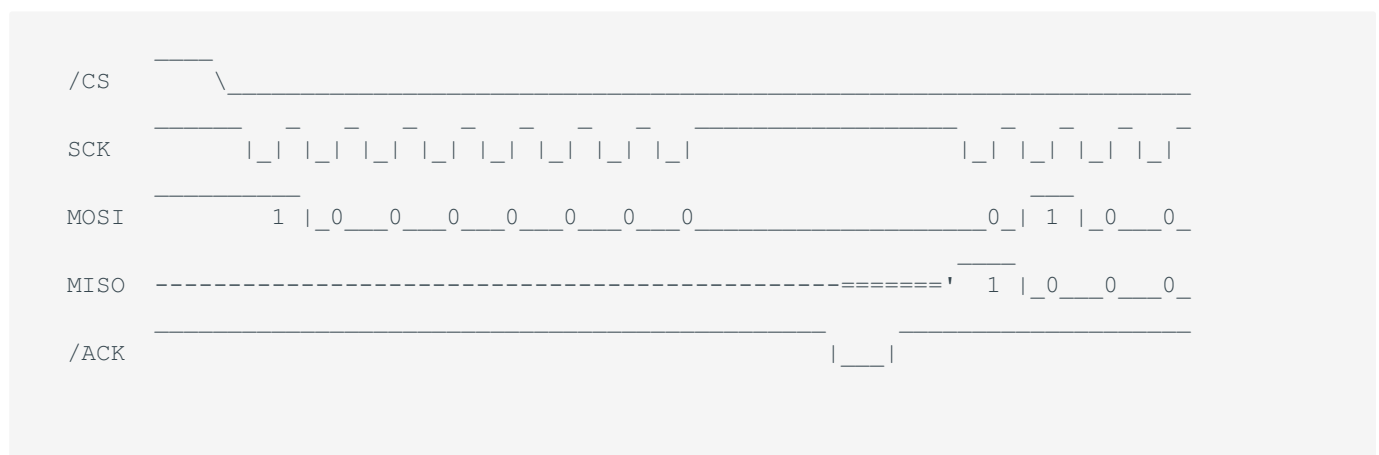
The other exception is, when you have send all command bytes, and still want to receive further data, then you'll need to send dummy command bytes (should be usually 00h) to receive the response bytes.

14.2 Controller and Memory Card Signals

Overview



Address byte (01h) being sent



```

--- High impedance
=== Any state (don't care)

```

Notes:

- All bytes are sent LSB first.
- The standard baud rate used by the kernel is ~250 kHz. Some controllers and memory cards may work with faster rates, but others will not.
- The clock polarity is high-when-idle (sometimes referred to as CPOL=1). Each bit is output on a falling clock edge and sampled by the other end on the rising clock edge that follows it (CPHA=1).
- The device has to pull /ACK low for at least 2 μ s to request the host to transfer another byte. Once the last byte of the packet is transferred, the device shall no longer pulse /ACK.
- The kernel's controller driver will time out if /ACK is not pulled low by the device within 100 μ s from the last SCK pulse. It will also ignore /ACK pulses sent within the first 2-3 μ s (100 cycles) of the last SCK pulse.
- Devices should not respond immediately when /CS is asserted, but should wait for the address byte to be sent and only send an /ACK pulse back and start replying with data if the address matches.

14.3 Controller and Memory Card Multitap Adaptor

SCPH-1070 (Multitap)

The Multitap is an external adaptor that allows to connect 4 controllers, and 4 memory cards to one controller port. When using two adaptors (one on each slot), up to 8 controllers and 8 memory cards can be used.

Multitap Controller Access

Normally joystick reading is done by sending this bytes to the pad:

```
01 42 00 00 .. ;normal read
```

And with the multitap, there are even two different ways how to access extra pads:

```
01 42 01 00 .. ;method 1: receive special ID and data from ALL four pads
0n 42 00 00 .. ;method 2: receive data from pad number "n" (1..4)
```

The first method seems to be the more commonly used one (and its special ID is also good for detecting the multitap); see below for details.

The second method works more like "normal" reads, among other it's allowing to transfer more than 4 halfwords per slot (unknown if any existing games are using that feature).

The IRQ10 signal (for Konami Lightguns) is simply wired to all four slots via small resistors (without special logic for activating/deactivating the IRQ on certain slots).

Multitap Controller Access, Method 1 Details

Below LONG response is activated by sending "01h" as third command byte; observe that sending that byte does NOT affect the current response. Instead, it does request that the NEXT command shall return special data, as so:

```
Halfword 0      --> Controller ID for MultiTap (5A80h=Multitap)
Halfword 1..4   --> Player A (Controller ID, Buttons, Analog Inputs, if any)
Halfword 5..8   --> Player B (Controller ID, Buttons, Analog Inputs, if any)
Halfword 9..12  --> Player C (Controller ID, Buttons, Analog Inputs, if any)
Halfword 13..16 --> Player D (Controller ID, Buttons, Analog Inputs, if any)
```

With this method, the Multitap is always sending 4 halfwords per slot (padded with FFFFh values for devices like Digital Joypads and Mice; which do use less than 4 halfwords); for empty slots it's padding all 4 halfwords with FFFFh.

Sending the request is possible ONLY if there is a controller in Slot A (if controller Slot A is empty then the Slot A access aborts after the FIRST byte, and it's thus impossible to send the request in the THIRD byte).

Sending the request works on access to Slot A, trying to send another request during the LONG response is glitchy (for whatever strange reason); one must thus REPEATEDLY do TWO accesses: one dummy Slot A access (with the request), followed by the long Slot A+B+C+D access.

```
Previous access had REQ=0 and returned Slot A data ---> returns Slot A data
Previous access had REQ=0 and returned Slot A-D data -> returns Slot A data
Previous access had REQ=1 and returned Slot A data ---> returns Slot A-D data
Previous access had REQ=1 and returned Slot A-D data -> returns garbage
Previous access had REQ=1 and returned garbage -----> returns Slot A-D data
```

In practice:

Toggleing REQ on/off after each command: Returns responses toggling between normal Slot A data and long Slot A+B+C+D data.

Sending REQ=1 in ALL commands: Returns responses toggling between Garbage and long Slot A+B+C+D data.

Both of the above is working (one needs only the Slot A+B+C+D part, and it doesn't matter if the other part is Slot A, or Garbage; as long as the software is able/aware of ignoring the Garbage). Garbage response means that the multitap returns ONLY four bytes, like so: Hiz,80h,5Ah,LSB (ie. the leading HighZ byte, the 5A80h Multitap ID, and the LSB of the Slot A controller ID), and aborts transfer after that four bytes.

Multitap Memory Card Access

Normally memory card access is done by sending this bytes to the card:

```
80 xx .. .. ;normal access
```

And with the multitap, memory cards can be accessed as so:

```
8n xx .. .. ;access memory card in slot "n" (1..4)
```

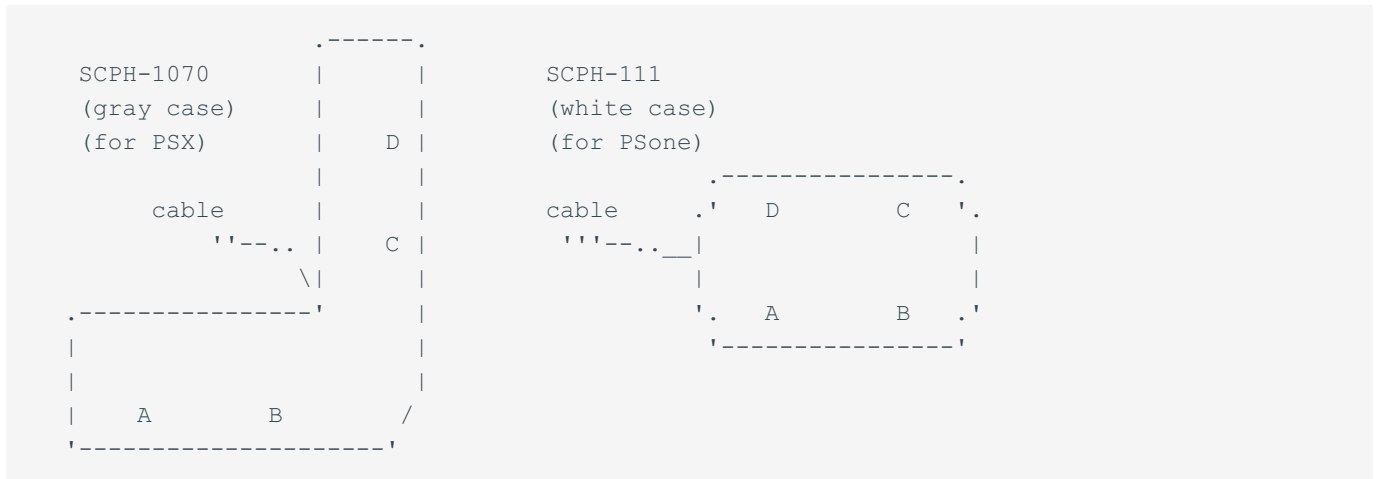
That's the way how its done in Silent Hill. Although for the best of confusion, it doesn't actually work in that game (probably the developer has just linked in the multitap library, without actually supporting the multitap at higher program levels).

Multitap Games

```
Bomberman / Bomberman Party Edition (requires Multitap on Port 2 instead of 1)
Bomberman World
Breakout: Off the Wall Fun
Circuit Breakers
Crash Team Racing
FIFA series soccer games
Frogger
Gauntlet: Dark Legacy
Hot Shots Golf 2 & 3
Jigsaw Island: Japan Graffiti / Jigsaw Madness (requires Multitap on Port 2 instead of
1)
NBA Live (any year) (up to 8 players with two multitaps)
Need For Speed 3
Need For Speed 5
Poy Poy (4 players hitting each other with rocks and trees)
Running Wild
S.C.A.R.S. (requires Multitap on Port 2 instead of 1)
Zen Nippon Pro Wrestling: Ouja no Tamashii (requires Multitap on Port 2 instead of 1)
```

Most Multitap games supporting up to 4 or 5 controllers require the device to be plugged into Port 1, but a small number of games strangely require the device to be plugged into Port 2 instead.

Multitap Versions



The cable connects to one of the PSX controller ports (which also carries the memory card signals). The PSX memory card port is left unused (and is blocked by a small edge on the Multitap's plug).

MultiTap Parsed Controller IDs

Halfword 0 is parsed (by the BIOS) as usually, ie. the LSB is moved to MSB, and LSB is replaced by status byte (so ID 5A80h becomes 8000h=Multitap/okay, or 0xFFh=bad). Halfwords 1,5,9,13 are NOT parsed (neither by the BIOS nor by the Multitap hardware), however, some info in the internet is hinting that Sony's libraries might be parsing these IDs too (so for example 5A41h would become 4100h=DigitalPad/okay, or 0xFFh=bad).

Power Supply

The Multitap is powered by the PSX controller port. Unknown if there are any power supply restrictions (up to eight controllers and eight cards may scratch some limits, especially when doing things like activating rumble on all joypads). However, the Multitap hardware itself doesn't do much on supply restrictions (+3.5V is passed through something; maybe some fuse, loop, or 1 ohm resistor or so) (and +7.5V is passed without any restrictions).

PS2 multitap

Sony made a multitap adapter for the PS2, however it is not compatible with the PS1 as it plugs into both the controller and memory card ports (which are not wired in parallel on the PS2). The protocol is also different: rather than modifying packets it seems to act as a mostly-passive port multiplexer, accepting switching commands with address 61h. Unknown if the PS2 multitap is backwards compatible with the SCPH-1070 protocol.

See also

[Pinouts - Component List and Chipset Pin-Outs for Multitap, SCPH-1070](#)

14.4 Controllers - Communication Sequence

Controller Communication Sequence

```

Send Reply Comment
01h  Hi-Z  Controller address
42h  idlo  Receive ID bit0..7 (variable) and Send Read Command (ASCII "B")
TAP  idhi  Receive ID bit8..15 (usually/always 5Ah)
MOT  swlo  Receive Digital Switches bit0..7
MOT  swhi  Receive Digital Switches bit8..15
--- transfer stops here for digital pad (or analog pad in digital mode) ---
00h  adc0  Receive Analog Input 0 (if any) (eg. analog joystick or mouse)
00h  adc1  Receive Analog Input 1 (if any) (eg. analog joystick or mouse)
--- transfer stops here for analog mouse -----
00h  adc2  Receive Analog Input 2 (if any) (eg. analog joystick)
00h  adc3  Receive Analog Input 3 (if any) (eg. analog joystick)
--- transfer stops here for analog pad (in analog mode) -----
--- transfer stops here for nonstandard devices (steering/twist/paddle) ---

```

The TAP byte should be usually zero, unless one wants to activate Multitap (multi-player mode), for details, see

[Controller and Memory Card Multitap Adaptor](#)

The two MOT bytes are meant to control the rumble motors (for normal non-rumble controllers, that bytes should be 00h), however, the MOT bytes have no effect unless rumble is enabled via config commands, for details, see

[Controllers - Configuration Commands](#)

[Controllers - Vibration/Rumble Control](#)

Controller ID (Halfword Number 0)

```

0-3  Number of following halfwords (01h..0Fh=1..15, or 00h=16 halfwords)
4-7  Controller Type (or currently selected Controller Mode)
8-15 Fixed (5Ah)

```

Known 16bit ID values are:

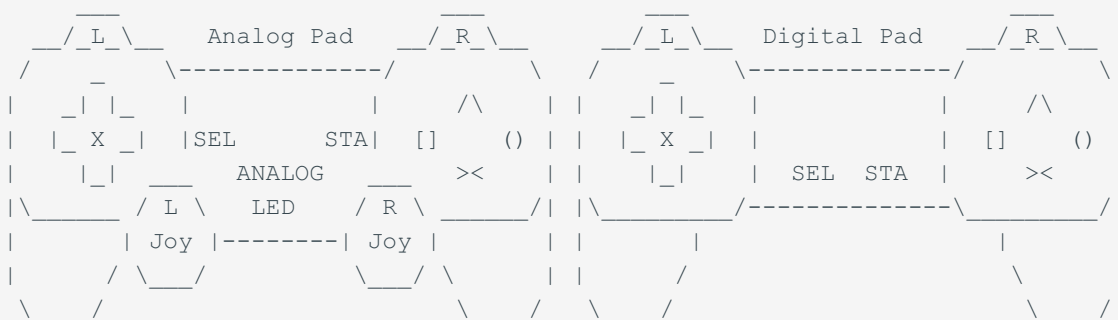
```

xx00h=N/A                (initial buffer value from InitPad BIOS function)
5A12h=Mouse               (two button mouse)
5A23h=NegCon              (steering twist/wheel/paddle)
5A31h=Konami Lightgun     (IRQ10-type)
5A41h=Digital Pad         (or analog pad/stick in digital mode; LED=Off)
5A53h=Analog Stick        (or analog pad in "flight mode"; LED=Green)
5A63h=Namco Lightgun      (Cinch-type)
5A73h=Analog Pad          (in normal analog mode; LED=Red)
5A7xh=Dualshock2          (with variable number of inputs enabled)
5A79h=Dualshock2          (with all analog/digital inputs enabled)
5A80h=Multitap            (multiplayer adaptor) (when activated)
5A96h=Keyboard            (rare lightspan keyboard)
5AE3h=Jogcon              (steering dial)
5AE8h=Keyboard/Sticks     (rare homebrew keyboard/segasticks adaptor)
5AF3h=Config Mode         (when in config mode; see rumble command 43h)
FFFFh=High-Z              (no controller connected, pins floating High-Z)

```

The PS2 DVD remote receiver identifies as either 5A41h (i.e. a digital controller) when polled using standard controller commands, or 5A12h when using address 61h to access the IR functionality.

14.5 Controllers - Standard Digital/Analog Controllers



Standard Controllers

```

__Halfword 0 (Controller Info)____
0-15  Controller Info (5A41h=digital, 5A73h=analog/pad, 5A53h=analog/stick)
__Halfword 1 (Digital Switches)____
0  Select Button      (0=Pressed, 1=Released)
1  L3/Joy-button      (0=Pressed, 1=Released/None/Disabled) ;analog mode only

```

```

2   R3/Joy-button      (0=Pressed, 1=Released/None/Disabled) ;analog mode only
3   Start Button       (0=Pressed, 1=Released)
4   Joypad Up          (0=Pressed, 1=Released)
5   Joypad Right       (0=Pressed, 1=Released)
6   Joypad Down        (0=Pressed, 1=Released)
7   Joypad Left        (0=Pressed, 1=Released)
8   L2 Button          (0=Pressed, 1=Released) (Lower-left shoulder)
9   R2 Button          (0=Pressed, 1=Released) (Lower-right shoulder)
10  L1 Button          (0=Pressed, 1=Released) (Upper-left shoulder)
11  R1 Button          (0=Pressed, 1=Released) (Upper-right shoulder)
12  /\ Button         (0=Pressed, 1=Released) (Triangle, upper button)
13  () Button         (0=Pressed, 1=Released) (Circle, right button)
14  >< Button         (0=Pressed, 1=Released) (Cross, lower button)
15  [] Button         (0=Pressed, 1=Released) (Square, left button)
__Halfword 2 (Right joystick) (analog pad/stick in analog mode only)_____
0-7   adc0 RightJoyX (00h=Left, 80h=Center, FFh=Right)
8-15  adc1 RightJoyY (00h=Up, 80h=Center, FFh=Down)
__Halfword 3 (Left joystick) (analog pad/stick in analog mode only)_____
0-7   adc2 LeftJoyX (00h=Left, 80h=Center, FFh=Right)
8-15  adc3 LeftJoyY (00h=Up, 80h=Center, FFh=Down)
__Further Halfword(s) (Dualshock2 only, and only if enabled)_____
0-7   ..   Analog Button (if enabled) (00h=Released, FFh=Max Pressure)
8-15  ..   Analog Button (if enabled) (00h=Released, FFh=Max Pressure)
..    ..    ..

```

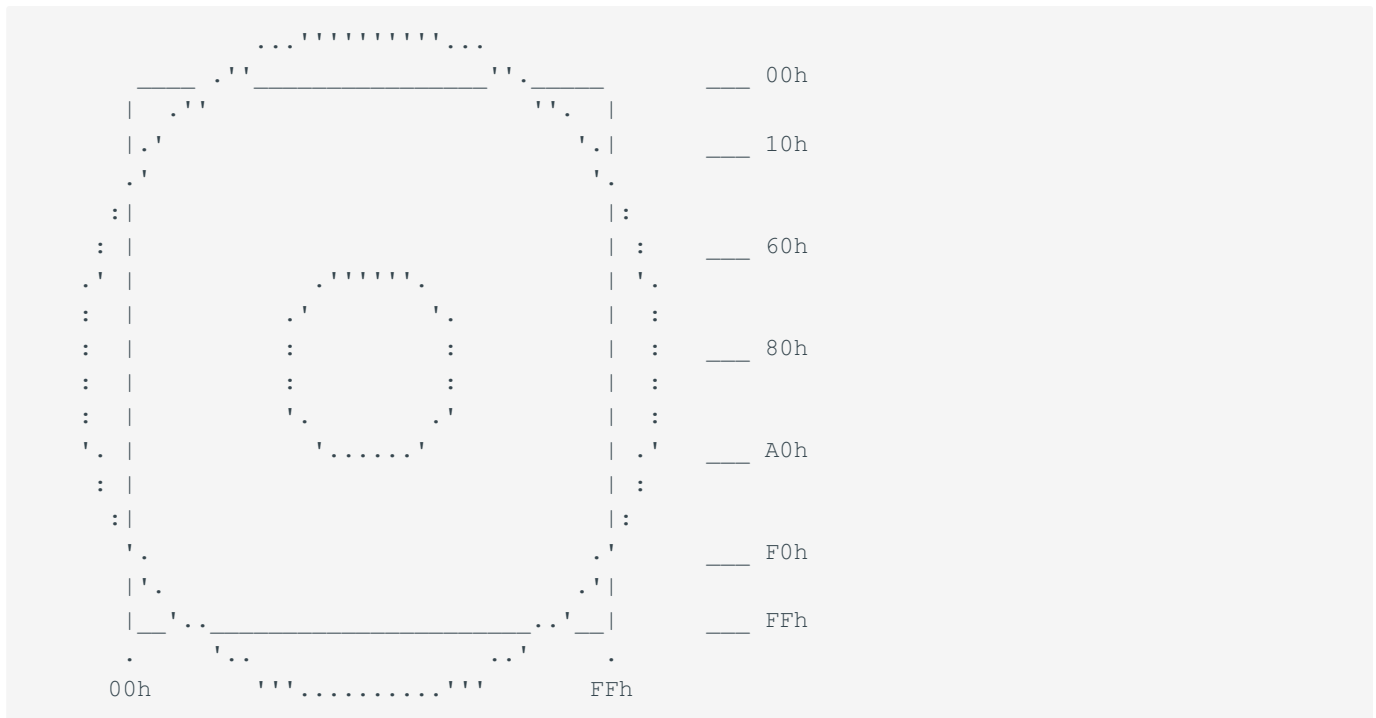
Analog Mode Note

On power-up, the controllers are in digital mode (with analog inputs disabled). Analog mode can be (de-)activated manually by pushing the Analog button. Alternately, analog mode can be (de-)activated by software via rumble configuration commands (though that's supported only on newer pads; those with two rumble motors). It is essential that emulators and any third-party hardware have a way of manually toggling analog mode, similar to original analog controllers, as certain games like Gran Turismo 1 will not attempt to enter analog mode on their own, even if they support analog controls and detect an analog controller.

Since analog pads boot in digital mode and will return the same ID byte as digital controllers, the most common way of distinguishing between the 2 is to send a Dualshock-only command (Typically command 43h - enter/exit config mode) and seeing how the controller responds to it.

The analog sticks are mechanically restricted to a "circular field of motion" (most joypads can reach "min/max" values only in "straight" horizontal or vertical directions, but not in "diagonal" directions).

Analog Joypad Range



Big Circle --> Mechanically possible field of motion
 Square Area --> Digitally visible 8bit field of motion
 Small Circle --> Resting position when releasing the joystick

Example min/center/max values for three different pads:

SCPH-1150	Min=(00,00), Mid: (72..90,79..AC), Max=(FF,FF) at 25'C
SCPH-1200	Min=(0E,0E), Mid: (6C..8A,75..79), Max=(ED,ED) at 16'C
SCPH-110	Min=(11,11), Mid: (8A..9F,70..96), Max=(FD,FD) at 16'C

Values may vary for other pads and/or different temperatures.

Dual Analog Pad in LED=Green Mode

Basically same as normal analog LED=Red mode, with following differences:

ID is 5A53h (identifying itself as analog stick) (rather than analog pad)
 Left/right joy-buttons disabled (as for real analog stick, bits are always 1)
 Some buttons are re-arranged: bit9=L1 bit10=[] bit11=/\ bit12=R1 bit15=R2

Concerning the button names, the real analog-stick does NOT have re-arranged buttons (eg. it's L1 button is in bit10), however, concerning the button locations, the analog stick's buttons are arranged completely differently as on analog pads (so it might be rather uncomfortable to play analog stick games on analog pads in LED=Red mode; the LED=Green mode is intended to solve that problem).

Might be useful for a few analog-stick games like MechWarrior 2, Ace Combat 2, Descent

Maximum, and Colony Wars. In most other cases the feature is rather confusing (that's probably why the LED=Green mode wasn't implemented on the Dual Shock).

See also

[Pinouts - Component List and Chipset Pin-Outs for Digital Joypad, SCPH-1080](#)
[Pinouts - Component List and Chipset Pin-Outs for Analog Joypad, SCPH-1150](#)
[Pinouts - Component List and Chipset Pin-Outs for Analog Joypad, SCPH-1200](#)
[Pinouts - Component List and Chipset Pin-Outs for Analog Joypad, SCPH-110](#)

14.6 Controllers - Mouse

Sony Mouse Controller

```

__Halfword 0 (Controller Info)____
0-15  Controller Info  (5A12h=Mouse)
__Halfword 1 (Mouse Buttons)____
0-7   Not used        (All bits always 1)
8-9   Unknown          (Seems to be always 0) (maybe SNES-style sensitivity?)
10    Right Button     (0=Pressed, 1=Released)
11    Left Button      (0=Pressed, 1=Released)
12-15 Not used        (All bits always 1)
__Halfword 2 (Mouse Motion Sensors)____
0-7   Horizontal Motion (-80h..+7Fh = Left..Right) (00h=No motion)
8-15  Vertical Motion   (-80h..+7Fh = Up..Down)   (00h=No motion)

```

Sony Mouse Hardware Bug on Power-On

On Power-on (or when newly connecting it), the Sony mouse does draw /ACK to LOW on power-on, and does then hold /ACK stuck in the LOW position.

For reference: Normal controllers and memory cards set /ACK=LOW only for around 100 clk cycles, and only after having received a byte from the console.

The /ACK pin is shared for both controllers and both memory cards, so the stuck /ACK is also "blocking" all other connected controllers/cards. To release the stuck /ACK signal: Send a command (at least one 01h byte) to both controller slots.

Sony Mouse Compatible Games

```

3D Lemmings
Alien Resurrection
Area 51
Ark of Time

```

Atari Anniversary Edition
 Atlantis: The Lost Tales
 Breakout: Off the Wall Fun
 Broken Sword: The Shadow of the Templars
 Broken Sword II: The Smoking Mirror
 Clock Tower: The First Fear
 Clock Tower II: The Struggle Within
 Command & Conquer: Red Alert
 Command & Conquer: Red Alert - Retaliation
 Constructor (Europe)
 Die Hard Trilogy
 Die Hard Trilogy 2: Viva Las Vegas
 Discworld
 Discworld II: Missing Presumed...!?
 Discworld Noir
 Dune 2000
 Final Doom
 Galaxian 3
 Ghoul Panic
 Klaymen Klaymen: Neverhood no Nazon (Japan)
 Lemmings and Oh No! More Lemmings
 Monopoly
 Music 2000
 Myst
 Neorude (Japan)
 Perfect Assassin
 Policenauts (Japan)
 Puchi Carat
 Quake II
 Railroad Tycoon II
 Rescue Shot
 Risk
 Riven: The Sequel to Myst
 RPG Maker
 Sentinel Returns
 SimCity 2000
 Syndicate Wars
 Tempest 2000 (Tempest X3)
 Theme Aquarium (Japan)
 Transport Tycoon
 Warhammer: Dark Omen
 Warzone 2100
 X-COM: Enemy Unknown
 X-COM: Terror from the Deep
 Z

Note: There are probably many more mouse compatible games.

Certain games, mostly FPS games such as Quake II and Doom, have players plug a standard digital/analog pad in port 1 and a mouse in port 2. This way, players can use the mouse for aiming and shooting, while the pad can be used for moving, reloading, and so on.

Sony Mouse Component List

PCB "TD-T41V/\, MITSUMI"

Component Side:

```
1x 3pin    4.00MHz "[M]4000A, 85 2"
2x 2pin    button (left/right)
1x 8pin    connector (to cable with shield and 7 wires)
1x 3pin    "811, T994I"
2x 3pin    photo transistor (black) ;\or so, no idea which one is
2x 2pin    photo diode (transparent) ;/sender and which is sensor
1x 2pin    electrolyt capacitor 16V, 10uF
```

Solder/SMD Side:

```
1x 32pin   "(M), SC442116, FB G22K, JSAA815B"
1x 14pin   "BA10339F, 817 L67" (Quad Comparator)
2x 3pin    "LC" (amplifier for photo diodes)
1x 3pin    "24-" (looks like a dual-diode or so)
plus many SMD resistors/capacitors
```

Cable:

```
PSX.Controller.Pin1 DAT    ---- brown  -- Mouse.Pin4
PSX.Controller.Pin2 CMD    ---- red    -- Mouse.Pin3
PSX.Controller.Pin3 +7.5V  ---- N/A
PSX.Controller.Pin4 GND    ---- orange -- Mouse.Pin7 GND (G)
PSX.Controller.Pin5 +3.5V  ---- yellow -- Mouse.Pin1
PSX.Controller.Pin6 /CSn   ---- green  -- Mouse.Pin5
PSX.Controller.Pin7 SCK    ---- blue   -- Mouse.Pin2
PSX.Controller.Pin8 /IRQ   ---- N/A
PSX.Controller.Pin9 /ACK   ---- purple  -- Mouse.Pin6
PSX.Controller.Shield ----- shield  -- Mouse.Pin8 GND (SHIELD)
```

PS/2 and USB Mouse Adaptors

Some keyboard adaptors are also including a mouse adaptor feature (either by simulating normal Sony Mouse controller data, or via more uncommon ways like using the PSX expansion port).

[Controllers - Keyboards](#)

RS232 Mice

Below is some info on RS232 serial mice. That info isn't directly PSX related as the PSX normally doesn't support those mice.

With some efforts, one can upgrade the PSX SIO port to support RS232 voltages, and

with such a modded console one could use RS232 mice (in case one wants to do that). The nocash PSX bios can map a RS232 mouse to a spare controller slot (thereby simulating a Sony mouse), that trick may work with various PSX games.

Standard Serial Mouse

A serial mouse should be read at 1200 bauds, 7 data bits, no parity, 1 stop bit (7N1) with DTR and RTS on. For best compatibility, the mouse should output 2 stop bits (so it could be alternately also read as 7N2 or 8N1). When the mouse gets moved, or when a button gets pressed/released, the mouse sends 3 or 4 characters:

```

__First Character__
6   First Character Flag (1)
5   Left Button  (1=Pressed)
4   Right Button (1=Pressed)
2-3 Upper 2bit of Vertical Motion
0-1 Upper 2bit of Horizontal Motion
__Second Character__
6   Non-first Character Flag (0)
5-0 Lower 6bit of Horizontal Motion
__Third Character__
6   Non-first Character Flag (0)
5-0 Lower 6bit of Vertical Motion
__Fourth Character (if any)__
6   Non-first Character Flag (0)
5   Middle Button (1=Pressed)
4   Unused ???
3-0 Wheel  ???

```

Additionally, the mouse outputs a detection character (when switching RTS (or DTR?) off and on:

```

"M" = Two-Button Mouse (aka "Microsoft" mouse)
"3" = Three-Button Mouse (aka "Logitech" mouse)
"Z" = Mouse-Wheel

```

Normally, the detection response consist of a single character (usually "M"), though some mice have the "M" followed by 11 additional characters of garbage or version information (these extra characters have bit6=0, so after detection, one should ignore all characters until receiving the first data character with bit6=1).

Mouse Systems Serial Mouse (rarely used)

Accessed at 1200 bauds, just like standard serial mouse, but with 8N1 instead 7N1, and with different data bytes.

```

__First Byte__
7-3  First Byte Code (10000b)
2    Left? Button   (0=Pressed)
1    Middle? Button (0=Pressed)
0    Right? Button  (0=Pressed)
__Second Byte__
7-0  Horizontal Motion (X1)
__Third Byte__
7-0  Vertical Motion   (Y1)
__Fourth Byte__
7-0  Horizontal Motion (X2)
__Fifth Byte__
7-0  Vertical Motion   (Y2)

```

The strange duplicated 8bit motion values are usually simply added together, ie. $X=X1+X2$ and $Y=Y1+Y2$, producing 9bit motion values.

Notes

The Sony Mouse connects directly to the PSX controller port. Alternately serial RS232 mice can be connected to the SIO port (with voltage conversion adaptor) (most or all commercial games don't support SIO mice, nor does the original BIOS do so, however, the nocash BIOS maps SIO mice to unused controller slots, so they can be used even with commercial games; if the game uses BIOS functions to read controller data). Serial Mice (and maybe also the Sony mouse) do return raw mickeys, so effects like double speed threshold must (should) be implemented by software. Mice are rather rarely used by PSX games. The game "Perfect Assassin" includes ultra-crude mouse support, apparently without threshold, and without properly matching the cursor range to the screen resolution.

14.7 Controllers - Racing Controllers

neGcon Racing Controller (Twist) (NPC-101/SLPH-00001/SLEH-0003)

```

__Halfword 0 (Controller Info)__
0-15  Controller Info  (5A23h=neGcon)
__Halfword 1 (Digital Switches)__
0-2    Not used        (always 1)      (would be Select, L3, R3 on other pads)

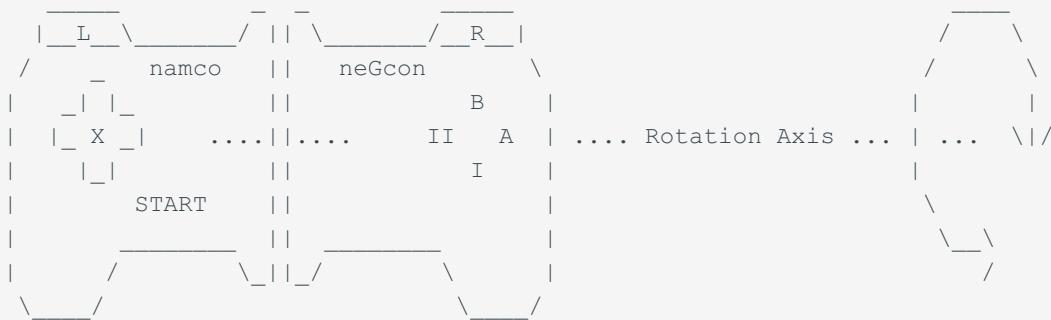
```

```

3      Start Button    (0=Pressed, 1=Released)
4      Joypad Up      (0=Pressed, 1=Released)
5      Joypad Right   (0=Pressed, 1=Released)
6      Joypad Down    (0=Pressed, 1=Released)
7      Joypad Left    (0=Pressed, 1=Released)
8-10   Not used       (always 1)           (would be L2, R2, L1 on other pads)
11     R Button       (0=Pressed, 1=Released) (would be R1 on other pads)
12     B Button       (0=Pressed, 1=Released) (would be /\ on other pads)
13     A Button       (0=Pressed, 1=Released) (would be () on other pads)
14-15  Not used       (always 1)           (would be ><, [] on other pads)
__Halfword 2 (Right joystick) (analog pad/stick in analog mode only)_____
0-7    Steering Axis   (00h=Left, 80h=Center, FFh=Right) (or vice-versa?)
8-15   Analog I button (00h=Out ... FFh=In) (Out=released, in=pressed?)
__Halfword 3 (Left joystick) (analog pad/stick in analog mode only)_____
0-7    Analog II button (00h=Out ... FFh=In) (Out=released, in=pressed?)
8-15   Analog L button (00h=Out ... FFh=In) (Out=released, in=pressed?)

```

The Twist controller works like a paddle or steering wheel, but doesn't have a wheel or knob, instead, it can be twisted: To move into one direction (=maybe right?), turn its right end away from you (or its left end towards you). For the opposite direction (=maybe left?), do it vice-versa.



Namco Volume Controller (a paddle with two buttons) (SLPH-00015)

This is a cut-down variant of the neGcon, just a featureless small box. It does have the same ID value as neGcon (ID=5A23h), but, it excludes most digital, and all analog buttons.

```

| namco |      Halfword 1 (digital buttons):
|       |      Bit3  Button A (0=Pressed) (aka neGcon Start button)
| A  B  |      Bit13 Button B (0=Pressed) (aka neGcon A button aka () button)
|       |      Other bits      (not used, always 1)
|       |      Halfword 2 and 3 (analog inputs):
| ( )  |      Steering Axis   (00h..FFh)   (as for neGcon)
|_____|      Analog I,II,L button values (not used, always 00h)

```

SANKYO N.ASUKA aka Nasca Pachinco Handle (SLPH-00007)

Another cut-down variant of the neGcon (with ID=5A23h, too). But, this one seems to have only one button. Unlike Namco's volume controller it doesn't look featureless. It looks pretty much as shown in the ascii-arts image below. Seems to be supported by several irem titles. No idea what exactly it is used for, it's probably not a sewing machine controller, nor an electronic amboss.

|_ / _ \

|_ / ()

|_ | _____

_____ |

| _____

Halfword 1 (digital buttons):

Bit12 Button (0=Pressed) (aka neGcon B button aka /\ button)

Other bits (not used, always 1)

Halfword 2 and 3 (analog inputs):

Steering Axis (00h..FFh) (as for neGcon)

Analog I,II,L button values (not used, always 00h)

Mad Catz Steering Wheel (SLEH-0006)

A neGcon compatible controller. The Twist-feature has been replaced by a steering wheel (can be turned by 270 degrees), and the analog I and II buttons by foot pedals. The analog L button has been replaced by a digital button (ie. in neGcon mode, the last byte of the controller data can be only either 00h or FFh). When not using the pedals, the I/II buttons on the wheel can be used (like L button, they aren't analog though).

/ \

/ () \

/ I \

/ \ II \

| | \ L _

| |) _ |

| | | _ X _

| | | _

| | \

\ \ /

\ \ /

| _____

Stick

()

A \ \ /

B /\ \ |

R / | | |

(| | _

| | | |

| | | /

/ | | /

\ \ /

\ \ /

Brakes Gas

II I

| | |

|!!!|_!!!|

/|!!!| |!!!|/

/ | | | /

/ ===== /

/ ===== /

/ _____ /

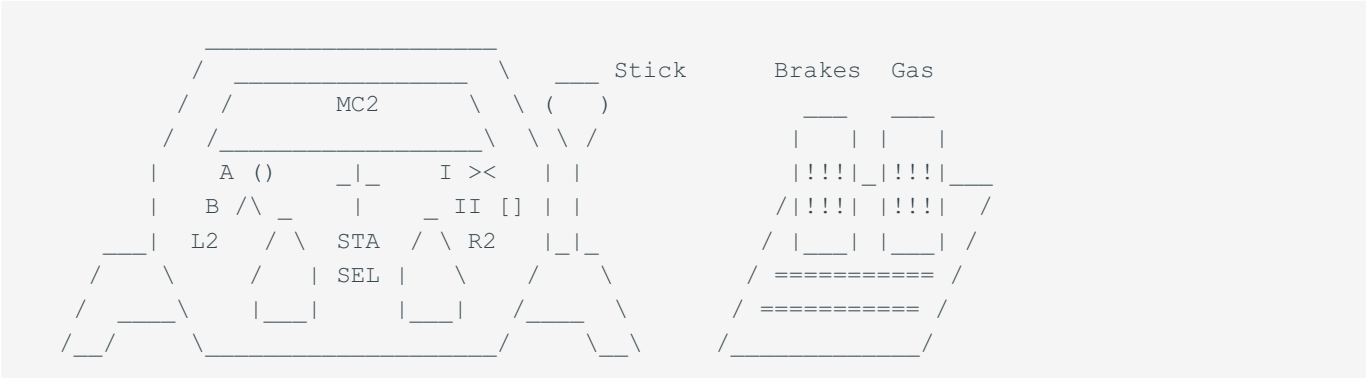
Unlike the neGon, the controller has Select, >\< and [] buttons, and a second set of L/R buttons (at the rear-side of the wheel) (no idea if L1/R1 or L2/R2 are at front?). Aside from the neGcon mode, the controller can be also switched to Digital mode (see below for button chart).

MadCatz Dual Force Racing Wheel

Same as above, but with a new Analog mode (additionally to Digital and neGcon modes). The new mode is for racing games that support only Analog Joypads (instead of neGcon). Additionally it supports vibration feedback.

MadCatz MC2 Vibration compatible Racing Wheel and Pedals

Same as above, but with a redesigned wheel with rearranged buttons, the digital pad moved to the center of the wheel, the L/R buttons at the rear-side of the wheel have been replaced by 2-way butterfly buttons ("pull towards user" acts as normal, the new "push away from user" function acts as L3/R3).



MadCatz Button Chart

Mode	Buttons.....	Gas	Brake	Stick	Wheel
Digital	>< [] () /\ L1 R1 L2 R2 L1 R1	>< ()		L1/R1	lt/rt
Analog	>< [] () /\ L1 R1 L2 R2 L3 R3	UP DN		L1/R1	LT/RT
Negcon	I II A B L R L R L R I II			up/dn	Twist

Whereas, lt/rt/up/dn=Digital Pad, UP/DN=Left Analog Pad Up/Down, LT/RT=Right Analog Pad Left/Right. Analog mode is supported only by the Dual Force and MC2 versions, L3/R3 only by the MC2 version.

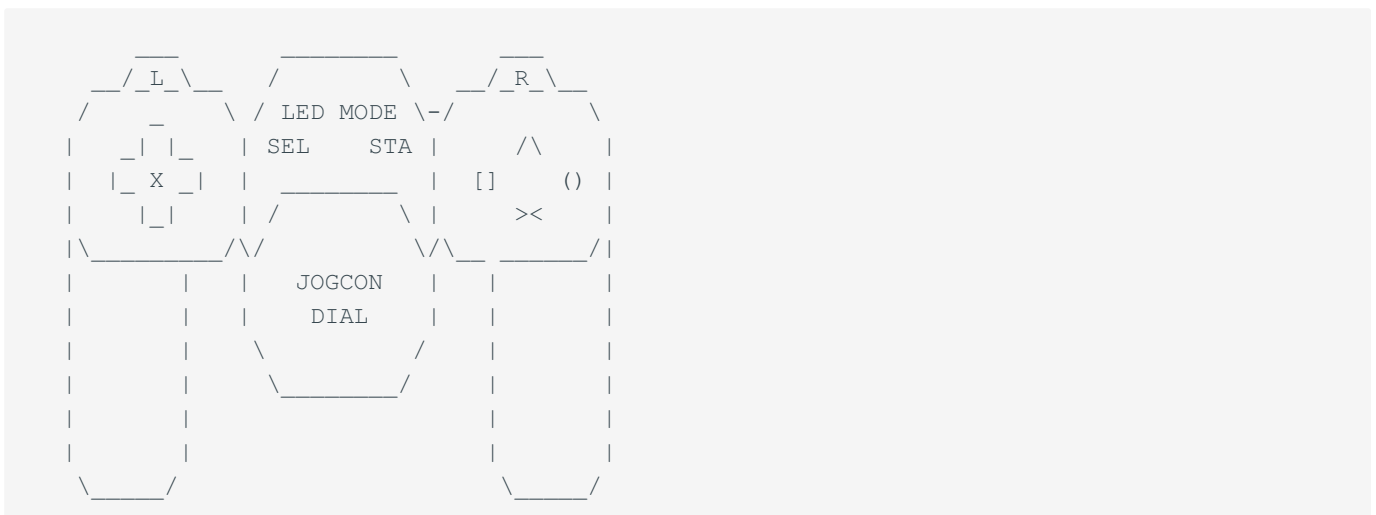
Namco Jogcon (NPC-105/SLEH-0020/SLPH-00126/SLUH-00059)

```
__Halfword 0 (Controller Info)_____  
0-15 Controller Info (5AE3h=Jogcon in Jogcon mode) (ie. not Digital mode)  
halfword1: buttons: same as digital pad  
halfword2:  
0      unknown (uh, this isn't LSB of rotation?)  
1-15 dial rotation (signed offset since last read?) (or absolute position?)  
halfword3:  
0      flag: dial was turned left (0=no, 1=yes)
```

```
1    flag: dial was turned right (0=no, 1=yes)
2-15 unknown
```

Rotations of the dial are recognized by an optical sensor (so, unlike potentiometers, the dial can be freely rotated; by more than 360 degrees). The dial is also connected to a small motor, giving it a real force-feedback effect (unlike all other PSX controllers which merely have vibration feedback). Although that's great, the mechanics are reportedly rather cheap and using the controller doesn't feel too comfortable. The Jogcon is used only by Ridge Racer 4 for PS1 (and Ridge Racer 5 for PS2), and Breakout - Off the Wall Fun.

The Mode button probably allows to switch between Jogcon mode and Digital Pad mode (similar to the Analog button on other pads), not sure if the mode can be also changed by software via configuration commands...? Unknown how the motor is controlled; probably somewhat similar to vibration motors, ie. by the M1 and/or M2 bytes, but there must be also a way to select clockwise and anticlockwise direction)...? The controller does reportedly support config command 4Dh (same as analog rumble).



14.8 Controllers - Lightguns

There are two different types of PSX lightguns (which are incompatible with each other).

Namco Lightgun (GunCon)

Namco's Cinch-based lightguns are extracting Vsync/Hsync timings from the video signal (via a cinch adaptor) (so they are working completely independent of software timings).

[Controllers - Lightguns - Namco \(GunCon\)](#)

Konami Lightgun (IRQ10)

Konami's IRQ10-based lightguns are using the lightgun input on the controller slot (which requires IRQ10/timings being properly handled at software side).

[Controllers - Lightguns - Konami Justifier/Hyperblaster \(IRQ10\)](#)

The IRQ10-method is reportedly less accurate (although that may be just due to bugs at software side).

Third-Party Lightguns

There are also a lot of unlicensed lightguns which are either IRQ10-based, or Cinch-based, or do support both.

For example, the Blaze Scorpion supports both IRQ10 and Cinch, and it does additionally have a rumble/vibration function; though unknown how that rumble feature is accessed, and which games are supporting it).

Lightgun Games

[Controllers - Lightguns - PSX Lightgun Games](#)

Compatibilty Notes (IRQ10 vs Cinch, PAL vs NTSC, Calibration)

Some lightguns are reportedly working only with PAL or only with NTSC games (unknown which guns, and unknown what is causing problems; the IRQ10 method should be quite hardware independed, the GunCon variant, too, although theoretically, some GunCon guns might have problems to extract Vsync/Hsync from either PAL or NTSC composite signals).

Lightguns from different manufacturers are reportedly returning slightly different values, so it would be recommended to include a calibration function in the game, using at least one calibration point (that would also resolve different X/Y offsets caused by modifying GP1 display control registers).

Lightguns are needing to sense light from the cathode ray beam; as such they won't work on regions of the screen that contain too dark/black graphics.

14.9 Controllers - Lightguns - Namco (GunCon)

GunCon Cinch-based Lightguns (Namco)

```

__Halfword 0 (Controller Info)____
0-15  Controller Info  (5A63h=Namco Lightgun; GunCon/Cinch Type)
__Halfword 1 (Buttons)____
0-2   Not used          (All bits always 1)
3     Button A (Left Side) (0=Pressed, 1=Released) ;aka Joypad Start
4-12  Not used          (All bits always 1)
13    Trigger Button     (0=Pressed, 1=Released) ;aka Joypad O-Button
14    Button B (Right Side) (0=Pressed, 1=Released) ;aka Joypad X-Button
15    Not used          (All bits always 1)
__Halfword 2 (X)____
0-15  8MHz clks since HSYNC (01h=Error, or 04Dh..1CDh)
__Halfword 3 (Y)____
0-15  Scanlines since VSYNC (05h/0Ah=Error, PAL=20h..127h, NTSC=19h..F8h)

```

Caution: The gun should be read only shortly after begin of VBLANK.

Error/Busy Codes

Coordinates X=0001h, Y=0005h indicates "unexpected light":

```
ERROR: Sensed light during VSYNC (eg. from a Bulb or Sunlight).
```

Coordinates X=0001h, Y=000Ah indicates "no light", this can mean either:

```
ERROR: no light sensed at all (not aimed at screen, or screen too dark).
BUSY: no light sensed yet (when trying to read gun during rendering).
```

To avoid the BUSY error, one should read the gun shortly after begin of VBLANK (ie. AFTER rendering, but still BEFORE vsync). Doing that isn't as simple as one might think: On a NTSC console, time between VBLANK and VSYNC is around 30000 cpu clks, reading the lightgun (or analog joypads) takes around 15000 cpu clks. So, reading two controllers within that timeframe may be problematic (and reading up to eight controllers via multitaps would be absolutely impossible). As a workaround, one may arrange the read-order to read lightguns at VBLANK (and joypads at later time). If more than one lightgun is connected, then one may need to restrict reading to only one (or maybe: max two) guns per frame.

Minimum Brightness

Below are some average minimum brightness values, the gun may be unable to return position data near/below that limits (especially coordinates close to left screen border are most fragile). The exact limits may vary from gun to gun, and will also depend on the TV Set's brightness setting.

A-Button (Left)	Trigger			SLPH-00034/SLEH-0007/SLUH-00035
B-Button (Right)				

See also

Pinouts - Component List and Chipset Pin-Outs for Namco Lightgun, NPC-103

14.10 Controllers - Lightguns - Konami Justifier/Hyperblaster (IRQ10)

Overall IRQ10-Based Lightgun Access

```
Send  01h 42h 00h x0h 00h
Reply HiZ 31h 5Ah buttons
```

The purpose of the "x0h" byte is probably to enable IRQ10 (00h=off, 10h=on), this would allow to access more than one lightgun (with only one per frame having the IRQ enabled).

Standard IRQ10-based Lightguns (Konami)

The Controller Data simply consists of the ID and buttons states:

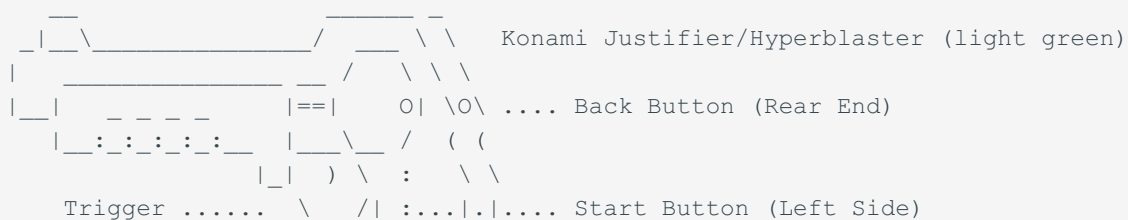
```

__Halfword 0 (Controller Info)_____
0-15  Controller Info   (5A31h=Konami Lightgun; Timer/IRQ10 type)
__Halfword 1 (Buttons)
0-2   Not used          (All bits always 1)
3     Start Button (Left Side) (0=Pressed, 1=Released)   ;aka Joypad Start
4-13  Not used          (All bits always 1)
14    Back Button   (Rear End) (0=Pressed, 1=Released)   ;aka Joypad X-Button
15    Trigger Button (0=Pressed, 1=Released)   ;aka Joypad []-Button

```

The coordinates aren't part of the controller data, instead they must be read from Timer 0 and 1 upon receiving IRQ10 (see IRQ10 Notes below).

Konami Lightgun Drawing





Konami IRQ10 Notes

The PSX does have a lightgun input (Pin 8 of the controller), but, Sony did apparently "forget" to latch the current cathode ray beam coordinates by hardware when sensing the lightgun signal (quite strange, since that'd be a simple, inexpensive, and very obvious feature for a gaming console).

Instead, the lightgun signal triggers IRQ10, and the interrupt handler is intended to "latch" the coordinates by software (by reading Timer 0 and 1 values, which must be configured to be synchronized with the GPU).

That method requires IRQ handling to be properly implemented in software (basically, IRQs should not be disabled for longer periods, and DMA transfers should not block the bus for longer periods). In practice, most programmers probably don't realize how to do that, to the worst, Sony seems to have delivered a slightly bugged library (libgun) to developers.

For details on Timers, see:

[Timers](#)

In some consoles, IRQ10 seems to be routed through a Secondary IRQ Controller, see:

[EXP2 DTL-H2000 I/O Ports](#)

IRQ10 Priority

For processing IRQ10 as soon as possible, it should be assigned higher priority than all other IRQs (ie. when using the SysEnqIntRP BIOS function, it should be the first/newest element in priority chain 0). The libgun stuff assigns an even higher priority by patching the BIOS exception handler, causing IRQ10 to be processed shortly before processing the priority chains (the resulting IRQ priority isn't actually higher as when using 1st element of chain 0; the main difference is that it skips some time consuming code which pushes registers R4..R30). For details on that patch, see:

[BIOS Patches](#)

Even if IRQ10 has highest priority, execution of (older) other IRQs may cause a new IRQ10 to be executed delayed (because IRQs are disabled during IRQ handling), to avoid that problem: Best don't enable any other IRQs except IRQ0 and IRQ10, or, if you need other IRQs, best have them enabled only during Vblank (there are no scanlines drawn during vblank, so IRQ10 should never trigger during that period). DMAs might also slow down IRQ execution, so best use them only during Vblank, too.

IRQ10 Timer Reading

To read the current timer values the IRQ10 handler would be required to be called \<immediately> after receiving the IRQ10 signal, which is more or less impossible; if the main program is trying to read a mul/div/gte result while the mul/div/gte operation is still busy may stop the CPU for some dozens of clock cycles, and active DMA transfers or cache hits and misses in the IRQ handler may cause different timings, moreover, timings may become completely different if IRQs are disabled (eg. while another IRQ is processed).

However, IRQ10 does also get triggered in the next some scanlines, so the first IRQ10 is used only as a notification that the CPU should watch out for further IRQ10's. Ie. the IRQ10 handler should disable all DMAs, acknowledge IRQ10, and then enter a waitloop that waits for the IRQ10 bit in I_STAT to become set again (or abort if a timeout occurs) and then read the timers, reportedly like so:

```
IF NTSC then X=(Timer0-140)*0.198166, Y=Timer1
IF PAL   then X=(Timer0-140)*0.196358, Y=Timer1
```

No idea why PAL/NTSC should use different factors, that factors are looking quite silly/bugged, theoretically, the pixel-to-clock ratio should be the exactly same for PAL and NTSC...?

Mind that reading Timer values in Dotclock/Hblank mode is unstable, for Timer1 this can be fixed by the read-retry method, for Timer0 this could be done too, but one would need to subtract the retry-time to get a correct coordinate; alternately Timer0 can run at system clock (which doesn't require read-retry), but it must be then converted to video clock (mul 11, div 7), and then from video clock to dot clock (eg. div 8 for 320-pixel mode).

Above can be repeated for the next some scanlines (allowing to take the medium values as result, and/or to eliminate faulty values which are much bigger or smaller than the other values). Once when you have collected enough values, disable IRQ10, so it won't trigger on further scanlines within the current frame.

IRQ10 Bugs

BUG: The "libgun" library doesn't acknowledge the old IRQ10 \<immediately> before waiting for a new IRQ10, so the timer values after sensing the new IRQ10 are somewhat random (especially for the first processed scanline) (the library allows to read further IRQ10's in further scanlines, which return more stable results).

No idea how many times IRQ10 gets typically repeated? Sporting Clays allocates a

buffer for up to 20 scanlines (which would cause pretty much of a slowdown since the CPU is just waiting during that period) (nethertheless, the game uses only the first timer values, ie. the bugged libgun-random values).

Unknown if/how two-player games (with 2 lightguns) are working with the IRQ10 method... if IRQ10 is generated ONLY after pressing the trigger button, then it may work, unless both players have Trigger pressed at the same time... and, maybe one can enable/disable the lightguns by whatever command being sent to the controller (presumably that "x0h" byte, see above), so that gun 1 generates IRQ10 only in each second frame, and gun 2 only in each other frame...?

14.11 Controllers - Lightguns - PSX Lightgun Games

PSX Lightgun Games

Some games are working only with IRQ10 or only with Cinch, some games support both methods:

```
Area 51 (Mesa Logic/Midway) (IRQ10)
Crypt Killer (Konami) (IRQ10)
Die Hard Trilogy 1: (Probe Entertainment) (IRQ10)
Die Hard Trilogy 2: Viva Las Vegas (n-Space) (IRQ10/Cinch)
Elemental Gearbolt (Working Designs) (IRQ10/Cinch)
Extreme Ghostbusters: Ultimate Invasion (LSP) (Cinch)
Galaxian 3 (Cinch)
Ghoul Panic (Namco) (Cinch)
Gunfighter: The Legend of Jesse James (Rebellion) (Cinch)
Judge Dredd (Gremlin) (Cinch)
Lethal Enforcers 1-2 (Konami) (IRQ10)
Maximum Force (Midway) (IRQ10/Cinch)
Mighty Hits Special (Altron) (EU/JPN) (Cinch)
Moorhuhn series (Phenomedia) (Cinch)
Point Blank 1-3 (Namco) (Cinch)
Project Horned Owl (Sony) (IRQ10)
Rescue Shot (Namco) (Cinch)
Resident Evil: Gun Survivor (Capcom) (JPN/PAL versions) (Cinch)
Silent Hill (IRQ10) ("used for an easter egg")
Simple 1500 Series Vol.024 - The Gun Shooting (unknown type)
Simple 1500 Series Vol.063 - The Gun Shooting 2 (unknown type)
Snatcher (IRQ10)
Sporting Clays (Charles Doty) (homebrew with buggy source code) (IRQ10/Cinch)
Star Wars Rebel Assault II (IRQ10)
Time Crisis, and Time Crisis 2: Project Titan (Namco) (Cinch)
```

Note: The RPG game Dragon Quest Monsters does also contain IRQ10 lightgun code (though unknown if/when/where the game does use that code).

14.12 Controllers - Configuration Commands

Some controllers can be switched from Normal Mode to Config Mode. The Config Mode was invented for activating the 2nd rumble motor in SCPH-1200 analog joypads. Additionally, the Config commands can switch between analog/digital inputs (without needing to manually press the Analog button), activate more analog inputs (on Dualshock2), and read some type/status bytes.

Normal Mode

```
42h "B" Read Buttons (and analog inputs when in analog mode)
43h "C" Enter/Exit Configuration Mode (stay normal, or enter)
```

Transfer length in Normal Mode is 5 bytes (Digital mode), or 9 bytes (Analog mode), or up to 21 bytes (Dualshock2).

Configuration Mode

```
40h "@" Unused, or Dualshock2: Get/Set ButtonAttr?
41h "A" Unused, or Dualshock2: Get Reply Capabilities
42h "B" Read Buttons AND analog inputs (even when in digital mode)
43h "C" Enter/Exit Configuration Mode (stay config, or exit)
44h "D" Set LED State (analog mode on/off)
45h "E" Get LED State (and Type/constants)
46h "F" Get Variable Response A (depending on incoming bit)
47h "G" Get whatever values (response HiZ F3h 5Ah 00h 00h 02h 00h 01h 00h)
48h "H" Unknown (response HiZ F3h 5Ah 00h 00h 00h 00h 01h 00h)
49h "I" Unused
4Ah "J" Unused
4Bh "K" Unused
4Ch "L" Get Variable Response B (depending on incoming bit)
4Dh "M" Get/Set RumbleProtocol
4Eh "N" Unused
4Fh "O" Unused, or Dualshock2: Set ReplyProtocol
```

Transfer length in Config Mode is always 9 bytes.

Normal Mode - Command 42h "B" - Read Buttons (and analog inputs when enabled)

```
Send 01h 42h 00h xx yy (00h 00h 00h 00h) (...)
Reply HiZ id 5Ah buttons (analog-inputs) (dualshock2 buttons...)
```

The normal read command, see Standard Controller chapter for details on buttons and analog inputs. The xx/yy bytes have effect only if rumble is unlocked; use Command 43h to enter config mode, and Command 4Dh to unlock rumble. Command 4Dh has billions of combinations, among others allowing to unlock only one of the two motors, and to exchange the xx/yy bytes, however, with the default values, xx/yy are assigned like so:

```
yy.bit0-7 ---> Left/Large Motor M1 (analog slow/fast) (00h=stop, FFh=fastest)
xx.bit0 ---> Right/small Motor M2 (digital on/off) (0=off, 1=on)
```

The Left/Large motor starts spinning at circa min=50h..60h, and, once when started keeps spinning down to circa min=38h. The exact motor start boundary depends on the current position of the weight (if it's at the "falling" side, then gravity helps starting), and also depends on external movements (eg. it helps if the user or the other rumble motor is shaking the controller), and may also vary from controller to controller, and may also depend on the room temperature, dirty or worn-out mechanics, etc.

Normal Mode - Command 43h "C" - Enter/Exit Configuration Mode

```
Send 01h 43h 00h xx 00h (zero padded...) (...)
Reply HiZ id 5Ah buttons (analog inputs...) (dualshock2 buttons...)
```

When issuing command 43h from inside normal mode, the response is same as for command 42h (button data) (and analog inputs when in analog mode) (but without M1 and M2 parameters). While in config mode, the ID bytes are always "F3h 5Ah" (instead of the normal analog/digital ID bytes).

```
xx=00h Stay in Normal mode
xx=01h Enter Configuration mode
```

Caution: Additionally to activating configuration commands, entering config mode does also activate a Watchdog Timer which does reset the controller if there's been no communication for about 1 second or so. The watchdog timer remains active even when returning to normal mode via Exit Config command. The reset does disable and lock rumble motors, and switches the controller to Digital Mode (with LED=off, and analog inputs disabled). To prevent this, be sure to keep issuing joypad reads even when not needing user input (eg. while loading data from CDROM).

Caution 2: A similar reset occurs when the user pushes the Analog button; this is causing rumble motors to be stopped and locked, and of course, the analog/digital state gets

changed.

Caution 3: If config commands were used, and the user does then push the analog button, then the 5Ah-byte gets replaced by 00h (ie. responses change from "HiZ id 5Ah ..." to "HiZ id 00h ...").

Config Mode - Command 42h "B" - Read Buttons AND analog inputs

```
Send 01h 42h 00h M2 M1 00h 00h 00h 00h
Reply HiZ F3h 5Ah buttons analog-inputs
```

Same as command 42h in normal mode, but with forced analog response (ie. analog inputs and L3/R3 buttons are returned even in Digital Mode with LED=Off).

Config Mode - Command 43h "C" - Enter/Exit Configuration Mode

```
Send 01h 43h 00h xx 00h 00h 00h 00h 00h
Reply HiZ F3h 5Ah 00h 00h 00h 00h 00h 00h
```

Equivalent to command 43h in normal mode, but returning 00h bytes rather than button data, can be used to return to normal mode.

```
xx=00h Enter Normal mode (Exit Configuration mode)
xx=01h Stay in Configuration mode
```

Back in normal mode, the rumble motors (if they were enabled) can be controlled with normal command 42h.

Config Mode - Command 44h "D" - Set LED State (analog mode on/off)

```
Send 01h 44h 00h Led Key 00h 00h 00h 00h
Reply HiZ F3h 5Ah 00h 00h Err 00h 00h 00h
```

The Led byte can be:

```
When Led=00h --> Digital mode, with LED=Off
When Led=01h --> Analog mode, with LED=On/red
When Led=02h..FFh --> Ignored (and, in case of dualshock2: set Err=FFh)
```

The Key byte can be:

```
When Key=00h..02h --> Unlock (allow user to push Analog button)
When Key=03h --> Lock (stay in current mode, ignore Analog button)
When Key=04h..FFh --> Acts same as (Key AND 03h)
```

The Err byte is usually 00h (except, Dualshock2 sets Err=FFh upon Led=02h..FFh; older PSX/PSone controllers don't do that).

Config Mode - Command 45h "E" - Get LED State (and Type/constants)

```
Send  01h 45h 00h 00h 00h 00h 00h 00h 00h
Reply HiZ F3h 5Ah Typ 02h Led 02h 01h 00h
```

Returns two interesting bytes:

```
Led: Current LED State (00h=Off, 01h=On/red)
Typ: Controller Type (01h=PSX/Analog Pad, 03h=PS2/Dualshock2)
```

The other bytes might indicate the number of rumble motors, analog sticks, or version information, or so.

Config Mode - Command 46h "F" - Get Variable Response A

```
Send  01h 46h 00h ii  00h 00h 00h 00h 00h
Reply HiZ F3h 5Ah 00h 00h cc  dd  ee  ff
```

When ii=00h --> returns cc,dd,ee,ff = 01h,02h,00h,0ah

When ii=01h --> returns cc,dd,ee,ff = 01h,01h,01h,14h

Otherwise --> returns cc,dd,ee,ff = all zeroes

Note: This is called PadInfoAct in official docs, ii is the actuator (aka motor) and the last response byte contains its current drain (10 or 20 units). Whereas, Sony insists that controllers should never exceed 60 units (eg. when having more than 2 joypads connected to multitaps).

Config Mode - Command 47h "G" - Get whatever values

```
Send  01h 47h 00h 00h 00h 00h 00h 00h 00h
Reply HiZ F3h 5Ah 00h 00h 02h 00h 01h 00h
```

Purpose unknown.

Config Mode - Command 4Ch "L" - Get Variable Response B

```
Send  01h 4Ch 00h ii  00h 00h 00h 00h 00h
Reply HiZ F3h 5Ah 00h 00h 00h dd  00h 00h
```


When ii=00h --> returns dd=04h.

When ii=01h --> returns dd=07h.

Otherwise --> returns dd=00h.

Config Mode - Command 48h "H" - Unknown (response HiZ F3h 5Ah 4x00h 01h 00h)

```
Send  01h 48h 00h ii  00h 00h 00h 00h 00h
Reply HiZ F3h 5Ah 00h 00h 00h 00h ee  00h
```

When ii=00h..01h --> returns ee=01h.

Otherwise --> returns ee=00h.

Purpose unknown. The command does not seem to be used by any games.

Config Mode - Command 4Dh "M" - Get/Set RumbleProtocol

[Controllers - Vibration/Rumble Control](#)

Config Mode - Command 40h "@" Dualshock2: Get/Set ButtonAttr?

Config Mode - Command 41h "A" Dualshock2: Get Reply Capabilities

Config Mode - Command 4Fh "O" Dualshock2: Set ReplyProtocol

[Controllers - Analog Buttons \(Dualshock2\)](#)

Config Mode - Command 49h "I" - Unused

Config Mode - Command 4Ah "J" - Unused

Config Mode - Command 4Bh "K" - Unused

Config Mode - Command 4Eh "N" - Unused

Config Mode - Command 40h "@" - Unused (except, used by Dualshock2)

Config Mode - Command 41h "A" - Unused (except, used by Dualshock2)

Config Mode - Command 4Fh "O" - Unused (except, used by Dualshock2)

```
Send 01h 4xh 00h 00h 00h 00h 00h 00h 00h
Reply HiZ F3h 5Ah 00h 00h 00h 00h 00h 00h
```

These commands do return a bunch of 00h bytes. These commands do not seem to be used by any games (apart from the Dualshock2 commands being used by Dualshock2 games).

Note

Something called "Guitar Hero controller" does reportedly also support Config commands. Unknown if that thing does have the same inputs & rumble motors as normal analog PSX joypads, and if it does return special type values.

14.13 Controllers - Vibration/Rumble Control

Rumble (aka "Vibration Function") is basically controlled by two previously unused bytes of the standard controller Read command.

There are two methods to control the rumble motors, the old method is very simple (but supports only one motor), the new method involves a bunch of new configuration commands (and supports two motors).

```
SCPH-1150 DualAnalog Pad with 1 motor ; -old rumble method
SCPH-1200 DualAnalog Pad with 2 motors, PSX-design ; \new rumble method
SCPH-110 DualAnalog Pad with 2 motors, PSone-design ; /
SCPH-10010 DualAnalog Pad with 2 motors, PS2/Dualshock2 ; -plus analog buttons
Blaze Scorpion Lightgun with rumble ; \unknow how to control rumble
Fishing controllers with rumble ; /
SCPH-1180 Analog Pad without rumble ; \unknow if there're config commands
SCPH-1110 Analog Stick without rumble ; /for analog mode (probably not)
```

Old Method, one motor, no config commands (SCPH-1150, SCPH-1200, SCPH-110)

The SCPH-1150 doesn't support any special config commands, instead, rumble is solely done via the normal joystick read command:

```
Send 01h 42h 00h xx yy (00h 00h 00h 00h)
Reply HiZ id 5Ah buttons ( analog-inputs )
```

The rumble motor is simply controlled by three bits in the xx/yy bytes:

```
xx --> must be 40h..7Fh (ie. bit7=0, bit6=1) ; \switches motor on
yy --> must be 01h,03h,...,FDh,FFh (ie. bit0=1) ; /
```

The motor control is digital on/off (no analog slow/fast), recommended values would be `yyxx=0140h=on`, and `yyxx=0000h=off`.

LED state is don't care (rumble works with led OFF, RED, and GREEN). In absence of config commands, the LED can be controlled only manually (via Analog button), the current LED state is implied in the controller "id" byte.

For backwards compatibility, the above old method does also work on SCPH-1200 and SCPH-110 (for controlling the right/small motor), alternately those newer pads can use the config commands (for gaining access to both motors).

New Method, two motors, with config commands (SCPH-1200, SCPH-110)

For using the new rumble method, one must unlock the new rumble mode, for that purpose Sony has invented a "slightly" overcomplicated protocol with not less than 16 new commands (the rumble relevant commands are 43h and 4Dh, also, command 44h may be useful for activating analog inputs by software, and, once when rumble is unlocked, command 42h is used to control the rumble motors). Anyways, here's the full command set...

Controllers - Configuration Commands

And, the rumble-specific config command is described below...

Config Mode - Command 4Dh "M" - Get/Set RumbleProtocol

```
Send  01h 4Dh 00h aa  bb  cc  dd  ee  ff      ;<-- set NEW aa..ff values
Reply Hiz F3h 5Ah aa  bb  cc  dd  ee  ff      ;<-- returns OLD aa..ff values
```

Bytes aa,bb,cc,dd,ee,ff control the meaning of the 4th,5th,6th,7th,8th,9th command byte in the controller read command (Command 42h).

```
00h      = Map Right/small Motor (Motor M2) to bit0 of this byte
01h      = Map Left/Large Motor (Motor M1) to bit0-7 of this byte
02h..FEh = Unknown (can be mapped, maybe for extra motors/outputs)
FFh      = Map nothing to this byte
```

In practice, one would usually send either one of these command/values:

```
Send  01h 4Dh 00h 00h 01h FFh FFh FFh FFh      ;enable new method (two motors)
Send  01h 4Dh 00h FFh FFh FFh FFh FFh FFh      ;disable motor control
```

Alternately, one could swap the motors by swapping values in aa/bb. Or one could map the motors anywhere to cc/dd/ee/ff (this will increase the command length in digital mode, hence changing digital mode ID from 41h to 42h or 43h). Or, one could map

further rumble motors or other outputs to the six bytes (if any such controller would exist).

In the initial state, aa..ff are all FFh, and the controller does then use the old rumble control method (with only one motor). However, that old method gets disabled once when having messed with config commands (unknown if/how one can re-enable the old method by software).

Unknown Dualshock2 Vibration

Dualshock2 does reportedly have "two more levels of vibration", unknown what that means and if it's used by any PSX or PS2 games... it might refer to the small motor which usually has only 2 levels (on/off) and might have 4 levels (fast/med/slow/off) on dualshock2... but, if so, it's unknown how to control/unlock that feature.

Also, the PSone controller (SCPH-110) appear to have been released shortly after Dualshock2, unknown if that means that it might have that feature, too.

Note

Rumble is a potentially annoying feature, so games that do support rumble should also include an option to disable it.

14.14 Controllers - Analog Buttons (Dualshock2)

Dualshock2 has three new commands (40h,41h,4Fh) for configuring analog buttons.

Additionally, Command 45h does return a different type byte for Dualshock2.

Dualshock2 is a PS2 controller. However, it can be also used with PSX games (either by connecting the controller to a PSX console, or by playing a PSX game on a PS2 console).

The analog button feature is reportedly rarely used by PS2 games (and there aren't any PSX games known to use it).

Config Mode - Command 40h "@" Dualshock2: Get/Set ButtonAttr?

```
Send  01h 40h 00h Idx Val 00h 00h 00h 00h  ;<-- Set NEW Val, array[Idx]=Val
Reply HiZ F3h 5Ah 00h 00h Val 00h 00h 00h  ;<-- Old Val (or FFh when Idx>0Bh)
```

Allows to change twelve 3bit values (with Idx=00h..0Bh, and Val=00h..03h). Default is Val=02h. Purpose is unknown, the 12 values might be related to the 12 analog buttons, but there is no noticable difference between Val=0,1,2,3. Maybe it does have some subtle

effects on things like...

Digital button sensitivity, or Analog button sensitivity, or
Analog button bit-depth/conversion speed, or something else?

Config Mode - Command 41h "A" Dualshock2: Get Reply Capabilities

```
Send 01h 41h 00h 00h 00h 00h 00h 00h 00h
Reply HiZ F3h 5Ah FFh FFh 03h 00h 00h 00h
```

This seems to return a constant bitmask indicating which reply bytes can be enabled/disabled via Command 4Fh (ie. 3FFFFh = 18 bits).

Config Mode - Command 4Fh "O" Dualshock2: Set ReplyProtocol

```
Send 01h 41h 00h aa bb cc dd ee ff
Reply HiZ F3h 5Ah 00h 00h 00h 00h 00h 00h
```

This can output some 48bit value (bit0=aa.bit0, bit47=ff.bit7), used to enable/disable Reply bytes in the controller read command (Command 42h).

-	HighZ	(always transferred)	1st byte
-	ID/Mode/Len	(always transferred)	2nd byte
-	5Ah	(always transferred)	3rd byte
0	LSB of digital buttons	(0=No, 1=Yes)	4th byte
1	MSB of digital buttons	(0=No, 1=Yes)	5th byte
2	RightJoyX	(0=No, 1=Yes)	6th byte
3	RightJoyY	(0=No, 1=Yes)	7th byte
4	LeftJoyX	(0=No, 1=Yes)	8th byte
5	LeftJoyY	(0=No, 1=Yes)	9th byte
6	DPAD Right	(0=No, 1=Yes) button 00h	10th byte
7	DPAD Left	(0=No, 1=Yes) button 01h	11th byte
8	DPAD Up	(0=No, 1=Yes) button 02h	12th byte
9	DPAD Down	(0=No, 1=Yes) button 03h	13th byte
10	Button /\	(0=No, 1=Yes) button 04h	14th byte
11	Button ()	(0=No, 1=Yes) button 05h	15th byte
12	Button ><	(0=No, 1=Yes) button 06h	16th byte
13	Button []	(0=No, 1=Yes) button 07h	17th byte
14	Button L1	(0=No, 1=Yes) button 08h	18th byte
15	Button R1	(0=No, 1=Yes) button 09h	19th byte
16	Button L2	(0=No, 1=Yes) button 0Ah	20th byte
17	Button R2	(0=No, 1=Yes) button 0Bh	21st byte
18-39	Must be 0 (otherwise command is ignored)		
40-47	Unknown (no effect?)		

Usually, one would use one of the following command/values:

```

Send  01h 41h 00h 03h 00h 00h 00h 00h 00h  Digital buttons
Send  01h 41h 00h 3Fh 00h 00h 00h 00h 00h  Digital buttons + analog sticks
Send  01h 41h 00h FFh FFh 03h 00h 00h 00h  Enable all 18 input bytes

```

The transfer order is 1st..21st byte as shown above (unless some bits are cleared, eg. if bit0-5=0 and bit6=1 then DPAD Right would appear as 4th byte instead of 10th byte). The command length increases/decreases depending on the number of enabled bits. The transfer length is always 3+N*2 bytes (including a 00h padding byte when the number of enabled bits is odd). The analog mode ID byte changes depending on number of halfwords.

CAUTION: Sending Command 44h does RESET the Command 4Fh setting (either to DigitalMode=000003h or AnalogMode=00003Fh; same happens when toggling mode via Analog button).

Note: Some Dualshock2 Config Mode commands do occasionally send 00h, 5Ah, or FFh as last (9th) reply byte (unknown if that is some error/status thing, or garbage).

Analog Button Sensitivity

The pressure sensors are rather imprecise and results may vary on various factors, including the pressure angle.

```

00h      Button released
01h..2Fh Normal (soft) pressure
30h..FEh Medium pressure
FFh      Hard pressure

```

Software can safely distinguish between soft and hard pressure.

Medium pressure is less predictably: The values do not increase linearly, it's difficult to apply a specific amount of medium pressure (such like 80h..9Fh), increasing pressure may sometimes jump from 24h to FFh, completely skipping the medium range.

Relying on the medium range might work for acceleration buttons (where the user could still adjust the pressure when the acceleration is too high or too low); but it would be very bad practice to assign irreversible actions to medium pressure (such like Soft=Load, Medium=Save, Hard=Quit).

Digital Button Sensitivity

Digital inputs are converting the analog inputs as so:

```
Analog=00h      --> not pressed
Analog=01h..FFh --> pressed (no matter if soft, medium, or hard pressure)
```

Digital inputs are working even when also having analog input enabled for the same button.

See also

[<https://gist.github.com/scanlime/5042071>] - tech (=mentions unknown details)

[<https://store.curiousinventor.com/guides/PS2/>] - guide (=omits unknown stuff)

14.15 Controllers - Dance Mats

PSX Dance Mats are essentially normal joypads with uncommonly arranged buttons, the huge mats are meant to be put on the floor, so the user could step on them.

Dance Mat vs Joypad Compatibility

There are some differences to normal joypads: First of, the L1/L2/R1/R2 shoulder buttons are missing in most variants. And, the mats are allowing to push Left+Right and Up+Down at once, combinations that aren't mechanically possible on normal joypads (some dancing games do actually require those combinations, whilst some joypad games may get confused on them).

Dance Mat Unknown Things

Unknown if the mat was sold in japan, and if so, with which SLPH/SCPH number.

Unknown if the mat's middle field is also having a button assigned.

Unknown if the mat is having a special controller ID, or if there are other ways to detect mats (the mats are said to be compatible with skateboard games, so the mats are probably identifying themselves as normal digital joypad; assuming that those skateboard games haven't been specifically designed for mats).

Dance Mat Games

```
D.D.R. Dance Dance Revolution 2nd Remix
(and maybe whatever further games)
```

The mats can be reportedly also used with whatever skateboard games.

Dance Mat Variants

There is the US version (DDR Dance Pad, SLUH-00071), and a slightly different European version (Official Dance Mat, SLEH-00023: shiny latex style with perverted colors, and Start/Select arranged differently). The Japanese version (RU017) resembles the US version, but without Triangle/Square symbols drawn in lower left/right edges. And there is a handheld version (with additional L1/L2/R2/R1 buttons; maybe unlicensed; produced as MINI DDR, and also as Venom Mini Dance Pad).

US Version (white/black/red/blue)

```

      .----- .
      |         \         /         |
      |  SELECT  '-----'  START  |
      |----- .----- .-----|
      | .'''' . /         \ .'''' . |
      | | \ / | | / \ | | .'' . |
      | | / \ | | / .. \ | | ' . ' |
      | | '....' | ' . | | ' . '....' |
      | .----- .'''''''' .-----|
      | / / | ' .         ' . \ \ | | | |
      | / | -- |         | -- | \ |
      | \ | -- | Stay Cool! | -- | / |
      | \ \ | ' .         ' . | / / |
      | '-----' '.....' '-----' |
      | .'''' . ' . | | ' . .'''' . | | | | |
      | | / \ | | \ '' / | | '''' |
      | | / _ \ | | \ / | | |.. |
      | | '....' | \         / | '....' |
      |-----'-----'-----|

```

European Version (pink/blue/yellow)

```

      .----- .
      |         \ SEL STA /         |
      |         '-----'         |
      |----- .----- .-----|
      | .'''' . | .'''' . | .'''' . | | | | | |
      | | \ / | | | / \ | | | .'' . |
      | | / \ | | | / .. \ | | | ' . ' |
      | | '....' | | ' . | | ' . '....' |
      |-----+-----+-----+-----|
      | .''/|' . / ' '''' \ .''|\'. | | | |
      | | / | -- | /         \ | -- | \ |
      | | \ | -- | \         / | -- | / |
      | | ' . \ | ' \         . . . . / ' . | / . ' |
      |-----+-----+-----+-----|
      | .'''' . | .''||' . | .'''' . | | | | |
      | | / \ | | | \ '' / | | | '''' |
      | | / _ \ | | | \ / | | | |.. |
      | | '....' | | ' . | | ' . '....' |
      |-----'-----'-----|

```

Handheld Version (blue/gray)

```

      ____ / MINI \ ____
      |         D.D.R.         |
      | L1 L2 SEL STA R2 R1 |
      | ____   ____   ____ |
      | | X | | ^ | | O | |
      | | ____ | | ____ | | ____ |
      | | ____ .----. ____ |
      | | < | | Stay | | > | |
      | | ____ | Cool! | | ____ |
      | | ____ ' ____ ' ____ |
      | | [ ] | | v | | / \ | |
      | | ____ | ____ | | ____ |
      |_____|

```

Gothic Dance Mat (black/silver)

```

      .----- .
      | \ SEL STA / | This one
      | '-----' | wasn't ever
      | .----- . | produced,
      | | .'''' . | | as cool as
      | | | / \ | | | it could have
      | | | / .. \ | | | been, the lame
      | | | ' . | | | marketing
      | | +-----+ | people didn't
      | | .'''' . | | even think
      | | | / \ | | | about it.
      | | | / .. \ | | |
      | | | ' . | | |
      | | +-----+ |
      | | .''||' . | |
      | | | \ '' / | | |
      | | | \ / | | |
      | | | '....' | | |
      | | +-----+ |
      | | .''||' . | |
      | | | \ '' / | | |
      | | | \ / | | |
      | | | '....' | | |
      | |-----' |
      |-----'

```


Stay Cool?

Despite of the "Stay Cool!" slogan, the mat wasn't very cool - not at all! It offered only two steps back-and-forth, and also allowed to do extremely uncool side-steps. Not to mention that it would melt when dropping a burning cigarette on it. Stay Away!

14.16 Controllers - Pop'n Controllers

Controllers used for Konami's Pop'n Music series. At least a few different versions of the controller (Pop'n Controller, Pop'n Controller 2, larger arcade-size version, possibly others and in different color variations) have been released for the PS1 and PS2. Unknown if the controllers released in the PS2 era have any additional commands not present in the original Pop'n Controller, but they are supposedly fully compatible with PS1 Pop'n Music games.

Pop'n Controllers report as digital controllers (ID byte 41h), but the left, right, and down d-pad controls are not connected to any physical buttons and are always reported as pressed (in the first transferred button byte, bits 5-7 are always 0). Pop'n Music games check these bits to determine if a Pop'n Controller is connected and will change the in-game controls accordingly if so.

14.17 Controllers - Taiko Controllers (Tatacon)

Drum controllers made by Namco and used by the Taiko no Tatsujin series on the PS2 (but compatible with the PS1, even though no PS1 Taiko game was ever made). These controllers behave like standard digital pads (ID 41h) and contain four hit sensors mapped to the following buttons:

Sensor	Button	Bit
Left ka (rim)	L1	10
Right ka (rim)	R1	11
Left don (center)	D-pad left	7
Right don (center)	Circle	13

Dedicated start and select buttons are also present. Unlike Pop'n Controllers, no additional buttons are hardcoded to be always pressed.

14.18 Controllers - Densha de Go! / Jet de Go! Controllers

Controllers used for Taito's Densha de Go! and Jet de Go! series. Unknown what method is being used by Densha de Go! and Jet de Go! games for detecting these controllers.

- The workings of Densha de Go! PSX controllers have been extensively researched in the [ddgo-controller-docs](#) repo.
- The Jet de Go! PSX controller comes in gray and black color. It seems to work the same as an analog controller and supports vibration. The steering wheel is mapped to the left stick (wheel rotation as horizontal, wheel raise/lower as vertical axis). The thrust throttle seems mapped to the right stick Y-axis full range (so half throttle matches vertically centered right stick).

14.19 Controllers - Fishing Controllers

The fishing rods are (next to lightguns) some of the more openly martial playstation controllers - using the credo that "as long as you aren't using dynamite: it's okay to kill them cause they don't have any feelings."

PSX Fishing Controller Games

```

Action Bass (Syscom Entertainment) (1999) (SLPH-00100)
Bass Landing (ASCII/agetec) (1999) (SLPH-00100, SLUH-00063)
Bass Rise, Fishing Freaks (Bandai) (1999) (BANC-0001)
Bass Rise Plus, Fishing Freaks (Bandai) (2000) (BANC-0001, SLPH-00100)
Breath of Fire IV (Capcom) (SLUH-00063)
Championship Bass (EA Sports) (2000) (SLUH-00063)
Fish On! Bass (Pony Canyon) (1999) (BANC-0001, SLPH-00100)
Fisherman's Bait 2/Exiting Bass2 - Big Ol'Bass (Konami) (SLPH-00100, SLUH-00063)
Fishing Club: (series with 3 titles) (have "headset-logo" on back?)
Lake Masters II (1999) (Dazz/Nexus) (SLPH-00100)
Lake Masters Pro (1999) (Dazz/Nexus) (BANC-0001, SLPH-00100)
Let's Go Bassfishing!: Bass Tsuru ni Ikou! (Banpresto) (1999) (SLPH-00100)
Matsukata Hiroki no World Fishing (BPS The Choice) (1999) (SLPH-00100)
Murakoshi Seikai-Bakuchou Nihon Rettou (Victor) (SLPH-00100)
Murakoshi Masami-Bakuchou Nippon Rettou:TsuruConEdition (1999) (SLPH-00100)
Pakuchikou Seabass Fishing (JP, 03/25/99) (Victor) (SLPH-00100)
Perfect Fishing: Bass Fishing (2000) (Seta) (yellow/green logo)
Perfect Fishing: Rock Fishing (2000) (Seta) (yellow/green logo)
Oyaji no Jikan: Nechan, Tsuru Iku De! (2000) (Visit) (BANC-0001, SLPH-00100)
Reel Fishing II / Fish Eyes II (2000) (Natsume/Victor) (SLPH-00100, SLUH-00063)
Simple 1500 Series Vol. 29: The Tsuru (2000) (yellow/green logo)
Suizokukan Project: Fish Hunter e no Michi (1999) (Teichiku) (SLPH-00100)
Super Bass Fishing (1999) (King) (BANC-0001, SLPH-00100, yellow/green logo)
Super Black Bass X2 (2000) (Starfish) (SLPH-00100)

```

```
Tsuwadou Keiryuu Mizuumihen (Best Edition) (2000) (ASCII PS1+PS2 controllers?)
Tsuwadou Seabass Fishing (PlayStation the Best) (1999) (Oz Club) (SLPH-00100)
Uki Uki Tsuru Tengoku Nagami/Uokami Densetsu Oe (2000) (Teichiku) (SLPH-00100)
Umi no Nushi Tsuru-Takarajima ni Mukatte (1999) (Victor) (BANC-0001,SLPH-00100)
Winning Lure (Hori) (2000) (for Hori HPS-97 controller) AKA HPS-98 ?
```

Logos on CD Covers

US Fishing games should have a "SLUH-00063" logo. European Fishing games don't have any fishing logos; apparently fishing controllers haven't been officially released/supported in Europe.

Japanese Fishing games can have a bunch of logos: Usually BANC-0001 or SLPH-00100 (or both).

Moreover, some japanese games have a yellow/green fishing logo with japanese text (found on Perfect Fishing: Bass Fishing, Perfect Fishing: Rock Fishing, Simple 1500 Series Vol. 29: The Tsuru, Super Bass Fishing) (unknown if that logo refer to other special hardware, or if it means the "normal" BANC-0001 or SLPH-00100 controllers.

And Moreover, some japanese games have some sort of "headset" logos with japanese text, these seem to have same meaning as SLPH-00100; as indicated by photos on CD cover of Tsuwadou Keiryuu Mizuumihen (Best Edition) (2000); that CD cover also has a "headset 2" logo, which seems to mean a newer PS2 variant of the SLPH-00100.

PSX Fishing Controllers

```
ASCII Tsuricon SLPH-00100 (also marked with a second serial, ASC-0514TR, on the
packaging box)
ASCII Tsuricon 2 ASC-0521TR2 (has a mode switch with 3 settings. "1" is original
Tsuricon mode, "2" is Tsuricon 2 mode. Unknown what the unnumbered mode does)
Sammy Tsuricon 2 SMY-0506FS (looks to be identical to the ASCII Tsuricon 2)
Sammy Tsuricon 2+ SMY-0511FS (unknown what the differences between this and the
Tsuricon 2 are)
Agetec Bass Landing Fishing Controller SLUH-00063 (US version of ASCII's SLPH-00100
controller)
Bandai Fishing Controller BANC-0001 (dark gray/blue) (has less buttons than ASCII/
agetec)
Interact Fission (light gray/blue) (similar to ASCII/agetec, 2 extra buttons?)
Naki (transparent blue) (looks like a clone of the ASCII/agetec controllers)
Hori HPS-97/HPS-98 (black/gray) (a fishing rod attached to a plastic fish)
```

Of these, the ASCII/agetec controllers seem to be most popular (and most commonly supported). The Bandai controller is also supported by a couple of games (though the Bandai controller itself seems to be quite rare). The Interact/Naki controllers are probably just clones of the ASCII/agetec ones. The Hori controller is quite rare (and with its string

and plastic fish, it's apparently working completely different than the other fishing controllers).

Tech Info (all unknown)

Unknown how to detect fishing controllers.

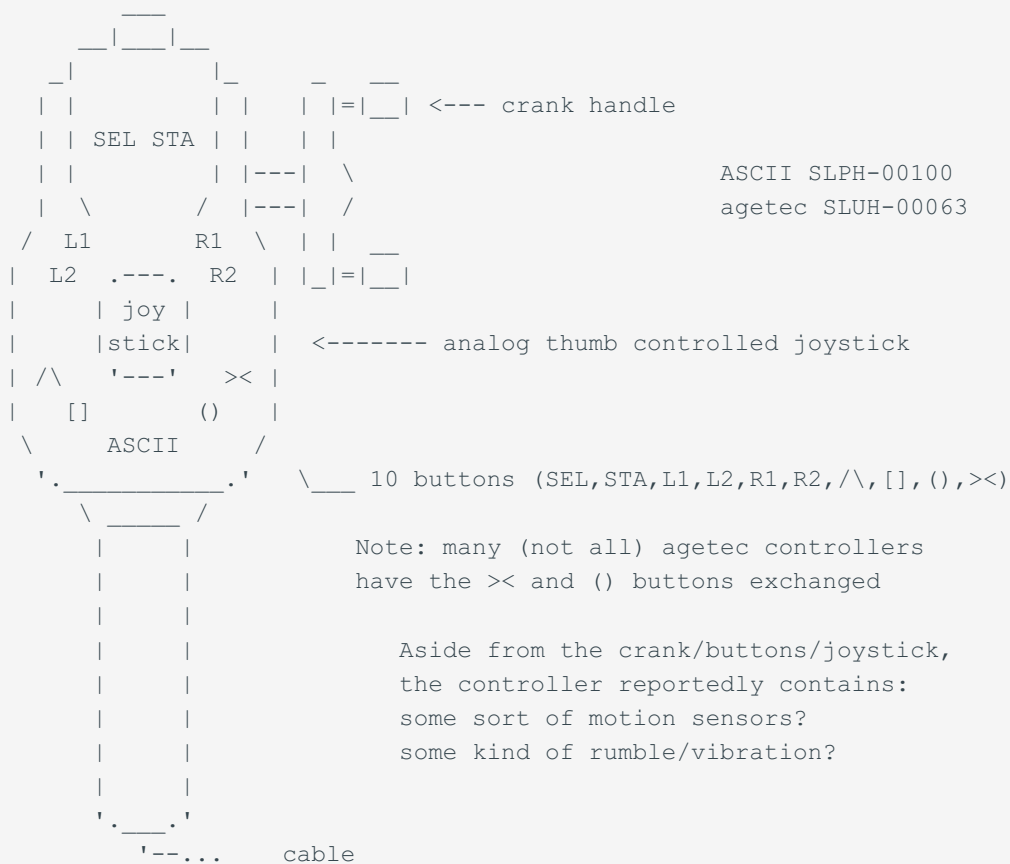
Unknown how to read buttons, joystick, crank, motion sensors.

Unknown how to control rumble/vibration.

Unknown if/how Bandai differs from ASCII/agetec (aside from less buttons).

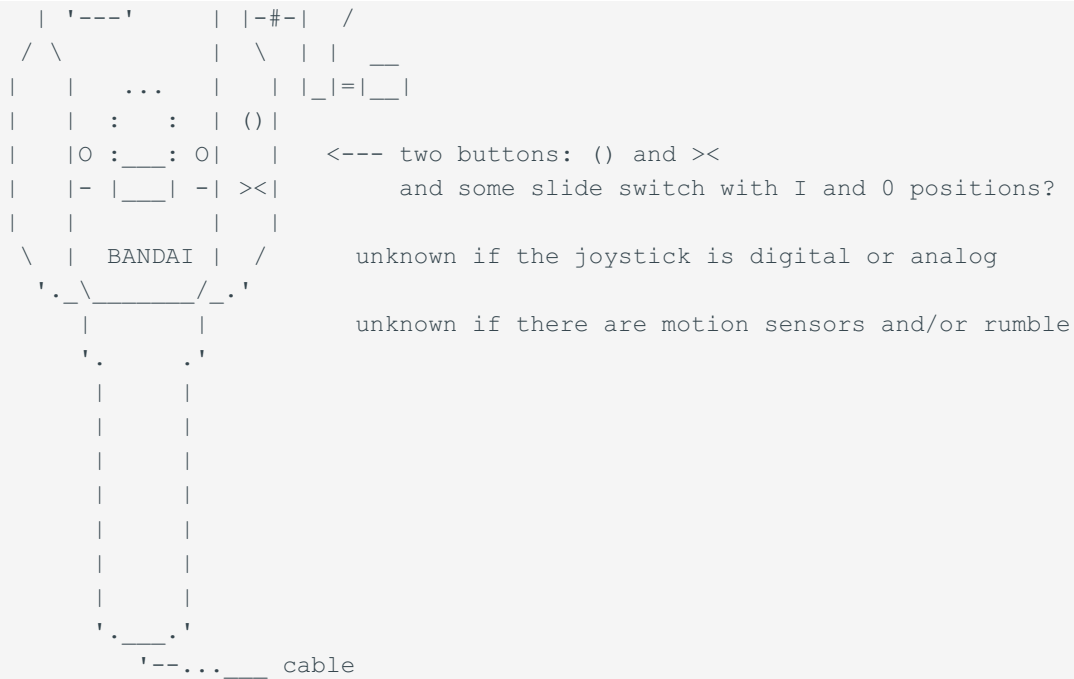
Unknown how the Hori thing works.

ASCII SLPH-00100 / agetec SLUH-00063 (silver)

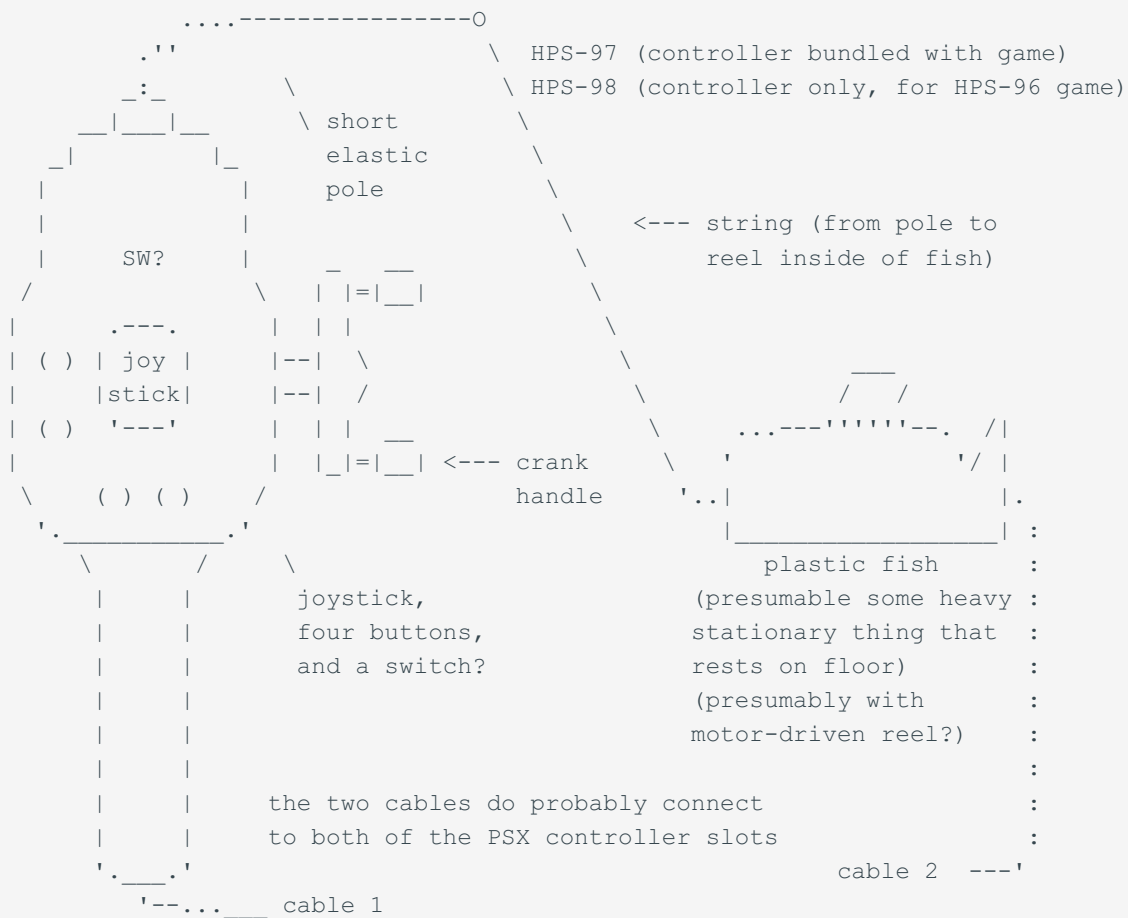


Bandai BANC-0001 (dark gray/blue)





Hori HPS-97 / HPS-98 (black/gray)



14.20 Controllers - PS2 DVD Remote

An accessory released by Sony for the PS2, consisting of an infrared remote control and a receiver dongle that plugs into a controller port. The remote features all standard controller buttons (including L3/R3) as well as additional controls for the PS2's DVD player.

The receiver behaves very differently from any other known device: it does not respond to any command until a button on the remote is pressed. When a valid IR code is received it will start accepting commands for about 2000-2500 ms, then become unresponsive again. It will initially behave as two different devices, one with address 01h acting like a standard digital controller and the other with address 61h exposing IR codes as received from the remote.

Command 04h - IR poll (and disable controller mode)

Send	Reply	Comment
61h	N/A	IR receiver address
04h	12h	Receive ID bits 0-7, send command byte
00h	5Ah	Receive ID bits 8-15
00h	len	Receive code length (20 for DVD remote, 0 if no button is pressed)
00h	code	Receive code bits 16-23
00h	code	Receive code bits 8-15
00h	code	Receive code bits 0-7

Returns the IR code of the currently pressed button and its length in bits, or 000000h if no button is pressed (and the receiver is still responding to commands). Received codes seem to "stick around" for some time even after the button has been released; when a button is held down the remote resends its code every 45 ms, so the receiver presumably keeps returning the same code for about 50 ms as a debouncing measure.

The code is returned LSB first and MSB aligned, i.e. it should be right-shifted by (24 - len) bits to obtain the "raw" code as sent by the remote. For instance:

```
Code sent by remote (first bit after preamble to last bit):
0000 0000 1011 1001 0010
Code sent by remote (MSB to LSB):
0100 1001 1101 0000 0000
Data returned by receiver:
code[16:23] = 01001001
code[8:15]  = 11010000
code[0:7]   = 0000xxxx ; xxxx = (24 - len) bits of padding (all zeroes)
Reassembled MSB-aligned code (MSB to LSB):
0100 1001 1101 0000 0000 xxxx
```

The receiver will stop acting like a digital controller and replying to address 01h after this command is sent for the first time. Command 06h can be used to restore controller functionality (see below), unknown if there is also a watchdog to automatically restore controller mode if no IR poll commands are issued.

Command 06h, 03h - Re-enable controller mode

Send	Reply	Comment
61h	N/A	IR receiver address
06h	12h	Receive ID bits 0-7, send command byte 1
03h	5Ah	Receive ID bits 8-15, send command byte 2
00h	?	Receive unknown data, send padding
00h	?	
00h	?	
00h	?	

Command 0Fh - Unknown

This command exists (the receiver will keep pulling /ACK low) but its purpose is currently unknown. It could possibly be an alternate poll command that does not disable controller mode.

IR code format

The DVD remote always emits 20-bit IR codes. The receiver does return the length of the code, but it's unclear if it can receive codes with lengths other than 20 bits.

All non-controller buttons on the remote are arranged in an 8x16 button matrix, shown below (transposed for readability):

Col	Row 0	Row 1	Row 2	Row 3	Row 4	Row 5
0	1			Previous		
1	2			Next		
2	3			Play		
3	4			Scan <<		
4	5			Scan >>		Display
5	6			Shuffle		
6	7					
7	8					
8	9		Time	Stop		
9	0			Pause		
10		Title	A<->B			
11	Enter	DVD Menu				
12			Repeat			
13						
14	Return					
15	Clear	Program				

Each button in the matrix is assigned a code as follows:

```
code = 49D00h OR (row << 4) OR (column) ; sent LSB first

; where row = 0..7, column = 0..15
```

Controller buttons are handled separately and assigned different codes:

```
code = DAD50h OR (id) ; sent LSB first

; where id = 0..15, index of the bit that would normally represent the button
; in the bitfield returned by a controller poll command
; (i.e. 0=Select, 1=L3, 2=R3, 3=Start, 4=Up, 5=Right, etc.)
```

Arrow buttons are a special case, as they are controller buttons but also have matrix codes assigned. For those the remote alternates between both codes (see below).

Low-level IR protocol

The remote emits IR pulses modulated with a 38 kHz carrier, as most remotes do. Codes are sent as a 2460 μ s "preamble" pulse followed by 24 data pulses, each of which can be either 1250 μ s (if the respective bit is 1) or 650 μ s (if the respective bit is 0) long. After each pulse including the preamble, the remote waits 530 μ s before sending the next pulse.

Every code is always sent at least 3 times in a row (more if the button is held down but not necessarily a multiple of 3), approximately every 45 ms. For arrow buttons the matrix code is sent 3 times first, then the respective controller button code is sent 3 times, then the sequence repeats until the button is released (with the total number of codes sent always being a multiple of 6 in this case).

Built-in IR receivers

In later PS2 models, Sony integrated the IR receiver into the console. Assuming the built-in receivers used the same circuitry as the external dongle, this may explain its weird behavior: the receiver was likely designed to be wired in parallel with one of the controller ports, and to be unresponsive until the remote is actually in use to avoid interfering with another controller plugged into the same port. Whether or not the integrated receivers are connected this way has not been confirmed.

There is a second revision of the DVD remote with power and eject buttons, meant to be used with the PS2 models that have a built-in receiver. Weirdly enough, however, it seems to be incompatible with the older receiver dongle.

14.21 Controllers - I-Mode Adaptor (Mobile Internet)

The I-Mode Adaptor cable (SCPH-10180) allows to connect an I-mode compatible mobile phone to the playstation's controller port; granting a mobile internet connection to japanese games.

PSX Games for I-Mode Adaptor (Japan only)

```
Doko Demo Issyo (PlayStation the Best release only) (Sony) 2000
Doko Demo Issyo Deluxe Pack (Bomber eXpress/Sony) 2001
Hamster Club-I (SLPS-03266) (Jorudan) 2002
iMode mo Issyo: Dokodemo Issho Tsuika Disc (Bomber/Sony) 2001
Keitai Eddy (iPC) 2000 (but, phone connects to SIO port on REAR side of PSX?)
Komocchi (Victor) 2001
Mobile Tomodachi (Hamster) 2002
```

Motto Trump Shiyoyo! i-Mode de Grand Prix (Pure Sound) 2002
 One Piece Mansion (Capcom) 2001 (japanese version only)

The supported games should have a I-Mode adaptor logo on the CD cover (the logo depicts two plugs: the PSX controller plug, and the smaller I-Mode plug).

Note: "Dragon Quest Monsters 1 & 2" was announced/rumoured to support I-mode (however, its CD cover doesn't show any I-Mode adapter logo).

Tech Details (all unknown)

Unknown how to detect the thing, and how to do the actual data transfers.

The cable does contain a 64pin chip, an oscillator, and some smaller components (inside of the PSX controller port connector).

Hardware Variant

Keitai Eddy seems to have the phone connect to the SIO port (on rear side of the PSX, at least it's depicted like so on the CD cover). This is apparently something different than the SCPH-10180 controller-port cable. Unknown what it is exactly - probably some mobile internet connection too, maybe also using I-mode, or maybe some other protocol.

14.22 Controllers - Keyboards

There isn't any official retail keyboard for PSX, however, there is a shitload of obscure ways to connect keyboards...

Sony SCPH-2000 PS/2 Keyboard/Mouse Adaptor (prototype/with cable) (undated)

Sony SCPH-2000 PS/2 Keyboard/Mouse Adaptor (without cable) (undated)

A PS/2 to PSX controller port adaptor. Maybe for educational Lightspan titles?

There are two hardware variants of the adaptor:

Adaptor with short cable to PSX-controller port (and prototype marking)
 Adaptor without cable, directly plugged into controller port (final version?)

Unknown ^how to access those adaptors, and unknown if the two versions differ at software side. There seem to be not much more than a handful of people owning that adaptors, and none of them seems to know how to use it, or even how to test if it's

working with existing software...

- Keyboard reading might work with the Online Connection CD.
- Mouse reading might work with normal mouse compatible PSX games.

Lightspan Online Connection CD Keyboard (1997)

The Online Connection CD is a web browser from the educational Lightspan series, the CD is extremely rare (there's only one known copy of the disc).

The thing requires a dial-up modem connected to the serial port (maybe simply using the same RS232 adaptor as used by Yaroze). User input can be done via joypad, or optionally, via some external keyboard (or keyboard adaptor) hardware:

```
Send  01h 42h 00h 00h 00h 00h 00h 00h 00h 00h 00h 00h 00h 06h
Reply HiZ 96h 5Ah num dat dat dat dat dat dat dat dat dat dat
```

The num byte indicates number of following scancodes (can be num=FFh, maybe when no keyboard connected?, or num=00h..0Bh for max 11 bytes, unless the last some bytes should have other meaning, like status/mouse data or so).

The keyboard scancodes are in "PS/2 Keyboard Scan Code Set 2" format.

The binary contains some (unused) code for sending data to the keyboard by changing the 4th-11th byte, and resuming normal operation by setting 4th and 11th byte back to zero:

```
Send  .. .. .. 01h xxh FFh FFh FFh FFh FFh 00h .. .. .. ..
Send  .. .. .. 00h .. .. .. .. .. .. 00h .. .. .. ..
```

Maybe 4th and 11th byte are number of following bytes, with xxh being some command, and FFh's just being bogus padding; the xxh looks more like an incrementing value though.

Despite of the mouse-based GUI, the browser software doesn't seem to support mouse hardware (neither via PS/2 mice, nor PSX mice). Instead, the mouse arrow can be merely moved via joypad's DPAD, or (in a very clumsy fashion) via keyboard cursor keys.

Note: The browser uses SysEnqIntRP to install some weird IRQ handler that forcefully aborts all controller (or memory card) transfers upon Vblank. Unknown if that's somehow required to bypass bugs in the keyboard hardware. The feature is kinda dangerous for memory card access (especially with fast memcard access in nocash kernel, which allows to transfer more than one sector per frame).

Spectrum Emulator Keyboard Adaptor (v1/serial port) (undated)

Made by Anthony Ball. [<http://www.sinistersoft.com/psxkeyboard>]

```
[1F801058h]=00CEh ;SIO_MODE 8bit, no parity, 2 stop bits (8N2)
[1F80105Ah]=771Ch ;SIO_CTRL rx enable (plus whatever nonsense bits)
[1F80105Eh]=006Ch ;SIO_BAUD 19200 bps
RX   Keyboard Scancode (same ASCII-style as in later versions?)
CTS  Caps-Lock state
DSR  Num-Lock state
```

Spectrum Emulator Keyboard & Sega Sticks Adaptor (v2/controller port) (2000)

Made by Anthony Ball. [<http://www.sinistersoft.com/psxkeyboard>]

This adaptor can send pad/stick data,

```
Send  01h 42h 00h  0h 0h
Reply HiZ 41h 5Ah  PadA
```

as well as pad/sticks+keyboard data,

```
Send  01h 42h 00h  0h 0h 0h 0h 0h 0h 0h 0h 00h 00h  0h 0h 0h 0h 0h 0h
Reply HiZ E8h 5Ah  PadA  PadB  PadC  PadD  Ver Lock  Buffer(0..5)
```

The above mode(s) can be switched via ACPI Power/Sleep/Wake keys (on keyboards that do have such keys).

```
Version=1      ; version number
0  SCROLL      ; scroll lock on
1  NUM         ; num lock on
2  CAPS        ; caps lock on
3  DONETEST    ; keyboard has just done a selftest
4  EMUA        ; emulation mode a
5  EMUB        ; emulation mode b
```

For whatever reason, the PS/2 scancodes are translated to ASCII-style scancode values (with bit7=KeyUp flag):

```
01  11 12 13 14  15 16 17 18  19 1A 1B 1C  1D 69 1F
60 21 22 68 24 25 5E 26 2A 28 29 5F 3D  2D  0B 0E 0F  67 2F 1E 2D
27  51 57 45 52 54 59 55 49 4F 50 5B 5D 0D 10 61 62  37 38 39
3B  41 53 44 46 47 48 4A 4B 4C 3A 40 23          34 35 36 2B
02 5C 5A 58 43 56 42 4E 4D 3C 3E 3F          03      63      31 32 33
04 05 06          20          07 08 09 0A  65 64 66  30      2E 6A
```

BUG: The thing conflicts with memory cards: It responds to ANY byte with value 01h (it should do so only if the FIRST byte is 01h).

Homebrew PS/2 Keyboard/Mouse Adaptor (undated/from PSone era)

```
Send  01h 42h 00h 00h 00h 00h 00h
Reply HiZ 12h 5Ah key flg dx  dy
```

flg:

```
bit0-1 = Always 11b (unlike Sony mouse)
bit2 = Left Mouse Button (0=Pressed, 1=Released)
bit3 = Right Mouse Button (0=Pressed, 1=Released)
bit4-5 = Always 11b (like Sony mouse)
bit6 = Key Release (aka F0h prefix) (0=Yes)
bit7 = Key Extended (aka E0h prefix) (0=Yes)
```

Made by Simon Armstrong. This thing emulates a standard PSX Mouse (and should thus work with most or all mouse compatible games). Additionally, it's sending keyboard flags/scancodes via unused mouse button bits.

Runix hardware add-on USB Keyboard/Mouse Adaptor (2001) (PIO extension port)

Runix is a homebrew linux kernel for PSX, it can be considered being the holy grail of the open source scene because nobody has successfully compiled it in the past 16 years.

- USB host controller SL811H driver with keyboard and mouse support;
- RTC support.

file: drivers/usb/sl811h.c

TTY Console

The PSX kernel allows to output "printf" debug messages via stdout. In the opposite direction, it's supporting to receive ASCII user input via "std_in_gets" (there isn't any software actually using that feature though, except maybe debug consoles like DTL-H2000).

14.23 Controllers - Additional Inputs

Reset Button

PSX only (not PSone). Reboots the PSX via /RESET signal. Probably including for forcefully getting through the WHOLE BIOS Intro, making it rather useless/annoying? No idea if it clears ALL memory during reboot?

CDROM Shell Open

Status bit of the CDROM controller. Can be used to sense if the shell is opened (and also memorizes if the shell was opened since last check; allowing to sense possible disk changes).

PocketStation

Memory Card with built-in LCD screen and Buttons (which can be used as miniature handheld console). However, when it is connected to the PSX, the buttons are vanishing in the cartridge slot, so the buttons cannot be used as additional inputs for PSX games.

Serial Port PSX only (not PSone)

With an external adaptor (voltage conversion), the serial port can be used (among others) to connect a RS232 Serial Mouse. Although, most or all commercial games with mouse input are probably (?) supporting only Sony's Mouse (on the controller port) (rather than standard RS232 devices on the serial port).

TTY Debug Terminal

If present, the external DUART can be used for external keyboard input, at the BIOS side, this is supported as "std_in".

14.24 Controllers - Misc

Standard Controllers

```
SCPH-1010  digital joyypad (with short cable)
SCPH-1080  digital joyypad (with longer cable)
SCPH-1030  mouse (with short cable)
SCPH-1090  mouse (with longer cable)
```

```

SCPH-1092  mouse (european?)
SCPH-1110  analog joystick
SCPH-1150  analog joypad (with one vibration motor, with red/green led)
SCPH-1180  analog joypad (without vibration motors, with red/green led)
SCPH-1200  analog joypad (with two vibration motors) (dualshock)
SCPH-110   analog joypad (with two vibration motors) (dualshock for psone)
SCPH-10010 dualshock2 (analog buttons, except L3/R3/Start/Select) (for ps2)
SCPH-1070  multitap

```

Special Controllers

```

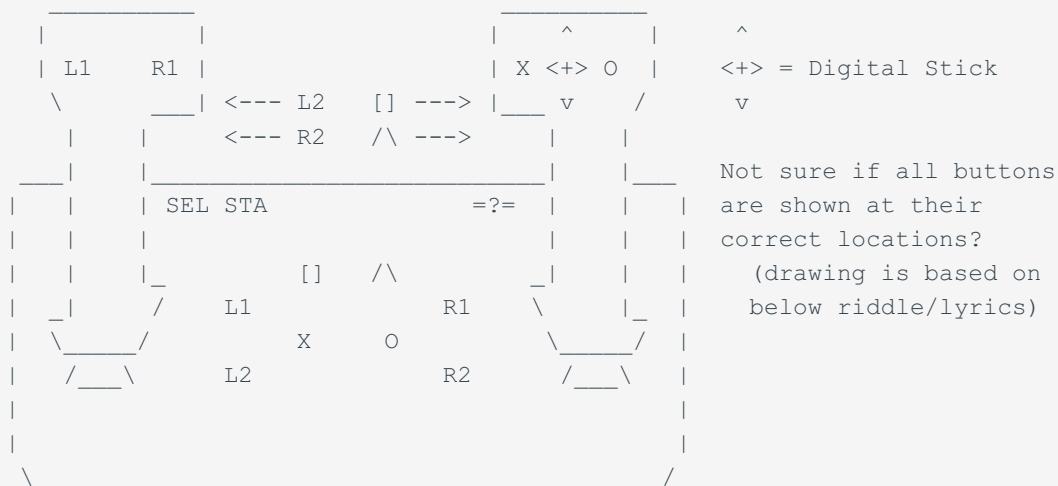
SCPH-4010 VPick (guitar-pick controller) (for Quest for Fame, Stolen Song)

```

SLPH-0001 (nejicon)

BANDAI "BANC-0002" - 4 Buttons (Triangle, Circle, Cross, Square) (nothing more)

Joystick



The thumb buttons on the left act as L1 and R1,
the trigger is L2, the pinky button is R2
The thumb buttons on the right act as X and O,
the trigger is Square and the pinky button is Triangle.
I find this odd as the triggers should've been L1 and R1,
the pinkies L2 and R2.
The buttons are redundantly placed on the base as large buttons like what
you'd see on a fight/arcade stick. Also with Start and Select.
There is also a physical analog mode switch,
not a button like on dual shock.

MX4SIO

The MX4SIO is a homebrew microSD card adapter for the PS2 that plugs into a memory card slot, taking advantage of the fact that SD cards support an SPI mode which is more or less compatible with SIO0. The adapter is completely passive and has the card wired up as follows:

uSD pin	Name	Wired to MC pin
1	D2 / NC	-
2	D3 / /CS	/CS
3	CMD / MOSI	CMD / MOSI
4	VCC	+3.5V
5	SCK	SCK
6	GND	GND, /ACK
7	D0 / MISO	DAT / MISO
8	D1 / NC	-

Unfortunately, this design has a fatal flaw that makes it unusable as-is on the PS1: /ACK is permanently shorted to ground, taking down the entire controller bus. However, it should be possible to use the MX4SIO on a PS1 with custom driver code once the MX4SIO's /ACK pin is masked out with some tape, or if no other controllers or memory cards are plugged in.

Note that, as SD cards do not employ the addressing scheme used by standard controllers and memory cards, the MX4SIO should get its own dedicated /CSn pin and not share the port with a controller (i.e. if the MX4SIO is plugged in slot 2, then controller port 2 shall be left unused).

14.25 Memory Card Read/Write Commands

Reading Data from Memory Card

```

Send Reply Comment
81h  N/A   Memory card address
52h  FLAG  Send Read Command (ASCII "R"), Receive FLAG Byte
00h  5Ah   Receive Memory Card ID1
00h  5Dh   Receive Memory Card ID2
MSB  (00h) Send Address MSB  ;\sector number (0..3FFh)
LSB  (pre) Send Address LSB  ;/
00h  5Ch   Receive Command Acknowledge 1  ;<-- late /ACK after this byte-pair

```



```

00h 5Dh  Receive Command Acknowledge 2
00h MSB  Receive Confirmed Address MSB
00h LSB  Receive Confirmed Address LSB
00h ...  Receive Data Sector (128 bytes)
00h CHK  Receive Checksum (MSB xor LSB xor Data bytes)
00h 47h  Receive Memory End Byte (should be always 47h="G"=Good for Read)

```

Non-sony cards additionally send eight 5Ch bytes after the end flag.

When sending an invalid sector number, original Sony memory cards respond with FFFFh as Confirmed Address (and do then abort the transfer without sending any data, checksum, or end flag), third-party memory cards typically respond with the sector number ANDed with 3FFh (and transfer the data for that adjusted sector number).

Writing Data to Memory Card

```

Send Reply Comment
81h N/A  Memory card address
57h FLAG Send Write Command (ASCII "W"), Receive FLAG Byte
00h 5Ah  Receive Memory Card ID1
00h 5Dh  Receive Memory Card ID2
MSB (00h) Send Address MSB ;\sector number (0..3FFh)
LSB (pre) Send Address LSB ;/
... (pre) Send Data Sector (128 bytes)
CHK (pre) Send Checksum (MSB xor LSB xor Data bytes)
00h 5Ch  Receive Command Acknowledge 1
00h 5Dh  Receive Command Acknowledge 2
00h 4xh  Receive Memory End Byte (47h=Good, 4Eh=BadChecksum, FFh=BadSector)

```

Get Memory Card ID Command

```

Send Reply Comment
81h N/A  Memory card address
53h FLAG Send Get ID Command (ASCII "S"), Receive FLAG Byte
00h 5Ah  Receive Memory Card ID1
00h 5Dh  Receive Memory Card ID2
00h 5Ch  Receive Command Acknowledge 1
00h 5Dh  Receive Command Acknowledge 2
00h 04h  Receive 04h
00h 00h  Receive 00h
00h 00h  Receive 00h
00h 80h  Receive 80h

```

This command is supported only by original Sony memory cards. Not sure if all sony cards are responding with the same values, and what meaning they have, might be number of sectors (0400h) and sector size (0080h) or whatever.

Invalid Commands

```
Send Reply Comment
81h  N/A    Memory card address
xxh  FLAG   Send Invalid Command (anything else than "R", "W", or "S")
```

Transfer aborts immediately after the faulty command byte, or, occasionally after one more byte (with response FFh to that extra byte).

FLAG Byte

The initial value of the FLAG byte on power-up (and when re-inserting the memory card) is 08h.

Bit3=1 is indicating that the directory wasn't read yet (allowing to sense memory card changes). For some strange reason, bit3 is NOT reset when reading from the card, but rather when writing to it. To reset the flag, games are usually issuing a dummy write to sector number 003Fh, more or less unnecessarily stressing the lifetime of that sector. Bit2=1 seems to be intended to indicate write errors, however, the write command seems to be always finishing without setting that bit, instead, the error flag may get set on the NEXT command.

Note: Some (not all) non-sony cards also have Bit5 of the FLAG byte set.

Timings

IRQ7 is usually triggered circa 1500 cycles after sending a byte (counted from the begin of the first bit), except, the last byte doesn't trigger IRQ7, and, after the 7th byte of the Read command, an additional delay of circa 31000 cycles occurs before IRQ7 gets triggered (that strange extra delay occurs only on original Sony cards, not on cards from other manufacturers).

There seems to be no extra delays in the Write command, as it seems, the data is written on the fly, and one doesn't need to do any write-busy handling... although, theoretically, the write shouldn't start until verifying the checksum... so it can't be done on the fly at all...?

Notes

Responses in brackets are don't care, (00h) means usually zero, (pre) means usually equal to the previous command byte (eg. the response to LSB is MSB).

Memory cards are reportedly "Flash RAM" which sounds like bullshit, might be battery backed SRAM, or FRAM, or slower EEPROM or FLASH ROM, or vary from card to card...?

14.26 Memory Card Data Format

Data Size

```
Total Memory 128KB = 131072 bytes = 20000h bytes
1 Block 8KB = 8192 bytes = 2000h bytes
1 Frame 128 bytes = 80h bytes
```

The memory is split into 16 blocks (of 8 Kbytes each), and each block is split into 64 sectors (of 128 bytes each). The first block is used as Directory, the remaining 15 blocks are containing Files, each file can occupy one or more blocks.

Header Frame (Block 0, Frame 0)

```
00h-01h Memory Card ID (ASCII "MC")
02h-7Eh Unused (zero)
7Fh      Checksum (all above bytes XORed with each other) (usually 0Eh)
```

Directory Frames (Block 0, Frame 1..15)

```
00h-03h Block Allocation State
    00000051h - In use ;first-or-only block of a file
    00000052h - In use ;middle block of a file (if 3 or more blocks)
    00000053h - In use ;last block of a file (if 2 or more blocks)
    000000A0h - Free ;freshly formatted
    000000A1h - Free ;deleted (first-or-only block of file)
    000000A2h - Free ;deleted (middle block of file)
    000000A3h - Free ;deleted (last block of file)
04h-07h Filesize in bytes (2000h..1E000h; in multiples of 8Kbytes)
08h-09h Pointer to the NEXT block number (minus 1) used by the file
        (ie. 0..14 for Block Number 1..15) (or FFFFh if last-or-only block)
0Ah-1Eh Filename in ASCII, terminated by 00h (max 20 chars, plus ending 00h)
1Fh      Zero (unused)
20h-7Eh Garbage (usually 00h-filled)
7Fh      Checksum (all above bytes XORed with each other)
```

Filesize [04h..07h] and Filename [0Ah..1Eh] are stored only in the first directory entry of a file (ie. with State=51h or A1h), other directory entries have that bytes zero-filled.

Filename Notes

The first some letters of the filename should indicate the game to which the file belongs, in case of commercial games this is conventionally done like so: Two character region code:

```
"BI"=Japan, "BE"=Europe, "BA"=America
```

followed by 10 character game code,

```
in "AAAA-NNNNN" form      ;for Pocketstation executables replace "-" by "P"
```

where the "AAAA" part does imply the region too; (SLPS/SCPS=Japan, SLUS/SCUS=America, SLES/SCES=Europe) (SCxS=Made by Sony, SLxS=Licensed by Sony), followed by up to 8 characters,

```
"abcdefgh"
```

(which may identify the file if the game uses multiple files; this part often contains a random string which seems to be allowed to contain any chars in range of 20h..7Fh, of course it shouldn't contain "?" and "*" wildcards).

Broken Sector List (Block 0, Frame 16..35)

```
00h-03h Broken Sector Number (Block*64+Frame) (FFFFFFFFh=None)
04h-7Eh Garbage (usually 00h-filled) (some cards have [08h..09h]=FFFFh)
7Fh      Checksum (all above bytes XORed with each other)
```

If Block0/Frame(16+N) indicates that a given sector is broken, then the data for that sector is stored in Block0/Frame(36+N).

Broken Sector Replacement Data (Block 0, Frame 36..55)

```
00h-7Fh Data (usually FFh-filled, if there's no broken sector)
```

Unused Frames (Block 0, Frame 56..62)

```
00h-7Fh Unused (usually FFh-filled)
```

Write Test Frame (Block 0, Frame 63)

Reportedly "write test". Usually same as Block 0 ("MC", 253 zero-bytes, plus checksum 0Eh).

Title Frame (Block 1..15, Frame 0) (in first block of file only)

```

00h-01h  ID (ASCII "SC")
02h      Icon Display Flag
          11h...Icon has 1 frame (static) (same image shown forever)
          12h...Icon has 2 frames (animated) (changes every 16 PAL frames)
          13h...Icon has 3 frames (animated) (changes every 11 PAL frames)
          Values other than 11h..13h seem to be treated as corrupted file
          (causing the file not to be listed in the bootmenu)
03h      Block Number (1-15) "icon block count" Uh?
          (usually 01h or 02h... might be block number within
          files that occupy 2 or more blocks)
          (actually, that kind of files seem to HAVE title frames
          in ALL of their blocks; not only in their FIRST block)
          (at least SOME seem to have such duplicated title frame,
          but not all?)
04h-43h  Title in Shift-JIS format (64 bytes = max 32 characters)
44h-4Fh  Reserved (00h)
50h-5Fh  Reserved (00h) ;<-- this region is used for the Pocketstation
60h-7Fh  Icon 16 Color Palette Data (each entry is 16bit CLUT)

```

For more info on entries [50h..5Fh], see

[Pocketstation File Header/Icons](#)

Icon Frame(s) (Block 1..15, Frame 1..3) (in first block of file only)

```

00h-7Fh  Icon Bitmap (16x16 pixels, 4bit color depth)

```

Note: The icons are shown in the BIOS bootmenu (which appears when starting the PlayStation without a CDROM inserted). The icons are drawn via GP0(2Ch) command, ie. as Textured four-point polygon, opaque, with texture-blending, whereas the 24bit blending color is 808080h (so it's quite the same as raw texture without blending). As semi-transparency is disabled, Palette/CLUT values can be 0000h=FullyTransparent, or 8000h=SolidBlack (the icons are usually shown on a black background, so it doesn't make much of a difference).

Data Frame(s) (Block 1..15, Frame N..63; N=excluding any Title/Icon Frames)

```

00h-7Fh  Data

```

Note: Files that occupy more than one block are having only ONE Title area, and only one Icon area (in the first sector(s) of their first block), the additional blocks are using sectors 0..63 for plain data.

Shift-JIS Character Set (16bit) (used in Title Frames)

Can contain japanese or english text, english characters are encoded like so:

```
81h,40h      --> SPC
81h,43h..97h --> punctuation marks
82h,4Fh..58h --> "0..9"
82h,60h..79h --> "A..Z"
82h,81h..9Ah --> "a..z"
```

Titles shorter than 32 characters are padded with 00h-bytes.

Note: The titles are \<usually> in 16bit format (even if they consist of raw english text), however, the BIOS memory card manager does also accept 8bit characters 20h..7Fh (so, in the 8bit form, the title could be theoretically up to 64 characters long, but, nethertheless, the BIOS displays only max 32 chars).

For displaying Titles, the BIOS includes a complete Shift-JIS character set,

BIOS Character Sets

Shift-JIS is focused on asian languages, and does NOT include european letters (eg. such with accent marks). Although the non-japanese PSX BIOSes DO include a european character set, the BIOS memory card manager DOESN'T seem to translate any title character codes to that character set region.

14.27 Memory Card Images

There are a lot of different ways to get a save from a memory card onto your PC's hard disk, and these ways sometimes involve sticking some additional information into a header at the beginning of the file.

Raw Memory Card Images (without header) (ie. usually 128K in size)

```
SmartLink .PSM,
WinPSM .PS,
DataDeck .DDF,
FPSX .MCR,
ePSXe .MCD...
```

don't stick any header on the data at all, so you can just read it in and treat it like a raw memory card.

All of these headers contain a signature at the top of the file. The three most common formats and their signatures are:

```
Connectix Virtual Game Station format (.MEM): "VgsM", 64 bytes
PlayStation Magazine format (.PSX): "PSV", 256 bytes
```

some programs will OMIT any blank or unallocated blocks from the end of the memory card -- if only three save blocks on the card are in use, for example, saving the other twelve is pointless.

Xploder and Action Replay Files (54 byte header)

```
00h..14h Filename in ASCII, terminated by 00h (max 20 chars, plus ending 00h)
15h..35h Title in ASCII, terminated by 00h (max 32 chars, plus ending 00h)
36h..   File Block(s) (starting with the Title sector)
```

This format contains only a single file (not a whole memory card). The filename should be the same as used in the Memory Card Directory. The title is more or less don't care; it may be the SHIFT-JIS title from the Title Sector converted to ASCII.

.MCS Files (Single Save Format)

MCS files consist of the 128 byte directory frame for the savefile's first block followed by all of that savefile's blocks in linked list order. When importing this format, the directory frame should be parsed for the save filename and the filesize while other fields should be ignored. The rest of the directory frame fields and any extra directory frames, in the case of multi-block saves, should be reconstructed based on the destination memory card.

.GME Files (usually 20F40h bytes)

InterAct GME format, produced by the DexDrive.

```
000h 12  ASCII String "123-456-STD",00h
00Ch 4    Usually zerofilled (or meaningless garbage in some files)
010h 5    Always 00h,00h,01h,00h,01h
015h 16   Copy of Sector 0..15 byte[00h] ;"M", followed by allocation states
025h 16   Copy of Sector 0..15 byte[08h] ;00h, followed by next block values
035h 11   Usually zerofilled (or meaningless garbage in some files)
040h F00h Fifteen Description Strings (each one 100h bytes, padded with 00h)
F40h 128K Memory Card Image (128K) (unused sectors 00h or FFh filled)
```

This is a very strange file format, no idea where it comes from. It contains a F40h bytes header (mainly zerofilled), followed by the whole 128K of FLASH memory (mainly zerofilled, too, since it usually contains only a small single executable file).

14.28 Memory Card Notes

Sony PSX Memory Cards

Sony has manufactured only 128KByte memory cards for PSX, no bigger/smaller ones.

Sony PS2 Memory Cards

A special case would be PS2 cards, these are bigger, but PS2 cards won't fit into PSX cards slots (unless when cutting an extra notch in the card edge connector), a PSX game played on a PS2 console could theoretically access PS2 cards (if it supports the different directory structure on that cards).

Third Party Cards with bigger capacity

Some third party cards contain larger memory chips, however, the PSX games/kernel are supporting only regular 128Kbyte cards, so the extra memory can be used only by dividing it into several 128Kbyte memory card images.

Selecting a different memory card image can be done by a switch or button on the card, or via joypad key combinations (joypad/card are sharing the same signals, so the card could watch the traffic on joypad bus, provided that the MIPS CPU is actually reading the joypad).

Third Party Cards with bigger capacity and Data Compression

Some cards are additionally using data compression to increase the card capacity, but that technique is having rather bad reputation and could result in data loss. For example, if a game has allocated four blocks on the memory card, then it'll expect to be able to overwrite that four blocks at any time (without needing to handle "memory card full" errors), however, if the card is full, and if the newly written data has worse compression ratio, then the card will be unable to store the new game position (and may have already overwritten parts of the old game position). As a workaround, such cards may use a LED to warn users when running low on memory (ideally, there should be always at least 128Kbytes of free memory).

Joytech Smart Card Adaptor

The smart card adaptor plugs into memory card slot, and allows to use special credit card-shaped memory cards. There don't seem to be any special features, ie. the hardware setup does just behave like normal PSX memory cards.

Datel VMEM (virtual memory card storage on expansion port)

The Datel/Interact VMEM exists as standalone VMEM cartridge, and some Datel Cheat Devices do also include the VMEM feature. Either way, the VMEM connects to expansion port, and contain some large FLASH memory, for storing multiple memory cards on it. Unknown, how that memory is accessed (maybe it must be copied to a regular memory card, or maybe they've somehow hooked the Kernel (or even the hardware signals?) so that games could directly access the VMEM?

Passwords (instead of Memory Cards)

Some older games are using passwords instead of memory cards to allow the user to continue at certain game positions. That's nice for people without memory card, but unfortunately many of that games are restricted to it - it'd be more user friendly to support both passwords, and, optionally, memory cards.

Yaroze Access Cards (DTL-H3020)

The Yaroze Access Card connects to memory card slot, the card resembles regular memory cards, but it doesn't contain any storage memory. Instead, it does merely support a very basic Access Card detection command:

Send Reply Comment

21h N/A? Probably replies HighZ (ie. probably reads FFh)?

53h 0xh? Replies unknown 8bit value (upper 4bit are known to be zero)?

Ie. when receiving 21h as first byte, it replies by an ACK, and does then output 0xh as response to the next byte.

Without the Access Card, the Yaroze Bootdisc will refuse to work (the disc contains software for transferring data to/from PC, for developing homebrew games).

Pocketstation (Memory Card with built-in LCD screen and buttons)

[Pocketstation](#)

15. Pocketstation

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15.1 Pocketstation Overview

Sony's Pocketstation (SCPH-4000) (1998)

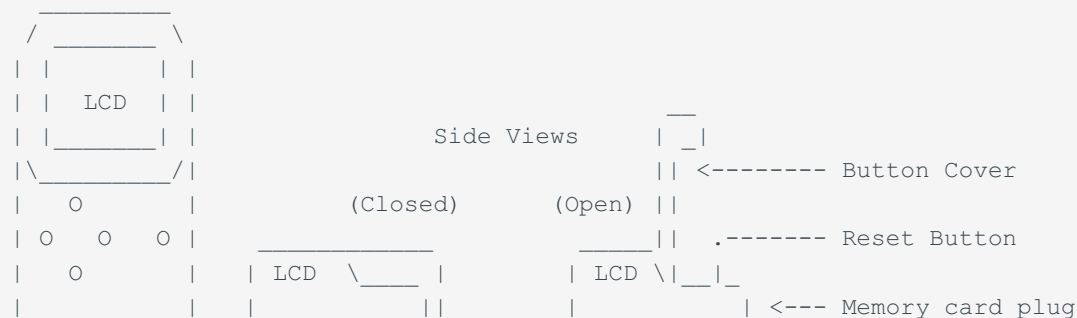
The Pocketstation is a memory card with built-in LCD screen and buttons; aside from using it as memory storage device, it can be also used as miniature handheld console.

CPU	ARM7TDMI (32bit RISC Processor) (variable clock, max 7.995MHz)
Memory	2Kbytes SRAM (battery backed), 16Kbytes BIOS ROM, 128Kbytes FLASH

```

Display    32x32 pixel LCD (black and white) (without any grayscales)
Sound      Mini Speaker "(12bit PCM) x 1 unit" / "8bit PCM with 12bit range"
Controls    5 input buttons, plus 1 reset button
Infrared    Bi-directional (IrDA based)
Connector  Playstation memory card interface
RTC         Battery backed Real-Time Clock with time/date function
Supply     CR2032 Battery (3VDC) (used in handheld mode, and for SRAM/RTC)

```



The RTC Problem

The main problem of the Pocketstation seems to be that it tends to reset the RTC to 1st January 1999 with time 00:00:00 whenever possible.

The BIOS contains so many RTC-reset functions, RTC-reset buttons, RTC-reset flags, RTC-reset communication commands, RTC-reset parameters, RTC-reset exceptions, RTC-reset sounds, and RTC-reset animations that it seems as if Sony actually WANTED the Time/Date to be destroyed as often as possible.

The only possible reason for doing this is that the clock hardware is so inaccurate that Sony must have decided to "solve" the problem at software engineering side, by erasing the RTC values before the user could even notice time inaccuracies.

CPU Specs

For details on the ARM7TDMI CPUs opcodes and exceptions, check GBATEK at, <http://problemkaputt.de/gbatek.htm> (or .txt)

The GBA uses an ARM7TDMI CPU, too.

Thanks to Exophase, Orion, Fezzik, Dr.Hell for Pocketstation info.

15.2 Pocketstation I/O Map

Memory and Memory-Control Registers

```

00000000h RAM          (2KB RAM) (first 512 bytes reserved for kernel)
02000000h FLASH1       Flash ROM (virtual file-mapped addresses in this region)

```

04000000h	BIOS_ROM	Kernel and GUI (16KB)
06000000h	F_CTRL	Control of Flash ROM
06000004h	F_STAT	Unknown?
06000008h	F_BANK_FLG	FLASH virtual bank mapping enable flags(16 bits) (R/W)
0600000Ch	F_WAIT1	waitstates...?
06000010h	F_WAIT2	waitstates, and FLASH-Write-Control-and-Status...?
06000100h	F_BANK_VAL	FLASH virtual bank mapping addresses (16 words) (R/W)
06000300h	F_EXTRA	Extra FLASH (256 bytes, including below F_SN, F_CAL)
06000300h	F_SN_LO	Extra FLASH Serial Number LSBs (nocash: 6BE7h)
06000302h	F_SN_HI	Extra FLASH Serial Number MSBs (nocash: 426Ch)
06000304h	F_?	Extra FLASH Unknown ? (nocash: 05CAh)
06000306h	F_UNUSED1	Extra FLASH Unused halfword (nocash: FFFFh)
06000308h	F_CAL	Extra FLASH LCD Calibration (nocash: 001Ah)
0600030Ah	F_UNUSED2	Extra FLASH Unused halfword (nocash: FFFFh)
0600030Ch	F_?	Extra FLASH Unknown ? (nocash: 0010h)
0600030Eh	F_UNUSED3	Extra FLASH Unused halfword (nocash: FFFFh)
06000310h	F_UNUSED4	Extra FLASH Unused (310..3FFh) (nocash: FFFFh-filled)
08000000h	FLASH2	Flash ROM (128KB) (physical addresses in this region)
08002A54h	F_KEY1	Flash Unlock Address 1 (W)
080055AAh	F_KEY2	Flash Unlock Address 2 (W)

Interrupts and Timers

0A000000h	INT_LATCH	Interrupt hold (R)
0A000004h	INT_INPUT	Interrupt Status (R)
0A000008h	INT_MASK_READ	Read Interrupt Mask (R)
0A000008h	INT_MASK_SET	Set Interrupt Mask (W)
0A00000Ch	INT_MASK_CLR	Clear Interrupt Mask (W)
0A000010h	INT_ACK	Clear Interrupt hold (W)
0A800000h	T0_RELOAD	Timer 0 Maximum value
0A800004h	T0_COUNT	Timer 0 Current value
0A800008h	T0_MODE	Timer 0 Mode
0A800010h	T1_RELOAD	Timer 1 Maximum value
0A800014h	T1_COUNT	Timer 1 Current value
0A800018h	T1_MODE	Timer 1 Mode
0A800020h	T2_RELOAD	Timer 2 Maximum value
0A800024h	T2_COUNT	Timer 2 Current value
0A800028h	T2_MODE	Timer 2 Mode
0B000000h	CLK_MODE	Clock control (CPU and Timer Speed) (R/W)
0B000004h	CLK_STOP	Clock stop (Sleep Mode)
0B800000h	RTC_MODE	RTC Mode
0B800004h	RTC_ADJUST	RTC Adjust
0B800008h	RTC_TIME	RTC Time (R)
0B80000Ch	RTC_DATE	RTC Date (R)

Communication Ports, Audio/Video

0C000000h	COM_MODE	Com Mode
0C000004h	COM_STAT1	Com Status Register 1 (Bit1=Error)
0C000008h	COM_DATA	Com RX Data (R) and TX Data (W)
0C000010h	COM_CTRL1	Com Control Register 1

0C000014h	COM_STAT2	Com Status Register 2 (Bit0=Ready)
0C000018h	COM_CTRL2	Com Control Register 2
0C800000h	IRDA_MODE	Infrared Control (R/W)
0C800004h	IRDA_DATA	Infrared TX Data
0C80000Ch	IRDA_MISC	Infrared Unknown/Reserved
0D000000h	LCD_MODE	Video Control (R/W)
0D000004h	LCD_CAL	Video Calibration (?)
0D000100h	LCD_VRAM	Video RAM (80h bytes; 32x32bit) (R/W)
0D800000h	IOP_CTRL	IOP control
0D800004h	IOP_STAT	Read Current Start/Stop bits? (R)
0D800004h	IOP_STOP	Stop bits? (W)
0D800008h	IOP_START	Start bits? (W)
0D80000Ch	IOP_DATA	IOP data? (not used by bios)
0D800010h	DAC_CTRL	DAC Control (R/W)
0D800014h	DAC_DATA	DAC data
0D800020h	BATT_CTRL	Battery Monitor Control

BIOS and FLASH can be read only in 16bit and 32bit units (not 8bit).

Upon reset, BIOS ROM is mirrored to address 00000000h (instead of RAM).

For most I/O ports, it is unknown if they are (R), (W), or (R/W)...?

I/O ports are usually accessed at 32bit width, occasionally some ports are (alternately) accessed at 16bit width. A special case are the F_SN registers which seem to be required to be accessed at 16bit (not 32bit).

Memory Access Time

Memory Access Time for Opcode Fetch:

WRAM	1 cycle (for ARM and THUMB)
FLASH	2 cycles (for ARM), or 1 cycle (for THUMB)
BIOS	?

Memory Access Time for Data Read/Write:

WRAM (and some F_XXX ports)	1 cycle
VIRT/PHYS/XTRA_FLASH, BIOS, VRAM, I/O	2 cycles

For data access, it doesn't matter if the access is 8bit/16bit/32bit (unlike as for opcode fetch, where 16bit/thumb can be faster than 32bit/arm). There seems to be no timing differences for sequential/non-sequential access.

Additional memory waitstates can be added via F_WAIT2 (and F_WAIT1 maybe).

Invalid/Unused Memory Locations

00000800h-00FFFFFFh	Mirrors of 00000000h-000007FFh (2K RAM)
01000000h-01FFFFFFh	Invalid (read causes data abort) (unused 16MB area)

```

020xxxxxh-0201FFFFh Invalid (read causes data abort) (disabled FLASH banks)
02020000h-02FFFFFFFh Invalid (read causes data abort) (no Virt FLASH mirrors)
03000000h-03FFFFFFFh Invalid (read causes data abort) (unused 16MB area)
04004000h-04FFFFFFFh Mirrors of 04000000h-04003FFFh (16K BIOS)
05000000h-05FFFFFFFh Invalid (read causes data abort)
06000014h-060000FFh Zerofilled (or maybe mirror of a ZERO port?) (F_xxx)
06000140h-060002FFh Zerofilled (or maybe mirror of a ZERO port?) (F_xxx)
06000400h-06FFFFFFFh Zerofilled (or maybe mirror of a ZERO port?) (F_xxx)
07000000h-07FFFFFFFh Invalid (read causes data abort) (unused 16MB area)
08020000h-08FFFFFFFh Mirrors of 08000000h-0801FFFFh (128K Physical FLASH)
09000000h-09FFFFFFFh Invalid (read causes data abort) (unused 16MB area)
0A000014h-0A7FFFFFFFh Mirrors of 0A000008h-0A00000Bh (INT_MASK_READ) (I_xxx)
0A80000Ch Mirror of 0A800000h-0A800003h (T0_RELOAD) (T0_xxx)
0A80001Ch Mirror of 0A800000h-0A800003h (T0_RELOAD) (T1_xxx)
0A80002Ch Mirror of 0A800000h-0A800003h (T0_RELOAD) (T2_xxx)
0A800030h-0AFFFFFFFh Mirrors of 0A800000h-0A800003h (T0_RELOAD) (T_xxx)
0B000008h-0B7FFFFFFFh Mirrors of .... ? (CLK_xxx)
0B800010h-0BFFFFFFFh Mirrors of 0B800008h-0B80000Bh (RTC_TIME)
0C00000Ch-0C00000Fh Zero (COM_xxx)
0C00001Ch-0C7FFFFFFFh Zerofilled (or maybe mirror of a ZERO port?) (COM_xxx)
0C800008h-0CFFFFFFFh ? (IRDA_xxx)
0D000008h-0D0000FFh Zerofilled (or maybe mirror of a ZERO port?) (LCD_xxx)
0D000180h-0D7FFFFFFFh Zerofilled (or maybe mirror of a ZERO port?) (LCD_xxx)
0D800018h ? (DAC_xxx)
0D80001Ch ? (DAC_xxx)
0D800024h-0DFFFFFFFh Zerofilled (or maybe mirror of a ZERO port?) (BATT_xxx)
0E000000h-FFFFFFFh Invalid (read causes data abort) (unused 3872MB area)

```

Unsupported 8bit Reads

```

02000000h-0201FFFFh VIRT_FLASH ;\
04000000h-04FFFFFFFh BIOS_ROM ; "garbage_byte" (see below)
06000300h-060003FFh EXTRA_FLASH ;
08000000h-08FFFFFFFh PHYS_FLASH ;/
0A800001h-0AFFFFFFFh Timer area, odd addresses (with A0=1) mirror to 0A800001h
0B800001h-0BFFFFFFFh RTC area, odd addresses (with A0=1) mirror to ...?

```

Unsupported 16bit Reads

```

0B800002h-0BFFFFFFEh RTC area, odd addresses (with A1=1) mirror to 0B80000Ah

```

garbage_byte (for unsupported 8bit reads)

The "garbage_byte" depends on the LSBs of the read address, prefetched opcodes, and recent data fetches:

```

garbage_word = (prefetch OR (ramdata AND FFFFFFFD0h))
garbage_byte = (garbage_word shr (8*(addr and 3))) AND FFh

```

For ARM code, the "prefetch" is the 2nd next opcode after the LDRB:

```
prefetch.bit0-31 = [curr_arm_opcode_addr+8] ; -eg. from arm LDRB
```

For THUMB code, the "prefetch" is the 2nd next opcode after the LDRB (no matter if that opcode is word-aligned or not), combined with the most recent ARM opcode prefetch (eg. from the BX opcode switched from ARM to THUMB mode; that value may get changed on interrupts):

```
prefetch.bit0-15 = [recent_arm_opcode_addr+8] ; -eg. from arm BX to thumb
prefetch.bit16-31 = [curr_thumb_opcode_addr+4] ; -eg. from thumb LDRB
```

The "ramdata" is related to most recent RAM read (eg. from POP or LDR opcodes that have read data from RAM; however, writes to RAM, or literal pool reads from FLASH don't affect it):

```
ramdata.bit0-31 = [recent_ram_read_addr] ; -eg. from LDR/POP from RAM
```

There might be some more/unknown things that affect the garbage (eg. opcode fetches from RAM instead of FLASH, partial 8bit/16bit data reads from RAM, or reads from I/O areas, current CPU clock speed, or unpredictable things like temperature).

Note: The garbage_byte is "used" by the pocketstation "Rockman" series games.

15.3 Pocketstation Memory Map

Overall Memory Map

00000000h	RAM	RAM (2K)	(or mirror of BIOS ROM upon reset)
02000000h	FLASH1	Flash ROM	(virtual file-mapped addresses in this region)
04000000h	BIOS_ROM	BIOS (16K)	(Kernel and GUI)
06000300h	F_SN...	Seems to contain a bunch of additional FLASH bytes?	
08000000h	FLASH2	Flash ROM (128K)	(physical addresses in this region)
0D000100h	LCD_VRAM	Video RAM (128 bytes)	(32x32 pixels, 1bit per pixel)

00000000h..000001FFh - Kernel RAM

The first 200h bytes of RAM are reserved for the kernel.

0000000h	20h	Exception handler opcodes (filled with LDR R15,[\$+20h] opcodes)
0000020h	20h	Exception handler addresses (in ARM state, no THUMB bit here)
0000040h	80h	Sector buffer (and BU command parameter work space)
00000C0h	8	ComFlags (see GetPtrToComFlags(), SWI 06h for details)

00000C8h	2	BU Command FUNC3 Address (see GetPtrToFunc3addr() aka SWI 17h)
00000CAh	1	Value from BU Command_50h, reset by SWI 05h (sense_auto_com)
00000CBh	2	Not used
00000CDh	1	Old Year (BCD, 00h..99h) (for sensing wrapping to new century)
00000CEh	1	Alternate dir_index (when [0D0h]=0) (see SWI 15h and SWI 16h)
00000CFh	1	Current Century (BCD, 00h..99h) (see GetBcdDate() aka SWI 0Dh)
00000D0h	2	Current dir_index (for currently executed file, or 0=GUI)
00000D2h	2	New dir_index (PrepareExecute(flag,dir_index,param), SWI 08h)
00000D4h	4	New param (PrepareExecute(flag,dir_index,param), SWI 08h)
00000D8h	8	Alarm Setting (see GetPtrToAlarmSetting() aka SWI 13h)
00000E0h	4	Pointer to SWI table (see GetPtrToPtrToSwiTable() aka SWI 14h)
00000E4h	3x4	Memory Card BU Command variables
00000F0h	1	Memory Card FLAG byte (bit3=new_card, bit2=write_error)
00000F1h	1	Memory Card Error offhold (0=none, 1=once)
00000F2h	6	Not used
00000F8h	4x4	Callback Addresses (set via SetCallbacks(index,proc), SWI 01h)
0000108h	4	Snapshot ID (0xh,00h,"SE")
000010Ch	74h	IRQ and SWI stack (stacktop at 180h)
0000180h	80h	FIQ stack (stacktop at 200h)

Although one can modify that memory, one usually shouldn't do that, or at least one must backup and restore the old values before returning control to the GUI or to other executables. Otherwise, the only way to restore the original values would be to press the Reset button (which would erase the RTC time/date).

00000200h..000007FFh - User RAM and User stack (stacktop at 800h)

This region can be freely used by the game. The memory is zerofilled when the game starts.

02000000h - FLASH1 - Flash ROM (virtual file-mapped addresses in this region)

This region usually contains the currently selected file (including its title and icon sectors), used to execute the file in this region, mapped to continous addresses at 2000000h and up.

08000000h - FLASH2 - Flash ROM (128K) (physical addresses in this region)

This region is used by the BIOS when reading the memory card directory (and when writing data to the FLASH memory). The banking granularity is 2000h bytes (one memory card block), that means that the hardware cannot map Replacement Sectors which may be specified in the for Broken Sector List.

04000000h - BIOS ROM (16K) - Kernel and GUI


```

4000000h 1E00h Begin of Kernel (usually 1E00h bytes)
4000014h 4      BCD Date in YYYYMMDDh format (19981023h for ALL versions)
4001DFCh 4      Core Kernel Version (usually "C061" or "C110")
4001E00h 2200h Begin of GUI (usually 2200h bytes)
4003FFCh 4      Japanese GUI Version (usually "J061" or "J110")

```

The "110" version does contain some patches, but does preserve same function addresses as the "061" version, still it'd be no good to expect the BIOS to contain any code/data at fixed locations (except maybe the GUI version string). Kernel functions can be accessed via SWI Opcodes, and, from the PSX-side, via BU Commands.

Bus-Width Restrictions

FLASH and BIOS ROM seem to be allowed to be read only in 16bit and 32bit units, not in 8bit units? Similar restrictions might apply for some I/O ports...? RAM can be freely read/written in 8bit, 16bit, and 32bit units.

Waitstates

Unknown if and how many waitstates are applied to the different memory regions. The F_WAIT1 and F_WAIT2 registers seem to be somehow waitstate related. FLASH memory does probably have a 16bit bus, so 32bit data/opcode fetches might be slower then 16bit reads...? Similar delays might happen for other memory and I/O regions...?

15.4 Pocketstation IO Video and Audio

0D000000h - LCD_MODE - LCD control word (R/W)

```

0-2 Draw mode; seems to turn off bits of the screen;
    0: All 32 rows on      ;\
    1: First 8 rows on    ;
    2: Second 8 rows on   ;
    3: Third 8 rows on    ; (these are not necessarily all correct?)
    4: Fourth 8 rows on   ;
    5: First 16 rows on   ;
    6: Middle 16 rows on  ;
    7: Bottom 16 rows on  ;/
3   CPEN      (0=Does some weird fade out of the screen, 1=Normal)
4-5 Refresh rate
    0: Makes a single blue (yes, blue, yes, on a black/white display)
        line appear at the top or middle of the screen - don't use!
    1: 64Hz? (might be 32Hz too, like 2)
    2: 32Hz
    3: 16Hz (results in less intensity on black pixels)

```

```

6      Display active          (0=Off, 1=On)
7      Rotate display by 180 degrees (0=For Handheld Mode, 1=For Docked Mode)
8-31   Unknown (should be zero)

```

Software should usually set LCD_MODE.7 equal to INT_INPUT.Bit11 (docking flag). In handheld mode, the button-side is facing towards the player, whilst in Docked mode (when the Pocketstation is inserted into the PSX controller port), the button-side is facing towards the PSX, so the screen coordinates become vice-versa, which can be "undone" by the Rotation flag.

0D000004h - LCD_CAL - LCD Calibration (maybe contrast or so?)

Upon the reset, the kernel sets LCD_CAL = F_CAL AND 0000003Fh. Aside from that, it doesn't use LCD_CAL.

0D000100h..D00017Fh - LCD_VRAM - 32x32 pixels, 1bit color depth (R/W)

This region consists of 32 words (32bit values),

```
[D000100h]=Top, through [D00017Ch]=Bottom-most scanline
```

The separate scanlines consist of 32bit each,

```
Bit0=Left, through Bit31=Right-most Pixel (0=White, 1=Black)
```

That [D000100h].Bit0=Upper-left arrangement applies if the Rotate bit in LCD_MODE.7 is set up in the conventional way, if it is set the opposite way, then it becomes [D00017Ch].Bit31=Upper-left.

The LCD_VRAM area is reportedly mirrored to whatever locations?

0D800010h - DAC_CTRL - Audio Control (R/W)

```

0      Audio Enable enable    (0=Off, 1=On)
1-31   Unknown, usually zero

```

Note: Aside from the bit in DAC_CTRL, audio must be also enabled/disabled via IOP_STOP/IOP_START bit5. Unknown if/which different purposes that bits have.

0D800014h - DAC_DATA - Audio D/A Converter

Unknown how many bits are passed to the D/A converter, probably bit8-15, ie. 8 bits...?

```

0-7   Probably unused, usually zero (or fractional part when lowered volume)
8-15  Signed Audio Outut Level (usually -7Fh..+7Fh) (probably -80h works too)
16-31 Probably unused, usually sign-expanded from bit15

```

The Pocketstation doesn't have any square wave or noise generator (nor a sound DMA channel). So the output levels must be written to DAC_DATA by software, this is usually done via Timer1/IRQ-8 (to reduce CPU load caused by high audio frequencies, it may be much more recommended to use Timer2/FIQ-13, because the FIQ handler doesn't need to push r8-r12).

For example, to produce a 1kHz square wave, the register must be toggled high/low at 2kHz rate. If desired, multiple channels can be mixed by software. High frequencies and multiple voices may require high CPU speed settings, and thus increase battery consumption (aside from that, battery consumption is probably increased anyways when the speaker is enabled).

15.5 Pocketstation IO Interrupts and Buttons

0A000004h - INT_INPUT - Raw Interrupt Signal Levels (R)

Bit	Type	Meaning	
0	IRQ	Button Fire	(0=Released, 1=Pressed)
1	IRQ	Button Right	(0=Released, 1=Pressed)
2	IRQ	Button Left	(0=Released, 1=Pressed)
3	IRQ	Button Down	(0=Released, 1=Pressed)
4	IRQ	Button Up	(0=Released, 1=Pressed)
5	?	Unknown?	(?)
6	FIQ (!)	COM	;for the COM_registers? (via /SEL Pin?)
7	IRQ	Timer 0	
8	IRQ	Timer 1	
9	IRQ	RTC (square wave)	(usually 1Hz) (when RTC paused: 4096Hz)
10	IRQ	Battery Low	(0=Normal, 1=Battery Low)
11	IRQ	Docked ("IOP")	(0=Undocked, 1=Docked to PSX) (via VCC Pin?)
12	IRQ	Infrared Rx	
13	FIQ (!)	Timer 2	
14-15	N/A	Not used	

The buttons are usually read directly from this register (rather than being configured to trigger IRQs) (except in Sleep mode, where the Fire Button IRQ is usually used to wakeup). Also, bit9-11 are often read from this register.

The direction keys seem to be separate buttons, ie. unlike as on a joystick or DPAD, Left/Right (and Up/Down) can be simultaneously pressed...?

0A000008h - INT_MASK_SET - Set Interrupt Mask (W)**0A00000Ch - INT_MASK_CLR - Clear Interrupt Mask (W)****0A000008h - INT_MASK_READ - Read Interrupt Mask (R)**

INT_MASK_SET	Enable Interrupt Flags	(0=No change, 1=Enable)	(W)
INT_MASK_CLR	Disable Interrupt Flags	(0=No change, 1=Disable)	(W)
INT_MASK_READ	Current Interrupt Enable Flags	(0=Disabled, 1=Enabled)	(R)

The locations of the separate bits are same as in INT_INPUT (see there).

0A000000h - INT_LATCH - Interrupt Request Flags (R)**0A000010h - INT_ACK - Acknowledge Interrupts (W)**

INT_LATCH	Latched Interrupt Requests	(0=None, 1=Interrupt Request)	(R)
INT_ACK	Clear Interrupt Requests	(0=No change, 1=Acknowledge)	(W)

The locations of the separate bits are same as in INT_INPUT (see there).

The interrupts seem to be edge-triggered (?), ie. when the corresponding bits in INT_INPUT change from 0-to-1. Unknown if the request bits get set when the corresponding interrupt is disabled in INT_MASK...?

ATTENTION: The GUI doesn't acknowledge Fire Button interrupts on wakeup... so, it seems as if button interrupts are NOT latched... ie. the button "INT_LATCH" bits seem to be just an unlatched mirror of the "INT_INPUT" bits... that might also apply for some other interrupt...?

However, after wakeup, the gui does DISABLE the Fire Button interrupt, MAYBE that does automatically acknowledge it... in that case it might be latched...?

Reading outside the readable region (that is where exactly?) seems to mirror to 0A000008h. Enabling IRQs for the buttons seems to make it impossible to poll them... is that really true?

15.6 Pocketstation IO Timers and Real-Time Clock

Timer and RTC interrupts

```

INT_INPUT.7    Timer 0 IRQ    ;used as 30Hz frame rate IRQ by GUI
INT_INPUT.8    Timer 1 IRQ    ;used as Audio square wave IRQ by GUI
INT_INPUT.13   Timer 2 FIQ (this one via FIQ vector, not IRQ vector)
INT_INPUT.9    RTC IRQ (usually 1Hz) (or 4096Hz when RTC paused)

```

0A800000h - T0_RELOAD - Timer 0 Reload Value**0A800010h - T1_RELOAD - Timer 1 Reload Value****0A800020h - T2_RELOAD - Timer 2 Reload Value**

```

0-15 Reload Value (when timer becomes less than zero)

```

Writes to this register are ignored if the timer isn't stopped?

0A800004h - T0_COUNT - Timer 0 Current value**0A800014h - T1_COUNT - Timer 1 Current value****0A800024h - T2_COUNT - Timer 2 Current value**

```

0-15 Current value (decrementing)

```

Timer interrupts: The timers will automatically raise interrupts if they're enabled, there's no need to set a bit anywhere for IRQs (but you need to enable the respect interrupts in INT_MASK).

0A800008h - T0_MODE - Timer 0 Control**0A800018h - T1_MODE - Timer 1 Control****0A800028h - T2_MODE - Timer 2 Control**

```

0-1 Timer Divider (0=Div2, 1=Div32, 2=Div512, 3=Div2 too)
2   Timer Enable  (0=Stop, 1=Decrement)
3-15 Unknown (should be zero)

```

Timers are clocked by the System Clock (usually 4MHz, when CLK_MODE=7), divided by the above divider setting. Note that the System Clock changes when changing the CPU speed via CLK_MODE, so Timer Divider and/or Timer Reload must be adjusted accordingly.

0B800000h - RTC_MODE - RTC control word

```

0    Pause RTC (0=Run/1Hz, 1=Pause/4096Hz)
1-3  Select value to be modified via RTC_ADJUST
4-31 Not used?

```

The selection bits can be:

```

00h = Second      ;\
01h = Minute      ;
02h = Hour        ; used in combination with RTC_ADJUST
03h = Day of Week  ; while RTC is paused
04h = Day          ;
05h = Month        ;
06h = Year         ;/
07h = Unknown      ;-usually used when RTC isn't paused

```

When paused, the RTC IRQ bit in INT_INPUT.9 runs at 4096Hz (instead 1Hz).

0B800004h - RTC_ADJUST - Modify value (write only)

Writing a value here seems to increment the current selected parameter (by the RTC control). What is perhaps (?) clear is that you have to wait for the RTC interrupt signal to go low before writing to this.

0B800008h - RTC_TIME - Real-Time Clock Time (read only) (R)

```

0-7   Seconds      (00h..59h, BCD)
8-15  Minutes      (00h..59h, BCD)
16-23 Hours        (00h..23h, BCD)
24-31 Day of week  (1=Sunday, ..., 7=Saturday)

```

Reading RTC_TIME seems to be somewhat unstable: the BIOS uses a read/retry loop, until it has read twice the same value (although it does read the whole 32bit at once by a LDR opcode, the data is maybe passed through a 8bit or 16bit bus; so the LSBs might be a few clock cycles older than the MSBs...?).

0B80000Ch - RTC_DATE - Real-Time Clock Date (read only) (R)

```

0-7   Day          (01h..31h, BCD)
8-11  Month        (01h..12h, BCD)
16-23 Year         (00h..99h, BCD)
24-31 Unknown?    (this is NOT used as century)

```

Reading RTC_DATE seems to require the same read/retry method as RTC_TIME (see there). Note: The century is stored in battery-backed RAM (in the reserved kernel RAM region) rather than in the RTC_DATE register. The whole date, including century, can be read via SWI 0Dh, GetBcdDate().

15.7 Pocketstation IO Infrared

The BIOS doesn't contain any IR functions (aside from doing some basic initialization and power-down stuff).

IR is used in Final Fantasy 8's Chocobo World (press Left/Right in the Map screen to go to the IR menu), and in Metal Gear Solid Integral (Press Up in the main screen), and in PDA Remote 1 & 2 (one-directional TV remote control).

0C800000h - IRDA_MODE - Controlling the protocol - send/recv, etc. (R/W)

```
0   Transfer Direction   (0=Receive, 1=Transmit)
1   Disable IRDA        (0=Enable, 1=Disable)
2   Unknown (reportedly IR_SEND_READY, uh?)
3   Unknown (reportedly IR_RECV_READY, uh?)
4-31 Unknown (should be zero)
```

0C800004h - IRDA_DATA - Infrared TX Data

```
0   Transmit Data in Send Direction (0=LED Off, 1=LED On)
1-31 Unknown (should be zero)
```

Bits are usually encoded as long or short ON pulses, separated by short OFF pulses. Where long is usually twice as long as short.

0C80000Ch - IRDA_MISC

Unknown? Reportedly reserved.

INT_INPUT.12 - IRQ - Infrared RX Interrupt

Seems to get triggered on raising or falling (?) edges of incoming data. The interrupt handler seems to read the current counter value from one of the timers (usually Timer 2, with reload=FFFFh) to determine the length of the incoming IR pulse.

IR Notes

Mind that IR hardware usually adopts itself to the normal light conditions, so if it receives an IR signal for a longer period, then it may treat that as the normal light conditions (ie. as "OFF" state). To avoid that, one would usually send a group of ON-OFF-ON-OFF pulses, instead of sending a single long ON pulse:

```

_____-_____ One HIGH bit send as SINGLE-LONG-ON pulse (BAD)
_____-_____ One HIGH bit send as MULTIPLE-ON-OFF pulses (OK)

```

that might be maybe done automatically by the hardware...?

Reportedly, Bit4 of Port 0D80000Ch (IOP_DATA) is also somewhat IR related...?

15.8 Pocketstation IO Memory-Control

06000000h - F_CTRL

0-31 Unknown

Written values are:

```

00000000h Used when disabling all virtual flash banks
00000001h Used before setting new virtual bank values
00000002h Used after setting virtual bank enable bits
03h       Replace ROM at 00000000h by RAM (used after reset)

```

The GUI does additionally read from this register (and gets itself trapped in a bizarre endless loop if bit0 was zero). Unknown if it's possible to re-enable ROM at location 00000000h by writing any other values to this register?

06000004h F_STAT

0-31 Unknown

The kernel issues a dummy read from this address (before setting F_CTRL to 00000001h).

06000008h F_BANK_FLG ;FLASH virtual bank mapping enable flags (16 bits)(R/W)


```

0-15   Enable physical banks 0..15 in virtual region (0=Disable, 1=Enable)
16-31  Unknown (should be zero)

```

06000100h F_BANK_VAL ;FLASH virtual bank mapping addresses (16 words)(R/W)

This region contains 16 words, the first word at 06000100h for physical bank 0, the last word at 0600013Ch for physical bank 15. Each word is:

```

0-3    Virtual bank number
4-31   Should be 0

```

Unused physical banks are usually mapped to 0Fh (and are additionally disabled in the F_BANK_FLG register).

0600000Ch F_WAIT1 ;waitstates...?

```

0..3   Unknown/not tested
4       hangs hardware? but that bit is used in some cases!
5..31  Unknown/not tested

```

Unknown, seems to control some kind of memory waitstates for FLASH (or maybe RAM or BIOS ROM). Normally it is set to the following values:

```

F_WAIT1=00000000h when CPU Speed = 00h..07h
F_WAIT1=00000010h when CPU Speed = 08h..0Fh

```

Note: The kernels Docking/Undocking IRQ-11 handler does additionally do this: "F_WAIT1=max(08h,(CLK_MODE AND 0Fh))" (that is a bug, what it actually wants to do is to READ the current F_WAIT.Bit4 setting).

06000010h F_WAIT2 ;waitstates, and FLASH-Write-Control-and-Status...?

```

0       no effect? but that bit is used in some cases! maybe write-enable?
1       hangs hardware?
2       no effect?          READ: indicates 0=write-busy, 1=ready?  (R)
3       hangs hardware?
4       makes FLASH slower?
5       makes WRAM and F_xxx as slow as other memory (0=1 cycle, 1=2 cycles)
6       hangs hardware? but that bit is used in some cases!
7       no effect?
8..31  Unknown/not tested

```

Unknown, seems to control some kind of memory waitstates, maybe for another memory region than F_WAIT1, or maybe F_WAIT2 is for writing, and F_WAIT1 for reading or so.

Normally it is set to the following values:

```
F_WAIT2=00000000h when CPU Speed = 00h..07h ;\same as F_WAIT1
F_WAIT2=00000010h when CPU Speed = 08h..0Fh ;/
```

In SWI 0Fh and SWI 10h it is also set to:

```
F_WAIT2=00000021h ;SWI 10h, FlashWritePhysical(sector,src)
F_WAIT2=00000041h ;SWI 0Fh, FlashWriteSerial(serial_number)
```

Before completion, those SWIs do additionally,

```
wait until reading returns F_WAIT2.Bit2 = 1
and then set F_WAIT2=00000000h
```

08002A54h - F_KEY1 - Flash Unlock Address 1 (W)

080055AAh - F_KEY2 - Flash Unlock Address 2 (W)

Unlocks FLASH memory for writing. The complete flowchart for writing sector data (or header values) is:

```
if write_sector                                ;\
    F_WAIT2=00000021h                          ; write enable or so
if write_header                                ;
    F_WAIT2=00000041h                          ;/
[80055AAh]=FFAAh                              ;\
[8002A54h]=FF55h                              ; unlock flash
[80055AAh]=FFA0h                              ;/
if write_sector                                ;\
    for i=0 to 3Fh                             ;
        [8000000h+sector*80h+i*2]=src[i*2]      ; write data
if write_header                                ;
    [8000000h]=new F_SN_LO value                ;
    [8000002h]=new F_SN_HI value                ;
    [8000008h]=new F_CAL value                  ;/
first, wait 4000 clock cycles                  ;\wait
then, wait until F_WAIT2.Bit2=1                ;/
F_WAIT2=00000000h                             ;-write disable or so
```

During the write operation one can (probably?) not read data (nor opcodes) from FLASH memory, so the above code must be executed either in RAM, or in BIOS ROM (see SWI 03h, SWI 0Fh, SWI 10h).

06000300h - F_SN_LO - Serial Number LSBs**06000302h - F_SN_HI - Serial Number MSBs****06000308h - F_CAL - Calibration value for LCD**

0-15 Data

This seems to be an additional "header" region of the FLASH memory (additionally to the 128K of data). The F_SN registers contain a serial number or so (purpose unknown, maybe intended as some kind of an "IP" address for more complex infrared network applications), the two LO/HI registers must be read by separate 16bit LDRH opcodes (not by a single 32bit LDR opcode). The F_CAL register contains a 6bit calibration value for LCD_CAL (contrast or so?).

Although only the above 3 halfwords are used by the BIOS, the "header" is unlike to be 6 bytes in size, probably there are whatever number of additional "header" locations at 06000300h and up...?

Note: Metal Gear Solid Integral uses F_SN as some kind of copy protection (the game refuses to run and displays "No copy" if F_SN is different as when the pocketstation file was initially created).

F_BANK_VAL and F_BANK_FLG Notes

Observe that the physical_bank number (p) is used as array index, and that the virtual bank number (v) is stored in that location, ie. table[p]=v, which is unlike as one may have expected it (eg. on a 80386 CPU it'd be vice-versa: table[v]=p).

Due to the table[p]=v assignment, a physical block cannot be mirrored to multiple virtual blocks, instead, multiple physical blocks can be mapped to the same virtual block (unknown what happens in that case, maybe the data becomes ANDed together).

15.9 Pocketstation IO Communication Ports

0C000000h - COM_MODE - Com Mode

```

0    Data Output Enable   (0=None/HighZ, 1=Output Data Bits)
1    /ACK Output Level   (0=None/HighZ, 1=Output LOW)
2    Unknown (should be set when expecting a NEW command...?)
3-31 Unknown (should be zero)
```

0C000008h - COM_DATA - Com RX/TX Data

0-7	Data (Write: to be transmitted to PSX, Read: been received from PSX)
8-31	Unknown

0C000004h - COM_STAT1 - Com Status Register 1 (Bit1=Error)

0	Unknown
1	Error flag or so (0=Okay, 1=Error)
2-31	Unknown

Seems to indicate whatever error (maybe /SEL disabled during transfer, or timeout, or parity error or something else?) in bit1. Meaning of the other bits is unknown. Aside from checking the error flag, the kernel does issue a dummy read at the end of each transfer, maybe to acknowledge something, maybe the hardware simply resets the error bit after reading (although the kernel doesn't handle the bit like so when receiving the 1st command byte).

Aside from the above error flag, one should check if INT_INPUT.11 becomes zero during transfer (which indicates undocking).

0C000014h - COM_STAT2 - Com Status Register 2 (Bit0=Ready)

0	Ready flag (0=Busy, 1=Ready) (when 8bits have been transferred)
1-31	Unknown

0C000010h - COM_CTRL1 - Com Control Register 1

0	Unknown (should be set AT BEGIN OF A NEW command...?)
1	Unknown (0=Disable something, 1=Enable something)
2-31	Unknown (should be zero)

Used values are:

00000000h	= unknown?	disable
00000002h	= unknown?	enable
00000003h	= unknown?	at BEGIN of a new command

When doing the enable thing, Bit1 should be set to 0-then-1...? Bit0 might enable the data shift register... and bit1 might be a master enable and master acknowledge for the COM interrupt... or something else?

0C000018h - COM_CTRL2 - Com Control Register 2

```

0      Unknown (should be set, probably starts or acknowledges something)
1      Unknown (should be set when expecting a NEW command...?)
2-31   Unknown (should be zero)

```

Used values are:

```

00000001h = unknown?  used before AND after each byte-transfer
00000003h = unknown?  used after LAST byte of command (and when init/reset)

```

Maybe that two bits acknowledge the ready/error bits?

INT_INPUT.6 FIQ (!) COM for the COM_registers? (via /SEL Pin?)

```
(via FIQ vector, not IRQ vector)
```

INT_INPUT.11 IRQ Docked ("IOP") (0=Undocked, 1=Docked to PSX)

Probably senses the voltage on the cartridge slots VCC Pin. Becomes zero when Undocked (and probably also when the PSX is switched off).

The Kernel uses IRQ-11 for BOTH sensing docking and undocking, ie. as if the IRQ would be triggered on both 0-to-1 and 1-to-0 transistions... though maybe that feature just relies on switch-bounce. For the same reason (switch bounce), the IRQ-11 handler performs a delay before it checks the new INT_INPUT.11 setting (ie. the delay skips the unstable switch bound period, and allows the signal to stabilize).

IOP_START/IOP_STOP.Bit1

The BIOS adjusts this bit somehow in relation to communication. Unknown when/why/how it must be used. For details on IOP_START/IOP_STOP see Power Control chapter.

Opcode E6000010h (The Undefined Instruction) - Write chr(r0) to TTY

This opcode is used by the SN Systems emulator to write chr(r0) to a TTY style text window. r0 can be ASCII characters 20h and up, or 0Ah for CRLF. Using that opcode is a not too good idea because the default BIOS undef instruction handler simply runs into an endless loop, so games that are using it (eg. Break-Thru by Jason) won't work on real hardware. That, unless the game would change the undef instruction vector at [04h] in Kernel RAM, either replacing it by a MOVS R15,R14 opcode (ignore exception and return to next opcode), or by adding exception handling that outputs the character via IR or via

whatever cable connection. Observe that an uninitialized FUNC3 accidentally destroys [04h], so first init FUNC3 handler via SWI 17h, before trying to change [04h], moreover, mind that SWI 05h may reset FUNC3, causing the problem to reappear.

Altogether, it'd be MUCH more stable to write TTY characters to an unused I/O port...

only problem is that it's still unknown which I/O ports are unused... ie. which do neither trap data aborts, nor do mirror to existing ports...?

15.10 Pocketstation IO Power Control

0B000000h - CLK_MODE - Clock control (CPU and Timer Speed) (R/W)

0-3	Clock Ratio (01h..08h, see below) (usually 7 = 3.99MHz)	(R/W)
4	Clock Change State (0=Busy, 1=Ready)	(Read-only)
5-15	?	

Allows to change the CPU clock (and Timer clock, which is usually one half of the CPU clock, or less, depending on the Timer Divider). Possible values are:

```

00h = hangs hardware      ;-don't use
01h = 0.063488 MHz        ;\
02h = 0.126976 MHz        ;
03h = 0.253952 MHz        ; 31*8000h / 1,2,4,8,16
04h = 0.507904 MHz        ;
05h = 1.015808 MHz        ;/
06h = 1.998848 MHz        ;\
07h = 3.997696 MHz        ; 61*8000h * 1,2,4
08h = 7.995392 MHz        ;/
09h..0Fh = same as 08h    ;-aliases

```

Before changing CLK_MODE, F_WAIT1 and F_WAIT2 should be adjusted accordingly (see there for details). Note that many memory regions have waitstates, the full CPU speed can be reached mainly with code/data in WRAM.

For emulator authors: Note that some Pocketstation software will expect bit 4 of CLK_MODE to go from 0 to 1 rather than just polling it until it's 1. For this reason, emulating bit 4 as always being 1 can very likely break.

0B000004h - CLK_STOP - Clock stop (Sleep Mode)

Stops the CPU until an interrupt occurs. The pocketstation doesn't have a power-switch nor standby button, the closest thing to switch "power off" is to enter sleep mode.

Software should do that when the user hasn't pressed buttons for 1-2 seconds (that, only in handheld mode, not when docked to the PSX; where it's using the PSX power

supply instead of the battery).

```
0    Stop Clock (1=Stop)
1-15 ?
```

Wakeup is usually done by IRQ-0 (Fire Button) and IRQ-11 (Docking). If alarm is enabled, then the GUI also enables IRQ-9 (RTC), and compares RTC_TIME against the alarm setting each time when it wakes up.

Before writing to CLK_STOP, one should do:

```
DAC_CTRL=0                ;\disable sound
IOP_STOP=20h              ;/
LCD_MODE=0                ;-disable video
IRDA=whatever              ;-disable infrared (if it was used)
BATT_CTRL=BATT_CTRL AND FFFFFFFCh ;-do whatever
INT_MASK_SET=801h         ;-enable Docking/Fire wakeup interrupts
```

The GUI uses CLK_STOP only for Standby purposes (not for waiting for its 30Hz "frame rate" timer 0 interrupt; maybe that isn't possible, ie. probably CLK_STOP does completely disable the system clock, and thus does stop Timer0-2...?)

0D800000h - IOP_CTRL - Configures whatever...? (R/W)

```
0-3  Probably Direction for IOP_DATA bit0..3 (0=Input, 1=Output)
4-31 Unknown/Unused (seems to be always zero)
```

Unknown. Set to 0000000Fh by BIOS upon reset. Aside from that, the BIOS does never use that register.

0D800004h - IOP_STAT (R) - Read Current bits? -- No, seems to be always 0

0D800004h - IOP_STOP (W) - Set IOP_DATA Bits

0D800008h - IOP_START (W) - Clear IOP_DATA Bits

These two ports are probably accessing a single register, writing "1" bits to IOP_STOP sets bits in that register, and writing "1" bits to IOP_START clears bits... or vice-versa...? Writing "0" bits to either port seems to leave that bits unchanged. The meaning of most bits is still unknown:

```
0    Unknown, STARTED by Kernel upon reset
1    Red LED, Communication related (START=Whatever, STOP=Whatelse) (?)
2    Unknown, STARTED by Kernel upon reset
```

```

3   Unknown, STARTED by Kernel upon reset
4   Never STARTED nor STOPPED by BIOS (maybe an INPUT, read via IOP_DATA)
5   Sound Enable (START=On, STOP=Off)
6   Unknown, STOPPED by Kernel upon reset
7-31 Unknown, never STARTED nor STOPPED by BIOS

```

Aside from Bit1, it's probably not necessary to change the unknown bits...?

Sound is usually disabled by setting IOP_STOP=00000020h. IOP_STAT is rarely used. Although, one piece of code in the BIOS disables sound by setting IOP_STOP=IOP_STAT OR 00000020h, that is probably nonsense, probably intended to keep bits stopped if they are already stopped (which would happen anyways), however, the strange code implies that reading from 0D800004h returns the current status of the register, and that the bits in that register seem to be 0=Started, and 1=Stopped...?

0D80000Ch - IOP_DATA (R)

```

0   ?
1   Red LED (0=On, 1=Off)
2   ?
3   ?
4   Seems to be always 1 (maybe Infrared input?)
5-31 Unknown/Unused (seems to be always zero)

```

Unknown. Not used by the BIOS. Reportedly this register is 0010h if IR Connection...?

This register is read by Rewrite ID, and by Harvest Moon. Maybe bit4 doesn't mean \<if> IR connection exist, but rather \<contains> the received IR data level...?

0D800020h - BATT_CTRL - Battery Monitor Control?

Unknown. Somehow battery saving related. Upon reset, and upon leaving sleep mode, the BIOS does set BATT_CTRL=00000000h. Before entering sleep mode, it does set BATT_CTRL=BATT_CTRL AND FFFFFFFFCh, whereas, assuming that BATT_CTRL was 00000000h, ANDing it with FFFFFFFFCh would simply leave it unchanged... unless the hardware (or maybe a game) sets some bits in BATT_CTRL to nonzero values...?

Battery Low Interrupt

```

INT_INPUT.10   IRQ   Battery Low   (0=Normal, 1=Battery Low)

```

Can be used to sense if the battery is low, if so, one may disable sound output and/or reduce the CPU speed to increase the remaining battery lifetime. Unknown how long the battery lasts, and how much the lifetime is affected by audio, video, infrared, cpu speed,

and sleep mode...?

The pocketstation can be also powered through the VCC pin (ie. when docked to the PSX, then it's working even if the battery is empty; or even without battery).

15.11 Pocketstation SWI Function Summary

SWI Function Summary

BIOS functions can be called via SWI opcodes (from both ARM and THUMB mode) (in ARM mode, the SWI function number is in the lower 8bit of the 24bit field; unlike as for example on the GBA, where it'd be in the upper 8bit). Parameters (if any) are passed in r0,r1,r2. Return value is stored in r0 (all other registers are left unchanged).

SWI 00h - Reset()	;don't use	out: everything destroyed
SWI 01h - SetCallbacks(index,proc)		out: old proc
SWI 02h - CustomSwi2(r0..r6,r8..r10)		out: r0
SWI 03h - FlashWriteVirtual(sector,src)		out: 0=okay, 1=failed
SWI 04h - SetCpuSpeed(speed)		out: old_speed
SWI 05h - SenseAutoCom()		out: garbage
SWI 06h - GetPtrToComFlags()		out: ptr (usually 0C0h)
SWI 07h - ChangeAutoDocking(flags.16-18)		out: incoming flags AND 70000h
SWI 08h - PrepareExecute(flag,dir_index,param)		out: dir_index (new or old)
SWI 09h - DoExecute(snapshot_saving_flag)		out: r0=r0 (failed) or r0=param
SWI 0Ah - FlashReadSerial()		out: F_SN
SWI 0Bh - ClearComFlagsBit10()		out: new [ComFlags] (with bit10=0)
SWI 0Ch - SetBcdDateTime(date,time)		out: garbage (RTC_DATE/10000h)
SWI 0Dh - GetBcdDate()		out: date (with century in MSBs)
SWI 0Eh - GetBcdTime()		out: time and day-of-week
SWI 0Fh - FlashWriteSerial(serial_number)		out: garbage (r0=0) ;old BIOS only!
SWI 10h - FlashWritePhysical(sector,src)		out: 0=okay, 1=failed
SWI 11h - SetComOnOff(flag)		out: garbage retadr to swi handler
SWI 12h - TestSnapshot(dir_index)		out: 0=normal, 1=MCX1 with 1,0,"SE"
SWI 13h - GetPtrToAlarmSetting()		out: ptr to alarm_setting
SWI 14h - GetPtrToPtrToSwiTable()		out: ptr-to-ptr to swi_table
SWI 15h - MakeAlternateDirIndex(flag,dir_index)		out: alt_dir_index (new/old)
SWI 16h - GetDirIndex()		out: dir_index (or alternate)
SWI 17h - GetPtrToFunc3addr()		out: ptr to func3 address
SWI 18h - FlashReadWhateverByte(sector)		out: [8000000h+sector*80h+7Eh]
SWI 19h..FFh	- garbage	
SWI 100h..FFFFFFh	- mirrors of SWI 00h..FFh	

The BIOS uses the same memory region for SWI and IRQ stacks, so both may not occur simultaneously, otherwise one stack would be destroyed by the other (normally that is no problem; IRQs are automatically disabled by the CPU during SWI execution, SWIs aren't used from inside of default IRQ handlers, and SWIs shouldn't be used from inside of hooked IRQ handlers).

15.12 Pocketstation SWI Misc Functions

SWI 01h - SetCallbacks(index,proc)

```

r0=0  Set SWI 02h callback          (r1=proc, or r1=0=reset/default)
r0=1  Set IRQ callback              (r1=proc, or r1=0=none/default)
r0=2  Set FIQ callback              (r1=proc, or r1=0=none/default)
r0=3  Set Download Notification callback (r1=proc, or r1=0=bugged/default)

```

All callbacks are called via BX opcodes (ie. proc.bit0 can be set for THUMB code).

SetCallbacks returns the old proc value (usually zero). The callbacks are automatically reset to zero when (re-)starting an executable, or when returning control to the GUI, so there's no need to restore the values by software.

IRQ and FIQ Callbacks

Registers r0,r1,r12 are pushed by the kernels FIQ/IRQ handlers (so the callbacks can use that registers without needing to push them). The FIQ handler can additionally use r8..r11 without pushing them (the CPU uses a separate set of r8..r12 registers in FIQ mode, nethertheless, the kernel DOES push r12 in FIQ mode, without reason). Available stack is 70h bytes for the FIQ callback, and 64h bytes for the IRQ callback.

The callbacks don't receive any incoming parameters, and don't need to respond with a return value. The callback should return to the FIQ/IRQ handler (via normal BX r14) (ie. it should not try to return to User mode).

The kernel IRQ handler does (after the IRQ callback) process IRQ-11 (IOP) (which does mainly handle docking/undocking), and IRQ-9 (RTC) (which increments the century if the year wrapped from 99h to 00h).

And the kernel FIQ handler does (before the FIQ callback) process IRQ-6 (COM) (which does, if ComFlags.Bit9 is set, handle bu_cmd's) (both IRQs and FIQs are disabled, and the main program is stopped until the bu_cmd finishes, or until a joypad command is identified irrelevant, among others that means that sound/timer IRQs aren't processed during that time, so audio output may become distorted when docked).

When docked, the FIQ callback should consist of only a handful of opcodes, eg. it may contain a simple noise, square wave generator, or software based sound "DMA" function, but it should not contain more time-consuming code like sound envelope processing; otherwise IRQ-6 (COM) cannot be executed fast enough to handle incoming commands.

SWI 02h - CustomSwi2(r0..r6,r8..r10) out: r0

Calls the SWI2 callback function (which can be set via SWI 01h). The default callback address is 00000000h (so, by default, it behaves identically as SWI 00h). Any parameters can be passed in r0..r6 and r8..r10 (the other registers aren't passed to the callback function). Return value can be stored in r0 (all other registers are pushed/popped by the swi handler, as usually). Available space on the swi stack is 38h bytes. SWI2 can be useful to execute code in privileged mode (eg. to initialize FIQ registers r8..r12 for a FIQ based sound engine) (which usually isn't possible because the main program runs in non-privileged user mode).

SWI 04h - SetCpuSpeed(speed) out: old_speed

Changes the CPU speed. The BIOS uses it with values in range 01h..07h. Unknown if value 00h can be also used? The function also handles values bigger than 07h, of which, some pieces of BIOS code look as if 08h would be the maximum value...? Before setting the new speed, the function sets F_WAIT1 and F_WAIT2 to 00000000h (or to 00000010h if speed.bit3=1). After changing the speed (by writing the parameter to CLK_MODE) it does wait until the new speed is applied (by waiting for CLK_MODE.bit4 to become zero). The function returns the old value of CLK_MODE, anded with 0Fh.

15.13 Pocketstation SWI Communication Functions

Communication (aka BU Commands, received from the PSX via the memory card slot) can be handled by the pocketstations kernel even while a game is running. However, communications are initially disabled when starting a game, so the game should enable them via SWI 11h, and/or via calling SWI 05h once per frame.

SWI 11h - SetComOnOff(flag)

Can be used to enable/disable communication. When starting an executable, communication is initially disabled, so it'd be a good idea to enable them (otherwise the PSX cannot communicate with the Pocketstation while the game is running). When flag=0, disables communication: Initializes the COM_registers, disables IRQ-6 (COM), and clears ComFlags.9. When flag=1, enables communication: Initializes the COM_registers, enables IRQ-6 (COM), sets ComFlags.9 (when docked), or clears Sys.Flags.9 (when undocked), and sets FAST cpu_speed=7 (only when docked). The function returns garbage (r0=retadr to swi_handler).

SWI 06h - GetPtrToComFlags()

Returns a pointer to the ComFlags word in RAM, which contains several communication related flags (which are either modified upon docking/undocking, or upon receiving certain bu_cmd's). The ComFlags word consists of the following bits:

```

0-3   Whatever (set/cleared when docked/undocked, and modified by bu_cmd's)
4-7   Not used (should be zero)
8     IRQ-11 (IOP) occurred (set by irq handler, checked/cleared by SWI 05h)
9     Communication Enabled And Docked (0=No, 1=Yes; prevents DoExecute)
10    Reject writes to Broken Sector Region (sector 16..55) (0=No, 1=Yes)
11    Start file request (set by bu_cmd_59h, processed by GUI, not by Kernel)
12-15 Not used (should be zero)
16    Automatically power-down DAC audio on insert/removal (0=No, 1=Yes)
17    Automatically power-down IRDA infrared on insert/removal (0=No, 1=Yes)
18    Automatically adjust LCD screen rotate on insert/removal (0=No, 1=Yes)
19-27 Not used (should be zero)
28    Indicates if a standard bu_cmd (52h/53h/57h) was received (0=No, 1=Yes)
29    Set date/time request (set by bu_cmd_FUNC0, processed by BIOS)
30    Destroy RTC and Start GUI request (set by bu_cmd_59h, dir_index=FFFEh)
31    Not used (should be zero)

```

Bit16-18 can be changed via SWI 07h, ChangeAutoDocking(flags). Bit10 can be cleared by SWI 0Bh, ClearComFlagsBit10().

SWI 07h - ChangeAutoDocking(flags.16-18)

```

0-15  Not used (should be zero)
16    Automatically power-down DAC audio on insert/removal (0=No, 1=Yes)
17    Automatically power-down IRDA infrared on insert/removal (0=No, 1=Yes)
18    Automatically adjust LCD screen rotate on insert/removal (0=No, 1=Yes)
19-31 Not used (should be zero)

```

Copies bit16-18 of the incoming parameter to ComFlags.16-18, specifying how the kernel IRQ-11 (IOP) handler shall process docking/undocking from the PSX cartridge slot. The function returns the incoming flags value ANDed with 70000h.

SWI 0Bh - ClearComFlagsBit10()

Resets ComFlags.Bit10, ie. enables bu_cmd_57h (write_sector) to write to the Broken Sector region in FLASH memory (sector 16..55). SWI 0Bh returns the current ComFlags value (the new value, with bit10=0).

Aside from calling SWI 0Bh, ComFlags.10 is also automatically cleared upon IRQ-10 (IOP) (docking/undocking). ComFlags.10 can get set/cleared by the Download Notification callback.

SWI 05h - SenseAutoCom()

Checks if docking/undocking has occurred (by examining ComFlags.8, which gets set by the kernel IRQ-11 (IOP) handler). If that flag was set, then the function does reset it, and does then reset FUNC3=0000h and [0CAh]=00h (both only if docked, not when undocked), and, no matter if docked or undocked, it enables communication; equivalent to SetComOnOff(1); which sets/clears ComFlags.9. The function returns garbage (r0=whatever).

The GUI is calling SWI 05h once per frame. The overall purpose is unknown. It's a good idea to reset FUNC3 and to Enable Communication (although that'd be required only when docked, not when undocked), but SWI 05h is doing that only on (un-)docking transitions (not when it was already docked). In general, it'd make more sense to do proper initializations via SWI 11h and SWI 17h as than trusting SWI 05h to do the job. The only possibly useful effect is that SWI 05h does set/clear ComFlags.9 when docked/undocked.

SWI 17h - GetPtrToFunc3addr()

Returns a pointer to a halfword in RAM which contains the FUNC3 address (for bu_cmd_5bh and bu_cmd_5ch). The address is only 16bit, originated at 02000000h in FLASH (ie. it can be only in the first 64K of the file), bit0 can be set for THUMB code. The default address is zero, which behaves bugged: It accidentally sets [00000004h]=00000000h, ie. replaces the Undefined Instruction exception vector by a "andeq r0,r0,r0" opcode, due to that NOP-like opcode, any Undefined Instruction exceptions will run into the SWI vector at [00000008h], and randomly execute an SWI function; with some bad luck that may execute one of the FlashWrite functions and destroy the saved files.

Although setting 0000h acts bugged, one should restore that setting before returning control to GUI or other executables; otherwise the address would still point to the FUNC3 address of the old unloaded executable, which is worse than the bugged effect. The FUNC3 address is automatically reset to 0000h when (if) SWI 05h (SenseAutoCom) senses new docking.

Download Notification callback

Can be used to mute sound during communication, see SWI 01h, SetCallbacks(index,proc), and BU Command 5Dh for details.

15.14 Pocketstation SWI Execute Functions

SWI 08h - PrepareExecute(flag,dir_index,param)

dir_index should be 0=GUI, or 1..15=First block of game. When calling DoExecute, param is passed to the entrypoint of the game or GUI in r0 register (see notes on GUI \<param> values belows). For games, param may be interpreted in whatever way. When flag=0, the function simply returns the old dir_index value. When flag=1, the new dir_index and param values are stored in Kernel RAM (for being used by DoExecute); the values are stored only if dir_index=0 (GUI), or if dir_index belongs to a file with "SC" and "MCX0" or "MCX1" IDs in it's title sector. If dir_index was accepted, then the new dir_index value is returned, otherwise the old dir_index is returned.

GUI \<param> values - for PrepareExecute(1,0,param)

PrepareExecute(1,0,param) prepares to execute the GUI (rather than a file). When executing the GUI, \<param> consists of the following destructive bits:

```
0-7  Command number (see below, MSBs=Primary command, LSBs=another dir_index)
8    Do not store Alarm setting in Kernel RAM (0=Normal, 1=Don't store)
9-31 Not used (should be zero)
```

The command numbers can be:

```
Command 0xh --> Erase RTC time/date
Command 1xh --> Enter GUI Time Screen with speaker symbol
Command 20h --> Enter GUI Time Screen with alarm symbol
Command 2xh --> Prompt for new Date/Time, then start dir_index (x)
Command 3xh --> Enter GUI File Selection Screen, with dir_index (x) selected
Command xxh --> Erase RTC time/date (same as Command 0xh)
```

For Command 2xh and 3xh, the lower 4bit of the command (x) must be a valid dir_index of the 1st block of a pocketstation executable, otherwise the BIOS erases the RTC time/date. Bit8 is just a "funny" nag feature, allowing the user to change the alarm setting, but with the changes being ignored (bit8 can be actually useful in BU Command 59h, after FUNC2 was used for changing alarm).

SWI 09h - DoExecute(), or DoExecute(snapshot_saving_flag) for MCX1

Allows to return control to the GUI (when dir_index=0), or to start an executable (when dir_index=1..15). Prior to calling DoExecute, parameters should be set via PrepareExecute(1,dir_index,param), when not doing that, DoExecute would simply

restart the current executable (which may be a desired effect in some cases).

The "snapshot_saving_flag" can be omitted for normal (MCX0) files, that parameter is used only for special (MCX1) files (see Snapshot Notes for details).

Caution: DoExecute fails (and returns r0=unchanged) when ComFlags.9=1 (which indicates that communications are enabled, and that the Pocketstation is believed to be docked to the PSX). ComFlags.9 can be forcefully cleared by calling SetComOnOff(0), or it can be updated according to the current docking-state by calling SetComOnOff(1) or SenseAutoCom().

SWI 16h - GetDirIndex()

Returns the dir_index for the currently executed file. If that value is zero, ie. if there is no file executed, ie. if the function is called by the GUI, then it does instead return the "alternate" dir_index (as set via SWI 15h).

SWI 15h - MakeAlternateDirIndex(flag,dir_index) out: alt_dir_index (new/old)

Applies the specified dir_index as "alternate" dir_index (for being retrieved via SWI 16h for whatever purpose). The dir_index is applied only when flag=1, and only if dir_index is 0=none, or if it is equal to the dir_index of the currently executed file (ie. attempts to make other files being the "alternate" one are rejected). If successful, the new dir_index is returned, otherwise the old dir_index is returned (eg. if flag=0, or if the index was rejected).

SWI 12h - TestSnapshot(dir_index)

Tests if the specified file contains a load-able snapshot, ie. if it does have the "SC" and "MCX1" IDs in the title sector, and the 01h,00h,"SE" ID in the snapshot header. If so, it returns r0=1, and otherwise returns r0=0.

Snapshot Notes (MCX1 Files)

Snapshots are somewhat automatically loaded/saved when calling DoExecute:

If the old file (the currently executed file) contains "SC" AND "MCX1" IDs in the title sector, then the User Mode CPU registers and User RAM at 200h..7FFh are automatically saved in the files snapshot region in FLASH memory, with the snapshot_saving_flag being applied as bit0 of the 0xh,00h,"SE" ID of the snapshot header).

If the new file (specified in dir_index) contains load-able snapshot data (ie. if it has "SC" and "MCX1" IDs in title sector, and 01h,00h,"SE" ID in the snapshot region), then the BIOS starts the saved snapshot data (instead of restarting the executable at its

entrypoint). Not too sure if that feature is really working... the snapshot loader seems to load User RAM from the wrong sectors... and it seems to jump directly to User Mode return address... without removing registers that are still stored on SWI stack... causing the SWI stack to underflow after loading one or two snapshots...?

15.15 Pocketstation SWI Date/Time/Alarm Functions

SWI 0Ch - SetBcdDateTime(date,time)

Sets the time and date, the parameters are having the same format as SWI 0Dh and SWI 0Eh return values (see there). The SWI 0Ch return value contains only garbage (r0=RTC_DATE/10000h).

SWI 0Dh - GetBcdDate()

0-7	Day	(01h..31h, BCD)
8-11	Month	(01h..12h, BCD)
16-31	Year	(0000h..9999h, BCD)

Returns the current date, the lower 24bit are read from RTC_DATE, the century in upper 8bit is read from Kernel RAM.

SWI 0Eh - GetBcdTime()

0-7	Seconds	(00h..59h, BCD)
8-15	Minutes	(00h..59h, BCD)
16-23	Hours	(00h..23h, BCD)
24-31	Day of week	(1=Sunday, ..., 7=Saturday)

Returns the current time and day of week, read from RTC_TIME.

SWI 13h - GetPtrToAlarmSetting()

Returns a pointer to a 64bit value in Kernel RAM, the upper word (Bit32-63) isn't actually used by the BIOS, except that, the bu_cmd FUNC3 does transfer the whole 64bits. The meaning of the separate bits is:

0-7	Alarm Minute	(00h..59h, BCD)
8-15	Alarm Hour	(00h..23h, BCD)
16	Alarm Enable	(0=Off, 1=On)
17	Button Lock	(0=Normal, 1=Lock) (pressing all 5 buttons in GUI)
18-19	Volume Shift	(0=Normal/Loud, 1=Medium/Div4, 2=Mute/Off)


```

20-22 Not used          (should be zero)
23   RTC Initialized (0=Not yet, 1=Yes, was initialized from within GUI)
24-31 Not used          (should be zero)
32-63 Pointer to 8x8 BIOS Charset (characters "0"... "9" plus strange symbols)

```

The RTC hardware doesn't have a hardware-based alarm feature, instead, the alarm values must be compared with the current time by software. Alarm is handled only by the GUI portion of the BIOS. The Kernel doesn't do any alarm handling, so alarm won't occur while a game is executed (unless the game contains code that handles alarm). Games are usually using only the lower 16bit of the charset address, ORed with 04000000h (although the full 32bit is stored in RAM).

```

CHR(00h..09h) = Digits "0..9"
CHR(0Ah) = Space " "
CHR(0Bh) = Colon ":"
CHR(0Ch) = Button Lock (used by Final Fantasy 8's Chocobo World)
CHR(0Dh) = Speaker Medium; or loud if followed by chr(0Eh)
CHR(0Eh) = Speaker Loud; to be appended to chr(0Dh)
CHR(0Fh) = Speaker Off
CHR(10h) = Battery Low (used by PocketMuuMuu's Cars)
CHR(11h) = Alarm Off
CHR(12h) = Alarm On
CHR(13h) = Memory Card symbol

```

15.16 Pocketstation SWI Flash Functions

SWI 10h - FlashWritePhysical(sector,src)

Writes 80h-bytes at src to the physical sector number (0..3FFh, originated at 08000000h), and does then compare the written data with the source data. Returns 0=okay, or 1=failed.

SWI 03h - FlashWriteVirtual(sector,src)

The sector number (0..3FFh) is a virtual sector number (originated at 02000000h), the function uses the F_BANK_VAL settings to translate it to a physical sector number, and does then write the 80h-bytes at src to that location (via the FlashWritePhysical function). Returns 0=okay, or 1=failed (if the write failed, or if the sector number exceeded the filesize aka the virtually mapped memory region).

SWI 0Ah - FlashReadSerial()

Returns the 32bit value from the two 16bit F_SN registers (see F_SN for details).

SWI 0Fh - FlashWriteSerial(serial_number) ;old BIOS only!

Changes the 32bit F_SN value in the "header" region of the FLASH memory. The function also rewrites the F_CAL value (but it simply rewrites the old value, so it's left unchanged). The function isn't used by the BIOS, no idea if it is used by any games. No return value (always returns r0=0).

This function is supported by the old "061" version BIOS only (the function is padded with jump opcodes which hang the CPU in endless loops on newer "110" version).

SWI 18h - FlashReadWhateverByte(sector)

Returns [8000000h+sector*80h+7Eh] AND 00FFh. Purpose is totally unknown... the actual FLASH memory doesn't contain any relevant information at that locations (eg. the in the directory sectors, that byte is unused, usually zero)... and, reading some kind of status or manufacturer information would first require to command the hardware to output that info...?

15.17 Pocketstation SWI Useless Functions

SWI 00h - Reset() ;don't use, destroys RTC settings

Reboots the pocketstation, similar as when pressing the Reset button. Don't use! The BIOS bootcode does (without any good reason) reset the RTC registers and alarm/century settings in RAM to Time 00:00:00, Date 01 Jan 1999, and Alarm 00:00 disabled, so, after reset, the user would need to re-enter these values.

Aside from the annoying destroyed RTC settings, the function is rather unstable: it does jump to address 00000000h in RAM, which should usually redirect to 04000000h in ROM, however, most pocketstation games are programmed in C language, where "pointer" is usually pronounced "pointer?" without much understanding of whether/why/how to initialize that "strange things", so there's a good probability that one of the recently executed games has accidentally destroyed the reset vector at [00000000h] in battery-backed RAM.

SWI 14h - GetPtrToPtrToSwiTable()

Returns a pointer to a word in RAM, which contains another pointer which usually points to SWI table in ROM. Changing that word could be (not very) useful for setting up a custom SWI table in FLASH or in RAM. When doing that, one must restore the original

setting before returning control to the GUI or to another executable (the setting isn't automatically restored).

SWI service routine

The default SWI service routine is slightly finicky

```
push {r1-r12, lr} @ Backup SVC-mode registers
mrs r12, cpsr      @ Old CPSR in r12
nop

@ Check if we were previously in Thumb mode
@ And adjust LR accordingly to fetch the SWI comment field
tst r12, #0x20
subeq lr, #2
sub lr, #2

@ Fetch the comment field
ldrh r12, [lr]
and r12, #0xFF

@ Load function pointer for SWI handler and call it
mov lr, #0xE0 ; Pointer to SWI table in LR
ldr r11, [lr]
add r11, r11, r12, lsl #2 @ r11 = &swi_table[comment]
ldr r11, [r11] @ Get function pointer
mov lr, pc        @ Set LR to return address
bx r11           @ Call SWI handler

@ Restore SVC regs, return from SWI service routine and restore SPSR into CPSR
pop {r1-r12, pc}^
```

It's important that the SWI service routine use a 16-bit load to fetch the comment field, as most memory on the Pocketstation can't be safely read using `ldrb`. Any custom handler needs to do the same, otherwise it won't work on real hardware. Also, for emulator developers, be wary of the last `pop` as it abuses an ldm edge case (S bit set with r15 in rlist - restores registers properly and then does CPSR = SPSR)

15.18 Pocketstation BU Command Summary

The Pocketstation supports the standard Memory Card commands (Read Sector, Write Sector, Get Info), plus a couple of special commands.

BU Command Summary

```

50h  Change a FUNC 03h related value or so
51h  N/A
52h  Standard Read Sector command
53h  Standard Get ID command
54h  N/A
55h  N/A
56h  N/A
57h  Standard Write Sector command
58h  Get an ID or Version value or so
59h  Prepare File Execution with Dir_index, and Parameter
5Ah  Get Dir_index, ComFlags, F_SN, Date, and Time
5Bh  Execute Function and transfer data from Pocketstation to PSX
5Ch  Execute Function and transfer data from PSX to Pocketstation
5Dh  Execute Custom Download Notification Function    ;via SWI 01h with r0=3
5Eh  Get-and-Send ComFlags.bit1,3,2
5Fh  Get-and-Send ComFlags.bit0

```

Commands 5Bh and 5Ch can use the following functions:

```

FUNC 00h - Get or Set Date/Time
FUNC 01h - Get or Set Memory Block
FUNC 02h - Get or Set Alarm/Flags
FUNC 03h - Custom Function 3                ;via SWI 17h, GetPtrToFunc3addr()
FUNC 80h..FFh - Custom Functions 80h..FFh ;via Function Table in File Header

```

15.19 Pocketstation BU Standard Memory Card Commands

For general info on the three standard memory card commands (52h, 53h, 57h), and for info on the FLAG response value, see:

[Memory Card Read/Write Commands](#)

BU Command 52h (Read Sector)

Works much as on normal memory cards, except that, on the Pocketstation, the Read Sector command return 00h as dummy values; instead of the "(pre)" dummies that occur on normal memory cards.

The Read Sector command does reproduce the strange delay (that occurs between 5Ch and 5Dh bytes), similar as on normal original Sony memory cards, maybe original cards did (maybe) actually DO something during that delay period, the pocketstation BIOS simply blows up time in a wait loop (maybe for compatibility with original cards).

BU Command 53h (Get ID)

The Get ID command (53h) returns exactly the same values as normal original Sony memory cards.

BU Command 57h (Write Sector)

The Write Sector command has two new error codes (additionally to the normal 47h="G"=Good, 4Eh="N"=BadChecksum, FFh=BadSector responses). The new error codes are (see below for details):

```
FDh Reject write to Directory Entries of currently executed file
FEh Reject write to write-protected Broken Sector region (sector 16..55)
```

And, like Read Sector, it returns 00h instead of "(pre)" as dummy values.

Write Error Code FDh (Directory Entries of currently executed file)

The FDh error code is intended to prevent the PSX bootmenu (or other PSX games) to delete the currently executed file (which would crash the pocketstation - once when the deleted region gets overwritten by a new file), because the PSX bootmenu and normal PSX games do not recognize the new FDh error code the pocketstation does additionally set FLAG.3 (new card), which should be understood by all PSX programs.

The FDh error code occurs only on directory sectors of the file (not on its data blocks). However, other PSX games should never modify files that belong to other games (so there should be no compatibility problem with other PSX programs that aren't aware of the file being containing currently executed code).

However, the game that has created the executable pocketstation file must be aware of that situation. If the file is broken into a Pocketstation Executable region and a PSX Gameposition region, then it may modify the Gameposition stuff even while the Executable is running. If the PSX want to overwrite the executable then it must first ensure that it isn't executed (eg. by retrieving the dir_index of the currently executed file via BU Command 5Ah, and comparing it against the first block number in the files FCB at the PSX side; for file handle "fd", the first block is found at "[104h] +fd*2Ch+24h" in PSX memory).

Write Error Code FEh (write-protected Broken Sector region, sector 16..55)

The write-protection is enabled by ComFlags.bit10 (which can be set/cleared via BU Command 5Dh). That bit should be set before writing Pocketstation executables (the

Virtual Memory banking granularity is 2000h bytes, which allows to map whole blocks only, but cannot map single sectors, which would be required for files with broken sector replacements).

Unlike Error FDh, this error code doesn't set FLAG.3 for notifying normal PSX programs about the error (which is no problem since normally Error FEh should never occur since ComFlags.10 is usually zero). For more info on ComFlags.10, see SWI 0Bh aka ClearComFlagsBit10(), and BU Command 5Dh.

15.20 Pocketstation BU Basic Pocketstation Commands

BU Command 50h (Change a FUNC 03h related value or so)

```
Send Reply Comment
81h  N/A   Memory Card Access
50h  FLAG  Send Command 50h
VAL  00h   Send new [0CAh], receive length of following data (00h)
```

Might be somehow related to FUNC 03h...?

BU Command 58h (Get an ID or Version value or so)

```
Send Reply Comment
81h  N/A   Memory Card Access
58h  FLAG  Send Command 58h
(0)  02h   Send dummy/zero, receive length of following data (02h)
(0)  01h   Send dummy/zero, receive whatever value           (01h)
(0)  01h   Send dummy/zero, receive another value            (01h)
```

BU Command 59h (Prepare File Execution with Dir_index, and Parameter)

```
Send Reply Comment
81h  N/A   Memory Card Access
59h  FLAG  Send Command 59h
(0)  06h   Send dummy/zero, receive length of following data (06h)
NEW  OLD   Send new dir_index.8-15, receive old dir_index.8-15
NEW  OLD   Send new dir_index.0-7, receive old dir_index.0-7
PAR  (0)   Send exec_parameter.0-7, receive dummy/zero
PAR  (0)   Send exec_parameter.8-15, receive dummy/zero
PAR  (0)   Send exec_parameter.16-23, receive dummy/zero
PAR  (0)   Send exec_parameter.24-31, receive dummy/zero
```

The new dir_index can be the following:

```

0000h..000Fh --> Request to Start GUI or File (with above parameter bits)
0010h..FFFDh --> Not used, acts same as FFFFh (see below)
FFFEh --> Request to Destroy RTC and Start GUI (with parameter 00000000h)
FFFFh --> Do nothing (transfer all bytes, but don't store the new values)

```

Upon `dir_index=0000h` (Start GUI) or `0001..000Fh` (start file), a request flag in `ComFlags.11` is set, the GUI does handle that request, but the Kernel doesn't handle it (so it must be handled in the game; ie. check `ComFlags.11` in your mainloop, and call `DoExecute` when that bit is set, there's no need to call `PrepareExecute`, since that was already done by the BU Command).

Caution: When `dir_index=0000h`, then `\<param>` should be a value that does NOT erase the RTC time/date (eg. `10h` or `20h`) (most other values do erase the RTC, see SWI 08h for details).

Upon `dir_index=FFFEh`, a similar request flag is set in `ComFlags.30`, and, the Kernel (not the GUI) does handle that request in its FIQ handler (however, the request is: To reset the RTC time/date and to start the GUI with uninitialized `irq/svc` stack pointers, so this unpleasant and bugged feature shouldn't ever be used). Finally, `dir_index=FFFFh` allows to read the current `dir_index` value (which could be also read via BU Command 5Ah).

BU Command 5Ah (Get Dir_index, ComFlags, F_SN, Date, and Time)

```

Send Reply Comment
81h  N/A    Memory Card Access
5Ah  FLAG   Send Command 5Ah
(0)  12h    Send dummy/zero, receive length of following data (12h)
(0)  INDX   Send dummy/zero, receive curr_dir_index.bit8-15    (00h)
(0)  INDX   Send dummy/zero, receive curr_dir_index.bit0-7     (00h..0Fh)
(0)  FLG    Send dummy/zero, receive ComFlags.bit0             (00h or 01h)
(0)  FLG    Send dummy/zero, receive ComFlags.bit1             (00h or 01h)
(0)  FLG    Send dummy/zero, receive ComFlags.bit3             (00h or 01h)
(0)  FLG    Send dummy/zero, receive ComFlags.bit2             (00h or 01h)
(0)  SN     Send dummy/zero, receive F_SN.bit0-7               (whatever)
(0)  SN     Send dummy/zero, receive F_SN.bit8-15              (whatever)
(0)  SN     Send dummy/zero, receive F_SN.bit16-23             (whatever)
(0)  SN     Send dummy/zero, receive F_SN.bit24-31             (whatever)
(0)  DATE   Send dummy/zero, receive BCD Day                   (01h..31h)
(0)  DATE   Send dummy/zero, receive BCD Month                 (01h..12h)
(0)  DATE   Send dummy/zero, receive BCD Year                  (00h..99h)
(0)  DATE   Send dummy/zero, receive BCD Century               (00h..99h)
(0)  TIME   Send dummy/zero, receive BCD Second                (00h..59h)
(0)  TIME   Send dummy/zero, receive BCD Minute                (00h..59h)
(0)  TIME   Send dummy/zero, receive BCD Hour                  (00h..23h)
(0)  TIME   Send dummy/zero, receive BCD Day of Week           (01h..07h)

```

At midnight, the function may accidentally return the date for the old day, and the time for the new day.

BU Command 5Eh (Get-and-Send ComFlags.bit1,3,2)

```

Send Reply Comment
81h  N/A   Memory Card Access
5Eh  FLAG  Send Command 5Eh
(0)  03h   Send dummy/zero, receive length of following data (03h)
NEW  OLD   Send new ComFlags.bit1, receive old ComFlags.bit1 (00h or 01h)
NEW  OLD   Send new ComFlags.bit3, receive old ComFlags.bit3 (00h or 01h)
NEW  OLD   Send new ComFlags.bit2, receive old ComFlags.bit2 (00h or 01h)

```

BU Command 5Fh (Get-and-Send ComFlags.bit0)

```

Send Reply Comment
81h  N/A   Memory Card Access
5Fh  FLAG  Send Command 5Fh
(0)  01h   Send dummy/zero, receive length of following data (01h)
NEW  OLD   Send new ComFlags.bit0, receive old ComFlags.bit0 (00h or 01h)

```

15.21 Pocketstation BU Custom Pocketstation Commands

BU Command 5Bh (Execute Function and transfer data from Pocketstation to PSX)

```

Send Reply Comment
81h  N/A   Memory Card Access
5Bh  FLAG  Send Command 5Bh
FUNC FFh  Send Function Number, receive FFh (indicating variable length)
(0)  LEN1  Send dummy/zero, receive length of parameters (depending on FUNC)
...  (0)   Send parameters (LEN1 bytes), and receive dummy/zero
<----- at this point, the function is executed for the first time
(0)  LEN2  Send dummy/zero, receive length of data (depending on FUNC)
(0)  ...   Send dummy/zero, receive data (LEN2 bytes) from pocketstation
(0)  FFh   Send dummy/zero, receive FFh
<----- at this point, the function is executed for the second time

```

See below for more info on the FUNC value and the corresponding functions.

BU Command 5Ch (Execute Function and transfer data from PSX to Pocketstation)

```

Send Reply Comment
81h  N/A   Memory Card Access
5Ch  FLAG  Send Command 5Ch
FUNC FFh  Send Function Number, receive FFh (indicating variable length)
(0)  LEN1  Send dummy/zero, receive length of parameters (depending on FUNC)
...  (0)   Send parameters (LEN1 bytes), and receive dummy/zero
<----- at this point, the function is executed for the first time
(0)  LEN2  Send dummy/zero, receive length of data (depending on FUNC)

```



```

... (0) Send data (LEN2 bytes) to pocketstation, receive dummy/zero
(0) FFh Send dummy/zero, receive FFh
<----- at this point, the function is executed for the second time

```

See below for more info on the FUNC value and the corresponding functions.

BU Command 5Dh (Execute Custom Download Notification Function)

Can be used to notify the GUI (or games that do support this function) about following "download" operations (or uploads or other BU commands).

BU commands are handled inside of the kernels FIQ handler, that means both IRQs and FIQs are disabled during a BU command transmission, so any IRQ or FIQ based audio frequency generators will freeze during BU commands. To avoid distorted noise, it's best to disable sound for the duration specified in bit0-7. If the PSX finishes before the originally specified duration has expired, then it can resend this command with bit8=1 to notify the pocketstation that the "download" has completed.

```

Send Reply Comment
81h N/A Memory Card Access
5Dh FLAG Send Command 5Dh
(0) 03h Send dummy/zero, receive length of following data (03h)
VAL (0) Send receive value.16-23 (whatever), receive dummy/zero
VAL (0) Send receive value.8-15 (download flags), receive dummy/zero
VAL (0) Send receive value.0-7 (download duration), receive dummy/zero

```

The Download Notification callback address can be set via SWI 01h, SetCallbacks(3,proc), see there for details. At kernel side, the function execution is like so:

```

If value.8-15 = 00h, then ComFlags.bit10=1, else ComFlags.bit10=0.
If download_callback<>0 then call download_callback with r0=value.0-23.

```

In the GUI, the bu_cmd_5dh_hook/callback handles parameter bits as so (and games should probably handle that bits in the same fashion, too):

```

bit0-7 download duration (in whatever units... 30Hz, RTC, seconds...?)
bit8 download finished (0=no, 1=yes, cancel any old/busy duration)
bit9-23 not used by gui

```

If PSX games send any of the standard commands (52h,53h,57h) to access the memory card without using command 5Dh, then GUI automatically sets the duration to 01h (and pauses sound only for that short duration).

FUNC 00h - Get or Set Date/Time (FUNC0)

LEN1 is 00h (no parameters), and LEN2 is 08h (eight data bytes):

```
DATE  Get or Send BCD Day      (01h..31h)
DATE  Get or Send BCD Month    (01h..12h)
DATE  Get or Send BCD Year     (00h..99h)
DATE  Get or Send BCD Century  (00h..99h)
TIME  Get or Send BCD Second   (00h..59h)
TIME  Get or Send BCD Minute   (00h..59h)
TIME  Get or Send BCD Hour     (00h..23h)
TIME  Get or Send BCD Day of Week (01h..07h)
```

At midnight, the function may accidentally return the date for the old day, and the time for the new day.

FUNC 01h - Get or Set Memory Block (FUNC1)

LEN1 is 05h (five parameters bytes):

```
ADDR  Send Pocketstation Memory Address.bit0-7
ADDR  Send Pocketstation Memory Address.bit8-15
ADDR  Send Pocketstation Memory Address.bit16-23
ADDR  Send Pocketstation Memory Address.bit24-31
LEN2  Send Desired Data Length (00h..80h, automatically clipped to max=80h)
```

LEN2 is variable (using the 5th byte of the above parameters):

```
...   Get or Send LEN2 Data byte(s), max 80h bytes
```

Can be used to write to RAM (and eventually also to I/O ports; when you know what you are doing). In the read direction it can read almost anything: RAM, BIOS ROM, I/O Ports, Physical and Virtual FLASH memory. Of which, trying to read unmapped Virtual FLASH does probably (?) cause a Data Abort exception (and crash the Pocketstation), so that region may be read only if a file is loaded (check that `dir_index` isn't zero, via BU Command 5Ah, and, take care not to exceed the filesize of that file).

BUG: When sending more than 2 data bytes in the PSX-to-Pocketstation direction, then ADDR must be word-aligned (the BIOS tries to handle odd destination addresses, but when doing that, it messes up the alignment of another internal pointer).

FUNC 02h - Get or Set Alarm/Flags (FUNC2)

LEN1 is 00h (no parameters), and LEN2 is 08h (eight data bytes):

```

DATA  Get or Send Alarm.bit0-7,    Alarm Minute    (00h..59h, BCD)
DATA  Get or Send Alarm.bit8-15,   Alarm Hour      (00h..23h, BCD)
DATA  Get or Send Alarm.bit16-23,  Flags, see SWI 13h, GetPtrToAlarmSetting()
DATA  Get or Send Alarm.bit24-31,  Not used (usually 00h)
DATA  Get or Send Alarm.bit32-39,  BIOS Charset Address.0-7
DATA  Get or Send Alarm.bit40-47,  BIOS Charset Address.8-15
DATA  Get or Send Alarm.bit48-55,  BIOS Charset Address.16-23
DATA  Get or Send Alarm.bit56-63,  BIOS Charset Address.24-31

```

Changing the alarm value while the GUI is running works only with some trickery: For a sinister reason, the GUI copies the alarm setting to User RAM when it gets started, that copy isn't affected by FUNC2, so the GUI believes that the old alarm setting does still apply (and writes that old values back to Kernel RAM when leaving the GUI). The only workaround is:

Test if the GUI is running, if so, restart it via Command 59h (with `dir_index=0`, and `param=0120h` or similar, ie. with `param.bit8` set), then execute FUNC2, then restart the GUI again (this time with `param.bit8` zero).

FUNC 03h - Custom Function 3 (aka FUNC3)

LEN1 is 04h (fixed) (four parameters bytes):

```

VAL    Send Parameter Value.bit0-7
VAL    Send Parameter Value.bit8-15
VAL    Send Parameter Value.bit16-23
VAL    Send Parameter Value.bit24-31

```

LEN2 is variable (depends on the return value of the 1st function call):

```

...    Get or Send LEN2 Data byte(s)

```

The function address can be set via SWI 17h, `GetPtrToFunc3addr()`, see there for details. Before using FUNC 03h one must somehow ensure that the desired file is loaded (and that it does have initialized the function address via SWI 17h, otherwise the pocketstation would crash).

The FUNC3 address is automatically reset to 0000h when (if) SWI 05h (`SenseAutoCom`) senses new docking.

Note: The POC-XBOO circuit uses FUNC3 to transfer TTY debug messages.

FUNC 80h..FFh - Custom Function 80h..FFh

LEN1 is variable (depends on the LEN1 value in Function Table in File Header):

```
...    Send LEN1 Parameter Value(s), max 80h bytes (destroys Kernel when >80h)
```

LEN2 is variable (depends on the return value of the 1st function call):

```
...    Get or Send LEN2 Data byte(s), max 80h bytes (clipped to max=80h)
```

The function addresses (and LEN1 values) are stored in the Function Table FLASH memory (see Pocketstation File Header for details).

```
;above LEN1 should be 00h..80h (the parameters are stored
;in a 80h-byte buffer in kernel RAM, so len LEN1=81h..FFh would
;destroy the kernel RAM that is located after that buffer)
```

Before using FUNC 80h..FFh one must somehow ensure that the desired file is loaded (ie. that the function table with the desired functions is mapped to flash memory; otherwise the pocketstation would crash).

First Function Call (Pre-Data)

Incoming parameters on 1st Function Call:

```
r0=flags (09h=Pre-Data to PSX, or 0Ah=Pre-Data from PSX)
r1=pointer to parameter buffer (which contains LEN1 bytes) (in Kernel RAM)
```

Return Value on 1st Function Call:

```
r0 = Pointer to 64bit memory location (or r0=00000000h=Failed)
```

That 64bits are:

```
0-31    BUF2 address of data buffer (src/dst)
32-63    LEN2 (00000000h..00000080h) (clipped to max 00000080h if bigger)
```

dst is written in 8bit units

src is read in 16bit units (and then split to 8bit units)

Second Function Call (Post-Data)

Incoming parameters on 2nd Function Call:

```
r0=flags (11h=Post-Data to PSX, 12h=Post-Data from PSX; plus 04h if Bad-Data)
r1=pointer to data buffer (which contains LEN2 bytes) (BUF2 address)
```

Return Value on 2nd Function Call:

There's no return value required on 2nd call (although the kernel functions seem to return the same stuff as on 1st call).

Function flags (r0)

For each function, there is only one single function vector which is called for both To- and From-PSX, and both Pre- and Post-Data, and also on errors. The function must decipher the flags in r0 to figure out which of that operations it should handle:

```
0   To-PSX    (when used by Command 5Bh)
1   From-PSX  (when used by Command 5Ch)
2   Error occurred during Data transfer
3   Pre-Data
4   Post-Data
5-31 Not used (zero)
```

There are only six possible flags combinations:

```
09h Pre-Data to PSX
0Ah Pre-Data from PSX
11h Post-Data to PSX
12h Post-Data from PSX
15h Post-Bad-Data to PSX
16h Post-Bad-Data from PSX
```

The kernel doesn't call FUNC 03h if the Error bit is set (ie. Post-Bad-Data needs to be handled only by FUNC 80h..FFh, not by FUNC 03h.)

15.22 Pocketstation File Header/Icons

Pocketstation File Content

Pocketstation files consists of the following elements (in that order):

```
PSX Title Sector          ;80h bytes
PSX Colored Icon(s)       ;(hdr[02h] AND 0Fh)*80h bytes
Pocketstation Saved Snapshot ;800h bytes if hdr[52h]="MCX1", else 0 bytes
Pocketstation Function Table ;(hdr[57h]*8+7Fh) AND NOT 7Fh bytes
Pocketstation File Viewer Mono Icon ;hdr[50h]*80h bytes
Pocketstation Executable Mono Icon List ;hdr[56h]*8 bytes
Body (Pocketstation Executable Code/Data, PSX Game Position, Exec-Icons)
```

The Title sector contains some information about the size of the above regions, but not about their addresses (ie. to find a given region, one must compute the size of the preceeding regions).

Special "P" Filename in Directory Sector

For pocketstation executables, the 7th byte of the filename must be a "P" (for other files that location does usually contain a "-", assuming the file uses a standard filename, eg. "BESLES-12345abcdefgh" for a Sony licensed european title).

Special Pocketstation Entries in the Title Sector at [50h..5Fh]

```

50h 2  Number of File Viewer Mono Icon Frames (or 0000h=Use Exec-Icons)
52h 4  Pocketstation Identifier ("MCX0"=Normal, "MCX1"=With Snapshot)
56h 1  Number of entries in Executable Mono Icon List (01h..FFh)
57h 1  Number of BU Command 5Bh/5Ch Get/Set Functions (00h..7Fh, usually 00h)
58h 4  Reserved (zero)
5Ch 4  Entrypoint in FLASH1 (ie. Fileoffset plus 02000000h) (bit0=THUMB)

```

In normal PSX files, the region at 50h..5Fh is usually zerofilled. For more info on the standard entries in the Title Sector (and for info on Directory Entries), see:

[Memory Card Data Format](#)

Snapshot Region (in "MCX1" Files only)

For a load-able snapshot the Snapshot ID must be 01h,00h,"SE", the Kernel uses snapshots only once (after loading a snapshot, it forcefully changes the ID to 00h, 00h,"SE" in FLASH memory).

```

000h  r1..r12 (ie. without r0)
030h  r13_usr (sp_usr)
034h  r14_usr (lr_usr)
038h  r15      (pc)
03Ch  psr_fc
040h  Snapshot ID (0xh,00h,"SE")
044h  unused (3Ch bytes)
200h  Copy of user RAM at 200h..7FFh

```

For MCX1 files, snapshots can be automatically loaded and saved via the SWI 09h, DoExecute function (the snapshot handling seems to be bugged though; see SWI 09h for details).

Function Table (FUNC 80h..FFh)

The table can contain 00h..7Fh entries, for FUNC 80h..FFh. Each entry occupies 8 bytes:

```
00h 4  LEN1 (00000000h..00000080h) (destroys Kernel RAM if bigger)
04h 4  Function Address (bit0 can be set for THUMB code)
```

If the number of table entries isn't a multiple of 10h, then the table should be zero-padded to a multiple of 80h bytes (the following File Viewer Mono Icon data is located on the next higher 80h-byte boundary after the Function Table).

For details see BU Commands 5Bh and 5Ch.

File Viewer Mono Icon

Animation Length (0001h..any number) (icon frames) is stored in hdr[50h], for the File Viewer Icon, the Animation Delay is fixed (six 30Hz units per frame).

The File Viewer Icon is shown in the Directory Viewer (which is activated when holding the Down-button pressed for some seconds in the GUI screen with the speaker and memory card symbols, and which shows icons for all files, including regular PSX game positions, whose colored icons are converted without any contrast optimizations to unidentifiable dithered monochrome icons). If the animation length of the File Viewer Icon is 0000h, then the Directory Viewer does instead display the first Executable Mono Icon.

Each icon frame is 32x32 pixels with 1bit color depth (32 words, =128 bytes),

```
1st word = top-most scanline, 31st word = bottom-most scanline
bit0 = left-most pixel, bit31 = right-most pixel (0=white, 1=black)
```

A normal icon occupies 80h bytes, animated icons have more than one frame and do occupy N*80h bytes.

Executable Mono Icon List

The number of entries in the Executable Mono Icon List is specified in hdr[56h] (usually 01h). Each entry in the Icon List occupies 8 bytes:

```
00h 2  Animation Length (0001h..any number) (icon frames)
02h 2  Animation Delay (N 30Hz units per icon frame)
04h 4  Address of icon frame(s) in Virtual FLASH (at 02000000h and up)
```

The icon frame(s) can be anywhere on a word-aligned location in the file Body (as specified in the above Address entry), the format of the frame(s) is the same as for File

Viewer Mono Icons (see there).

The Executable Icons are shown in the Executable File Selection Menu (which occurs when pressing Left/Right buttons in the GUI). Pressing Fire button in that menu starts the selected executable. If the Icon List has more than 1 entry, then pressing Up/Down buttons moves to the previous/next entry (this just allows to view the corresponding icons, but doesn't have any other purpose, namely, the current list index is NOT passed to the game when starting it).

The Executable Mono Icon List is usually zero-padded to 80h-bytes size (although that isn't actually required, the following file Body could start at any location).

Entrypoint

The whole file (including the header and icons) gets mapped to 02000000h and up. The entrypoint can be anywhere in the file Body, and it gets called with a parameter value in r0 (when started by the GUI, that parameter is always zero, but it may be nonzero when the executable was started by a game, ie. the \<param> from SWI 08h, PrepareExecute, or the \<param> from BU Command 59h).

Caution: Games (and GUI) are started with the ARM CPU running in Non-privileged User Mode (however, there are several ways to hook IRQ/FIQ handlers, and from there one can switch to Privileged System Mode).

Returning to the GUI

Games should always include a way to return to the GUI (eg. an option in the game over screen, a key combination, a watchdog timer, and/or the docking signal) (conventionally, games should prompt Exit/Continue when holding Fire pressed for 5 seconds), otherwise it wouldn't be possible to start other games - except by pushing the Reset button (which is no good idea since the bizarre BIOS reset handler does reset the RTC time for whatever reason).

The kernel doesn't pass any return address to the entrypoint (neither in R14, nor on stack). To return control to the GUI, use SWI functions PrepareExecute(1,0,GetDirIndex()+30h), and then DoExecute(0).

15.23 Pocketstation File Images

Pocketstation files are normally stored in standard Memory Card images,
[Memory Card Images](#)

Pocketstation specific files

Aside from that standard formats, there are two Pocketstation specific formats, the "SC" and "SN" variants. Both contain only the raw file, without any Directory sectors, and thus not including a "BESLESP12345"-style filename string. The absence of the filename means that a PSX game couldn't (re-)open these files via filenames, so they are suitable only for "standalone" pocketstation games.

Pocketstation .BIN Files ("SC" variant)

Contains the raw Pocketstation Executable (ie. starting with the "SC" bytes in the title sector, followed by icons, etc.), the filesize should be padded to a 2000h-byte block boundary.

Pocketstation .BIN Files ("SN" variant)

This is a strange incomplete .BIN file variant which starts with a 4-byte ID ("SN",00h, 00h), which is directly followed by executable code, without any title sector, and without any icons.

```
It seems as if the file (including the 4-byte ID) is intended to be
mapped to address 02000000h, and that the entrypoint is fixed at
02000004h (in ARM state).
Since the File doesn't have a valid file header with "SC" and "MCXn" IDs,
it won't be recognized by real hardware, the PSX BIOS would treat it as
a corrupted/deleted file, the Pocketstation BIOS would treat it as a
non-executable file.
So, that fileformat is apparently working only on whatever emulators,
apparently on the one developed by SN Systems.
If one should want to use that files on real hardware, one could add
a 2000h byte stub at the begin of the file; with valid headers, and
with a small executable that remaps the "SN" stuff to 02000000h via
the F_BANK_VAL registers.
Ah, and the "SN" files seem to access RAM at 01000000h and up, unknown
if RAM is mirrored to that location on real hardware, reportedly that
region is unused... and doesn't contain RAM...?
Some games use The Undefined Instruction for TTY Output.
Most games do strange 8bit writes to LCD_MODE+0 and LCD_MODE+1
The games usually don't allow to return to the GUI (except by Reset).
```

The filesize is don't care (no padding to block, sector, word, or halfword boundaries required).

15.24 Pocketstation XBOO Cable

This circuit allows to connect a pocketstation to PC parallel port, allowing to upload executables to real hardware, and also allowing to download TTY debug messages (particulary useful as the 32x32 pixel LCD screen is way too small to display any detailed status info).

POC-XBOO Circuit

Use a standard parallel port cable (with 36pin centronics connector or 25pin DB connector) and then build a small adaptor like this:

Pin	CNTR	DB25	Pocketstation	
ACK	10	10	1 JOYDTA	
D0	2	2	2 JOYCMD	9 7 6 5 4 3 2 1 CARD
GND	19-30	18-25	4 GND	
D1	3	3	6 /JOYSEL	
D2	4	4	7 JOYCLK	
PE	12	12	9 /JOYACK (/IRQ7)	9 8 7 6 5 4 3 2 1 PAD
NC			8 /JOYGUN (/IRQ10)	\
NC			3 7.5V (rumble.supply)	/
SUPPLY.5V	-- > --- > ---		5 3.5V (VCC) (eg. PC's +5V via two 1N4001 diodes)	
SUPPLY.0V			4 GND (not needed when same as GND on CNTR/DB25)	

The circuit is same as for "Direct Pad Pro" (but using a memory card connector instead of joystick connector, and needing +5V from PC power supply instead of using parallel port D3..D7 as supply). Note: IRQ7 is optional (for faster/early timeout).

POC-XBOO Upload

The upload function is found in no\$gba "Utility" menu. It does upload the executable and autostart it via standard memory card/pocketstation commands (ie. it doesn't require any special transmission software installed on the pocketstation side).

Notes: Upload is overwriting ALL files on the memory card, and does then autostart the first file. Upload is done as "read and write only if different", this provides faster transfers and higher lifetime.

POC-XBOO TTY Debug Messages

TTY output is conventionally done by executing the ARM CPU's Undefined Opcode with an ASCII character in R0 register (for that purpose, the undef opcode handler should simply point to a MOVS PC,LR opcode).

That kind of TTY output works in no\$gba's pocketstation emulation. It can be also used

via no\$gba's POC-XBOO cable, but requires some small customization in the executable: First of, the executable needs "TTY+" ID in some reserved bytes of the title sector (telling the xboo uploader to stay in transmission mode and to keep checking for TTY messages after the actual upload):

```
TitleSector[58h] = "TTY+"
```

With that ID, and with the XBOO-hardware being used, the game will be started with with "TTY+" in R0 (notifying it that the XBOO hardware is present, and that it needs to install special transmission handlers):

```
;-----
.data?
org 200h
...
tty_bufsiz equ 128 ;max=128=fastest (can be smaller if you are short of RAM)
func3_info:
    func3_buf_base    dd 0 ;fixed="func3_buf" ; \ ; \
    func3_buf_len     dd 0 ;range=0..128 ; / ; func3_info+04h
    func3_stack       dd 0 ; func3_info+08h
    func3_buffer:     defs tty_bufsiz ; / func3_info+0Ch
ptr_to_comflags      dd 0
...
.code
...
;-----
tty_wrchr: ;in: r0=char
    dd 0e6000010h ;=undef opcode ; -Write chr(r0) to TTY
    bx lr
;-----
init_tty: ;in: r0=param (from entrypoint)
    ldr r1,=2B595454h ;"TTY+" ; \check if xboo-cable present
    cmp r1,r0 ; (r0=incoming param from
    beq @@tty_by_xboo_cable ; /executable's entrypoint)
; - - -
    mov r1,0 ; \dummy und_handler
    ldr r2,=0e1b0f00eh ;=movs r15,r14 ; (just return from exception,
    str r2,[r1,04h] ;und_handler ; /for normal cable-less mode)
    b @@finish
; ---
@@tty_by_xboo_cable:
    swi 17h ;GetPtrToFunc3addr() ; \
    ldr r1,=(tty_func3_handler AND 0ffffh) ; init FUNC3 aka TTY handler
    strh r1,[r0] ; /
    ldr r1,=func3_info ; \
    mov r0,0 ; \ ; mark TTY as len=empty
    str r0,[r1,4] ;func3_buf_len ; / ; and
    add r0,r1,0ch ;=func3_buffer ; \ ; init func3 base
    str r0,[r1,0] ;func3_buf_base ; / ; /
    mov r1,0 ; \
```

```

ldr    r2,=0e59ff018h ;=ldr r15,[pc,NN] ;
str    r2,[r1,04h] ;und_handler ; special xboo und_handler
add    r2,=tty_xboo_und_handler ;
str    r2,[r1,24h] ;und_vector ;/
@@finish:
swi    06h ;GetPtrToComFlags() ;\
ldr    r1,=ptr_to_comflags ; get ptr to ComFlags
str    r0,[r1] ;/
bx     lr
;-----
tty_xboo_und_handler: ;in: r0=char
ldr    r13,=func3_info ;aka sp_und ;-base address (in sp_und)
str    r12,[r13,8] ;func3_stack ;-push r12
@@wait_if_buffer_full: ;\
ldr    r12,=ptr_to_comflags ; ;\exit if execute file request
ldr    r12,[r12] ;ptr to ComFlags ; ; ComFlg.Bit11 ("bu_cmd_59h"),
ldr    r12,[r12] ;read ComFlags ; ; ie. allow that flag to be
tst    r12,1 shl 11 ;test bit11 ; ; processed by main program,
bne    @@exit ; ;/without hanging here
ldrb   r12,[r13,4] ;func3_buf_len ; wait if buffer full
cmp    r12,tty_bufsiz ; (until drained by FIQ)
beq    @@wait_if_buffer_full ;/
mov    r12,1bh+0c0h ;mode=und, FIQ/IRQ=off ;\disable FIQ (no COMMUNICATION
mov    cpsr_ctl,r12 ;/interrupt during buffer write)
ldrb   r12,[r13,4] ;func3_buf_len ;\
add    r12,1 ;raise len ; write char to buffer
strb   r12,[r13,4] ;func3_buf_len ; and raise buffer length
add    r12,0ch-1 ;=func3_buffer+INDEX ;
strb   r0,[r13,r12] ;append char to buf ;/
@@exit:
ldr    r12,[r13,8] ;func3_stack ;-pop r12
movs   r15,r14 ;return from exception (and restore old IRQ/FIQ state)
;-----
tty_func3_handler: ;in: r0=flags, r1=ptr
tst    r0,10h ;test if PRE/POST data (pre: Z, post: NZ)
;ldreq r1,[r1] ;read 32bit param (aka the four LEN1 bytes of FUNC3)
ldr    r0,=func3_info ;ptr to two 32bit values (FUNC3 return value)
movne  r1,0 ;\for POST data: mark buffer empty
strne  r1,[r0,4] ;func3_buf_len=0 ;/
bx     lr ;-for PRE data: return r0=func3_info

```

Usage: Call "init_tty" at the executable's entrypoint (with incoming R0 passed on). Call "tty_wrchr" to output ASCII characters.

Note: The TTY messages are supported only in no\$gba debug version (not no\$gba gaming version).

16. Serial Interfaces (SIO)

The console has two serial interfaces, SIO0 (connected to the controller and memory card ports) and SIO1 (connected to the serial port). SIO0 is hardwired to run in synchronous mode, while SIO1 can only operate in asynchronous mode. Both units are fairly similar, although not identical, and seem to be vaguely based on the Intel 8251A USART chip.

1F801040h+N*10h - SIO#_TX_DATA (W)

0-7	Data to be sent
8-31	Not used

Writing to this register starts a transfer (if, or as soon as, TXEN=1 and CTS=on and SIO_STAT.2=Ready). Writing to this register while SIO_STAT.0=Busy causes the old value to be overwritten.

The "TXEN=1" condition is a bit more complex: Writing to SIO_TX_DATA latches the current TXEN value, and the transfer DOES start if the current TXEN value OR the latched TXEN value is set (ie. if TXEN gets cleared after writing to SIO_TX_DATA, then the transfer may STILL start if the old latched TXEN value was set; this appears for SIO transfers in Wipeout 2097).

1F801040h+N*10h - SIO#_RX_DATA (R)

0-7	Received Data	(1st RX FIFO entry) (oldest entry)
8-15	Preview	(2nd RX FIFO entry)
16-23	Preview	(3rd RX FIFO entry)
24-31	Preview	(4th RX FIFO entry) (5th..8th cannot be previewed)

A data byte can be read when SIO_STAT.1=1. Some emulators behave incorrectly when this register is read using a 16/32-bit memory access, so it should only be accessed as an 8-bit register.

1F801044h+N*10h - SIO#_STAT (R)

0	TX FIFO Not Full	(1=Ready for new byte) (depends on CTS) (TX requires CTS)
1	RX FIFO Not Empty	(0=Empty, 1=Data available)
2	TX Idle	(1=Idle/Finished) (depends on TXEN and on CTS)
3	RX Parity Error	(0=No, 1=Error; Wrong Parity, when enabled) (sticky)
4	SIO1 RX FIFO Overrun	(0=No, 1=Error; received more than 8 bytes) (sticky)

5	SIO1 RX Bad Stop Bit	(0=No, 1=Error; Bad Stop Bit) (when RXEN) (sticky)
6	SIO1 RX Input Level	(0=Normal, 1=Inverted) ;only AFTER receiving Stop Bit
7	DSR Input Level	(0=Off, 1=On) (remote DTR) ;DSR not required to be on
8	SIO1 CTS Input Level	(0=Off, 1=On) (remote RTS) ;CTS required for TX
9	Interrupt Request	(0=None, 1=IRQ) (See SIO_CTRL.Bit4,10-12) (sticky)
10	Unknown	(always zero)
11-31	Baudrate Timer	(15-21 bit timer, decrementing at 33MHz)

Bit 0 gets set after sending the start bit, bit 2 is set after sending all bits including the stop bit if any.

On SIO0, DSR is wired to the /ACK pin on the controller and memory card ports; bit 7 is thus set when /ACK is low (asserted) and cleared when it is high. Bits 4-6 and 8 are always zero.

The number of bits actually used by the baud rate timer is probably affected by the reload factor set in SIO_MODE.

1F801048h+N*10h - SIO#_MODE (R/W) (eg. 004Eh --> 8N1 with Factor=MUL16)

0-1	Baudrate Reload Factor	(1=MUL1, 2=MUL16, 3=MUL64) (or 0=MUL1 on SIO0, STOP on SIO1)
2-3	Character Length	(0=5 bits, 1=6 bits, 2=7 bits, 3=8 bits)
4	Parity Enable	(0=No, 1=Enable)
5	Parity Type	(0=Even, 1=Odd) (seems to be vice-versa...?)
6-7	SIO1 stop bit length	(0=Reserved/1bit, 1=1bit, 2=1.5bits, 3=2bits)
8	SIO0 clock polarity (CPOL)	(0=High when idle, 1=Low when idle)
9-15	Not used (always zero)	

Bits 6-7 on SIO0 and bit 8 on SIO1 are always zero. On SIO0 the character length shall be set to 8, the clock polarity should be set to high-when-idle and parity should be disabled, as all controllers and memory cards expect these settings.

1F80104Ah+N*10h - SIO#_CTRL (R/W)

0	TX Enable (TXEN)	(0=Disable, 1=Enable)
1	DTR Output Level	(0=Off, 1=On)
2	RX Enable (RXEN)	(SIO1: 0=Disable, 1=Enable) ;Disable also clears RXFIFO (SIO0: 0=only receive when /CS low, 1=force receiving single byte)
3	SIO1 TX Output Level	(0=Normal, 1=Inverted, during Inactivity & Stop bits)
4	Acknowledge	(0=No change, 1=Reset SIO_STAT.Bits 3,4,5,9) (W)
5	SIO1 RTS Output Level	(0=Off, 1=On)
6	Reset	(0=No change, 1=Reset most registers to zero) (W)
7	SIO1 unknown?	(read/write-able when FACTOR non-zero) (otherwise always zero)
8-9	RX Interrupt Mode	(0..3 = IRQ when RX FIFO contains 1,2,4,8 bytes)
10	TX Interrupt Enable	(0=Disable, 1=Enable) ;when SIO_STAT.0-or-2 ;Ready
11	RX Interrupt Enable	(0=Disable, 1=Enable) ;when N bytes in RX FIFO

12	DSR Interrupt Enable	(0=Disable, 1=Enable) ;when SIO_STAT.7 ;DSR high or /ACK low
13	SIO0 port select	(0=port 1, 1=port 2) (/CS pulled low when bit 1 set)
14-15	Not used	(always zero)

On SIO0, DTR is wired to the /CS pin on the controller and memory card ports; bit 1 will pull (assert) /CS low when set. Bit 13 is used to select which port's /CS shall be asserted (all other signals are wired in parallel).

Bit 2 behaves differently on SIO0: when not set, incoming data will be ignored unless bit 1 is also set. When set, data will be received regardless of whether /CS is asserted, however bit 2 will be automatically cleared after a byte is received.

Note that some emulators do not implement all SIO0 interrupts, as the kernel's controller driver only ever uses the DSR (/ACK) interrupt.

1F80105Ch - SIO1_MISC (R/W)

This is an internal register, which usually shouldn't be accessed by software. Messing with it has rather strange effects: After writing a value "X" to this register, reading returns "X ROR 8" eventually "ANDed with 1F1Fh and ORed with C0C0h or 8080h" (depending on the character length in SIO_MODE). SIO0 does not have this register.

1F80104Eh+N*10h - SIO#_BAUD (R/W) (eg. 00DCh --> 9600 bps; when Factor=MUL16)

0-15	Baudrate Reload value for decremting Baudrate Timer
------	---

The timer is decremented on every clock cycle and reloaded when writing to this register and when it reaches zero. Upon reload, the 16-bit Reload value is multiplied by the Baudrate Factor (see SIO_MODE.Bit0-1), divided by 2, and then copied to the 21-bit Baudrate Timer (SIO_MODE.Bit11-31). The resulting transfer rate can be calculated as follows:

SIO0:	BitsPerSecond = 33868800 / MIN(((Reload*Factor) AND NOT 1),1)
SIO1:	BitsPerSecond = 33868800 / MIN(((Reload*Factor) AND NOT 1),Factor)

According to the original nocash page, the way this register works is actually slightly different for SIO0 vs. SIO1:

SIO0_BAUD	is multiplied by Factor, and does then elapse "2" times per bit.
SIO1_BAUD	is NOT multiplied, and, instead, elapses "2*Factor" times per bit.

The standard baud rate for SIO0 devices, including both controllers and memory cards, is ~250 kHz, with SIO0_BAUD being set to 0088h (serial clock high for 44h cycles then low for 44h cycles).

SIO_TX_DATA Notes

The hardware can hold (almost) 2 bytes in the TX direction (one being currently transferred, and, once when the start bit was sent, another byte can be stored in SIO_TX_DATA). When writing to SIO_TX_DATA, both SIO_STAT.0 and SIO_STAT.2 become zero. As soon as the transfer starts, SIO_STAT.0 becomes set (indicating that one can write a new byte to SIO_TX_DATA; although the transmission is still busy). As soon as the transfer of the most recently written byte ends, SIO_STAT.2 becomes set.

SIO_RX_DATA Notes

The hardware can hold 8 bytes in the RX direction (when receiving further byte(s) while the RX FIFO is full, then the last FIFO entry will be overwritten by the new byte, and SIO_STAT.4 gets set; the hardware does NOT automatically disable RTS when the FIFO becomes full). The RX FIFO overrun flag is not accessible on SIO0.

Data can be read from SIO_RX_DATA when SIO_STAT.1 is set, that flag gets automatically cleared after reading from SIO_RX_DATA (unless there are still further bytes in the RX FIFO). Note: The hardware does always store incoming data in RX FIFO (even when Parity or Stop bits are invalid).

Note: A 16bit read allows to read two FIFO entries at once; nevertheless, it removes only ONE entry from the FIFO. On the contrary, a 32bit read DOES remove FOUR entries (although, there's nothing that'd indicate if the FIFO did actually contain four entries). Reading from Empty RX FIFO returns either the most recently received byte or zero (the hardware stores incoming data in ALL unused FIFO entries; eg. if five entries are used, then the data gets stored thrice, after reading 6 bytes, the FIFO empty flag gets set, but nevertheless, the last byte can be read two more times, but doing further reads returns 00h).

Interrupt Acknowledge Notes

First reset I_STAT.8, then set SIO_CTRL.4 (when doing it vice-versa, the hardware may miss a new IRQ which may occur immediately after setting SIO_CTRL.4) (and I_STAT.8 is edge triggered, so that bit can be reset even while SIO_STAT.9 is still set).

When acknowledging via SIO_CTRL.4 with the enabled condition(s) in SIO_CTRL.10-12 still being true (eg. the RX FIFO is still not empty): the IRQ does trigger again (almost)

immediately (it goes off only for a very short moment; barely enough to allow I_STAT.8 to sense a edge).

Note

For more details on how SIO0 is used to communicate with controllers and memory cards, see:

[Controller and Memory Card Overview](#)

For serial port pinouts, PSone SIO1 upgrading, and for building RS232 adaptors, see: [Pinouts - SIO Pinouts](#)

Aside from the internal SIO port, the PSX BIOS supports two additional external serial ports, connected to the expansion port.

[EXP2 Dual Serial Port \(for TTY Debug Terminal\)](#)

SIO1 link cable games

The serial ports on two consoles can be connected with an SCPH-1040 Link Cable (known as Taisen Cable, or "Fight Cable" in Japan) for multiplayer functionality on games that support this method. This was used by a small number of games in the console's lifecycle, but inconveniently required a second console and copy of the game.

Two-Console Link Cable Games (Incomplete List):

```
Andretti Racing
Armored Core (and Armored Core "Link Versus Demo" disc)
Armored Core Project Phantasma
Armored Core Master of Arena
Assault Rigs
Ayrton Senna Kart Duel
Blast Radius
Bogey Dead 6
Burning Road
Bushido Blade
Bushido Blade 2
C1 -Circuit-
CART World Series
Command & Conquer Red Alert
Command & Conquer Red Alert Retaliation
Cool Boarders 2
Dead in the Water
Descent
Descent Maximum
Destruction Derby
Duke Nukem Total Meltdown
Dodgem Arena
Doom
```

Dune 2000
 Explosive Racing (X Racing in NTSC-J)
 Final Doom
 Formula 1
 Formula 1 98
 Grand Tour Racing '98 (Gekisou!! Grand Racing -Total Driving'- in NTSC-J, Total Drivin in PAL)
 Independence Day
 Krazy Ivan
 Leading Jockey Highbred
 Metal Jacket
 Mobile Suit Z-Gundam
 Monaco Grand Prix Racing Simulation 2 (Monaco Grand Prix in NTSC-U/C)
 Motor Toon Grand Prix (reportedly NTSC-U/C version only)
 Motor Toon Grand Prix 2
 Motor Toon Grand Prix USA Edition
 The Need for Speed (Over Drivin' DX in NTSC-J)
 PrePre Vol. 2
 Pro Pinball Big Race USA
 RacinGroovy
 Real Robots Final Attack
 Red Asphalt (Rock & Roll Racing 2 Red Asphalt in PAL)
 Ridge Racer Revolution
 R4 Ridge Racer Type 4
 Robo Pit
 Rogue Trip Vacation 2012
 San Francisco Rush Extreme Racing (reportedly PAL version only)
 Shutokou Battle R
 Sidewinder
 Sidewinder USA
 Soukou Kihei Votoms Gaiden: Ao no Kishi Berserga Monogatari
 Streak Hoverboard Racing
 Test Drive 4
 Test Drive Off-Road (reportedly NTSC-U/C only)
 TOCA 2 Touring Car Challenge (TOCA 2 Touring Cars in PAL)
 Trick'N Snowboarder (Tricky Sliders Freestyle Snowboard in NTSC-J)
 Twisted Metal III
 Wing Over
 Wipeout
 Wipeout 3 Special Edition
 Wipeout XL (Wipeout 2097 in PAL)
 Zero Pilot Ginyoku no Senshi

The serial port is used (for 2-player link) by Wipeout 2097 (that game accidentally assumes BAUDs based on 64*1024*1025 Hz rather than on 600h*44100 Hz).

Ridge Racer Revolution is also said to support 2P link.

Keitai Eddy seems to allow to connect a mobile phone to the SIO port (the games CD cover suggests so; this seems to be something different than the "normal" I-Mode adaptor, which would connect to controller port, not to SIO port).

17. Expansion Port (PIO)

Expansion Port can contain ROM, RAM, I/O Ports, etc. For ROM, the first 256 bytes would contain the expansion ROM header.

For region 1, the CPU outputs a chip select signal (CPU Pin 98, /EXP).

For region 2, the CPU doesn't produce a chip select signal (the region is intended to contain multiple I/O ports, which require an address decoder anyways, that address decoder could treat any /RD or /WR with A13=Hi and A23=Hi and A22=Lo as access to expansion region 2 (for /WR, A22 may be ignored; assuming that the BIOS is read-only)).

Size/Bus-Width

The BIOS initializes Expansion Region 1 to 512Kbyte with 8bit bus, and Region 2 to 128 bytes with 8bit bus. However, the size and data bus-width of these regions can be changed, see:

[Memory Control](#)

For Region 1, 32bit reads are supported even in 8bit mode (eg. 32bit opcode fetches are automatically processed as four 8bit reads).

For Region 2, only 8bit access seems to be supported (except that probably 16bit mode allows 16bit access), anyways, larger accesses seem to cause exceptions... not sure if that can be disabled...?

Expansion 1 - EXP1 - Intended to contain ROM

[EXP1 Expansion ROM Header](#)

Expansion 2 - EXP2 - Intended to contain I/O Ports

[EXP2 Dual Serial Port \(for TTY Debug Terminal\)](#)

[EXP2 DTL-H2000 I/O Ports](#)

[EXP2 Post Registers](#)

[EXP2 Nocash Emulation Expansion](#)

Expansion 3 - EXP3 - Intended to contain RAM

Not used by BIOS nor by any games. Seems to contain 1Mbyte RAM with 16bit databus (ie. 512Kx16) in DTL-H2000.

Other Expansions

Aside from the above, the Expansion regions can be used for whatever purpose, however, mind that the BIOS is reading from the ROM header region, and is writing to the POST register (so 1F000000h-1F0000FFh and 1F802041h should be used only if the hardware isn't disturbed by those accesses).

Most arcade boards have their custom I/O registers (and sometimes game ROMs) mapped into the EXP1 and/or EXP2 regions.

Missing Expansion Port

The expansion port is installed only on older PSX boards, newer PSX boards and all PSone boards don't have that port. However, the CPU should still output all expansion signals, and there should be big soldering points on the board, so it'd be easy to upgrade the console.

Latched Address Bus

Note that A0..A23 are latched outputs, so they can be used as general purpose 24bit outputs, provided that the system bus isn't used for other purposes (such like /BIOS, /SPU, /CD accesses) (A0..A23 are not affected by Main RAM and GPU addressing, nor by internal I/O ports like Timer and IRQ registers).

17.1 EXP1 Expansion ROM Header

Expansion 1 - ROM Header (accessed with 8bit databus setting)

Address	Size	Content
1F000000h	4	Post-Boot Entrypoint (eg. 1F000100h and up)
1F000004h	2Ch	Post-Boot ID ("Licensed by Sony Computer Entertainment Inc.")
1F000030h	50h	Post-Boot TTY Message (must contain at least one 00h byte)
1F000080h	4	Pre-Boot Entrypoint (eg. 1F000100h and up)
1F000084h	2Ch	Pre-Boot ID ("Licensed by Sony Computer Entertainment Inc.")
1F0000B0h	50h	Not used (should be zero, but may contain code/data/io)
1F000100h	..	Code, Data, I/O Ports, etc.

The entrypoints are called if their corresponding ID strings are present, return address to BIOS is passed in R31, so the expansion ROM may return control to BIOS, if that should be desired.

Aside from verifying the IDs, the BIOS will also display the Post-Boot ID string (and the following message string) via TTY (done right before calling the Post-Boot Entrypoint).

Pre-Boot Function

The Pre-Boot function is called almost immediately after Reset, with only some Memory Control registers initialized, the BIOS function vectors at A0h, B0h, and C0h are NOT yet initialized, so the Pre-Boot function can't use them.

Post-Boot Function

The Post-Boot function gets called while showing the "PS" logo, but before loading the .EXE file. The BIOS function vectors at A0h, B0h, and C0h are already installed and can be used by the Post-Boot Function.

Note that the Post-Boot Function is called ONLY when the "PS" logo is shown (ie. not if the CDROM drive is empty, or if it contains an Audio CD).

Mid-Boot Hook

One common trick to hook the Kernel after BIOS initialization, but before CDROM loading is to use the Pre-Boot handler to set a COP0 opcode fetch hardware breakpoint at 80030000h (after returning from the Pre-Boot handler, the Kernel will initialize important things like A0h/B0h/C0h tables, and will then break again when starting the GUI code at 80030000h) (this trick is used by Action Replay v2.0 and up).

Note

Expansion ROMs are most commonly used in cheat devices,
[Cheat Devices](#)

17.2 EXP2 Dual Serial Port (for TTY Debug Terminal)

SCN2681 Dual Asynchronous Receiver/Transmitter (DUART)

The PSX/PSone retail BIOS contains some TTY Debug Terminal code; using an external SCN2681 chip which can be connected to the expansion port.

Whilst supported by all PSX/PSone retail BIOSes on software side, there aren't any known PSX consoles/devboards/expansions actually containing DUARTs on hardware side.

1F802023h/Read - RHRA - DUART Rx Holding Register A (FIFO) (R)

1F80202Bh/Read - RHRB - DUART Rx Holding Register B (FIFO) (R)

1F802023h/Write - THRA - DUART Tx Holding Register A (W)

1F80202Bh/Write - THRB - DUART Tx Holding Register B (W)

7-0 Data (aka Character)

The hardware can hold max 2 Tx characters per channel (1 in the THR register, and one currently processed in the Tx Shift Register), and max 4 Rx characters (3 in the RHR FIFO, plus one in the Rx Shift Register) (when receiving a 5th character, the "old newest" value in the Rx Shift Register is lost, and the overrun flag is set).

1F802020h/FirstAccess - MR1A - DUART Mode Register 1.A (R/W)

1F802028h/FirstAccess - MR1B - DUART Mode Register 1.B (R/W)

7	RxRTS Control	(0=No, 1=Yes)
6	RxINT Select	(0=RxRDY, 1=FFULL)
5	Error Mode	(0=Char, 1=Block)
4-3	Parity Mode	(0=With Parity, 1=Force Parity, 2=No Parity, 3=Multidrop)
2	Parity Type	(0=Even, 1=Odd)
1-0	Bits per Character	(0=5bit, 1=6bit, 2=7bit, 3=8bit)

Note: In block error mode, block error conditions must be cleared by using the error reset command (command 4) or a receiver reset (command 2).

1F802020h/SecondAccess - MR2A - DUART Mode Register 2.A (R/W)

1F802028h/SecondAccess - MR2B - DUART Mode Register 2.B (R/W)

7-6	Channel Mode	(0=Normal, 1=Auto-Echo, 2=Local loop, 3=Remote loop)
5	TxRTS Control	(0=No, 1=Yes) (when 1 --> OP0=RTSA / OP1=RTSB)
4	CTS Enable	(0=No, 1=Yes) (when 1 --> IP0=CTSA / IP1=CTSB)
3-0	Tx Stop Bit Length	(00h..0Fh = see below)

Stop Bit Lengths:

```
0=0.563  1=0.625  2=0.688  3=0.750  4=0.813  5=0.875  6=0.938  7=1.000
8=1.563  9=1.625  A=1.688  B=1.750  C=1.813  D=1.875  E=1.938  F=2.000
```

Add 0.5 to values shown for 0..7 if channel is programmed for 5 bits/char.

1F802021h/Write - CSRA - DUART Clock Select Register A (W)

1F802029h/Write - CSRB - DUART Clock Select Register B (W)

```
7-4 Rx Clock Select (0..0Ch=See Table, 0Dh=Timer, 0Eh=16xIP, 0Fh=1xIP)
3-0 Tx Clock Select (0..0Ch=See Table, 0Dh=Timer, 0Eh=16xIP, 0Fh=1xIP)
```

The 2681 has some sets of predefined baud rates (set1/set2 selected via ACR.7), additionally, in BRG Test Mode, set3/set4 are used instead of set1/set2, the baud rates for selections 00h..0Dh are:

Rate	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	0Ah	0Bh	0Ch
Set1	50	110	134.5	200	300	600	1200	1050	2400	4800	7200	9600	38400
Set2	75	110	134.5	150	300	600	1200	2000	2400	4800	1800	9600	19200
Set3	4800	880	1076	19200	28800	57600	115200	1050	57600	4800	57600	9600	38400
Set4	7200	880	1076	14400	28800	57600	115200	2000	57600	4800	14400	9600	19200

Selection 0Eh/0Fh are using an external clock source (derived from IP3,IP4,IP5,IP6 pins; for TxA,RxA,TxB,RxB respectively).

1F802022h/Write - CRA - DUART Command Register A (W)

1F80202Ah/Write - CRB - DUART Command Register B (W)

```
7 Not used (should be 0)
6-4 Miscellaneous Commands (0..7 = see below)
3 Disable Tx (0=No change, 1=Disable)
2 Enable Tx (0=No change, 1=Enable) ;Don't use with Command 3 (Reset Rx)
1 Disable Rx (0=No change, 1=Disable)
0 Enable Rx (0=No change, 1=Enable) ;Don't use with Command 2 (Reset Tx)
```

The command values for CRA (or CRB) are:

```
0 No command ;no effect
1 Reset MR pointer ;force "FirstAccess" state for MR1A (or MR1B) access
2 Reset receiver ;reset RxA (or RxB) registers, disable Rx, flush Fifo
3 Reset transmitter ;reset TxA (or TxB) registers
4 Reset Error Flags ;reset SRA.7-4 (or SRB.7-4) to zero
```

```

5 Reset Break-Change IRQ Flag ;reset ISR.2 (or ISR.6) to zero
6 Start break ;after current char, pause Tx with TxDA=Low (or TxDB=Low)
7 Stop break ;output one High bit, then continue Tx (ie. undo pause)

```

Access to the upper four bits of the command register should be separated by 3 edges of the X1 clock. A disabled transmitter cannot be loaded.

1F802025h/Read - ISR - DUART Interrupt Status Register (R)

1F802025h/Write - IMR - DUART Interrupt Mask Register (W)

7	Input Port Change	(0=No, 1=Yes)	(Ack via reading IPCR) ;see ACR.3-0
6	Break Change B	(0=No, 1=Yes)	(Ack via CRB/Command5)
5	RxRDYB/FFULLB	(0=No, 1=Yes)	(Ack via reading data) ;see MR1B.6
4	THRB Empty (TxRDYB)	(0=No, 1=Yes)	(Ack via writing data) ;same as SRB.2
3	Counter Ready	(0=No, 1=Yes)	(Ack via CT_STOP)
2	Break Change A	(0=No, 1=Yes)	(Ack via CRA/Command5)
1	RxRDYA/FFULLA	(0=No, 1=Yes)	(Ack via reading data) ;see MR1A.6
0	THRA Empty (TxRDYA)	(0=No, 1=Yes)	(Ack via writing data) ;same as SRA.2

1F802021h/Read - SRA - DUART Status Register A (R)

1F802029h/Read - SRB - DUART Status Register B (R)

7	Rx Received Break*	(0=No, 1=Yes)	;received 00h without stop bit
6	Rx Framing Error*	(0=No, 1=Yes)	;received data without stop bit
5	Rx Parity Error*	(0=No, 1=Yes)	;received data with bad parity
4	Rx Overrun Error	(0=No, 1=Yes)	;Rx FIFO full + RxShiftReg full
3	Tx Underrun (TxEMT)	(0=No, 1=Yes)	;both TxShiftReg and THR empty
2	Tx THR Empty (TxRDY)	(0=No, 1=Yes)	;same as ISR.0 / ISR.4
1	Rx FIFO Full (FFULL)	(0=No, 1=Yes)	;set upon 3 or more characters
0	Rx FIFO Not Empty (RxRDY)	(0=No, 1=Yes)	;set upon 1 or more characters

Bit7-5 are appended to the corresponding data character in the receive FIFO. A read of the status provides these bits (7:5) from the top of the FIFO together with bits (4:0). These bits are cleared by a "reset error status" command. In character mode they are discarded when the corresponding data character is read from the FIFO. In block error mode, block error conditions must be cleared by using the error reset command (command 4x) or a receiver reset.

1F802024h/Write - ACR - DUART Aux. Control Register (W)


```

7   Select Baud Rate Generator (BRG) Set    (0=Set1/Set3, 1=Set2/Set4)
6-4 Counter/Timer Mode and Source          (see below)
3-0 IP3..IP0 Change Interrupt Enable Flags (0=Off, 1=On)

```

Counter/Timer Mode and Clock Source Settings:

Num	Mode	Clock Source
0h	Counter	External (IP2)
1h	Counter	TxCA - 1x clock of Channel A transmitter
2h	Counter	TxCB - 1x clock of Channel B transmitter
3h	Counter	Crystal or external clock (x1/CLK) divided by 16
4h	Timer	External (IP2)
5h	Timer	External (IP2) divided by 16
6h	Timer	Crystal or external clock (x1/CLK)
7h	Timer	Crystal or external clock (x1/CLK) divided by 16

In Counter Mode, the Counter Ready flag is set on any underflow, and the counter wraps to FFFFh and keeps running (but may get stopped by software).

In Timer Mode, automatic reload occurs on any underflow, the counter flag (which can be output to OP3) is toggled on any underflow, but the Counter Ready flag is set only on each 2nd underflow (unlike as in Counter mode).

1F802024h/Read - IPCR - DUART Input Port Change Register (R)

```

7-4 IP3..IP0 Change Occured Flags (0=No, 1=Yes)    ;auto reset after read
3-0 Current IP3-IP0 Input states (0=Low, 1=High)   ;Same as IP.3-0

```

Reading from this register automatically resets IPCR.7-4 and ISR.7.

1F80202Dh/Read - IP - DUART Input Port (R)

```

7   Not used (always 1)
6-0 Current IP6-IP0 Input states (0=Low, 1=High)   ;LSBs = Same as IPCR.3-0

```

IP0-6 can be used as general purpose inputs, or for following special purposes:

IP6	External RxB Clock	;see CSRB.7-4
IP5	External TxB Clock	;see CSRB.3-0
IP4	External RxA Clock	;see CSRA.7-4
IP3	External TxA Clock	;see CSRA.3-0
IP2	External Timer Input	;see AUX.6-4
IP1	Clear to Send B (CTSB)	;see MR2B.5
IP0	Clear to Send A (CTSA)	;see MR2A.5

Note: The 24pin chip doesn't have any inputs, the 28pin chip has only one input (IP2), the 40pin/44pin chips have seven inputs (IP0-IP6).

1F80202Eh/Write - DUART Set Output Port Bits Command (Set means Out=LOW)

1F80202Fh/Write - DUART Reset Output Port Bits Command (Reset means Out=HIGH)

```
7-0  Change "OPR" OP7-OP0 Output states (0=No change, 1=Set/Reset)
```

Note: The 24pin chip doesn't have any outputs, the 28pin chip has only two outputs (OP0,OP1), the 40pin/44pin chips have eight outputs (OP0-OP7).

1F80202Dh/Write - OPCR - DUART Output Port Configuration Register (W)

```
7   OP7   (0=OPR.7, 1=TxRDYB)
6   OP6   (0=OPR.6, 1=TxRDYA)
5   OP5   (0=OPR.5, 1=RxRDY/FFULLB)
4   OP4   (0=OPR.4, 1=RxRDY/FFULLA)
3-2 OP3   (0=OPR.3, 1=Clock/Timer Output, 2=TxCB(1x), 3=RxCB(1x))
1-0 OP2   (0=OPR.2, 1=TxCA(16x), 2=TxCA(1x), 3=RxCA(1x))
```

Additionally, the OP0 and OP1 outputs are controlled via MR2A.5 and MR2B.5.

1F802022h/Read - - DUART Toggle Baud Rate Generator Test Mode (Read=Strobe)

1F80202Ah/Read - - DUART Toggle 1X/16X Test Mode (Read=Strobe)

```
7-0  Not used (just issue a dummy-read to toggle the test mode on/off)
```

BGR Test switches between Baud Rate Set1/Set2 and Set3/Set4.

1X/16X Test switches between whatever...?

1F80202Eh/Read - CT_START - DUART Start Counter Command (Read=Strobe)

1F80202Fh/Read - CT_STOP - DUART Stop Counter Command (Read=Strobe)

```
7-0  Not used (just issue a dummy-read to strobe start/stop command)
```

Start: Forces reload (copies CTLR/CTUR to CTL/CTU), and starts the timer.

Stop-in-Counter-Mode: Resets ISR.3, and stops the timer.

Stop-in-Timer-Mode: Resets ISR.3, but doesn't stop the timer.

1F802026h/Read - CTU - DUART Counter/Timer Current Value, Upper/Bit15-8 (R)

1F802027h/Read - CTL - DUART Counter/Timer Current Value, Lower/Bit7-0 (R)

1F802026h/Write - CTUR - DUART Counter/Timer Reload Value, Upper/Bit15-8 (W)

1F802027h/Write - CTLR - DUART Counter/Timer Reload Value, Lower/Bit7-0 (W)

The CTLR/CTUR reload value is copied to CTL/CTU upon Start Counter Command. In Timer mode (not in Counter mode), it is additionally copied automatically when the timer undeflows.

1F80202Ch - N/A - DUART Reserved Register (neither R nor W)

Reserved.

Chip versions

The SCN2681 is manufactured with 24..44 pins, the differences are:

```
24pin basic cut-down version           ;without IP0-1/OP0-1 = without CTS/RTS
28pin additional IP2,OP0,OP1,X2         ;without IP0-1 = without CTS
40pin additional IP0-IP6,OP0-OP7,X2     ;full version
44pin same as 40pin with four NC pins ;full version (SMD)
```

Unknown which of them is supposed to be used with the PSX?

Note: The Motorola 68681 should be the same as the Philips/Signetics 2681.

Notes

Unknown if the Interrupt signal is connected to the PSX... there seems to be no spare IRQ for it, though it \<might> share an IRQ with whatever other hardware...?

The BIOS seems to use only one of the two channels; for the std_io functions:

[BIOS TTY Console \(std_io\)](#)

Aside from the external DUART, the PSX additionally contains an internal UART,
[Serial Interfaces \(SIO\)](#)

The DTL-H2000 devboard uses a non-serial "ATCONS" channel for TTY stuff,
[EXP2 DTL-H2000 I/O Ports](#)

17.3 EXP2 DTL-H2000 I/O Ports

The DTL-H2000 contains extended 8Mbyte Main RAM (instead of normal 2Mbyte), plus additional 1Mbyte RAM in Expansion Area at 1FA00000h, plus some I/O ports at 1F8020xxh:

1F802000h - DTL-H2000: EXP2: - ATCONS STAT (R)

```
0    Unknown, used for something
1    Unknown/unused
2    Unknown, used for something
3    TTY/Atcons TX Ready      (0=Busy, 1=Ready)
4    TTY/Atcons RX Available (0=None, 1=Yes)
5-7  Unknown/unused
```

1F802002h - DTL-H2000: EXP2: - ATCONS DATA (R and W)

```
0-7  TTY/Atcons RX/TX Data
```

TTY channel for message output (TX) and debug console keyboard input (RX). The DTL-H2000 is using this "ATCONS" stuff instead of the DUART stuff used in retail console BIOSes ("CONS" seems to refer to "Console", and "AT" might refer to PC/AT or whatever).

1F802004h - DTL-H2000: EXP2: - 16bit - ?

```
0-15 Data...?
```

1F802030h - DTL-H2000: Secondary IRQ10 Controller (IRQ Flags)

This register does expand IRQ10 (Lightgun) to more than one IRQ source. The register contains only Secondary IRQ Flags (there seem to be no Secondary IRQ Enable bits; at least not for Lightguns).

```
0    ... used for something
1    Lightgun IRQ (write: 0=No change, 1=Acknowledge) (read: 0=None, 1=IRQ)
2-3  Unknown/unused (write: 0=Normal)
4    ... acknowledged at 1FA00B04h, otherwise unused
5    ... TTY RX ?
6-7  Unknown/unused (write: 0=Normal)
8-31 Not used by DTL-H2000 BIOS (but Lightgun games write 0 to these bits)
```

Retail games that support IRQ10-based "Konami" Lightguns are containing code for detecting and accessing port 1F802030h. The detection works by examining a value in the BIOS ROM like so:

```
IF [BFC00104h]=00002000h then Port 1F802030h does exist      (DTL-H2000)
IF [BFC00104h]=00002500h then Port 1F802030h does NOT exist
IF [BFC00104h]=00000003h then Port 1F802030h does NOT exist (default)
IF [BFC00104h]= <other>   then Port 1F802030h does NOT exist
```

Normal consoles don't include Port 1F802030h, and IRQ10 is wired directly to the controller port, and the value at [BFC00104h] is always 00000003h. Accordingly, one cannot upgrade the console just by plugging a Secondary IRQ10 controller to the expansion port (instead, one would need to insert the controller between the CPU and controller plug, and to install a BIOS with [BFC00104h]=00002000h).

The DTL-H2000 BIOS accesses 1F802030h with 8bit load/store opcodes, however, the Lightgun games use 32bit load/store - which is theoretically overlapping port 1F802032h, though maybe the memory system does ignore the upper bits.

1F802032h - DTL-H2000: EXP2: - maybe IRQ enable?

```
0    Used for something (CLEARED on some occassions)
1-3  Unknown/unused
4    Used for something (SET on some occassions)
5-7  Unknown/unused
```

1F802040h - DTL-H2000: EXP2: 1-byte - DIP Switch?

```
0-7  DIP Value (00h..FFh, but should be usually 00h..02h)
```

This register selects the DTL-H2000 boot mode, for whatever reason it's called "DIP Switch" register, although the DTL-H2000 boards don't seem to contain any such DIP Switches (instead, it's probably configured via some I/O ports on PC side). Possible values are:

```
DIP=0 --> .. long delay before TTY?   with "PSX>" prompt, throws CDROM cmds
DIP=1 --> .. long delay before TTY?   no "PSX>" prompt           PSY-Q?
DIP=2 --> .. instant TTY?             with "PSX>" prompt
DIP=3 --> Lockup
DIP=04h..FFh --> Lockup with POST=04h..FFh
```

1F802042h - DTL-H2000: EXP2: POST/LED (R/W)[EXP2 Post Registers](#)

17.4 EXP2 Post Registers

1F802041h - POST - External 7-segment Display (W)

```

0-3  Current Boot Status (00h..0Fh)
4-7  Not used by BIOS    (always set to 0)

```

During boot, the BIOS writes incrementing values to this register, allowing to display the current boot status on an external 7 segment display (much the same as Port 80h used in PC BIOSes).

1F802042h - DTL-H2000: EXP2: POST/LED (R/W)

```

0-7  Post/LED value

```

8bit wide, otherwise same as POST 1F802041h on retail consoles.

1F802070h - POST2 - Unknown? (W) - PS2

Might be a configuration port, or it's another POST register (which is used prior to writing the normal POST bytes to 1FA00000h).

The first write to 1F802070h is 32bit, all further writes seem to be 8bit.

1FA00000h - POST3 - External 7-segment Display (W) - PS2

Similar to POST, but PS2 BIOS uses this address.

17.5 EXP2 Nocash Emulation Expansion

1F802060h Emu-Expansion ID1 "E" (R)

1F802061h Emu-Expansion ID2 "X" (R)

1F802062h Emu-Expansion ID3 "P" (R)

1F802063h Emu-Expansion Version (01h) (R)

Contains ID and Version.

1F802064h Emu-Expansion Enable1 "O" (R/W)

1F802065h Emu-Expansion Enable2 "N" (R/W)

Activates the Halt and Turbo Registers (when set to "ON").

1F802066h Emu-Expansion Halt (R)

When enabled (see above), doing an 8bit read from this address stops the CPU emulation unless/until an Interrupt occurs (when "CAUSE AND SR AND FF00h" becomes nonzero). Can be used to reduce power consumption, and to make the emulation faster.

1F802067h Emu-Expansion Turbo Mode Flags (R/W)

When enabled (see above), writing to this register activates/deactivates "turbo" mode, which is causing new data to arrive immediately after acknowledging the previous interrupt.

```

0   CDROM Turbo      (0=Normal, 1=Turbo)
1   Memory Card Turbo (0=Normal, 1=Turbo)
2   Controller Turbo  (0=Normal, 1=Turbo)
3-7 Reserved (must be zero)
```

17.6 EXP2 PCSX-Redux Emulation Expansion

PCSX-Redux contains some specific hardware registers for the purpose of testing and debugging. They are located past the 1F802080h address, which means that accessing

them on the real hardware will cause an exception, unless the [1F80101Ch register](#) has been set to be at least twice its normal size.

1F802080h 4 Redux-Expansion ID "PCSX" (R)

Identification string. Use this to query that your binary is running under PCSX-Redux.

1F802080h 1 Redux-Expansion Console putchar (W)

Adds this character to the console output. This is an easier way to write to the console than using the BIOS.

1F802081h 1 Redux-Expansion Debug break (W)

Causes a debug breakpoint to be triggered. PCSX-Redux will pause and the user will be alerted of a software breakpoint.

1F802082h 1 Redux-Expansion Exit code (W)

Sets the exit code for the program. When in test mode, PCSX-Redux will exit with this code.

1F802084h 4 Redux-Expansion Notification message pointer (W)

Displays a pop-up message to the user with the specified string.

See [PCSX-Redux's documentation](#) for more details and examples.

18. Memory Control

The Memory Control registers are initialized by the BIOS, and, normally software doesn't need to change that settings. Some registers are useful for expansion hardware (allowing to increase the memory size and bus width).

1F801000h - Expansion 1 Base Address (usually 1F000000h)

0-23	Base address	(R/W)
24-31	Fixed, always 1Fh	(R)

The behavior of this register is somewhat inconsistent. Normally, the base address is forcefully aligned to the EXP1 region's size by masking off the bottommost N bits (where N = number of address lines, as set in register 1F801008h). For instance, if the number of EXP1 address lines is set to 8, setting this register to 1F000000h or 1F0000FFh has the same effect.

When performing a PIO DMA transfer, however, all bits of this register are output on the bus regardless of the currently set region size. The System 573 relies on this behavior as it changes the base address to 1F480000h prior to reading data from the IDE CD-ROM using DMA (and does not reset it to 1F000000h afterwards).

Note: presumably the masking lets the bus interface compute addresses quickly by replacing masked off bits with the LSBs of the incoming address value from the CPU, thus only requiring a few multiplexers instead of a full adder.

1F801004h - Expansion 2 Base Address (usually 1F802000h)

Same as 1F801000h, however trying to use ANY other value than 1F802000h seems to disable the Expansion 2 region, rather than mapping it to the specified address (ie. Port 1F801004h doesn't seem to work).

For Expansion 3, the address seems to be fixed (1FA00000h).

1F801008h - Expansion 1 Delay/Size (usually 0013243Fh) (512Kbytes, 8bit bus) (573: 24173F47h)

1F80100Ch - Expansion 3 Delay/Size (usually 00003022h) (1 byte)

1F801010h - BIOS ROM Delay/Size (usually 0013243Fh) (512Kbytes, 8bit bus)

1F801014h - SPU Delay/Size (200931E1h) (use 220931E1h for SPU-RAM reads)

1F801018h - CDROM Delay/Size (00020843h or 00020943h)

1F80101Ch - Expansion 2 Delay/Size (usually 00070777h) (128 bytes, 8bit bus)

0-3	Write Delay	(00h..0Fh=01h..10h Cycles)
4-7	Read Delay	(00h..0Fh=01h..10h Cycles)
8	Recovery Period	(0=No, 1=Yes, uses COM0 timings)
9	Hold Period	(0=No, 1=Yes, uses COM1 timings)
10	Floating Period	(0=No, 1=Yes, uses COM2 timings)
11	Pre-strobe Period	(0=No, 1=Yes, uses COM3 timings)
12	Data Bus-width	(0=8bits, 1=16bits)
13	Auto Increment	(0=No, 1=Yes)
14-15	Unknown (R/W)	
16-20	Number of address bits (memory window size = $1 \ll N$ bytes)	
21-23	Unknown (always zero)	
24-27	DMA timing override	
28	Address error flag. Write 1 to it to clear it.	
29	DMA timing select	(0=use normal timings, 1=use bits 24-27)
30	Wide DMA	(0=use bit 12, 1=override to full 32 bits)
31	Wait	(1=wait on external device before being ready)

When booting, all these registers are using the maximum cycle delays for both reads and writes. Then, the BIOS will immediately select a faster read access delay, resulting in a visible speed up after the first few instructions. The effects aren't immediate however. The BIOS boots using the following instructions:

```

bfc00000    lui      $t0, 0x0013
bfc00004    ori      $t0, 0x243f
bfc00008    lui      $at, 0x1f80
bfc0000c    sw       $t0, 0x1010($at)
bfc00010    nop
bfc00014    li       $t0, 0x0b88
bfc00018    lui      $at, 0x1f80
bfc0001c    sw       $t0, 0x1060($at)
bfc00020    nop

```

When using a logic analyzer to monitor the boot sequence, the instruction at bfc00014 is still read using the old timings since reset, and then the instruction at bfc00018 is finally read using the sped up timings.

Reads and writes access times aren't symmetrical, and are each controlled with their own values. By default, EXP1 will be set to 16 cycles when writing, which is the slowest possible. If the programmer wants to write to a flash chip on EXP1, or communicate with a computer, speeding up write access is recommended.

The fastest a port could go would be by setting the lowest 16 bits to zero, which will result in 3 CPU cycles for a single byte access.

!CS always goes active at least one cycle before !WR or !RD go active. The various timing changes are between all the events inside the data read/write waveform. The whole formula for computing the total access time is fairly complex overall, and difficult to properly describe.

- The pre-strobe period will add delays between the moment the data bus is set, and the moment !CS goes active.
- The hold period will keep the data in the data bus for some more cycles after !WR goes inactive, and before !CS goes inactive. The accessed device is supposed to sample the data bus during this interval.
- The floating period will keep the data bus floating for some more cycles after !RD goes inactive, and before !CS goes inactive. The accessed device is supposed to stop driving the data bus during this interval. The CPU will sample the data bus somewhere before or exactly when !CS goes inactive.
- The recovery period will add delays between two operations.

The data bus width will influence if the CPU does full 16 bits reads, or only 8 bits. When doing 32 bits operations, the CPU will issue 2 16-bits operations, or 4 8-bits operations, keeping !CS active the whole time, and strobing !WR or !RD accordingly. When doing these sequences, the address bus will also increment automatically between each operation, if the auto-increment bit is active.

This means it is possible to slightly shorten the read time of 4 bytes off the same address by disabling auto-increment, and reading a full word. The CPU will then read 4 bytes off the same address, and place them all into each byte of the loaded register.

The DMA timing override portion will replace the access timing when doing DMA, only if the DMA override flag is set.

The Wide DMA flag will enable full 32 bits DMA operations on the bus, by reusing the low 16-bits address signals as the high 16-bits data. This means that if the CPU is doing Wide DMA reads, the low 16-bits of the address bus will become inputs.

Trying to access addresses that exceed the selected size causes a bus exception. Maximum size would be Expansion 1 = 17h (8MB), BIOS = 16h (4MB), Expansion 2 = 0Dh (8KB), Expansion 3 = 15h (2MB). Trying to select larger sizes would overlap the internal I/O ports, and crash the PSX. The Size bits seem to be ignored for SPU/CDROM. The SPU timings seem to be applied for both the 200h-byte SPU region at 1F801C00h and for the 200h-byte unknown region at 1F801E00h.

1F801020h - COM_DELAY / COMMON_DELAY (00031125h or 0000132Ch or 00001325h)

```
0-3   COM0 - Recovery period cycles
4-7   COM1 - Hold period cycles
8-11  COM2 - Floating release cycles
12-15 COM3 - Strobe active-going edge delay
16-31 Unknown/unused (read: always 0000h)
```

This register contains clock cycle offsets that can be added to the Access Time values in Port 1F801008h..1Ch. Works (somehow) like so:

```
1ST=0, SEQ=0, MIN=0
IF Use_COM0 THEN 1ST=1ST+COM0-1, SEQ=SEQ+COM0-1
IF Use_COM2 THEN 1ST=1ST+COM2, SEQ=SEQ+COM2
IF Use_COM3 THEN MIN=COM3
IF 1ST<6 THEN 1ST=1ST+1 ;(somewhat like so)
1ST=1ST+AccessTime+2, SEQ=SEQ+AccessTime+2
IF 1ST<(MIN+6) THEN 1ST=(MIN+6)
IF SEQ<(MIN+2) THEN SEQ=(MIN+2)
```

The total access time is the sum of First Access, plus any Sequential Access(es), eg. for a 32bit access with 8bit bus: Total=1ST+SEQ+SEQ+SEQ.

If the access is done from code in (uncached) RAM, then 0..4 cycles are added to the Total value (the exact number seems to vary depending on the used COMx values or so).

1F801060h - RAM_SIZE (R/W) (usually 00000B88h) (or 00000888h)

```
0-2   Unknown (no effect)
3     Crashes when zero (except PU-7 and EARLY-PU-8, which <do> set bit3=0)
4-6   Unknown (no effect)
7     Delay on simultaneous CODE+DATA fetch from RAM (0=None, 1=One Cycle)
8     Unknown (no effect) (should be set for 8MB, cleared for 2MB)
9     RAM chip size 1 (0=1MB or 2MB, 1=4MB or 8MB)
10    Enable /RAS1 bank (0=disable/bus fault on access, 1=enable)
```

```

11    RAM chip size 2 (0=1MB or 4MB, 1=2MB or 8MB)
12-15 Unknown (no effect)
16-31 Unknown (Garbage)

```

Possible values for bits 9-11 are:

```

000 = 1MB bank on /RAS0 + 15MB unmapped
001 = 4MB bank on /RAS0 + 12MB unmapped
010 = 1MB bank on /RAS0 + 1MB bank on /RAS1 (?) + 14MB unmapped
011 = 4MB bank on /RAS0 + 4MB bank on /RAS1 (?) + 8MB unmapped
100 = 2MB bank on /RAS0 + 14MB unmapped
101 = 8MB bank on /RAS0 + 8MB unmapped
110 = 2MB bank on /RAS0 + 2MB bank on /RAS1 (?) + 12MB unmapped
111 = 8MB bank on /RAS0 + 8MB bank on /RAS1 (?)

```

The BIOS writes different values depending on the console revision:

```

PU-7, EARLY-PU-8:
  0B80h    Single 2MB bank (four 512Kx8 chips) on /RAS0
           (incorrectly set as an 8MB bank, correct setting would be 0880h)
Later consoles:
  0B88h    Single 2MB bank (one 512Kx32 chip) on /RAS0
           (incorrectly set as an 8MB bank, correct setting would be 0888h)
DTL-H2000, DTL-H2700, DTL-H2500:
  0B88h    Single 8MB bank (four 2Mx8 chips) on /RAS0
           (correctly set as 8MB)
System 573 (700A01, 700B01 if ASIC revision bit = 1):
  0C80h    Two 2MB banks (four 512Kx8 chips each) on /RAS0 and /RAS1 respectively
           (correctly set as 4MB)
System 573 (700B01 if ASIC revision bit = 0):
  4788h    Two 4MB banks on /RAS0 and /RAS1 respectively
           (probably an incorrect setting for the two alternate 1Mx16 RAM
           footprints on revision D of the PCB, labeled "DR16M16")

```

"Unmapped" means that the CPU generates an exception when accessing that area.

Note: Wipeout uses a BIOS function that changes RAM_SIZE to 00000888h (ie. with corrected size of 2MB, and with the unknown Bit8 cleared). Gundam Battle Assault 2 does actually use the "8MB" space (with stacktop in mirrored RAM at 807FFFxxh).

Clearing bit7 causes many games to hang during CDROM loading on both EARLY-PU-8 and LATE-PU-8 (but works on PU-18 through PM-41).

FFFE0130h - BCC, BIU/Cache Configuration Register (R/W)

0	LOCK	Enable cache lock mode	(when COP0_SR.IsC=1)
1	INV	Enable cache invalidation mode	(when COP0_SR.IsC=1)
2	TAG	Enable cache tag test mode	(when COP0_SR.IsC=1, used to flush i-cache)
3	RAM	Enable cache scratchpad mode	(usually 1, broken - see note)

4-5	DBLKSZ	Data cache refill size	(usually 0, broken - see note)
6	-	Always 0 (R)	
7	DS	Enable data cache	(usually 1, disables scratchpad when 0)
8-9	IBLKSZ	Instruction cache refill size	(0=2 words, 1=4 words/default, 2-3=invalid/crash)
10	ISO	Always 0 (R)	(supposedly "Enable instruction cache set 0")
11	IS1	Enable instruction cache	
12	INTP	Supposedly "Interrupt polarity"	(usually 0)
13	RDPRI	Supposedly "Enable read priority"	(usually 1)
14	NOPAD	Supposedly "No wait state"	(usually 1)
15	BGNT	Supposedly "Enable bus grant"	(usually 1)
16	LDSCH	Supposedly "Enable load scheduling"	(usually 1)
17	NOSTR	Supposedly "No streaming"	(usually 0)
18-31	-	Reserved (R/W)	

Documented in chapter 14 of the datasheet for LSI's L64360, which specifically states it "includes the LR33300 Family Control Registers described in the CW33300 manual". Used primarily by the BIOS to flush the i-cache in combination with the COP0 status register, like so:

```
uint32_t sr = COP0_SR;

BCC      = TAG | IS1;
COP0_SR = IsC;

for (int i = 0; i < 0x1000; i += 16) // Clear tags (one for each 4-word line)
    *((volatile uint32_t *) i) = 0;

COP0_SR = 0;
BCC      = IS1;
COP0_SR = IsC;

for (int i = 0; i < 0x1000; i += 4) // Clear cache lines
    *((volatile uint32_t *) i) = 0;
for (int i = 0; i < 8; i++)          // Wait by reading dummy words from uncached RAM?
    *((volatile uint32_t *) 0xa0000000);

COP0_SR = 0;
BCC      = RAM | DS | IBLKSZ_4 | IS1 | RDPRI | NOPAD | BGNT | LDSCH;
COP0_SR = sr;
```

At least one game (TOCA World Touring Cars, SLES-02572) flushes the cache using custom code running from uncached RAM (KSEG1) instead of calling the BIOS function described above. It follows a slightly different sequence:

```
uint32_t bcc = BCC, sr = COP0_SR;

COP0_SR = 0;
```

```

BCC      = (BCC & ~(LOCK | INV | DS | IS0)) | TAG | IS1;
COP0_SR = IsC;

for (int i = 0; i < 0x1000; i += 16) // Clear tags (one for each 4-word line)
    *((volatile uint32_t *) i) = 0;

COP0_SR = 0;
BCC      = bcc;
COP0_SR = sr;

```

A usable version of this code [is available](#).

Bit 3 may be cleared to unmap the scratchpad from memory and use it as a data cache instead, however doing so will result in erratic behavior due to it not being equipped with tag memory; each cache line's "tag" seems to be hardcoded to its respective scratchpad address instead. With bit 3 cleared, data in the scratchpad will be updated during CPU loads but no cache hits will ever occur.

Bits 4-5 seem to have no effect whatsoever. The CPU will always fetch one word at a time from RAM, rather than attempting to prefetch an entire line using a burst read (as it does with the i-cache).

19. Unpredictable Things

Normally, I/O ports should be accessed only at their corresponding size (ie. 16bit read/write for 16bit ports), and of course, only existing memory and I/O addresses should be used. When not recursing that rules, some more or less (un-)predictable things may happen...

I/O Write Datasize

Address	Content	W.8bit	W.16bit	W.32bit	
00000000h-00FFFFFFh	Main RAM	OK	OK	OK	
1F800000h-1F8003FFh	Scratchpad	OK	OK	OK	
1F801000h-1F801023h	MEMCTRL	(w32)	(w32)	OK	
1F80104xh	JOY_xxx	(w16)	OK	CROP	
1F80105xh	SIO_xxx	(w16)	OK	CROP	
1F801060h-1F801063h	RAM_SIZE	(w32)	(w32)	OK	(with crash)
1F801070h-1F801077h	IRQCTRL	(w32)	(w32)	OK	
1F8010x0h-1F8010x3h	DMAx.ADDR	(w32)	(w32)	OK	
1F8010x4h-1F8010x7h	DMAx.LEN	OK	OK	OK	
1F8010x8h-1F8010xFh	DMAx.CTRL/MIRR	(w32)	(w32)	OK	
1F8010F0h-1F8010F7h	DMA.DPCR/DICR	(w32)	(w32)	OK	
1F8010F8h-1F8010FFh	DMA.unknown	IGNORE	IGNORE	IGNORE	
1F801100h-1F80110Bh	Timer 0	(w32)	(w32)	OK	
1F801110h-1F80111Bh	Timer 1	(w32)	(w32)	OK	
1F801120h-1F80112Bh	Timer 2	(w32)	(w32)	OK	
1F801800h-1F801803h	CDROM	OK	?	?	
1F801810h-1F801813h	GPU.GP0	?	?	OK	
1F801814h-1F801817h	GPU.GP1	?	?	OK	
1F801820h-1F801823h	MDEC.CMD/DTA	?	?	OK	
1F801824h-1F801827h	MDEC.CTRL	?	?	OK	
1F801C00h-1F801E7Fh	SPU	(i16)	OK	OK	
1F801E80h-1F801FFFh	SPU.UNUSED	IGNORE	IGNORE	IGNORE	
1F802020h-1F80202Fh	DUART	OK	?	?	
1F802041h	POST	OK	?	?	
FFFE0130h-FFFE0133h	CACHE.CTRL	(i32)	(i32)	OK	

Whereas,

```

OK      works
(w32) write full 32bits (left-shifted if address isn't word-aligned)
(w16) write full 16bits (left-shifted if address isn't halfword-aligned)
(i32) write full 32bits (ignored if address isn't word-aligned)
(i16) write full 16bits (ignored if address isn't halfword-aligned)
CROP write only lower 16bit (and leave upper 16bit unchanged)

```


It's somewhat "legit" to use 16bit writes on 16bit registers like RAM_SIZE, I_STAT, I_MASK, and Timer 0-2.

Non-4-byte aligned 8bit/16bit writes to RAM_SIZE do crash (probably because the "(w32)" effect is left-shifting the value, so lower 8bit become zero).

Results on unaligned I/O port writes (via SWL/SWR opcodes) are unknown.

I/O Read Datasize

In most cases, I/O ports can be read in 8bit, 16bit, or 32bit units, regardless of their size, among others allowing to read two 16bit ports at once with a single 32bit read. If there's only one 16bit port within a 32bit region, then 32bit reads often return garbage in the unused 16bits. Also, 8bit or 16bit VRAM data reads via GPUREAD probably won't work? Expansion 2 Region can be accessed only via 8bit reads, and 16bit/32bit reads seem to cause exceptions (or rather: no such exception!) (except, probably 16bit reads are allowed when the region is configured to 16bit databus width).

There are at least some special cases:

```
FFFE0130h-FFFE0133h 8bit (+16bit?) read works ONLY from word-aligned address
```

I/O Write Datasize

Performing a 8-bit or 16-bit write (`sb` / `sh`) will place the entirety of the GPR on the bus, regardless of the write size. Therefore, the data is **not** masked. This has an effect when performing a narrower write to a wider address, for example the DMA controller, but not others such as the CD-ROM controller.

Emulators should therefore treat all access widths as having 32 bits of data, but depending on the device perform masking/splitting (see [Memory Control](#)).

The CD audio visualizer (aka Soundscope) in the SCPH-7xxx series of consoles is an example of where this behavior is required, as it issues halfword writes to the DMA controller addresses.

Cache Problems

The functionality of the Cache is still widely unknown. Not sure if DMA transfers are updating or invalidating cache. Cached Data within KSEG0 should be automatically also cached at the corresponding mirrored address in KUSEG and vice versa. Mirrors within KSEG1 (or within KUSEG) may be a different thing, eg. when using addresses spread

across the first 8MB region to access the 2MB RAM. Same problems may occur for Expansion and BIOS mirrors, although, not sure if that regions are cached.

Writebuffer Problems

The writebuffer seems to be disabled for the normal I/O area at 1F801000h, however, it appears to be enabled for the Expansion I/O region at 1F802000h (after writing to 1F802041h, the BIOS issues 4 dummy writes to RAM, apparently (?) in order to flush the writebuffer). The same might apply for Expansion Memory region at 1F000000h, although usually that region would contain ROM, so it'd be don't care whether it is write-buffered or not.

CPU Load/Store Problems

XXcpuREG ---> applies ONLY to LOAD (not to store)

Memory read/write opcodes take a 1-cycle delay until the data arrives at the destination, ie. the next opcode should not use the destination register (or more unlikely, the destination memory location) as source operand. Usually, when trying to do so, the second opcode would receive the OLD value - however, if an exception occurs between the two opcodes, then the read/write operation may finish, and the second opcode would probably receive the NEW value.

CPU Register Problems - R1 (AT), R26 (K0), R29 (SP)

Exception handlers cannot preserve all registers, before returning, they must load the return address into a general purpose register (conventionally R26 aka K0), so be careful not to use that register, unless you are 100% sure that no interrupts and no other exceptions can occur. Some exception handlers might also destroy R27 aka K1 (though exception handler in the PSX Kernel leaves that register unchanged).

Some assemblers (not a22i in nocash syntax mode) are internally using R1 aka AT as scratch register for some pseudo opcodes, including for a "sw rx,imm32" pseudo opcode (which is nearly impossible to separate from the normal "sw rx,imm16" opcode), be careful not to use R1, unless you can trust your assembler not to destroy that register behind your back.

The PSX Kernel uses "Full-Decrementing-Wasted-Stack", where "Wasted" means that when calling a sub-function with N parameters, then the caller must pre-allocate N words on stack, and the sub-function may freely use and destroy these words; at [SP+0..N*4-1].

Locked Locations in Memory and I/O Area

```

00800000h      ; -when Main RAM configured to end at 7FFFFFFh
1F080000h 780000h ; -when Expansion 1 configured to end at 7FFFFFFh
1F800400h C00h    ; -region after Scratchpad
1F801024h 1Ch     ; \
1F801064h 0Ch     ;
1F801078h 08h     ;
1F801140h 6C0h    ; gaps in I/O region
1F801804h 0Ch     ;
1F801818h 08h     ;
1F801828h 3D8h    ; /
1F802080h 3FDF80h ; -when Expansion 2 configured to end at 7Fh
1FC80000h 60380000h ; -when BIOS ROM configured to end at 7FFFFFFh
C0000000h 1FFE0000h ; \
FFFE0020h E0h     ; gaps in KSEG2 (cache control region)
FFFE0140h 1FEC0h  ; /

```

Trying to access these locations generates an exception. For KSEG0 and KSEG1, locked regions are same as for first 512MB of KUSEG.

Mirrors in I/O Area

```
1F80108Ch+N*10h - D#_CHCR Mirrors - (N=0..6, for DMA channel 0..6)
```

Read/writeable mirrors of DMA Control registers at 1F801088h+N*10h.

Garbage Locations in I/O Area

```

1F801062h (2 bytes) ; \
1F801072h (2 bytes) ; unused addresses in Memory and Interrupt Control area
1F801076h (2 bytes) ; /
1F801102h (2 bytes) ; \
1F801106h (2 bytes) ; unused addresses in Timer 0 area
1F80110Ah (6 bytes) ; /
1F801112h (2 bytes) ; \
1F801116h (2 bytes) ; unused addresses in Timer 1 area
1F80111Ah (6 bytes) ; /
1F801122h (2 bytes) ; \
1F801126h (2 bytes) ; unused addresses in Timer 2 area and next some bytes
1F80112Ah (22 bytes) ; /
1F801820h (4 bytes) ; -read MDEC Data-Out port (if there is no data)
FFFE0000h (32 bytes) ; \
FFFE0100h (48 bytes) ; unused addresses in Cache control area
FFFE0132h (2 bytes) ; (including write-only upper 16bit of Port FFFE0130h)
FFFE0134h (12 bytes) ; /

```

Unlike all other unused I/O addresses, these addresses are unlocked (ie. they do not trigger exceptions on access), however they do not seem to contain anything useful. The BIOS never seems to use them. Writing any values to them seems to have no effect. And reading acts somewhat unstable:

Usually returns zeros in most cases. Except that, the first byte on a 10h-byte boundary often returns the lower 8bit of the memory address (eg. [FFFE0010h]=10h). And, when [FFFE0130h].Bit11=0, then reading from these registers does return the 32bit opcode that is to be executed next (or at some locations, the opcode thereafter).

PSX as Abbreviation for Playstation 1

In gaming and programming scene, "PSX" is most commonly used as abbreviation for the original Playstation series (occasionally including PSone). Sony has never officially used that abbreviation, however, the Playstation BIOS contains the ASCII strings "PSX" and "PS-X" here and there. The letters "PS" are widely believed to stand for PlayStation, and the meaning of the "X" is totally unknown (although, actually it may stand for POSIX.1, see below).

PSX as Abbreviation for POSIX.1

According to JMI Software Systems, "PSX" is a trademark of themselves, and stands for "single-user, single-group, subset of POSIX.1" (POSIX stands for something commonly used by HLL programmers under UNIX or so). That "PSX" kernel from JMI is available for various processors, including MIPS processors, and like the playstation, it does include functions like "atoi", and does support TTY access via Signetics 2681 DUART chips. The DTL-H2000 does also have POSIX-style "PSX>" prompt. So, altogether, it's quite possible that Sony has licensed the kernel from JMI.

PSX as Abbreviation for an Extended Playstation 2

As everybody agrees, PSX should be used only as abbreviation for Playstation 1, and nobody should never ever use it for the Playstation 2. Well, nobody, except Sony... despite of the common use as abbreviation for Playstation 1 (and despite of the JMI trademark)... in 2003, Sony has have released a "Playstation 2 with built-in HDD/DVD Videorecorder" and called that thing "PSX" for the best of confusion.

20. CPU Specifications

CPU

[CPU Registers](#)
[CPU Opcode Encoding](#)
[CPU Load/Store Opcodes](#)
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System Control Coprocessor (COP0)

[COP0 - Register Summary](#)
[COP0 - Exception Handling](#)
[COP0 - Misc](#)
[COP0 - Debug Registers](#)

20.1 CPU Registers

All registers are 32bit wide.

Name	Alias	Common Usage
R0	zero	Constant (always 0)
R1	at	Assembler temporary (destroyed by some assembler pseudoinstructions!)
R2-R3	v0-v1	Subroutine return values, may be changed by subroutines
R4-R7	a0-a3	Subroutine arguments, may be changed by subroutines
R8-R15	t0-t7	Temporaries, may be changed by subroutines
R16-R23	s0-s7	Static variables, must be saved by subs
R24-R25	t8-t9	Temporaries, may be changed by subroutines
R26-R27	k0-k1	Reserved for kernel (destroyed by some IRQ handlers!)
R28	gp	Global pointer (rarely used)
R29	sp	Stack pointer
R30	fp(s8)	Frame Pointer, or 9th Static variable, must be saved
R31	ra	Return address (used so by JAL,BLTZAL,BGEZAL opcodes)
-	pc	Program counter
-	hi,lo	Multiply/divide results, may be changed by subroutines

R0 is always zero.

R31 can be used as general purpose register, however, some opcodes are using it to store the return address: JAL, BLTZAL, BGEZAL. (Note: JALR can optionally store the return address in R31, or in R1..R30. Exceptions store the return address in cop0r14 - EPC).

R29 (SP) - Full Decrementing Wasted Stack Pointer

The CPU doesn't explicitly have stack-related registers or opcodes, however, conventionally, R29 is used as stack pointer (SP). The stack can be accessed with normal load/store opcodes, which do not automatically increase/decrease SP, so the SP register must be manually modified to (de-)allocate data.

The PSX BIOS is using "Full Decrementing Wasted Stack".

Decrementing means that SP gets decremented when allocating data (that's common for most CPUs) - Full means that SP points to the first ALLOCATED word on the stack, so the allocated memory is at SP+0 and above, free memory at SP-1 and below, Wasted means that when calling a sub-function with N parameters, then the caller must pre-allocate N words on stack, and the sub-function may freely use and destroy these words; at [SP+0..N*4-1].

For example, "push ra,r16,r17" would be implemented as:

```
sub    sp,20h
mov    [sp+14h],ra
mov    [sp+18h],r16
mov    [sp+1Ch],r17
```

where the allocated 20h bytes have the following purpose:

```
[sp+00h..0Fh]  wasted stack (may, or may not, be used by sub-functions)
[sp+10h..13h]  8-byte alignment padding (not used)
[sp+14h..1Fh]  pushed registers
```

20.2 CPU Opcode Encoding

Primary opcode field (Bit 26..31)

00h=SPECIAL	08h=ADDI	10h=COP0	18h=N/A	20h=LB	28h=SB	30h=LWC0	38h=SWC0
01h=BcondZ	09h=ADDIU	11h=COP1	19h=N/A	21h=LH	29h=SH	31h=LWC1	39h=SWC1
02h=J	0Ah=SLTI	12h=COP2	1Ah=N/A	22h=LWL	2Ah=SWL	32h=LWC2	3Ah=SWC2
03h=JAL	0Bh=SLTIU	13h=COP3	1Bh=N/A	23h=LW	2Bh=SW	33h=LWC3	3Bh=SWC3
04h=BEQ	0Ch=ANDI	14h=N/A	1Ch=N/A	24h=LBU	2Ch=N/A	34h=N/A	3Ch=N/A
05h=BNE	0Dh=ORI	15h=N/A	1Dh=N/A	25h=LHU	2Dh=N/A	35h=N/A	3Dh=N/A

06h=BLEZ	0Eh=XORI	16h=N/A	1Eh=N/A	26h=LWR	2Eh=SWR	36h=N/A	3Eh=N/A
07h=BGTZ	0Fh=LUI	17h=N/A	1Fh=N/A	27h=N/A	2Fh=N/A	37h=N/A	3Fh=N/A

Secondary opcode field (Bit 0..5) (when Primary opcode = 00h)

00h=SLL	08h=JR	10h=MFHI	18h=MULT	20h=ADD	28h=N/A	30h=N/A	38h=N/A
01h=N/A	09h=JALR	11h=MTHI	19h=MULTU	21h=ADDU	29h=N/A	31h=N/A	39h=N/A
02h=SRL	0Ah=N/A	12h=MFLO	1Ah=DIV	22h=SUB	2Ah=SLT	32h=N/A	3Ah=N/A
03h=SRA	0Bh=N/A	13h=MTLO	1Bh=DIVU	23h=SUBU	2Bh=SLTU	33h=N/A	3Bh=N/A
04h=SLLV	0Ch=SYSCALL	14h=N/A	1Ch=N/A	24h=AND	2Ch=N/A	34h=N/A	3Ch=N/A
05h=N/A	0Dh=BREAK	15h=N/A	1Dh=N/A	25h=OR	2Dh=N/A	35h=N/A	3Dh=N/A
06h=SRLV	0Eh=N/A	16h=N/A	1Eh=N/A	26h=XOR	2Eh=N/A	36h=N/A	3Eh=N/A
07h=SRAV	0Fh=N/A	17h=N/A	1Fh=N/A	27h=NOR	2Fh=N/A	37h=N/A	3Fh=N/A

Opcode/Parameter Encoding

31..26		25..21		20..16		15..11		10..6		5..0		
6bit		5bit		5bit		5bit		5bit		6bit		
-----+-----+-----+-----+-----+-----+-----												
000000		N/A		rt		rd		imm5		0000xx		shift-imm
000000		rs		rt		rd		N/A		0001xx		shift-reg
000000		rs		N/A		N/A		N/A		001000		jr
000000		rs		N/A		rd		N/A		001001		jalr
000000		<-----comment20bit----->								00110x		sys/brk
000000		N/A		N/A		rd		N/A		0100x0		mfhi/mflo
000000		rs		N/A		N/A		N/A		0100x1		mthi/mtlo
000000		rs		rt		N/A		N/A		0110xx		mul/div
000000		rs		rt		rd		N/A		10xxxx		alu-reg
000001		rs		00000		<--immediat16bit-->				bltz		
000001		rs		00001		<--immediat16bit-->				bgez		
000001		rs		10000		<--immediat16bit-->				bltzal		
000001		rs		10001		<--immediat16bit-->				bgezal		
00001x		<-----immediate26bit----->								j/jal		
00010x		rs		rt		<--immediat16bit-->				beq/bne		
00011x		rs		N/A		<--immediat16bit-->				blez/bgtz		
001xxx		rs		rt		<--immediat16bit-->				alu-imm		
001111		N/A		rt		<--immediat16bit-->				lui-imm		
100xxx		rs		rt		<--immediat16bit-->				load rt,[rs+imm]		
101xxx		rs		rt		<--immediat16bit-->				store rt,[rs+imm]		
x1xxxx		<-----coprocessor specific----->								coprocessor (see below)		

Coprocessor Opcode/Parameter Encoding

31..26		25..21		20..16		15..11		10..6		5..0		
6bit		5bit		5bit		5bit		5bit		6bit		
-----+-----+-----+-----+-----+-----+-----												
0100nn		0 0000		rt		rd		N/A		000000		MFCn rt,rd_dat ;rt = dat
0100nn		0 0010		rt		rd		N/A		000000		CFCn rt,rd_cnt ;rt = cnt
0100nn		0 0100		rt		rd		N/A		000000		MTCn rt,rd_dat ;dat = rt

```

0100nn |0|0110| rt   | rd   | N/A   | 000000 | CTCn rt,rd_cnt ;cnt = rt
0100nn |0|1000|00000 | <--immediate16bit--> | BCnF target ;jump if false
0100nn |0|1000|00001 | <--immediate16bit--> | BCnT target ;jump if true
0100nn |1| <-----immediate25bit-----> | COPn imm25
010000 |1|0000| N/A   | N/A   | N/A   | 000001 | COP0 01h ;=TLBR, unused on PS1
010000 |1|0000| N/A   | N/A   | N/A   | 000010 | COP0 02h ;=TLBWI, unused on PS1
010000 |1|0000| N/A   | N/A   | N/A   | 000110 | COP0 06h ;=TLBWR, unused on PS1
010000 |1|0000| N/A   | N/A   | N/A   | 001000 | COP0 08h ;=TLBP, unused on PS1
010000 |1|0000| N/A   | N/A   | N/A   | 010000 | COP0 10h ;=RFE
1100nn | rs   | rt   | <--immediate16bit--> | LWCn rt_dat,[rs+imm]
1110nn | rs   | rt   | <--immediate16bit--> | SWCn rt_dat,[rs+imm]

```

Illegal Opcodes

All opcodes that are marked as "N/A" in the Primary and Secondary opcode tables are causing a Reserved Instruction Exception (excode=0Ah).

The unused operand bits (eg. Bit21-25 for LUI opcode) should be usually zero, but do not necessarily trigger exceptions if set to nonzero values.

20.3 CPU Load/Store Opcodes

Load instructions

```

lb  rt,imm(rs)    rt=[imm+rs] ;byte sign-extended
lbu rt,imm(rs)    rt=[imm+rs] ;byte zero-extended
lh  rt,imm(rs)    rt=[imm+rs] ;halfword sign-extended
lhu rt,imm(rs)    rt=[imm+rs] ;halfword zero-extended
lw  rt,imm(rs)    rt=[imm+rs] ;word

```

Load instructions can read from the data cache (if the data is not in the cache, or if the memory region is uncached, then the CPU gets halted until it has read the data) (however, the PSX doesn't have a data cache).

Load and store instructions can generate address error exceptions if the memory address is not properly aligned (To a halfword boundary for lh/lhu/sh or a word boundary for lw/sw. lwl/lwr/swl/swr can't access misaligned address as they force align the memory address). Additionally, accessing certain invalid memory locations will cause a bus error exception. If an exception occurs during a load instruction, the rt register is left untouched.

Caution - Load Delay

The loaded data is NOT available to the next opcode, ie. the target register isn't updated until the next opcode has completed. So, if the next opcode tries to read from the load destination register, then it would (usually) receive the OLD value of that register (unless an IRQ occurs between the load and next opcode, in that case the load would complete during IRQ handling, and so, the next opcode would receive the NEW value). MFC2/CFC2 also have a 1-instruction delay until the target register is loaded with its new value (more info in the GTE section).

Store instructions

```
sb  rt,imm(rs)    [imm+rs]=(rt AND FFh)    ;store 8bit
sh  rt,imm(rs)    [imm+rs]=(rt AND FFFFh)   ;store 16bit
sw  rt,imm(rs)    [imm+rs]=rt              ;store 32bit
```

Store operations are passed to the write-queue, so they can execute within a single clock cycle (unless the write-queue was full, in that case the CPU gets halted until there's room in the queue). For more information on the write-queue, visit [this page](#).

Caution - 8/16-bit writes to certain IO registers

During an 8-bit or 16-bit store, all 32 bits of the GPR are placed on the bus. As such, when writing to certain 32-bit IO registers with an 8 or 16-bit store, it will behave like a 32-bit store, using the register's full value. The soundscope on some shells is known to rely on this, as it uses `sh` to write to certain DMA registers. If this is not properly emulated, the soundscope will hang, waiting for an interrupt that will never be fired.

Load/Store Alignment

Halfword addresses must be aligned by 2, word addresses must be aligned by 4, trying to access mis-aligned addresses will cause an exception. There's no alignment restriction for bytes.

Unaligned Load/Store

```
lwr  rt,imm(rs)    load right bits of rt from memory (usually imm+0)
lwl  rt,imm(rs)    load left  bits of rt from memory (usually imm+3)
swr  rt,imm(rs)    store right bits of rt to memory (usually imm+0)
swl  rt,imm(rs)    store left  bits of rt to memory (usually imm+3)
```

There's no delay required between `lwl` and `lwr`, so you can use them directly following each other, eg. to load a word anywhere in memory without regard to alignment:

```
lwl    r2,$0003(t0)    ;\no delay required between these
lwr    r2,$0000(t0)    ;/(although both access r2)
nop                                ;-requires load delay HERE (before reading from r2)
and    r2,r2,0ffffh    ;-access r2 (eg. reducing it to unaligned 16bit data)
```

Unaligned Load/Store (Details)

`LWR/SWR` transfers the right (=lower) bits of `Rt`, up-to 32bit memory boundary:

```
lwr/swr [N*4+0]    transfer whole 32bit of Rt to/from [N*4+0..3]
lwr/swr [N*4+1]    transfer lower 24bit of Rt to/from [N*4+1..3]
lwr/swr [N*4+2]    transfer lower 16bit of Rt to/from [N*4+2..3]
lwr/swr [N*4+3]    transfer lower 8bit of Rt to/from [N*4+3]
```

`LWL/SWL` transfers the left (=upper) bits of `Rt`, down-to 32bit memory boundary:

```
lwl/swl [N*4+0]    transfer upper 8bit of Rt to/from [N*4+0]
lwl/swl [N*4+1]    transfer upper 16bit of Rt to/from [N*4+0..1]
lwl/swl [N*4+2]    transfer upper 24bit of Rt to/from [N*4+0..2]
lwl/swl [N*4+3]    transfer whole 32bit of Rt to/from [N*4+0..3]
```

The CPU has four separate byte-access signals, so, within a 32bit location, it can transfer all fragments of `Rt` at once (including for odd 24bit amounts). The transferred data is not zero- or sign-expanded, eg. when transferring 8bit data, the other 24bit of `Rt` and `[mem]` will remain intact.

Note: The aligned variant can also misused for blocking memory access on aligned addresses (in that case, if the address is known to be aligned, only one of the opcodes are needed, either `LWL` or `LWR`).... Uhhhhhhhm, OR is that NOT allowed... more PROBABLY that doesn't work?

20.4 CPU ALU Opcodes

arithmetic instructions

```
add    rd,rs,rt        rd=rs+rt (with overflow trap)
addu   rd,rs,rt        rd=rs+rt
sub     rd,rs,rt        rd=rs-rt (with overflow trap)
subu   rd,rs,rt        rd=rs-rt
```

```

addi  rt,rs,imm      rt=rs+(-8000h..+7FFFh) (with ov.trap)
addiu rt,rs,imm      rt=rs+(-8000h..+7FFFh)

```

The opcodes "with overflow trap" do trigger an exception (and leave rd unchanged) in case of overflows.

comparison instructions

```

slt   rd,rs,rt  if rs<rt (signed comparison) then rd=1 else rd=0
sltu  rd,rs,rt  if rs<rt (unsigned comparison) then rd=1 else rd=0
slti  rt,rs,imm if rs<(sign-extended immediate in range [-8000h..+7FFFh], signed
comparison) then rt=1 else rt=0
sltiu rt,rs,imm if rs<(sign-extended immediate in range [0..7FFFh] U
[FFFF8000h..FFFFFFFFh], unsigned comparison) then rt=1 else rt=0

```

logical instructions

```

and  rd,rs,rt      rd = rs AND rt
or   rd,rs,rt      rd = rs OR  rt
xor  rd,rs,rt      rd = rs XOR rt
nor  rd,rs,rt      rd = FFFFFFFFh XOR (rs OR rt)
andi rt,rs,imm     rt = rs AND (0000h..FFFFh)
ori  rt,rs,imm     rt = rs OR  (0000h..FFFFh)
xori rt,rs,imm     rt = rs XOR (0000h..FFFFh)

```

shifting instructions

```

sllv rd,rt,rs      rd = rt SHL (rs AND 1Fh)
srlv rd,rt,rs      rd = rt SHR (rs AND 1Fh)
srav rd,rt,rs      rd = rt SAR (rs AND 1Fh)
sll  rd,rt,imm     rd = rt SHL (00h..1Fh)
srl  rd,rt,imm     rd = rt SHR (00h..1Fh)
sra  rd,rt,imm     rd = rt SAR (00h..1Fh)
lui  rt,imm        rt = (0000h..FFFFh) SHL 16

```

Unlike many other opcodes, shifts use 'rt' as second (not third) operand. The hardware does NOT generate exceptions on SHL overflows.

Multiply/divide

```

mult  rs,rt        hi:lo = rs*rt (signed)
multu rs,rt        hi:lo = rs*rt (unsigned)
div   rs,rt        lo = rs/rt, hi=rs mod rt (signed)
divu  rs,rt        lo = rs/rt, hi=rs mod rt (unsigned)
mfhi  rd           rd=hi ;move from hi
mflo  rd           rd=lo ;move from lo

```

```

mthi  rs      hi=rs ;move to hi
mtlo  rs      lo=rs ;move to lo

```

The mul/div opcodes are starting the multiply/divide operation, starting takes only a single clock cycle, however, trying to read the result from the hi/lo registers while the mul/div operation is busy will halt the CPU until the mul/div has completed. For multiply, the execution time depends on rs (ie. "small*large" can be much faster than "large*small").

```

__multu_execution_time__
Fast  (6 cycles)  rs = 00000000h..000007FFh
Med   (9 cycles)  rs = 00000800h..000FFFFFFh
Slow  (13 cycles) rs = 00100000h..FFFFFFFFh
__mult_execution_time__
Fast  (6 cycles)  rs = 00000000h..000007FFh, or rs = FFFFF800h..FFFFFFFFh
Med   (9 cycles)  rs = 00000800h..000FFFFFFh, or rs = FFF00000h..FFFFF801h
Slow  (13 cycles) rs = 00100000h..7FFFFFFFh, or rs = 80000000h..FFF00001h
__divu/div_execution_time__
Fixed (36 cycles) no matter of rs and rt values

```

For example, when executing "multu 123h,12345678h" and "mflo r1", one can insert up to six (cached) ALU opcodes, or read one value from PSX Main RAM (which has 6 cycle access time) between the "multu" and "mflo" opcodes without additional slowdown. The hardware does NOT generate exceptions on divide overflows, instead, divide errors are returning the following values:

Opcode	Rs	Rt	Hi/Remainder	Lo/Result
divu	0..FFFFFFFFh	0 -->	Rs	FFFFFFFFh
div	0..+7FFFFFFFFh	0 -->	Rs	-1
div	-80000000h..-1	0 -->	Rs	+1
div	-80000000h	-1 -->	0	-80000000h

For divu, the result is more or less correct (as close to infinite as possible). For div, the results are total garbage (about furthest away from the desired result as possible). Note: After accessing the lo/hi registers, there seems to be a strange rule that one should not touch the lo/hi registers in the next 2 cycles or so... not yet understood if/when/how that rule applies...?

20.5 CPU Jump Opcodes

jumps and branches

Note that the instruction following the branch will always be executed.

j	dest	pc=(pc and F0000000h)+(imm26bit*4)
jal	dest	pc=(pc and F0000000h)+(imm26bit*4),ra=\$+8
jr	rs	pc=rs
jalr	(rd,)rs(,rd)	pc=rs, rd=\$+8 ;see caution
beq	rs,rt,dest	if rs=rt then pc=\$+4+(-8000h..+7FFFh)*4
bne	rs,rt,dest	if rs<>rt then pc=\$+4+(-8000h..+7FFFh)*4
bltz	rs,dest	if rs<0 then pc=\$+4+(-8000h..+7FFFh)*4
bgez	rs,dest	if rs>=0 then pc=\$+4+(-8000h..+7FFFh)*4
bgtz	rs,dest	if rs>0 then pc=\$+4+(-8000h..+7FFFh)*4
blez	rs,dest	if rs<=0 then pc=\$+4+(-8000h..+7FFFh)*4
bltzal	rs,dest	if rs<0 then pc=\$+4+(..)*4; ra=\$+8;
bgezal	rs,dest	if rs>=0 then pc=\$+4+(..)*4; ra=\$+8;

jr/jalr can be used to jump to an unaligned address, in which case an address error (AdEL) exception will be raised on the next instruction fetch.

Additionally, bltzal/bgezal will always place the return address in \$ra, whether or not the branch is taken. Additionally, if `rs` is \$ra, then the value used for the comparison is \$ra's value before linking.

JALR cautions

Caution: The JALR source code syntax varies (IDT79R3041 specs say "jalr rs,rd", but MIPS32 specs say "jalr rd,rs"). Moreover, JALR may not use the same register for both operands (eg. "jalr r31,r31") (doing so would destroy the target address; which is normally no problem, but it can be a problem if an IRQ occurs between the JALR opcode and the following branch delay opcode; in that case BD gets set, and EPC points "back" to the JALR opcode, so JALR is executed twice, with destroyed target address in second execution).

exception opcodes

Unlike for jump/branch opcodes, exception opcodes are immediately executed (ie. without executing the following opcode).

syscall	imm20	generates a system call exception
break	imm20	generates a breakpoint exception

The 20bit immediate doesn't affect the CPU (however, the exception handler may interpret it by software; by examining the opcode bits at [epc-4]).

20.6 CPU Coprocessor Opcodes

Coprocessor Instructions (COP0..COP3)

```

mfc# rt,rd      ;rt = cop#datRd ;data regs
cfc# rt,rd      ;rt = cop#cntRd ;control regs
mtc# rt,rd      ;cop#datRd = rt ;data regs
ctc# rt,rd      ;cop#cntRd = rt ;control regs
cop# imm25      ;exec cop# command 0..1FFFFFFFh
lwc# rt,imm(rs) ;cop#dat_rt = [rs+imm] ;word
swc# rt,imm(rs) ;[rs+imm] = cop#dat_rt ;word
bc#f dest       ;if cop#flg=false then pc=$+disp
bc#t dest       ;if cop#flg=true then pc=$+disp
rfe             ;return from exception (COP0)
tlb<xx>         ;virtual memory related (COP0), unused in the PS1

```

Unknown if any tlb-opcodes (tlbr,tlbwi,tlbwr,tlbp) are implemented in the psx hardware?

Caution - Load Delay

When reading from a coprocessor register, the next opcode cannot use the destination register as operand (much the same as the Load Delays that occur when reading from memory; see there for details).

Reportedly, the Load Delay applies for the next TWO opcodes after coprocessor reads, but, that seems to be nonsense (the PSX does finish both COP0 and COP2 reads after ONE opcode).

Caution - Store Delay

In some cases, a similar delay occurs when writing to a coprocessor register. COP0 is more or less free of store delays (eg. one can read from a cop0 register immediately after writing to it), the only known exception is the cop2 enable bit in cop0r12.bit30 (setting that cop0 bit acts delayed, and cop2 isn't actually enabled until after 2 clock cycles or so).

Writing to cop2 registers has a delay of 2..3 clock cycles. In most cases, that is probably (?) only 2 cycles, but special cases like writing to IRGB (which does additionally affect IR1,IR2,IR3) take 3 cycles until the result arrives in all registers).

Note that Store Delays are counted in numbers of clock cycles (not in numbers of

opcodes). For 3 cycle delay, one must usually insert 3 cached opcodes (or one uncached opcode).

20.7 CPU Pseudo Opcodes

Pseudo instructions (native/spasm)

```

nop                ;alias for sll r0,r0,0
move rd,rs         ;alias for addu rd,rs,r0
la  rx,imm32       ;load address  (alias for lui rx / addiu rx)
li  rx,imm32       ;load immediate (alias for lui rx / ori  rx)
li  rx,imm16       ;load immediate (alias for ori, range 0..FFFFh)
li  rx,-imm15      ;load immediate (alias for addiu, range -1..-8000h)
li  rx,imm16*10000h ;load immediate (alias for lui)
lw  rx,imm32       ;load from address (lui rx / lw rx,rx)
sw  rx,imm32       ;store to address  (lui r1 / sw rx,r1) (destroys r1!)
lb,lh,lwl,lwr,lbu,lhu ;as above pseudo lw
sb,sh,swl,swr     ;as above pseudo sw (ie. also destroys r1!)
alu  rx,op         ;alias for alu  rx,rx,op
alu(u) rx,rx,imm   ;alias for alui(u) rx,rx,imm
jalr rx            ;alias for jalr (RA,)rx,(RA)
subi(u) rt,rs,imm  ;alias for addi(u) rt,rs,-imm
beqz rx,dest       ;alias for beq rx,r0,dest
bnez rx,dest       ;alias for bne rx,r0,dest
b  dest           ;alias for beq r0,r0,dest (jump relative/spasm)
bra dest           ;alias for bgez r0, r0, dest
bal dest           ;alias for bgezal r0, r0, dest

```

Pseudo instructions (nocash/a22i, not present on most other assemblers)

```

mov  rx,NNNN0000h  ;alias for lui  rx,NNNNh
mov  rx,0000NNNNh  ;alias for or   rx,r0,NNNNh ;max +FFFFh
mov  rx,-imm15     ;alias for add  rx,r0,-NNNNh ;min -8000h
mov  rx,ry         ;alias for or   rx,ry,0 (or "addiu")
jrel dest          ;alias for blez R0,dest ;relative jump
crel dest          ;alias for callns R0,dest ;relative call
jz  rx,dest        ;alias for je   rx,R0,dest
jnz rx,dest        ;alias for jne  rx,R0,dest
call rx            ;alias for call rx,ret=RA
ret               ;alias for jmp  ra
subt rt,rs,imm     ;alias for addt rt,rs,-imm
sub  rt,rs,imm     ;alias for add  rt,rs,-imm
alu  rx,op         ;alias for alu  rx,rx,op
neg(t) rx,ry       ;alias for sub(t) rx,R0,ry
not  rx,ry         ;alias for nor   rx,R0,ry
neg(t)/not rx      ;alias for neg(t)/not rx,rx
setz rx,ry         ;alias for setb rx,ry,1 (set if zero)

```

```
setnz rx,ry      ;alias for setb rx,R0,ry (set if nonzero)
syscall/break    ;alias for syscall/break 000000h
```

Below are pseudo instructions combined of two 32bit opcodes...

```
movp rx,imm32    ;alias for lui rx,imm16 -plus- or rx,rx,imm16)
mov(bhs)p rx,[imm32] ;load from address (lui rx,imm16 / mov rx,[rx+imm16])
movu [rs+imm]    ;alias for lwr/swr [rs+imm] plus lwl/swl [rs+imm+3]
reti            ;alias for jmp k0 plus rfe
```

Below are pseudo instructions combined of two or more 32bit opcodes...

```
push rlist      ;alias for sub sp,n*4 -- mov [sp+(1..n)*4],r1..rn
pop rlist       ;alias for mov r1..rn,[sp+(1..n)*4] -- add sp,n*4
pop pc,rlist    ;alias for pop ra,rlist -- jmp ra
```

Directives (nocash)

```
.mips            ;select MIPS instruction set (alternately .hc05 for MC68HC05)
.bios           ;create a .ROM file (instead of .EXE)
.auto_nop       ;append NOPs to jumps ;unless next opcode starts with a +
org imm         ;assume following code to be originated at address "imm"
db n(,n(...))   ;define 8bit data values(s) or quoted ASCII strings
dw n(,n(...))   ;define 16bit data values(s) (not 32bit data!)
dd n(,n(...))   ;define 32bit data values(s)
.align imm      ;
0               ;alias for immediate 0 and register R0 (whichever fits)
```

Directives (native)

```
org imm         ;self-explaining (but, default=$80010000 for spasm!)
align imm       ;self-explaining (probably zeropadded?)
db n(,n(...))   ;define 8bit data values(s) or quoted ASCII strings
dh n(,n(...))   ;define 16bit data values(s)
dw n(,n(...))   ;define 32bit data values(s) (not 16bit data!)
dcb len,value   ;fill <len> bytes by <value> (different as DCB on ARM CPUs)
xyz             ;define label "xyz" at current address (without colon)
xyz equ n       ;assign value n to xyz
xyz = n         ;probably same/similar as "equ"
;xyz           ;comments invoked with semicolon (spasm)
incbin file.bin ;import binary file
include file.asm ;import asm file
zero           ;alias for r0
>imm32         ;alias for (i-(i AND 8000h))/10000h, and/or i/10000h ?
<imm32         ;alias for (i AND 0FFFFh), used for SW(+/-) and ORI(+)?
end            ;N/A ;no "end" or ".end" directive needed/used by spasm
r1 aka at      ;N/A ;some assemblers may (optionally) reject to use r1/at
```


Syntax for unknown assembler (for pad.s)

It uses "0x" for HEX values (but doesn't use "\$" for registers).

It uses "#" instead of ";" for comments.

It uses ":" for labels (fortunately).

The assembler has at least one directive: ".byte" (equivalent to "db" on other assemblers).

I've no clue which assembler is used for that syntax... could that be the Psy-Q assembler?

20.8 COP0 - Register Summary

COP0 Register Summary

Number	Mnemonic	Name	R/W
cop0r0-r2	N/A		
cop0r3	BPC	Breakpoint Program Counter	R/W
cop0r4	N/A		
cop0r5	BDA	Breakpoint Data Address	R/W
cop0r6	TAR	Target Address	R
cop0r7	DCIC	Debug and Cache Invalidate Control	R/W
cop0r8	BadA	Bad Address	R
cop0r9	BDAM	Breakpoint Data Address Mask	R/W
cop0r10	N/A		
cop0r11	BPCM	Breakpoint Program Counter Mask	R/W
cop0r12	SR	Status Register	R/W
cop0r13	CAUSE	Cause of the last exception	R
cop0r14	EPC	Exception Program Counter	R
cop0r15	PRID	Processor Revision Identifier	R
cop0r16-r31		Garbage	
cop0r32-r63	N/A	Control regs	

20.9 COP0 - Exception Handling

cop0r13 - CAUSE - (Read-only, except, Bit8-9 are R/W)

Describes the most recently recognised exception.

Bits	Mnemonic	Description
0-1		Not used (zero)
2-6	ExcCode	Describes what kind of exception occurred (see below)
7		Not used (zero)
8-9	Sw	Software Interrupts. Write to these bits to manually cause an exception. Clear them before returning.
10-15	IP	Interrupt pending field. As long as any of the bits are set they will cause an interrupt if the corresponding bit in the IPEN register is set.
16-27		Not used (zero)
28-29	CE	Contains the coprocessor number if the exception occurred because of a coprocessor instruction for which the coprocessor is not available.
30	BT	When BD is set, BT determines whether the branch is taken. The Target Address Register holds the target address.
31	BD	Is set when EPC points to the branch instruction instead of the instruction in the branch delay slot, which is the case for branches to the next instruction.

ExcCode values:

Value	Mnemonic	Description
00h	INT	External Interrupt
01h	MOD	TLB modification (none such in PSX)
02h	TLBL	TLB load (none such in PSX)
03h	TLBS	TLB store (none such in PSX)
04h	AdEL	Address error, Data load or Instruction fetch
05h	AdES	Address error, Data store. The address errors occur when attempting to read outside of KUseg in user mode.
06h	IBE	Bus error on Instruction fetch
07h	DBE	Bus error on Data load/store
08h	Sys	Generated unconditionally by syscall instruction
09h	Bp	Breakpoint - break instruction
0Ah	RI	Reserved instruction
0Bh	CpU	Coprocessor unusable
0Ch	Ovf	Arithmetic overflow
0Dh-1Fh		Not used

cop0r12 - SR - System status register (R/W)

```

0    IEc Current Interrupt Enable  (0=Disable, 1=Enable) ;rfe pops IUp here
1    KUc Current Kernel/User Mode  (0=Kernel, 1=User)   ;rfe pops KUp here
2    IEp Previous Interrupt Enable                                     ;rfe pops IUo here
3    KUp Previous Kernel/User Mode                                     ;rfe pops KUo here
4    IEo Old Interrupt Enable                                           ;left unchanged by rfe
5    KUo Old Kernel/User Mode                                           ;left unchanged by rfe
6-7  -    Not used (zero)
8-15 Im 8 bit interrupt mask fields. When set the corresponding
        interrupts are allowed to cause an exception.
16    Isc Isolate Cache (0=No, 1=Isolate)
        When isolated, all load and store operations are targetted
        to the Data cache, and never the main memory.
        (Used by PSX Kernel, in combination with Port FFFE0130h)
17    Swc Swapped cache mode (0=Normal, 1=Swapped)
        Instruction cache will act as Data cache and vice versa.
        Use only with Isc to access & invalidate Instr. cache entries.
        (Not used by PSX Kernel)
18    PZ When set cache parity bits are written as 0.
19    CM Shows the result of the last load operation with the D-cache
        isolated. It gets set if the cache really contained data
        for the addressed memory location.
20    PE Cache parity error (Does not cause exception)
21    TS TLB shutdown. Gets set if a programm address simultaneously
        matches 2 TLB entries.
        (initial value on reset allows to detect extended CPU version?)
22    BEV Boot exception vectors in RAM/ROM (0=RAM/KSEG0, 1=ROM/KSEG1)
23-24 -    Not used (zero)
25    RE Reverse endianness  (0=Normal endianness, 1=Reverse endianness)
        Reverses the byte order in which data is stored in
        memory. (lo-hi -> hi-lo)
        (Affects only user mode, not kernel mode) (?)
        (The bit doesn't exist in PSX ?)
26-27 -    Not used (zero)
28    CU0 COP0 Enable (0=Enable only in Kernel Mode, 1=Kernel and User Mode)
29    CU1 COP1 Enable (0=Disable, 1=Enable) (none in PSX)
30    CU2 COP2 Enable (0=Disable, 1=Enable) (GTE in PSX)
31    CU3 COP3 Enable (0=Disable, 1=Enable) (none in PSX)

```

cop0r14 - EPC - Return Address from Trap (R)

```

0-31 Return Address from Exception

```

This register points to the address at which an exception occurred, unless BD in CAUSE is set, in which case EPC is set to the address of the exception - 4.

Interrupts should always return to EPC+0, no matter of the BD flag. That way, if BD=1, the branch gets executed again, that's required because EPC stores only the current program counter, but not additionally the branch destination address.

Other exceptions may require to handle BD. In simple cases, when BD=0, the exception handler may return to EPC+0 (retry execution of the opcode), or to EPC+4 (skip the

opcode that caused the exception). Note that jumps to faulty memory locations are executed without exception, but will trigger address errors and bus errors at the target location, ie. EPC (and BadAddr, in case of address errors) point to the faulty address, not to the opcode that has jumped to that address).

Interrupts vs GTE Commands

If an interrupt occurs "on" a GTE command (cop2cmd), then the GTE command is executed, but nevertheless, the return address in EPC points to the GTE command. So, if the exception handler would return to EPC as usually, then the GTE command would be executed twice. In best case, this would be a waste of clock cycles, in worst case it may lead to faulty result (if the results from the 1st execution are re-used as incoming parameters in the 2nd execution). To fix the problem, the exception handler must do:

```
if (cause AND 7Ch)=00h          ;if excode=interrupt
if ([epc] AND FE000000h)=4A000000h ;and opcode=cop2cmd
    epc=epc+4                  ;then skip that opcode
```

Note: The above exception handling is working only in newer PSX BIOSes, but in very old PSX BIOSes, it is only incompletely implemented (see "BIOS Patches" chapter for common workarounds; or write your own exception handler without using the BIOS). Of course, the above exception handling won't work in branch delays (where BD gets set to indicate that EPC was modified) (best workaround is not to use GTE commands in branch delays).

Several games are known to rely on this, notably including the Crash Bandicoot trilogy, Jinx and Spyro the Dragon, all of which will render broken geometry if running on an emulator which doesn't emulate this, or if the installed interrupt service routine doesn't account for it.

cop0cmd=10h - RFE opcode - Prepare Return from Exception

The RFE opcode moves some bits in cop0r12 (SR): bit2-3 are copied to bit0-1, and bit4-5 are copied to bit2-3, all other bits (including bit4-5) are left unchanged.

The RFE opcode does NOT automatically jump to EPC. Instead, the exception handler must copy EPC into a register (usually R26 aka K0), and then jump to that address. Because of branch delays, that would look like so:

```
mov  k0,epc ;get return address
push k0     ;save epc in memory (if you expect nested exceptions)
...        ;whatever (ie. process CAUSE)
pop  k0     ;restore from memory (if you expect nested exceptions)
```

```

jmp k0      ;jump to K0 (after executing the next opcode)
+rfe        ;move SR bit4/5 --> bit2/3 --> bit0/1

```

If you expect exceptions to be nested deeply, also push/pop SR. Note that there's no way to leave all registers intact (ie. above code destroys K0).

cop0r8 - BadVaddr - Bad Virtual Address (R)

Contains the address whose reference caused an exception. Set on any MMU type of exceptions, on references outside of kuseg (in User mode) and on any misaligned reference. BadVaddr is updated ONLY by Address errors (Excode 04h and 05h), all other exceptions (including bus errors) leave BadVaddr unchanged.

Exception Vectors (depending on BEV bit in SR register)

Exception	BEV=0	BEV=1	
Reset	BFC00000h	BFC00000h	(Reset)
UTLB Miss	80000000h	BFC00100h	(Virtual memory, none such in PSX)
COP0 Break	80000040h	BFC00140h	(Debug Break)
General	80000080h	BFC00180h	(General Interrupts & Exceptions)

Note: Changing vectors at 800000xxh (kseg0) seems to be automatically reflected to the instruction cache without needing to flush cache (at least it worked SOMETIMES in my test proggy... but NOT always? ...anyways, it'd be highly recommended to flush cache when changing any opcodes), whilst changing mirrors at 000000xxh (kuseg) seems to require to flush cache.

The PSX uses only the BEV=0 vectors (aside from the reset vector, the PSX BIOS ROM doesn't contain any of the BEV=1 vectors).

Exception Priority

Reset At any time (highest)	;-reset
AdEL Memory (Load instruction)	;\
AdES Memory (Store instruction)	; memory (data load/store)
DBE Memory (Load or store)	;/
MOD ALU (Data TLB)	;\
TLBL ALU (DTLB Miss)	; none such
TLBS ALU (DTLB Miss)	;/
Ovf ALU	;-overflow
Int ALU	;-interrupt
Sys RD (Instruction Decode)	;\
Bp RD (Instruction Decode)	;
RI RD (Instruction Decode)	;
CpU RD (Instruction Decode)	;/
TLBL I-Fetch (ITLB Miss)	;-none such

```
AdEL IVA (Instruction Virtual Address) ;\memory (opcode fetch)
IBE RD (end of I-Fetch, lowest) ;/
```

20.10 COP0 - Misc

cop0r15 - PRID - Processor Revision Identifier (R)

```
0-7   Revision
8-15  Implementation
16-31 Not used
```

For a Playstation with CXD8606CQ CPU, the PRID value is 00000002h.
Unknown if/which other Playstation CPU versions have other values...?

cop0r6 - TAR - Target Address (R)

```
0-31 Return Address
```

When an exception occurs in the delay slot of a jump or branch (cop0r13.31=1), and the branch is to be taken (or it's an unconditional jump) (cop0r13.30=1), this register is updated to contain the destination address of the jump or branch.

cop0r0..r2, cop0r4, cop0r10, cop0r32..r63 - N/A

Registers 0,1,2,4,10 control virtual memory on some MIPS processors (but there's none such in the PSX), and Registers 32..63 (aka "control registers") aren't used in any MIPS processors. Trying to read any of these registers causes a Reserved Instruction Exception (excode=0Ah).

cop0cmd=01h,02h,06h,08h - TLBR,TLBWI,TLBWR,TLBP

The PSX supports only one cop0cmd (cop0cmd=10h aka RFE). Trying to execute the TLBxx opcodes causes a Reserved Instruction Exception (excode=0Ah).

jf/jt cop0flg,dest - conditional cop0 jumps

mov [mem],cop0reg / mov cop0reg,[mem] - coprocessor cop0 load/store

Not supported by the CPU. Trying to execute these opcodes causes a Coprocessor Unusable Exception (excode=0Bh, ie. unlike above, not 0Ah).

cop0r16-r31 - Garbage

Trying to read these registers returns garbage (but does not trigger an exception). When reading one of the garbage registers shortly after reading a valid cop0 register, the garbage value is usually the same as that of the valid register. When doing the read later on, the return value is usually 00000020h, or when reading much later it returns 00000040h, or even 00000100h. No idea what is causing that effect...?

Note: The garbage registers can be accessed (without causing an exception) even in "User mode with cop0 disabled" (SR.Bit1=1 and SR.Bit28=0); accessing any other existing cop0 registers (or executing the rfe opcode) in that state is causing Coprocessor Unusable Exceptions (excode=0Bh).

20.11 COP0 - Debug Registers

"Normal" R30xx CPUs like IDT's R3041 and R3051 don't have similar debug registers, however they are described in LSI's "L64360" datasheet, chapter 14, and in their LR33300/LR33310 datasheet, chapter 4.

cop0r7 - DCIC - Debug and Cache Invalidate Control (R/W)

Bit	Mnemonic	Name	Description
0	DB	Debug	Automatically set upon Any break
1	PC	Program Counter	Automatically set upon BPC Program Counter break
2	DA	Data Address	Automatically set upon BDA Data Address break
3	R	Read Reference	Automatically set upon BDA Data Read break
4	W	Write Reference	Automatically set upon BDA Data Write break
5	T	Trace	Automatically set upon Trace break
6-11		Not used	Always zero
12-13		Jump Redirection	0=Disable, 1..3=Enable (see note)
14-15		Unknown?	
16-22		Not used	Always zero
23	DE	Debug Enable	0=Disabled, 1=Enable bits 24-31
24	PCE	Program Counter Breakpoint Enable	0=Disabled, 1=Enabled (see BPC, BPCM)
25	DAE	Data Address Breakpoint Enable	0=Disabled, 1=Enabled (see BDA, BDAM)
26	DR	Data Read Enable	0=No, 1=Break/when Bit25=1
27	DW	Data Write Enable	0=No, 1=Break/when Bit25=1
28	TE	Trace Enable	0=No, 1=Break on branch/jump/call/etc.
29	KD	Kernel Debug Enable	0=Disabled, 1=Break in kernel mode
30	UD	User Debug Enable	0=Disabled, 1=Break in user mode
31	TR	Trap Enable	0=Only set status bits, 1=Jump to debug vector

When a breakpoint address match occurs the PSX jumps to 80000040h (i.e. unlike normal exceptions, not to 80000080h). The Excode value in the CAUSE register is set to 09h (same as BREAK opcode), and EPC contains the return address, as usual. One of the first things to be done in the exception handler is to disable breakpoints (e.g. if "trace" break is enabled, then it must be disabled BEFORE jumping from 80000040h to the actual exception handler).

cop0r7.bit12-13 - Jump Redirection Note

If one or both of these bits are nonzero, then the PSX seems to check for the following opcode sequence,

```

mov rx,[mem]    ;load rx from memory
...             ;one or more opcodes that do not change rx
jmp/call rx     ;jump or call to rx

```


if it does sense that sequence, then it sets PC=[00000000h], but does not store any useful information in any cop0 registers, namely it does not store the return address in EPC, so it's impossible to determine which opcode has caused the exception. For the jump target address, there are 31 registers, so one could only guess which of them contains the target value; for "POP PC" code it'd be usually R31, but for "JMP [vector]" code it may be any register. So far the feature seems to be more or less unusable...?

cop0r5 - BDA - Breakpoint Data Address (R/W)

cop0r9 - BDAM - Breakpoint Data Address Mask (R/W)

Break condition is " $((\text{addr XOR BDA}) \text{ AND BDAM})=0$ ".

cop0r3 - BPC - Breakpoint Program Counter (R/W)

cop0r11 - BPCM - Breakpoint Program Counter Mask (R/W)

Break condition is " $((\text{PC XOR BPC}) \text{ AND BPCM})=0$ ".

Note (BREAK Opcode)

Additionally, the BREAK opcode can be used to create further breakpoints by patching the executable code. The BREAK opcode uses the same Excode value (09h) in CAUSE register. However, the BREAK opcode jumps to the normal exception handler at 80000080h (not 80000040h).

Note (LibCrypt)

The debug registers are mis-used by "Legacy of Kain: Soul Reaver" (and maybe also other games) for storing libcrypt copy-protection related values (ie. just as a "hidden" location for storing data, not for actual debugging purposes).

[CDROM Protection - LibCrypt](#)

Note (Cheat Devices/Expansion ROMs)

The Expansion ROM header supports only Pre-Boot and Post-Boot vectors, but no Mid-Boot vector. Cheat Devices are often using COP0 breaks for Mid-Boot Hooks, either with BPC=BFC06xxxh (break address in ROM, used in older cheat firmwares), or with BPC=80030000h (break address in RAM aka relocated GUI entrypoint, used in later

cheat firmwares). Moreover, aside from the Mid-Boot Hook, the Xplorer cheat device is also supporting a special cheat code that uses the COP0 break feature.

21. Kernel (BIOS)

- BIOS Overview
- BIOS Memory Map
- BIOS Function Summary
- BIOS File Functions
- BIOS File Execute and Flush Cache
- BIOS CDROM Functions
- BIOS Memory Card Functions
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- BIOS Internal Boot Functions
- BIOS More Internal Functions
- BIOS PC File Server
- BIOS TTY Console (std_io)
- BIOS Character Sets
- BIOS Control Blocks
- BIOS Versions
- BIOS Patches

21.1 BIOS Overview

BIOS CDROM Boot

The main purpose of the BIOS is to boot games from CDROM, unfortunately, before doing that, it displays the Sony intro. It's also doing some copy protection and region checks, and refuses to boot unlicensed games, or illegal copies, or games for other regions.

BIOS Bootmenu

The bootmenu shows up when starting the Playstation without CDROM inserted. The menu allows to play Audio CDs, and to erase or copy game positions on Memory Cards.

BIOS Functions

The BIOS contains a number of more or less useful, and probably more or less inefficient functions that can be used by software.

No idea if it's easy to take full control of the CPU, ie. to do all hardware access and interrupt handling by software, without using the BIOS at all?

Eventually the BIOS functions for accessing the CDROM drive are important, not sure how complicated/compatible it'd be to access the CDROM drive directly via I/O ports... among others, there might be different drives used in different versions of the Playstation, which aren't fully compatible with each other?

BIOS Memory

The BIOS occupies 512Kbyte ROM with 8bit address bus (so the BIOS ROM is rather slow, for faster execution, portions of it are relocated to the first 64K of RAM). For some very strange reason, the original PSX BIOS executes all ROM functions in uncached ROM, which is incredible slow (nocash BIOS uses cached ROM, which does work without problems).

The first 64Kbyte of the 2Mbyte Main RAM are reserved for the BIOS (containing exception handlers, jump tables, other data, and relocated code). That reserved region does unfortunately include the "valuable" first 32Kbytes (valuable because that memory could be accessed directly via [R0+immediate], without needing to use R1..R31 as base register).

21.2 BIOS Memory Map

BIOS ROM Map (512Kbytes)

```
BFC00000h Kernel Part 1  (code/data executed in uncached ROM)
BFC10000h Kernel Part 2  (code/data relocated to cached RAM)
BFC18000h Intro/Bootmenu (code/data decompressed and relocated to RAM)
BFC64000h Character Sets
```

BIOS ROM Header/Footer

```
BFC00100h Kernel BCD date  (YYYYMMDDh)
BFC00104h Console Type      (see Port 1F802030h, Secondary IRQ10 Controller)
BFC00108h Kernel Maker/Version Strings (separated by one or more 00h bytes)
BFC7FF32h GUI Version/Copyright Strings (if any) (separated by one 00h byte)
```

BIOS RAM Map (1st 64Kbytes of RAM) (fixed addresses mainly in 1st 500h bytes)

```
00000000h 10h    Garbage Area (see notes below)
00000010h 30h    Unused/reserved
00000040h 20h    COP0 debug-break vector (not used by Kernel) (in KSEG0)
00000060h 4      RAM Size (in megabytes) (2 or 8)
00000064h 4      Unknown (set to 00000000h)
00000068h 4      Unknown (set to 000000FFh)
0000006Ch 14h    Unused/reserved
00000080h 10h    Exception vector (actually in KSEG0, ie. at 80000080h)
00000090h 10h    Unused/reserved
000000A0h 10h    A(nnh) Function Vector
000000B0h 10h    B(nnh) Function Vector
000000C0h 10h    C(nnh) Function Vector
000000D0h 30h    Unused/reserved
00000100h 58h    Table of Tables (BIOS Control Blocks) (see below)
00000158h 28h    Unused/reserved
00000180h 80h    Command line argument from SYSTEM.CNF; BOOT = fname argument
00000200h 300h   A(nnh) Jump Table
00000500h ...    Kernel Code/Data (relocated from ROM)
0000Cxxxh ...    Unused/reserved
0000DF80h 80h    Used for BIOS Patches (ie. used by games, not used by BIOS)
0000DFFCh 4      Response value from Intro/Bootmenu
0000E000h 2000h  Kernel Memory; ExCBs, EvCBs, and TCBs allocated via B(00h)
```

User Memory (not used by Kernel)

```
00010000h ...    Begin of User RAM (Exefile, Data, Heap, Stack, etc.)
001FFF00h ...    Default Stacktop (usually in KSEG0)
1F800000h 400h   Scratchpad (Data-Cache mis-used as Fast RAM)
```

Table of Tables (see BIOS Control Blocks for details)

Each table entry consists of two 32bit values; containing the base address, and total size (in bytes) of the corresponding control blocks.

00000100h	ExCB	Exception Chain Entrypoints	(addr=var, size=4*08h)
00000108h	PCB	Process Control Block	(addr=var, size=1*04h)
00000110h	TCB	Thread Control Blocks	(addr=var, size=N*0Ch)
00000118h	-	Unused/reserved	
00000120h	EvCB	Event Control Blocks	(addr=var, size=N*1Ch)
00000128h	-	Unused/reserved	
00000130h	-	Unused/reserved	
00000138h	-	Unused/reserved	
00000140h	FCB	File Control Blocks	(addr=fixed, size=10h*2Ch)
00000148h	-	Unused/reserved	
00000150h	DCB	Device Control Blocks	(addr=fixed, size=0Ah*50h)

File handles (fd=00h..0Fh) can be simply converted as fcb=[140h]+fd*2Ch.
 Event handles (event=F10000xxh) as evcb=[120h]+(event AND FFFFh)*1Ch.

Garbage Area at Address 00000000h

The first some bytes of memory address 00000000h aren't actually used by the Kernel, except for storing some garbage at that locations. However, this garbage is actually important for bugged games like R-Types and Fade to Black (ie. games that do read from address 00000000h due to using uninitialized pointers).

Initially, the garbage area is containing a copy of the 16-byte exception handler at address 80h, but the first 4-bytes are typically smashed (set to 00000003h from some useless dummy writes in some useless CDROM delays). Ie. the 16-bytes should have these values:

```
[00000000h]=3C1A0000h ;<-- but overwritten by 00000003h after soon
[00000004h]=275A0C80h ;<-- or 275A0C50h (in older BIOS)
[00000008h]=03400008h
[0000000Ch]=00000000h
```

For R-Types, the halfword at [0] must non-zero (else the game will do a DMA to address 0, and thereby destroy kernel memory). Fade to Black does several garbage reads from [0..9], a wrong byte value at [5] can cause the game to crash with an invalid memory access exception upon memory card access.

21.3 BIOS Function Summary

Parameters, Registers, Stack

Argument(s) are passed in R4,R5,R6,R7,[SP+10h],[SP+14h],etc.

Caution: When calling a sub-function with N parameters, the caller MUST always allocate N words on the stack, and, although the first four parameters are passed in registers rather than on stack, the sub-function is allowed to use/destroy these words at [SP+0..N*4-1].

BIOS Functions (and custom callback functions) are allowed to destroy registers R1-R15, R24-R25, R31 (RA), and HI/LO. Registers R16-R23, R29 (SP), and R30 (FP) must be left unchanged (if the function uses that registers, then it must push/pop them). R26 (K0) is reserved for exception handler and should be usually not used by other functions. R27 (K1) and R28 (GP) are left more or less unused by the BIOS, so one can more or less freely use them for whatever purpose.

The return value (if any) is stored in R2 register.

A-Functions (Call 00A0h with function number in R9 Register)

```

A(00h) or B(32h) open(filename,accessmode)
A(01h) or B(33h) lseek(fd,offset,seektype)
A(02h) or B(34h) read(fd,dst,length)
A(03h) or B(35h) write(fd,src,length)
A(04h) or B(36h) close(fd)
A(05h) or B(37h) ioctl(fd,cmd,arg)
A(06h) or B(38h) exit(exitcode)
A(07h) or B(39h) isatty(fd)
A(08h) or B(3Ah) getc(fd)
A(09h) or B(3Bh) putc(char,fd)
A(0Ah) todigit(char)
A(0Bh) atof(src) ;Does NOT work - uses (ABSENT) cop1 !!!
A(0Ch) strtoul(src,src_end,base)
A(0Dh) strtol(src,src_end,base)
A(0Eh) abs(val)
A(0Fh) labs(val)
A(10h) atoi(src)
A(11h) atol(src)
A(12h) atob(src,num_dst)
A(13h) setjmp(buf)
A(14h) longjmp(buf,param)
A(15h) strcat(dst,src)
A(16h) strncat(dst,src,maxlen)
A(17h) strcmp(str1,str2)
A(18h) strncmp(str1,str2,maxlen)
A(19h) strcpy(dst,src)
A(1Ah) strncpy(dst,src,maxlen)

```

```

A(1Bh) strlen(src)
A(1Ch) index(src, char)
A(1Dh) rindex(src, char)
A(1Eh) strchr(src, char) ;exactly the same as "index"
A(1Fh) strrchr(src, char) ;exactly the same as "rindex"
A(20h) strpbrk(src, list)
A(21h) strspn(src, list)
A(22h) strcspn(src, list)
A(23h) strtok(src, list) ;use strtok(0, list) in further calls
A(24h) strstr(str, substr) ;Bugged
A(25h) toupper(char)
A(26h) tolower(char)
A(27h) bcopy(src, dst, len)
A(28h) bzero(dst, len)
A(29h) bcmp(ptr1, ptr2, len) ;Bugged
A(2Ah) memcpy(dst, src, len)
A(2Bh) memset(dst, fillbyte, len)
A(2Ch) memmove(dst, src, len) ;Bugged
A(2Dh) memcmp(src1, src2, len) ;Bugged
A(2Eh) memchr(src, scanbyte, len)
A(2Fh) rand()
A(30h) srand(seed)
A(31h) qsort(base, nel, width, callback)
A(32h) strtod(src, src_end) ;Does NOT work - uses (ABSENT) cop1 !!!
A(33h) malloc(size)
A(34h) free(buf)
A(35h) lsearch(key, base, nel, width, callback)
A(36h) bsearch(key, base, nel, width, callback)
A(37h) calloc(sizx, sizy) ;SLOW!
A(38h) realloc(old_buf, new_siz) ;SLOW!
A(39h) InitHeap(addr, size)
A(3Ah) _exit(exitcode)
A(3Bh) or B(3Ch) getchar()
A(3Ch) or B(3Dh) putchar(char)
A(3Dh) or B(3Eh) gets(dst)
A(3Eh) or B(3Fh) puts(src)
A(3Fh) printf(txt, param1, param2, etc.)
A(40h) SystemErrorUnresolvedException()
A(41h) LoadTest(filename, headerbuf)
A(42h) Load(filename, headerbuf)
A(43h) Exec(headerbuf, param1, param2)
A(44h) FlushCache()
A(45h) init_a0_b0_c0_vectors
A(46h) GPU_dw(Xdst, Ydst, Xsiz, Ysiz, src)
A(47h) gpu_send_dma(Xdst, Ydst, Xsiz, Ysiz, src)
A(48h) SendGPICommand(gp1cmd)
A(49h) GPU_cw(gp0cmd) ;send GP0 command word
A(4Ah) GPU_cwp(src, num) ;send GP0 command word and parameter words
A(4Bh) send_gpu_linked_list(src)
A(4Ch) gpu_abort_dma()
A(4Dh) GetGPUStatus()
A(4Eh) gpu_sync()
A(4Fh) SystemError
A(50h) SystemError

```



```

A(51h) LoadExec(filename,stackbase,stackoffset)
A(52h) GetSysSp
A(53h) SystemError ;PS2: set_ioabort_handler(src)
A(54h) or A(71h) _96_init()
A(55h) or A(70h) _bu_init()
A(56h) or A(72h) _96_remove() ;does NOT work due to SysDeqIntRP bug
A(57h) return 0
A(58h) return 0
A(59h) return 0
A(5Ah) return 0
A(5Bh) dev_tty_init() ;PS2: SystemError
A(5Ch) dev_tty_open(fcb,and unused:"path\name",accessmode) ;PS2: SystemError
A(5Dh) dev_tty_in_out(fcb,cmd) ;PS2: SystemError
A(5Eh) dev_tty_ioctl(fcb,cmd,arg) ;PS2: SystemError
A(5Fh) dev_cd_open(fcb,"path\name",accessmode)
A(60h) dev_cd_read(fcb,dst,len)
A(61h) dev_cd_close(fcb)
A(62h) dev_cd_firstfile(fcb,"path\name",dirent)
A(63h) dev_cd_nextfile(fcb,dirent)
A(64h) dev_cd_chdir(fcb,"path")
A(65h) dev_card_open(fcb,"path\name",accessmode)
A(66h) dev_card_read(fcb,dst,len)
A(67h) dev_card_write(fcb,src,len)
A(68h) dev_card_close(fcb)
A(69h) dev_card_firstfile(fcb,"path\name",dirent)
A(6Ah) dev_card_nextfile(fcb,dirent)
A(6Bh) dev_card_erase(fcb,"path\name")
A(6Ch) dev_card_undelete(fcb,"path\name")
A(6Dh) dev_card_format(fcb)
A(6Eh) dev_card_rename(fcb1,"path\name1",fcb2,"path\name2")
A(6Fh) ? ;card ;[r4+18h]=00000000h ;card_clear_error(fcb) or so
A(70h) or A(55h) _bu_init()
A(71h) or A(54h) _96_init()
A(72h) or A(56h) _96_remove() ;does NOT work due to SysDeqIntRP bug
A(73h) return 0
A(74h) return 0
A(75h) return 0
A(76h) return 0
A(77h) return 0
A(78h) CdAsyncSeekL(src)
A(79h) return 0 ;DTL-H: Unknown?
A(7Ah) return 0 ;DTL-H: Unknown?
A(7Bh) return 0 ;DTL-H: Unknown?
A(7Ch) CdAsyncGetStatus(dst)
A(7Dh) return 0 ;DTL-H: Unknown?
A(7Eh) CdAsyncReadSector(count,dst,mode)
A(7Fh) return 0 ;DTL-H: Unknown?
A(80h) return 0 ;DTL-H: Unknown?
A(81h) CdAsyncSetMode(mode)
A(82h) return 0 ;DTL-H: Unknown?
A(83h) return 0 ;DTL-H: Unknown?
A(84h) return 0 ;DTL-H: Unknown?
A(85h) return 0 ;DTL-H: Unknown?, or reportedly, CdStop (?)
A(86h) return 0 ;DTL-H: Unknown?

```

```

A(87h) return 0 ;DTL-H: Unknown?
A(88h) return 0 ;DTL-H: Unknown?
A(89h) return 0 ;DTL-H: Unknown?
A(8Ah) return 0 ;DTL-H: Unknown?
A(8Bh) return 0 ;DTL-H: Unknown?
A(8Ch) return 0 ;DTL-H: Unknown?
A(8Dh) return 0 ;DTL-H: Unknown?
A(8Eh) return 0 ;DTL-H: Unknown?
A(8Fh) return 0 ;DTL-H: Unknown?
A(90h) CdromIoIrqFunc1()
A(91h) CdromDmaIrqFunc1()
A(92h) CdromIoIrqFunc2()
A(93h) CdromDmaIrqFunc2()
A(94h) CdromGetInt5errCode(dst1,dst2)
A(95h) CdInitSubFunc()
A(96h) AddCDROMDevice()
A(97h) AddMemCardDevice() ;DTL-H: SystemError
A(98h) AddDuartTtyDevice() ;DTL-H: AddAdconsTtyDevice ;PS2: SystemError
A(99h) add_nullcon_driver()
A(9Ah) SystemError ;DTL-H: AddMessageWindowDevice
A(9Bh) SystemError ;DTL-H: AddCdromSimDevice
A(9Ch) SetConf(num_EvCB,num_TCB,stacktop)
A(9Dh) GetConf(num_EvCB_dst,num_TCB_dst,stacktop_dst)
A(9Eh) SetCdromIrqAutoAbort(type,flag)
A(9Fh) SetMem(megabytes)

```

Below functions A(A0h..B4h) not supported on pre-retail DTL-H2000 devboard:

```

A(A0h) _boot()
A(A1h) SystemError(type,errorcode)
A(A2h) EnqueueCdIntr() ;with prio=0 (fixed)
A(A3h) DequeueCdIntr() ;does NOT work due to SysDeqIntrP bug
A(A4h) CdGetLbn(filename) ;get 1st sector number (or garbage when not found)
A(A5h) CdReadSector(count,sector,buffer)
A(A6h) CdGetStatus()
A(A7h) bufs_cb_0()
A(A8h) bufs_cb_1()
A(A9h) bufs_cb_2()
A(AAh) bufs_cb_3()
A(ABh) _card_info(port)
A(ACH) _card_load(port)
A(ADh) _card_auto(flag)
A(AEh) bufs_cb_4()
A(AFh) card_write_test(port) ;CEX-1000: jump_to_00000000h
A(B0h) return 0 ;CEX-1000: jump_to_00000000h
A(B1h) return 0 ;CEX-1000: jump_to_00000000h
A(B2h) ioabort_raw(param) ;CEX-1000: jump_to_00000000h
A(B3h) return 0 ;CEX-1000: jump_to_00000000h
A(B4h) GetSystemInfo(index) ;CEX-1000: jump_to_00000000h
A(B5h..BFh) N/A ;jump_to_00000000h

```

B-Functions (Call 00B0h with function number in R9 Register)

```

B(00h) alloc_kernel_memory(size)
B(01h) free_kernel_memory(buf)
B(02h) init_timer(t,reload,flags)
B(03h) get_timer(t)
B(04h) enable_timer_irq(t)
B(05h) disable_timer_irq(t)
B(06h) restart_timer(t)
B(07h) DeliverEvent(class, spec)
B(08h) OpenEvent(class,spec,mode,func)
B(09h) CloseEvent(event)
B(0Ah) WaitEvent(event)
B(0Bh) TestEvent(event)
B(0Ch) EnableEvent(event)
B(0Dh) DisableEvent(event)
B(0Eh) OpenTh(reg_PC,reg_SP_FP,reg_GP)
B(0Fh) CloseTh(handle)
B(10h) ChangeTh(handle)
B(11h) jump_to_00000000h
B(12h) InitPAD2(buf1,siz1,buf2,siz2)
B(13h) StartPAD2()
B(14h) StopPAD2()
B(15h) PAD_init2(type,button_dest,unused,unused)
B(16h) PAD_dr()
B(17h) ReturnFromException()
B(18h) ResetEntryInt()
B(19h) HookEntryInt(addr)
B(1Ah) SystemError ;PS2: return 0
B(1Bh) SystemError ;PS2: return 0
B(1Ch) SystemError ;PS2: return 0
B(1Dh) SystemError ;PS2: return 0
B(1Eh) SystemError ;PS2: return 0
B(1Fh) SystemError ;PS2: return 0
B(20h) UnDeliverEvent(class,spec)
B(21h) SystemError ;PS2: return 0
B(22h) SystemError ;PS2: return 0
B(23h) SystemError ;PS2: return 0
B(24h) jump_to_00000000h
B(25h) jump_to_00000000h
B(26h) jump_to_00000000h
B(27h) jump_to_00000000h
B(28h) jump_to_00000000h
B(29h) jump_to_00000000h
B(2Ah) SystemError ;PS2: return 0
B(2Bh) SystemError ;PS2: return 0
B(2Ch) jump_to_00000000h
B(2Dh) jump_to_00000000h
B(2Eh) jump_to_00000000h
B(2Fh) jump_to_00000000h
B(30h) jump_to_00000000h
B(31h) jump_to_00000000h
B(32h) or A(00h) open(filename,accessmode)

```

```

B(33h) or A(01h) lseek(fd,offset,seektype)
B(34h) or A(02h) read(fd,dst,length)
B(35h) or A(03h) write(fd,src,length)
B(36h) or A(04h) close(fd)
B(37h) or A(05h) ioctl(fd,cmd,arg)
B(38h) or A(06h) exit(exitcode)
B(39h) or A(07h) isatty(fd)
B(3Ah) or A(08h) getc(fd)
B(3Bh) or A(09h) putc(char,fd)
B(3Ch) or A(3Bh) getchar()
B(3Dh) or A(3Ch) putchar(char)
B(3Eh) or A(3Dh) gets(dst)
B(3Fh) or A(3Eh) puts(src)
B(40h) cd(name)
B(41h) format(devicename)
B(42h) firstfile2(filename,dirent)
B(43h) nextfile(dirent)
B(44h) rename(old_filename,new_filename)
B(45h) erase(filename)
B(46h) undelete(filename)
B(47h) AddDrv(device_info) ;subfunction for AddXxxDevice functions
B(48h) DelDrv(device_name_lowercase)
B(49h) PrintInstalledDevices()

```

Below functions B(4Ah..5Dh) not supported on pre-retail DTL-H2000 devboard:

```

B(4Ah) InitCARD2(pad_enable) ;uses/destroys k0/k1 !!!
B(4Bh) StartCARD2()
B(4Ch) StopCARD2()
B(4Dh) _card_info_subfunc(port) ;subfunction for "_card_info"
B(4Eh) _card_write(port,sector,src)
B(4Fh) _card_read(port,sector,dst)
B(50h) _new_card()
B(51h) Krom2RawAdd(shiftjis_code)
B(52h) SystemError ;PS2: return 0
B(53h) Krom2Offset(shiftjis_code)
B(54h) _get_errno()
B(55h) _get_error(fd)
B(56h) GetC0Table
B(57h) GetB0Table
B(58h) _card_chan()
B(59h) testdevice(devicename)
B(5Ah) SystemError ;PS2: return 0
B(5Bh) ChangeClearPAD(int)
B(5Ch) _card_status(slot)
B(5Dh) _card_wait(slot)
B(5Eh..FFh) N/A ;jump_to_00000000h ;CEX-1000: B(5Eh..F6h) only
B(100h....) N/A ;garbage ;CEX-1000: B(F7h.....) and up

```

C-Functions (Call 00C0h with function number in R9 Register)

```

C(00h) EnqueueTimerAndVblankIrqs(priority) ;used with prio=1
C(01h) EnqueueSyscallHandler(priority) ;used with prio=0
C(02h) SysEnqIntRP(priority,struct) ;bugged, use with care
C(03h) SysDeqIntRP(priority,struct) ;bugged, use with care
C(04h) get_free_EvCB_slot()
C(05h) get_free_TCB_slot()
C(06h) ExceptionHandler()
C(07h) InstallExceptionHandler() ;destroys/uses k0/k1
C(08h) SysInitMemory(addr,size)
C(09h) SysInitKernelVariables()
C(0Ah) ChangeClearRCnt(t,flag)
C(0Bh) SystemError ;PS2: return 0
C(0Ch) InitDefInt(priority) ;used with prio=3
C(0Dh) SetIrqAutoAck(irq,flag)
C(0Eh) return 0 ;DTL-H2000: dev_sio_init
C(0Fh) return 0 ;DTL-H2000: dev_sio_open
C(10h) return 0 ;DTL-H2000: dev_sio_in_out
C(11h) return 0 ;DTL-H2000: dev_sio_ioctl
C(12h) InstallDevices(ttyflag)
C(13h) FlushStdInOutPut()
C(14h) return 0 ;DTL-H2000: SystemError
C(15h) _cdevinput(circ,char)
C(16h) _cdevscan()
C(17h) _circgetc(circ) ;uses r5 as garbage txt for _ioabort
C(18h) _circputc(char,circ)
C(19h) _ioabort(txt1,txt2)
C(1Ah) set_card_find_mode(mode) ;0=normal, 1=find deleted files
C(1Bh) KernelRedirect(ttyflag) ;PS2: ttyflag=1 causes SystemError
C(1Ch) AdjustA0Table()
C(1Dh) get_card_find_mode()
C(1Eh..7Fh) N/A ;jump_to_00000000h
C(80h.....) N/A ;mirrors to B(00h.....)

```

SYS-Functions (Syscall opcode with function number in R4 aka A0 Register)

```

SYS(00h) NoFunction()
SYS(01h) EnterCriticalSection()
SYS(02h) ExitCriticalSection()
SYS(03h) ChangeThreadSubFunction(addr) ;syscall with r4=03h, r5=addr
SYS(04h..FFFFFFFh) calls DeliverEvent(F0000010h,4000h)

```

The 20bit immediate in the "syscall imm" opcode is unused (should be zero).

BREAK-Functions (Break opcode with function number in opcode's immediate)

BRK opcodes may be used within devkits, however, the standard BIOS simply calls DeliverEvent(F0000010h,1000h) and SystemError_A_40h upon any BRK opcodes (as well as on any other unresolved exceptions).

```
BRK(1C00h) Division by zero (commonly checked/invoked by software)
BRK(1800h) Division overflow (-80000000h/-1, sometimes checked by software)
```

Below breaks are used in DTL-H2000 BIOS:

```
BRK(1h) Whatever lockup or so?
BRK(101h) PCInit() Inits the fileserver.
BRK(102h) PCCreat(filename, fileattributes)
BRK(103h) PCOpen(filename, accessmode)
BRK(104h) PCClose(filehandle)
BRK(105h) PCRead(filehandle, length, memory_destination_address)
BRK(106h) PCWrite(filehandle, length, memory_source_address)
BRK(107h) PClSeek(filehandle, file_offset, seekmode)
BRK(3C400h) User has typed "break" command in debug console
```

The break functions have argument(s) in A1,A2,A3 (ie. unlike normal BIOS functions not in A0,A1,A2), and TWO return values (in R2, and R3). These functions require a commercial/homebrew devkit... consisting of a Data Cable (for accessing the PC's harddisk)... and an Expansion ROM (for handling the BREAK opcodes)... or so?

21.4 BIOS File Functions

A(00h) or B(32h) - open(filename, accessmode) - Opens a file for IO

```
out: V0 File handle (00h..0Fh), or -1 if error.
```

Opens a file on the target device for io. Accessmode is set like this:

```
bit0      1=Read ;\These bits aren't actually used by the BIOS, however, at
bit1      1=Write ;/least 1 should be set; won't work when all 32bits are zero
bit2      1=Exit without waiting for incoming data (when TTY buffer empty)
bit9      0=Open Existing File, 1=Create New file (memory card only)
bit15     1=Asynchronous mode (memory card only; don't wait for completion)
bit16-31  Number of memory card blocks for a new file on the memory card
```

The PSX can have a maximum of 16 files open at any time, of which, 2 handles are always reserved for std_io, so only 14 handles are available for actual files. Some functions (cd, testdevice, erase, undelete, format, firstfile2, rename) are temporarily allocating 1 filehandle (rename tries to use 2 filehandles, but, it does accidentally use only 1 handle, too). So, for example, erase would fail if more than 13 file handles are opened by the game.

A(01h) or B(33h) - lseek(fd, offset, seektype) - Move the file pointer

```
seektype 0 = from start of file          (with positive offset)
          1 = from current file pointer (with positive/negative offset)
          2 = Bugs. Should be from end of file.
```

Moves the file pointer the number of bytes in A1, relative to the location specified by A2. Movement from the eof is incorrect. Also, movement beyond the end of the file is not checked.

A(02h) or B(34h) - read(fd, dst, length) - Read data from an open file

```
out: V0  Number of bytes actually read, -1 if failed.
```

Reads the number of bytes from the specified open file. If length is not specified an error is returned. Read per \$0080 bytes from memory card (bu:) and per \$0800 from cdrom (cdrom:).

A(03h) or B(35h) - write(fd, src, length) - Write data to an open file

```
out: V0  Number of bytes written.
```

Writes the number of bytes to the specified open file. Write to the memory card per \$0080 bytes. Writing to the cdrom returns 0.

A(04h) or B(36h) - close(fd) - Close an open file

Returns r2=fd (or r2=-1 if failed).

A(08h) or B(3Ah) - getc(fd) - read one byte from file

```
out: R2=character (sign-expanded) or FFFFFFFFh=error
```

Internally redirects to "read(fd,tempbuf,1)". For some strange reason, the returned character is sign-expanded; so, a return value of FFFFFFFFh could mean either character FFh, or error.

A(09h) or B(3Bh) - putc(char,fd) - write one byte to file

Observe that "fd" is the 2nd paramter (not the 1st paramter as usually).

```
out:  R2=Number of bytes actually written, -1 if failed
```

Internally redirects to "write(fd,tempbuf,1)".

B(40h) - cd(name) - Change the current directory on target device

Changes the current directory on the specified device, which should be "cdrom:" (memory cards don't support directories). The PSX supports only a current directory, but NOT a current device (ie. after cd, the directory name may be omitted from filenames, but the device name must be still included in all filenames).

```
in:  A0  Pointer to new directory path (eg. "cdrom:\path")
```

Returns 1=okay, or 0=failed.

The function doesn't verify if the directory exists. Caution: For cdrom, the function does always load the path table from the disk (even if it was already stored in RAM, so cd is causing useless SLOW read/seek delays).

B(42h) - firstfile2(filename,direntry) - Find first file to match the name

Returns r2=direntry (or r2=0 if no matching files).

Searches for the first file to match the specified filename; the filename may contain "?" and "*" wildcards. "*" means to ignore ALL following characters; accordingly one cannot specify any further characters after the "*" (eg. "DATA*" would work, but "*.DAT" won't work). "?" is meant to ignore a single character cell. Note: The "?" wildcards (but not "*") can be used also in all other file functions; causing the function to use the first matching name (eg. erase "?????" would erase the first matching file, not all matching files).

Start the name with the device you want to address. (ie. pcdrv:) Different drives can be accessed as normally by their drive names (a:, c:, huh?) if path is omitted after the device, the current directory will be used.

A direntry structure looks like this:

```
00h 14h Filename, terminated with 00h
14h 4   File attribute (always 0 for cdrom) (50h=norm or A0h=del for card)
18h 4   File size
1Ch 4   Pointer to next direntry? (not used?)
20h 4   First Sector Number
24h 4   Reserved (not used)
```


BUG: If "?" matches the ending 00h byte of a name, then any further characters in the search expression are ignored (eg. "FILE?.DAT" would match to "FILE2.DAT", but accidentally also to "FILE").

BUG: For CDROM, the BIOS includes some code that is intended to realize disk changes during firstfile2/nextfile operations, however, that code is so bugged that it does rather ensure that the BIOS does NOT realize new disks being inserted during firstfile2/nextfile.

BUG: firstfile2/nextfile is internally using a FCB. On the first call to firstfile2, the BIOS is searching a free FCB, and does apply that as "search fcb", but it doesn't mark that FCB as allocated, so other file functions may accidentally use the same FCB. Moreover, the BIOS does memorize that "search fcb", and, even when starting a new search via another call to firstfile2, it keeps using that FCB for search (without checking if the FCB is still free). A possible workaround is not to have any files opened during firstfile2/nextfile operations.

B(43h) - nextfile(direntry) - Searches for the next file to match the name

Returns r2=direntry (or r2=0 if no more matching files).

Uses the settings of a previous firstfile2/nextfile command.

B(44h) - rename(old_filename, new_filename)

Returns 1=okay, or 0=failed.

B(45h) - erase(filename) - Delete a file on target device

Returns 1=okay, or 0=failed.

B(46h) - undelete(filename)

Returns 1=okay, or 0=failed.

B(41h) - format(devicename)

Erases all files on the device (ie. for formatting memory cards).

Returns 1=okay, or 0=failed.

B(54h) - _get_errno()

Indicates the reason of the most recent file function error (open, lseek, read, write, close, _get_error, ioctl, cd, testdevice, erase, undelete, format, rename). Use _get_errno() ONLY if an error has occurred (the error code isn't reset to zero by functions

that are passing okay). firstfile2/nextfile do NOT affect `_get_errno()`. See below list of File Error Numbers for more info.

B(55h) - `_get_error(fd)`

Basically same as B(54h), but allowing to specify a file handle for which error information is to be received; accordingly it doesn't work for functions that do use 'hidden' internal file handles (eg. erase, or unsuccessful open). Returns FCB[18h], or FFFFFFFFh if the handle is invalid/unused.

A(05h) or B(37h) - `ioctl(fd,cmd,arg)`

Used only for TTY.

A(07h) or B(39h) - `isatty(fd)`

Returns bit1 of the file's DCB flags. That bit is set only for Duart/tty, and is cleared for Dummy/tty, Memory Card, and CDROM.

B(59h) - `testdevice(devicename)`

Whatever. Checks the devicename, and if it's accepted, calls a device specific function. For the existing devices (cdrom,bu,ty) that specific function simply returns without doing anything. Maybe other devices (like printers or modems) would do something more interesting.

File Error Numbers for B(54h) and B(55h)

```
00h okay (though many successful functions leave old error code unchanged)
02h file not found
06h bad device port number (tty2 and up)
09h invalid or unused file handle
10h general error (physical I/O error, unformatted, disk changed for old fcb)
11h file already exists error (create/undelete/rename)
12h tried to rename a file from one device to another device
13h unknown device name
16h sector alignment error, or fpos>=filesize, unknown seektype or ioctl cmd
18h not enough free file handles
1Ch not enough free memory card blocks
FFFFFFFh invalid or unused file handle passed to B(55h) function
```

21.5 BIOS File Execute and Flush Cache

A(41h) - LoadTest(filename, headerbuf)

Loads the 800h-byte exe file header to an internal sector buffer, and does then copy bytes [10h..4Bh] of that header to headerbuf[00h..3Bh].

A(42h) - Load(filename, headerbuf)

Same as LoadTest (see there for details), but additionally loads the body of the executable (using the size and destination address in the file header), and does call FlushCache. The exe can be then started via Exec (this isn't done automatically by LoadTest). Unlike "LoadExec", the "LoadTest/Exec" combination allows to return the new exe file to return to the old exe file (instead of restarting the boot executable).

BUG: Uses the unstable FlushCache function (see there for details).

A(43h) - Exec(headerbuf, param1, param2)

Can be used to start a previously loaded executable. The function saves R16,R28,R30,SP,RA in the reserved region of headerbuf (rather than on stack), more or less slowly zerofills the memfill region specified in headerbuf, reads the stack base and offset values and sets SP and FP to base+offset (or leaves them unchanged if base=0), reads the GP value from headerbuf and sets GP to that value. Then calls the executables entrypoint, with param1 and param2 passed in r4,r5.

If the executable (should) return, then R16,R28,R30,SP,RA are restored from headerbuf, and the function returns with r2=1.

A(51h) - LoadExec(filename, stackbase, stackoffset)

This is a rather bizarre function. In short, it does load and execute the specified file, and thereafter, it (tries to) reload and restart to boot executable.

Part1: Takes a copy of the filename, with some adjustments: Everything up to the first ":" or 00h byte is copied as is (ie. the device name, if it does exist, or otherwise the whole path\filename.ext;ver), the remaining characters are copied and converted to uppercase (ie. the path\filename.ext;ver part, or none if the device name didn't exist), finally, checks if a ";" exists (ie. the version suffix), if there's none, then it appends ";1" as default version. CAUTION: The BIOS allocates ONLY 28 bytes on stack for the copy of the filename, that region is followed by 4 unused bytes, so the maximum length would be 32 bytes (31 characters plus EOL) (eg. "device:\pathname\filename.ext;1",00h).

Part2: Enables IRQs via ExitCriticalSection, memorizes the stack base/offset values from the previously loaded executable (which should have been the boot executable, unless LoadExec should have been used in nested fashion), does then use LoadTest to load the desired file, replaces the stack base/offset values in its headerbuf by the LoadExec parameter values, and does then execute it via Exec(headerbuf,1,0).

Part3: If the exe file returns, or if it couldn't be loaded, then the boot file is (unsuccessfully) attempted to be reloaded: Enables IRQs via ExitCriticalSection, loads the boot file via LoadTest, replaces the stack base/offset values in its headerbuf by the values memorized in Part2 (which \<should> be the boot executable's values from SYSTEM.CNF, unless the nesting stuff occurred), and does then execute the boot file via Exec(headerbuf,1,0).

Part4: If the boot file returns, or if it couldn't be loaded, then the function looks up in a "JMP \$" endless loop (normally, returning from the boot exe causes SystemError("B", 38Ch), however, after using LoadExec, this functionality is replaced by the "JMP \$" lockup.

BUG: Uses the unstable FlushCache function (see there for details).

BUG: Part3 accidentally treats the first 4 characters of the exename as memory address (causing an invalid memory address exception on address 6F726463h, for "cdrom:filename.exe").

A(9Ch) - SetConf(num_EvCB, num_TCB, stacktop)

Changes the number of EvCBs and TCBs, and the stacktop. These values are usually initialized from the settings in the SYSTEM.CNF file, so using this function usually shouldn't ever be required.

The function deallocates all old ExCBs, EvCBs, TCBs (so all Exception handlers, Events, and Threads (except the current one) are lost, and all other memory that may have been allocated via alloc_kernel_memory(size) is deallocated, too. It does then allocate the new control blocks, and enqueue the default handlers. Despite of the changed stacktop, the current stack pointer is kept intact, and the function returns to the caller.

A(9Dh) - GetConf(num_EvCB_dst, num_TCB_dst, stacktop_dst)

Returns the number of EvCBs, TCBs, and the initial stacktop. There's no return value in the R2 register, instead, the three 32bit return values are stored at the specified "dst" addresses.

A(44h) - FlushCache()

Flushes the Code Cache, so opcodes are ensured to be loaded from RAM. This is required when loading program code via DMA (ie. from CDROM) (the cache controller apparently doesn't realize changes to RAM that are caused by DMA). The LoadTest and LoadExec functions are automatically calling FlushCache (so FlushCache is required only when loading program code via "read" or via "CdReadSector").

FlushCache may be also required when relocating or modifying program code by software (the cache controller doesn't seem to realize modifications to memory mirrors, eg. patching the exception handler at 80000080h seems to be work without FlushCache, but patching the same bytes at 00000080h doesn't).

Note: The PSX doesn't have a Data Cache (or actually, it has, but it's misused as Fast RAM, mapped to a fixed memory region, and which isn't accessible by DMA), so FlushCache isn't required for regions that contain data.

BUG: The FlushCache function contains a handful of opcodes that do use the k0 register without having IRQs disabled at that time, if an IRQ occurs during those opcodes, then the k0 value gets destroyed by the exception handler, causing FlushCache to get trapped in an endless loop.

One workaround would be to disable all IRQs before calling FlushCache, however, the BIOS does internally call the function without IRQs disabled, that applies to:

```
load_file   A(42h)
load_exec   A(51h)
add_device  B(47h) (and all "add_xxx_device" functions)
init_card   B(4Ah)
and by intro/boot code
```

for load_file/load_exec, IRQ2 (cdrom) and IRQ3 (dma) need to be enabled, so the "disable all IRQs" workaround cannot be used for that functions, however, one can/should disable as many IRQs as possible, ie. everything except IRQ2/IRQ3, and all DMA interrupts except DMA3 (cdrom).

Executable Memory Allocation

LoadTest and LoadExec are simply loading the file to the address specified in the exe file header. There's absolutely no verification whether that memory is (or isn't) allocated via malloc, or if it is used by the boot executable, or by the kernel, or if it does contain RAM at all.

When using the "malloc" function combined with loading exe files, it may be

recommended not to pass all memory to InitHeap (ie. to keep a memory region being reserved for loading executables).

Note

For more info about EXE files and their headers, see [CDROM File Formats](#)

21.6 BIOS CDROM Functions

General File Functions

CDROMs are basically accessed via normal file functions, with device name "cdrom:" (which is an abbreviation for "cdrom0:", anyways, the port number is ignored).

[BIOS File Functions](#)

[BIOS File Execute and Flush Cache](#)

Before starting the boot executable, the BIOS automatically calls `_96_init()`, so the game doesn't need to do any initializations before using CDROM file functions.

Absent CD-Audio Support

The Kernel doesn't include any functions for playing Audio tracks. Also, there's no BIOS function for setting the XA-ADPCM file/channel filter values. So CD Audio can be used only by directly programming the CDROM I/O ports.

Asynchronous CDROM Access

The normal File functions are always using synchroneous access for CDROM (ie. the functions do wait until all data is transferred) (unlike as for memory cards, `accessmode.bit15` cannot be used to activate asynchronous cdrom access).

However, one can read files in asynchroneous fashion via `CdGetLbn`, `CdAsyncSeekL`, and `CdAsyncReadSector`. CDROM files are non-fragmented, so they can be read simply from incrementing sector numbers.

A(A4h) - `CdGetLbn(filename)`

Returns the first sector number used by the file, or -1 in case of error.

BUG: The function accidently returns -1 for the first file in the directory (the first file should be a dummy entry for the current or parent directory or so, so that bug isn't

much of a problem), if the file is not found, then the function accidentally returns garbage (rather than -1).

A(A5h) - CdReadSector(count,sector,buffer)

Reads \<count> sectors, starting at \<sector>, and writes data to \<buffer>. The read is done in mode=80h (double speed, 800h-bytes per sector). The function waits until all sectors are transferred, and does then return the number of sectors (ie. count), or -1 in case of error.

A(A6h) - CdGetStatus()

Retrieves the cdrom status via CdAsyncGetStatus(dst) (see there for details; especially for cautions on door-open flag). The function waits until the event indicates completion, and does then return the status byte (or -1 in case of error).

A(78h) - CdAsyncSeekL(src)

Issues Setloc and SeekL commands. The parameter (src) is a pointer to a 3-byte sector number (MM,SS,FF) (in BCD format).

The function returns 0=failed, or 1=okay. Completion is indicated by events (class=F0000003h, and spec=20h, or 8000h).

A(7Ch) - CdAsyncGetStatus(dst)

Issues a GetStat command. The parameter (dst) is a pointer to a 1-byte location that receives the status response byte.

The function returns 0=failed, or 1=okay. Completion is indicated by events (class=F0000003h, and spec=20h, or 8000h).

Caution: The command acknowledges the door-open flag, but doesn't automatically reload the path table (which is required if a new disk is inserted); if the door-open flag was set, one should call a function that does forcefully load the path table (like cd).

A(7Eh) - CdAsyncReadSector(count,dst,mode)

Issues SetMode and ReadN (when mode.bit8=0), or ReadS (when mode.bit8=1) commands. count is the number of sectors to be read, dst is the destination address in RAM, mode.bit0-7 are passed as parameter to the SetMode command, mode.bit8 is the ReadN/ReadS flag (as described above). The sector size (for DMA) depends on the mode value: 918h-bytes (bit4=1, bit5=X), 924h-bytes (bit4=0, bit5=1), or 800h-bytes

(bit4,5=0).

Before CdAsyncReadSector, the sector number should be set via CdAsyncSeekL(src). The function returns 0=failed, or 1=okay. Completion is indicated by events (class=F0000003h, and spec=20h, 80h, or 8000h).

A(81h) - CdAsyncSetMode(mode)

Similar to CdAsyncReadSector (see there for details), but issues only the SetMode command, without any following ReadN/ReadS command.

A(94h) - CdromGetInt5errCode(dst1,dst2)

Returns the first two response bytes from the most recent INT5 error: [dst1]=status, [dst2]=errorcode. The BIOS doesn't reset these values in case of successful completion, so the values are quite useless.

A(54h) or A(71h) - _96_init()

A(56h) or A(72h) - _96_remove() ;does NOT work due to SysDeqIntRP bug

A(90h) - CdromlIrqFunc1()

A(91h) - CdromDmalrFunc1()

A(92h) - CdromlIrqFunc2()

A(93h) - CdromDmalrFunc2()

A(95h) - CdInitSubFunc() ;subfunction for _96_init()

A(9Eh) - SetCdromIrqAutoAbort(type,flag)

A(A2h) - EnqueueCdIntr() ;with prio=0 (fixed)

A(A3h) - DequeueCdIntr() ;does NOT work due to SysDeqIntRP bug

Internally used CDROM functions for initialization and IRQ handling.

21.7 BIOS Memory Card Functions

General File Functions

Memory Cards aka Backup Units (bu) are basically accessed via normal file functions, with device names "bu00:" (Slot 1) and "bu10:" (Slot 2),

BIOS File Functions

Before using the file functions for memory cards, first call InitCARD2(pad_enable), then StartCARD2(), and then _bu_init().

File Header, Filesize, and Sector Alignment

The first 100h..200h bytes (2..4 sectors) of the file must contain the title and icon bitmap(s). For details, see:

Memory Card Data Format

The filesize must be a multiple of 2000h bytes (one block), the maximum size would be 1E000h bytes (when using all 15 blocks on the memory card). The filesize must be specified when creating the file (ie. accessmode bit9=1, and bit16-31=number of blocks). Once when the file is created, the BIOS does NOT allow to change the filesize (unless by deleting and re-creating the file).

When reading/writing files, the amount of data must be a multiple of 80h bytes (one sector), and the file position must be aligned to a 80h-byte boundary, too. There's no restriction on fragmented files (ie. one may cross 2000h-byte block boundaries within the file).

Poor Memcard Performance

PSX memory card accesses are typically super-slow. That, not so much because the hardware would be slow, but rather because of improper inefficient code at the BIOS side. The original BIOS tries to synchronize memory card accesses with joypad accesses simply by accessing only one sector per frame (although it could access circa two sectors). To the worst, the BIOS accesses Slot 1 only on each second frame, and Slot 2 only each other frame (although in 99% of all cases only one slot is accessed at once, so the access time drops to 0.5 sectors per frame).

Moreover, the memory card id, directory, and broken sector list do occupy 26 sectors (although the whole information would fit into 4 or 5 sectors) (a workaround would be to read only the first some bytes, and to skip the additional unused bytes - though that'd also mean to skip the checksums which are unfortunately stored at the end of the sector).

And, anytime when opening a file (in synchronous mode), the BIOS does additionally read sector 0 (which is totally useless, and gets especially slow when opening a bunch of files; eg. when extracting the title/icon from all available files on the card).

Asynchronous Access

The BIOS supports synchronous and asynchronous memory card access. Synchronous means that the BIOS function doesn't return until the access has completed (which means, due to the poor performance, that the function spends about 75% of the time on inactivity) (except in nocash PSX bios, which has better performance), whilst asynchronous access means that the BIOS function returns immediately after invoking the access (which does then continue on interrupt level, and does return an event when finished).

The file "read" and "write" functions act asynchronous when accessmode bit15 is set when opening the file. Additionally, the A(ACh) `_card_load(port)` function can be used to tell the BIOS to load the directory entries and broken sector list to its internal RAM buffers (eg. during the games title screen, so the BIOS doesn't need to load that data once when the game enters its memory card menu). All other functions like erase or format always act synchronous. The open/findfirst/findnext functions do normally complete immediately without accessing the card at all (unless the directory wasn't yet read; in that case the directory is loading in synchronous fashion).

Unfortunately, the asynchronous response doesn't rely on a single callback event, but rather on a bunch of different events which must be all allocated and tested by the game (and of which, one event is delivered on completion) (which one depends on whether function completed okay, or if an error occurred).

Multitap Support (and Multitap Problems)

The BIOS does have some partial support for accessing more than two memory cards (via Multitap adaptors). Device/port names "bu01:", "bu02:", "bu03:" allow to access extra memory carts in slot1 (and "bu11:", "bu12:", "bu13:" in slot2). Namely, those names will send values 82h, 83h, 84h to the memory card slot (instead of the normal 81h value).

However, the BIOS `directory_buffer` and `broken_sector_list` do support only two memory cards (one in slot1 and one in slot2). So, trying to access more memory cards may cause great data corruption (though there might be a way to get the BIOS to reload those buffers before accessing a different memory card).

Aside from that problem, the BIOS functions are very-very-very slow even when

accessing only two memory cards. Trying to use the BIOS to access up to eight memory cards would be very-extremly-very slow, which would be more annoying than useful.

B(4Ah) - InitCARD2(pad_enable) ;uses/destroys k0/k1 !!!

B(4Bh) - StartCARD2()

B(4Ch) - StopCARD2()

A(55h) or A(70h) - _bu_init()

--- Below are some lower level memory card functions ---

A(ABh) - _card_info(port)

B(4Dh) - _card_info_subfunc(port) ;subfunction for "_card_info"

Can be used to check if the most recent call to _card_write has completed okay. Issues an incomplete dummy read command (similar to B(4Fh) - _card_read). The read command is aborted once when receiving the status byte from the memory card (the actual data transfer is skipped).

A(AFh) - card_write_test(port) ;not supported by old CEX-1000 version

Resets the card changed flag. For some strange reason, this flag isn't automatically reset after reading the flag, instead, the flag is reset upon sector writes. To do that, this function issues a dummy write to sector 3Fh.

B(50h) - _new_card()

Normally any memory card read/write functions fail if the BIOS senses the card change flag to be set. Calling this function tells the BIOS to ignore the card change flag on the next read/write operation (the function is internally used when loading the "MC" ID from sector 0, and when calling the card_write_test function to acknowledge the card change flag).

B(4Eh) - _card_write(port,sector,src)**B(4Fh) - _card_read(port,sector,dst)**

Invokes asynchronous reading/writing of a single sector. The function returns 1=okay, or 0=failed (on invalid sector numbers). The actual I/O is done on IRQ level, completion of the I/O command transmission can be checked, among others, via get/wait_card_status(slot) functions (with slot=port/10h).

In case of the write function, completion of the \<transmission> does NOT mean that the actual \<writing> has completed, instead, write errors are indicated upon completion of the \<next sector> read/write transmission (or, if there are no further sectors to be accessed; one can use _card_info to verify completion of the last written sector).

The sector number should be in range of 0..3FFh, for some strange reason, probably a BUG, the function also accepts sector 400h. The specified sector number is directly accessed (it is NOT parsed through the broken sector replacement list).

B(5Ch) - _card_status(slot)**B(5Dh) - _card_wait(slot)**

Returns the status of the most recent I/O command, possible values are:

```
01h=ready
02h=busy/read
04h=busy/write
08h=busy/info
11h=failed/timeout (eg. when no cartridge inserted)
21h=failed/general error
```

_card_status returns immediately, _card_wait waits until a non-busy state occurs.

A(A7h) - bufs_cb_0()**A(A8h) - bufs_cb_1()****A(A9h) - bufs_cb_2()****A(AAh) - bufs_cb_3()****A(AEh) - bufs_cb_4()**

These five callback functions are internally used by the BIOS, notifying other BIOS functions about (un-)successful completion of memory card I/O commands.

B(58h) - _card_chan()

This is a subfunction for the five bufs_cb__xxx functions (indicating whether the callback occurred for a slot1 or slot2 access).

A(ACh) - _card_load(port)

Invokes asynchronous reading of the memory card directory. The function isn't too useful because the BIOS tends to read the directory automatically in various places in synchronous mode, so there isn't too much chance to replace the automatic synchronous reading by asynchronous reading.

A(ADh) - _card_auto(flag)

Can be used to enable/disable auto format (0=off, 1=on). The _bu_init function initializes auto format as disabled. If auto format is enabled, then the BIOS does automatically format memory cards if it has failed to read the "MC" ID bytes on sector 0. Although potentially useful, activating this feature is rather destructive (for example, read errors on sector 0 might occur accidentally due to improperly inserted cards with dirty contacts, so it'd be better to prompt the user whether or not to format the card, rather than doing that automatically).

C(1Ah) - set_card_find_mode(mode)**C(1Dh) - get_card_find_mode()**

Allows to get/set the card find mode (0=normal, 1=find deleted files), the mode setting affects only the firstfile2/nextfile functions. All other file functions are used fixed mode settings (always mode=0 for open, rename, erase, and mode=1 for undelete).

21.8 BIOS Interrupt/Exception Handling

The Playstation's Kernel uses an incredible inefficient and unstable exception handler; which may have been believed to be very powerful and flexible.

Inefficiency

For a maximum of slowness, it does always save and restore all CPU registers (including such that aren't used in the exception handler). It does then go through a list of installed interrupt handlers - and executes ALL of them. For example, a Timer0 IRQ is first passed to the Cdrom and Vblank handlers (which must reject it, no thanks), before it does eventually reach the Timer0 handler.

Unstable IRQ Handling

A fundamental mistake in the exception handler is that it doesn't memorize the incoming IRQ flags. So the various interrupt handlers must check Port 1F801070h one after each other. That means, if a high priority handler has rejected IRQ processing (because the desired IRQ flag wasn't set at that time), then a lower priority handler may process it (assuming that the IRQ flag got set in the meantime), and, in worst case it may even acknowledge it (so the high priority handler does never receive it).

To avoid such problems, there should be only ONE handler installed for each IRQ source. However, that isn't always possible because the Kernel automatically installs some predefined handlers. Most noteworthy, the totally bugged DefaultInterruptHandlers is always installed (and cannot be removed), so it does randomly trigger Events. Fortunately, it does not acknowledge the IRQs (unless SetIrqAutoAck was used to enable that fatal behaviour).

B(18h) - ResetEntryInt()

Applies the default "Exit" structure (which consists of a pointer to ReturnFromException, and the Kernel's exception stacktop (minus 4, for whatever reason), and zeroes for the R16..R23,R28,R30 registers. Returns the address of that structure.

See HookEntryInt for details.

B(19h) - HookEntryInt(addr)

addr points to a structure (with same format as for the setjmp function):

```

00h 4    r31/ra,pc ;usually ptr to ReturnFromException function
04h 4    r28/sp    ;usually exception stacktop, minus 4, for whatever reason
08h 4    r30/fp    ;usually 0
0Ch 4x8  r16..r23 ;usually 0
2Ch 4    r28/gp    ;usually 0

```

The hook function is executed only if the ExceptionHandler has been fully executed (after processing an IRQ, many interrupt handlers are calling ReturnFromException to abort further exception handling, and thus do skip the hook function). Once when the hook function has finished, it should execute ReturnFromException. The hook function is called with r2=1 (that is important if the hook address was recorded with setjmp, where it "returns" to the setjmp caller, with r2 as "return value").

Priority Chains

The Kernel's exception handler has four priority chains, each may contain one or more Interrupt or Exception handlers. The default handlers are:

```

Prio Chain Content
0    CdromDmaIrq, CdromIoIrq, SyscallException
1    CardSpecificIrq, VblankIrq, Timer2Irq, Timer1Irq, Timer0Irq
2    PadCardIrq
3    DefInt

```

The exception handler calls all handlers, starting with the first element in the priority 0 chain (ie. usually CdromDmaIrq). The separate handlers must check if they want to process the IRQ (eg. CdromDmaIrq would process only CDROM DMA IRQs, but not joystick IRQs or so). If it has processed and acknowledged the IRQ, then the handler may execute ReturnFromException, which causes the handlers of lower priority to be skipped (if there are still other unacknowledge IRQs pending, then the hardware will re-enter the exception handler as soon as the RFE opcode in ReturnFromException does re-enable interrupts).

C(02h) - SysEnqIntRP(priority,struct) ;bugged, use with care

Inserts a new element in the specified priority chain. The new element is inserted at the begin of the chain, so (within that priority chain) the new element has highest priority.

```

00h 4  pointer to next element      (0=none)  ;this pointer is inserted by BIOS
04h 4  pointer to SECOND function (0=none)  ;executed if func1 returns r2<>0
08h 4  pointer to FIRST  function (0=none)  ;executed first
0Ch 4  Not used (usually zero)

```

BUG: SysDeqIntRP can remove only the first element in the chain (see there for details), so adding new chain elements may cause OTHER functions to be unable to remove their chain elements. The BIOS seems to be occasionally adding/removing the "CardSpecificIrq" and "PadCardIrq" (with priority 1 and 2), so using that priorities may cause the BIOS to be unable to remove that IRQ handlers. Using priority 0 and 3 should work (as long as the software takes care to remove only the newest elements) (but there should be no conflicts with the BIOS which does never remove priority 0 and 3 elements) (leaving apart that DequeueCdIntr and _96_remove try to remove priority 0 elements, but that functions won't work anyways; due to the same bug).

C(03h) - SysDeqIntRP(priority,struct) ;bugged, use with care

Removes the specified element from the specified priority chain.

BUG: The function tries to search the whole chain (and to remove the element if it finds it). However, it does only check the first element properly, and, thereafter it reads a garbage value from an uninitialized stack location, and acts more or less unpredictable. So, it can remove only the first element in the chain, ie. it should be called only if you are SURE that there's no newer element in the chain, and only if you are SURE that the element IS in the chain.

SYS(01h) - EnterCriticalSection() ;syscall with r4=01h

Disables interrupts by clearing SR (cop0r12) Bit 2 and 10 (of which, Bit2 gets copied to Bit0 once when returning from the syscall exception). Returns 1 if both bits were set, returns 0 if one or both of the bits were already zero.

SYS(02h) - ExitCriticalSection() ;syscall with r4=02h

Enables interrupts by set SR (cop0r12) Bit 2 and 10 (of which, Bit2 gets copied to Bit0 once when returning from the syscall exception). There's no return value (all registers except SR and K0 are unchanged).

C(0Dh) - SetIrqAutoAck(irq,flag)

Specifies if the DefaultInterruptHandler shall automatically acknowledge IRQs. The "irq" paramter is the number of the interrupt, ie. 00h..0Ah = IRQ0..IRQ10. The "flag" value should be 0 to disable AutoAck, or non-zero to enable AutoAck. By default, AutoAck is disabled for all IRQs.

Mind that the DefaultInterruptHandler is totally bugged. Especially the AutoAck feature doesn't work very well: It may cause higher priority handlers to miss their IRQ, and it may even cause the DefaultInterruptHandler to miss its own IRQs.

C(06h) - ExceptionHandler()

The C(06h) vector points to the exception handler, ie. to the function that is invoked from the 4 opcodes at address 80000080h, that opcodes jump directly to the exception handler, so patching the C(06h) vector has no effect.

Reading the C(06h) entry can be used to let a custom 80000080h handler pass control back to the default handler (that, by a "direct" jump, not by the usual "MOV R9,06h / CALL 0C0h" method, which would destroy main programs R9 register).

Also, reading C(06h) may be useful for patching the exception handler (which contains a bunch of NOP opcodes, which seem to be intended to insert additional opcodes, such like debugger exception handling) (Note: some of that NOPs are reserved for Memory Card IRQ handling).

BUG: Early BIOS versions did try to examine a copy of cop0r13 in r2 register, but did forgot cop0r13 to r2 (so they examined garbage), this was fixed in newer BIOS versions, additionally, most commercial games still include patches for compatibility with the old BIOS.

B(17h) - ReturnFromException()

Restores the CPU registers (R1-R31,HI,LO,SR,PC) (except R26/K0) from the current TCB. This function is usually executed automatically at the end of the ExceptionHandler, however, functions in the exception chain may call ReturnFromException to return immediately, without processing chain elements of lower priority.

C(00h) - EnqueueTimerAndVblankIrqs(priority) ;used with prio=1

C(01h) - EnqueueSyscallHandler(priority) ;used with prio=0

C(0Ch) - InitDeflnt(priority) ;used with prio=3

Internally used to add some default IRQ and Exception handlers.

No Nested Exceptions

The Kernel doesn't support nested exceptions, that would require a decreasing exception stack, however, the kernel saves the incoming CPU registers in the current TCB, and an exception stack with fixed start address for internal push/pop during exception handling. So, nesting would overwrite these values. Do not enable IRQs, and don't trap other exceptions (like break or syscall opcodes, or memory or overflow errors) during exception handling.

Note: The exception stack has a fixed size of 1000h bytes (and is located somewhere in the first 64Kbytes of memory).

21.9 BIOS Event Functions

B(08h) - OpenEvent(class, spec, mode, func)

Adds an event structure to the event table.

```
class,spec - triggers if BOTH values match
mode - (1000h=execute function/stay busy, 2000h=no func/mark ready)
func - Address of callback function (0=None) (used only when mode=1000h)
out: R2 = Event descriptor (F1000000h and up), or FFFFFFFFh if failed
```

Opens an event, should be called within a critical section. The return value is used to identify the event to the other event functions. A list of event classes, specs and modes is at the end of this section. Initially, the event is disabled.

Note: The desired max number of events can be specified in the SYSTEM.CNF boot file (the default is "EVENT = 10" (which is a HEX number, ie. 16 decimal; of which 5 events are internally used by the BIOS for CDROM functions, so, of the 16 events, only 11 events are available to the game). A bigger amount of events will slowdown the DeliverEvent function (which always scans all EvCBs, even if all events are disabled).

B(09h) - CloseEvent(event) - releases event from the event table

Always returns 1 (even if the event handle is unused or invalid).

B(0Ch) - EnableEvent(event) - Turns on event handling for specified event

Always returns 1 (even if the event handle is unused or invalid).

B(0Dh) - DisableEvent(event) - Turns off event handling for specified event

Always returns 1 (even if the event handle is unused or invalid).

B(0Ah) - WaitEvent(event)

Returns 0 if the event is disabled. Otherwise hangs in a loop until the event becomes ready, and returns 1 once when it is ready (and automatically switches the event back to busy status). Callback events (mode=1000h) do never set the ready flag (and thus WaitEvent would hang forever).

The main program simply hangs during the wait, so when using multiple threads, it may be more recommended to create an own waitloop that checks TestEvent, and to call ChangeTh when the event is busy.

BUG: The return value is unstable (sometimes accidentally returns 0=disabled if the event status changes from not-ready to ready shortly after the function call).

B(0Bh) - TestEvent(event)

Returns 0 if the event is busy or disabled. Otherwise, when it is ready, returns 1 (and automatically switches the event back to busy status). Callback events (mode=1000h) do never set the ready flag.

B(07h) - DeliverEvent(class, spec)

This function is usually called by the kernel, it triggers all events that are enabled/busy, and that have the specified class and spec values. Depending on the mode, either the callback function is called (mode=1000h), or the event is marked as enabled/ready (mode=2000h).

B(20h) - UnDeliverEvent(class, spec)

This function is usually called by the kernel, undelivers all events that are enabled/ready, and that have mode=2000h, and that have the specified class and spec values. Undeliver means that the events are marked as enabled/busy.

C(04h) - get_free_EvCB_slot()

A subfunction for OpenEvent.

Event Classes**File Events:**

```
00000000xh memory card (for file handle fd=x)
```

Hardware Events:

```
F0000001h IRQ0  VBLANK
F0000002h IRQ1  GPU
F0000003h IRQ2  CDROM Decoder
F0000004h IRQ3  DMA controller
F0000005h IRQ4  RTC0 (timer0)
F0000006h IRQ5/IRQ6 RTC1 (timer1 or timer2)
F0000007h N/A   Not used (this should be timer2)
F0000008h IRQ7  Controller (joypad/memcard)
F0000009h IRQ9  SPU
F000000Ah IRQ10 PIO ;uh, does the PIO have an IRQ signal? (IRQ10 is joypad)
F000000Bh IRQ8  SIO
F0000010h Exception ;CPU crashed (BRK,BadSyscall,Overflow,MemoryError, etc.)
F0000011h memory card (lower level BIOS functions)
F0000012h memory card (not used by BIOS; maybe used by Sony's devkit?)
F0000013h memory card (not used by BIOS; maybe used by Sony's devkit?)
```

Event Events:

```
F1xxxxxxh event (not used by BIOS; maybe used by Sony's devkit?)
```

Root Counter Events (Timers and Vblank):

```
F2000000h Root counter 0 (Dotclock) (hardware timer)
F2000001h Root counter 1 (horizontal retrace?) (hardware timer)
F2000002h Root counter 2 (one-eighth of system clock) (hardware timer)
F2000003h Root counter 3 (vertical retrace?) (this is a software timer)
```

User Events:

```
F3xxxxxxh user (not used by BIOS; maybe used by games and/or Sony's devkit?)
```

BIOS Events (including such that have nothing to do with BIOS):

```
F4000001h memory card (higher level BIOS functions)
F4000002h libmath (not used by BIOS; maybe used by Sony's devkit?)
```

Thread Events:

```
FFxxxxxxh thread (not used by BIOS; maybe used by Sony's devkit?)
```

Event Specs

```
0001h counter becomes zero
0002h interrupted
0004h end of i/o
0008h file was closed
0010h command acknowledged
0020h command completed
0040h data ready
0080h data end
0100h time out
0200h unknown command
0400h end of read buffer
0800h end of write buffer
1000h general interrupt
2000h new device
4000h system call instruction ;SYS(04h..FFFFFFFFh)
8000h error happened
8001h previous write error happened
0301h domain error in libmath
0302h range error in libmath
```

Event modes

```
1000h Execute callback function, and stay busy (do NOT mark event as ready)
2000h Do NOT execute callback function, and mark event as ready
```

21.10 BIOS Event Summary

Below is a list of all events (class,spec values) that are delivered and/or undelivered by the BIOS in one way or another. The BIOS does internally open five events for cdrom (class=F0000003h with spec=10h,20h,40h,80h,8000h). The various other class/spec's

are only delivered by the BIOS (but not received by the BIOS) (ie. a game may open/enable memory card events to receive notifications from the BIOS).

CDROM Events

```
F0000003h,10h  cdrom DMA finished (all sectors finished)
F0000003h,20h  cdrom ?
F0000003h,40h  cdrom dead feature (delivered only by unused functions)
F0000003h,80h  cdrom INT4 (reached end of disk)
F0000003h,100h      n/a ? ;undelivered, but not opened, nor delivered
F0000003h,200h      ;undelivered, but not opened
F0000003h,8000h
```

Memory Card - Higher Level File/Device Events

```
00000000xh,4      card file handle (x=fd) done okay
F4000001h,4        card done okay (len=0)
F4000001h,100h     card err busy ;A(A9h)
F4000001h,2000h    card err eject ;A(AAh) or unformatted (bad "MC" id)
F4000001h,8000h    card err write ;A(A8h) or A(AEh) or general error
```

Memory Card - Lower Level Hardware I/O Events

```
F0000011h,4        finished okay
F0000011h,100h     err busy
F0000011h,200h     n/a ?
F0000011h,2000h    err
F0000011h,8000h    err
F0000011h,8001h    err (this one is NOT undelivered!)
```

Timer/Vblank Events

```
F2000000h,2        Timer0 (IRQ4)
F2000001h,2        Timer1 (IRQ5)
F2000002h,2        Timer2 (IRQ6)
F2000003h,2        Vblank (IRQ0) (unstable since IRQ0 is also used for joypad)
```

Default IRQ Handler Events (very unstable, don't use)

```
F0000001h,1000h ;IRQ0 (VBLANK)
F0000002h,1000h ;IRQ1 (GPU)
F0000003h,1000h ;IRQ2 (CDROM)
F0000004h,1000h ;IRQ3 (DMA)
F0000005h,1000h ;IRQ4 (TMR0)
F0000006h,1000h ;IRQ5 (TMR1)
```

```

F0000006h,1000h ;IRQ6  (TMR2) (accidentally uses same event as TMR1)
F0000008h,1000h ;IRQ7  (joypad/memcard)
F0000009h,1000h ;IRQ9  (SPU)
F000000Ah,1000h ;IRQ10 (Joypad and PIO)
F000000Bh,1000h ;IRQ8  (SIO)

```

Unresolved Exception Events

```

F0000010h,1000h unknown exception ;neither IRQ nor SYSCALL
F0000010h,4000h unknown syscall   ;syscall(04h..FFFFFFFFh)

```

21.11 BIOS Thread Functions

B(0Eh) - OpenTh(reg_PC,reg_SP_FP,reg_GP)

Searches a free TCB, marks it as used, and stores the initial program counter (PC), global pointer (GP aka R28), stack pointer (SP aka R29), and frame pointer (FP aka R30) (using the same value for SP and FP). All other registers are left uninitialized (eg. may contain values from an older closed thread, that includes the SR register, see note). The return value is the new thread handle (in range FF000000h..FF000003h, assuming that 4 TCBs are allocated) or FFFFFFFFh if there's no free TCB. The function returns to the old current thread, use "ChangeTh" to switch to the new thread.

Note: The desired max number of TCBs can be specified in the SYSTEM.CNF boot file (the default is "TCB = 4", one initially used for the boot executable, plus 3 free threads).

BUG - Unitialized SR Register

OpenTh does NOT initialize the SR register (cop0r12) of the new thread. Upon powerup, the bootcode zerofills the TCB memory (so, the SR of new threads will be initially zero; ie. Kernel Mode, IRQ's disabled, and COP2 disabled). However, when closing/reopening threads, the SR register will have the value of the old closed thread (so it may get started with IRQs enabled, and, in worst case, if the old thread should have switched to User Mode, even without access to KSEG0, KSEG1 memory).

Or, ACTUALLY, the memory is NOT zerofilled on powerup... so SR is total random?

B(0Fh) - CloseTh(handle)

Marks the TCB for the specified thread as unused. The function can be used for any threads, including for the current thread.

Closing the current thread doesn't terminate the current thread, so it may cause

problems once when opening a new thread, however, it should be stable to execute the sequence "DisableInterrupts, CloseCurrentThread, ChangeOtherThread".

The return value is always 1 (even if the handle was already closed).

B(10h) - ChangeTh(handle)

Pauses the current thread, and activates the selected new thread (or crashes if the specified handle was unused or invalid).

The return value is always 1 (stored in the R2 entry of the TCB of the old thread, so the return value will be received once when changing back to the old thread).

Note: The BIOS doesn't automatically switch from one thread to another. So, all other threads remain paused until the current thread uses ChangeTh to pass control to another thread.

Each thread is having it's own CPU registers (R1..R31,HI,LO,SR,PC), the registers are stored in the TCB of the old thread, and restored when switching back to that thread.

Mind that other registers (I/O Ports or GTE registers aren't stored automatically, so, when needed, they need to be pushed/popped by software before/after ChangeTh).

C(05h) - get_free_TCB_slot()

Subfunction for OpenTh, returns the number of the first free TCB (usually in range 0..3) or FFFFFFFFh if there's no free TCB.

SYS(03h) ChangeThreadSubFunction(addr) ;syscall with r4=03h, r5=addr

Subfunction for ChangeTh, R5 contains the address of the new TCB, just like all exceptions, the syscall exception is saving the CPU registers in the current TCB, but does then apply the new TCB as current TCB, and so, it does then enter the new thread when returning from the exception.

21.12 BIOS Timer Functions

Timers (aka Root Counters)

The three hardware timers aren't internally used by any BIOS functions, so they can be freely used by the game, either via below functions, or via direct I/O access.

Vblank

Some of the below functions are allowing to use Vblank IRQs as a fourth "timer".

However, Vblank IRQs are internally used by the BIOS for handling joypad and memory card accesses. One could theoretically use two separate Vblank IRQ handlers, one for joypad, and one as "timer", but the BIOS is much too unstable for such "shared" IRQ handling (it may occassionally miss one of the two handlers).

So, although Vblank IRQs are most important for games, the PSX BIOS doesn't actually allow to use them for purposes other than joypad access. A possible workaround is to examine the status byte in one of the joypad buffers (ie. the InitPAD2(buf1,22h,buf2,22h) buffers). Eg. a wait_for_vblank function could look like so: set buf1[0]=55h, then wait until buf1[0]=00h or buf1[0]=FFh.

B(02h) - init_timer(t,reload,flags)

When t=0..2, resets the old timer mode by setting [1F801104h+t*16]=0000h, applies the reload value by [1F801108h+t*16]=reload, computes the new mode:

```
if flags.bit4=0 then mode=0048h else mode=0049h
if flags.bit0=0 then mode=mode OR 100h
if flags.bit12=1 then mode=mode OR 10h
```

and applies it by setting [1F801104h+t*16]=mode, and returns 1. Does nothing and returns zero for t>2.

B(03h) - get_timer(t)

Reads the current timer value: Returns halfword[1F801100h+t*16] for t=0..2. Does nothing and returns zero for t>2.

B(04h) - enable_timer_irq(t)

B(05h) - disable_timer_irq(t)

Enables/disables timer or vblank interrupt enable bits in [1F801074h], bit4,5,6 for t=0,1,2, or bit0 for t=3, or random/garbage bits for t>3. The enable function returns 1 for t=0..2, and 0 for t=3. The disable function returns always 1.

B(06h) - restart_timer(t)

Sets the current timer value to zero: Sets $[1F801100h + t * 16] = 0000h$ and returns 1 for $t=0..2$. Does nothing and returns zero for $t>2$.

C(0Ah) - ChangeClearRCnt(t,flag) ;root counter (aka timer)

Selects what the kernel's timer/vblank IRQ handlers shall do after they have processed an IRQ ($t=0..2$: timer $0..2$, or $t=3$: vblank) ($flag=0$: do nothing; or $flag=1$: automatically acknowledge the IRQ and immediately return from exception). The function returns the old (previous) flag value.

21.13 BIOS Joypad Functions

Pad Input

Joypads should be initialized via `InitPAD2(buf1,22h,buf2,22h)`, and `StartPAD2()`. The main program can read the pad data from the `buf1/buf2` addresses (including Status, ID1, button states, and any kind of analogue inputs). For more info on ID1, Buttons and analogue inputs, see

[Controllers and Memory Cards](#)

Note: The BIOS doesn't include any functions for sending custom data to the pads (such like for controlling rumble motors).

B(12h) - InitPAD2(buf1, siz1, buf2, siz2)

Memorizes the desired `buf1/buf2` addresses, zerofills the buffers by using the `siz1/siz2` buffer size values (which should be `22h` bytes each). And does some initialization on the `PadCardIrq` element (but doesn't enqueue it, that must be done by a following call to `StartPAD2`), and does set the "pad_enable_flag", that flag can be also set/cleared via `InitCARD2(pad_enable)`, where it selects if the Pads are kept handled together with Memory Cards. `buf1/buf2` are having the following format:

```
00h      Status (00h=okay, FFh=timeout/wrong ID2)
01h      ID1    (eg. 41h=digital_pad, 73h=analogue_pad, 12h=mouse, etc.)
02h..21h Data  (max 16 halfwords, depending on lower 4bit of ID1)
```

Note: `InitPAD2` does initially zerofill the buffers, so, until the first IRQ is processed, the initial status is `00h=okay`, with buttons=`0000h` (all buttons pressed), to fix that situation, change the two status bytes to `FFh` after calling `InitPAD2` (or alternately, reject `ID1=00h`).

Once when the PadCardIrq is enqueued via StartPAD2, and while "pad_enable_flag" is set, the data for (both) Pad1 and Pad2 is read on Vblank interrupts, and stored in the buffers, the IRQ handler stores up to 22h bytes in the buffer (regardless of the siz1/siz2 values) (eg. a Multitap adaptor uses all 22h bytes).

B(13h) - StartPAD2()

Should be used after InitPAD2. Enqueues the PadCardIrq handler, and does additionally initialize some flags.

B(14h) - StopPAD2()

Dequeues the PadCardIrq handler. Note that this handler is also used for memory cards, so it'll "stop" cards, too.

B(15h) - PAD_init2(type, button_dest, unused, unused)

This is an extremely bizarre and restrictive function - don't use! The function fails unless type is 20000000h or 20000001h (the type value has no other function). The function uses "buf1/buf2" addresses that are located somewhere "hidden" within the BIOS variables region, the only way to read from that internal buffers is to use the ugly "PAD_dr()" function. For some strange reason it FFh-fills buf1/buf2, and does then call InitPAD2(buf1,22h,buf2,22) (which does immediately 00h-fill the previously FFh-filled buffers), and does then call StartPAD2().

Finally, it does memorize the "button_dest" address (see PAD_dr() for details on that value). The two unused parameters have no function, however, they are internally written back to the stack locations reserved for parameter 2 and 3, ie. at [SP+08h] and [SP+0Ch] on the caller's stack, so the function MUST be called with all four parameters allocated on stack. Return value is 2 (or 0 if type was disliked).

B(16h) - PAD_dr()

This is a very ugly function, using the internal "buf1/buf2" values from "PAD_init2" and the "button_dest" value that was passed to that function.

If "button_dest" is non-zero, then this function is automatically called by the PadCardIrq handler, and stores it's return value at [button_dest] (where it may be read by the main program). If "button_dest" is zero, then it isn't called automatically, and it \<can> be called manually (with return value in R2), however, it does additionally write the return value to [button_dest], ie. to [00000000h] in this case, destroying that memory location.

The return value itself is useless garbage: The lower 16bit contain the pad1 buttons, the upper 16bit the pad2 buttons, of which, both values have reversed byte-order (ie. the first button byte in upper 8bit). The function works only with controller IDs 41h (digital joystick) and 23h (nonstandard device). For ID=23h, the halfword is ORed with 07C7h, and bit6,7 are then cleared if the analogue inputs are greater than 10h. For ID=41h the data is left intact. Any other ID values, or disconnected joypads, cause the halfword to be set to FFFFh (same as when no buttons are pressed), that includes newer analogue pads (unless they are switched to "digital" mode).

21.14 BIOS GPU Functions

A(48h) - SendGP1Command(gp1cmd)

Writes [1F801814h]=gp1cmd. There's no return value (r2 is left unchanged).

A(49h) - GPU_cw(gp0cmd) ;send GP0 command word

Calls gpu_sync(), and does then write [1F801810h]=gp0cmd. Returns the return value from the gpu_sync() call.

A(4Ah) - GPU_cwp(src,num) ;send GP0 command word and parameter words

Calls gpu_sync(), and does then copy "num" words from [src and up] to [1F801810h], src should usually point to a command word, followed by num-1 parameter words. Transfer is done by software (without DMA). Always returns 0.

A(4Bh) - send_gpu_linked_list(src)

Transfer an OT via DMA. Calls gpu_sync(), and does then write [1F801814h]=4000002h, [1F8010F4h]=0, [1F8010F0h]=[1F8010F0h] OR 800h, [1F8010A0h]=src, [1F8010A4h]=0, [1F8010A8h]=1000401h. The function does additionally output a bunch of TTY status messages via printf. The function doesn't wait until the DMA is completed. There's no return value.

A(4Ch) - gpu_abort_dma()

Writes [1F8010A8h]=401h, [1F801814h]=4000000h, [1F801814h]=2000000h, [1F801814h]=1000000h. Ie. stops GPU DMA, and issues GP1(4), GP1(2), GP1(1). Returns 1F801814h, ie. the I/O address.

A(4Dh) - GetGPUStatus()

Reads [1F801814h] and returns that value.

A(46h) - GPU_dw(Xdst,Ydst,Xsiz,Ysiz,src)

Waits until GPUSTAT.Bit26 is set (unlike gpu_sync, which waits for Bit28), and does then [1F801810h]=A0000000h, [1F801810h]=YdstXdst, [1F801810h]=YsizXsiz, and finally transfers "N" words from [src and up] to [1F801810h], where "N" is "Xsiz*Ysiz/2". The data is transferred by software (without DMA) (by code executed in the uncached BIOS region with high waitstates, so the data transfer is very SLOW).

Caution: If "Xsiz*Ysiz" is odd, then the last halfword is NOT transferred, so the GPU stays waiting for the last data value.

Returns [SP+04h]=Ydst, [SP+08h]=Xsiz, [SP+0Ch]=Ysiz, [SP+10h]=src+N*4, and R2=src=N*4.

A(47h) - gpu_send_dma(Xdst,Ydst,Xsiz,Ysiz,src)

Calls gpu_sync(), writes [1F801810h]=A0000000h, [1F801814h]=4000002h, [1F8010F0h]=[1F8010F0h] OR 800h, [1F8010A0h]=src, [1F8010A4h]=N*10000h+10h (where N="Xsiz*Ysiz/32"), [1F8010A8h]=1000201h.

Caution: If "Xsiz*Ysiz" is not a multiple of 32, then the last halfword(s) are NOT transferred, so the GPU stays waiting for that values.

Returns R2=1F801810h, and [SP+04h]=Ydst, [SP+08h]=Xsiz, [SP+0Ch]=Ysiz.

A(4Eh) - gpu_sync()

If DMA is off (when GPUSTAT.Bit29-30 are zero): Waits until GPUSTAT.Bit28=1 (or until timeout).

If DMA is on: Waits until D2_CHCR.Bit24=0 (or until timeout), and does then wait until GPUSTAT.Bit28=1 (without timeout, ie. may hang forever), and does then turn off DMA via GP1(04h).

Returns 0 (or -1 in case of timeout, however, the timeout values are very big, so it may take a LOT of seconds before it returns).

21.15 BIOS Memory Allocation

A(33h) - malloc(size)

Allocates size bytes on the heap, and returns the memory handle (aka the address of the allocated memory block). The address of the block is guaranteed to be aligned to 4-byte memory boundaries. Size is rounded up to a multiple of 4 bytes. The address may be in KUSEG, KSEG0, or KSEG1, depending on the address passed to InitHeap.

Caution: The BIOS (tries to) initialize the heap size to 0 bytes (actually it accidentally overwrites that initial setting by garbage during relocation), so any call to malloc will fail, unless InitHeap has been used to initialize the address/size of the heap.

A(34h) - free(buf)

Deallocates the memory block. There's no return value, and no error checking. The function simply sets [buf-4]=[buf-4] OR 00000001h, so if buf is an invalid handle it may destroy memory at [buf-4], or trigger a memory exception (for example, when buf=0).

A(37h) - calloc(sizx, sizy) ;SLOW!

Allocates xsiz*ysiz bytes by calling malloc(xsiz*ysiz), and, unlike malloc, it does additionally zerofill the memory via SLOW "bzero" function. Returns the address of the memory block (or zero if failed).

A(38h) - realloc(old_buf, new_size) ;SLOW!

If "old_buf" is zero, executes malloc(new_size), and returns r2=new_buf (or 0=failed). Else, if "new_size" is zero, executes free(old_buf), and returns r2=gabage. Else, executes malloc(new_size), bcopy(old_buf,new_buf,new_size), and free(old_buf), and returns r2=new_buf (or 0=failed).

Caution: The bcopy function is SLOW, and realloc does accidentally copy "new_size" bytes from old_buf, so, if the old_size was smaller than new_size then it'll copy whatever garbage data - in worst case, if it exceeds the top of the 2MB RAM region, it may crash with a locked memory exception, although that'd happen only if SetMem(2) was used to restrict RAM to 2MBs.

A(39h) - InitHeap(addr, size)

Initializes the address and size of the heap - the BIOS does not automatically do this, so, before using the heap, InitHeap must be called by software. Usually, the heap would

be memory region between the end of the boot executable, and the bottom of the executable's stack. InitHeap can be also used to deallocate all memory handles (eg. when a new exe file has been loaded, it may use it to deallocate all old memory). The heap is used only by malloc/realloc/calloc/free, and by the "qsort" function.

B(00h) - alloc_kernel_memory(size)

B(01h) - free_kernel_memory(buf)

Same as malloc/free, but, instead of the heap, manages the 8kbyte control block memory at A000E000h..A000FFFFh. This region is used by the kernel to allocate ExCBs (4x08h bytes), EvCBs (N*1Ch bytes), TCBs (N*0C0h bytes), and the process control block (1x04h bytes). Unlike the heap, the BIOS does automatically initialize this memory region via SysInitMemory(addr,size), and does automatically allocate the above data (where the number of EvCBs and TCBs is as specified in the SYSTEM.CNF file). Note: FCBs and DCBs are located elsewhere, at fixed locations in the kernel variables area.

Scratchpad Note

The kernel doesn't include any allocation functions for the scratchpad (nor do any kernel functions use that memory area), so the executable can freely use the "fast" memory at 1F800000h..1F8003FFh.

A(9Fh) - SetMem(megabytes)

Changes the effective RAM size (2 or 8 megabytes) by manipulating port 1F801060h, and additionally stores the size in megabytes in RAM at [00000060h].

Note: The BIOS bootcode accidently sets the RAM value to 2MB (which is the correct physical memory size), but initializes the I/O port to 8MB (which mirrors the physical 2MB within that 8MB region), so the initial values don't match up with each other.

Caution: Applying the correct size of 2MB may cause the "realloc" function to crash (that function may accidently access memory above 2MB).

21.16 BIOS Memory Fill/Copy/Compare (SLOW)

Like most A(NNh) functions, below functions are executed in uncached BIOS ROM, the ROM has very high waitstates, and the 32bit opcodes are squeezed through an 8bit bus. Moreover, below functions are restricted to process the data byte-by-byte. So, they are very-very-very slow, don't even think about using them.

Of course, that applies also for most other BIOS functions. But it's becoming most obvious for these small functions; memcpy takes circa 160 cycles per byte (reasonable would be less than 4 cycles), and bzero takes circa 105 cycles per byte (reasonable would be less than 1 cycles).

A(2Ah) - memcpy(dst, src, len)

Copies len bytes from [src..src+len-1] to [dst..dst+len-1]. Refuses to copy any data when dst=00000000h or when len>7FFFFFFFh. The return value is always the incoming "dst" value.

A(2Bh) - memset(dst, fillbyte, len)

Fills len bytes at [dst..dst+len-1] with the fillbyte value. Refuses to fill memory when dst=00000000h or when len>7FFFFFFFh. The return value is the incoming "dst" value (or zero, when len=0 or len>7FFFFFFFh).

A(2Ch) - memmove(dst, src, len) - bugged

Same as memcpy, but (attempts) to support overlapping src/dst regions, by using a backwards transfer when src<dst (and, for some reason, only when dst>=src+len).
BUG: The backwards variant accidentally transfers len+1 bytes from [src+len..src] down to [dst+len..dst].

A(2Dh) - memcmp(src1, src2, len) - bugged

Compares len bytes at [src1..src1+len-1] with [src2..src2+len-1], and (attempts) to return the difference between the first mismatching bytes, ie. [src1+N]-[src2+N], or 0 if there are no mismatches. Refuses to compare data when src1 or src2 is 00000000h, and returns 0 in that case.

BUG: Accidentally returns the difference between the bytes AFTER the first mismatching bytes, ie. [src1+N+1]-[src2+N+1].

That means that a return value of 0 can mean absolutely anything: That the memory blocks are identical, or that a mismatch has been found (but that the NEXT byte after the mismatch does match), or that the function has failed (due to src1 or src2 being 00000000h).

A(2Eh) - memchr(src, scanbyte, len)

Scans [src..src+len-1] for the first occurrence of scanbyte. Refuses to scan any data when src=00000000h or when len>7FFFFFFFh. Returns the address of that first occurrence, or 0 if the scanbyte wasn't found.

A(27h) - bcopy(src, dst, len)

Same as "memcpy", but with "src" and "dst" exchanged. That is, the first parameter is "src", the refuse occurs when "src" is 00000000h, and, returns the incoming "src" value (whilst "memcpy" uses "dst" in that places).

A(28h) - bzero(dst, len)

Same as memset, but uses 00h as fixed fillbyte value.

A(29h) - bcmp(ptr1, ptr2, len) - bugged

Same as "memcmp", with exactly the same bugs.

21.17 BIOS String Functions

A(15h) - strcat(dst, src)

Appends src to the end of dst. Searches the ending 00h byte in dst, and copies src to that address, up to including the ending 00h byte in src. Returns the incoming dst value. Refuses to do anything if src or dst is 00000000h (and returns 0 in that case).

A(16h) - strncat(dst, src, maxlen)

Same as "strcat", but clipped to "MaxSrc=(min(0,maxlen)+1)" characters, ie. the total length is max "length(dst)+min(0,maxlen)+1". If src is longer or equal to "MaxSrc", then only the first "MaxSrc" chars are copied (with the last byte being replaced by 00h). If src is shorter, then everything up to the ending 00h byte gets copied, but without additional padding (unlike as in "strncpy").

A(17h) - strcmp(str1, str2)

Compares the strings up to including ending 00h byte. Returns 0 if they are identical, or otherwise [str1+N]-[str2+N], where N is the location of the first mismatch, the two

bytes are sign-expanded to 32bits before doing the subtraction. The function rejects str1/str2 values of 00000000h (and returns 0=both are zero, -1=only str1 is zero, and +1=only str2 is zero).

A(18h) - strncmp(str1, str2, maxlen)

Same as "strcmp" but stops after comparing "maxlen" characters (and returns 0 if they did match). If the strings are shorter, then comparison stops at the ending 00h byte (exactly as for strcmp).

A(19h) - strcpy(dst, src)

Copies data from src to dst, up to including the ending 00h byte. Refuses to copy anything if src or dst is 00000000h. Returns the incoming dst address (or 0 if copy was refused).

A(1Ah) - strncpy(dst, src, maxlen)

Same as "strcpy", but clipped to "maxlen" characters. If src is longer or equal to maxlen, then only the first "maxlen" chars are copied (but without appending an ending 00h byte to dst). If src is shorter, then the remaining bytes in dst are padded with 00h bytes.

A(1Bh) - strlen(src)

Returns the length of the string up to excluding the ending 00h byte (or 0 when src is 00000000h).

A(1Ch) - index(src, char)

A(1Dh) - rindex(src, char)

A(1Eh) - strchr(src, char) ;exactly the same as "index"

A(1Fh) - strrchr(src, char) ;exactly the same as "rindex"

Scans for the first (index) or last (rindex) occurrence of char in the string. Returns the memory address of that occurrence (or 0 if there's no occurrence, or if src is 00000000h). Char may be 00h (returns the end address of the string). Note that, despite of the

function names, the return value is always a memory address, NOT an index value relative to src.

A(20h) - strpbrk(src, list)

Scans for the first occurrence of a character that is contained in the list. The list contains whatever desired characters, terminated by 00h.

Returns the address of that occurrence, or 0 if there was none. BUG: If there was no occurrence, it returns 0 only if src[0]=00h, and otherwise returns the incoming "src" value (which is the SAME return value as when a occurrence did occur on 1st character).

A(21h) - strspn(src, list)

A(22h) - strcspn(src, list)

Scans for the first occurrence of a character that is (strspn), or that isn't (strcspn) contained in the list. The list contains whatever desired characters, terminated by 00h. Returns the index (relative to src) of that occurrence. If there was no occurrence, then it returns the length of src. That silly return values do not actually indicate if an occurrence has been found or not (unless one checks for [src+index]=00h or so).

"The strcspn() function shall compute the length (in bytes) of the maximum initial segment of the string pointed to by s1 which consists entirely of bytes not from the string pointed to by s2."

"The strspn() function shall compute the length (in bytes) of the maximum initial segment of the string pointed to by s1 which consists entirely of bytes from the string pointed to by s2."

Hmmmm, that'd be vice-versa?

A(23h) - strtok(src, list) ;first call

A(23h) - strtok(0, list) ;further call(s)

Used to split a string into fragments, list contains a list of characters that are to be treated as separators, terminated by 00h.

The first call copies the incoming string to a buffer in the BIOS variables area (the buffer size is 100h bytes, so the string should be max 255 bytes long, plus the ending 00h byte, otherwise the function destroys other BIOS variables), it does then search the first

fragment, starting at the begin of the buffer. Further calls (with src=00000000h) are searching further fragments, starting at the buffer address from the previous call. The internal buffer is used only for strtok, so its contents (and the returned string fragments) remain intact until a new first call to strtok takes place.

The separate fragments are processed by searching the first separator, starting at the current buffer address, the separator is then replaced by a 00h byte, and the old buffer address is returned to the caller. Moreover, the function tries to skip all continuously following separators, until reaching a non-separator, and does memorize that address for the next call (due to that skipping further calls won't return empty fragments, the first call may do so though). That skipping seems to be bugged, if list contains two or more different characters, then additional separators aren't skipped.

```

",,TEXT,,,END" with list="," returns "", "TEXT", "END"
",,TEXT,,,END" with list=","." returns "", "", "TEXT", "", "", "END"

```

Once when there are no more fragments, then 00000000h is returned.

A(24h) - strstr(str, substr) - buggy

Scans for the first occurrence of substr in the string. Returns the memory address of that occurrence (or 0 if it was unable to find an occurrence).

BUG: After rejecting incomplete matches, the function doesn't fallback to the old str address plus 1, but does rather continue at the current str address. Eg. it doesn't find substr="aab" in str="aaab" (in that example, it does merely realize that "aab"<>"aaa" and then that "aab"<>"b").

21.18 BIOS Number/String/Character Conversion

A(0Eh) - abs(val)

A(0Fh) - labs(val) ;exactly same as "abs"

Returns the absolute value (if val<0 then R2=-val, else R2=val).

A(0Ah) - todigit(char)

Takes the incoming character, ANDed with FFh, and returns 0..9 for characters "0..9" and 10..35 for "A..Z" or "a..z", or 0098967Fh (9,999,999 decimal) for any other 7bit characters, or garbage for characters 80h..FFh.

A(25h) - toupper(char)**A(26h) - tolower(char)**

Returns the incoming character, ANDed with FFh, with letters "A..Z" converted to uppercase/lowercase format accordingly. Works only for char 00h..7Fh (some characters in range 80h..FFh are left unchanged, others are randomly "adjusted" by adding/subtracting 20h, and by sign-expanding the result to 32bits).

A(0Dh) - strtol(src, src_end, base)

Converts a string to a number. The function skips any leading "blank" characters (that are, 09h..0Dh, and 20h) (ie. TAB, CR, LF, SPC, and some others) (some characters in range 80h..FFh are accidentally treated as "blank", too).

The incoming base value should be in range 2..11, although the function does also accept the buggy values in range of 12..36 (for values other than 2..36 it defaults to decimal/base10). The used numeric digits are "0..9" and "A..Z" (or less when base is smaller than 36).

The string may have a negative sign prefix "-" (negates the result) (a "+" is NOT recognized; and will be treated as the end of the string). Additionally, the string may contain prefixes "0b" (binary/base2), "0x" (hex/base16), or "o" (octal/base8) (only "o", not "0o"), allowing to override the incoming "base" value.

BUG: Incoming base values greater than 11 don't work due to the prefix feature (eg. base=16 with string "0b11" will be treated as 11 binary, and base=36 with string "o55" will be treated as 55 octal) (the only workaround would be to add/remove leading "0" characters, ie. "b11" or "00b11" or "0o55" would work okay).

Finally, the function initializes result=0, and does then process the digits as "result=result*base+digit" (without any overflow checks) unless/until it reaches an unknown digit (or when digit>=base) (ie. the string may end with 00h, or with any other unexpected characters).

The function accepts both uppercase and lowercase characters (both as prefixes, and as numeric digits). The function returns R2=result, and [src_end]=end_address (ie. usually the address of the ending 00h byte; or of any other unexpected end-byte). If src points to 00000000h, then the function returns r2=0, and leaves [src_end] unchanged.

A(0Ch) - strtoul(src, src_end, base)

Same as "strtol" except that it doesn't recognize the "-" sign prefix (ie. works only for unsigned numbers).

A(10h) - atoi(src)**A(11h) - atol(src) ;exactly same as "atoi" (but slightly slower)**

Same as "strtol", except that it doesn't return the string end address in [src_end], and except that it defaults to base=10, but still supports prefixes, allowing to use base2,8,16. CAUTION: For some super bizarre reason, this function treats "0" (a leading ZERO digit) as OCTAL prefix (unlike strtol, which uses the "o" letter as octal prefix) (the "0x" and "0b" prefixes are working as usually).

A(12h) - atob(src, num_dst)

Calls "strtol(str,src_end,10)", and does then exchange the two return values (ie. sets R2=[src_end], and [num_dst]=value_32bit).

A(0Bh) - atof(src) ;USES (ABSENT) COP1 FPU !!!**A(32h) - strtod(src, src_end) ;USES (ABSENT) COP1 FPU !!!**

These functions are intended to convert strings to floating point numbers, however, the functions are accidently compiled for MIPS processors with COP1 floating point unit (which is not installed in the PSX, nor does the BIOS support a COP1 software emulation), so calling these functions will produce a coprocessor exception, causing the PSX to lockup via A(40h) SystemErrorUnresolvedException.

Note

On other systems (eg. 8bit computers), "abs/atoi" (integer) and "labs/atol" (long) may act differently. However, on the Playstation, both use signed 32bit values.

21.19 BIOS Misc Functions

A(2Fh) - rand()

Advances the random generator as "x=x*41C64E6Dh+3039h" (aka plus 12345 decimal), and returns a 15bit random value "R2=(x/10000h) AND 7FFFh".

A(30h) - srand(seed)

Changes the current 32bit value of the random generator.

A(B4h) - GetSystemInfo(index) ;not supported by old CEX-1000 version

Returns a word, halfword, or string, depending on the selected index value:

00h	Get Kernel BCD Date	(eg. 19951204h) (YYYYMMDDh)
01h	Get Kernel Flags or so	(usually/always 000000003h)
02h	Get Kernel Version String	(eg. "CEX-3000/1001/1002 by K.S.",0)
03h	Get whatever halfword	(usually 0) ;PS2: returns cop0r15
04h	Get whatever halfword	(usually 0)
05h	Get RAM Size in kilobytes	(usually 2048) ;=[00000060h] SHL 10
06h..0Eh	Get whatever halfwords	(usually 0,400h,0,200h,0,0,1,1,1)
0Fh	N/A (returns zero)	;PS2: returns 0000h (effectively = same as zero)
10h..FFFFFFFh	Not used	(returns zero)

Note: The Date/Version are referring to the Kernel (in the first half of the BIOS). The Intro and Bootmenu (in the second half of the BIOS) may have a different version, there's no function to retrieve info on that portion, however, a version string for it can be usually found at BFC7FF32h (eg. "System ROM Version 4.5 05/25/00 E",0) (in many bios versions, the last letter of that string indicates the region, but not in all versions) (the old SCPH1000 does not include that version string at all).

B(56h) - GetC0Table()**B(57h) - GetB0Table()**

Retrieves the address of the jump lists for B(NNh) and C(NNh) functions, allowing to patch entries in that lists (however, the BIOS does often jump directly to the function addresses, rather than indirectly via the list, so patching may have little effect in such cases). Note: There's no function to retrieve the address of the A(NNh) jump list, however, that list is usually/always at 00000200h.

A(31h) - qsort(base, nel, width, callback)

Sorts an array, using a super-slow implementation of the "quick sort" algorithm. base is the address of the array, nel is the number of elements in the array, width is the size in bytes of each element, callback is a function that receives pointers to two elements which need to be compared; callback should return zero if the elements are identical, or a positive/negative number to indicate which element is bigger.

The qsort function rearranges the contents of the array, ie. depending on the callback result, it may swap the contents of the two elements, for some bizarre reason it doesn't swap them directly, but rather stores one of the elements temporarily on the heap (that

means, qsort works only if the heap was initialized with InitHeap, and only if "width" bytes are free). There's no return value.

A(35h) - lsearch(key, base, nel, width, callback)

A(36h) - bsearch(key, base, nel, width, callback)

Searches an element in an array (key is the pointer to the searched element, the other parameters are same as for "qsort"). "lsearch" performs a slow linear search in an unsorted array, by simply comparing one array element after each other. "bsearch" assumes that the array contains sorted elements (eg. via qsort), which is allowing to skip some elements, and to jump back and forth in the array, until it has found the desired element (or the location where it'd be, if it'd be in the array). Both functions return the address of the element (or 0 if it wasn't found).

C(19h) - _ioabort(txt1,txt2)

Displays the two strings on the TTY (in some cases the BIOS does accidentally pass garbage instead of the 2nd string though). And does then execute _ioabort_raw(1), see there for more details.

A(B2h) - _ioabort_raw(param) ;not supported by old CEX-1000 version

Executes "longjmp(ioabortbuffer,param)". Internally used to recover from failed I/O operations, param should be nonzero to notify the setjmp caller that the abort has occurred.

A(13h) - setjmp(buf)

This is a somewhat incomplete implementation of posix's setjmp, by storing the ABI-saved CPU registers in the specified buffer (30h bytes):

```
00h 4    r31 (ra) (aka caller's pc)
04h 4    r29 (sp)
08h 4    r30 (fp)
0Ch 4x8  r16..r23
2Ch 4    r28 (gp)
```

That type of buffer can be used with "_ioabort", "longjmp", and also "HookEntryInt(addr)".

The "setjmp" function returns 0 when called directly. However, it may return again - to

the same return address, and the same stack pointer - with another return value (which should be usually non-zero, to indicate that the state has been restored (eg. `_ioabort` passes 1 as return value)).

Also noteworthy from what a compliant `setjmp` implementation should be doing is the absence of saving the state of `cop0` and `cop2`, thus making this slightly unsuitable for a typical coroutine system implementation.

A(14h) - `longjmp(buf, param)`

Restores the R16-R23,GP,SP,FP,RA registers from a previously recorded `jmp_buf` buffer, and "returns" to that new RA address (rather than to the caller of the `longjmp` function). The "param" value is passed as "return value" to the code at RA, ie. usually to the caller of the original `setjmp` call. Noteworthy difference from a conformant `longjmp` implementation is that the "param" value won't be clamped to 1 if you pass 0 to it. So since `setjmp` returns 0 on the first call, the caller of `longjmp` must take care that "param" is non-zero, so the callsite of `setjmp` can make the difference between the first call and a rollback. See `setjmp` for further details.

A(53h) - `set_ioabort_handler(src)` ;PS2 only ;PSX: `SystemError`

Normally the `_ioabort` handler is changed only internally during booting, with this new function, games can install their own `_ioabort` handler. `src` is pointer to a 30h-byte "savestate" structure, which will be copied to the actual `_ioabort` structure.

A(06h) or B(38h) - `exit(exitcode)`

Terminates the program and returns control to the BIOS; which does then lockup itself via A(3Ah) `_exit`.

A(A0h) - `_boot()`

Performs a warmboot (resets the kernel and reboots from CDRom). Unlike the normal coldboot procedure, it doesn't display the "<S>" and "PS" intro screens (and doesn't verify the "PS" logo in the ISO System Area), and, doesn't enter the bootmenu (even if the disk drive is empty, or if it contains an Audio disk). And, it doesn't reload the `SYSTEM.CNF` file, so the function works only if the same disk is still inserted (or another disk with identical `SYSTEM.CNF`, such like Disk 2 of the same game).

A(B5h..BFh) B(11h,24h..29h,2Ch..31h,5Eh..FFh) C(1Eh..7Fh) - N/A - Jump 0

These functions jump to address 00000000h. For whatever reason, that address does usually contain a copy of the exception handler (ie. same as at address 80000080h). However, since there's no return address stored in EPC register, the functions will likely crash when returning from the exception handler.

A(57h..5Ah,73h..77h,79h..7Bh,7Dh,7Fh..80h,82h..8Fh,B0h..B1h,B3h), and**C(0Eh..11h,14h) - N/A - Returns 0**

No function. Simply returns with r2=00000000h.

Reportedly, A(85h) is CdStop, but that seems to be nonsense?

SYS(00h) - NoFunction()

No function. Simply returns without changing any registers or memory locations (except that, of course, the exception handler destroys k0).

SYS(04h..FFFFFFFFh) - calls DeliverEvent(F0000010h,4000h)

These are syscalls with invalid function number in R4. For whatever reason that is handled by issuing DeliverEvent(F0000010h,4000h). Thereafter, the syscall returns to the main program (ie. it doesn't cause a SystemError).

A(3Ah) - _exit(exitcode)**A(40h) - SystemErrorUnresolvedException()****A(A1h) - SystemError(type,errorcode) ;type "B"=Boot,"D"=Disk**

These are used "SystemError" functions. The functions are repeatedly jumping to themselves, causing the system to hang. Possibly useful for debugging software which may hook that functions.

A(4Fh,50h,52h,53h,9Ah,9Bh) B(1Ah..1Fh,21h..23h,2Ah,2Bh,52h,5Ah) C(0Bh) - N/A

These are additional "SystemError" functions, but they are never used. The functions are repeatedly jumping to themselves, causing the system to hang.

BRK(1C00h) - Division by zero (commonly checked/invoked by software)

BRK(1800h) - Division overflow (-80000000h/-1, sometimes checked by software)

The CPU does not generate any exceptions upon divide overflows, because of that, the Kernel code and many games are commonly checking if the divider is zero (by software), and, if so, execute a BRK 1C00h opcode. The default BIOS exception handler doesn't handle BRK exceptions, and does simply redirect them to `SystemErrorUnresolvedException()`.

21.20 BIOS Internal Boot Functions

A(45h) - init_a0_b0_c0_vectors

Copies the three default four-opcode handlers for the A(NNh),B(NNh),C(NNh) functions to A00000A0h..A00000CFh.

C(07h) - InstallExceptionHandler() ;destroys/uses k0/k1

Copies the default four-opcode exception handler to the exception vector at 80000080h..8000008Fh, and, for whatever reason, also copies the same opcodes to 80000000h..8000000Fh.

C(08h) - SysInitMemory(addr,size)

Initializes the address (A000E000h) and size (2000h) of the allocate-able Kernel Memory region, and, seems to deallocate any memory handles which may have been allocated via B(00h).

C(09h) - SysInitKernelVariables()

Zerofills all Kernel variables; which are usually at [00007460h..0000891Fh].

Note: During the boot process, the BIOS accidentally overwrites the first opcode of this function (by the last word of the A0h table), so, thereafter, this function won't work anymore (nor would it be of any use).

C(12h) - InstallDevices(ttyflag)

Initializes the size and address of the File and Device Control Blocks (FCBs and DCBs). Adds the TTY device by calling "KernelRedirect(ttyflag)", and the CDROM and Memory Card devices by calling "AddCDROMDevice()" and "AddMemCardDevice()".

C(1Ch) - AdjustA0Table()

Copies the B(32h..3Bh) and B(3Ch..3Fh) function addresses to A(00h..09h) and A(3Bh..3Eh). Apparently Sony's compiler/linker can't insert the addresses in the A0h table directly at compilation time, so this function is used to insert them during execution of the boot code.

21.21 BIOS More Internal Functions

Below are mainly internally used device related subfunctions.

Internal Device Stuff

```

A(5Bh) dev_tty_init() ;PS2: SystemError
A(5Ch) dev_tty_open(fcb, and unused:"path\name", accessmode) ;PS2: SystemError
A(5Dh) dev_tty_in_out(fcb, cmd) ;PS2: SystemError
A(5Eh) dev_tty_ioctl(fcb, cmd, arg) ;PS2: SystemError
A(5Fh) dev_cd_open(fcb, "path\name", accessmode)
A(60h) dev_cd_read(fcb, dst, len)
A(61h) dev_cd_close(fcb)
A(62h) dev_cd_firstfile(fcb, "path\name", direntry)
A(63h) dev_cd_nextfile(fcb, direntry)
A(64h) dev_cd_chdir(fcb, "path")
A(65h) dev_card_open(fcb, "path\name", accessmode)
A(66h) dev_card_read(fcb, dst, len)
A(67h) dev_card_write(fcb, src, len)
A(68h) dev_card_close(fcb)
A(69h) dev_card_firstfile(fcb, "path\name", direntry)
A(6Ah) dev_card_nextfile(fcb, direntry)
A(6Bh) dev_card_erase(fcb, "path\name")
A(6Ch) dev_card_undelete(fcb, "path\name")
A(6Dh) dev_card_format(fcb)
A(6Eh) dev_card_rename(fcb1, "path\name1", fcb2, "path\name2")
A(6Fh) ? ; card ; [r4+18h]=00000000h ; card_clear_error(fcb) or so
A(96h) AddCDROMDevice()
A(97h) AddMemCardDevice()
A(98h) AddDuartTtyDevice() ;PS2: SystemError
A(99h) add_nullcon_driver()
B(47h) AddDrv(device_info) ;subfunction for AddXxxDevice functions
B(48h) DelDrv(device_name_lowercase)
B(5Bh) ChangeClearPAD(int) ;pad AND card (ie. used also for Card)

```

```

C(15h) _cdevinput(circ, char)
C(16h) _cdevscan()
C(17h) _circgetc(circ)      ;uses r5 as garbage txt for _ioabort
C(18h) _circputc(char, circ)

```

Device Names

Device Names are case-sensitive (usually lowercase, eg. "bu" for memory cards). In filenames, the device name may be followed by a hexadecimal 32bit non-case-sensitive port number (eg. "bu00:" for selecting the first memory card slot). Accordingly, the device name should not end with a hexdigit (eg. "usb:" would be treated as device "us" with port number 0Bh).

Standard device names are "cdrom:", "bu00:", "bu10:", "tty00:". Other, nonstandard devices are:

```

Castlevania is trying to access an unknown device named "sim:".
Caetla (a firmware replacement for Cheat Devices) supports "pcdrv:" device.

```

21.22 BIOS PC File Server

DTL-H2000

Below BRK's are internally used in DTL-H2000 BIOS for two devices: "mwin:" (Message Window) and "sim:" (CDROM Sim).

Caetla Blurb

Caetla (a firmware replacement for Cheat Devices) supports "pcdrv:" device, the SN systems (=what?) device extension to access files on the drive of the pc. This fileserver can be accessed by using the kernel functions, with the "pcdrv:" device name prefix to the filenames or using the SN system calls.

The following SN system calls for the fileserver are provided. Accessed by setting the registers and using the break command with the specified field.

The break functions have argument(s) in A1,A2,A3 (ie. unlike normal BIOS functions not in A0,A1,A2), and TWO return values (in V0, and V1).

BRK(101h) - PCInit() - Inits the fileserver

No parameters.

BRK(102h) - PCCreat(filename, fileattributes) - Creates a new file on PC

```
out: V0  0 = success, -1 = failure
      V1  file handle or error code if V0 is negative
```

Attributes Bits (standard MSDOS-style):

bit0	Read only file	(R)
bit1	Hidden file	(H)
bit2	System file	(S)
bit3	Not used	(zero)
bit4	Directory	(D)
bit5	Archive file	(A)
bit6-31	Not used	(zero)

BRK(103h) - PCOpen(filename, accessmode) - Opens a file on the PC

```
out: V0  0 = success, -1 = failure
      V1  file handle or error code if V0 is negative
```

BRK(104h) - PCClose(filehandle) - Closes a file on the PC

```
out: V0  0 = success, -1 = failure
      V1  0 = success, error code if V0 is negative
```

BRK(105h) - PCRead(filehandle, length, memory_destination_address)

```
out: V0  0 = success, -1 = failure
      V1  number of read bytes or error code if V0 is negative.
```

Note: PCRead does not stop at EOF, so if you set more bytes to read than the filelength, the fileserver will pad with zero bytes. If you are not sure of the filelength obtain the filelength by PCISseek (A2=0, A3=2, V1 will return the length of the file, don't forget to reset the file pointer to the start before calling PCread!)

BRK(106h) - PCWrite(filehandle, length, memory_source_address)

```
out: V0  0 = success, -1 = failure
      V1  number of written bytes or error code if V0 is negative.
```

BRK(107h) - PCISseek(filehandle, file_offset, seekmode) - Change Filepos

seekmode may be from 0=Begin of file, 1=Current fpos, or 2=End of file.

```
out: V0  0 = success, -1 = failure
      V1  file pointer
```

21.23 BIOS TTY Console (std_io)

A(3Fh) - Printf(txt,param1,param2,etc.) - Print string to console

```
in:  A0          Pointer to 0 terminated string
      A1,A2,A3, [SP+10h..]  Argument(s)
```

Prints the specified string to the TTY console. Printf does internally use "putchar" to output the separate characters (and expands char 09h and 0Ah accordingly).

The string can contain C-style escape codes (prefixed by "%" each):

```
c      display ASCII character
s      display ASCII string
i,d,D  display signed Decimal number (d/i=default32bit, D=force32bit)
u,U    display unsigned Decimal number (u=default32bit, U=force32bit)
o,O    display unsigned Octal number (o=default32bit, O=force32bit)
p,x,X  display unsigned Hex number (p=lower/force32bit, x=lower, X=upper)
n      write 32bit/16bit string length to [parameter] (default32bit)
```

Additionally, following prefixes (inserted between "%" and escape code):

```
+ or SPC show leading plus or space character in positive signed numbers
NNN      fixed width (for padding or so) (first digit must be 1..9) (not 0)
.NNN     fixed width (for clipping or so)
*        variable width (using one of the parameters) (negative=ending_spc)
.*       variable width
-        force ending space padding (in case of width being specified)
#        show leading "0x" or "0X" (hex), or ensure 1 leading zero (octal)
0        show leading zero's
L        unknown/no effect?
h,l      force 16bit (h=halfword), or 32bit (l=long/word)
```

The force32bit codes (D,U,O,p,l) are kinda useless since the PSX defaults to 32bit parameters anyways. The force16bit code (h) may be useful as "%hn" (writeback 16bit value), otherwise it's rather useless, unless signed 16bit parameters have garbage in upper 16bit, for unsigned 16bit parameters it doesn't work at all (accidently sign-expands

16bit to 32bit, and then displays that signed 32bit value as giant unsigned value). Printf supports only octal, decimal, and hex (but not binary).

A(3Eh) or B(3Fh) - puts(src) - Write string to TTY

```
in: R4=address of string (terminated by 00h)
```

Like "printf", but doesn't resolve any "%" operands. Empty strings are handled in a special way: If R4 points to a 00h character then nothing is output (as one would expect it), but, if R4 is 00000000h then "\<NULL>" is output (only that six letters; without appending any CR or LF).

A(3Dh) or B(3Eh) - gets(dst) - Read string from TTY (keyboard input)

```
in: r4=dst (pointer to a 128-byte buffer) - out: r2=dst (same is incoming r4)
```

Internally uses "getchar" to receive the separate characters (which are thus masked by 7Fh). The received characters are stored in the buffer, and are additionally sent back as echo to the TTY via std_out_putc.

The following characters are handled in a special way: 09h (TAB) is replaced by a single SPC. 08h or 7Fh (BS or DEL) are removing the last character from the buffer (unless it is empty) and send 08h,20h,08h (BS,SPC,BS) to the TTY. 0Dh or 0Ah (CR or LF) do terminate the input (append 00h to the buffer, send 0Ah to the TTY, which is expanded to 0Dh,0Ah by the std_out_putc function, and do then return from the gets function).

The sequence 16h,NNh forces NNh to be stored in the buffer (even if NNh is a special character like 00h..1Fh or 7Fh). If the buffer is full (circa max 125 chars, plus one extra byte for the ending 00h), or if an unknown control code in range of 00h..1Fh is received without the 16h prefix, then 07h (BELL) is sent to the TTY.

A(3Bh) or B(3Ch) - getchar() - Read character from TTY

Reads one character from the TTY console, by internally redirecting to "read(0,tempbuf, 1)". The returned character is ANDed by 7Fh (so, to read a fully intact 8bit character, "read(0,tempbuf,1)" must be used instead of this function).

A(3Ch) or B(3Dh) - putchar(char) - Write character to TTY

Writes the character to the TTY console, by internally redirecting to "write(1,tempbuf, 1)". Char 09h (TAB) is expanded to one or more SPC characters, until reaching the next tabulation boundary (every 8 characters). Char 0Ah (LF) is expanded to 0Dh,0Ah

(CR,LF). Other special characters (which should be handled at the remote terminal side) are 08h (BS, backspace, move cursor one position to the left), and 07h (BELL, produce a short beep sound).

C(13h) - FlushStdInOutPut()

Closes and re-opens the std_in (fd=0) and std_out (fd=1) file handles.

C(1Bh) - KernelRedirect(ttyflag) ;PS2: ttyflag=1 causes SystemError

Removes, re-mounts, and flushes the TTY device, the parameter selects whether to mount the real DUART-TTY device (r4=1), or a Dummy-TTY device (r4=0), the latter one sends any std_out to nowhere. Values other than r4=0 or r4=1 do remove the device, but do not re-mount it (which might result in problems).

Caution: Trying to use r4=1 on a PSX that does not has the DUART hardware installed causes the BIOS to hang (so one should first detect the DUART hardware, eg. by writing two different bytes to Port 1F802020h.1st/2nd access, and the read and verify that two bytes).

Activating std_io

The std_io functions can be enabled via C(1Bh) KernelRedirect(ttyflag), the BIOS is unable to detect the presence of the TTY hardware, by default the BIOS bootcode disables std_io by setting the initial KernelRedirect value at [A000B9B0h] to zero, this is hardcoded shortly after the POST(E) output:

```
call    output_post_r4      ;\output POST(E)
+mov    r4,0Eh              ;/
mov     r1,0A0010000h       ;\set [0A000B9B0h]=0 ;TTY=dummy/off
call    reset_cont_d_3      ; and call reset_cont_d_3
+mov    [r1-4650h],0        ;/
```

assuming that R28=A0010FF0h, the last 3 opcodes of above code can be replaced by:

```
mov     r1,1h               ;\set [0A000B9B0h]=1 ;TTY=duart/on
call    reset_cont_d_3      ; and call reset_cont_d_3
+mov    [r28-4650h-0ff0h],r1 ;/
```

with that patch, the BIOS bootcode (and many games) are sending debug messages to the debug terminal, via expansion port, see:

[EXP2 Dual Serial Port \(for TTY Debug Terminal\)](#)

Note: The nocash BIOS automatically detects the DUART hardware, and activates TTY if it is present.

B(49h) - PrintInstalledDevices()

Uses printf to display the long and short names from the DCB of the currently installed devices. Doesn't do anything else. There's no return value.

Note

Several BIOS functions are internally using printf to output status information, timeout, and error messages, etc. So, trying to close the TTY file handles (fd=0 and fd=1) would cause such functions to work unstable.

21.24 BIOS Character Sets

B(51h) - Krom2RawAdd(shiftjis_code)

```
In: r4 = 16bit Shift-JIS character code
Out: r2 = address in BIOS ROM of the desired character (or -1 = error)
```

r4 should be 8140h..84BEh (charset 2), or 889Fh..9872h (charset 3).

B(53h) - Krom2Offset(shiftjis_code)

```
In: r4 = 16bit Shift-JIS character code
Out: r2 = offset within charset (without charset base address)
```

This is a subfunction for B(51h) Krom2RawAdd(shiftjis_code).

Character Sets in ROM (112Kbytes)

The character sets are located at BFC64000h and up, intermixed with some other stuff:

```
BFC64000h  Charset 1 (16x15 pix, letters with accent marks)      (NOT in JAPAN)
BFC65CB6h  Garbage      (four-and-a-half reverb tables, ioports, printf strings)
BFC66000h  Charset 2 (16x15 pix, various alphabets, english, greek, etc.)
BFC69D68h  Charset 3 (16x15 pix, japanese or chinese symbols or so)
BFC7F8DEh  Charset 4 (8x15 pix, mainly ASCII letters)
BFC7FE6Fh  Charset 5 (8x15 pix, additional punctuation marks)   (NOT in PS2)
BFC7FF32h  Version      (Version and Copyright strings)          (NOT in SCPH1000)
```

```
BFC7FF8Ch  Charset 6 (8x15 pix, seven-and-a-half japanese chars) (NOT in PS2)
BFC80000h  End      (End of 512kBYTE BIOS ROM)
```

Charset 1 (and Garbage) is NOT included in japanese BIOSes (in the SCPH1000 version that region contains uncompressed program code, in newer japanese BIOSes that regions are zero-filled)

Charset 1 symbols are as defined in JIS-X-0212 char(2661h..2B77h), and EUC-JP char(8FA6E1h..8FABF7h).

Version (and Copyright) string is NOT included in SCPH1000 version (that BIOS includes further japanese 8x15 pix chars in that region).

For charset 2 and 3 it may be recommended to use the B(51h)

Krom2RawAdd(shiftjis_code) to obtain the character addresses. Not sure if that BIOS function (or another BIOS function) allows to retrieve charset 1, 4, 5, and 6 addresses?

Charset 4 is halfwidth, single-byte Shift JIS codes 21h through 7Eh. This matches ASCII except code 5Ch which is the halfwidth yen sign (¥) and 7Eh which is overline (¯).

Charset 5 contains overhead/combining tilde, backslash (\), broken bar (¡), Shift JIS codes A1h through A5h and B0h, DEh, and DFh, left double quotation mark ("), left single quotation mark ('), and tilde (~).

Charset 6 is Shift JIS codes 82A5h through 82ACh, but in halfwidth, and the last one is cut off.

21.25 BIOS Control Blocks

Exception Control Blocks (ExCB) (4 blocks of 8 bytes each)

```
00h 4  ptr to first element of exception chain
04h 4  not used (zero)
```

Event Control Blocks (EvCB) (usually 16 blocks of 1Ch bytes each)

```
00h 4  class  (events are triggered when class and spec match)
04h 4  status (0=free,1000h=disabled,2000h=enabled/busy,4000h=enabled/ready)
08h 4  spec   (events are triggered when class and spec match)
0Ch 4  mode   (1000h=execute function/stay busy, 2000h=no func/mark ready)
10h 4  ptr to function to be executed when ready (or 0=none)
14h 8  not used (uninitialized)
```

Thread Control Blocks (TCB) (usually 4 blocks of 0C0h bytes each)

```

00h 4   status      (1000h=Free TCB, 4000h=Used TCB)
04h 4   not used    (set to 1000h by OpenTh) (not for boot executable?)
08h 80h r0..r31     (entries for r0/zero and r26/k0 are unused)
88h 4   cop0r14/epc (aka r26/k0 and pc when returning from exception)
8Ch 8   hi,lo       (the mul/div registers)
94h 4   cop0r12/sr   (stored/restored by exception, NOT init by OpenTh)
98h 4   cop0r13/cause (stored when entering exception, NOT restored on exit)
9Ch 24h not used    (uninitialized)

```

Process Control Block (1 block of 4 bytes)

```

00h 4   ptr to TCB of current thread

```

The PSX supports only one process, and thus only one Process Control Block.

File Control Blocks (FCB) (16 blocks of 2Ch bytes each)

```

00h 4   status (0=Free FCB) (nonzero=accessmode)
04h 4   cdrom: disk_id (checksum across path table of the corresponding disk),
        memory card: port number (00h=slot1, 10h=slot2)
08h 4   transfer address (for dev_in_out function)
0Ch 4   transfer length (for dev_in_out function)
10h 4   current file position
14h 4   device flags (copy of DCB[04h])
18h 4   error ;used by B(55h) - _get_error(fd)
1Ch 4   Pointer to DCB for the file
20h 4   filesize
24h 4   logical block number (start of file) (for cdrom: at least)
28h 4   file control block number (simply 0..15 for FCB number 0..15)

```

Device Control Blocks (DCB) (10 blocks of 50h bytes each)

```

00h 4   ptr to lower-case short name ("cdrom", "bu", "tty") (or 0=Free DCB)
04h 4   device flags (cdrom=14h, bu=14h, tty/dummy=1, tty/duart=3)
08h 4   sector size (cdrom=800h, bu=80h, tty=1)
0Ch 4   ptr to upper-case long name ("CD-ROM", "MEMORY CARD", "CONSOLE")
10h 4   ptr to init() (TTY only)
14h 4   ptr to open(fcb,"path\name",accessmode)
18h 4   ptr to in_out(fcb,cmd) (TTY only)
1Ch 4   ptr to close(fcb)
20h 4   ptr to ioctl(fcb,cmd,arg) (TTY only)
24h 4   ptr to read(fcb,dst,len)
28h 4   ptr to write(fcb,src,len)
2Ch 4   ptr to erase(fcb,"path\name")
30h 4   ptr to undelete(fcb,"path\name")
34h 4   ptr to firstfile2(fcb,"path\name",dirent)
38h 4   ptr to nextfile(fcb,dirent)
3Ch 4   ptr to format(fcb)

```

```

40h 4   ptr to cd(fcb,"path")                                (CDROM only)
44h 4   ptr to rename(fcb1,"path\name1",fcb2,"path\name2")
48h 4   ptr to remove()
4Ch 4   ptr to testdevice(fcb,"path\name")

```

21.26 BIOS Versions

Kernel Versions

For the actual kernel, there seem to be only a few different versions. Most PSX/PSone's are containing the version from 1995 (which is kept 1:1 the same in all consoles; without any PAL/NTSC related customizations).

```

28-Jul-1994  "DTL-H2000"                                ;v0.x (pre-retail devboard)
22-Sep-1994  "CEX-1000 KT-3  by S.O."                    ;v1.0 through v2.0
no-new-date  "CEX-3000 KT-3  by K.S."                    ;v2.1 only (old Port 1F801060h)
27-Jul-1995  "Konami OS by T.H."                        ;Twinkle System
01-Sep-1995  "Konami OS by T.H."                        ;Konami GV, GQ, System 573
04-Dec-1995  "CEX-3000/1001/1002 by K.S."                ;v2.2 through v4.5 (except v4.0)
29-May-1997  "CEX-7000/-7001 by K.S."                    ;v4.0 only (new Port 1F801010h)
17-Jan-2000  "PS compatible mode by M.T."                ;v5.0 (Playstation 2)

```

The date and version string can be retrieved via `GetSystemInfo(index)`.

The "CEX-7000/-7001" version was only "temporarily" used (when the kernel/gui grew too large they changed the ROM size from 512K to 1024K; but did then figure out that they could use a self-decompressing GUI to squeeze everything into 512K; but they did accidentally still use the 1024K setting) (newer consoles fixed that and switched back to the old version from 1995) (aside from the different date/version string, the only changed thing is the opcode at BFC00000h, which initializes port 1F801010h to BIOS ROM size of 1MB, instead of 512KB; no idea if that BIOS does actually contain additional data?).

The "CEX-3000 KT-3" version is already almost same as "CEX-3000/1001/1002", aside from version/date, the only differences are at offset BFC00014h..1Fh, and BFC003E0h (both related to Port 1F801060h).

Bootmenu/Intro Versions

This portion was updated more often. It's customized for PAL/NTSC displays, japanese/english language, and (maybe?) region/licence string checks. The SCPH1000 uses uncompressed Bootmenu/Intro code with "<S>" intro, but without "PS" intro (or, "PS" is shown only on region matches?), newer versions are using selfdecompressing code, with both intro screens. The GUI in older PSX models looks like a drawing program for

children, the GUI in newer PSX models and in PSone's looks more like a modernized bathroom furniture, unknown how the PS2 GUI looks like?

Games are communicating only with the Kernel, so the differences in the Bootmenu/Intro part should have little or effect on compatibility (although some I/O ports might be initialized differently, and although some games might (accidently) read different (garbage) values from the ROM).

Ver	CRC32	Used in	System ROM Version	Kernel
0.xj	18D0F7D8	DTL-H2000	(no version string)	dtlh2000
1.0j	3B601FC8	SCPH-1000 and DTL-H1000	(no version string)	cex1000
1.1j	3539DEF6	SCPH-3000 and DTL-H1000H	"1.1 01/22/95"	""
2.0a	55847D8C	DTL-H1001	"2.0 05/07/95 A"	""
2.0e	9BB87C4B	SCPH-1002 and DTL-H1002	"2.0 05/10/95 E"	""
2.1j	BC190209	SCPH-3500	"2.1 07/17/95 J"	cex3000
2.1a	AFF00F2F	SCPH-1001 and DTL-H1101	"2.1 07/17/95 A"	""
2.1e	86C30531	SCPH-1002 and DTL-H1102	"2.1 07/17/95 E"	""
2.2j	24FC7E17	SCPH-5000 and DTL-H1200	"2.2 12/04/95 J"	cex3000/100x
2.2a	37157331	SCPH-1001 and DTL-H1201/3001	"2.2 12/04/95 A"	""
2.2e	1E26792F	SCPH-1002 and DTL-H1202/3002	"2.2 12/04/95 E"	""
2.2v	446EC5B2	SCPH-5903 (VCD, 1Mbyte)	"2.2 12/04/95 J"	""
2.2d	DECB22F5	DTL-H1100	"2.2 03/06/96 D"	""
3.0j	FF3EEB8C	SCPH-5500	"3.0 09/09/96 J"	""
3.0a	8D8CB7E4	SCPH-5501/7003	"3.0 11/18/96 A"	""
3.0e	D786F0B9	SCPH-5502/5552	"3.0 01/06/97 E"	""
4.0j	EC541CD0	SCPH-7000/9000	"4.0 08/18/97 J"	cex7000
4.1w	B7C43DAD	SCPH-7000W	...XXX...	
4.1a	502224B6	SCPH-7001/7501/7503/9001	"4.1 12/16/97 A"	cex3000/100x
4.1e	318178BF	SCPH-7002/7502/9002	"4.1 12/16/97 E"	""
4.3j	F2AF798B	SCPH-100 (PSone)	"4.3 03/11/00 J"	""
4.4a	6A0E22A0	SCPH-101 (PSone)	"4.4 03/24/00 ..XXX..	
4.4e	0BAD7EA9	SCPH-102 (PSone)	"4.4 03/24/00 E"	""
4.5a	171BDCEC	SCPH-101 (PSone)	"4.5 05/25/00 A"	""
4.5e	76B880E5	SCPH-102 (PSone)	"4.5 05/25/00 E"	""
5.0t	B7EF81A9	SCPH10000 (Playstation 2)	"5.0 01/17/00 T"	PS compatible

The System ROM Version string can be found at BFC7FF32h (except in v1.0).

v2.2j/a/e use exactly the same GUI as v2.1 (only the kernel was changed). v2.2d is almost same as v2.2j (but with some GUI patches or so).

v4.1 and v4.5 use exactly the same GUI code for "A" and "E" regions (the only difference is the last byte of the version string; which does specify whether the GUI shall use PAL or NTSC).

v5.0 is playstation 2 bios (4MB) with more or less backwards compatible kernel.

Character Set Versions

The 16x15 pixel charsets at BFC66000h and BFC69D68h are included in all BIOSes, however, the 16x15 portion for letters with accent marks at BFC64000h is included only in non-japanese BIOSes, and in some newer japanese BIOSes (not included in v4.0j, but they are included in v4.3j).

The 8x15 pixel charset with characters 21h..7Fh is included in all BIOSes. In the SCPH1000, this region is followed by additional 8x15 punctuation marks at char 80h and up, however, this region is missing in PS2 BIOS. Moreover, some BIOSes include an incomplete 8x15 japanese character set (which ends abruptly at BF7FFFFh), in newer BIOSes, some of theses chars are replaced by the version string at BFC7FF32h, and, the remaining 8x15 japanese chars were removed in the PS2 BIOS version.

21.27 BIOS Patches

The original PSX Kernel mainly consists of messy and unstable compiler generated code, and, to the worst, the \<same> author seems to have attempted to use assembler code in some places. In result, most commercial games are causing a greater mess by inserting patches in the kernel code...

Which has been a nasty surprise when making the nocash PSX bios; which obviously wasn't compatible with these patches. The only solutions would have been to insert hundreds of NOPs to make my bios \<exactly> as bloated as the original bios (which I really didn't want to do), or to create anti-patch-patches.

Patches and Anti-Patch-Patches

As shown below, all known patches are invoked by a B(56h) or B(57h) function call. In the nocash PSX bios, these two functions are examining the following opcodes, if the opcodes are a known patch, then the BIOS reproduces the desired behaviour, and does then continue normal execution after those opcodes. If the opcodes are unknown, then the BIOS simply locks up; and shows an error message with the address of that opcodes in the TTY window; info about any such unknown opcodes would be welcome!

Compatibility

If you want to (or need to) use patches, please use byte-identical opcodes as commercial games do (as shown below; only the "xxxx" address digits are don't care), so the nocash PSX bios (or other homebrewn BIOSes) can detect and reproduce them.

Or alternately, don't use the BIOS, and access I/O ports directly, which is much better and faster anyways.

patch_missing_cop0r13_in_exception_handler:

In newer Kernel version, the exception handler reads cop0r13/cause to r2, examines the Excode value in r2, and if the exception was caused by an interrupt, and if the next opcode (at EPC) is a GTE/COP2 command, then it does increment EPC by 4. The GTE commands are executed even if an interrupt occurs simultaneously, so, without adjusting EPC, the command would be executed twice. With some commands that'd just waste some clock cycles, with other commands it may cause data to be written twice to the GTE FIFOs, or may re-use the result from the 1st command execution as input to the 2nd execution.

The old "CEX-1000 KT-3" Kernel version did examine r2, but it "forgot" to previously load cop0r13 to r2, so it did randomly examine a garbage value. The patch inserts the missing opcode, used in elo2 at 80033740h, and in Pandemonium II at 8007F3FCh:

```

240A00B0 mov  r10,0B0h          ;\  00000000 nop
0140F809 call r10                ;   00000000 nop
24090056 +mov  r9,56h            ;/  241A0100 mov  k0,100h
3C0Axxxx mov  r10,xxxx0000h     ;\  8F5A0008 mov  k0,[k0+8h]
3C09xxxx mov  r9,xxxx0000h     ;   00000000 nop
8C420018 mov  r2,[r2+06h*4] ;=C(06h) ; 8F5A0000 mov  k0,[k0]
254Axxxx add  r10,xxxxh ;=@@new_data ; 00000000 nop
2529xxxx add  r9,xxxxh ;=@@new_data_end ;/ 235A0008 addt k0,8h
      @@copy_lop:                ;\  AF410004 mov  [k0+4h],r1
8D430000 mov  r3,[r10]           ;   AF420008 mov  [k0+8h],r2
254A0004 add  r10,4h             ;   AF43000C mov  [k0+0Ch],r3
24420004 add  r2,4h              ;   AF5F007C mov  [k0+7Ch],ra
1549FFFC jne  r10,r9,@@copy_lop ;   40026800 mov  r2,cop0r13
AC43FFFC +mov  [r2-4h],r3        ;/  00000000 nop

```

Alternately, same as above, but using k0/k1 instead of r10/r9, used in Ridge Racer at 80047B14h:

```

240A00B0 mov  r10,0B0h          ;\  00000000 nop
0140F809 call r10                ;   00000000 nop
24090056 +mov  r9,56h            ;/  241A0100 mov  k0,100h
3C1Axxxx mov  k0,xxxx0000h     ;\  8F5A0008 mov  k0,[k0+8h]
3C1Bxxxx mov  k1,xxxx0000h     ;   00000000 nop
8C420018 mov  r2,[r2+06h*4] ;=C(06h) ; 8F5A0000 mov  k0,[k0]
275Axxxx add  k0,xxxxh ;=@@new_data ; 00000000 nop
277Bxxxx add  k1,xxxxh ;=@@new_data_end ;/ 235A0008 addt k0,8h
      @@copy_lop:                ;\  AF410004 mov  [k0+4h],r1
8F430000 mov  r3,[k0]           ;   AF420008 mov  [k0+8h],r2
275A0004 add  k0,4h             ;   AF43000C mov  [k0+0Ch],r3

```



```

24420004 add    r2,4h                ;      AF5F007C mov    [k0+7Ch],ra
175BFFFC jne    k0,k1,@@copy_lop    ;      40026800 mov    r2,cop0r13
AC43FFFC +mov   [r2-4h],r3           ;/      00000000 nop

```

Alternately, slightly different code used in `metal_gear_solid` at `80095CC0h`, and in `alone1` at `800A3ECCh`:

```

24090056 mov    r9,56h                ;\
240A00B0 mov    r10,0B0h              ; B(56h) GetC0Table
0140F809 call   r10                  ;
00000000 +nop                        ;/
8C420018 mov    r2,[r2+06h*4] ;=00000C80h = exception_handler = C(06h)
00000000 nop
24420028 add    r2,28h
00407821 mov    r15,r2
3C0Axxxx lui    r10,xxxxh ;\@@ori_data ;\
254Axxxx add    r10,xxxxh ;/
3C09xxxx lui    r9,xxxxh ;\@@ori_data_end ; @@ori_data:
2529xxxx add    r9,xxxxh ;/          ; AF410004 mov [k0+4h],r1
      @@verify_lop:                  ; AF420008 mov [k0+8h],r2
8D430000 mov    r3,[r10]              ; AF43000C mov [k0+0Ch],r3
8C4B0000 mov    r11,[r2]              ; AF5F007C mov [k0+7Ch],ra
254A0004 add    r10,4h                ; 40037000 mov r3,cop0r14
146B000E jne    r3,r11,@@verify_mismatch ; 00000000 nop
24420004 +add   r2,4h                ;
1549FFFA jne    r10,r9,@@verify_lop  ;
00000000 +nop                        ;/
01E01021 mov    r2,r15
3C0Axxxx lui    r10,xxxxh ;\@@new_data ;\
254Axxxx add    r10,xxxxh ;/
3C09xxxx lui    r9,xxxxh ;\@@new_data_end ; @@new_data:
2529xxxx add    r9,xxxxh ;/          ; AF410004 mov [k0+4h],r1
      @@copy_lop:                    ; AF420008 mov [k0+8h],r2
8D430000 mov    r3,[r10]              ; 40026800 mov r2,cop0r13
00000000 nop                        ; AF43000C mov [k0+0Ch],r3
AC430000 mov    [r2],r3               ; 40037000 mov r3,cop0r14
254A0004 add    r10,4h                ; AF5F007C mov [k0+7Ch],ra
1549FFFB jne    r10,r9,@@copy_lop    ;
24420004 +add   r2,4h                ;/
      @@verify_mismatch:

```

Alternately, a bugged/nonfunctional homebrew variant (used by Hitmen's "minimum" demo):

```

;BUG1: 8bit "movb r6" should be 32bit "mov r6"
;BUG2: @@copy_lop should transfer 6 words (not 7 words)
;BUG3: and, asides, the minimum demo works only with PAL BIOS (not NTSC)
0xxxxxxx call   xxxxxxxxh            ;\B(56h) GetC0Table
00000000 +nop                        ;/(mov r8,0B0h, jmp r8, +mov r9,56h)
3C04xxxx mov    r4,xxxx0000h ;\@@ori_data
2484xxxx add    r4,xxxxh            ;/
90460018 movb   r6,[r2+06h*4] ;BUG1 ;exception_handler = C(06h)

```

```

24870018 add r7,r4,18h ;@@ori_end ;\
24C50028 add r5,r6,28h ;C(06h)+28h ;
00A03021 mov r6,r5 ; @@ori_data:
    @@verify_lop: ; 80086520 AF410004 mov [k0+4h],r1
8CA30000 mov r3,[r5] ; 80086524 AF420008 mov [k0+8h],r2
8C820000 mov r2,[r4] ; 80086528 AF43000C mov [k0+0Ch],r3
00000000 nop ; 8008652C AF5F007C mov [k0+7Ch],ra
1462000C jne r3,r2,@@verify_mismatch ; 80086530 40037000 mov r3,cop0r14
24840004 +add r4,4h ; 80086534 00000000 nop
1487FFFA jne r4,r7,@@verify_lop ; @@ori_end:
24A50004 +add r5,4h ;/
00C02821 mov r5,r6 ;\ @@new_data:
3C04xxxx mov r4,xxxx0000h ;\@@new_data; 80086538 AF410004 mov [k0+4h],r1
2484xxxx add r4,xxxxh ;/ ; 8008653C AF420008 mov [k0+8h],r2
2483001C add r3,r4,1Ch ;@@bugged_end ; 80086540 40026800 mov r2,cop0r13
    @@copy_lop: ; 80086544 AF43000C mov [k0+0Ch],r3
8C820000 mov r2,[r4] ; 80086548 40037000 mov r3,cop0r14
24840004 add r4,4h ; 8008654C AF5F007C mov [k0+7Ch],ra
ACA20000 mov [r5],r2 ; @@new_end:
1483FFFC jne r4,r3,@@copy_lop ; 80086550 00000000 nop ;BUG2
24A50004 +add r5,4h ;/ @@bugged_end:
    @@verify_mismatch:

```

early_card_irq_patch:

Because of a hardware glitch the card IRQ cannot be acknowledged while the external IRQ signal is still LOW, making it necessary to insert a delay that waits until the signal gets HIGH before acknowledging the IRQ.

The original BIOS is so inefficient that it takes hundreds of clock cycles between the interrupt request and the IRQ acknowledge, so, normally, it doesn't require an additional delay.

However, the central mistake in the IRQ handler is that it doesn't memorize which IRQ has originally triggered the interrupt. For example, it may get triggered by a timer IRQ, but a newer card IRQ may occur during IRQ handling, in that case, the card IRQ may get processed and acknowledged without the required delay.

Used in Metal Gear Solid at 8009AA5Ch, and in alone1 at 800AE2F8h:

```

24090056 mov r9,56h ;\ ; @@new_data:
240A00B0 mov r10,0B0h ; B(56h) GetC0Table ;3C02A001 lui r2,0A001h
0140F809 call r10 ; ;2442DFAC sub r2,2054h
00000000 +nop ;/ ;00400008 jmp r2 ;=@@new_cont_d
8C420018 mov r2,[r2+06h*4] ;\get C(06h) ;00000000 +nop ;=A000DFACH
00000000 nop ;/ ;00000000 nop
8C430070 mov r3,[r2+70h] ;\ ; @@new_data_end:
00000000 nop ; get ; @@new_cont_d:
3069FFFF and r9,r3,0FFFFh ; early_card ;8C621074 mov r2,[r3+1074h]
00094C00 shl r9,10h ; irq_handler ;00000000 nop
8C430074 mov r3,[r2+74h] ; ;30420080 and r2,80h ;I_STAT.7

```

```

00000000 nop ; ;1040000B jz r2,@@ret
306AFFFF and r10,r3,0FFFFh ;/ ;00000000 +nop
012A1821 add r3,r9,r10 ; @@wait_lop:
24620028 add r2,r3,28h ;=early+28h ;8C621044 mov r2,[r3+1044h]
3C0Axxxx lui r10,xxxxh ;\@@new_data ;00000000 nop
254Axxxx sub r10,xxxxh ;/ ;30420080 and r2,80h ;JOY_STAT.7
3C09xxxx lui r9,xxxxh ;\@@new_data_end ;1440FFFC jnz r2,@@wait_lop
2529xxxx sub r9,xxxxh ;/ ;00000000 +nop
@@copy_lop: ;3C020001 lui r2,0001h
8D430000 mov r3,[r10] ;8C42DFFC mov r2,[r2-2004h]
00000000 nop ;00000000 nop
AC430000 mov [r2],r3 ;00400008 jmp r2 ;=[0000DFFCh]
254A0004 add r10,4h ;00000000 +nop
1549FFFB jne r10,r9,@@copy_lop ; @@ret:
24420004 +add r2,4h ;03E00008 ret
3C010001 lui r1,0001h ;\[DFFCh]=r2 ;00000000 +nop
0xxxxxxx call xxxxxxxxh ; and call ... ;
AC22DFFC +mov [r1-2004h],r2 ;/ ;

```

Alternately, elo2 uses slightly different code at 8003961Ch:

```

240A00B0 mov r10,0B0h ;\ ; @@new_data:
0140F809 call r10 ; B(56h) GetC0Table ;3C02xxxx lui r2,8xxxxh
24090056 +mov r9,56h ;/ ;2442xxxx sub r2,xxxxh
8C420018 mov r2,[r2+06h*4] ;\get C(06h) ;00400008 jmp r2 ;=@@new_cont_d
00000000 nop ;/ ;00000000 +nop ;=8xxxxxxxh
8C430070 mov r3,[r2+70h] ;\ ;00000000 nop
00000000 nop ; get ; @@new_data_end:
3069FFFF and r9,r3,0FFFFh ; early_card ; @@new_cont_d:
8C430074 mov r3,[r2+74h] ; irq_handler ;8C621074 mov r2,[r3+1074h]
00094C00 shl r9,10h ; ;00000000 nop
306AFFFF and r10,r3,0FFFFh ; ;30420080 and r2,80h ;I_STAT.7
012A1821 add r3,r9,r10 ;/ ;1040000B jz r2,@@ret
3C0Axxxx mov r10,xxxx0000h ;00000000 +nop
3C09xxxx mov r9,xxxx0000h ; @@wait_lop:
24620028 add r2,r3,28h ;=early+28h ;8C621044 mov r2,[r3+1044h]
254Axxxx sub r10,xxxxh ;=@@new_data ;00000000 nop
2529xxxx sub r9,xxxxh ;=@@new_data_end ;30420080 and r2,80h ;JOY_STAT.7
@@copy_lop: ;1440FFFC jnz r2,@@wait_lop
8D430000 mov r3,[r10] ;00000000 +nop
254A0004 add r10,4h ;3C02xxxx lui r2,8xxxxh
24420004 add r2,4h ;8C42xxxx mov r2,[r2-xxxxh]
1549FFFC jne r10,r9,@@copy_lop ;00000000 nop
AC43FFFC +mov [r2-4h],r3 ;00400008 jmp r2 ;=[8xxxxxxxh]
3C018xxx mov r1,8xxx0000h ;\[...]=r2, ;00000000 +nop
0xxxxxxx call xxxxxxxxh ; and call ... ; @@ret:
AC22xxxx +mov [r1+xxxxh],r2 ;/ ;03E00008 ret
... ;00000000 +nop

```

Note: The above @@wait_lop's should be more preferably done with timeouts (else they may hang endless if a Sony Mouse is newly connected; the mouse does have /ACK stuck LOW on power-up).

patch_uninstall_early_card_irq_handler:

Used to uninstall the "early_card_irq_vector" (the BIOS installs that vector from inside of B(4Ah) InitCARD2(pad_enable), and, without patches, the BIOS doesn't allow to uninstall it thereafter).

Used in Breath of Fire III (SLES-01304) at 8017E790, and also in Ace Combat 2 (SLUS-00404) at 801D23F4:

```

240A00B0 mov  r10,0B0h          ;\
0140F809 call r10              ; B(56h) GetC0Table
24090056 +mov  r9,56h          ;/
3C0Axxxx mov  r10,xxxx0000h
3C09xxxx mov  r9,xxxx0000h
8C420018 mov  r2,[r2+06h*4] ;=00000C80h = exception_handler = C(06h)
254Axxxx add  r10,xxxxh ;@@new_data
2529xxxx add  r9,xxxxh ;@@new_data_end
      @@copy_lop:              ;\  @@new_data:
8D430000 mov  r3,[r10]          ;    00000000 nop
254A0004 add  r10,4h            ;    00000000 nop
24420004 add  r2,4h            ;    00000000 nop
1549FFFC jne  r10,r9,@@copy_lop ;  @@new_data_end:
AC43006C +mov  [r2+70h-4],r3    ;/

```

Alternately, more inefficient, used in Blaster Master-Blasting Again (SLUS-01031) at 80063FF4h, and Raiden DX at 80029694h:

```

24090056 mov  r9,56h          ;\
240A00B0 mov  r10,0B0h          ; B(56h) GetC0Table
0140F809 call r10              ;
00000000 +nop                  ;/
8C420018 mov  r2,[r2+06h*4] ;=00000C80h = exception_handler = C(06h)
3C0Axxxx mov  r10,xxxx0000h ;\@@new_data
254Axxxx add  r10,xxxxh ;/
3C09xxxx mov  r9,xxxx0000h ;\@@new_data_end
2529xxxx add  r9,xxxxh ;/
      @@copy_lop:              ;\
8D430000 mov  r3,[r10]          ;  @@new_data:
00000000 nop                  ;    00000000 nop
AC430070 mov  [r2+70h],r3      ;    00000000 nop
254A0004 add  r10,4h ;src      ;    00000000 nop
1549FFFB jne  r10,r9,@@copy_lop ;  @@new_data_end:
24420004 +add  r2,4h ;dst      ;/

```

Note: the above code is same as "patch_install_lightgun_irq_handler", except that it writes to r2+70h, instead of r2+80h.

patch_card_specific_delay:

Same purpose as the "early_card_irq_patch" (but for the command/status bytes rather than for the data bytes). The patch looks buggy since it inserts the delay AFTER the acknowledge, but it DOES work (the BIOS accidently acknowledges the IRQ twice; and the delay occurs PRIOR to 2nd acknowledge).

Used in Metal Gear Solid at 8009AAF0h, and in Legacy of Kain at 801A56D8h, and in alone1 at 800AE38Ch:

```

24090057 mov  r9,57h      ;\
240A00B0 mov  r10,0B0h ; B(57h) GetB0Table
0140F809 call r10        ;/
00000000 +nop
8C42016C mov  r2,[r2+5Bh*4] ;B(5Bh)
00000000 nop
8C4309C8 mov  r3,[r2+9C8h] ;blah
3C0Axxxx lui  r10,xxxxh ;\@@new_data
254Axxxx sub  r10,xxxxh ;/
3C09xxxx lui  r9,xxxxh ;\@@new_data_end
2529xxxx sub  r9,xxxxh ;/
      @@copy_lop:
8D480000 mov  r8,[r10]
00000000 nop
AC4809C8 mov  [r2+9C8h],r8 ;B(5Bh)+9C8h..
254A0004 add  r10,4h
1549FFFB jne  r10,r9,@@copy_lop
24420004 +add  r2,4h
      ...
      ;@@new_data:
      ; 3C08A001 lui  r8,0A001h
      ; 2508DF80 sub  r8,2080h
      ; 0100F809 call r8 ;=A000DF80h
      ; 00000000 +nop
      ; 00000000 nop
      ;@@new_data_end:
      ; 946F000A movh r15,[r3+0Ah]
      ; 3C080000 mov  r8,0h
      ; 01E2C025 or   r24,r15,r2
      ; 37190012 or   r25,r24,12h
      ; A479000A movh [r3+0Ah],r25
      ; 24080028 mov  r8,28h
      ;@@wait_lop:
      ; 2508FFFF sub  r8,1h
      ; 1500FFFE jnz  r8,@@wait_lop
      ; 00000000 +nop
      ; 03E00008 ret   ;above delay is
      ; 00000000 +nop ;in UNCACHED RAM

```

Alternately, slightly different code used in elo2 at 800396D4h, and in Resident Evil 2 at 800910E4h:

```

240A00B0 mov  r10,0B0h ;\
0140F809 call r10      ; B(57h) GetB0Table
24090057 +mov  r9,57h   ;/
8C42016C mov  r2,[r2+5Bh*4] ;B(5Bh)
3C0Axxxx mov  r10,xxxx0000h
3C09xxxx mov  r9,xxxx0000h
8C4309C8 mov  r3,[r2+9C8h] ;blah
254Axxxx sub  r10,xxxxh ;=@@swap_begin
2529xxxx sub  r9,xxxxh   ;=@@swap_end
      @@swap_lop:
8C4309C8 mov  r3,[r2+9C8h] ;B(5Bh)+9C8h..
8D480000 mov  r8,[r10]
254A0004 add  r10,4h
AD43FFFC mov  [r10-4h],r3
24420004 add  r2,4h
1549FFFA jne  r10,r9,@@swap_lop
AC4809C4 +mov  [r2+9C4h],r8
      ;@@swap_begin:
      ; 3C088xxx lui  r8,8xxxh
      ; 2508xxxx sub  r8,xxxxh
      ; 0100F809 call r8 ;=8xxxxxxxh
      ; 00000000 +nop
      ; 00000000 nop
      ;@@swap_end:
      ; - - -
      ; 00000000 nop
      ; 240800C8 mov  r8,0C8h
      ;@@wait_lop:
      ; 2508FFFF sub  r8,1h
      ; 1500FFFE jnz  r8,@@wait_lop
      ; 00000000 +nop
      ; 03E00008 ret   ;above delay is
      ; 00000000 +nop ;in CACHED RAM

```

patch_card_info_step4:

The "card_info" function sends an incomplete read command to the card; in order to receive status information. After receiving the last byte, the function does accidentally send a further byte to the card, so the card responds by another byte (and another IRQ7), which is not processed nor acknowledged by the BIOS. This patch kills the opcode that sends the extra byte.

Used in alone1 at 800AE214h:

```

24090057 mov  r9,57h                ;\
240A00B0 mov  r10,0B0h              ; B(57h) GetB0Table
0140F809 call r10                  ;
00000000 +nop                       ;/
240A0009 mov  r10,9h                ;=blah
8C42016C mov  r2,[r2+5Bh*4] ;=B(5Bh)
00000000 nop
20431988 addt r3,r2,1988h           ;=B(5Bh)+1988h ;\store a NOP,
0xxxxxxx call xxxxxxxxh            ; and call ...
AC600000 +mov [r3],0                ;=nop ;/

```

patch_pad_error_handling_and_get_pad_enable_functions:

If a transmission error occurs (or if there's no controller connected), then the Pad handler handler does usually issue a strange chip select signal to the OTHER controller slot, and does then execute the bizarre_pad_delay function. The patch below overwrites that behaviour by NOPs. Purpose of the original (and patched) behaviour is unknown.

Used by Perfect Assassin at 800519D4h:

```

240A00B0 mov  r10,0B0h                ;\
0140F809 call r10                    ; B(57h) GetB0Table
24090057 +mov r9,57h                  ;/
8C42016C mov  r2,[r2+5Bh*4] ;=B(5Bh)
3C01xxxx mov  r1,xxxx0000h
20430884 addt r3,r2,884h              ;B(5Bh)+884h
AC23xxxx mov  [r1+xxxxh],r3 ;<--- SetPadEnableFlag()
3C01xxxx mov  r1,xxxx0000h
20430894 addt r3,r2,894h              ;B(5Bh)+894h
2409000B mov  r9,0Bh                  ;len
AC23xxxx mov  [r1+xxxxh],r3 ;<--- ClearPadEnableFlag()
      @@fill_lop:                      ;\
2529FFFF sub  r9,1h                    ;
AC400594 mov  [r2+594h],0              ;B(5Bh)+594h.. ; erase error handling
1520FFFD jnz  r9,@@fill_lop           ;
24420004 +add r2,4h                    ;/

```

Alternately, same as above, but with inefficient nops, used by Sporting Clays at 8001B4B4h:

```

24090057 mov  r9,57h          ;\
240A00B0 mov  r10,0B0h        ; B(57h) GetB0Table
0140F809 call r10             ;
00000000 +nop                  ;/
8C42016C mov  r2,[r2+5Bh*4]
2409000B mov  r9,0Bh ;len
20430884 addt r3,r2,884h
3C01xxxx mov  r1,xxxx0000h
AC23xxxx mov  [r1+xxxxh],r3 ;<--- SetPadEnableFlag()
20430894 addt r3,r2,894h
3C01xxxx mov  r1,xxxx0000h
AC23xxxx mov  [r1+xxxxh],r3 ;<--- ClearPadEnableFlag()
      @@fill_lop:              ;\
AC400594 mov  [r2+594h],0      ;
24420004 add  r2,4h            ; erase error handling
2529FFFF sub  r9,1h           ;
1520FFFC jnz  r9,@@fill_lop ;
00000000 +nop                  ;/

```

Alternately, same as above, but without getting PadEnable functions, used in Pandemonium II (at 80083C94h and at 8010B77Ch):

```

240A00B0 mov  r10,0B0h          ;\
0140F809 call r10              ; B(57h) GetB0Table
24090057 +mov  r9,57h           ;/
8C42016C mov  r2,[r2+5Bh*4] ;=B(5Bh)
2409000B mov  r9,0Bh            ;len          ;\
      @@fill_lop:              ;
2529FFFF sub  r9,1h            ; erase error handling
AC400594 mov  [r2+594h],0      ;B(5Bh)+594h.. ;
1520FFFD jnz  r9,@@fill_lop    ;
24420004 +add  r2,4h            ;/

```

patch_optional_pad_output:

The normal BIOS functions are only allowing to READ from the controllers, but not to SEND data to them (which would be required to control Rumble motors, and to auto-activate Analog mode without needing the user to press the Analog button). Internally, the BIOS does include some code for sending data to the controller, but it doesn't offer a function vector for setting up the data source address, and, even if that would be supported, it clips the data bytes to 00h or 01h. The patch below retrieves the required SetPadOutput function address (in which only the src1/src2 addresses are relevant, the blah1/blah2 values aren't used), and suppresses clipping (ie. allows to send any bytes in range 00h..FFh).

Used in Resident Evil 2 at 80091914h:

```

240A00B0 mov  r10,0B0h                ;\
0140F809 call r10                      ; B(57h) GetB0Table
24090057 +mov r9,57h                   ;/
8C42016C mov  r2,[r2+5Bh*4] ;B(5Bh)
3C0Axxxx mov  r10,xxxx0000h
3C09xxxx mov  r9,xxxx0000h
3C01xxxx mov  r1,xxxx0000h
204307A0 addt r3,r2,7A0h               ;B(5Bh)+7A0h
254Axxxx add  r10,xxxxh ;==@new_data
2529xxxx add  r9,xxxxh ;==@new_data_end
AC23xxxx mov  [r1-xxxxh],r3 ;<--- SetPadOutput(src1,blah1,src2,blah2)
        @@double_copy_loop:           ;\
8D430000 mov  r3,[r10]                 ;          @@new_data:
254A0004 add  r10,4h                   ; 00551024 and      r2,r21
AC4303D8 mov  [r2+3D8h],r3 ;<--- here  ; 00000000 nop
24420004 add  r2,4h                   ; 00000000 nop
1549FFFB jne  r10,r9,@double_copy_loop ; 00000000 nop
AC4304DC +mov [r2+4DCh],r3 ;<--- here  ;/          @@new_data_end:

```

Alternately, more inefficient (with NOPs), used in Lemmings at 80036618h:

```

24090057 mov  r9,57h                ;\
240A00B0 mov  r10,0B0h               ; B(57h) GetB0Table
0140F809 call r10                    ;
00000000 +nop                        ;/
3C0Axxxx mov  r10,xxxx0000h
254Axxxx add  r10,xxxxh ;==@new_data
3C09xxxx movp r9,xxxx0000h
2529xxxx add  r9,xxxxh ;==@new_data_end
8C42016C mov  r2,[r2+5Bh*4] ;B(5Bh)
00000000 nop
204307A0 addt r3,r2,7A0h             ;B(5Bh)+7A0h
3C01xxxx mov  r1,xxxx0000h
AC23xxxx mov  [r1+xxxxh],r3 ;<--- SetPadOutput(src1,blah1,src2,blah2)
        @@double_copy_loop:           ;\
8D430000 mov  r3,[r10]               ;          @@new_data:
00000000 nop                        ; 00551024 and      r2,r21
AC4303D8 mov  [r2+3D8h],r3           ; 00000000 nop
AC4304E0 mov  [r2+4E0h],r3           ; 00000000 nop
24420004 add  r2,4h                 ; 00000000 nop
254A0004 add  r10,4h                ;          @@new_data_end:
1549FFF9 jne  r10,r9,@double_copy_loop ;
00000000 +nop                        ;/

```

patch_no_pad_card_auto_ack:

This patch suppresses automatic IRQ0 (vblank) acknowledging in the Pad/Card IRQ handler, that, even if auto-ack is enabled. Obviously, one could as well disable auto-ack

via B(5Bh) ChangeClearPAD(int), so this patch is total nonsense. Used in Resident Evil 2 at 800919ACh:

```

240A00B0 mov    r10,0B0h                ;\
0140F809 call   r10                    ; B(57h) GetB0Table
24090057 +mov    r9,57h                ;/
8C42016C mov     r2,[r2+5Bh*4] ;=B(5Bh)
240A0009 mov     r10,9h                ;len      ;\
2043062C addt    r3,r2,62Ch            ;=B(5Bh)+62Ch ;
        @@fill_lop:                    ;
254AFFFF sub     r10,1h                ;
AC600000 mov     [r3],0                ;
1540FFFD jnz     r10,@@fill_lop        ;
24630004 +add    r3,4h                ;/

```

Alternately, same as above, but more inefficient, used in Sporting Clays at 8001B53Ch:

```

24090057 mov     r9,57h                ;\
240A00B0 mov     r10,0B0h              ; B(57h) GetB0Table
0140F809 call    r10                  ;
00000000 +nop                          ;/
240A0009 mov     r10,9h                ;len
8C42016C mov     r2,[r2+5Bh*4]
00000000 nop
2043062C addt    r3,r2,62Ch
        @@fill_lop:                    ;\
AC600000 mov     [r3],0                ;
24630004 add     r3,4h                ;
254AFFFF sub     r10,1h                ;
1540FFFC jnz     r10,@@fill_lop        ;
00000000 +nop                          ;/

```

Either way, no matter if using the patch or if using ChangeClearPAD(int), having auto-ack disabled allows to install a custom vblank IRQ0 handler, which is probably desired for most games, however, mind that the PSX BIOS doesn't actually support the same IRQ to be processed by two different IRQ handlers, eg. the custom handler may acknowledge the IRQ even when the Pad/Card handler didn't process it, so pad input may become bumpy.

patch_install_lightgun_irq_handler:

Used in Sporting Clays at 80027D68h (when Konami Lightgun connected):

```

240A00B0 mov     r10,0B0h                ;\
0140F809 call    r10                  ; B(56h) GetC0Table
24090056 +mov     r9,56h                ;/
3C0Axxxx mov     r10,xxxx0000h ;src
3C09xxxx mov     r9,xxxx0000h ;src.end
8C420018 mov     r2,[r2+06h*4] ;C(06h)

```

```

254Axxxx add r10,xxxxh ;src
2529xxxx add r9,xxxxh ;src.end (=src+10h)
    @@copy_lop: ;\ ; @@src:
8D430000 mov r3,[r10] ; ;3C02xxxx mov r2,xxxx0000h
254A0004 add r10,4h ; ;2442xxxx add r2,xxxxh
24420004 add r2,4h ; ;0040F809 call r2 ;lightgun_proc
1549FFFC jne r10,r9,@@copy_lop ; ;00000000 +nop
AC43007C +mov [r2+80h-4],r3 ;/ @@src_end:

```

Alternately, same as above, but more inefficient, used in DQM (Dragon Quest Monsters 1&2) at 80089390h (install) and 800893F8h (uninstall):

```

24090056 mov r9,56h ;\
240A00B0 mov r10,0B0h ; B(56h) GetC0Table
0140F809 call r10 ;
00000000 +nop ;/
8C420018 mov r2,[r2+06h*4] ;=00000C80h = exception_handler = C(06h)
3C0Axxxx mov r10,xxxx0000h ;\@@new_data (3xNOP)
254Axxxx add r10,-xxxxh ;/
3C09xxxx mov r9,xxxx0000h ;\@@new_data_end
2529xxxx add r9,-xxxxh ;/
    @@copy_lop: ;\
8D430000 mov r3,[r10] ; @@new_data: ;for (un-)install...
00000000 nop ; 00000000 nop / 3C02xxxx mov r2,xxxx0000h
AC430080 mov [r2+80h],r3 ; 00000000 nop / 2442xxxx add r2,-xxxxh
254A0004 add r10,4h ; 00000000 nop / 0040F809 call r2 ;proc
1549FFFB jne r10,r9,@@copy_lop ; @@new_data_end:
24420004 +add r2,4h ;/

```

Some lightgun games (eg. Project Horned Owl) do (additionally to above stuff) hook the exception vector at 00000080h, the hook copies the horizontal coordinate (timer0) to a variable in RAM, thus getting the timer0 value "closest" to the actual IRQ execution. Doing that may eliminate some unpredictable timing offsets that could be caused by cache hits/misses during later IRQ handling (and may also eliminate a rather irrelevant 1-cycle inaccuracy depending on whether EPC was pointing to a GTE opcode, and also eliminates constant cycle offsets depending on whether early_card_irq_handler was installed and enabled, and might eliminate timing differences for different BIOS versions).

set_conf_without_realloc:

Used in Spec Ops Airborne Commando at 80070AE8h, and also in the homebrew game Roll Boss Rush at 80010B68h and 8001B85Ch. Purpose is unknown (maybe to override improperly defined .EXE headers).

```

8C030474 mov r3,[200h+(9Dh*4)] ;\get ptr to A(9Dh) GetConf (done so,
00000000 nop ;/as there's no "GetA0Table" funtion)
94620000 movh r2,[r3+0h] ;lui msw ;\

```

```

84630004 movhs r3,[r3+4h] ;lw lsw+8 ; extract ptr to "boot_cnf_values"
00021400 shl r2,10h ;msw*10000h ; (from first 2 opcodes of GetConf)
2442FFF8 sub r2,8h ;undo +8 ;
00431021 add r2,r3 ;lsw ;/
AC450000 mov [r2+0h],r5 ;num_TCB ;\set num_EvCB,num_TCB,stacktop
AC440004 mov [r2+4h],r4 ;num_EvCB ; (unlike A(9Ch) SetConf, without
03E00008 ret ; actually reallocoting anything)
AC460008 +mov [r2+8h],r6 ;stacktop ;/

```

Cheat Devices

CAETLA detects the PSX BIOS version by checksumming BFC06000h..BFC07FFFh and does then use some hardcoded BIOS addresses based on that checksum. The reason for doing that is probably that the Pre-Boot Expansion ROM vector is called with the normal A0h/B0h/C0h vectors being still uninitialized.

Problems are that the hardcoded addresses won't work with all BIOSes (eg. not with the no\$psx bios clone, probably also not with the newer PS2 BIOS), moreover, the checksumming can fail with patched original BIOSes (eg. no\$psx allows to enable TTY debug messages and to skip the BIOS intro).

The Cheat Firmwares are probably also hooking the Vblank handler, and maybe also some other functions.

ACTION REPLAY (at least later versions like 2.81) uses the Pre-Boot handler to set a COP0 hardware breakpoint at 80030000h and does then resume normal BIOS booting (which will then initialize important things like A0h/B0h/C0h tables, and will then break when starting the GUI code at 80030000h).

XPLORER searches opcode 24040385h at BFC06000h and up, and does then place a COP0 opcode fetch breakpoint at the opcode address+10h (note: this is within a branch delay slot, which makes COP0 emulation twice as complicated). XPLORER does also require space in unused BIOS RAM addresses (eg. Xplorer v3.20: addr 7880h at 1F002280h, addr 017Fh at 1F006A58h).

Note

Most games include two or three patches. The only game that I've seen so far that does NOT use any patches is Wipeout 2097.

22. Arcade Cabinets

The following arcade PCBs are known to be based on PlayStation hardware:

Manufacturer	Board	CPU clock	GPU	RAM	VRAM	Additional
Konami	GV	33 MHz	v0	2 MB	1 MB	
Konami	GQ	33 MHz	v1	4 MB	2 MB	68000
Konami	System 573	33 MHz	v2	4 MB	2 MB	H8/3002
Konami	Twinkle System	33 MHz	v2	4 MB	2 MB	Optional (SPU),
Namco	System 10	50 MHz	v2	16 MB	2 MB	
Sony	COH-100	33 MHz	v1	4 MB	2 MB	Provided
Sony	COH-110	33 MHz	v2	4 MB	2 MB	Provided
Sony	COH-700	50 MHz	v2b	4 MB	2 MB	Provided
Sony	COH-716	50 MHz	v2	16 MB	2 MB	Provided
Sony	ZN-1	33 MHz	v2	4-8 MB	1-2 MB	Provided
Sony	ZN-2	50 MHz	v2 or v2b	4-16 MB	2 MB	Provided

The following systems are based on a Sony CPU daughterboard mounted on top of a custom manufacturer-specific main board:

Manufacturer	Main board	CPU board	Additional CPUs	Audio
Namco	System 11	COH-100 or COH-110	Namco C76 (custom H8)	Namco C352 PCM
Namco	System 12	COH-700 or COH-716	H8/3002, optional SH-2 (CDXA PCB)	Namco C352 PCM, XA-ADPCM (PCB)

The following systems are based on a Sony ZN-1 or ZN-2 motherboard with a manufacturer-specific daughterboard mounted on top:

Manufacturer	Main board	Daughterboard	Additional CPUs	Audio
Acclaim	ZN-1	PCB-100102	Optional ADSP-2181 (PCB-100095)	PCM from
Atari	ZN-1	Primal Rage 2 (PSXTRA)		
Atlus	ZN-1	Heaven's Gate (ATHG-01)	68000	Yamaha YM
Capcom	ZN-1 or ZN-2	95681-2	Z80	Capcom Q
Capcom	ZN-2	97695-1	Z80	Capcom Q
Eighting/Raizing	ZN-1	RA9701 SUB	68000	Yamaha YM
Eighting/Raizing, Tecmo	ZN-1	PS9805	68000	Yamaha YM
Eighting/Raizing	ZN-1	Bust-A-Move 2 (MTR990601-(A))	H8/3644	PCM strear
Taito	ZN-1	FX-1 (SROM PCB-A)	Z80	Yamaha YM
Taito	ZN-1	FX-1 (ZROM PCB)	MN1020012A, TMS57002	Zoom ZSG
Taito	ZN-1 or ZN-2	G-NET (FC PCB)	MN1020012A, TMS57002	Optional Z
Tecmo	ZN-1	TPS System (TPS1-7)	Optional Z80	Optional Y
Video System	ZN-1	VS34		

Currently only documentation for the System 573 exists. More information about other arcade boards could be obtained from MAME source code.

22.1 CPU

Most boards use the same CPUs as retail consoles and development units but extend main RAM to up to 16 MB, with 4 MB being the most common configuration. The System 10, COH-716 and ZN-2 run the CPU at 50 MHz instead of 33 and feature a different chip revision from any known stock console, presumably rated for the higher clock speed but otherwise functionally identical.

22.2 GPU

Most systems have a regular 208-pin v2 GPU but expand VRAM from 1 to 2 MB, arranged as a 1024x1024 buffer rather than 1024x512. The Konami GQ and COH-100 instead use the v1 "prototype" GPU, which employs a different command format. As the

System 11 could come fitted with either a COH-100 or COH-110, some System 11 games support both formats.

As with CPUs, some ZN-2 variants and the COH-700 use a later arcade-only revision ("v2b") of the v2 GPU. This change may also be related to the clock speed increase, however not all systems running at 50 MHz seem to use the newer GPU.

22.3 Audio

Almost all boards extend the SPU's functionality with additional hardware, usually consisting of a custom PCM mixer and in some cases a separate CPU driving it. The extra circuitry is typically in charge of playing music (fulfilling the same role as CD-DA and XA-ADPCM on retail consoles), with the SPU still handling playback of all other audio.

The Konami GQ and all systems based on Sony's CPU daughterboards omit the SPU altogether and rely entirely on custom sound hardware. The Twinkle System has the SPU populated but all games that require its dedicated audio board will leave it unused.

22.4 Controls

Most systems are designed to be connected to a cabinet through a JAMMA board edge connector, which carries power, a video output, player controls and coin/service button inputs. These inputs are typically accessed via custom memory-mapped I/O ports. As control schemes may vary greatly from game to game, many systems also provide means to connect additional inputs or expansion boards.

Some boards feature a JVS port (a standardized serial bus protocol used to connect controls and peripherals to modern arcade systems), allowing standard JVS I/O boards to be used if supported by games.

22.5 Storage

With the exception of Konami, all manufacturers adopted solid state game storage (mask ROMs, EPROMs and/or flash memory). The wiring and layout of the ROMs varies across boards; on some systems the BIOS, game binary and its assets are part of the same ROM region, while others split them into separate areas. Boards with custom

sound hardware usually store samples and other audio data in dedicated ROMs accessed directly by the hardware in question.

Konami systems store game executables and assets on standard SCSI/IDE hard drives or CD-ROMs. The System 573 can also boot from its built-in flash or a PCMCIA flash card, using the CD-ROM drive only to install new games, however the vast majority of 573 games are too large to fit entirely in the flash and still rely on reading files from the disc after installation. The Twinkle System is particularly unusual as it has a CD-ROM drive accessed by the main CPU, a separate hard drive used by the audio board and an external DVD player unit for background videos.

The System 12, System 10 and the ZN-1 with the Bust-A-Move 2 ROM board are the only currently known non-Konami PCBs with CD-ROM support. The former requires an expansion module that provides an IDE interface and XA-ADPCM decoding through an integrated SH-2 CPU, while the latter two can be connected directly to a drive. In all cases the CD-ROM is only used for audio streaming and the boards are not otherwise capable of booting directly from it without a ROM board installed.

22.6 Security

The implementation of anti-piracy measures varies for each manufacturer.

- Namco's System 11 and 12 employ a CPLD or ASIC ("KEYCUS" chip) on each ROM module as a game-specific security coprocessor the CPU communicates with. In the case of the System 12, the KEYCUS chip seems to double as a lockout device and restrict access to the ROMs until the game issues an unlocking sequence.
- Namco System 10 games also use a KEYCUS CPLD but wire it between the CPU and ROMs, allowing it to perform on-the-fly unscrambling of their encrypted contents in addition to the lockout functionality.
- Similarly, most Taito G-NET games are stored on non-standard PCMCIA flash cards that require unlock sequences specific to each game prior to being accessed.
- Sony's ZN-1 and ZN-2 are fitted by each manufacturer with a custom BIOS ROM and security/decryption ASIC, which the game-specific ROM daughterboard then relies on. This makes it harder to convert ZN-1 or ZN-2 games by simply swapping out the daughterboard.
- CD-ROMs for Konami boards were typically shipped alongside a security dongle or cartridge that must be plugged in to boot the game. Some games write the system's serial number to the dongle during installation, preventing installation of the same game on more than one cabinet. The System 573's optional MP3 decoder board additionally features an FPGA used to decrypt MP3 files on the disc during playback.

22.7 Games

Some of the most notable arcade titles to use the boards listed here include:

- **Beatmania IIDX** up to 8th Style (Twinkle System)
- **Dance Dance Revolution** up to EXTREME (System 573)
- **DrumMania** up to 10thMIX (System 573)
- **GuitarFreaks** up to 11thMIX (System 573)
- **Point Blank 2** (System 11 or System 12)
- **Point Blank 3** (System 10)
- **Soul Calibur** (System 12)
- **Soul Edge** (System 11)
- **Street Fighter EX** (Capcom ZN-1)
- **Street Fighter EX2** (Capcom ZN-2)
- **Taiko no Tatsujin** up to 6 (System 10)
- **Tekken** and **Tekken 2** (System 11)
- **Tekken 3** (System 12)
- **Tetris: The Grand Master** (Capcom ZN-2)

23. Konami System 573

The System 573 is a PlayStation-based system used in a number of Konami arcade games from the late 90s and early 2000s, most notably Dance Dance Revolution and other titles from the Bemani series of rhythm games.

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This document is currently work-in-progress. Here is an incomplete list of things the authors believe need more research:

- The BIOS and games are notoriously picky about ATAPI drives due to Konami's libraries not always respecting timings and polling registers in the way suggested by the specifications. Such issues shall be documented more in detail.
- The `GE765-PWB(B)A` and `PWB0000073070` I/O boards have been fully and partially reverse engineered respectively, but documentation for them is missing.
- The `GN845-PWB(B)` DDR stage PCB's communication protocol is largely unknown. More tests need to be done on real hardware and its CPLD shall be dumped if possible.
- The protocol used by the 573 to communicate with the `PWB0000100991` network PCB has been reversed, however very little about the PCB's own hardware and software stack is otherwise known.
- Some revisions of the main board have two resistor footprints next to the Konami ASIC, one labeled `FJ` and the other `SH`. Only one of them is populated; it presumably sets or clears a bit in one of the ASIC input ports. Given the labels it may be related to the manufacturer of the onboard flash memory (Fujitsu or Sharp), however even boards fitted with Sharp chips come with the `FJ` resistor populated. Moreover, all known games identify the chips by probing their JEDEC ID.

23.1 Differences vs. PS1

23.1.1 Main changes

- **Main RAM is 4 MB** instead of 2 MB and **VRAM is 2 MB** instead of 1 MB. SPU RAM is still 512 KB.
- **The CD-ROM drive is completely different.** While the PS1's drive is fully integrated into the motherboard and uses a custom protocol, the 573 employs a standard ATAPI drive. It can thus boot from burned CD-Rs or even CD-RWs just fine (as long as the drive itself is capable of reading them in the first place), with no modifications needed to the stock hardware. There is no provision for playing XA-ADPCM, however CD-DA playback through the drive's own audio output (fed into the 573 motherboard via a 4-pin audio cable) is supported and used by some games.
- **The SIO0 bus for controllers and memory cards is unused.** It is broken out to a connector, however no known I/O board uses it. Some games supported PS1

controllers and memory cards through an adapter connected over JVS (see the external modules section).

- **The "parallel I/O" expansion port is replaced by 2 PCMCIA slots.** These slots are wired in parallel and mapped at the same address as the internal flash through bank switching. They are fairly limited though as they only support 16-bit bus accesses (i.e. `/CE1` and `/CE2` are tied together, even though the CPU actually exposes them as separate signals!), have no DMA and don't expose the PCMCIA I/O and configuration space (`/IORD` and `/IOWR` are not connected at all). This makes them incompatible with CF cards and most PCMCIA devices.

23.1.2 Additional hardware

- **Audio and video outputs:** unlike the PS1, which outputs composite, S-video and RGB, the 573 only outputs RGB with C-sync through the JAMMA connector and a DB15 port compliant with the JVS specification (same pinout as VGA but not directly compatible, as VGA normally runs at higher resolutions and uses separate H/V sync pins). A built-in 15 watt stereo speaker amplifier is also provided for cabinets that lack their own sound system.
- **JAMMA interface and built-in I/O ports:** the 573 provides multiple digital and analog ports for interfacing with arcade cabinet controls. Depending on the I/O board the system came with, these signals might be broken out through connectors on the system's case.
- **Internal 16 MB flash memory:** the 573's BIOS is capable of booting either from the CD drive or from an array of flash memory chips soldered to the motherboard, which are also memory mapped. Most Konami games are designed to run from flash: when attempting to run them from CD without also having them installed, the executable on the disc will erase the flash and install the game before starting. Most games still require the CD, in some cases a different one, to be kept in the drive after installation as they use it for music playback or to stream additional data.
- **PCMCIA memory card:** some games shipped with additional flash memory in the form of one or more 16 or 32 MB PCMCIA cards. Note that these are "linear" memory mapped flash cards without any built-in controller, not CF or ATA-compatible cards. See the BIOS section for more details on why CF cards are not supported.
- **RTC and battery-backed 8 KB RAM:** used by games to store settings, save data and installation info (possibly including serial numbers). Unfortunately the RTC chip is one

of those all-in-one things with a battery sealed inside, soldered directly to the motherboard.

- **JVS host:** allows connection of multiple daisy chained peripherals using the standardized JVS protocol, based on a serial (RS-485) bus. The JVS port on the 573 was only ever "officially" used for the PS1 memory card reader module, however some games seem to support JVS I/O boards and input devices in addition to the built-in JAMMA connector.
- **Security cartridge:** optionally installed on the 573's side, contains a password protected EEPROM that holds factory pre-programmed data as well as keys generated during game installation, plus in some case a 64-bit serial number ROM. Security cartridges were bundled with most game discs as a way to prevent copying, as the discs themselves had no other protection of any kind. The CPU's serial port (SIO1) is also wired to the security cartridge slot.

23.2 Register map

All standard PS1 registers, with the exception of the CD-ROM drive's, are present and accessible. System 573-specific hardware is mapped into the EXP1 region at `0x1f000000`. IRQ10 and DMA5, normally reserved for the expansion bus (and lightguns) on a regular PS1, are used to access the ATAPI drive, while IRQ2 and DMA3 go unused.

NOTE: EXP1 must be configured prior to accessing any of these registers. The configuration value written by Konami's code to the EXP1 delay/size register at `0x1f801008` is `0x24173f47`. Afterwards, *all* bus writes shall be 16 or 32 bits wide. The behavior of 8-bit writes is undefined, but 8-bit reads work as intended.

Address range	Description
<code>0x1f000000-0x1f3fffff</code>	Bank switched, can be mapped to flash or PCMCIA slots
<code>0x1f400000-0x1f40000f</code>	Konami ASIC registers
<code>0x1f480000-0x1f48000f</code>	IDE register bank 0
<code>0x1f4c0000-0x1f4c000f</code>	IDE register bank 1
<code>0x1f620000-0x1f623fff</code>	RTC registers and battery-backed RAM
<code>0x1f640000-0x1f6400ff</code>	I/O board registers
<code>0x1f500000-0x1f6a0001</code>	Other registers

23.2.1 Konami ASIC registers

Registers in the `0x1f400000-0x1f40000f` region are handled by the Konami 056879 I/O ASIC, consisting of a single 8-bit output port and at least six 16-bit input ports. The same chip was used in other Konami arcade boards of the time.

`0x1f400000` (ASIC register 0): ADC / Coin counters / Audio control

Bits	RW	Description
0	W	Data input to ADC (<code>DI</code>)
1	W	Chip select to ADC (<code>/CS</code>)
2	W	Data clock to ADC (<code>CLK</code>)
3	W	Coin counter 1 (1 = energize counter coil)
4	W	Coin counter 2 (1 = energize counter coil)
5	W	Built-in audio amplifier enable (0 = muted)
6	W	External audio input enable (0 = muted)
7	W	SPU DAC output enable (0 = muted)
8	W	JVS MCU reset output (0 = pull reset low)
9-15		<i>Unused</i>

The ADC chip is an ADC0834 from TI, which uses a proprietary SPI-like protocol. Its four inputs are wired to the `ANALOG` connector on the 573 motherboard. Refer to the ADC083x datasheet for details on how to bitbang the protocol.

Mechanical coin counters are incremented by games whenever a coin is inserted by setting bit 3 or 4 for a fraction of a second and then clearing them. Bit 5 controls whether the onboard audio amp is enabled but does not affect the RCA line level outputs, which are always enabled. Setting bit 5 has no effect immediately as the amplifier takes about a second to turn on.

Bit 6 is used by games to mute audio from the CD-ROM drive or digital I/O board. However, testing on real hardware seems to suggest it is actually some sort of attenuation control, as the audio is still audible (albeit at a very low volume) when the bit is cleared. Note that some games, such as GuitarFreaks, break the CD/MP3 output to separate jacks on the front I/O panel rather than routing it through the motherboard, making bit 6 meaningless.

Bit 8 resets the JVS MCU. Since the reset pin is active-low, resetting is done by writing 0, waiting at least 10 H8 clock cycles (the BIOS waits 2 hblanks) and writing 1 again.

Resetting the MCU will clear `JVSDRDY` but not `JVSIRDY`. As the 056879 ASIC's output register is only 8 bits wide, bit 8 is actually handled by a discrete flip-flop on the motherboard.

Unknown what reading from this port does.

`0x1f400004` (ASIC register 2): DIP switches / JVS status / Security cartridge

Bits	RW	Description
0-3	R	DIP switch 1-4 status (0 = on, 1 = off)
4-5	R	Current JVS MCU status code
6-7	R	Current JVS MCU error code
8-15	R	<code>I0-I7</code> from security cartridge

The MCU status code can be one of the following values:

Code	Description
0	Waiting for the 573 to read or write the first word of a packet
1	Busy (sending a packet or waiting for a response)
2	Waiting for the 573 to finish reading or writing a packet
3	<i>Unused</i>

The MCU error code can be one of the following values:

Code	Description
0	<i>Unused</i>
1	Packet written by the 573 has an invalid checksum
2	Packet written by the 573 does not start with a <code>0xe0</code> sync byte
3	No error

Once an error is reported, the MCU will enter an endless loop and become unresponsive. In order to clear the error the MCU must be reset using bit 8 in register `0x1f400000`.

The highest 8 bits read from this register are the current state of the security cartridge's `I0-I7` pins. See the security cartridge section for an explanation of what each bit is wired to. Unknown whether reading from this register will clear the `IRDY` flag, if previously set by the cartridge.

Bit 3 (DIP switch 4) is used by the BIOS to determine whether to boot from flash. If set, the BIOS will attempt to search for a valid executable on the internal flash and both PCMCIA cards prior to falling back to the CD-ROM.

0x1f400006 (ASIC register 3): Misc. inputs

Bits	RW	Description
0	R	Data output from ADC (<code>DO</code>)
1	R	SAR status from ADC (<code>SARS</code>)
2	R	From <code>IO0</code> on security cartridge
3	R	Sense input from JVS port
4	R	<code>JVSIRDY</code> status from JVS MCU
5	R	<code>JVSDRDY</code> status from JVS MCU
6	R	<code>IRDY</code> status from security cartridge
7	R	<code>DRDY</code> status from security cartridge
8	R	Coin switch input 1 (0 = coin being inserted)
9	R	Coin switch input 2 (0 = coin being inserted)
10	R	PCMCIA card 1 insertion (0 = card present)
11	R	PCMCIA card 2 insertion (0 = card present)
12	R	Service button (JAMMA pin R, 0 = pressed)
13-15		Unused?

See the security cartridge section for more details about `IRDY` and `DRDY`. In order for bit 2 to be valid, `IO0` should be set as an input by clearing the respective bit in register `0x1f500000`.

0x1f400008 (ASIC register 4): JAMMA controls

Bits	RW	Description
0	R	Player 2 joystick left (JAMMA pin X)
1	R	Player 2 joystick right (JAMMA pin Y)
2	R	Player 2 joystick up (JAMMA pin V)
3	R	Player 2 joystick down (JAMMA pin W)
4	R	Player 2 button 1 (JAMMA pin Z)
5	R	Player 2 button 2 (JAMMA pin a)
6	R	Player 2 button 3 (JAMMA pin b)
7	R	Player 2 start button (JAMMA pin U)
8	R	Player 1 joystick left (JAMMA pin 20)
9	R	Player 1 joystick right (JAMMA pin 21)
10	R	Player 1 joystick up (JAMMA pin 18)
11	R	Player 1 joystick down (JAMMA pin 19)
12	R	Player 1 button 1 (JAMMA pin 22)
13	R	Player 1 button 2 (JAMMA pin 23)
14	R	Player 1 button 3 (JAMMA pin 24)
15	R	Player 1 start button (JAMMA pin 17)

As buttons are active-low (wired between JAMMA pins and ground), all bits are 0 when a button is pressed and 1 otherwise. The BIOS and games often read from this register and discard the result as a way of (inefficiently) flush the CPU's write queue.

0x1f40000a (ASIC register 5): Data from JVS MCU

Bits	RW	Description
0-15	R	Current data word from MCU

This register is only valid when the `JVSIRDY` flag is set. After reading, a dummy write to `0x1f520000` shall be issued to clear `JVSIRDY`. If the MCU has more data available, it will update the register and set the flag again.

0x1f40000c (ASIC register 6): JAMMA controls / External inputs

Bits	RW	Description
0-7		Unused?
8	R	Player 1 button 4 (JAMMA pin 25)
9	R	Player 1 button 5 (JAMMA pin 26)
10	R	Test button (built-in and JAMMA pin 15)
11	R	Player 1 button 6
12-15		Unused?

As buttons are active-low (wired between JAMMA pins and ground), all bits are 0 when a button is pressed and 1 otherwise.

The signals for buttons 4 and 5 are wired in parallel to both JAMMA and the `EXT-IN` connector, while button 6 can only be connected through `EXT-IN` and is usually unused.

0x1f40000e (ASIC register 7): JAMMA controls / External inputs

Bits	RW	Description
0-7		Unused?
8	R	Player 2 button 4 (JAMMA pin c)
9	R	Player 2 button 5 (JAMMA pin d)
10		Main RAM layout type (0 = new, 1 = old)
11	R	Player 2 button 6
12-15		Unused?

As buttons are active-low (wired between JAMMA pins and ground), all bits are 0 when a button is pressed and 1 otherwise.

The signals for buttons 4 and 5 are wired in parallel to both JAMMA and the `EXT-IN` connector, while button 6 can only be connected through `EXT-IN` and is usually unused.

Bit 10 is probed by the 700B01 BIOS kernel to determine how to configure the main RAM controller. If cleared, the configuration register at `0x1f801060` is set to `0x4788`, otherwise it is set to `0x0c80`. This check was introduced alongside revision D of the main board, which features alternate footprints for two 2 MB chips in place of eight 512 KB ones.

23.2.2 IDE registers

The IDE interface consists of a 16-bit parallel data bus with a 3-bit address bus and two bank select pins (`/CS0` and `/CS1`), giving a total of sixteen 16-bit registers of which only nine are typically used. On the 573 the two IDE banks are mapped to two separate memory regions at `0x1f480000` and `0x1f4c0000` respectively. The IDE interrupt pin is routed into IRQ10 through the CPLD, while all other signals on the 40-pin connector (DMA handshaking lines, status pins, etc.) go unused.

Most 573 games, with the exception of those that run entirely from the internal flash or PCMCIA cards, expect an ATAPI CD-ROM drive to be always connected and configured as the primary (master) drive. Connecting an additional ATA hard drive, CF card, IDE-to-SATA bridge or other device configured as secondary will not interfere with the BIOS or games, thus homebrew games and apps can leverage such a drive to store data separately from the currently installed game.

Note that IDE and ATAPI give slightly different meanings to each register. Refer to the ATA and ATAPI specifications for more details.

`0x1f480000` (IDE bank 0, address 0): Data

Bits	RW	Description
0-15	RW	Current packet or data word

Data transfers can also be performed through DMA. See below for details.

0x1f480002 (IDE bank 0, address 1): Error / Features

When read:

Bits	RW	Description (ATA)	RW	Description (ATAPI)
0		<i>Reserved</i>	R	Illegal length flag (<i>ILI</i>)
1	R	No media flag (<i>NM</i>)	R	End of media flag (<i>EOM</i>)
2	R	Command aborted flag (<i>ABRT</i>)	R	Command aborted flag (<i>ABRT</i>)
3	R	Media change request flag (<i>MCR</i>)		<i>Reserved</i>
4	R	Address not found flag (<i>IDNF</i>)	R	SCSI sense key bit 0
5	R	Media changed flag (<i>MC</i>)	R	SCSI sense key bit 1
6	R	Uncorrectable error flag (<i>UNC</i>)	R	SCSI sense key bit 2
7	R	DMA CRC error flag (<i>ICRC</i>)	R	SCSI sense key bit 3
8-15		<i>Unused</i>		<i>Unused</i>

When written:

Bits	RW	Description (ATA)	RW	Description (ATAPI)
0	W	Command-specific feature index or flags	W	Use overlapped mode for ne
1	W	Command-specific feature index or flags	W	Transfer data for next comm
2-7	W	Command-specific feature index or flags	W	<i>Reserved</i> (should be 0)
8-15		<i>Unused</i>		<i>Unused</i>

0x1f480004 (IDE bank 0, address 2): Sector count

Bits	RW	Description (ATA)	RW	Description (ATAPI)
0	W	Transfer sector count bit 0	R	Pending transfer type (<i>C/D</i> , 0 = data, 1 = command)
1	W	Transfer sector count bit 1	R	Pending transfer direction (<i>I/O</i> , 0 = to device, 1 = to host)
2	W	Transfer sector count bit 2	R	Pending transfer bus release flag (<i>REL</i>)
3-7	W	Transfer sector count bits 3-7	RW	Current command tag
8-15		<i>Unused</i>		<i>Unused</i>

In ATA 48-bit LBA mode, bits 8-15 of the number of sectors to transfer must be written to this register first, followed by bits 0-7.

In ATA CHS or 28-bit LBA mode, setting this register to 0 will cause 256 sectors to be transferred.

0x1f480006 (IDE bank 0, address 3): Sector number

Bits	RW	Description (ATA)	RW	Description (ATAPI)
0-7	W	CHS sector index or LBA bits 0-7		Unused
8-15		Unused		Unused

In ATA 48-bit LBA mode, bits 24-31 of the target LBA must be written to this register first, followed by bits 0-7.

0x1f480008 (IDE bank 0, address 4): Cylinder number low

Bits	RW	Description (ATA)	RW	Description (ATAPI)
0-7	RW	CHS cylinder index bits 0-7 or LBA bits 8-15	RW	Transfer chunk size bits
8-15		Unused		Unused

In ATA 48-bit LBA mode, bits 32-39 of the target LBA must be written to this register first, followed by bits 8-15.

When reset, ATAPI drives will set this register to 0x14.

0x1f48000a (IDE bank 0, address 5): Cylinder number high

Bits	RW	Description (ATA)	RW	Description (ATAPI)
0-7	RW	CHS cylinder index bits 8-15 or LBA bits 16-23	RW	Transfer chunk size b
8-15		Unused		Unused

In ATA 48-bit LBA mode, bits 40-47 of the target LBA must be written to this register first, followed by bits 16-23.

When reset, ATAPI drives will set this register to 0xeb.

0x1f48000c (IDE bank 0, address 6): Head number / Drive select

Bits	RW	Description (ATA)	RW	Description (ATAPI)
0-3	W	CHS head index or 28-bit LBA bits 24-27		<i>Reserved</i> (should be 0)
4	RW	Drive select (0 = primary, 1 = secondary)	RW	Drive select (0 = primary, 1 = secondary)
5		<i>Reserved</i> (should be 1?)		<i>Reserved</i> (should be 1?)
6	W	Sector addressing mode (0 = CHS, 1 = LBA)		<i>Reserved</i> (should be 0)
7		<i>Reserved</i> (should be 1?)		<i>Reserved</i> (should be 1?)
8-15		<i>Unused</i>		<i>Unused</i>

Bits 0-3 are not used in ATA 48-bit LBA mode.

0x1f48000e (IDE bank 0, address 7): Status / Command

When read:

Bits	RW	Description (ATA)	RW	Description (ATAPI)
0	R	Error flag (ERR)	R	Check condition flag (CHK)
1		<i>Reserved</i>		<i>Reserved</i>
2		<i>Reserved</i>		<i>Reserved</i>
3	R	Data request flag (DRQ)	R	Data request flag (DRQ)
4	R	Drive write error flag (DWE)	R	Overlapped service flag (SERV)
5	R	Drive fault flag (DF)	R	Drive fault flag (DF)
6	R	Drive ready flag (DRDY)	R	Drive ready flag (DRDY)
7	R	Drive busy flag (BSY)	R	Drive busy flag (BSY)
8-15		<i>Unused</i>		<i>Unused</i>

When written:

Bits	RW	Description
0-7	W	Command index
8-15		<i>Unused</i>

In order to issue a command, the features, sector, cylinder and head registers must be set up appropriately before writing the command ID to this register. Refer to the ATA specification for a list of available commands and their parameters.

`DRDY` is set by the drive when it is ready to execute an ATA command. Note that ATAPI drives will *not* set `DRDY` initially, while still accepting ATAPI commands, in order to prevent misdetection as a hard drive. Before sending any command, a polling loop shall be used to wait until `BSY` is cleared.

`DRQ` is set when the drive is waiting for data to be read or written. Depending on the drive and command, an interrupt may also be fired when `DRQ` goes high after a command is issued. `ERR / CHK` is set if the last command executed resulted in an error; in that case the error register will contain more information about the cause of the error.

Reading from this register will acknowledge any pending drive interrupt and deassert IRQ10. Note that, as with all PS1 interrupts, IRQ10 must additionally be acknowledged at the interrupt controller side in order for it to fire again.

0x1f4c000c (IDE bank 1, address 6): Alternate status

Read-only mirror of the status register at `0x1f48000e` that returns the same flags, but does not acknowledge any pending IRQ when read.

IDE DMA and quirks

DMA channel 5, normally reserved for the expansion port on a PS1, can be used to transfer data to/from the IDE bus... with some caveats. The "correct" way to connect an IDE drive to the PS1's DMA controller would be to wire up `DMARQ` and `/DMACK` from the drive directly to the respective pins on the CPU, allowing the DMA controller to synchronize transfers to the drive's internal buffer in chunked mode.

However, Konami being Konami, they did not do this on the 573. IDE drives will instead interpret DMA reads or writes as a burst of regular ("PIO", as defined in the ATA specification) CPU-issued reads or writes. As such, the drive shall be configured for PIO data transfers rather than DMA using the "set features" ATA command, and bits 9-10 in the `DMA5_CHCR` register shall be cleared to put the channel in manual synchronization mode. The `DRQ` bit in the status register must also be polled manually prior to starting a transfer, to ensure the drive is ready for it.

23.2.3 RTC registers

The RTC is an ST M48T58. This chip behaves like an 8 KB 8-bit static RAM, wired to the lower 8 bits of the 16-bit data bus. It must thus be accessed by performing 16-bit bus accesses and ignoring/masking out the upper 8 bits (as with IDE control registers).

The first 8184 bytes are mapped to the `0x1f620000-0x1f623fef` region and are simply battery-backed SRAM, which will retain its contents across power cycles as long as the RTC's battery is not dead. The last 8 bytes are used as clock and control registers.

The values of the clock registers are buffered: they are stored in intermediate registers rather than being read from or written to the clock counters directly. Bits 6 and 7 in the control register at `0x1f623ff0` are used to control transfers between the registers and clock counters. All clock values are returned in BCD format.

`0x1f623ff0` (M48T58 register `0x1ff8`): Calibration / Control

Bits	RW	Buffered	Description
0-4	RW	Unknown	Calibration offset (0-31), adjusts oscillator frequency
5	RW	Unknown	Sign bit for calibration offset (1 = positive)
6	W	No	Read mutex (1 = prevent buffered register updates)
7	W	No	Write mutex and trigger
8-15			Unused

The values of all buffered clock registers are updated automatically. Setting bit 6 will disable this behavior while keeping the counters running, allowing for the registers to be read reliably without the RTC updating them at the same time. The bit shall be cleared after reading the registers.

Setting bit 7 will also halt buffered register updates, so that they can be overwritten manually with new values. Clearing it afterwards will result in the registers' values being copied back to the clock counters.

0x1f623ff2 (M48T58 register 0x1ff9): Seconds / Stop

Bits	RW	Buffered	Description
0-3	RW	Yes	Second units (0-9)
4-6	RW	Yes	Second tens (0-5)
7	RW	Unknown	Stop flag (0 = clock paused, 1 = clock running)
8-15			Unused

0x1f623ff4 (M48T58 register 0x1ffa): Minute

Bits	RW	Buffered	Description
0-3	RW	Yes	Minute units (0-9)
4-6	RW	Yes	Minute tens (0-5)
7			Reserved (must be 0)
8-15			Unused

0x1f623ff6 (M48T58 register 0x1ffb): Hour

Bits	RW	Buffered	Description
0-3	RW	Yes	Hour units (0-9, or 0-3 if tens = 2)
4-5	RW	Yes	Hour tens (0-2)
6-7			Reserved (must be 0)
8-15			Unused

Hours are always returned in 24-hour format, as there is no way to switch to 12-hour format.

0x1f623ff8 (M48T58 register 0x1ffc): Day of week / Century

Bits	RW	Buffered	Description
0-2	RW	Yes	Day of week (1-7)
3			Reserved (must be 0)
4	RW	Yes	Century flag
5	RW	Unknown	Century flag toggling enable (1 = enabled)
6	RW	Unknown	Enable 512 Hz clock signal output on pin 1
7			Reserved (must be 0)
8-15			Unused

The day of week register is a free-running counter incremented alongside the day counter. There is no logic for calculating the day of the week, so it must be updated manually when setting the time. Konami games use 1 as Sunday, 2 as Monday and so on.

Bit 4 is a single-bit "counter" that gets toggled each time the year counter overflows. It can be frozen by clearing bit 5. Konami games do not use the century flag, as they interpret any year counter value in 70-99 range as 1970-1999 and all other values as a year after 2000.

0x1f623ffa (M48T58 register 0x1ffd): Day of month / Battery state

Bits	RW	Buffered	Description
0-3	RW	Yes	Day of month units (range depends on tens and month)
4-5	RW	Yes	Day of month tens (range depends on month)
6	R	No	Low battery flag (1 = battery voltage is below 2.5V)
7	RW	Unknown	Battery monitoring enable (1 = enabled)
8-15			<i>Unused</i>

Bit 6 is updated when the system is power cycled, if bit 7 has previously been set.

0x1f623ffc (M48T58 register 0x1ffe): Month

Bits	RW	Buffered	Description
0-3	RW	Yes	Month units (1-9, or 0-2 if tens = 1)
4	RW	Yes	Month tens (0-1)
5-7			<i>Reserved</i> (must be 0)
8-15			<i>Unused</i>

0x1f623ffe (M48T58 register 0x1fff): Year

Bits	RW	Buffered	Description
0-3	RW	Yes	Year units (0-9)
4-7	RW	Yes	Year tens (0-9)
8-15			<i>Unused</i>

The year counter covers a full century, going from 00 to 99. On each overflow the century flag in the day of week register is toggled.

23.2.4 Other registers

These registers are implemented almost entirely using 74-series logic and the XC9536 CPLD on the main board.

0x1f500000 : Bank switch / Security cartridge

Bits	RW	Description
0-5	W	Bank number (0-47, see below)
6	W	<code>IO0</code> direction on security cartridge (0 = input/high-z)
7		Unknown (goes into CPLD)
8-15		<i>Unused</i>

Bit 6 controls whether `IO0` on the security cartridge is an input or an output. If set, `IO0` will output the same logic level as `D0`, otherwise the pin will be floating. Bits 0-5 are used to switch the device mapped to the 4 MB `0x1f000000-0x1f3fffff` region:

Bank	Mapped to
0	Internal flash 1 (chips <code>31M</code> , <code>27M</code>)
1	Internal flash 2 (chips <code>31L</code> , <code>27L</code>)
2	Internal flash 3 (chips <code>31J</code> , <code>27J</code>)
3	Internal flash 4 (chips <code>31H</code> , <code>27H</code>)
4-15	<i>Unused</i>
16-31	PCMCIA card slot 1
32-47	PCMCIA card slot 2
48-63	<i>Unused</i>

0x1f520000 : JVSIRDY clear

Bits	RW	Description
0-15		<i>Unused</i>

This register is a dummy write-only port that clears the `JVSIRDY` flag when any value is written to it. The flag is set by the JVS MCU whenever a new data word is available for reading from `0x1f40000a`.

0x1f560000 : IDE reset control

Bits	RW	Description
0	W	Reset pin output (0 = pull reset low)
1-15		Unused

Since the IDE reset pin is active-low, a reset is performed by writing 0 to this register, then waiting a few milliseconds and writing 1 again. Note that the IDE specification also defines a way to "soft-reset" devices (e.g. to abort execution of a command) using the `SRST` bit in the device control register.

0x1f5c0000 : Watchdog clear

Bits	RW	Description
0-15		Unused

This register is a dummy write-only port that clears the watchdog timer embedded in the Konami 058232 power-on reset and coin counter driver chip when any value is written to it. The BIOS and games write to this port roughly once per frame.

If the watchdog is not cleared at least every 350-400 ms, it will pull the system's reset line low for about 50 ms in order to force a reboot. The watchdog can be disabled without affecting power-on reset by placing a jumper on `S86` (see the pinouts section).

0x1f600000 : External outputs

Bits	RW	Description
0-7	W	To <code>OUT0-OUT7</code> on <code>EXT-OUT</code> connector
8-15		Unused

The lower 8 bits written to this register are latched on pins `OUT0-OUT7` of the external output connector (see the pinouts section). This connector is used by some games to control cabinet lights without using an I/O board.

0x1f680000 : Data to JVS MCU

Bits	RW	Description
0-15	W	Data word to MCU

In order to prevent overruns, this register shall only be accessed when `JVSDRDY` is cleared. Writing to it will set `JVSDRDY`.

0x1f6a0000 : Security cartridge outputs

Bits	RW	Description
0-7	W	To <code>D0-D7</code> on security cartridge
8-15		<i>Unused</i>

The lower 8 bits written to this register are latched on pins `D0-D7` of the cartridge slot. See the security cartridge section for an explanation of what each pin is wired to. Bit 0 additionally controls the `IO0` pin when configured as an output through the bank switch register. Writing to this register will set the `DRDY` flag, which can then be cleared by the cartridge.

23.3 JVS interface

The System 573 is equipped with a JVS host interface, allowing for connection of I/O modules, controllers and other devices that implement the JVS protocol commonly used in arcade cabinets.

JVS uses a single RS-485 bus running at 115200 bits per second, shared by all devices. The standard JVS connector is a single USB-A port, with the data lines used as the RS-485 differential pair and the `VBUS` pin as a sensing line (see the JVS specification for details). JVS devices typically have a full size USB-B port for connection to the host, plus optionally another USB-A port for daisy chaining additional devices. The RS-485 bus needs to be terminated; some boards will automatically insert a termination resistor when connected as the last node in a daisy chain.

23.3.1 Packet format

A JVS packet can be up to 258 bytes long and is made up of the following fields:

Byte	Description
0	Synchronization byte, must be <code>0xe0</code>
1	Destination address
2	Length (number of payload bytes including checksum)
3-	Payload
	Checksum (sum of address, length and payload bytes modulo 256)

NOTE: when a JVS packet is sent over the RS-485 bus, any `0xd0` or `0xe0` byte other than the synchronization byte must be escaped as `0xd0 0xcf` or `0xd0 0xdf` respectively, in order to allow downstream devices to reliably determine the end of a packet. On the 573, the JVS MCU handles escaping outbound packets and unescaping inbound packets automatically. The escaping process does *not* update the length field to reflect the escaped length of the packet.

Refer to the JVS specification for details on the contents of standard and vendor-specific payloads.

23.3.2 MCU communication protocol

The system's JVS interface is managed by a dedicated H8/3644 microcontroller, interfaced through two 16-bit latches and handshaking lines (in a similar way to the 8-bit ports on the security cartridge slot). The MCU's firmware is stored in OTP ROM and consists of a simple loop that buffers the data written by the 573, sends it, waits for a response to be received and lets the 573 read it.

In order to perform a JVS transaction the 573 must:

1. Reset the MCU through register `0x1f400000` , clear `JVSIRDY` by writing to `0x1f520000` then wait for the status and error codes in register `0x1f400004` to be set to 0 and 3 respectively.
2. Write the packet two bytes at a time to `0x1f680000` , waiting for `JVSDRDY` to go low before each write. Words are little endian, so for instance the first word of a packet with destination address `0x01` would be `0x01e0` . If the total length of the packet is odd, the last byte shall still be written as a word (with the upper byte zeroed out).
3. Wait for the status code to become 1. At this point the MCU will send the packet and wait for a response from a device on the bus.
4. Wait for the status code to become 0, signalling a valid response has been received and can be read out. A timeout should be implemented here, as the MCU will wait for a response indefinitely even if no device is present.
5. Read the packet, again two bytes at a time, from `0x1f40000a` , waiting for `JVSIRDY` to go high before each read and clearing it by writing to `0x1f520000` after each read. The status code will be set to 2 after the first word is read and back to 0 once no more data is available to read.

The MCU does not allow for non-JVS packets to be sent as it validates the sync byte, checksum and uses the length field to determine packet length. Responses cannot be received without sending a packet first either. The MCU will also insert a 200 μ s minimum delay between the last byte of a received packet and the first byte of the next packet.

23.4 I/O boards

The System 573 was designed to be expanded with game-specific hardware using I/O expansion boards mounted on top of the main board, and/or custom security cartridges.

I/O boards have access to the 16-bit system bus and are accessible through the `0x1f640000-0x1f6400ff` region.

- Analog I/O board (GX700-PWB (F))
- Digital I/O board (GX894-PWB (B) A)
- Alternate analog I/O board (GX700-PWB (K))
- Fishing controller I/O board (GE765-PWB (B) A)
- DDR Karaoke Mix I/O board (GX921-PWB (B))
- GunMania I/O board (PWB0000073070)
- Hypothetical debugging board

23.4.1 Analog I/O board (GX700-PWB (F))

Used in early Bemani games such as DDR 1stMIX and 2ndMIX, as well as some non-Bemani games. The name is misleading as the board does not deal with any analog signals whatsoever; the name was given retroactively to distinguish it from the digital I/O board. It provides up to 28 optoisolated open-drain outputs typically used to control cabinet lights, split across 4 banks:

- **Bank A** (CN33): 8 outputs (A0-A7)
- **Bank B** (CN34): 8 outputs (B0-B7)
- **Bank C** (CN35): 8 outputs (C0-C7)
- **Bank D** (CN36): 4 outputs (D0-D3)

Some games shipped with partially populated analog I/O boards, thus not all banks may be available. See the game-specific information section for details on how lights are wired up on each cabinet type.

0x1f640080 : Bank A

Bits	RW	Description
0	W	Output A1 (0 = grounded, 1 = high-z)
1	W	Output A3 (0 = grounded, 1 = high-z)
2	W	Output A5 (0 = grounded, 1 = high-z)
3	W	Output A7 (0 = grounded, 1 = high-z)
4	W	Output A6 (0 = grounded, 1 = high-z)
5	W	Output A4 (0 = grounded, 1 = high-z)
6	W	Output A2 (0 = grounded, 1 = high-z)
7	W	Output A0 (0 = grounded, 1 = high-z)
8-15		<i>Unused</i>

0x1f640088 : Bank B

Bits	RW	Description
0	W	Output B1 (0 = grounded, 1 = high-z)
1	W	Output B3 (0 = grounded, 1 = high-z)
2	W	Output B5 (0 = grounded, 1 = high-z)
3	W	Output B7 (0 = grounded, 1 = high-z)
4	W	Output B6 (0 = grounded, 1 = high-z)
5	W	Output B4 (0 = grounded, 1 = high-z)
6	W	Output B2 (0 = grounded, 1 = high-z)
7	W	Output B0 (0 = grounded, 1 = high-z)
8-15		<i>Unused</i>

0x1f640090 : Bank C

Bits	RW	Description
0	W	Output C1 (0 = grounded, 1 = high-z)
1	W	Output C3 (0 = grounded, 1 = high-z)
2	W	Output C5 (0 = grounded, 1 = high-z)
3	W	Output C7 (0 = grounded, 1 = high-z)
4	W	Output C6 (0 = grounded, 1 = high-z)
5	W	Output C4 (0 = grounded, 1 = high-z)
6	W	Output C2 (0 = grounded, 1 = high-z)
7	W	Output C0 (0 = grounded, 1 = high-z)
8-15		<i>Unused</i>

0x1f640098 : Bank D

Bits	RW	Description
0	W	Output D3 (0 = grounded, 1 = high-z)
1	W	Output D2 (0 = grounded, 1 = high-z)
2	W	Output D1 (0 = grounded, 1 = high-z)
3	W	Output D0 (0 = grounded, 1 = high-z)
4-15		<i>Unused</i>

23.4.2 Digital I/O board (GX894-PWB (B) A)

Used by later Bemani games, such as DDR from Solo onwards. This board features the same 28 isolated open-drain outputs as the analog I/O board, plus a Xilinx XCS40XL Spartan-XL FPGA and a Micronas MAS3507D audio decoder ASIC used to play encrypted MP3 files. The FPGA has 24 MB of dedicated DRAM into which the files are preloaded on startup, then decrypted on the fly and fed to the decoder. The board also features 128 KB of SRAM used as a cache, RS-232 and ARCnet transceivers for communication with other hardware and a DS2401 serial number chip, used to prevent usage of the same security cartridge on more than one 573.

The vast majority of the registers provided by this board (including some but not all light outputs) are handled by its FPGA, which requires a configuration bitstream to be uploaded to it in order to work. Registers in the `0x1f6400f0-0x1f6400ff` region are

handled by a CPLD and are functional even if no bitstream is loaded. There are several known versions of Konami's bitstream:

SHA-1 (41337 bytes, LSB first)	First used by
32d455a25eb26fe4e4b577cb0f0e3bebd0f82959	Dance Dance Revolution Solo Bass Mix
a53b8906de95c34b6e3f053bd7488c888bc904b6	Dance Dance Revolution 3rdMIX
5d27c84e812f71401f940621f79c5c6114192895	GuitarFreaks 2ndMIX
450b12627b7eacd3ea3f8b0b7a16589a13010c41	Mambo a Go-Go
53d0c1e3f6ae042d7d45ce889b79a12f1be5eabd	Martial Beat e-Amusement
d1d0f123bbb9d5abfefbd556c366f9ded0779e41	Martial Beat (leftover file 1, unused)
f354619fe1a80cabe0b774784181b3bfeff0a3e9	Martial Beat (leftover file 2, unused)

The DDR and Mambo bitstreams all implement the same registers (listed below) and seem to only differ in the MP3 decryption algorithm, while the unused Martial Beat bitstreams seem to behave in a completely different way.

Homebrew software may also load custom bitstreams developed using the Xilinx ISE 4.2 toolchain (the last version to support Spartan-XL parts). The following custom bitstreams are known to exist so far:

SHA-1 (41337 bytes, LSB first)	First used by
9d5acaae61f03f4d71831ebdb013af6189802ed2	573in1 1.0.0
e9212e9ff24fa876158f510e3c17649a110f60a4	573in1 (development branch)

0x1f640080 (FPGA, all bitstreams): Magic number

Bits	RW	Description
0-15	R	Magic number (0x1234 for Konami bitstreams, 0x573f for 573in1 bitstreams)

This register is checked by some versions of Konami's digital I/O board driver to make sure the bitstream was properly loaded.

0x1f640082 (FPGA, 573in1 bitstream): Configuration

Bits	RW	Description
0-7	R	Bitstream version (currently 0x02)
8	RW	MP3 looping enable (1 = continue playing from start address when end address is reached)
9	RW	Automatically clear DAC sample counter registers when starting MP3 playback (1 = clear)
10	RW	Automatically clear register 0x1f6400cc when DAC sample counter delta is read (1 = clear)
11	RW	Automatically disable sample counter if cleared while MP3 playback is stopped (1 = disable)
12	RW	Primary MP3 descrambler key (0 = key1 , 1 = scrambled XOR of key1 and key2)
13	RW	Secondary MP3 descrambler key (0 = none, 1 = scrambled counter initialized from key3)
14	RW	MP3 data feeder endianness (0 = read bits 15-8 then 7-0, 1 = read bits 7-0 then 15-8)
15	RW	Swap bits 14 and 15 of key1 when mutating it (1 = swap)

Custom register only implemented by the 573in1 bitstream, in order to allow for emulation of quirks present in different versions of Konami's bitstreams as well as control some additional features.

Bits 9-11 tune the behavior of the DAC sample counter registers (0x1f6400ca , 0x1f6400cc and 0x1f6400cf). Setting all of them will make the registers replicate the behavior of those provided by the DDR 3rdMIX bitstream onwards, while clearing them will bring them closer to the earlier DDR Solo Bass Mix bitstream's behavior.

Bits 12, 13 and 15 control the MP3 decryption algorithm. All of them shall be set to decrypt MP3 files from DDR 3rdMIX onwards (scrambled with key1 , key2 and key3) or cleared to play DDR Solo Bass Mix files (scrambled with key1 only). Bit 14 controls which byte of each 16-bit word in DRAM is fed to the MAS3507D first and should be cleared for encrypted MP3 playback.

The 573in1 bitstream's descrambler can be configured to play unencrypted data by performing the following steps:

- clear bits 12, 13 and 15;
- set bit 14 (encrypted MP3s are byte swapped as part of the scrambling process but an unencrypted file will have to be swapped during playback);
- clear key1 by writing zero to register 0x1f6400a8 , which will render the decryption step a no-op.

0x1f640090 (FPGA, all bitstreams): Network board address

0x1f640092 (FPGA, all bitstreams): Unknown (network related)

0x1f6400a0 (FPGA, all bitstreams): MP3 data start address high

0x1f6400a2 (FPGA, all bitstreams): MP3 data start address low

0x1f6400a4 (FPGA, all bitstreams): MP3 data end address high

0x1f6400a6 (FPGA, all bitstreams): MP3 data end address low

0x1f6400a8 (FPGA, all bitstreams): MP3 frame counter / Descrambler key 1

When read:

Bits	RW	Description
0-15	R	Current MP3 frame count (number of MAS3507D <code>PI4</code> rising edges)

When written:

Bits	RW	Description
0-15	W	Initial <code>key1</code> value

The frame counter is only active when bit 15 in register `0x1f6400ae` is set. Note that the MAS3507D also has an internal frame counter readable through I2C, independent of this register.

0x1f6400aa (FPGA, all bitstreams): MP3 playback status

When read:

Bits	RW	Description
0-11		<i>Unused</i>
12	R	MAS3507D MP3 data request flag (<code>PI19</code>)
13	R	MAS3507D MP3 error flag (<code>PI8</code>)
14	R	MAS3507D MP3 frame sync flag (<code>PI4</code>)
15	R	MAS3507D master clock ready flag (<code>WRDY</code>)

When written:

Bits	RW	Description
0-11		Unused
12	W	MAS3507D chip reset (/POR , 0 = pull low)
13	W	MAS3507D PIO chip select (/PCS , 0 = pull low)
14-15		Unused

During normal operation the reset input should be high and the PIO chip select low. Setting the chip select high will result in the MAS3507D tristating `PI19` , `PI8` and `PI4` .

`0x1f6400ac` (FPGA, all bitstreams): MAS3507D I2C

Bits	RW	Description
0-11		Unused
12	RW	MAS3507D <code>SDA</code> (write 0 = pull low)
13	RW	MAS3507D <code>SCL</code> (write 0 = pull low)
14-15	RW	Unused

Due to the MAS3507D relying heavily on I2C clock stretching (pulling `SCL` low to request the host to wait), both `SDA` and `SCL` are bidirectional open-drain signals.

`0x1f6400ae` (FPGA, all bitstreams): MP3 data feeder control

Bits	RW	Description
0-11		Unused
12	R	Current playback status (0 = paused, 1 = playing)
13	W	Playback enable (0 = disabled/ignore bit 14, 1 = enabled)
14	W	Playback control (0 = pause, 1 = play)
15	W	MP3 frame counter enable (0 = disabled/reset, 1 = enabled)

Data is only fed to the MAS3507D when both bits 13 and 14 are set. Bit 12 is a read-only copy of bit 14 and remains set if playback is stopped by clearing bit 13 only.

Bit 15 controls whether to increment register `0x1f6400a8` each time a rising edge is detected on the MAS3507D's `PI4` (frame sync) pin. The counter is automatically reset to zero when this bit is cleared.

0x1f6400b0 (FPGA, all bitstreams): DRAM write address high

0x1f6400b2 (FPGA, all bitstreams): DRAM write address low

0x1f6400b4 (FPGA, all bitstreams): DRAM data

Bits	RW	Description
0-15	RW	Current data word

NOTE: on some bitstream versions, all registers in the 0x1f6400b0-0x1f6400bf region seem to mirror this register when read (possibly due to incomplete address decoding), however only a read from 0x1f6400b4 will increment the current read pointer and kick off prefetching of the next word.

0x1f6400b6 (FPGA, all bitstreams): DRAM read address high

0x1f6400b8 (FPGA, all bitstreams): DRAM read address low

0x1f6400ba (FPGA, all bitstreams): Unknown

0x1f6400c0 (FPGA, all bitstreams): Network data

0x1f6400c2 (FPGA, all bitstreams): Network TX FIFO length

0x1f6400c4 (FPGA, all bitstreams): Network RX FIFO length

0x1f6400c6 (FPGA, all bitstreams): Unknown

Seems to return 0x7654 on startup.

0x1f6400c8 (FPGA, all bitstreams): Unknown (network related)

Seems to also return 0x7654 on startup.

0x1f6400ca (FPGA, all bitstreams except Solo): DAC sample counter high

0x1f6400cc (FPGA, all bitstreams): DAC sample counter low

0x1f6400ce (FPGA, all bitstreams): DAC sample counter delta

0x1f6400e0 (FPGA, all bitstreams): Bank A

Bits	RW	Description
0-11		<i>Unused</i>
12	W	Output A4 (0 = grounded, 1 = high-z)
13	W	Output A5 (0 = grounded, 1 = high-z)
14	W	Output A6 (0 = grounded, 1 = high-z)
15	W	Output A7 (0 = grounded, 1 = high-z)

0x1f6400e2 (FPGA, all bitstreams): Bank A

Bits	RW	Description
0-11		<i>Unused</i>
12	W	Output A0 (0 = grounded, 1 = high-z)
13	W	Output A1 (0 = grounded, 1 = high-z)
14	W	Output A2 (0 = grounded, 1 = high-z)
15	W	Output A3 (0 = grounded, 1 = high-z)

0x1f6400e4 (FPGA, all bitstreams): Bank B

Bits	RW	Description
0-11		<i>Unused</i>
12	W	Output B4 (0 = grounded, 1 = high-z)
13	W	Output B5 (0 = grounded, 1 = high-z)
14	W	Output B6 (0 = grounded, 1 = high-z)
15	W	Output B7 (0 = grounded, 1 = high-z)

0x1f6400e6 (FPGA, all bitstreams): Bank D

Bits	RW	Description
0-11		<i>Unused</i>
12	W	Output D0 (0 = grounded, 1 = high-z)
13	W	Output D1 (0 = grounded, 1 = high-z)
14	W	Output D2 (0 = grounded, 1 = high-z)
15	W	Output D3 (0 = grounded, 1 = high-z)

0x1f6400e8 (FPGA, all bitstreams): Internal logic reset

Bits	RW	Description
0-11		<i>Unused</i>
12	W	Unknown reset (0 = reset)
13	W	Reset MP3 feeder and master clock divider to DAC (0 = reset)
14	W	Unknown reset (0 = reset)
15	W	Unknown reset (0 = reset)

Konami's code writes `0xf000`, followed by `0x0000`, a delay and `0xf000` again, to this register after uploading the bitstream.

0x1f6400ea (FPGA, all bitstreams): Descrambler key 2

Bits	RW	Description
0-15	W	Initial <code>key2</code> value

0x1f6400ec (FPGA, all bitstreams): Descrambler key 3

Bits	RW	Description
0-7	W	Initial <code>key3</code> value
8-15		<i>Unused</i>

0x1f6400ee (FPGA, all bitstreams): 1-wire bus

When read:

Bits	RW	Description
0-7		Unused
8	R	DS2433 1-wire bus readout
9-11		Unused
12	R	DS2401 1-wire bus readout
13-15		Unused

When written:

Bits	RW	Description
0-7		Unused
8	W	Drive DS2433 1-wire bus low (1 = pull low, 0 = high-z)
9-11		Unused
12	W	Drive DS2401 1-wire bus low (1 = pull low, 0 = high-z)
13-15		Unused

In addition to the DS2401 the board has an unpopulated footprint for a DS2433 1-wire EEPROM, connected to a separate FPGA pin.

0x1f6400f0 (CPLD): Unknown (unused?)

Konami's code does not write to this CPLD register.

0x1f6400f2 (CPLD): Unknown (unused?)

Konami's code does not write to this CPLD register.

0x1f6400f4 (CPLD): DAC reset

Bits	RW	Description
0-14		Unused
15	W	Audio DAC reset/disable (0 = reset)

Konami's code uses this register to mute the DAC during FPGA and MAS3507D initialization.

0x1f6400f6 (CPLD): FPGA status and control

When read:

Bits	RW	Description
0-11		Unused
12	R	Possibly <code>/INIT</code> from FPGA
13	R	Possibly <code>DONE</code> from FPGA
14	R	Board identification? (always 1)
15	R	Board identification? (always 0)

NOTE: all registers in the `0x1f6400f0-0x1f6400ff` region seem to return the same value as this register when read, possibly due to incomplete address decoding in the CPLD. Konami's driver only ever reads from this register and treats all other CPLD registers as write-only.

When written:

Bits	RW	Description
0-11		Unused
12	W	Possibly <code>/INIT</code> to FPGA
13	W	Possibly <code>DONE</code> to FPGA
14	W	Possibly <code>/PROGRAM</code> to FPGA
15	W	Unused? (always 1)

This register is only written to 3 times when resetting the FPGA prior to loading the bitstream. The values written are `0x8000` first, then `0xc000` and finally `0xf000`.

0x1f6400f8 (CPLD): FPGA bitstream upload

Bits	RW	Description
0-14		Unused
15	W	Bit to send to the FPGA

Bits written to this register are sent to the FPGA's configuration interface (`DIN` and `CCLK` pins, see the XCS40XL datasheet). There is no separate bit to control the `CCLK` pin as clocking is handled automatically. The FPGA is wired to boot in "slave serial" mode and wait for a bitstream to be loaded by the 573 through this port.

All known games load the bitstream from an array embedded in the executable or a file on the internal flash (usually named `data/fpga/fpga_mp3.bin`), then write its contents to this port LSB first and monitor the FPGA status register. The bitstream is always 330696 bits (41337 bytes) long as per the XCS40XL datasheet.

0x1f6400fa (CPLD): Bank C

Bits	RW	Description
0-11		<i>Unused</i>
12	W	Output C0 (0 = grounded, 1 = high-z)
13	W	Output C1 (0 = grounded, 1 = high-z)
14	W	Output C2 (0 = grounded, 1 = high-z)
15	W	Output C3 (0 = grounded, 1 = high-z)

0x1f6400fc (CPLD): Bank C

Bits	RW	Description
0-11		<i>Unused</i>
12	W	Output C4 (0 = grounded, 1 = high-z)
13	W	Output C5 (0 = grounded, 1 = high-z)
14	W	Output C6 (0 = grounded, 1 = high-z)
15	W	Output C7 (0 = grounded, 1 = high-z)

0x1f6400fe (CPLD): Bank B

Bits	RW	Description
0-11		<i>Unused</i>
12	W	Output B0 (0 = grounded, 1 = high-z)
13	W	Output B1 (0 = grounded, 1 = high-z)
14	W	Output B2 (0 = grounded, 1 = high-z)
15	W	Output B3 (0 = grounded, 1 = high-z)

23.4.3 Alternate analog I/O board (GX700-PWB (K))

Used by Kick & Kick. Has several optocouplers, plus a DS2401 serial number chip and several unpopulated footprints.

This board is currently undocumented.

23.4.4 Fishing controller I/O board (GE765-PWB(B)A)

Used by the Fisherman's Bait series. Uses an NEC uPD4701 mouse/trackball chip to track motion of the fishing reel's rotary encoders and contains PWM drivers for the feedback motors. Along with the analog I/O board, it is the only known board that does *not* have a DS2401.

This board is currently undocumented.

23.4.5 DDR Karaoke Mix I/O board (GX921-PWB(B))

Used by DDR Karaoke Mix 1 and 2. Similarly to the digital I/O board, this board features several optoisolated light outputs, an ARCnet PHY and a DS2401 serial number chip. It also has composite video inputs and outputs, a video encoder to convert the 573's native RGB output to composite and additional circuitry to superimpose it onto the video feed from an external karaoke machine. An onboard PC16552 UART is provided to communicate with the machine (the security cartridge also exposes SIO1).

This board is currently undocumented.

23.4.6 GunMania I/O board (PWB0000073070)

Used by GunMania and GunMania Zone Plus. Contains an RGB to S-video converter which drives the cabinet's projector, several motor drivers, optoisolators, a PC16552 UART and a DS2401 serial number chip. A DB25 connector on the side of the board is used to interface to the resistive matrix used to detect bullet shots.

This board is currently undocumented.

23.4.7 Hypothetical debugging board

There is no proof whatsoever of this board having ever existed, but the BIOS and some games attempt to access the hardware on it. It seems to contain at least a Fujitsu MB89371 UART and a 7-segment display, although these may have actually been on two separate boards (or built into a prototype board used by Konami during development).

The MB89371 does not have a publicly available datasheet.

0x1f640000 : UART data

0x1f640002 : UART control

0x1f640004 : UART baud rate select

0x1f640006 : UART mode

0x1f640010 : 7-segment display

Bits	RW	Description
0	W	Right digit segment G (0 = on)
1	W	Right digit segment F (0 = on)
2	W	Right digit segment E (0 = on)
3	W	Right digit segment D (0 = on)
4	W	Right digit segment C (0 = on)
5	W	Right digit segment B (0 = on)
6	W	Right digit segment A (0 = on)
7		<i>Unused</i>
8	W	Left digit segment G (0 = on)
9	W	Left digit segment F (0 = on)
10	W	Left digit segment E (0 = on)
11	W	Left digit segment D (0 = on)
12	W	Left digit segment C (0 = on)
13	W	Left digit segment B (0 = on)
14	W	Left digit segment A (0 = on)
15		<i>Unused</i>

Used by the BIOS kernel while booting (in a similar way to the standard PS1 kernel, which uses register `0x1f802041` instead) as well as the shell and some games. This may have been meant to be a POST display integrated into the 573 main board at some point.

23.5 Security cartridges

Most System 573 games use cartridges that plug into the slot on the right side of the main board as an anti-piracy measure and/or to add game specific I/O functionality (particularly for games that do not otherwise require any I/O board). Cartridges typically contain a password protected EEPROM, used to store game and installation information, and in some cases a DS2401 unique serial number chip.

- [Electrical interface](#)
- [Cartridge EEPROM types](#)
- [EEPROM-less cartridge variants](#)
- [X76F041 cartridge variants](#)
- [ZS01 cartridge variants](#)
- [Cartridge identifiers](#)

23.5.1 Electrical interface

All communication with the cartridge is performed through the following means:

- an 8-bit parallel input port (`IO0-IO7`), readable via register `0x1f400004` ;
- a latched 8-bit parallel output port (`D0-D7`), controlled by register `0x1f6a0000` ;
- a single tristate I/O pin (`IO0`), which can be either configured as a floating input or set to output the same logic level as `D0` through register `0x1f500000` ;
- the CPU's SIO1 interface (`TX` , `RX` , `/RTS` , `/CTS` , `/DTR` , `/DSR`);
- four bus handshaking lines (`IRDY` , `DRDY` , `/IREQ` , `/DACK`).

As all EEPROMs used in cartridges have an I2C interface rather than a parallel one, `IO0` is used in combination with individual bits of the parallel I/O ports to bitbang I2C. The SIO1 interface either goes unused or is translated to RS-232 voltage levels and broken out to a connector on the cartridge.

See the pinouts section for more information on the security cartridge slot.

Handshaking lines

The cartridge slot carries two status lines *unofficially* known as `IRDY` and `DRDY` plus two inputs named `/IREQ` and `/DACK`, probably meant for synchronization with cartridges that would actually use `D0-D7` and `I0-I7` as a parallel data bus rather than to bitbang serial protocols. No currently known cartridge uses these pins.

`DRDY` is set whenever the 573 writes to the output port, even if no bits have actually changed. The cartridge can monitor this signal to know when to read a byte from the port and then pull `/DACK` low to reset it. To send a byte to the 573 the cartridge can pulse `/IREQ`, which will cause `IRDY` to go high until the 573 accesses the input port. The 573 can read the status of `IRDY` (as well as `DRDY`) through the Konami ASIC and wait for it to be set before reading the next byte.

The cartridge I/O ports can basically be thought of as a single-byte FIFO, with `DRDY` being the "TX buffer full" flag and `IRDY` the "RX buffer not empty" flag. The handshaking lines are implemented using a handful of 74LS74 flip flops.

NOTE: the JVS MCU also has its own handshaking lines, `JVSIRDY` and `JVSDRDY`, which are actually used and work in pretty much the same way. See the JVS interface section for more information on communicating with the MCU.

Note about RTS/CTS

The PS1 CPU's SIO1 UART has hardware flow control and will not transmit data until CTS is asserted. In order to get around this most cartridges tie CTS to RTS, allowing it to be controlled in software. Cartridges that use the serial port (i.e. ones with a network port) have the pins tied together on the PCB, while other cartridge types usually break them out to a shorted 2-pin jumper.

Some earlier games that do not use SIO1 for networking purposes redirect their debug logging output to it (by calling the `AddSIO()` function provided by the Sony SDK) if CTS and RTS are shorted on startup. On later 573 motherboard revisions, the SIO1 pins are additionally broken out to a separate connector (`CN24`) and made accessible even when a cartridge without a network port is inserted.

23.5.2 Cartridge EEPROM types

Konami's security cartridge driver supports the following EEPROMs:

Manufacturer	Chip	"Response to reset" ID	Capacity
Xicor	X76F041	19 55 aa 55 (LSB first)	512 bytes
Xicor	X76F100	19 00 aa 55 (LSB first)	112 bytes
Konami/Microchip	ZS01 (PIC16CE625)	5a 53 00 01 (MSB first)	112 bytes

NOTE: Konami seems to have never manufactured X76F100 cartridges, however most games that expect an X76F041 can also use the X76F100 interchangeably. ZS01 support was only added in later versions of the driver.

ZS01 protocol

The "ZS01" EEPROM (also known as "NS2K001") is actually a PIC16 microcontroller that mostly replicates the X76F100's functionality, allowing the 573 to store up to 112 bytes of data protected by a 64-bit password. Unlike the X76F041 and X76F100, which use plaintext commands, all communication with the ZS01 is obfuscated using a rudimentary scrambling algorithm. A CRC16 is attached to each packet and used to detect attempts to tamper with the obfuscation. Attempting to send too many requests with an invalid CRC16 will cause the ZS01 to self-erase and reset the password.

A ZS01 transaction can be broken down into the following steps:

1. The 573 prepares a 12-byte packet to be sent to the ZS01, containing a command, address and payload:

Bytes	Description
0	Command flags
1	Address bits 0-7
2-9	Payload (data for writes, response key for reads)
10-11	CRC16 of bytes 0-9, big endian

The first byte is a 3-bit bitfield encoding the command and access type:

Bits	Description
0	Command (0 = write/erase, 1 = read)
1	Address bit 8 (unused, should be 0)
2	Access type (0 = unprivileged, 1 = privileged)
3-7	Unused? (should be 0)

The access type bit specifies whether the command is privileged. Privileged commands require the ZS01's current password, while unprivileged commands do not.

The address must be one of the following values:

Address	Length	Privileged	Description
0x00-0x03	32 bytes	No	Unprivileged data area
0x04-0x0e	80 bytes	Yes	Privileged data area
0xfc	8 bytes	No	Internal ZS01 serial number
0xfd	8 bytes	No	External DS2401 serial number
0xfd	8 bytes	Yes	Erases data area when written (write-only)
0xfe	8 bytes	Yes	Configuration registers
0xff	8 bytes	Yes	New password (write-only)

Data is always read or written in aligned 8 byte blocks. Unprivileged areas can be read using either a privileged or unprivileged read command, but writing to them still requires a privileged write command.

2. If the command is a read command, a random 8-byte "response key" is generated (typically as an MD5 hash of the current time from the RTC) and written to the payload field; the ZS01 will later use it to encrypt the returned data as a replay attack prevention measure. For write commands, the payload field is populated with the 8 bytes to be written.

3. A CRC16 is calculated over the first 10 bytes of the packet and stored in the last 2 bytes in big endian format. The CRC is computed as follows:

```
#define ZS01_CRC16_POLYNOMIAL 0x1021

uint16_t zs01_crc16(const uint8_t *data, size_t length) {
    uint16_t crc = 0xffff;

    for (; length; length--) {
        crc ^= *(data++) << 8;

        for (int bit = 8; bit; bit--) {
            uint16_t temp = crc;

            crc <<= 1;
            if (temp & (1 << 15))
                crc ^= ZS01_CRC16_POLYNOMIAL;
        }
    }

    return (~crc) & 0xffff;
}
```

4. If the command is privileged, the 573 scrambles the payload field with the chip's currently set password, using the following algorithm:

```
// Note that this state is preserved across calls to zs01_scramble_payload()
// and must be updated when a response is received (see step 8).
uint8_t zs01_scrambler_state = 0;

void zs01_scramble_payload(
    uint8_t *output, const uint8_t *input, size_t length,
    const uint8_t *password
) {
    for (; length; length--) {
        int value = *(input++) ^ zs01_scrambler_state;
        value      = (value + password[0]) & 0xff;

        for (int i = 1; i < 8; i++) {
            int add    = password[i] & 0x1f;
            int shift  = password[i] >> 5;

            int shifted = value << shift;
            shifted      |= value >> (8 - shift);
            shifted      &= 0xff;

            value = (shifted + add) & 0xff;
        }

        zs01_scrambler_state = value;
        *(output++)          = value;
    }
}
```

```

    }
}

```

The CRC16 is *not* updated to reflect the new data. This step is skipped for unprivileged read commands.

5. All 12 bytes of the packet are scrambled with a fixed "command key", using the following algorithm:

```

static const uint8_t ZS01_COMMAND_ADD[]    = { 237, 8, 16, 11, 6, 4, 8, 30 };
static const uint8_t ZS01_COMMAND_SHIFT[] = {  0, 3, 2,  2, 6, 2, 2,  1 };

void zs01_scramble_packet(
    uint8_t *output, const uint8_t *input, size_t length
) {
    // Unlike zs01_scramble_payload(), this state is *not* preserved across
    // calls.
    uint8_t state = 0xff;

    output += length;
    input  += length;

    for (; length; length--) {
        int value = *(--input) ^ state;
        value     = (value + ZS01_COMMAND_ADD[0]) & 0xff;

        for (int i = 1; i < 8; i++) {
            int shifted = value << ZS01_COMMAND_SHIFT[i];
            shifted      |= value >> (8 - ZS01_COMMAND_SHIFT[i]);
            shifted      &= 0xff;

            value = (shifted + ZS01_COMMAND_ADD[i]) & 0xff;
        }

        state      = value;
        * (--output) = value;
    }
}

```

6. The scrambled packet is sent to the ZS01, which will respond to the first 11 bytes immediately with an I2C ACK and to the last byte with an ACK after a short delay. The 573 then proceeds to read 12 bytes from the ZS01, issuing an I2C ACK for each byte received up until the last one.
7. The 573 uses the response key generated in step 2 to unscramble the packet returned by the ZS01. The unscrambling algorithm is the same one used in step 5, applied in reverse:

```

void zs01_unscramble_packet(
    uint8_t *output, const uint8_t *input, size_t length,
    const uint8_t *response_key
) {
    // ... (unscrambling logic) ...
}

```

```

) {
    uint8_t state = 0xff;

    output += length;
    input  += length;

    for (; length; length--) {
        int value      = *(--input);
        int last_state = state;
        state          = value;

        for (int i = 1; i < 8; i++) {
            int add      = response_key[i] & 0x1f;
            int shift     = response_key[i] >> 5;

            int subtracted = (value - add) & 0xff;

            value = subtracted >> shift;
            value |= subtracted << (8 - shift);
            value &= 0xff;
        }

        value = (value - response_key[0]) & 0xff;
        * (--output) = value ^ last_state;
    }
}

```

For write commands, the response key required to unscramble the packet is the one sent as part of the last read command issued. For read commands, the ZS01 may either use the key provided in the payload field or the one from the last read command issued; Konami's code tries unscrambling responses with both.

8. The unscrambled packet will contain the following fields:

Bytes	Description
0	Status code (0 = success, 1-5 = error)
1	New payload scrambler state
2-9	Payload (empty for writes, data for reads)
10-11	CRC16 of bytes 0-9, big endian

The 573 proceeds to compute the CRC16 of the first 10 bytes. If it does not match the one in the packet, it will try unscrambling the packet with a different response key (see step 7) before giving up. Otherwise, the global `zs01_scrambler_state` variable from step 4 is set to the value of byte 1, regardless of whether the status code is zero or not.

The exact meaning of non-zero status codes is currently unknown.

23.5.3 EEPROM-less cartridge variants

Hyper Bishi Bashi Champ 3-player cartridge (GX700-PWB (E))

This is the only known cartridge type that has no EEPROM (although the PCB does have an unpopulated X76F041 footprint). It has no plastic case, as it's meant to be enclosed in the same case as the 573 itself. It has open-drain outputs for driving up to 12 lights, arranged as 3 banks of 4 outputs each (one bank for each player's buttons), plus an RS-232 transceiver for SIO1. The following pins are used:

Name	Dir	Usage
TX	O	TX to network port (via RS-232 transceiver)
RX	I	RX from network port (via RS-232 transceiver)
/RTS	O	Shorted to /CTS to enable SIO1
/CTS	I	Shorted to /RTS to enable SIO1
/DSR	I	Cartridge insertion detection (grounded)
D0	O	Updates/latches bank 3 when pulsed
D1	O	Updates/latches bank 2 when pulsed
D3	O	Updates/latches bank 1 when pulsed
D4	O	Data for light output 0 (green button)
D5	O	Data for light output 1 (blue button)
D6	O	Data for light output 2 (red button)
D7	O	Data for light output 3 (start button)
?	O	DTR to network port (via RS-232 transceiver)
?	I	DSR from network port (via RS-232 transceiver)

This cartridge has three connectors:

- CN2 (5-pin): RS-232 port. Note that this port is *not* electrically isolated and shares its ground with the 573, unlike all other cartridges with an RS-232 connector.
- CN3 (16-pin): breaks out the light outputs and the incoming 12V supply from CN4.
- CN4 (4-pin): 12V power input, connected through a short cable to CN17 on the 573 main board.

23.5.4 X76F041 cartridge variants

All X76F041 cartridges use the following pins:

Name	Dir	Usage
<code>/DSR</code>	I	Cartridge insertion detection (grounded)
<code>D0</code>	O	Drives X76F041 I2C <code>SDA</code> when <code>IO0</code> is set as output
<code>D1</code>	O	X76F041 I2C <code>SCL</code>
<code>D2</code>	O	X76F041 chip select (<code>/CS</code>)
<code>D3</code>	O	X76F041 reset (<code>RST</code>)
<code>IO0</code>	IO	X76F041 I2C <code>SDA</code> readout

X76F041 cartridges equipped with a DS2401 additionally use the following pins:

Name	Dir	Usage
<code>D4</code>	O	Drives 1-wire bus low when pulled high
<code>I6</code>	I	DS2401 1-wire bus readout

Generic cartridge (`GX700-PWB (D)`)

Rectangular cartridge used by the earliest 573 games and as a separate installation key for some later games. Contains only the X76F041 EEPROM and no DS2401, but the PCB has an unpopulated footprint for an unknown 64-pin TQFP part.

Generic cartridge with DS2401 (`GX894-PWB (D)`)

Rectangular cartridge similar to `GX700-PWB (D)` but equipped with a DS2401. The PCB has two unpopulated SOIC footprints, one of which may possibly be for an X76F100 or another I2C EEPROM.

Early serial port cartridge (GX896-PWB (A) A)

Seems to be an older variant of the more common GX883-PWB (D) cartridge, with the same ports but no DS2401. As with the 3-player Bishi Bashi cartridge, it has no case and is instead meant to sit inside the 573's own case.

Name	Dir	Usage
TX	O	TX to network port (via RS-232 transceiver)
RX	I	RX from network port (via RS-232 transceiver)
/RTS	O	Shorted to /CTS to enable SIO1
/CTS	I	Shorted to /RTS to enable SIO1
?	O	CTRL0 to control port
?	O	CTRL1 to control port
?	O	CTRL2 to control port
?	O	DTR to network port (via RS-232 transceiver)
?	I	DSR from network port (via RS-232 transceiver)

This cartridge has two connectors:

- CN2 (5-pin): electrically isolated RS-232 port. The transceiver is powered by an isolated DC-DC module and all signals going from/to the 573 are optoisolated.
- CN3 (6-pin): three 5V logic level signals, used in some cabinets to control lights or the speaker amplifier.

Serial port cartridge with DS2401 (GX883-PWB (D))

T-shaped cartridge with a DS2401, a "network" (RS-232) port and a "control" or "amp box" port, commonly used by pre-ZS01 Bemani games. Uses the following pins:

Name	Dir	Usage
TX	O	TX to network port (via RS-232 transceiver)
RX	I	RX from network port (via RS-232 transceiver)
/RTS	O	Shorted to /CTS to enable SIO1
/CTS	I	Shorted to /RTS to enable SIO1
?	O	CTRL0 to control port
?	O	CTRL1 to control port
?	O	CTRL2 to control port
?	O	DTR to network port (via RS-232 transceiver)
?	I	DSR from network port (via RS-232 transceiver)

This cartridge has two connectors:

- Network (5-pin, unlabeled on PCB): electrically isolated RS-232 port. The transceiver is powered by an isolated DC-DC module and all signals going from/to the 573 are optoisolated.
- Control/amp box (6-pin, unlabeled on PCB): three 5V logic level signals, used in some cabinets to control lights or the speaker amplifier.

PunchMania cartridge (GX700-PWB (J))

T-shaped cartridge used only by PunchMania/Fighting Mania series. Contains an X76F041, a DS2401 and an ADC0838 used to measure up to 8 analog inputs. The ADC uses the following pins:

Name	Dir	Usage
D0	O	Chip select to ADC (/CS), shared with X76F041 SDA
D1	O	Data clock to ADC (CLK), shared with X76F041 SCL
D5	O	Data input to ADC (DI)
I0	I	Data output from ADC (DO)
I1	I	SAR status from ADC (SRS)

This cartridge has two connectors:

- Unknown (12-pin): analog input connector. As with the ADC built into the 573 motherboard there seems to be no protection on the inputs, so only voltages in 0-5V range are accepted.
- **CN4** (10-pin): unknown purpose. Seems to be always unpopulated.

Hyper Bishi Bashi Champ 2-player cartridge (**PWB0000068819**)

T-shaped cartridge with open-drain outputs for driving up to 8 lights, arranged as 2 banks of 4 outputs each. Unlike the **GX700-PWB(E)** 3-player variant, it has an X76F041 (but no DS2401), lacks the RS-232 port and does not seem to be designed to be mounted inside the 573. The latches driving the light outputs use the following pins:

Name	Dir	Usage
?	O	Updates/latches bank 1 when pulsed
?	O	Updates/latches bank 2 when pulsed
?	O	Data for light output 0 (green button)
?	O	Data for light output 1 (blue button)
?	O	Data for light output 2 (red button)
?	O	Data for light output 3 (start button)

This cartridge has two connectors:

- **CN2** (16-pin): breaks out the light outputs and the incoming 12V supply from **CN3**.
- **CN3** (4-pin): 12V power input, presumably connected to the power supply externally (i.e. not through the main board).

Salary Man Champ cartridge (**PWB0000088954**)

T-shaped cartridge with open-drain outputs for driving up to 8 lights (although only 6 outputs seem to be populated). Contains an X76F041, a DS2401 and two 4094 shift registers, presumably chained. The shift registers use the following pins:

Name	Dir	Usage
D5	O	Shift register clock
D6	O	Shift register reset
D7	O	Shift register data

This cartridge has two connectors:

- Unlabeled (16-pin): breaks out the light outputs and the incoming 12V supply.
- Unlabeled (4-pin): 12V power input, presumably connected to the power supply externally (i.e. not through the main board).

23.5.5 ZS01 cartridge variants

All ZS01 cartridges use the following pins:

Name	Dir	Usage
<code>/DSR</code>	I	Cartridge insertion detection (grounded)
<code>D0</code>	O	Drives ZS01 I2C <code>SDA</code> when <code>IO0</code> is set as output
<code>D1</code>	O	ZS01 I2C <code>SCL</code>
<code>D3</code>	O	ZS01 reset
<code>IO0</code>	IO	ZS01 I2C <code>SDA</code> readout

All cartridges are fitted with a DS2401, however it is connected to a GPIO pin on the ZS01 rather than being directly exposed to the 573. The ZS01 additionally provides its own unique serial number, which seems to be unused by games.

Serial port cartridge (`GE949-PWB (D) A`)

ZS01 variant of the `GX883-PWB (D)` cartridge. Uses the following pins:

Name	Dir	Usage
<code>TX</code>	O	<code>TX</code> to network port (via RS-232 transceiver)
<code>RX</code>	I	<code>RX</code> from network port (via RS-232 transceiver)
<code>/RTS</code>	O	Shorted to <code>/CTS</code> to enable SIO1
<code>/CTS</code>	I	Shorted to <code>/RTS</code> to enable SIO1
<code>?</code>	O	<code>CTRL0</code> to control port
<code>?</code>	O	<code>CTRL1</code> to control port
<code>?</code>	O	<code>CTRL2</code> to control port
<code>?</code>	O	<code>DTR</code> to network port (via RS-232 transceiver)
<code>?</code>	I	<code>DSR</code> from network port (via RS-232 transceiver)

This cartridge has two connectors:

- Network (5-pin, unlabeled on PCB): electrically isolated RS-232 port. The transceiver is powered by an isolated DC-DC module and all signals going from/to the 573 are optoisolated.
- Control/amp box (6-pin, unlabeled on PCB): three 5V logic level signals, used in some cabinets to control lights or the speaker amplifier.

Stripped down serial port cartridge (`GE949-PWB (D) B`)

T-shaped cartridge that uses the same PCB as `GE949-PWB (D) A` but only has the ZS01, DS2401 and supporting parts are populated. Used by games that do not need the RS-232 interface.

23.5.6 Cartridge identifiers

Most games use the security cartridge's EEPROM to store, among other data such as the game code and region, a set of up to four 8-byte identifiers.

SID (silicon/serial ID?)

The serial number of the cartridge's DS2401, always present in cartridges that have one. As per the 1-wire specification it has the following format:

Bytes	Description
0	1-wire family code (<code>0x01</code> for DS2401)
1-6	48-bit progressive serial number, little endian
7	CRC8 of bytes 0-6

The CRC is computed as follows:

```
#define DS2401_CRC8_POLYNOMIAL 0x8c

uint8_t ds2401_crc8(const uint8_t *data, size_t length) {
    uint8_t crc = 0;

    for (; length; length--) {
        uint8_t value = *(data++);

        for (int bit = 8; bit; bit--) {
            uint8_t temp = crc ^ value;
```

```
        value >>= 1;
        crc   >>= 1;
        if (temp & 1)
            crc ^= DS2401_CRC8_POLYNOMIAL;
    }
}

return crc & 0xff;
}
```

Refer to the DS2401 datasheet and Maxim 1-wire documentation for more details.

TID (trace ID)

Seems to be a cartridge-type-agnostic serial number. On cartridges without a DS2401 the trace ID is assigned by Konami at manufacture time (see the master calendar section) and has the following format:

Bytes	Description
0	Trace ID type (0x81)
1-2	16-bit "main" serial number, big endian
3-6	32-bit "sub" serial number, big endian
7	Checksum (sum of bytes 0-6 xor'd with 0xff)

On cartridges with a DS2401 the trace ID is instead derived from the SID:

Bytes	Description
0	Trace ID type (0x82)
1-2	DS2401 serial number hash, big or little endian depending on game
3-6	<i>Reserved</i> (must be 0)
7	Checksum (sum of bytes 0-6 xor'd with 0xff)

The hash is calculated over bytes 1-6 of the SID (excluding the family code and CRC8) using the following algorithm:

```
// Note that some games set this to 14 instead of 16.
#define TRACE_ID_HASH_BIT_WIDTH 16

uint16_t trace_id_hash(const uint8_t *data, size_t length) {
    uint16_t hash = 0;

    for (size_t i = 0; i < (length * 8); i += 8) {
        uint8_t value = *(data++);
```

```

    for (size_t j = i; j < (i + 8); j++, value >>= 1) {
        if (value & 1)
            hash ^= 1 << (j % TRACE_ID_HASH_BIT_WIDTH);
    }

    return hash;
}

```

MID (medium ID?)

Seems to be some kind of cartridge type flag, possibly indicating whether the cartridge shall be used during or after game installation, or if it was used when performing a game upgrade and shall no longer be usable to run the game it initially shipped with.

Bytes	Description
0	Cartridge type? (always <code>0x00</code> , <code>0x01</code> or <code>0x02</code>)
1-6	<i>Reserved</i> (must be 0)
7	Checksum (sum of bytes 0-6 xor'd with <code>0xff</code>)

NOTE: `00 00 00 00 00 00 00 00` seems to be a valid MID value, despite having an otherwise invalid checksum, and to have a different meaning from `00 00 00 00 00 00 00 ff`.

XID (external ID?)

The serial number of the digital I/O board's DS2401, written to the cartridge during installation by most games that use it in order to prevent reinstallation on a different system. Has the same format as the SID. On a cartridge that has not yet been paired to a 573 the XID is set to `00 00 00 00 00 00 00 00`.

When finishing installation or attempting to use a cartridge with a mismatching XID the game will display the digital I/O board's serial number as an 8-digit value (`XXXX-YYYY`), generated as follows:

```

// Some games seem to only use the lower 32 bits of the DS2401's serial number,
// while others use all 48 bits.
size_t xid_to_string_32(char *output, const uint8_t *xid) {
    uint32_t value = 0
        | (xid[1] << 0)
        | (xid[2] << 8)
        | (xid[3] << 16)
        | (xid[4] << 24);
}

```

```

    int high = (value / 10000) % 10000;
    int low  = value % 10000;

    return sprintf(output, "%04d-%04d", high, low);
}

size_t xid_to_string_48(char *output, const uint8_t *xid) {
    uint64_t value = 0
        | (xid[1] << 0)
        | (xid[2] << 8)
        | (xid[3] << 16)
        | (xid[4] << 24)
        | (xid[5] << 32)
        | (xid[6] << 40);

    int high = (int) ((value / 10000) % 10000);
    int low  = (int) (value % 10000);

    return sprintf(output, "%04d-%04d", high, low);
}

```

Cartridges for games that use the digital I/O board typically come with a blank label onto which the 8-digit ID can be written by the operator, to help keep track of which cartridge goes into which system after installation.

Note that games that use other I/O boards with a DS2401, such as Kick & Kick and DDR Karaoke Mix, do not seem to write those boards' serial numbers to the cartridge; they are stored in the internal flash memory instead.

23.6 External modules

Over the 573's lifetime Konami introduced several add-ons that extended its functionality. Unlike the I/O boards, these were external to the 573 unit and not always mandatory. Not much is currently known about any of these.

23.6.1 Relay board (GN845-PWB (A))

A relatively simple lamp driver board, controlled by the optoisolated outputs from the analog or digital I/O board. Commonly mounted in a metal box alongside audio amplifier boards in most cabinets.

23.6.2 DDR stage I/O board (GN845-PWB (B))

Sits between the 573 and the sensors in each stage's arrow panels in Dance Dance Revolution cabinets. It is based on a Xilinx XC9536 CPLD and allows the 573 to check the status of a specific pressure sensor (each panel has 4 sensors, one along each edge), in addition to ensuring DDR games can only be played with an actual stage rather than just a joystick or buttons wired up to the 573's JAMMA connector. Konami kept using the same board long after the 573 was discontinued, with the last game to use it being DDR X/X2 (PC based).

Each stage's board communicates with the 573 over 6 wires, of which 4 are the up/down/left/right signals going to the JAMMA connector and 2 are light outputs from the I/O board being misused as data and clock lines (see above). The board initially asserts the right and up signals and waits for the 573 to issue an initialization command by bitbanging it over the light outputs. Received bits are acknowledged by the board by echoing them on the right signal and toggling the up signal.

Once initialization is done the board goes into passthrough mode, asserting the up/down/left/right signals whenever any of the respective arrow panels' sensors are pressed. The 573 can issue another command to retrieve the status of each sensor separately, which is then sent by the board in serialized form over the right and up signals. DDR games only use this command to display sensor status in the operator menu, no commands are sent to the board during actual gameplay.

The initialization protocol is currently unknown. The protocol used after initialization is partially known (see links) but needs to be verified and documented properly.

23.6.3 PS1 controller and memory card adapter (GE885-PWB (A))

A ridiculously overengineered JVS board providing support for accessing PS1 controllers and memory cards plugged into ports on the front of the cabinet. Contains a Toshiba TMPR3904 CPU, a Xilinx XCS10XL Spartan-XL FPGA, 512 KB of RAM and a 512 KB boot ROM; the ROM is only a small bootloader and the actual firmware is downloaded from the 573 into RAM. There are also two connectors for security dongles. Returns the following JVS identifier string:

```
KONAMI CO.,LTD.;White I/O;Ver1.0;White I/O PCB
```

Memory card support became common in later Bemani games, allowing players to save their scores and play custom charts. GuitarFreaks is the only game known to support external controllers through this board.

23.6.4 PunchMania 2 PCMCIA splitter (PWB0000085445)

Combines two 32 MB PCMCIA flash cards into the same address space, allowing them to be accessed as if they were a single 64 MB card. Connects to the 573 through a cable that plugs into a passive PCMCIA slot adapter. Only used by PunchMania 2.

23.6.5 e-Amusement network unit (PWB0000100991)

Used by some Bemani games, in particular later GuitarFreaks and DrumMania releases. Provides networking functionality (DHCP and TCP/UDP sockets) as well as a 10 or 20 GB IDE hard drive for storage of downloaded content. The module contains a Toshiba TMPR3927 CPU, a Xilinx XC2S100 Spartan-2 FPGA, 16 MB of RAM, a 512 KB boot ROM and a DP83815 PCI Ethernet MAC. As with the controller and memory card adapter, the bulk of the firmware seems to be loaded from the 573. Connects through PCMCIA slot 2, using the same cable and adapter as the PunchMania PCMCIA splitter.

23.6.6 Multisession unit (GXA25-PWB (A))

A fairly large box containing a Toshiba TMPR3927 CPU, a Xilinx XC2S200 Spartan-2 FPGA and four (!) hardware MP3 decoders. It comes with up to four daughterboards installed, each of which hosts a stereo DAC and has RCA jacks for audio input and output plus a mini-DIN connector for RS-232 communication with a cabinet. The box also has its own ATAPI CD-ROM drive and power supply.

Its purpose is to enable "session mode" in later Bemani games, which allows for the same song to be played on multiple games at the same time with the box playing the backing tracks and routing audio between the machines. It connects to each cabinet's 573 using RS-232, through the "network" port on the security cartridge.

23.6.7 Master calendar

A JVS device used internally by Konami to initialize motherboards and security cartridges during manufacturing. The exact hardware Konami used is unknown, but the protocol

can be inferred from game code. All games search the JVS bus on startup and enter a "factory test" mode if any device with the following identifier string is present:

```
KONAMI CO.,LTD.;Master Calendar;<any value>;<any value>
```

The game will then proceed to request the current date, time, game and region information from the master calendar, initialize the RTC and program the security cartridge. The master calendar also returns a unique trace ID (see the cartridge data formats section) for each 573, used for identification purposes on cartridges that lack a DS2401.

0x70 : Get date and time

0x71 : Get game region or initialization data

0x7c, 0x7f, 0x00 : Get trace ID "main" serial number

0x7c, 0x80, 0x00 : Get trace ID "sub" serial number

0x7d, 0x80, 0x10 : Get next ID

0x7e : Set DS2401 identifiers

0x7f : Unknown

0xf0 : Reset master calendar

23.7 BIOS

The System 573 BIOS is based on a slightly modified version of Sony's standard PS1 kernel, plus a custom shell executable.

- [Shell revisions](#)
- [Kernel differences](#)
- [Boot sequence](#)
- [Command-line arguments](#)
- [JVS MCU test sequence](#)
- [DVD-ROM support](#)
- [Scrapped CF card support](#)

23.7.1 Shell revisions

There seem to be either three or four different versions of the BIOS, all of which share the same kernel but feature different shells:

ROM marking	MAME ROM name	SHA-1	Used by
700A01	700a01.22g	e1284add4aadd5337bd7f4e27614460d52b5b48	Most games
700A01	700a01.gchgchmp.22g	9aab8c637dd2be84d79007e52f108abe92bf29dd	Gachagachamp
700A01			Unknown (undumped, see below)
700B01	700b01.22g	a2421d0a494892c0e71003c96995ce8f945064dd	Dancing Stage EuroMIX 2

700A01 is the earliest and most common version. The only difference between the two known variants of it is that they were linked to slightly different Sony SDK releases; Konami's own code is identical across the two. There reportedly is a third variant that shipped on systems that came with the JVS MCU unpopulated (presumably it would skip the check for it), however no evidence of its existence has ever been found. The shell is stored in ROM in both variants at `0xbfc40000`, in the form of a standard PS1 executable (including the header) that gets loaded at `0x803c0000` by the kernel.

700B01 has a more complicated structure: it is split up into two separate executables, one (at `0xbfc28000`, loaded at `0x80010000`) in charge of running the self-test sequence and the other (at `0xbfc60000`, loaded at `0x80380000`) handling CD-ROM or flash booting. The overall coding style suggests that it was developed alongside the installers/launchers used by later Bemani games, but dropped as the main feature it would have introduced over the **700A01** shell - CF card support - was broken due to a PCB wiring mistake.

23.7.2 Kernel differences

The kernel in both the **700A01** and **700B01** shells identifies itself as `Konami OS by T.H.` with a 1995-09-01 build date. All other Konami PS1-based arcade boards, with the exception of the Twinkle System, use a kernel with the same identifier and date (but potentially different code). The kernels used by other manufacturers' arcade boards also contain the same `T.H.` initials, possibly hinting at the fact there was a single Sony employee in charge of providing customized kernels to all arcade system manufacturers.

While the 573's kernel is functionally identical to its retail counterpart (aside from its lack of support for the PS1's CD-ROM drive), several parts of it have been slightly tweaked to account for the hardware:

- Most CD-ROM APIs and the ISO9660 filesystem driver seem to have been purged.
- The code to parse `SYSTEM.CNF` and launch the boot executable from the CD-ROM has been made inaccessible. The shell handles executable loading and booting on its own, without ever returning to the kernel.
- The kernel initializes the EXP1 region and clears the watchdog periodically while booting. It does *not* keep clearing it in the background (e.g. from the exception handler) once the shell is loaded.
- `700B01` performs a "memory initialization" sequence that fills various RAM areas with pseudorandom values (possibly for heap debugging purposes), showing `c1` through `c7` on the debugging board's 7-segment display in the process.
- `700B01` reads register `0x1f40000e` to determine which RAM footprints on the board are populated, then configures the main RAM controller accordingly.
- The GPU is reset and a series of color bars is displayed while the shell is being relocated to RAM. This feature is also present in other non-retail kernels such as the DTL-H2000's.
- The shell is launched through a stub that contains a `Lisenced by Sony Computer Entertainment Inc.(SCEI)` [sic] string, validated by the kernel in a similar (but not identical) way to PS1 expansion port ROMs.

23.7.3 Boot sequence

All variants of the shell are far simpler than their PS1 counterparts, as they lack any kind of UI (aside from a non-interactive status screen) and have *no copy protection or anti-piracy checks* of any kind. Once loaded by the kernel, they start by initializing the

system bus and proceed to run a hardware self-test. The outcome of all checks is displayed on screen, with the following ones being performed:

- **22G** : BIOS ROM integrity check. A checksum is computed and verified against the one present in the ROM at `0xbfc7fffc-0xbfc7ffff` ;
- **16H** , **16G** , **14H** , **14G** : main RAM read/write test (first row of chips on the board, closest to the CPU);
- **12H** , **12G** , **9H** , **9G** : main RAM read/write test (second row of chips on the board, closest to the JAMMA connector);
- **4L** , **4P** : VRAM read/write test. This causes the 573 to briefly display random pixels as framebuffers are overwritten during the check;
- **10Q** : SPU RAM read/write test;
- **18E** : JVS MCU reset and status check;
- **CDR** : ATAPI CD-ROM drive initialization and executable loading.

NOTE: **700A01** shells do not actually test **4P** ! The GPU starts up in 1 MB VRAM mode by default and the shell does not enable the chip select for the second bank, so the first VRAM chip is tested twice instead. This bug was fixed in the **700B01** shell, which initializes the GPU correctly.

If any check fails the shell locks up, shows a blinking "HARDWARE ERROR... RESET" prompt and stops clearing the watchdog after a few seconds, causing the 573 to reboot. Otherwise, the state of DIP switch 4 is checked and the shell attempts to load an executable from four different sources in the following order:

- PCMCIA flash card in slot 2 (if inserted and DIP switch 4 is on);
- PCMCIA flash card in slot 1 (if inserted and DIP switch 4 is on);
- Internal flash memory (if DIP switch 4 is on);
- **PSX.EXE** in the root directory of the disc inserted in the CD-ROM drive. The drive is only initialized after booting from flash or PCMCIA fails or if DIP switch 4 is off, thus the shell will not error out if a drive is not connected but a boot executable is present on the flash. Note that the drive must be set up as an IDE primary/master device using the appropriate jumpers.

As with Sony's PS1 shell, the 573 shell's ISO9660 filesystem driver only implements a minimal subset of the specification and may not properly support non-8.3 file names. It

also **only allocates 2 KB for the disc's path table**, so the total number of directories on the disc must be kept to a minimum in order to prevent the shell from crashing. Unlike the PS1, however, the 573 ignores `SYSTEM.CNF` completely regardless of whether or not it is present on the disc; the shell is hardcoded to always load `PSX.EXE`. Homebrew discs can take advantage of this behavior to provide separate PS1 and 573 executables instead of detecting the system type at runtime.

If DIP switch 4 is on, the shell expects to find a standard PS1 executable (including the full 2048-byte header) at offset `0x24` on either the built-in flash memory or one of the two PCMCIA flash cards, preceded by a CRC32 checksum of it at offset `0x20`. The CRC is stored in little endian format and is *not* calculated on the whole executable, but rather only on bytes whose offsets are a power of two (i.e. on bytes at `0x24 + 0`, `0x24 + 1`, `0x24 + 2`, `0x24 + 4` and so on). The check is implemented as follows:

```
#define EXE_CRC32_POLYNOMIAL 0xedb88320 // 0x04c11db7 bit-reversed

uint32_t exe_crc32(const uint8_t *data, size_t length) {
    size_t offset = 0;
    uint32_t crc = 0xffffffff;

    while (offset < length) {
        crc ^= data[offset];

        for (int bit = 8; bit; bit--) {
            uint16_t temp = crc;

            crc >>= 1;
            if (temp & 1)
                crc ^= EXE_CRC32_POLYNOMIAL;
        }

        if (offset)
            offset <<= 1;
        else
            offset = 1;
    }

    return ~crc;
}

#define DIP_SWITCH_PTR ((const uint32_t *) 0x1f400004)
#define EXE_CRC32_PTR ((const uint32_t *) 0x1f000020)
#define EXE_HEADER_PTR ((const uint8_t *) 0x1f000024)
// Offset of the "text section size" field within the executable header
#define EXE_TEXT_SIZE_PTR ((const uint32_t *) 0x1f000040)

bool is_exe_valid(void) {
    if (*DIP_SWITCH_PTR & (1 << 3)) // 1 = DIP switch off
```



```

    return false;
if (memcmp(EXE_HEADER_PTR, "PS-X EXE", 8))
    return false;

// BUG: the actual size of the executable including the header is
// (2048 + *EXE_TEXT_SIZE_PTR), however neither the 700A01 nor 700B01 shells
// take this into account and instead end up ignoring the executable's last
// 2048 bytes.
uint32_t crc = exe_crc32(EXE_HEADER_PTR, *EXE_TEXT_SIZE_PTR);

return (crc == *EXE_DATA_PTR);
}

```

Installing a new game usually involves inserting the installation disc and turning off DIP switch 4 in order to prevent the shell from booting the game currently installed on the internal flash.

23.7.4 Command-line arguments

PS1 executables are generally launched with CPU registers `$a0` and `$a1` set to zero, in order to make sure programs that interpret them as `argc` and `argv` respectively will not crash by trying to parse invalid data. The `700A01` shell follows this convention.

The `700B01` shell, however, does pass two arguments to the executable it loads. `$a0` is thus set to 2, while `$a1` is set to point to an array containing pointers to the following strings:

- `boot.rom=700B01`
- `boot.from=<device>`, where `<device>` is one of the following:
- `flash.0` (internal flash memory)
- `flash.1` (PCMCIA flash card in slot 1)
- `flash.2` (PCMCIA flash card in slot 2)
- `ata.2` (CF card in slot 2)
- `cdrom`

The launchers used by later Bemani games use these arguments if present to determine where to load the main game executable from, and fall back to autodetecting the game's installation location otherwise.

23.7.5 JVS MCU test sequence

The JVS MCU check is implemented in a different way between the two shell revisions. While the `700A01` shell simply resets the MCU and validates the status and error codes, the `700B01` self-test sequence performs 35 (!) different checks, each validating the codes returned under different conditions. The following tests are done:

1. Reset MCU, clear `JVSIRDY`, ensure that:
 - status code = 0
 - error code = 3
 - `JVSIRDY` = 0
 - `JVSDRDY` = 0
 - incoming JVS data = `0x0000`
2. Reset MCU, write valid dummy packet header (`0x00e0`), ensure that:
 - status code = 2
 - error code = 3
3. Reset MCU, write invalid dummy packet header (`0x001f`), ensure that:
 - status code = 2
 - error code = 2
4. Reset MCU, write 16 dummy packets (`0x1fe0`, `0x0004`, `1 << i`, checksum), for each packet ensure that:
 - status code = 1
 - error code = 3
5. Reset MCU, write 16 dummy packets (same as above) with an invalid checksum, for each packet ensure that:
 - status code = 1
 - error code = 1

It is currently unclear if any data is actually sent to the JVS bus during step 4, as the shell may reset the MCU it before it starts sending the packet.

23.7.6 DVD-ROM support

Even though neither of the shell versions was explicitly designed with DVD-ROM support in mind, it *is* possible to run games from a DVD-ROM thanks to the fact that the ATAPI commands used by the shell and games to read sectors from the disc are medium-agnostic. Games that rely on CD-DA playback obviously cannot be put on a DVD, however all other games (including ones that rely on the digital I/O board for MP3 playback) will work as long as the disc is formatted as if it were a typical 573 CD-ROM (ISO9660 with no extensions, no UDF, 8.3 file names and a path table smaller than 2 KB).

NOTE: due to ATAPI incompatibility issues only a very limited number of DVD-ROM drives will actually be recognized and work properly with the shells and games. This is unrelated to the DVD format itself and is purely due to the fact that, unlike CD-ROM drives, most DVD drives were manufactured after the ATAPI specification got updated in a way that broke the 573's compatibility.

This accidental capability was greatly abused by bootleg Bemani "superdiscs" that bundled multiple games on a single DVD-ROM and shipped with a modified installation menu, allowing the user to pick which game to install. Each game on a superdisc is patched to load its files from a subdirectory rather than from the DVD's root.

Homebrew 573 software can be distributed as an ISO9660 image larger than 650 MB meant to be burned to a DVD-R, if sacrificing PS1 compatibility and CD-DA support is an option. In such case the image shall be distributed as an `.iso` file with 2048-byte sectors, rather than the typical `.bin` and `.cue` file pair used for PS1 games with 2352-byte Mode 2 sectors.

23.7.7 Scrapped CF card support

In addition to booting from "linear" memory mapped PCMCIA flash cards, the `700B01` shell features a driver for CF cards and a FAT filesystem parser that allows it to mount a CF card inserted in PCMCIA slot 2 (via a passive CF-to-PCMCIA adapter), search for a flash card image file and interpret its contents as if it were an actual flash card, loading the executable directly from it. Or at least, that *would* allow it to do so, had Konami not screwed up the wiring of the PCMCIA slots.

CF cards can operate in three different interfacing modes: memory mapped, I/O mapped and IDE compatibility mode. On the 573 only memory mapped mode is accessible as the

other modes require usage of I/O chip select pins that are not connected. This mode, however, requires the host to issue 8-bit writes to the card's 16-bit bus through the use of individual chip select lines for each byte (`/CE1` and `/CE2`). While the PS1's CPU *does* have separate lower (`/WR0`) and upper (`/WR1`) byte write strobes that could have been easily adapted to the appropriate signals, Konami decided to cut this specific corner and shorted `/CE1` and `/CE2` on each PCMCIA slot together, making it impossible to issue a single-byte write.

NOTE: later revisions of the 573 main board seem to have unpopulated jumpers next to the PCMCIA slots that can be used to rewire the chip select signals. It is currently unclear if these jumpers are actually sufficient to enable CF card booting without any additional hardware or BIOS modifications.

23.8 Bootleg mod boards

It is not uncommon to find 573s fitted with a bootleg BIOS "mod board" in place of the stock `700A01` or `700B01` mask ROM. These boards used to be bundled alongside bootleg game CD-ROMs and were apparently required in order to bypass the "anti-piracy checks" in Konami's BIOS.

Of course, since neither version of the shell has any such checks, the claims were completely misleading. The actual purpose of these boards was not to tamper with the BIOS, but rather to piggyback on the system bus and provide a crude authentication mechanism to the bootleg game, allowing it to verify that it was indeed running on a 573 equipped with an appropriate mod board. In other words, **mod boards were actually the bootleggers' implementation of Konami's security cartridge system**, meant to prevent people from simply burning copies of a bootleg CD-ROM and forcing them to buy bootleg kits from whoever produced them instead. *Oh the irony.*

The added authentication circuitry will not create any issues with official nor homebrew software, however most of these boards feature an additional party trick: *the shell executable is altered to load a differently named executable*, making bootleg discs

unable to boot on a stock 573 and vice versa. The following names have been found so far in modified BIOS ROMs:

- QSY.DXD
- SSW.BXF
- TSV.AXG
- GSE.NXX
- NSE.GXX

The following names have been found on unofficial game discs, but are not confirmed to have ever been used in modified BIOS ROMs:

- OSE.FXX
- QSU.DXH
- QSX.DXE
- QSZ.DXC
- RSU.CXH
- RSV.CXG
- RSW.CXF
- RSZ.CXC
- SSX.BXE
- SSY.BXD
- TSW.AXF
- TSX.AXE
- TSY.AXD
- TSZ.AXC

Homebrew software should thus place multiple copies of the boot executable on the CD-ROM to ensure any BIOS, modded or not, can successfully load it. An interesting side note is that, for any of these names, summing the ASCII codes of each character will always yield the same result. Presumably bootleggers were unable to find the code in charge of BIOS ROM checksum validation and found it easier to just turn the string into random nonsense whose checksum collided with the original one.

23.8.1 DDRTURBO mod board

Board required by and specific to the DDR Extreme PLUS hack. Unlike all other currently known boards, this one actually adds new functionality to the system: the ability to speed up MP3 playback... *by taking the place of the 29.45 MHz main oscillator* on the digital I/O board, which is desoldered and replaced with a bodge wire. It features three crystal oscillators supplying the following clocks:

- **29.5 MHz** (0.16% faster than stock, referred to as "Normal Speed" in Extreme PLUS)
- **33 MHz** (12.05% faster than stock, referred to as "Speed up 10%" in Extreme PLUS)
- **36 MHz** (22.24% faster than stock, referred to as "Speed up 20%" in Extreme PLUS)

The board listens for reads from the upper half of BIOS ROM

(`0xbfc40000-0xbfc7ffff`) and latches bits 5-6 of the byte read to determine which clock to output to the digital I/O board:

Byte read	Clock
<code>0b*00*****</code>	33 MHz
<code>0b*01*****</code>	36 MHz
<code>0b*10*****</code>	29.5 MHz
<code>0b*11*****</code>	Unknown (none?)

NOTE: kernel code execution while the game is running will *not* affect the clock as the kernel is contained entirely within the ROM's first half. The second half is in fact only accessed on startup when relocating the shell executable to RAM and computing the ROM checksum.

In order to switch clocks, Extreme PLUS always reads from one of the following addresses:

Address read	Byte read	Clock
<code>0xbfc40ebf</code>	<code>0x55</code>	29.5 MHz
<code>0xbfc40810</code>	<code>0x00</code>	33 MHz
<code>0xbfc41341</code>	<code>0xaa</code>	36 MHz

The board's EPROM holds a copy of the 700A01 BIOS with the last byte of the checksum at `0xbfc7ffff` modified from `0xf9` to `0x39`. Extreme PLUS uses this change to detect the mod board and will refuse to run if it is not present. The padding byte at

`0xbfc7ffff` is also changed from `0xff` to `0x3f` in order for the contents of the ROM to match the new checksum.

23.9 Game-specific information

23.9.1 Black case I/O connectors

Fisherman's Bait and a few other non-Bemani games use a 573 housed in a black case with blue front and back panels. Unlike the gray metal cases used by other games, this case model has no cutouts for removable front and back panels that hold game-specific connectors and instead has a fixed set of ports exposed:

- **Power:** 2x4 Molex connector that can be used as a power input or output, wired to `CN17`.
- **Option 1:** DE9 connector providing four analog inputs, wired to `CN3` on the main board.
- **Option 2:** DE9 connector providing six button (digital) inputs, of which four are also exposed on the JAMMA connector. Wired to `CN5` on the motherboard.
- **Reel connector** (back side): 3x3 Molex connector wired to the `GE765-PWB (B) A` fishing controller I/O board. Probably missing on systems that that did not come with Fisherman's Bait.

23.9.2 DDR I/O connectors

Dance Dance Revolution uses a 573 enclosed in a gray metal case, with either an analog or digital I/O board installed. The front panel has a cutout covered by a metal plate, which in turn holds the following connectors:

- **1P** (10-pin white, only 7 pins used): connects to the left stage and controls arrow lights, in addition to being used for bitbanged communication with the stage PCB. Wired to light bank A on the I/O board.
- **2P** (10-pin orange, only 7 pins used): same as above for the right stage. Wired to light bank B on the I/O board.
- Unlabeled (10-pin red, only 7 pins used): connects to cabinet button and marquee lights. Wired to light bank C.
- Unlabeled (6-pin white, only 2 pins used): controls the inverter that drives the neon rings around the speakers. Wired to light bank D.

The back panel has a similar cutout, covered by a plate with holes for the digital I/O board's RCA networking jacks.

23.9.3 DDR light mapping

Dance Dance Revolution cabinets (standard 2-player ones, not Solo) have lights wired up to the analog or digital I/O board as follows:

Output	Connected to
A0	Player 1 up arrow
A1	Player 1 down arrow
A2	Player 1 left arrow
A3	Player 1 right arrow
A4	Data to player 1 stage I/O
A5	Clock to player 1 stage I/O
A6-A7	<i>Unused</i>
B0	Player 2 up arrow
B1	Player 2 down arrow
B2	Player 2 left arrow
B3	Player 2 right arrow
B4	Data to player 2 stage I/O
B5	Clock to player 2 stage I/O
B6-B7	<i>Unused</i>
C0-C1	<i>Unused</i>
C2	Player 1 buttons
C3	Player 2 buttons
C4	Bottom right marquee light
C5	Top right marquee light
C6	Bottom left marquee light
C7	Top left marquee light
D0	Speaker neon
D1-D3	<i>Unused</i>

Light outputs A4, A5, B4 and B5 do not actually control any lamps, but are used to communicate with each stage's I/O board. See the external modules section for more details.

23.9.4 DDR Solo input and light mapping

Dance Dance Revolution Solo cabinets, unlike 2-player cabinets, do not use a stage I/O board to multiplex the sensors as each arrow panel only has 2 sensors (rather than 4). Each sensor is instead wired directly to the JAMMA connector, making use of most of the available inputs.

JAMMA input	Connected to
Player 1 left	Left sensor A
Player 1 right	Right sensor A
Player 1 up	Up sensor A
Player 1 down	Down sensor A
Player 1 button 1	Up-left sensor B
Player 1 button 2	Left sensor B
Player 1 button 3	Down sensor B
Player 1 button 4	<i>Unused</i>
Player 1 button 5	Left button
Player 1 start	Start button
Player 2 left	Up-left sensor A
Player 2 right	Up-right sensor A
Player 2 up	<i>Unused</i>
Player 2 down	<i>Unused</i>
Player 2 button 1	Up sensor B
Player 2 button 2	Right sensor B
Player 2 button 3	Up-right sensor B
Player 2 button 4	<i>Unused</i>
Player 2 button 5	Right button
Player 2 start	<i>Unused (shorted?)</i>

The light mapping is currently unknown. Solo cabinets have less lights compared to their 2-player counterparts (e.g. arrow panel lamps are missing).

23.9.5 DrumMania light mapping

First-generation DrumMania cabinets have lights wired up to the I/O board as follows:

Output	Connected to
A0-A7	<i>Unused</i>
B0-B7	<i>Unused</i>
C0	Hi-hat
C1	Snare
C2	High tom
C3	Low tom
C4	Cymbal
C5	<i>Unused</i>
C6	Start button
C7	Select button
D0	Spotlight
D1	Top neon
D2	<i>Unused</i>
D3	Bottom neon

The wiring was changed in later cabinets, which use the following mapping instead:

Output	Connected to
A0	Hi-hat
A1	Snare
A2	High tom
A3	Low tom
A4-A7	<i>Unused</i>
B0	Spotlight
B1	Bottom neon
B2	Top neon
B3	<i>Unused</i>
B4	Cymbal
B5	<i>Unused</i>
B6	Start button
B7	Select button
C0-C7	<i>Unused</i>
D0-D3	<i>Unused</i>

23.10 Notes

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23.10.1 Hard-to-install games

While the vast majority of 573 games can be trivially installed by inserting the respective game disc (or sometimes a separate install disc) and a new security cartridge, there are a few ones that require more complex installation procedures:

- **Games without a CD-ROM:** for what should be obvious reasons, such games cannot be installed without either using homebrew flashing tools or injecting a flash image into another game's CD-ROM installer. Konami's "official" installation method was to boot the flash image from a PCMCIA card, which the game will detect and copy over to the internal flash.
- **Hyper Bishi Bashi Champ, Handle/Steering Champ:** RTC RAM is employed as a "suicide battery" of sorts by pre-populating it with a header and other data at the factory. If any of the data is corrupted or missing, the game will display "HARDWARE UNMATCHED" and refuse to boot any further.
- **Dance Dance Revolution (JAB version):** also checks RTC RAM and will not boot if its header is missing from the first 32 bytes (subsequent data can be uninitialized and will be rebuilt automatically if needed). Additionally, even though the game requires a CD-ROM, its disc only contains CD-DA tracks and lacks an installer or flash image, requiring the same workarounds as CD-ROM-less games in order to install it.
- **Dance Dance Revolution 4thMIX PLUS and PLUS Solo:** as this game is an upgrade to DDR 4thMIX, the installer will refuse to proceed unless 4thMIX's header is present in the first 32 bytes of RTC RAM. This check is only performed during installation; the game itself will rebuild the entire contents of the RTC if the header is invalid.
- **Dancing Stage feat. Dreams Come True** (both analog I/O and digital I/O versions): notorious for requiring a lot of juggling with security cartridges. The installer prompts for a cartridge from a previous game that is allowed to be upgraded, which will be invalidated and made unusable as part of the installation process.

23.10.2 Homebrew guidelines

It is relatively easy to develop homebrew games that can run on both a System 573 and a regular PlayStation 1, or to port existing PS1 homebrew to the 573. Nevertheless, there are some significant differences between the two systems and a game meant to

run on both shall avoid using any feature that is only available on one. "Hybrid" PS1/573 games shall adhere to the following guidelines:

- **Do not use the extra RAM.** With the exception of development kits and modified units, consoles always have 2 MB of main RAM and 1 MB of VRAM. The additional RAM on the 573 might still be useful for 573-specific purposes such as FAT filesystem handling if an IDE hard drive is used.
- **Do not use XA-ADPCM.** XA is not supported by any ATAPI drive. CD-DA is supported by both the PS1 CD drive and ATAPI drives, however it will not work out-of-the-box on a 573 fitted with a digital I/O board as the 4-pin CD audio cable will not be plugged into the drive. Homebrew games that use CD-DA should display a splash screen showing how to unplug the cable from the I/O board and plug it into the drive (which is a quick reversible modification). SPU audio streaming can replace XA and will work on both platforms.
- **Have separate executables for PS1 and 573.** Since the PS1 BIOS parses `SYSTEM.CNF` while the 573 BIOS ignores it, a disc can have two different executables, one named `PSX.EXE` (which will be launched on a 573) and the other (which will run on a PS1) referenced by `SYSTEM.CNF`. This makes it easier to have two separate builds of the game rather than having to detect system type at runtime. Additional copies of `PSX.EXE` with the file names commonly used by BIOS mod boards (`QSY.DXD`, `TSV.AXG` and so on) shall also be present.
- **Do not rely on the RTC.** Most 573 boards have a dead RTC battery by now. As the battery is sealed inside the RTC it is basically impossible to replace without replacing the entire chip, which is something not all 573 owners can do. RTC RAM is additionally used by some games to store security-related data and shall not be used for saving.
- **Implement an operator/settings menu.** Among other things, the menu should allow the user to adjust the SPU's master volume, enable or disable the 573's built-in amplifier (which has no physical volume controls), test cabinet lights and eject the CD (as some cases hide the drive's eject button behind a small hole or make it difficult to access otherwise).

23.10.3 Missing support for PAL mode

The 573 only supports 60 Hz mode (i.e. "NTSC", even though the video DAC has no composite or S-video output so no color modulation is involved). Attempting to switch

the GPU into 50 Hz PAL mode using the `GP1 (0x08)` command will result in a crash, as only the NTSC clock input pin is wired up.

Support for 50 Hz can be added back by shorting pins 192 and 196 on the GPU (which will give "PAL-on-NTSC" timings) or by connecting pin 192 to an external oscillator tuned to generate a PAL clock. See the timings section of the GPU page for more details.

23.10.4 Flash chips and PCMCIA cards

The PCMCIA flash cards required by most 573 games are "linear" (memory mapped) cards consisting of one or more parallel flash memory chips wired directly to the bus, rather than CF or ATA-compatible cards. As neither linear cards nor parallel flash command sets are fully standardized, working with these cards may be difficult without some prior knowledge.

There are two main variants of such cards:

- **8-bit:** these contain one or more pairs of flash chips with an 8-bit data bus each. Each pair has one chip wired to the lower byte of the data bus and the other wired to the upper byte. Commands must thus be issued to both chips at once by repeating the command byte (e.g. writing `0x9090` to issue the `0x90` JEDEC ID command). Issuing 8-bit writes to a single chip is *not* supported on the 573 due to the way chip select lines are wired up; see the BIOS CF card support section for more details.
- **16-bit:** these contain flash chips with a native 16-bit bus. The chips are simply mapped next to each other within the card's address space.

Konami's flash driver only supports 8-bit cards that use one of the following chips:

Manufacturer	Chip	Capacity	Manuf. ID	Device ID
Fujitsu	MBM29F016A	2 MB	<code>0x04</code>	<code>0xad</code>
Fujitsu	MBM29F017A	2 MB	<code>0x04</code>	<code>0x3d</code>
Fujitsu	MBM29F040A	512 KB	<code>0x04</code>	<code>0xa4</code>
Intel	28F016S5	2 MB	<code>0x89</code>	<code>0xaa</code>
Sharp	LH28F016S	2 MB	<code>0x89</code>	<code>0xaa</code>

Most games, including the launchers used by later Bemani games, will check the JEDEC IDs of the cards' chips on startup and **reject any unsupported chip, even if valid game data is otherwise present on the card**. This makes it impossible to manually

install a game onto an unsupported card (e.g. through homebrew tools) without also patching the launcher in order to skip the check.

The 573 main board seems to always be fitted with either MBM29F016A or LH28F016S chips. The internal flash memory is accessed using the same driver as the flash cards and has the same caveats (having to issue commands to two chips at once and so on).

23.10.5 Known working replacement PCMCIA cards

This is an incomplete list of PCMCIA flash cards that are known to work, or not to work, with Konami's flash driver. Due to the JEDEC ID checks, only cards that contain flash chips listed in the previous section will work.

Manufacturer	Model	Flash chips	Capacity	Bus type	Ma
Centennial	PM24265, FL32M-20-* 67	16x 28F016S5	32 MB	8-bit	0x
Centennial	PM24265, FL32M-20-* 67	16x AM29F016	32 MB	8-bit	0x
Centennial	PM24276, FL32M-20-* J5-03	4x 28F640J5	32 MB	16-bit	0x
Centennial	PM24282, FL32M-20-* S5-03	16x AM29F016	32 MB	8-bit	0x
Fujitsu	"32MB Flash Card" (no model number?)	16x MBM29F016A	32 MB	8-bit	0x
Fujitsu	"32MB Flash Card" (no model number?)	16x MBM29F017A	32 MB	8-bit	0x
Sharp	ID245G01	4x LH28F016S	8 MB	8-bit	0x
Sharp	ID245P01	16x LH28F016S	32 MB	8-bit	0x

Note that most of these cards have identical labels and can typically only be told apart from the model number printed on the bottom side or one of the edges.

IMPORTANT: the model numbers on Centennial cards seem to be inconsistent and not necessarily related to which flash chips the card is fitted with. As such **buying these cards for use with 573 games is strongly discouraged**, even though some of them are known to use parts compatible with Konami's driver.

23.10.6 Known working replacement drives

This is an incomplete list of drives that are known to work, or to be incompatible, with the ATAPI driver Konami used in the BIOS shell and games. The driver was likely written using an old version of the ATAPI specification as a reference; CD-ROM drives manufactured in the late 1990s and very early 2000s have a higher chance of being

compatible than drives manufactured later, possibly due to changes introduced in later revisions of the ATAPI specification that broke the assumptions Konami's driver makes.

CD-DA playback is particularly problematic as Konami's code seems to be unable to handle the subtle implementation differences across different drives. To add insult to injury, some of the few drives that *do* work have bugs in their subchannel handling that

result in incorrect playback status data being reported to the 573, completely breaking pre-digital-I/O Bemani titles that rely heavily on audio timing.

Manufacturer	Known rebrands	Model	Type	BIOS	CD-DA
ASUSTeK		DVD-E616P3	DVD	Yes	Unknown
Creative		CD4832E	CD	Yes	No
Hitachi		CDR-7930	CD	Yes	No
LG	Compaq	CRD-8400B		Yes	Unknown
LG?	Compaq	CRN-8241B	CD	Yes	Yes
LG		GCE-8160B	CD	Yes	No
LG		GCR-8523B	CD	Yes	Unknown
LG		GCR-8525B	CD	Yes	Yes
LG		GDR-8163B	DVD	Yes	Yes
LG	HP	GDR-8164B	DVD	Yes	Yes
LG		GH22LP20	DVD	Yes	Unknown
LG		GH22NP20	DVD	Yes	Unknown
LG		GSA-4165B	DVD	No	
LG		GWA-4166B	DVD	Yes	Unknown
Lite-On		DH-20A4P		Yes	Unknown
Lite-On		LH-18A1H	DVD	Yes	Yes
Lite-On		LTD-163	DVD	Yes	Unknown
Lite-On		LTD-165H	DVD	Yes	Unknown
Lite-On		LTR-40125S	CD	Yes	Unknown
Lite-On		SHW-160P6S	DVD	Yes	Unknown
Lite-On		SOHR-48327S		Yes	Unknown
Lite-On	HP	SOHR-4839S	CD	Yes	Unknown
Lite-On		XJ-HD166S	DVD	Yes	Unknown
Matsushita/Panasonic		CR-583	CD	Yes	Yes
Matsushita/Panasonic		CR-587	CD	Yes	Yes
Matsushita/Panasonic		CR-589B	CD	Yes	Yes
Matsushita/Panasonic		CR-594C	CD	Yes	Unknown
Matsushita/Panasonic	HP	SR-8585B	DVD	Yes	Unknown
Matsushita/Panasonic		SR-8589B	DVD	Yes	Unknown
Matsushita/Panasonic		UJDA770		Yes	Unknown
Mitsumi		CRMC-FX4830T	CD	Yes	Unknown
NEC		CDR-1900A	CD	Yes	Unknown
NEC		ND-2510A	DVD	No	
Sony	Compaq	CDU701-Q1	CD	Yes	Unknown

Manufacturer	Known rebrands	Model	Type	BIOS	CD-DA
Sony		CRX217E	CD	Yes	Unknown
Sony		DRU-510A	DVD	Yes	Unknown
Sony		DRU-810A	DVD	Yes	Unknown
TDK		AI-CDRW241040B	CD	Yes	Unknown
TDK		AI-481648B	CD	Yes	Unknown
TEAC		CD-W552E	CD	Yes	Unknown
Toshiba		SW-252		Yes	Unknown
Toshiba		TS-H292C	CD	Yes	Unknown
Toshiba		XM-5702B	CD	Yes	Unknown
Toshiba		XM-6102B	CD	Yes	Yes
Toshiba		XM-7002B	CD	Yes	Unknown

NOTE: Konami shipped some units with a Toshiba XM-7002B laptop drive and a passive adapter board (`GX874-PWB (B)`) to break out the drive's signals to a regular 40-pin IDE connector. Laptop drives were also used by Konami in the `GXA25-PWB (A)` multisession unit.

23.10.7 Bemani launcher error and status codes

The installers and launchers used by Bemani titles that require the digital I/O board have an extensive error and status reporting system. Launcher messages are easily recognizable as they are always displayed in a blue window and have a 3-digit status code, however Japanese versions of the games will show them in Japanese with no way to switch language (short of patching the launcher; all launcher variants contain both English and Japanese strings).

Below is a list of all messages from launcher version 1.95 in both English and Japanese, along with the respective status codes and indices in the launcher's internal message array.

Index	Type	Status codes	Description (English)	Description (Japanese)
0	Error	100	Boot is not available from this device. DEVICE=%s1	DEVICE=%s1
1	Error	101	Digital Sound PCB initialization failed.	
2	Error	102	Digital Sound PCB ROM error.	ROM
4	Error	104	CD-ROM initialization failed.	CD-ROM
7	Error	107	File system mounting failed. Please check that correct CD-ROM is in use.	CD-ROM
9	Error	109	File system mounting failed. Please check that correct CD-ROM is in use.	CD-ROM
10	Error	110	File system mounting failed. Please check that correct CD-ROM is in use.	CD-ROM
11	Error	111	File system mounting failed. Please check that correct CD-ROM is in use.	CD-ROM
12	Error	112	File system mounting failed. Please check that correct CD-ROM is in use.	CD-ROM
13	Error	113	Disc device initialization failed.	
14	Error	114	You are using an incorrect CD-ROM. Replace CD-ROM to %s1 and turn on the main power.	CD-ROM CD-ROM %s1
15	Error	115	Disc device initialization failed.	
16	Error	116	Disc device initialization failed.	
17	Error	117	Config file error. FILE=%s1 ERROR=%d2, LINE=%d3, COLUMN=%d4	FILE=%s1 ERROR=%d2, LINE=%d3, COLUMN=%d4
19	Error	119	You are using an incorrect CD-ROM. Replace CD-ROM to %s1 and turn on the main power.	CD-ROM CD-ROM %s1
20	Error	120	Cassette is not installed. Turn off the main power and install the correct cassette then turn the power on.	
21	Error	121	Cassette error. (%d1) Cassette does not match this game. Check if the cassette is for this game (%s2) Refer to manual for more information.	(%d1) (%s2)
25	Error	125	Boot is not available from this device. DEVICE=%s1	DEVICE=%s1
26	Error	126	Cassette error (%d1)	(%d1)
27	Error	127	Master Calendar network error.	
28	Error	128	Master Calendar network error.	

Index	Type	Status codes	Description (English)	Description (Japanese)
29	Error	129	Master Calendar network error.	.
30	Error	130	Installation boot device error. Installation cassette is inserted. Turn off the power. Before turning the power on: 1. Change the cassette to the Operating Cassette to enter the game or 2. Set DIP-SW4 to "OFF" to install.	. . DIP-SW4 OFF
31	Error	131	Installation Cassette does not correspond to the machine. Please use Installation Cassette marked %s1 for installation.	. %s1
32	Error	132	Cassette error (%d1)	(%d1)
35	Error	135	This cassette is used to convert another game. This can not be used as an operating cassette.	.
36	Error	136	Cassette error (%d1)	(%d1)
38	Error	138	File not found. FILE=%s1	. FILE=%s1
39	Error	139	File reading error. FILE=%s1	. FILE=%s1
40	Error	140	File not found. FILE=%s1	. FILE=%s1
41	Error	141	File reading error. FILE=%s1	. FILE=%s1
42	Error	142	File reading error. FILE=%s1	. FILE=%s1
43	Error	143	File reading error. FILE=%s1	. FILE=%s1
44	Error	144	File data error. FILE=%s1	. FILE=%s1
45	Error	145	File data error. FILE=%s1	. FILE=%s1
46	Error	146	Turn off the power and check if the Flash Card is inserted properly. Please turn the power on after checking. DEVICE=%s1	. . DEVICE=%s1
47	Error	147	Checksum error. If you have the latest CD-ROM, please replace. Turn off the power and insert installation cassette. Set DIP-SW4 to "OFF", then turn on the power and reinstall CD-ROM.	. CD-ROM , . ,DIP-SW4 OFF
48	Error	148	Area specification error. Only area specification below is available. %s1 Check the DIP-SW of Master Calendar.	. . %s1 DIP-SW

Index	Type	Status codes	Description (English)	Description (Japanese)
49	Error	149	Cassette initialization error. The cassette is already initialized as Operating Cassette (%s1) Reinitialization can not be completed.	. (%s1)
50	Error	150	Cassette initialization error. The cassette is already initialized as Installation Cassette (%s1) Reinitialization can not be completed.	. (%s1)
51	Error	151	File not found. FILE=%s1	. FILE=%s1
52	Error	152	Turn off the power and check if the Flash Card is inserted properly. Please turn the power on after checking. DEVICE=%s1	. , DEVICE=%s1
53	Error	153	Installation failed. (%d1)	. (%d1)
54	Error	154	Assertion failed. FILE=%s1 LINE=%d2	. FILE=%s1 LINE=%d2
55	Error	155	Argument buffer overflow.	.
56	Error	156	File not found. FILE=%s1	. FILE=%s1
57	Error	157	File data error. FILE=%s1	. FILE=%s1
58	Error	158	File reading error. FILE=%s1	. FILE=%s1
59	Error	159	Security Chip error. (%d1) This Security Chip was initialized for another title.	. (%d1)
60	Error	160	CD-ROM drive error	. CD-ROM
61	Error	161	RTC error	. RTC
62	Error	162	Specification selection error Only specification below can be selected for this title. %s1 Check the DIP-SW of machine.	. %s1 DIP-SW
64	Error	164	Operating Cassette is not corresponding with the machine. Turn off the power and replace it with Operating Cassette No.%s1 then reboot.	. , %s1
66	Error	166	Incorrect cassette installed.	.
67	Error	167	Security Chip initialization failed. (%d1)	. (%d1)
69	Error	169	Cannot use this security cassette as Installation Cassette.	.
70	Error	170	Cannot use this security cassette as Installation Cassette.	.

Index	Type	Status codes	Description (English)	Description (Japanese)
71	Error	171	This version cannot initialize a cassette. Please replace CD-ROM to %s1 for initialize, and turn off the power. Set DIP-SW4 to "OFF", then turn on the power.	CD-ROM %s1 ,DIP-SW4 OFF .
72	Error	172	You are using an incorrect CD-ROM. Replace CD-ROM to %s1 and turn on the main power.	CD-ROM CD-ROM %s1 , .
73	Error	173	Cannot use this security cassette.	.
74	Error	174	Cannot use this security cassette.	.
75	Error	175	Cassette is not corresponding with the machine. Turn off the power and replace it with Cassette No. %s1 then reboot.	, %s1 .
76	Error	176	Cassette is not corresponding with the machine. Turn off the power and replace it with Cassette No. %s1 then reboot.	, %s1 .
77	Error	177	Checksum error. If you have the latest CD-ROM, please replace. Turn off the power and set DIP-SW4 to "OFF", then turn on the power and reinstall CD-ROM.	. CD-ROM DIP-SW4 OFF , .
78	Error	178	This cassette is used to convert another game. This can not be used to this game.	. .
79	Error	179	Boot is not available from this device. DEVICE=%s1	DEVICE=%s1 .
80	Error	180	You are using an incorrect CD-ROM. Replace CD-ROM to %s1 and turn on the main power.	CD-ROM CD-ROM %s1 , .
81	Error	181	File system mounting failed. Please check that correct CD-ROM is in use.	CD-ROM .
82	Error	182	File system mounting failed. Please check that correct CD-ROM is in use.	CD-ROM .
83	Error	183	Installation boot device error. Please turn off the power for installation, and set DIP-SW4 to "OFF", then turn on the power.	. ,DIP-SW4 .
84	Error	184	CD-ROM drive error	CD-ROM .
85	Error	185	CD-ROM drive version update failed. (%d1) Please call a dealer near you.	CD-ROM .(%d1) .

Index	Type	Status codes	Description (English)	Description (Japanese)
86	Error	186	Cassette error (%d1)	(%d1)
87	Error	187	You are using the cassette of another cabinet. Please use the correct cassette. Please see details in operator's manual.	.
88	Error	188	You are using the cassette of another cabinet. Please use the correct cassette. Please see details in operator's manual.	.
89	Error	189	You are using unknown cabinet. Check all connectors. Please see details in operator's manual.	.
90	Error	190	You are using unknown cabinet. Check all connectors. Please see details in operator's manual.	.
91	Error	191	Non-applicable game installed. To install this game, %s1 shall be installed first.	.
92	Error	192	This software is for the e-Amusement system. The game will only work on the e-Amusement cabinet.	e-Amusement ()
93	Error	193	This software is not for the e-Amusement system. The game doesn't work on the e-Amusement cabinet.	e-Amusement ()
94	Error	194	Non-applicable game installed. To install this game, %s1 shall be installed first.	.
95	Error	195	Cassette initialization error. The cassette is already initialized as %s1 Reinitialization can not be completed.	.
96	Error	196	Cassette initialization error. The cassette is already initialized as %s1 Reinitialization can not be completed.	.
97	Error	197	Cassette initialization error. The cassette is already initialized as %s1 Reinitialization can not be completed.	.
98	Info	198, 500	Installation completed. Please write down the No.%s2 on cassette and machine. Turn off the	.

Index	Type	Status codes	Description (English)	Description (Japanese)
			power and replace cassette to %s1 then turn on the power.	%s1 , .
99	Info	199, 501	Installation complete. Please write down the No.%s3 on cassette and machine. Replace CD-ROM to %s1 and turn off the power then replace cassette to %s2. Set DIP-SW4 to "ON", then turn on the power.	. %s3 . CD-ROM %s1 , %s2 , DIP-SW4 ON .
100	Info	200, 502	Operating cassette initialized. The cassette was initialized as Operating Cassette (%s1)	. (%s1)
101	Info	201, 503	Installation cassette initialized. The cassette was initialized as Installation Cassette (%s1)	. (%s1)
102	Info	202, 504	Initialized Operating Cassette The cassette is already initialized as Operating Cassette (%s1) Reinitialization is not necessary.	. (%s1)
103	Info	203, 505	Initialized Installation Cassette The cassette is already initialized as Installation Cassette (%s1) Reinitialization is not necessary.	. (%s1)
104	Info	204, 506	Installation completed. Please write down the No.%s2 on cassette and machine. Turn off the power and replace cassette to %s1 then turn on the power.	. %s2 %s1 , .
105	Info	205, 507	Installation complete. Please write down the No.%s3 on cassette and machine. Replace CD-ROM to %s1 and turn off the power then replace cassette to %s2. Set DIP-SW4 to "ON", then turn on the power.	. %s3 . CD-ROM %s1 , %s2 , DIP-SW4 ON .
106	Info	206, 508	Installation completed. Please write down the No.%s1 on cassette and machine. Turn off the power, then reboot.	. %s1 .
107	Info	207, 509	Installation complete. Please write down the No.%s2 on cassette and machine. Replace CD-ROM to %s1 and turn off the power. Set DIP-SW4 to "ON", then reboot.	. %s2 . CD-ROM %s1 , DIP-SW4 ON .
108	Info	208, 510	Security cassette initialized. The cassette was initialized for %s1.	. %s1 .

Index	Type	Status codes	Description (English)	Description (Japanese)
109	Info	209, 511	<p>Initialized Security Cassette</p> <p>The cassette is already initialized for %s1.</p> <p>Reinitialization is not necessary.</p>	<p>%.1s</p>
110	Info	210, 512	<p>SERVICE button is pressed.</p> <p>To force installation, turn off the power, change the cassette to the Installation Cassette, and turn on the power with pressing SERVICE switch.</p>	<p>、</p> <p>、</p> <p>、</p>
111	Note	211, 513, 602	<p>CD-ROM drive version update in progress.</p> <p>Please do not shut off power.</p> <p>This will take a few moments.</p>	<p>CD-ROM</p> <p>、</p>
112	Note	212, 514, 603	<p>CD-ROM drive version update completed.</p>	<p>CD-ROM</p> <p>、</p>
113	Note	213, 515, 604	<p>Starting CD-ROM drive version update.</p> <p>Please do not turn off the power while updating.</p> <p>Press TEST button to begin updating.</p>	<p>CD-ROM</p> <p>、</p> <p>、</p>
114	Note	214, 516, 605	<p>Cleared RTC-RAM.</p> <p>At Game Demo screen, press the test button for the Test Mode and re-do the settings.</p> <p>Press the Test Button for the next screen.</p>	<p>RTC-RAM</p> <p>、</p> <p>、</p>

23.11 Pinouts

- [Main board pinouts \(GX700-PWB \(A\) \)](#)
- [Analog I/O board pinouts \(GX700-PWB \(F\) \)](#)
- [Digital I/O board pinouts \(GX894-PWB \(B\) A \)](#)
- [Security cartridge pinouts](#)

23.11.1 Main board pinouts (GX700-PWB (A))

Analog input port (ANALOG , CN3)

The inputs are wired directly to the 573's built-in ADC with no protection, so they can only accept voltages in 0-5V range. This connector is usually used for potentiometers and similar resistive analog controls.

Pin	Name	Dir
1	5V	
2	5V	
3	5V	
4	5V	
5	CH0	I
6	GND	
7	CH1	I
8	CH2	I
9	CH3	I
10	GND	

Digital output port (EXT-OUT , CN4)

Unlike the light output ports on most I/O boards, these are unisolated 5V logic level outputs.

Pin	Name	Dir
1	5V	
2	5V	
3	OUT7	O
4	OUT6	O
5	OUT5	O
6	OUT4	O
7	OUT3	O
8	OUT2	O
9	OUT1	O
10	OUT0	O
11	GND	
12	GND	

Digital input port (EXT-IN , CN5)

Unlike EXT-OUT , this port is not a separate input port. It piggybacks on the JAMMA button inputs instead, exposing the button 4 and 5 pins for both players as well as a

sixth button input which is not available on the JAMMA connector. All inputs have a pullup resistor to 5V.

Pin	Name	Dir	JAMMA pin
1	5V		
2	5V		
3	P1_B4	I	25
4	P1_B5	I	26
5	P1_B6	I	
6	GND		
7	P2_B4	I	c
8	P2_B5	I	d
9	P2_B6	I	
10	GND		

Amplified speaker output (SOUND-OUT , CN9)

The pinout of this connector is currently unknown.

Main I/O board connector (CN10)

Used by I/O boards to connect to the motherboard. Note that the address and data bus are 3.3V, while all other signals are 5V as they go through the CPLD.

Pin	Name	Dir	Pin	Name	Dir
A1	5V		B1	5V	
A2	5V		B2	5V	
A3	5V		B3	5V	
A4	5V		B4	5V	
A5	5V		B5	5V	
A6	/RD	O	B6	/WR0	O
A7	/WR1	O	B7	GND	
A8	GND		B8	SYSCLK	O
A9	GND		B9	GND	
A10	/RESET	O	B10	/RESET	O
A11	GND		B11	GND	
A12	/CS1	O	B12	DMARQ5	I
A13	GND		B13	GND	
A14	DMARQ5	I	B14	/CS1	O
A15	/CS2	O	B15	NC	
A16	/IRQ10	I	B16	/IRQ10	I
A17	A22	O	B17	A23	O
A18	A20	O	B18	A21	O
A19	A14	O	B19	A15	O
A20	A12	O	B20	A13	O
A21	A6	O	B21	A7	O
A22	A4	O	B22	A5	O
A23	A2	O	B23	A3	O
A24	A0	O	B24	A1	O
A25	D14	IO	B25	D15	IO
A26	D12	IO	B26	D13	IO
A27	D10	IO	B27	D11	IO
A28	D8	IO	B28	D9	IO
A29	D6	IO	B29	D7	IO
A30	D4	IO	B30	D5	IO
A31	D2	IO	B31	D3	IO
A32	D0	IO	B32	D1	IO
A33	GND		B33	GND	

Pin	Name	Dir	Pin	Name	Dir
A34	GND		B34	GND	
A35	GND		B35	GND	
A36	3.3V		B36	3.3V	
A37	3.3V		B37	3.3V	
A38	3.3V		B38	3.3V	
A39	3.3V		B39	3.3V	
A40	3.3V		B40	3.3V	

Analog CD-DA/MP3 audio input (CD-DA IN , CN12)

Connected to either the CD-ROM drive's audio output or to CN16 on the digital I/O board on systems equipped with a drive.

Pin	Name	Dir
1	LIN	I
2	AGND	
3	AGND	
4	RIN	I

Security cartridge slot (CN14)

All signals are 5V as they go through level shifters.

Pin	Name	Dir	Notes	Pin	Name
1	GND			23	GND
2	GND			24	GND
3	/DSR	I	Usually shorted to ground	25	MCUCLK
4	NC		May actually be /DTR ?	26	GND
5	TX	O		27	DRDY
6	RX	I		28	IO0
7	/RESET	IO	System reset (from watchdog)	29	/IREQ
8	GND			30	/DACK
9	GND			31	IRDY
10			Key (missing pin)	32	
11	?		Not connected?	33	I7
12	?		Not connected?	34	I6
13	D7	O		35	I5
14	D6	O		36	I4
15	D5	O		37	I3
16	D4	O		38	I2
17	D3	O		39	I1
18	D2	O		40	I0
19	D1	O		41	5V
20	D0	O		42	5V
21	5V			43	/RTS
22	5V			44	/CTS

Power input or output (**CN17**)

Commonly used to distribute the 12V rail to security cartridges with built-in light drivers or external modules, but it can also be used instead of the JAMMA connector to supply power to the 573. The pinout is silkscreened on the board.

Pin	Name
1	12V
2	12V
3	GND
4	GND
5	5V
6	5V

I2S digital SPU audio output (**DIGITAL-AUDIO** , **CN19**)

Always unpopulated. Pin 4 outputs a 16.9344 MHz master clock (system clock divided by 2, or 44100 Hz sampling rate multiplied by 384). This port does *not* output audio from the CD-DA/MP3 input, which is not routed through the SPU.

Pin	Name	Dir
1	BCLK	O
2	SDOUT	O
3	GND	
4	MCLK	O
5	LRCK	O

Secondary I/O board connector (CN21)

The address lines not wired to CN10 , as well as the otherwise unused SIO0 controller and memory card bus, are broken out to this connector. No currently known I/O board uses it. All signals are 3.3V.

Pin	Name	Dir	Pin	Name	Dir
A1	A8	O	B1	A9	O
A2	A10	O	B2	A11	O
A3	A16	O	B3	A17	O
A4	A18	O	B4	A19	O
A5	GND		B5	?	
A6	GND		B6	?	
A7	GND		B7	GND	
A8	GND		B8	DOTCLK	O
A9	GND		B9	GND	
A10	GND		B10	/DSR	I
A11	GND		B11	/DTR2	O
A12	GND		B12	/DTR1	O
A13	GND		B13	RX	I
A14	GND		B14	TX	O
A15	GND		B15	SCK	O

Watchdog test header (WD-CHECK , CN22)

Always unpopulated. Exposes the watchdog's clear input (pulsed whenever the CPU writes to the watchdog clear register) as well as the reset output. Injecting pulses to forcefully clear the watchdog should work, although it's much easier to simply disable it by placing a jumper on S86 .

Pin	Name	Dir
1	WDCLR	IO
2	/RESET	O
3	5V	
4	GND	

GPU clock and compositing output (CN23)

Only present on later revisions of the main board and only populated on DDR Karaoke Mix, which uses the semitransparency plane of the currently displayed framebuffer as an alpha mask in order to composite the 573's output on top of the incoming karaoke video feed.

Pin	Name	Dir	GPU pin
1	FSC	O	153
2	DMASK	O	202
3	GND		

Security cartridge serial port (CN24)

Only present on later revisions of the main board and always unpopulated. Exposes the same 5V SIO1 signals as the security cartridge slot.

Pin	Name	Dir	Cart pin
1	TX	O	5
2	RX	I	6
3	GND		
4	GND		
5	/RTS	O	43
6	/CTS	I	44

RGB video output (CN25)

Only present on later revisions of the main board and only populated on GunMania and DDR Karaoke Mix, whose I/O boards feature RGB to S-video and composite converters respectively. Exposes the same RGB signals as the JAMMA and DB15 connectors.

Pin	Name	Dir	JAMMA pin
1	GND	O	
2	CSYNC	O	P
3	BOUT	O	13
4	GOUT	O	N
5	ROUT	O	12

Watchdog configuration jumper (S86)

Always unpopulated. Shorting pins 2 and 3 will disable the watchdog while keeping power-on reset functional. Pin 1 seems to be an active-high reset output, unused by the 573.

Pin	Name	Dir
1	RESET	O
2	GND	
3	WDEN	I

H8/3644 JVS MCU pin mapping

Pin	H8 GPIO	Dir	Connected to	Usage
11	P9_0	I		Unused
12	P9_1-2	O	Konami ASIC	Status code (readable from 0x1f400004)
12	P9_3-4	O	Konami ASIC	Error code (readable from 0x1f400004)
16	IRQ0	I		Unused
17-24	P6_0-7	O	Konami ASIC	Low byte of value readable from 0x1f40000a
25-32	P5_0-7	O	Konami ASIC	High byte of value readable from 0x1f40000a
34	P7_3	I	Handshaking logic	Current JVSDDY status
35	P7_4	I	Handshaking logic	Current JVSIRDY status
36	P7_5	I		Unused
37	P7_6	I		Unused
38	P7_7	I		Unused
39-46	P8_0-7	I	Bus (via latch)	High byte of value written to 0x1f680000
47	P2_0	O	RS-485 transceiver	JVS driver output enable
48	P2_1	I	RS-485 transceiver	JVS serial port RX
49	P2_2	O	RS-485 transceiver	JVS serial port TX
50	P3_2	I		Unused
51	P3_1	I		Unused
52	P3_0	I		Unused
53	P1_0	O	Handshaking logic	/JVSDACK (clears JVSDDY when pulsed low)
54	P1_4	O	Handshaking logic	JVSIREQ (sets JVSIRDY when pulsed high)
55	P1_5	I		Unused
56	P1_6	I		Unused
57	P1_7	I		Unused
59-2	PB_7-0	I	Bus (via latch)	Low byte of value written to 0x1f680000

23.11.2 Analog I/O board pinouts (GX700–PWB (F))

Output banks A, B (CN33 , CN34 respectively)

All outputs are open-drain. Pins 1 and 10 are tied together and connected to the optocouplers' emitters.

Pin	Name	Dir
1	ACOM / BCOM	
2	A0 / B0	O
3	A1 / B1	O
4	A2 / B2	O
5	A3 / B3	O
6	A4 / B4	O
7	A5 / B5	O
8	A6 / B6	O
9	A7 / B7	O
10	ACOM / BCOM	

Output bank C (CN35)

All outputs are open-drain. Unlike banks A and B, pin 10 is not tied to pin 1 but is instead connected to the EMI filters' ground (FGND), isolated from the system ground but shared across all output banks.

Pin	Name	Dir
1	CCOM	
2	C0	O
3	C1	O
4	C2	O
5	C3	O
6	C4	O
7	C5	O
8	C6	O
9	C7	O
10	FGND	

Output bank D (CN36)

All outputs are open-drain.

Pin	Name	Dir
1	DCOM	
2	D0	O
3	D1	O
4	D2	O
5	D3	O
6	FGND	

23.11.3 Digital I/O board pinouts (GX894-PWB (B) A)

Output bank C (CN10)

All outputs are open-drain. The optocouplers driving C0-C3 have their emitters wired to CCOM0 , while those driving C4-C7 have their emitters wired to CCOM1 .

Pin	Name	Dir
1	CCOM0	
2	C0	O
3	C1	O
4	C2	O
5	C3	O
6	CCOM1	
7	C4	O
8	C5	O
9	C6	O
10	C7	O

Output bank B (CN11)

All outputs are open-drain. The optocouplers driving B0–B3 have their emitters wired to BCOM0 , while those driving B4–B7 have their emitters wired to BCOM1 .

Pin	Name	Dir
1	BCOM0	
2	B0	O
3	B1	O
4	B2	O
5	B3	O
6	BCOM1	
7	B4	O
8	B5	O
9	B6	O
10	B7	O
11	NC	
12	NC	

Output bank A (CN12)

All outputs are open-drain. The optocouplers driving A0–A3 have their emitters wired to ACOM0 , while those driving A4–A7 have their emitters wired to ACOM1 .

Pin	Name	Dir
1	ACOM0	
2	A0	O
3	A1	O
4	A2	O
5	A3	O
6	ACOM1	
7	A4	O
8	A5	O
9	A6	O
10	A7	O
11	NC	
12	NC	
13	NC	

Output bank D (CN13)

All outputs are open-drain.

Pin	Name	Dir
1	DCOM	
2	D0	O
3	D1	O
4	D2	O
5	D3	O

Input bank (CN14)

The pinout of this connector is currently unknown.

RS-232 serial port (CN15)

Pin	Name	Dir
1	TX	O
2	RX	O
3	GND	
4	GND	
5	RTS	O
6	CTS	O
7	DTR	O
8	DSR	O

Analog MP3 audio output (CN16)

Usually connected to CN12 on the main board. GuitarFreaks routes this output to a separate set of RCA jacks on the front I/O panel instead.

Pin	Name	Dir
1	LOUT	O
2	AGND	
3	AGND	
4	ROUT	O

Unknown (CN17)

The pinout of this connector is currently unknown.

I2S digital MP3 audio output (CN18)

Pin	Name	Dir	FPGA pin
1	MCLK	O	97
2	BCLK	O	94
3	SDOUT	O	96
4	LRCK	O	95
5	?		
6	?		

Digital I/O XC9536 CPLD pin mapping

Pin	JTAG	CPLD alt.	Dir	Connected to	Usage
1	51		IO	System bus	Data bus bit 15
2	105		IO	System bus	Data bus bit 14
3	102		IO	System bus	Data bus bit 13
4	96		IO	System bus	Data bus bit 12
5	99	GCK1		Unknown	Unknown (system clock?)
6	93	GCK2			Unused
7	87	GCK3	O	Light bank B	Output B3
8	90		O	Light bank B	Output B2
9	84		O	Light bank B	Output B1
11	81		O	Light bank B	Output B0
12	78		O	Light bank C	Output C7
13	75		O	Light bank C	Output C6
14	72		O	Light bank C	Output C5
18	69		O	Light bank C	Output C4
19	66		O	Light bank C	Output C3
20	63		O	Light bank C	Output C2
22	60		O	Light bank C	Output C1
24	57		O	Light bank C	Output C0
25	3		O	Audio DAC	Chip reset/mute
26	6		?	FPGA	Configuration status/reset (/ INIT)
27	9		?	FPGA	Configuration status (DONE)
28	12		O	FPGA	Configuration reset (/ PROGRAM)
29	15		O	FPGA	Configuration data (DIN)
33	18		O	FPGA	Configuration bit clock (CCLK)
34	21		I	System bus	I/O board chip select (/CS?)
35	24		I	System bus	Read/write strobe?
36	27		I	System bus	Read/write strobe?
37	30		I	System bus	Address bus bit 7
38	33		I	System bus	Address bus bit 6
39	36	GSR	I	System bus	Address bus bit 5
40	39	GTS2	I	System bus	Address bus bit 4
42	45	GTS1	I	System bus	Address bus bit 3

Pin	JTAG	CPLD alt.	Dir	Connected to	Usage
43	42		I	System bus	Address bus bit 2
44	48		I	System bus	Address bus bit 1

Digital I/O XCS40XL FPGA pin mapping

Pin	JTAG	FPGA alt.	Dir	Delay	Slew	Conn
2	170	GCK1	IO	No	Slow	DRAM
3	173		IO	No	Slow	DRAM
4	176		IO	No	Slow	DRAM
5	179		IO	No	Slow	DRAM
6	182	TDI				
7	185	TCK				
8	194		IO	No	Slow	DRAM
9	197		IO	No	Slow	DRAM
10	200		IO	No	Slow	DRAM
11	203		IO	No	Slow	DRAM
12	206					
14	212		IO	No	Slow	DRAM
15	215		IO	No	Slow	DRAM
16	218	TMS				
17	221		IO	No	Slow	DRAM
19	236		IO	No	Slow	DRAM
20	239		IO	No	Slow	DRAM
21	242		IO	Yes	Slow	SRAM
22	245		IO	Yes	Slow	SRAM
23	248		IO	Yes	Slow	SRAM
24	251		IO	Yes	Slow	SRAM
27	254		IO	Yes	Slow	SRAM
28	257		IO	Yes	Slow	SRAM
29	260		IO	Yes	Slow	SRAM
30	263		O		Slow	SRAM
31	266		IO	Yes	Slow	SRAM
32	269		O		Slow	SRAM
34	284		O		Fast	SRAM
35	287		O		Slow	SRAM
36	290		O		Slow	SRAM
37	293		O		Slow	SRAM
39	299					
40	302		O		Fast	SRAM
41	305		O		Slow	SRAM

Pin	JTAG	FPGA alt.	Dir	Delay	Slew	Connect
42	308		O		Slow	SRAM
43	311		O		Slow	SRAM
44	320		O		Slow	SRAM
45	323		O		Slow	SRAM
46	326		O		Slow	SRAM
47	329		O		Slow	SRAM
48	332		O		Slow	SRAM
49	335	GCK2	O		Slow	SRAM
55	342	GCK3	O		Fast	SRAM
56	345	/HDC	O		Slow	SRAM
57	348		O		Slow	SRAM
58	351		O		Slow	SRAM
59	354		O		Slow	Light
60	357	LDC	O		Slow	Light
61	366		I	No		Input
62	369		I	No		Input
63	372		I	No		Input
64	375		I	No		Input
65	378					
67	384		O		Slow	Light
68	387		O		Slow	Light
69	390		O		Slow	Light
70	393		O		Slow	Light
72	396		O		Slow	Light
73	399		O		Slow	Light
74	414		O		Slow	Light
75	417		O		Slow	Light
76	420		O		Slow	Light
77	423	/INIT	IO	-	-	CPLD
80	426		O		Slow	Light
81	429		O		Slow	Light
82	432		O		Slow	Light
83	435		O		Slow	Light
84	438		O		Slow	Light

Pin	JTAG	FPGA alt.	Dir	Delay	Slew	Connect
85	441		I	No		RS-232
87	456		O		Slow	RS-232
88	459		I	No		RS-232
89	462		O		Slow	RS-232
90	465		I	Yes		RS-232
92	471					
93	474		O		Slow	RS-232
94	477		O		Slow	Audio
95	480		O		Slow	Audio
96	483		O		Slow	Audio
97	492		O		Slow	Audio
98	495		O		Slow	ARCNet
99	498		O		Slow	ARCNet
100	501		I	Yes		ARCNet
101	504					
102	507	GCK4				
104		DONE	IO	-	-	CPLD
106		/PROGRAM	I	-	-	CPLD
107	510	D7	IO	No	Slow	DS24C01
108	513	GCK5				
109	516		IO	No	Slow	DS24C01
110	519		I	No		System
111	525					
112	534	D6	I	No		System
113	537		I	No		System
114	540		I	No		System
115	543		I	No		System
116	546		I	No		System
117	549		I	No		System
119	558		O		Slow	Unknown
120	561		IO	Yes	Slow	System
122	564	D5	IO	Yes	Slow	System
123	567		IO	Yes	Slow	System
124	576		IO	Yes	Slow	System

Pin	JTAG	FPGA alt.	Dir	Delay	Slew	Connect
125	579		IO	Yes	Slow	System
126	582		IO	Yes	Slow	System
127	585		IO	Yes	Slow	System
128	588	D4	IO	Yes	Slow	System
129	591		IO	Yes	Slow	System
132	594	D3	IO	Yes	Slow	System
133	597		IO	Yes	Slow	System
134	600		IO	Yes	Slow	System
135	603		IO	Yes	Slow	System
136	606		IO	Yes	Slow	System
137	609		IO	Yes	Slow	System
138	618	D2	IO	Yes	Slow	System
139	621					
141	624					
142	627		I	No		System
144	639					
145	642		I	No		System
146	645		I	No		System
147	648					
148	651		I	No		MAS3
149	654	D1	O		Slow	MAS3
150	657		IO	No	Slow	MAS3
151	666		IO	No	Slow	MAS3
152	669		O		Slow	MAS3
153	672	D0 / DIN	I	-	-	CPLD
154	675	GCK6 / DOUT				
155		CCLK	I	-	-	CPLD
157	0	TDO				
159	2		I	No		MAS3
160	5	GCK7	I	No		Crystal
161	8		I	No		MAS3
162	11		I	No		MAS3
163	14	CS1	O		Slow	MAS3

Pin	JTAG	FPGA alt.	Dir	Delay	Slew	Connect
164	17		O		Slow	MAS3
165	26					
166	32		O		Slow	MAS3
167	35		O		Slow	MAS3
168	38		I	No		MAS3
169	41		I	No		MAS3
171	44		I	No		MAS3
172	47		I	No		MAS3
174	62		O		Slow	DRAM
175	65		O		Slow	DRAM
176	68		O		Slow	DRAM
177	71		O		Slow	DRAM
178	74		O		Slow	DRAM
179	77		O		Slow	DRAM
180	80		O		Slow	DRAM
181	83		O		Slow	DRAM
184	86		O		Slow	DRAM
185	89		O		Slow	DRAM
186	92		O		Slow	DRAM
187	95		O		Slow	DRAM
188	98		O		Slow	DRAM
189	101		O		Fast	DRAM
190	104		O		Fast	DRAM
191	107		O		Fast	DRAM
193	122		O		Fast	DRAM
194	125		O		Fast	DRAM
196	128		O		Fast	DRAM
197	131		O		Fast	DRAM
198	134		O		Fast	DRAM
199	137		O		Fast	DRAM
200	140		O		Fast	DRAM
201	143		O		Fast	DRAM
202	152					
203	155					

Pin	JTAG	FPGA alt.	Dir	Delay	Slew	Conn
204	158		IO	No	Slow	DRAM
205	161		IO	No	Slow	DRAM
206	164		IO	No	Slow	DRAM
207	167	GCK8	I	No		Crysta

Notes:

- The FPGA has no access to the 33.8688 MHz system clock, despite it being broken out to the I/O board connector. Konami's bitstreams use the 29.45 MHz oscillator as the main clock, additionally dividing it down to 14.725 MHz and feeding it to the MAS3507D's clock input.
- The 19.6608 MHz clock is left unused by most (all?) bitstream variants, but was likely meant to be used for RS-232. Dividing it by 512, 1024, 2048 or 4096 will give the standard baud rates of 38400, 19200, 9600 and 4800 respectively. The UART driving the RS-232 port may have been removed from the bitstream at some point to make room for the other circuitry.
- Most input pins have external pullup resistors, so enabling the FPGA's internal pullups is not necessary.
- Light outputs must be configured as open-drain in order to work properly. The optocouplers' anodes are fed 5V rather than 3.3V; setting the outputs high instead of putting them into high-z will result in a voltage difference of ~1.7V across the optocouplers' LEDs, which is enough to trigger them.
- The "5V tolerant I/O" option in Xilinx's bitstream generator **must** be enabled when building custom bitstreams. There are no level shifters between the FPGA and the 573's system bus.
- The FPGA's `M0`, `M1` and `/PWRDWN` pins seem to be hardwired to 3.3V.
- The DAC's `CKS` pin is hardwired to ground, so the I2S master clock must always be $256 * \text{the sampling rate}$.
- Pin 119 is set up by the DDR bitstream as a logical AND of pins 61-64. It is currently unclear if it goes to any other part on the board.
- Konami's bitstreams map the DRAM chips into a single address space as follows:
 - `0x0000000-0x07ffffff` : 22H
 - `0x0800000-0x0fffffff` : 22J
 - `0x1000000-0x17ffffff` : 22G

23.11.4 Security cartridge pinouts

RS-232 "network" connector

Present on GX700-PWB (E) , GX896-PWB (A) A , GX883-PWB (D) and GE949-PWB (D) A cartridges. All signals use RS-232 voltage levels. Note that DTR and DSR are *not* wired to the respective SIO1 pins but to the security cartridge I/O pins.

On the GX700-PWB (E) cartridge the signals are referenced to the 573's ground and not isolated. On all other cartridge types, the RS-232 transceiver is powered through an isolated DC-DC module and fully electrically isolated from the 573; the GND pin is the transceiver's isolated ground.

Pin	Name	Dir
1	TX	O
2	RX	I
3	DTR	O
4	DSR	I
5	GND	

"Control" or "amp box" connector

Present on GX896-PWB (A) A , GX883-PWB (D) and GE949-PWB (D) A cartridges. Unlike the RS-232 connector these are unisolated 5V logic level signals driven through open-drain buffers, with pullup resistors to 5V.

Pin	Name	Dir
1	GND	
2	CTRL0	O
3	GND	
4	CTRL1	O
5	CTRL2	O
6	5V	

23.12 Credits, sources and links

This document is the result of a joint effort consisting of years' worth of research, brought to you by:

- **spicyjpeg** (documentation writing, software reverse engineering, testing)
- **Naoki Saito** (hardware reverse engineering, schematic tracing, testing)
- **987123879113** (digital I/O board reverse engineering, testing)
- **smf** (initial reverse engineering and implementation of the 573 MAME driver)
- **tensionvex** (testing)
- **Shiz** (security cartridge details)

Traced schematics, images, datasheets and additional resources are available in [Naoki's 573 repo](#). Shiz also maintains a [general documentation repo](#) for several arcade systems including the 573.

Some information has been aggregated from the following sources:

- [System 573 MAME driver](#)
- [987123879113's MAME fork](#) and [gobbletools](#)
- ATAPI specification (revision 2.6, January 1996)
- ATA/ATAPI-6 specification (revision 1e, June 2001)
- JVS specification (third edition, command reference revision 1.3)
- HD6473644, M48T58, ADC0834, XCS40XL, MAS3507D, X76F041 and X76F100 datasheets
- [DDR stage I/O protocol notes](#)
- [JVS protocol notes](#)
- [Original \(incomplete\) list of working ATAPI drives](#)
- ["The Almost Definitive Guide to Session Mode Linking"](#)
- [Callus Next PCB information](#)
- [Light output for Salary Man Champ](#) and [Hyper Bishi Bashi Champ](#)
- [system573_tool](#)
- [Arduino-based master calendar implementation](#)
- [Z-I-v forum post with security cartridge info](#)

Huge thanks to the Rhythm Game Cabs Discord server and everyone who provided valuable information about the 573!

24. Cheat Devices

Action Replay, GameShark, Gamebuster, GoldFinger, Equalizer (Datel/clones)

The Datel devices exist in various official/cloned hardware revisions, the DB25 connector requires a special Comms Link ISA card (or a "FiveWire" mod for making it compatible with normal PC parallel ports). Later "PAR3" models are said to not require Comms Link, and do thus probably work directly with normal parallel ports).

[Cheat Devices - Datel I/O](#)

[Cheat Devices - Datel DB25 Comms Link Protocol](#)

[Cheat Devices - Datel Chipset Pinouts](#)

[Cheat Devices - Datel Cheat Code Format](#)

Xplorer/Xploder/X-Terminator (FCD/Blaze)

The FCD/Blaze devices are all same hardware-wise (with some cosmetic PCB revisions, and with extra SRAM and bigger FLASH installed in some carts). The DB25 connector can be directly connected to a PC parallel port.

[Cheat Devices - Xplorer Memory and I/O Map](#)

[Cheat Devices - Xplorer DB25 Parallel Port Function Summary](#)

[Cheat Devices - Xplorer DB25 Parallel Port Command Handler](#)

[Cheat Devices - Xplorer DB25 Parallel Port Low Level Transfer Protocol](#)

[Cheat Devices - Xplorer Versions](#)

[Cheat Devices - Xplorer Chipset Pinouts](#)

[Cheat Devices - Xplorer Cheat Code Format](#)

[Cheat Devices - Xplorer Cheat Code and ROM-Image Decryption](#)

FLASH Chips (for both Xplorer and Datel)

[Cheat Devices - FLASH/EEPROMs](#)

<http://gamehacking.org/faqs/hackv500c.html> - cheat code formats

http://doc.kodewerx.org/hacking_psx.html - cheat code formats

<http://xianaix.net/museum.htm> - around 64 bios versions

<http://www.murraymoffatt.com/playstation-xplorer.html> - xplorer bioses

Separating between Gameshark and Xplorer Codes

First Digit	Usage
3,8	Same for Gameshark & Xplorer (for Xplorer: can be encrypted)
1,2,C,D,E	Gameshark
4,6,7,9,B,F	Xplorer
0,5	Meaning differs for Gameshark & Xplorer
A	Unused

Codebreaker

Megacom Power Replay III Game Enhancer

24.1 Cheat Devices - Datel I/O

Datel Memory and I/O Map (for PAR2 or so)

```

1F000000h-1F01FFFFh R/W Flash (first 128K)
1F020010h           R   Comms Link STB pin state (bit0)
1F020018h           R   Switch Setting (bit0: 0=Off, 1=On)
1F040000h-1F05FFFFh R/W Flash (second 128K) + feedback area (see below)
1F060000h           R   Comms Link data in (byte)
1F060008h           W   Comms Link data out (byte, pulses ACK to Comms Link)

```

Datel PAR1

Original PAR1 might have supported only 128K FLASH (?) if so, the I/O ports are probably same as above, but without the "second 128K" FLASH area.

Datel PAR3

The PAR3 version is said to work with parallel ports (not needing the Comms Link IDA card), and said to support more FLASH with bankswitching, so the I/O ports must work somehow entirely different as described above.

Some notes from a (poorly translated) japanese document:

PAR3 Memory:

```

1f000000-1f01ffff ROM. Change in bank switching.
1f020000-1f03ffff ROM. Change in bank switching.
1f040000-1f05ffff whopping RAM. It is able to use.
1f060000-1f06003f I/O. Intently mirror to the subsequent 1f07ffff.

```

PAR3 I/O:

```

1f060000 for reception. (1f060000 use only.) All bytes same treatment like.
           It is 01h in the state that does not connected anything.

```

```

1f060008 for transmission. (1f060008 use only.) This is ffh in the state
        that does not connected anything.
1f060010 during data reception it will stand the least significant bit.
        Usually is fe.
1f060018 state of the push button. In not pressed and fefefefefefefefe,
        it will Ost ffffffffffffffff.
1f060020 I think 1f060020 unused. It is ffffffffffffffff.
1f060028 I think 1f060028 unused. It is ffffffffffffffff.
1f060030 bank switching. 1 put and run-time of the ROM, and changes to the
        3's and the start-up of the ROM.
1f060038 would be what? It is lbu. Like there is a meaning bits 0 and 1.
        It was fcfcfcfcfcfcfcfc. I think that it is bank cult.

```

24.2 Cheat Devices - Datel DB25 Comms Link Protocol

Boot Command Handler

The Boot Command Handler is executed once at Pre-Boot, and also (at least in some firmware versions) once before displaying the GUI. Following command(s) can be sent from PC side:

```

Repeatedly send 8bit "W", until receiving "R"
Repeatedly send 8bit "B", until receiving "W"
Send 8bit command "X" (upload/exec) or "U" (upload/flash), and receive ECHO
Send 32bit ADDRESS, and receive ECHO or "BX" (bad command)
Send 32bit LENGTH, and receive ECHO
Send DATA[LENGTH], and receive ECHO
Send 16bit CHECKSUM, and receive ECHO
(for upload/flash and if checksum was good, PSX will now BURN ADDR,LENGTH)
Send 16bit DUMMY, and receive "OK"/"BC"/"BF" (okay, bad chksum, bad flash)
(for upload/exec and if checksum was good, PSX will now CALL ADDR)
(thereafter, PAR2.0 and up will reboot via jmp BFC00000h)

```

Data is always transferred as byte-pair (send one byte, receive one byte), 16bit/32bit values are transferred MSB first (with ECHO after each byte).

The upload/exec command is supported by both Datel and Caetla, the upload/flash command is supported by Datel only (but it's totally bugged in PAR1.99, and might also have upwards compatibility issues in later versions, so it's better to upload a custom flash function via upload/exec instead of using upload/flash).

The 16bit checksum is all DATA[len] bytes added together, and then ANDed with 0FFFh (ie. actually only 12bit wide).

Menu/Game Command Handler

There must be some further command handler(s) after the Boot Command Handler, with support for additional cheat related commands, and (at least in Caetla) with support for uploading EXE files with Kernel functions installed (the Boot Command Handler at Pre-Boot time can also upload EXE code, but doesn't have Kernel installed).

Original Datel commands for Menu/Game mode are unknown. The Caetla commands are documented in japanese, and there are also two english translations:

<http://www.psxdev.net/forum/viewtopic.php?f=49&t=370> - good (though incomplete)

<http://www.psxdev.net/forum/viewtopic.php?f=53&t=462#p6849> - very bad (beware)

24.3 Cheat Devices - Datel Chipset Pinouts

There appear to be numerous Datel hardware revisions (and possibly numerous Datel clones). So this chapter is unlikely to cover all hardware revisions.

PSX Expansion cards:

PCB	Controller	FLASH	DB25	spotted by
DATEL REF 1215	GAL + 74HC245	128K+128K	yes	Type79
DATEL REF 1288	DATEL ASIC1	256K	yes	nocash
DATEL xxx?	GAL + PIC + HC245	128K	yes	CharlesMacD
noname?	GAL + 74HC245	256K+0K	yes	Type79
DATEL REF 1324	lots of chips?	lots?	no	CyrusDevX
DATEL REF 1326	lots of chips?	lots?	yes	Type79
PS-121 ZISAN	GAL + PIC? + HC245	128K	yes	Kryptonick

Comms Link ISA cards:

PCB	Chipset	spotted by
DATEL COMMS LINK, XXX?	blurry SMD chipset?	lowres photo
DATEL REF 1113, IBM SATURN LINK	1x74HC74, 2x74HC373, 1xXXX?	Type79
EMS, PCCOM	1x74HC74, 2x74HC373, 1xXXX?	jokergameth

DIY Alternatives to Comms Link

FiveWire	;simple hardware mod for use with parallel ports, for SPP/EPP
FreeWing	;parallel port adaptor, lots of 74xxx TTL chips, for SPP/EPP
ExStand	;parallel port adaptor, lots of 74xxx TTL chips, for EPP
CommLinkUSB	;USB adaptor, Buy-and-Diy technology (adafruit/teensy based)

DATEL REF1288 board (with DATEL ASIC1 chip)

The ASIC1 chip is found in this hardware:

```
Label: "EQUALIZER, EVEN THE ODDS" (sticker on outside of case)
Case:  "DATEL ENGLAND" (printed inside of case)
PCB:   "DATEL REF1288 SONY SONYPX2meg"
U:     44pin "DATEL, ASIC1, A8B1944A, 9832" ;custom logic chip
U:     32pin "SST, 29EE020, 150-4C-NH, 981918-D" ;256Kx8 EEPROM
```

```

U: 8pin "83BA, LM78L, 05ACM" ;5V voltage regulator
CN: 25pin DB25 connector (for Comms Link ISA card)
CN: 68pin PSX expansion port connector
SW: 3pin Switch

```

The ASIC1 is basically same as the PAL/GAL on other boards, with the 74HC245 transceiver intergrated; the ASIC1 is using a 44pin PLCC package, with pin1 being upper-middle, and pin7 being upper-left. Pinouts are:

7 D0	18 DB25.2.DATA0	29 D0 (same as pin7)	40 A3
8 D1	19 DB25.3.DATA1	30 EEPROM./WE	41 A4
9 D2	20 DB25.4.DATA2	31 /WR	42 /EXP
10 GND	21 GND	32 GND	43 GND
11 D3	22 DB25.5.DATA3	33 /RD	44 A17
12 D4	23 DB25.6.DATA4	34 /MODE ("jumper")	1 A18
13 D5	24 DB25.7.DATA5	35 VCC	2 GND
14 VCC	25 VCC	36 DB25.11.ACK	3 VCC
15 D6	26 DB25.8.DATA6	37 ?	4 EEPROM./OE
16 VCC	27 DB25.9.DATA7	38 VCC	5 DB25.10.STB
17 D7	28 EEPROM./CS	39 ?	6 SWITCH

D0 is wired to both pin7 and pin29. The /MODE pin is NC (but could be GNDed via the two solder points in middle of the PCB). The SWITCH has 10K pullup (can can get GNDed depending on switch setting).

PALCE20V8 Cuthbert Action Replay schematic (from hitmen webpage)

1-NC	8-NC	15-NC	22-NC
2-FBIN	9-CPU.A4	16-GNDed	23-FLASH./WE
3-CPU.A17	10-CPU./EXP	17-DB25.pin10 (PAR.STB)	24-FBOUT
4-CPU./WR	11-CPU.A3	18-FLASH./CS	25-FLASH./OE (and BUF.DIR)
5-CPU./RD	12-CPU.A5	19-DB25.pin11 (PAR.ACK)	26-BUF./EN
6-CPU.A18	13-SWITCH	20-CPU.D0	27-unused
7-CPU.A20	14-GND	21-FLASH.A17	28-VCC

Charles MacDonald Game Shark schematic

1-FBIN	7-CPU.A4.NC?	13-GNDed	19-FLASH./WE
2-PIC.RC1	8-CPU./EXP.NC?	14-PAR.STB	20-FBOUT
3-CPU./WR	9-CPU.A3	15-PIC.RA0	21-BUF.DIR
4-CPU./RD	10-CPU.A2	16-PAR.ACK	22-BUF./OE
5-CPU.A18	11-SWITCH	17-CPU.D0	23-PIC.RC0
6-CPU.A17	12-GND	18-FLASH./OE	24-VCC

Uhm, schematic shows "PAR.ACK" instead of "BUF.DIR" as transceiver direction?

The 24pin PAL in Charles schematic does actually seem to be a 28pin PLCC GAL in actual

hardware (which has four NC pins, hence the 24pin notation in the schematic).

The three PIC pins connect to a 28pin PIC16C55 microprocessor (unknown purpose). Most of the PIC pins are NC (apart from the above three signals, plus supply, plus OSC ... derived from some oscillator located "behind" the DB25 connector?).

Charles MacDonald Gold Finger schematic

1-FBIN	6-CPU.A17	11-CPU.A2	16-FBOUT
2-SWITCH	7-CPU.A4.NC?	12-PAR.ACK	17-CPU.A20
3-CPU./WR	8-CPU./EXP.NC?	13-CPU.D0	18-PAR.STB
4-CPU./RD	9-CPU.A3	14-FLASH./OE	19-BUF./OE
5-CPU.A18	10-GND	15-FLASH./WE	20-VCC

Note: This is a datel clone, without "BUF.DIR" signal (instead, the transceiver DIR pin is wired to "PAR.ACK"; it's probably functionally same as real datel hardware, assuming that "PAR.ACK" is only a short pulse during writing; then reading should be possible anytime else).

Charles MacDonald Comms Link schematic

PAL

1-/STATUS	7-ISA.A6	13-JP2	19-NC
2-ISA.A1	8-ISA.A7	14-ISA.A9	20-PCWR
3-ISA.A2	9-ISA.A8	15-NC	21-/PCRD
4-ISA.A3	10-ISA.AEN	16-ISA./IOW	22-NC
5-ISA.A4	11-JP1	17-/IRQ	23-ISA./IOR
6-ISA.A5	12-GND	18-ISA.D0	24-VCC

The JP1/JP2 pins allow to select Port 300h,310h,320h,330h via two jumpers. The /IRQ pin could be forward to ISA./IRQ2..7 via six jumpers (but the feature is unused and the six jumpers aren't installed at all).

DB25 Connector

Pin	Parallel Port	CommsLink (PC)	cable	PAR (PSX)
1	/STB ---->	"strobe" ----.	o-----o--	-- NC
2-9	DATA <-/->	DATA <--	--o-----o----->	DATA
10	/ACK <----	"strobe" ----'	--o-----o----->	"strobe"
11	BUSY <----	"ack" <-----	o-----o-----	"ack"
12	PE <----	NC --	--o-----o---	-- NC
13	SLCT <----	NC --	--o-----o---	-- NC
14	/AUTOLF ---->	NC --	--o-----o--.	GNDED
15	/ERROR <----	NC --	--o-----o--.	GNDED
16	/INIT ---->	NC --	--o-----o--.	GNDED

```

17    /SELECT ---->  GNDed    --.  .--o-----o--.  .-- GNDed
18-25 GND      ----- GND      --'--'--o-----o--'--'-- GND

```

nocash FiveWire mod (for connecting datel expansion cart to parallel port)

```

disconnect DB25.pin14,15,16,17 from GND (may require to desolder the DB25)
repair any GND connections that were "routed through" above pins
wire DB25.pin1./STB      to DB25.pin10./ACK
wire DB25.pin16./INIT   to PSX.EXPANSION.pin2./RESET
wire DB25.pin15./ERROR  to PSX.EXPANSION.pin28.A20
wire DB25.pin13.SLCT    to PSX.EXPANSION.pin62.A21
wire DB25.pin12.PE      to PSX.EXPANSION.pin29.A22

```

24.4 Cheat Devices - Datel Cheat Code Format

PSX Gameshark Code Format

```

30aaaaaa 00dd    ; -8bit Write  [aaaaaa]=dd
80aaaaaa dddd    ; -16bit Write [aaaaaa]=dddd

```

Below for v2.2 and up only

```

D0aaaaaa dddd    ; -16bit/Equal      If dddd=[aaaaaa] then (exec next code)
D1aaaaaa dddd    ; -16bit/NotEqual   If dddd<>[aaaaaa] then (exec next code)
D2aaaaaa dddd    ; -16bit/Less       If dddd<[aaaaaa] then (exec next code)
D3aaaaaa dddd    ; -16bit/Greater    If dddd>[aaaaaa] then (exec next code)
E0aaaaaa 00dd    ; -8bit/Equal       If dd=[aaaaaa] then (exec next code)
E1aaaaaa 00dd    ; -8bit/NotEqual    If dd<>[aaaaaa] then (exec next code)
E2aaaaaa 00dd    ; -8bit/Less        If dd<[aaaaaa] then (exec next code)
E3aaaaaa 00dd    ; -8bit/Greater     If dd>[aaaaaa] then (exec next code)
10aaaaaa dddd    ; -16bit Increment  [aaaaaa]=[aaaaaa]+dddd
11aaaaaa dddd    ; -16bit Decrement  [aaaaaa]=[aaaaaa]-dddd
20aaaaaa 00dd    ; -8bit Increment   [aaaaaa]=[aaaaaa]+dd
21aaaaaa 00dd    ; -8bit Decrement   [aaaaaa]=[aaaaaa]-dd

```

Below for v2.41 and up only

```

D4000000 dddd    ; -Buttons/If      If dddd=JoypadButtons then (exec next code)
D5000000 dddd    ; -Buttons/On      If dddd=JoypadButtons then (turn on all codes)
D6000000 dddd    ; -Buttons/Off     If dddd=JoypadButtons then (turn off all codes)
C0aaaaaa dddd    ; -If/On           If dddd=[aaaaaa] (turn on all codes)

```

Below probably v2.41, too (though other doc claims for v2.2)

```

5000nnbb dddd    ;\Slide Code aka Patch Code aka Serial Repeater
aaaaaaaa ??ee    ;/for i=0 to nn-1, [aaaaaaaa+(i*bb)]=dddd+(i*??ee), next i
00000000 0000    ;-Dummy (do nothing?) needed between slides (CD version only)

```

Below probably v2.41, too (though other doc claims for ALL versions)

```

C1000000 nnnn    ;-Delays activation of codes by nnnn (4000-5000 = 20-30 sec)
C2ssssss nnnn    ;\Copy ssss bytes from 80ssssss to 80tttttt
80tttttt 0000    ;/

```

Below from Caetla .341 release notes

These are probably caetla-specific, not official Datel-codes. In fact, Caetla .341 itself might be an unofficial hacked version of Caetla .34 (?) so below might be totally unofficial stuff:

```

C3aaaaaa 0000    ;\Indirect 8bit Write  [[aaaaaa]+bbbb]=dd
9100bbbb 000000dd ;/
C3aaaaaa 0001    ;\Indirect 16bit Write [[aaaaaa]+bbbb]=dddd (Tomb Raider 2)
9100bbbb 0000dddd ;/
C3aaaaaa 0002    ;\Indirect 32bit Write [[aaaaaa]+bbbb]=dddddddd
9100bbbb dddddddd ;/
FFFFFFFF 0001    ;-Optional prefix for GameShark 2.2 codes(force non-caetla)
12aaaaaa dddddddd ;-32bit Increment [aaaaaa]=[aaaaaa]+dddddddd
22aaaaaa dddddddd ;-32bit Decrement [aaaaaa]=[aaaaaa]-dddddddd

```

Notes

- A maximum of 30 increment/decrement codes can be used at a time.
- A maximum of 60 conditionals can be used at a time (this includes Cx codes).
- Increment/decrement codes should (must?) be used with conditionals.
- Unknown if greater/less conditionals are signed or unsigned.
- Unclear if greater/less compare dddd by [aaaaaa], or vice-versa.
- Unknown if 16bit codes do require memory alignment.

24.5 Cheat Devices - Xplorer Memory and I/O Map

Xplorer Memory Map

```

1F000000h-1F03FFFFh.RW  First 256K of FLASH (fixed mapping)
1F040000h-1F05FFFFh.RW  Map-able: 2x128K FLASH or 4x128K SRAM (if any)
1F060000h-1F060007h.xx  I/O Ports

```

1F060008h-1F06FFFFh	Mirrors of I/O at 1F060000h..1F060007h
1F070000h-1F07FFFFh	Unused (open bus)

FLASH can be 256Kbyte (normal), or 512Kbyte (in FX versions). When programming FLASH chips: Observe that the carts can be fitted with chips from different manufacturers, and, Xplorer carts can have either one or two 256K chips, or one 512K chip.

SRAM can be 0Kbyte (normal/none), or 128Kbyte (in FX versions). The PCB supports max 512K SRAM (but there aren't any carts having that much memory installed).

Xplorer I/O Map

1F005555h.W	FLASH Cmd 1st/3rd byte ;\for first FLASH chip
1F002AAAh.W	FLASH Cmd 2nd byte ;/
1F045555h.W	FLASH Cmd 1st/3rd byte ;\for 2nd FLASH chip (if any)
1F042AAAh.W	FLASH Cmd 2nd byte ;/
1F060000h.R	I/O - Switch Setting (bit0: 0=Off, 1=On)
1F060001h.R	I/O - 8bit Data from PC (bit0-7)
1F060001h.W	I/O - 8bit Latch (Data to PC, and Memory Mapping)
	0 DB25.pin13.SLCT ;\
	1 DB25.pin12.PE ; used for data to PC
	2 DB25.pin11.BUSY ;/
	3 DB25.pin10./ACK ;-used for handshake to PC
	4 Memory Mapping (0=EEPROM, 1=SRAM)
	5 Memory Mapping (EEPROM A17 when A18=1)
	6 Memory Mapping (SRAM A17 or SRAM CE2)
	7 Memory Mapping (SRAM A18 or NC)
1F060002h.R	I/O - Handshake from PC (bit0) (DB25.pin17./SEL)
1F060005h.W	I/O - Unknown (used by Xplorer v4.52, set to 03h)
1F060006h.R	I/O - Unknown (used by Xplorer v4.52, bit0 used)
1F060007h.R	I/O - Unknown (used by Xplorer v4.52, bit0 used)

24.6 Cheat Devices - Xplorer DB25 Parallel Port Function Summary

Xplorer Parallel Port Commands (from PC side)

GetByteByAddr32	Tx(5702h,Addr32), Rx(Data8)
OldMenuBuReadFile	Tx(5703h), TxFilename, RxDataFFEEh
OldMenuBuDeleteFile	Tx(5704h), TxFilename
OldMenuBuWriteFile	Tx(5705h), TxFilename, TxFiledata
OldMenuBuGetFileHdr	Tx(5706h), TxFilename, Rx(00h,00h), RxTurbo, Rx(02h)
OldMenuBuOpenEvents	Tx(5707h)
SetCop0Breakpoint	Tx(5708h,Addr32,Mask32,Ctrl32) ;Menu: Dummy?
OldMenuBuCopyFile	Tx(5709h), TxFilename ;to other memcard

OldMenuBuFormat	Tx(570Ah,Port8)	
OldMenuBuGetStatus2x	Tx(570Bh), Rx(Stat8,Stat8)	;\different in old/new
NewMenuBuGetStatus1x	Tx(570Bh,Port8), Rx(Stat8)	;/
MenuGetSetFlag	Tx(570Ch), Rx(Flag8)	;get old flg, then set flg=01h
NewMenuBuReadSector	Tx(570Dh,Port8,Sector16), Rx(Data[80h])	
NewMenuBuWriteSector	Tx(570Eh,Port8,Sector16,Data[80h])	
NewRawExecute	Tx(570Fh,Addr32)	;call Addr
MidMenuBuggedExecJump	Tx(5710h,ORra32,ORgp32,ORsp32,pc32)	;aka r31,r28,r29,pc
MidMenuSendComment	Tx(5711h,Len8,AsciiMessage[Len])	
NewMenuFillVram	Tx(5712h,Xloc32,Yloc32,Xsiz32,Ysiz32,FillValue32)	
NewGetVram	Tx(5713h,Xloc32,Yloc32), Rx(Data[800h])	;32x32pix
NewGetSetIrqMask	Tx(5714h), Rx(OldMask16), Tx(NewMask16)	;Menu: Dummy
NewSetVram	Tx(5715h,Xloc8,Yloc8,Data[800h])	;X/Y=div32 ;32x32pix
NewMenuGetFlgAndOrVal	Tx(5716h), Rx(00h, or 01h,Val32)	;\
NewMenuGetTwoValues	Tx(5717h), Rx(Val32,Val32)	;
NewMenu...	Tx(5718h), ...	;
NewMenuGet2kGarbage	Tx(5719h,Dummy32), Rx(Garbage[800h])	; whatever
NewMenuGetSomeValue	Tx(571Ah), Rx(Val32)	;
NewMenu...	Tx(571Bh,Data[4])	;similar to 5763h ;
NewMenuNoLongerSupp.	Tx(571Ch)	;probably WAS supported someday ;/
GameAddCheatCode	Tx(5741h,Addr32,Data16), Rx(Index8)	
MenuReBootKernel	Tx(5742h)	;jumps to BFC00000h
GameDelCheatCode	Tx(5744h,Index8)	
GetMem	Tx(5747h,Addr32,Len32), Rx(Data[Len]), TxRxChksum	
Lock/Freeze	Tx(574Ch)	
OldMenuBuGetDirectory	Tx(574Dh), RxTurbo	
MenuTestDB25Handshake	Tx(574Eh), ...	
MenuOptimalGetMem	Tx(574Fh,Addr32,Len32), RxFaster(Data[Len]), TxRxChksum	
OldMenuGetWhatever	Tx(5750h), RxDataFFEEh	;~whatever
Release/Unfreeze	Tx(5752h)	
SetMem	Tx(5753h,Addr32,Len32,Data[Len]), TxRxChksum	
TurboGetMem	Tx(5754h,Addr32,Len32), RxFast(Data[Len]), TxRxChksum	
MenuSetMemAndBurnFirm	Tx(5755h,Addr32,Len32,Data[Len]), TxRxChksum	;burnFlash
GetStateGameOrMenu	Tx(5757h), Rx(47h=Game, or 58h=Menu)	
SetMemAndExecute	Tx(5758h,Addr32,Len32,Data[Len]), TxRxChksum	;call Addr
NewMenu...	Tx(5763h,Val32)	;similar to 571Bh ;~whatever
GetByteByAddr24	Tx(5767h,Addr24), Rx(Data8)	
NewMenuBuggedExecJump	Tx(577Ah,ORra32,ORgp32,ORsp32,pc32)	;formerly 5710h
NewMenuFlashAndReboot	Tx(57C7h,Dest32,Len32,DataXorD3h[Len])	

Function names starting with "Game/Menu" and/or "New/Mid/Old" are working only in Game/Menu mode, or only in New/Old xplorer firmware versions (new commands exist in v4.52, old commands exist in v1.091, mid commands exist in v2.005, but neither in v1.091 nor v4.52, unknown when those new/mid/old commands have been added/removed exactly, in which specific versions).

The only useful command is SetMemAndExecute, which works in ALL versions, and which can be used to do whatever one wants to do (unfortunately, most of the official & inofficial tools are relying on other weird commands, which are working only with specific xplorer firmware versions).

24.7 Cheat Devices - Xplorer DB25 Parallel Port Command Handler

The command handler is called once and then during booting, during xplorer GUI, and during Game execution.

Each call to the command handler does allow to execute ONLY ONE command, however, the "Freeze" command can be used to force the xplorer to stay in the command handler, so one can send MORE commands, until leaving the command handler by sending the "Unfreeze" command.

The command handling can vary depending on current boot phase (see below cautions on Pre-Boot, Mid-Boot, and In-Game phases).

Pre-Boot Handler

This is called shortly after the kernel has done some basic initialization, and after the xplorer has relocated its EEPROM content to RAM (which means it may be called about a second after reset when using official PSX kernel and Xplorer Firmware).

```

OLD Explorer Firmware: Call command handler ONCE (in MENU mode)
NEW Explorer Firmware: Call command handler TWICE (in MENU mode)
if SWITCH=ON or [80000030h]="WHB." then
    NEW Explorer Firmware: Call command handler ONCE AGAIN (in MENU mode)
    Install Mid-Boot hook
endif
  
```

Observe that the Kernel function vectors at A0h, B0h, and C0h aren't installed at this point. If you want to upload an EXE with Kernel vectors installed: send THREE dummy commands (eg. Unfreeze) to skip the above early command handling. On the other hand, the ReBootKernel command can be used if you WANT to upload something during Pre-Boot (the ReBootKernel command works only in MENU mode though, ie. during Xplorer GUI, but not during Game).

Mid-Boot Handler (Xplorer GUI)

The Xplorer GUI is called only if the Pre-Boot handler has installed it (eg. if the SWITCH was ON). The handler is called alongsides with joypad reading (which does NOT take place during the Xplorer intro, so there will be a long dead spot between Pre-Boot and Mid-Boot command handling).

```

Call command handler ONCE (in MENU mode) alongsides with each joypad read
  
```

Observe that the GUI may have smashed various parts of the Kernel initialization, so you can upload EXE files, and can use Kernel functions, but the EXE won't get booted in same state as when booting from CDROM. The boot state can also vary dramatically depending on the Xplorer Firmware version.

Post-Boot Handler (at start of CDROM booting)

This is called when starting CDROM booting.

```
Install GAME mode hook for the B(17h) ReturnFromException() handler
OLD Explorer Firmware: Call command handler ONCE (still in MENU mode)
NEW Explorer Firmware: Call command handler ONCE (already in GAME mode)
```

In-Game Handler (after CDROM booting) (...probably also DURING booting?)

This is called via the hooked B(17h) ReturnFromException() handler.

```
if SWITCH=ON
    Call command handler ONCE (in GAME mode) upon each B(17h)
    And, process game cheat codes (if any) upon each B(17h)
endif
```

Observe that GAME mode doesn't support all commands. And, above will work only if the game does use B(17h), eg. when using non-kernel exception handling, or if it has crashed, or disabled exceptions. Some internal kernel functions are using ReturnFromException() directly (without going through the indirect B(17h) function table entry; so the hook cannot trap such direct returns).

24.8 Cheat Devices - Xplorer DB25 Parallel Port Low Level Transfer Protocol

All 16bit/24bit/32bit parameters are transferred MSB first.

Tx(Data) - transmit data byte(s)

Output 8bit data to DATA0-7	(DB25.pin2-9)	;-Send Data (D0-D7)
Output /SEL=HIGH	(DB25.pin17)	;\Handshake High
Wait until /ACK=HIGH	(DB25.pin10)	;/
Output /SEL=LOW	(DB25.pin17)	;\Handshake Low
Wait until /ACK=LOW	(DB25.pin10)	;/

Rx(Data) - receive data byte(s)

```

Wait until /ACK=HIGH      (DB25.pin10)      ;\
Get 3bit from SLCT,PE,BUSY (DB25.pin13,12,11) ; 1st Part (D6,D7,HIGH)
Output /SEL=HIGH          (DB25.pin17)      ;/
Wait until /ACK=LOW       (DB25.pin10)      ;\
Get 3bit from SLCT,PE,BUSY (DB25.pin13,12,11) ; 2nd Part (D3,D4,D5)
Output /SEL=LOW           (DB25.pin17)      ;/
Wait until /ACK=HIGH      (DB25.pin10)      ;\
Get 3bit from SLCT,PE,BUSY (DB25.pin13,12,11) ; 3rd Part (D0,D1,D2)
Output /SEL=HIGH          (DB25.pin17)      ;/
Wait until /ACK=LOW       (DB25.pin10)      ;\4th Part (ver,LOW,LOW)
Get 3bit from SLCT,PE,BUSY (DB25.pin13,12,11) ; (ver=LOW for v1.091)
Output /SEL=LOW           (DB25.pin17)      ;/ (ver=HIGH for v4.52)
Wait until all 4bits LOW   (DB25.pin13,12,11,10);-xlink95 fails if not

```

RxFast(Data) for TurboGetMem - slightly faster than normal Rx(Data)

First, for invoking the Turbo transfer:

```

Wait for BUSY=LOW      (DB25.pin11)
Output DATA = 00h     (DB25.pin2-9)
Wait for BUSY=HIGH     (DB25.pin11)
Output DATA = ECh     (DB25.pin2-9)

```

Thereafter, receive the actual Data byte(s) as so:

```

Wait for /ACK transition (DB25.pin10)      ;\
Get 3bit from SLCT,PE,BUSY (DB25.pin13,12,11) ; 1st Part (D6,D7,LOW)
Output DATA = 02h        (DB25.pin2-9)      ;/
Wait for /ACK transition (DB25.pin10)      ;\
Get 3bit from SLCT,PE,BUSY (DB25.pin13,12,11) ; 2nd Part (D3,D4,D5)
Output DATA = 04h        (DB25.pin2-9)      ;/
Wait for /ACK transition (DB25.pin10)      ;\
Get 3bit from SLCT,PE,BUSY (DB25.pin13,12,11) ; 3rd Part (D0,D1,D2)
Output DATA = 01h        (DB25.pin2-9)      ;/

```

The /ACK transitions can be sensed by polling the parallel port IRQ flag on PC side.

RxFaster(Data) for OptimalGetMem - much faster than normal Rx(Data)

First, for invoking the Turbo transfer:

```

Output DATA = 00h ;<-- crap (DB25.pin2-9) ; -BUGGY, but REQUIRED

```

Thereafter, receive the actual Data byte(s) as so:


```

Get 4bit from SLCT,PE,BUSY,/ACK (DB25.pin13,12,11,10);\1st Part (D4,D5,D6,D7)
Output DATA = 00h (DB25.pin2-9) ;/
Get 4bit from SLCT,PE,BUSY,/ACK (DB25.pin13,12,11,10);\2nd Part (D0,D1,D2,D3)
Output DATA = 01h (DB25.pin2-9) ;/

```

BUG: The first received byte will be garbage with upper and lower 4bit both containing the lower 4bits (the bugged firmware does explicitly want DATA=00h before transfer, although DATA=00h is also 'confirming' that the upper 4bit can be 'safely' replaced by lower 4bit).

TxRxChksum for SetMem/GetMem functions

```
Tx(chkMsb), Rx(chkMsb), Tx(chkLsb), Rx(chkLsb), Rx("OK" or "CF" or "BG")
```

The 16bit checksum is all bytes in Data[Len] added together. The two final response bytes should be "OK"=Okay, or, if the transmitted chksum didn't match, either "CF"=ChecksumFail (for SetMem functions) or "BG"=BadGetChecksum (for GetMem functions). MenuSetMemAndBurnFirm is a special case with three response codes: "OF"=FlashOkay, "CF"=ChecksumFail, "FF"=FlashWriteFail.

TxFilename for Memcard (bu) functions

```
Rx(Addr32), Tx(Addr32,Len32,Data[Len]), TxRxChksum
```

This is internally using the standard "SetMem" function; preceeded by Rx(Addr32). Whereas Addr is the target address for the filename (just pass the Rx'ed address to the Tx part), Len should be max 38h, Data should be the filename with ending zero (eg. "bu10:name",00h).

TxFiledata for Memcard (bu) WriteFile

```

Rx(Filename[26h])           ; -name from TxFilename, echo'ed back
Rx(Addr32)                  ; -buffer address for fragments
Tx(NumFragments8)           ; -number of fragments
Tx(Addr32,Len32,Data[Len]), TxRxChksum ; <-- repeat this for each fragment
Rx(FileHandle8)             ; -ending dummy byte (filehandle)

```

This is also using the standard "SetMem" function, plus some obscure extra's. The filedata is split into fragments, Len should be max 2000h per fragment.

RxDataFFEEh for Memcard (bu) ReadFile and GetWhatever

```
Rx(FFEH, "W", Len32, Data[Len]) ;<-- can be repeated for several fragments
Rx(FFEH, "CA") ;<-- End Code (after last fragment)
```

Memcard ReadFile does transfer N fragments of Len=2000h (depending on filesize). The GetWhatever function transfers one fragment with Len=80h, followed by N*6 fragments with Len=40Ah.

RxTurbo for Memcard (bu) GetDirectory/GetFileHeader functions

```
Rx(Addr32), Tx(Addr32, Len32), RxFast(Data[Len]), TxRxChksum
```

This is internally using the standard "TurboGetMem" function; preceded by Rx(Addr32). Whereas Addr is the source address of the actual data (just pass the Rx'ed address to the Tx part).

For GetDirectory, Len should be max 800h (actual/data data is only 4B0h bytes, ie. 258h bytes per memcard, aka 28h bytes per directory entry). For GetFileHeader, Len should be max 80h.

24.9 Cheat Devices - Xplorer Versions

Xplorer names

```
Xploder (Germany/USA)
Xplorer (England/Spain/Netherlands)
X-Terminator (Japan)
```

Xplorer suffices

```
V1/V2/V3  normal boards   (256K EEPROM, no SRAM, no DB25 resistor)
FX/DX     extended boards (512K EEPROM, 128K SRAM, with DB25 resistor)
PRO       meaningless suffix
```

The V1/V2/V3 suffix does just indicate the pre-installed firmware version (so that suffices become meaningless after software upgrades).

The FX suffix (or DX in japan) indicates that the PCB contains more memory and an extra resistor (the memory/resistor are intended for use with the "X-Assist" add-on device).

Xplorer PCB types

- 1) PXT6 ;original board
- 2) Nameless ;with alternate solder pads for smaller SRAM/GAL
- 3) PXT6-3 ;with alternate solder pads for smaller SRAM/GAL and 2nd EEPROM

Xplorer Compatibility Issues

The three PCB versions are functionally identical, and do differ only by cosmetic changes for alternate/smaller chip packages.

However, some things that can make difference in functionality are the installed components and installed firmware version:

- FX carts have some extra components & more memory installed.
(needed for "bigger" firmwares, mainly needed for the X-Assist add-on)
- FLASH chips from different manufacturers can occasionally cause problems
(eg. older software not knowing how to program newer FLASH chips).
- DB25 transfer protocol has some changed commands in each firmware version
(and most transfer tools tend to rely on such commands, so most tools will fail unless the cart is flashed with a certain firmware version).

X-Assist add-on for Xplorer carts

The X-Assist is a quity huge clumsy controller with DPAD, plus 4 buttons, plus small LCD screen. The thing connects to the Xplorer's DB25 connector, allowing to enter/search cheat codes without using a PC.

The device works only with "FX" Xplorer boards (which contain an extra resistor for outputting supply power on the DB25 connector, plus more memory which is somewhat intended for use by the X-Assist thing).

24.10 Cheat Devices - Xplorer Chipset Pinouts

Xplorer Pinout GAL20V8 (generic array logic)

```

1  IN0  (DB25.pin17./SEL)
2  IN1  (PSX.pin14.A0)
3  IN2  (PSX.pin48.A1)
4  IN3  (PSX.pin15.A2)
5  IN4  (74373.pin15.Q5)
6  IN5  (PSX.pin4./EXP)
7  IN6  (74373.pin12.Q4)
8  IN7  (PSX.pin26.A16) (EEPROM.pin2.A16) (SRAM.pin2.A16) (10000h)
9  IN8  (PSX.pin60.A17)                                     (20000h)
10 IN9  (PSX.pin27.A18) (EEPROM.pin1.A18 or NC)              (40000h)
11 IN10 (PSX.pin30./RD)
```

```

12 GND
---
13 IN11 (GND)
14 IN12 (/SWITCH_ON)
15 IO   (74373.pin11.LE)
16 IO   (PSX.pin6.D0)
17 IO   (SRAM./CE.pin22)
18 IO   (EEPROM2./CE.pin22) (for 2nd EEPROM chip, if any)
19 IO   (EEPROM1./CE.pin22) (for 1st EEPROM chip)
20 IO   (NC)                (reportedly has wire?)
21 IO   (EEPROM.pin30.A17)   (reportedly A14 ?)
22 IO   (74245.pin19./E)
23 IN13 (PSX.pin64./WR) (SRAM.29, EEPROM.31)
24 VCC

```

The GALs are programmed nearly identical for all Xplorer versions, some small differences are: One or two EEPROM chip selects (depending on EEPROM chipset), and extra ports at 1F060005h, 1F060006h, 1F060007h (used in v4.52).

Note: The 28pin PLCC GAL has same pinout as the 24pin chip, but with four NC pins inserted (at pin 1,8,15,22, whereof, there is a wire routed "through" pin 8, so that pin isn't literally NC).

Xplorer Pinout 74373 (8bit tristate latch)

```

1  /OE (GND)
2  Q0  (DB25.pin13.SLCT)
3  D0  (PSX)
4  D1  (PSX)
5  Q1  (DB25.pin12.PE)
6  Q2  (DB25.pin11.BUSY)
7  D2  (PSX)
8  D3  (PSX)
9  Q3  (DB25.pin10./ACK)
10 GND
11 LE  (GAL.pin15.LatchEnable)
12 Q4  (GAL.pin7)                (0=EEPROM, 1=SRAM)
13 D4  (PSX)
14 D5  (PSX)
15 Q5  (GAL.pin5)                (EEPROM bank 2/3)
16 Q6  (SRAM.pin30.A17 or CE2)
17 D6  (PSX)
18 D7  (PSX)
19 Q7  (SRAM.pin1.A18 or NC)
20 VCC

```

Xplorer Pinout 74245 (8bit bus transceiver)

```

1  DIR (GNDed)
2  D7  (PSX)

```

```

3  D6  (PSX)
4  D5  (PSX)
5  D4  (PSX)
6  D3  (PSX)
7  D2  (PSX)
8  D1  (PSX)
9  D0  (PSX)
10 GND
11 D0  (DB25.pin2)
12 D1  (DB25.pin3)
13 D2  (DB25.pin4)
14 D3  (DB25.pin5)
15 D4  (DB25.pin6)
16 D5  (DB25.pin7)
17 D6  (DB25.pin8)
18 D7  (DB25.pin9)
19 /E  (GAL.pin22)
20 VCC

```

Xplorer Pinout 7805 (voltage regulator)

```

1  5V   (VCC)
2  GND  (GND)
3  7.5V (PSX.pin18,52)

```

Xplorer Pinout SWITCH (on/off)

```

OFF  NC
COM  PAL.pin14 (with 10K pull-up to VCC)
ON   GND

```

Xplorer Pinout DB25 (parallel/printer port)

```

1  In  /STB  (NC)
2  In  DATA0 (74245.pin11)
3  In  DATA1 (74245.pin12)
4  In  DATA2 (74245.pin13)
5  In  DATA3 (74245.pin14)
6  In  DATA4 (74245.pin15)
7  In  DATA5 (74245.pin16)
8  In  DATA6 (74245.pin17)
9  In  DATA7 (74245.pin18)
10 Out /ACK  (74373.Q3)
11 Out BUSY  (74373.Q2)
12 Out PE    (74373.Q1)
13 Out SLCT  (74373.Q0)
---
14 In  /LF    (NC)
15 Out /ERR   (VCC via 0.47ohm) (installed only on carts with SRAM)

```

```

16 In  /INIT  (NC)
17 In  /SEL   (GAL.IN0.pin1)
18..25 GND    (Ground)

```

EEPROM.pin1 is NC on 256Kx8 chip (however it is wired to A18 for use with 512Kx8 chips).

EEPROM.pin30 is A17 from GAL.pin21 (not from PSX.A17), accordingly GAL.pin21 is EEPROM.A17 (not A14).

Boards with solder pads for TWO EEPROMs are leaving A18 not connected on the 2nd EEPROM (but do connect A18 to the first EEPROM, so one could either use one 512K chip or two 256K chips).

DB25.pin15./ERR is VCC via 0.47ohm (installed only on carts with SRAM, intended as supply for the X-ASSIST thing).

SRAM (if any) is wired to GAL.pin17 (/CE), 74373.Q6 (A17 or CE2), 74373.Q7 (A18 or NC), other SRAM pins are wired straight to D0-D7, A0-A16, /RD, /WR.

VCC is 5V, derived from a 7805 voltage converter (with 7.5V used as input).

Existing boards seem to have 128K SRAM (if any), so SRAM A17/A18 aren't actually used (unless a board would have 512K SRAM), however, for 128K SRAMs one should switch SRAM CE2 (aka A17) high.

24.11 Cheat Devices - Xplorer Cheat Code Format

PSX Xplorer/Xploder Code Format

```

3taaaaaa 00dd  ; -8bit write  [aaaaaa]=dd
8taaaaaa dddd  ; -16bit write [aaaaaa]=dddd
00aaaaaa dddd  ; -32bit write [aaaaaa]=0000dddd <-- not "0taaaaaa dddd" ?
4t000000 000x  ; -Slow Motion (delay "x" whatever/ns,us,ms,frames?)
7taaaaaa dddd  ; -IF [aaaaaa]=dddd then <execute following code>
9taaaaaa dddd  ; -IF [aaaaaa]<>dddd then <execute following code>
Ftaaaaaa dddd  ; -IF [aaaaaa]=dddd then activate "other selected" codes (uh?)
5taaaaaa ?nnn  ; \
d0d1d2d3 d4d5  ; write "?nnn" bytes to [aaaaaa] ;ordered d0,d1,d2... ?
d6d7d8.. ....  ; /
6t000000 nnnn  ; \COP0 hardware breakpoint
aaaaaaa cccc  ; aaaaaaa=break_address, mmmmmmm=break_mask
mmmmmmmm d0d1  ; nnnn=num_bytes (d0,d1,d2,etc.), cccc=break_type (see below)
d2d3d4.. ....  ; /
B?nnbbbb eeee  ; \Slide/Patch Code, with unclear end: "end=?nn+/-1" ?
10aaaaaa dddd  ; /for i=0 to end, [aaaaaa+(i*bbbb)]=dddd+(i*eeee), next i
C0aaaaaa dddd  ; -garbage/mirror of 70aaaaaa dddd ? ;\or maybe meant to be
D0aaaaaa dddd  ; -garbage/mirror of 70aaaaaa dddd ? ;/same as on GameShark?

```

The second code digit (t) contains encryption type (bit0-2), and a "default on/off" flag (bit3: 0=on, 1=off; whatever that means, it does probably require WHATEVER actions to enable codes that are "off"; maybe via the Ftaaaaaa dddd code).

break_type (cccc) (aka MSBs of cop0r7 DCIC register)

```
E180 (instruction gotton by CPU but not yet implemented) (uh, gotton what?)
EE80 (data to be read or written) ;<--looks okay
E680 (data to be read) ;<--looks okay
EA80 (data to be wrtten) ;<--looks okay
EF80 (instruction) ;<-- looks crap, should be probably E180
```

The CPU supports one data breakpoint and one instruction breakpoint (though unknown if the Xplorer does support to use both simultaneously, or if it does allow only one of them to be used).

If the break_type/address/mask to match up with CPU's memory access actions... then "something" does probably happen (maybe executing a sub-function that consists of the d0,d1,d2,etc-bytes, if so, maybe at a fixed/unknown memory address, or maybe at some random address; which would require relocatable code).

Notes

The "Slide" code shall be used only with even addresses, unknown if other 16bit/32bit codes do also require aligned addresses.

24.12 Cheat Devices - Xplorer Cheat Code and ROM-Image Decryption

decrypt_xplorer_cheat_code:

```
key = x[0] and 07h ;''''''' AABCCDD EEFF ''''''';
x[0] = x[0] xor key ; / / / \ \ \ ;
if key=0 ; x[0] --' / / \ \ '--- x[5] ;
;unencrypted (keep as is) ; x[1] ---' / \ '--- x[4] ;
elseif key=4 ; x[2] ----' '----- x[3] ;
x[1] = x[1] xor (025h) ;,,,,,,,,,,,,,,,,,,,,,,,,,,,,,;
x[2] = x[2] xor (0FAh + (x[1] and 11h))
x[3] = x[3] xor (0C0h + (x[2] and 11h) + (x[1] xor 12h))
x[4] = x[4] xor (07Eh + (x[3] and 11h) + (x[2] xor 12h) + x[1])
x[5] = x[5] xor (026h + (x[4] and 11h) + (x[3] xor 12h) + x[2] + x[1])
elseif key=5
x[1] = (x[1] + 057h) ;"W"ayne
x[2] = (x[2] + 042h) ;"B"eckett
```

```

    x[3] = (x[3] + 031h) ; "1"
    x[4] = (x[4] + 032h) ; "2"
    x[5] = (x[5] + 033h) ; "3"
elseif key=6
    x[1] = (x[1] + 0ABh) xor 01h
    x[2] = (x[2] + 0ABh) xor 02h
    x[3] = (x[3] + 0ABh) xor 03h
    x[4] = (x[4] + 0ABh) xor 04h
    x[5] = (x[5] + 0ABh) xor 05h
elseif key=7
    x[5] = x[5] + 0CBh
    x[4] = x[4] + 0CBh + (x[5] and 73h)
    x[3] = x[3] + 05Ah + (x[4] and 73h) - (x[5] xor 90h)
    x[2] = x[2] + 016h + (x[3] and 73h) - (x[4] xor 90h) + x[5]
    x[1] = x[1] + 0F5h + (x[2] and 73h) - (x[3] xor 90h) + x[4] + x[5]
else
    error ; (key=1,2,3)
endif

```

decrypt_xplorer_fcd_rom_image:

```

for i=0 to romsize-1
    x=45h
    y=(i and 37h) xor 2Ch
    if (i and 001h)=001h then x=x xor 01h
    if (i and 002h)=002h then x=x xor 01h
    if (i and 004h)=004h then x=x xor 06h
    if (i and 008h)=008h then x=x xor 04h
    if (i and 010h)=010h then x=x xor 18h
    if (i and 020h)=020h then x=x xor 30h
    if (i and 040h)=040h then x=x xor 60h
    if (i and 080h)=080h then x=x xor 40h
    if (i and 100h)=100h then x=x xor 80h
    if (i and 006h)=006h then x=x xor 0ch
    if (i and 00Eh)=00Eh then x=x xor 08h
    if (i and 01Fh)>=016h then x=x-10h
    rom[i]=(rom[i] XOR x)+y
next i

```

24.13 Cheat Devices - FLASH/EEPROMs

FLASH/EEPROM Commands

Below commands should work on all chips (for write: page size may vary, eg. 1 byte, 128 bytes, or 256 bytes). Some chips do have some extra commands (eg. an alternate older get id command, or sector erase commands, or config commands), but those extras aren't needed for basic erase/write operations.


```
[5555h]=AAh, [2AAAh]=55h, [5555h]=A0h, [addr..]=byte(s) ;write page
[5555h]=AAh, [2AAAh]=55h, [5555h]=90h, id=[0000h..0001h] ;enter id mode
[5555h]=AAh, [2AAAh]=55h, [5555h]=F0h ;exit id mode
[5555h]=AAh, [2AAAh]=55h, [5555h]=80h ;erase chip, step 1
[5555h]=AAh, [2AAAh]=55h, [5555h]=10h ;erase chip, step 2
```

Above addresses are meant to be relative to the chip's base address (ie. "5555h" would be 1F005555h in PSX expansion ROM area, or, if there are two flash chips, then it would be 1F045555h for the 2nd chip in xplorer and datel carts; whereas, that region is using bank switching in xplorer carts, so one must output some FLASH address bits I/O ports, and the others via normal CPU address bus; whilst datel carts have noncontinuous FLASH areas at 1F000000h and 1F040000h, with a gap at 1F020000h).

Observe that the chips will output status info (instead of FLASH data) during write/erase/id mode (so program code using those commands must execute in RAM, not in FLASH memory).

FLASH/EEPROM Wait Busy

Waiting is required after chip erase and page write (after writing the last byte at page end), and on some chips it's also required after enter/exit id mode. Some chips indicate busy state via a toggle bit (bit6 getting inverted on each 2nd read), and/or by outputting a value different than the written data, and/or do require hardcoded delays (eg. AM29F040). Using the following 3-step wait mechanism should work with all chips:

```
Wait 10us (around 340 cpu cycles on PSX) ;-step 1, hardcoded delay
Wait until [addr]=[addr] ;-step 2, check toggle bit
Wait until [addr]=data ;-step 3, check data
```

Whereas, "addr" should be the last written address (or 0000h for erase and enter/exit id mode). And "data" should be the last written data (or FFh for erase, or "don't care" for enter/exit id mode).

Board and Chip Detection

First of, one should detect the expansion board type, this can be done as so:

```
Enter Chip ID mode (at 1F000000h)
Compare 400h bytes at 1F000000h vs 1F020000h
If different --> assume Datel PAR1/PAR2 hardware
If same --> assume Xplorer hardware (or Datel PAR3, whatever that is)
Exit Chip ID mode (at 1F000000h)
```

Next, detect the Chip ID for the (first) FLASH chip:

```
Enter Chip ID mode (at 1F000000h)
Read the two ID bytes (at 1F00000xh)
Exit Chip ID mode (at 1F000000h)
```

Finally, one needs to check if there's a second FLASH chip, there are two such cases:

```
If cart=xplorer AND 1st_chip=256K --> might have a 2nd 256K chip
If cart=datel AND 1st_chip=128K --> might have a 2nd 128K chip
```

In both cases, the 2nd chip would be mapped at 1F400000h, and one can test the following four combinations:

```
Enter Chip ID (at 1F000000h) and Enter Chip ID (at 1F400000h) ;id1+id2
Exit Chip ID (at 1F000000h) and Enter Chip ID (at 1F400000h) ;id2
Exit Chip ID (at 1F400000h) and Enter Chip ID (at 1F000000h) ;id1
Exit Chip ID (at 1F400000h) and Exit Chip ID (at 1F000000h) ;none
```

For each combination compare 400h bytes at 1F000000h vs 1F400000h.

```
If they are all same --> there is only one chip (mirrored to both areas)
If different --> 1F400000h is either garbage, or a 2nd chip
```

In the latter case, do Chip ID detection at 1F400000h to see if there's really another chip there, and which type it is (if present, then it should be usually the same type as the 1st chip; and if it's not present, then there might be just open bus garbage instead of valid ID values).

FLASH/EEPROM Chip IDs

ChipID	Kbyte	Page	Maker/Name	;notes
1Fh,D5h	128K	128	ATMEL AT29C010A	;xplorer/prototypes?
1Fh,35h	128K	128	ATMEL AT29LV010A	;-
1Fh,DAh	256K	256	ATMEL AT29C020	;xplorer
1Fh,BAh	256K	256	ATMEL AT29BV020	;xplorer
1Fh,A4h	512K	256	ATMEL AT29C040A	;xplorer
1Fh,C4h	512K	256	ATMEL AT29xV040A	;-
BFh,07h	128K	128	SST SST29EE010	;-
BFh,08h	128K	128	SST SST29xE010	;-
BFh,22h	128K	128	SST SST29EE010A	;-
BFh,23h	128K	128	SST SST29xE010A	;-
BFh,10h	256K	128	SST SST29EE020	;xplorer
BFh,12h	256K	128	SST SST29xE020	;xplorer
BFh,24h	256K	128	SST SST29EE020A	;-
BFh,25h	256K	128	SST SST2xE020A	;-
BFh,04h	512K	256	SST SST28SF040	;said to be used in "AR/GS Pro"

```

DAh,C1h 128K 128 WINBOND W29EE01x ; -
DAh,45h 256K 128 WINBOND W29C020 ; -
DAh,46h 512K 256 WINBOND W29C040 ; xplorer
01h,A4h 512K 1 AMD AM29F040 ; nocash psone bios (intact console)
20h,20h 128K 1 ST M29F010B ; nocash psone bios (broken console)
31h,B4h 128K ?? CATALYST CAT28F010 ; NEEDS VPP=12V !!! ("PS-121 ZISAN")

```

The above Atmel/SST/Winbond chips are commonly used in Datel or Xplorer carts (or both). The CATALYST chip is used in some Datel clones (but seems to require 12 volts, meaning that it can't be properly programmed on PSX, nethertheless, it's reportedly working "well enough" to encounter flash corruption upon programming attempts). The two ST/AMD chips aren't really common in PSX world (except that I've personally used them in my PSones).

25. PSX Dev-Board Chipsets

Sony DTL-H2000 CPU Board

```

CL825  20pin pin test points (2x10 pins)
CL827  20pin pin test points (2x10 pins)
U83    64pin SEC KM4216V256G-60 (DRAM 256Kx16) ;dual-ported VRAM
U84    64pin SEC KM4216V256G-60 (DRAM 256Kx16) ;dual-ported VRAM
CL828  20pin pin test points (2x10 pins)
CL826  20pin pin test points (2x10 pins)
X10    4pin JC53.20      (PAL, 53.203425MHz)
X2     4pin 53.69317MHz (NTSC, 53.693175MHz)
U62    20pin LVT244 (dual 4-bit 3-state noninverting buffer/line driver)
U27    64pin Sony CXD2923AR      ;GPU'b
CL813  20pin pin test points (2x10 pins)
CL814  20pin pin test points (2x10 pins) (with one resistor or so installed)
U16    160pin Sony CXD8514Q      ;GPU'a
X7     4pin 67.73760 MHz
CL807  20pin pin test points (2x10 pins)
CL809  20pin pin test points (2x10 pins)
CL811  20pin pin test points (2x10 pins)
U801   208pin Sony CXD8530BQ     ;CPU
U11    28pin SEC KM48V2104AJ-6 (DRAM 2Mx8) ;Main RAM
U10    28pin SEC KM48V2104AJ-6 (DRAM 2Mx8) ;Main RAM
U9     28pin SEC KM48V2104AJ-6 (DRAM 2Mx8) ;Main RAM
U8     28pin SEC KM48V2104AJ-6 (DRAM 2Mx8) ;Main RAM
CN801  100pin Blue connector (to other ISA board)
U66    48pin LVT16244? (quad 4-bit 3-state noninverting buffer/line driver)
U65    48pin LVT16244? (quad 4-bit 3-state noninverting buffer/line driver)
U64    48pin LVT16245? (dual 8-bit 3-state noninverting bus transceiver)
U34    100pin Sony CXD2922Q      ;SPU
U63    14pin 74F74N (dual flipflop)
U32    44pin SEC KM416V256B1-8 (DRAM 256Kx16) ;SoundRAM
CL801  20pin pin test points (2x10 pins)
CL802  20pin pin test points (2x10 pins)
Q881   3pin voltage stuff?
U31    20pin 74ACT244P (dual 4-bit 3-state noninverting buffer/line driver)
U35    18pin Sony CXD2554P or OKI M6538-01 (aka MSM6538-01?) (audio related?)
U36    20pin Sanyo LC78815 ;16bit D/A Converter
U37    8pin NEC ...? C4558C? D426N0B or 9426HOB or so?
J806   8pin solder pads...
J805   9pin solder pads...
J804   10pin solder pads... (11pins, with only 10 contacts?)
-      48pin solder pads (12x4pin config jumpers or so)
U26    20pin SN74ALSxxx logic?
U71    24pin Sony CXA1xxxx? ;RGB?
JPxx   9pin PAL/NTSC Jumpers (three 3pin jumpers)
J801   24pin solder pads...
J803   9pin rear connector: Serial Port (3.3V) (aka "J308") (DB9) (5+4pin)

```

```
J802    15pin rear connector: AV Multi-out    (5+5+5pin)
CN881   98pin ISA Bus Cart-edge (2x31 basic pins, plus 2x18 extended pins)
```

Sony DTL-H2000 PIO Board

```
JP72x 68pin Black connector (maybe equivalent to 68pin PSX expansion port?)
SWI    5pin solder pads...
U371   40pin HN27C4000G-12 (512Kx8 / 256Kx16 EPROM) (sticker: "94/7/27")
U370   84pin Altera EPM7160ELC84-12 (sticker: "U730, cntl 1")
U3     14pin SN74ALS1004N (hex inverters)
U43    44pin Altera EPM7032LC44-10 (sticker: "U43, add 1")
U716   28pin Sharp LH5498D-35 (FIFO 2Kx9)
U717   28pin Sharp LH5498D-35 (FIFO 2Kx9)
U719   28pin Sharp LH5498D-35 (FIFO 2Kx9)
U720   28pin Sharp LH5498D-35 (FIFO 2Kx9)
U724   20pin SN74ALS688N (8bit inverting identity comparator with enable)
U722   20pin SN74ALS245AN (8bit tristate noninverting bus transceiver)
U47    20pin 74FCT244ATP (dual 4-bit 3-state noninverting buffer/line driver)
U732   48pin LVT16245? (dual 8-bit 3-state noninverting bus transceiver)
U711   20pin SN74ALS244BN (dual 4-bit 3-state noninverting buffer/line driver)
U712   20pin SN74ALS244BN (dual 4-bit 3-state noninverting buffer/line driver)
U713   20pin 74HC244AP (dual 4-bit 3-state noninverting buffer/line driver)
U714   20pin 74HC244AP (dual 4-bit 3-state noninverting buffer/line driver)
U721   20pin SN74ALS244BN (dual 4-bit 3-state noninverting buffer/line driver)
U55    14pin SN74ALS08N (quad 2-input AND gates)
U726   20pin SN74ALS245AN (8bit tristate noninverting bus transceiver)
U715   20pin 74HC244AP (dual 4-bit 3-state noninverting buffer/line driver)
JPxx 100pin Blue connector (to other ISA board)
U738   20pin LVT244 (SMD) (dual 4-bit 3-state noninverting buffer/line driver)
U734   32pin KM684000G-7 (SRAM 512Kx8) ;\maybe 1Mbyte EXP3 RAM ?
U733   32pin KM684000G-7 (SRAM 512Kx8) ;/
U725   20pin SN74ALS688N (8bit inverting identity comparator with enable)
S700   24pin 12bit DIP switch (select I/O Address bits A15..A4)
JP700   8pin Jumper (4x2 pins) (select IRQ15/IRQ12/IRQ11/IRQ10)
JP7xx 12pin Jumper (3x4 pins) (select DMA7/DMA6/DMA5)
U64    48pin LVT16245? (dual 8-bit 3-state noninverting bus transceiver)
U65    48pin LVT16244? (quad 4-bit 3-state noninverting buffer/line driver)
U66    48pin LVT16244? (quad 4-bit 3-state noninverting buffer/line driver)
U737   48pin LVT16244? (quad 4-bit 3-state noninverting buffer/line driver)
U710   20pin SN74ALS244BN (dual 4-bit 3-state noninverting buffer/line driver)
U709   20pin HD74HC245P (8bit tristate noninverting bus transceiver)
U723   14pin SN74ALS38AN (quad open-collector NAND gates with buffered output)
U2     14pin SN74LS19AN (hex inverters with schmitt-trigger)
U1     8pin Dallas DS1232 (MicroMonitor Chip) ;power-good-detect ?
U708   20pin HD74HC245P (8bit tristate noninverting bus transceiver)
X3     2pin 4.1900 (4.19MHz for SPC700 CPU)
U42    80pin P823, U01Q (Sony CXP82300 SPC700 CPU with piggyback EPROM socket)
U42'   32pin 27C256A-15 (EPROM 32Kx8) (sticker: "94/11/28")
U706   10pin some slim chip with 1x10 pins
BT700  2pin battery (or super-cap?) for DS1302S (?) (not installed)
U729?  5pin voltage stuff?
U40    8pin Dallas DS1302S (real time clock)
X4     2pin small crystal (32.768kHz for DS1302S)
```

```

JP702 34pin Black connector (maybe for internal CDROM Emulator ISA cart?)
U736  28pin Sony CXK58257ASP-70L (SRAM 32Kx8)           ;CDROM Sector Buffer?
U735 100pin Sony CXD1199BQ      ;CDROM Decoder/FIFO
JP715 40pin Blue connector... to external DTL-H2010 CDROM drive?
JP721  9pin rear connector: Joypad/Memcard 2 (DB9)
JP719  9pin rear connector: Joypad/Memcard 1 (DB9)
?      -      rear hole for cdrom-cable to Blue 40pin connector?
J70x  98pin ISA Bus Cart-edge (2x31 basic pins, plus 2x18 extended pins)

```

JP715 must be either connected to an external CDROM drive, or to some of "terminator" plug (which shortcuts Pin23 and Pin26 with each other; software may hang upon certain I/O operations without that terminator).

Sony DTL-H2500 Dev board (PCI bus)

Newer revision of the DTL-H2000 board. Consists of a single PCI card (plus tiny daughterboard with Controller ports).

```

Mainboard      "PI-27 1-589-867-11, DTL-H2500, MAIN BOARD 1575E01A0, SONY"
Daughterboard  "SONY,CN-102 1-589-865-11,CONNECTOR BOARD,DTL-H2500,1575E02A0"
CJ1           9pin rear connector: DB9
CJ2?          15pin rear connector: AV Multi-out      (5+5+5pin)
CJ3           10pin gray connector (to controller daughterboard with two DB9's)
CJ4           34pin black connector (maybe for internal CDROM Emulator ISA cart?)
CJ5           50pin black connector (to DTL-H2510, Gray Internal CDROM Drive?)
CJ6           68pin black connector (maybe equivalent to 68pin PSX expansion port?)
-            124pin PCI bus cart edge connector
CJ1'          9pin rear connector: DB9 (CTR1, joypad 1)      ;\
CJ2'          9pin rear connector: DB9 (CTR2, joypad 2)      ; on daughterboard
CJ3'          10pin gray ribbon cable (to CJ3 on main board) ;/
IC103 208pin Sony CXD8530CQ (CPU)
IC106 28pin SEC KM48V2104AT-6 (DRAM 2Mx8)
IC107 28pin SEC KM48V2104AT-6 (DRAM 2Mx8)
IC108 28pin SEC KM48V2104AT-6 (DRAM 2Mx8)
IC109 28pin SEC KM48V2104AT-6 (DRAM 2Mx8)
IC201 64pin SEC KM4216V256G-60 (DRAM 256Kx16) ;dual-ported VRAM
IC202 64pin SEC KM4216V256G-60 (DRAM 256Kx16) ;dual-ported VRAM
IC203 160pin Sony CXD8514Q      ;GPU'a
IC207 64pin Sony CXD2923AR      ;GPU'b
IC303 28pin HM62W256LFP-7T (CDROM SRAM 32Kx8)           ;on back side
IC304 52pin "D 2021, SC430920PB, G64C 185, JSAA9618A" (Sub-CPU) ;on back
IC305 100pin Sony CXD1199BQ (CDROM Decoder/FIFO)         ;on back side
IC308 100pin Sony CXD2922BQ (SPU)                         ;on back side
IC310 44pin SEC KM416V256BLT-7 (DRAM 256Kx16) ;SoundRAM ;on back side
IC402 24pin something bigger
IC404 8pin something small
IC405 8pin something small
IC501 24pin Sony CXA1645M (Analog RGB to Composite)       ;on back side
IC701 4pin "RD, 5B" or so                                   ;on back side
IC801 +++pin "ALTERA, FLEX, EPF8820ARC208-3, A9607"
IC802 20pin LVT245A <--                                   ;on back side

```

```

IC803  52pin "IDT71321, LA35J, S9704P" (2Kx8 dual port SRAM)
IC804  20pin LVT244A
IC805   8pin something with socket (sticker: "PD3")
IC807-2 32pin MX 27C1000MC-90 (PROM) ;\on back side
IC808  32pin F 29F040A-90 (FLASH) ;/BIOS on these chip(s) or so?
IC901   4pin 37, 69 ;\on back side
IC902   4pin 37, 69 ;/
ICxxx? 28pin "DALLAS, DS1230Y-100, NONVOLATILE SRAM"
U28     20pin LVT244A
Z1      20pin LVT244A ;\on back side
Z2      20pin LVT245A <-- ;/
Z3      20pin LVT244A
Z4      20pin LVT244A ;\
Z5      20pin LVT245A <-- ; on back side
Z6      20pin LVT244A ;/
Z7      20pin LVT244A
Z8      20pin LVT244A
Z9      20pin LVT244A
X101    4pin RC67.73, JVC 5L (67.7376MHz oscillator for main cpu)
X201    4pin JC53.20, JVC 6A (for GPU, PAL)
X202    4pin JC53.69, JVC 6A (for GPU, NTSC)
X302    3pin 4.000MHz (for sub-cpu)

```

Sony DTL-H2700 Dev board (ISA bus) (CPU, ANALYZER ...?)

Another revision of the DTL-H2000/DTL-H2500 boards. Consists of a single ISA card stacked together with two huge daughterboards, and probably additionally having a small connector daughterboard. Exact chipset is unknown (there might be components on both sides of the PCBs, most of them not visible due to the PCB stacking, so taking photos/scans of the PCBs would require advanced techniques with screwdrivers). Currently the only known chip name is an EPROM (MX 27C1000DC-90, with sticker "Title=DTL-H2700, Ver=1.00, Date=96.12.4, Sum=046B No."). The ISA card is having markings: "SONY HCD MWB-7? MADE IN JAPAN, PA47 1-589-003-01 1642E03A0". One uncommon feature is an extra connector for a "trigger switch" (foot pedal), which is reportedly used for activating performance analyzer logging.

Sony DTL-H201A / DT-HV - Graphic Artist Board (IBM PC/ATs to NTSC video)

```

X2      xpin TXC-2 OSC 66.000MHz
X1      xpin TXC-2AOSC 53.693MHz
U16     14pin 74F74 (dual flipflop)
U29     14pin 74AS04 (hex inverters)
U14     20pin LVT244 (dual 4-bit 3-state noninverting buffer/line driver)
U18     20pin LVT244 (dual 4-bit 3-state noninverting buffer/line driver)
U15     20pin ACT244 (dual 4-bit 3-state noninverting buffer/line driver)
U11     84pin Altera EPM7096LC84-12 (sticker: "artpc13" or "ARTPC13")
U13     160pin Sony CXD8514Q ;GPU'a
U5      14pin ALS38A ? (quad open-collector NAND gates with buffered output)

```

```

U27  20pin ALS244AJ ? (dual 4bit tristate noninverting buffer/line driver)
Q1    3pin T B596
U23  64pin KM4216V256G-60 (DRAM 256Kx16) ;dual-ported VRAM
U22  64pin KM4216V256G-60 (DRAM 256Kx16) ;dual-ported VRAM
U28  64pin Sony CXD2923AR ;GPU'b
S1   16pin 8bit DIP switch (select I/O address A15..A8)
S2    8pin 4bit DIP switch (select I/O address A7..A4)
U1   20pin SN74ALS688N (8bit inverting identity comparator with enable)
U2   20pin SN74ALS688N (8bit inverting identity comparator with enable)
U3   20pin ALS245A (8bit tristate noninverting bus transceiver)
JP9  12pin Jumper (6x2 pins) (select IRQ15/IRQ11/IRQ10/IRQ9/IRQ5/IRQ3)
U26  24pin Sony CXA1145M ? ;RGB?
JP10  3pin Jumper ;\
JP12  3pin Jumper ; select "S" or "O" (?)
JP11  3pin Jumper ;/
J3    2pin? Yellow connector (composite video out?)
J2?   pin? Mini DIN? connector (maybe S-video out?)
J1    15pin High Density SubD (maybe video multi out?)
CJx   98pin ISA Bus Cart-edge (2x31 basic pins, plus 2x18 extended pins)

```

DTL-S2020 aka Psy-Q CD Emu

```

Yellow PCB "CD Emulator System, (C) Cirtech & SN Systems Ltd, 1994 v1.2"
IC    24pin GAL20V8B
IC    68pin Analog Devices ADSP-2101 (16bit DSP Microprocessor)
IC    20pin HD74HC244P
IC15  20pin HD74HC244P
IC14  20pin CD74HCT245E
IC7   28pin 27C512-10 (EPROM 64Kx8) (yellow sticker, without text)
IC    28pin HY62256ALP-70 (SRAM 32Kx8)
IC12  28pin HY62256ALP-70 (SRAM 32Kx8)
IC    28pin HY62256ALP-70 (SRAM 32Kx8)
IC13  84pin Emulex/QLogic FAS216 (Fast Architecture SCSI Processor)
IC5   84pin Emulex/QLogic FAS216 (Fast Architecture SCSI Processor)
IC4   24pin GAL20V8B (near IO Addr jumpers)
IC    20pin 74LS244B1 (near lower 8bit of ISA databus)
IC    20pin SN74LS245N? (near lower 8bit of ISA databus)
IC    20pin SN74LS245N (near upper 8bit of ISA databus)
DMA   12pin Jumpers (select DMA7/6/5)
IRQ   12pin Jumpers (select IRQ15/12/11/10/7/5)
IO    16pin Jumpers (select IO Addr 300/308/310/318/380/388/390/398)
SCSI  6pin Jumpers (select SCSI ID 4/2/1) (aka 3bit 0..7 ?)
PL3   34pin Connector to DTL-H2000 ?
PL1   50pin Connector to INTERNAL SCSI hardware ?
PL2   50pin? Connector to EXTERNAL SCSI hardware ? (25pin plug/50pin cable?)
Jx    98pin ISA Bus Cart-edge (2x31 basic pins, plus 2x18 extended pins)

```

Note: There's also a similar ISA cart (DTL-S510B) with less chips and less connectors.

Note: The SN Systems carts seem to have been distributed by Sony (with "DTL-Sxxxx" numbers), and also distributed by Psygnosis. The external SCSI connectors can be possibly also used with Psy-Q Development Systems for SNES and Sega Saturn?

PSY-Q Development System (Psygnosis 1994)

```

32pin GM76C8128ALLFW85 (SRAM 128Kx8)
44pin ALTERA EPM7032LC44-15T
34pin EMULEX FAS101 (SCSI Interface Processor)
28pin 27C64 (EPROM 8Kx8) (green sticker, without text)
20pin LCX245 (=74245?)
8pin 2112, CPA, H9527 (?)
3pin transistor? voltage regulator?
20pin DIP socket (containing two 10pin resistor networks)
20pin DIP socket (containing two 10pin resistor networks)
2pin CR2032 Battery 3V
68pin Connector to PSX "Parallel I/O" expansion port
25pin Connector to SCSI hardware (to DTL-S510B or DTL-S2020 ISA cart or so?)

```

Sony DTL-H800 Sound Artist Board (with optical fibre audio out)

```

U15 24pin ?
U5 28pin 27C256 (EPROM 32Kx8) (not installed)
U7 4pin 67.7376MHz oscillator
U8 14pin ?
U11 44pin SEC KM416V256B1-8 (DRAM 256Kx16) ;SoundRAM
      (44pin package with middle 4pin missing, 40pins used)
U10 100pin Sony CXD2925Q ;SPU
U4 160pin Lattice IspLSI 3256 (sticker: "VER3")
U6 128pin Lattice IspLSI xxxx ?
U12 48pin ?
U13 48pin ?
U3 20pin 74ACT244
U14 5pin "LM25755, -3.3 P+" ?
U2 54pin ?
U1 54pin ?
U9 ?pin GP1F31T (light transmitting unit for optical fibre cable)
? 124pin PCI bus cart edge connector
? 8pin internal jumper/connector? (7pin installed, 1pin empty)

```

Note: There's also a similar board (DTL-H700) for MAC/NuBus instead of PCI bus.

Sony COH-2000 (unknown purpose)

```

U1 14pin SN74ALS388N ?
U2 20pin SN74ALS688N (8bit inverting identity comparator with enable)
U3 20pin SN74ALS688N (8bit inverting identity comparator with enable)
U4 24pin PALxxx ?
U5 20pin SN74ALS245AN
U6 20pin SN74ALS245AN
U7 20pin SN74ALS244N
U8 20pin SN74ALS244N
U9 20pin SN74ALS245AN
U10 20pin SN74ALS245AN

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U11  20pin SN74ALS244N
S2   16pin 8bit DIP switch (ISA 15/14/13/12/11/10/9/8) ;I/O address bit15-8
S1   8pin 4bit DIP switch (ISA 7/6/5/4) ;I/O address bit7-4
S3   8pin 4bit DIP switch (BISO? 3/2/1/0) ;BISO? or BISO? or 8150?
JPxx .... several jumpers (unknown purpose)
Jx   98pin ISA Bus Cart-edge (2x31 basic pins, plus 2x18 extended pins)
J5   68pin Connector on rear side (unknown purpose)

```

Unknown what COH-2000 was used for. One theory was that it's related to PSX-based arcade cabinets. The 68pin connector might be also related to the 68pin PSX "Parallel I/O" expansion port.

Sony DTL-H2010 (Black External CDROM Drive for DTL-H2000, CD-R compatible)

External front loading CDROM drive with Eject button. Connects to the blue 40pin connector on DTL-H2000 boards.

```

IC101 100pin SONY CXD2515Q (Signal Processor + Servo Amp) ;\
IC102 28pin BA6297AFP ; on mainboard
ICxx 20pin SONY CXA1571N (RF Amp) (on tiny daughtboard) ; (HCMK-81X)
CN101 21pin connector to DEX2010.SCH board ;
CN10x 12pin connector to KSS-240A (laser pickup) ;
S101 2pin pos0 switch or so? ;
M101 2pin spindle motor ;/
U1 20pin 74ALS244BN ;\
U2 20pin 74ALS244BN ;
U3 20pin 74ALS244BN ; on DEX2010.SCH board
J1 2pin connector to EJECT BUTTON ;
J2 5pin connector to LOADING MOTOR ;
J3 21pin connector to mainboard ;
JP1 40pin external connector to DTL-H2000 ;/
CN151 5pin connector to DEX2010.SCH board ;\
M151 2pin loading motor (eject motor) ; on CDM 14, CMK PSX board
S151 2pin OUT SW ;\switches, probably to ;
S152 2pin IN SW ;/sense load/eject status ;/
CN1 2pin connector to DEX2010.SCH board ;\on DTL-H2010(1) board
SW1 2pin eject button ;/

```

The required cable consists of a Yamaichi NFS-40a female connector (blue connector on DTL-H2000 side), 0.635mm pitch ribbon cable, and 3M Sub-D MDR40 connector (silver connector on DTL-H2010 side). But caution: the odd/even pins on the cable are somewhat swapped, on DTL-H2000 side the wires should be ordered 1,2,3,4,..,39,40, but on DTL-H2010 side they should be ordered 2,1,4,3,..,40,39.

Sony DTL-H2510 (Gray Internal CDROM Drive)

This is some sort of a mimicked front loading PC CDROM drive (consisting of a tray that contains a normal (top-loading) PSX cdrom drive unit).

```
IC309 80pin Sony CXD2510Q (CDROM Signal Processor)
ICxx   ?pin Unknown if there are further ICs (eg. CXA1782BR should exist?)
CN1    10pin Connector to daughterboard (with drive unit)
CN2     4pin Connector to PC power supply (12V/5V and 2xGND)
CN3    50pin Connector to DTL-H2500 or so? (need "PCS-E50FC" plug?)
```

There is no eject button, unknown if there's some eject motor, or if one needs to push/pull the drive tray manually.

Sony SCPH-9903 (Gray SCEX-free Playstation)

A rare SCEX-free Playstation that can boot from CDR's without SCEX strings; maybe intended for beta-testers. Marked "Property of Sony Computer Entertainment", "U/C".

26. Hardware Numbers

Sony's own hardware (for PSX) (can be also used with PSone)

```

SCPH-1000 PlayStation (1994) (NTSC-J) (with S-Video)
SCPH-1001 PlayStation (1995) (NTSC-U/C) (without S-Video)
SCPH-1002 PlayStation (199x) (PAL) (without S-Video)
SCPH-1010 Digital joypad (with short cable) (1994)
SCPH-1020 Memory Card 1Mbits (1994)
SCPH-1030 2-button Mouse (with short cable) (1994)
SCPH-1040 Serial Link Cable
SCPH-1050 RGB Cable (21-pin RGB Connector)
SCPH-1060 RFU Cable/Adaptor (antennae connector) (NTSC-JP?) (1995)
SCPH-1061 RFU Cable/Adaptor (antennae connector) (NTSC-US?)
SCPH-1062 RFU Cable/Adaptor (antennae connector) (PAL)
SCPH-1070 Multitap adaptor (four controllers/memory cards on one slot) (1995)
SCPH-1080 Digital joypad (with longer cable) (1996)
SCPH-1090 2-button Mouse (with longer cable) (1998)
SCPH-1100 S Video Cable (1995)
SCPH-1110 Analog Joystick (1996)
SCPH-1120 RFU Adaptor (antennae connector) (NTSC-JP?) (1996)
SCPH-1121 RFU Adaptor (antennae connector) (NTSC-US?)
SCPH-1122 RFU Adaptor (antennae connector) (PAL)
SCPH-1130 AC Power Cord (1996)
SCPH-1140 AV Cable (1997)
SCPH-1150 Analog Joypad (with one vibration motor, with red/green led) (1997)
SCPH-1160 AV Adaptor (1997)
SCPH-1170 Memory Card Triple Pack (three Memory Cards) (1996)
SCPH-1180 Analog Joypad (without vibration motors, with red/green led)
SCPH-119X Memory Card (X=different colors) (1997)
SCPH-1200 Analog Joypad (with two vibration motors) (dualshock) (1997)
SCPH-1210 Memory Card Case (1998)
SCPH-2000 Keyboard/Mouse adapter (PS/2 to PSX controller port; for Lightspan)
SCPH-3000 PlayStation (1995) (NTSC-J) (with the S-video output removed)
SCPH-3500 PlayStation Fighting Box (console bundled with 2 controllers) (1996)
SCPH-4000 PocketStation (Memory Card with LCD-screen) (1999)
SCPH-4010 VPick (guitar-pick controller) (for Quest for Fame, Stolen Song)
SCPH-4020 Long Strap for PocketStation (1999)
SCPH-4030 Wrist Strap for PocketStation (1999)
SCPH-5000 PlayStation (cost reduced) (Japan) (1996) ;\exists in these three
SCPH-5001 PlayStation (cost reduced) (North America) ; regions only (not
SCPH-5003 PlayStation (Asia) ;/in Europe)
SCPH-5500 PlayStation without Cinch sockets (ie. AV Multi Out only) (1996) (J)
SCPH-5501 "" North American version of the 5500
SCPH-5502 "" European version of the 5500 (shipped with 1 digital joypad)
SCPH-5552 Same as SCPH-5502 (but shipped with memcard and 2 digital joypads)
SCPH-5903 PlayStation with built-in MPEG Video-CD decoder (Asia-only)
SCPH-7000 PlayStation with Dualshock (1997) (Japan)
SCPH-7001 PlayStation with Dualshock (199x) (North America)
SCPH-7002 PlayStation with Dualshock (199x) (Europe)

```

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SCPH-7003 PlayStation with Dualshock (199x) (Asia)
SCPH-7000W PlayStation (10 million model, not for sale, blue, region free)
SCPH-7500 PlayStation with Dualshock, cost reduced (1999) (Japan)
SCPH-7501 PlayStation with Dualshock, cost reduced (199x) (North America)
SCPH-7502 PlayStation with Dualshock, cost reduced (199x) (Europe)
SCPH-7503 PlayStation with Dualshock, cost reduced (199x) (Asia)
SCPH-9000 PlayStation without Parallel I/O port (1999) (Japan)
SCPH-9001 PlayStation without Parallel I/O port (199x) (North America)
SCPH-9002 PlayStation without Parallel I/O port (199x) (Europe)
SCPH-9003 PlayStation without Parallel I/O port (199x) (Asia)
SCPH-9903 Rare SCEX-free PSX (Property of Sony Computer Entertainment, U/C)
SFX-100 PlayStation Super Disc Prototype (with SNES chipset, no PSX chips)

```

Sony's own hardware (for PSone)

```

SCPH-100 PSone (miniaturized PlayStation) (2000) (Japan)
SCPH-101 PSone (miniaturized PlayStation) (200x) (North America)
SCPH-102 PSone (miniaturized PlayStation) (200x) (Europe)
SCPH-103 PSone (miniaturized PlayStation) (200x) (Asia)
SCPH-102A PSone Europe (UK/AU, with A/V cable) ;\revision of "SCPH-102"
SCPH-102B PSone Europe (UK, with RFU adaptor) ; with PM-41(2) board ?
SCPH-102C PSone Europe (Continent, with A/V cable) ;/
SCPH-110 Dual Analog Pad (for PSone) (Dualshock) (2000)
SCPH-111 Multitap for PSone (seems to be quite rare, except in brazil)
SCPH-112 AC adapter for PSone (In: 110-220VAC, Out: 7.5VDC, 2.0A, Japan)
SCPH-113 AC adapter for PSone (In: 120VAC/60Hz, Out: 7.5VDC, 2.0A, USA)
SCPH-114 AC adapter for PSone (In: 220-240VAC, Out: 7.5VDC, 2.0A, Europe)
SCPH-115 AC adapter for PSone (In: 220-240VAC, Out: 7.5VDC, 2.0A, UK)
SCPH-116 AC adapter for PSone (In: 220-240VAC, Out: 7.5VDC, 2.0A, Australia)
SCPH-117 AC adapter for PSone (In: 110VAC, Out: 7.5VDC, 2.0A, Asia?)
SCPH-120 AC adapter for PSone with LCD Screen (In: 100VAC, Out: 7.5VDC, 3.0A)
SCPH-130 LCD Screen for PSone (to be attached to the console) (2001)
SCPH-140 PSone and LCD screen combo (2001)
SCPH-152 LCD screen for PSone (PAL SCPH-152C)
SCPH-162 PSone and LCD screen (PAL SCPH-162C)
SCPH-170 Car Adapter for PSone from car cigarette lighter (2001)
SCPH-180 AV Connection Cable for LCD-screen's AV IN
SCPH-10180K DoCoMo I-Mode Adaptor Cable (for internet via mobile phones)

```

Sony's own hardware (for PS2, can be used with PSX/PSone)

```

SCPH-10150 PS2 DVD remote
SCPH-10160 IR receiver dongle for PS2 DVD remote

```

Sony's own devkits

```

DTL-H201A Graphic Artist Board (ISA bus) (with NTSC video out)
DTL-H240 PS-X RGB Cable
DTL-H500C Digital joypad prototype (SNES-style design, with DB9 connector)

```

DTL-H505 PS-X (Code Name) Target Box ? (PSX prototype, SCSI instead CDROM?)
 DTL-H700 Sound Artist Board (NuBus for Mac)
 DTL-H800 Sound Artist Board (PCI Bus for IBM) (with optical fibre sound out)
 DTL-H1000 Debugging Station (CD-R compatible PSX console) (Japan)
 DTL-H1001 Debugging Station (CD-R compatible PSX console) (North America)
 DTL-H1002 Debugging Station (CD-R compatible PSX console) (Europe)
 DTL-H1030 Mouse ?
 DTL-H1040 Link Cable ?
 DTL-H1050 RGB Cable ?
 DTL-H110x Debugging Station revision? (DC-powered)
 DTL-H120x Debugging Station revision? (AC-powered)
 DTL-H1500 Stand-Alone Box ? With ethernet, for SGI Workstation ?
 DTL-H2000 Dev board v1 (PSX on two ISA carts) (old pre-retail)
 DTL-H2010 Black External CDROM Drive for DTL-H2000 (CD-R compatible)
 DTL-H2040 Memory Box ?
 DTL-H2050 Adaptor for Controller port ?
 DTL-H2060 Serial Link cable
 DTL-H2070 RGB Cable ?
 DTL-H2080 Controller Box (joypad/memcard adaptor for DTL-H2000/DTL-xxxx?)
 DTL-H2500 Dev board (PCI bus)
 DTL-H2510 Gray Internal CDROM Drive for DTL-H2500/DTL-H2700 (CD-R compatible)
 DTL-H2700 Dev board (ISA bus) (CPU, ANALYZER ...?)
 DTL-H3000 Net Yaroze (hobby programmer dev kit) (Japan)
 DTL-H3001 Net Yaroze (hobby programmer dev kit) (North America)
 DTL-H3002 Net Yaroze (hobby programmer dev kit) (Europe)
 DTL-H3020 Access Card (for yaroze)
 DTL-H3050 Communication Cable (link port to rs232, for yaroze)
 DTL-D2020 Documentation: BUILD CD (Manual of Programmer's Tool)
 DTL-D2120 Documentation: (Manual of Programmer's Tool)
 DTL-D2130 Documentation: PsyQ (Manual of Programmer's Tool)
 DTL-D2130 Documentation: SdevTC (Manual of Programmer's Tool)
 DTL-D2140A Documentation: Ver.1.0 (Manual of Programmer's Tool)
 DTL-D2150A Documentation: Ver.2.0 (Manual of Programmer's Tool)

SN System / Psy-Q devkit add-ons / SCSI cards

DTL-S510B Unknown (another CDROM emulator version?)
 DTL-S2020 CD-ROM EMULATOR for DTL-H2000/DTL-H2500/DTL-H2700

Sony Licensed Hardware (Japan)

SLPH-00001 Namco neGcon (white) (NPC-101), Twist controller (SLEH-0003)
 SLPH-00002 Hori Fighting stick, digital stick with autofire/slowmotion/rumble
 SLPH-00003 ASCII Fighter stick V, psx-shaped digital stick (SLEH-0002)
 SLPH-00004 Sunsoft Sunstation pad, digital pad with autofire/slowmotion
 SLPH-00005 ASCII ASCIIIPAD V, digital pad with autofire/slowmotion
 SLPH-00006 Imagineer Sandapaddo ThunderPad
 SLPH-00007 SANKYO N.ASUKA aka Nasca Pachinco Handle, bizarre paddle
 SLPH-00008 Spital SANGYO Programmable joystick
 SLPH-00009 Hori Fighting commander 2way controller
 SLPH-00010 Optec Super Pro Commander

SLPH-00011 Super Pro Commander Accessory / Extended memo repack memory
 SLPH-00012 Hori Fighting Commander 10B Pad (gray), digital pad with extras
 SLPH-00013 Konami Hyper Blaster (green) ;\IRQ10-based Lightgun
 SLPH-00014 Konami Hyper Blaster (black) ;/(SLEH-0005/SLUH-00017)
 SLPH-00015 Namco Volume controller, paddle with 2 buttons
 SLPH-00016 Waka Up Scan Converter "[chiyo] clean! peripheral equipment?"
 SLPH-00017 Hori Fighting Commander 10B Pad (black), digital pad with extras
 SLPH-00018 Hori Real Arcade Stick, digital stick, small L1/L2 (HPS-10)
 SLPH-00019 Konami Hyperstick
 SLPH-00020 Imagineer Thunder Pad Transparent
 SLPH-00021 Imagineer Imagegun
 SLPH-00022 Optec AI Commander Pro, digital pad with extras / lcd display
 SLPH-00023 Namco Joystick (SLEH-00004)
 SLPH-00024 Optec Cockpit Wheel, analog joystick/analog pedals or so
 SLPH-00025 Optec AI Commander Accessory (extended memo repack ZERO2 version)
 SLPH-00026 Hori Command Stick PS (SLPH-00026 aka HPS11)
 SLPH-00027 ASCII Grip, single-handed digital pad (SLEH-00008)
 SLPH-00028 Hori Grip (gray) (see also: SLPH-00040, and 00086..00088)
 SLPH-00029 Hori Horipad (clear), digital pad
 SLPH-00030 Hori Horipad (black), digital pad
 SLPH-00031 Hori Horipad (gray), digital pad
 SLPH-00032 Hori Horipad (white), digital pad
 SLPH-00033 Hori Horipad (blue), digital pad
 SLPH-00034 Namco G-CON 45, Cinch-based Lightgun (SLEH-0007/SLUH-00035)
 SLPH-00035 ASCII Fighter stick V Jr. (SLEH-00009)
 SLPH-00036 Optec Wireless Dual Shot, digital pad with turbo button
 SLPH-00037 ?
 SLPH-00038 ASCII Pad V Jr., digital pad without any extras
 SLPH-00039 ASCII Pad V2 (gray), digital pad with turbo switches (SLEH-00010)
 SLPH-00040 Hori Grip (black)
 SLPH-00041 ASCII Grip V
 SLPH-00042 ASCII Grip V plus (Derby Stallion'99 supplement set), single-hand
 SLPH-00043 ASCII Pad V2 (clear pink)
 SLPH-00044 ASCII Pad V2 (clear white)
 SLPH-00045 ASCII Pad V2 (clear blue)
 SLPH-00046 ASCII Pad V2 (clear green)
 SLPH-00047 ASCII Pad V2 (clear black)
 SLPH-00048 ASCII Pad V2 (clear red/lead?)
 SLPH-00049 ASCII Pad V2 (clear yellow)
 SLPH-00050 ASCII Pad V2 (clear orange)
 SLPH-00051 Taito Streetcar GO! Controller 2 steering "wheel?" tie toe strange
 SLPH-00052 Koei Video Capture, Ergosoft EGWord, and Lexmark Printer bundle
 SLPH-00053 Koei Word Processor Ergosoft September EGWORD Ver.2.00
 SLPH-00054 Hori Zerotech Steering Controller (black)
 SLPH-00055 Hori Grip (clear blue)
 SLPH-00056 Hori Grip (clear pink)
 SLPH-00057 Hori Grip (clear yellow)
 SLPH-00058 ASCII Pad V2 (gold)
 SLPH-00059 ASCII Pad V2 (silver)
 SLPH-00060 ASCII Biohazard, digital pad with re-arranged buttons (SLEH-0011)
 SLPH-00061 ASCII Pad V2 (pearl white)
 SLPH-00062 ASCII Pad V2 (pearl blue)
 SLPH-00063 ASCII Pad V2 (pearl pink)
 SLPH-00064 ASCII Pad V2 (pearl green)

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SLPH-00065 ASCII Pad V Pro, with lcd for button-combinations (ASC-0508GX)
SLPH-00066 ASCII Arcade Stick 3 "Ultimate"
SLPH-00067 ASCII Pad V2 (purple metallic)
SLPH-00068 ASCII Pad V2 (lead metallic)
SLPH-00069 Namco neGcon (black) (NPC-104), Twist controller (SLEH-0003)
SLPH-00070 Sankyo Pachinko FF Controller (alternate to SLPH-00007)
SLPH-00071 Hori Command Stick PS Custom
SLPH-00072 ASCII Command Pack (memory card add-on or so)
SLPH-00073 Optec Wireless digital set (gray) ;\
SLPH-00074 Optec Wireless digital set (black) ; pad with receiver
SLPH-00075 Optec Wireless digital set (clear) ;
SLPH-00076 Optec Wireless digital set (clear blue) ;
SLPH-00077 Optec Wireless digital set (clear black) ;/
SLPH-00078 Optec Wireless digital shot (gray) ;\
SLPH-00079 Optec Wireless digital shot (black) ; extra pad for
SLPH-00080 Optec Wireless digital shot (clear) ; second player
SLPH-00081 Optec Wireless digital shot (clear blue) ; (without receiver)
SLPH-00082 Optec Wireless digital shot (clear black) ;/
SLPH-00083 ASCII Stick Justice controller
SLPH-00084 Hori ZeroTech Steering Controller (clear)
SLPH-00085 Hori Compact joystick (black)
SLPH-00086 Hori Compact joystick (clear)
SLPH-00087 Hori Compact joystick (clear blue)
SLPH-00088 Hori Multi Analog Pad (clear) or Hori Grip (pink?)
SLPH-00089 Hori AV Cable with selector
SLPH-00090 Hori Multi Analogue Pad (clear black)
SLPH-00091 Hori AV Multi-Out Converter
SLPH-00092 ASCII Pad V2 (margin green)
SLPH-00093 ASCII Pad V2 (margin blue)
SLPH-00094 ASCII Pad V2 (margin pink)
SLPH-00095 ASCII Pad V2 (margin orange)
SLPH-00096 ASCII Hyper Steering V ("high pass tear ring V controller?")
SLPH-00097 Hori S Cable with selector (uh, maybe S-video or so?) (HPS-36)
SLPH-00098 NSYSCOM Pachinko slot controller (NSC-1)
SLPH-00099 ASCII Pad V2 (rainbow)
SLPH-00100 ASCII 'Hanging' Fishing Controller, controller for fishing games
SLPH-00101 Optec Cockpit big shock
SLPH-00102 ASCII Grip V (set for mars story)
SLPH-00103 Hori Pad V2 (clear)
SLPH-00104 Hori Pad V2 (clear blue)
SLPH-00105 Hori Pad V2 (clear pink)
SLPH-00106 Hori Pad V2 (black)
SLPH-00107 Hori Compact Joystick (camouflage)
SLPH-00108 Hori Rumble Digital Pad (clear blue)
SLPH-00109 Hori Monoaural AV Cable
SLPH-00110 ASCII Pad V2 (marble)
SLPH-00111 ASCII Pad V2 (camouflage)
SLPH-00112 ASCII Pad V3
SLPH-00113 ASCII Pad V3 with cable reel
SLPH-00114 ASCII Pad V3 with V2 (pearl white) bundle
SLPH-00115 ASCII Pad V3 with V2 (pearl pink) bundle
SLPH-00116 ASCII Pad V3 with V2 (pearl blue) bundle
SLPH-00117 ASCII Pad V3 (blue) with V2 (pearl green) bundle
SLPH-00118 Hori Pad V3

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SLPH-00119 Hori Pad V3 (white)
SLPH-00120 Hori Analog Rumble Pad (clear pink)
SLPH-00121 Hori Analog Rumble Pad (clear)
SLPH-00122 Hori Analog Rumble Pad (clear blue)
SLPH-00123 Hori Analog Rumble Pad (clear red)
SLPH-00124 Hori Analog Rumble Pad (clear black)
SLPH-00125 Hori Analog Rumble Pad (clear yellow)
SLPH-00126 Namco Jogcon, digital pad, steering dial (SLEH-0020/SLUH-00059)
SLPH-00127 ?
SLPH-00128 ASCII stick ZERO3
SLPH-00129 ASCII Pad V2 (wood grain pitch)
SLPH-00130 Hori Real Arcade (camouflage)
SLPH-00131 Hori Ehrgeiz Stick
SLPH-00132 ASCII Pad V3 (blue)
SLPH-00133 ASCII Fighter Stick V Jr. (limited edition)
SLPH-00134 ASCII Pad V3 (blue) with cable reel
SLPH-00135 ASCII Pad V3 (blue) with V2 (silver)
SLPH-00136 ASCII Pad V3 with V2 (purple metallic)
SLPH-00137 ASCII Pad V3 with V2 (gold)
SLPH-00138 ASCII Pad V3 with "VPRO. aka Ascii Fighter Stick V"
SLPH-00139 Hori Analog Rumble Pad (gray)
SLPH-00140 Hori Analog Rumble Pad (black)
SLPH-00141 Hori Analog Rumble Pad (blue)

```

And, maybe unlicensed (they don't have official SLPH numbers, still they are listed as official controllers on PSX CDROM back covers):

```

ASC-05158B ASCII Beatmania Junk (similar to SLEH-0021)
ASC-0528T  Sammy Shakkato Tambourine
BANC-0001  Bandai Fishing Controller
BANC-0002  Bandai Kids Station
RU017      Konami Dance Dance Revolution Controller (Dance Mat)
GAE001     G.A.E. Baton stick with 2 buttons (for The Maestromusic)

```

And whatever:

```

RU029      Konami Beatmania IIDX
RU014      Konami Pop'n Music (buttons A,B,C,D,E,F,G,H,I, and Select/Start)
RU014-J2   Konami Pop'n Controller 2
RU036      Konami Pop'n Controller (Arcade Style)
?          Produce! Paca Paca Passion
?          Sega/Ascii Minimoni Shakatto Tambourine

```

Sony Licensed Hardware (Europe)

```

SLEH-00001 Ascii Specialized Pad (similar to SLPH-00005: ASCII ASCIIIPAD V)
SLEH-00002 Ascii Arcade Stick, psx-shaped digital stick (SLPH-00003)
SLEH-00003 Namco Negcon, Twist controller (SLPH-00001)
SLEH-00004 Namco Arcade Stick (SLPH-00023)
SLEH-00005 Konami Hyper Blaster, IRQ10-based Lightgun (SLPH-00014/SLUH-00017)

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SLEH-00006 Mad Catz Steering Wheel (SLPH-?)
 SLEH-00007 Namco G-Con 45, Cinch-based Lightgun (SLPH-00034/SLUH-00035)
 SLEH-00008 Ascii Grip, single-handed digital pad (SLPH-00027/SLUH-00038)
 SLEH-00009 Ascii Arcade Stick v2 (SLPH-00035)
 SLEH-00010 Ascii Enhanced Control Pad (similar as SLEH-00001) (SLPH-00039)
 SLEH-00011 Resident Evil Pad (aka SLPH-00060 ASCII Biohazard)
 SLEH-00012 Reality-Quest The Glove (right-handed only) (SLUH-00045/SLPH-?)
 SLEH-00013 CD Case (small nylon bag for fourteen CDs) (SLPH-?)
 SLEH-00014 ?
 SLEH-00015 PlayStation Case (bigger bag for the console) (SLPH-?)
 SLEH-00016 PlayStation Case + Digital Joypad + Memory Card
 SLEH-00017 ?
 SLEH-00018 Ascii Sphere 360 (SLUH-00028/SLPH-?)
 SLEH-00019 Interact V3 Racing Wheel (SLPH-?)
 SLEH-00020 Namco JogCon, digital pad, steering dial (SLPH-00126/SLUH-00059)
 SLEH-00021 Konami Beatmania Controller (SLPH-?)
 SLEH-00022 ?
 SLEH-00023 Official Dance Mat (RU017/SLUH-00071) (for PSone and PS2)
 SLEH-00024 Fanatec Speedster 2 (wheel with pedals) (for PSone and PS2)
 SLEH-00025 Mad Catz 8MB Memory Card (for PS2)
 SLEH-00026 Olympus Eye-Trek FMD-20P Game/DVD glasses (for PS2)
 SLEH-00027 Logitech Cordless Controller... or Eye-Trek FMD-20P, too? (PSx?)
 SLEH-00028 ?
 SLEH-00029 Fanatec Speedster 3 (for PS2)
 SLEH-00030 Logitech Eye Toy (camera?) (for PS2)

And, maybe unlicensed:

Mad Catz Wrist Rumbler (rumble add-on for pre-dualshock controllers)

Sony Licensed Hardware (USA)

SLUH-00001 Specialized Joystick (single-axis, digital?)
 SLUH-00002 Control Pad (redesigned joypad)
 SLUH-00003 InterAct Piranha Pad, digital pad, autofire/slowmotion
 SLUH-00017 Konami Justifier, IRQ10-based Lightgun (Hyperblaster/SLPH-00014)
 SLUH-00018 Enhanced Pad (joypad with whatever extra functions)
 SLUH-00022 Analog and Digital Steering Wheel with pedals (for testdrive 4?)
 SLUH-00026 Optec Mach 1 (gray steering/flight controller with pedals)
 SLUH-00028 Ascii Sphere 360 (SLEH-00018)
 SLUH-00029 Namco NPC-102 Joystick (single-axis, digital?)
 SLUH-00031 Interact Program Pad
 SLUH-00033 Piranha Pad (redesigned joypad)
 SLUH-00034 NUBY Manufacturing The Heater, white lightgun (irq10 or cinch?)
 SLUH-00035 Namco G-CON 45, Cinch-based Lightgun (SLEH-0007/SLPH-00034)
 SLUH-00037 Arcade Stick (single-axis, digital?)
 SLUH-00038 ASCII Grip V, single-handed digital pad (SLPH-00027/SLEH-00008)
 SLUH-00040 System Organizer (huh? looks like... a black storage box?)
 SLUH-00041 V3 Racing Wheel with pedals
 SLUH-00043 GunCon (bundled with Time Crisis 1)
 SLUH-00044 Remote Wizard (looks like wireless joypad or so)
 SLUH-00045 Reality-Quest The Glove (right-handed only) (SLEH-00012/SLPH-?)

```

SLUH-00046 GunCon (bundled with Point Blank)
SLUH-00055 Aftershock Wheel with pedals
SLUH-00056 UltraRacer Steering Controller (grip-style)
SLUH-00057 EA Sports Game Pad (redesigned joypad)
SLUH-00058 something for point blank 2 (?) (maybe a lightgun)
SLUH-00059 Namco Jogcon, digital pad, steering dial (SLEH-0020/SLPH-00126)
SLUH-00061 MadCatz MC2 Racing Wheel (black/gray)
SLUH-00063 Bass Landing Fishing Reel controller
SLUH-00066 Sportster racing wheel
SLUH-00068 Jungle Book Rhythm N Groove Dance Pack
SLUH-00071 Konami Dance Pad (DDR Dance Pad) (RU017)
SLUH-00072 GunCon (bundled with Point Blank 3)
SLUH-00073 GunCon (bundled with Time Crisis 2 - Project Titan)
SLUH-00077 Logitech Cordless Controller, analog pad (ps1/ps2)
SLUH-00081 Logitech NetPlay Controller, pad with keyboard (usb/ps2)
SLUH-00083 Konami Dance Dance Revolution Controller (for PS1 and PS2)
SLUH-00084 NYKO iType2, pad with keyboard (usb/ps2)
SLUH-00085 Logitech Cordless Action Controller (for PS2)
SLUH-00086 Namco/Taiko Drum Master (Taiko Controller Pack) (for PS2)
SLUH-00088 RedOctane In the Groove Dance Pad Controller ?
SLUH-00090 Dance Pad (bundled with Pump It Up) (for PS2)

```

Sony Licensed Hardware (Asia)

Unknown (if any)

Newer hardware add-ons?

SCEH-0001 SingStar (USB to Microfon) (for PS2)

Note

Early SLEH/SLUH devices used 4-digit numbers (eg. the "official" name for SLEH-00003 is SLEH-0003; unlike as shown in the above list).

Software (CDROM Game Codes)

```

CPCS-00701 Dino Crisis 5th Anniversary Box Serial
DTL-NNNNN Development Tool Licensed (Net Yaroze)
ESPM-NNNNN Sony Music Entertainment Japan (Music Video Discs)
LSP-NNNNNN Lightspan series (non-retail educational games)
PAPX-NNNNN Japanese Demos/Rental Editions/Taikenban
BPBX-NNNNN Official Playstation Sampler Discs (USA/UK)
PCPX-NNNNN Japanese Otameshi Discs (Samplers)
PEPX-NNNNN Analog Controller Service Disc
PUPX-NNNNN Analog controller Service Disc
PSRM-017100 Syphon Filter 2 Disc 2 Preview Version
PSXCDCLEAN Laser Clean

```

```

PTPX-NNNNN Aging Disk
SCAJ-NNNNN Sony Computer Entertainment America ... ?
SCED-NNNNN Sony Computer Europe Demo
SCES-NNNNN Sony Computer Europe Software
SCPM-NNNNN Sony Computer Japan ...?
SCPS-NNNNN Sony Computer Japan Software
SCUS-NNNNN Sony Computer USA Software
SCZS-NNNNN Sony Computer ... Software? (Fan Books)
SIPS-NNNNN Sony Imports ...? (All Imports to Japan)
SLED-NNNNN Sony Licensed Europe Demo
SLES-NNNNN Sony Licensed Europe Software
SLKA-NNNNN Sony Licensed Korea ...? (3 Korean Releases)
SLPM-NNNNN Sony Licensed Japan ... ?
SLPS-NNNNN Sony Licensed Japan Software
SLUS-NNNNN Sony Licensed USA Software
SPUS-NNNNN Sony Playstation US ...? (Playstation Picks Disc)

```

Note: Multi-disc games have more than one game code. The game code for Disc 1 is also printed on the CD cover, and used in memory card filenames. The per-disc game codes are printed on the discs, and are used as boot-executable name in SYSTEM.CNF file. There is no fixed rule for the multi-disc numbering; some games are using increasing numbers of XNNNN or NNNNX (with X increasing from 0 upwards), and some are randomly using values like NNNXX and NNNYY for different discs.

27. Pinouts

External Connectors

[Pinouts - Controller Ports and Memory-Card Ports](#)

[Pinouts - Audio, Video, Power, Expansion Ports](#)

[Pinouts - SIO Pinouts](#)

Internal Pinouts

[Pinouts - Chipset Summary](#)

[Pinouts - CPU Pinouts](#)

[Pinouts - GPU Pinouts \(for old 160-pin GPU\)](#)

[Pinouts - GPU Pinouts \(for new 208-pin GPU\)](#)

[Pinouts - SPU Pinouts](#)

[Pinouts - DRV Pinouts](#)

[Pinouts - VCD Pinouts](#)

[Pinouts - HC05 Pinouts](#)

[Pinouts - MEM Pinouts](#)

[Pinouts - CLK Pinouts](#)

[Pinouts - PWR Pinouts](#)

[Pinouts - Component List and Chipset Pin-Outs for Digital Joypad, SCPH-1080](#)

[Pinouts - Component List and Chipset Pin-Outs for Analog Joypad, SCPH-1150](#)

[Pinouts - Component List and Chipset Pin-Outs for Analog Joypad, SCPH-1200](#)

[Pinouts - Component List and Chipset Pin-Outs for Analog Joypad, SCPH-110](#)

[Pinouts - Component List and Chipset Pin-Outs for Namco Lightgun, NPC-103](#)

[Pinouts - Component List and Chipset Pin-Outs for Multitap, SCPH-1070](#)

[Pinouts - Memory Cards](#)

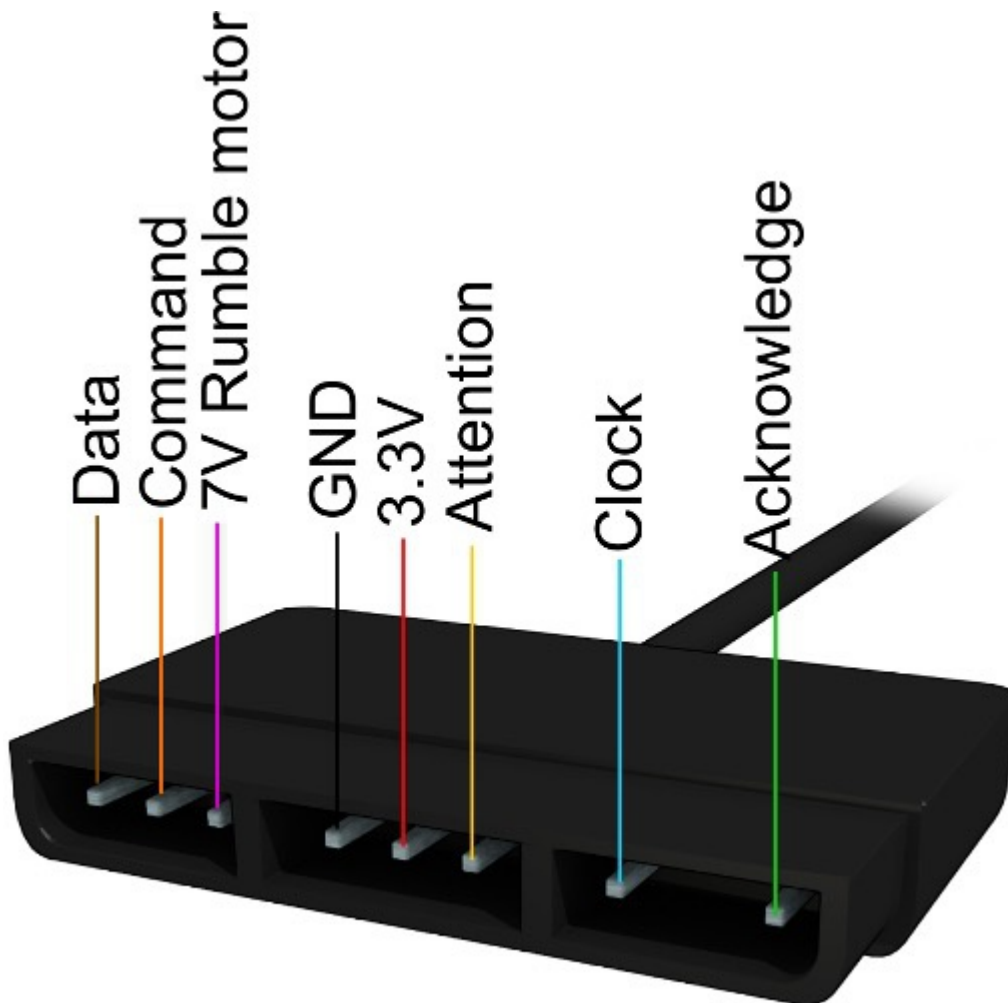
Mods/Upgrades

[Mods - Nocash PSX-XBOO Upload](#)

[Mods - PAL/NTSC Color Mods](#)

27.1 Pinouts - Controller Ports and Memory-Card Ports

Controller Ports and Memory-Card Ports



```
Memory card slot: | 9 7 6 | 5 4 3 | 2 1 |
                  | _ _ _ _ | _ _ _ _ | _ _ _ _ |
                  | 9 8 7 | 6 5 4 | 3 2 1 |
```

```
Controller port:  | * * * | * * * | * * * |
                  '\_____|_____|_____|'
```

Pin	Dir	Name	SIO0 pin	Description
1	In	DAT / MISO	RX	Serial data from device
2	Out	CMD / MOSI	TX	Serial data to device
3		+7.5V		Supply for rumble motors
4		GND		Ground
5		+3.5V		Supply for main logic
6	Out	/CSn	DTRn	Port select
7	Out	SCK	SCK	Serial data clock
8	In	/IRQ	/IRQ10	Lightgun IRQ (controller only)
9	In	/ACK	DSR	Data acknowledge IRQ

/CSn are two separate signals (/CS1 for controller/memory card port 1, /CS2 for port 2). All other signals are exactly the same on all four connectors (with the memory card slots lacking the /IRQ pin and shield).

/IRQ pin

Most or all controllers leave pin 8 unused, the pin can be used as lightpen input (not sure if the CPU is automatically latching a timer somewhere?), if there's no auto-latched timer, then the interrupt would be required to be handled as soon as possible; ie. don't disable interrupts, and don't "halt" the CPU for longer periods (as far as I understood, the GTE can halt the CPU when trying to read results of incomplete operations; to avoid that, one could wait by software, eg. inserting NOPs, before reading GTE results...?) (Some (or maybe all?) existing psx lightguns are reportedly connected to the Video output on the Multiout port for determining the current cathode ray position though).

27.2 Pinouts - Audio, Video, Power, Expansion Ports

AV Multi Out (Audio/Video Port)

- 1 RGB-Video Green
- 2 RGB-Video Red
- 3 Supply +5.0V (eg. supply for external RF adaptor)
- 4 RGB-Video Blue
- 5 Supply Ground
- 6 S-Video C (chrominance)


```

GND  =|16   50 |= GND
+3.5V ==|17  51 |== +3.5V
+7.5V ==|18  52 |== +7.5V
GND  =|19   53 |= GND
A4   =|20   54 |= A5
A6   =|21   55 |= A7
A8   =|22   56 |= A9
A10  =|23   57 |= A11
A12  =|24   58 |= A13
A14  =|25   59 |= A15
A16  =|26   60 |= A17
A18  =|27   61 |= A19
A20  =|28   62 |= A21
A22  =|29   63 |= A23
/RD  =|30   64 |= /WR0
(/IRQ2)NC =|31  65 |= NC (/CS5)
SYSCK =|32   66 |= LRCK
BCLK  =|33   67 |= SDIN
GND  ==|34   68 |== GND
      |_____|

```

On a stock console, pin 5 is ground and pins 31 and 65 are not connected. These pins are repurposed by the PSIO's switch board to allow the PSIO to emulate the CD-ROM drive; when pin 5 (SBEN) is high, the switch board disconnects the CPU's /CS5 and /IRQ2 pins from the CD drive and routes them to pins 65 and 31 respectively, allowing the PSIO to take over. Pin 39 can also be repurposed in a similar way to allow /CS2 and thus the internal BIOS ROM to be overridden.

For more details see:

[pcsx-redux - PIO port](#)

[pcsx-redux - Switch Board](#)

Internal Power Supply (PSX)

The PSX contains an internal power supply, however, like the PSone, it's only having a "Standby" button, which merely disconnects 3.5V and 7.9V from the mainboard. The actual power supply remains powered, and wastes energy day and night, thanks Sony!

External Power Supply (PSone)

```

Inner +7.5V DC 2.0A    (inside diameter 0.8mm)
Outer GND              (outside diameter 5.0mm)

```

27.3 Pinouts - SIO Pinouts

Serial Port

That port exists only on original Playstation (not on the PSone). The shape of the Serial Port is identical to the 12pin Multiout (audio/video) port, but with only 8pins.

1	SIO1 In	RXD receive data	(from remote TXD)	
2	SIO2 -	VCC +3.5VDC	(supply, eg. for voltage conversion)	
3	SIO3 In	DSR	(from remote DTR)	
4	SIO4 Out	TXD transmit data	(to remote RXD)	
5	SIO5 In	CTS clear to send	(from remote RTS)	8 7 6 5 4 3 2 1
6	SIO6 Out	DTR	(to remote DSR)	
7	SIO7 -	GND Ground	(supply, eg. for voltage conversion)	
8	SIO8 Out	RTS request to send	(to remote CTS)	
Shield	GND Ground	(to/from remote GND)		

Can be used to communicate with another PSX via simple cable connection. With an external RS232 adaptor (for voltage conversion) it could be also used to communicate with a PC, a mouse, a modem, etc.

PSone Serial Port

The PSone doesn't have an external serial connector, however, easy to use soldering points for serial port signals are found as cluster of 5 soldering points (below CPU pin52), and a single soldering point (below CPU pin100), arranged like so (on PM-41 boards) (might be different on PM-41(2) boards):

```

          CPU70.RTS
CPU71.CTS  CPU74.TxD
          CPU72.DTR  CPU75.RxD
                                     CPU73.DSR

```

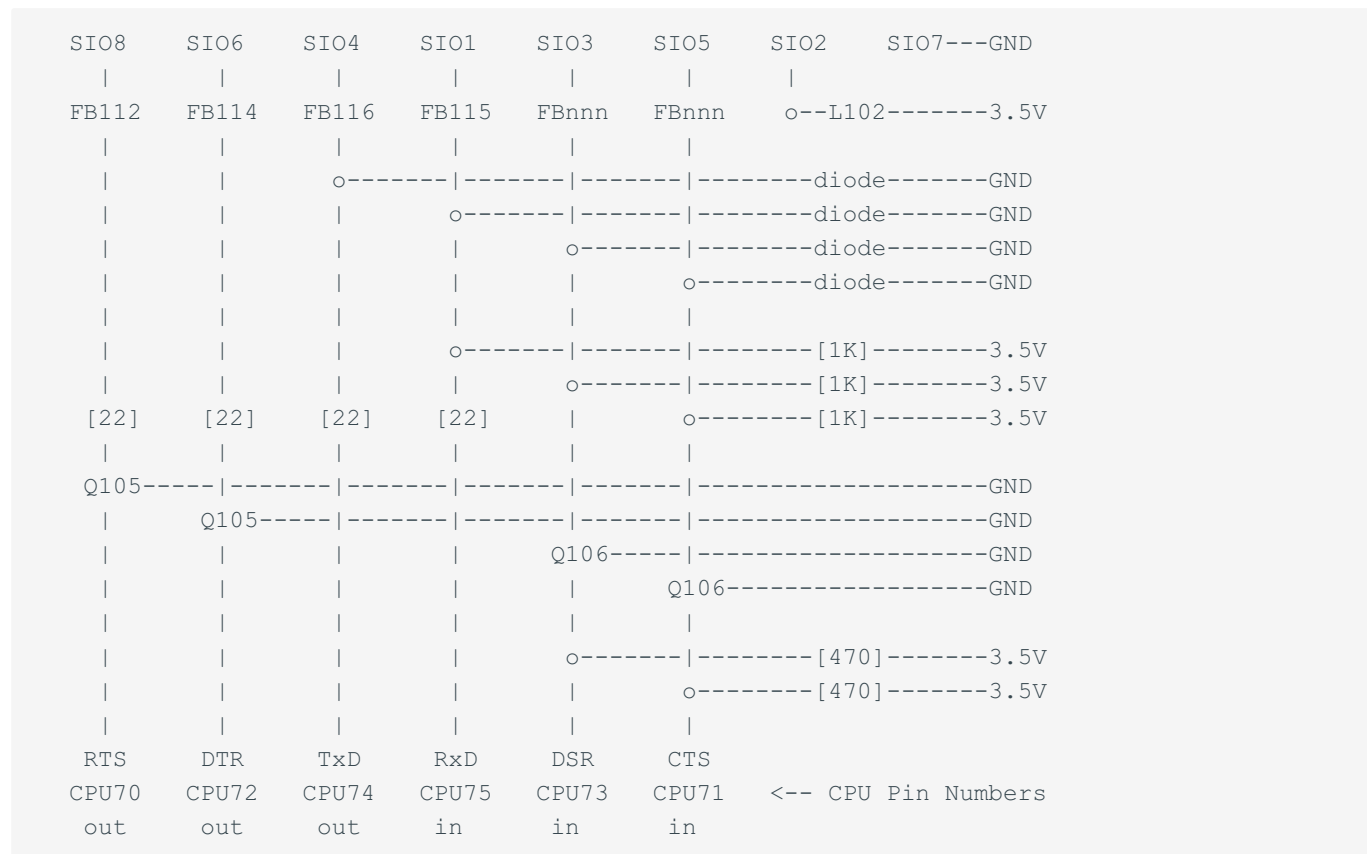
The three outputs (RTS,DTR,TXD) are left floating, the RXD input is wired via a 1K ohm pull-up resistor to 3.5V, the other two inputs (CTS,DSR) are wired via 1K ohm pull-down resistors to GND.

If you want to upgrade the PSone, remove that resistors, and then install the PSX-style serial circuit (as shown below), or, think of a more simplified circuit without (dis-)inverted signals.

PSX Serial Port Connection (PU-23 board) (missing on PM-41 board)

The PSX serial circuit basically consists of a few transistors, diodes, and resistors. The relevant part is that most of the signals are inverted - compared with RS232 signals, the

CPU uses normal high/low levels (of course with 0V and 3.5V levels, not -12V and +12V), and the signals at the serial port socket are inverted. Ie. if you want to built a RS232 adaptor, you must either externally undo the inversion, or, disconnect the transistors, and wire your circuit directly to the CPU signals.



All six signals are passed through fuses (or loops or so). The three inputs have 1K ohm pull-ups, and diodes as protection against negative voltages, two of the inputs are inverted via transistors, with 470 ohm pull-ups at the CPU side, the other input is passed through 22 ohm to the CPU. The three outputs are also passed through 22 ohm, one of them having a diode as negative voltage protection, the other two are inverted via transistors (which may also serve as negative voltage protection).

Note that there is no positive voltage protection (ie. +12V inputs would do no good, also strong -12V inputs might overheat the diodes/fuses, so if you want to use RS232 voltages, better use a circuit for voltage conversion).

Serial RS232 Adaptor

The PSX serial port uses 0V/3.5V logic, whilst RS232 uses -5V/+5V...-15V/+15V logic. An example circuit for converting the logic levels would be:

PSX.VCC--+ --PSX.GND	PSX.GND----	DSUB.5.GND----	DSUB.SHIELD	DSUB.1,9----	NC
,----- +-- 1	16 -----PSX.VCC	,----- +-- 1	16 -----PSX.VCC		
PSX.GND--- +-- 2	15 -----PSX.GND	PSX.GND--- +-- 2	15 -----PSX.GND		
'----- 3	14 ----DSUB.3.TXD	'----- 3	14 --- N/A		
,---+ -- 4	13 ----DSUB.2.RXD	,---+ -- 4	13 --- N/A		
'----- 5	12 -----PSX.RXD	'----- 5	12 --- N/A		
PSX.GND--+ -- 6	11 -----PSX.TXD	PSX.GND--+ -- 6	11 --- N/A		
DSUB.7.RTS---- 7	10 --o< --PSX.RTS	DSUB.4.DTR---- 7	10 --o< --PSX.DTR		
DSUB.8.CTS---- 8	9 -- >o--PSX.CTS	DSUB.6.DSR---- 8	9 -- >o--PSX.DSR		
_____		_____			

Parts List: 1 or 2 MAX232 chips (voltage conversion), 0 or 1 7400 (NAND, used as inverter), 4 or 8 1uF/16V capacitors, 1x 10uF/16V capacitor, 1x 9pin male SubD plug. The four inverters are needed only for external adapters (which need to undo the transistor inversion on the PSX mainboard) (ie. the inverters are not needed when connecting the circuit directly to the PSX CPU).

The second MAX232 chip is needed only if DTR/DSR "not ready" conditions are required (for an "always ready" condition: DSUB.4.DTR can be wired to -8.5V, which is available at Pin6 of the first MAX232 chip, and PSX.DSR can be wired to +3.5V).

With the above DSUB pin numbers, peripherals like mice or modems can be connected directly to the circuit. For connection to another computer, use a "null modem" cable (with crossed RXD/TXD, RTS/CTS, DTR/DSR wires).

The circuit works with both VCC=5V (default for MAX232) and with VCC=3.5V (resulting in slightly weaker signals, but still strong enough even for serial mice; which are misusing the RS232 signals as power supply).

27.4 Pinouts - Chipset Summary

PSX/PSone Mainboards

Board	Expl.
PU-7	PSX, with AV multiout+cinch+svideo, GPU in two chips (160+64pins)
PU-8	PSX, with AV multiout+cinch, four 8bit Main RAM chips
	EARLY-PU-8: "PU-8 1-658-467-11, N4" --> old chipset, resembles PU-7
	LATE-PU-8: "PU-8 1-658-467-22, N6" --> new chipset, other as PU-7
PU-9	PSX, without SCPH-number (just sticker saying "NOT FOR SALE, SONY)
PU-16	PSX, with extra Video CD daughterboard (for SCPH-5903)
PU-18	PSX, with AV multiout only, single 32bit Main RAM (instead 4x8bit)
PU-20	PSX, unknown if/how it differs from PU-18
PU-22	PSX, unknown if/how it differs from PU-18
PU-23	PSX, with serial port, but without expansion port
PM-41	PSone, older PSone, for GPU/SPU with RAM on-board (see revisions)
PM-41(2)	PSone, newer PSone, for GPU/SPU with RAM on-chip

There are at least two revisions of the "PM-41" board:

```
PM-41, 1-679-335-21  PSone with incomplete RGB signals on multiout port
PM-41, 1-679-335-51  PSone with complete RGB signals on multiout port
```

The "incomplete" board reportedly requires to solder one wire to the multiout port to make it fully functional... though no idea which wire... looks like the +5V supply? Also, the capacitors near multiout are arranged slightly differently.

CPU chips

```
IC103 - 208pin - "SONY CXD8530BQ" ;seen on PU-7 board
IC103 - 208pin - "SONY CXD8530CQ" ;seen on PU-7 and PU-8 boards
IC103 - 208pin - "SONY CXD8606Q" ;seen in PU-18 schematic
IC103 - 208pin - "SONY CXD8606AQ" ;seen on PU-xx? board
IC103 - 208pin - "SONY CXD8606BQ" ;seen on PM-41, PU-23, PU-20 boards
IC103 - 208pin - "SONY CXD8606CQ" ;seen on PM-41 board, too
```

These chips contain the MIPS CPU, COP0, and COP2 (aka GTE), MDEC and DMA.

GPU chips - Graphics Processing Unit

```
IC203 - 160pin - "SONY CXD8514Q" ;seen on PU-7 and EARLY-PU-8 boards
IC203 - 208pin - "SONY CXD8561Q" ;seen on LATE-PU-8 board
IC203 - 208pin - "SONY CXD8561BQ" ;seen on PU-18, PU-20 boards
IC203 - 208pin - "SONY CXD8561CQ" ;seen on PM-41 board
IC203 - 208pin - "SONY CXD9500Q" ;with on-chip RAM ;for PM-41(2) board
IC21 - 208pin - "SONY CXD8538Q" ;seen on GP-11 (namco System 11) boards
IC103 - 208pin - "SONY CXD8654Q" ;seen on GP-15 (namco System 12) boards
```

SPU chips - Sound Processing Unit

```
IC308 - 100pin - "SONY CXD2922Q" (SPU) ;PU-7 and EARLY-PU-8
IC308 - 100pin - "SONY CXD2922BQ" (SPU) ;EARLY-PU-8
IC308 - 100pin - "SONY CXD2925Q" (SPU) ;LATE-PU-8, PU-18, PU-20
IC732 - 208pin - "SONY CXD2938Q" (SPU+CDROM) ;PSone/PM-41 Board
IC732 - 176pin - "SONY CXD2941R" (SPU+CDROM+SPU_RAM) ;PSone/PM-41(2) Board
IC402 - 24pin - "AKM AK4309VM" (Serial 2x16bit DAC);older boards only
IC405 - 8pin - "NJM2100E (TE2)" Audio Amplifier ;PU-8 and PU-22 boards
IC405 - 14pin - "NJM2174" Audio Amplifier with Mute ;later boards
```

IC106 CPU-RAM / Main RAM chips

```
IC106/IC107/IC108/IC109 - NEC 424805AL-A60 (28pin, 512Kx8) (PU-8 board)
IC106 - "Samsung K4Q153212M-JC60" (70pin, 512Kx32) (newer boards)
IC106 - "Toshiba T7X16 (70pin, 512Kx32) (newer boards, too)
```

GPU-RAM / Video RAM chips

```
IC201 - 64pin NEC uPD482445LGW-A70-S ;VRAM ;\on PU-7 and EARLY-PU-8 board
IC202 - 64pin NEC uPD482445LGW-A70-S ;VRAM ;/split into 2 chips !
IC201 - 64pin SEC KM4216Y256G-60 ;VRAM ;\on other PU-7 board
IC202 - 64pin SEC KM4216Y256G-60 ;VRAM ;/split into 2 chips !
IC201 - 100pin - Samsung KM4132G271BQ-10 (128Kx32x2) ;-on later boards
IC201 - 100pin - Samsung K4G163222A-PC70 (256Kx32x2) ;-on PM-41
```

Note: The older 64pin VRAM chips are special dual-ported DRAM, the newer 100pin VRAM chips are just regular DRAM.

Note: The PM-41 board uses a 2MB VRAM chip (but allows to access only 1MB)

Note: The PM-41(2) board has on-chip RAM in the GPU (no external memory chip)

IC310 - SPU-RAM - Sound RAM chips

```
IC310 - 40pin - "TOSHIBA TC51V4260DJ-70" ;seen on PU-8 board
IC310 - 40pin - EliteMT M11B416256A-35J (256K x 16bit)
```

Note: The PM-41(2) board has on-chip RAM in the SPU (no external memory chip)

BIOS ROM

```
IC102 - 40pin - "SONY ..." ;seen on PU-7 & early-PU-8 board (40pin!)
IC102 - 44pin - "SONY M538032E-02" ;seen on PU-16 (video CD, 1Mbyte BIOS)
IC102 - 32pin - "SONY M534031C-25" ;seen on later-PU-8 board
IC102 - 32pin - "SONY 2022" ;seen on PU-8 (1-658-467-23)
IC102 - 32pin - "SONY 2030" ;seen on PU-18 board
IC102 - 32pin - "SONY M534031E-47" ;seen on PM-41 board and PM-41(2)
IC102 - 32pin - "SONY M27V401D-41" ;seen on PM-41 board, too
```

Oscillators and Clock Multiplier/Divider

```
X101 - 4pin - "67.737" (NTSC, presumably) ;PU-7 .. PU-20
X201 - 2pin - "17.734" (PAL) or "14.318" (NTSC) ;PU-22 .. PM-41(2)
IC204 - 8pin - "2294A" (PAL) or <unknown?> (NTSC) ;PU-22 .. PM-41(2)
```

Voltage Converter (for +7.5V to +5.0V conversion)

```
IC601 - 3pin - "78M05" or "78005" ;used in PSone
```

Pulse-Width-Modulation Power-Control Chip

```
IC606 16pin/10mm "TL594CD" (alternately to IC607) ;seen on PM-41 board
IC607 16pin/5mm  "T594"      (alternately to IC606) ;seen on PM-41 board, too
```

The PM-41 board has locations for both IC606 and IC607, some boards have the bigger IC606 (10mm) installed, others the smaller IC607 (5mm), both chips have exactly the same pinouts, the only difference is the size.

Reset Generator

```
IC002 - 8pin - <not installed> (would be alternately to IC003) ;\on PSone
IC003 - 5pin - <usually installed>                               ;/
IC101 - 5pin - M51957B (Reset Generator) (on PSX-power supply boards)
```

CDROM Chips

```
U42   80pin   SUB-CPU (CXP82300) with piggyback EPROM ;DTL-H2000
IC304 80pin   SUB-CPU (MC68HC05L16) 80pin package      ;PU-7 and EARLY-PU-8
IC304 52pin   SUB-CPU (MC68HC05G6) 52pin package       ;LATE-PU-8 and up
IC305 - 100pin SONY CXD1199BQ (Decoder/FIFO)           ;PU-7
IC305 - 100pin SONY CXD1815Q (Decoder/FIFO)           ;PU-8, PU-18
IC309 - 100pin SONY CXD2516Q (Signal Processor)        ;PU-7 (100pin!)
IC309 - 80pin  SONY CXD2510Q (Signal Processor)        ;PU-8 and DTL-H2510
IC702 - 48pin  SONY CXA1782BR (Servo Amplifier)        ;PU-7, PU-8
IC101 - 100pin SONY CXD2515Q (=CXD2510Q+CXA1782BR)    ;DTL-H2010
IC701 - 100pin SONY CXD2545Q (=CXD2510Q+CXA1782BR)    ;PU-18
IC720 - 144pin SONY CXD1817R (=CXD2545Q+CXD1815Q)     ;PU-20
IC102 - 28pin - "BA6297AFP"                          ;seen on DTL-H2010 drives
IC704 - 28pin - "BA6398FP"                            ;seen on PU-7
IC722 - 28pin - "BA6397FP"                            ;seen on late PU-8
IC722 - 28pin - "BA5947FP"                            ;seen on PM-41 and various boards
IC722 - 28pin - "Panasonic AN8732SB"                  ;seen on PM-41 board
ICxxx - 20pin  SONY CXA1571N (RF Amplifier) (on DTL-H2010 drives)
IC703 - 20pin  SONY CXA1791N (RF Amplifier) (on PU-18 boards)
IC723 - 20pin  SONY CXA2575N-T4 (RF Matrix Amplifier) (on PU-22 .. PM-41(2))
```

Note: The SUB-CPU contains an on-chip BIOS (which does exist in at least seven versions, plus US/JP/PAL-region variants, plus region-free debug variants).

RGB Chips

```

IC207 64pin "SONY CXD2923AR" VRAM Data to Analog RGB      ;\oldest
IC501 24pin "SONY CXA1645M" Analog RGB to Composite      ;/
IC202 44pin "Philips TDA8771H" Digital RGB to Analog RGB ;\old boards
IC202 44pin "Motorola MC141685FT" Digital RGB to Analog RGB ;/
IC?   48pin "H7240AKV" 24bit RGB to Analog+Composite    ;-SCPH-7001?
IC502 48pin "SONY CXA2106R-T4" 24bit RGB to Analog+Composite ;-newer boards

```

MISC

```

CDROM Drive: "KSM-440BAM" ;seen used with PM-41 board
IC602 5pin      "L/\1B" or "<symbol> 3DR"

```

Controller/Memory Card Chips

```

U?  24pin "9625H, CFS8121"      ;SCPH-1080, digital pad (alternate?)
U?   ?pin "SC438001"            ;SCPH-1080, digital pad (alternate?)
U?  32pin "(M), SC401800"        ;SCPH-1080, digital pad
U?  32pin "(M), SC442116"        ;SCPH-xxxx, mouse
IC? 64pin "SONY CXD103, -166Q"   ;SCPH-1070, multitap
U1  42pin "SD657, 9702K3006"     ;SCPH-1150, analog pad, single motor
U1  42pin "SD657, 9726K3002"     ;SCPH-1180, analog pad, without motor
U1  44pin "SONY CXD8771Q"        ;SCPH-1200, analog pad, two motors (PSX)
U1  44pin "SD707, 039 107"      ;SCPH-110, analog pad, two motors (PSone)
U1  44pin "SD787A"              ;SCPH-xxx, analog pad, two motors (PS2?)
U?  64pin "SONY CXD8732AQ"       ;SCPH-1020, memory card, on-chip FLASH
U?  XXpin other chips           ;SCPH-xxxx, memory card, external FLASH
U1  44pin "NAMCO103P"           ;NPC-103, namco lightgun

```


27.5 Pinouts - CPU Pinouts

CPU Pinouts (IC103)

Pin	Name	Pin	Name	Pin	Name	Pin
1	VDD	53	VDD	105	VDD	157
2	VDD	54	VDD	106	VDD	158
3	CRYSTALN	55	RAM.A11	107	SBUS.D0	159
4	CRYSTALP	56	RAM.A10	108	SBUS.D1	160
5	RAM.D31	57	RAM.A9	109	SBUS.D2	161
6	RAM.D30	58	RAM.A8	110	SBUS.D3	162
7	RAM.D29	59	RAM.A7	111	SBUS.D4	163
8	RAM.D28	60	RAM.A6	112	SBUS.D5	164
9	RAM.D27	61	RAM.A5	113	SBUS.D6	165
10	RAM.D26	62	RAM.A4	114	SBUS.D7	166
11	RAM.D25	63	RAM.A3	115	SBUS.D8	167
12	RAM.D24	64	RAM.A2	116	SBUS.D9	168
13	RAM.D23	65	GND	117	GND	169
14	VDD	66	VDD	118	VDD	170
15	GND	67	RAM.A1	119	SBUS.D10	171
16	RAM.D22	68	RAM.A0	120	SBUS.D11	172
17	RAM.D21	69	/RC_NET	121	SBUS.D12	173
18	RAM.D20	70	SIO1./RTS	122	SBUS.D13	174
19	RAM.D19	71	SIO1./CTS	123	SBUS.D14	175
20	RAM.D18	72	SIO1./DTR	124	SBUS.D15	176
21	RAM.D17	73	SIO1./DSR	125	SBUS.A0	177
22	RAM.D16	74	SIO1.TX	126	SBUS.A1	178
23	RAM.D15	75	SIO1.RX	127	SBUS.A2	179
24	RAM.D14	76	/EXT_RESET	128	SBUS.A3	180
25	RAM.D13	77	SIO0./DTR2	129	SBUS.A4	181
26	VDD	78	GND	130	GND	182
27	GND	79	VDD	131	VDD	183
28	RAM.D12	80	SIO0./DTR1	132	SBUS.A5	184
29	RAM.D11	81	SIO0./SCK	133	SBUS.A6	185
30	RAM.D10	82	SIO0./DSR	134	SBUS.A7	186
31	RAM.D9	83	SIO0.TX	135	SBUS.A8	187
32	RAM.D8	84	SIO0.RX	136	SBUS.A9	188
33	RAM.D7	85	SBUS.DACK5_PIO	137	SBUS.A10	189

Pin	Name	Pin	Name	Pin	Name	Pin
34	RAM.D6	86	SBUS.DREQ5_PIO	138	SBUS.A11	190
35	RAM.D5	87	SBUS.DACK4_SPU	139	SBUS.A12	191
36	RAM.D4	88	SBUS.DREQ4_SPU	140	SBUS.A13	192
37	RAM.D3	89	/IRQ10_PIO	141	SBUS.A14	193
38	VDD	90	/IRQ9_SPU	142	SBUS.A15	194
39	GND	91	GND	143	GND	195
40	RAM.D2	92	VDD	144	VDD	196
41	RAM.D1	93	/CSHTST	145	SBUS.A16	197
42	RAM.D0	94	/IRQ2_CDROM	146	SBUS.A17	198
43	RAM./WE	95	SBUS./CS5_CDROM	147	SBUS.A18	199
44	RAM./RAS1	96	SBUS./CS4_SPU	148	SBUS.A19	200
45	RAM./RAS0	97	SBUS./CS2_BIOS	149	SBUS.A20	201
46	RAM./CAS3	98	SBUS./CS0_EXP1	150	SBUS.A21	202
47	RAM./CAS2	99	SBUS./WR1	151	SBUS.A22	203
48	RAM./CAS1	100	SBUS./WR0	152	SBUS.A23	204
49	RAM./CAS0	101	SBUS./RD	153	GPU.A0	205
50	VDD	102	/IRQ1_GPU	154	SYSCK1	206
51	GND	103	GND	155	GND	207
52	GND	104	GND	156	GND	208

Pin5-68 = Main RAM bus. Pin 95-152 = System bus. Pin 102,153,159-206 = Video bus.

CPU Pinout Notes

- On (some?) retail consoles, RAM.A11 is wired to the RAM chips' A8 line, while RAM.A8 and RAM.A10 are left unconnected.
- RAM./RAS1 is only used on systems with 4 or 8 MB RAM.
- /RC_NET is tied to 3.5V, while /CSHTST (test pin?) is wired to ground.
- SYSCK0 (33 MHz), DSYSCK0 (67 MHz) and SYSCK1 (33 MHz) are clock outputs from the CPU to the rest of the system.
- TIMER0.CLK is fed from the GPU's DOTCK output, while TIMER1.CLK is fed from its HBLANK output.

- `CRYSTALP` and `CRYSTALN` are meant to be connected to a crystal, however all known console models feed `CRYSTALP` with the clock generated by an external oscillator and leave `CRYSTALN` open.
- `SBUS./WR1` (upper byte write strobe) is routed to the expansion port but otherwise left unused, as all system bus devices are either 8-bit (CD-ROM, BIOS ROM) or only support 16-bit writes (SPU).
- `SBUS.A0-SBUS.A23` are latched outputs and are not affected by RAM and GPU addressing.

27.6 Pinouts - GPU Pinouts (for old 160-pin GPU)

Old 160-pin GPU is used on PU-7 boards and EARLY-PU-8 boards.

IC203 - Sony CXD8514Q - Old 160pin GPU for use with Dual-ported VRAM

Unlike the later 208pin GPU's, the old 160pin GPU has less supply pins, and, it doesn't have a 24bit RGB output (nor any other video output at all), instead, it's used with a RGB D/A converter that reads the video data directly from the Dual-ported VRAM chips (ie. from special RAM chips with two data busses, one bus for GPU read/write access, and one for the RGB video output).

1-VCC	21-GND	41-D16	61-D2	81-D12'a	101-GND	121-D7'b	141-GND
2-GND	22-D31	42-D15	62-D1	82-D11'a	102-DT/OE'b	122-D6'b	142-53MHz
3-/GPUCS	23-D30	43-VCC	63-D0	83-D10'a	103-DT/OE'a	123-D5'b	143-VCC
4-GPU.A2	24-D29	44-GND	64-GND	84-D9'a	104-/RAS	124-D4'b	144-GND
5-/GPURD	25-D28	45-D14	65-VCC	85-D8'a	105-/WE'a	125-D3'b	145-FSC
6-/GPUWR	26-D27	46-D13	66-A8'a	86-VCC	106-/WE'b	126-D2'b	146-VCC
7-DACK2	27-D26	47-D12	67-A7'a	87-GND	107-/SE	127-D1'b	147-GND
8-/RESET	28-VCC	48-D11	68-A6'a	88-D7'a	108-SC	128-D0'b	148-DOTCLK
9-VCC	29-GND	49-D10	69-A5'a	89-D6'a	109-VCC	129-VCC	149-VCC
10-GND	30-D25	50-GND	70-GND	90-D5'a	110-GND	130-GND	150-GND
11-SYSCK0	31-D24	51-VCC	71-A4'a	91-D4'a	111-D15'b	131-A8'b	151-MEMCK1
12-VCC	32-D23	52-D9	72-A3'a	92-D3'a	112-D14'b	132-A7'b	152-MEMCK2
13-GND	33-D22	53-D8	73-A2'a	93-D2'a	113-D13'b	133-A6'b	153-BLANK
14-DREQ2	34-D21	54-D7	74-A1'a	94-D1'a	114-D12'b	134-A5'b	154-/24BPP
15-/IRQ1	35-D20	55-D6	75-A0'a	95-D0'a	115-D11'b	135-A4'b	155-/CSYNC
16-HBLANK	36-VCC	56-D5	76-GND	96-VCC	116-D10'b	136-A3'b	156-/HSYNC
17-VBLANK	37-GND	57-D4	77-VCC	97-DSF	117-D9'b	137-A2'b	157-/VSYNC
18-high?	38-D19	58-D3	78-D15'a	98-/CAS'b	118-D8'b	138-A1'b	158-VCC
19-high?	39-D18	59-GND	79-D14'a	99-/CAS'a	119-VCC	139-A0'b	159-GND
20-VCC	40-D17	60-VCC	80-D13'a	100-VCC	120-GND	140-VCC	160-DSYSCK0

Pin 1-63,148,160 = CPU Bus, Pin 66-139 = VRAM Bus (two chips, A and B), Pin 142-155 = Misc (CXA and RGB chips), Pin 18-19,156-157 = Test points.

Pin 3,5,6,11,98,99,102,103,108,148,160 via 22 ohm. Pin 104,105,106 via 100 ohm. Pin 107 via 220 ohm. Pin 155 via 2200 ohm. Pin 145 via 220+2200 ohm.

```

151-?      ---      (mem clock?)
152-?      (mem clock?)
153-BLANK   (high in HBLANK & VBLANK)
154-/24BPP  (high=15bpp, low=24bpp)
156-/HSYNC  rate:65us=15KHz, low:3.5us
157-/VSYNC  rate:20ms=50Hz, low:130us=TwoLines

```

IC207 - SONY CXD2923AR - Digital VRAM to Analog RGB Converter (for old GPU)

This chip is used with the old 160pin GPU and two Dual-ported VRAM chips. The 2x16bit databus is capable of reading up to 32bits of VRAM data, and the chip does then extract the 15bit or 24bit RGB values from that data (depending on the GPU's current color depth).

The RGB outputs (pin 5,7,9) seem to be passed through transistors and capacitors... not sure how the capacitors could output constant voltage levels... unless the RGB signals are actually some kind of edge-triggering PWM pulses rather than real analog levels(?)

1-test?	9-BLUE	17-GND	25-D0'a	33-D8'a	41-D15'a	49-D7'b	57-D13'b
2-test?	10-Vxx	18-MEMCK1	26-D1'a	34-D9'a	42-D0'b	50-D8'b	58-D14'b
3-Vxx	11-test?	19-/24BPP	27-D2'a	35-D10'a	43-D1'b	51-D9'b	59-D15'b
4-Vxx	12-test?	20-MEMCK2	28-D3'a	36-D11'a	44-D2'b	52-D10'b	60-GND
5-RED	13-test?	21-BLANK	29-D4'a	37-D12'a	45-D3'b	53-D11'b	61-GND
6-Vxx	14-aGND?	22-DOTCLK	30-D5'a	38-D13'a	46-D4'b	54-D12'b	62-GND
7-GREEN	15-aGND?	23-GND	31-D6'a	39-D14'a	47-D5'b	55-GND	63-test?
8-GND	16-aGND?	24-Vxx	32-D7'a	40-GND	48-D6'b	56-Vxx	64-GND

Pin 5,7,9 = RGB outputs (via transistors and capacitors?), Pin 18-22 = GPU, Pin 25-59 = VRAM (chip A and B), Pin 1-2,11-13,63 = Test points.

IC201 - 64pin NEC uPD482445LGW-A70-S or SEC KM4216Y256G-60 (VRAM 256Kx16)

IC202 - 64pin NEC uPD482445LGW-A70-S or SEC KM4216Y256G-60 (VRAM 256Kx16)

These are special Dual-ported VRAM chips (with two data busses), the D0-D15 pins are wired to the GPU (for read/write access), the Q0-Q15 pins are wired to the RGB D/A converter (for sequential video output).

1-VCC	9-Q2	17-D5	25-/UWE	33-GND	41-DSF	49-Q10	57-VCC
2-/DT/OE	10-D2	18-VCC	26-/RAS	34-A3	42-GND	50-D11	58-D14
3-GND	11-Q3	19-Q6	27-A8	35-A2	43-D8	51-Q11	59-Q14
4-Q0	12-D3	20-D6	28-A7	36-A1	44-Q8	52-GND	60-D15
5-D0	13-GND	21-Q7	29-A6	37-A0	45-D9	53-D12	61-Q15
6-Q1	14-Q4	22-D7	30-A5	38-QSF	46-Q9	54-Q12	62-GND
7-D1	15-D4	23-GND	31-A4	39-/CAS	47-VCC	55-D13	63-/SE
8-VCC	16-Q5	24-/LWE	32-VCC	40-NC	48-D10	56-Q13	64-SC

The 8bit /LWE and /UWE write signals are shortcut with each other and wired to the GPU's 16bit /WE write signal.

IC501 24pin "SONY CXA1645M" Analog RGB to Composite (older boards only)

1-GND1	4-BIN	7-NPIN	10-SYNCIN	13-IREF	16-YOUT	19-VCC2	22-GOUT
2-RIN	5-NC	8-BFOUT	11-BC	14-VREF	17-YTRAP	20-CVOUT	23-ROUT
3-GIN	6-SCIN	9-YCLPC	12-VCC1	15-COUT	18-FO	21-BOUT	24-GND2

Used only on older boards (eg. PU-7, PU-8, PU-16), newer boards generate composite signal via 48pin IC502.

Pin7 (NPIN): NTSC=VCC, PAL=GND. Pin6 (SCIN aka FSC): Sub Carrier aka PAL/NTSC color clock, which can be derived from three different sources:

```
GPU pin 145 (old 160-pin GPU)
GPU pin 154 (new 208-pin GPU)
IC204 (on later boards, eg. PSone)
```

for the color clocks from GPU pins, the GPU does try to automatically generate PAL or NTSC clock depending on current frame rate, which is resulting in "wrong" color clock when changing between 50Hz/60Hz mode).

27.7 Pinouts - GPU Pinouts (for new 208-pin GPU)

New 206-pin GPU is used LATE-PU-8 boards and up.

GPU Pinouts (IC203)

Pin	Name	Pin	Name	Pin	Name	Pin
1	HOST./CS	53	HOST.D10	105	GND	157
2	HOST.A0	54	HOST.D9	106	VDD	158
3	HOST./RD	55	HOST.D8	107	SGRAM.D9	159
4	HOST./WR	56	HOST.D7	108	SGRAM.D8	160
5	HOST.DACK	57	HOST.D6	109	SGRAM.D7	161
6	/RESET	58	HOST.D5	110	SGRAM.D6	162
7	VDD	59	HOST.D4	111	SGRAM.D5	163
8	GND	60	GND	112	SGRAM.D4	164
9	/SYSCLK	61	VDD	113	GND	165
10	VDD	62	HOST.D3	114	VDD	166
11	GND	63	HOST.D2	115	SGRAM.D3	167
12	HOST.DREQ	64	HOST.D1	116	SGRAM.D2	168
13	HOST./IRQ	65	HOST.D0	117	SGRAM.D1	169
14	HBLANK	66	GND	118	SGRAM.D0	170
15	GND	67	VDD	119	GND	171
16	VDD	68	PCKSL2	120	VDD	172
17	VBLANK	69	PCKSL1	121	SGRAM./CS1	173
18	HVHLD	70	PCKSL0	122	SGRAM./CS0	174
19	GND	71	TEST3	123	SGRAM.DSF	175
20	GND	72	TEST2	124	SGRAM./RAS	176
21	NC	73	TEST1	125	SGRAM./CAS	177
22	VDD	74	TEST0	126	SGRAM./WE	178
23	VDD	75	VDD	127	SGRAM.DQMH	179
24	HOST.D31	76	GND	128	SGRAM.DQML	180
25	HOST.D30	77	SGRAM.D31	129	GND	181
26	HOST.D29	78	SGRAM.D30	130	VDD	182
27	HOST.D28	79	SGRAM.D29	131	MCLKOUT	183
28	HOST.D27	80	VDD	132	GND	184
29	VDD	81	GND	133	VDD	185
30	GND	82	SGRAM.D28	134	MCLKIN	186
31	HOST.D26	83	SGRAM.D27	135	GND	187
32	HOST.D25	84	SGRAM.D26	136	VDD	188
33	HOST.D24	85	SGRAM.D25	137	SGRAM.A9	189

Pin	Name	Pin	Name	Pin	Name	Pin
34	HOST.D23	86	SGRAM.D24	138	SGRAM.A8	190
35	HOST.D22	87	VDD	139	SGRAM.A7	191
36	HOST.D21	88	GND	140	SGRAM.A6	192
37	VDD	89	SGRAM.D23	141	VDD	193
38	GND	90	SGRAM.D22	142	GND	194
39	HOST.D20	91	SGRAM.D21	143	SGRAM.A5	195
40	HOST.D19	92	SGRAM.D20	144	SGRAM.A4	196
41	HOST.D18	93	SGRAM.D19	145	SGRAM.A3	197
42	HOST.D17	94	SGRAM.D18	146	GND	198
43	VDD	95	SGRAM.D17	147	VDD	199
44	GND	96	GND	148	SGRAM.A2	200
45	HOST.D16	97	VDD	149	SGRAM.A1	201
46	HOST.D15	98	SGRAM.D16	150	SGRAM.A0	202
47	HOST.D14	99	SGRAM.D15	151	VDD	203
48	HOST.D13	100	SGRAM.D14	152	GND	204
49	HOST.D12	101	SGRAM.D13	153	FSC	205
50	HOST.D11	102	SGRAM.D12	154	VDD	206
51	VDD	103	SGRAM.D11	155	GND	207
52	GND	104	SGRAM.D10	156	CSYNC	208

Pin 77..150 = Video RAM Bus. Pin 156..189 = Video Out Bus. Other = CPU Bus. Pin 153: Sub Carrier (NC on newer boards which pick color clock from IC204).

GPU Pinout Notes

- SGRAM./CS1 is only used on arcade boards with 2 MB VRAM (two 1 MB chips).
- HVHLD is a lightgun input (similar to /IRQ10 but handled in hardware) used only by some arcade boards. On retail consoles it has a 4.7k pullup to 3.5V.
- TEST0-TEST3 are tied to 3.5V. PCKSL0-PCKSL2 (outputs possibly related to the current horizontal/vertical resolution and thus pixel clock?) are left unconnected.
- MCLKIN and MCLKOUT are tied together and wired to the DAC's clock input. MCLKIN could possibly be an external clock input for genlocking purposes.

- On earlier motherboards and on most arcade boards only `VCLK_PAL` or `VCLK_NTSC` is wired up, depending on the console's region. On later boards both are tied together and connected to a programmable clock generator, which is preprogrammed to generate the appropriate frequency.
- `/VSYNC` and `/HSYNC` are only connected to test points.
- `/CSYNC = (/VSYNC AND /HSYNC)` . `BLANK = (VBLANK OR HBLANK)` .
- `SGRAM.DQML` is wired to both `DQM0` and `DQM2` on the SGRAM, while `SGRAM.DQMH` is wired to both `DQM1` and `DQM3` .
- `DMASK` outputs the mask/"alpha" bit of the current pixel and is used by some arcade boards to composite the GPU's output on top of an external video source. `ODE2` indicates which field is currently being output in interlaced mode.

IC202 44pin "Philips TDA8771H" Digital to Analog RGB (older boards only)

Region Japan+Europe: TDA8771AN

Region America+Asia: MC151854FLTEG or so?

1-IREF	6-GNDd1	11-R1	16-G4	21-B7	26-B2	31-CLK	36-OUTB	41-NC
2-GNDa1	7-VDDd1	12-R0	17-G3	22-B6	27-VDDd2	32-VDDa1	37-NC	42-GNDa2
3-R7	8-R4	13-G7	18-G2	23-B5	28-GNDd2	33-VREF	38-NC	43-VDDa4
4-R6	9-R3	14-G6	19-G1	24-B4	29-B1	34-NC	39-VDDa3	44-OUTR
5-R5	10-R2	15-G5	20-G0	25-B3	30-B0	35-VDDa2	40-OUTG	

Used only LATE-PU-8 boards (and PU-16, which does even have two TDA8771AH chips: one on the mainboard, and one on the VCD daughterboard).

Earlier boards are generating analog RGB via 64pin IC207, and later boards RGB via 48pin IC502.

IC502 48pin "SONY CXA2106R-T4" - 24bit RGB video D/A converter

Pin	Name	Pin	Name	Pin	Name	Pin
1	BCLAMP	13	NTSC/PAL	25	G7	37
2	AGND2	14	SYNCIN	26	G6	38
3	ROUT	15	SCIN	27	G5	39
4	GOUT	16	R7	28	G4	40
5	BOUT	17	R6	29	G3	41
6	YOUT	18	R5	30	G2	42
7	COUT	19	R4	31	G1	43
8	VOUT	20	DVDD	32	G0	44
9	AVCC2	21	R3	33	B7	45
10	YTRAP	22	R2	34	B6	46
11	NC	23	R1	35	B5	47
12	POWER_SAVE	24	R0	36	B4	48

Pin 3..8 (analogue outputs) are passed via external 75 ohm resistors.

Pin 6,7 additionally via 220uF. Pin 8 additionally via smaller capacitor.

Pin 10 (YTRAP) wired via 2K7 to 5.0V.

Pin 1,44,46,48 (can) connect via capacitors to ground (only installed for 44).

The 4.4MHz clock is obtained via 2K2 from IC204.Pin6.

The /PAL pin can be reportedly GROUNDED to force PAL colors in NTSC mode, when doing that, you may first want to disconnect the pin from the GPU.

Note: Rohm BH7240AKV has same pinout (XXX but with pin7/pin8 swapped?)

Beware

Measuring in the region near GPU Pin10 is the nocash number one source for blowing up components on the mainboard. If you want to measure that signals while power is on, better measure them at the CPU side.

27.8 Pinouts - SPU Pinouts

IC308 - SONY CXD2922Q (SPU) (on PU-7, EARLY-PU-8 boards)

IC308 - SONY CXD2925Q (SPU) (on LATE-PU-8, PU-16, PU-18, PU-20 boards)

1-D0	14-D11	27-A8	40-GND	53-3.5V	66-A15	79-5V	92-LRIA
2-D1	15-GND	28-3.5V	41-SYSCK	54-GND	67-A14	80-A3	93-DTIA
3-3.5V	16-D12	29-GND	42-GND	55-D7	68-A13	81-A2	94-BCIB
4-GND	17-D13	30-A9	43-TEST	56-D6	69-A12	82-A1	95-LRIB
5-D2	18-D14	31-/SPU	44-TES2	57-D5	70-A11	83-A0	96-DTIB
6-D3	19-D15	32-/RD	45-D15	58-D4	71-A10	84-/WE0	97-BCKO
7-D4	20-A1	33-/WR	46-D14	59-D3	72-A9	85-/OE0	98-LRCO
8-D5	21-A2	34-DACK	47-D13	60-D2	73-A8	86-/WE1	99-DATO
9-D6	22-A3	35-/IRQ	48-D12	61-D1	74-A7	87-/OE1	100-WCKO
10-D7	23-A4	36-DREQ	49-D11	62-D0	75-A6	88-GND	
11-D8	24-A5	37-MUTE	50-D10	63-/RAS	76-A5	89-XCK	
12-D9	25-A6	38-/RST	51-D9	64-/CAS	77-A4	90-GND	
13-D10	26-A7	39-NC	52-D8	65-GND	78-GND	91-BCIA	

Pin 1..36 = MIPS-CPU bus. Pin 45..87 = SPU-RAM bus (A0,A10-A15,/WE1,OE1=NC). Pin 91..99 = Digital serial audio in/out (A=CDROM, B=EXP, O=OUT).

IC732 - SONY CXD2941R (SPU+CDROM+SPU_RAM) (on PM-41(2) boards)

1-DA16	23-FILO	45-LOCK	67-FSTO	89-SCSY	111-XCS	133-HD9	155-VSS5
2-DA15	24-FILI	46-SSTP	68-COUT	90-SCLK	112-XRD	134-HD8	156-HA1
3-DA14	25-PCO	47-SFDR	69-XDRST	91-SQSO	113-XWR	135-HD7	157-HA0
4-VDDM0	26-CLTV	48-SRDR	70-DA11	92-SENS	114-HINT	136-HD6	158-VDDM3
5-DA13	27-AVSSO	49-TFDR	71-DA10	93-DATA	115-XIRQ	137-VDD4	159-XCK
6-DA12	28-RFAC	50-TRDR	72-DA09	94-XLAT	116-VDDM2	138-HD5	160-DTIB
7-LRCK	29-BIAS	51-VSSM1	73-DA08	95-CLOCK	117-XSCS	139-HD4	161-BCKO
8-WDCK	30-ASYI	52-FFDA	74-AVSMO	96-XINT	118-XHCS	140-HD3	162-LRCO
9-VDD0	31-AVDDO	53-FRDA	75-AVDMO	97-A4	119-XHRD	141-HD2	163-DAVDD0
10-VSS0	32-ASYO	54-MDP	76-DA07	98-A3	120-XHWR	142-VSS4	164-DAREFL
11-PSSL	33-VC	55-MDS	77-DA06	99-A2	121-DACK	143-HD1	165-AOUTL
12-ASYE	34-CE	56-VDD2	78-VDDM1	100-A1	122-DREQ	144-HD0	166-DAVSS0
13-GND	35-CEO	57-VSS2	79-DA05	101-A0	123-XRST	145-VSSM3	167-DAVSS1
14-C4M	36-CEI	58-MIRR	80-DA04	102-D7	124-VDD3	146-HA9	168-AOUTR
15-C16M	37-RFDC	59-DFCT	81-DA03	103-D6	125-SYSCK	147-HA8	169-DAREFR
16-FSOF	38-ADIO	60-AVSM1	82-DA02	104-D5	126-VSS3	148-HA7	170-DAVDD1
17-XTSL	39-AVDD1	61-AVDM1	83-DA01	105-D4	127-HD15	149-HA6	171-MUTO
18-VDD1	40-IGEN	62-FOK	84-WFCK	106-VSSM2	128-HD14	150-HA5	172-DATO
19-GND	41-AVSS1	63-PWMI	85-SCOR	107-D3	129-HD13	151-HA4	173-MTS3
20-VPCO1	42-TE	64-FSW	86-SBSO	108-D2	130-HD12	152-VDD5	174-MTS2
21-VPCO2	43-SE	65-MON	87-EXCK	109-D1	131-HD11	153-HA3	175-MTS1
22-VCTL	44-FE	66-ATSK	88-SQCK	110-D0	132-HD10	154-HA2	176-MTS0

IC732 - SONY CXD2938Q (SPU+CDROM) (on newer boards) (PM-41 boards)

1-SCLK	27-RFAC	53-TrckR	79-/XINT	105-A0	131-3.5V	157-(tst)	183-A8
2-GNDed	28-GNDed	54-TrckF	80-SQCK	106-3.5V	132-D9	158-(tst)	184-A7
3-GNDed	29-CLTV	55-FocuR	81-SQSO	107-A1	133-D8	159-GND	185-A6
4-SBSO	30-PCO	56-3.5V	82-SENSE	108-A2	134-D7	160-D15	186-A5
5-WFCK	31-FILI	57-FocuF	83-GND	109-A3	135-D6	161-D0	187-GND
6-GNDed	32-FILO	58-SledR	84-GND	110-A4	136-D5	162-D14	188-A4

7-C16M	33-VCTL	59-SledF	85-CD.D7	111-A5	137-3.5V	163-D1	189-A3
8-3.5V	34-VPC02	60-NC	86-CD.D6	112-3.5V	138-D4	164-D13	190-A2
9-C4M	35-VPC01	61-GND	87-CD.D5	113-A6	139-D3	165-3.5V	191-A1
10-GNDed	36-VC	62-NC	88-CD.D4	114-A7	140-D2	166-D2	192-A0
11-4.3MHz	37-FE	63-GND	89-CD.D3	115-A8	141-D1	167-D12	193-3.5V
12-12MHz	38-SE	64-(tst)	90-CD.D2	116-A9	142-D0	168-D3	194-NC
13-V16M	39-TE	65-(tst)	91-CD.D1	117-/IRQ2	143-GND	169-D11	195-(tst)
14-DOUT	40-CE	66-note	92-CD.D0	118-/IRQ9	144-33MHzS	170-D10	196-GND
15-LACK	41-CEO	67-note	93-3.5V	119-/RD	145-	171-D4	197-(tst)
16-WDCK	42-CEI	68-(tst)	94-CD/CS	120-/WR	146-3.48V	172-D9	198-NC
17-3.5Ved	43-RFDC	69-3.5V	95-CD/WR	121-DMA4	147-ZZ11	173-GND	199-NC
18-LOCK	44-ADIO	70-(tst)	96-CD/RD	122-GND	148-GND	174-D5	200-NC
19-GND	45-GND	71-(tst)	97-CD.A0	123-GND	149-GND	175-D8	201-3.5V
20-MDS	46-IGEN	72-(tst)	98-CD.A1	124-/SPUW	150-ZZ7	176-D6	202-NC
21-MDP	47-AVD1	73-(tst)	99-CD.A2	125-D15	151-3.48V	177-D7	203-NC
22-3.5Ved	48-GNDed	74-DATA	100-GND	126-D14	152-/RES	178-/CAS	204-NC
23-AVDO	49-GNDed	75-XLAT	101-CDA3	127-D13	153-3.5V	179-/WE	205-GND
24-ASYO	50-GND	76-CLOK	102-CDA4	128-D12	154-ZZ5	180-3.5V	206-(tst)
25-ASYI	51-GNDed	77-SCOR	103-/CD	129-D11	155-(tst)	181-/OE	207-(tst)
26-BIAS	52-GNDed	78-GND	104-/SPU	130-D10	156-(tst)	182-/RAS	208-GND

Pin 74..102 = SubCPU. Pin 103..144 = MainCPU. Pin 160..192 = Sound RAM Bus.

Pin 21 and 53..59 = Drive Motor Control (IC722).

Pin 1..47 are probably mainly CDROM related.

Pin 39 "TE9" = IC723.Pin16 - CL709, and via 15K to SPU.39

Pin 66 connects via 4K7 to IC723.Pin19.

Pin 67 not connected (but there's room for an optional capacitor or resistor)

The (tst) pins are wired to test points (but not connected to any components)

CXD2938Q SPU Pinout Notes

Pin 74,75,76,119,120 are connected via 22 ohm.

Pin 103,104 are connected via 100 ohm.

ZZnn = IC405 Pin nn (analog audio related, L/R/MUTE).

Pin 103..142 = System Bus (BIOS,CPU). Pin 160..192 = Sound RAM Bus.

Pin 178 used for both /CASL and /CASH (which are shortcut with each other).

Pin 146 and 151 are 3.48V (another supply, not 3.5V).

Pin 147 and 150 are connected via capacitors.

Pin 195 and 197 testpoints are found below of the pin 206/207 testpoints.

```
SPU155 (tst) always low           ;=maybe external audio (serial) this?
SPU156 (tst) 45kHz (22us)         ;=probably 44.1kHz (ext audio sample-rate)
SPU157 (tst) 2777kHz (0.36us)     ;=probably 64*44.1kHz (ext audio bit-rate)
SPU158 (tst) always high          ;=maybe external audio (serial) or this?
```

SPU.Pin5 connects to MANY modchips

SPU.Pin42 connects to ALL modchips

SPU.Pin42 via capacitor to SPU.Pin41, and via resistor?/diode? to IC723.10

CXD2938Q CDROM clocks

```
SPU197  (*) 7.35kHz (44.1kHz/6) (stable clock, maybe DESIRED drive speed)
SPU5    (*) 7.35kHz (44.1kHz/6) (unstable clock, maybe ACTUAL drive speed)
SPU15   (*) 44.1kHz (44.1kHz*1)
SPU16   (*) 88.2kHz (44.1kHz*2)
SPU206  (*) circa 2.27MHz
SPU70   (*) whatever clock (with SHORT low pulses)
```

(*) these frequencies are twice as fast in double speed mode.

CXD2938Q CDROM signals

```
SPU207  fastsignal?
SPU195  slowsignal?
SPU18   usually high, low during seek or spinup or so
SPU44   superslow hi/lo with superfast noise on it
SPU73   mainly LOW with occasional HIGH levels...
SPU71   LOW=SPIN_OK, PULSE=SPIN_UP/DOWN_OR_STOPPED
SPU72   similar as SPU71
SPU64   LOW=STOP, HI=SPIN
SPU68   always low...?
SPU65   whatever?
SPU75   mainly HIGH, short LOW pulses when changing speed up/down/break
```

CXD2938Q CDROM/SPU Testpoints (on PM-41 board)

```

      |
      | CXD2938Q (SPU)
      | (on PM-41 board)
      |
SPU206 SPU207 |_____|
SPU197
      |
      | SPU16
SPU195          SPU44
      |
      | SPU18 SPU5 SPU15
      | SPU12
```

IC402 - 24pin AKM AK4309VM (or AK4309AVM/AK4310VM) - Serial 2x16bit DAC

1-TST?	4-/PD	7-CKS	10-LRCK	13-NC?	16-AOUTL	19-GNDa	22-VREFH
2-VCCd	5-/RST	8-BICK	11-NC?	14-NC?	17-VCOM	20-NC?	23-VREFL
3-GNDd	6-MCLK	9-SDATA	12-NC?	15-AOUTR	18-VCCa	21-NC?	24-DZF?

Used only on older boards (eg. PU-8), newer boards seem to have the DAC in the 208pin SPU.

No 24pin AK4309VM datasheet exists (however it seems to be same as 20pin AK4309B's, with four extra NC pins at pin10-14).

IC405 - "2174, 1047C, JRC" or "3527, 0A68" (on newer boards)

Called "NJM2174" in service manual. Audio Amplifier with Mute.

```

1  GND
2  NC      ? via 100ohm to multiout pin 9      ;Audio Left (white cinch)
3  OUT-R   ?
4  MUTE1    ;specified as LOW = Mute
5  MUTE2    ;specified as HIGH = Mute
6  MUTE1    ;unspecified, maybe capacitor, or output based on MUTE1+MUTE2?
7  IN-R     via capacitor to SPU.150
8  BIAS
9  NC
10 NC
11 IN-L     via capacitor to SPU.147
12 OUT-L   ?
13 NC      ? via 100ohm to multiout pin 11    ;Audio Right (red cinch)
14 VCC     +5.0V (via L401)

```

Audio amplifier, for raising the signals to 5V levels.

IC405 - "NJM2100E (TE2)" Audio Amplifier (on older PU-8 and PU-22 boards)

```

1-ROUT
2-RIN- IC732.SPU.150
3-RIN+
4-GND
5-LIN+
6-LIN- IC732.SPU.147
7-LOUT
8-VCC 4.9V (+5.0V via L401)

```

27.9 Pinouts - DRV Pinouts

IC304 - 52pin/80pin - Motorola HC05 8bit CPU

[Pinouts - HC05 Pinouts](#)

IC305 - SONY CXD1815Q - CDROM Decoder/FIFO (used on PU-8, PU-16, PU-18)

1-D0	14-/XINT	27-/HRD	40-GND	53-VDD	66-/MWR	79-GND	92-LRCK
2-D1	15-GND	28-VDD	41-HDRQ	54-GND	67-MDB0	80-CLK	93-WCKO
3-VDD	16-A0	29-GND	42-/HAC	55-MA8	68-MDB1	81-HCLK	94-BCKO
4-GND	17-A1	30-/HWR	43-MA0	56-MA9	69-MDB2	82-CKSL	95-MUTE
5-D2	18-A2	31-HD0	44-MA1	57-MA10	70-MDB3	83-RMCK	96-TD7
6-D3	19-A3	32-HD1	45-MA2	58-MA11	71-MDB4	84-LRCK	97-TD6
7-D4	20-A4	33-HD2	46-T01	59-MA12	72-MDB5	85-DATA	98-TD5
8-D5	21-TD0	34-HD3	47-T02	60-MA13	73-MDB6	86-BCLK	99-TD4
9-D6	22-/HRS	35-HD4	48-MA3	61-MA14	74-MDB7	87-C2PO	100-TD3
10-D7	23-/HCS	36-HD5	49-MA4	62-MA15	75-MDBP	88-EMP	
11-/CS	24-HA0	37-HD6	50-MA5	63-MA16	76-XTL2	89-/RST	
12-/RD	25-HA1	38-HD7	51-MA6	64-/MOE	77-XTL1	90-GND	
13-/WR	26-HINT	39-HDP	52-MA7	65-GND	78-VDD	91-DATO	

Pin 1..20 to HC05 CPU, pin 22..42 to MIPS cpu, pin 43..75 to SRAM cd-buffer.

The pinouts/registers in CXD1199AQ datasheet are about 99% same as CXD1815Q.

Note: Parity on the 8bit data busses is NC. SRAM is 32Kx8 (A15+A16 are NC). Later boards have this integrated in the SPU.

ICsss - SONY CXA1782BR - CDROM Servo Amplifier (used on PU-8 boards)

1-FEO	7-FE_M	13-RA_O	19-CLK	25-FOK	31-RF_O	37-FE_BIAS	43-LPFI
2-FEI	8-SRCH	14-SL_P	20-XLT	26-CC2	32-RF_M	38-F	44-TEI
3-FDFCT	9-TGU	15-SL_M	21-DATA	27-CC1	33-LD	39-E	45-ATSC
4-FGD	10-TG2	16-SL_O	22-XRST	28-CB	34-PD	40-EI	46-TZC
5-FLB	11-FSET	17-ISET	23-C.OUT	29-CP	35-PD1	41-GND	47-TDFCT
6-FE_O	12-TA_M	18-VCC	24-SENS	30-RF_I	36-PD2	42-TEO	48-VC

Datasheet exists. Later boards have CXA1782BR+CXD2510Q integrated in CXD2545Q, and even later boards have it integrated in the SPU.

IC309 - SONY CXD2510Q - CDROM Signal Processor (used on PU-8, PU-16 boards)

1-FOK	11-PDO	21-GNDa	31-WDCK	41-DA09-XPLCK	51-APTL	61-EMPH	71-DATA
2-FSW	12-GND	22-VLTV	32-LRCK	42-DA08-GFS	52-GND	62-WFCK	72-XLAT
3-MON	13-TEST0	23-VDDa	33-VDD 5V	43-DA07-RFCK	53-XTAI	63-SCOR	73-VDD
4-MDP	14-NC	24-RF	34-DA16-SDTA48	44-DA06-C2PO	54-XTAO	64-SBSO	74-CLOK
5-MDS	15-NC	25-BIAS	35-DA15-SCLK48	45-DA05-XRAOF	55-XTSL	65-EXCK	75-SEIN
6-LOCK	16-VPCO	26-ASYI	36-DA14-SDTA64	46-DA04-MNT3	56-FSTT	66-SQSO	76-CNIN
7-NC	17-VCKI	27-ASYO	37-DA13-SCLK64	47-DA03-MNT2	57-FSOF	67-SQCK	77-DATO
8-VC00	18-FILO	28-ASYE	38-DA12-LRCK64	48-DA02-MNT1	58-C16M	68-MUTE	78-XLTO
9-VC0I	19-FILI	29-NC	39-DA11-GTOP	49-DA01-MNT0	59-MD2	69-SENS	79-CLKO
10-TEST	20-PCO	30-PSSL	40-DA10-XUGF	50-APTR	60-DOUT	70-XRST	80-MIRR

Datasheet exists. Later boards have CXA1782BR+CXD2510Q integrated in CXD2545Q, and even later boards have it integrated in the SPU.

IC701 - SONY CXD2545Q - Signal Processor + Servo Amp (used on PU-18 boards)

1-SRON	14-TEST	27-TE	40-VDDa	53-DA09-XPLCK	66-FSTI	79-MUTE	92-DFCT
2-SRDR	15-GND	28-SE	41-VDD	54-DA08-GFS	67-FSTO	80-SENS	93-FOK
3-SFON	16-TES2	29-FE	42-ASYE	55-DA07-RFCK	68-FSOF	81-XRST	94-FSW
4-TFDR	17-TES3	30-VC	43-PSSL	56-DA06-C2PO	69-C16M	82-DIRC	95-MON
5-TRON	18-PDO	31-FILO	44-WDCK	57-DA05-XRAOF	70-MD2	83-SCLK	96-MDP
6-TRDR	19-VPCO	32-FILI	45-LRCK	58-DA04-MNT3	71-DOUT	84-DFSW	97-MDS
7-TFON	20-VCKI	33-PCO	46-DA16-SDTA48	59-DA03-MNT2	72-EMPH	85-ATSK	98-LOCK
8-FFDR	21-VDDa	34-CLTV	47-DA15-SCLK48	60-DA02-MNT1	73-WFCK	86-DATA	99-SSTP
9-FRON	22-IGEN	35-GNDa	48-DA14-SDTA64	61-DA01-MNT0	74-SCOR	87-XLAT	100-SFDR
10-FRDR	23-GNDa	36-RFAC	49-DA13-SCLK64	62-XTAI	75-SBSO	88-CLOK	
11-FFON	24-ADIO	37-BIAS	50-DA12-LRCK64	63-XTAO	76-EXCK	89-COUT	
12-VCOO	25-RFC	38-ASYI	51-DA11-GTOP	64-XTSL/GNDed	77-SQSO	90-VDD	
13-VCOI	26-RFDC	39-ASYO	52-DA10-XUGF	65-GND	78-SQCK	91-MIRR	

Datasheet exists. The CXD2545Q combines the functionality of CXA1782BR+CXD2510Q from older boards (later boards have it integrated in the SPU). XTAI/XTAO input is 16.9344MHz (44.1kHz*180h), with XTSL=GND. Clock outputs are FSTO=16.9344MHz/3, FSOF=16.9344MHz/4, C16M=16.9344MHz/1.

IC101 - SONY CXD2515Q - Signal Processor + Servo Amp (used on DTL-H2010)

Pinouts are same as CXD2545Q, except, three pins are different: Pin24=ADII (instead of ADIO), Pin25=ADIO (instead of RFC), Pin68=C4M (instead of FSOF).

IC720 - 144pin SONY CXD1817R (=CXD2545Q+CXD1815Q) ;PU-20

```
1..48 - unknown
49 - SCOR
50..144 - unknown
```

IC701 - 8pin chip (on bottom side, but NOT installed) (PU-7 and EARLY-PU-8)

```
1-8 Unknown (maybe CDROM related, at least it's near other CDROM chips)
```

IC722 "BA5947FP" or "Panasonic AN8732SB" - IC for Compact Disc Players

Drive Motor related.

```
1 to pin24,27
2 SPINDLE - via 15K to SPU21
3 SW (ON/OFF) - IC304.27
4 TRACKING FORWARD
5 TRACKING REVERSE
```

```

6 FOCUS FORWARD
7 FOCUS REVERSE
8 GND - CN702 pin 11
9 NC (INTERNAL) - via C731 (10uF) to GND
10 +7.5V (Pow VCC ch1,2)
11 FOCUS COIL (1) - CN702 pin 15
12 FOCUS COIL (2) - CN702 pin 14
13 TRACKING COIL (1) - CN702 pin 16
14 TRACKING COIL (2) - CN702 pin 13
15 SPINDLE MOTOR (1) - CN701 pin 4
16 SPINDLE MOTOR (2) - CN701 pin 3
17 SLED MOTOR (1) - CN701 pin 1
18 SLED MOTOR (2) - CN701 pin 2
19 +7.5V (Pow VCC ch3,4)
20 MUTE - /RES (via 5K6)
21 GND
22 SLED REVERSE
23 SLED FORWARD
24 to pin1
25 via capacitors to pin1
26 BIAS 1.75V
27 to pin1
28 +7.5V (Pre VCC)

```

Additionally to the above 28pins, the chip has two large grounded pins (between pin 7/8 and 21/22) for shielding or cooling purposes.

IC703 - 20pin - "SONY CXA1791N" (RF Amplifier) (on PU-18 boards)

```

1 LD      O APC amplifier output
2 PD      I APC amplifier input
3 PD1     I Input 1 for RF I-V amplifiers
4 PD2     I Input 2 for RF I-V amplifiers
5 GND/VEE - Supply Ground
6 F       I Input F for I-V amplifier
7 E       I Input E for I-V amplifier
8 VR      O DC Voltage Output (VCC+VEE)/2
9 VC      I Center Voltage Input
10 NC     - NC
11 NC     - NC
12 EO     O Monitoring Output for I-V amplifier E
13 EI     - Gain Adjust for I-V amplifier E
14 TE     O Tracking Error Amplifier Output
15 FE_BIAS I BIAS Adjustment for Focus Error
16 FE     O Focus Error Amplifier Output
17 RFO    O RF Amplifier Output
18 RFI    I RF Amplifier Input
19 /LD_ON I APC amplifier ON=GND, OFF=VCC
20 VCC    - Supply

```

Datasheet for CXA1791N does exist. Later boards have IC703 replaced by IC723. Older PU-7/PU-8 boards appear to have used a bunch of smaller components (8pin chips and/or transistors) instead of 20pin RF amplifiers.

IC723 - 20pin - "SONY CXA2575N-T4" (RF (Matrix?) Amplifier) (PU-22..PM-41(2))

```

1-TEIM
2-TEIG
3-VEE      GND
4-E        via 33K to CN702 pin 4
5-F        via 33K to CN702 pin 8
6-PD2      via 36K to CN702 pin 6
7-PD1      via 36K to CN702 pin 7
8-PD       to CN702 pin 9
9-LD
10-VC      CL710, and CN702.Pin3, and via resistor?/diode? to SPU42
11-LD_ON   IC304.Pin49 "LDON" ..... XXX or is that Pin 20 "LD_ON" ?
12-G_CONT                                     ;or AL/TE?
13-RF0     CL704, and...
14-RFM
15-FE      CL708, and... (maybe focus error?)
16-TE      CL709, and via 15K to SPU.39 (maybe tracking error?)
17-TE0
18-COMP+
19-MIRR    via 4K7 to SPU66
20-VCC     3.48V (not 3.5V)

```

Used only on PU-22 .. PM-41(2) boards (PU-18 boards used IC703 "CXA1791N", and even older boards... maybe had this in CXA1782BR... or maybe had it in a bunch of 8pin NJMxxxx chips?).

There is no CXA2575N datasheet (but maybe some signals do resemble CXA2570N/CXA2571N/CXA1791N datasheets).

CN702 CDROM Data Signal socket (PU-23 and PM-41 board)

```

1-LD      to Q701
2-VCC     to Q701
3-VC      to IC723.Pin10 (and CL710)
4-F-      to IC723.Pin4 (via 33K ohm)
5-NC      to CL776
6-PD2     to IC723.Pin6 (via 33K ohm)
7-PD1     to IC723.Pin7 (via 33K ohm)
8-E-      to IC723.Pin5 (via 33K ohm)
9-M1      to IC723.Pin8
10-VR     via 91 ohm to GND
11-GND    GND
12-LS     /POS0 (switch, GNDed when at head is at inner-most position)
13-FCS+   TRACKING COIL (2) ;\

```

```

14-TRK+  FOCUS COIL (2)      ; or swapped?
15-TRK   FOCUS COIL (1)      ;
16-FCS   TRACKING COIL (1)   ;/

```

PU-23 and PM-41 board seem to be using exactly the same Drive, the only difference is the length (and folding) of the attached cable.

CN701 CDROM Motor socket (PU-8, PU-18, PU-23, PM-41 boards)

```

1-SL-    SLED MOTOR (1)
2-SL+    SLED MOTOR (2)
3-SP+    SPINDLE MOTOR (2)
4-SP-    SPINDLE MOTOR (1)

```

CLnnn - Calibration Points (PU-23 and PM-41 boards)

```

CL616 +7.5V (PM-41 only, not PM-23) (before power switch)
CL617 GND    (PM-41 only, not PM-23)
CL316 to IC304 pin 21
CL704 to IC723.Pin13
CL706 GND
CL708 to IC723.Pin15
CL709 to IC723.Pin16
CL710 to IC723.Pin10, and CN702.Pin3
CL711 via 1K to IC723.Pin15
CL776 to CN702.Pin5

```

Probably test points for drive calibration or so.

27.10 Pinouts - VCD Pinouts

SCPH-5903 Video CD PlayStation

VCD Mainboard "PU-16, 1-655-191-11" Component List

The overall design is very close to LATE-PU-8 boards (1-658-467-2x). Changed components are IC102/IC304 (different kernel and cdrom firmware), C318/C325/C327 (height reduced capacitors for mounting the daughterboard above of them). Plus some extra components: Three triple multiplexors (for switching between PSX and VCD audio/video), and the daughterboard connector.

```

IC102 44pin SONY, M538032E-02, JAPAN 6465401 (uncommonly big BIOS, 1Mx8)
IC304 52pin C 4021 SC430924PB (HC05 sub-cpu, with extra Video CD command 1Fh)
C318 2pin S5 ;\tantalum capacitors with lower height (instead

```

```

C325  2pin CA7      ; of the electrolytic capacitors on PU-8 boards)
C327  2pin CA7      ;/
ICnnn 16pin 4053C (Triple multiplexor, for Audio LRCK,BCLK,DATA) (PCB top)
ICnnn 16pin 4053C (Triple multiplexor, for Video FSC,CSYNC)      (PCB bottom)
ICnnn 16pin 2283 (Triple multiplexor, for Video R,G,B)          (PCB bottom)
CNnnn 30pin Connector to daughterboard                          (PCB top)

```

VCD Daughterboard "MP-45, 1-665-192-11" Component List

```

IC102  3pin TA78M05F voltage regulator (7.5V to 5V) (Toshiba)
IC104 120pin CXD1852AQ Video CD decoder (Sony)
IC106  40pin MB814260-70 (256Kx16 DRAM) (Fujitsu) ;see also: IC114
IC107  20pin 6230FV 649 115 (OSD, similar to BU6257AFV-E2) (PCB back)
IC109  14pin Y2932 (TLC2932 PLL) (TI) (for RGB.DAC.CLK)
IC110  44pin TDA8771AH Triple Video DAC for RGB (Philips) (PCB back)
IC111  64pin CXP10224-603R 732A02E (MCU) (Sony)
IC112  14pin HCT32A (74HCT32 Quad OR gate) (TI) (PCB back) (for RGB.DAC.CLK)
IC113   8pin H74 7H (single D-type flip-flop; OSD clock divider) (PCB back)
IC114  40pin MB814260-70 (256Kx16 DRAM) (Fujitsu) ;see also: IC106
CN101  30pin Male Connector (to female 30pin socket on PU-16 mainboard)
X103   2pin 45.00MHz (for VCD decoder chip)
X104   4pin 12.000MHz (for MCU chip)
X105   2pin 28.636MHz (for VCD decoder chip) (8*3.579545 NTSC clock)

```

VCD Daughterboard Connector

```

          .---.---.
          GND / 1   2 | GND
(CXD1815Q.86) CD.BCLK | 3   4 | CD.LRCK   (CXD1815Q.84)
(CXD1815Q.87) CD.C2PO | 5   6 | CD.DATA   (CXD1815Q.85)
          GND | 7   8 | CD.SQCK   (CXD2510Q.67) CXP.31
(TDA.44) VIDEO.OUTR | 9  10 | CD.SQSO   (CXD2510Q.66) CXP.29
          GND | 11  12 | SIO.OUT   (HC05.51.PORTF1 to CXP.47)
(TDA.40) VIDEO.OUTG | 13  14 | SIO.IN   (HC05.50.PORTF0 from CXP.48)
          GND | 15  16 | SIO.CLK   (HC05.52.PORTF2 to CXP.49)
(TDA.36) VIDEO.OUTB | 17  18 | VIDEO.FSC (CXD1852AQ.95)
          GND | 19  20 | VIDEO.CSYNC (CXD1852AQ.96)
(PSU.3)      3.5V | 21  22 | 3.5V     (PSU.3)
(PSU.1)      7.5V | 23  24 | AUDIO.FSXI (CXD1852AQ.103 to VCD)
(PSU.7)      /RES | 25  26 | AUDIO.DATA (CXD1852AQ.100)
(CXD1852AQ.102) AUDIO.BCLK | 27  28 | AUDIO.LRCK (CXD1852AQ.101)
          GND | 29  30 | GND
          '-----'

```

IC104 "Sony CXD1852AQ" (MPEG-1 Decoder for Video CD) (120 pin)

1-GND	16-HD7	31-GND	46-MD4	61-GND	76-G/Y3	91-GND	106-XTL2O
2-XTL0O	17-MA3	32-MA7	47-MD11	62-/VOE	77-G/Y4	92-HSYNC	107-XTL2I
3-XTL0I	18-MA4	33-MA8	48-MD3	63-R/Cr0	78-G/Y5	93-VSYNC	108-VDD

4-VDD	19-MA2	34-/RAS	49-MD12	64-R/Cr1	79-G/Y6	94-FID/FHREF	109-C2PO
5-HA2	20-MA5	35-/MWE	50-MD2	65-R/Cr2	80-G/Y7	95-CBLNK/FSC	110-LRCI
6-HA3	21-MA1	36-/CAS2	51-MD13	66-R/Cr3	81-B/Cb0	96-CSYNC	111-DATI
7-HD0	22-GND	37-/CAS0	52-MD1	67-R/Cr4	82-B/Cb1	97-/SGRST	112-BCKI
8-HD1	23-MA6	38-MD7	53-MD14	68-R/Cr5	83-B/Cb2	98-CLK00	113-DOIN
9-HD2	24-MA0	39-MD8	54-MD0	69-R/Cr6	84-B/Cb3	99-DOUT	114-/HCS
10-HD3	25-BC	40-MD6	55-MD15	70-R/Cr7	85-B/Cb4	100-DATO	115-/HDT
11-HD4	26-TCKI	41-MD9	56-OSDEN	71-G/Y0	86-B/Cb5	101-LRCO	116-HRW
12-HD5	27-TDI	42-MD5	57-OSDB	72-G/Y1	87-B/Cb6	102-BCKO	117-/HIRQ
13-HD6	28-TENA1	43-MD10	58-OSDG	73-G/Y2	88-B/Cb7	103-FSXI	118-/RST
14-VDD	29-TDO	44-VDD	59-OSDR	74-VDD	89-DCLK	104-VDD	119-HA0
15-GND	30-VST	45-GND	60-VDD	75-GND	90-VDD	105-GND	120-HA1

The Hxxx pins are for the Host (the 8bit CXP CPU), the Mxxx for the RAM chips, the R/G/B pins are 24bit RGB video. Pin36 can be /CAS2 or MA9 (and, the VCD daughterboard has alternate solderpads for one large RAM instead of two small RAMs).

IC107 "6230FV" (OSD chip, similar to BU6257AFV-E2) (20 pin)

1-SIO.CLK	5-VDD	9-TEST	13-BLK2	17-OSDG
2-SIO./CS	6-/CKOUT	10-GND	14-VC2	18-OSDB
3-SIO.DTA	7-OSCOU	11-BLK1	15-OSDEN	19-/VSYNC
4-/RESET	8-OSCIN	12-VC1	16-OSDR	20-/HSYNC

SIO pin1/2/3 are wired to CXP pin38/37/36. OSCIN is the RGB DAC CLK divided by two (from H74 chip pin5). OSD/SYNC on pin15-20 connect to the MPEG1 decoder chip.

No datasheet (but pinouts are same/similar as for BU6257AFV, documented in several service manuals for tape decks with vcd player: HCD-V5500, HCD-V8900/V8900AV, HCD-V909AV).

IC111 "Sony CXP10224-603R" (8bit SPC700 CPU) (64pin LQFP)

1-PB5=TP	17-PD5=/HCS	33-AVREF=VDD	49-PG5/SCK1=HC05.PF2
2-PB4=TP	18-PD4=TP	34-AVDD=VDD	50-PG4=/RST.OUT
3-PB3=HA3	19-PD3=TP	35-PF7/AN7=TP	51-PG3/TO=TP
4-PB2=HA2	20-PD2=TP	36-PF6/AN6=OSD.DTA	52-PA7=TP
5-PB1=HA1	21-PD1=TP	37-PF5/AN5=OSD./CS	53-PA6=TP
6-PB0=HA0	22-PD0=TP	38-PF4/AN4=OSD.CLK	54-PA5=TP
7-PC7=HD7	23-MP/TEST=GND	39-PF3/AN3=GND	55-PA4=TP
8-PC6=HD6	24-XTAL=12MHZ	40-PF2/AN2=GND	56-VPP=VDD
9-PC5=HD5	25-EXTAL=12MHZ	41-PF1/AN1=GND	57-VDD=VDD
10-PC4=HD4	26-VSS=GND	42-PF0/AN0=10KtoGND	58-VSS=GND
11-PC3=HD3	27-/RST=/RES	43-PE3/PWM1=TP	59-PA3=TP
12-PC2=HD2	28-/CS0=VDD	44-PE2/PWM0=TP	60-PA2=TP
13-PC1=HD1	29-SI0=CD.SQSO	45-PE1/INT2/EC=/VSYNC	61-PA1=TP
14-PC0=HD0	30-SO0=TP	46-PE0/INT0=/HIRQ	62-PA0=TP

15-PD7=HRW	31-/SCK0=CD.SQCK	47-PG7/SI1/INT1=HC05.PF1	63-PB7=TP
16-PD6=/HDT	32-AVSS=GND	48-PG6/SO1=HC05.PF0	64-PB6=TP

Pin 3-15,45,46,50 connect to MPEG1 decoder. Pin 36-38 to OSD. Pin 47-49 to HC05.PortF. Pin 27 is /RESET from PSU. Pin 29,31 are SUBQ from CXD2510Q. The "TP" pins connect to test points (but seem to be NC otherwise).

Pinouts are same as in CXP811P24 datasheet (which uses SPC700 instruction set; that instruction set is also used by SNES sound CPU).

IC109 "TLC2932" (PLL) (14pin)

1-LOGIC_VDD=5V	5-FIN-B=HSYNC.PLL	9-PFD_INHIBIT=GND	13-BIAS
2-SELECT=5V	6-PFD_OUT	10-VCO_INHIBIT=GND	14-VCO_VDD=5V
3-VCO_OUT=RGB.DAC.CLK.PLL	7-LOGIC_GND=GND	11-VCO_GND=GND	
4-FIN-A=FID/FHREF.PLL	8-NC	12-VCO_IN	

Used to generate the CLK for the TDA chip (that is, the dotclk, paused during VSYNC, or so?). The same CLK, divided by two, is also used as OSD.OSCIN.

IC112 "74HCT32" (Quad OR gate) (14pin)

1-FID/FHREF.MPEG	4-HSYNC.MPEG	8-(low)	11-RGB.DAC.CLK.TDA	7-GND
2-FID/FHREF.MPEG	5-HSYNC.MPEG	9-GNDed	12-RGB.DAC.CLK.PLL	14-VCC/5V
3-FID/FHREF.PLL	6-HSYNC.PLL	10-GNDed	13-RGB.DAC.CLK.PLL	

Used to sharpen the output from the PLL chip, and to level-shift signals for the two PLL inputs from 3.5V to 5V. The input-pairs for the OR gates are shortcut with each other, so the chip isn't actually ORing anything.

IC113 "H74 7H" (single D-type flip-flop; OSD clock divider) (8 pin)

1-CLK	2-D	3-/Q	4-GND	5-Q	6-/RES	7-/SET	8-VCC
-------	-----	------	-------	-----	--------	--------	-------

Used to divide the RGB DAC CLK by two. CLK comes from TDA.pin31, D and /Q are shortcut with each other, /RES and /SET are wired to VDD, and Q goes to OSD.OSCIN.

ICnnn "4053C" (Triple multiplexor, for Audio LRCK,BCLK,DATA) (16pin)

1-IN2B=DATA.VCD	5-IN3A=LRCK.SPU	9-SEL3=LRCK.SEL	13-IN1B=BCLK.VCD
2-IN2A=DATA.SPU	6-/OE=GNDed	10-SEL2=DATA.SEL	14-OUT1=BCLK.OUT
3-IN3B=LRCK.VCD	7-VEE=GNDed	11-SEL1=BCLK.SEL	15-OUT2=DATA.OUT
4-OUT3=LRCK.OUT	8-GND=GND	12-IN1A=BCLK.SPU	16-VDD=VDD/3.5V

The three SEL pins are wired to HC05.PortF3, the three SPU pins are wired via 10Kohm.

ICnnn "4053C" (Triple multiplexor, for Video FSC,CSYNC) (16pin)

1-IN2B=FSC.VCD	5-IN3A=CSYNC.PSX	9-SEL3=CSYNC.SEL	13-IN1B=GNDed
2-IN2A=FSC.PSX	6-/OE=GNDed	10-SEL2=FSC.SEL	14-OUT1=NCed
3-IN3B=CSYNC.VCD	7-VEE=GNDed	11-SEL1=DUMMY.SEL	15-OUT2=FSC.OUT
4-OUT3=CSYNC.OUT	8-GND=GND	12-IN1A=GNDed	16-VDD=VCC/5V

The three SEL pins are wired to HC05.PortF3, the two OUTx pins are wired via 2.2Kohm.

ICnnn "NJM2283" (Triple multiplexor, for Video R,G,B) (16pin)

1-IN1B=R.VCD	5-OUT2=G.OUT	9-IN3B=B.VCD	13-V=VCC/5V
2-SEL1=R.SEL	6-OUT3=B.OUT	10-GND3=81ohm/GND	14-IN2B=G.VCD
3-OUT1=R.OUT	7-SEL3=B.SEL	11-IN2A=G.PSX	15-GND1=GND
4-GND2=GND	8-IN3A=B.PSX	12-SEL2=G.SEL	16-IN1A=R.PSX

The three SEL pins are wired to HC05.PortF3, the six INxx pins wired through resistors and capacitors, the three OUTx pins are wired through capacitors.

27.11 Pinouts - HC05 Pinouts

Motorola HC05 chip versions for PSX cdrom control

80pin "4246xx" - MC68HC05L16, on-chip ROM (DTL-H120x & old retail consoles)
 80pin "MC68HC705L16CFU" - MC68HC705L16, on-chip ROM (DTL-H100x, and PU-9)
 52pin "SC4309xx" - MC68HC05G6, on-chip ROM (newer retail consoles)

The early DTL-H2000 devboard is also using a 80pin CPU (with piggyback EPROM socket), but that CPU is a Sony CXP82300 SPC700 CPU, not a Motorola HC05 CPU.

IC304 - "C 3060, SC430943PB, G63C 185" (PAL/PSone) - CDROM Controller

Called "MC68HC05G6PB" in service manual (=8bit CPU).

1	NC	NC (TEST:DTR/out) (VCD:AVSEL/out)	;-Port F	;PortF.Bit3
2	VDD	3.5V		
3	NC	NC	;\	;maybe PortE.Bit7?
4	NC	NC	; maybe MSBs of Port E	;maybe PortE.Bit6?
5	NC	NC	;/	;maybe PortE.Bit5?
6	DECA4	SPU102	;\	;PortE.Bit4
7	DECA3	SPU101	; Port E [04h], aka Address/Index	;PortE.Bit3
8	DECA2	SPU99	;	;PortE.Bit2


```

9  DECA1  SPU98      ;                               ;PortE.Bit1
10 DECA0  SPU97      ;/                               ;PortE.Bit0
11 VSS    GND
12 NDLY    GND      reserved for factory test, should be wired to VDD, not GND?
13 /RES    /RES (via 5K6)
14 OSC1    4.3MHz (SPU11) (used as external clock for some modchips) (low volts)
15 OSC2    NC
16 F-BIAS  aka FOK=NC (in SCPH-5500)                   ;PortB.Bit0
17 CG      NC      aka CG=CG (in SCPH-5500)           ;this IS portb.1! ;PortB.Bit1
18 LMTSW   /POS0 (switch, GNDed when head at inner-most position) ;PortB.Bit2
19 DOOR    SHELL_OPEN                                   ;PortB.Bit3
20 TEST2   NC                                           ;PortB.Bit4
21 TEST1   to CL316                                     ;PortB.Bit5
22 COUT    NC                                           ;PortB.Bit6
23 SENSE   SPU82 ;CXD2510Q.69                           ;PortB.Bit7
24 SUBQ    SPU81 ;CXD2510Q.66                           ;PortC.Bit0
25 NC      NC      ;NC                                   ;PortC.Bit1
26 SQCK    SPU80 ;CXD2510Q.67                           ;PortC.Bit2
27 SPEED   IC722.Pin3 (SW)                             ;PortC.Bit3
28 AL/TE    ;transisor aka MIRROR=.. (in SCPH-5500);ISN'T PortB.Bit1 !
29 ROMSEL   ;NC      aka ROMSEL=SCLK (in SCPH-5500)     ;PortC.Bit5
30 /XINT    SPU79 ;CXD1815Q.14                           ;PortC.Bit6
31 SCOR     SPU77 ;CXD2510Q.63                           ;PortC.Bit7
32 VDD      3.5V
33 DECD0    CD.D0      ;\                               ;PortA.Bit0
34 DECD1    CD.D1      ;                               ;PortA.Bit1
35 DECD2    CD.D2      ;                               ;PortA.Bit2
36 DECD3    CD.D3      ; Port A [00h], aka Data          ;PortA.Bit3
37 DECD4    CD.D4      ;                               ;PortA.Bit4
38 DECD5    CD.D5      ;                               ;PortA.Bit5
39 VSS      GND        ;
40 DECD6    CD.D6      ;                               ;PortA.Bit6
41 DECD7    CD.D7      ;/                               ;PortA.Bit7
42 NC       NC                                           ;maybe PortD.Bit0?
43 DATA    SPU74 (via 22 ohm)                           ;PortD.Bit1
44 XLAT     SPU75 (via 22 ohm)                           ;PortD.Bit2
45 CLOK     SPU76 (via 22 ohm)                           ;PortD.Bit3
46 DECCS    SPU94                                           ;PortD.Bit4
47 DECWR    SPU95                                           ;PortD.Bit5
48 DECRD    SPU96                                           ;PortD.Bit6
49 LDON     IC723.Pin11                                   ;PortD.Bit7
50 NC       NC (TEST:TX/out) (VCD:SIO.IN/in) ;\PortF (used by ;PortF.Bit0
51 NC       NC (TEST:RX/in) (VCD:SIO.OUT/out) ; Motorola Testmode;PortF.Bit1
52 NC       NC (TEST:RTS/out) (VCD:SIO.CLK/out) ;/and VCD version) ;PortF.Bit2

```

This chip isn't connected directly to the CPU, but rather to a Fifo Interface, which is then forwarding data to/from the CPU. On older PSX boards, that Fifo Interface has been located in a separate chip, on newer PSX boards and PSone boards, the Fifo stuff is contained in the SPU chip. The CDROM has a 32K buffer, which is also implemented at the Fifo Interface side.

OSC input (internally HC05 is running at OSC/2, ie. around 2MHz):

```

PU-8      4.0000MHz from separate 4.000MHz oscillator (X302)
PU-16     4.0000MHz from separate 4.000MHz oscillator (X302)
DTL-H2000 4.1900MHz from separate 4.1900MHz oscillator (SPC700, not HC05)
PU-18     4.2336MHz from CXD2545Q.pin68 (Servo+Signal) (FSOF=16.9344MHz/4)
PU-20     4.2xxxMHz from CXD1817R.pin? (Servo+Signal+Decoder)
PM-41     4.2xxxMHz from CXD2938Q.pin11 (Servo+Signal+Decoder+SPU)

```

HC05 - 80pin version (pinout from MC68HC05L16 datasheet)

```

1 VDD
2 FP28/PE6      ;\
3 FP29/PE5      ;
4 FP30/PE4      ;
5 FP31/PE3      ; Port E LSBs
6 FP32/PE2      ;
7 FP33/PE1      ;
8 FP34/PE0      ;/
9 FP35/PD7      ;\
10 FP36/PD6     ; Port D MSBs
11 FP37/PD5     ;
12 FP38/PD4     ;/
13 VLCD3
14 VLCD2
15 VLCD1
16 VSS
17 NDLY
18 XOSC1
19 XOSC2
20 /RESET
---
21 OSC1
22 OSC2
23 PA0          ;\
24 PA1          ;
25 PA2          ;
26 PA3          ; Port A
27 PA4          ;
28 PA5          ;
29 PA6          ;
30 PA7          ;/
31 PB0/KWI0     ;\
32 PB1/KWI1     ;
33 PB2/KWI2     ;
34 PB3/KWI3     ; Port B
35 PB4/KWI4     ;
36 PB5/KWI5     ;
37 PB6/KWI6     ;
38 PB7/KWI7     ;/
39 PC0/SDI      ;\
40 PC1/SDO      ;
---
41 PC2/SCK      ; Port C

```

```

42 PC3/TCAP      ;
43 PC4/EVI       ;
44 PC5/EVO       ;
45 PC6/IRQ2      ;
46 PC7/IRQ1      ;/
47 VDD
48 BP3/PD3        ;\
49 BP2/PD2        ; Port D LSBs
50 BP1/PD1        ;
51 BP0 (no "PD0") ;/
52 FP0
53 FP1
54 FP2
55 FP3
56 FP4
57 FP5
58 FP6
59 FP7
60 VSS
---
61 FP8
62 FP9
63 FP10
64 FP11
65 FP12
66 FP13
67 FP14
68 FP15
69 FP16
70 FP17
71 FP18
72 FP19
73 FP20
74 FP21
75 FP22
76 FP23
77 FP24
78 FP25
79 FP26
80 FP27/PE7      ; - Port E MSB

```

HC05 - 32pin/64pin Versions

Sony's Digital Joypad and Mouse contain 32pin CPUs, which are probably also HC05's:

[Pinouts - Component List and Chipset Pin-Outs for Digital Joypad, SCPH-1080](#)

Moreover, some old memory cards contain a 64pin Motorola SC419510FU (probably also a HC05) with separate Atmel AT29LV010A (128Kx8 FLASH).

27.12 Pinouts - MEM Pinouts

IC102 - BIOS ROM (32pin, 512Kx8, used on LATE-PU-8 boards, and newer boards)

1-A19	5-A7	9-A3	13-D0	17-D3	21-D7	25-A11	29-A14	
2-A16	6-A6	10-A2	14-D1	18-D4	22-/CE	26-A9	30-A17	; /CE=/BIOS
3-A15	7-A5	11-A1	15-D2	19-D5	23-A10	27-A8	31-A18	
4-A12	8-A4	12-A0	16-GND	20-D6	24-/OE	28-A13	32-3.5V	; /OE=/RD

Uses standard EPROM pinouts, VCC is 3.5V though, when replacing the ROM by an EPROM, it may be required to replace the supply by 5V. Note that, on PM-41 boards at least, Pin 1 is connected to A19 (allowing to install a 1MB BIOS chip on that board, however, normally, a 512KB BIOS chip is installed, and, the CPU is generating an exception when trying to access more than 512KB, but that 512K limit can be disabled via memory control registers).

Datasheet for (MS-)M534031E does exist.

IC102 - BIOS ROM (40pin, 512Kx8, used on PU-7 boards, and EARLY-PU-8 boards)

1-A18	6-A4	11-GND	16-D9	21-VCC	26-D6	31-GND (/BYTE)	36-A13
2-A8	7-A3	12-/OE	17-D2	22-D4	27-D14	32-A17	37-A12
3-A7	8-A2	13-D0	18-D10	23-D12	28-D7	33-A16	38-A11
4-A6	9-A1	14-D8	19-D3	24-D5	29-A0 (D15)	34-A15	39-A10
5-A5	10-/CS	15-D1	20-D11	25-D13	30-GND	35-A14	40-A9

The chip supports 8bit/16bit mode, on the PSX D0-D14 are actually wired, but A0/D15 is wired to A0, and /BYTE is wired to GND, so 16bit mode doesn't work.

Datasheet for MX23L4100 does exist.

IC102 - BIOS ROM (44pin, 1Mx8, used on P16-boards, ie. VCD console)

1-NC	5-A7	9-A3	13-GND	17-D1	21-D3	25-D12	29-D14	33-/BYT	37-A14	41-A10
2-A19	6-A6	10-A2	14-/OE	18-D9	22-D11	26-D5	30-D7	34-A17	38-A13	42-A9
3-A18	7-A5	11-A1	15-D0	19-D2	23-VCC	27-D13	31-D15/A0	35-A16	39-A12	43-NC
4-A8	8-A4	12-/CE	16-D8	20-D10	24-D4	28-D6	32-GND	36-A15	40-A11	44-NC

Pinouts are from OKI MSM538032E datasheet.

CPU-RAM (four 28pin chips) (older boards)

Unknown.

Note: The newer 70pin RAM comes up without external /REFRESH signal, but maybe the 28pin RAMs required refresh (the CPU has some odd delays once and when).

IC106 - CPU-RAM (single 70pin chip, on newer boards)

"Samsung K4Q153212M-JC60" (70pin, 512Kx32) (newer boards)

"Toshiba T7X16" (70pin, 512Kx32) (newer boards, too)

1-VCC	11-N.C	21-DQ15	31-A3	41-N.C	51-DQ17	61-DQ24
2-DQ0	12-VCC	22-N.C	32-A4	42-N.C	52-DQ18	62-DQ25
3-DQ1	13-DQ8	23-N.C!	33-A5	43-/OE	53-DQ19	63-DQ26
4-DQ2	14-DQ9	24-N.C	34-A6	44-/W	54-VSS	64-DQ27
5-DQ3	15-DQ10	25-N.C	35-VCC	45-/CAS3	55-DQ20	65-VSS
6-VCC	16-DQ11	26-N.C	36-VSS	46-/CAS2	56-DQ21	66-DQ28
7-DQ4	17-VCC	27-/RAS	37-A7	47-/CAS1	57-DQ22	67-DQ29
8-DQ5	18-DQ12	28-A0	38-A8	48-/CAS0	58-DQ23	68-DQ30
9-DQ6	19-DQ13	29-A1	39-A9	49-N.C	59-VSS	69-DQ31
10-DQ7	20-DQ14	30-A2	40-N.C	50-DQ16	60-N.C	70-VSS

Notes: Pin23 must NC or VSS. In the PSone, /OE is wired to GND.

Datasheet for K4Q153212M-JC60 does exist (the chip supports 27ns Hyper Page mode access, which seems to be used for DMA).

IC106/IC107/IC108/IC109 - CPU-RAM (four 28pin chips, on PU-8, PU-18 boards)

SEC KM48V514BJ-6 (DRAM 512Kx8) (four pieces = 512Kx32 = 2Mbyte)

1-VCC	5-DQ3	9-A9	13-A3	17-A5	21-NC	25-DQ5
2-DQ0	6-NC	10-A0	14-VCC	18-A6	22-/OE	26-DQ6
3-DQ1	7-/W	11-A1	15-GND	19-A7	23-/CAS	27-DQ7
4-DQ2	8-/RAS	12-A2	16-A4	20-A8	24-DQ4	28-GND

Datasheet for KM48V514B-6 and BL-6 exist (though none for BJ-6). The chips support 25ns Hyper Page mode access.

IC310 - SPU-RAM (512Kbyte)

EliteMT M11B416256A-35J (256K x 16bit) (40pin SOJ, PM-41 boards)

Nippon Steel NN514256ALTT-50 (256K x 16bit) (40pin TSOP-II, PU-23 boards)

Toshiba TC51V4260DJ-70 (40pin, PU-8 board) (PseudoSRAM)

1-5.0V	6-5.0V	11-NC	16-A0	21-VSS	26-A8	31-I/O8	36-I/O12
2-I/O0	7-I/O4	12-NC	17-A1	22-A4	27-/OE	32-I/O9	37-I/O13
3-I/O1	8-I/O5	13-/WE	18-A2	23-A5	28-/CASH	33-I/O10	38-I/O14
4-I/O2	9-I/O6	14-/RAS	19-A3	24-A6	29-/CASL	34-I/O11	39-I/O15
5-I/O3	10-I/O7	15-NC	20-5.0V	25-A7	30-NC	35-VSS	40-VSS

Note: SPU-RAM supply can be 3.5V (PU-8), or 5.0V (PU-22 and PM-41).

Note: The /CASL and /CASH pins are shortcut with each other on the mainboard, both wired to the /CAS pin of the SPU (ie. always accessing 16bit data at once).

Note: The TSOP-II package (18mm length, super-flat and with spacing between pin 10/11 and 30/31) is used on PU-23 boards. The pinouts and connections are identical for SOJ and TSOP-II.

Note: Nippon Steels NN514256-series is normally 256Kx4bit, nethertheless, for some bizarre reason, their 256Kx16bit chip is marked "NN514256ALTT"... maybe that happened accidently in the manufacturing process.

Note: The PM-41(2) board has on-chip RAM in the SPU (no external memory chip).

IC303 - CDROM Buffer (32Kbyte)

"HM62W256LFP-7T" (SRAM 32Kx8) (PCB bottom side) (PU-8)

"SONY CXK5V8257BTM" 32Kx8 SRAM (PU-18)

1-A14	4-A6	7-A3	10-A0	13-D2	16-D4	19-D7	22-/OE	25-A8	28-VCC
2-A12	5-A5	8-A2	11-D0	14-GND	17-D5	20-/CS	23-A11	26-A13	
3-A7	6-A4	9-A1	12-D1	15-D3	18-D6	21-A10	24-A9	27-/WE	

Used only on older boards (eg. PU-8, PU-18), newer boards seem to have that RAM included in the 208pin SPU chip.

IC201 - GPU-RAM (1MByte) (or 2MByte, of which, only 1MByte is used though)

Samsung KM4132G271BQ-10 (128K x 32bit x 2 Banks, Synchronous Graphic RAM) 1MB

Samsung K4G163222A-PC70 (256K x 32bit x 2 Banks, Synchronous Graphic RAM) 2MB

1-DQ3	13-DQ19	25-/WE	37-N.C	49-A6	61-DQ9	73-VDDQ	85-VSS	97-DQ0
2-VDDQ	14-VDDQ	26-/CAS	38-N.C	50-A7	62-VSSQ	74-DQ24	86-N.C	98-DQ1
3-DQ4	15-VDD	27-/RAS	39-N.C	51-A8	63-DQ10	75-DQ25	87-N.C	99-VSSQ
4-DQ5	16-VSS	28-/CS	40-N.C	52-N.C	64-DQ11	76-VSSQ	88-N.C	100-DQ2
5-VSSQ	17-DQ20	29-A9 (BA)	41-N.C	53-DSF	65-VDD	77-DQ26	89-N.C	
6-DQ6	18-DQ21	30-NC (GND)	42-N.C	54-CKE	66-VSS	78-DQ27	90-N.C	
7-DQ7	19-VSSQ	31-A0	43-N.C	55-CLK	67-VDDQ	79-VDDQ	91-N.C	
8-VDDQ	20-DQ22	32-A1	44-N.C	56-DQM1	68-DQ12	80-DQ28	92-N.C	
9-DQ16	21-DQ23	33-A2	45-N.C	57-DQM3	69-DQ13	81-DQ29	93-N.C	
10-DQ17	22-VDDQ	34-A3	46-VSS	58-NC	70-VSSQ	82-VSSQ	94-N.C	

11-VSSQ	23-DQM0	35-VDD	47-A4	59-VDDQ	71-DQ14	83-DQ30	95-N.C
12-DQ18	24-DQM2	36-N.C	48-A5	60-DQ8	72-DQ15	84-DQ31	96-VDD

Newer boards often have 2MB VRAM installed (of which only 1MB is used, apparently the 2MB chips became cheaper than the 1MB chips). At the chip side, the only difference is that Pin30 became an additional address line (that, called A8, and, accordingly, the old A8,A9 pins were renamed to A9,A10). At the mainboard side, the connection is exactly the same for both 1MB and 2MB chips; Pin30 is grounded on both PU-23 boards (which typically have 1MB) and PM-41 boards (which typically have 2MB).

Note: The PM-41(2) board has on-chip RAM in the GPU (no external memory chip).

27.13 Pinouts - CLK Pinouts

The "should-be" CPU clock is 33.868800 Hz (ie. the 44100Hz CDRUM/Audio clock, multiplied by 300h). However, the different PSX/PSone boards are using different oscillators, multipliers and dividers, which aren't exactly reaching that "should-be" value. The PSone are using a single oscillator for producing CPU/GPU clocks, and for producing the TV/color signal:

```
For PAL,   Fsc=4.43361875MHz (5^6*283.75Hz+25Hz) --> 4*Fsc=17.734MHz
For NTSC,  Fsc=3.579545MHz   (4.5*455/572 MHz)   --> 4*Fsc=14.318MHz
```

PSone/PAL - IC204 8pin - "CY2081, SL-509" or "2294A, 1913"

Clock Multiplier/Divider

```
1 53MHz           ;17.734MHz*3 = 53.202 MHz (?)
2 GND
3 X1 17.734MHz
4 X2 17.734MHz
5 67MHz           ;17.734MHz*3*2*7/11 = 67.711636 MHz (?)
6 4.4Mhz          ;17.734MHz/4 = 4.4335MHz (?) ;via 2K2 to IC502.pin15
7 3.5V
8 3.5V
```

PSone/NTSC - IC204 8pin "CY2081 SL-500" (PSone, and PSX/PU-20 and up)

Unknown. Uses a 14.318MHz oscillator, so multiply/divide factors must be somehow different.

```
3*3*7*5/2/11 = 14.3181818
3*3*7*7*100 = 44100
```

The "optimal" conversion would be (hardware is barely able to do that):

```
14.3181818 * 3*7*11*64 / (5*5*5*5*5) = 67.737600
```

So, maybe it's doing

```
14.3181818 * 2*2*13/11 ... or so?
```

PSX/PAL

PU-7 and PU-8 boards are using three separate oscillators:

```
X101: 67.737MHz (div2 = CPU Clock = 33.8685MHz) (div600h = 44.1kHz audio)
X201: 53.20MHz (GPU Clock) (div12 = PAL color clock)
X302: 4.000MHz (for CDROM SUB CPU)
```

PU-18 does have same X101/X201 as above, but doesn't seem to have X302.

PSX/NTSC

PU-7 and PU-8 boards are using three separate oscillators:

```
X101: 67.737MHz (div2 = CPU Clock = 33.8685MHz) (div600h = 44.1kHz audio)
X201: 53.69MHz (GPU Clock) (div15 = NTSC color clock)
X302: 4.000MHz (for CDROM SUB CPU)
```

PU-20 works more like PSone (a single oscillator, and CY2081 SL-500 divider)

27.14 Pinouts - PWR Pinouts

Voltage Summary

```
+7.5V  Used to generate other voltages and CDROM/Joypad/MemoryCard/Expansion
+5.0V  Used for Multiout, IC405, and IC502, and IC602
+3.5V  Used for most ICs, and for Joypad/MemoryCard/Expansion
+3.48V Used for SPU and CDROM
GND    Ground, shared for all voltages
```


Fuses

There are a lot of SMD elements marked FBnnn, these are NOT fuses (at least they don't seem to blow-up whatever you do). The actual fuses are marked PSnnn, found near the power switch and near the power socket.

IC601 3pin +5.0V "78M05, RZ125, (ON)"

```
1 +7.5V
2 GND
3 +5.0V    (used for Multiout, IC405, and IC502)
```

IC602 - Audio/CDROM Supply

Called "LP29851MX-3.5" in service manual.

```
1 VIN      5.0V (in)
2 GND      GND
3 ON/OFF   5.0V (in)
4 NOISE    ?
5 VOUT     3.48V (out)
```

IC002/IC003 - Reset Generator (PM-41 board)

IC002	IC003	Expl.
2	2	connected to Q002 (reset input?)
5	5	connected via capacitor to GND
6	1	reset-output (IC002=wired to /RES, IC003: via Q004 to /RES)
7	-	7.5V
4	3	GND
1,3,8	4	NC

/RES is connected via 330 ohm to GPU/CPU, and via 5K6 SPU/IC722/IC304.

Note: Either IC002 or IC003/Q004 can be installed on PM-41 boards. Most or all boards seem to contain IC003/Q004.

Note: PSX consoles have something similar on the Power Supply boards (IC101: M51957B).

IC606/IC607 - TL594CD - Pulse-Width-Modulation Power-Control Chip

```
1 1IN+
2 1IN-
3 FEEDBACK
4 DTC
```

```

5 CT
6 RT
7 GND
8 C1
9 E1
10 E2
11 C2
12 VCC
13 OUTPUT CTRL
14 REF
15 2IN-
16 2IN+

```

Q602

```

x +7.5V
y +3.5V
z REG

```

CN602 - PU-8, PU-9 board Power Socket (to internal power supply board)

```

1 Brown    7.5V (actually 7.69V)
2 Red      GND  Ground
3 Orange   3.5V (actually 3.48V)
4 Yellow   GND  Ground
5 White    STAND-BY (3.54V, always ON, even if power switch is off)
6 Blue     GND  Ground
7 Magenta  /RES Reset input (from power-on logic and reset button)

```

Purpose of the standby voltage is unknown... maybe to expansion port?

CN602 - PU-18, PU-23 board Power Socket (to internal power supply board)

```

1 Brown    7.5V (actually 7.92V or so) (ie. higher than in PSone)
2 Red      GND  Ground
3 Orange   3.5V (actually 3.53V or so) (ie. quite same as PSone)
4 Yellow   GND  Ground
5 White    /RES Reset input (from power-on logic and reset button)

```

CN102 - Controller/memory card daughter-board connector (PU-23 board)

```

1 /IRQ10 (/IRQ10)
2 /ACK (/IRQ7)
3 /JOY2
4 7.5V (or actually 7.92V)
5 /JOY1
6 DAT

```

```

7 GND
8 CMD
9 3.5V
10 CLK

```

27.15 Pinouts - Component List and Chipset Pin-Outs for Digital Joypad, SCPH-1080

Digital Joypad Component List (SCPH-1080)

```

Case: "SONY, CONTROLLER, Sony Computer Entertainment Inc. H"
Case: "SCPH-1080 Made in China"
PCB: "CMK-PIHB /\, CFS8121-200010-01"
U?: 32pin "(M), SC401800, FB C37B, JSJD520C" (Motorola) (TQFP-32 package)
U?: 14pin "BA10339F, 528 293" (Quad Comparator) (/ACK,JOYDAT,and reset or so)
X?: 3pin "4.00G1f" (on PCB bottom side)
Z1: 2pin z-diode or so (on PCB bottom side) (+1.7V VREF for BA10339F)
CN?: 7pin cable to controller port (plus shield; but not connected to PCB)
C1 2pin to GND and R5
C2 2pin capacitor for power supply input (between +3.5V and GND)
C3 2pin between BA.pin8 and (via R6) BA.pin15
R1 2pin 1M ohm (for X1)
R2 2pin 2.7K
R3 2pin 8xK ohm?
R4 2pin 100K
R5 2pin 22K ohm
R6 2pin 56K ohm
RN1 8pin 4x200 ohm (/JOYn,JOYCMD,JOYCLK)
RN2 8pin 4x22K ohm (pull-ups for button bit0..3)
RN3 8pin 4x22K ohm (pull-ups for button bit12..15)
RN4 8pin 4x22K ohm (pull-ups for button bit8..11)
RN5 8pin 4x22K ohm (pull-ups for button bit4..7)

```

Digital Joypad Connection Cable:

```

PSX.1 -----brown---- PAD.2 JOYDAT
PSX.2 -----orange--- PAD.6 JOYCMD
PSX.3 --- NC +7.5V
PSX.4 -----black---- PAD.3 GND
PSX.5 -----red----- PAD.4 +3.5V
PSX.6 -----yellow--- PAD.5 /JOYn
PSX.7 -----blue----- PAD.7 JOYCLK
PSX.8 --- NC /IRQ10
PSX.9 -----green---- PAD.1 /ACK
PSX.Shield --shield--- NC (cable is shielded but isn't connected in joypad)

```

Digital Joypad 32pin SC401800 Chip Pin-Outs

```

1 Bit14 SW-X
2 Bit13 SW-O
3 Bit12 SW-/\
4 Bit11 SW-R1 (via cable pin1, white wire)
5 Bit10 SW-L1 (via cable pin1, white wire)
6 Bit9 SW-R2 (via cable pin3, black wire)
7 Bit8 SW-L2 (via cable pin3, black wire)
8 via BA10339F.pin7 to cn.2 JOYDAT (PSX.1)
---
9 via RN1 (200 ohm) to cn.5 /JOYn (PSX.6)
10 via RN1 (200 ohm) to cn.6 JOYCMD (PSX.2)
11 via RN1 (200 ohm) to cn.7 JOYCLK (PSX.7)
12 GND to cn.3 (PSX.4)
13 Bit7 SW-LEFT
14 Bit6 SW-DOWN
15 Bit5 SW-RIGHT
16 via BA10339F.pin5 to cn.1 /ACK (PSX.9)
---
17 Bit4 SW-UP
18 Bit3 SW-START
19 Bit2 (HI) (would be R3 on Analog Pads) ;\unused, but working button inputs
20 Bit1 (HI) (would be L3 on Analog Pads) ;/(each fitted with a RN2 pullup)
21 Bit0 SW-SELECT
22
23
24 wired to SC401800.pin25
---
25 wired to SC401800.pin24
26 4.00MHz'a
27 4.00MHz'b
28 +3.5V to cn.4 (PSX.5)
29 wired to SC401800.pin32, and via 22K ohm to +3.5V, and to BA.14
30
31 Bit15 SW-[]
32 wired to SC401800.pin29

```

Digital Joypad 14pin BA10339F Chip Pin-Outs

```

1 OUT2 CN.2 JOYDAT (PSX.1)
2 OUT1 CN.1 /ACK (PSX.9)
3 VCC +3.5V
4 -IN1 +1.7V VREF via Z1 to GND
5 +IN1 CXD.16 /ACK
6 -IN2 +1.7V VREF via Z1 to GND
7 +IN2 CXD.8 JOYDAT
---
8 -IN3 +1.7V VREF via Z1 to GND
9 +IN3 C3,R3,R4
10 -IN4 C1 to +3.5V
11 +IN4 GND

```

```

12 GND GND
13 OUT4 NC ??
14 OUT3 CXD.29/32

```

27.16 Pinouts - Component List and Chipset Pin-Outs for Analog Joypad, SCPH-1150

This applies for two controller versions:

```

SCPH-1150 Analog Pad with Single Rumble Motor (japan only)
SCPH-1180 Analog Pad without Rumble Motor

```

Both are using the same PCB, and the same SD657 chip. The difference is that the motor, transistors, and some resistors aren't installed in SCPH-1180.

Analog Joypad Component List (SCPH-1150, single motor)

```

Case "SONY, ANALOG, CONTROLLER, SonyCompEntInc. A, SCPH-1150 MADE IN CHINA"
PCB1 "DD1P09A" (mainboard with digital buttons)
PCB2 "DD1Q14A" (daughterboard with analog joysticks)
PCB3 "DD1Q15A-R" (daughterboard with R-1, R-2 buttons) (J3)
PCB4 "DD1Q15A-L" (daughterboard with L-1, L-2 buttons) (J2)
U1 42pin "SD657, 9702K3006" (2x21pins, L=17.8mm, W=7mm, W+Pins=11mm)
U2 3pin "DR, 4.Z"
Q1 3pin "BQ03" or so (motor post-amp)
Q2 3pin "S6","SG","9S" or so (motor pre-amp)
Y1 3pin "400CMA"
CN1 8pin cable to PSX controller port
CN2 8pin ribbon cable to analog-joystick daughterboard (not so robust cable)
J1 2pin wires to rumble motor (in left handle) (digital, on/off)
J2 3pin ribbon cable to L-1, L-2 button daughterboard
J3 3pin ribbon cable to R-1, R-2 button daughterboard
LED1 4pin red/green LED (optics without mirror)
D1,D2 diodes
plus resistors/capacitors

```

Analog Joypad Connection Cables (SCPH-1150)

CN1 (cable to PSX controller port) (same for SCPH-1150 and SCPH-1200)

```

PSX.1 -----brown---- PAD.2 JOYDAT
PSX.2 -----orange--- PAD.6 JOYCMD
PSX.3 -----magenta-- PAD.8 +7.5V
PSX.4 -----black---- PAD.3 GND
PSX.5 -----red----- PAD.4 +3.5V

```

```

PSX.6 -----yellow---- PAD.5 /JOYn
PSX.7 -----blue----- PAD.7 JOYCLK
PSX.8 ----              NC      /IRQ10
PSX.9 -----green----- PAD.1 /ACK
PSX.Shield --shield--- NC      (cable is shielded but isn't connected in joypad)

```

CN2 (ribbon cable to analog-joystick daughterboard) (SCPH-1150)

```

8 +3.5V to POT pins
7 Button L3 pins A,C
6 GND to POT pins and Button L3/R3 pins B,D
5 Button R3 pins A,C
4 Axis R_Y middle POT pin (SD657.18)
3 Axis R_X middle POT pin (SD657.17)
2 Axis L_Y middle POT pin (SD657.16)
1 Axis L_X middle POT pin (SD657.15)

```

J3 (ribbon cable to R-1, R-2 button daughterboard) (SCPH-1150)

```

1 (red)  R1
2 (gray) GND
3 (gray) R2

```

J2 (ribbon cable to L-1, L-2 button daughterboard) (SCPH-1150)

```

1 (red)  L1
2 (gray) GND
3 (gray) L2

```

J1 wires to small rumble motor (SCPH-1150)

```

1 (red)    +7.5V
2 (black)  Q1

```

Analog Joypad Chipset Pin-Outs (SCPH-1150)

U1 42pin "SD657, 9702K3006"

```

1  NC?
2  NC?
3  /RESET? (U2.3)
4  OSC
5  OSC
6  BUTTON Bit3 START SW1
7  BUTTON Bit2 R3 (via CN2.5)
8  BUTTON Bit1 L3 (via CN2.7)
9  BUTTON Bit0 SELECT SW3
10 GND

```

```

11 BUTTON Bit7 LEFT SW4
12 BUTTON Bit6 DOWN SW5
13 BUTTON Bit5 RIGHT SW6
14 BUTTON Bit4 UP SW7
15 Analog Axis L_X (via CN2.1)
16 Analog Axis L_Y (via CN2.2)
17 Analog Axis R_X (via CN2.3)
18 Analog Axis R_Y (via CN2.4)
19 NC?
20 3.5V
21 3.5V
---
22 BUTTON Bit15 [] SW11
23 BUTTON Bit14 >< SW10
24 BUTTON Bit13 () SW9
25 BUTTON Bit11 R1 (via J3.1)
26 BUTTON Bit12 /\ SW8
27 BUTTON Bit10 L1 (via J3.1)
28 BUTTON Bit9 R2 (via J3.3)
29 BUTTON Bit8 L2 (via J3.3)
30 PSX.2/CN1.6 JOYCMD orange (via 220 ohm R14)
31 PSX.1/CN1.2.JOYDAT brown (via 22 ohm R13 and diode D2)
32 PSX.7/CN1.7 JOYCLK blue (via 220 ohm R12)
33 PSX.6/CN1.5./JOYn yellow (via 220 ohm R11)
34 LED.GREEN (LED.4)
35 LED.RED (LED.3)
36 MOTOR (via 4.7Kohm R8 to Q2, then via Q1 to motor)
37 NC?
38 NC?
39 PSX.9/CN1.1./ACK green (via 22 ohm R10)
40 NC?
41 MODE SW2 (analog button)
42 GND

```

U2 (probably reset signal related)

```

1 from 3.5V (via R1,D1,R2)
2 to U1.3 (/RESET?) (U2.rear contact = same as U2.pin2)
3 GND

```

Q1 "BQ03" or so (motor post-amp)

```

1 Q2.2 (via 1Kohm R7)
2 to Motor (-)
3 GND

```

Q2 "S6","SG","9S" or so (motor pre-amp)

```

1 SD657.36 (via 4.7Kohm R8)
2 Q1.1 (via 1Kohm R7) (and via 100Kohm R13 to GND)
3 3.5V

```

Motor

Left/Single Motor (SCPH-1150)

27.5mm Total Length (18.5mm Motor, 2mm Axis, 7mm Weight/block)
12.0mm Width/Diameter (of Weight, and of Motor at flat side)

27.17 Pinouts - Component List and Chipset Pin-Outs for Analog Joypad, SCPH-1200

Analog Joypad Component List (SCPH-1200, two motors)

```
Case "SONY, ANALOG, CONTROLLER, SonyCompEntInc. H, SCPH-1200 MADE IN CHINA"
PCB1 "01, /\YG-H2, (r)RU" (mainboard with digital buttons)
PCB2 "M-29-01, YG-H3, (r)RU" (daughterboard with analog joysticks)
PCB3 "E, /\YG-H2, (r)RU, 01" (daughterboard with R-1, R-2 buttons) (J1)
PCB4 "01, W, /\YG-H2, (r)RU" (daughterboard with L-1, L-2 buttons) (J2)
U1 44pin "SONY, CXD8771Q 4A03, JAPAN 9840 HAL, 148896"
U2 4pin ",\ 29" (PST9329) (System Reset with 2.9V detection voltage)
U3 8pin "2904, 8346G, JRC" (NJM2904) (Dual Operational Amplifier)
Q1 3pin ".Y S'" (big transistor for big M1 rumble motor)
Q2 3pin "Z" (small transistor for small M2 rumble motor)
Y1 3pin "800CMLX" or so (hides underneath of the CN2 ribbon cable)
CN1 8pin cable to PSX controller port
CN2 8pin ribbon cable to analog-joystick daughterboard
J1 3pin ribbon cable to R-1, R-2 button daughterboard
J2 3pin ribbon cable to L-1, L-2 button daughterboard
M1 2pin wires to left/big rumble motor (analog, slow/fast)
M2 2pin wires to right/small rumble motor (digital, on/off)
ZD1,ZD2 some Z-diodes
D1,D2 diodes near M1,M2 motors (these diodes aren't installed)
LED1 red analog mode LED (with transparent optics/light direction mirror)
plus resistors/capacitors
```

Note: There's also a different SCPH-1200 revision, which having a smaller mainboard with analog joysticksonboard, plus a single sided PCB for the digital buttons (that is, similar to SCPH-110, but with the single sided PCB instead of membrane foil).

Analog Joypad Connection Cables (SCPH-1200)

CN1 (cable to PSX controller port) (same for SCPH-1150 and SCPH-1200)

```
PSX.1 -----brown----- PAD.2 JOYDAT
PSX.2 -----orange---- PAD.6 JOYCMD
PSX.3 -----magenta-- PAD.8 +7.5V
```



```

PSX.4 -----black----- PAD.3 GND
PSX.5 -----red----- PAD.4 +3.5V
PSX.6 -----yellow---- PAD.5 /JOYn
PSX.7 -----blue----- PAD.7 JOYCLK
PSX.8 ---- NC /IRQ10
PSX.9 -----green----- PAD.1 /ACK
PSX.Shield --shield--- NC (cable is shielded but isn't connected in joypad)

```

CN2 (ribbon cable to analog-joystick daughterboard) (SCPH-1200)

```

1 +3.5V to POT pins
2 Button L3 pins C,D
3 GND to POT pins and Button L3/R3 pins A,B
4 Button R3 pins C,D
5 Axis R_Y middle POT pin (CXD.20)
6 Axis R_X middle POT pin (CXD.19)
7 Axis L_X middle POT pin (CXD.21)
8 Axis L_Y middle POT pin (CXD.22)

```

J1 (ribbon cable to R-1, R-2 button daughterboard) (SCPH-1200)

```

1 (red) R1
2 (gray) GND
3 (gray) R2

```

J2 (ribbon cable to L-1, L-2 button daughterboard) (SCPH-1200)

```

1 (red) L1
2 (gray) GND
3 (gray) L2

```

M1 wires to big rumble motor (SCPH-1200)

```

+ (red) Q1.E
- (black) GND

```

M2 wires to small rumble motor (SCPH-1200)

```

+ (red) +7.5V
- (black) Q2.C

```

Analog Joypad Chipset Pin-Outs (SCPH-1200)

U1 SONY CXD8771Q

```

1 PSX.7/CN1.7 JOYCLK (via 220 ohm R2)
2 via R10 to U3.3 (for big M1 motor)

```

```

3 via R15 to Q2.B (for small M2 motor)
4 GND
5 BUTTON Bit15 []
6 BUTTON Bit14 ><
7 BUTTON Bit13 ()
8 BUTTON Bit12 /\
9 BUTTON Bit11 R1 (via J1.1)
10 BUTTON Bit10 L1 (via J2.1)
11 BUTTON Bit9 R2 (via J1.3)
---
12 BUTTON Bit8 L2 (via J2.3)
13 GND
14 U2.Pin3 (reset)
15 Y1'a
16 Y1'b
17 GND
18 +3.5V
19 Analog Axis R_X via CN2.6
20 Analog Axis R_Y via CN2.5
21 Analog Axis L_X via CN2.7
22 Analog Axis L_Y via CN2.8
---
23 GND
24 GND
25 GND
26 GND
27 GND
28 +3.5V
29 BUTTON Bit0 SELECT
30 BUTTON Bit1 L3 (via CN2.2)
31 BUTTON Bit2 R3 (via CN2.4)
32 BUTTON Bit3 START
33 BUTTON Bit4 UP
---
34 BUTTON Bit5 RIGHT (aka spelled RIHGT on the PCB)
35 BUTTON Bit6 DOWN
36 BUTTON Bit7 LEFT
37 PSX.6/CN1.5./JOYn (via 220 ohm R1)
38 ANALOG BUTTON
39 GND
40 +3.5V
41 /LED (to LED1, and from there via 300 ohm R6 to +3.5V)
42 PSX.9/CN1.1./ACK (via 22 ohm R5)
43 PSX.1/CN1.2.JOYDAT (via 22 ohm R3)
44 PSX.2/CN1.6 JOYCMD (via 220 ohm R4)

```

U2 PST9329 (System Reset with 2.9V detection voltage)

```

1 NC    GND
2 GND   GND
3 Vout  U1.14
4 VCC   +3.5V

```

U3 NJM2904 (Dual Operational Amplifier)

```

1 A.OUTPUT  Q1.B (big motor M1 transistor)
2 A.INPUT-  to R11/R12
3 A.INPUT+  to R10/R17
4 GND       PSX.4/CN1.3 GND
5 B.INPUT+  GND
6 B.INPUT-  NC?
7 B.OUTPUT  NC?
8 VCC       PSX.3/CN1.8 +7.5V

```

Q1 (transistor for big M1 motor)

```

E M1+
B U3.1 (NJM2904)
C +7.5V

```

Q2 (transistor for small M2 motor)

```

E GND
B via 1K ohm R15 to U1.3 (CXD), and via 100K ohm R16 to GND
C M2-

```

Motors

```

Left/Large Motor (SCPH-1200)
24.0mm Total Length (12.0mm Motor, 2.5mm Axis, 9.5mm Weight/plates)
24.0mm Diameter (Motor), 20.0mm Diameter (Weight/plates)
Right/Small Motor (SCPH-1200)
25.4mm Total Length (18.7mm Motor, 2mm Axis, 4.7mm Weight/plates)
12.0mm Width/Diameter (of Weight, and of Motor at flat side)

```

27.18 Pinouts - Component List and Chipset Pin-Outs for Analog Joypad, SCPH-110

Analog Joypad Component List (SCPH-110, two motors, PSone-design)

```

Case "SONY, ANALOG CONTROLLER, SonyCompEntInc. A, SCPH-110 MADE IN CHINA"
PCB1 "SA1Q22A, <PF-LP>, KPC, 7694V-0" (mainboard with joysticks onboard)
PCB2 "..." (membrane/foil with digital buttons)
U1  44pin "SD707, 039 107" (4x11pin)
Q1  3pin "KA" (big transistor for left/big M1 rumble motor)
Q2  3pin "LG" (small transistor for right/small M2 rumble motor)
D1  2pin diode (for large motor, reference Z-diode with pull-up?)
D2  3pin dual-diode (R5/IRQ7 to GND and R3/DAT to GND)

```

```

CN1  9pin cable to PSX controller port
J1   16pin ribbon cable from membrane/foil
M1   2pin wires to left/big rumble motor (analog, slow/fast)
M2   2pin wires to right/small rumble motor (digital, on/off)
LED1 2pin red analog mode LED (with long legs, without mirror/optics)
plus resistors/capacitors

```

Analog Joypad Connection Cables (SCPH-110)

CN1 (cable to PSX controller port)

```

1 +3.5V (logic supply)
2 GND3   (logic supply)
3 /IRQ7
4 /SEL
5 CMD
6 DAT
7 CLK
8 GND7   (motor supply)
9 +7.5V  (motor supply)

```

J1 (ribbon cable with membrane/foil with digital buttons)

```

1 BUTTON Bit8 L2
2 BUTTON Bit10 L1
3 BUTTON Bit4 UP
4 BUTTON Bit5 RIGHT
5 BUTTON Bit6 DOWN
6 BUTTON Bit7 LEFT
7 GND3
8 ANALOG BUTTON
9 BUTTON Bit0 SELECT
10 BUTTON Bit3 START
11 BUTTON Bit15 SQUARE  []
12 BUTTON Bit14 CROSS   ><
13 BUTTON Bit13 CIRCLE   ()
14 BUTTON Bit12 TRIANGLE /\
15 BUTTON Bit11 R1
16 BUTTON Bit9 R2

```

M1 wires to left/big rumble motor (SCPH-110)

```

1 (red)    Q1
2 (black)  GND (via some ohm)

```

M2 wires to right/small rumble motor (SCPH-110)

```

1 (red)    +7.5V
2 (black)  Q2

```

U1 ("SD707, 039 107")

```

1 via R9/Q2 to M2 (right/small)      (digital 0V=off, 3V=on)
2 via "JP1" to LED (330 ohm)
3 +3.5V
4 BUTTON Bit2 R3
5 vr2 RX (lt/rt)
6 vr1 RY (up/dn)
7 vr4 LX (lt/rt)
8 vr3 LY (up/dn)
9 BUTTON Bit1 L3
10 GND3
11 GND7
---
12 via Q1 to M1 (left/large)          (1V=off, 6V=fast)
13 via D1/R7 to M1 (left/large)       (6.7V)
14 +7.5V
15 +7.5V
16 BUTTON Bit8 L2
17 BUTTON Bit10 L1
18 BUTTON Bit4 UP
19 BUTTON Bit5 RIGHT
20 BUTTON Bit6 DOWN
21 BUTTON Bit7 LEFT
22 GND3
---
23 BUTTON Bit9 R2
24 BUTTON Bit11 R1
25 BUTTON Bit12 TRIANGLE /\
26 BUTTON Bit13 CIRCLE   ()
27 BUTTON Bit14 CROSS    ><
28 BUTTON Bit15 SQUARE   []
29 BUTTON Bit3 START
30 BUTTON Bit0 SELECT
31 ANALOG BUTTON
32 NC
33 +3.5V
---
34 GND3
35 NC
36 via R5 to /IRQ7
37 via R1 to /SEL
38 via R4 to CMD
39 via R3 to DAT
40 via R2 to CLK
41 +7.5V
42 +7.5V
43 GND7
44 GND7

```

Misc

VR1..VR4 -- analog inputs
 R1..R5 -- signals to/from psx
 R6 ?
 R7 M1
 R8
 R9
 R10
 JP1
 C1 3.5V to GND3 (22uF)
 C2 3.5V to GND3 (U1)
 C3 VR1 to GND3
 C4 VR2 to GND3
 C5 VR3 to GND3
 C6 VR4 to GND3
 C7 M2+ to M2-
 C8 M1+ to M1-
 C9 M1 related
 S5
 S6

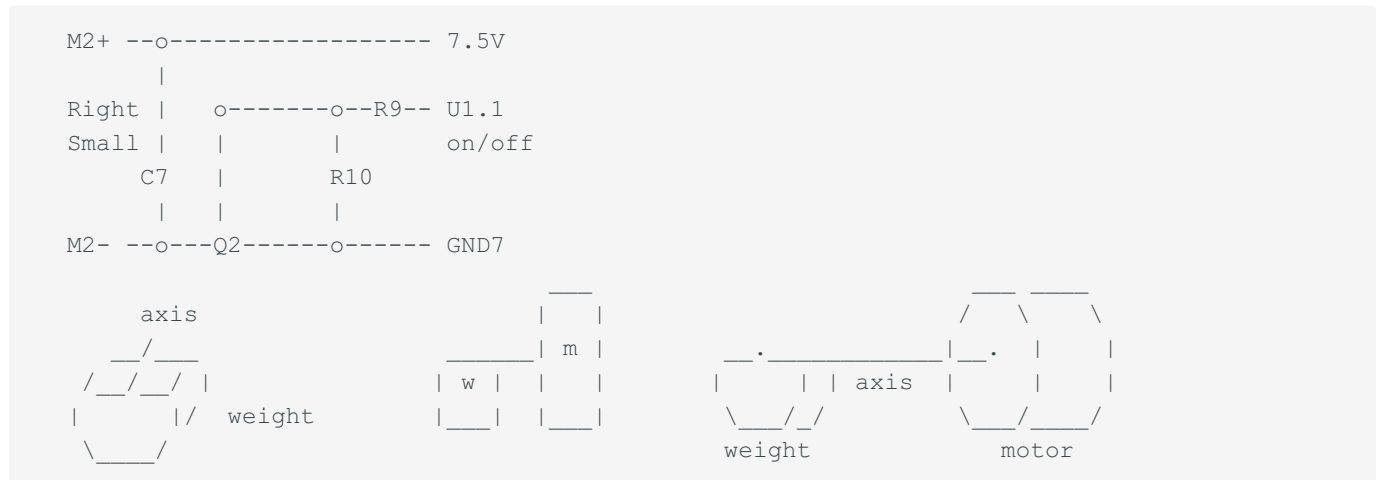
Motors

Left/Large Motor (SCPH-110)
 23.0mm Total Length (12.0mm Motor, 3mm Axis, 8.0mm Weight/plates)
 24.0mm Diameter (Motor), 20.0mm Diameter (Weight/plates)
 Right/Small Motor (SCPH-110)
 25.4mm Total Length (18.7mm Motor, 2mm Axis, 4.7mm Weight/plates)
 12.0mm Width/Diameter (of Weight, and of Motor at flat side)

```

M1+ --o---Q1---o----- U1.12
      |   |   |          analog
Left  |   |   C9
Large |   |   |
      |   o---o----- 7.5V
      |       |
      C8     R7
      |   D1   |       6.7V
      o---|>|--o----- U1.13
      |
M1- --o----- GND7
  
```

D1 is probably a Z-diode with R7 as pull-up, creating a reference/source voltage at U1.13 for the analog output at U1.12.



27.19 Pinouts - Component List and Chipset Pin-Outs for Namco Lightgun, NPC-103

Schematic

<http://www.nicolaselectronics.be/reverse-engineering-the-playstation-g-con45/>

Namco Lightgun "NPC-103, (C) 1996 NAMCO LTD." Component List

PCB "DNP-0500A, NPC10300, namco, CMK-P3X"

```
U1  44pin "NAMCO103P, 1611U1263, JAPAN 9847EAI, D0489AAF"
U2   8pin "7071, 8C19" (=BA7071F, Sync Separator IC with AFC)
XTAL 2pin "CSA 8.00WT"
PS1   3pin Light sensor with metal shielding
J1    9pin Connector for 9pin cable to PSX controller and GunCon plugs
plus resistors and capacitors, and A1,A2,B1,B2,T1,T2 wires to buttons
```

PCB "DN-P-0501"

DIP Button (with black T1,T2 wires) (trigger)

PCB "DN-P-0502"

Button A (with red A1,A2 wires) (left side)
Button B (with white B1,B2 wires) (right side)

Other Components

Lens (20mm)

Cable Pinouts

```
J1.Pin1 green PSX.Controller.Pin5 +3.5V
J1.Pin2 brown PSX.Controller.Pin4 GND
J1.Pin3 black PSX.Controller.Pin9 /ACK/IRQ7
J1.Pin4 red PSX.Controller.Pin6 /JOYn
J1.Pin5 yellow PSX.Controller.Pin1 JOYDAT
J1.Pin6 orange PSX.Controller.Pin2 JOYCMD
J1.Pin7 blue PSX.Controller.Pin7 JOYCLK
J1.Pin8 gray GunCon shield (GND)
J1.Pin9 white GunCon composite video
N/A PSX.Controller.Pin3 +7.5V
N/A PSX.Controller.Pin8 /IRQ10
N/A PSX.Controller Shield
```

U1 "NAMCO103P" Pinouts (44pin, arranged as 4x11pin)

1 GND	12 SYNC (from U2)	23 3.5V	34 SW1 (A)
2 GND	13 3.5V	24 3.5V	35 3.5V
3 GND	14 3.5V	25 3.5V	36 3.5V
4 GND	15 SW3 (TRIGGER)	26 GND	37 SW2 (B)
5 GND	16 JOYCLK (J1.Pin7 via 220 ohm R7)	27 GND	38 3.5V
6 GND	17 3.5V	28 GND	39 3.5V
7 GND	18 JOYCMD (J1.Pin6 via 220 ohm R8)	29 GND	40 LIGHT (from PS1)
8 GND	19 JOYDAT (J1.Pin5 via 0 ohm R10)	30 -	41 GND
9 -	20 /JOYn (J1.Pin4 via 220 ohm R9)	31 GND	42 GND
10 GND	21 /ACK/IRQ7 (J1.Pin3 via 0 ohm R11)	32 GND	43 OSC 8MHz
11 GND	22 GND	33 GND	44 OSC 8MHz

U2 "7071" Pinouts (=BA7071F, Sync Separator IC with AFC) (2x4pin)

```
1 VIN      = SYNC.IN from J1.Pin9 Composite Video (via C5/C6/C7/R6)
2 HD_OUT   = NC
3 GND      = GND
4 PD_OUT   = NC
5 HOSC_R    = via 100K to GND
6 VCC      = 3.5V
7 VD_OUT   = NC
8 SYNC_OUT = SYNC.OUT to U1.pin12 (with R4 pull-up)
```


27.20 Pinouts - Component List and Chipset Pin-Outs for Multitap, SCPH-1070

Multitap Component List

```
Case "SONY, MULTITAP, SonyComputerEntertainmentInc, SCPH-1070 MADE IN CHINA"
PCB1 "SONY 1-659-343-11" (mainboard with Slot A,B, ICs, X1, PSX-cable)
PCB2 "SONY 1-711-414-11" (daughterboard with Slot C,D)
IC? 64pin "SONY JAPAN, CXD103, -166Q, 550D66E" (smd/back side)
IC02 8pin "7W14, 5K" some tiny SMD chip (for JOYCLK) (smd/back side)
X1 2pin "4.00G CMj" oscillator (front side)
J34 2pin fuse or 1 ohm resistor or so (for +3.5V input) (front side)
Jxx 2pin normal wire bridges (except: J34 is NOT a wire) (front side)
```

Cables from Multitap PCB1 to PCB2:

```
1pin black wire Shield/GND (lower edge)
1pin black wire Shield/GND (upper edge)
2x8pin red/gray ribbon cable (side edge)
2x2pin red/gray ribbon cable (lower edge)
2pin red/gray ribbon cable (upper middle) (gray=+3.3V, red=+7.5V)
```

plus a bunch of SMD capacitors and around 70 SMD resistors.

Multitap PSX Controller Port Cable

```
PSX.1 -----brown----- TAP.1 JOYDAT ;via 47 ohm (R57) to CXD.35
PSX.2 -----orange----- TAP.2 JOYCMD ;via 220 ohm (R58) to CXD.37
PSX.3 -----magenta----- TAP.3 +7.5V ;directly to +7.5V on JOY/CARD's
PSX.4 -----black----- TAP.4 GND ;directly to GND
PSX.5 -----red----- TAP.5 +3.5V ;via 1 ohm or so (J34) to +3.3V
PSX.6 -----yellow----- TAP.6 /JOYn ;via 220 ohm (R59) to CXD.46
PSX.7 -----blue----- TAP.7 JOYCLK ;via 220 ohm (R60) to IC02.pin6
PSX.8 -----gray----- TAP.8 /IRQ10 ;via 47 ohm (R02/R16/R30/R44) to JOY's
PSX.9 -----green----- TAP.9 /ACK ;via 47 ohm (R61) to CXD.51
PSX.Shield --shield----- TAP.shielding.plate (GND)
```

Multitap CARD A/B/C/D Slots

```
1 JOYDAT Via 47 ohm (R11/R25/R38/R5x) to CXD.18/29/60/5 (and to JOY slot)
2 JOYCMD Via 220 ohm (R10/R24/R39/R52) to CXD.19/30/62/6
3 +7.5V Directly to PSX.3
4 GND Directly to PSX.4
5 +3.3V Via J34 to PSX.5 (+3.5V)
6 /JOYn Via 220 ohm (R09/R2x/Rxx/R51) to CXD.11/22/52/61
```

```

7 JOYCLK Via 220 ohm (R08/R2x/Rxx/R50) to CXD.33/33/47/47
9 /ACK Via 47 ohm (R07/R2x/Rxx/R49) to CXD.12/21/45/64

```

Multitap JOY A/B/C/D Slots

```

1 JOYDAT Via 47 ohm (R06/Rxx/R34/R5x) to CXD.18/29/60/5 (and to CARD slot)
2 JOYCMD Via 220 ohm (R05/R19/R35/R5x) to CXD.17/28/59/4
3 +7.5V Directly to PSX.3
4 GND Directly to PSX.4
5 +3.3V Via 1 ohm or so (J34) to PSX.5 (+3.5V)
6 /JOYn Via 220 ohm (R04/R18/R32/R4x) to CXD.16/20/55/63
7 JOYCLK Via 220 ohm (R03/R17/R31/R45) to CXD.15/23/56/2
8 /IRQ10 Via 47 ohm (R02/R16/R30/R44) to PSX.8
9 /ACK Via 47 ohm (R01/R15/R29/R43) to CXD.13/27/54/7
Shield Directly to Shield/GND

```

Multitap IC02 8pin "7W14, 5K" some tiny SMD chip

```

1
2
3
4 GND
5
6 via 220 ohm (R60) to PSX.7 (JOYCLK)
7 to CXD.Pin48
8 +3.3V, aka via 1 ohm (J34) to PSX.5 (+3.5V)

```

Multitap "SONY CXD103-166Q" Chip Pin-Outs (Multitap CPU)

```

1 via to 10K (R63) to +3.3V, and via C13 to GND (probably power-on reset)
2 JOY.D.7.JOYCLK
3
4 JOY.D.2.JOYCMD
5 JOY/CARD.D.1.JOYDAT
6 CARD.D.2.JOYCMD
7 JOY.D.9./ACK
8 4MHz X1/C12
9 4MHz X1/C11
10 GND
11 CARD.A.6./JOYn
12 CARD.A.9./ACK
13 JOY.A.9./ACK
14
15 JOY.A.7.JOYCLK
16 JOY.A.6./JOYn
17 JOY.A.2.JOYCMD
18 JOY/CARD.A.1.JOYDAT
19 CARD.A.2.JOYCMD
---
```

```

20 JOY.B.6./JOYn
21 CARD.B.9./ACK
22 CARD.B.6./JOYn
23 JOY.B.7.JOYCLK
24
25 GND
26 +3.3V
27 JOY.B.9./ACK
28 JOY.B.2.JOYCMD
29 JOY/CARD.B.1.JOYDAT
30 CARD.B.2.JOYCMD
31 GND
32
---
33 CARD.A/B.7.JOYCLK
34
35 PSX.1.JOYDAT
36
37 PSX.2.JOYCMD
38
39
40
41
42 GND
43
44 GND
45 CARD.C.9./ACK
46 PSX.6./JOYn
47 CARD.C/D.7.JOYCLK
48 IC02.Pin7.PSX.JOYCLK
49
50
51 PSX.9./ACK
---
52 CARD.C.6./JOYn
53
54 JOY.C.9./ACK
55 JOY.C.6./JOYn
56 JOY.C.7.JOYCLK
57 GND
58 +3.3V
59 JOY.C.2.JOYCMD
60 JOY/CARD.C.1.JOYDAT
61 CARD.D.6./JOYn
62 CARD.C.2.JOYCMD
63 JOY.D.6./JOYn
64 CARD.D.9./ACK

```

27.21 Pinouts - Memory Cards

Sony Playstation Memory Card (SCPH-1020)

The "SONY CXD8732AQ" chip is installed on memory cards with "SPC02K1020B" boards, however, the text layer on the board says that it's an "LC86F8604A" chip. So, the CXD8732AQ is most probably a standard LC86F8604A chip (more on that below) with a Sony Memory Card BIOS ROM on it.

The "SONY CXD8732AQ" comes in a huge 64pin package, but it connects only to:

5 = /IRQ7 (via 22 ohm)	2 = /RESET (from U2)
6 = JOYCLK (via 220 ohm)	30,31 = CF1,CF2 (12 clock pulses per 2us)
7 = /JOYn (via 220 ohm)	14,16,25,32,38,39,61 = 3.5V (via 3.3 ohm)
12 = JOYCMD (via 220 ohm)	8,15,28,29 = GND
13 = JOYDAT (via 22 ohm)	All other pins = Not connected

Aside from that chip, the board additionally contains some resistors, capacitors, z-diodes (for protection against too high voltages), a 6MHz oscillator (for the CPU), and a 5pin reset generator (on the cart edge connector, the supply pins are slightly longer than the data signal pins, so when inserting the cartridge, power/reset gets triggered first; the 7.5V supply pin is left unconnected, only 3.5V are used).

Caution: The "diagonal edge" at the upper-left of the CXD8732AQ chip is Pin 49 (not pin 1), following the pin numbers on the board (and the Sanyo datasheet pinouts), pin 1 is at the lower-left.

Sanyo LC86F8604A

8bit CPU with 132Kbyte EEPROM, 4Kbyte ROM, 256 bytes RAM, 2 timers, serial port, and general purpose parallel ports. The 132K EEPROM is broken into 128K plus 4K, the 4K might be internally used by the CPU, presumably containing the BIOS (not too sure if it's really containing 4K EEPROM plus 4K ROM, or if it's meant to be only either one).

1=P40/A0	9=P13	17=TP0	25=VDD	33=A11	41=NC	49=A7	57=NC
2=/RES	10=P14	18=TP1	26=NC	34=A9	42=NC	50=A6	58=NC
3=TEST2	11=P15	19=TP2	27=NC	35=A8	43=NC	51=A5	59=NC
4=TEST1	12=P16	20=TP3	28=NC	36=A13	44=NC	52=A4	60=NC
5=P10	13=P17	21=TP4	29=VSS	37=A14	45=A17	53=NC	61=NC61
6=P11	14=/CE	22=TP5	30=CF1	38=/WE	46=A16	54=NC	62=P43/A3
7=P12	15=A10	23=TP6	31=CF2	39=VDD	47=A15	55=NC	63=P42/A2
8=VSS	16=/OE	24=TP7	32=VDD	40=EP	48=A12	56=NC	64=P41/A1

Ports P10..P17 have multiple functions (I/O port, data bus, serial, etc):

P10/DQ0/SEPMOD	P12/DQ2/FSIO	P14/DQ4	P16/DQ6/SIO/FSTART
P11/DQ1/SCLK0/FSCLK	P13/DQ3	P15/DQ5	P17/DQ7/SO0/FRW

In March 1998, Sanyo has originally announced the LC86F8604A as an 8bit CPU with "2.8V FLASH, achieved for the first time in the industry", however, according to their datasheet, what they have finally produced is an 8bit CPU with "3.5V EEPROM". Although, maybe the 3.5V EEPROM version came first, and the 2.8V FLASH was announced to be a later low-power version of the old chip; namely, otherwise, it'd be everyones guess what kind of memory Sony used in memory cards before 1998?

Note

For the actual pin-outs of the cart-edge connector, see
[Pinouts - Controller Ports and Memory-Card Ports](#)

27.22 Mods - Nocash PSX-XBOO Upload

Nocash PSX-XBOO Connection (required)

GND (BOARD)	-----	GND	(SUBD.18-25, CNTR.19-30)	
A16 (ROM.2)	-----	SLCT	(SUBD.13, CNTR.13)	;\
A17 (ROM.30)	-----	PE	(SUBD.12, CNTR.12)	; 4bit.dta.out
A18 (ROM.31)	-----	/ACK	(SUBD.10, CNTR.10)	;
A19 (ROM.1)	-----	BUSY	(SUBD.11, CNTR.11)	;/
/RESET	--- > ---	/INIT	(SUBD.16, CNTR.31)	;-reset.in
D0..D7 (74HC541)	-----	DATA	(SUBD.2-9, CNTR.2-9)	;\
Y0..Y7 (74HC541)	-----	D0..D7	(ROM.13-15,17-21)	; 7bit.dta.in, and
/OE1 (74HC541.1)	-----	/EXP	(CPU.98)	; 1bit.dta.clk.in
/OE2 (74HC541.19)	-----	/OE	(ROM.24)	;
GND (74HC541.10)	-----	GND	(BOARD)	;
VCC (74HC541.20)	-----	+5V	(BOARD)	;/

Nocash PSX-BIOS Connection (required)

A0..A19 (ROM)	-----	A0..A19 (EPROM)
D0..D7 (ROM)	-----	D0..D7 (EPROM)
/BIOS (CPU.97)	-----	/CS (EPROM.22)
/OE (ROM.24)	-----	/OE (EPROM.24)
+5V (BOARD)	-----	VCC (EPROM.32)
GND (BOARD)	-----	GND (EPROM.16)
/CS (ROM.22)	--/cut/--	/BIOS (CPU.97)
/CS (ROM.22)	-----	+5V (BOARD) (direct, or via 100k ohm)

Nocash BIOS "Modchip" Feature (optional)

```
SPU.Pin42 "data" -----|>|----- CPU.Pin149 (A20)
SPU.Pin5  "sync" ----- IC723.Pin17
```

The nocash PSX bios outputs the "data" signal on the A20 address line, so (aside from the BIOS chip) one only needs to install a 1N4148 diode and two wires to unlock the CDROM.

For more variants, see:

[CDROM Protection - Chipless Modchips](#)

Composite NTSC/PAL Mod (optional)

[Mods - PAL/NTSC Color Mods](#)

Component List

```
32pin socket for EPROM
EPROM (or FLASH)
74HC541 (8-bit 3-state noninverting buffer/line driver)
1N4148 diode (for reset signal)
1N4148 diode (for optional "modchip" feature)
36pin Centronics socket for printer cable (or 25pin dsub)
```

PSX-XBOO Upload BIOS

The required BIOS is contained in no\$psx (built-in in the no\$psx.exe file), the Utility menu contains a function for creating a standalone ROM-image (file PSX-XBOO.ROM in no\$psx folder; which can be then burned to FLASH or EPROM).

Pinouts

A19,VPP12	1		32	VCC6	/OE1	1		20	VCC
A16	2		31	A18,/PGM	D0	2		19	/OE2
A15	3		30	A17	D1	3		18	Y0
A12	4		29	A14	D2	4		17	Y1
A7	5		28	A13	D3	5	74541	16	Y2
A6	6		27	A8	D4	6		15	Y3
A5	7		26	A9,IDENT12	D5	7		14	Y4
A4	8		25	A11	D6	8		13	Y5
A3	9		24	/OE,VPP12	D7	9		12	Y6
A2	10		23	A10	GND	10		11	Y7
A1	11		22	/CE, (/PGM)					
A0	12		21	D7					

D0		13		20		D6
D1		14		19		D5
D2		15		18		D4
GND		16		17		D3

Note

Instead of the above internal mod, the nocash kernel clone can be also installed on cheat devices, which do also include DB25 connectors for parallel port uploads, too. For DB25 parallel port uploads, do the following mods to the cheat device:

- Datel: use the FiveWire mod to get it parallel port compatible
- Xplorer: simply wire DB25./INIT to EXP./RESET (with diode, if needed)

27.23 Mods - PAL/NTSC Color Mods

The PSX hardware is more or less capable of generating both PAL and NTSC signals. However, it's having the bad habit to do this automatically depending on the game's frame rate. And worse, it's doing it regardless of whether the board is having matching oscillators installed (eg. a PAL board in 60Hz mode will produce NTSC encoding with faulty NTSC color clock).

color encoding	PAL	NTSC
color clock	4.43361875MHz	3.579545MHz
frame rate	50Hz	60Hz

RGB Cables

RGB cables don't rely on composite PAL/NTSC color encoding, and thus don't need any color mods (except, see the caution on GNDed pins for missing 53.20MHz/53.69MHz oscillators below).

Newer Consoles (PU-22, PU-23, PM-41, PM-41(2))

These consoles have 17.734MHz (PAL) or 14.318MHz (NTSC) oscillators with constant dividers, so the color clock will be always constant, and one does only need to change the color encoding:

```
/PAL (IC502.pin13) ---/cut/--- /PAL (GPU.pin157)
/PAL (IC502.pin13) ----- GND (PAL) or VCC (NTSC)
```

This forces the console to be always producing the desired composite color format (regardless of whether the GPU is in 50Hz or 60Hz mode).

That works for NTSC games on PAL consoles (and vice-versa). However, it won't work for NTSC consoles with PAL TV Sets (for that case it'd be easiest to install an extra oscillator, as done on older consoles).

Older Consoles (PU-7, PU-8, PU-16, PU-18, PU-20)

These consoles have 53.20MHz (PAL) or 53.69MHz (NTSC) oscillators and the GPU does try to change the clock divider depending on the frame rate (thereby producing a nonsense clock signal that's neither PAL nor NTSC). Best workaround is to install an extra 4.43361875MHz (PAL) or 3.579545MHz (NTSC) oscillator (with internal amplifier, ie. in 4pin package, which resembles DIP14, hence the pin 1,7,8,14 numbering):

```
GPU -----/cut/--- CXA1645M.pin6 SCIN
GPU -----/cut/--- CXA1645M.pin7 /PAL
Osc.pin14 VCC ----- CXA1645M.pin12 VCC (5V)
Osc.pin7 GND ----- CXA1645M.pin1 GND
Osc.pin8 OUT ----- CXA1645M.pin6 SCIN
Osc.pin1 NC --
GND (PAL) or VCC (NTSC) ----- CXA1645M.pin7 /PAL
```

Caution: Many mainboards have solder pads for both 53.20MHz and 53.69MHz oscillators, the missing oscillator is either GNDed or shortcut with the installed oscillator (varies from board to board, usually via 0 ohm resistors on PCB bottom side). If it's GNDed, remove that connection, and instead have it shortcut with the installed oscillator.

Alternately, instead of the above mods, one could also install the missing oscillator (and remove its 0 ohm resistor), so the board will have both 53.20MHz and 53.69MHz installed; that will produce perfect PAL and NTSC signals in 50Hz and 60Hz mode accordingly, but works only if the TV Set recognizes both PAL and NTSC signals.

Notes

External 4.433MHz/3.579MHz oscillators won't be synchronized with the GPU frame rate (normally you don't want them to be synchronized, but there's some small risk that they might get close to running in sync, which could result in static or crawling color artifacts).

For the CXA1645 chip modded to a different console region, one should also change one of the resistors (see datasheet), there's no noticable difference on the TV picture though.

Region Checks

Some kernel versions contain regions checks (additionally to the SCEX check), particularly for preventing NTSC games to run on PAL consoles, or non-japanese games on japanese consoles. Some PAL modchips can bypass that check (by patching the region byte in BIOS). Expansions ROMs or nocash kernel clone could be also used to avoid such checks.

28. About & Credits

Credits

Contributors to Martin Korth's original documentation:

```
GPU.TXT by doomed/padua; based on info from K-communications & Nagra/Blackbag
GTE.TXT by doomed@c64.org / psx.rules.org
SPU.TXT by doomed@c64.org / psx.rules.org
CDINFO.TXT by doomed with big thanks to Barubary, who rewrote a large part
SYSTEM.TXT by doomed with thanx to Herozero for breakpoint info
PS_ENG.TXT PlayStation PAD/Memory Interface Protocol by HFB03536
IDT79R3041 Hardware User's Manual by Integrated Device Technology, Inc.
IDTR3051, R3052 RISController User's Manual by Integrated Device Technology
PSX.* by Joshua Walker (additional details in various distorted file formats)
LIBMIRAGE by Rok; info/source code for various cdrom-image formats
psxdev.ru; cdrom sub-cpu decapping
```

All the contributors to the [psx-spx.github.io](https://github.com/psx-spx) repo who've helped update, correct and expand this information.

PSXSPX homepage

- [no\\$psx emulator/debugger](#)
- [psx specs in html format](#)
- [psx specs in text format](#)

Contact

- [Martin Korth's email](#)
- [psx-spx issue tracker](#)
- [PSX.Dev Discord server](#)

29. CDROM Video CDs (VCD)

VCDs are Video CDs with MPEG compression, yielding a playtime of 72 minutes per disc (whole movies usually being stored on two CDs). VCDs are popular in asia (as opposed to VHS tapes used in western world).

VCDs on Playstation

For the Playstation, the asian SCPH-5903 model includes a special daughterboard with MPEG decoding hardware for playing VCDs.

[CDROM - Video CD Commands](#)

[Pinouts - VCD Pinouts](#)

Without that hardware it has been widely believed to be impossible to play VCDs on Playstations, although, as of 2017, it turned out that the Playstation's CPU and MDEC decoder are fast enough for that purpose (when skipping B-frames, rendering the movie in monochrome without colors, and reducing audio output to 11kHz/mono).

ISO Filesystem (Track 1)

[VCD ISO Basic Files \(INFO, ENTRIES, AVSEQnn, ISO Filesystem\)](#)

[VCD ISO Playback Control PBC Files \(PSD, LOT, ITEMnnnn\)](#)

[VCD ISO Search Files \(SCANDATA, SEARCH, TRACKS, SPICONTX\)](#)

[VCD ISO Misc files \(CAPTnn, AUDIOnn, KARINFO, PICTURES, CDI\)](#)

MPEG Streams (Track 2 and up)

[VCD MPEG-1 Multiplex Stream](#)

[VCD MPEG-1 Video Stream](#)

[XXX MPEG-1 Macroblocks](#)

[VCD MP2 Audio Stream](#)

VCD Versions & Variants

XXX

29.1 VCD ISO Basic Files (INFO, ENTRIES, AVSEQnn, ISO Filesystem)

Primary Volume Descriptor (00:02:16)

VCDs are having a standard ISO Primary Volume Descriptor, with some VCD specific entries:

```
008h 32  System Identifier (always "CD-RTOS CD-BRIDGE" for VCDs)
028h 32  Volume Identifier (often nonsense, eg. "" or "___" or "VolumeLabel")
23Eh 128 Application Identifier ("CDI/CDI_APPL.VCD;1" or "CDI/CDI_VCD.APP;1")
400h 8   CD-XA Identifying Signature ("CD-XA001" for PSX and VCD)
```

There are some more differences to normal CDROMs:

```
VCDs are using MODE2 (with 800h-byte and 914h-byte sectors)
MPEG videos are on extra data tracks (outside of the ISO area on Track 1)
Files in VCD or SVCD folders use fixed sectors numbers (00:04:00 and up)
All 16bit/32bit values in files in VCD,SVCD,EXT,etc are BIG-ENDIAN
```

Due to the fixed sector numbers, VCDs players can completely ignore the ISO filesystem with filenames and folders, and just address everything via sector numbers (though accessing files in EXT and CDI folders seem to require using the filesystem).

VCD\INFO.VCD or SVCD\INFO.SVD (00:04:00) (800h bytes, one sector)

```
000h 8   ID "VIDEO_CD" for VCD (or "SUPERVCD"/"HQ-VCD " for SVCD)
008h 1   Version                ;Version Major (01h) (or 02h for VCD 2.0)
009h 1   System Profile Tag    ;Version Minor (00h) (or 01h for VCD 1.1 or HQ)
00Ah 16  Album ID/Desc (name in ASCII, padded with SPC) (usually empty)
01Ah 2   Total Number of CDs in Album (1..N) ;\usually always 1,1 (even
01Ch 2   Number of this CD in Album   (1..N) ;/for movies with 2 discs)
01Eh 13  PAL Flags, 98x1bit, for each Track? (0=NTSC, 1=PAL)
02Bh 1   InfoStatusFlags (see below)
Below is usually zero-filled when not using PBC
02Ch 4   Size of PSD.VCD file (or PSD.SVD?) (0=None)
030h 3   First segment addr MM:SS:00 in BCD   (00:02:00 ???)
033h 1   Offset Multiplier for "PsdOffset" values in PSD.VCD (must be 8)
034h 2   Number of ListIDs in LOT.VCD file (1..7FFFh, plus 1 in some discs)
036h 2   Number of ITEMnnnn.DAT files (plus nonsense in some discs?)
Below is usually zero-filled (maybe exists on SVCD only?)
038h 1980 SegmentContent[1..1980] (b0-1=Audio, b2-4=Video, b5=Cont, b6-7=OGT)
7F4h 5*2 volume start time[0]: 5x16bit ;aka playing_time[5] in seconds (?)
7FEh 2   Reserved (0)
```

InfoStatusFlags at [02Bh] describes certain characteristics of the disc:

```

bit0   Reserved, must be zero
bit1-2 Restriction (0=No, 1..3=Restricted category 1..3) (eg. "not for kids")
bit3   Special Information is encoded in the pictures, uh?
bit4   MPEG User Data is used for Closed Caption (user_data_cc) (0=No, 1=Yes)
bit5   Next Disc with PBC      (0=Start at ListID#1, 1=Start at ListID#2)
bit6   Next Disc without PBC   (0=Start at Track #2, 1=Start at Track #3)
bit7   Extended PBC available (0=No, 1=Yes... aka EXT\PSD_X exists?)

```

Note: Bit5/6 are used only if the next disc has the same Album ID (eg. the feature allows to skip copyright messages if the same message was already shown on another disc).

First_segment_addr: The location of the first sector of the Segment Play Item Area [that is... the first ITEMnnnnn.DAT file?], in the form mm:ss:00. Must be 00:00:00 if PSD size is zero. If PSD size is nonzero, but no segments used: Usually set to 00:02:00.

VCD\ENTRIES.VCD or SVCD\ENTRIES.SVD (00:04:01) (800h bytes, one sector)

```

000h 8      ID "ENTRYVCD" for VCD and SVCD (or "ENTRYSVCD" for VCD30)
008h 1      Version                      ;\same as in INFO.VCD/SVD
009h 1      System Profile Tag           ;/
00Ah 2      Number of Entries/Chapters (1..500)
00Ch 4*500  Entry[N] (Track 02h..99h, and MM:SS:FF) (all 4 bytes in BCD)
7DCh 36     Reserved (0)

```

Version;

```

0x02 --- VCD2.0
0x01 --- SVCD, should be same as version in INFO.SVD

```

Sys_prof_tag;

```

0x01 if VCD1.1
0x00 else

```

MPEGAVAVSEQnn.DAT (pointers to max 98 MPEG-1 Tracks, nn=01..98) (for VCDs)

MPEG2\AVSEQnn.MPG (pointers to max 98 MPEG-2 Tracks, nn=01..98) (for SVCDs)

MPEGAVAVSEQnn.MPG (pointers to WHATEVER) (as so on some SVCDs or VCD30?)

These filesystem entries contain pointers to the video tracks (that is, outside of the ISO area on Track 1).

Commercially made SVCDs can reportedly contain 7 folders: Autorun, Data, Ext,

Mpegav, Segment, Svcd and Vmp (ie. there's no MPEG2 folder on all SVCDs? though that MPEGAV folder is said to contain a .MPG file instead of .DAT file).

29.2 VCD ISO Playback Control PBC Files (PSD, LOT, ITEMnnnn)

Playback Control (PBC) is an optional feature that allows to define menus, pictures or text pages (whereas all those is internally just consisting of MPEG compressed bitmaps; rather than of text characters).

Presence of the PBC feature is indicated by PSD.VCD filesize entry (in INFO.VCD) being nonzero. PBC seems to be supported by most VCDs (except older discs from around 1997), however, many VCDs are merely including a single PlayList entry for the movie track, without any further menus/extras.

VCD\PSD.VCD or SVCD\PSD.SVD (00:04:34 and up) (max 256 sectors)

The Descriptors in this file can be considered as being "program code". The program is usually stuck on "executing" the current descriptor (eg. playing a movie, or showing a selection menu) without automatically increasing the program counter. Actual program flow occurs only if the user presses a button (or upon selection timeouts), causing the program to "goto" to a new PsdOffset. And, something does probably happen upon end-of-track/item... maybe that does automatically trigger the Next button handler?

```
<B> PsdPlayListDescriptor (14+2*N bytes):</B>
00h 1   Type (10h=PlayList)
01h 1   Number of Items (noi)      ;for Start-of-Movie and Numeric-Input?
02h 2   ListID for this Descriptor (1..7FFFh)
04h 2   PsdOffset for Prev button   (FFFFh=Disable)
06h 2   PsdOffset for Next button   (FFFFh=Disable)
08h 2   PsdOffset for Return/back button (FFFFh=Disable)
0Ah 2   Play time in 1/15s (=max 72.8 minutes) (or 0000h=full item)
0Ch 1   Delay time in "1s/10s" units after ;<-- uh, after? after what?
0Dh 1   Auto pause time in "1s/10s" units (used for each item in list if
        the auto pause flag in a sector is true) [WHAT is that? Trigger bit?]
0Eh 2*N ItemID[N] ;item number (0..599 or 1000..2979)
        Entry 0 is for "start of movie" (usually 0002h=Track 2)
        Entry 1..N-1 is for numeric input ?

<B> PsdSelectionListDescriptor (20+2*N bytes, or 36+6*N bytes):</B>
00h    1   Type (18h=SELECTION_LIST, or 1Ah=EXT_SELECTION_LIST)
01h    1   Flags (bit0=SelectionArea, bit1=CommandList, bit2-7=Reserved)
02h    1   nos    <-- aka Number of Numeric-input selections ?
03h    1   bsn    <-- ?
04h    2   ListID for this Descriptor (1..7FFFh)
06h    2   PsdOffset for Prev button
08h    2   PsdOffset for Next button
0Ah    2   PsdOffset for Return/back button
```

```

0Ch      2    PsdOffset for Default button (uh, what is that?)
0Eh      2    PsdOffset for Timeout
10h      1    totime <-- aka Timeout Time maybe? in WHAT units?
11h      1    loop   <-- aka ?
12h      2    itemid <-- aka Item to be displayed during the selection?
14h      2*N   PsdOffset[N] for Numeric-input ?
Below only for SVCDs (with Type=18h), or for Extended VCDs (with Type=1Ah):
(14h+2*N) 4    Area for Prev      (x1,y1,x2,y2) ;\these extra entries exist for
(18h+2*N) 4    Area for Next      (x1,y1,x2,y2) ; SVCDs with Type=18h, and
(1Ch+2*N) 4    Area for Return    (x1,y1,x2,y2) ; Extended VCDs with Type=1Ah
(20h+2*N) 4    Area for Default    (x1,y1,x2,y2) ; (but do NOT exist for
(24h+2*N) 4*N   Area[N]           (x1,y1,x2,y2) ;/older VCDs with Type=18h
<B> PsdEndListDescriptor (8 bytes)</B>
00h 1      Type (1Fh=EndList)
01h 1      Next_disc ;00h to stop PBC or NNh to switch to disc no NN (BCD!?)
02h 2      Item (0 or 1000..2979, should be still image, eg. Change Disc pic)
04h 4      Reserved (0)
N/A -      This descriptor doesn't have a ListID (unlike as other descriptors)
<B> PsdCommandListDescriptor (5+2*N bytes)</B>
00h 1      Type (20h=CommandList)
01h 2      Command_count
03h 2      ListID for this Descriptor (1..7FFFh)
05h 2*N    command[EMPTY_ARRAY_SIZE] ;uh, WHAT is a command?
<B> PsdAlignmentPadding (after each list entry)</B>
00h 0..7   Padding to next 8-byte PsdOffset boundary (00h-filled)

```

Delay values in "1s/10s" units (for PlayList[0Ch,0Dh]):

```

1..60    --> wait "N" seconds
61..254  --> wait "(N-60)*10+60" seconds
255      --> wait infinite

```

Item numbers (0..599 or 1000..2979) can be:

```

0..1      - Play nothing
2..99     - Play Track 2..99 (TOC tracks, for AVSEQnn.DAT and AUDIOnn.DAT?)
100..599  - Play Entry 1..500 from table in ENTRIES file up to end of track
600..999  - Reserved
1000..2979 - Play SPI Segment Play Item 1..1980 (ITEMnnnn.DAT file)
2980..65535 - Reserved

```

PsdOffset values can be:

```

0..N      Offset within PSD.VCD file, in 8-byte units
FFFDh     PSD_OFS_MULTI_DEF_NO_NUM ;\uh, what is that?
FFFEh     PSD_OFS_MULTI_DEF        ;/
FFFFh     PSD_OFS_DISABLED          ;-no function assigned to the button

```

For whatever reason, some PsdOffsets are specified as ListID (lid), these ListID values must be translated to actual PsdOffset via the ListID Offset Table (aka LOT.VCD/LOT.SVD file).

VCD\LOT.VCD or SVCD\LOT.SVD (00:04:02..33) (64Kbyte, 32 sectors)

The ListID Offset Table (LOT) allows to translate ListIDs to PsdOffsets. The file is always 64Kbyte in size (unused entries should be set to FFFFh).

The PSD.VCD file does also assign ListIDs to each descriptor (ie. instead of using the LOT.VCD file, one could also scan all descriptors in PSD.VCD when searching a specific ListID).

```
0000h 2      Reserved (0)
0002h 2*7FFFh PsdOffset[1..7FFFh] ;for ListID 1..7FFFh
```

Note: ListID#1 is used as entrypoint to PSD.VCD when inserting a new disc (or when inserting another disc of the SAME movie, the entrypoint can be ListID#2, depending on the Next Disc flag in INFO.VCD).

SEGMENT\ITEMnnnn.DAT (Pictures, Menu screens) (nnnn=0001..1980)

These files contain Pictures/Menu screens referenced from PSD.VCD. The files seem to be stored in FORM2 sectors (not FORM1). Unknown if the files are located on Track 1. The content of the files seems to resemble short MPEG video clips (with only one picture frame, or eventually with a few frames for short animations, including audio in some cases). Still images are said to be allowed to use twice the resolution of MPEG videos.

EXT\PSD_X.VCD or EXT\PSD_X.SVD (extended version of PSD.VCD)

EXT\LOT_X.VCD or EXT\LOT_X.SVD (extended version of LOT.VCD)

The "extended" files are often identical to the normal PSD/LOT files. The difference is that, if disc uses SelectionLists, then PSD should use the normal descriptor (18h), and PSD_X should use the extended descriptor (1Ah), the latter one seems to be intended to allow to highlight the current menu selection (particular useful when using +/- buttons instead of Numeric Keypad input). Note: Nethertheless, Muppets from Space uses descriptor 18h in PSD_X.

Unknown if SVCDs do really have "extended" files, too (theoretically the VCD extension should be a default feature for SVCDs).

Playback Control Issues

Although PBC was intended as "nice extra feature", many VCDs are containing faulty PSD files. In general, VCD players should either leave PBC unsupported (or at the very least, provide an option for disabling it).

Red Dragon from 2003 uses extended selection lists, but crops PSD_X.VCD to the same filesize as PSD.VCD.

Muppets from Space from 1999 assigns weird functions to Prev/Next buttons (Next wraps from Last Track to First Track, but Prev doesn't wrap from First to Last; default Non-PBC Prev/Next functions are more user friendly).

Sony's SCPH-5903 console refuses to display the HH:MM:SS playback time when using PBC (instead it does only display a "PBC" logo).

29.3 VCD ISO Search Files (SCANDATA, SEARCH, TRACKS, SPICONTX)

Below files can help searching I-frames, and provide some info about the content of Tracks and Segments.

Essentially, searching I-frames is possible without these files - however, if present, then the files may be useful in two cases: For discs with variable bitrates (which isn't allowed on VCDs though), and, for CDROM firmwares that don't support "inaccurate" seeking (like telling it to start reading anywhere NEAR some MM:SS:FF value, so one could skip sectors till reaching an I-frame) (ie. if the firmware insists on a "accurate" seek position, then it's best to give it a known I-frame address).

Caution: Overlapping Sectors (!?!)

Reportedly the new SVCD files TRACKS.SVD and SEARCH.DAT are on these sectors:

```
TRACKS_SVD_SECTOR = (PSD_VCD_SECTOR+1)      ;aka 2nd sector in PSD.SVD?
SEARCH_DAT_SECTOR = (TRACKS_SVD_SECTOR+1) ;aka 3rd..Nth sector in PSD.SVD?
```

If that's correct, then the files would overlap with PSD.SVD (when PSD.SVD is bigger than one sector), that would be weird, but possible (ie. the "PsdOffset" in PSD.SVD would need to "skip" the region used by those two files).

EXT\SCANDATA.DAT (12+3*N bytes for VCD 2.0) (or 16+3*N+2*X+3*Y+3*Z for SVCD)

This file fulfills much the same purpose of the SEARCH.DAT file except that this file is mandatory only if the System Profile Tag of the INFO.SVD file is 0x01 (HQ-VCD) and also that it contains sector addresses also for each video Segment Play Items in addition to the regular MPEG tracks.

```
SCANDATA.DAT Format for VCD 2.0 (12+3*N bytes):
000h 8    ID "SCAN_VCD"
008h 1    Version (02h for VCD 2.0)
009h 1    Reserved (0)
00Ah 2    Number of scan points (in 0.5s units) (max FFFFh = ca. 9.1 hours)
00Ch 3*N  Scan Point[0..N-1] ;MM:SS:FF of closest I-frame
SCANDATA.DAT Format for SVCD (16+3*N+2*X+3*Y+3*Z bytes):
000h 8    ID "SCAN_VCD"
008h 1    Version (01h for SVCD)
009h 1    Reserved (0)
00Ah 2    scandata_count ;number of 3-byte entries in the table
00Ch 2    track_count    ;number of MPEG tracks on disc
00Eh 2    spi_count      ;number of consecutively recorded play item segments
                        ; (as opposed to the number of segment play items).
010h 3*N  msf_t cum_playtimes[N] ;cumulative playing time up to track N.
                        ; (track time just wraps at 99:59:74)
xxxxh 2*X spi_indexes[X]        ;Indexes into the following scandata table
xxxxh 2    mpegtrack_start_index ;Index into the following scandata table
                        ; (where the MPEG track scan points start)
xxxxh 3*Y The scandata table... [Y] ;8bit Track Number and 16bit Index
                uint8_t track_num;    /* Track number as in TOC
                uint16_t table_offset; /* Index into scandata table
xxxxh 3*Z msf_t scandata_table[Z] ;MM:SS:FF
```

SVCD\SEARCH.DAT (13+3*N bytes)

This file defines where the scan points are. It covers all mpeg tracks together. A scan point at time T is the nearest I-picture in the MPEG stream to the given time T. Scan points are given at every half-second for the entire duration of the disc.

```
000h 8    ID "SEARCHSV"
008h 1    Version (01h)
009h 1    Reserved (0)
00Ah 2    Number of scan points
00Ch 1    Time_interval (in units of 0.5 seconds) (must be 01h)
00Dh 3*N  Scan Point[0..N-1] ;MM:SS:FF of closest I-frame
```

Note: This SVCD file is about same as the old EXT\SCANDATA.DAT file on VCDs (with one extra entry for Time Interval). Whilst, SVCDs are storing some different stuff in EXT\SCANDATA.DAT (despite of the identical filename).

SVCD\TRACKS.SVD (11+4*N bytes) (or rarely:11+5*N bytes)

The TRACKS.SVD file contains a series of structures, one for each track, which indicates the track's playing time (in sectors, not actually real time) and contents.

SVCD\TRACKS.SVD is a mandatory file which describes the numbers and types of MPEG tracks on the disc.

```
SVCD\TRACKS.SVD Format for SVCD (11+4*N bytes):
000h 8   ID "TRACKSVD"
008h 1   Version (01h)
009h 1   Reserved (0)
00Ah 1   Number of MPEG tracks (N)
00Bh 3*N Track_playing_time[N] (MM:SS:FF, in BCD) (in sectors, not real time)
0xxh 1*N TrackContent[N] ;bit0-1=Audio,bit2-4=Video,bit5=Reserved,bit6-7=OGT
SVCD\TRACKS.SVD Format for VCD30 (11+5*N bytes) (some sort of SVCD-prototype):
000h 8   ID "TRACKSVD"
008h 1   Version (01h)
009h 1   Reserved (0)
00Ah 1   Number of MPEG tracks (N)
00Bh 5*N Cum_Playing_time and Content (MM:SS:FF in BCD, and OGT, Audio)
```

SVCD\SPICONTX.SVD (1000h bytes, two sectors)

Unknown if/when/where/why this file exists, possibly only on VCD30?

Note: The same info can be stored in INFO.SVD at offsets [038h..7F3h].

```
0000h 8   ID "SPICONSVD"
0008h 1   Version (01h)
0009h 1   Reserved (0)
000Ah 2*1980 Segment Content[1..1980] (1st byte=OGT, 2nd byte=Audio)
0F82h 126  Reserved (0)
```

Content Flags for Segments and Tracks

For SVCD\INFO.SVD and SVCD\TRACKS.SVD (on SVCD) these are encoded in 1 byte:

```
bit0-1 Audio characteristics:
      0 = No MPEG audio stream
      1 = One MPEG1 or MPEG2 audio stream without extension
      2 = Two MPEG1 or MPEG2 audio streams without extension
      3 = One MPEG2 multi-channel audio stream with extension
bit2-4 Video characteristics:
      In TRACKS.SVD this must be 0,3,7 (no still pictures)
      0 = No MPEG video data
      1 = NTSC still picture
      2 = NTSC Reserved (NTSC still pic hires?)
      3 = NTSC motion picture
```

```

    4 = Reserved
    5 = PAL still picture
    6 = PAL Reserved (PAL still pic hires?)
    7 = PAL motion picture
bit5   Indicates segment is continuation of an item
       In TRACKS.SVD this must be 0 (reserved)
       0 = First or only segment of item
       1 = Second or later segment of item
bit6-7 Overlay Graphics/Text (OGT):
       0 = No OGT substream
       1 = Sub-stream 0 available
       2 = Sub-stream 0 & 1 available
       3 = All OGT sub-substreams available

```

For SPICONTX.SVD and SVCD\TRACKS.SVD (on VCD30) these are encoded in 2 bytes:

```

1st byte = Audio characteristics      ;\probably same values as
2nd byte = Overlay Graphics/Text (OGT) ;/in above bitfields?

```

29.4 VCD ISO Misc files (CAPTnn, AUDIOnn, KARINFO, PICTURES, CDI)

EXT\CAPTnn.DAT (Closed Caption data, aka subtitles) (SVCD only?)

VCDs with subtitles are usually/always having the subtitles encoded directly in the picture frames (ie. in the MPEG macroblocks, rather than using the Closed Caption feature).

These CAPTnn.DAT files are intended for Closed Captions (eg. subtitles in different languages and/or for deaf people).

Alternately, the "user_data_cc" flag in INFO.VCD?/INFO.SVD can indicate to store Closed Captions in MPEG User Data (with START_CODE=000001B2h=User Data) instead of in EXT\CAPTnn.DAT. Either way, the format of those Closed Captions is unknown.

Moreover, Content can be flagged to have Overlay Graphics/Text (OGT), whatever that is: it might be related to Closed Captions.

Note: Reportedly CAPTnn.DAT can exist on VCDs and SVCDs (although the same person reported that VCDs do not support subtitles, so that info sounds wrong).

CDDA\AUDIOnn.DAT (pointers to uncompressed CD Audio Tracks)

These filesystem entries contain pointers to uncompressed audio tracks tracks (that is, outside of the ISO area on Track 1).

Most VCDs don't have audio tracks (though some VCDs do contain empty CDDA folders).

Maybe the feature is occassionally used the other way around: Music discs containing VCD clips as bonus feature?

KARAOKE\KARINFO.xxx (whatever)

The KARAOKE folder exists on many VCDs (about 50%), but it's usually/always empty on all discs.

Reportedly the folder can contain "KARINFO.xxx" files, but the purpose/format of that files is unknown.

Reportedly there are Midi VCDs (MVCDs) for karaoke, maybe those discs have "KARINFO.xxx" files(?)

PICTURES*. * (whatever)

Unknown purpose. The PICTURES folder has been spotted on one VCD (Wallace and Gromit), but the folder was just empty.

CDI*. * (some kind of GUI/driver for Philips CDI Players)

The CDI folder is some relict for Philips CDI Players, it isn't used by normal VCD players, however, the CDI folder & files are included on most or all VCDs.

The path/name for the CDI executable is stored at offset 23Eh in the ISO Primary Volume Descriptor (usually "CDI/CDI_APPL.VCD;1" or "CDI/CDI_VCD.APP;1") (or accidentally "CDI_CDI_VCD.APP;1" on homebrew Nero discs).

The files in the CDI folder are usually just some standard files (without any customizations), however, there are some different revisions of these files:

```
<B> Revision A (spotted on two discs from 1997 and 1999):</B>
  CDI_APPL.VCD    80702 bytes, 04-Mar-1996, CRC32=AE8FC5D0h ;executable
  VCD_BACK.DYV   92572 bytes, 18-Jul-1995, CRC32=00693E5Eh ;whatever?
  VCD_BTN.C8      93719 bytes, 18-Jul-1995, CRC32=FF0A636Ah ;whatever?
<B> Revision B (spotted on a disc from 2003):</B>
  CDI_VCD.APP     20648 bytes, 00-Nul-0000 CRC32=DC885F70h ;executable
  CDI_FONT.FNT    145388 bytes, 00-Nul-0000 CRC32=FB4D63F4h ;font?
  CDI_ALL.RTF      ? bytes,                CRC32=? ;realtimefile?
  CDI_BUM.RTF      ? bytes,                CRC32=? ;realtimefile?
<B> Revision C (spotted on a disc from 2006, and homebrews from 2001 and 2017):</B>
  CDI_VCD.APP     102400 bytes, 00-Nul-0000 CRC32=E91E128Dh ;executable
  CDI_VCD.CFG      193 bytes, 00-Nul-0000 CRC32=D1C6F7ADh ;config/ascii
  CDI_TEXT.FNT     13616 bytes, 00-Nul-0000 CRC32=BDC55E86h ;font?
  CDI_IMAG.RTF    1510028 bytes, 00-Nul-0000 CRC32=(RIFF) ;realtimefile?
```

CDI_VCD.CFG is some ASCII text file (with uncommon 0Dh,0Dh,0Ah line breaks), the file could be customized to change things like GUI colors, but most or all discs seem to

contain the same file with CRC32=D1C6F7ADh. Note: The CFG file is missing on the homebrew DemoVCD.

CDI_IMAG.RTF is seen as 1510028 byte file under windows (that is, with a windows RIFF header, and with data area containing the whole 930h bytes from each sector; this includes the MM:SS:FF values from the sector header, so the RTF file may look slightly different depending on which sectors it has been stored on, although the files are usually exactly same apart from those MM:SS:FF values). Note: The RTF file is cropped to 1324220 bytes (instead of 1510028) on the homebrew DemoVCD (apart from that, the file is same as normal).

CDI_ALL.RTF and CDI_BUM.RTF cannot be read/copied under Windows 7 (which is weirdly reporting them to use an "invalid MS-DOS function"; some people also reported having CDI_IMAG.RTF files with similar problems). The reason is unknown, maybe windows doesn't fully support the CD filesystem, or some VCDs are violating the filesystem specs, or whatever... maybe windows is mis-identifying certain RTF files as Rich Text Format files and tries to prevent virus-infections by throwing a faked "MS-DOS" error message.

29.5 VCD MPEG-1 Multiplex Stream

Multiplex Stream & Sector Boundaries

The Multiplex stream is some higher level stream, intended to help to distinguish between Audio- and Video-streams (which are enclosed in the Multiplex stream). MPEG's are somewhat organized in "sectors", with sector size varying for normal .mpg files and VCDs:

```
VCD discs    --> Sector Size = 914h bytes (the discs MODE2/FORM2 sector size)
.mpg files   --> Sector Size = 800h bytes (regardless of physical sector size)
```

Sectors are always beginning with a Multiplex Packet (and Multiplex Packets are never crossing sector boundaries). If the amount of video data exceeds the sector size, then it's split into several Multiplex packets, whereas, that may happen anywhere in the video stream (ie. there can be Multiplex Headers occurring even in the middle of Video packet).

MPEG-1 Multiplex Pack (sector header) (12 bytes)

The Pack Header is found at the begin of the stream (on VCDs, it's also found at the begin of each sector). The SCR values might help on identifying the current playback position, and, with the bitrate value, this could be also used to compute the distance to

another position (though there are other ways to determine the position/bitrate, so the Pack is kinda useless).

```

32bit PACK_START_CODE (000001BAh)                ;-4byte
2bit Fixed (00b for MPEG-1) (would be 01b for MPEG-2) ;\
2bit Fixed (10b)                                   ;
3bit System Clock Reference, bit32-30             ;\
1bit Marker (1)                                   ; System Clock Reference (SCR) ;
15bit System Clock Reference, bit29-15             ; (intended Time,                ; 5byte
1bit Marker (1)                                   ; in 90kHz clock cycles)                ;
15bit System Clock Reference, bit14-0              ;/
1bit Marker (1)                                   ;/
1bit Marker (1)                                   ;\
22bit Multiplex Rate (total bitrate of the stream, in 400bit/s units) ; 3byte
1bit Marker (1)                                   ;/

```

MPEG-1 Multiplex System Header (12+N*3 bytes)(optionally)(at start of stream)

The System Header is usually found after the first Pack at the begin of the stream.

```

32bit SYSTEM_HEADER_START_CODE (000001BBh)        ;\6byte
16bit Header Length minus 6 (in bytes) (0006h+N*3) ;/
1bit Marker (1)                                   ;\
22bit Rate bound (max multiplex rate of all packs in the stream, ; 3byte
1bit Marker (1)                                   ;/
6bit Audio Bound (max number of audio streams in this ISO stream) ;\
1bit Fixed Flag (1=Fixed bitrate)                  ; 1byte
1bit CSPS Flag (1=Constrained)                     ;/
1bit System Audio Lock Flag XXX                     ;\
1bit System Video Lock Flag XXX                     ; 1byte
1bit Marker (1)                                   ;
5bit Video Bound (max number of video streams in this ISO stream) ;/
8bit Reserved (FFh)                                ;-1byte

```

Followed by N*3 bytes for the streams (each with first bit=set):

```

8bit Stream ID (C0h..DFh=Audio, E0h..EFh=Video)    ;\
2bit Fixed (11b)                                   ; 3byte
1bit STD buffer scale (0=Mul128/audio, 1=Mul1024/video) ;
13bit STD buffer size (largest required buffer over all packets) ;/

```

Terminated by a value with first bit=cleared (eg. next 000001xxh value).

MPEG-1 Multiplex Video/Audio/Special Packets (7..24 bytes, plus data)

These packets are encapsulating the lower-level Video/Audio streams.

```

32bit  START (000001xxh BDh-BFh=Special, C0h-DFh=Audio, E0h-EFh=Video);\6byte
16bit  Packet Length minus 6 (in bytes) (1..18, plus data)          ;/

```

If (and while) next two bits are 11b (0..16 padding bytes):

```

(2bit) Fixed (11b, indicates presence of stuffing)          ;\optional 0..16byte
(6bit) Fixed (111111b)                                     ;/

```

If next two bits are 01b (buffer size info):

```

(2bit) Fixed (01b, indicates presence of buffer size)       ;\
(1bit) STD Buffer Scale (0=Mul128/audio, 1=Mul1024/video)   ; optional 2byte
(13bit) STD Buffer Size (for decoding, in above scale units) ;/

```

Always:

```

2bit  Fixed (00b, indicates no further stuffing/buffer info);\
1bit  PTS Flag (Presentation Time Stamp)                    ; 0.5 bytes
1bit  DTS Flag (Decoding Time Stamp)                        ;/

```

If PTS Flag set:

```

(3bit) Presentation Time Stamp, bit32-30                    ;\
(1bit) Marker (1)                                           ; optional 4.5 bytes
(15bit) Presentation Time Stamp, bit29-15                    ; (time when to output the
(1bit) Marker (1)                                           ; the packet to audio/video
(15bit) Presentation Time Stamp, bit14-0                     ; hardware, in 90kHz cycles)
(1bit) Marker (1)                                           ;/

```

If DTS Flag set (in this case PTS Flag must be also set):

```

(4bit) Fixed (0001b)                                        ;\
(3bit) Decoding Time Stamp, bit32-30                        ; optional 5 bytes
(1bit) Marker (1)                                           ; (recommended time when
(15bit) Decoding Time Stamp, bit29-15                        ; to decode the block,
(1bit) Marker (1)                                           ; in 90kHz cycles)
(15bit) Decoding Time Stamp, bit14-0                        ;
(1bit) Marker (1)                                           ;/

```

If PTS and DTS Flags are both zero:

```

(4bit) Fixed (1111b)                                       ;-optional 0.5 bytes

```

Always:

```

... packet data bytes                                     ;-data...(not crossing sector)

```


Note: The first Multiplex Video Packet would usually start with a Sequence Header Code (000001B3h), and the first Multiplex Audio Packet should always start with an Audio Sync Word (FFFh).

However, the size of the Multiplex packets does usually differ from the size of the packets in the audio/video stream, so new Multiplex Packets may occur anywhere in the middle of those streams (eg. in the middle of a video slice, the next Multiplex Video packet would then begin with the remaining slice bytes, rather than with a 000001xxh code; it's also possible that a Multiplex Audio packet gets inserted in the middle of the video slice). The best (or easiest) way to get continuous data for the lower level streams might be to memcpy the data from Multiplex packets to separate Audio & Video buffers.

MPEG-1 Multiplex End Code (4 bytes)

```
32bit END_CODE (000001B9h) ; -4byte
```

This should occur at the end of the video. On a VCD it does also occur at the end of each video track.

29.6 VCD MPEG-1 Video Stream

The Video stream is part of the Multiplex stream, meaning that the Video packets preceeded (and interrupted) by Multiplex headers. Ie. before processing the Video packets, one must first extract the video snippets from the Multiplex stream (see previous chapter).

MPEG-1 Video Sequence Header (12, 76, or 140 bytes, ie. 12+N*64)

```
32bit SEQUENCE_HEADER_CODE (000001B3h) ; -4byte
12bit Width in pixels (1..4095) ; \3byte
12bit Height in pixels (1..2800, for max AFh slices) ; /
4bit Aspect Ratio (01h..0Eh, see below) ; \1byte
4bit Framerate (01h..08h, see below) ; /
18bit Bitrate (in 400bit/s units, 3FFFFh=variable rate) ; \
1bit Marker (1) ; 3byte
10bit VBV (required decoding memory size, in "16 kB" units) ; +6bit
1bit Constrained Parameter Flag ; /
1bit Load Intra Q Matrix (0=No, use Standard Matrix, 1=Yes, Custom)
```

Next 64byte only when above bit was set:

```
(64byte) Intra Quantizer Matrix (64 x 8bit, unsigned) (in zigzag order)
1bit Load Non-Intra Q Matrix (0=No, use Standard Matrix, 1=Yes, Custom)
```

Next 64byte only when above bit was set:

```
(64byte) Non-Intra Quantizer Matrix (64 x 8bit, unsigned) (in zigzag order)
```

Aspect Ratio values:

```
0      -      ;forbidden
1      1.0     ;square pixels
2      0.6735  ;0.6735
3      0.7031  ;16:9, 625 line, PAL
4      0.7615  ;0.7615
5      0.8055  ;0.8055
6      0.8437  ;16:9, 525 line, NTSC
7      0.8935  ;0.8935
8      0.9157  ;4:3, 625 line, PAL, CCIR601
9      0.9815  ;0.9815
10     1.0255  ;1.0255
11     1.0695  ;1.0695
12     1.0950  ;4:3, 525 line, NTSC, CCIR601
13     1.1575  ;1.1575
14     1.2015  ;1.2015
15     -      ;reserved
```

Frame Rate values:

```
0      -      ;forbidden
1      23.976 (24000/1001) ;NTSC encapsulated film rate
2      24.0    ;Standard international cinema film rate
3      25.0    ;PAL video frame rate (625/50)
4      29.97 (30000/1001) ;NTSC video frame rate
5      30.0    ;NTSC video frame rate drop-frame (525/60)
6      50.0    ;PAL double frame rate/progressive
7      59.94 (60000/1001) ;NTSC double frame rate
8      60.0    ;NTSC double frame rate drop-frame
9-15   -      ;reserved
```

MPEG-1 Video Group of Pictures (GOP) (8 bytes) XXX...

```
32bit GROUP_START_CODE (000001B8h)
1bit Drop Frame (1=drop this frame; for reducing 30 fps to 29.97 fps)
5bit Time Code Hours (0..23)
6bit Time Code Minutes (0..59)
1bit Marker (1)
6bit Time Code Seconds (0..59)
6bit Time Code Picture (0..59)
```

```
1bit Closed GOP
1bit Broken Link
```

MPEG-1 Video Picture Header XXX...

```
32bit PICTURE_START_CODE (00000100h) ;\
10bit Temporal Reference (display order, 0..3FFh) ; 61bit
3bit Coding Type (0=Invalid, 1=I, 2=P, 3=B, 4=D, 5-7=Reserved);
16bit VBV Delay (in 90kHz cycles, FFFFh=variable bitrate) ;/
```

If Coding Type is 2 or 3 (P-Frame or B-Frame):

```
(1bit) full forward vector (0=half pix, 1=full pix) ;\optional 4bit
(3bit) forward f code (0=invalid, 1..7=0..6bits) ;/
```

If Coding Type is 3 (B-Frame):

```
(1bit) full backward vector ;\optional 4bit
(3bit) backward f code ;/
```

If (and while) next bit is set:

```
(1bit) Fixed (1, indicates presence of Extra Info) ;\opt. N*9bit
(8bit) Extra Information ;/
```

End of Extra:

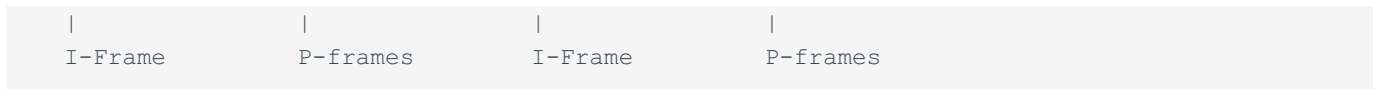
```
1bit Fixed (0, indicates no further Extra Info) ;-1bit
0-7bit Padding to byte boundary (0) ;-0..7bit
```

Coding Type values:

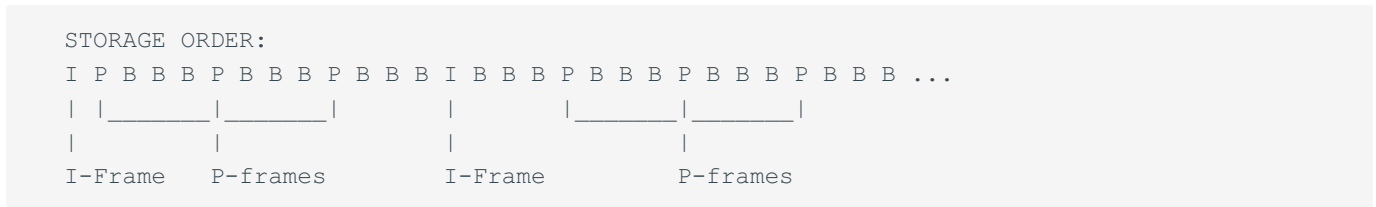
```
0 Forbidden
1 I - Intra Coded (full image)
2 P - Predictive Coded (based on prev I or P frame)
3 B - Bidirectionally Predictive Coded (based on prev+next I or P frame)
4 D - DC Intra Coded (don't care, lowres thumbnail)
5 Reserved
6 Reserved
7 Reserved
```

Frame Order

```
DISPLAY ORDER:
I B B B P B B B P B B B P B B B I B B B P B B B P B B B P B B B ...
|         |_____|_____|         |         |_____|_____|
```



The B-frames require to know the next P- (or I-) frame in advance, for that reason, the frames are stored as "PBBB" (although being played as "BBBP"):



MPEG-1 Video Slice

Slices are containing the actual 16x16 pixel Macro Blocks. Usually a Slice contains one horizontal line - although, theoretically, it could be longer or shorter, ie. a slice could wrap to next line, or a line could be split into several slices (with the leading "MBA Increment" value greater than 1 to define the horizontal start offset).

```
32bit  PACK_START_CODE (000001xxh; xx=01h..AFh; vertical index) ;-4byte
5bit   Quantizer Scale (1..31) (may be later changed by blocks) ;-5bit
```

If (and while) next bit is set:

```
(1bit) Fixed (1, indicates presence of Extra Info)                ;\opt. N*9bit
(8bit) Extra Information                                           ;/
```

End of Extra:

```
1bit  Fixed (0, indicates no further Extra Info)                  ;-1bit
```

If (and while) next 23bit are nonzero (ie. until next 000001xxh):

```
...   Macroblock (within horizontal line)                         ;...
```

Final padding:

```
0-7bit  Padding to byte boundary (0)                               ;-0..7bit
```

MPEG-1 Video Group/Sequence Extension Data (reserved)

MPEG-1 Video User Data (optional)

```
32bit START_CODE (000001B2h=User Data, 000001B5h=Extension Data)      ;-4byte
... data (end is signaled by presence of next 000001xxh code)           ;-data
```

User Data can contain Closed Captions (see flag in VCD\INFO.VCD or SVCD\INFO.SVD).
User Data contains 11h-byte "Created with Nero" in some homebrew discs.

MPEG-1 Video Sequence End Code (4 bytes)

```
32bit SEQUENCE_END_CODE (000001B7h)                                     ;-4byte
```

MPEG-1 Video 4:2:0 Macroblock

```
N*11bit  Macroblock_address_increase escape/stuffing codes (if any)
1..11bit Macroblock_address_increase
1-6bit   Macroblock_type
5bit     Quantizer_scale
...      Motion_vector
3-9bit   Coded_block_pattern
...      Block(i)
```

Aka...

```
Addr Incr
Type
Motion Vector
QScale
CBP
Block b0 (Y1)
Block b1 (Y2)
Block b2 (Y3)
Block b3 (Y4)
Block b4 (Cb)
Block b5 (Cr)
```

29.7 VCD MP2 Audio Stream

VCD video discs and .mpg movie files are having the MP2 Audio Stream enclosed in the Multiplex stream (whilst .mp2 audio files may contain raw MP2 data without Multiplex stream).

Each MP2 frame is starting with a FFFh syncword (which is always located on a byte boundary). Unfortunately, the value FFFh can also occur anywhere in the audio data (eg. a 16bit sample with value 3FFCh).

So, when starting mid-stream, one will need some guessing when searching a valid syncword. The best method is to compute the frame size (based on the supposed frame header), and then to check if supposed frame begins AND ends with a sync word. Moreover, one could check for invalid sample rate values in the frame header, or invalid "groupings" in the frame's data part.

VCDs are conventionally having three audio frames encoded in one CDROM sector, so the first syncword can be simply found right after the multiplex packet header (though that might differ in some cases: VCD2.0 allows different audio bitrates, and a CDROM sector could be theoretically shared for Audio and Video data).

Overall MP2 Frame Format

```
Header (32bit)
Optional CRC (16bit) (or 0bit if none)
Allocation Information
Scale Factor Selector Information
Scale Factors
Data
```

MP2 Header

```
12bit Syncword (FFFh) ;\
1bit Revision (0=MPEG-2, 1=MPEG-1) ; 2 bytes
2bit Layer (2=Audio LayerII) ;for VCDs ;
          (3=LayerI, 1=LayerIII, 0=reserved) ;not on VCDs ;
1bit Protection_bit (1=no crc) ;/
4bit Bitrate_index (1..14) ;\
          (0=free format, 15=reserved) ;
2bit Sampling_frequency ; 1 byte
1bit Padding_bit ;
1bit Private_bit ;/
2bit Mode ;\
2bit Mode_extension (aka bound) ;
1bit Copyright ; 1 byte
1bit Original/home ;
2bit Emphasis ;/
```

MP2 Checksum (optional)

```
16bit CRC
```

Allocation Information

Scale Factor Selector Information

Scale Factors

Data

XXX...

30. CDROM Internal Info on PSX CDROM Controller

PSX software can access the CDROM via Port 1F801800h..1F801803h (as described in the previous chapters). The following chapters describe the inner workings of the PSX CDROM controller - this information is here for curiosity only - normally PSX software cannot gain control of those lower-level stuff (although some low level registers can be manipulated via Test commands, but that will usually conflict with normal operation).

Motorola MC68HC05 (8bit single-chip CPU)

The Playstation CDROM drive is controlled by a MC68HC05 8bit CPU with on-chip I/O ports and on-chip BIOS ROM. There is no way to reprogram that BIOS, nor to tweak it to execute custom code in RAM.

[CDROM Internal HC05 Instruction Set](#)

[CDROM Internal HC05 On-Chip I/O Ports](#)

[CDROM Internal HC05 I/O Port Usage in PSX](#)

[CDROM Internal HC05 Motorola Selftest Mode](#)

The PSX can read HC05 I/O Ports and RAM via Test Commands:

[CDROM - Test Commands - Read HC05 SUB-CPU RAM and I/O Ports](#)

Decoder/FIFO (CXD1199BQ or CXD1815Q)

This chip handles error correction and ADPCM decoding, and acts as some sort of FIFO interface between main/sub CPUs and incoming cdrom sector data. On the MIPS Main CPU it is controlled via Port 1F801800h..1F801803h.

[CDROM Controller I/O Ports](#)

On the HC05 Sub CPU it is controlled via Port A (data in/out), Port E (address/index), and Port D (read/write/select signals); the HC05 doesn't have external address/data bus, so one must manually access the CXD1815Q via those ports.

[CDROM Internal CXD1815Q Sub-CPU Configuration Registers](#)

[CDROM Internal CXD1815Q Sub-CPU Sector Status Registers](#)

[CDROM Internal CXD1815Q Sub-CPU Address Registers](#)

[CDROM Internal CXD1815Q Sub-CPU Misc Registers](#)

The PSX can read/write the Decoder I/O Ports and SRAM via Test commands:

[CDROM - Test Commands - Read/Write Decoder RAM and I/O Ports](#)

The sector buffer used in the PSX is 32Kx8 SRAM. Old PU-7 boards are using CXD1199BQ chips, later boards are using CXD1815Q, and even later boards have the stuff intergrated in the SPU. Note: The CXD1199BQ/CXD1815Q are about 99% same as described in CXD1199AQ datasheet.

Signal Processor and Servo Amplifier

Older PSX mainboards are using two separate chips:

[CDROM Internal Commands CX\(0x..3x\) - CXA1782BR Servo Amplifier](#)

[CDROM Internal Commands CX\(4x..Ex\) - CXD2510Q Signal Processor](#)

Later PSX mainboards have the above intergrated in a single chip, with some extended features:

[CDROM Internal Commands CX\(0x..Ex\) - CXD2545Q Servo/Signal Combo](#)

Later version is CXD1817R (Servo/Signal/Decoder Combo).

Even later PSX mainboards have it integrated in the Sound Chip: CXD2938Q (SPU+CDROM) with some changed bits and New SCEX transfer:

[CDROM Internal Commands CX\(0x..Ex\) - CXD2938Q Servo/Signal/SPU Combo](#)

Finally, PM-41(2) boards are using a CXD2941R chip (SPU+CDROM+SPU_RAM), unknown if/how far the CDROM part of that chip differs from CXD2938Q.

Some general notes:

[CDROM Internal Commands CX\(xx\) - Notes](#)

[CDROM Internal Commands CX\(xx\) - Summary of Used CX\(xx\) Commands](#)

The PSX can manipulate the CX(..) registers via some test commands:

[CDROM - Test Commands - Test Drive Mechanics](#)

Note: Datasheets for CXD2510Q/CXA1782BR/CXD2545Q do exist.

CDROM Pinouts

[Pinouts - DRV Pinouts](#)

[Pinouts - HC05 Pinouts](#)

30.1 CDROM Internal HC05 Instruction Set

ALU, Load/Store, Jump/Call

Opcode	Clk	HINZC	Name	Syntax	
x6 ...	2-5	--NZ-	LDA	MOV A, <op>	; A=op
xE ...	2-5	--NZ-	LDX	MOV X, <op>	; X=op
x7 ...	4-6	--NZ-	STA	MOV <op>, A	; op=A

xF ...	4-6 --NZ-	STX	MOV <op>,X	;op=X
xC ...	2-4 -----	JMP	JMP <op>	;PC=op
xD ...	5-7 -----	JSR	CALL <op>	;[SP]=PC, PC=op
xB ...	2-5 H-NZC	ADD	ADD A,<op>	;A=A+op
x9 ...	2-5 H-NZC	ADC	ADC A,<op>	;A=A+op+C
x0 ...	2-5 --NZC	SUB	SUB A,<op>	;A=A-op
x2 ...	2-5 --NZC	SBC	SBC A,<op>	;A=A-op-C
x4 ...	2-5 --NZ-	AND	AND A,<op>	;A=A AND op
xA ...	2-5 --NZ-	ORA	OR A,<op>	;A=A OR op
x8 ...	2-5 --NZ-	EOR	XOR A,<op>	;A=A XOR op
x1 ...	2-5 --NZC	CMP	CMP A,<op>	;A-op
x3 ...	2-5 --NZC	CPX	CMP X,<op>	;X-op
x5 ...	2-5 --NZ-	BIT	TEST A,<op>	;A AND op
A7,AF,AC = Reserved (no STA/STX/JMP with immediate operand)				

Operands can be...

Opcode	Clk	ALU/LDA/LDX	Clk	STA/STX	Clk	JMP/CALL
Ax nn	2	cmd r,nn	-	N/A	-/6	call relative (BSR)
Bx nn	3	cmd r,[nn]	4	mov [nn],r	2/5	cmd nn
Cx nn mm	4	cmd r,[nnmm]	5	mov [nnmm],r	3/6	cmd nnmm
Dx nn mm	5	cmd r,[X+nnmm]	6	mov [X+nnmm],r	4/7	cmd X+nnmm
Ex nn	4	cmd r,[X+nn]	5	mov [X+nn],r	3/6	cmd X+nn
Fx	3	cmd r,[X]	4	mov [X],r	2/5	cmd X

Read-Modify-Write

Opcode	Clk	HINZC	Name	Syntax		
xC ...	3-6 --NZ-	INC	INC op	;increment	;op=op+1	
xA ...	3-6 --NZ-	DEC	DEC op	;decrement	;op=op-1	
xF ...	3-6 --01-	CLR	?? op,00h	;clear	;op=op AND 00h	
x3 ...	3-6 --NZ1	COM	NOT op	;complement	;op=op XOR FFh	
x0 ...	3-6 --NZC	NEG	NEG op	;negate	;op=00h-op	
x9 ...	3-6 --NZC	ROL	RCL op	;rotate left through carry		
x6 ...	3-6 --NZC	ROR	RCR op	;rotate right through carry		
x8 ...	3-6 --NZC	LSL	SHL op	;shift left logical		
x4 ...	3-6 --0ZC	LSR	SHR op	;shift right logical		
x7 ...	3-6 --NZC	ASR	SAR op	;shift right arithmetic		
xD ...	3-5 --NZ-	TST	TEST op,FFh	;test for negative or zero (AND FFh?)		
x1,x2,x5,xB,xE = Reserved (except for: 42 = MUL)						

Operands can be...

Opcode	Clk	RMW	Clk	CLR	Clk	TST
3x nn	5	cmd [nn]	5	MOV [nn],00h	4	TEST [nn],0FFh
4x	3	cmd A	3	MOV A,00h,slow	3	TEST A,0FFh,slow
5x	3	cmd X	3	MOV X,00h,slow	3	TEST X,0FFh
6x nn	6	cmd [X+nn]	6	MOV [X+nn],00h	5	TEST [X+nn],0FFh
7x	5	cmd [X]	5	MOV [X],00h	4	TEST [X],0FFh

CLR includes a dummy-read-cycle, whilst TST does omit the dummy-write cycle. The ",slow" RMW opcodes are smaller, but slower than equivalent ALU opcodes.

Bit Manipulation and Bit Test with Relative Jump (to \$+3+/-dd)

Opcode	Clk	HINZC	Name	Syntax	
00h+i*2 nn dd 5 ----C	BRSET	JNZ	[nn].i,dest	;C=[nn].i, branch if set	
01h+i*2 nn dd 5 ----C	BRCLR	JZ	[nn].i,dest	;C=[nn].i, branch if clear	
10h+i*2 nn 5 -----	BSET	SET	[nn].i	;set [nn].i	
11h+i*2 nn 5 -----	BCLR	RES	[nn].i	;clear [nn].i	

Branch (Relative jump to \$+2+/-nn)

Opcode	Clk	HINZC	Name	Syntax	
20 nn	3	-----	BRA	JR nn	;branch always
21 nn	3	-----	BRN	NUL nn	;branch never
22 nn	3	-----	BHI	JA nn	;if C=0 and Z=0, higher ?
23 nn	3	-----	BLS	JBE nn	;if C=1 or Z=1, lower or same ?
24 nn	3	-----	BCC/BHS	JNC/JAE nn	;if C=0, carry clear, higher.same
25 nn	3	-----	BCS/BLO	JC/JB nn	;if C=1, carry set, lower
26 nn	3	-----	BNE	JNZ/JNE nn	;if Z=0, not equal / not zero
27 nn	3	-----	BEQ	JZ/JE nn	;if Z=1, equal / zero
28 nn	3	-----	BHCC	JNH nn	;if H=0, half-carry clear
29 nn	3	-----	BHCS	JH nn	;if H=1, half-carry set
2A nn	3	-----	BPL	JNS nn	;if S=0, plus / not signed
2B nn	3	-----	BMI	JS nn	;if S=1, minus / signed
2C nn	3	-----	BMC	JEI nn	;if I=0, interrupt mask clear
2D nn	3	-----	BMS	JDI nn	;if I=1, interrupt mask set
2E nn	3	-----	BIL	JIL nn	;if XX=LO, interrupt line low
2F nn	3	-----	BIH	JIH nn	;if XX=HI, interrupt line high
AD nn	6	-----	BSR	CALL relative nn	;branch to subroutine always

Control/Misc

Opcode	Clk	HINZC	Name	Syntax	
9D	2	-----	NOP	NOP	;no operation
97	2	-----	TAX	MOV X,A	;transfer A to X
9F	2	-----	TXA	MOV A,X	;transfer X to A
9C	2	-----	RSP	MOV SP,00FFh	;reset stack pointer (SP=00FFh)
42	11	0---0	MUL	MUL X,A	;X:A=X*A (unsigned multiply)
81	6	-----	RTS	RET	;return from subroutine
80	9	xxxxx	RTI	RETI	;return from interrupt
99	2	----1	SEC	STC	;set carry flag
98	2	----0	CLC	CLC	;clear carry flag
9B	2	-1---	SEI	DI	;set interrupt mask (disable ints)
9A	2	-0---	CLI	EI	;clear interrupt mask (enable ints)
8E	..2	-0---	STOP	STOP	;?
8F	..2	-0---	WAIT	WAIT	;?
83	10	-1---	SWI	SWI	;software interrupt ...? PC=[FFFCh]

<IRQ>	? ????? Interrupt	;?	PC=[FFFxh]
<RESET>	? ????? Reset	;?	PC=[FFFEh]
82,84..8D,90..96,9E = Reserved			

MUL isn't supported in original "M146805 CMOS" family (MUL is used/supported in PSX cdrom controller).

Registers

```

A   8bit  accumulator
X   8bit  index register
SP  6bit  stack pointer (range 00C0h..00FFh)
PC  16bit program pointer (range 0000h..FFFFh)
CCR 5bit  condition code register (flags) (111HINZC)

```

Pushed on IRQ are:

```

SP.highest PC.lo
           PC.hi
           X
           A
SP.lowest  Flags (CCR, 5bit condition code register) (111HINZC)

```

Addressing Modes

nn	immediate	;00h..FFh
[nn]	direct address	;[0000h..00FFh]
[nnmm]	extended address	;[0000h..FFFFh]
[X]	indexed, no offset	;[0000h..00FFh]
[X+nn]	indexed, 8bit offset	;[0000h..01FEh]
[X+nnmm]	indexed, 16bit offset	;[0000h..FFFFh]
[nn].i	bit	;[0000h..00FFh].bit0..7
dd	relative	;\$+2..3+(-80h..+7Fh)

Notes:

```

operand "X+nn" performs an unsigned addition, and can address 0000h..01FEh.
16bit operands (nnmm) are encoded in BIG-ENDIAN format (same for pushed PC).

```

Exception Vectors

Exception vectors are 16bit BIG-ENDIAN values at FFF0h-FFFFh (or at FFE0h-FFEFh when running in Motorola Bootstrap mode).

Vector	Prio	Usage
FFF0h	7=lo	TBI Vector (Timebase)
FFF2h	6	SSPI Vector (SPI bus) (SPI1 and SPI2)
FFF4h	5	Timer 2 Interrupt Vector (Timer 2 Input/Compare)
FFF6h	4	Timer 1 Interrupt Vector (Timer 1 Input/Compare/Overflow)
FFF8h	3	KWI Vector (Key Wakeup) (KWI0..7 pins)
FFFAh	2	External Interrupt Vector (/IRQ1 and /IRQ2 pins)
FFFCh	none	Software Interrupt Vector (SWI opcode) ;\regardless of
FFFEh	1=hi	Reset Vector (/RESET signal and COP) ;/CPU's "I"

Directives/Pseudos (used by a22i assembler; in no\$psx utility menu)

```
.hc05      select HC05 instruction set (default would be .mips)
.nocash    select nocash syntax (default would be .native opcode names)
db ...     define 8bit byte(s), or quoted ascii strings
dw ...     define 16bit word(s) in BIG ENDIAN (for HC05 exception vectors)
org nnnn   change origin for following opcodes
end        end of file
mov c,[nn].i  alias for "jnz [nn].i,$+3" (dummy jump & set carry=[nn].i)
```

30.2 CDROM Internal HC05 On-Chip I/O Ports

HC05 Port 3Eh - MISC - Miscellaneous Register (R/W)

0	OPTM	Option Map Select (bank-switching for Port 00h..0Fh)
1	FOSCE	Fast (Main) Oscillator Enable (0=Disable OSC, 1=Normal)
2-3	SYS	System Clock Select (0=OSC/2, 1=OSC/4, 2=OSC/64, 3=XOSC/2)
4-5	-	Not used (0)
6	STUP	XOSC Time Up Flag (R)
7	FTUP	OSC Time Up Flag (R) (0=Busy, 1=Ready/Good/Stable)

Note: For PSX, OSC is 4.0000MHz (PU-7/PU-8), 4.2336MHz (PU-18 and up). SysClk is usually set to OSC/2, ie. around 2MHz.

HC05 Port OPTM=0:00h - PORTA - Port A Data Register (R/W)**HC05 Port OPTM=0:01h - PORTB - Port B Data Register (R)****HC05 Port OPTM=0:02h - PORTC - Port C Data Register (R/W)****HC05 Port OPTM=0:03h - PORTD - Port D Data Register (R/W)****HC05 Port OPTM=0:04h - PORTE - Port E Data Register (R/W)****HC05 Port OPTM=0:05h - PORTF - Port F Data Register (R) (undoc: R/W)**

These are general purpose I/O ports (controlling external pins). Some ports are Input-only, and some can be optionally used for special things (like IRQs, SPI-bus, or as Timer input/output).

PA.0-7	PAn	Port A Bit0..7	Input/Output		(0=Low, 1=High)	(R/W)
PB.0-7	PBn	Port B Bit0..7	Input	/KWI0..7	(0=Low, 1=High)	(R)
PC.0	PC0	Port C Bit0	Input/Output	/SDI1 (SPI)	(0=Low, 1=High)	(R/W)
PC.1	PC1	Port C Bit1	Input/Output	/SDO1 (SPI)	(0=Low, 1=High)	(R/W)
PC.2	PC2	Port C Bit2	Input/Output	/SCK1 (SPI)	(0=Low, 1=High)	(R/W)
PC.3	PC3	Port C Bit3	Input/Output	/TCAP (T1)	(0=Low, 1=High)	(R/W)
PC.4	PC4	Port C Bit4	Input/Output	/EVI (T2)	(0=Low, 1=High)	(R/W)
PC.5	PC5	Port C Bit5	Input/Output	/EVO (T2)	(0=Low, 1=High)	(R/W)
PC.6	PC6	Port C Bit6	Input/Output	/IRQ2	(0=Low, 1=High)	(R/W)
PC.7	PC7	Port C Bit7	Input/Output	/IRQ1	(0=Low, 1=High)	(R/W)
PD.0-7	PDn	Port D Bit0..7	Input/Output		(0=Low, 1=High)	(R/W)
PE.0-7	PEn	Port E Bit0..7	Input/Output		(0=Low, 1=High)	(R/W)
PF.0-7	PFn	Port F Bit0..7	Input/Undoc	A/D-input	(0=Low, 1=High)	(R) (R/W)

HC05 Port OPTM=1:00h - DDRA - Port A Data Direction Register (R/W)**HC05 Port OPTM=1:02h - DDRC - Port C Data Direction Register (R/W)****HC05 Port OPTM=1:03h - DDRD - Port D Data Direction Register (R/W)****HC05 Port OPTM=1:04h - DDRE - Port E Data Direction Register (R/W)****HC05 Port OPTM=1:05h - DDRF - Port F Data Direction Register (undoc)**

DDRX.0-7	DDRXn	Port X Data Direction Bit0..7	(0=Input, 1=Output)	(R/W)
----------	-------	-------------------------------	---------------------	-------

Officially, there are no DDRB and DDRF registers (Port B and F are always Inputs). Although, actually, Motorola's Bootstrap RAM \<does> manipulate DDRF.

HC05 Port OPTM=1:08h - RCR1 - Resistor Control Register 1 (R/W)

HC05 Port OPTM=1:09h - RCR2 - Resistor Control Register 2 (R/W)

RCR1.0	RAL	Port A.Bit0-3 Pullup Resistors (0=Off, 1=On)
RCR1.1	RAH	Port A.Bit4-7 Pullup Resistors (0=Off, 1=On)
RCR1.2	RBL	Port B.Bit0-3 Pullup Resistors (0=Off, 1=On)
RCR1.3	RBH	Port B.Bit4-7 Pullup Resistors (0=Off, 1=On)
RCR1.4	RGL	Port G.Bit0-3 Pullup Resistors (0=Off, 1=On) ; \
RCR1.5	RGH	Port G.Bit4-7 Pullup Resistors (0=Off, 1=On) ; on chips
RCR1.6	RHL	Port H.Bit0-3 Pullup Resistors (0=Off, 1=On) ; with Port G,H
RCR1.7	RHH	Port H.Bit4-7 Pullup Resistors (0=Off, 1=On) ; /
RCR2.0-7	RCn	Port C.Bit0-7 Pullup Resistors (0=Off, 1=On)

HC05 Port OPTM=1:0Ah - WOM1 - Open Drain Output Control Register 1 (R/W)

HC05 Port OPTM=1:0Bh - WOM2 - Open Drain Output Control Register 2 (R/W)

WOM1.0	AWOML	Port A.Bit0-3 Open Drain Mode when DDR=1 (0=No, 1=Open Drain)
WOM1.1	AWOMH	Port A.Bit4-5 Open Drain Mode when DDR=1 (0=No, 1=Open Drain)
WOM1.2	GWOML	Port G.Bit0-3 Open Drain Mode when DDR=1 (0=No, 1=Open Drain)
WOM1.3	GWOMH	Port G.Bit4-5 Open Drain Mode when DDR=1 (0=No, 1=Open Drain)
WOM1.4	HWOML	Port H.Bit0-3 Open Drain Mode when DDR=1 (0=No, 1=Open Drain)
WOM1.5	HWOMH	Port H.Bit4-5 Open Drain Mode when DDR=1 (0=No, 1=Open Drain)
WOM1.6-7	-	Not used (0)
WOM2.0-5	CWOMn	Port C.Bit0..5 Open Drain Mode when DDR=1 (0=No, 1=Open Drain)
WOM2.6-7	-	Not used (always both bits set)

==== Interrupts =====

HC05 Port OPTM=0:08h - INTCR - Interrupt Control Register (R/W)

0-1	-	Not used (0)
2	IRQ2S	IRQ2 Select Edge-Sensitive Only (0=LowLevelAndNegEdge, 1=NegEdge)
3	IRQ1S	IRQ1 Select Edge-Sensitive Only (0=LowLevelAndNegEdge, 1=NegEdge)
4	KWIE	Key Wakeup Interrupt Enable (0=Disable, 1=Enable)
5	-	Not used (0)
6	IRQ2E	IRQ2 Interrupt Enable (0=Disable, 1=Enable)
7	IRQ1E	IRQ1 Interrupt Enable (0=Disable, 1=Enable)

HC05 Port OPTM=0:09h - INTSR - Interrupt Status Register (R and W)

0	RKWIF	Reset Key Wakeup Interrupt Flag	(0=No Change, 1=Reset)	(W)
1	-	Not used	(0)	
2	RIRQ2	Reset IRQ2 Interrupt Flag	(0=No Change, 1=Reset)	(W)
3	RIRQ1	Reset IRQ1 Interrupt Flag	(0=No Change, 1=Reset)	(W)
4	KWIF	Key Wakeup Interrupt Flag (PB/KWI)	(0=No, 1=IRQ)	(R)
5	-	Not used	(0)	
6	IRQ2F	IRQ2 Interrupt Flag (PC6)	(0=No, 1=IRQ)	(R)
7	IRQ1F	IRQ1 Interrupt Flag (PC7)	(0=No, 1=IRQ)	(R)

HC05 Port OPTM=1:0Eh - KWIE - Key Wakeup Interrupt Enable Register (R/W)

0-7 KWIE_n Port B.Bit0..7 Key Wakeup Interrupt Enable (0=Disable, 1=Enable)

==== SPI Bus ====

HC05 Port OPTM=0:0Ah - SPCR1 - Serial Peripheral Control Register 1 (R/W)

0	SPR _n	SPI Clock Rate	(0=ProcessorClock/2, 1=ProcessorClock/16)	
1-3	-	Not used	(0)	
4	MSTR _n	SPI Master Mode Select	(0=Slave/SCK.In, 1=Master/SCK.Out)	
5	DORD _n	SPI Data Transmission Order	(0=MSB First, 1=LSB First)	
6	SPEN	SPI Enable (SPI1:PortC, SPI2:PortG)	(0=Disable, 1=Enable)	
7	SPIEN	SPI Interrupt Enable (... ack HOW?)	(0=Disable, 1=Enable)	

HC05 Port OPTM=0:0Bh - SPSR1 - Serial Peripheral Status Register 1 (R)

0-5	-	Not used	(0)	
6	DCOL _n	SPI Data Collision Occurred	(0=No, 1=Collision)	
7	SPIF _n	SPI Transfer Complete Flag	(0=Busy, 1=Complete)	(R)

Note: SPSR1.7 appears to be reset after reading SPSR1 (probably same for SPSR1.6, and maybe also same for whatever SPI IRQ signal).

HC05 Port OPTM=0:0Ch - SPDR1 - Serial Peripheral Data Register 1 (R/W)

0-7 BIT_n Data to be sent / being received

==== Time Base / Config ====

HC05 Port 10h - TBCR1 - Time Base Control Register 1 (R/W)

0-1	T2R	Timer2 Prescaler	(0=SysClk, 1=SysClk/4, 2=SysClk/32, 3=SysClk/256)	
2-3	T3R	PWM Prescaler	(0=CLK3, 1=CLK3/2, 2=CLK3/8, 3=Timer2compare)	


```

4-6 -      Not used (0)
7   TBCLK Time Base Clock (0=XOSC, 1=OSC/128) ;<-- write-able only ONCE

```

HC05 Port 11h - TBCR2 - Time Base Control Register 2 (R/W, some bits R or W)

```

0   COPC  COP Clear 2bit COP timeout divider (0=No Change, 1=Clear) (W)
1   COPE  COP Enable                          ;<-- write-able only ONCE
2   -      Not used (0)
3   RTBIF Reset Time Base Interrupt Flag (0=No Change, 1=Clear TBIF) (W)
4-5 TBR   Time Base Interrupt Rate (0=TBCLK/128, 1=/4096, 2=/8192, 3=/16384)
6   TBIE  Time Base Interrupt Enable (0=Disable, 1=Enable)
7   TBIF  Time Base Interrupt Flag (0=No, 1=IRQ) (R)

```

HC05 Port OPTM=1:0Fh - MOSR - Mask Option Status Register (R)

```

0-4 -      Not used (0)
5   XOSCR XOSC Feedback Resistor (0=None, 1=Implemented)
6   OSCR  OSC Feedback Resistor (0=None, 1=Implemented)
7   RSTR  /RESET Pullup Resistor (0=None, 1=Implemented)

```

Reading this register returns A0h (on PSX/PSone with 52pin chips).

==== Timer 1 ====

HC05 Port 12h - TCR - Timer 1 Control Register (R/W)

```

0   OLVL  Output Level on TCMP pin on Compare Match? (0=Low, 1=High)
1   IEDG  Input Edge on TCAP pin (0=NegativeEdge, 1=PositiveEdge)
2-4 -      Not used (0)
5   TOIE  Timer Overflow Interrupt Enable (0=Disable, 1=Enable)
6   OC1IE Output Compare Interrupt Enable (0=Disable, 1=Enable)
7   ICIE  Input Capture Interrupt Enable (0=Disable, 1=Enable)

```

HC05 Port 13h - TSR - Timer 1 Status Register (R)

```

0-4 -      Not used (0)
5   TOF   Timer Overflow Flag (0=No, 1=Yes) (R) ;clear by Port 19h access
6   OC1F  Output Compare Flag (0=No, 1=Yes) (R) ;clear by Port 17h access
7   ICF   Input Capture Flag (0=No, 1=Yes) (R) ;clear by Port 15h access

```

HC05 Port 14h - ICH - Timer 1 Input Capture High (undoc)

HC05 Port 15h - ICL - Timer 1 Input Capture Low (undoc)

0-15 Capture Value

HC05 Port 16h - OC1H - Timer 1 Output Compare 1 High (undoc)

HC05 Port 17h - OC1L - Timer 1 Output Compare 1 Low (undoc)

0-15 Compare Value

HC05 Port 18h - TCNTH - Timer 1 Counter 1 High (undoc)

HC05 Port 19h - TCNTL - Timer 1 Counter 1 Low (undoc)

0-15 Counter

HC05 Port 1Ah - ACNTH - Alternate Counter High (undoc)

HC05 Port 1Bh - ACNTL - Alternate Counter Low (undoc)

0-15 Alternate Counter (uh, what?)

==== Timer 2 ====

HC05 Port 1Ch - TCR2 - Timer 2 Control Register (R/W)

0	OL2	Timer Output 2 Edge (0=Falling, 1=Rising)
1	OE2	Timer Output 2 Enable (EVO) (0=Disable, 1=Enable)
2	IL2	Timer Input 2 Edge/Level (0=Low/Falling, 1=High/Rising)
3	IM2	Timer Input 2 Mode Select for EVI (0=EventMode, 1=GatedByCLK2)
4	T2CLK	Timer 2 Clock Select (0=CLK2 from Prescaler, 1=EXCLK from EVI)
5	-	Not used (0)
6	OC2IE	Output Compare 2 Interrupt Enable (0=Disable, 1=Enable)
7	TI2IE	Timer Input 2 Interrupt Enable (EVI) (0=Disable, 1=Enable)

HC05 Port 1Dh - TSR2 - Timer 2 Status Register (R/W)

0-1	-	Not used (0)
2	ROC2F	Reset Output Compare 2 Interrupt Flag (0=No Change, 1=Clear) (W)
3	RTI2F	Reset Timer Input 2 Interrupt Flag (0=No Change, 1=Clear) (W)
4-5	-	Not used (0)
6	OC2F	Output Compare 2 Interrupt Flag (0=No, 1=Yes) (R)
7	TI2F	Timer Input 2 Interrupt Flag (EVI) (0=No, 1=Yes) (R)

HC05 Port 1Eh - OC2 - Timer 2 Output Compare Register (R/W)

```
0-7  Compare Value ("Transferred to buffer on certain events?")
```

HC05 Port 1Fh - TCNT2 - Timer 2 Counter Register (R) (W=Set Counter to 01h)

```
0-7  Counter Value, incremented at T2R (set to 01h on Compare Matches)
```

==== Reserved =====

HC05 Port 3Fh - Unknown/Unused

Reading this port via Sony's test command returns 20h (same as openbus), but reading it via Motorola's selftest function returns 00h (unlike openbus), so it seems to have some unknown/undocumented function; bit5 might indicate selftest mode, or it might reflect initialization of whatever other ports.

HC05 Port OPTM=0:06h..07h,0Dh..0Fh - Reserved**HC05 Port OPTM=1:01h,06h..07h,0Ch..0Dh - Reserved****HC05 Port 20h..3Dh - Reserved**

These ports are unused/reserved. Trying to read them on a PSone does return 20h (possibly the prefetched next opcode value from the RAM test command). Other HC05 variants contain some extra features in these ports:

[CDROM Internal HC05 On-Chip I/O Ports - Extras](#)

The PSX CDROM BIOS doesn't use any of these ports - except, it is writing [20h]=2Eh (possibly to disable unused LCD hardware; which might be actually present in the huge 80pin HC05 chips on old PU-7 mainboards).

HC05 Openbus

Openbus values can be read from invalid memory locations, on PSX with 52pin chips:

```
I/O bank 0:      0:06h..07h, 0:0Dh..0Fh
I/O bank 1:      1:01h, 1:06h..07h, 1:0Ch..0Dh, and upper 4bit of 1:05h
Unbanked I/O:    20h..3Dh
Unused Memory:  0240h..0FFFh, 5000h..FDEFh
```

The returned openbus value depends on the opcode's memory operand:

```
[nn], [mmnn], [nn+x], [mmnn+x] --> returns LAST byte of current opcode (=nn)
[x]                               --> returns FIRST byte of following opcode
```

30.3 CDROM Internal HC05 On-Chip I/O Ports - Extras

HC05 Port OPTM=0:0Dh - SPCR2 - Serial Peripheral Control Register 2 (R/W)

HC05 Port OPTM=0:0Eh - SPSR2 - Serial Peripheral Status Register 2 (R)

HC05 Port OPTM=0:0Fh - SPDR2 - Serial Peripheral Data Register 2 (R/W)

This is a second SPI channel, works same as first SPI channel, but using the lower 3bits of Port G (instead of Port C) for the SPI signals.

HC05 Port OPTM=0:06h - PORTG - Port G Data Register (R/W)

HC05 Port OPTM=0:07h - PORTH - Port H Data Register (R/W)

HC05 Port 3Ch - PORTJ - Port J Data Register (R/W)

PG.0	PG0	Port G Bit0	Input/Output /SDI2	(0=Low, 1=High)	(R/W)
PG.1	PG1	Port G Bit1	Input/Output /SDO2	(0=Low, 1=High)	(R/W)
PG.2	PG2	Port G Bit2	Input/Output /SCK2	(0=Low, 1=High)	(R/W)
PG.3	PG3	Port G Bit3	Input/Output /TCMP	(0=Low, 1=High)	(R/W)
PG.4	PG4	Port G Bit4	Input/Output /PWM0	(0=Low, 1=High)	(R/W)
PG.5	PG5	Port G Bit5	Input/Output /PWM1	(0=Low, 1=High)	(R/W)
PG.6	PG6	Port G Bit6	Input/Output /PWM2	(0=Low, 1=High)	(R/W)
PG.7	PG7	Port G Bit7	Input/Output /PWM3	(0=Low, 1=High)	(R/W)
PH.0-7	PHn	Port H Bit0..7	Input/Output	(0=Low, 1=High)	(R/W)
PJ.0-3	PJn	Port J Bit0..3	Output	(0=Low, 1=High)	(R/W)
PJ.4-7	-	Not used	(0)		

HC05 Port OPTM=1:06h - DDRG - Port G Data Direction Register (R/W)

HC05 Port OPTM=1:07h - DDRH - Port H Data Direction Register (R/W)

```
0-7 DDRXn Port X Data Direction Bit0..7 (0=Input, 1=Output) (R/W)
```

HC05 Port 20h - LCDCR - LCD Control Register (R/W)

0	-	Not used (0)
1	PDH	Select Port D (H) (0=FP35-FP38 pins, 1=PD7-PD4 pins)
2	PEL	Select Port E (L) (0=FP31-FP34 pins, 1=PE3-PE0 pins)
3	PEH	Select Port E (H) (0=FP27-FP30 pins, 1=PE7-PE4 pins)
4	-	Not used (0)
5-6	DUTY	LCD Duty Select (...)
7	LCDE	LCD Output Enable BP and FP pins (0=Disable, 1=Enable)

HC05 Port 21h..34h - LCDDR1..20 - LCD Data Register 1..20 (R/W)

0-3	First Data Unit	;\Fourty 4bit LCD values (in the twenty registers)
4-7	Second Data Unit	;/ (some duties use only the LSBs of that 4bit values)

HC05 Port 34h - PWMCR - PWM Pulse Width Modulation Control Register (R/W)

0-3	CH0-3	PWM Channel 0..3 on Port G.Bit4-7 Enable (0=Disable, 1=Enable)
4-7	-	Not used (0)

HC05 Port 35h - PWMCNT - PWM Counter Register (R) (W=Set Counter to FFh)

0-7	PWM Counter,	incremented at PHI2 (range 01h..FFh)
-----	--------------	--------------------------------------

HC05 Port 36h - PWMDR0 - PWM Duty Register 0 (R/W)**HC05 Port 37h - PWMDR1 - PWM Duty Register 1 (R/W)****HC05 Port 38h - PWMDR2 - PWM Duty Register 2 (R/W)****HC05 Port 39h - PWMDR3 - PWM Duty Register 3 (R/W)**

0-7	Duty (N cycles High, 255-N cycles Low)
-----	--

HC05 Port 3Ah - ADR - A/D Data Register (R)

0-3	A/D Conversion result	(probably unsigned, 00h=Lowest, FFh=Max voltage?)
-----	-----------------------	---

HC05 Port 3Bh - ADSCR - A/D Status and Control Register (R/W)

```

0-3  CH0-3  A/D Channel (0..7=PortF.Bit0-7, 8..0Fh=Reserved/Vref/FactorTest)
4    -      Not used (0)
5    ADON   A/D Charge Pump enable (0=Disable, 1=Enable)
6    ADRC   A/D RC Oscillator On (0=Normal/Use CPU Clock, 1=Use RC Clock)
7    COCO   A/D Conversion Complete (0=Busy, 1=Complete) (R)

```

HC05 Port 3Dh - PCR - Program Control Register (R/W) (for EPROM version)

```

0    PGM    EPROM Program Command (0=Normal, 1=Apply Programming Power)
1    ELAT   EPROM Latch Control (0=Normal/Read, 1=Latch/Write)
2-7  RES    Reserved for Factory Testing (always 0 in user mode)

```

30.4 CDROM Internal HC05 I/O Port Usage in PSX

Port A - Data (indexed via Port E)

```

porta.0-7 i/o  CXD1815Q.Data (indexed via Port E)
porta.0   in   debug.dta.serial.in ;\normally unused (exists in early bios)
porta.1   out  debug.dta.serial.out ; (prototype/debug_status stuff)
porta.2   out  debug.clk.serial.out ;/(with portc.5 = debug.select)

```

Port B - Inputs

```

portb.0   in   F-BIAS ;unused
portb.1   in   SCEx input (serial 250 baud, received via 1000Hz timer2 irq)
portb.2   in   LMTSW aka /POS0 ;\pos0 and door switches
portb.3   in   DOOR aka SHELL_OPEN ;/
portb.4   in   TEST2
portb.5   in   TEST1 (CL316) enter test mode (instead of mainloop)
portb.6   in   COUT ;<-- unused, extra pin, not "SENSE=COUT"
portb.7   in   CXD2510Q.SENSE ; -from CXD2510Q (and forwarded from CXA1782BR)

```

Port C - Inputs/Outputs

```

portc.0   in   CXD2510Q.SUBQ ;\
portc.1   in?  NC (SPI.OUT) ; used via SPDR1 to receive SPI bus SUBQ data
portc.2   out  CXD2510Q.SQCK ;/
portc.3   out  SPEED
portc.4   out  ="SPEED XOR 1" ... AL/TE ... or CG ... or MIRR ?
portc.5   out  ROMSEL: debug.select (or "SCLK" on later boards???)
portc.6   in   CXD1815Q.XINT/IRQ2 ;unused (instead INTSTS bits are polled)
portc.7   in   CXD2510Q.SCOR/IRQ1 ;used via polling INTSR.7 (not as irq)

```

Port D - Outputs

```

portd.0  out  NC                ;~unused (always 1)
portd.1  out  CXD2510Q.DATA      ;\serial bus for CXD2510Q
portd.2  out  CXD2510Q.XLAT      ; (and also forwarded to CXA1782BR)
portd.3  out  CXD2510Q.CLOCK    ;/
portd.4  out  CXD1815Q.DECCS    ;\
portd.5  out  CXD1815Q.DECWR     ; control for data/index on Port A/E
portd.6  out  CXD1815Q.DECRD     ;/
portd.7  out  LDON   ... IC723.Pin11 ... maybe "laser on" ?

```

Port E - Index (for data on Port A)

```

porte.0-4 out  CXD1815Q.Index (for data on Port A)
porte.5  out  NC, not used
porte.6  out  NC, see "idx_4xh" maybe test signal ???
porte.7  out? NC, TEST? configured as OUTPUT... but used as INPUT?

```

Port F - Motorola Bootstrap Serial I/O (not used in cdrom bios)

```

portf.0  out  NC, TX            ;\
portf.1  in   NC, RX            ; not used by sony's cdrom bios
portf.2  out  NC, RTS           ; (but used by motorola's bootstrap rom)
portf.3  out  NC, DTR           ;/
portf.0  in   Serial Data In   (from daughterboard) ;\
portf.1  out  Serial Data Out   (to daughterboard)  ; usage in SCPH-5903
portf.2  out  Serial Clock Out  (to daughterboard)  ; (PSX with Video CD)
portf.3  out  Audio/Video Select (0=Normal, 1=VCD) ;/
portf.4-7 -   NC, not used (probably pins don't even exist)

```

Other HC05 I/O Ports

```

SPI 1    - used for receiving SUBQ (via Port C)
IRQ 1    - used for latching/polling SUBQ's "SCOR" (not used as interrupt)
IRQ 2    - connects to CXD1815Q.XINT, but isn't actually used at all
Timer 1  - unused
Timer 2  - generates 1000Hz interrupts (for 250 baud "SCEx" string transfers)
DDRx     - data directions for Port A-F (as listed above)

```

Note: The PSX has the HC05 clocked via 4.00MHz oscillator (older boards), or via 4.3MHz signal from SPU (newer boards); internally, the HC05 is clocked at half of those frequencies (ie. around 2 MHz).

30.5 CDROM Internal HC05 Motorola Selftest Mode

52-pin HC05 chips (newer psx cdrom controllers)

52-pin chips are used on LATE-PU-8 boards, and on later boards ranging from PU-18 up to PM-41(2).

[CDROM Internal HC05 Motorola Selftest Mode \(52pin chips\)](#)

80-pin HC05 chips (older psx cdrom controllers)

80-pin chips are used PU-7, EARLY-PU-8, and PU-9 boards.

[CDROM Internal HC05 Motorola Selftest Mode \(80pin chips\)](#)

32-pin HC05 chips (joypad/mouse)

Sony's Digital Joypad and Mouse are using 32pin chips (with TQFP-32 package), which are probably containing Motorola HC05 CPUs, too. Unknown if/how those chips can be switched into bootstrap/dumping modes.

Pinouts

[Pinouts - HC05 Pinouts](#)

30.6 CDROM Internal HC05 Motorola Selftest Mode (52pin chips)

Motorola Bootstrap ROM

The Motorola MC68HC05 chips are including a small bootstrap ROM which gets activated upon /RESET when having two pins strapped to following levels:

```
Pin30 PortC.6 (/IRQ2) (/XINT) ----> wire to 3.5V (VCC)
Pin31 PortC.7 (/IRQ1) (SCOR) ----> wire to 7V (2xVCC)
```

Moreover, two pins are needed on /RESET for selecting a specific test mode:

```
Pin16 PortB.0 ----> ModeSelectBit0 (0=GND, 1=3.5V)
Pin17 PortB.1 ----> ModeSelectBit1 (0=GND, 1=3.5V)
```

The selectable four modes are:


```

Mode0: Jump to RAM Address 0040h (useless when RAM is empty)
Mode1: Semifunctional Selftest (useless)
Mode2: Upload 200h bytes to RAM & jump to 0040h (allows fast/custom dumping)
Mode3: Download ROM as ASCII hexdump (nice, but very slow)

```

The upload/download functions are using following additional pins:

```

Pin50 PortF.0 ----> TX output (11bytes: 0Dh,0Ah," AAAA DD ")
Pin51 PortF.1 <---- RX input (1byte: "!" to request next 11 bytes)
Pin52 PortF.2 ----> RTS output or so (not needed)
Pin1  PortF.3 ----> DTR output or so (not needed)
Ground ----- GND for RX/TX

```

RX/TX are RS232-like serial signals (but using other voltages, 0=0V and 1=3.5V). Transfer format is 8-N-1, ie. one startbit(0), 8 databits LSB first, no parity, one stopbit(1). Baudrate is OSC/2/208 (ie. 9616 bps for 4.000MHz, or 10176 bps for 4.2336MHz clock derived from CXD2545Q/CXD2938Q).

Note: Above pins may vary on some chips (namely on chips that don't have PortF). The pins for entering bootstrap mode (PortC in this case) should be described in datasheets; but transfer protocol and mode selection (PortB) and transmission (PortF) aren't officially documented.

Mode2: Upload 200h bytes to RAM & jump to 0040h

This mode is very simple and powerful: After /RESET, you send 200h bytes to the RX input (without any response on TX output), the bytes are stored at 0040h..023Fh in RAM, and the chip jumps to 0040h after transferring the last byte. The uploaded program can contain a custom highspeed dumping function, or perform hardware tests, etc. A custom dumping function for PSX/PSone can be found at:

```
http://www.psxdev.net/forum/viewtopic.php?f=70&t=557
```

After uploading the 200h-byte dumping function it will respond by send 4540h bytes (containing some ASCII string, the 16.5Kbyte ROM image, plus dumps for RAM and (banked) I/O port region, plus openbus tests for unused memory and I/O regions.

Wiring for Mode2 on PSX/PSone consoles with 52-pin HC05 chips

```

          .----- pin31, PC7, SCOR, cut the connection
          | 27      to Signal Processor,
          |         then wire Pin31 to 7.5V
39      |
.-----|
40 |    | 26
   | C nnnn |

```

```

          | SC4309nnPB |
          | G63C 185   |
pin50, TX <--- |         | --- pin17, PB1, SCEX, wire to 3.5V,
pin51, RX ---> |         |         for Mode2 Selection
          52 | 0       | 14
          '-----'
              1         13

```

Good places to pick 3.5V and 7.5V from nice solder pads are:

```

CN602.Pin1  = 7.5V      ;\on PSX boards (with either 5pin or
CN602.Pin3  = 3.5V      ;/              7pin CN602 connectors)
IC601.Pin1  = 7.5V      ;-on PSone boards (3pin 78M05 voltage regulator)
IC102.Pin32 = 3.5V      ;-on PSone boards (32pin Main BIOS ROM chip)

```

The SCOR trace on Pin31, connects to Signal Processor...

```

CXD2510Q.Pin63 (eg. on PU-8 boards) ;\
CXD2545Q.Pin74 (eg. on PU-18 boards) ; either one of these, depending
CXD1817R.Pin49 (eg. on PU-20 boards) ; on which chipset you have
CXD2938Q.Pin77 (eg. on PM-41 boards) ;
CXD2941R.Pin85 (eg. PM-41(2) boards) ;/

```

cut that trace (preferably on the PCB between two vias or test points, so you can later repair it easily) (better don't try to lift Pin31, it breaks off easily)

Note: Mode2 also requires Pin16=Low, and Pin30=High (but PSX/PSone boards should have those pins at that voltages anyways).

Mode3: Download ROM as ASCII hexdump

This mode is very slow and not too powerful. But it may useful if you can't get Mode2 working for whatever reason. Wiring for Mode3 is same as above, plus PortB.0=3.5V. In this mode, the chip will send one 0Dh,0Ah," AAAA DD " string immediately after /RESET (with 16bit address "AAAA" (initially 1000h), and 8bit data "DD"). Thereafter the chip will wait for incoming commands:

```

4-digit ASCII HEX address --> change address, and return 0Dh,0Ah," AAAA DD "
chr(00h) --> increment address, and return 0Dh,0Ah," AAAA DD "
chr(07h) --> jump to current address (not so useful)
other characters --> same as chr(00h)
All digits/characters sent to RX input will produce an echo on TX output.

```

Basic setup would be wiring RX to GND (the chip will treat that as infinite stream of start bits with chr(00h), so it will respond by sending data from increasing addresses automatically; the increment wraps from 4FFFh to FE00h (skipping the gap between Main

ROM and Bootstrap ROM), and also wraps from FFFFh to 0000h; transfer is ultraslow: 13 characters needed per dumped byte: chr(00h) to chip, chr(00h) echo from chip, and 0Dh, 0Ah," AAAA DD " from chip.

30.7 CDROM Internal HC05 Motorola Selftest Mode (80pin chips)

80pin Sony 4246xx chips

And for anyone else planning to try this, these are the connections:

```
Pin PortC
46 PC7/IRQ1 (SCOR) disconnect from PCB, then wire the pin to Vtst (7.6V)
45 PC6/IRQ2 (/XINT) wire to Vdd (3.5V) (you have to solder to the pin)
```

In bootstrap mode, Port A is used as follows:

```
Pin PortA DDRA Usage
23 PA0 in RXD
24 PA1 out TXD
25 PA2 in -
26 PA3 in Testmode.bit0 (GND=0, 3.5V=1)
27 PA4 in Testmode.bit1 (GND=0, 3.5V=1)
28 PA5 in Testmode.bit2 (GND=0, 3.5V=1)
29 PA6 out RTS (don't care)
30 PA7 out -
```

The selectable testmodes are:

```
PA5 PA4 PA3 Effect
0 x x Jump to 0040h ;\
1 0 0 Test (complex) ; not so useful
1 0 1 Test (simple loop) ;/
1 1 0 ROM Dump 4200h bytes (plain binary, non-ASCII)
1 1 1 RAM Upload 100h bytes to 0040h..013Fh, then jump to 0040h
```

RX/TX are plain binary (non-ASCII), baudrate is 9600 (when using 4.000MHz oscillator), transfer format is 8,N,2 (aka 8,N,1 with an extra pause bit).

Wiring for Upload/Download on PSX consoles with 80-pin HC05 chips

```

          .----- pin46, PC7/IRQ1, SCOR, cut & wire to 7.5V
          |----- pin45, PC6/IRQ2, wire to 3.5V
          || 41
60 -----
61 |             o | 40
```

```

| Sony Computer | ,----- pin28, PA5, wire to 3.5V
| Entertainment | _____/ ,--- pin27, PA4, wire to 3.5V
| Inc. (C) E35D | ====='---- pin26, PA3, mode select
| 4246xx 185 | ----> pin24, PA1, TXD (for ROM dump)
| | | <---- pin23, PA0, RXD (for RAM upload)
80 | 0 | 21
| '-----'
| 1 20

```

Good places to pick 3.5V and 7.5V from nice solder pads are:

```

CN602.Pin1 = 7.5V ;\on PSX boards (with 7pin CN602 connectors)
CN602.Pin3 = 3.5V ;/

```

Credits to TriMesh for finding the 80pin chip's bootstrap signals.

Other 80pin chips

DTL-H100x uses 80pin chip with onchip PROM (chip text "(M) MC68HC705L15", instead of "Sony [...] 4246xx"), wiring for serial dumping on that is unknown (the bootstrap ROM may be a little different because it should contain PROM burning functions). PU-9 boards seem to use a similar PROM (with some sticker on it).

DTL-H2000 uses 80pin CXP82300 chip with socketed piggyback 32pin EPROM - that chip is a Sony SPC700 CPU, not a Motorola HC05 CPU. Accordingly there's no Motorola Bootstrap mode in it, but of course one can simply dump the EPROM with standard eprom utilities, as done by TriMesh).

30.8 CDROM Internal CXD1815Q Sub-CPU Configuration Registers

00h - DRVIF - Drive Interface (W)

```

0-1 "L"      Reserved (should be 0)
2  LSB 1st CD DSP DATA order          (0=MSB first, 1=LSB first)
3-4 BCK MD   CD DSP Number of BCLKs per WCLK (0=16, 1=24, 2=32, 3=Reserved)
5  BCK RED Strobe DATA on BLCK Edge    (0=Falling Edge, 1=Rising Edge)
6  LCH LOW Channel on LRCK=Low          (0=Right, 1=Left)
7  C2PL1st   ... C2PO lower byte 1st

```

01h - CONFIG 1 - Configuration 1 (W)

```

0  HCLKDIS  HCLK Pin Output (0=8.4672MHz, 1=Disable; Fixed Low)
1  CLKDIS   CLK Pin Output (0=16.9344MHz, 1=Disable; Fixed Low)
2  9BITRAM  SRAM Databus width (0=8bit/normal, 1=9bit)
3-4 RAM SZ  SRMA Address bus (0=32K, 1=64K, 2=128K, 3=Reserved)
5  PRTYCTL  ... Priority Control
6  XSLOW    Number of clock cycles per DMA cycle (0=12, 1=4) (for SRAM)
7  "L"      Reserved (should be 0)

```

02h - CONFIG 2 - Configuration 2 (W)

```

0  "L"      Reserved (should be 0)
1  DACODIS  .... DAC Out Disable
2  DAMIXEN  Digital Audio Mixer Enable (0=Attenuator/Mixer for CD-DA, 1=No)
3  SMBF2    Number of Sound Map Buffer Surfaces (0=Three, 1=Two)
4  SPMCTL   Sound Parameter Majority Control (0=?) ;\for ADPCM params
5  SPECTL   Sound Parameter Error Control (0=?) ;/
6-7 "L"     Reserved (should be 0)

```

03h - DECCTL - Decoder Control (W)

```

0-2 DECMD   Decoder Mode (0-7)
          0 or 1 Decoder Disable          ; -disable sector reading
          2 or 3 Monitor-only Mode        ; \no error correction
          4      Write-only Mode          ; /
          5      Real-time Correction Mode ; \with error correction
          6      Repeat Correction Mode    ; /
          7      CD-DA Mode                ; -audio
3  AUTODIST  Auto Distinction (0=Use MODESEL/FORMSEL bits, 1=Use Sector Hdr)
          (Error Correction is done according to above MODE/FORM values)
4  FORMSEL   Form Select (0=FORM1, 1=FORM2) (must be 0 for MODE1)
5  MODESEL   Mode Select (0=MODE1, 1=MODE2)
6  ECCSTR    ECC Strategy (0=Normal, 1=Use Error Flags; requires 9bit SRAM)
7  ENDLADR   Enable Drive Last Address ...

```

07h - CHPCTL - Chip Control (W)

```

0  "L"      Reserved (should be 0)
1  DBLSPD   Double Speed Mode (0=Normal, 1=Double) (init CD DSP first)
2  RPSTART  Repeat Correction Start (0=No, 1=Start) (automatically cleared)
3  SWOPEN   Sync Window Open (0=SyncControlledByIC, 1=OpenDetectionWindow)
4  CD-DA    CD-DA Play (0=No, 1=Playback CD-DA as audio)
5  CDDAMUTE CD-DA Mute (0=Normal, 1=Mute CD-DA Audio)
6  RTMUTE   Real-time Mute (0=Normal, 1=Mute CDROM ADPCM)
7  SMMUTE   Sound Map Mute (0=Normal, 1=Mute Sound Map ADPCM)

```

30.9 CDROM Internal CXD1815Q Sub-CPU Sector Status Registers

00h - ECCSTS - ECC Status (R)

```

0 CFORM    FORM assumed by Error Correction (0=FORM1, 1=FORM2)
1 CMODE    MODE assumed by Error Correction (0=MODE1, 1=MODE2)
2 ECCOK    ECC Okay (0=Bad, 1=Okay)
3 EDCOK    EDC Okay (0=Bad, 1=Okay)
4 CORDONE  Correction Done (0=None, 1=Error occurred and was corrected)
5 CORINH   Correction Inhibit (0=Okay, 1=AUTODIST couldn't determine MODE/FORM)
6 ERINBLK  Erasure in Block (0=Okay, 1=At least 1 byte is wrong & uncorrected)
7 EDCALL0  EDC all-zero (0=No/EDC Exists, 1=Yes/All four EDC bytes are 00h)

```

01h - DECSTS - Decoder Status (R)

```

0 NOSYNC   No Sync (0=Okay, 1=Sector Sync Mark Missing)
1 SHRTSCT  Short Sector (0=Okay, 1=Sector Sync Mark within Sector Data)
2-4 -      Reserved (undefined)
5 RTADPSY  Real-time ADPCM Busy (0=No, 1=Busy/playback)
6-7 -      Reserved (undefined)

```

02h - HDRFLG - Header/Subheader Error Flags for HDR/SHDR registers (R)

```

0 CI       Error in 4th Subheader byte (Coding Info) (0=Okay, 1=Error)
1 SUBMODE  Error in 3rd Subheader byte (Submode) (0=Okay, 1=Error)
2 CHANNEL  Error in 2nd Subheader byte (Channel) (0=Okay, 1=Error)
3 FILE     Error in 1st Subheader byte (File) (0=Okay, 1=Error)
4 MODE     Error in 4th Header byte (MODE) (0=Okay, 1=Error)
5 BLOCK    Error in 3rd Header byte (FF) (0=Okay, 1=Error)
6 SEC      Error in 2nd Header byte (SS) (0=Okay, 1=Error)
7 MIN      Error in 1st Header byte (MM) (0=Okay, 1=Error)

```

Error flags for current sector are probably stored straight in this register (ie. these flags are probably available even without using 9bit SRAM).

Or maybe not... if the chip supports receiving newer sectors during time-consuming error corrections... then those newer would need to be stored in SRAM, and would thus require 9bit SRAM for the error flags?

03h - HDR - Header Bytes (R)

```

1st read: 1st Header byte (MM)
2nd read: 2nd Header byte (SS)

```

```
3rd read: 3rd Header byte (FF)
4th read: 4th Header byte (MODE)
```

04h - SHDR - Subheader Bytes (R)

```
1st read: 1st Subheader byte (File)
2nd read: 2nd Subheader byte (Channel)
3rd read: 3rd Subheader byte (Submode) (SM)
4th read: 4th Subheader byte (Coding Info) (CI)
```

The contents of the HDRFLG, HDR, SHDR registers indicate:

```
(1) The corrected value in the real-time correction or
    repeat correction mode
(2) Value of the raw data from the drive in the monitor-only
    or write-only mode
The CMOME? and CMODE bits (bits 1, 0) of ECCSTS indicate the FORM and MODE
of the sector the decoder has discriminated by the raw data from the drive.
Due to erroneous correction, the values of these bits may be at variance
with those of the HDR register MODE byte and SHDR register submode byte
bit5.
```

Unknown when 1st..4th read indices are reset for HDR and SHDR (maybe on access to certain I/O ports, or maybe anytime when receiving a new sector), also unknown what happens on 5th read and up.

30.10 CDROM Internal CXD1815Q Sub-CPU Address Registers

Drive Address -- used for storing incoming CDROM sectors in Buffer RAM

Host Address -- used for transferring Buffer RAM to (or from) Main CPU

ADPCM Address -- used for Real-time ADPCM audio output from Buffer RAM

05h - CMADR - Drive Current Minute Address (R)

```
0-6   CMADR   Address bit10-16 (in 1Kbyte steps)
7      -      Reserved (undefined)
```

Indicates the start address of the most recently decoded sector (called "Minute Address" because it points to the MM byte of the MM:SS:FF:MODE sector header). Normally, CMADR should be forwarded to Host:

```
HADR = (CMADR AND 7Fh)*400h+offset
HXFR = length OR 4000h
```

Whereas, offset would be usually 00h, 04h, or 0Ch (to start reading from the begin of the sector, or to skip 4-byte MODE1 header, or 12-byte MODE2 header). And length would be usually 800h (normal data sector), or 924h (entire sector, excluding the leading 12 sync-bytes). Length bit14 is undocumented/reserved, but the PSX CDROM BIOS does set that bit for whatever reason.

Alternately, the sector can be forwarded to the Real-time ADPCM decoder:

```
ADPMNT = (CMADR AND 7Fh) OR 80h
```

19h - ADPMNT - ADPCM "MNT" Address (W)

```
0-6   ADPxxx   ADPCM source Address bit10-16 (in 1Kbyte-steps)
7     RTADPEN  Real-time ADPCM Enable (0=Disable, 1=Enable Real-time ADPCM)
```

04h - DLADR-L, Drive Last Address, bit0-7 (W)

05h - DLADR-M, Drive Last Address, bit8-15 (W)

06h - DLADR-H, Drive Last Address, bit16 (W)

```
0-16  DLADR   Addr. bit0-16      ...
17-23 "L"     Reserved (should be 0)
```

10h - DADRC-L - Drive Address Counter, bit0-7 (W)

11h - DADRC-M - Drive Address Counter, bit8-15 (W)

12h - DADRC-H - Drive Address Counter, bit16 (W)

```
0-16  DADRC   Incrementing Drive-to-Buffer Write Address, bit0-16
17-23 "L"     Reserved (should be 0)
```

0Eh - DADRC-L - Drive Address Counter, Bit0-7 (R)

0Fh - DADRC-M - Drive Address Counter, Bit8-15 (R)

```
0-15  DADRC   Address bit0-15 ;bit16 is in Port 0Bh      ...
```


0Ch - HXFR-L - Host Transfer Length, bit0-7 (W)**0Dh - HXFR-H - Host Transfer Length, bit8-11 and stuff (W)**

```

0-11  HXFR      number of data bytes, bit0-11 (0..FFFh)      ...
12    HADR.16   HADR   bit16
13    "L"       Reserved (should be 0)
14    "L" ??    Reserved (should be 0)    ;<-- XXX but on PSX: Always 1 !?!
                                           ;      seems to Disable INT8 ?!!!
15    DISHXFRC  Disable HXFRC (0=Use HXFRC, 1=Disable, Infinite-or-Zero Len?)

```

0Eh - HADR-L - Host Transfer Address, bit0-7 (W)**0Fh - HADR-M - Host Transfer Address, bit8-15 (W)**

```

0-15  HADR      Addr. bit0-15    ;bit16 in Port 0Dh      ...

```

0Ah - HXFRC-L - Host Transfer Remain Counter, bit0-7 (R)**0Bh - HXFRC-H - Host Transfer Remain Counter, bit8-11, and other bits (R)**

```

0-11  HXFRC Host Transfer Counter bit0-11 (number of remaining bytes)
12    HADRC bit16    ;MSB of Port 0Ch/0Dh
13    DADRC bit16    ;MSB of Port 0Eh/0Fh
14-15 -            Reserved (undefined) (usually both bits set)

```

0Ch - HADRC-L - Host Transfer Address Counter, bit0-7 (R)**0Dh - HADRC-M - Host Transfer Address Counter, bit8-15 (R)**

```

0-15  HADRC Address bit0-15    ;bit16 is in Port 0Bh

```

"This counter keeps the addresses which write or read the data with host into/from the buffer.

When data from the host is written into the buffer or data to the host is read from the buffer, the HADRC value is output from MA0 to 16. HADRC is incremented each time one byte of data from the drive is read from the buffer (BFRD is high) or written into the buffer (BFWR is high)."

Note

When reading from SRAM, data seems to go through a 8-byte data fifo, the HXFRC (remain) and HADRC (addr) values aren't aware of that FIFO (ie. if there's data in the fifo, then addr will be 8 bigger and remain 8 smaller than what has arrived at the host).

Unclear Notes

"If sound map data is to be transferred before the data is transferred (immediately after the host has set the BFRD and BFWR bits (bits 7 and 6) of the HCHPCTL register high)":

```
900h is loaded into HXFRC
and 600Ch, 6A0Ch, or 740Ch is loaded into HADRC
(at least, supposedly, above addresses , for cases when using 32K SRAM)
```

"At any other time":

```
HADR and HXFR are loaded into HADRC and HXFRC
```

Unknown what the above crap is trying to say exactly.

"At any other time" does apparently refer to cases when transfers get started (whilst during transfer, the address/remain values are obviously increasing/decreasing).

For sound map, theoretically, the SMEN bit should be set, but above does somewhat suggest that BFRD or BFWR (or actually: both BFRD and BFWR) need to be set...?

Sector Buffer Memory Map (32Kx8 SRAM)

```
0000h 1st Sector (at 0000h..0923h) (unused gap at 0924h..0BFFh)
0C00h 2nd Sector (at 0C00h..1523h) (unused gap at 1524h..17FFh)
1800h 3rd Sector (at 1800h..2123h) (unused gap at 2124h..23FFh)
2400h 4th Sector (at 2400h..2D23h) (unused gap at 2D24h..2FFFh)
3000h 5th Sector (at 3000h..3923h) (unused gap at 3924h..3BFFh)
3C00h 6th Sector (at 3C00h..4523h) (unused gap at 4524h..47FFh)
4800h 7th Sector (at 4800h..5123h) (unused gap at 5124h..53FFh)
5400h 8th Sector (at 5400h..5D23h) (unused gap at 5D24h..5FFFh)
6000h Soundmap ADPCM Buffer (at 600Ch..690Bh) (gaps at 6000h and 690Ch)
6A00h Soundmap ADPCM Buffer (at 6A0Ch..730Bh) (gaps at 6A00h and 730Ch)
7400h Soundmap ADPCM Buffer (at 740Ch..7D0Bh) (gaps at 7400h and 7D0Ch)
7E00h Unknown/Unused
```

30.11 CDROM Internal CXD1815Q Sub-CPU Misc Registers

16h - HIFCTL - Host Interface Control (W)

0-2	HINT	Request Host Interrupt (INT1..INT7, or 0=None/No change)
3-7	"L"	Reserved (should be 0)

11h - HIFSTS - Host Interface Status (R)

0-2	HINTSTS	Pending Host Interrupt (INT1..INT7, or 0=None/All acknowledged)
3	DMABUSY	DMA Busy (0=Data FIFO Empty and HXFRC=0, 1=Data Transfer Busy)
4	PRMRRDY	Parameter Read Ready (0=Parameter FIFO Empty, 1=Ready/Not Empty)
5	RSLEMPY	Result Empty (0=Response FIFO Not Empty, 1=Empty)
6	RSLWRDY	Result Write Ready (0=Response FIFO Full, 1=Ready/Not Full)
7	BUSYSTS	Command Busy Status (0=Command Not Empty, 1=Ack'ed by CLRBUSY)

0Ah - CLRCTL - Clear Control (W)

0	RESYNC	Sync with CD DSP (0=No change, 1=Resync, eg. after speed change)
1-3	"L"	Reserved (should be 0)
4	RTADPCLR	Abort Real-time ADPCM (0=No Change, 1=Abort; when ADPMNT.7=0)
5	CLRRSLT	Clear Reply FIFO (0=No change, 1=Acknowledge; clear FIFO)
6	CLRBUSY	Acknowledge Command (0=No change, 1=Acknowledge; clear BUSYSTS)
7	CHPRST	Chip Reset (0=No change, 1=Do Chip Initialization)

07h - INTSTS - Interrupt Status (R) - (0=No, 1=IRQ)

09h - INTMSK - Interrupt Mask (W) - (0=Disable, 1=Enable)

0Bh - CLRINT - Clear Interrupt Status (W) - (0=No change, 1=Clear/Ack)

0	HCRISD	Host Chip Reset Issued	
1	HSTCMND	Host Command	...
2	DECINT	Decoder Interrupt	..
3	HDMACMP	Host DMA Complete	. <-- PSX: used for retry ?!?!!!
4	RTADPEND	Real-time ADPCM end	
5	RSLTEMPY	Result Empty	
6	DECTOUT	Decoder Time Out	
7	DRVOVRN	Drive Overrun	

12h - HSTPRM - Host Parameter (R)

0-7	Param FIFO (check HIFSTS.4 to see if the FIFO is empty)
-----	---

HIFSTS.4 goes off when all bytes read.

Said to have 8-byte FIFO in CXD1199AQ datasheet.

But, PSX has 16-byte Parameter FIFO...!?!

13h - HSTCMD - Host Command (R)

0-7 Command (check INTSTS.1 or HIFSTS.7 to see if a command was sent)

Command should be ack'ed via CLRINT.1 and CLRCTL.6.

17h - RESULT - Response FIFO (W)

0-7 Data (has 8-byte FIFO)

Said to have 8-byte FIFO in CXD1199AQ datasheet.

But, PSX has 16-byte Response FIFO...!?!

08h - ADPCI - ADPCM Coding Information (R)

0	S/M	ADPCM Stereo/Mono	(0=Mono, 1=Stereo)
1	-	Reserved (undefined)	
2	FS	ADPCM Sampling Frequency	(0=37.8kHz, 1=18.9kHz)
3	-	Reserved (undefined)	
4	BITLNTH	ADPCM Sample Bit Length	(0=Normal/4bit, 1=8bit)
5	ADPBUSY	ADPCM Decoding	(0=No, 1=Yes/Busy)
6	EMPHASIS	ADPCM Emphasis	(0=Normal/Off, 1=On)
7	MUTE	DA Data is Muted (uh?)	(0=No, 1=Yes/Muted)

Unknown if ADPCI is affected by configurations by Main-CPU's Sound Map ADPCM or by Sub-CPU's Real-time ADPCM (or by both)?

Note: Bit5,7 are semi-undocumented in the datasheet (mentioned in the ADPCI description, but missing in overall register summary).

1Bh - RTCI - Real-time ADPCM Coding Information (W)

0	S/M	ADPCM Stereo/Mono	(0=Mono, 1=Stereo)
1	"L"	Reserved (should be 0)	
2	FS	ADPCM Sampling Frequency	(0=37.8kHz, 1=18.9kHz)
3	"L"	Reserved (should be 0)	
4	BITLNTH	ADPCM Sample Bit Length	(0=Normal/4bit, 1=8bit)
5	"L"	Reserved (should be 0)	
6	EMPHASIS	ADPCM Emphasis	(0=Normal/Off, 1=On)
7	"L"	Reserved (should be 0)	

06h,09h,10h,14h..1Fh - Reserved (R)

```
0-7  Reserved (undefined)
```

Of these, 09h and 10h are officially unused/reserved. And addresses 06h and 14h..1Fh aren't officially mentioned to exist at all.

Trying to read these registers on a PSone returns Data=C0h for 06h, 09h, 10h, 15h-16h, 18h-1Fh, and Data=FFh for 14h, and Data=DEh for 17h.

08h,13h-15h,18h,1Ah,1Ch-1Fh - Reserved (W)

```
0-7  Reserved (should be 00h) (or don't write at all)
```

Of these, 09h,13h-15h,18h,1Ah are officially unused/reserved. And addresses 1Ch-1Fh aren't officially mentioned to exist at all.

30.12 CDROM Internal Commands CX(0x..3x) - CXA1782BR Servo Amplifier

CXA1782BR - CX(0x) - Focus Servo Control - "FZC" FocusZeroCross at SENS pin

```
23-20 4bit  Command (00h)
19     1bit  FS4 Focus Servo (0=Off, 1=On)
18     1bit  FS3 DEFECT
17     1bit  FS2 Enable Focus Search Voltage (0=Off, 1=On)
16     1bit  FS1 Select Focus Search Voltage (0=Falling, 1=Rising)
15-0   16bit Unused (don't care)
```

For Focus Search: Keep FS1=on, and toggle FS2 on and off (this will generate a waveform, and SENS will indicate when reaching a good focus voltage).

CXA1782BR - CX(1x) - Tracking/Brake/Sled - "DEFECT" at SENS pin

```
23-20 4bit  Command (01h)
19     1bit  TG1,TG2 ON/OFF Tracking Servo Gain Up/Normal (hmmm?)
18     1bit  Brake Circuit ON/OFF
17-16 2bit  PS Sled Kick Height (0=+/-1, 1=+/-2, 2=Undoc, 3="Don't use"?)
15-0   16bit Unused (don't care)
```

Note: The PSX CDROM BIOS does use the "Undoc" setting (ie. bit17=1), but the effect is undoc/unknown?

Note: CX(1x) works different on CXD2545Q (some bits are moved around, and the "SledKickHeight" bits are renamed to "SledKickLevel" and moved to different/new CX(3X) commands.

CXA1782BR - CX(2x) - Tracking and Sled Servo Control - "TZC" at SENS pin

```

23-20 4bit  Command (02h)
19-18 2bit  Tracking Control (0=Off, 1=Servo On, 2=F-Jump, 3=R-Jump) ;TM1,3,4
17-16 2bit  Sled Control      (0=Off, 1=Servo On, 2=F-Fast, 3=R-Fast) ;TM2,5,6
15-0  16bit Unused (don't care)

```

CXA1782BR - CX(3x) - "Automatic Adjustment Comparator Output" at SENS pin

```

23-20 4bit  Command (03h)
19     1bit  Value to be adjusted (0=Balance, 1=Gain)
18-16 3bit  New Balance or Gain value (depending on above bit)
15-0  16bit Unused (don't care)

```

Note: CX(3x) is extended and works very different on CXD2545Q.

CXA1782BR Command 4x..7x - "HIGH-Z" at SENS pin

```

N-N    4bit  Command (04h..07h)

```

CXA1782BR Command 8x..Fx - "UNSPECIFIED???" at SENS pin

```

N-N    4bit  Command (08h..0Fh)

```

Note

The Servo Amplifier isn't directly connected to the CPU. Instead, it's connected as a slave device to the Signal Processor. There are two ways to access the Servo Amplifier:

- 1) The CPU can send CX(0X..3X) commands to the Signal Processor (which will then forward them to the Servo Amplifier).
- 2) The Signal Processor can send CX(0X..3X) commands to the Servo Amplifier (this happens during CX(4xxx) Auto Sequence command).

30.13 CDROM Internal Commands CX(4x..Ex) - CXD2510Q Signal Processor

CXD2510Q - CX(4xxx) - Auto Sequence

```

23-20 4bit  Command (4)
19-16 4bit  AS3-0 Auto Sequence Command (see below)
15-12 4bit  MT3-0 Max Timer Value (N timer units, or 0=Invalidate Timer)
11     1bit  LSSL Timer Units      (0=2.9ms, 1=186ms) (for above MT value)
10-8   3bit  Unused (zero)
7-0    8bit  Unused (don't care)

```

Values for AS (Auto Sequence Command):

```

00h      Cancel
04h/05h Forward/Reverse Fine Search    ;<--sends CX(25h) ;\these do internally
07h      Focus-On                      ;<--sends CX(02h) ; send commands to
08h/09h Forward/Reverse 1 Track Jump    ;\                      ; CXA1782BR
0Ah/0Bh Forward/Reverse 10 Track Jump    ; sends CX(25h) ; and, auto sequence
0Ch/0Dh Forward/Reverse 2N Track Jump    ;/                      ;/is interrupted?
0Eh/0Fh Forward/Reverse 1N Track Move    ;<--CXD2545Q only(Reserved on CXD2510Q)
01h..03h,06h = Reserved

```

CXD2510Q - CX(5x) - Blind,Brake,Overflow Timer

```

23-20 4bit  Command (5)
19-16 4bit  TR3-0 Timer (N*0.022ms for Blind/Overflow, N*0.045ms for Brake)
15-8   8bit  Unused (don't care on CXD2510Q, zero on CXD2545Q)
7-0    8bit  Unused (don't care)

```

CXD2510Q - CX(6xx) - SledKick,Brake,Kick Timer

```

23-20 4bit  Command (6)
19-16 4bit  SD3-0 Timer KICK.D (N*2.9ms for Fine Search? else N*1.45ms?)
15-12 4bit  KF3-0 Timer KICK.F (N*0.09ms)
11-8   4bit  Unused (don't care on CXD2510Q, zero on CXD2545Q)
7-0    8bit  Unused (don't care)

```

CXD2510Q - CX(7xxxx) - Track jump count setting (for Auto Sequence Command)

```

23-20 4bit  Command (7)
19-4   16bit Track Jump Count Setting (0..65535) for Command 4x
3-0    4bit  Unused (don't care)

```

CXD2510Q - CX(8xx) - MODE Specification

23-20	4bit	Command (8)	
19	1bit	CDROM	(0=Audio, 1=CDROM; no average and pre-value stuff)
18	1bit	DOUT Mute	(0=Not muted, 1=Mute DOUT)
17	1bit	D.out Mute-F	(0=Not muted, 1=Mute DA)
16	1bit	WSEL	(0=Enhanced Sync Window, 1=Enhanced Anti-Rolling)
15	1bit	VCO SEL	(0=Double Correction, 1=Quadruple Correction)
14	1bit	ASHS	(0=Double Correction, 1=Quadruple Correction)
13	1bit	SOCT	(0=Output SubQ to SQSO, 1=Output Each? to SQSO)
12	1bit	Unused (zero)	
11-8	4bit	Unused (don't care on CXD2510Q, zero on CXD2545Q)	
7-0	8bit	Unused (don't care)	

CXD2510Q - CX(9xx) - Function Specification

23-20	4bit	Command (9)	
19	1bit	DCLV ON-OFF	(complex stuff, related to gain and frequencies)
18	1bit	DSPB ON-OFF	(0=Normal Speed, 1=Double Speed; fixed pitch)
17	1bit	ASEQ ON-OFF	(select output on SENS pin)
16	1bit	DPLL ON-OFF	(0=Analog RFPLL, 1=Digital RFPLL)
15-14	1bit	Bilingual Audio	(0=Stereo, 1=RightOnly, 2=LeftOnly, 3=Mute)
13	1bit	FLFC	(normally 0)
12	1bit	Unused (zero)	
11-8	4bit	Unused (don't care on CXD2510Q, zero on CXD2545Q)	
7-0	8bit	Unused (don't care)	

CXD2510Q - CX(Axx) - Audio Control

23-20	4bit	Command (0Ah)	
19	1bit	Vari Up	(write 1-then-0 to increase pitch by +0.1%)
18	1bit	Vari Down	(write 1-then-0 to decrease pitch by -0.1%)
17	1bit	Mute	(0=Not muted; unless muted elsewhere, 1=Mute & Peak=0)
16	1bit	ATT	(0=Attenuation off, 1=Minus 12 dB)
15-14	2bit	PCT	(0=Normal, 1=LevelMeter, 2=PeakMeter, 3=Normal) (0-1=QuadC2)
13-12	2bit	Unused (zero)	
11-8	4bit	Unused (don't care on CXD2510Q, zero on CXD2545Q)	
7-0	8bit	Unused (don't care)	

Normal: SQSO outputs... WHAT?

PeakMeter: SQSO outputs highest peak ever on any channel (bit15: usually 0)

LevelMeter: SQSO outputs recent peak (with bit15 toggled: 0=Right, 1=Left)

CXD2510Q - CX(Bxxxx) - Traverse Monitor Counter Setting

23-20	4bit	Command (0Bh)
19-4	16bit	Traverse Monitor Count (used when monitored by COMP and COUT) (?)
3-0	4bit	Unused (don't care)

CXD2510Q - CX(Cxx) - Spindle Servo Coefficient Setting

23-20	4bit	Command (0Ch)
19-18	2bit	Gain MDP for CLVP mode (0=-6db, 1=0dB, 1=+6dB, 3=Reserved)
17-16	2bit	Gain MDS for CLVS/CLVP (0=-12dB, 1=-6dB, 2=0dB, 3=Reserved)
15	1bit	Zero (zero)
14	1bit	Gain DCLV0 overall gain (0=0dB, 1=+6dB)
13-12	2bit	Unused (zero)
11-8	4bit	Unused (don't care on CXD2510Q, zero on CXD2545Q)
7-0	8bit	Unused (don't care)

CXD2510Q - CX(Dx) - CLV Control

23-20	4bit	Command (0Dh)
19	1bit	DCLV PWM MD Digital CLV PWM mode (0=Use MDS+MDP, 1=Ternary MDP)
18	1bit	TB Bottom Hold in CLVS/CLVH modes (0=At cycle RFCK/32, 1=RFCK/16)
17	1bit	TP Peak Hold in CLVS mode (0=At cycle RFCK/4, 1=RFCK/2)
16	1bit	Gain CLVS for CLVS mode (0=0dB, 1=+6dB) (always +6dB in CLVP mode)
15-8	8bit	Unused (don't care on CXD2510Q, zero on CXD2545Q)
7-0	8bit	Unused (don't care)

CXD2510Q - CX(Ex) - CLV Mode

23-20	4bit	Command (0Eh)
19-16	4bit	CM3-0
15-8	8bit	Unused (don't care on CXD2510Q, zero on CXD2545Q)
7-0	8bit	Unused (don't care)

Values for CM (CLV Mode):

00h	Stop	Spindle Motor Stop mode
06h	CLVA	Automatic CLVS/CLVP switching mode, normally used for playback
08h	Kick	Spindle Motor Forward rotation mode
0Ah	Brake	Spindle Motor Reverse rotation mode
0Ch	CLVH	Peak hold at 34kHz
0Eh	CLVS	Rough Servo Mode, RF-PLL related
0Fh	CLVP	PLL Servo mode

N/A - CX(F) - Reserved

23-0	N/A	Don't use
------	-----	-----------

SUBQ Output

```
80bit subq
15bit peak level (lsb first) (absolute/unsigned value)
1bit peak l/r flag (aka appears as "MSB" of peak level)
```

L/R is toggled after each SUBQ reading, however the PSX Report mode does usually forward SUBQ only every 10 frames, so it stays stuck in one setting (but may toggle after one second; ie. every 75 frames). And, peak is reset after each read, so 9 of the 10 frames are lost.

CXD2510Q - SENS output

Index	ASEQ=0	ASEQ=1	; <-- ASEQ can be set via CX(9xx)
0X	HighZ	SEIN (FZC)	; \aka SENS output
1X	HighZ	SEIN (A.S)	... aka DEFECT ; from CXA1782BR
2X	HighZ	SEIN (T.Z.C)	... aka TZC ; forwarded through
3X	HighZ	SEIN (SSTOP)	... aka Gain/Bal ; /CXD2510Q
4X	HighZ	XBUSY	
5X	HighZ	FOK	
6X	HighZ	SEIN (HighZ)	
AX	GFS	GFS	
BX	COMP	COMP	
CX	COUT	COUT	
EX	/OV64	/OV64	
7X-9X, DX, FX	HighZ	0	

Whereas,

FZC	Focus Zero Cross
DEFECT	Defect?
TZC	Tracking Zero Cross
SSTOP	Gain or Balance adjust reached wanted level
XBUSY	Low while the auto sequencer operation is busy
FOK	High for "focus OK" (same as FOK pin)
GFS	High when the played back frame sync is obtained with correct timing
COMP	Measures the number of tracks set with Reg B. High when Reg B is latched, low when the initial Reg B number is input by CNIN
COUT	Measures the number of tracks set with Reg B. High when Reg B is latched, toggles each time the Reg B number is input by CNIN. While \$44 and \$45 are being executed, toggles with each CNIN 8-count instead of the Reg B number
OV64	Low when filtered EFM signal is lengthened by 64 channel clock pulses or more

30.14 CDROM Internal Commands CX(0x..Ex) - CXD2545Q Servo/Signal Combo

CXD2545Q - CX(0x) and CX(2x) - same as CXA1782BR Servo Amplifier

[CDROM Internal Commands CX\(0x..3x\) - CXA1782BR Servo Amplifier](#)

CXD2545Q - CX(4x..Ex) - same as CXD2510Q Signal Processor

[CDROM Internal Commands CX\(4x..Ex\) - CXD2510Q Signal Processor](#)

One small difference is that the CXD2545Q supports a new "M Track Move" function as part of the CX(4xxx) command. And, some "don't care" bits are now reserved (ie. some commands need to be padded with additional leading "0" bits).

CXD2545Q - CX(1x) - Anti Shock/Brake/Tracking Gain/Filter

```

23-20 4bit  Command (01h)
19     1bit  Anti Shock (0=Off, 1=On)
18     1bit  Brake      (0=Off, 1=On)
17     1bit  Tracking Gain (0=Normal, 1=Up)
16     1bit  Tracking Gain Filter (0=Select 1, 1=Select 2)
15-0   16bit Unused (don't care)
```

CXD2545Q - CX(30..33) - Sled Kick Level

```

23-20 4bit  Command (03h)
19-18 2bit  Subcommand (0)
17-16 2bit  Sled Kick Level (0=+/-1, 1=+/-2, 2=+/-3, 3=+/-4)
15-0   16bit Unused (don't care)
```

CXD2545Q - CX(34xxxx) - Write to Coefficient RAM

```

23-16 8bit  Command (34h)
15     1bit  Zero (0)
14-8   7bit  Address (00h..4Fh = Select Coefficient K00..K4F)
7-0    8bit  Data      (00h..FFh = New value)
PLUS   8bit  Eight more bits on PSone (!)
```

Allows to change the default preset coefficient values,
[CDROM Internal Coefficients \(for CXD2545Q\)](#)

CXD2545Q - CX(34Fxxx) - Write to Special Register

```

23-12 12bit Command (34Fh)
11-10 2bit Index (0=TRVSC, 1=FBIAS, 2=?, 3=?)
9-0    10bit Data (for FBIAS: bit0=don't care)

```

CXD2545Q - CX(35xxxx) - FOCUS SEARCH SPEED/VOLTAGE/AUTO GAIN

```

23-16 8bit Command (35h)
15-14 2bit FT Focus Search-up speed 1
13-8   6bit FS Focus Search limit voltage (default 011000b) (+/-1.875V)
7      1bit FTZ Focus Search-up speed 2
6-0    7bit FG AGF Convergence Gain Setting (default 0101101b)

```

CXD2545Q - CX(36xxxx) - DTZC/TRACK JUMP VOLTAGE/AUTO GAIN

```

23-16 8bit Command (36h)
15     1bit Zero (0)
14     1bit DTZC DTZC Delay (0=4.25us/Default, 1=8.5us)
13-8   6bit TJ Track Jump voltage (default 001110b) (+/-1.09V)
7      1bit Zero (0)
6-0    7bit TG AGT Convergence Gain Setting (default 0101110b)

```

CXD2545Q - CX(37xxxx) - FZSL/SLED MOVE/Voltage/AUTO GAIN

```

23-16 8bit Command (37h)
15-14 2bit FZS XXX pg. 84
13-8   6bit SM Sled Move Voltage
7      1bit AGS
6      1bit AGJ
5      1bit AGGF
4      1bit AGGT
3      1bit AGV1
2      1bit AGV2
1      1bit AGHS
0      1bit AGHT

```

CXD2545Q - CX(38xxxx) - Level/Auto Gain/DFSW (Initialize)

```

23-16 8bit Command (38h)
15     1bit VCLM VC level measurement on/off
14     1bit VCLC VC level compensation for FCS_In Register on/off
13     1bit FLM Focus zero level measurement on/off
12     1bit FLC0 Focus zero level compensation for FZC Register on/off
11     1bit RFLM RF zero level measurement on/off
10     1bit RFLC RF zero level compensation on/off

```

9	1bit	AGF	Focus automatic gain adjustment on/off
8	1bit	AGT	Tracking automatic gain adjustment on/off
7	1bit	DFSW	Defect switch disable (1=disable defect measurement)
6	1bit	LKSW	Lock switch (1=disable sled free-running prevention)
5	1bit	TBLM	Traverse center measurement on/off
4	1bit	TCLM	Tracking zero level measurement on/off
3	1bit	FLC1	Focus zero level compensation for FCS_In Register on/off
2	1bit	TLC2	Traverse center compensation on/off
1	1bit	TLC1	Tracking zero level compensation on/off
0	1bit	TLC0	VC level compensation for TRK/SLD_In register on/off

VCLM,FLM,RFLM,TCLM are accepted every 2.9ms.

CXD2545Q - CX(39xx) - Select internal RAM/Registers for serial readout

23-16	8bit	Command (39h)
15	1bit	DAC Serial data readout DAC mode on/off
14-8	7bit	SD Serial readout data select (see below)
7-0	8bit	Unused (don't care)

Serial Readout Addresses:

Addr	Data	Content
00h	8bit	VC input signal
01h	8bit	SE input signal
02h	8bit	TE input signal
03h	8bit	FE input signal
04h-07h	9bit	TE AVRГ register (mirrored to 04h-07h)
08h-0Bh	9bit	FE AVRГ register (mirrored to 08h-0Bh)
0Ch-0Fh	9bit	VC AVRГ register (mirrored to 0Ch-0Fh)
12h	8bit	RFDC envelope (peak)
13h	8bit	RFDC envelope (bottom)
1Ch	9bit	TRVSC register
1Dh	9bit	FBIAS register
1Eh	8bit	RFDC input signal
1Fh	8bit	RF AVRГ register
20h-3Fh	16bit	Data RAM (M00-M1F)
40h-7Fh	8bit	Coefficient RAM (K00-K3F) (note: K40-K4F cannot be read out)

CXD2545Q - CX(3Ax000) - Focus BIAS addition enable

23-16	8bit	Command (3Ah)
15	1bit	Zero (0)
14	1bit	FBON: FBIAS register addition (0=off, 1=Add FBIAS to FCS)
13-0	14bit	Zero (0)

CXD2545Q - CX(3Bxxxx) - Operation for MIRR/DFCT/FOK

23-16	8bit	Command (3Bh)	
15-14	2bit	SFO FOK Slice Level (...depends on SFOX)	
13-12	2bit	SDF DFCT Slice Level (0=89mV, 1=134mV, 2=179mV, 3=224mV)	
11-10	2bit	MAX DFCT Maximum Time (0=No Limit, 1=2ms, 2=2.36ms, 3=2.72ms)	
9	1bit	SFOX FOK Slice Level (...depends on SFO)	
8	1bit	BTF Bottom Hold Double-Speed Count-Up mode for MIRR (0=off)	
7-6	2bit	D2V Peak Hold 2 for DFCT (0=22.05kHz, 1=44.1, 2=88.2, 3=176.4)	
5-4	2bit	D1V Peak Hold 1 for DFCT (0=176.4kHz, 1=352.8, 2=705.6, 3=1411)	
3-0	4bit	Zero (0)	

CXD2545Q - CX(3Cxxxx) - TZC for COUT SLCT HPTZC (Default)

23-16	8bit	Command (3Ch)	
15-0	16bit	Unused (don't care)	

CXD2545Q - CX(3Dxxxx) - TZC for COUT SLCT DTZC

23-16	8bit	Command (3Dh)	
15-0	16bit	Unused (don't care)	

CXD2545Q - CX(3Exxxx) - Filter

23-16	8bit	Command (3Eh)	
15-14	2bit	F1NDM FCS servo filter 1st stage (1=normal, 2=down)	
13-12	2bit	F3NUM FCS servo filter 3rd stage (1=normal, 2=up)	
11-10	2bit	T1NDM TRK servo filter 1st stage (1=normal, 2=down)	
9-8	2bit	T3NUM TRK servo filter 3rd stage (1=normal, 2=up)	
7	1bit	DFIS FCS hold filter input extraction node (0=M05, 1=M04)	
6	1bit	TLCD Mask TLC2 set by D2 of CX(38) only when FOK low	
5	1bit	RFLP Pass signal from RFDC pin through low-pass-filter	
4-0	5bit	Zero (0)	

CXD2545Q - CX(3Fxxxx) - Others

23-16	8bit	Command (3Fh)	... XXX pg. 89
15-14	2bit	Unused (0)	
13-12	2bit	XTD	
11	1bit	Unused (0)	
10-8	3bit	DRR	
7	1bit	Unused (0)	
6	1bit	ASFG	
5	1bit	Unused (0)	
4	1bit	LPAS	
3-2	2bit	SRO	
1-0	2bit	Unused (0)	

CXD2545Q feedback on 39xx: see pg. 77 (eg. 390C = VC AVRG)

XXX

CXD2545Q - SENS output

Index	ASEQ=0	ASEQ=1	Length
\$0X	Z	FZC	-
\$1X	Z	AS	-
\$2X	Z	TZC	-
\$38	Z	AGOK*1	-
\$38	Z	XAVEBSY*1	-
\$30-37, \$3A-3F	Z	SSTP	-
\$3904	Z	TE Avrg Reg.	9 bit
\$3908	Z	FE Avrg Reg.	9 bit
\$390C	Z	VC Avrg Reg.	9 bit
\$391C	Z	TRVSC Reg.	9 bit
\$391D	Z	FB Reg.	9 bit
\$391F	Z	RFDC Avrg Reg.	8 bit
\$4X	Z	XBUSY	-
\$5X	Z	FOK	-
\$6X	Z	0	-
\$AX	GFS	GFS	-
\$BX	COMP	COMP	-
\$CX	COUT	COUT	-
\$EX	OV64	OV64	-
\$7X-9X, DX, FX	Z	0	-

*1 \$38 outputs AGOK during AGT and AGF command settings, and XAVEBSY during AVRG measurement.

SSTP is output in all other cases.

30.15 CDROM Internal Commands CX(0x..Ex) - CXD2938Q Servo/Signal/SPU Combo

Most commands are same as on CXD2545Q. New/changed commands are:

CXD2938Q - CX(349xxxxx) - New SCEX

Older PSX consoles have received the "SCEX" string at 250 baud via HC05 PortB.bit1, which allowed modchips to injected faked "SCEX" signals to that pin. To prevent that, the CXD2938Q contains some new 32bit commands that allow to receive somewhat encrypted "SCEX" strings via SPI bus. The used commands are:

```

CX(34910000) NewScexStopReading
CX(3491xy80) NewScexRandomKey(xy)
CX(34920000) NewScexFlushResyncOrSo
CX(34944A00) NewScexInitValue1
CX(3498C000) NewScexInitValue2
CX(349C1000) NewScexThis    ;\inverse    ;\use CX(3C2080) for COUT selection
CX(349D1000) NewScexThat    ;/of COUT    ;/

```

The relevant command is `NewScexRandomKey(xy)` which does send a random value ($x=01h..0Fh$, and $y=01h$), and does then receive a 12-byte response via SPI bus (which is normally used to receive SUB-Q data).

```

1st byte: Unknown/unused (normally ADR/Control) ;\these should be probably
2nd byte: Unknown/unused (normally Track)        ; set to some invalid values
3rd byte: Unknown/unused (normally Index/Point) ;/to avoid SUB-Q confusion
4th..10th byte: SCEEx data or Dummy bytes (depending on xy.bit7..1)
11th..12th byte: Unknown/unused (normally Audio Peak level)

```

The 12-byte packet does contain one SCEEx character encoded in 4th..10th byte corresponding to Flags in "xy" bit 7..1 (in that order):

All bytes with Flag=1 are ORed together to compute a Character byte (those bytes could be all set to 53h for "S", or if more than one flag is set, it could be theoretically split to something like 41h and 12h).

All bytes with Flag=0 are ORed together to compute a Dummy byte. If the Character byte is same as the Dummy byte, then it gets destroyed by setting Character=00h (to avoid that, one could set all dummies to 00h, or set one or more dummies to FFh, for example). Finally, "xy" bit0=0 indicates that the resulting character byte is inverted (XORed by FFh), however, the CDROM BIOS does always use bit0=1, so the inversion feature is never used.

For the whole SCEEx string, there must be at least one 00h byte inserted between each character (or some Char=Dummy mismatch, which results in Char=00h either), and there should be a few more 00h bytes preceeding the first character ("S").

Note: Modchips didn't bother to reproduce that new SCEEx transfers, instead they have simply bypassed it by injecting the 250 baud SCEEx string to some analog lower level signal.

CXD2938Q - CX(3Bxxxx) - Some Changed Bits

Same as in older version, but initialized slightly differently: CXD2545Q used CX(3B2250) whilst CXD2938Q is using CX(3B7250).

CXD2938Q - CX(3Cxxxx) - TzcCoutSelect with New/Changed Extra Bits

The CXD2545Q used two 8bit commands, CX(3C) and CX(3D), for TzcOut selection, which are now replaced by a single 24bit command, CX(3Cxxxx), and which do include a new mode related to New SCEX.

```
CXD2545Q    CXD2938Q
CX(3C)      CX(3C0080) TzcCoutSelectHPTZC;\ <--formerly CX(3C)
-           CX(3C2080) TzcCoutSelectSCEX ; <--special NewSceX mode
CX(3D)      CX(3C4080) TzcCoutSelectDTZC ;/ <--formerly CX(3D)
```

CXD2938Q - CX(8xxxxx) - Disc Mode with New/Changed Extra Bits

Command CX(8xx) has been 12bit wide on CXD2545Q, and is now expanded 24bit width (with some changed/unknown bits).

```
CXD2545Q    CXD2938Q
CX(8180)    CX(810408) MODE = Audio (CD-DA)
CX(8120)    CX(812400) MODE = Audio (CD-DA) (manual SPI bus access)
CX(8980)    CX(890408) MODE = CDROM (Data)
-           CX(898000) MODE = CDROM (Data) (used on RESET)
```

CXD2938Q - CX(9xx000) - Normal/Double Speed with New Extra Bits

Command CX(9xx) has been 12bit wide on CXD2545Q (with bit12=reserved/zero), and is now expanded 24bit width (with bit12=unknown/one and bit11-0=unknown/zero).

CXD2938Q - CX(Dx0000) and CX(Ex0000) - New Zero Padding

Commands CX(Dx) and CX(Ex) have been 8bit wide on CXD2545Q, and are now zeropadded to 24bit width, ie. CX(Dx0000) and CX(Ex0000). Unknown if the extra bits are hiding any extra features. In practice, the CDROM BIOS is always setting them zero (except in some test commands which are accidentally still using the old 8bit form, resulting in garbage in lower 16bits).

30.16 CDROM Internal Commands CX(xx) - Notes

Serial Command Transmission (for Signal Processor and Servo Amplifier)

Commands are sent serially LSB first via DATA,CLOCK,XLAT pins: DATA+CLOCK are used to send commands to the chip, command execution is then applied by dragging XLAT low

for a moment.

Commands can be up to 24bits in length, but unused LSBs (the "don't care" bits) can be omitted; the PSX BIOS clips the length to 8bit/16bit where possible (due to the LSB-first transfer order, the chip does treat the most recently transferred bit as MSB=bit23, and there's no need to transfer the LSBs if they aren't used).

Aside from being used as command number, the four most recently transferred bits are also used to select SENS status feedback (for the SENS selection it doesn't matter if the four bits were terminated by XLAT or not).

Sled Motor / Track Jumps / Tracking

The Sled motor moves the drive head to the current read position. On a Compact Disc, the term "Track" does normally refer to Audio tracks (songs). But the drive hardware uses the terms "Track" and "Tracking" for different purposes:

Tracking appears to refer to moving the Optics via magnets (ie. moving only the laser/lens, without actually moving the whole sled) (this is done for fine adjustments, and it seems to happen more or less automatically; emulators can just return increasing sectors without needing to handle special tracking commands).

Track jumps refer to moving the entire Sled, one "track" is equal to one spiral winding (1.6 micrometers). One winding contains between 9 sectors on innermost windings, and 22.5 sectors on outermost windings (the PSX cdrom bios is translating the sector-distance to non-linear track-distance, and emulators must undo that translation; otherwise the sled doesn't arrive at the intended location; the cdrom bios will retry seeking a couple of times and eventually settle down at the desired location - but it will timeout if the sled emulation is too inaccurate).

The PSX hardware uses two mechanisms for moving the Sled:

Command CX(4xxx) Forward/Reverse Track Jump: allows to move the sled by 1..131070 tracks (ie. max 210 millimeters), and the hardware does stop automatically after reaching the desired distance.

Command CX(2x) Forward/Reverse Fast Sled: moves the sled continuously until it gets stopped by another command (in this mode, software can watch the COUT signal, which gets toggled each "N" tracks; whereas "N" can be selected via Command CX(Bxxxx), which is configured to N=100h in PSX).

The PSX cdrom bios is issuing another Fast Sled command (in opposite direction) after Fast Sled commands, emulators must somehow interpret this as "sled slowdown" (rather than as actually moving the sled in opposite direction, which could move the sled miles away from the target). For some reason vC1 BIOS is using a relative short slowdown period, whilst vC2/vC3 are using much longer slowdown periods

(probably related to different SledKickHeight aka SledKickLevel settings and/or to different Sled Move Voltage settings).

Focus / Gain / Balance

The hardware includes commands for adjusting & measuring focus/gain/balance. Emulators can just omit that stuff, and can always signalize good operation (except that one should emulate failures for Disc Missing; and eventually also for cases like Laser=Off, or Spindle=Stopped).

Focus does obviously refer to moving the lens up/down. Gain does probably refer to reflection level/laser intensity. Balance might refer to tracking adjustments or so.

30.17 CDROM Internal Commands CX(xx) - Summary of Used CX(xx) Commands

The PSX CDROM BIOS versions vC1, vC2, and vC3 are using following CX() commands:

```
<B>  <--vC1-->  <--vC2-->  <--vC3--></B>
<B>  CXD2510Q   CXD2545Q   CXD2938Q</B>
CX(00)    CX(00)    CX(00)    AllFocusSwitchesOff
CX(02)    CX(02)    CX(02)    FocusSearchVoltageFalling
CX(03)    CX(03)    CX(03)    FocusSearchVoltageRising ;ForTestOnly
CX(08)    CX(08)    CX(08)    FocusServoOn
CX(0C)    CX(0C)    CX(0C)    FocusServoOnAndDefectOn ;diff.usage vC# ?
-----
CX(11)    -         -         SledKickHeight2
CX(12)    -         -         SledKickHeightInvalid
CX(19)    -         -         TrackingGainAndSledKickHeight2
CX(1D)    -         -         TrackingGainBrakeAndSledKickHeight2
CX(1E)    -         -         TrackingGainBrakeAndSledKickHeightInvalid
-----
-         CX(11)    CX(11)    AntiShockOff                ;\
-         CX(13)    CX(13)    AntiShockOffGainUp              ;
-         CX(17)    CX(17)    AntiShockOffGainUpBrake          ;/
-----
CX(20)    CX(20)    CX(20)    SledAndTrackingOff
CX(21)    CX(21)    CX(21)    SledServoOn                ;ForTestOnly
CX(22)    CX(22)    CX(22)    SledFastForward
CX(23)    CX(23)    CX(23)    SledFastReverse
CX(24)    -         -         TrackingServoOn
CX(25)    CX(25)    CX(25)    SledAndTrackingServoOn
-         CX(26)    CX(26)    SledFastForwardAndTrackingServoOn
CX(28)    CX(28)    CX(28)    TrackingForwardJump      ;ForTestOnly
CX(2C)    CX(2C)    CX(2C)    TrackingReverseJump      ;ForTestOnly
-----
CX(30+n)  -         -         BalanceAdjust(0..7)
```

```

CX (38+n)  -      -      GainAdjust (0..7)
-----
-      CX (30)      CX (30)      SetSledKickLevel1      ;\
-      CX (31)      CX (31)      SetSledKickLevel2      ;
-      CX (32)      CX (32)      SetSledKickLevel3      ;/
-----
-      CX (3400E6) CX (3400E6) SetK00toE6hSledInputGain      ;def=E0h
-      CX (340730) CX (340730) SetK07to30hSledAutoGain      ;blah ;def=30h
-      CX (34114A) CX (34114A) SetK11to4AhFocusOutputGain    ;def=32h
-      CX (341330) CX (341330) SetK13to30hFocusAutoGain      ;blah ;def=30h
-      CX (341D6F) CX (341D6F) SetK1Dto6FhTrackingLowBoostFilterAL ;def=44h
-      CX (341F64) CX (341F64) SetK1Fto64hTrackingLowBoostFilterBL ;def=5Eh
-      CX (342220) CX (342220) SetK22to20hTrackingOutputGain    ;def=18h
-      CX (342330) CX (342330) SetK23to30hTrackingAutoGain      ;blah ;def=30h
-      CX (342D28) CX (342D28) SetK2Dto28hFocusGainDownOutputGain ;def=1Bh
-      CX (343E70) CX (343E70) SetK3Eto70hTrackingGainUpOutputGain ;def=57h
-      -      CX (34910000) NewScexStopReading      ;\
-      -      CX (3491x180) NewScexRandomKey (x)      ;
-      -      CX (34920000) NewScexFlushResyncOrSo      ; SCEX SPECIAL
-      -      CX (34944A00) NewScexInitValue1      ; see also:
-      -      CX (3498C000) NewScexInitValue2      ; CX (3C2080)
-      -      CX (349C1000) NewScexThis      ;\inverse ;
-      -      CX (349D1000) NewScexThat      ;/of COUT ;/
-      CX (34F000) CX (34F000) SetTRVSCto000h
-      CX (34Fxxx) CX (34Fxxx) SetFBIAStoNNNh
-----
-      CX (3740AA) CX (3740AA) SetSMto00h      ;\set SM to 0,6,7,9
-      CX (3746AA) CX (3746AA) SetSMto06h      ; (sled move voltage)
-      CX (3747AA) CX (3747AA) SetSMto07h      ; (and init several
-      CX (3749AA) CX (3749AA) SetSMto09h      ;/fixed settings)
-----
-      CX (380010) CX (380010) ModeMeasureTrackingZeroLevel ;\Measure modes
-      CX (380800) CX (380800) ModeMeasureRfZeroLevel      ; (accepted
-      CX (382000) CX (382000) ModeMeasureFocusZeroLevel    ; every 2.9ms)
-      CX (388000) CX (388000) ModeMeasureVcLevel      ;/
-      CX (38140A) CX (38140A) ModeCompensate
-      CX (38140E) CX (38140E) ModeCompensateAndTraverseCenter
-      CX (38148A) CX (38148A) ModeCompensateAndDefectOff
-      CX (38148E) CX (38148E) ModeCompensateAndDefectOffTraverseCenter
-      CX (3814AA) CX (3814AA) ModeCompensateAndStuffAndMeasureTraverse ;!
-      CX (38150A) CX (38150A) ModeCompensateAndTrackingAutoGain
-      CX (38150E) CX (38150E) ModeCompensateAndTrackingAutoGain
-      CX (38160A) CX (38160A) ModeCompensateAndFocusAutoGain
-----
-      CX (391E)      -      SenseRFDCinputSignalWithoutDAC ;\rather
-      CX (3983)      -      SenseFEinputSignalWithDAC      ;/unused
-      CX (399C)      -      SenseTRVSCregisterWithDAC      ;\only if
-      CX (399D)      -      SenseFBIASregisterWithDAC      ;/TEST1=LOW
-----
-      CX (3A0000) CX (3A0000) FocusBiasAdditionOff      ;\
-      CX (3A4000) CX (3A4000) FocusBiasAdditionOn      ;/
-      CX (3B2250) !CX (3B7250) !InitOperationForMirrDfctFok <-- vC2/vC3 DIFF
-      CX (3C)      !!!CX (3C0080) TzcCoutSelectHPTZC;\ <--formerly CX (3C)
-      -      !!!CX (3C2080) TzcCoutSelectSCEX ; <--special NewScex mode

```

```

-          CX(3D)   !!!CX(3C4080) TzcCoutSelectDTZC ;/ <--formerly CX(3D)
-          CX(3E0000) CX(3E0000) InitFilterBits           ;\
-          CX(3E0008) CX(3E0008) InitFilterBitsInvalid      ;/
-          CX(3F0008) CX(3F0008) InitOtherStuff             ;-
-----
CX(4000)    CX(4000)    CX(4000)    AutoSeqCancel
CX(4700)    CX(4700)    CX(4700)    AutoSeqFocusOn
CX(4800)    CX(4800)    CX(4800)    Forward1track
CX(4900)    CX(4900)    CX(4900)    Reverse1track
CX(4C00)    CX(4C00)    CX(4C00)    Forward2Ntrack
CX(4D00)    CX(4D00)    CX(4D00)    Reverse2Ntrack
-----
CX(54)      CX(54)      CX(54)      BlindBrakeOverflowTimer=4
CX(5A)      CX(5A)      CX(5A)      BlindBrakeOverflowTimer=A
CX(6100)    CX(6100)    CX(6100)    SledKickBrakeKickTimer
CX(70xxx0)  CX(70xxx0)  CX(70xxx0)  TrackJumpCountSetting
CX(8180)    CX(8180) !!!CX(810408) MODE = Audio (CD-DA)
-          CX(8120) !!!CX(812400) MODE = Audio (CD-DA) (manual SPI bus access)
-          -            CX(810000)/UNUSED)
-          -            CX(812000)/UNUSED)
CX(8980)    CX(8980)    CX(890408) MODE = CDROM (Data)
-          -            CX(898000) MODE = CDROM (Data) (used on RESET)
CX(9B00)    CX(9B00) !!!CX(9B1000) NormalSpeed
CX(9F00)    CX(9F00) !!!CX(9F1000) DoubleSpeed
CX(A040)    CX(A040)    CX(A040)    Attenuation Off
CX(A140)    CX(A140)    CX(A140)    Attenuation -12 dB
CX(B01000)  CX(B01000) CX(B01000) TraverseMonitorCounterSetting
CX(C600)    CX(C600)    CX(C600)    SpindleServoCoefficientSetting
CX(D7)      CX(D7)      CX(D70000) ClvControl (fixed)
CX(E0)      CX(E0)      CX(E00000) SpindleMotorStop
-          -            CX(E02000) <-- aka bugged CX(E0) with CRAP=2000h
CX(E6)      CX(E6)      CX(E60000) AutomaticNormal
CX(E8)      CX(E8)      CX(E80000) SpindleMotorForward
-          -            CX(E8crap) <-- aka bugged CX(E8) with CRAP=xxxxh
CX(EA)      CX(EA)      CX(EA0000) SpindleMotorReverse
-          -            CX(EAcrap) <-- aka bugged CX(EA) with CRAP=xxxxh
CX(EE)      CX(EE)      CX(EE0000) RoughServo
-----
CX(F)       CX(F)       CX(F)       Unused (N/A)
-----
CX(Xx)      CX(Xx)      CX(Xx)      ;\
CX(Xxxx)    CX(Xxxx)    CX(Xxxx)    ; TestCommand (cmd_19h_50h)
CX(Xxxxxxx) CX(Xxxxxxx) CX(Xxxxxxx) ;
-          -            CX(Xxxxxxxxx) ;/
-          CX(Xxxxxxx) CX(Xxxxxxx) SerialSense, CX(Xxxx) with extra 8bit junk

```

Note: for vC2, some CX(38xxxx) values may differ depending on "set_mid_lsb_to_140Eh".

For vC2, CX(Dx) and CX(Ex) should be officially zero-padded to CX(Dx00) and CX(Ex00), but the vC2 BIOS doesn't do that, it still uses short 8bit form.

For vC2, CX(Dx) and CX(Ex) should be apparently zero-padded to CX(Dx0000) and

CX(Ex0000), at least, the vC3 BIOS is doing so (except on some test commands that do still use the CX(Ex) short form).

Used Sense Values

```
sense(30)  SEIN.BAL      ;vC2: SSTP
sense(38)  SEIN.GAIN     ;vC2: AGOK(AGT/AGF) or XAVEBSY(AVRG) or SSTP(else?)
sense(40)  XBUSY (low=AutoSeqBusy)
sense(50)  FOK (high=FokusOkay)
sense(A0)  GFS (high=GoodFrameSync, ie. CorrectPlaybackSpeed)
sense(C5)  COUT (toggles each 100h 'tracks') (100h=selected via CX(B01000))
sense(EA)  /OV64 (low=EFM too long?)
```

30.18 CDROM Internal Coefficients (for CXD2545Q)

The CXD2545Q contains Preset Coefficients in internal ROM, which are copied to internal Coefficient RAM shortly after Reset. CX(34xxxx) allows to change those RAM settings, and CX(39xxxx) allows to readout some of those values serially.

CXD2545Q - Coefficient Preset Values

Addr	Val	Expl.
K00	E0	Sled input gain
K01	81	Sled low boost filter A-H
K02	23	Sled low boost filter A-L
K03	7F	Sled low boost filter B-H
K04	6A	Sled low boost filter B-L
K05	10	Sled output gain
K06	14	Focus input gain
K07	30	Sled auto gain
K08	7F	Focus high cut filter A
K09	46	Focus high cut filter B
K0A	81	Focus low boost filter A-H
K0B	1C	Focus low boost filter A-L
K0C	7F	Focus low boost filter B-H
K0D	58	Focus low boost filter B-L
K0E	82	Focus phase compensate filter A
K0F	7F	Focus defect hold gain
K10	4E	Focus phase compensate filter B
K11	32	Focus output gain
K12	20	Anti shock input gain
K13	30	Focus auto gain
K14	80	HPTZC / Auto Gain High pass filter A
K15	77	HPTZC / Auto Gain High pass filter B
K16	80	Anti shock high pass filter A
K17	77	HPTZC / Auto Gain low pass filter B
K18	00	Fix (should not change this preset value)

K19	F1	Tracking input gain
K1A	7F	Tracking high cut filter A
K1B	3B	Tracking high cut filter B
K1C	81	Tracking low boost filter A-H
K1D	44	Tracking low boost filter A-L
K1E	7F	Tracking low boost filter B-H
K1F	5E	Tracking low boost filter B-L
K20	82	Tracking phase compensate filter A
K21	44	Tracking phase compensate filter B
K22	18	Tracking output gain
K23	30	Tracking auto gain
K24	7F	Focus gain down high cut filter A
K25	46	Focus gain down high cut filter B
K26	81	Focus gain down low boost filter A-H
K27	3A	Focus gain down low boost filter A-L
K28	7F	Focus gain down low boost filter B-H
K29	66	Focus gain down low boost filter B-L
K2A	82	Focus gain down phase compensate filter A
K2B	44	Focus gain down defect hold gain
K2C	4E	Focus gain down phase compensate filter B
K2D	1B	Focus gain down output gain
K2E	00	Not used
K2F	00	Not used
K30	80	Fix (should not change this preset value)
K31	66	Anti shock low pass filter B
K32	00	Not used
K33	7F	Anti shock high pass filter B-H
K34	6E	Anti shock high pass filter B-L
K35	20	Anti shock filter comparate gain
K36	7F	Tracking gain up2 high cut filter A
K37	3B	Tracking gain up2 high cut filter B
K38	80	Tracking gain up2 low boost filter A-H
K39	44	Tracking gain up2 low boost filter A-L
K3A	7F	Tracking gain up2 low boost filter B-H
K3B	77	Tracking gain up2 low boost filter B-L
K3C	86	Tracking gain up phase compensate filter A
K3D	0D	Tracking gain up phase compensate filter B
K3E	57	Tracking gain up output gain
K3F	00	Not used
K40	04	Tracking hold filter input gain
K41	7F	Tracking hold filter A-H
K42	7F	Tracking hold filter A-L
K43	79	Tracking hold filter B-H
K44	17	Tracking hold filter B-L
K45	6D	Tracking hold filter output gain
K46	00	Not used
K47	00	Not used
K48	02	Focus hold filter input gain
K49	7F	Focus hold filter A-H
K4A	7F	Focus hold filter A-L
K4B	79	Focus hold filter B-H
K4C	17	Focus hold filter B-L
K4D	54	Focus hold filter output gain

K4E	00	Not used
K4F	00	Not used