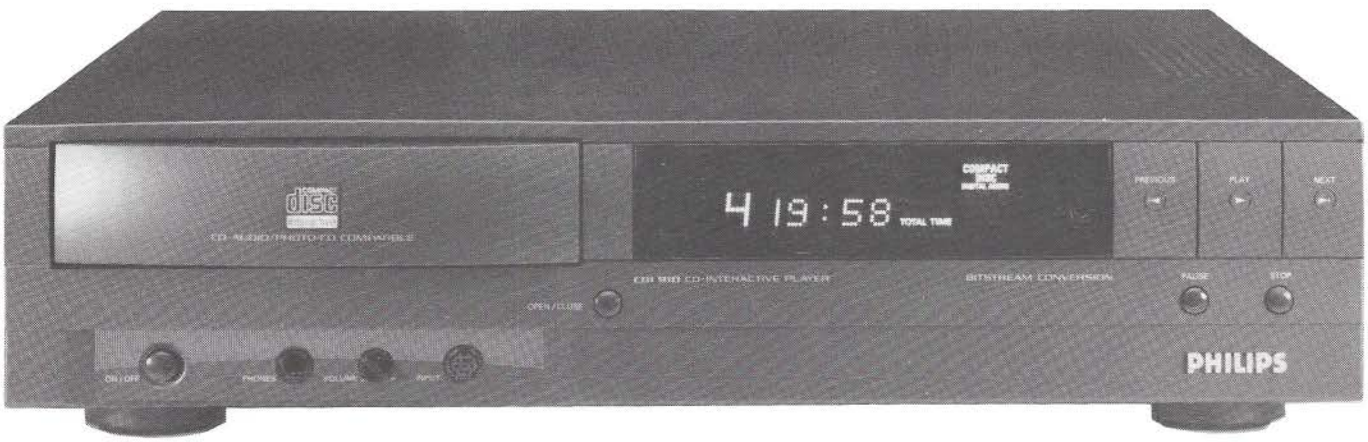
Philips Consumer Electronics Company
A Division of North American Philips Corporation

Technical Training Manual



Compact Disc - Interactive
Philips CDI910

ST1436-292 MR/KP

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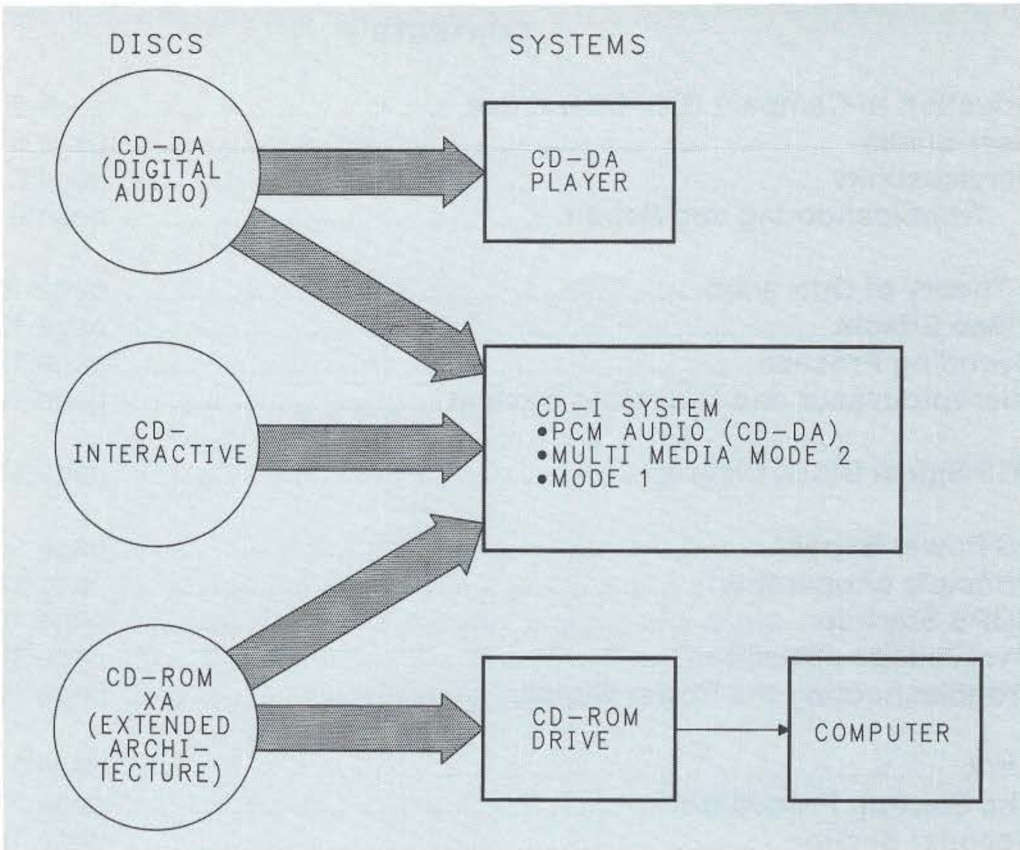

Figure 1 – Compact Disc Compatibility

Introduction to Compact Disc-Interactive

The introduction of the Laservision player by Magnavox in 1978 has led to a host of devices that use a laser beam to read analog or digital optical recordings (Compact Disc, CD-ROM, CD-Video). The latest of such devices is the CD-I (Compact Disc-Interactive) player (see cover photo). As the name implies, the CD-I player basically uses the Compact Disc format and expands on this format with Interactivity. The CD-I player also lead to the development of expanded forms of formatting information placed on the disc (therefore the need for additional decoding methods). The CD-I player is also compatible with existing CD formats, such as the standard Digital Audio CD (CD-DA) and Photo CD (CD-ROM XA).

There are both commercial and consumer applications for CD-I. CD-I applications include education (interactive training), entertainment (games), information, and reference. The CD-I operating system is the Compact Disc — Real Time Operating System (CD-RTOS), based on the OS-9 operating system. CD-I software enables synchronization of Audio and Video information due to the interleaving of digital audio and video data on the disc. CD-I may combine audio, video (stills or moving), and text in a single application. For example, a CD-I application may have a narration (audio) along with text on the screen while a picture (video) is displayed on the monitor (standard TV monitor). Or, another application may use animation in sync with the audio. CD-I also allows for the selection of one of several languages (application dependent). For example, a disc may include selectable narration in English, French, Japanese, and Spanish.

CD-I player operation depends on the application and type of disc. All Compact Discs have some common features, including error correction, interleaving, EFM (Eight-to-Fourteen Modulation), and a capacity of storing up to 650MB of digital information. Figure 1 illustrates the compatibility of each disc type.

CD-DA

The most familiar and popular is the standard **Compact Disc-Digital Audio (CD-DA)**. Refer to Philips ST1307 Training Manual for a detailed description of Compact Disc technology. The Compact Disc is recorded to provide High Fidelity with virtually no distortion or noise. The CD-DA format is the basis for all other CD formats. CD-DA makes use of 16-bit PCM (Pulse Code Modulation) to place data on disc. In the encoding process, the analog audio is converted to 16 bits per channel at a sample rate of 44.1kHz. Each 16 bit sample is then divided down to an eight-bit symbol.

The CD-DA encoding process (see Figure 2) arranges six stereo sample periods of 192 bits or 24 bytes (6 samples times 32 bits or 4 bytes for right

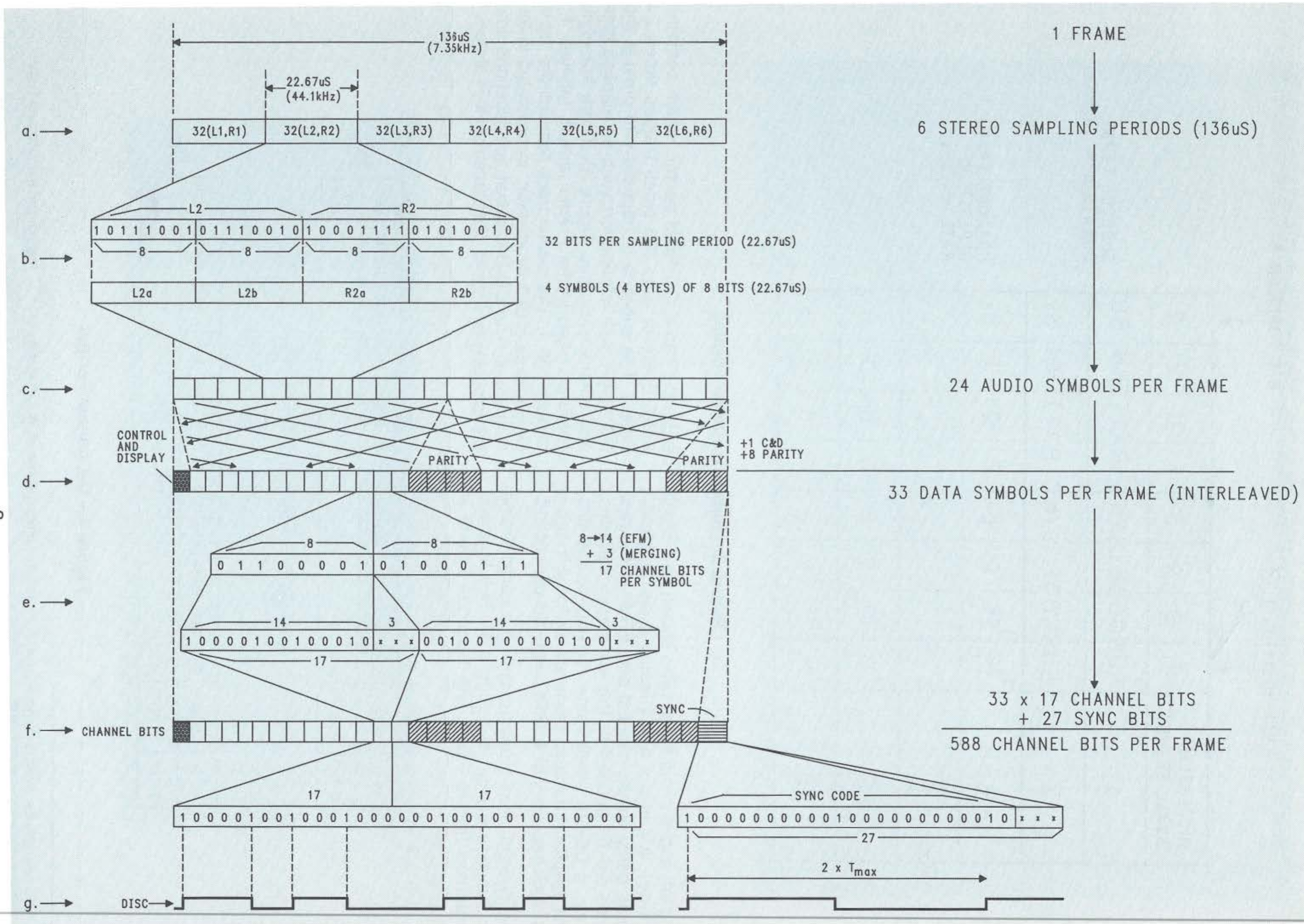

Figure 2 – CD Frame Format

BIT POSITION 1 ... BIT POSITION 8

SUCCESSIVE 'SMALL FRAMES'	P	Q	R	S	T	U	V	W
1	SUBCODE SYNC PATTERN S0							
2	SUBCODE SYNC PATTERN S1							
3	1 OR 0	1 OR 0	0	0	0	0	0	0
• • •								
97	1 OR 0	1 OR 0	0	0	0	0	0	0
98	1 OR 0	1 OR 0	0	0	0	0	0	0

SUBCODE FRAME DURATION = 13.3ms

SUBCODE FRAME REPETITION RATE = 75Hz

Figure 3 – Subcode Frame Format

and left audio) into a frame (also known as a Small Frame). A Control and Display code (subcode data), parity codes, merging bits, EFM, and a sync code are all applied to the six stereo samples. Thus, a CD-DA small frame consists of 588 bits. This results in a frame frequency of 7.35kHz and a bit clock frequency of 4.3218 mega-bits per second.

Ninety-eight small frames make up a Large Frame or Subcode Frame (see Figure 3). The subcode repetition rate is 75Hz. The Subcode Frame is equivalent to a CD-ROM sector, which contains 2352 Bytes of data (98 small frames times 24 Bytes). The subcode is necessary to provide the CD player with information such as elapsed time and control data (see Figure 4). There are eight channels used in the Frame format, labeled "P" through "W" †. The lead-in track contains the Table Of Contents (TOC) information, incorporated in the Q-channel. The CD-DA format specifications limit the total playing time to 72 minutes of HI-FI stereo.

S0,S1	CONTROL	ADR	MNR	POINT	MIN	SEC	FRAME	ZERO	PMIN	PSEC	PFRAME	CRC
2 BITS	4 BITS	4 BITS	72 DATA BITS									16 BITS

98 BITS

a. DURING LEAD-IN TRACK(TOC)

S0,S1	CONTROL	ADR	MNR	INDEX	MIN	SEC	FRAME	ZERO	AMIN	ASEC	AFRAME	CRC
2 BITS	4 BITS	4 BITS	72 DATA BITS									16 BITS

98 BITS

Figure 4 – Q-Channel Format

† Until now, only the P and Q channels have been used. The other channels, R-W, can now be used for graphics and text. Compact Discs with graphics are known as CD+G.

CD-ROM

Another type of disc is the **CD-ROM (Compact Disc - Read Only Memory)**. A CD-ROM disc contains over 600 mega-bytes of storage capacity for programs, data, and graphics. This storage capacity makes the CD-ROM advantageous for storage of large databases and program packages. However, CD-ROM discs are hardware dependent, as in any computer software. CD-ROM software, including programs and data, is thus developed for specific computer systems. Since programs are hardware dependent, the CD-I player does not run CD-ROM programs designed for computers. The CD-I player is also not designed to read data (graphics or text) from CD-ROM. A CD-ROM format which can be read by the CD-I player is CD-ROM XA (Extended Architecture). One such application for CD-ROM XA is the Photo-CD. The Photo-CD can store up to 100 high resolution photos on a single disc.

CD-ROM defines data in the form of sectors. Each sector contains 2352 bytes of information and is recorded using the same EFM (Eight-to-Fourteen Modulation) technique used in CD-DA. EFM provides a first level of error protection well suited to audio data as well as binary data in general.

The sector contains synchronization, address and mode information. In addition, a sector contains a user data area of either 2048 bytes for Mode 1 or 2336 bytes for Mode 2 (See Figure 5). The difference between these two modes is that Mode 1 uses 288 bytes to provide an additional level of error detection (ED) and error correction (EC). This ensures a level of data integrity essential for critical information that does not degrade gracefully, such as text and binary data typically contained in databases. Mode 2 trades this benefit of additional data security for a maximum data transfer rate by making the additional 288 byte area available as user data. In this case the EFM is adequate for error protection of data such as video and audio encoded information that degrade gracefully.

The standard CD Table of Contents (TOC), although not available to the computer program, may be used by the CD-ROM player to locate a requested track. The TOC appears in the Q channel in the lead-in area of each disc. There are two types of tracks that the TOC can identify as stored on a CD-ROM disc: CD Digital Audio tracks, and data tracks.

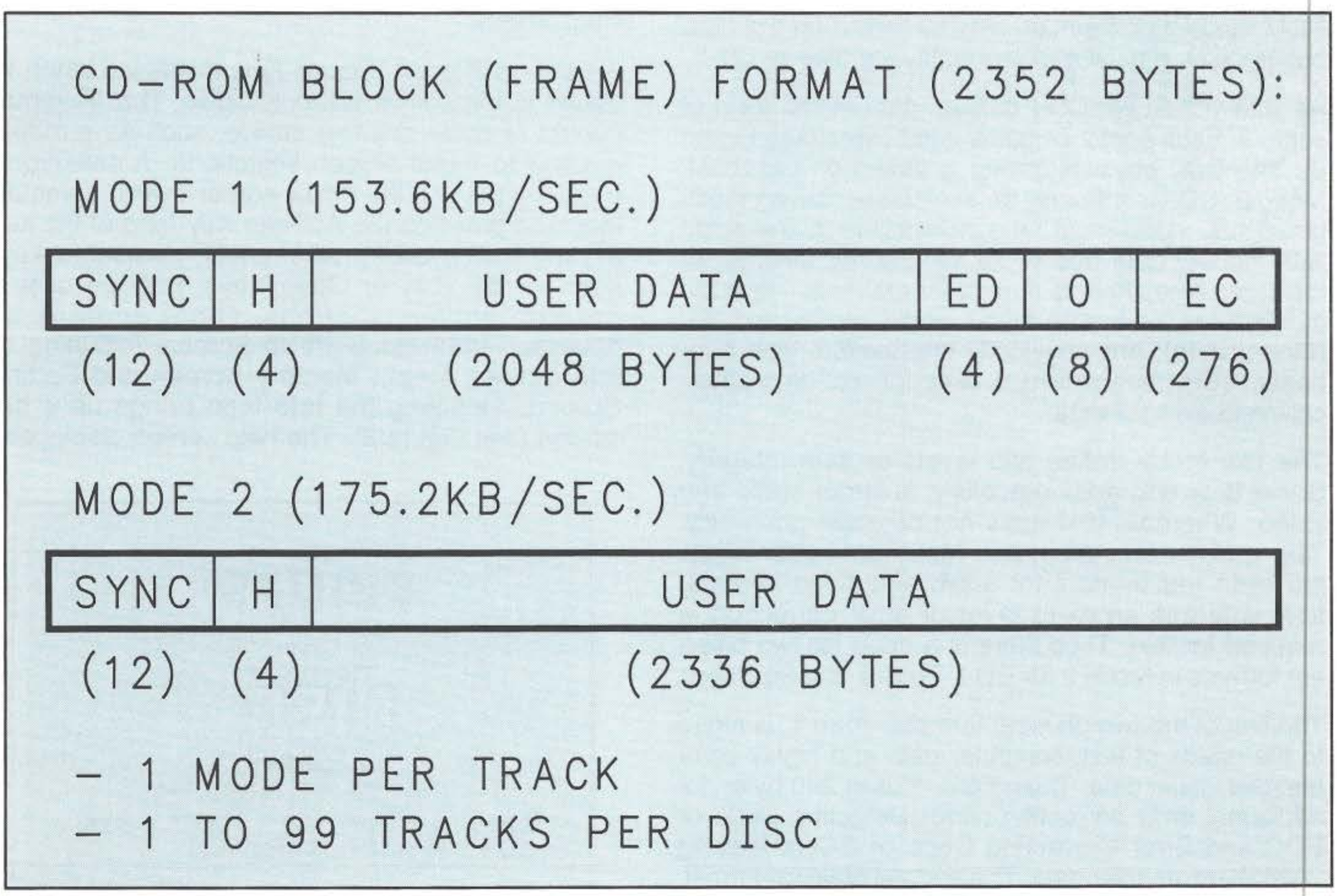

Figure 5 – CD-ROM Sector

BASED ON MODE 2

FORM 1:

SYNC 12B	HEADER 4B	SUBHEADER 8B	USER DATA 2048B	EDC 4B	ECC 276B

FORM 2:

SYNC 12B	HEADER 4B	SUBHEADER 8B	USER DATA 2324B	RESERVED 4B

Figure 6 – CD-I Forms

CD-I (Compact Disc - Interactive) specifically meets the needs and requirements of the CD-I player. Since CD-I information may include audio, video, text, and program data, several different encoding methods are used (Video and Audio encoding methods are covered in the CD-I Theory of Operation section). Encoding standards are established for CD-DA, CD-ROM, and CD-I. Formats may be mixed on the disc, but Track One must always identify the disc as CD-I.

As with CD-ROM, CD-I defines data in the form of sectors. Each sector contains 2352 bytes (see Figure 6). The CD-I physical format is based on CD-ROM, Mode 2. CD-I is primarily an audio/video driven medium. Thus, video must be synchronized to the audio with the CD data rate of 75 sectors per second. At the same time, there is a need for real-time interactivity. Thus all three data types, audio, video, and text (binary data), are physically interleaved. The sub-header (SH) mechanism is used for real time physical interleaving of data.

The two forms define two levels of data integrity. Some data degrades gracefully, such as audio and video. Whereas, text does not degrade gracefully. Text is either present or not. Maximum bandwidth is the main requirement for audio and video information, whereas an extra layer of error correction is required for text. Thus there is a need for two different formats in Mode 2 for CD-I, Form 1 and Form 2.

The first of the two physical formats, Form 1, is tuned to the needs of text, computer data and highly compressed visual data. Thus, Form 1 uses 280 bytes for additional error correction (Error Detecting Code or EDC and Error Correcting Code or ECC), leaving 2048 Bytes as user data. The second physical format, Form 2, is used to fill the requirements of real time audio and visual data, leaving 2324 bytes of user data plus 4 bytes of reserved data.

The CD player is designed for varying the rotational speed to ensure a constant linear velocity at the read-out head, resulting in a constant data transfer rate (frame rate) of 75 sectors per second. The resulting data transfer rates are 153.6KB/s for Form 1 and 174.6KB/s for Form 2.

User Shells

A Start-up Screen (Figure 7) is displayed when the player is turned On without a disc. The IR remote control or other pointing device, such as a mouse, is used to make screen selections. A selection is made by placing the arrow curser over a command icon and pressing the Activate Key (one of the keys around the joystick). Alternately, dedicated keys, such as the Play or Open Keys, may be used to perform player functions. Other screens are accessed from the Start-up Screen, including the Info Screen (Help), Memory Screen and Settings Screen. Selecting the Info Icon brings up a help screen (see Figure 8). The help screen displayed is

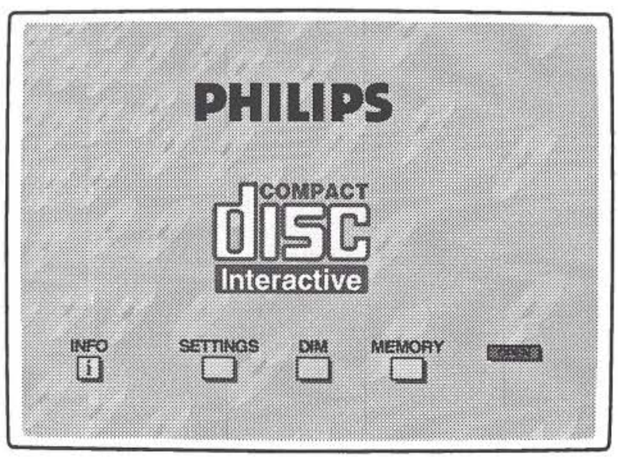

Figure 7 – Start-up Screen

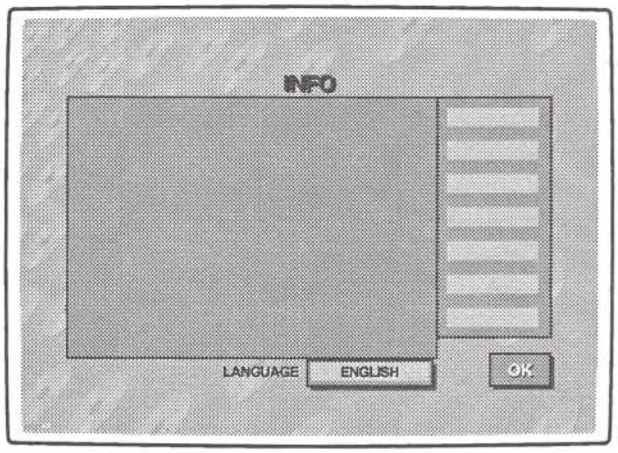

Figure 8 – Help Screen

dependent on the type of disc that is currently loaded in the player. If no disc is present, the help screen displays a message about loading a disc.

The Settings Screen (Figure 9) allows a user to set the date and time, as well as selecting options regarding the playing of discs. For example, the user may choose to turn the Auto Shuffle option On. Then, the Auto Shuffle option is active any time a CD-DA is loaded into the player.
Figure 10 illustrates the user shell that comes up when a CD-DA (Compact Disc - Digital Audio) disc is loaded. All functions normally available on CD

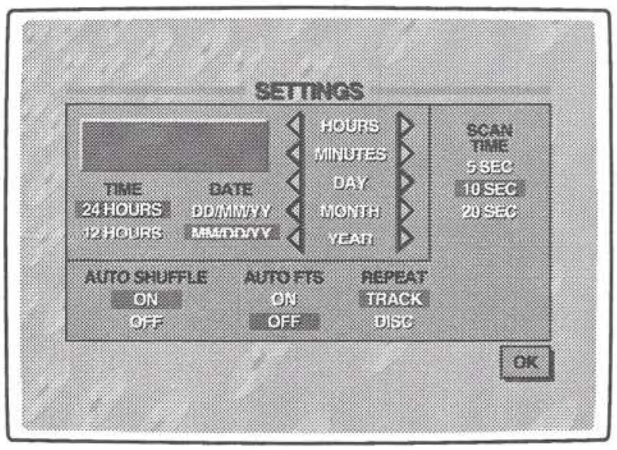

Figure 9 – Settings Screen

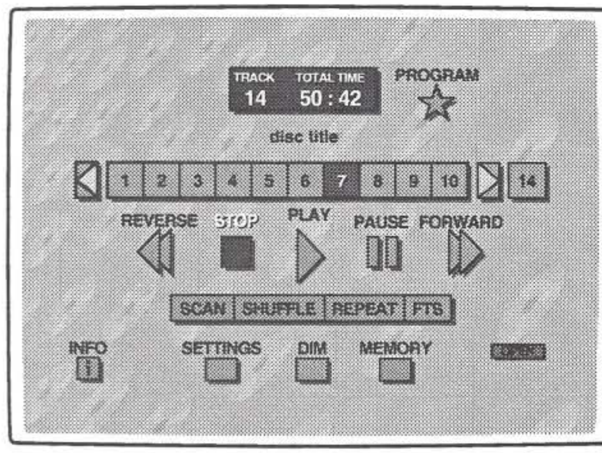

Figure 10 – CD-DA Start-up Screen

players are found in this shell. Tracks may be programmed for play or the whole disc may be played. Also, a programmed play sequence may be stored in FTS (Favorite Track Selection) for later playback. FTS programming also allows the user to enter a title. From then on, when that disc is played the title will appear above the Track Bar. The FTS may also be changed at any time by the user or may even be deleted. Selecting the Memory Icon (see Figure 11) allows the user to select and delete a disc from FTS. This screen also allows the user to scan the titles that have been saved in FTS memory.

The CD-I start-up screen of Figure 12 is displayed when a CD-I is loaded in the player. Clicking on "Play CD-I" begins the CD-I application. The next

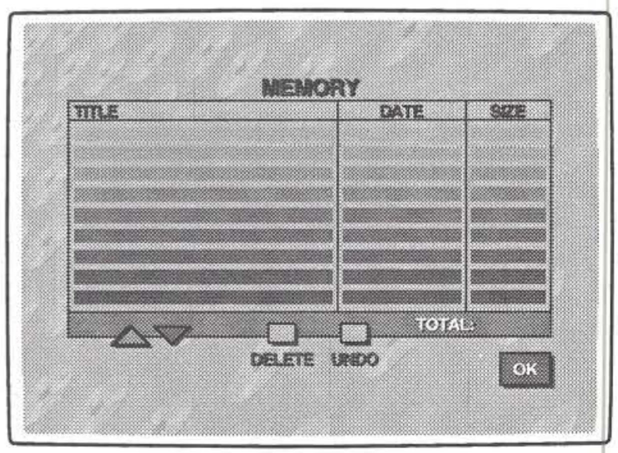

Figure 11 – Memory Screen

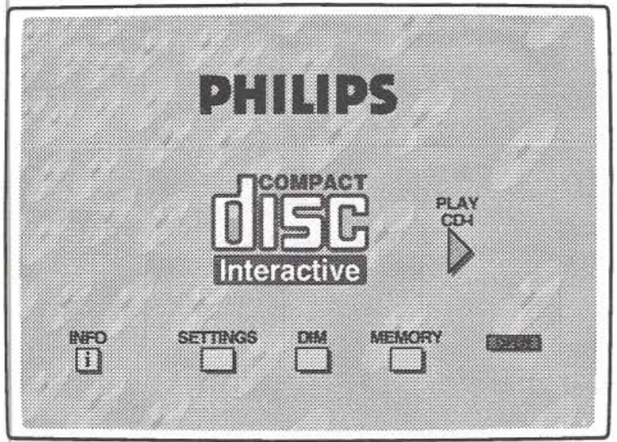

Figure 12 – CD-I Start-up Screen

displayed screen, normally an introduction screen, is dependent on the software.

Serviceability

The circuit boards are accessible for service after removing the top and bottom covers (see Figure 13). The service manual contains exploded views along with a disassembly flowchart. The main assemblies and circuit boards include: the MMC Panel, the Power Supply Panel, the Encoder Panel, the APU (Audio Processing Unit) Panel, the CD Panel, the CDM-9, the Loading Tray Assembly, and the Front Assembly. The Control Panel and Headphone Panel (not shown) are fastened to the Front Assembly and may be accessed by removing the Front Assembly.

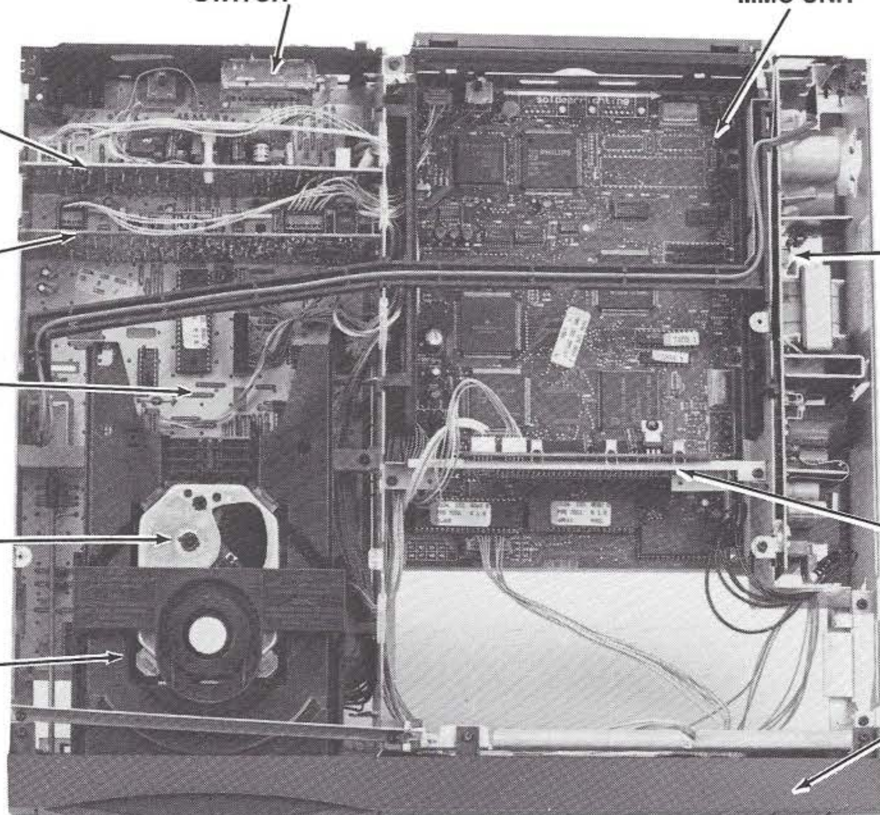

Figure 13 – CDI910 Service

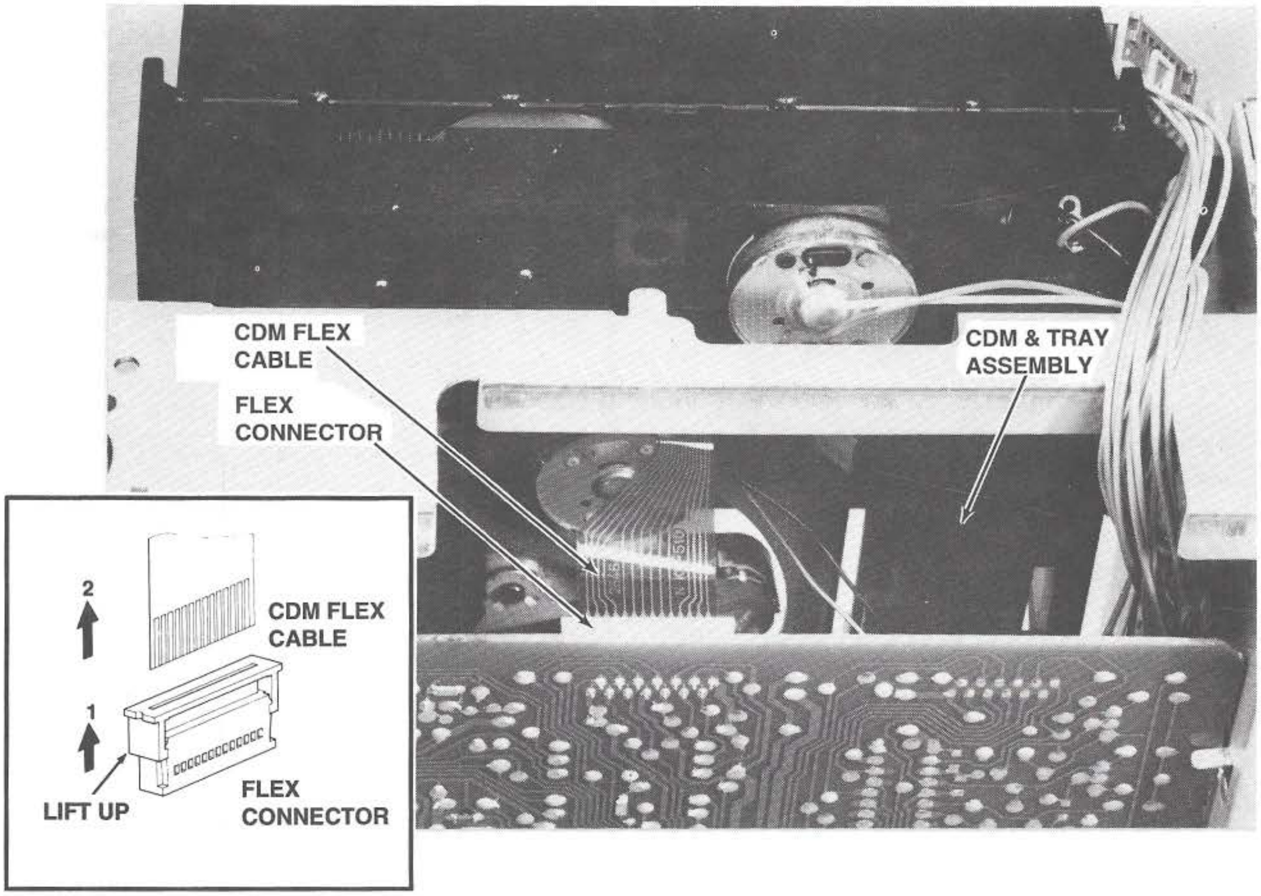

Figure 14 – Flex Cable Removal

CAUTION: be careful in removing the CDM and Tray Assembly. The CDM flex cable (Figure 14) must first be disconnected to prevent damage of the flex cable. To disconnect the flex cable, lift the upper part of the flex cable connector (Figure 14 inset) to release the flex cable. Then carefully remove the cable. Short the flex cable contacts, with a conductive clip (paper clip), to prevent ESD damage to the laser assembly. Make certain the flex cable is properly seated and locked during re-assembly.

Troubleshooting and Repair

The service manual contains some troubleshooting guides to aid the technician in troubleshooting the CDI player. The CD servo section and Audio Processing Unit are similar to any CD player. Thus, the same techniques for troubleshooting a CD player may be used. An added feature in servicing the CDI player is the Service Shell (see Figure 15). To enter the Service Shell, the player must be powered while shorting Pins 2 and 3 of the input port (Port 1). The Service Shell provides tests for the Video, CD Servo, and Audio circuits. Appendix A covers all the Service Shell test procedures and troubleshooting hints.

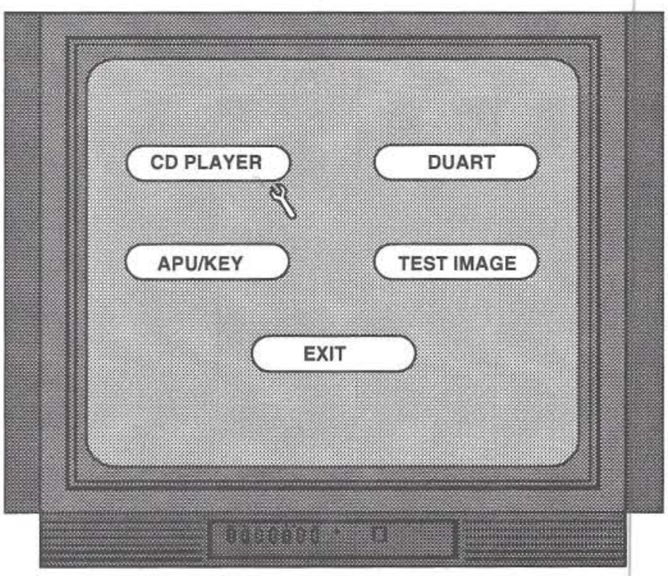

Figure 15 – Service Shell Screen

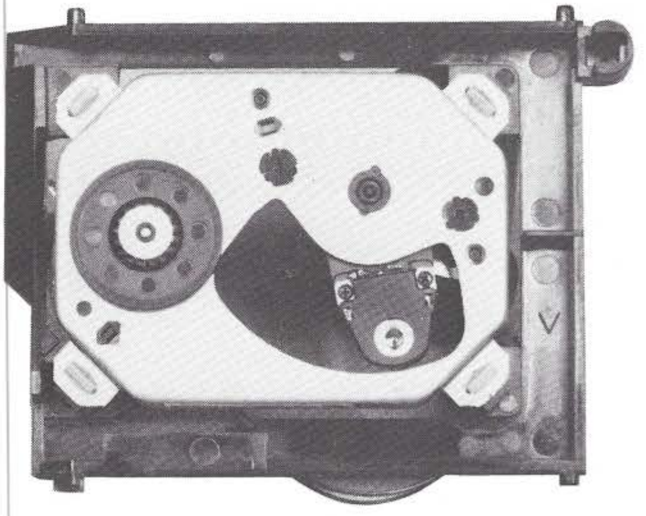

Figure 16 – CDM-9

All circuit board assemblies can be serviced to the component level except the MMC board. Due to the complexity of the MMC board, replacement is recommended when defective. The CDM-9 CD Mechanism (Figure 16) is also replaced as an assembly. Disassembly instructions and exploded views are provided in the service manual.

CD-I Theory of Operation

Audio Formats:

The audio formats are illustrated in Chart 1. There are four Audio formats which may be applied to CD-I. The first is the familiar CD-DA. The standardized format for encoding CD-DA as Pulse Code Modulation (PCM) includes the 16-bit samples (Significance), at a 44.1kHz Sampling Frequency (fS). This results in a dynamic range of greater than 90db with a bandwidth (BW) of 20kHz and a maximum playing time of 72 minutes of Hi-Fi stereo audio.

Besides the normal CD-DA information, the audio data coding used in CD-I is 8 or 4-bit Adaptive Delta Pulse Code Modulation (ADPCM). A lower sampling rate and a different coding technique is used since no more than 50% of the time is allocated for audio information. The Adaptive Delta PCM (ADPCM) coding technique used to store audio information more efficiently, requires additional processing beyond 16-bit PCM for both encoding and decoding.

The chart shows the specifications for each level. The level used depends on the application. For example, to provide maximum time where high fidelity is unnecessary, such as a narration, Level C is used. Using this level limits the frequency response to 8.5kHz, but allows up to approximately 19 hours † (with no other data: video, CD-DA, text) of mono audio or 9 hours stereo on a single disc.

FORMAT	fs IN kHz	SIGNI-FICANCE bits per sample	BW IN kHZ	CHANNELS	XSYS IN MHz	† MAX IN MIN STEREO (MONO)
CD-DA (PCM)	44.1	16	20	1 STEREO	11.2896	72
LEVEL A (AD-PCM)	37.8	8	17	2 STEREO 4 MONO	9.6768	144 (288)
LEVEL B (AD-PCM)	37.8	4	17	4 STEREO 8 MONO	9.6768	288 (576)
LEVEL C (AD-PCM)	18.9	4	8.5	8 STEREO 16 MONO	4.8384	576 (1152)

Chart 1 - CD-I Audio Formats

Level A is comparable to High Fidelity from an LP record with a bandwidth of about 17kHz and Level B is comparable to FM broadcast audio. Both Levels A and B are suitable for music, although the frequency response and significance (bits per sample) are not as good as CD-DA. Level C limits the frequency response to only 8.5kHz and is therefore unsuitable for music.

By using the three levels of ADPCM, information other than audio (video, text, and program) can be included on a disc, while still allowing 72 minutes of audio, as illustrated in Figure 17. The CD Information Intensity Chart shows the percentage of data which can be allotted for non-audio data for each level compared to CD-DA. Thus, 100% of a CD-DA disc is used when 72 minutes of audio is encoded onto the disc. Whereas, if the same 72 minutes is encoded using ADPCM Level A, only 50% of the disc is used for audio, leaving 50% for non-audio data. Likewise, Level B allows 25% for 72 minutes of audio and 75% for non-audio data. Level C allows 6% for audio and 94% for non-audio data.

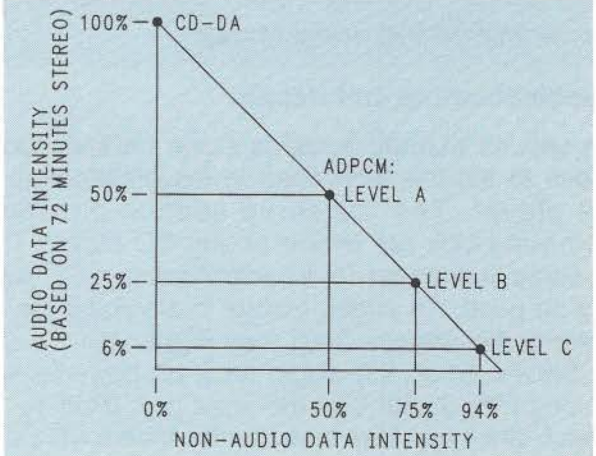

Figure 17 – CD Information Intensity Chart

† A channel is equivalent to a maximum of about 72 minutes continuous playing time. The "19 hours" are composed of 16 parallel channels of some 72 minutes each, with a 1 to 3 second gap before the next continuous "hour" can be listened to.

Video Formats:

Since there are several television systems used around the world (see Chart 2), the video encoding system for CD-I allows for a world-wide standard. That is, the video data can be decoded to play on NTSC, PAL, or SECAM television systems. Besides the various audio quality levels, there is a need for various video quality levels. The video quality levels offer a choice of resolution and picture type (encoding process).

CD-I VIDEO FORMATS:

- WORLD-WIDE FORMAT
  - NTSC, PAL, AND SECAM
- THREE RESOLUTION MODES
- THREE PICTURE TYPES (ENCODING METHODS)

Chart 2 - Video Formats

The resolution modes provide for both present and future television systems (see Chart 3). The three modes are Normal, Double or Enhanced, and High resolution. The chart shows the three modes with their respective horizontal and vertical lines of resolution for all three television standards.

	NTSC 525 Lines	PAL/SECAM 625 Lines
Normal	360X240 Pixels	384X280 Pixels
Double	720X240 Pixels	768X280 Pixels
High	720X480 Pixels	768X560 Pixels

Chart 3 - Video Resolution Modes

The picture code depends on the type of picture to be displayed. Chart 4 compares each type of coding system. Picture coding provides for two picture quality levels: natural pictures and graphics. Natural stills are best handled by YUV † coding for an equivalent of 24-bit color depth. Color Look-up Tables (CLUT's) provide high quality complex graphics. Absolute RGB coding is best used for user manipulated graphics. Run Length Encoding is used for text, graphic animations, and graphic images which require few colors in large areas of the screen. Compression techniques are required to provide full screen animation in the graphic modes.

Natural pictures, using YUV (Y, R-Y, and B-Y) coding, occupy about 325kB per picture without interlacing (650kB with interlacing). To decrease throughput times and maintain a high quality image, all natural pictures are compressed with DYUV (Delta-YUV) coding. DYUV reduces the memory requirements to 108kB/picture. Thus, the DYUV coding system provides a transfer rate of one full-frame in about 0.6 seconds at a data rate of 174.6kB/s (Form 2).

The CLUT (Color Look-Up Table) mode is used for graphics animation. CLUT can be used as 256 colors out of 16 million, requiring 108kB of storage capacity per picture. Compression can reduce this to less than 10kB per picture. CLUT with compression provides full-screen animation with the interleaving of pictures and sound. A picture refresh rate of 17 frames per second is achievable in Form 2.

The other graphics mode is based on absolute RGB coding and is applied to user manipulated graphics. Fifteen-bit RGB graphics (32,768 colors) produce exceptionally crisp pictures at a cost of about 215kB per picture. No compression is used in this encoding system.

FORMAT	APPLICATION	MEMORY	COLORS
DYUV Super VHS	NATURAL STILLS	108KB/PICTURE	ALL
CLUT	GRAPHICS ANIMATION	108KB/PICTURE	256 of 16 Million
RGB	USER MANIPU-LATED GRAPHICS	215KB/PICTURE	32,768
RLE	GRAPHICS	10-20KB PICTURE	128

Chart 4 - Picture Types (Encoding Process)

Text Coding:

Text encoding may by handled using two basic methods, by a bit map process ‡ or with character encoding (see Figure 18). The bit-map process requires five bytes for each character. This limits the number of characters to a maximum of 120 million per disc, if only 16 colors are used in an 8 x 10 matrix of any shape.

Character encoded text can be system text or application text. The standard character encoded text (system text), using one byte per character, allows 600 million characters in a full disc. Application text is encoded with two bytes per character. The second byte specifies factors like color, font type, and size. This extended coding method allows 300 to 600 million characters per disc. Character coding allows interactive manipulation of text. For example, the user may incorporate part of the text from the disc into another document.

† See YUV Encoding in the glossary.

‡ The bit-map process may be with or without data compression (CLUT plus compression techniques).

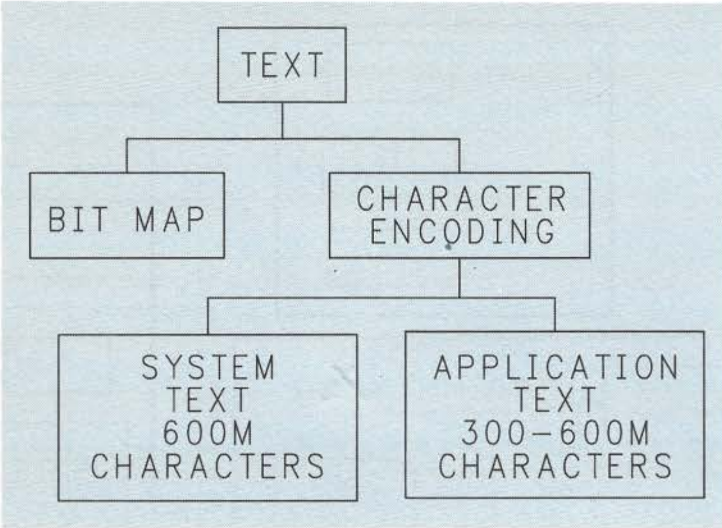

Figure 18 – Text Coding

There is a need to limit the number of characters on screen due to the limited resolution of a normal TV. Thus, text is limited to 40 characters on 20 lines. The characters are contained in a safety area of 320 x 210 pixels in the center of the screen. With the high-resolution screens used in computer monitors and future high definition or digital TV's, the High Resolution mode allows 80 characters to be presented on up to 40 lines. The safety area for the High Resolution mode is 640 x 420 pixels. The text is only stored once since compatibility between the two resolution modes is maintained.

Video Effects

A wide range of visual effects are provided in the CD-I system, including: wipes, cuts, scrolls, overlays, dissolves and fades. Up to four overlaying video planes are provided, with both transparency and translucency for all except the background plane. One plane is reserved for the background and another for the cursor.

Decoding Process

The system must have the ability to decode information stamped on the disc. Decoding is straightforward in the standard CD-DA since it uses only one type of encoding method. However, the CD-I system uses more than one type of encoding process, which includes audio, video, and text. The data, once read from the disc, must be routed to the correct decoding circuits to be converted to its respective analog signal, whether audio, video, or text.

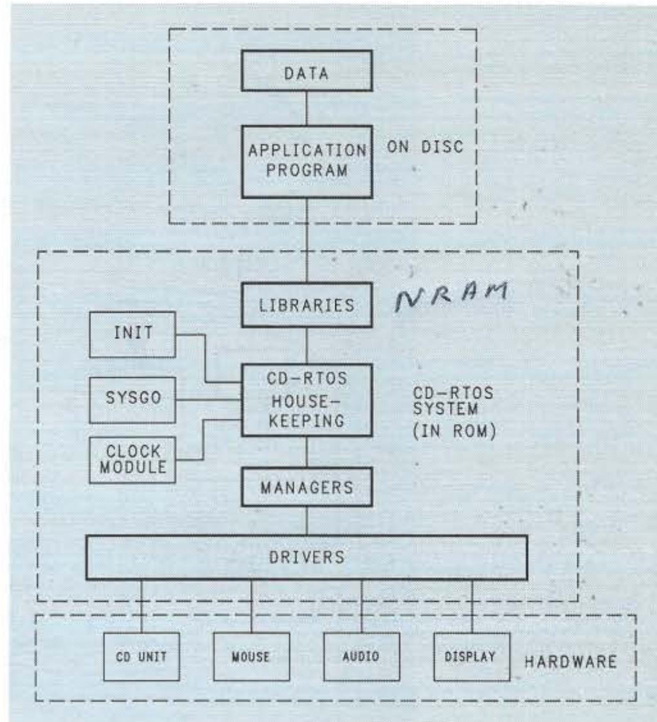

Figure 19 - CD-RTOS Organization

Microprocessor and Operating System

The CD-I software (discs) includes more than just the video, text, and audio information. The disc also provides instructions (application program) to the CD-I player (program). In addition, there is a need to provide real time operation in applications such as entertainment and education. Real time applications require machine language (from the disc) to execute specific tasks. All machine language sets are specific to a microprocessor family. Specifying the microprocessor family and operating system makes it possible to produce discs carrying audio, video, text, binary data and application programs that will work on all CD-I players from all manufacturers. The microprocessor family specified for CD-I is based on the Motorola 68000 family. The Philips CDI910, CDI601 and CDI602 use the SCC68070 microprocessor.

The Compact Disc Real Time Operating System (CD-RTOS) used in CD-I is based on the OS-9 real time operating system † (see Figure 19). A series of instructions (CD-RTOS) is loaded from ROM into memory (booted) to create the user shell ‡ and load the operating system libraries, managers and drivers when the player is turned On. The user shell along with the peripheral devices, such as the mouse or the remote control, allows the user to interface with the system hardware and software.

† CD-RTOS is customized to fit the needs of the CD-I system.

‡ The player shell is dependent ont he the software or type of disc (CD-DA, CD-I) and whether ther is a disc loaded in the player.

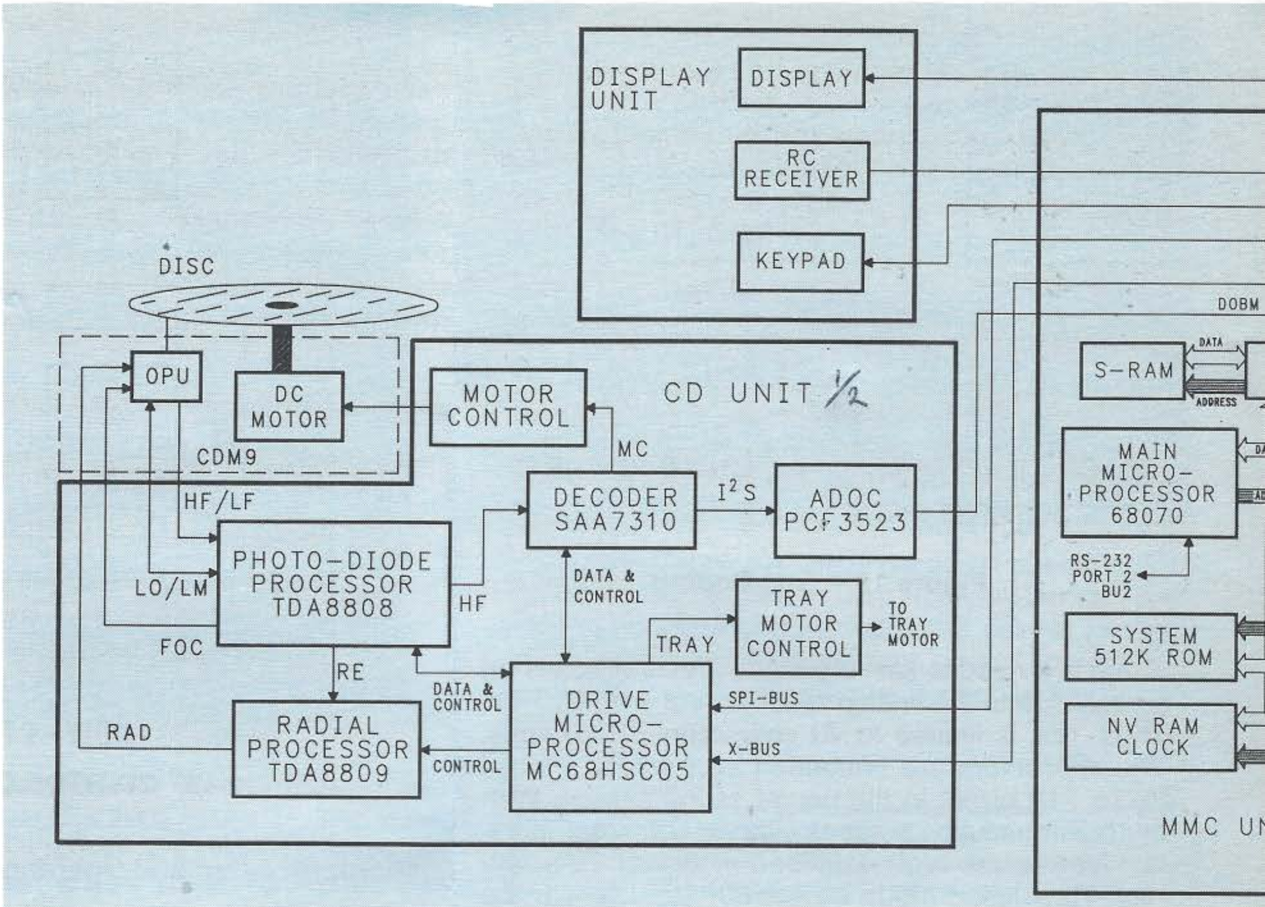

Figure 20 – CDI9

CDI910 Signal Block Diagram

The CDI910 Block Diagram (see Figure 20) identifies the main circuits in the player. The major processing circuits are found on four circuit boards: the MMC Unit, the CD Unit, the Encoder Unit, and the APU. Other boards and assemblies in the CDI910 include: the Power Supply, the Display Panel, the CDM-9 Assembly, and the Tray Assembly. The Power Supply is a Switch Mode Power Supply (SMPS), which supplies 5Vdc, 8Vdc, -8Vdc, 12Vdc, -12Vdc, and 30Vdc to the system.

The MMC (Multi Media Controller) Unit can be divided into three sections: Master Control, Audio Processing, and Video and Subsystem circuits. The MMC Unit contains the 68070 Master Microprocessor, the 6805 Slave Microprocessor, the DSP (Digital Signal Processor), the CDIC (Compact Disc Interface Circuit), two VSC,s (one master and one slave Video System Controller), the VSD (Video Synthesizer Decoder) and the Video DAC. The CD Unit contains: the Drive Microprocessor (MC6805), the servo IC's (TDA8808 and TDA8809), the Motor Control circuitry, and the CD3A Decoder (SAA7310). The CDM-9 Optical Pick-up Unit (OPU), with the Tray Assembly, is mounted over the CD Unit and is connected to the CD Unit via flex cables.

The Master Microprocessor (68070) controls and manages all the activity in the CD-I player, including the CD section. Bidirectional communication between the Master Microprocessor and the Drive Microprocessor is by two communications buses. One is the SPI Bus (Serial Peripheral Interface) via the Slave Microprocessor and the other is by the X-bus via the DSP (Digital Signal Processor). The Slave Microprocessor is also connected to other peripheral devices, such as the Remote Control receiver, the front panel keys, and Port 1 (RS-232 Serial Port). Thus, RC-5 codes and RS-232 data are sent to the Master Microprocessor by way of the Slave Microprocessor. The Slave Microprocessor sends control signals to the APU (Audio Processing Unit) to manage the MUTE signal and the different amplifier ranges of the audio.

The CD Unit is controlled by the MC6805 Drive Microprocessor which is linked indirectly to the Master Microprocessor (MC68070) by the MC6805 Slave Microprocessor. When a user enters a command, the command is interpreted and executed by the Master Microprocessor. The Master Microprocessor issues instructions to the Slave Microprocessor which in turn initiates commands, such as start-up, to the Drive Microprocessor. From

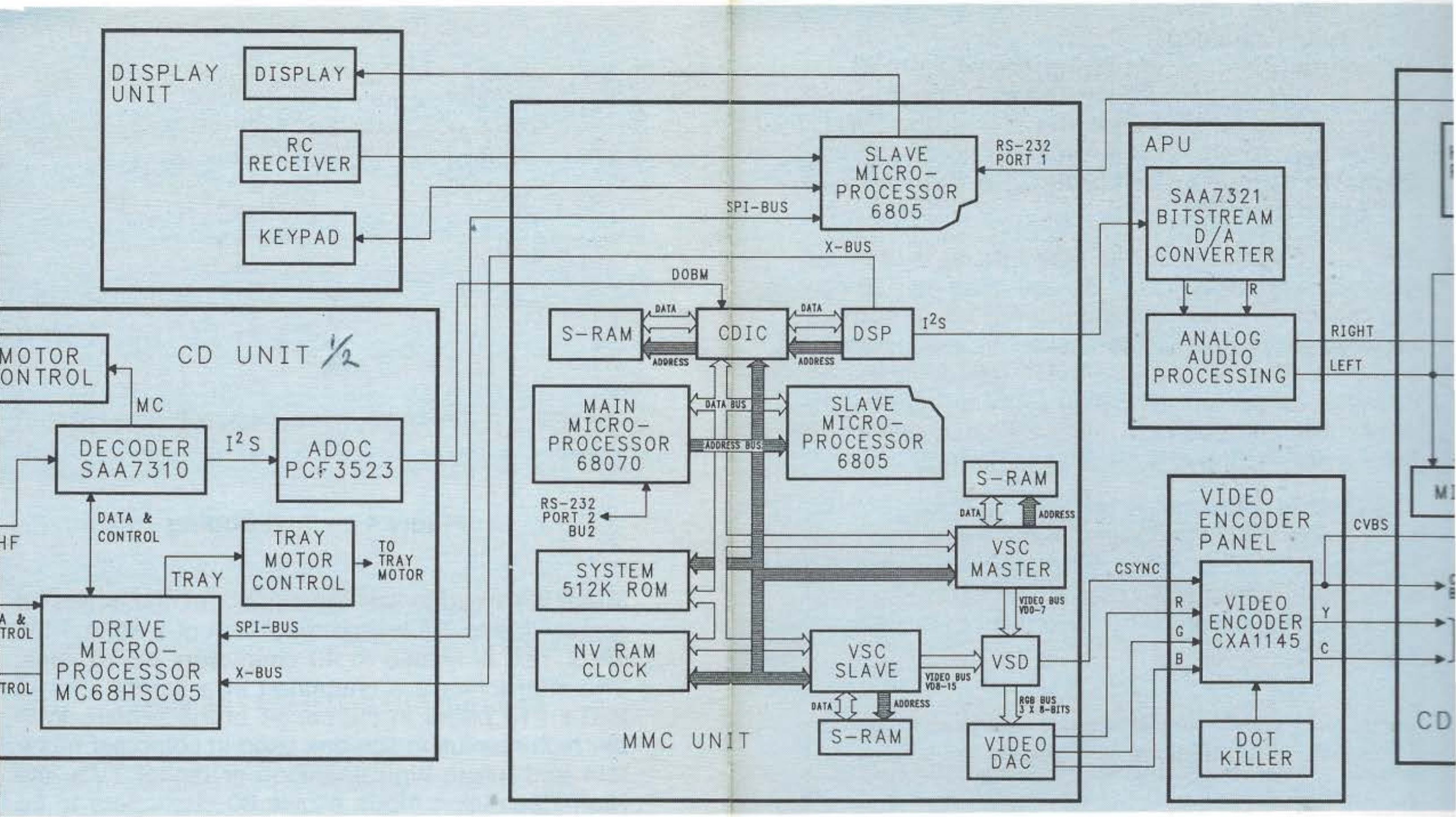

Figure 20 – CDI910 Block Diagram

The Master Microprocessor (68070) controls and manages all the activity in the CD-I player, including the CD section. Bidirectional communication between the Master Microprocessor and the Drive Microprocessor is by two communications buses. One is the SPI Bus (Serial Peripheral Interface) via the Slave Microprocessor and the other is by the X-bus via the DSP (Digital Signal Processor). The Slave Microprocessor is also connected to other peripheral devices, such as the Remote Control receiver, the front panel keys, and Port 1 (RS-232 Serial Port). Thus, RC-5 codes and RS-232 data are sent to the Master Microprocessor by way of the Slave Microprocessor. The Slave Microprocessor sends control signals to the APU (Audio Processing Unit) to manage the MUTE signal and the different amplifier ranges of the audio.

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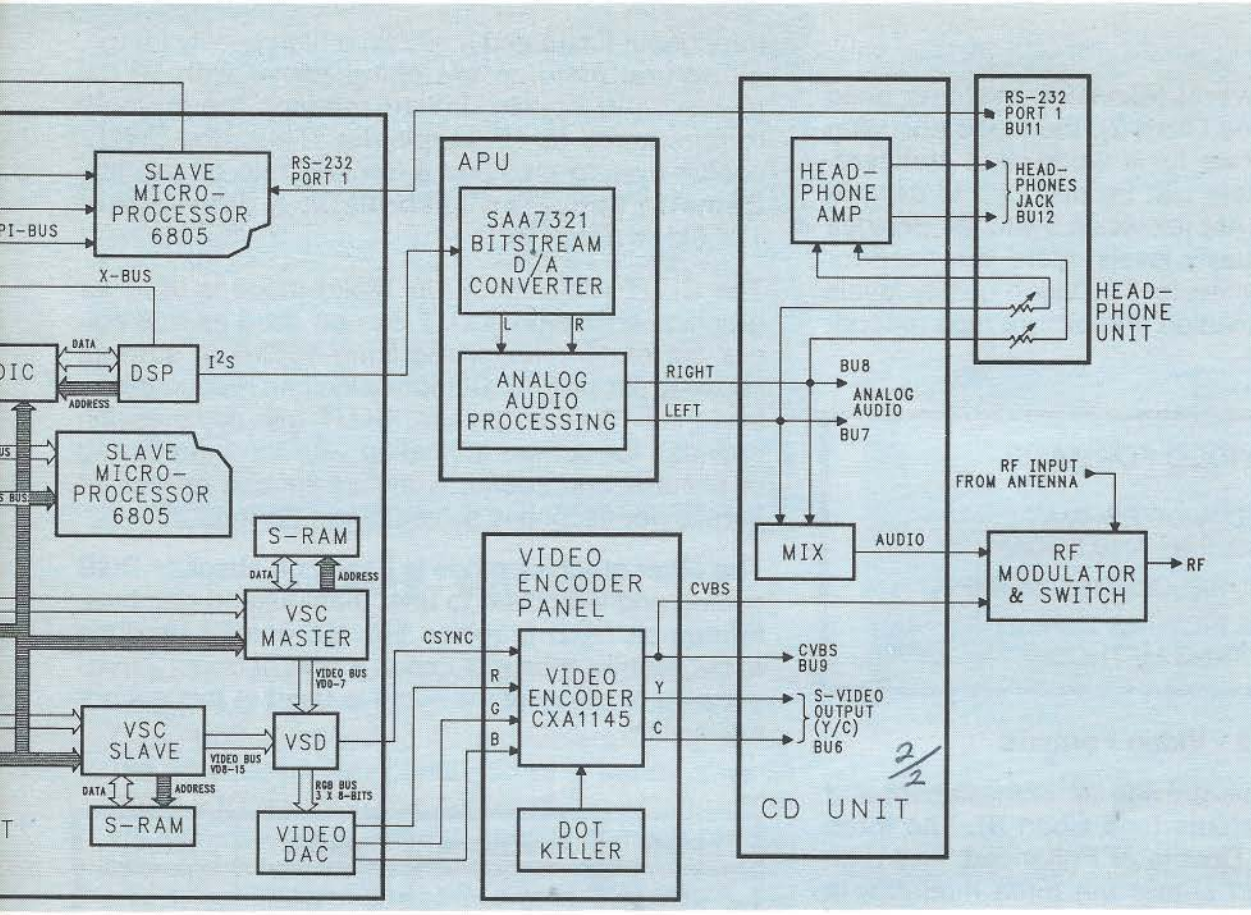
When the player is first turned On, all of the microprocessors are reset. Next, the instructions from ROM are executed by the Master Microprocessor, setting up the operating system for CD-I. The start-up procedure for detecting and reading a disc is also followed. When a disc is detected, the TOC is read to determine the type of disc installed. The appropriate user shell is then displayed on the monitor. The front panel also displays the type of disc detected.

When the player is turned On without a disc, the focus start-up procedure is followed. After two focus attempts, the player shell is displayed, but the play function is disabled. From this player shell the user is prompted to insert a disc.

The CD Unit contains the standard Compact Disc IC's normally used for radial tracking and optical pickup, including the TDA8808, TDA8809, and the SAA7310. A typical start-up for CD is also followed

† The I^2S Format consists of three lines: WSAB (Word Select), CLAB (C
is also developed in the Decoder IC.

‡ This DOBM signal is described in the CD-DA standard as Digital Audi



0 Block Diagram

this point the Drive Microprocessor controls the activity in the CD panel. If an error is detected, the Drive Microprocessor communicates the fault to the Master Microprocessor.

When the player is first turned On, all of the microprocessors are reset. Next, the instructions from ROM are executed by the Master Microprocessor, setting up the operating system for CD-I. The start-up procedure for detecting and reading a disc is also followed. When a disc is detected, the TOC is read to determine the type of disc installed. The appropriate user shell is then displayed on the monitor. The front panel also displays the type of disc detected.

When the player is turned On without a disc, the focus start-up procedure is followed. After two focus attempts, the player shell is displayed, but the play function is disabled. From this player shell the user is prompted to insert a disc.

The CD Unit contains the standard Compact Disc IC's normally used for radial tracking and optical pickup, including the TDA8808, TDA8809, and the SAA7310. A typical start-up for CD is also followed in the CD-I player (a detailed start-up procedure is outlined in the CD circuit description).

The CD Unit is used to retrieve and decode data from the disc. After reading the disc, the Decoder circuit converts the HF (High Frequency) signal to the standard I^2S CD Format †. The I^2S is in turn converted to a digital data stream identified as DOBM (Digital Output Bi-phase Mark Code) ‡. The DOBM data stream is then applied to the MMC Unit for further processing.

The following description explains the overall signal flow of the CD-I player when a CD-I disc is in the play mode. First the CD panel retrieves the HF (High Frequency) from the disc. After processing the HF signal by the standard CD chip set, the retrieved data is converted to the DOBM signal by the ADOC (Audio Digital Output Circuit) IC (PCF3523) and is applied to the MMC Unit. The DOBM signal is sent to the CDIC (Compact Disc Interface Circuit). The DSP (Digital Signal Processor) IC and CDIC function together to separate the DOBM signal into Audio and Video digital data. The APU converts the audio digital data to analog audio. The VSC's along with their respective

† The I^2S Format consists of three lines: WSAB (Word Select), CLAB (Clock), and DAAB (Data). Along with these three lines, an error flag (EFAB) is also developed in the Decoder IC.

‡ This DOBM signal is described in the CD-DA standard as Digital Audio Interface for domestic use.

RAM's are used to store and control the video data from planes a and b. The VSD then decodes the video from the VSC's and selects, mixes, or overlays each video plane. The Video DAC converts the RGB digital data to RGB. The Encoder Unit converts the RGB to Composite Video, S-Video (Y/C), and RF.

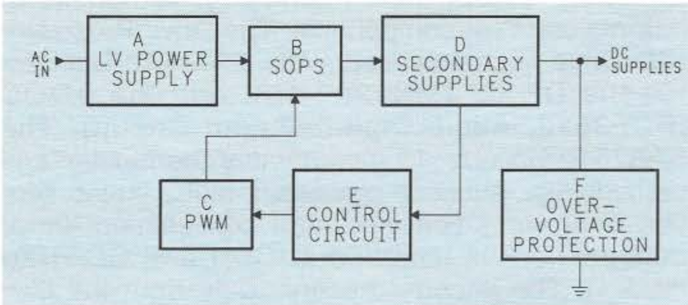


Figure 21 - Power Supply Block Diagram

SOPS Power Supply

The Power Supply Block Diagram is shown in Figure 21. The Power Supply is a Self Oscillating Parallel Switched Mode Power Supply (SOPS). The SOPS Power Supply develops ac isolated dc voltages of 5 volts, 8 volts, -8 volts, 12 volts, -12 volts, and 30 volts. The power supply has a power capacity of 13 to 55 Watts, provided the 5V source is loaded by at least 1.5 amps. The power supply is protected against overloads and short-circuits.

The Power Supply can be divided into six main blocks as illustrated in the block diagram:

A. The LV Power Supply Block consists of the ac input filter, the primary rectifier and the filter circuits.

B. The SOPS Block contains the SMPS transformer and the control circuit.

C. The PWM (Pulse Width Modulator) Block includes the pulse-width modulator circuitry.

D. The Secondary Supplies Block contains the secondary rectifiers and filtering.

E. The Control Circuit Block consists of the control circuit feedback loop via the opto-coupler.

F. The Overvoltage Protection Block provides protection to the CDI circuits if an overvoltage condition is sensed.

Principle of operation

The power supply works according to a discontinuous flyback principle (see Figure 22). The energy stored by Transformer 5002, while Switching Regulator Transistor 7002 was On, is completely dissipated via the secondary windings during the transistor's Off time. The On time of the Switching Regulator is determined by the pulse-width modula-

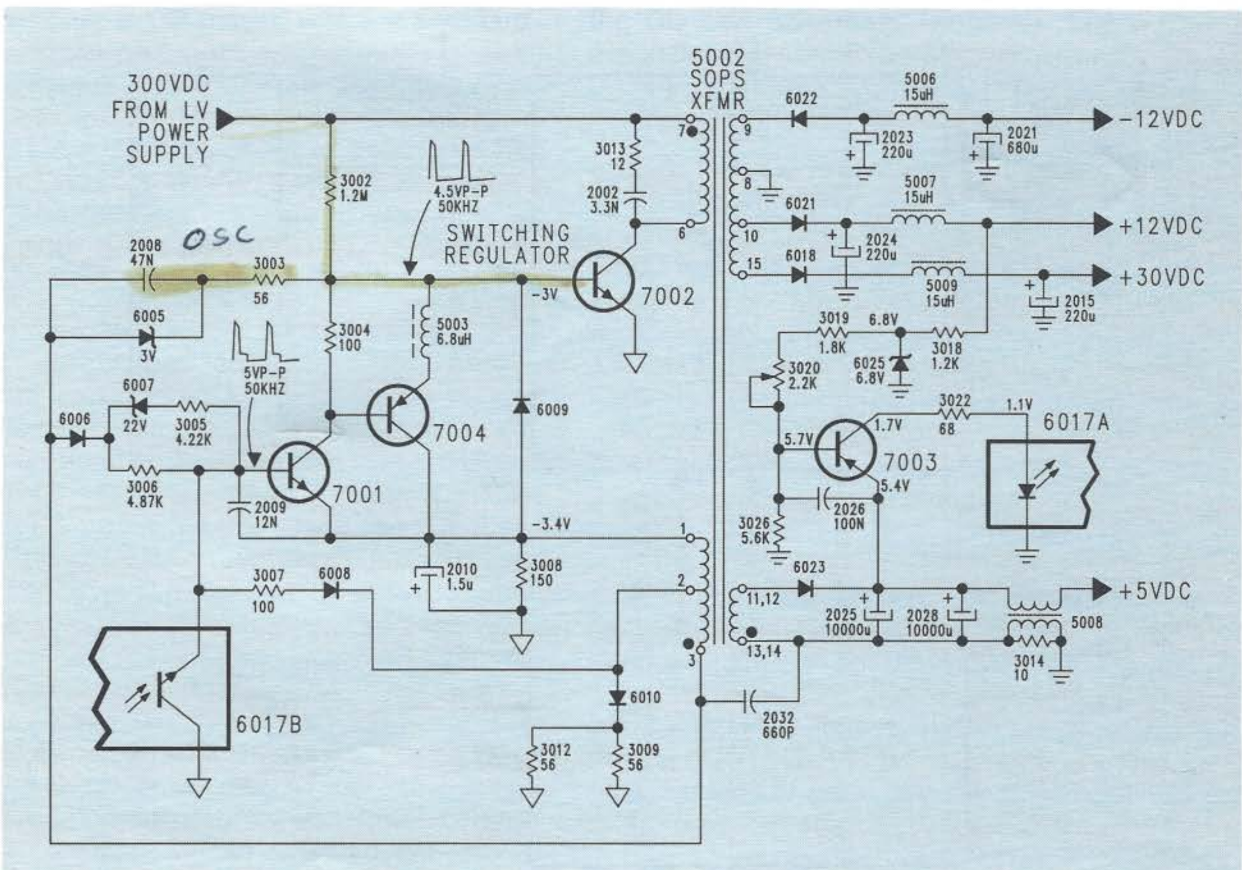


Figure 22 - Self Oscillating Parallel SMPS

tor. The Off time is determined by the output voltage, the load and the preceding On time.

SOPS Start-up

When power is applied, the Switching Regulator (7002) starts to conduct as Capacitor 2008 begins to charge via Resistors 3002 and 3003. Since the auxiliary winding (pins 1-3) is in phase with the primary winding (pins 7-6), a small voltage across this winding increases the base current of Transistor 7002 via Diode 6005 and Resistor 3003. This turns the switching transistor fully On. At the same time, 2009 is charged via Diode 6006 and Resistor 3006, and Capacitor 2010 is charged via Diode 6010. After a short period, the voltage across Capacitor 2009 reaches the forward bias threshold of Transistor 7001. Transistor 7004 turns On, reverse biasing Transistor 7002. The voltages on the transformer are reversed and the energy is dissipated via the secondary windings until the transformer's magnetic field is completely collapsed. At the end of this phase, the voltages are reversed again so that the Switch regulator is again turned On to repeat the cycle.

The pulse width to control the switching transistor is dependent on several conditions, including the AC input voltage and the load. The timer components, Capacitor 2009, Resistors 3005 and 3006, Diode 6007, and the transformer's 1-2 winding, are used as a coarse adjustment for regulating the dc supplies. While the switching transistor conducts, the Timing Capacitor 2009 is charged via 6006, 3006, 3005, 6007 and the 1-3 winding. When 2009 is sufficiently charged to turn Transistor 7001 On, Transistor 7001 conducts turning 7004 On and cutting Switching Transistor 7002 Off. After the switching transistor turns Off, Timer Capacitor 2009 is discharged by 3007, 6008 and the transformer's 1-2 winding, reverse biasing Transistor 7001. As the charging takes place in the conducting phase of the switching transformer, the voltage across winding 1-3 is proportional to the ac input voltage. When the ac is high, Capacitor 2009 charges more quickly and the switching time becomes shorter.

The control circuit, which includes the Opto-coupler 6017 and feedback components, provides the final regulation (fine adjustment) of the dc output voltages. The control circuit (block E of Figure 21) monitors the 5Vdc supply. A reference voltage, obtained from the 12Vdc output, is applied to the Base of 7003 where it is compared with the 5Vdc. If the 5Vdc increases, 7003 conducts more current. This control information is transferred by the opto-coupler to the primary side of the switching transformer. Consequently, capacitor 2009 is charged more quickly, turning off 7002 sooner and transferring less energy.

Overvoltage protection

The Over-voltage protect circuit is shown in Figure 23. To protect the player's circuitry, including the power supply, an over-voltage protection circuit monitors the 5Vdc source. This circuit is activated at 6.2Vdc ±0.5 volt. If the voltage across 3024 exceeds 2.5 volts, 6011 starts conducting, firing Triac 7007. This clamps the 30V supply to the 5V supply, causing an overload on the secondary. With this load on the secondary, all the secondary voltages are reduced, including the 5V supply. An audible squeal may be heard from the power supply when the Overvoltage Protection circuit is activated. If the Overvoltage Protection circuit is activated, there is a fault in the control circuitry.

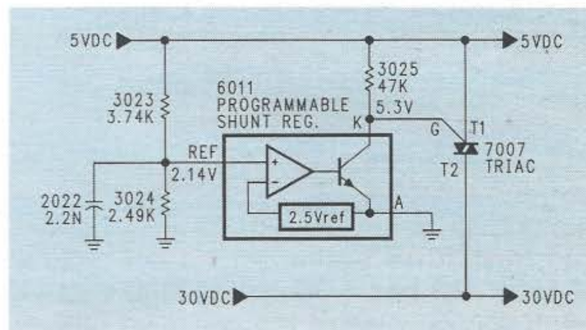


Figure 23 - Over-voltage Protect Circuit

Troubleshooting the Power Supply

The Power Supply can be checked and serviced after removal from the main chassis. The connectors to the player's circuits (the loads) may be unplugged to check the power supply. However, the 5Vdc source must be loaded with a 5 ohm resistor (10 watts), to provide a current of about 1 amp. (Note: if a load is not used, the Overvoltage Protect circuit is activated.) A variac may be used to slowly increase the ac voltage, while checking the 5Vdc source. As the ac is increased, an audible squeal is heard between 10 and 50 volts ac (starting of the power supply).

Service hints:

* If the fuse is open, Switching Transistor 7002 is probably shorted. Also check transistors 7001 and 7004.
* There are two possible error conditions if the power supply squeals:
  1) there may be a short circuit in the secondary side of the power supply circuit or in the other player circuits.
  2) the overvoltage protection circuit is activated. If the overvoltage protection is energized, 7007 becomes hot. Check the control circuit.

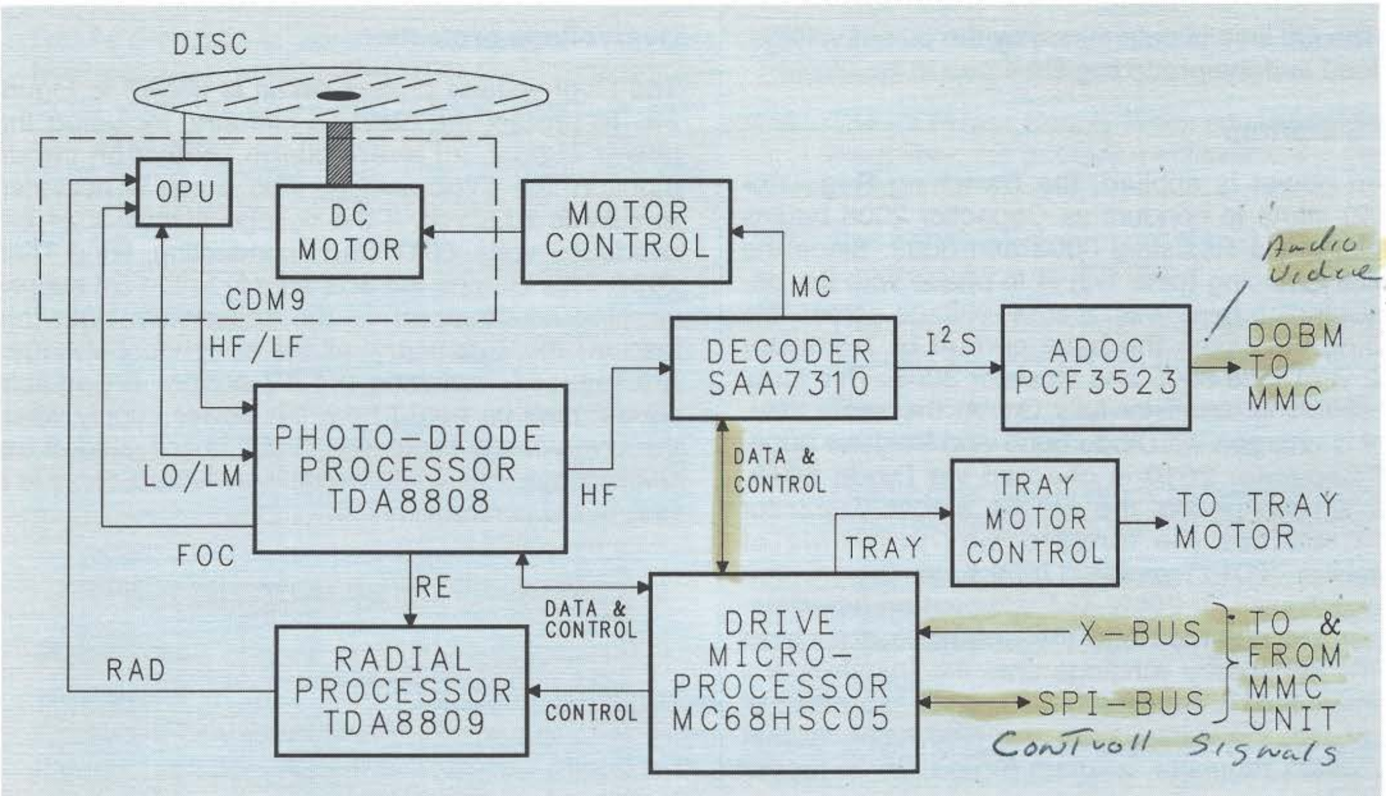


Figure 24 - CD Unit Block Diagram

CD Unit

The CD Unit Block Diagram is shown in Figure 24 (see also the CD Unit Schematic Diagrams). The CD Unit is basically a CD player, with the standard CD control, servo and decoding circuits†. The CDI910 incorporates the new CDM9 assembly. The CDM9 is a swing-arm disc reading mechanism, incorporating the integrated one-spot light pen, the LDGU (Laser Detector Grating Unit). This system uses single-beam disc tracking and operates in conjunction with the servo IC's, TDA8808 and TDA8809.

The Drive Microprocessor controls and monitors the servo and decoding circuits. The Drive Microprocessor also controls the player's tray motor. The microprocessor receives disc-access commands (for example: Jump to an absolute time, Pause, Stop, and Read-TOC) from the Master Microprocessor, MC68070 (located on the MMC Unit), via the DSP and X-bus. The Drive Microprocessor initiates the start-up sequence of the CD Unit. It activates the focus start-up circuit of the Photodiode Processor, controls the position of the CDM9 Swing Arm via the Radial Processor, and starts the CDM Motor by way of the Decoder SAA7310. The Drive Microprocessor also monitors error conditions from the Photodiode Processor and Decoder circuits. At the same time, the Drive Microprocessor sends messages (such as radial error or no disc detected) to the MMC Unit via the SPI-bus.

The Start-up Procedure

The following procedure applies to starting a disc for Play after the player has been turned on (refer to the CD Unit Schematic Diagram). The commands are initiated by the Drive Microprocessor. The Start-up procedure can be checked via the player's internal Service Shell.

Step 1. Pull the arm inside and initiate Focus start-up. Pulling the arm inside is done by making b3...b0 = +25uA. Starting the focus is done by making Si/RD open (high impedance). At start-up, the focus procedure is done by the internal TDA8808 hardware. When focus is found, the TDA8808 makes the Si/RD line Low for a short period. Because this signal is asynchronous, the servo software does not recognize this pulse (and does not know at this moment that the focus point is found).

Step 2. Wait 400ms to give the hardware time to focus; enable TL (Track Lost) interrupt.

Step 3. Start the turntable motor and look for four TL pulses within 400ms. The four TL pulses are used to signal the servo software that the OPU is in focus. If these four pulses are not present during the 400ms, the start up procedure is re-initiated. If the four TL pulses are not detected the second time, the player goes into the stop mode (turntable motor off, laser off).

Step 4. Wait 400ms to start up the turntable motor

† See Philips Technical Training Manual ST1307 for a detailed explanation of the Compact Disc control, servo, and decoding circuits.

for Play Mode.

Step 5. Search for the point of minimum eccentricity. The minimum eccentricity is found by first looking for two TL pulses with REDIG Low; if these two pulses are detected, then system checks for one TL pulse with REDIG High. If this condition is found, then the point of minimum eccentricity is found or else an eccentricity error is generated and the player is stopped.

Step 6. If there is no TL during 1.6ms (swing-arm is following the track) then go to play mode.

Step 7. The player is set in normal play mode (b3..b0 = 0111). At this moment the digital audio or data is valid.

When the CD Unit is in the play mode (refer to Figure 24) the OPU picks up the Low Frequency Signal developed from the wobble signal (generated in the Radial Processor) to make focus and radial corrections as the disc plays. Also, the HF signal (digital data) is picked up by the OPU and is amplified by the Photodiode Processor.

The HF is coupled to the Decoder (SAA7310) for further processing. Here, the High Frequency signal is processed to supply the I^2S format to the ADOC (Audio Digital Output Circuit). The DOBM signal from the ADOC includes not just the audio digital data, but also all the digital data (control codes, video data, text data, and program data) picked up from the disc. The DOBM data stream is applied to the MMC Unit for decoding.

Decoder Section

Decoding of the HF is accomplished by the Decoding Section (see Figure 25), comprised of four major active components: The Drive Processor (CD Drive Microprocessor), the SAA7310 Decoder IC, the DRAM (MN4269-15), and the ADOC (PCF3523, Audio Digital Output Circuit). The SAA7310 Decoder IC incorporates the functions of demodulator, subcode processor, motor speed control, error correction, and error concealment (error concealment is disabled in CD-I and CD-ROM modes). The decoder accepts data from the disc and outputs serial data via the Inter-IC signal bus (IIS or I^2S bus) directly to the ADOC IC. The I^2S bus consists of three lines: WSAB (Word Select), CLAB (Clock), and DAAB (Data). The Decoder IC also sends error codes via the EFAB (Error Flag) line. In the case of CD-I or CD-ROM, the error concealment function of the Decoder IC is disabled. This is because of the added error correction encoding included in the CD-I and CD-ROM formats. In addition to the I^2S signal, subcode data is sent to the ADOC via the SCAB (Subcode Clock) and SDAB (Subcode Data) lines. The System Clock (XSYS) is also transferred to the ADOC IC.

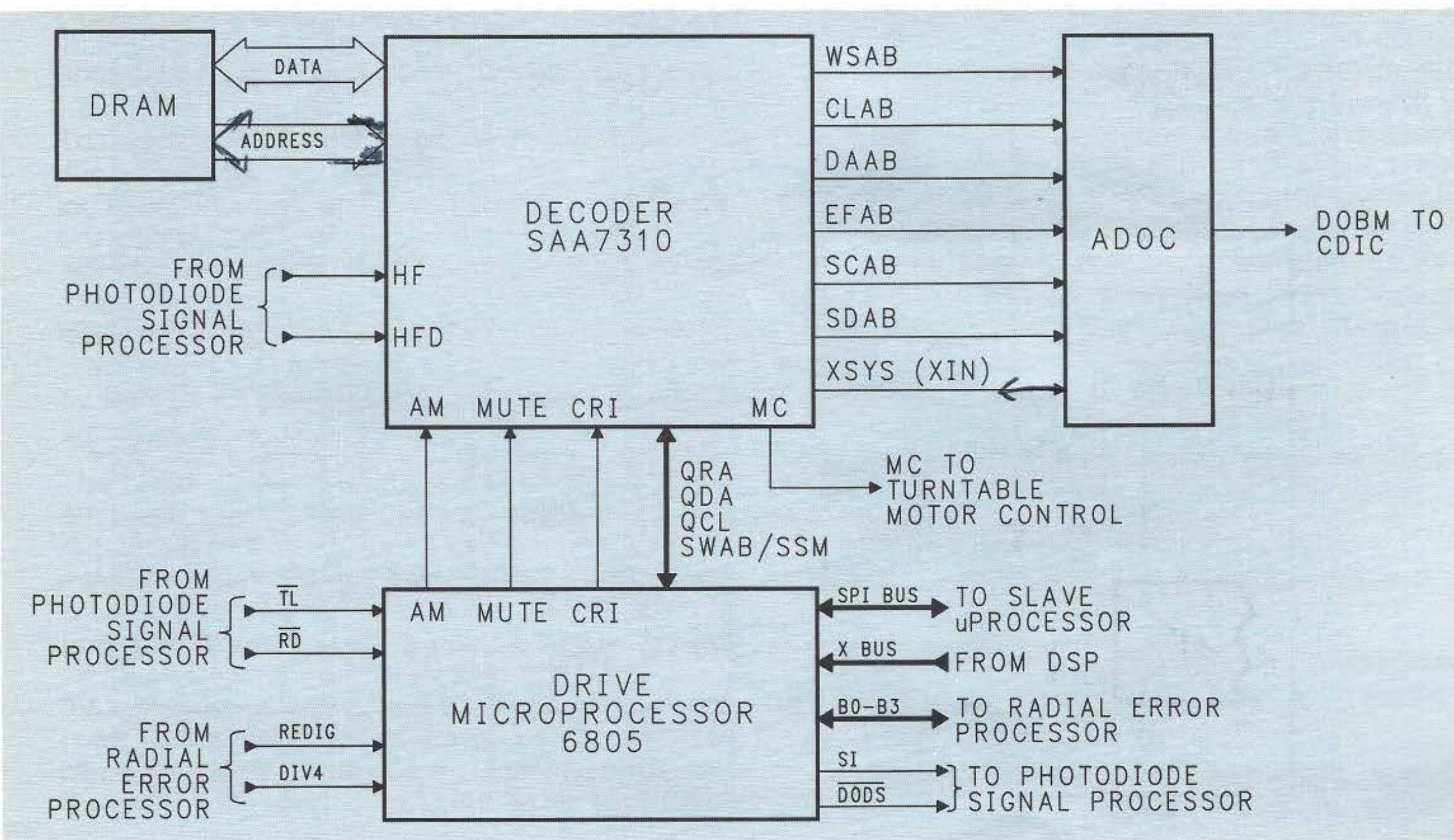


Figure 25 - CD Decoder Block

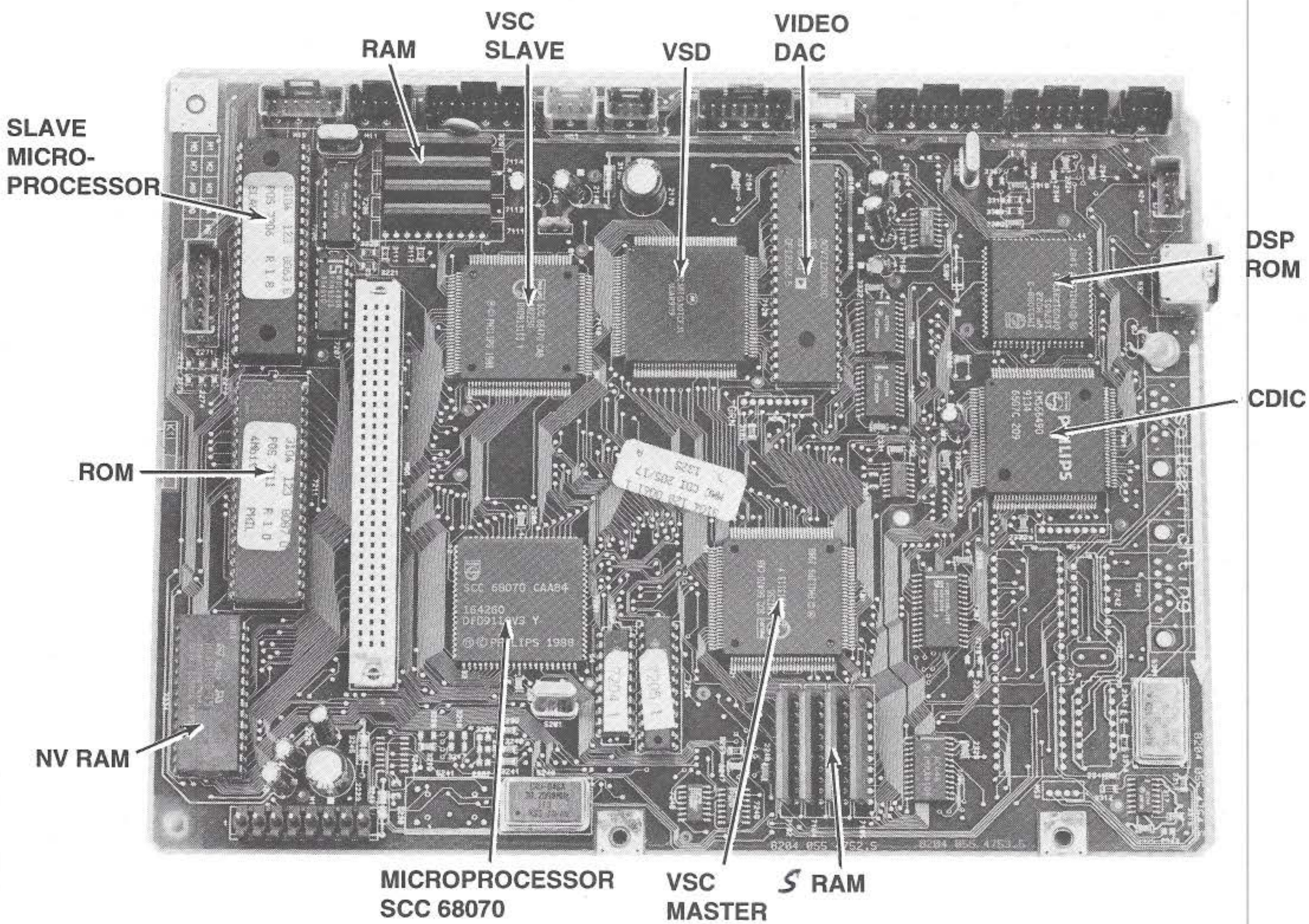


Figure 26 - MMC Module

MMC (Multi Media Controller)

The MMC Module is the heart of the CDI system. The MMC board design includes a four-layer board which contains the main CDI processing components. Figure 26 identifies the main components of the MMC Module.

The key MMC components and their functions are:

- **CDIC (CD Interface Circuit):** sends commands to the CD unit via the DSP and decodes DOBM (Digital Output) from the ADOC.
- **DSP (Digital Signal Processor):** interface between CDIC data and address lines and X-bus to communicate with CD Unit.
- **VSC's (Video and System Controllers):** build images for planes a and b respectively; control access to video RAM and (EP)ROM.
- **VSD (Video Synthesizer):** combines or selects inputs from both VSC's. Also adds special effects (wipes, fades, dissolves, etc.) when switching between planes. Note: The CDI601/602 uses a VSR IC, which incorporates the Video DAC.
- **Video DAC:** eight-bit Digital to Analog Converter. Converts the video digital data to analog RGB.
- **Master Microprocessor (68070 MPU):** central control microprocessor. Manages all functions and data of the MMC Unit.
- **Slave Microprocessor:** control of port 1, RC5 decoding, and attenuation control.
- **System ROM (512k bytes):** stores CD-RTOS software executed by Master Microprocessor (68070).
- **NV RAM/Clock:** Random Access Memory containing data for system configuration at system boot.

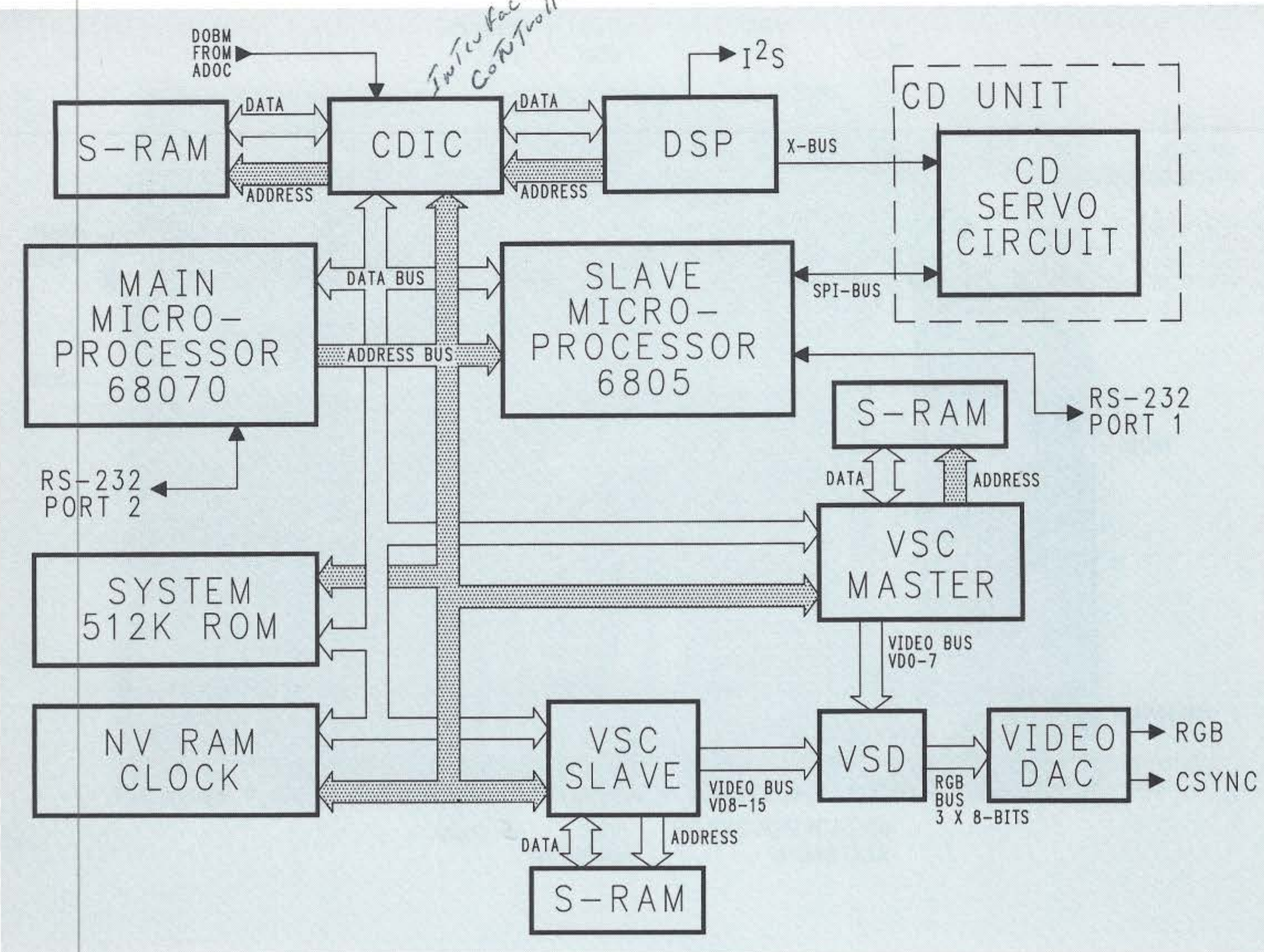


Figure 27 - MMC Block Diagram

Figure 27 illustrates the functions of the MMC Module. The Main Microprocessor (68070) manages all of the MMC Unit's activity and data. All the data transfer (control, video, and audio) within the MMC board is over the 16-bit data bus and 24 bit-address bus structure. The system ROM's (4 in the CDI601/602 professional CDI players and one in the CDI910) contain the operating system (OS-9), the user shell test pictures and the service shell. The NV RAM contains the Configuration Status Description (CSD) and settings of the player shell. The CSD allows an application to determine what devices are available and contains entries for each available device. When the player is turned On, and after reset, the kernel (operating system housekeeping routine) stored in ROM is executed by the microprocessor.

The start-up of the system is as follows:

1. **Power On reset.**
2. **ROM fetches -** The first ROM fetch should have address and data lines all zero.
3. **Video initialization.**
4. **Low level RAM/ROM search -** During this search, ROM will be added to a list. The search will find on board ROM and ROM located in extensions.
5. **Jump to Kernel -** The Kernel is the main software part of CD-RTOS. It will search for other software components (called modules) in ROM areas found by the low level RAM/ROM search, initialize system tables and look for available RAM in the extension area.
6. **Update of CSD (Configuration Status Description) -** A dedicated module will check for the presence of device status descriptors in ROM and update the Configuration Status Description file in non volatile RAM.
7. **Configuration check -** Checks the presence of some devices (terminal and CDI input devices on ports 1 and 2) and updates the Configuration Status Description file accordingly. During this

check, the RTS line of port 2 switches

8. **Initial process** - If a special connector is plugged in on port 1, the service shell will be started, otherwise the player shell is started.

   Note: Since the ROM contains the operating System and the Service Shell, a ROM failure will cause a system start-up failure. If the Service Shell cannot be implemented, the ROM may be defective. A failure in implementing the Low Level Test indicates a failure in the Master Microcomputer circuit; the Microcomputer's reset, voltage sources, Clock, and communication lines should be checked.

Drive Microprocessor start-up (part of CD Servo Circuit) - After reset, the Drive Microprocessor has its own start-up procedure. It attempts to focus and if a disc is present, it determines the type of disc (from the TOC) loaded. The type of disc data is sent to the Master Microprocessor (68070) via the Slave Microprocessor. Every time a disc is changed, the Drive Microprocessor determines its type (see the CD Start-up Procedure under the CD Unit circuit description).

Slave Microprocessor start-up - At start-up, the slave checks if a service shell connector is present at port 1. Later on it checks for CDI input devices on port 1. It keeps doing this, making it possible to change input devices (mouse, tablet, etc.) during operation. Information from the remote control joystick and the pointing device on port 1 is combined by the Slave Microprocessor and is sent to the Master Microprocessor.

Microprocessor Communication

To access the disc, the Master Microprocessor sends commands to the Drive Microprocessor via the DSP. The DSP (PCB5010) uses the X-bus to transfer the commands to the Drive Microprocessor.

The X-bus consists of 4 lines:

1. **SOXEN** - SOC (Serial Output Control) enable signal from an external device:
   0 - enables SOC
   1 - disables SOC
2. **SOXRQN** - SOC ready indicator for the external device:
   0 - SOC ready to shift data out
   1 - SOC not-ready to shift
3. **DOX** - serial data output.
4. **COX** - serial output clock from an external device.

COX is an external clock (from the Drive Microprocessor) present at all times with a frequency between 30 and 100kHz. When the DSP has a command ready signal, it sets the SOXRQN line Low. When the Drive Microprocessor receives the Low from the SOXRQN line, it sets the SOXEN line Low. When this line goes Low, the command is clocked out of the DSP at the falling edge of the clock (COX). The command (data) is transmitted over the DOX line. A DSP command is always 32 bits long. After 32 clock pulses, the SOXRQN line becomes High and the Drive Microprocessor sets the SOXEN line High, indicating the end of the communication.

An extra controller line, COC, indicates the status of the Drive Microprocessor. COC Low indicates the Drive Microprocessor is executing the command. After the command is executed, COC goes High. No commands from the DSP are received while COC is low. The COC line may be used in troubleshooting. It indicates there is still communication between the DSP and the Drive Microprocessor. If COC is always Low, it means that the drive can't execute the received command; it is still busy attempting to execute the command. When COC is always High with COX present, it means that the DSP has no command, or command not received, to send to the drive.

Messages from and to the slave processor:

Bidirectional communication between the Master Microprocessor and the Drive Microprocessor is necessary for the following reasons:

- service test for the CD panel.
- some information from the CD must be sent to the Master Microprocessor (for example: the tray switch, error messages, CD status, and software version number).

The communication link between the two 6805 microprocessors (Slave and Drive) provides bidirectional communication between the Master Microprocessor (68070) and the CD Servo Circuit's Drive Microprocessor. The bidirectional communication bus between the Slave and Drive microprocessors is the SPI bus. The SPI bus consists of: SCK (Serial Clock), MOSI (Master Out Slave In), MISO (Master In Slave Out), and SPISS (Serial Peripheral Interface Slave Select) lines.

Troubleshooting and Service

The MMC board is replaced as a module when defective. The technician must know the functions of the MMC Unit to diagnose a CDI player. The CDI player contains some built-in diagnostics to aid in troubleshooting. One diagnostic tool is the Service Shell (see Appendix A) and the other is the Low Level Test (LL Test; see Appendix B). The LL Test should be performed if there is access to neither the Player Shell nor the Service Shell. If the Low Level MMC test indicates a fault, replace the MMC Unit. If the Low Level Test Cannot be initiated, check the power sources to the MMC board. If all supplies are present, replace the MMC Unit.

The LL Test is implemented in the boot software of CD-RTOS. It does not need a lot of hardware to run. The test can be performed using a VT-100 terminal † or the Low Level Test PCB.

The LL Test displays the header and release number and checks the following MMC functions and circuits:

1. VSC
2. ROM
3. NVRAM
4. DRAM
5. CDIC
6. Slave Microprocessor (68HC05)

TEST SEQUENCE

Table 1 below shows all the steps of the test program for the CDI601/602. The CDI910 skips tests 2 through 4 since it contains only one ROM. Note: early production CDI910 players may indicate an error in Step 5.

STEP	ACTION/TEST PERFORMED
00	VSC master/slave unit
01	ROM 10
02	ROM 11
03	ROM 20
04	ROM 21
05	NVRAM
06	DRAM BANK0 & BANK1
07	DRAM BANK0
08	DRAM BANK1
09	CDIC
10	SLAVE

Table 1 : Low Level Test Steps

LOW LEVEL TEST IMPLEMENTATION

The Low Level Test is implemented in the boot part of the CD-RTOS software. The whole test occupies about 10kB of ROM and is written in assembler. The test runs without the use of any external RAM. It only uses internal CPU registers. The 68070's UART is used as the communication channel. The following sequence is followed before starting the normal player boot:

1. Initializing the Master Microprocessor's (68070) UART:

   9600 baud

   1 start bit

   8 data bits

   1 stop bit

   no parity

   no handshake

2. Clear the RXD buffer.
3. Wait 5 ms.
4. Read the RXD buffer.
5. If the character received was a space ($20), then start the terminal LL Test.
6. If the character received was an ACK ($06) then start the PCB LL Test.
7. Else start the normal player boot.

Two different methods, described below, are listed for implementing the LL Test, one for (a) the service pcb and one for (b) the VT100 terminal.

a. <u>LL Test with the service pcb:</u>

   1. Remove power to the player (switch Off).
   2. Connect the service pcb to Port 2 of the CDI910 player.
   3. Apply power to the player.
   4. The service pcb display should now show "CDI RLxx" (with xx being the release number).
   5. The pcb LL Test is now ready to proceed.

b. <u>LL Test with the VT100 terminal:</u>

   1. Remove power to the player (switch Off).
   2. Connect the terminal to Port 2 of the CDI910 player.
   3. While pressing the SPACE-bar of the terminal, apply power to the player.
   4. The terminal should now show the title of the terminal LL Test.

† A Personal Computer with a VT-100 terminal emulation program may be used as a VT-100 terminal.

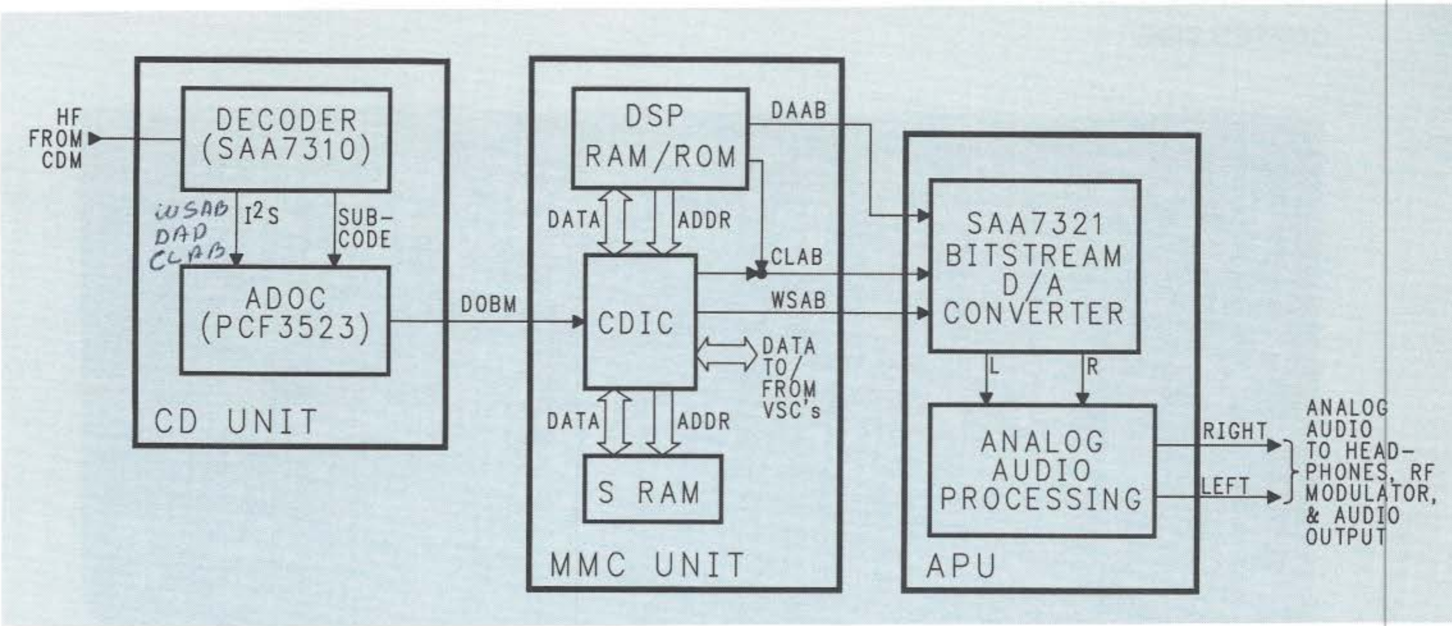


Figure 28 - Audio Processing Block

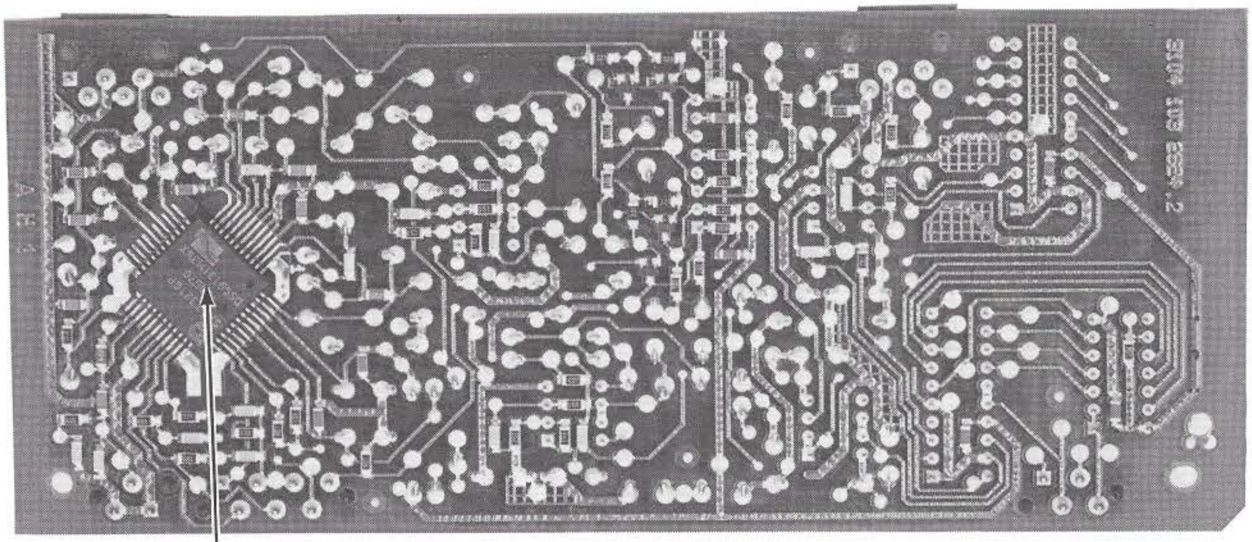
Audio Processing

The complete audio circuit (digital and analog circuits) is mainly contained on three circuit boards (see Figure 28): the CD Unit, the MMC Unit, and the APU (Audio Processing Unit). The audio processing path is illustrated in the simplified Audio Processing Block diagram. The HF (high-frequency information) is read from the disc, decoded (demodulated) in the Decoder (SAA7310) and transformed by the ADOC chip (PCF3523) into a serial data stream, DOBM (Digital Output Bi-phase Mark Code). These two chips (CD-3A Decoder and ADOC) are located on the CD panel.

The DOBM signal is sent to the CD interface circuit (CDIC) on the MMC panel. The heart of the CD interface consists of the CDIC (IMS66490) and the DSP (Digital Signal Processor) IC's. The CDIC in conjunction with the DSP determines the type of DOBM data received. If the data is CD-DA the CDIC is switched to the transparent mode. That is, the DOBM is converted to the I^2S format, but there is no other decoding or data management of CD-DA. The CD-DA signals are sent to the APU for digital to analog conversion.

The video data and ADPCM audio data are routed under the control of the main Microprocessor data bus. The ADPCM audio can thus be memory managed to allow synchronization with the video information. The ADPCM audio data is decoded using both the CDIC and the DSP circuits. The decoded ADPCM or PCM (CD-DA) is applied to the D/A convertor in accordance with the I^2S format.

COPPER SIDE



IC7400
DAC SAA7321

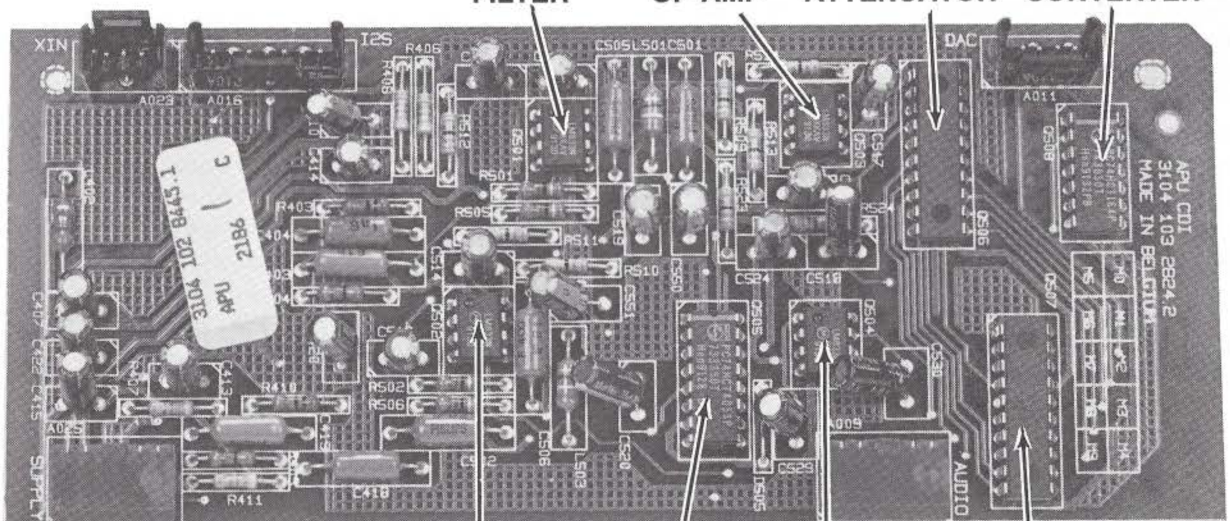
COMPONENT SIDE

IC7501
ACTIVE
FILTER

IC7503
OP-AMP

IC7506
ATTENUATOR

IC7508
SERIAL TO
PARALLEL
CONVERTER



IC7502
ACTIVE
FILTER

IC7505
SWITCH

IC7504
OP-AMP

IC7507
ATTENUATOR

Figure 29 - APU Panel

The digital information is now converted into an analog audio signal by the Bitstream D/A (Digital to Analog) Converter. The APU also provides additional analog audio processing, such as volume control and mixing for CDI applications. The L (Left) and R (Right) audio signals are applied to the Headphones circuit, RF Modulator, and Analog Audio Output jacks (for stereo amplifier or TV monitor).

APU Panel (Audio Processing Unit)

Figure 29 identifies the active components of the Audio Processing Unit (also see APU Circuit Diagram). The SAA7321 Bit-stream DAC (7400) is a 44 pin quad flat pack mounted on the copper side of the circuit board. Op Amps IC7501 and IC7502 are used as active filters. Other Op Amps (7503

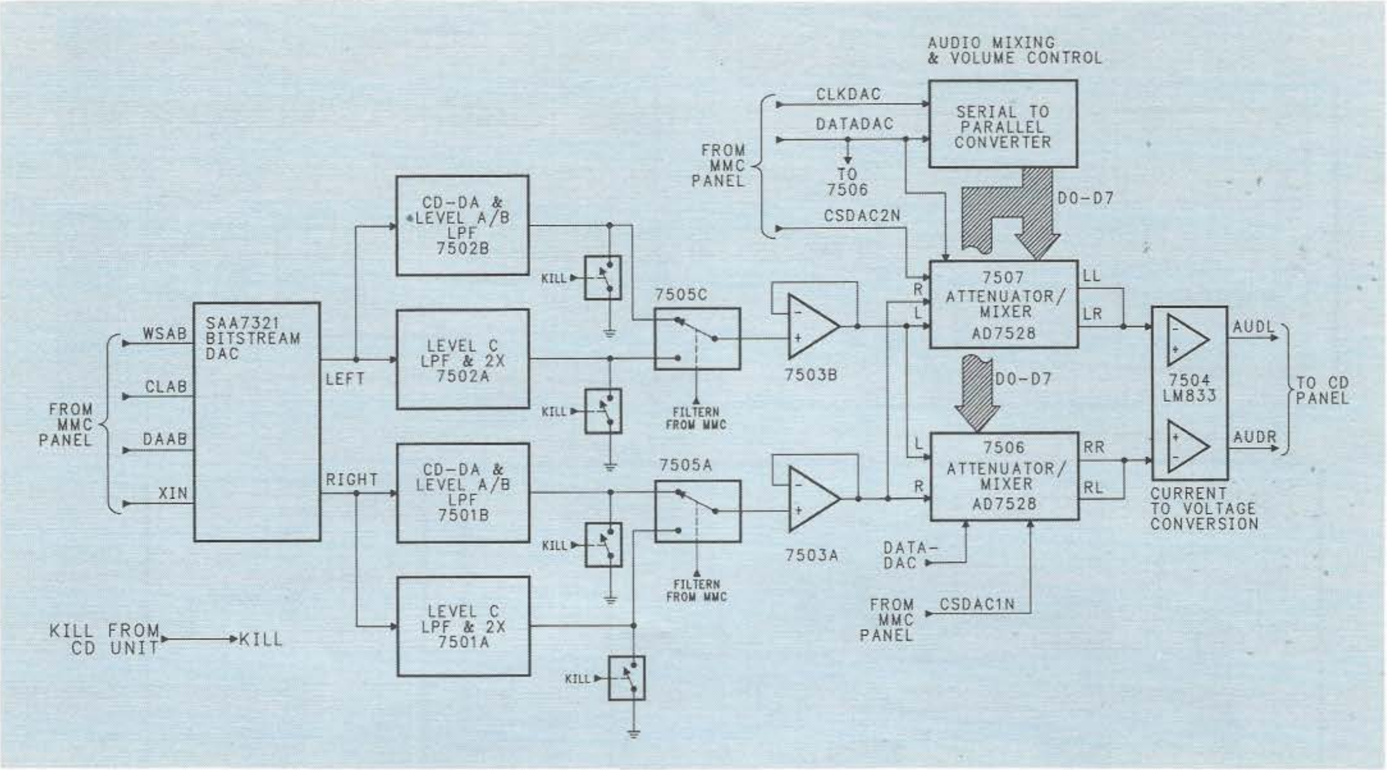


Figure 30 - Audio Processing Unit Block

and 7504) are also used on the APU. The APU panel also includes: attenuators (IC's 7506 and 7507), an Analog Multiplexer/Demultiplexer (IC7505 switch), and a Serial/Parallel Converter (IC7508).

Figure 30 shows the audio processing and control functions of the Audio Processing Unit (see also APU Circuit Diagram). The APU processes the data (I^2S) obtained from the CDIC to output Left and Right analog audio signals. Two other audio operations take place on this panel, volume control and audio mixing.

The data applied to the inputs of the APU comes from either CD-DA tracks or from CD-I tracks in the I^2S (Inter-IC Sound) format.

The serial digital information (DAAB), clock signal (CLAB) and the corresponding synchronization signal for the Left and Right channels (WSAB) are supplied to pins 30, 31 and 32 of IC 7400 (SAA7321). The incoming digital samples are first converted into a high-speed 1-bit data stream. This data stream is then used by a 1-bit DAC for the actual conversion to the analog signal.

The main functions in the 1-bit data stream D/A conversion are:

- Digital filtering and over-sampling (256 x in all)
- Noise shaping and code conversion to 1-bit data stream.
- 1-Bit switch capacitor network as 1-bit DAC.

The digital to analog conversion of both audio channels is followed by the third-order low-pass filters. For CD-DA, the 16-bit sample is over-sampled 256 times in all. Thus, with a sample frequency of 44.1kHz, a 1-bit data stream of 11.2896MHz (44.1kHz x 4 x 2 x 32) is obtained. This is the system clock frequency (XIN) applied to the DAC's crystal oscillator, pins 24 and 25. The 11.2896Mhz clock signal applies to CD-DA. The data for the CD-I audio levels (ADPCM levels A, B, or C) is transmitted with a different system clock frequency (XIN). The clock signal (XIN) is dependent on the original sampling frequency (fS) as listed below:

FORMAT:	fS:	XIN (XSYS):
CD-DA	44.1kHz	11.2896MHz
LEVEL A	37.8kHz	9.6768MHz
LEVEL B	37.8kHz	9.6768MHz
LEVEL C	18.9kHz	4.8384MHz

The output level of IC7400 is also determined by the clock frequency. For level C the output level is not as high as the other audio formats, thus the need for compensation. In addition to the low pass filter function, the filter for level C provides a two times gain factor. For CD-DA and the CD-I A and B levels no amplitude compensation takes place. The outputs from each of the filters are fed to electronic switches (IC7505C). These switches select the fil-

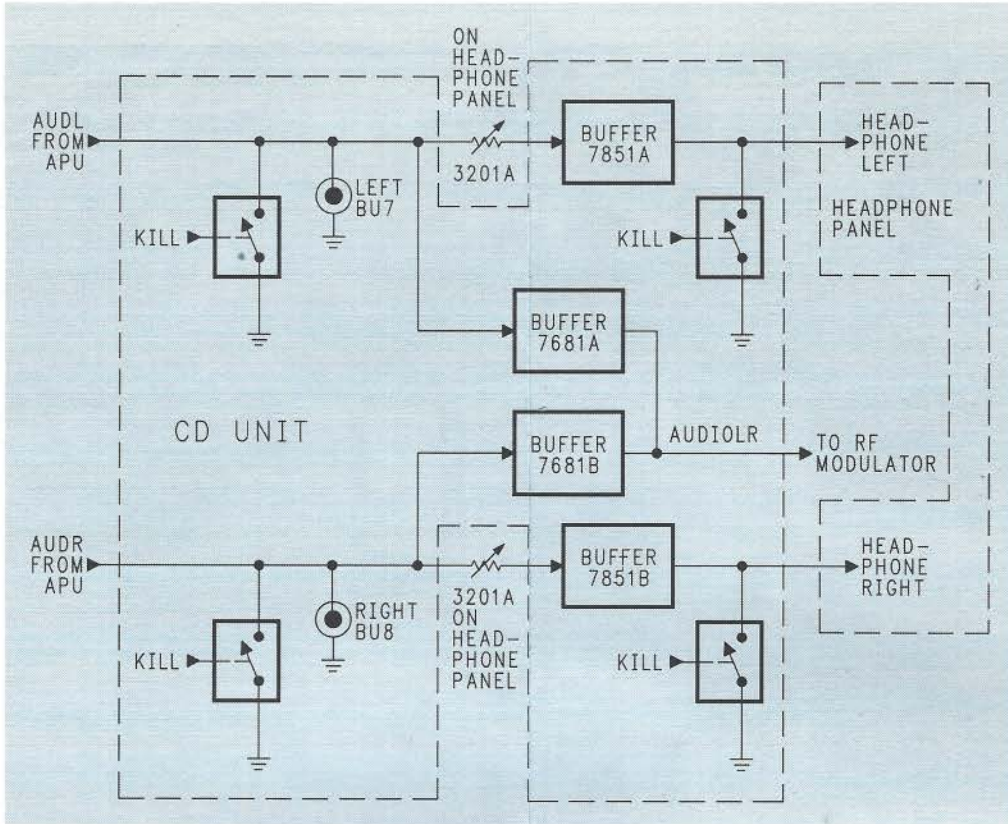


Figure 31 - Audio Outputs

tered outputs which correspond to the audio format applied to the SAA7321. The electronic switches are controlled by the FILTERN signal applied from the CDIC on the MMC panel.

The outputs of these electronic switches are supplied to the attenuator/mixer circuit via voltage follower IC7503 (A and B for the R and L channels). Both audio channels are fed to both attenuators, IC7506 and IC7507, to control the volume and the mixing of the left and right audio channels. Attenuation of the Attenuator/Mixer circuits is controlled by the Remote Control Transmitter's volume control keys. Audio mixing for CD-I audio is dependent on the application. For example, if the application uses mono audio, only one of the channels is routed to both output stages. The commands for this, originating from the Slave Microprocessor on the MMC panel, are presented serially to the Serial/Parallel Converter, IC7508. Here, the serial data is converted to parallel (D0 to D7) data to control the activity of the attenuators. Each attenuator (IC7506/7507, type number AD7528) contains two identical 8-bit D/A converters: DACA and DACB. Each DAC consists of an inverting R-2R ladder network with 8 weighted bit switches. In this way a binary-weighted current, dependent on the condition of the bit switches, is obtained at the output. Next, the Left and Right channels are fed to IC7504 (A and B), where current-to-voltage conversion takes place. The amplified left and right analog audio signals are then fed to the CD panel as AUDL (Left Audio) and AUDR (Right Audio).

On the CD panel (see Figure 31), the audio signals are available at the output jacks, BU-7 (Left) and BU-8 (Right), and to buffers 7681A and 7681B. Here, the Right and Left audio channels are mixed and fed to the RF modulator. The audio signals for the headphones are first routed to the Headphone Panel volume controls and returned to the CD Panel to be buffered by IC7551. The outputs of 7551 are sent to the headphones connector on the Headphone Panel.

A mute signal is generated from the RESETCD (not shown) signal for the whole audio circuit. This signal is called KILL and operates the mute switches (7510 - 7513) on the APU panel as well as the mute switches (6652 - 6655) on the CD panel. The mute switches prevent noise (popping) at the audio outputs during reset caused by discharging of electrolytic capacitors in the audio circuit.

Audio Section Troubleshooting

A problem in the CD-I player can be isolated to a particular circuit by carefully observing the symptoms. For example, if there is no audio, but a picture from a CD-I disc is displayed, it is obvious that the CD Servo and decoding circuits are functional. Therefore the fault can be isolated to the audio decoding circuits only. Or the symptom may be

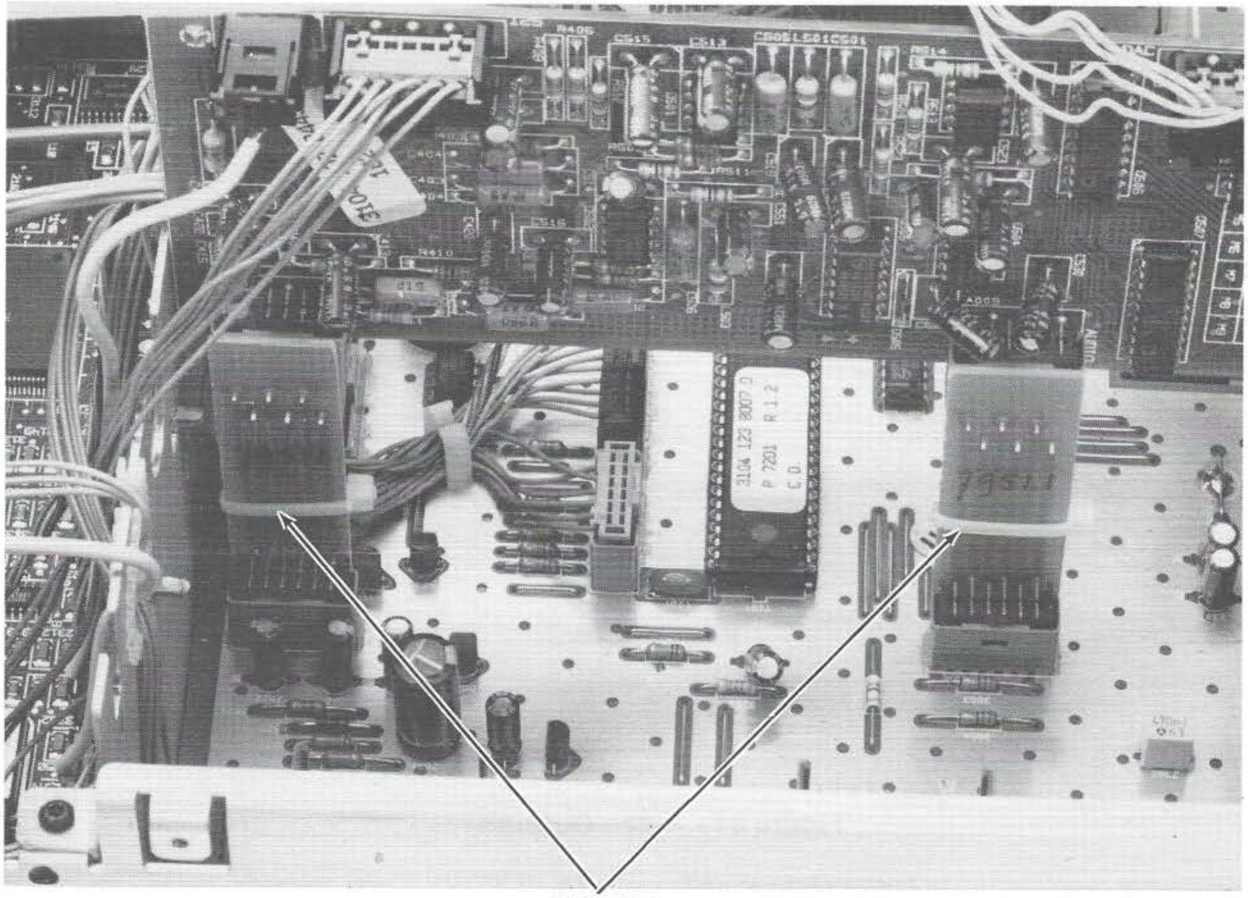


Figure 32 - APU Panel Service Position

opposite, the audio circuits may be working, but not the video. Again, the servo circuits must be functioning. Troubleshooting of the video decoding should then be followed.

When there is a symptom indicating a fault in the CD Drive circuitry, troubleshooting techniques used in CD players can be followed since the CD Unit portion of the CD-I player is basically a CD player (refer to the CD Unit schematic diagrams in the service manual). If the CDM does not start, check for Vdd, clock, and reset on the CD Drive Microprocessor. If these signals are present, perform the X-bus test in the Service Shell. Also check for activity on the X-bus and SPI-bus. If there is a communication failure, proceed with the MMC Low Level Test to determine if there is a failure in the system control circuitry. If the communication buses are functional, check the CD servo circuits using the Service Shell test modes. These modes are the standard CD servo test modes to test the OPU, turntable and radial arm. If there is a failure in the servo test modes, further checks with a DVM should reveal the fault (see Training Manual ST1307 for more on troubleshooting the CD servo circuits).

If the servo circuits are functioning, check the decoder circuits. Activity should be seen on the I^2S (DAAB, CLAB, and WSAB) and subcode (SCAB and SDAB) lines from the SAA7310 Decoder IC. If there is no activity, check the supply (Vdd) and input signals (HF, XIN). If there is activity, check the ADOC circuitry.

When the servo and decoder circuits are functioning properly, there may be a problem in the Audio Processing Unit. The APU Panel plugs in to the CD Unit circuit board (see APU schematic and Wiring Diagram in the service manual). Interconnections are thus made to the CD Unit via two connectors on the bottom of the board. The three connectors at the top of the APU provide interconnection with the MMC Panel. Extension connectors (part number 4822 321 22268; requires 2 for service) are available to gain access to the bottom connectors for troubleshooting (see Figure 32). Supply voltages and signals going into the APU Panel can be checked at the connectors. For example, the I^2S bus from the MMC panel can be checked on connector A16 (7 Pin connector) on the top of the board. Also, the analog output can be checked at connector A9 on the bottom of the board. If the

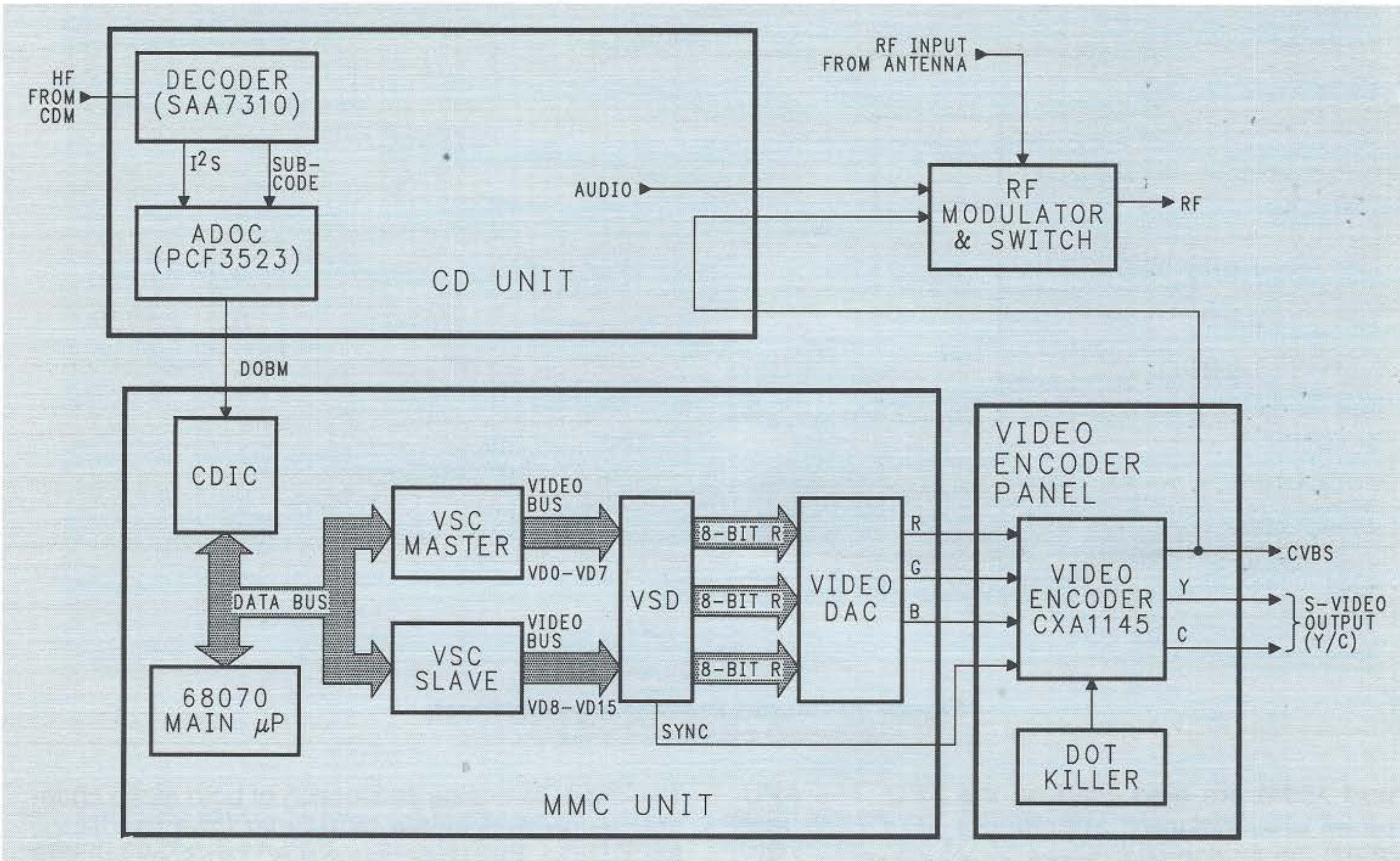


Figure 33 - Video Processing Block Diagram

input signals are present, but not the analog audio at the output, then the fault is located on the APU. Further checks of the APU circuitry should be followed. If the analog audio signals are present at the output of the APU, then the signal path on the CD Unit should be followed to find the fault. The Kill and buffer circuitry on the CD Unit should be checked for proper operation.

Video Signal Processing

The Video Processing Block diagram (Figure 33) shows the overall signal flow for developing the video signal. The HF information coming off the disc is processed the same way as in the Audio Processing circuit. The difference in the processing takes place on the MMC Unit in the CDIC. Data (16 bits), under the control of the Main Microprocessor, is sent to the Master and Slave VSC (Video and System Controller) circuits to develop the a and b video layers to be displayed. The VSC's output both video planes in digital form (8 bits) to the VSD (Video Synthesizer). The VSD receives the encoded image data at a rate of 7.5MB per second from the two VSC's. The VSD decodes the RGB, CLUT, or DYUV encoded data and adds blanking, weighting, and visual effects (dissolves, wipes, and mosaic transitions) to the data. The curser and backdrop are also developed and added to the decoded video in the VSD. The decoded video data is then passed to the Video DAC as eight-bit parallel data for each component (Red, Green, and Blue). The DAC converts digital RGB to analog RGB.

The analog RGB and sync signals are transferred to the Encoder Panel where RGB is converted to composite video (CVBS) and S-Video (Y/C) signals. The composite video and analog audio are also modulated to provide RF (channel 3 or 4) to a standard TV receiver. The Dot Killer circuit is used to remove dots (due to chroma phase errors present with non-interlaced video) in the picture when non-interlaced signals are generated by the decoding circuits.

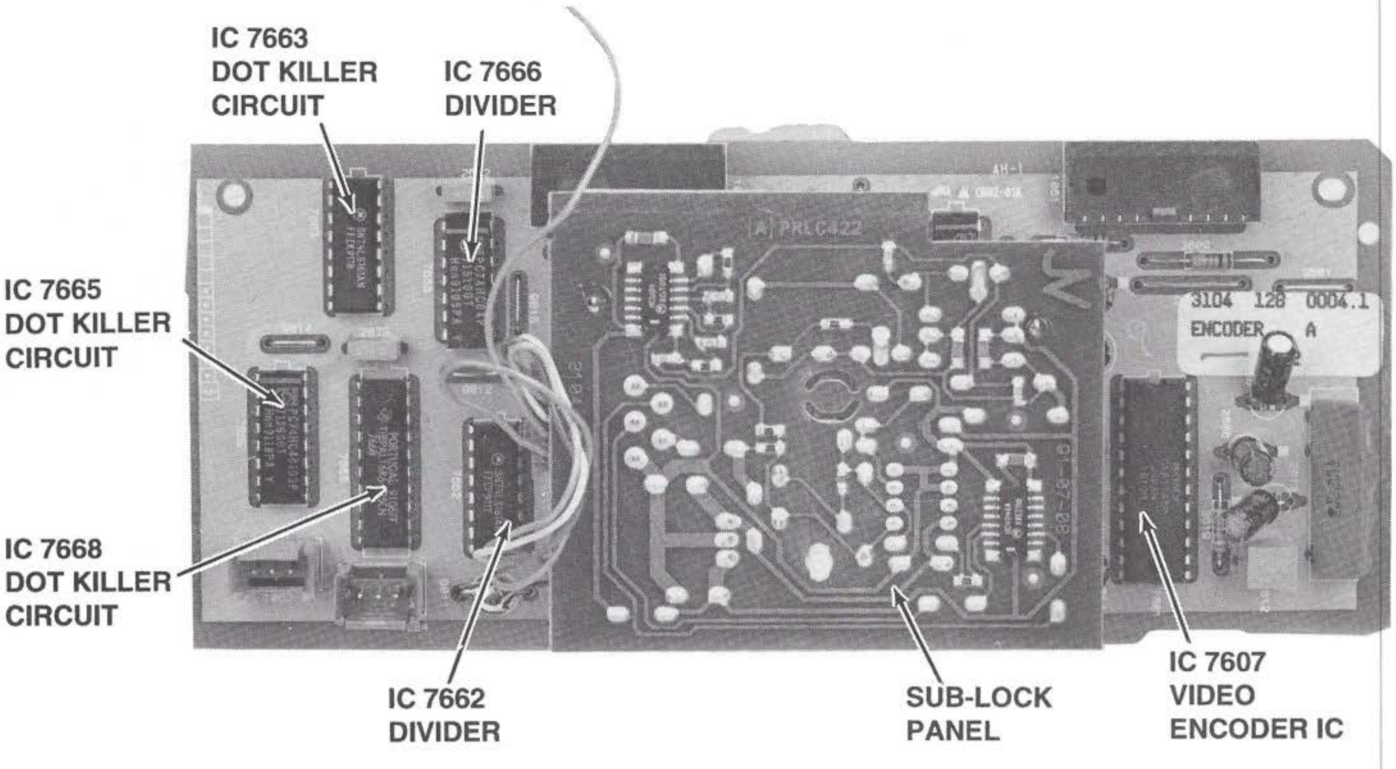


Figure 34 - Video Encoder Panel

Encoder circuit

The Video Encoder Panel is shown in Figure 34 with the main components called out. The Encoder IC (CXA1145P) is used to convert the RGB to composite video and S-Video (Y/C). The other circuitry on the Encoder Panel is used to produce the subcarrier (3.58MHz) frequency for the Encoder IC.

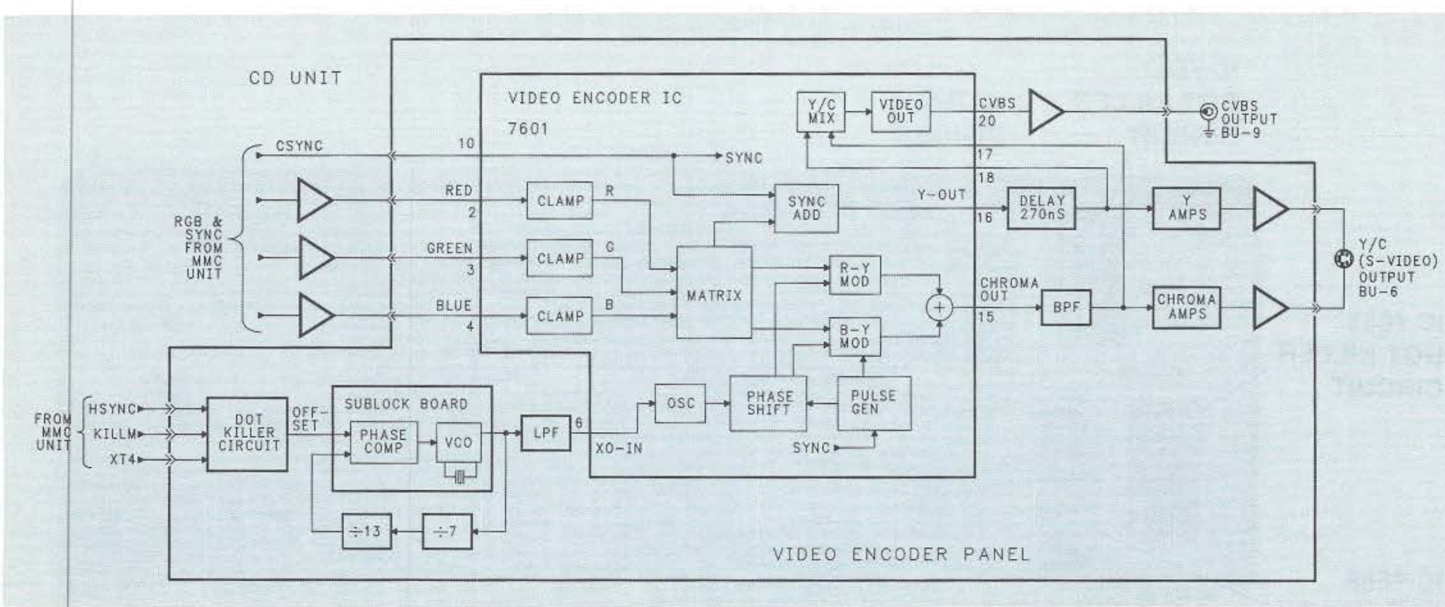


Figure 35 - Video Encoder Block Diagram

The Video Encoder block diagram is shown in Figure 35 (Also refer to the Video Encoder schematic diagram and wiring diagram in the service manual). The Red, Green and Blue (RGB) analog video signals and the Csync (composite sync) from the MMC are buffered and applied to the Video Encoder Panel via the CD Panel. The Video Encoder Panel plugs into the CD Panel directly behind the APU. The Hsync (horizontal sync), KILLM (Dot Killer enable signal) and XT4 (system clock) signals are also sent to the Video Encoder Panel from the MMC.

The subcarrier for modulation of the chroma is generated on the Video Encoder Panel. A PLL circuit is used to generate the subcarrier frequency. The PLL circuit consists of a VCO, a phase discriminator and a dot killer circuit. The CD-I player allows non-interlaced video to be processed. However, a dot pattern is introduced in the composite video when non-interlaced video is used. Therefore, the dot killer circuit is used to remove this effect. This circuit is used only when non-interlaced video is decoded.

The level of SW defines the standard, NTSC or PAL, at the encoder output. If this signal is High (+5V), the system operates in the NTSC mode, if it is low, the system operates in PAL. This line is always High in the CDI910 since it is not a multi-standard model (CDI601/602 is a multi-standard player). The other inputs for The Video Encoder (IC7601) are RGB (Red, Green and Blue video) and CS (Composite Sync). From these signals the luminance signal (Y), to which the CSYNC is added in the ADDER, is obtained in the matrix. The color difference signals R-Y and B-Y are also derived from the RGB in the Matrix circuit. The C (chroma) is derived from the R-Y and B-Y signals via the adder circuit. The Chroma signal is sent through a band-pass filter (5601). The timing difference between the chroma and luminance is removed by passing the luminance signal (Y) through delay line 5603. Both signals are amplified and buffered, enabling them to be loaded with 75 Ohms.

The Y/C (luminance and Chrominance) signals are applied to the Video Encoder's Yin and Chroma inputs to produce the CVBS (composite video) output signal. The CVBS signal is buffered by 7643 to make it available via output jack BU-9 from the CD Panel. The signal is also sent to the modulator to output RF, channel 3 or 4.

Video Section Troubleshooting

Note 1: Refer to the Video Encoder Circuit Diagram, MMC Circuit Diagram, and the Interconnect Wiring Diagram in the service manual.

Note 2: Use two service extension cables (part number 4822 321 22267) to allow easy access to the Video Encoder Panel.

The symptoms displayed can help the technician isolate the problem to a particular circuit. The following examples illustrate how a fault can be isolated.

Symptom 1: The player shell is displayed, but video from the disc cannot be displayed. If this condition exists, the Video Encoder Panel and video analog circuits are functioning. Since the player shell is displayed, the video synthesizer circuit is functioning. However, there must be a fault on the MMC Panel, since this is where the video decoding takes place. Thus the problem is isolated to the video decoding section on the MMC Panel.

Symptom 2: no video. This symptom may be caused by either the Video Encoder Panel or by the MMC Panel. A few voltage and signal measurements can quickly isolate the problem. Hint, also check all the video outputs: S-video, RF, and CVBS. If video is not present from any output, check the RGB, composite sync, and power source inputs from the CD Unit to the Video Encoder Panel (Connector 1061 on the bottom of the Video Encoder Panel). If these signals are present, the MMC Panel's decoder circuits are functional. Further checks of the Video Encoder circuit can isolate the problem further. Check the Video Encoder IC. Also check Vcc1 and Vcc2 to the Video Encoder IC. If both sources are missing, check Resistor 3660. If Vcc1 is missing, check Resistor 3618 and if Vcc2 is missing, check 3619.

Symptom 3: no color. This symptom is most likely caused by a problem in the APU circuit. Check the subcarrier oscillator at Pin 6 of the Video Encoder IC. If this signal is present (correct frequency), check the chroma output signal at Pin 15. If there is no chroma output, IC7601 may be the fault. Also check for short circuits between pins of the IC. If the chroma is present, check the chroma input at Pin 17. If the chroma is not present here, check the coupling components between Pins 15 and 17. If there is chroma at this point, check the composite output at Pin 20. If the chroma is missing, suspect the Video Encoder IC (IC7601).

The CD-I has built-in software modules for service. These modules are activated by the Service Shell.

Notes:

APPENDIX A - THE SERVICE SHELL

The modules are for the testing of:

- Video circuitry, by a color-bar test pattern
- CDM and servo circuitry
- Input/Output ports
- Audio circuitry

Only a CD-DA disc should be used when testing the CDM, servo and audio circuitry in the Service Shell.

Starting the Service Shell

The Service Shell is started by connecting the RXD and TXD lines of port 1 (Pins 2 and 3) during start-up (insert test-plug before power).

Layout information

Selectable/non selectable items

Each menu of the Service Shell consists of boxes and text strings (see Service Shell Screen). Some of these boxes can be selected by moving the screen cursor above the box and clicking on one of the joystick or mouse keys. Only the highlighted boxes can be selected. Clicking on one of the other boxes has no affect.

Messages (error) on the screen

The Service Shell provides information and errors in a box at the bottom of the screen. To remove such a message and continue with the test, a button on the remote control joystick must be clicked.

Menu structure

The main menu appears when the Service Shell is started. Selecting some boxes activate a sub-menu. Other boxes activate a test immediately. Selecting the EXIT box stops the Service Shell and restarts the player. Selecting EXIT in a sub-menu returns you to the previous menu.

Main menu

The main menu contains four test item boxes and the EXIT box. Selecting TEST IMAGE gives immediate action, a color-bar pattern is displayed. The other three test items display a sub-menu.

CD TEST

This menu has two information boxes at the top of the screen, CD STATUS and TEST MODE. Below it are three test items for the CD player: DRIVE TEST, X BUS, and DIG OUT. Below these are three icons that can be selected only during the DRIVE TEST: ARM IN, ARM OUT, and NEXT STEP. Only the three highlighted test item boxes can be selected

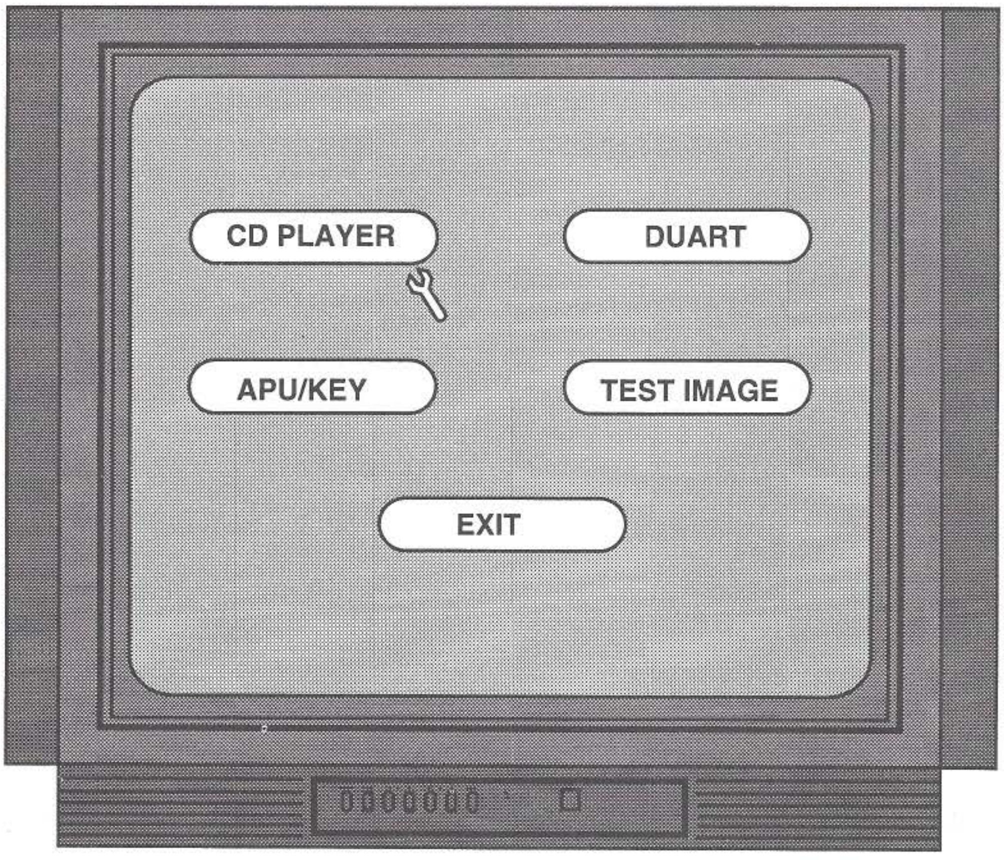


Figure 1 - Service Shell Screen

when the menu is first entered. Subjects of the CD test are the CD drive itself, the X bus and a test of the Digital Output (DOBM) line.

When this menu is selected in the main menu, the communication channel with the Drive Microprocessor is checked. A message is displayed giving the result of this check (either OK or NO RESPONSE). After pressing one of the mouse buttons or remote control action keys (to remove the message), the CD menu is displayed.

The X bus test checks the communication channel between the CDIC and CD Unit's Drive Microprocessor that is normally used to send commands to the Drive Microprocessor. The result is either OK or NO RESPONSE.

The DIG OUT test checks whether or not the CDIC receives a Digital Output signal. The result of this test is OK or NO DIGITAL OUT.

CD DRIVE TEST

The CD DRIVE TEST performs the service loop as implemented in Philips CD audio players. A disc (CD-DA) is needed for this test. When the CD DRIVE TEST is selected, the same screen appears, but with other buttons highlighted. You cannot select the X BUS and DIG OUT test anymore. Selecting the EXIT button returns the player to the CD menu. (X BUS and DIG OUT button highlighted). The DRIVE TEST consists of the following steps:

Mode 0: The software release number of the Drive Microprocessor is displayed in the box at the top, left of the screen (CD STATUS button). Mode 0 is displayed in the box at the top right of the screen (mode button). During the CD DRIVE TEST, this icon displays the current mode. In mode 0, the ARM

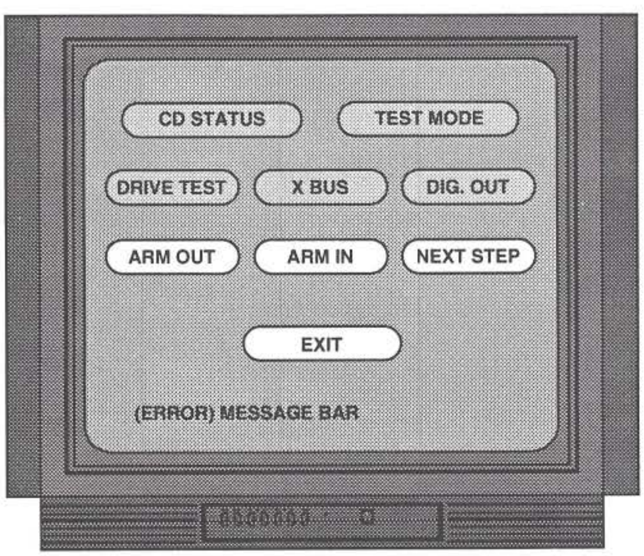


Figure 2 - CD test menu

IN and ARM OUT icons can be selected. Selecting NEXT STEP brings initiates mode 1.

Mode 1: In mode 1 the Drive Microprocessor performs the focus start-up. If focus is achieved (a disc must be present), the message IN FOCUS appears in the status button. Otherwise, the message NO FOCUS appears after 16 focus attempts. In that case (no focus found), the test returns to mode 0. When focus is achieved, selecting NEXT STEP initiates mode 2.

Mode 2: The turntable motor rotates and is controlled by the rough HF (turntable motor servo lock). Moving the CDM arm (by hand) outwardly slows the disc down. If an error occurs, the test returns to mode 0. Selecting NEXT STEP in mode 2 brings the player to mode 3.

Mode 3: Mode 3 allows the control of the radial arm. If the radial arm servo is operating, you can select ARM IN and ARM OUT to radially move the CDM arm toward the inside or outside of the disc in small jumps. If an error occurs, the test returns to mode 0. NEXT STEP in mode 3 puts the player in the normal playing mode (the test jumper must be removed).

Normal playing mode:

The player shell is started and errors sent by the Drive Microprocessor are displayed in a box on the screen. The player cannot return to the Service Shell unless the test jumper is plugged into Port 1 and the player is restarted (Service Shell initiation).

ERROR MESSAGES

display : A5 xx0000

xx = 2	: focus error
xx = 3	: radial error
xx = 5	: off error (TL stays low for 50 msec.)
xx = 6	: jump error
xx = 7	: subcode error, no valid subcode in 3 sec.
xx = 8	: TOC error : out of lead-in area while reading the TOC
xx = 30	: too many grooves to jump
xx = 31	: search time out
xx = 32	: bin. search error
xx = 33	: search index error
xx = 34	: search time error
xx = 37	: selection error

Duart test (CDI601 and CDI602 only)

The DUART menu has two buttons to select the port of the duart that will be tested and an EXIT button. After a port has been selected, you will be asked to connect a test plug on the port you selected. The following pins must be connected in this test plug: 7 to 8 and 2 to 3. After pressing a button (to remove the message), the test will start. If everything is functioning properly, an OK message appears after a few seconds, otherwise an error message is displayed.

APU/KEY TEST

This is a combined menu. The attenuation can be changed via this menu and the remote control and player keys can be tested. There are three buttons for every attenuation path on the screen. Two of them can be selected (to increment/decrement) and one is used to display the current attenuation value for the path. There is also a MONO/STEREO button on the screen. In STEREO, two attenuation paths are disabled (left to right and right to left). In MONO all attenuation paths are enabled. Maximum attenuation is reached at value 47 (no sound). A CD audio disc is needed for the attenuation test. The test routine starts playing the disc when entered.

The Key Test is used to check the Remote Control and Front Panel Keys. When a key is pressed, text appears on the Key Button on the right side of the screen, identifying the button pressed. The text disappears when the key is released.

VIDEO TEST IMAGE

When the VIDEO TEST IMAGE button is selected,

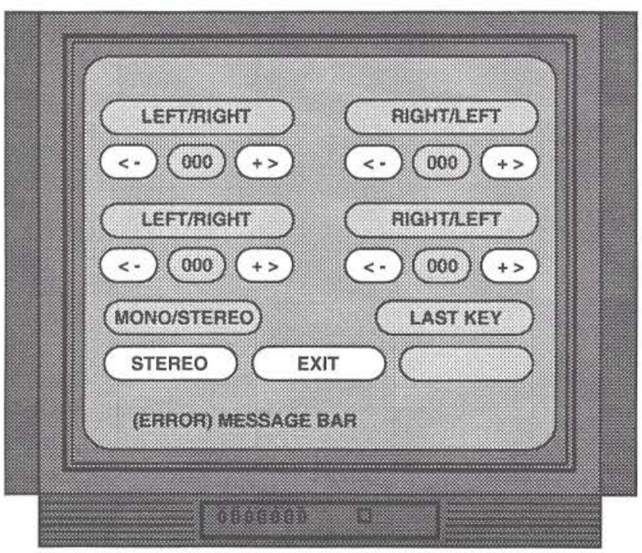


Figure 3 - APU test menu

a color-bar is displayed on the screen. Pressing a button after the screen has been filled completely returns the player to the main menu. There are no error messages for this test.

Troubleshooting hints:

Symptom: Service Shell cannot be started with the test plug.
Possible fault: Connections between port 1 and Slave Microprocessor may be bad.
Test plug could be wrong.
Slave Microprocessor may be defective.
Hint: If the Player Shell cannot be started, perform the Low Level Test (LL TEST).

APPENDIX B - THE LOW LEVEL TEST (LL Test)

This test is developed for service and low level hardware debugging purposes only. It is meant to be used with the Service PCB as described below or with a VT100 or compatible terminal. The test executed with the Service PCB is called the PCB Low Level Test. The test executed with the VT100 terminal is called the Terminal Low Level Test. Since the Service PCB displays only 8 digits, only the most important information is displayed. The VT100 test method displays all the test results.

PCB Low Level Test:

In this test the Service PCB acts as a micro terminal, able to display some alphabetical and numerical characters. Only some characters can be displayed since it uses 7-segment displays.

The three keys on the Service PCB are:
TEST - test all display LED's.
Yes - Send an ASCII "Y".
No - Send an ASCII "N".

The communication parameters are fixed at: 9600 baud, 8 data bits, 1 stop bit, and no parity.

To implement the PCB LL Test:

1. Switch the player Off.
2. Connect the Service PCB to Port 2 of the CDI910 player.
3. Apply power to the player.
4. The Service PCB display should now show "CDI RLxx" (with xx being the release number).
5. The PCB LL Test is now ready to proceed.

The LL Test is now waiting for an action from the service technician. The technician should now press either the Y or N key to continue the test. The LL Test is implemented in the steps listed in Table 1. Consult the service manual for a detailed test description.

STEP	DESCRIPTION
0a	VSC master initialization
0b	VSC slave initialization
1a	ROM10 release number
1b	ROM10 position check
1c	ROM10 checksum check
2a	ROM11 release number
2b	ROM11 position check
2c	ROM11 checksum check
3a	ROM20 release number
3b	ROM20 position check
3c	ROM20 checksum check
4a	ROM21 release number
4b	ROM21 position check
4c	ROM21 checksum check
5	NVRAM test with rom data as data
6af	DRAM fill bank0 & bank1 with address as data
6ar	DRAM read and compare data
6bf	DRAM fill bank0&bank1 with inverted address as data
6br	DRAM read and compare data
7af	DRAM fill bank0 with address as data
7ar	DRAM read and compare
7bf	DRAM fill bank0 with inverted address as data
7br	DRAM read and compare data
8af	DRAM fill bank1 with address as data
8ar	DRAM read and compare
8bf	DRAM fill bank1 with inverted address as data
8br	DRAM read and compare data
9a	CDIC RAM test with address as data
9b	CDIC RAM test with inverted address as data
9c	CDIC register test
10a	SLAVE test :write request to slave
10b	SLAVE test :read echo from slave
10c	SLAVE test :read SLAVE release number from slave
10d	SLAVE test :read CD release number from slave
11	CLOCK CAL DON'T TEST

Table 1: PCB LL Test steps overview

To implement the VT100 terminal LL Test:

1. Switch the player Off.
2. Connect the terminal to Port 2 of the CDI910 player.
3. While pressing the SPACE bar of the terminal, apply power to the player.
4. The terminal should now show the title of the terminal LL Test.
5. The VT100 terminal test is now ready to proceed.

LL Test Results are displayed on the terminal. If an error is detected, the test will stop. Table 2 summarizes the error codes that may result (see the service manual for more information on error codes and LL Test readout).

ERROR	DESCRIPTION	DISPLAY
01	ROM10 in wrong position	Er01
02	ROM11 in wrong position	Er02
03	ROM20 in wrong position	Er03
04	ROM21 in wrong position	Er04
05	ROM10 checksum error	Er05
06	ROM11 checksum error	Er06
07	ROM21 checksum error	Er07
08	ROM22 checksum error	Er08
09	NVRAM error	Er09
10	NVRAM error (for inverted data)	Er10
11	DRAM error (bank0 & bank1)	Er11
12	DRAM error (bank0 & bank1, inverted data)	Er12
13	DRAM bank0 error	Er13
14	DRAM bank0 error (inverted data)	Er14
15	DRAM bank1 error	Er15
16	DRAM bank1 error (inverted data)	Er16
17	CDIC RAM error	Er17
18	CDIC RAM error (inverted data)	Er18
19	CDIC register error	Er19
20	SLAVE error (wrong echo from slave)	Er20
21	Invalid release number from slave	Er21
22	Invalid release number from CD proc	Er22

Table 2: Error codes overview

APPENDIX C - IC PIN IDENTIFICATION

Drive Microprocessor MC68HSC05C8 (ITEM 7101 ON CD PANEL)

ABBREV.	PIN	DESCRIPTION
VDD	40	Supply voltage input 5V.
OSC1	39	Oscillator input 1.
OSC2	38	Oscillator input 2.
TCAP	37	Timer Capture interrupt line.
TL	36	Track Lost signal.
TCMP	35	Timer Compare output.
SPISS	34	Serial Peripheral Interface. Slave Select line.
SCK	33	Serial Clock.
MOSI	32	Master Out Slave In.
MISO	31	Master In Slave Out.
REDIG	30	Radial Error digital.
MC	29	Motor Control signal.
COXN	28	X-bus Clock.
SOXENN	27	X-bus Serial Output Enable.
COC	26	Command Control.
V-FLAG	25	Error flag.
SOXRQN	24	Serial Output Request line.
DIV4	23	Divide by 4.
DOXN	22	Data Out line.
CADDYSWITCH	21	Caddy switch detection.
VSS	20	Power supply ground input.
SPISS	19	SPI Slave Select line.
MUTE	18	Soft mute.
TRAY	17	Tray Motor On/Off.
QCL	16	Q channel clock.
CADDY-IN	15	Caddy busy indication signal.
QRA	14	Q data Request.
QDA	13	Q data line.
AM	12	Additional Mute.
IDAC	11	1 bit DAC correction signal.
BO - B3	10	7DAC/control of Radial processor.
SWAB/SSM	6	Start/Stop signal for Turntable motor.
SI/RD	5	Start Initialization Focus / start. Ready signal.
CRI/DODS	4	Counter Reset Inhibit / Drop Out Detection Suppression.
not connected	3	
TRQ	2	Not used.
RESETCD	1	Reset input.

Photodiode Signal Processor TDA8808 (item 7101)

ABBREV.	PIN	DESCRIPTION
DEC	28	Decoupling input (Internal bypass).
HF IN	26	HF current input to HF amplifier.
D1-D4	22-25	Current inputs to DC and LF photodiode amplifier.
RE1	21	Radial Error signal 1 (summation of amplified currents D3 and D4).
RE2	20	Radial Error signal 2 (summation of amplified currents D1 and D2).
GCLF	19	Gain control input for AC and LF amplifiers. Current output from LF amplitude detector.
LM	18	Laser Monitor diode input.
LO	17	Laser amplifier current output.
FE lag	16	Focus Error signal output for LAG network.
FE	15	Focus Error signal output.
CLPF (LPF)	14	Low Pass filter.
VBB (Vext)	13	Negative Supply for FE and FE lag output stage.
DODS (DODS)	12	Drop Out Detection Suppression input.
TL(TL)	11	Track Lost output.
HFD (PLLH)	10	High Frequency Detector output.
FS (FOC Start)	9	Focus normalizing circuit starting current.
BGC	8	DC and LF gain control reference input.
BEQ	7	Equalizer reference current I input.
SI/RD(SI/RD)	6	On/Off control for laser supply and focus circuit. Ready Signal, starting up procedure successful.
SC	5	Starting up capacitor input.
DET	4	HF detector voltage input.
HFout	3	HF amplifier and equalizer voltage output.
Vp	2	Positive supply voltage.
GCHF	1	Gain Control input of HF amplifier. Current output from HF amplitude detector.

Radial Error Signal Processor TDA8809 (item 7121)

ABBREV.	PIN	DESCRIPTION
RE2	28	Input for amplified currents from photodiodes D3 and D4.
RE1	27	Input for amplified currents from photodiodes D1 and D2.
CHPF	26	High Pass Filter for RE1 and RE2.
CLPF	25	Low Pass Filter for RE1 and RE2.
Offset out	24	Radial offset control output.
Offset in	23	Radial offset control input.
RDAC	22	Current output for bias resistor.
AGC	21	Automatic Gain Control for RE signal.
LEAD	19	Lead output.
Lag	18	Connection of integrator for (RE1-RE2) input current.
RElag	17	Voltage output of integrated (RE2-RE1) input currents.
REI (RE in)	16	Radial Error Input.
REO (RADout)	15	Current output of amplified (RE2-RE1) input currents.
B0-B3	8-11	Input control bits for radial circuit.
RP (REdig)	7	Digital output signal (RE2-RE1).
DIV4 (DIV4)	6	Divide by 4 input.
Rosc	5	Biasing resistor for oscillator.
Rwob	4	Wobble generator input.
Cosc2	3	Frequency setting capacitor for wobble oscillator.
Cosc1	2	Frequency setting capacitor for wobble oscillator.
Vp	1	Positive supply voltage.

SAA7310 Decoder IC Pin Functions

ABBREV.	PIN	DESCRIPTION
EFAB	1	Error Flag output indicating data unreliable.
DAAB	2	Data output of I^2S bus.
CLAB	3	Clock output of I^2S bus.
WSAB	4	Word select output of I^2S bus.
DINT2	5	Data Interpolated input.
A0-A7	7-14	Address outputs to External RAM
RAS (RAS)	15	Row Address Select output to External RAM
R/W (R/W)	16	Read/Write output signal to External RAM.
MUTE (MUTE)	18	Mute signal input from µP
D1-D3	19-21	Data inputs / outputs to External RAM.
D4	23	Data input/output to External RAM.
CAS (CAS)	22	Column Address Select output to External RAM.
MC (MSC)	24	Motor Speed Control output.
XTAL2	25	Crystal output.
XTAL1	26	Crystal Input.
PD/OC	29	Phase Detector Output / Oscillator Control Input.
CREF (Iref)	30	Current Reference Input.
FB	31	Feedback output.
HFI	32	High Frequency Input.
HFD	34	High Frequency Detector.
CRI (CRI)	36	Counter Reset Inhibit.
QDA	37	Q-Channel Data signal output.
QRA	38	Q-Channel Request input/Acknowledge output.
QCL	40	Q-Channel Clock input.
SWAB/SSM	42	Subcoding Word Clock output and Start/Stop Motor input.
SDAB	43	Subcode Data output.
SCAB	44	Subcode Clock output

APPENDIX D - CD-I GLOSSARY

ABSOLUTE DISC ADDRESS In CD-I, the address of a sector in minutes, seconds and sector number.

ABSOLUTE RGB CODING See direct RGB coding

ABSOLUTE SECTOR ADDRESS In CD-I, the address part of the sector header field. Its value corresponds to the absolute disc address.

ABSOLUTE TIME In CD-DA, the total time a disc has been playing. The absolute time is included in the subcode and is thus available for display during playback.

ACCESS (1) In computing, the manner in which files or data sets are referred to by the computer. (2)In CD-I, the process of locating information in a data store.

ACCESS PROTECTION In CD-I, the method of preventing unauthorized access to confidential data stored on a disc.

ACTIVE DISPLAY The contents of a video memory currently displayed, as opposed to screen contents being held in memory for later display if needed.

ADAPTIVE DELTA PULSE CODE MODULATION Delta modulation assumes close correlation between successive samples. It cannot accurately express large transients in an audio signal, because the correlation between successive samples is too low. Adaptive Delta Pulse Code Modulation (ADPCM) is a variant of delta modulation in which the quantization steps are adapted to the dynamic amplitude variation. This adaptation can include a temporary switch to PCM. See Delta Modulation and Pulse Code Modulation.

ADPCM See Adaptive Delta Pulse Code Modulation

ADDRESS DATA The part of the total data that is concerned with addressing.

ALBUM DESCRIPTOR In CD-I, the section of the disc label identifying the album of which the disc is a part.

ANIMATION The art or process of synthesizing apparent mobility of inanimate objects or drawings, either through the medium of cinematography or possibly through the use of computer graphics.

ASPECT RATIO (1) In cinematography, the height to width ratio of a motion picture frame, normally 3 to 4 or 1:1.33. (2) In television, the ratio of the dimensions of a TV screen, normally 3 to 4.

ATTRIBUTE (1) In databases, a field that contains information about an entity, e.g. in a personnel database "home address" would be an attribute of entity "employee". (2) In CD-I, and in computer disk operating systems, a word in the field descriptor indicating how a file is accessed, the owner and the identification, e.g. as a CD-Digital Audio file.

AUDIO BLOCK A block of audio information in CD-I format.

AUDIO DATA (1) Audio information expressed in digital form. (2) In CD-DA, multiplexed and pulse code modulated stereo information with CIRC and subcode added. (3) In CD-I, audio information encoded in accordance with the CD-I specification.

AUDIO QUALITY LEVEL The reproduction quality of an audio signal. CD-I, for example, provides for five audio quality levels (in decreasing order of quality): CD-DA, hi-fi, mid-fi, speech and synthesized speech.

AUDIO TRACK In Compact Disc, a CD-DA track as defined in the CD-DA specification; a separately addressable section of a CD-DA disc, normally carrying a self-contained piece of music. An audio has a minimum duration of 4 seconds and a maximum duration of 72 minutes. One CD-DA disc can contain between one and 99 audio tracks, but the total disc playing time cannot exceed 72 minutes.

AUXILIARY DATA FIELD In CD-ROM and CD-I, the last 288 bytes of a sector, either used for extra error detection and correction (mode 1 and form 1) or available as user data area (mode 2 and form 2). See Mode 1, Mode 2, Form 1, Form 2.

BASE CASE DISC In CD-I, a hypothetical disc that can exercise all the capabilities of a Base Case system. See Base Case system.

BASE CASE SYSTEM In CD-I, the lowest level system that can still carry the CD-I logo. All CD-I systems must at least be able to operate in the way that a Base Case system does while playing a CD-I disc, no matter what their configuration or content.

BIT ERROR RATE A measure of the capacity of a data medium to store or transmit bits without errors. Expressed as the average number of bits the medium can handle with only one bit in error. CD-ROM and CD-I, which employ three layers of error detection and correction (CIRC and EDC/ECC), have a bit error rate of 1018 (one error per 1018 bits).

BLOCK In CD-ROM and CD-I, the user-data portion of a sector.

BLOCK NUMBER In CD-ROM and CD-I, the logical number of a block after block zero.

BLOCK ZERO In CD-ROM and CD-I, the first block on a disc, with main channel or absolute disc address of 00 minutes, 02 seconds, 00 sector number.

BOOT RECORD In CD-I, an optional part of the disc label bootstrap routine used to loaf the boot modules into memory. The boot program, be it in system ROM or on disc, is used implicitly when starting up a CD-I system.

BYTE (1) In computing, a binary character operated upon as a unit and usually shorter than a computer word. A byte is the smallest addressable unit of storage and is usually eight bits long. The word itself is a contraction of 'by eight'. (2) The representation of a character. (3) In Compact Disc, an 8-bit unit representing one symbol before eight-to-fourteen modulation. See Symbol.

CAV See constant angular velocity.

CD See Compact Disc.

CD-DA TRACK In Compact Disc, synonymous with audio track.

CD-DA QUALITY In CD-I, the highest available sound quality, identical to CD-DA sound. See audio quality level.

CD DEVICE DRIVER The lowest software level to handle CD drives. The only software to communicate directly with the CD control unit, it resides in ROM on a CD-I player.

CD-DISC MASTER A CD master disc, produced by exposing a photosensitive coating on a glass substrate to a laser beam. The laser is modulated by the digital program information from the CD-tape master, together with the subcode, which is generated during the disc mastering process from the subcode cue code, also on the CD tape master. The exposed coating is developed, covered with silver coating and nickel plated to form a 'metal father' recording mould. See also CD Mastering, Metal Father.

CD GRAPHICS (CD+G) In CD-DA, a technique for generating text, still pictures or animated graphics, related to the music. The graphic information is recorded in subcode channels R-W. Not related to the graphics facilities of CD-I.

CD-I See Compact Disc-Interactive

CD-I CHANNEL The main channel of a CD-I track corresponding to the specifications of CD-ROM, mode 2, and the CD-I logical and physical formats.

CD-I DIGITAL AUDIO In CD-I, there is a requirement to have audio data on disc at a number of distinct quality levels.

In addition to CD-DA sound in 16-bit pulse code modulation (PCM) format, CD-I audio data is also coded in 8-bit or 4-bit Adaptive Delta Pulse Code Modulation (ADPCM) formats. This technique is chosen as a way of coding sound more efficiently then for CD-DA, such that 50% or less of the total data is occupied by stereo audio information. At least 50% of the data can therefore be used for other purposes, principally the transfer of visual information. The HiFi music mode uses an 8-bit word size and a sampling rate of 37.8kHz in order to take full advantage of the form 2 sector space of 2324 Bytes, while retaining the highest useable integral fraction of 44.1kHz (16-bit PCM sampling rate). HiFi music mode is equivalent in quality to a high-quality LP played for the first time. In order to use the same coding technique to span the requirement for various audio levels and still maintain optimal quality by proper post-filtering, the word size of the first level is reduced from 8 bits to 4 bits to give the Mid-Fi music mode. This is equivalent to FM broadcast quality sound as broadcast from the studio, and offers a maximum of 4 stereo or 8 mono channels available in the HiFi music mode. To achieve a further reduction in data rate, and thereby increase the number of audio channels to 8 stereo or 16 mono, the sampling rate is reduced by half to 18.9kHz. This results in speech mode quality, which is equivalent to AM broadcast quality sound as broadcast from the studio.

It should be noted that a channel, as described above, is equivalent to some 72 minutes of uninterrupted playing time. Multiple channels can only be played with a 1-4 second gap between them. This gap is due to the fact that the laser read-out mechanism must be repositioned back to the beginning of the disc.

An alternative way of using the channels is as a sequence of up to 16 parallel channels of audio information. These channels could tell the same story but in different languages, for example, so that the user could switch from one language to another instantly at any time. This last case moves away from the question of what is on the disc alone, to the question of how that information can be used in a CD-I system.

Audio information from the disc can reach the user in three different ways:
(1) From the disc directly to the 16-bit PCM decoder, and out through the audio HiFi system as CD-DA sound. (2) From the disc directly through the ADPCM and PCM decoders and the HiFi system as ADPCM sounds. (3) From disc into a microprocessor-controlled random access memory, where it can either be held awaiting its singular or repeated use whenever a certain event occurs (for example a ball bouncing on the screen, which must be accompanied by the appropriate sound), or it can be slightly altered as a function of different events and then sent under microprocessor control through the ADPCM and PCM decoders and out to the HiFi system. This latter approach allows for audio interactivity with a quality that has not been achievable in the past.

See Adaptive Delta Pulse Code Modulation, Delta Modulation, Pulse Code Modulation.

CD-I DIGITAL VIDEO In CD-I, there is a requirement for various video quality levels to offer a choice of resolution and color depths to satisfy various pictorial functions in the applications. Three resolution levels are defined: the best achievable resolution for pictures on present normal TV receivers (normal resolution); the best achievable resolution for characters displayed on present normal TV receivers (double resolution); the best achievable resolution with the coming enhanced-quality TV sets (high resolution). As for color depth, the quality necessary depends on the type of image that is being handled. Natural stills use YUV (luminance and color signals B-Y and R-Y) coding for an equivalent of 24-bit total color depth per pixel, quality graphics employ Color Look-up Tables (CLUT), and user-manipulated graphics use direct RGB coding.

A key requirement is that the disc must be compatible regardless of where it is purchased and on which system it is used; for example, playback should be independent of the particular TV standard. Given these and other similarities and differences, CD-I video requirements are translated into specifications related to three areas: display resolution, picture coding, and visual effects.

CD-I TRACK A data track containing only mode 2 sectors conforming to the CD-ROM mode 2 specification as well as the CD-I specification.

CD-MASTERING As with conventional disc mastering, a CD master disc is produced from a master tape. But in addition to the actual recorded program, Compact Discs also carry a control and display subcode, which is inserted during the encoding stage of the disc mastering process, just prior to eight-to-fourteen modulation. The information for the subcode has to come from the recording studio, since it is related to the recorded program.

The recording studio therefore produces a digital master tape, assembled and edited into the required sequence, and in the correct CD pulse code modulated format.

CD-ROM See Compact Disc-Read Only Memory.

CD-ROM CHANNEL The main channel of a CD-ROM track.

CD-RTOS See Compact Disc - Real Time Operating System.

CD-TAPE MASTER The tape used to produce the CD-disc master; a CD master tape with subcode cue code on audio track 1. See CD mastering, cue code.

CD TRACK A separately-addressable section of a Compact Disc, normally carrying a self-contained piece of information.

CHROMA KEY See color key.

CIRC See Cross-Interleaved Reed-Solomon Code.

CLUT See Color Look-Up Table.

CLUT ANIMATION In CD-I, a technique used to impart motion to graphic objects by repeatedly changing the data in the color look-up table.

CLV See Constant Linear Velocity.

COLOR KEY A system based on color matching to control overlay transparency. A technique in which parts of an image are determined to be transparent based on their color values. Also known as chroma key.

COLOR LOOK-UP TABLE A means of compressing the amount of information needed to store color pictorial information by allowing only a specific number of colors (tints and brightness), and holding these values in a table. The color of a given picture element or pixel is then defined as a value from this table.

COMBI PLAYER A combined Laser Vision and Compact Disc player.

COMPACT DISC System for reproduction of high-density digital data from an optical disc. Originally conceived as a medium for high fidelity music reproduction, for which Compact Disc-Digital Audio is now an accepted world standard. Because of the very high disc data storage capacity, Compact Disc is now being applied as a text/data medium for electronic publishing (CD-ROM) and a multiple-function (audio/video/text/data) medium for electronic interactive programs (CD-I). See Compact Disc-Digital Audio, Compact Disc-Interactive and Compact Disc-Read Only Memory.

COMPACT DISC-DIGITAL AUDIO Developed jointly by Phillips and Sony, and launched in October 1982, Compact Disc-Digital Audio has revolutionized high fidelity recording with its pure sound reproduction, small size and immunity from surface scratching.

The Compact Disc system records music, in the form of digital data, onto a light but robust 12 cm (5 inches) diameter disc, thereby virtually eliminating the problems of dynamic range, background noise, wow and flutter, and other sound disturbances common to earlier sound recording systems. 32-bit analog-to-digital conversion at a sampling rate of 44.1kHz, in conjunction with CIRC (Cross Interleaved Reed-Solomon Code) error correction and EFM (Eight-to-Fourteen Modulation), a reproducible bandwidth of 10 Hz to 20kHz within 0.2 dB, a signal to noise ratio of over 100 dB, a dynamic range of over 95 dB and imperceptible wow and flutter.

See also CD mastering, Cross-Interleaved Reed-Solomon Code, Eight-to-Fourteen Modulation, Pulse Code Modulation. Refer to Training Manual ST1444 or ST1307 for a full description of the basic Compact Disc digital audio system.

COMPACT DISC DRIVE Device specifically designed to read digital data from CD-ROM or CD-I discs. CD-I drives can also play CD-DA discs.

COMPACT DISC-INTERACTIVE The Compact Disc-Interactive standards specifies a multi-media, interactive information carrier that is mainly real-time audio and video driven, but also has text, binary data and computer program capabilities. It is both a media and a system specification, and defines what can be present on the disc, how it is coded and organized, and how disc/system compatibility can be maintained. From a technical point of view, CD-I is based on CD-ROM, but from a player/product point of view it is based on CD-DA. Like CD-DA, it is dependent on processor hardware, but unlike CD-DA or CD-ROM, it is also system-software dependent. The reasons for CD-I's hardware and system-software dependence are motivated by, and based on, the real-time audio/video decoding and data-handling requirements that CD-I applications demand, as well as the requirement to maintain disc/system interchangeability in the same way that CD-DA does. In practical terms, this means that any CD-I disc will play on any CD-I player, regardless of where in the world both were purchased.

This latter point is achieved in the CD-I specification by defining a set of rules for a minimum level system called the Base Case, which must be observed by all discs. The CD-I specification also allows for mixing of CD-DA and CD-I discs, and requires CD-DA decoding hardware in CD-I systems.

COMPACT DISC PLAYER Device specifically designed to read CD-DA discs. If provided with digital output and control interface, can also be used, in conjunction with a suitable signal processor, to read CD-ROM or CD-I discs.

COMPACT DISC - READ ONLY MEMORY A natural derivative of Compact Disc-Digital Audio. Defined by Philips and Sony in 1985, the CD-ROM makes use of the identical physical characteristics, disc size, rotational speed and read-out mechanism, as well as the same disc mastering and replication processes as used for CD-Digital Audio.

Where CD-ROM and CD-DA differ is in their application. Instead of a single, dedicated application, namely hi fi music, CD-ROM specification limits itself to defining the method by which data is stored on the disc, and no more. The nature of the data, and the purpose for which it is to be interpreted, is left to the information providers making use of the medium. The disc can be divided into tracks in the same manner as for CD-DA; indeed the specification foresees the possibility of combining CD-DA tracks on a single disc.

CD-ROM makes use of the same CIRC error protection used in CD-DA as well as EFM (Eight-to-Fourteen Modulation). However, the data recorded on the disc is organized into sectors of 2352 bytes. Each sector is further subdivided. After 12 bytes of synchronization, and a 4-byte header to identify the address and nature, or mode, of data in the block, the main User Data area follows, containing 2048 bytes of data. Following this area is a 288 byte long Auxiliary Data Area.

Concerning the mode information, CD-ROM normally only uses mode 1, where an additional level of error protection (EDC/ECC) is included in the Auxiliary Data Area to reduce the chance of error to less than a single bit per disc. Mode 2, also defined for CD-ROM, allocates the space used in Mode 1 for error correction for recording additional user data. Mode 0 is used for CD-DA applications. The mode being used is fixed for the duration of a track. Details of the modes of all tracks are also held in the Q sub-channel in the lead-in area of each disc.

COMPACT DISC - REAL-TIME OPERATING SYSTEM CD-RTOS, the operating system used in CD-I, is specified so that the real-time capabilities of CD-I are useable, as far as possible, in a device-independent way. CD-RTOS is a multi-tasking operating system with real-time response, has a versatile modular design, and can be loaded into ROM. It supports a variety of arithmetic and I/O co-processors and is device-independent and interrupt-driven. CD-RTOS can handle multi-level tree-structured disc directories, supports both byte-addressable random-access files and real-time files, and is OS-9 compatible.

CD-RTOS is composed of four major blocks:

1. Libraries; these guarantee that the necessary specialized user library functions such as high-level access and data synchronization, as well as math, I/O and other functions are available in CD-I systems. One of the most important of these is synchronization.
2. CD-RTOS kernel; this is a customized version of the OS-9 kernel.
3. Managers; these define the virtual device level for graphics, visuals, text, audio, CD control, etc. The managers provide software support for graphics/visual devices, pointing devices, and the CD-I audio processing devices, as well as taking care of disc I/O and optimized disc access and reading.
4. Drivers; these are the interfaces between the virtual, i.e. hardware-independent, level and the actual hardware used by various manufactures in their CD-I systems.

COMPATIBILITY (1) In computing and communications, pertaining to pairs of devices that have met the requirements for code, speed and signal level conversion to enable direct interconnections. (2) In computing, pertaining to machines on which programs may be interchanged without appreciable modification. (3) In Compact Disc, the extent to which different types of discs can be interpreted by different types of players or drives. For example, all CD-DA discs are fully compatible with all CD-DA players, so that any player can reproduce music from any disc regardless of manufacturer.

COMPRESSION (1) In communications, a process in which the effective gain applied to a signal is varied as a function of the signal magnitude, the effective gain being greater for small signals. (2) In CD-I, a technique for reducing the amount of data needed to store audio or visual information. The methods used are based on the principle that, after the first picture or sound sample has been represented as data, the only further data required is that which represents relative changes.

CONCEALMENT In digital signal processing, the hiding of errors for example, by an interpolation scheme.

CONSTANT ANGULAR VELOCITY A disc rotation mode in which the disc always rotates at the same speed, so that the time of one revolution is always the same. Used in interactive Laser Vision.

CONSTANT LINEAR VELOCITY A disc rotation mode in which the disc rotation speed changes as the read radius changes so that the linear reading speed (i.e., the speed at which the read-out device scans the track) is always the same. Maximizes disc information storage capacity. Used in CD and in non-interactive Laser Vision.

CONTENT PROVIDER Synonymous with information provider.

CRC See cyclic redundancy check.

CROSS-INTERLEAVED REED-SOLOMON CODE An error protection code specially developed for Compact Disc. It consists of two Reed-Solomon codes interleaved crosswise. CIRC makes it possible for a CD player decoder to detect and correct or conceal large burst errors. Errors up to 4000 data bits (2.5mm of track) can be corrected. Errors up to 12,304 data bits can be concealed.

The CIRC encoder uses 2 stages of encoding and 3 stages of interleaving. The 12 PCM audio samples (24 symbols) of one Compact Disc audio frame are fed in parallel to the first encoder. The second symbol of each audio sample is delayed by two symbols, so that the symbols of two successive frames are interleaved. The first encoder then adds 4 parity symbols, making 28 in all.

These 28 symbols are fed to the second encoder through delay lines of different lengths. The second encoder adds four more parity symbols, making 32 in all. Finally, alternative audio signals are delayed by one symbol.

The total effect is to spread the symbols of one frame over eight frames. The two stages of CIRC encoding make it possible for the CIRC in a CD player to correct two symbols in each received frame directly, or to correct four symbols in each received frame by erasure and circulation. Furthermore, it allows detection of up to 32 successive incorrect symbols so that interpolated values can be substituted. Because of the dispersion of symbols over 8 frames, up to 4000 wrong data bits can be corrected and up to 12,304 wrong data bits can be concealed. The final (1 symbol) delay provides protection against random errors.

See also Compact Disc-Digital Audio and Eight-to-Fourteen Modulation.

CUE CODE In Compact Disc, a code used in tape mastering. Recorded on audio track 1 of the CD-tape master, it contains the information necessary to generate subcode during disc mastering. See CD mastering.

CURSOR (1) In computing, a short line or character on a VDU indicating where the next character is to be typed. (2) A symbol or character on a screen display, which indicates a position or a path to be followed. Moved by the application program to guide the user, and by the user to define a requirement.

CURSOR PLANE In multiplane video representations, the plane in which the computer cursor is presented.

CUT In film and video, a direct change from one image to another.

CVBS Composite Video Blanking and Sync signal. The standard form of color TV baseband broadcast signal in which the intensity and relation of the red, green, and blue components are represented by a luminance signal and a chrominance signal.

CYCLIC REDUNDANCY CHECK In Compact Disc, a separate error detection scheme for the Compact Disc subcode. See polynomial code.

DATA CHANNEL (1) In CD, a channel carrying data, as opposed to audio information. (2) In CD-ROM, a channel carrying mode 1 data.

DATA DRIVEN ACTION TAGGING In CD-I, the technique for identifying or tagging events on the different data streams (audio, video, text/data) so that they can be synchronized according to the requirements of the application program.

DATA TRACK In CD-ROM or CD-I, a track containing data, as opposed to CD-DA information. As such, one of the two track types identified in the table of contents. Compare audio track.

DECODING HARDWARE In Compact Disc, the equipment required to interpret the encoded data recorded on the disc.

DE-EMPHASIS See pre-emphasis.

DELTA MODULATION In data communications, a form of differential PCM in which only 1 bit for each sample is used.

DELTA PULSE CODE MODULATION See delta modulation.

DELTA-YUV A high-efficiency image-coding scheme for natural pictures used in CD-I. The delta coding takes advantage of the fact that there is a high correlation between adjacent pixel values, making it possible to encode only the differences between the absolute YU or YV pixel values. This coding scheme is applied per line. See YUV encoding.

DIFFERENTIAL PCM In data communications, a version of pulse code modulation in which a difference in value between a sample and the previous sample is encoded. Because fewer bits are required for transmission than under PCM, this technique is used in satellite communications. In CD-I, this technique is applied in video encoding as well as audio encoding. See Adaptive Delta Pulse Code Modulation, Delta YUV.

DIGITAL-OPTICAL TECHNOLOGY The combination of digital and optical techniques. See Compact Disc, fiber optics, fiber optics recording.

DIGITAL PRODUCTION MASTER A digitally recorded audio tape used in editing to produce a master tape. It may be a studio mix, an equalized copy from a mastering suite, or a transfer from a previous master.

DIGITAL RECORDING Recording audio or video signals in digital form. The level of the signal to be recorded is sampled at a rate at least double the highest frequency to be reproduced, and the instantaneous amplitude of the signal is quantized and stored in numerical or digital form.

DIRECT RGB CODING Picture coding scheme used in CD-I for high-quality graphics that can easily be changed by the user. Images are encoded on disc as red, green and blue components using 5 bits for each color plus one overlay or control bit.

DISC BOOTSTRAP ROUTINE Optional routine on a CD-I disc to add or replace operating system capabilities in a Base Case System.

DISC INTERCHANGEABILITY The ability to exchange discs between players of different manufacture. This is an essential feature of both CD-DA and CD-I.

DISC LABEL In CD-I, the disc identifying in terms of its volume and album description. Recorded in the first track of the disc. See Super Table of Contents.

DISC MEMORY Secondary storage using an optical or magnetic disc. Synonymous with disc storage.

DISC REPLICATION The production of copy discs from a master disc, usually for commercial distribution.

DISC STORAGE Data storage on optical or magnetic disc, characterized by low cost and relatively fast data access, compared with tape storage.

DISPLAY RESOLUTION The measure of the number of pixels, and thus the amount of detail, that a screen can display. Horizontal resolution is a function of bandwidth, vertical resolution is a function of the number of scan lines. Present-day color TV sets, with a band-width of 4-5MHz, can display 40 alphanumeric characters per line. High-resolution monitors, with a bandwidth of 20MHz or more, can usually display 80 and sometimes 132 characters per line.

DISSOLVE A slow change from one picture (global) or part of a picture (local), to another.

DOUBLE RESOLUTION In CD-I, a display resolution mode between the normal and high resolution modes, with 768 pixels (horizontal) and 280 pixels (vertical).

DOUBLE-WRITTEN In CD-I, data written twice with a 4-byte separation. This achieves a data integrity level equivalent to mode 1.

DPCM See delta modulation.

DYNAMIC LOADING In CD-I, updating the contents of the Color Look-Up Table (CLUT) during the horizontal retrace period (up to 4 colors) or during the vertical retrace period (up to 256 colors).

DYUV See Delta YUV

ECC See Error Correction Code.

EDC See Error Detection Code.

EFM See Eight-to-Fourteen Modulation.

EIGHT-TO-FOURTEEN MODULATION In Compact Disc, the pulse code modulated signal produced by analog-to-digital conversion is a simple non-return-to-zero bit stream of ones and zeros. It is not self-clocking, and there is no restriction on run length (the number of successive 1's and 0's). To record this signal directly on to the disc would not only be inefficient in terms of disc storage capacity, it would also make playback very difficult, if not impossible. EFM is therefore applied, to produce a signal format suitable for recording. EFM imposes a minimum run length of three bits and a maximum run length of eleven bits. It also changes the signal into a non-return-to-zero inverted bit stream, in which a one is represented by a transition, and a zero by no transition. Finally, EFM introduces a unique synchronization pattern to each frame of audio information.

EFM greatly reduces the number of transitions for the same amount of data. This means that the data can be read more reliably, with much less risk of interference between symbols. It also means that 25% more data can be recorded on the same disc area. At the same time, EFM ensures that there are always enough transitions to allow bit clock regeneration in the Compact Disc player. The data is thus made self-clocking.

EFM also minimizes the difference between the number of ones and zeros in the bit stream. This suppresses low frequency components which could otherwise interfere with the player's focussing, tracking and motor control servos.

Finally, the synchronization pattern allows each frame to be recognized. This is essential, particularly for error correction and subcode separation. EFM changes each 8-bit symbol in the signal into a 14-bit symbol. The 14-bit symbols all have a minimum of 3 and a maximum of 11 successive zeros. 256 such symbols are needed to match all the possible 8-bit combinations. (In fact 267 14-bit symbols meet this requirement; 11 are not used). The 256 14-bit symbols form a look-up table held in a RAM.

The run length conditions must be maintained between symbols as well as within them. This is achieved by inserting two merging bits. A third merging bit maintains the balance between the number of ones and zeros in the bit stream. Thus, each 8-bit symbol becomes a 17-bit symbol (14+3). The synchronization pattern consists of 24 bits, and is uniquely identifiable. It, too, has three merging bits.

An EFM modulated audio frame is composed of 33 seventeen-bit symbols (24 audio, 8 parity and 1 subcode) plus a 27-bit synchronization pattern; a total of 588 channel bits. This is the signal written on to the disc, where each "one" is represented by the beginning or end of a pit.

See also Compact Disc-Digital Audio, Pulse Code Modulation, and Figure 2 in the main text. See Philips Training Manual ST1444 or ST1307 for additional information on compact disc encoding methods.

EMPHASIS See pre-emphasis.

ERASABLE OPTICAL DISC Using a technique known as magneto-optical recording, erasable optical discs have been produced experimentally. Writing and reading depend on the physical effects of small, reverse-polarized magnetic domains in a thin polarized magnetic layer. Writing is performed by reversing the polarization of the domain, while under the influence of an external magnetic field, by heating it above the compensation point temperature with a short laser pulse. Reading is performed by measuring the Kerr effect, which rotates polarized light when it is reflected under the influence of a magnetic field.

ERROR CORRECTION Identification and correction of errors arising in the transfer of information. Used extensively in computer storage media such as Compact Discs. See Cross-Interleaved Reed-Solomon Code, Cyclic Redundancy Check, Error Correction Code, Error Detection Code.

ERROR CORRECTION CODE (1) In computing and communications, a code designed to detect an error, in a word or character, identify the incorrect bit and replace it with the correct one. (2) An error correction code used in CD-ROM and CD-I to achieve high data integrity. See Form 1, Mode 1.

ERROR DETECTION CODE (1) In computing and communications, a code designed to detect, but not correct, an error in a word or character. (2) An error detection code used in CD-ROM and CD-I to achieve high data integrity. See Form 1, Mode 1.

EXECUTABLE OBJECT CODE The output from a compiler's or assembler's linkage editor or linker, which is in the machine code for a particular processor, with each loadable program being one named file (module). In CD-I, such an object does not contain audio or video data. See executable code.

EXTENDED DISC In CD-I, a hypothetical disc that can exercise all the capabilities of an 'extended' system as defined by the CD-I extended system specification. The Base Case specification is a subset of the extended system specification.

EXTENDED SYSTEM In CD-I, a system conforming to Base Case specification, plus any extensions that conform to the 'extended' CD-I system specification.

EXTENSION (1) In CD-I, an upward compatible module to replace an existing system module in ROM. During initialization, all modules in CD-RTOS (except the protection modules) may be replaced by extended modules which have revision numbers higher than the ones they replace. (2) In CD-I, a hardware module supporting a functional extension conforming to the CD-I 'extended' system specification. During initialization, CD-RTOS identifies the extension and includes the software modules from it.

FADE See Fading.

FADE IN See Fading.

FADE OUT See Fading.

FADING Gradual reduction of a video or audio signal to zero (fade-out) or gradual increase from zero to normal level (fade-in).

FILE DESCRIPTOR RECORD In CD-I, all files have a sector called a file descriptor record. This contains a list of the data segments, their starting logical sector number (block number), size and file attributes.

FILE MANAGER In CD-I, a system software module which handles I/O requests for a class of similar devices.

FORM 1 The CD-I sector format with EDC/ECC error detection and correction. Equivalent to CD-ROM mode 1, but with the form identity included in a sub-header to permit interleaving of form 1 and form 2 sectors to meet the requirements of real-time operation.

FORM 2 The CD-I sector format with an auxiliary data field instead of EDC/ECC error detection and correction. Equivalent to CD-ROM mode 2, but with the form identity included in a sub-header to permit interleaving of form 1 and form 2 sectors to meet the requirements of real-time operation.

FRAME (1) In computing the array of bits across the width of magnetic or paper tape. (2) In an automatic switching telephone system, a complete cycle during which all the devices in a group are inspected by a common control system. (3) In a packet switching network, a complete sequence of bits identified by an opening synchronization character, and usually including a field containing the user's data. (4) In filming, an individual picture on a film, filmstrip or video. The size of the frame is determined by the limits of the camera aperture. (5) In television, a single television tube picture scan combining interlaced information. (6) In videotext, a page of data displayed on a terminal. (7) In artificial intelligence, a data structure for representing a stereotype situation; this concept may be useful in dealing with linguistic ambiguities which arise in machine translation. (8) In CD-DA, one complete pattern of digital audio information, comprising 6 PCM stereo samples, with CIRC and one subcode symbol, EFM modulated, with a synchronization pattern.

FRAME GRABBER (1) In recording, an electronic technique for storing and regenerating a video frame from a helical video tape signal. This method avoids the need for the continuous head to tape contact that would otherwise be required in freeze frame operation. (2) An electronic device for extracting a complete frame from a video signal and storing it in memory for further processing.

GLASS MASTER An optical master disc produced by exposing a photosensitive coating on a glass substrate to a laser beam, then developing the exposed coating and covering it with a silver coating. See CD-disc Master, CD Mastering.

GLOBAL DISSOLVE A dissolve affecting the whole of a video picture.

GLOBAL FADE A fade affecting the whole of a video picture.

GRACEFUL DEGRADATION (1) Failure of a computer system in terms of increasingly inadequate performance, rather than sudden breakdown. This occurs particularly in multi-user systems, and is often the result of increasing program complexity or growing user demand exceeding system capability, leading to unacceptably long response times and failure to handle update routines. 2) In CD-I, degradation of audio or video quality due to increasing error content.

GREEN BOOK Informal name for CD-I specification.

GREEN DISC Synonymous with CD-I disc.

HARDWARE CO-PROCESSOR See co-processor.

HEADER FIELD In CD-ROM or CD-I, that part of a data sector containing the absolute sector address and mode byte.

HI FI QUALITY In CD-I, the second sound quality. A bandwidth of 17kHz is obtained using 8-bit ADPCM at a sampling frequency of 37.8kHz. Comparable with LP record sound quality. See Audio Quality Level.

HIGH RESOLUTION (1) The degree of detailed visual definition (800x600 pixels) that gives readable 80 column text display. The monitors used with professional computers normally have high resolution, as will the new generation of enhanced-quality TV's. (2) In CD-I, a display resolution mode of 768 pixels (horizontal) by 560 pixels (vertical). See Enhanced-Quality TV. Compare normal resolution.

HIGH RESOLUTION TV See Enhanced-Quality TV.

HIGH SIERRA GROUP An ad-hoc standards group set to recommend compatible standards for CD-ROM. The group includes representatives from the hardware, software and publishing industries, and was named after the hotel in Lake Tahoe where it first met in the summer of 1985.

HORIZONTAL LINE UPDATE The modification of all or part of a single line in a video image.

HORIZONTAL RETRACE PERIOD Time during which the horizontal line scan on a TV screen returns to the beginning of the next line.

HRTV High-resolution TV. Synonymous with high-definition TV. See Enhanced-Quality TV.

IMAGE PLANE (1) In photography, the plane, perpendicular to the optical axis of a lens, at which an image is formed by the lens. This plane is normally coincident with the plane occupied by the emulsion surface of a film. (2) In multiplane video representations, more than one image can be combined in different ways to create a single image in real-time. The CD-I system has a maximum of five image planes including the cursor and backdrop plane.

INFORMATION CARRIER Any medium by which information is carried from its point of origin to its point of use, e.g. magnetic tape, Compact Disc, transmission line, broadcasting channel, or paper.

INFORMATION CHANNEL In CD-I, a real-time record may contain several information channels. This is done to minimize the amount of disc space wasted by gaps between audio blocks and to associate an audio sequence with its accompanying visual sequence.

INTELLIGENT PLAYER A CD player or LaserVision drive with additional computing facilities built in, enabling the player to interact with the user, or to operate under program control. CD-I players are intelligent players. See Intelligent Device.

INTERACTIVE LASERVISION A system which employs a LaserVision drive and a (micro) computer, either built-in or external, to run interactive programs from a CAV type LaserVision disc.

INTERACTIVE LEARNING Form of education using interactive media. The pupil learns by interacting with the medium, which fulfills the role of teacher.

INTERACTIVE MEDIUM Medium which presents information in such a way that, by means of an application program, it is delivered in the course of a dialogue with the user. The application program may also be included in the medium. Examples include Interactive LaserVision and CD-I.

INTERACTIVE MODE Presentation of information in a sequence determined by a dialogue between the information medium and the recipient. Examples include CD-I and Interactive LaserVision. Compare linear mode. See Interactive Medium.

INTERACTIVE SYSTEM A system of using an interactive medium to supply information to the user.

INTERCHANGEABILITY The characteristics that make it possible to change components of a system for other components from a different source, and still obtain performance within the system specification. For example, all compact cassettes and cassette recorders are interchangeable, as are CD-DA and CD-I discs and players.

INTERLACED SCANNING Picture scanning using two fields, the lines of the second field being interposed between those of the first.

INTERLEAVING (1) In computing, the act of accessing two or more bytes or streams of data from separate storage units simultaneously. Also, the alternating of two or more operations or functions at the same time from one computer. (2) In computing, the spacing out of logical sectors along the physical sectors of a disk track. In cases where it takes longer to process the data in a sector than to read it, interleaving minimizes access time. Depending on the processing time required, a delay equivalent to one or more disk revolutions is introduced between successive logical sectors. (3) In CD-I, the interspacing of sectors at intervals that correspond to the nature of the data. For audio, a regular interspaced pattern is used which depends on the sound quality level required. The subheader indicates the interleaving pattern at file, channel and data type levels.

INTERNATIONAL STANDARD RECORDING CODE Code used by record manufacturers. Gives information about country of origin, owner, year of issue and serial number of individual music tracks. May optionally appear in CD-DA subcode.

I/O FUNCTIONS In CD-I, the transfer functions Read and Play which perform the physical transfer of data from the disc.

JOYSTICK (1) In visual display units, a rotary lever which enables an operator to alter or move images on the display. (2) In filming, a device connected to a cable for remote lens control.

KERNEL In computer programming, (1) that part of an operation system that must always be in main memory when any part of it is loaded. It comprises the routines that perform basic loading and supervisory functions, (2) that part of a segmented program that must always be in main storage when any other segment is loaded.

KEY CONTROLLER A control unit with keys. For example, a remote control unit for a TV set.

LASER DISC Strictly, any disc recorded and read by a laser, but in general usage a LaserVision disc.

LASERVISION Optical videodisc system developed by Philips for reproducing color video pictures and 2-channel sound. Uses the same optical readout principle as Compact Disc, but the discs are larger (20 or 30 cm) and may be double-sided. The speed of rotation and the data rate are also higher. The program information is analog, although the control information is digital.

LASERVISION DISC 30 or 20 cm diameter, single or double-sided optical disc for the LaserVision system.

LEAD-IN TRACK In CD, a track on the disc before the program tracks. Contains the Table of Contents.

LEADING-EDGE TECHNOLOGY The most advanced technology available in a particular field. Capable of leading to further progress either in its own field, or another.

LEAD-OUT TRACK In CD, a track on the disc following the program tracks.

LIGHT PEN (1) In computer graphics, a light sensitive device that is shaped like a pen and connected to a VDU. The tip of the light pen contains a light sensitive element which, when placed against the screen, will register a pulse from the scanning spot. A coincidence pulse is generated from which a computer can identify the location of the pen on the screen. (2) In optical disc, the laser unit complete with optics and photodiodes.

LINE MULTIPLICATION A technique used in CD-I to make high-resolution line information compatible with a lower-resolution system.

LINEAR MODE Presentation of information in a fixed sequence, uninfluenced by the recipient. Examples include films and TV programs. Compare Interactive Mode.

LINE UPDATE In information presentation, the modification of single line, or part of a line, of graphics stored on a file.

LOAD TIME In video, the time taken to put a complete picture on the screen.

LOCAL DISSOLVE A dissolve affecting a portion of the image.

LOCAL FADE A fade affecting a portion of an image.

LOW RESOLUTION A degree of detailed visual definition below the normal domestic color TV sets.

LV See LaserVision.

MAGNETIC MEDIUM Magnetically sensitive carrier for the storage and distribution of information, e.g. hard disc, floppy disc, compact cassette, video cassette.

MASTER DISC An original disc, from which copies can be made by a replication process.

MASTERING In optical disc, the production of the master disc.

MAIN CHANNEL In CD-ROM and CD-I, the only accessible, absolutely addressable, information channel recorded on a disc. In CD-DA, the main channel carries the digital audio (music) information. Compare a subcode channel.

MEDIA (1) In computing, the material on which data and instructions are recorded, e.g. magnetic disc, paper tape, floppy disc, magnetic tape, punch cards, etc. (2) In communications, the means whereby information is conveyed within the communications industry: book, cinema, newspaper, radio, TV.

MEDIUM (1) A physical means to represent information for or transfer e.g. tape, disc or paper. (2) A means of communicating information, e.g. video, audio, printed publications.

MEMORY Synonymous with storage. Any facility for holding data. Often used alone to describe main or internal memory, in which case a distinction must be made from external memory. See Back-up Memory, Random Access Memory, Read Only Memory, Tape Memory.

METAL FATHER A recording mould formed by nickel plating on a master disc. Can be used directly for replication, or as the basis for the production, by two further stages of plating, of stampers for large-quantity production.

MENU (1) In computing and interactive systems, a display of a list of available functions for selection by an operator. (2) In videotext, a list of up to nine choices on a page for selection by a user for routing to various parts of the database.

MENU-DRIVEN The course of events in an application program, interactively controlled by means of menu selections.

MID FI QUALITY In CD-I, the third sound quality. A bandwidth of 17kHz is obtained by using 4-bit ADPCM at a sampling rate of 37.8kHz. Comparable with FM broadcast sound quality. See Audio Quality Level.

MODE 1 One of the two physical sector formats defined for CD-ROM. Incorporates EDC/ECC error detection and correction.

MODE 2 One of the two physical formats defined for CD-ROM. Incorporates an auxiliary data field instead of EDC/ECC error detection and correction.

MODE BYTE In CD-ROM, the byte in the header field of a sector that defines whether a sector is mode 1 or mode 2.

MOSAIC GRAPHICS In CD-I, low-resolution graphics achieved by repeating pixels or lines by a certain factor.

MOTHER In disc replication, a negative mould intermediate between metal father and stamper. Formed by nickel plating on the metal father. See Metal Father.

MOUSE In computing, a palm sized unit equipped with a number of control buttons, used to manipulate a screen display and invoke utility functions. The mouse is rolled over a tablet surface and the movement of the ball is measured and fed to the computer. Control of functions are invoked by moving the mouse to designated tablet areas or pressing the button. It may be employed to input graphics or to manipulate text on displayed documents, e.g. scrolling, cut and paste.

MULTIMEDIA SYSTEM (1) In computer, a system architecture based on the use of different media to carry the data and application programs. In a CD-ROM system, for example, the data is carried on a CD-ROM disc, while the application program is stored on a magnetic medium such as floppy disc.

(2) An information presentation system using more than one medium. Examples include book-audio tape combinations for language learning, and teletext sub-titling of television programs.

MULTIPLANE A video image in which different pictures are overlaid on top of the other.

NATURAL IMAGES See natural pictures.

NATURAL PICTURES In video, pictures of real-life subjects.

NEW MEDIA Media now becoming available, or envisaged as becoming available, for mass information presentation. Examples include CD-ROM for use with home and personal computers, and CD-I and LaserVision which use dedicated drives. Principle advantages lie in the fast access times which make interactive applications possible, and very high storage capacities. These open the way to increasingly sophisticated applications.

NON-LINEAR QUANTIZATION Quantization using steps of different sizes, to distribute the steps more efficiently over the dynamic range. Takes advantage of the fact that quantization errors are less perceptible when signal changes are large.

NORMAL RESOLUTION (1) The degree of detailed visual definition (600x300 pixels) presented by domestic television receiver screens. (2) In CD-I, a display resolution mode of 384 pixels (horizontal) by 280 pixels (vertical).

OMNI PLAYER A combined Compact Disc Laser Vision player that can also play CD-I discs.

OPTICAL DIGITAL DISC An optical disc in which information is stored digitally. May be a read-only disc, replicated from a master, e.g. a Compact Disc, or a disc that is written by the user, e.g. DOR.

OPTICAL DISC A disc in which information is impressed as a series of pits in a flat surface, and is read out by optical means, i.e. by a laser.

OPTICAL INPUT In optical media, the light signal before it is converted into an electrical signal.

OPTICAL MEDIUM Medium employing optics for the storage and distribution of information, e.g. DOR, LaserVision.

OPTICAL RECORDING The recording of information in such a way that it can be read by a beam of light. Modern optical recording technology is almost entirely concentrated on the use of low-power lasers to write and read information on optical discs. Optical disks can carry very large amounts of information per unit volume. They are highly resistant to damage and immune to electromagnetic influences. Access to information is fast and error rates can be made very low. Laser read-out completely eliminates wear during use. DOR, Digital Optical Recording systems can write and read digital data (though at present without any erasure facility). Their principle application is in large-scale archiving. Rapid developments are being made in read-only optical recordings systems, which include CD-DA, CD-ROM, CD-I and LaserVision.

OPTICAL STORAGE Storage of information in such a way that it can be read using optics. Characterized by very high storage density.

OPTICAL TECHNOLOGY Technology based on the use of optical effects for the transmission or storage of information.

OS-9 The real-time operating system which forms the basis for the CD-I operating system CD-RTOS.

OVERLAY Laying an image from one source on top of an image from another source.

OVERLAY CONTROL In CD-I, the mechanism which controls transparency between planes.

PALETTE In video, a range of colors analogous to those in a painter's palette. In CD-I, a palette is used by the User Communications Manager to support the Color Look-up Table. The maximum size of the palette at any instant in time is 256 colors, with the red, green and blue components each defined to bit accuracy.

PARTIAL UPDATE In information presentation, the modification of part of the text, graphics or natural image displayed on a screen.

PAUSE (1) In audio, a temporary interruption of recording or playback. (2) In computing, an interruption in program execution.

P CHANNEL One of the eight Compact Disc subcode channels (P-W). The P channel carries the music flag, indicating presence or absence of a music track.

PCM (1) A pulse-code-modulated audio signal. (2) In CD-DA the audio signal after the first stage of encoding, i.e. a multiplexed signal with six 32-bit stereo samples in each audio frame.

PICTURE ELEMENT (1) In computer graphics, the smallest element of a display space that can be addressed. A picture element will have one or more attributes of color, intensity and flashing. (2) In optical character recognition, an area on a document which coincides with the scanning spot at a given moment. (3) In micrographics, the area of the first detail that can be effectively reproduced.

PITCH In acoustics, the frequency of a sound wave.

PIXEL Synonymous with picture element.

PIXEL MULTIPLICATION In CD-I, a technique used in decoding pictorial information to make high-resolution pixel information compatible with a lower-resolution system.

PLANE In video, one layer of a bit-mapped display.

PREDICTION FILTERS The filters used in ADPCM encoding to achieve effective response to audio frequency distribution fluctuations.

PRE-EMPHASIS (1) In video recording, pertaining to the amplification of the high frequency components of the video signal prior to the frequency modulation process. (2) Increasing the level of certain signal frequencies relative to the other frequencies prior to recording or broadcasting, in order to preserve overall frequency definition. Subsequent de-emphasis during reproduction reduces the pre-emphasized frequencies to their proper level. Used to improve signal-to-noise ratio.

PRE-MASTERING In recording, the process in which basic program material is processed to produce a master tape. In CD-I and interactive Laser Vision, the stage between authoring and mastering.

PROGRAM-RELATED DATA In CD-I, the data concerning the application. Includes the data modules containing the executable object code for the CD-I processor as well as all application data other than audio and video data, e.g., data representing system text or phonetically encoded speech.

PULSE CODE MODULATION Technique for converting analog information into digital form. The analog signal is sampled at a rate equal to at least twice the maximum signal frequency component, and the sampled value is represented by a fixed length binary number. This number is then transmitted as a corresponding set of pulses. In telephony, the sampling rate is 8000 times per second. In CD-DA, the sampling rate is 44,100 times per second and the binary numbers are 16 bits long. Thus a stereo sample is 32 bits long; it is structured into four 8-bit symbols, with left and right channel symbols interleaved, 6 stereo samples (24 symbols) make up one CD audio frame.

Q CHANNEL One of the eight Compact Disc subcode channels (P-W). The Q channel carries the main control and display information. It identifies tracks, indexes and running times, and the absolute playing time of the disc. It also indicates whether the recorded information is audio or data, whether pre-emphasis is applied and whether digital copying is permitted. It can also indicate 2 or 4 channel audio, should 4-channel audio be introduced. Optionally, it can include a disc catalogue number and ISRC information. Finally, it includes its own CRC (Cyclic Redundancy Check).

QUANTIZE In communications, to assign one of a fixed set of values to an analog signal as part of an analog to digital conversion process, e.g. in Pulse Code Modulation, an analog signal is sampled, quantized and a corresponding set of binary pulses is produced. See Pulse Code Modulation.

R CHANNEL One of the eight Compact Disc subcode channels (P-W). At present only allocated to CD graphics.

RANDOM ACCESS MEMORY In computing, (1) a memory chip used with microprocessors, information can be both read from and written into the memory but the contents are lost when the power supply is removed, (2) any form of storage in which the access time for any item of data is independent of the location of the data most recently obtained, e.g. immediate access store has a random access capability but magnetic disc does not.

RANDOM AREA UPDATE In video, an area of any shape, updated as a succession of horizontal whole or partial line updates.

READ/WRITE MEDIUM A medium that can be both written (record) and read (playback). Magnetic media can generally be written, read, erased and re-written repeatedly. Optical carriers are at present read-only, or write once, read many times (WORM). Erasable optical discs are the subject of intensive research.

READ ONLY MEMORY In computing, a storage device whose contents can be changed by a particular user, by particular operating conditions or by a particular external process. Read Only Memory can include storage media where the writing action is inhibited by the operating system or by some mechanical device, e.g. a tag on a diskette. The term ROM implies a storage device not designed to be modified by conventional write procedures and which is used to store permanent information in computers and microcomputers, e.g. the operating system and BASIC interpreters are often supplied in ROM on microcomputers.

REAL TIME DATA In CD-I, data taken directly from the disc, whose flow cannot be interrupted or stopped within the bounds of a real-time data record.

REAL TIME DATA RECORD In CD-I, the smallest amount of real-time data that can be randomly accessed.

REAL TIME INTERACTIVE SYSTEM An interactive system which responds to events directly as they occur, i.e. in real-time. CD-I is a real-time interactive system.

REAL TIME OPERATING SYSTEM An operating system that functions within the constraints of real time, e.g. CD-RTOS, the OS-9-based operating system of CD-I. Such an operating system is essential for full interactivity.

REAL TIME SECTOR In CD-I, a sector with the real-time bit set. The data in this sector must be processed without interrupting the real-time behavior of the CD-I system.

RECTANGULAR UPDATE In video, update of a rectangular area, comprising the whole or part of the screen.

RED DISC Synonymous with CD-DA disc.

RED BOOK Informal name for the CD-DA specification.

REGION GENERATION In video, an overlay technique defining the overlay area separate from the image contents.

REPLICATION The production of copies from a master, usually for commercial distribution.

RETRIEVAL In computing, the process of searching for, locating and reading out data.

RGB ENCODING A video encoding technique used for graphics in CD-I. For each pixel, the primary colors (Red, Green and Blue) are each quantized and represented by 5 bits of information, giving 32 levels of intensity from one extreme value to each other.

RGB (5:5:5) A video encoding technique used for graphics in CD-I. For each pixel the primary colors (Red, Green and Blue) are each quantized and represented by 5 bits of information, giving 32 levels of intensity from one extreme value to the other.

ROTATE In film or video, the rotation of a picture, or portion of a picture, with respect to its original position.

ROTATIONAL LATENCY In disc drive system, the average delay time, caused by the disc rotation needed to gain access, between a request for read or write action and the commencement of that action.

RTOS See real-time operating system.

RUN LENGTH In a data stream, the number of bits between transitions.

RUN LENGTH CODING In digital video, an encoding technique which compresses the data required to store a given image by recording the values of distances between transitions or changes from one color or intensity to the next, as well as the values of the color or intensities between transitions.

RUNNING TIME In CD-DA, the time that an audio track has been running. Included in the subcode and thus available for display during playback.

S CHANNEL One of the eight Compact Disc subcode channels (P-W). At present only allocated to CD graphics.

SAFETY AREA The area on a display's surface over which visibility of text or graphics information is guaranteed. The safety area takes account of all allowable tolerances for display monitors and TV sets. It is always less than the total available screen area.

SCROLL In video, the continuous horizontal or vertical movement of the video information displayed such that, as old data disappears at one edge, new data appears at the opposite edge.

SECTOR The smallest unit of absolutely addressable information in a CD-ROM or CD-I disc. A sector is 2352 bytes long containing a synchronization pattern, header field and digital data. It may also contain a sub-header and EDC/ECC error protection. See Sector Structure.

SECTOR ADDRESS In CD-ROM and CD-I, the physical address of a sector expressed in minutes, seconds and sector number. Contained in the address part of the sector header.

SECTOR STRUCTURE In CD-ROM and CD-I, the 2352 sequential bytes of a sector may be divided in one of four ways, depending on the system and the degree of data integrity required. See form 1, form 2, mode 1, mode 2.

SEEK LATENCY Delay between a request for search action and arrival at the location sought.

SHRINK In filming and video, a visual effect in which one image becomes smaller and smaller until it is completely replaced by another.

SINGLE-MEDIUM SYSTEM In computers, a system architecture based on the use of a single medium which carries all the software needed for a given application. In CD-I for example, all the program data (video, sound, text and computer), application and driver software is held on the CD-I disc itself. Only the basic operating system kernel is stored - in ROM in the base case CD-I player - external to the disc. This is in contrast to cases where CD-ROM is used as a computer peripheral, and only the program (text or computer) data is held on VV, CD-ROM disc, all the applications, driver and operating system software being stored on separate magnetic media. Compare Multimedia System.

SOFTWARE DISTRIBUTION MEDIUM Device or material used for distributing pre-recorded software, e.g. floppy disc, Compact Cassette, Compact Disk, Laser Vision disc.

SOUND ATTRIBUTE In CD-I, a particular property assigned to all or part of the sound information, e.g. language, bandwidth.

SOUND GROUP In CD-I, part of the user data field in an ADPCM audio sector. Each ADPCM audio sector has 18 sound groups.

SOUND MACRO A predefined sound or sound sequence stored in computer form. For example, a standard set of words, such as the numbers from 1 to 100, or set of commonly occurring words such as "Yes", "No", etc.

SPEECH QUALITY In CD-I, the fourth sound quality. A bandwidth of 8.5kHz is obtained using 4-bit ADPCM at a sampling frequency of 18.9kHz. Comparable with AM broadcast sound quality. See Audio Quality Level.

SQUASH In filming and video, a visual effect in which one image appears to be pushed out from both top and bottom by another.

SQUEEZE In filming and video, a visual effect in which one image appears to be pushed out from both sides by another.

STAMPER A recording mould used to press gramophone records or optical discs.

STANDARDIZATION Agreement on technical specifications for use by different manufactures, e.g. standardization of connectors, TV signals and formats, international telephone networks, computers and peripherals, CD-DA format and encoding techniques.

STORAGE CAPACITY The amount of data a particular store can accommodate, generally specified in bytes. Storage can also be quantified in terms of the type of information stored. The over 660MB storage capacity of a Compact Disc, for example, can hold the data needed to reproduce over 160,000 pages of typed text, 72 minutes of the finest quality sound, or some 5000 video-quality natural pictures.

SUBCODE CHANNEL In Compact Disc, one of eight subchannels, referred to as P to W, which exist in parallel to the main channel. They are used for control and display information.

SUBHEADER In CD-I, a field indicating the nature of, data in the sector, thus allowing real-time interactive operation. See Sector Structure, Synchronization.

SUPERIMPOSE Place a computer-generated image over an image from another source. See Overlay.

SUPER TABLE OF CONTENTS In CD-I, synonymous with disc label; the information which is required to start up the CD-I player. Stored in the first track on the disc, it concerns the disc type and format, the status of the disc as a single entity or part of an album, the data size and the position of the file directory and bootstrap.

SWITCHING OVERLAY In video, a technique in which every pixel in the displayed image is selected from one or other of the corresponding source images.

SYMBOL In Compact Disc, the basic unit of digitized data, parity and subcode data. Initially 8 bits long, is expanded to 17 (14+3) bits by eight-to-fourteen modulation.

SYNCHRONIZATION The process of maintaining common timing and coordination between two or more operations, events or processes. In the CD-I system, featuring simultaneous pictorial, sound and text information, the synchronization of the various elements which form the total presentation is an essential task of, applications program, under the control of the CD-I operating system, CD-RTOS.

The data stream from the disc, which carries the information to be interpreted by a CD-I player for presentation on a video screen and reproduction by the hi fi system, consists of a series of sectors. A subheader at the beginning of each sector, directly following the data stream synchronization and header fields indicates to the CD-I controlling microprocessor the nature of the information in the user data block which directly follows the subheader information. This user data information can be part of the application program (or the boot or start-up information for the application). It can be data for interpretation by the video processor as pictorial information, or by the audio processor as audio information. Or it can be text or other program data to be interpreted by the main microprocessor.

Based on the indication contained in the sub-header, microprocessor switches the user data block to the appropriate circuit.

It is then the task of the application program to instruct the microprocessor how to handle the information once it has passed through the relevant decoding processes. In some cases, such as for CD-DA music tracks, the output data will be switched directly to the audio output channels.

In the cases of applications program or computing data, the information may well be stored in the main memory, while video data will pass to the video memory to build up a picture for later display.

The synchronization function of the application then relates the various outputs from these data buffers to data coming directly from the appropriate decoding circuitry, to ensure that they are all presented in correct synchronization.

SYNCHRONIZATION FIELD In CD-ROM and CD-I, the first 12 bytes of a sector containing synchronization information.

SYNCHRONIZATION SIGNALS In CD-I, real-time software interrupts, often generated by a device driver during hardware interrupt processing when a predefined condition has been met.

SYNTHESIS PARAMETERS The parameters used to regenerate audio information from data stored in a compressed or encoded format on media such as CD-I.

SYSTEM TEXT In CD-ROM and CD-I, a message processed by the operating system without the need to load and process any special text processing application program.

T CHANNEL One of the eight Compact Disc subcode channels (P-W). At present only allocated to CD graphics.

TABLE OF CONTENTS Information defining the sequential number, start, length and end times of tracks on a Compact Disc, together with their type, i.e. digital audio or data. The table of contents is contained in the Q sub-code channel of the lead-in area of all Compact Discs.

TEXT DATA In CD-I, data related to presentation of text as opposed to audio, video or computer data.

TRACK (1) In recording and computing, a path along which data is recorded, on a continuous or rotational medium, e.g. magnetic tape, magnetic disc. In video recording the track is diagonal on tape. In magnetic discs the data is recorded on a series of circular tracks. (2) In Compact Disc, a sequence of contiguous data, the beginning, length, mode and end of which are defined in the table of contents, which is held in the Q subcode channel of the lead-in area of the disc. The two types of tracks currently defined are the CD-DA track according to CD-DA specification and the data track according to the CD-ROM specification, which is also used in CD-I. In CD-DA the length of a track is related to playing times between 4 seconds and 72 minutes.

TRACK NUMBER The sequential number of a track.

TRACKING The following of a track by a readout or pick-up device.

TRANSITION (1) In filming and video, change from one image to another. (2) In facsimile, the change from black to white (vise-versa) as at the edges of letters. (3) In digital technology, change of state in a bit stream.

TRANSPARENCY BIT In CD-I, a dedicated bit controlling overlay transparency in the cursor plane and the RGB (5:5:5) plane.

TRIGGER BIT In CD-I, a bit in the subheader which generates an interrupt to synchronize application software, such as visuals to audio, and also real-time data.

U CHANNEL One of the eight Compact Disc subcode channels (P-W). At present only allocated to CD graphics.

USER COMMUNICATIONS MANAGER A CD-RTOS module used by an application to manipulate audio and video output devices and user input devices of CD-I players.

USER DATA In CD-ROM and CD-I, data supplied by an information provider for an application. As such, includes retrieval software, but not information the information provider may be required to supply to facilitate authoring.

USER DATA FIELD In CD-ROM and CD-I, a 2048-byte-long portion of the data field in an addressable sector, dedicated to user data.

USER INTERFACE The interface through which the user and a system or computer communicate. Includes input and output devices such as a keyboard, a hand control, a touch pad, a touch screen, a printer and a display, and also the software-controlled means by which the user is prompted to supply data needed by the application, and by which he is notified of his errors and how to correct them.

USER SHELL In computers, a program between the operating system and application program on the one hand, and the user of the other, to enhance the manner of information presentation and command.

V CHANNEL One of the eight Compact Disc subcode channels (P-W). At present only allocated to CD graphics.

VERTICAL RETRACE PERIOD Time during which the vertical field scan on a TV screen returns to the beginning of the next field.

VIDEO CHIP A dedicated integrated circuit, either in analog or digital IC technology, designed to fulfill specific video functions.

VIDEO DATA In CD-I, data related to one or more units of video information as encoded in DYUV, RGB, CLUT or run length encoding techniques.

VIDEO ERROR CONCEALMENT In digital video, a technique to reduce the visual effect of disturbances arising from erroneous video data.

VIDEO INPUT-OUTPUT The facility for video input as well as output from a computer. With frame grabbing, for example, video signals can be input to the computer for additional processing, and then output to the display. See Frame Grabber.

VIDEO QUALITY LEVEL The reproduction quality of a video signal. CD-I, for example, provides for four video quality levels.

VISUAL EFFECTS FUNCTION In CD-I, one of the set of functions, such as signal mixing and color palette control, used to achieve visual effects.

VOICE GRADE AUDIO INFORMATION Audio information of a quality sufficient for reproducing the human voice, normally having a bandwidth of 4-8 kilohertz. See Speech Quality.

VOLUME DESCRIPTOR In CD-I, that part of the disc label identifying a given disc.

VOLUME FLAG In CD-I, the field in the file structure descriptor containing the logical name of the CD-I disc.

W CHANNEL One of the eight Compact Disc subcode channels (P-W). At present only allocated to CD graphics.

WIPE In film and video, the change from one image to another by wiping out the first image according to a certain pattern, to reveal the second image.

WORLD DISC A CD-I disc on which the video data is encoded in such a way that it can be played and displayed on any CD-I player, irrespective of 525 or 625 line TV standard. Other optical discs, such as Laser Vision discs, are produced for a specific color TV system, e.g. PAL, SECAM, NTSC.

WORM See Write-Once, Read-Many(-times) medium.

WRITE-ONCE MEDIUM Medium in which data, once written, cannot be erased to permit re-writing, e.g. card, paper tape and DOR optical disc.

WRITE-ONCE, READ-MANY(TIMES) MEDIUM Synonymous with write-once medium.

WRITE/READ MEDIUM See read/write medium.

X-Y DEVICE Input device for entering X and Y coordinates, mainly used for accurate cursor positioning.

YELLOW BOOK Informal name for the CD-ROM specification.

YELLOW DISC Synonymous with CD-ROM disc.YUV In video, symbol denoting the luminance signal (Y) and the two chrominance signal (U and V). See YUV encoding.

YUV ENCODING A video encoding scheme taking advantage of the human eye's reduced sensitivity to color variations as opposed to intensity variations. In each picture line, the luminance (Y) information is encoded at full bandwidth, while on alternative lines the chrominance (U and V) signals are encoded at half bandwidth.

ZOOM In video and photography the facility to enlarge, (zoom-in) or diminish (zoom-out).

APPENDIX E - Glossary of Abbreviations

ADOC	Audio Digital Output Circuit
ADPCM	Adaptive Delta Pulse Code Modulation
APU	Audio Processing Unit
CD Unit	Compact Disc Unit
CDIC	Compact Disc Interface Circuit
CDM-9	Compact Disc Mechanism - 9
CLAB	Clock A-Chip to B-Chip I^2S Format
COX	Serial output clock from an external device
CSD	Configuration Status Description
CTS	Clear To Send
DAAB	Data A-Chip to B-Chip I^2S Format
DAC	Digital to Analog Converter
DOBM	Digital Output Bi-phase Mark Code
DOX	Serial data output
DRAM	Dynamic RAM
DSP	Digital Signal Processor
EFAB	Error Flag A-Chip to B-Chip
FTS	Favorite Track Selection
HF	High Frequency
I^2S	Inter-IC Sound: CLAB, DAAB, and WSAB
LDGU	Laser Detector Grating Unit
LL Test	Low Level Test
MISO	Master In Slave Out
MMC	Multi Media Controller Unit
MOSI	Master Out Slave In
NTSC	National Television Systems Committee
NVRAM	Non Volatile RAM
OPU	Optical Pick-up Unit
PAL	Phase Alternate Line
PCM	Pulse Code Modulation
RAM	Random Access Memory
RGB	Red, Green, and Blue Video Components of a color signal

ROM	Read Only Memory
RTS	Request To Send
SCAB	Subcode Clock
SCK	Serial Clock
SDAB	Subcode Data
SMPS	Switching Mode Power Supply
SOC	Serial Output Control SOPS Self Oscillating Parallel Switching Mode Power Supply
SOXENSOC	Serial Output Control enable signal from an external device: 0 - enables SOC 1 - disables SOC
SOXRQNSOC	ready indicator for the external device: 0 - SOC ready to shift data out 1 - SOC not-ready to shift
SPI	Serial Peripheral Interface
SPISS	Serial Peripheral Interface Slave Select
SRAM	Static RAM
TL	Track Lost
TOC	Table Of Contents
UART	Universal Asynchronous Receive Transmit
VCO	Variable Crystal Oscillator
VSC	Video and System Controller
VSD	Video Synthesizer Decoder
WSAB	Word Select
XIN	System Clock
XSYS	System Clock
Y/C	Luminance/Chrominance

APPENDIX F - CD-I Special Tools and Equipment:

Part Number:	Description:
~~4822 321 22267~~ (2) 4822 310 57179	10 Pin Extension Cable for Video Encoder Unit (2 required).
~~4822 321 22268~~ (2) 4822 310 57178	6 Pin Extension Cable for APU (2 required).
(1) 4835 310 57146	CD-I Prototype Disc (for testing CD-I functions).
4835 310 57147	Low Level Test Computer Cable.
4835 310 57148	Service Shell Jumper Plug.
4835 310 57151	Low Level Test Unit.
4835 395 17212	T-9 Torx driver.

Notes:

This section contains only two sections of the CDI910 service manual (Manual 5467). The Service Information section is divided into two sections. Section 2 contains the exploded views and Section 3 contains the schematic diagrams and circuit board layouts (see Service Information Contents below).

SERVICE INFORMATION CONTENTS