Service
Service
Service

The basics of Compact Disc Recordable and Compact Disc ReWritable (reference set is CDR870)

Circuit Description

Table of Contents

1. Introduction
2. CD-Recording discs
3. The CD-Recordable/ReWritable Audio Recorder

Published by JO 9862 Service Disc Systems Printed in The Netherlands Subject to modification

GB 4822 725 25242

PHILIPS

Philips Sound & Vision

CDR870

Philips CD-Recorder

The fulfilment of a long-standing wish: with this Philips CD-Recorder, you can make your own audio CDs, on your home audio installation. Compilations made from your favourite music will play back, in the original sound quality, not only on the CDR 870 itself, but also on your car CD player, sound machine, portable CD player, or any other CD playback device.

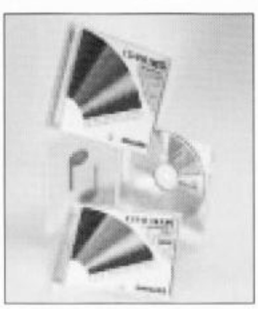
The CDR 870 gives you the choice of creating your own CDs on 'write-once' CD-Recordable discs or on re-usable CD-ReWritable discs, all at once or in sessions.

- **Records and plays CD-Recordable and CD-ReWritable discs; plays all audio CDs**
- **Records from all home stereo analogue and digital sources**
- **Optical and coaxial digital input and output**
- **Automatic sample rate conversion from 32 and 48 kHz to 44.1 kHz**
- **Automatic or manual track numbering**
- **CD-Sync autostart recording from digital sources**
- **SCMS Serial Copy Management System**
- **Precision diecast mechanism**
- **1-bit Analogue-to-Digital converter**

Making your own CDs - the final functionality for your audio system

This unique Philips CD-Recorder gives you the capability, for the first time, to make your own top-quality audio CDs, on either 'write-once' CD-Recordable discs or re-usable CD-ReWritable discs. Subject to the digital copy constraints of the SCMS system, you can make CDs from all analogue or digital sources in your audio system. Discs can be recorded all at once, or in stages, known as 'sessions'.

Just as on a prerecorded CD, you can put track numbers on your own discs, automatically or manually, depending on the source and your own preference. And when 'finalized' for playback, these discs behave in exactly the same way as your regular prerecorded CDs.



CD-Recordable - The 'Write-Once' Discs

Blank CD-Recordable (CD-R) discs feature an organic dye layer for recording, applied over a substrate containing a wobbulated 'pre-groove' to guide the laser beam. The 'pre-groove' is FM modulated with time code and other disc information. The average wobbulation frequency is used to control the turntable speed, while the time code is used to position the recordings on the disc. During recording, the laser forms 'bumps' in the dye layer, which have the same effect as the pits in a pre-recorded CD. When fully recorded and 'finalized', CD-R discs are fixed for life, and will play on all CD players and recorders.

CD-Rewritable - The Erasable And Reusable Disc

Blank CD-ReWritable (CD-RW) discs use 'phase change' technology for recording, and the same wobbulated 'pre-groove' principle. A low-reflectance domain of amorphous (or non-crystalline) phase, is produced when the laser heats the recording layer rapidly above its melting point of 500-700° C. Cooling quickly, this amorphous domain 'freezes' and becomes reflective. If, on the other hand, the recording layer is heated to a rather lower temperature for a somewhat longer time, a light-diffusing crystalline phase is formed. Because these changes are reversible, CD-RW discs can be erased and rewritten, at least a thousand times.

During recording, individual tracks can be erased; when fully recorded and 'finalized', these discs must be erased completely before re-use. Finalized CD-RW discs will play on all CD-RW-compatible CD players and recorders. Philips will start to make it's CD-players compatible with RW-discs in 1998.

Note: The CDR-870 is designed to use CD-R and CD-RW discs optimized for audio recording, and bearing these logos.CD-R and CD-RW discs produced specially for use with CD-R/RW computer drives are not suitable. The logo's on these discs do not contain 'Digital Audio'.

Analogue Recording

This is just like recording on to cassette tape. You adjust the record level control so that the loudest passages fill the blue section of the record level meter on the display, without going into the red overload section.

If you choose automatic track numbering, the CDR 870 inserts a new track number each time it detects a 3-second pause in the music. With manual track numbering, you can insert track numbers any place you like during recording. When the recording stops, the discs's temporary Table Of Contents is automatically updated, and when you come back to resume recording, the player automatically finds the end of the last recording session.

Digital Recording

No record level setting is required for digital recording; the level is regulated in the digital input signal.

If you choose automatic track numbering, the CDR 870 inserts track numbers directly from the source material.

With manual track numbering, you can

again insert track numbers any place you like during recording.

When the recording stops, the discs's temporary Table Of Contents is automatically updated, and when you come back to resume recording, the player automatically finds the end of the last recording session.

CD Sync Recording

With this ultimate convenience feature, recording starts automatically as soon as the source begins to play. CD-Sync Recording lets you record either individual tracks or an entire disc from any digital input, with automatic or manual track numbering.

SCMS

The CDR 870 incorporates the internationally-accepted SCMS Serial Copy Management System. With SCMS, only single direct copies of digital source material are permitted: it is not possible to copy digital copies.

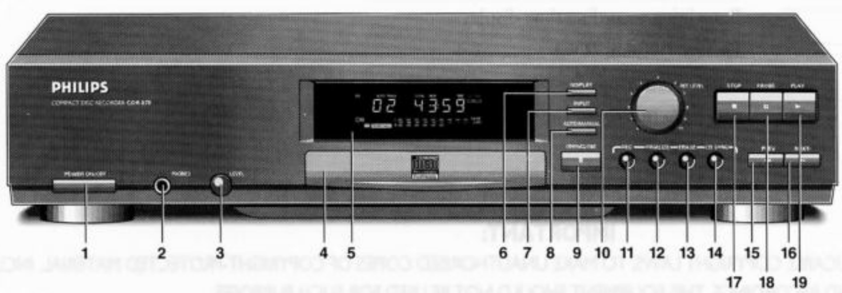
Finalizing A Disc

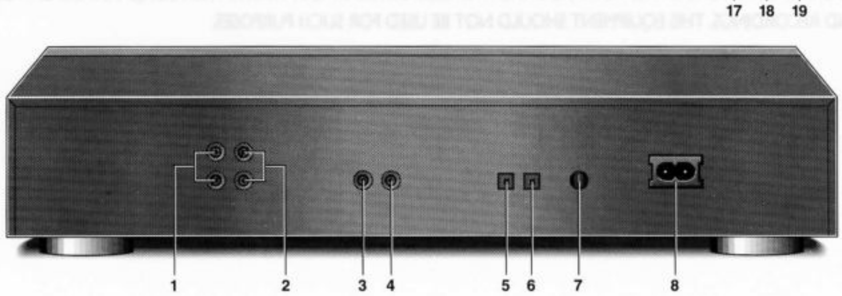
Finalizing a fully-recorded disc is a simple matter of pressing the Finalize key, followed by Record. Once initiated, the procedure is fully automatic.

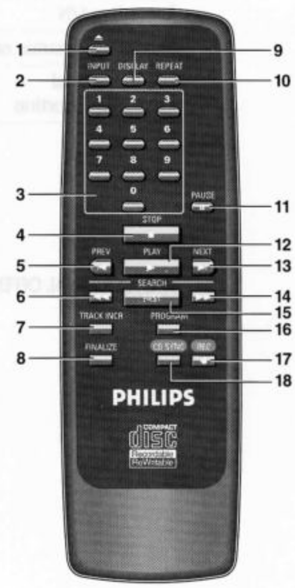
After finalization, discs will play on other CD players or recorders, but further music tracks cannot be added. CD-RW discs can be rewritten after they have been completely erased.

Playback

The CDR 870 has all the familiar CD playback features: play, pause, next and previous track, track selection by number, 2-speed fast forward and reverse search, and programmed playback.







Front

1 POWER ON/OFF
2 Headphone jack (PHONES)
3 Headphone level (LEVEL)
4 Disc tray
5 Display
6 OPEN/CLOSE
7 Record (REC)
8 FINALIZE
9 ERASE
10 CDSYNC
11 Previous track selection (PREV)
12 Next track selection (NEXT)
13 PLAY
14 PAUSE
15 STOP
16 Level Meter (analogue input)
17 AUTO/MANUAL track increment selection
18 DISPLAY indication selection
19 INPUT select

Rear

1 Analogue line input jacks
2 Analogue line output jacks
3 Digital input
4 Digital output
5 Optical digital input
6 Optical digital output
7 Voltage selector (not on all versions)
8 AC Mains input

Remote

1 OPEN/CLOSE
2 INPUT selector
3 Numeric buttons 0-9
4 STOP
5 PREVIOUS
6 Search reverse button
7 TRACK INCRement
8 FINALIZE
9 CDSYNC
10 REC
11 PROGRAM
12 FAST search button
13 Search forward button
14 NEXT
15 PLAY
16 PAUSE
17 REPEAT
18 DISPLAY indication modes

TECHNICAL SPECIFICATIONS CDR870

GENERAL

System	Compact disc digital audio
Number of channels	2 (stereo)
Applicable discs	CD, CD-R, CD-RW
Power supply	AC 230V (/00), 120V (/17), 120/230V (/11)
Power consumption	15W
Operating temperature	5-35°C
Weight	4 Kg
Dimensions	435 x 310 x 75 mm (w x d x h)

AUDIO

Frequency response	20 Hz - 20 kHz
Playback S/N	105 dB
Playback dynamic range	98 dB
Playback total harmonic distortion	85 dB
Recording S/N	90 dB
Recording dynamic range	95 dB
Recording total harmonic distortion	85 dB

Line output voltage	2 Vrms
Digital coaxial output	0.5V(pp)/75Ω
Digital optical output	-20 dBm
Headphones	0-5Vrms/8-2000Ω

Recording values for line input/output

Digital coaxial input (automatic sample rate conversion)	32-48 kHz
Digital optical input (automatic sample rate conversion)	32-48 kHz
Analogue input	700mVrms/50 kΩ

RECORDING FUNCTIONS

- Recording
- Auto start recording (Cdsync)
- Pause recording
- Erase last track (CD-RW disc)
- Erase disc (CD-RW disc)
- Manual track Increment
- Automatic track Increment
- Remaining recording time display
- Finalize (writing TOC)
- SCMS (Serial Copy Management System)
- RID code (Recorder Unique Identifier)

PLAYBACK FUNCTIONS

- Play
- Pause
- Stop
- Direct track selection
- Next/Previous track selection
- Search forward/reverse
- Fast search forward/reverse
- Repeat (all/1-track)
- Program play (20 tracks)
- Time display switching

ACCESSORIES

- Remote control (+batteries)
- Audio cable (x2)
- Digital coaxial cable (x1)
- AC mains cable

IMPORTANT:

IT IS A CRIMINAL OFFENCE, UNDER APPLICABLE COPYRIGHT LAWS, TO MAKE UNAUTHORISED COPIES OF COPYRIGHT-PROTECTED MATERIAL, INCLUDING SOUND RECORDINGS. THIS EQUIPMENT SHOULD NOT BE USED FOR SUCH PURPOSES.

Philips Sound & Vision
Business Unit Disc Systems
P.O. Box 80002
5600 JB Eindhoven
The Netherlands

http://www.philips.com

PHILIPS

Let's make things better.

The products and services described here are not necessarily available in all countries. Due to continuous product improvements this specification is subject to change without notice. Printed in the Netherlands. 08/97 3122 321 78132

DETAILED CONTENTS:

1	**Introduction**	**2**
1.1	**The CD-Recording system**	**2**
1.2	**The most important differences between CD-R/CD-RW discs and pre-recorded CDs**	**2**
1.3	**The requirements for the CD-Recording system**	**3**
2	**CD-Recording discs**	**3**
2.1	**The CD-Recording discs**	**3**
2.1.1	Dimensions	3
2.1.2	The structure	3
2.2	The principle of recording	4
2.2.1	The writing process CD-R	4
2.2.2	The Writing process CD-RW	4
2.2.2.1	Recording	4
2.2.2.2	Erasing	5
2.2.2.3	Overwriting	5
2.3	**The groove in the CD-Recording discs**	**5**
2.3.1	Dimensions	5
2.3.2	The wobble of the groove	5
2.3.3	The wobble modulation	5
2.4	**The requirements for the CD-Recording discs**	**6**
2.4.1	The unrecorded (blank) disc	6
2.4.2	The recorded disc	6
2.5	**Data Organization**	**6**
2.5.1	Power Calibration Area	6
2.5.2	Program Memory Area	6
2.5.3	Lead In Area	6
2.5.4	Program Area	6
2.5.5	Recordable User Area + Lead Out Area	6
2.5.6	The general linking rules	7
2.5.7	Misrecording	7
3	**The CD-Recordable/ReWritable Audio Recorder**	**8**
3.1	**Blockdiagram of a CD-Recordable/ ReWritable Audio recorder**	**8**
3.2	**The Mechanical part with its control systems**	**12**
3.2.1	The CD-Recording drive	12
3.2.1.1	The CDM mechanism	13
3.2.1.2	The CDM requirements	13
3.2.1.3	The 3-spots push pull system	14
3.2.1.4	shock sensitivity	14
3.2.1.5	focus radius	14
3.2.1.6	eccentricity	14
3.2.2	The CDM board	14
3.2.2.1	Laser Control	15
3.2.2.2	Optical Power Calibration	15
3.2.2.3	Normalizing	16
3.2.3	The Servo Functions	16
3.2.3.1	Turntable Motor Control in recording and play-back mode	16
3.2.3.2	Focus servo	16
3.2.3.3	Radial servo	16
3.2.4	The Wobble Processing	16
3.2.5	The Servo microcontroller	17
3.3	**The Electrical part**	**17**
3.3.1	The input part of the circuit with the ENCODER path	17
3.3.1.1	Digital In	17
3.3.1.2	Analogue Digital converter	18
3.3.1.3	Cross Interleave Read/Solomon Code to Eight-to-Fourteen-Modulation (CIRC EFM) Encoder	18
3.3.2	The output part of the circuit with the DECODER path	18
3.3.2.1	DAC analogue output	19
3.3.2.2	Digital output	19
3.3.2.3	Monitoring	19

1 Introduction

1.1 The CD-Recording system

The CD-Recording system consists of a CD-Recorder/player and the exchangeable software carrier CD-Recording disc. Most known CD systems, like CD-Audio, CD-ROM, CD-I CD-ROM XA, Photo CD, Video CD are pre-recorded systems, and lack the facility of recording as enjoyed by tape systems. This CD-Recording system addresses this deficiency.
Dependant to the applied disc carrier two different solutions are in use: CD-Recordable and CD-ReWritable.
CD-Recordable (CD-R), a so-called Write-Once principle, has the advantage of full compatibility with all pre-recorded CD systems.
CD-ReWritable is able to write, read and rewrite CD-ReWritable discs (CD-RW). CD-RW discs have a lower reflectance than standard CDs and therefore cannot be played-back by all today's CD players.
Above that both recording disc systems can be split to a Professional application (e.g. CD-ROM) and a Consumer (Audio) application.
Both applications have their own CD-Recordable and CD-ReWritable discs with appropriate logo, to comply with copyright legislation in various countries. The Audio CD-Recorder/player will only make recordings on CD-R and CD-RW discs bearing the appropriate 'Digital Audio' logo. These discs are subject to levies that are payable to the relevant copyright protection associations.
Concerning the lower reflectance of Audio CD-RW discs:
For CD-Audio players, from production 1998 onwards, Philips intends to extend all her future CD-Audio players so that they will be able to play Audio CD-ReWritable discs.
With the introduction of the CD-R/RW Audio Recorder at the end of 1997 both recording functions (Recordable and ReWritable) are combined in one Audio CD-Recorder/player.
This description assumes the knowledge of the conventional CD-Audio system.

1.2 The most important differences between CD-R/CD-RW discs and pre-recorded CDs.

The main physical difference between CD-R/CD-RW disc types and the pre-recorded CD is that the latter has no recording layer; the information is permanently stamped in the aluminium reflecting layer.
There is also a difference in terms of the data areas on the disc. Compared with standard CDs, there is a CD-R/CD-RW area that is located in front of the Lead-In Area. This additional area is used to store data specific to the recording process and is divided into the Program Memory Area (PMA) and the Program Calibration Area (PCA). In chapter 2.5 Data Organization these areas are explained in more detail. As long as recordings are made on the disc the Lead-In Area is not filled. At the moment the recording disc is converted into a standard CD-format, the PMA information is recorded in the Lead-In Area. This process is called 'Finalizing', because after this procedure no more recordings on this disc can be made.

1.3 The requirements for the CD-Recording system

The most important requirement for the CD-Recording system is to be compatible with the conventional CD-Audio system. The CD-Recording system has an added advantage to make an incremental recording. This means that a recording session can be interrupted at any time, and can be continued at a later time, possibly using a different recorder. The successive parts of information are recorded sequentially on the disc.

The Audio recorded disc is compatible with the CD-Audio system.
This is only true for the fully recorded CD-R disc, which means that the Lead-In Area has been recorded after the recording of the last track of the disc (Finalizing). For 'finalized' CD-RW discs (reflection) adapted players will play back these discs only.

The blank CD-Recording disc contains a sensitive layer of a material which has a reflection decrease if an effect (called a pit) is recorded by heating up the sensitive layer locally. The requirements for the recorded signals as well as for the rest of the disc parameters are basically the same as the CD-Audio system.
In other words, the CD-Recording system is fully compatible with the conventional CD-Audio system.

The Audio CD-Recorder/player is a CD-Audio player with the following basic functions:

- It can play back a disc of the existing CD-disc standard, so it is a player which is compatible with the Compact Disc system.
- It makes recording on the recording disc according to CD-Recordable or CD-ReWritable standard possible.
- It enables to play back a partially recorded disc.
- It records additional tracks on partially recorded disc.
- It makes a fixing up of a recorded disc to a compatible disc of the existing CD-disc standard (Finalizing).

Other main parameters are:

- Recording/playing time is equal to normal CD (max. about 74 minutes).
- Scanning velocity of the laser spot: Constant Linear Velocity (CLV) is 1.2 to 1.4 m/s.
- Disc diameter is 120 mm.
- CIRC/EFM encoding.
- Track pitch is nominally 1.6 μm. The Program Area is recorded between 50 and max. 116 mm diameter.
- Audio encoding: 2 channel stereo, 16 bit quantization, 44.1 kHz sampling frequency.
- Data encoding: block encoding with approximate user data transfer rate of 1.4 Mbit/s.

All these parameters are a contribution to guarantee the exchangeability between all Compact Discs and CD-Recording discs recorded on other CD-Recording players.

The CD-Recording disc has to meet with the mechanical and optical specifications lay down in the CD-Recordable and CD-ReWritable standard.

2 CD-Recording discs

2.1 The CD-Recording discs

Both CD-R and CD-RW discs have the same basic structure but with significant differences. The CD-R disc has a dye-based recording layer, with a reflectivity of 40 - 70%, while the CD-RW disc has a phase-change recording layer with a reflectivity of 15 - 25%. Both discs have an additional reflecting layer: golden for the CD-R, which accounts for that disc's distinctive appearance, and silver (aluminium) for the CD-RW.

2.1.1 Dimensions

In figure 1, 2 and 3 the dimensions of the unrecorded, partially recorded and recorded disc are drawn.

Layout_of_an_Unrecorded_Disc

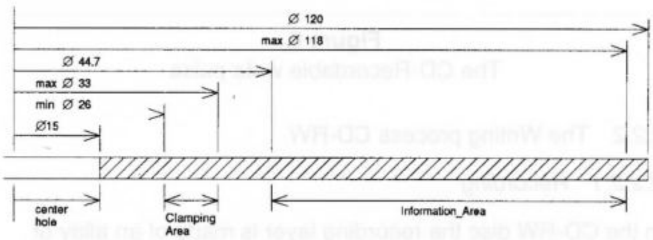


Figure 1
Layout of the unrecorded disc

The most important difference between the conventional disc and the recordable disc is the beginning of the Information Area. Between diameter 44.7 and 46 mm there is the information of temporary table of contents of the disc: PCA en PMA. See figure 2. The meaning of the PCA and PMA are explained in chapter 2.5: "Data organization".

Layout_of_a_Partially_Recorded_Disc

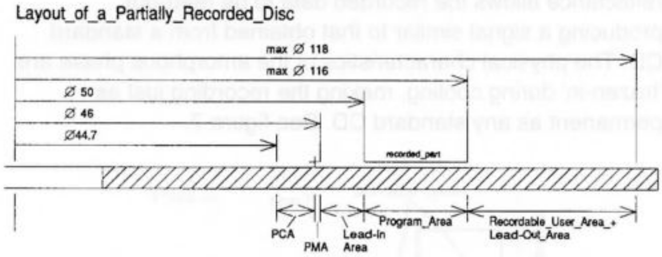


Figure 2
Layout of the partially recorded disc

The line above the disc surface indicates the recorded part.

After the fixing up of the disc the temporary table of contents is moved to the Lead-in Area of the disc. See figure 3.

Layout_of_a_Recorded_Disc

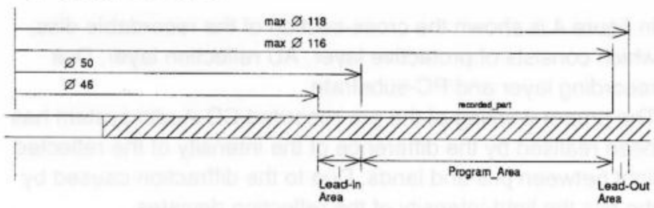


Figure 3
Layout of the recorded disc

The line above the disc surface indicates the recorded part.

2.1.2 The structure

The PC-substrate of the CD-Recording disc is basically the same as for a conventional pre-recorded CD.
In a pre-recorded CD, the reflection layer contains a spiral shaped track consisting of depressions, the so called: "pits". The aluminium reflection layer on top of this substrate contains the same pit pattern.
In the CD-Recording disc, the reflection layer contains a spiral shaped groove instead of pits. Later on the pits will be recorded 'under' this groove. On a blank disc, the groove is important because it enables rotational speed control, radial tracking control and time indication on the disc (see chapter 2.5, "Data organization").
Between the substrate and the grooved surface of the reflective layer (gold or aluminium) is the sensitive layer (an organic dye material). Additionally a protective coat and a label are used. A cross-section of a CD-R disc is drawn in figure 4. The substrate layer is of polycarbonate material: PC-substrate; the golden reflective layer is called AU-reflective layer;

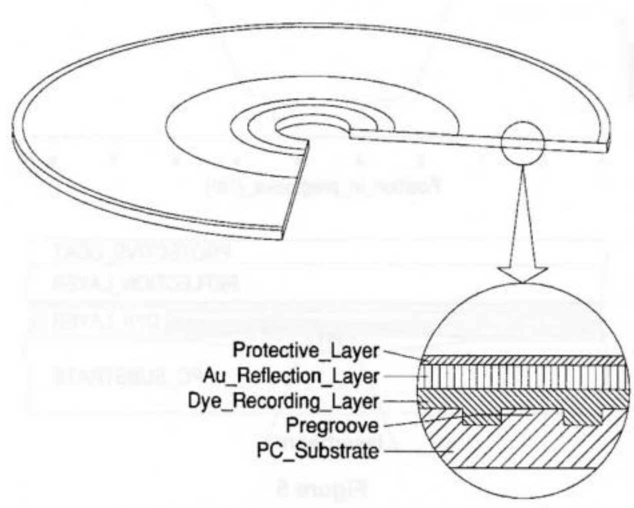


Figure 4
A cross section of the CD-R disc

2.2 The principle of recording

2.2.1 The writing process CD-R

In figure 4 is shown the cross-section of the recordable disc, which consists of protective layer, AU reflection layer, Dye recording layer and PC-substrate.
The proper working of the pre-recorded CD-Audio system has been realised by the difference of the intensity of the reflected light between pits and lands. Due to the diffraction caused by the pits the light-intensity of the reflection deviates.
If an unrecorded CD-R disc has been read the intensity of the laser beam is so low that nothing changes on the disc and almost all laser light will be reflected. With the reflected information the position of the laser-spot with respect to the pregroove will be detected and the pregroove track will be followed.
In the recording mode the intensity of the laserlight is at the same intensity to read and follow the pregroove information. On that location where a pit should be written the intensity of the laserlight will be increased to a high level. Now all laserbeams will be reflected by the AU-reflection layer. The energy of the laserlight (in the range 4 - 11mW) causes limited heating of the Dye recording layer and the PC-substrate to approximately 250°C. At this temperature the recording layer melts reducing its volume, while the substrate expands into the space that becomes available. By constant switching between writing and reading power, a pit pattern corresponding to that of a pre-recorded CD is produced.

The write pulse initially has a higher power to produce the required heating of the dye. Subsequently, the power is reduced to a level that is sufficient to maintain the dye temperature at the desired level. (See also detailed information at paragraph 3.2.2.2. Optical Power Calibration)

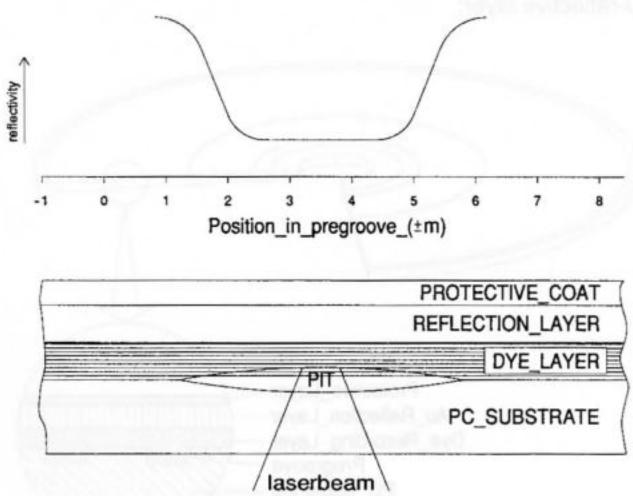


Figure 5
The principle of recording on CD-R disc

The write pulse initially has a higher power to produce the required heating of the dye. Subsequently, the power is reduced to a level that is sufficient to maintain the dye temperature at the desired level. (See also detailed information at paragraph 3.2.2.2. Optical Power Calibration)
See figure 6.

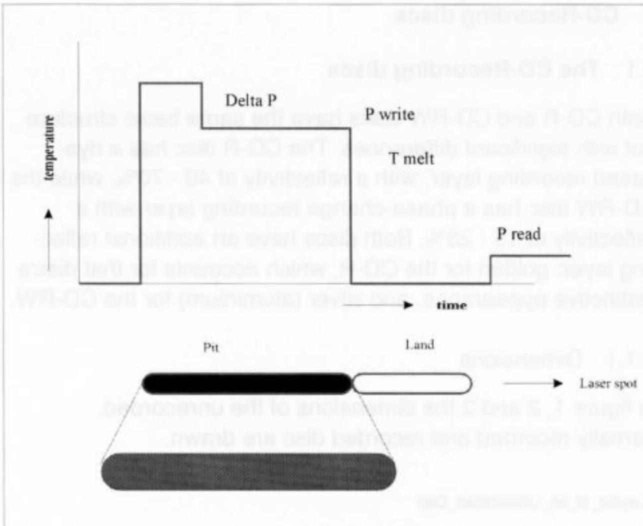


Figure 6
The CD-Recordable write pulse

2.2.2 The Writing process CD-RW

2.2.2.1 Recording

In the CD-RW disc the recording layer is made of an alloy of silver, indium, antimony and tellurium. In its original state, this layer has a polycrystalline structure. During the recording process, the laser selectively heats tiny areas of the recording track to a temperature above the layer's melting point (500 - 700°C). For CD-RW writing, the laser power used is in the range 8 to 14mW.
The pulsed energy delivered by the laser beam melts the crystals in the heated areas into a non-crystalline amorphous phase ('pits'), which has a much lower reflectance than the remaining crystalline areas ('lands'). This difference in reflectance allows the recorded data to be read-out, producing a signal similar to that obtained from a standard CD. The physical characteristics of the amorphous phase are 'frozen-in' during cooling, making the recording just as permanent as any standard CD. See figure 7.

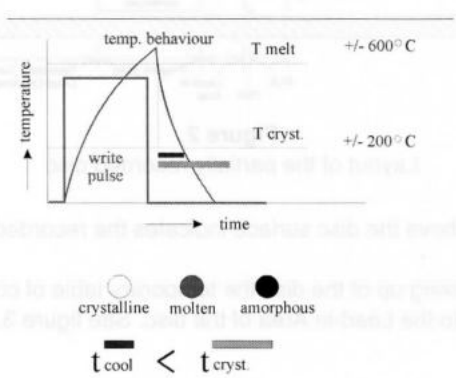


Figure 7
CD-RW writing

2.2.2.2 Erasing

Erasing of a CD-RW disc is performed by returning the material in the recording layer which has been changed to the amorphous state back to the crystalline state. This is done by an annealing process, consisting of heating the layer to a temperature of about 200°C (= less than melting point) and maintaining that temperature for an extended period. The disc is than returned to its original, completely unrecorded state. This function is called **DC-Erase** and takes about 37 minutes for a complete disc. See figure 8.
A much faster 'on the fly' erasing facility is also available, allowing the last recorded track to be erased simply by erasing the subcode reference to that track while leaving the recorded data in place in the recording layer.

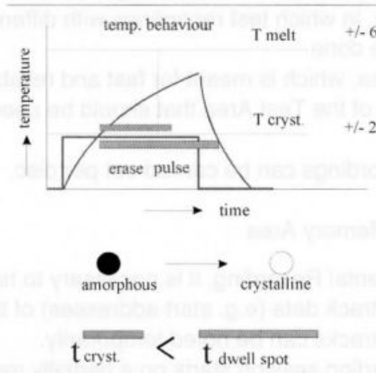


Figure 8
CD-RW erasing

2.2.2.3 Overwriting

A direct overwrite strategy is obtained by combining the write and erase technologies. In this case, new pits are written in the recorder layer using the same pulsed laser beam energy as in the recording strategy. However, in the areas between the newly recorded pits, a lower-energy, non-pulsed laserbeam is switched to the lower-energy erase level between the new pits, resulting in complete erasure of the audio data that was formerly contained on these areas.
As in the writing of a CD-R disc, a higher energy level is used initially to create the temperature increase required to melt the recording layer. Between the pits, the temperature is reduced to the erase level. This provides a higher starting temperature, so less energy is subsequently needed each time the melting temperature has to be reached. See figure 9.

2.3 The groove in the CD-Recording discs

2.3.1 Dimensions

In a conventional CD system the spiral shaped track with pits is used for radial tracking, rotational speed control and time indication. As there are no pits in the blank CD-R disc, the groove in the substrate is used for the same purposes.
The typical dimensions of such a groove are:

- width : 600 nm
- depth : 100 nm
- profile : U-shape

A groove with these dimensions can be used for radial tracking of the laser spot.

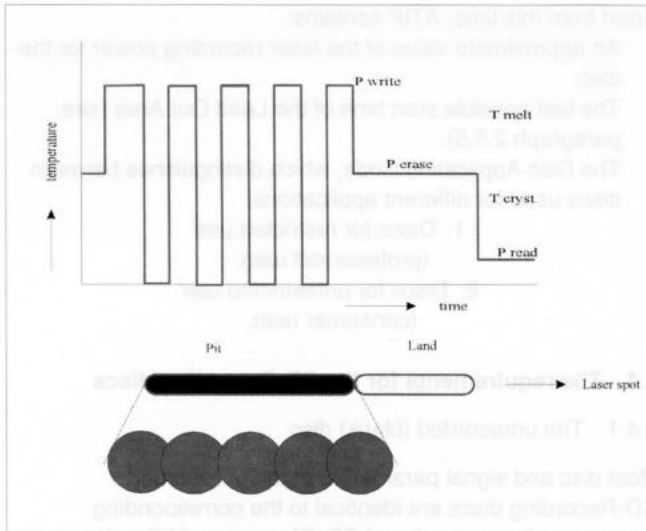


Figure 9
CD-RW overwriting

2.3.2 The wobble of the groove

The groove is not a perfect spiral. It deviates from the ideal spiral shape with a sine wave. The amplitude of this sinusoidal radial deviation is typically 30 nm, and the spatial period is about 60 µm. This wobbling of the groove is visible in the reflected read out light beam (more specific: in the radial tracking error signal derived from it). By locking the wobbling read out signal to a specified frequency of 22.05 kHz, the disc will rotate at the correct rotational velocity.

2.3.3 The wobble modulation

The groove is not wobbled with a constant period of the sinewave. Around the average frequency of 22.05 kHz it is additionally modulated in frequency with a deviation of ± 1 kHz. By adding this modulation to the groove wobble, additional information is stored in the disc. The most important information is the absolute time, which increases monotone from inside to outside the diameter of the disc. This is called ATIP: Absolute Time In Pregroove.

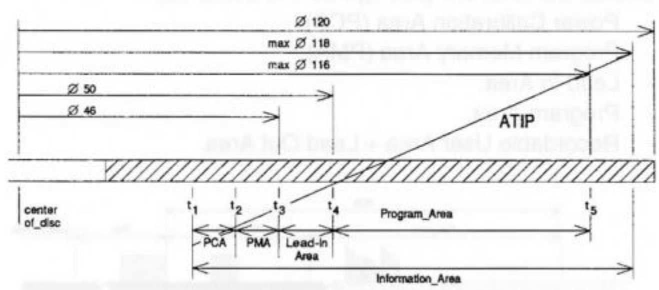


Figure 10
ATIP versus disc diameters

Apart from this time, ATIP contains:
- An approximate value of the laser recording power for the disc.
- The last possible start time of the Lead Out Area (see paragraph 2.5.5).
- The Disc Application Code, which distinguishes between discs used for different applications:
  1: 'Discs for restricted use' (professional use).
  2: 'Discs for unrestricted use' (consumer use).

2.4 The requirements for the CD-Recording discs

2.4.1 The unrecorded (blank) disc

Most disc and signal parameters of the unrecorded CD-Recording discs are identical to the corresponding parameters for conventional CD. The main additional requirements, related to the recording capability of the disc, are in the write condition the optimum recording power and the wavelength of the recording spot. The reflection in the unwritten part should be approx. 70%.

2.4.2 The recorded disc

The recorded disc fulfils all requirements of conventional CD system.
The main additional requirements, related to the recording capability of the disc are in the read condition the normal reading power and the wavelength of the recording spot. The reflection of the land should be approx. 70% and the written part (pit) should be approx. 30%. It is about this reflection the CD-ReWritable disc is deviating from the original standard. Updating of standard has been realized, CD players have to be adapted accordingly.

2.5 Data Organization

The CD-R disc is divided into five different area's. This chapter describes what the purpose of each area is, which data should be recorded in it, and in what sequence the data should be recorded. The five different area's, from inside to outside diameter are (see figures 1 to 3 and 10):
- Power Calibration Area (PCA).
- Program Memory Area (PMA).
- Lead In Area.
- Program Area.
- Recordable User Area + Lead Out Area.

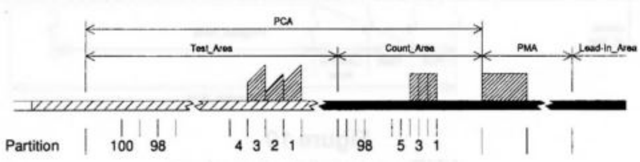


Figure 11
Organization of the PCA, PMA and Lead In Area

On this disc there is an incrementally, partially recorded CD-R disc. The hatched area's are recorded parts of the disc.

Since Incremental Recording (or interrupted recording, see chapter 1.3 "The requirements for the CD-Recording system") is possible, there are requirements for the linking of the different successive recordings.

Also there are requirements for the synchronization between the ATIP time in the groove, and the time encoded in the recorded data.
To prevent misrecordings some hints are given at the end of this chapter.

2.5.1 Power Calibration Area

The PCA is reserved for obtaining the exact optimum recording power for the disc. Using the exact laser recording power improves system margins. At the start up of a recording session, the recorder checks in its memory whether it has already determined the exact power for this particular disc. If not, the procedure for determining the exact power is started.
The PCA is divided into two area's (see figure 11):
1: The Test Area, in which test recordings with different laser powers can be done.
2: The Count Area, which is meant for fast and reliable read out of the part of the Test Area that should be used next.

In total 99 testrecordings can be carried out per disc.

2.5.2 Program Memory Area

In case of Incremental Recording, it is necessary to have an area in which the track data (e.g. start addresses) of the already recorded tracks can be noted temporarily.
When a new recording session starts on a partially recorded disc, all necessary data can be read from this PMA (see figure 11).
The PMA may contain three types of data:
1: Track numbers with their start and stop times. This is the temporary table of contents for the partially recorded disc.
2: Disc Identification. A six digit number can be noted in the PMA to identify each individual disc. This identification number can be used e.g. to avoid repeated fixing of the optimum recording power (see paragraph 2.5.1 "Power Calibration Area").

2.5.3 Lead In Area

The description of this area is basically the same as the one used in conventional CD. It contains the Table of Contents of the finalized recorded disc. Additionally, some extra information like the identification of the disc might be encoded.

2.5.4 Program Area

This is the area where the Audio tracks have been recorded (see figure 2 and 3). The specification of this area is basically the same as the one used in conventional CD. Only the Copy bit is used to indicate a first or higher generation copy of a Copyright protected track.

2.5.5 Recordable User Area + Lead Out Area

The Recordable User Area is the remaining unrecorded (blank) area of the disc where additional tracks can be recorded (see figure 2). The Lead Out Area marks the end of the Program Area. The specification is basically the same as in conventional CD's.

2.5.6 The general linking rules

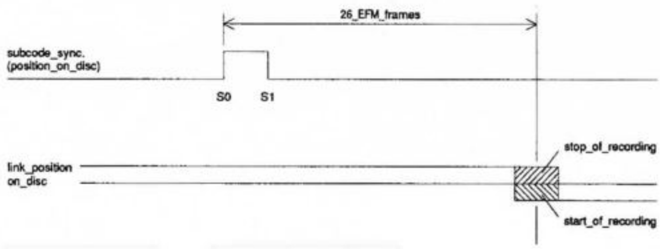


Figure 12
General linking rules

If a piece of music has been recorded the information will be written over the pregroove information. To stop the recording the stop key has to be activated. The writing however continues writing till 26 (EFM-)frames after next subcode sync. It is first after that the CD-R drive stops. If later on the recording on the same disc will be continued, the temporary table of contents in the PMA of the disc carries the information of the last recording and drives the spot (Light Device Unit) to the end of that recorded track. To link to that position the recorder looks for the last recorded subcode sync framenumber. When the recording is activated, the recorder starts reading the first of the extra recorded 26 EFM-frames to assure the timing of the registered signal with the timing of the new recording signal. After those 26 EFM-frames the writing starts really. In this way the EFM signal is adapted to the conventional standard.

2.5.7 Misrecording

Misrecording may occur if during a recording there is a heavy bump against the recorder. Then the spot may be lost from the pregroove. During the recording only at every 13.3 ms the recorder reads the pregroove information. If the times of ATIP do not continue consecutively, caused by the bump, the recording will be stopped. The laser will be switched off but the CD-recordable disc is irreparable damaged. To anticipate to this phenomenon it is necessary to prevent bumps during recording.
See also shock sensitivity, paragraph 3.2.1.4.

Bumps that stop the recording on the CD-ReWritable disc are not destroying this disc. However the recording of the piece of music has failed. With the erasing facility the failed track can be erased and in case the original piece of music is still available a new recording can be re-started.
After a number of recordings it is also possible to erase that complete disc for re-use.
A CD-ReWritable disc can be played back on CD-players prepared for ReWritable Discs after finalizing
(current CD-players are not prepared).

3 The CD-Recordable/ReWritable Audio Recorder

3.1 Blockdiagram of a CD-Recordable/ReWritable Audio recorder

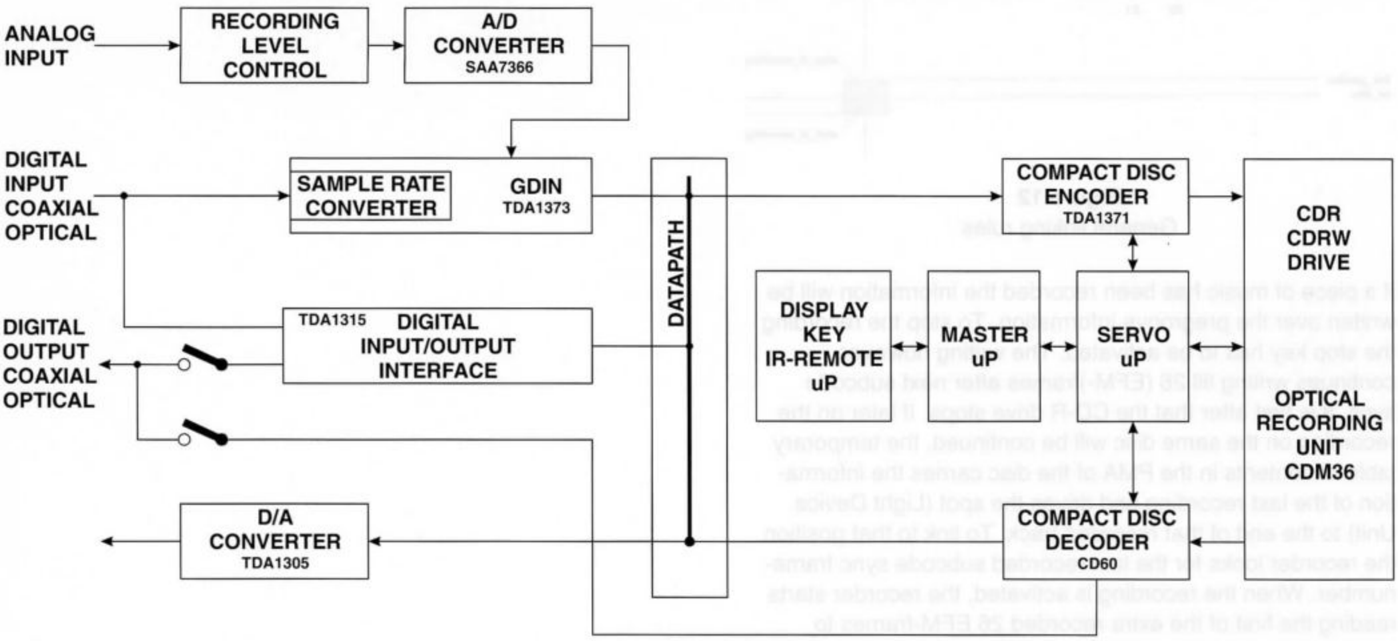


Figure 13
Blockdiagram of a CD-Recordable/ReWritable audio recorder

The Recording signal in above drawn simplified blockdiagram is moving according to the following steps.
Starting at the analogue input side:
- the Analogue input signal to
- the RECORDING LEVEL CONTROL unit and then via
- the Analogue/DIGITAL CONVERTER the analogue signal will be transformed into a digital signal (sample frequency 44.1 kHz) and this digital signal is forwarded via
- the General Digital Input (GDIN) to
- the Datapath bus (I^2S).

The digital input connects the electrical and optical signals directly to the:
- the General Digital Input (GDIN) where via the internal Sample Rate Converter the digital signal is adapted to the CD sample frequency (44.1 kHz) and after that forwarded to
- the Datapath bus.

Via the Datapath bus the digital signal is connected to
- the Compact Disc Encoder, which transforms the signal into EFM format. The EFM signal is forwarded to
- CDR / CDRW Drive unit with optical recording unit (CDM = CDMechanism). In recording mode, but also in play mode this drive is controlled by
- control µProcessor (Servo microcontroller) which on its turn is actuated by
- the Master µProcessor (System controller). This processor co-ordinates all activities which are started by the user via
- the Front Keys and/or IR Remote control signals and the results are displayed on Display unit. These activities are processed by a slave µProcessor (user microprocessor) on the display board and the slave µProcessor communicates with the Master µP.

In Play mode the signal flows as follows:
- From CDR drive the EFM signal read from disc is forwarded to
- Compact Disc Decoder and decoded digital signal is forwarded via
- the Datapath bus (I^2S) to
- Digital/Analogue Converter (Analogue output) or via DOBM IEC958 format to
- Digital and Optical out connector.

Monitoring the audio recorded signal is only possible via the electrical input circuits until Datapath bus and than the output circuit.
Notice that the recorded signal on the disc is not "monitored".
From each input signal there is immediately a digital output signal available at digital out.
The blocks of blockdiagram of figure 14 are gathered in the Basic Engine part with the CDM, servo drivers, Basic Engine µProcessor (or Servo µProcessor), encoder, decoder and the loader unit and the User part is consisting of input and output datapath and User µProcessor (System controller) unit.
The Display part contains the keys & display with slave µP.
The I/O part contains the connectors on the connector board and the Power supply supplies.

For servicing reasons the CDM Loader Module consisting of loader, CDM, CDM board and Main board is treated as one central repair module. Local repairs on component level can be executed on Power supply, I/O connector and Display boards. See next drawing fig. 14.

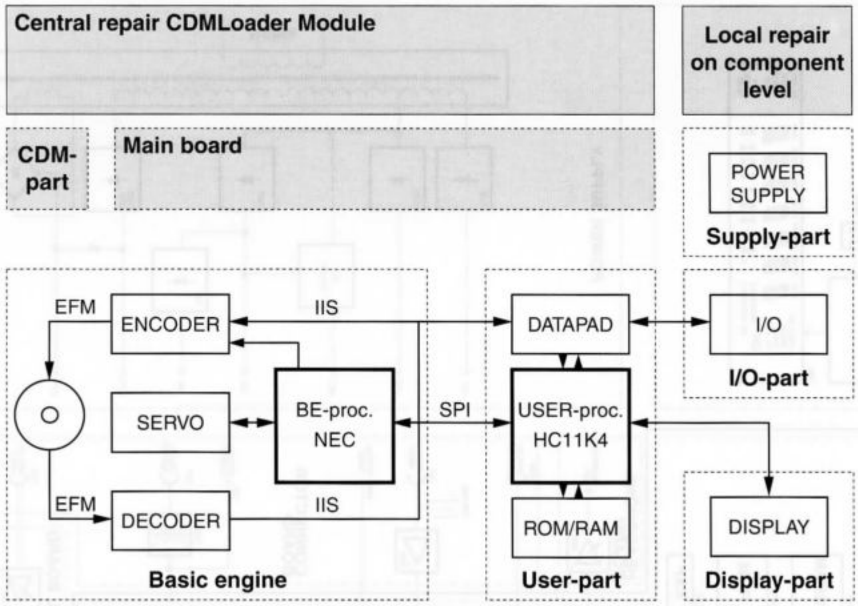


Figure 14
Central repair CDM loader module

For easy diagnostics of the CDM Loader Module, the set is equipped with a selfdiagnostics program.
This basic description contains some details of the working/ functions of the CDM Loader Module.

All functions in the recorder can be divided into mechanical activities with the disc and separate electrical circuits.
In chapter 3.2 and included paragraphs the mechanical part with its control systems with the encoding and decoding is described, in chapter 3.3 and its paragraphs the rest of the Electrical part is explained.

On next drawing the OVERALL BLOCKDIAGRAM is shown.

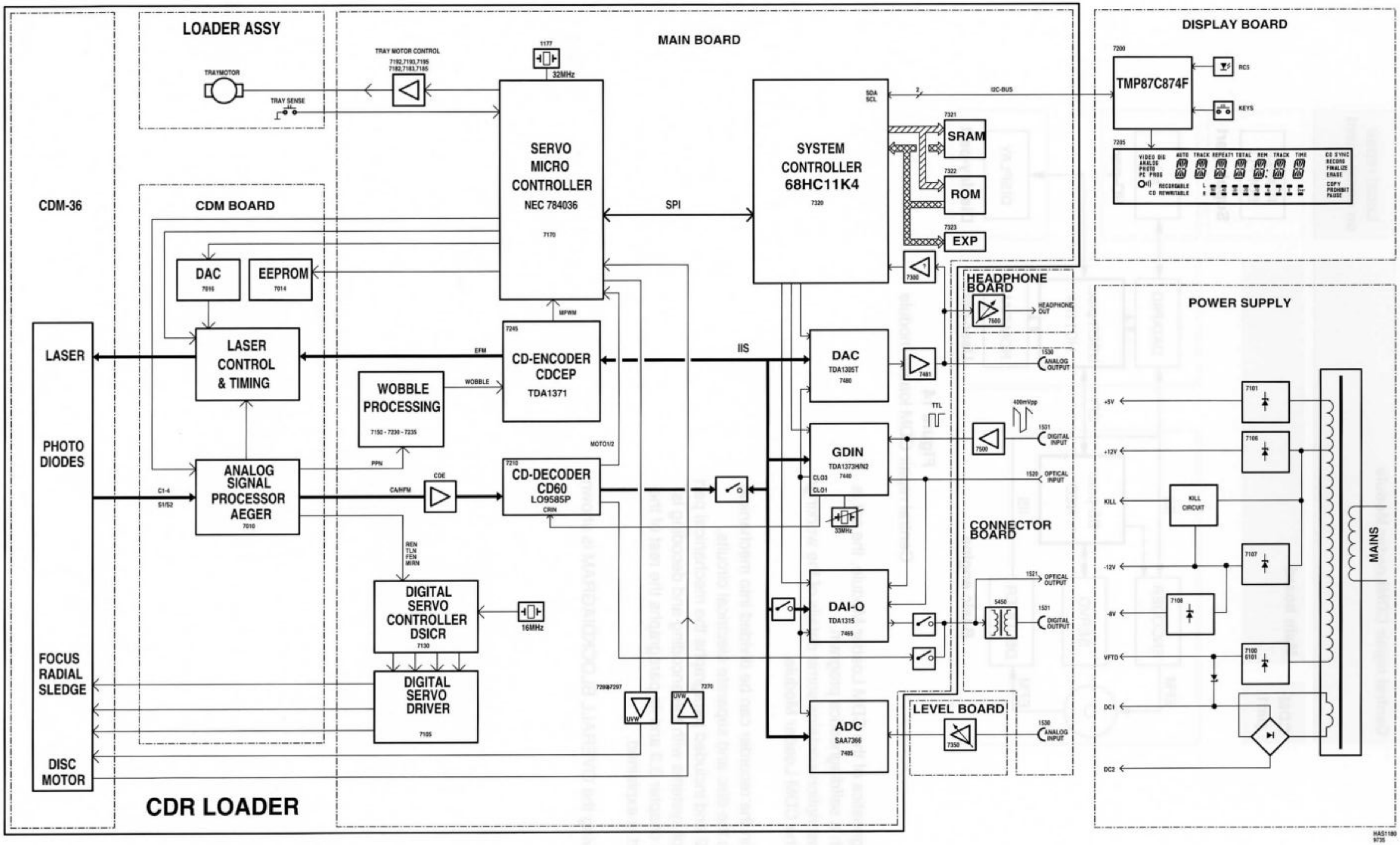


Figure 15
Overall blockdiagram

On the more extended overall blockdiagram most important components are shown again. The electrical signal flow of the recording signal from the analogue input on the connector board is as follows:

- the analogue recording level is adjusted on the level board and then
- the A/D conversion (ADC) to I^2S format (datapath);
- the Digital Audio Input (DAI-O) and General Digital Input (GDIN) are inserting the coaxial and optical input signals which are converted into I^2S format (datapath), from Datapath the signals are sent to
- the Compact Disc CIRC-EFM Encoder Plus (CDCEP) which encodes the signal into EFM, then the signal is lead to
- CDM Board with the Laser & timing unit and on
- CDM36 the Laser Driver Unit is processing the signal onto the disc. The processing of all these activities is mastered by
- the System Controller. The servo drivers on the CDM board are driven by commands from
- Servo Microcontroller and
- the scanning of input keys is processed by the slave µP on the display board.

The **analogue inputs** are pre-amplifiers which adapt the signal level to the operational level. Adjustments can be done about the **recording level.** Prevent over-amplification of the analogue signal because clipped audiosignals are registered as mutes and are "damaging" the recording quality. For that it is better to have a "safe" input level. After that the analogue audio signal will be converted in **ADC** into the I^2S format.
The **digital input** from the IEC958 standard format with data in Biphase marked code needs no adjustment and will be transferred into the I^2S format too by **GDIN**. The subcode information of the digital input signal will be processed to the subcode information for the new CD-R or CD-RW disc.
The I^2S signal is converted into the CIRC/EFM format in the **CDCEP encoder**. Each input audiosignal is worked up to the EFM format which will be written on the disc via the **Laser & Timing device** on the **CDM board** and **laser device unit** on the CD mechanism **CDM36.**

In case both inputs (analogue and digital) are supplying signals, preference is given to the digital input source.
The digital input, but also the I^2S signal from the analogue input, are connected to **DAI-O** which calculates a new digital output signal. Via the I^2S signal to the DAC IC the analogue output signal is also available. So for monitoring both digital and analogue output signals can be used.

On the Main board the "User" µProcessor (System Controller), scans via the **slave µProcessor** the keyboard for commands from the user. After that the user µP executes that command. The user µP or System Controller is the heart of the set.
It co-ordinates all functions within the set. The writing process in the CDR-loader is controlled by the components on the CDM Board. This board consists of a.o. a laser control and timing device. On this board the reading and writing moments are started and the laserdiode will be actuated at correct level (reading CD, reading CD-RW, writing CD-R, writing CD-RW) and the laserlight will be processed onto the disc.

During the writing operation the wobble processing device takes care for the track following of the pregroove. This is done during the reading moments. At the same time the disc rotation is controlled via the ATIP-pregroove wobble information. As long as the recording disc is not finalized the ATIP information is processed for controlling CDM, even in playback mode.
When reading a conventional or finalized disc the driver control is switched to the well-known EFM-motorcontrol (MOTO 1/2) and the wobble processing is switched off.

On the CDM Board there is also the AEGER IC (Analogue Error signal Generator for Erasable and Recordable CD) with a normalizer circuit. This internal circuit amplifies all signals from the Light Device Unit to the same average level as the total reflected signal. By this adaption all photodiode signals are brought to a "normal" level. Now servo signals like Focus-error, Radial-error can be processed better. Even the HF-signal will be equalized in the AEGER.

The parts that provide output signals are in principal the same stages as known from the conventional CD-player where the EFM signal is recovered into the audiosignal:

- the CIRC-EFM decoder (CD60) decodes to I^2S datapath bus format, from this to
- the D/A conversion (DAC).
- the digital outputs are received from CD60.
- the analogue output from DAC.

Notice that the signal available for monitoring in the recording mode is not the recorded signal but it is only the input I^2S signal which can be controlled. In case the original input signal is an analogue input this signal can activate automatic track increment. If the output level via the internal monitor indicates a signal below -60 dB, the next track will be generated. In the digital input mode the subcode information indicates the next track. There is no need to say that all these functions are processed by a system microprocessor software program on the MAIN Board.

In the following an example of the use of a recording disc and a short description of the activities in the recorder.
After that the power on and open tray keys have been activated, the unrecorded disc (e.g. CD-R) will be put on the tray. Close the tray and the information on the area of the lead-in will be read. Because it is an unrecorded disc there is no information in the lead-in. Now the spot has been moved under the PMA area and the system controller switches over to so-called "ATIP-mode", pregroove information. The brand-new disc has not been recorded before so there is no information too. In the pregroove the recorder finds a recommended Optical Power Calibration value. Now this recommended power is taken as the middle of the 15 steps to make a test recording on the pregroove in the Power Calibration Area of the disc.
After recording, the written value is being read. If the intensity of the reading signal corresponds with a calibrated value the power ok sign is indicated and the corresponding OPC-value is stored. (See paragraph 3.2.2.2.) If after one run the ideal value is not found the next 15 steps are written on the disc. This procedure can be repeated 4 times. All figures of the disc are stored in the memory of the microprocessor.

After this OPC procedure, one can decide to make a recording of a piece of music. This will be written in the first track, "under" the pregroove on the reflection layer of the disc in the recording layer area.

Note: the ATIP information on pregroove remains. Only by diffracting the dye-layer new information is stored on "pit" spots. As long as disc is not finalized the recorder is able to read ATIP information.

To stop the recording the stop key has to be activated. The writing continues to the next subcode sync and another 26 (EFM-)frames more. (See paragraph 2.5.5.6. General linking rules.) First after recording those 26 frames the CD-R drive stops recording in the data area of the disc. Immediately, all stored information in the microprocessor, like disc number and the number of registered tracks, will be written down in the PMA of the disc. (See paragraph 3.2.2.2) After that procedure the tray is allowed to bring the disc outside the recorder.

To continue the recording on the same disc the close key has to be activated. Now still there is no information on the lead-in area but in the PMA the key identification information of the disc has been found. For each new record a new OPC is made. In this area it is possible to record only a maximum of 99 testrecordings.
However with the temporary table of contents in the PMA of the disc, the microprocessor knows the last track and drives the spot (Light Device Unit) to the end of that recorded track. To link to that position the recorder looks for the last recorded subcode sync framenumber. When the recording should start the recorder starts reading at first the last 26 EFM-frames to assure the timing of the registered signal with the timing of the new recording signal. After those 26 EFM-frames the writing starts. In this way there exists a continuous EFM pattern on the disc which is adapted to the conventional standard.
For CD-R discs the Power Calibration Area (PCA) can only record a maximum of 99 OPC testrecordings. To prevent that to often loaded discs are full without any recording the last (99th) OPC recording is used for all further recordings. So user should prevent loading discs to often without making a recording, to prevent misadjustments of OPC value.
The CD-RW disc does not have this limitation. After 99 OPC records have been stored in the PCA at the next OPC at first PCA will be erased and again 99 OPC values can be stored.

At the end of the recording the recorder operates in the same way as already described. Before opening the tray it is possible to decide that this recorded disc has been completed. Now the fixing up procedure (finalizing) may be activated. Then all the content of the temporary table of contents (PMA) is transferred to the lead-in area. Behind the last track the lead-out information will be written. After the fixing up there is not any possibility to make another recording on this CD-Recordable Audio disc. But from now on the finalized CD-R disc can be played back on every CD-Audio player. Finalizing (fixing up) of a CD-ReWritable disc is done via the same procedure, however with this restriction that only CD-RW prepared CD-Audio players are able to play back this finalized disc.

In the next section the mechanical actions to get the information on and from the recording disc are described.

3.2 The Mechanical part with its control systems

In the mechanical part of the recorder the track following, focusing and reading and writing of a disc are carried out. All these actions are adapted to the new write and rewrite situation and should be compatible with the conventional CD-system.
These conditions are fulfilled by the CD-Recording drive. A very important item of this drive is the Light Device Unit. This consists of the laserdiode with an optical 3-spots lightpath. This Light Device Unit is driven and/or controlled by the following electrical circuits:

- laser control,
- normalizer,
- focus control,
- 3-spot radial tracking system,
- motorcontrol.

All these functions are carried out in close co-operation with the servo microcontroller.

3.2.1 The CD-Recording drive

In the mechanical part of the recorder the following conditions are implemented.

- The spot follows the tracks very closely. Here has been chosen for an adapted 3-spot system with a 2-stage radial tracking slide mechanism.
- The mechanism is derived from the conventional CD-system.
- Writing of the PMA and PCA is done on the inner track before the lead-in. The spot has to be moved at 22 mm radiation from the middle. This requires an adequate functioning of objective, actuator and turntable motor. The mechanical part of the CD-Recorder has to be adapted to reach the new, most inside position.
- To get as much laserlight as possible on the disc, polarizing optics have been used. Also a couple of objectives has been added and a high power laserdiode has been applied.
- Tolerances of the tilting of the disc ask for adaption of the real time optical power. This is controlled by the real time Optical Power Control. (O.P.C.) See paragraph 3.2.2.2.

All these functions are implemented in the CD-Recording drive which consists of the CDM mechanism and the electrical circuitry which is concentrated on the CDM Board and on the Main Board.

The CD-Recording drive with the Light Device Unit constitutes an interface between the lightpath on the one hand and the encoder and decoder on the other hand. See figure 16: CDR drive blockdiagram.

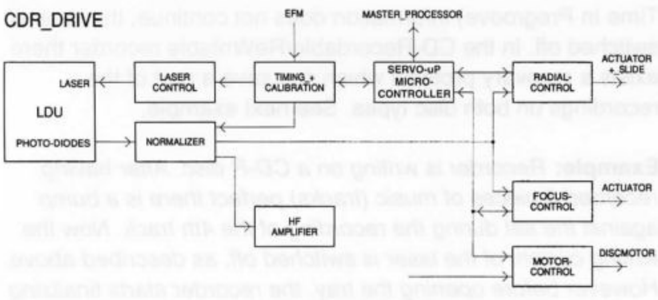


Figure 16
CDR drive blockdiagram

In the CDM mechanism the laser sends its output light to the disc through the lightpath. A part of the source beam is catched by the Forward Sense photodiode, placed just behind the grating. The resulting electrical FS photodiode signal is used to control the laser output power by means of a laser control circuit. The beam reflected by the disc is led to a photodiode system, where signals are generated on behalf of servo control and data extraction.
The CDM board contains the servo error extracting AEGER IC (Analogue Error signal Generator for Erasable and Recordable CD), the discrete laser control circuit and other functions.
The AEGER provides error signals for focus and radial servo control, a push-pull signal for disc motor control and a central aperture signal for disc motor control and data extraction.
The Main Board comprises most of the servo functions.
The DSICR IC incorporates the focus and radial servo transfer functions. The DSICR output signals are power amplified by the DSD driver IC and fed to the focus and radial actuator, as well as the sledge motor on the CDM mechanism.

3.2.1.1 The CDM mechanism

The CDM mechanism consists of the Light Device Unit and a 2D actuator. Both units are mounted on a slide which is driven by the slide motor.
Further on there is the Brushless Hall turntablemotor to spin the CD-disc.
The radial tracking system is a 2-stage servo with a 3 spot lightpath. Let us first compare the conventional lightpath with the CD-R lightpath.
The 3 spot lightpath of the conventional CD system consists of a laserdiode with the feedback information of the monitor-diode, grating, plane parallel plate, collimator lens, objective lens and photodiode. See figure 17.

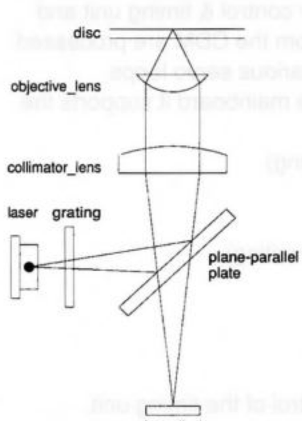


Figure 17
3 spot CD lightpath

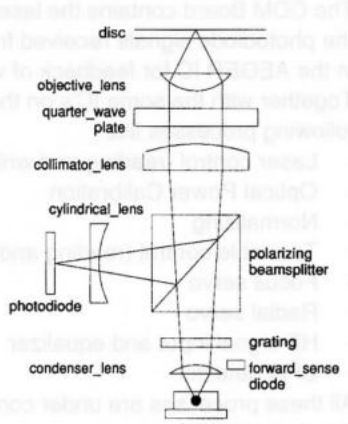


Figure 18
3 spot CD-R lightpath

The 3 spot lightpath of the CD-R lightpath consists of the following components:
- laserdiode, condenser lens, forward sense diode, grating, polarizing beamsplitter, collimator lens, quarter wave plate, objective lens, cylindrical lens, photodiode. See figure 18.

In the following a short description of this lightpath:
The condenser lens couples all laserlight to get a better result of the output of the laserdiode. The internal monitor diode of the laser is not in use in this path. Instead of that the forward sense diode has been used to measure the intensity of the output of the laser. Via the grating the lightbeam has been divided into 3 spots. The polarizing beamsplitter conducts all laserlight through the splitter. The collimator lens now forms parallel beams of the 3 spots. In the quarter wave plate the polarizing direction rotates for 45°. The moveable objective lens has been focused on the reflecting layer on the disc. The reflected beams return their way back to the quarter wave plate where again 45° rotation has been made.
Now the total polarization rotation comes to 90°. This means in the polarizing beamsplitter that all reflected lightbeams are diffracted to the cylindrical lens. The effect of this lens consists in the astigmatism of the spot on the photodiode. On figure 19 this effect has been demonstrated.

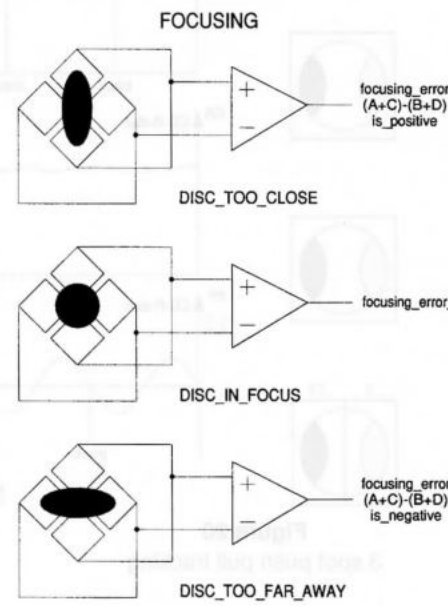


Figure 19
Focusing

<u>Resuming</u>: the differences between the 3 spot CD lightpath and the 3 spot CD-R lightpath are the polarizing components (quarter wave plate together with the beamsplitter) and the forward sense diode.

3.2.1.2 The CDM requirements

The CDM requirements are:
- Good spot quality
- Accurate track following
- Eccentricity < 100μm
- Low shocksensitivity
- Inner position: r = 22 mm

Good spot:
The used laserdiode is a high power laserdiode, to be able to write with enough power during the writing conditions. For the reading condition the laser has been switched on the low power level. To obtain in both situations a stabilized wave-length of the light the laser output in the read mode has been modulated with 200 MHz.
In the next section the accurate track following has been explained.

3.2.1.3 The 3-spots push pull system

In the CD-Recording disc there is a small pregroove on this disc. To find this pregroove the mechanism uses the satellite spots. These spots are positioned just in the middle between two tracks and not, like the conventional 3-spot CD system, at the border of the track. The second deviation of the conventional system is that the photodiodes of both satellite spots are divided into two parts. With these modifications a push pull signal can be constructed. On figure 20 the effect of push pull has been shown.

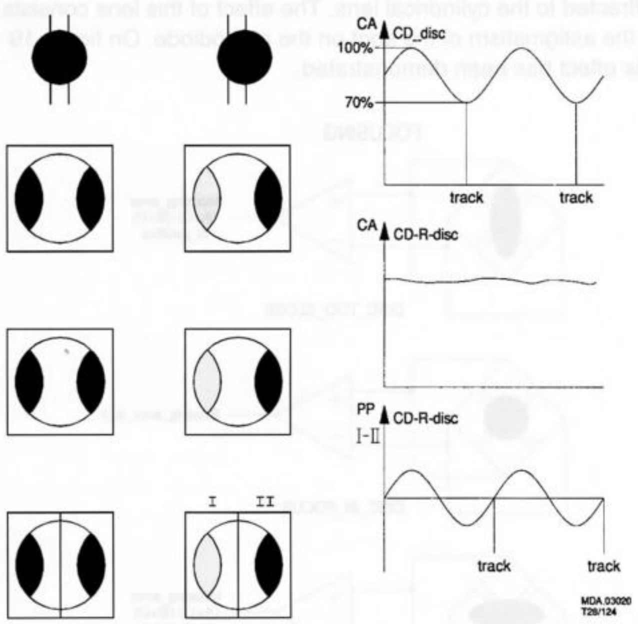


Figure 20
3 spot push pull tracking

As already known from the conventional CD system there is a difference between the intensity of a partly reflected light from a pit/land cross over and the intensity of the reflected light from a complete land spot and the intensity from a complete pit spot. The second order reflected light from the cross over shows a third level light intensity. By dividing the satellite photodiodes in two pieces the intensity of both reflected parts can be subtracted and a recognizable radial error signal is obtained.

3.2.1.4 shock sensitivity

The shock sensitivity should be as low as possible, because during the writing situation there is no possibility to correct that kind of disturbances. The prevention of a shock is so important because if it occurs during the writing mode the CD-Recordable disc should have been damaged irreparably. The reading time interval between the writing pulses is 13.3 ms. If after such a bump the timetable of the ATIP (Absolute Time In Pregroove) information does not continue, the laser is switched off. In the CD-Recordable/ReWritable recorder there exists a recovery protocol which can save a part of the recordings on both disc types. See next example.

Example: *Recorder is writing on a CD-R disc. After having recorded 3 pieces of music (tracks) perfect there is a bump against the set during the recording of the 4th track. Now the writing current of the laser is switched off, as described above. However before opening the tray, the recorder starts finalizing this disc, otherwise all information in the master µP should have been lost. This disc however, will only consist out of the 3 perfect recorded tracks. Not any track can be added (because it is finalized) but in this way the 3 perfect recorded tracks are saved. The reason for doing so is that it is impossible to connect new EFM signal in a good shape to the suddenly interrupted existing EFM pattern. That's why the last track is decided to be lost and the CD-Recordable disc can be used only for the already perfect recorded and completed tracks.*

In case the same accident should happen with a CD-RW disc, then only 3 tracks are stored in PMA and when a new recording should be added it will be inserted automatically after the third and perfect recorded piece of music. The already recorded part of the music from the 4th track will always be overwritten. However the ReWritable disc can be filled completely afterwards.

3.2.1.5 focus radius

The focus radius is the minimum distance between the spindle of the turntable motor and the objective. This distance deviates from the existing CD format because the PCA and PMA areas are inside them. Now the stud for the objective is at a radius of 22 mm from the centre the spindle (was 23 mm).

3.2.1.6 eccentricity

The eccentricity is dependant to two circumstances. First the disc eccentricity, second the eccentricity of the spindle of the turntable motor. To lower the eccentricity of the spindle a selfcentring carrier has been applied. There is no need to say that the eccentricity for a recordable disc is more important than the eccentricity of a conventional disc.

3.2.2 The CDM board

The CDM Board contains the laser control & timing unit and the photodiode signals received from the CDM are processed in the AEGER IC for feedback of various servo loops.
Together with the some IC's on the mainboard it supports the following processes like:

- Laser control (reading and writing)
- Optical Power Calibration
- Normalizing
- Turntable control (reading and writing)
- Focus servo
- Radial servo
- HF-signal input and equalizer
- EFM detector

All these processes are under control of the timing unit. See figure 21.

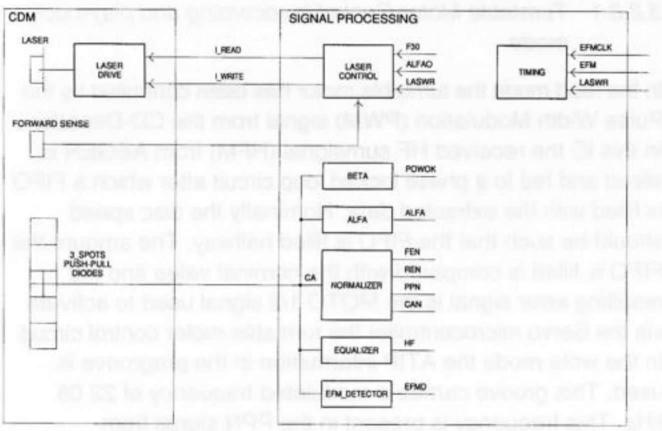


Figure 21
Blockdiagram of the CDM Board with CDM mechanism

3.2.2.1 Laser Control

The laser output level has to be stabilized by the forward sense diode. For that reason the forward sense has three reference currents to compare with.
- The read current.
- The write low current.
- The write high current.

The timing unit switches between the read and write power stages and the output signal has been controlled according to the EFM signal. See figure 22.

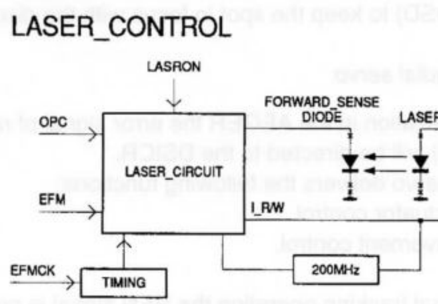


Figure 22
Laser control

The read current is the lowest current in these three situations. To get a proper working of the laser with such a low current the DC current has been modulated with a frequency of about 200 MHz. The levels of the laser write power have been determined by the Optical Power Calibration.

3.2.2.2 Optical Power Calibration

In the read mode the power of the laser has been determined by the fixed value of the read current. During writing the write current has to meet with the adjusted value of the Optical Power Calibration recorded on the used disc. The signals which control these levels are from the so called Beta circuit. To optimize the recording this Beta value has to be checked during the writing operation. In case there is a black dot, fingerprint, tilting or dust this results in a lower power intensity on the disc. That's why the write current has to be adapted to an optimum recording due to the variable conditions of the disc. These adaptations have been carried out by the Alfa circuit.

First look at the Beta reference measuring which has been checked at the moment the first Optical Power Calibration has been carried out. If the recorder reads an unknown disc the first thing he does is to make a testrecording on that disc. With the Power Calibration Procedure the Light Device Unit has been moved to the Program Calibration Area where the information has been stored of the position of the first free Power Calibration part. During 15 consecutive ATIP frames a random EFM signal has been written with an increasing power (FSO) at every frame. The power range of those 15 steps is 7 below and 7 above the advised OPC value in the ATIP lead-in. After the writing the first position is being looked for and the next 15 ATIP frames are read to find out which frame satisfies the critical condition of the writing power. See figure 23.

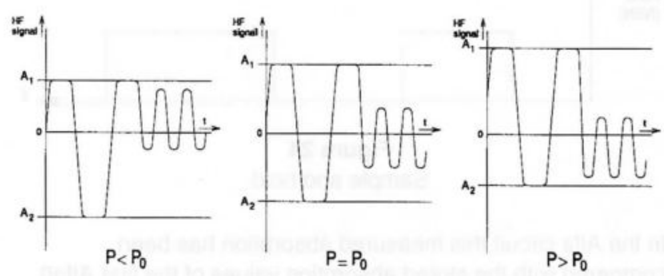


Figure 23
The power ok decision

The values from that frame such as the FSO (Forward Sense Offset) and Alfa (Powerabsorption) are registered as setpoints to FSO and Alfa0. In recordings later on these values take care for adjusting the output level current at the OPC level.

On top of that there is an additional power regulation to obtain a constant absorption in the disc. It is the intensity of the absorption which results in the deforming of the disc. This depends of the local quality of the disc, the spot, tilting, dust and fingerprints. This function has to be controlled during the writing by the ALFA circuit. The principle of sample and hold has been used to measure the intensity of absorption. At the beginning of a write pulse the intensity is a high write current. This is always the same pulse (current and time value). After that pulse, the contents of the EFM signal together with the timing unit, decide how long the low write current continues. At the same time that the high pulse has been transmitted, the reflected light is also measured (reading). The difference between send pulse and reflected pulse is a gradation of the absorption. See figure 24.

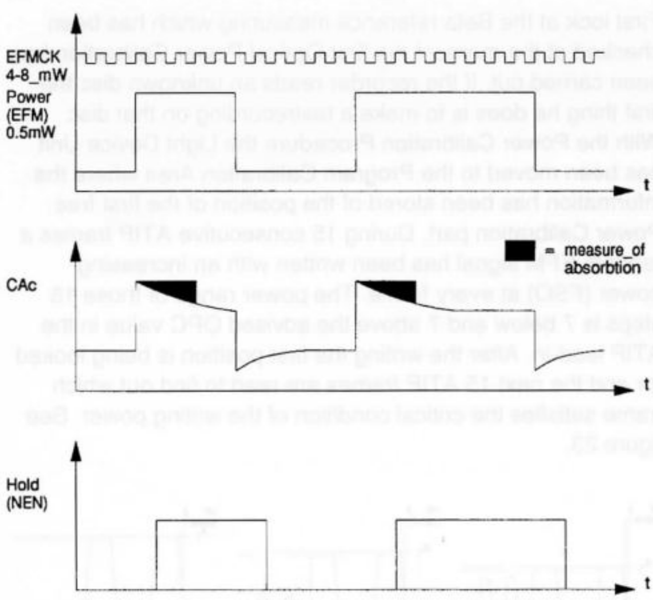


Figure 24
Sample and hold

In the Alfa circuit this measured absorption has been compared with the stored absorption values of the first Alfa0 setpoint. The difference has to be corrected via the Alfa circuit.

3.2.2.3 Normalizing

The normalizing function normalizes the photodiode signals from the LDU. The reason for normalizing is the great difference in reflection of various discs. To prevent the influences of these variations in the rest of the circuits all photodiode signals are brought to the "normal" level in the beginning of the circuit. The normalizer processes in this way the sum-signal of the mainspot called: Central Aperture (CA), but also the focus and radial error signals. The output signals are called FEN, REN, CAN. From the CA signal is made a push pull signal too. That normalized signal is called: PPN. From the HF-sumsignal the HF signal has been formed. In the read mode this signal has been directed to the decoder panel after equalization in the Modulation Transfer Function. In the write mode this signal has been switched to the Alfa circuit.

3.2.3 The Servo Functions

The electrical circuitries of the turntable motor control and focus and radial servo drivers are on the main board. These servo circuits execute the recorder commands via an own servo microcontroller (Servo µP) and the main functions are:
- communicating with the master µP (System Controller).
- processing the single commands from the master µP.
- reporting the error conditions to the master µP.

The servo devices on the mainboard also processes the error signals received from AEGER IC on the CDM Board like:
- controlling the turntable motor in recording and play-back mode.
- controlling the focus- and radial actuator.
- controlling the slide movement.

3.2.3.1 Turntable Motor Control in recording and play-back mode

In the read mode the turntable motor has been controlled by the Pulse Width Modulation (PWM) signal from the CD-Decoder. In this IC the received HF sumsignal (HFM) from AEGER is sliced and fed to a phase locked loop circuit after which a FIFO is filled with the extracted data. Nominally the disc speed should be such that the FIFO is filled halfway. The amount the FIFO is filled is compared with the nominal value and the resulting error signal is the MOTO 1/2 signal used to activate via the Servo microcontroller the turntable motor control circuit.
In the write mode the ATIP information in the pregroove is used. This groove carries a modulated frequency of 22.05 kHz. This frequency is present in the PPN signal from AEGER. To have speed adjusted the received wobble frequency is compared with the fixed frequency in the wobble processing unit. Via CDCEP the MPWM signal is sent to the servo microcontroller, which controls on its turn the turntable Hallmotor.

3.2.3.2 Focus servo

After normalization in the AEGER the focus error signal (FEN) will be directed to the Digital Servo IC for Recordable CD (DSICR) on the Main Board.
The focus servo function starts with the start up, to move the actuator through the focal point. From the DSICR the digital message focus found will be sent to the Servo micro controller. Other digital signals are directed to Digital Servo Driver IC (DSD) to keep the spot in focus with the disc.

3.2.3.3 Radial servo

After normalization in the AEGER the error signal of radial servo (REN) will be directed to the DSICR.
The radial servo delivers the following functions:
- radial actuator control.
- slide movement control.

During normal tracking operation the REN signal is processed in the AEGER into a DC error signal which provides the radial actuator. Most of the time the slide motor is not driven.
The radial actuator, while keeping track, will slowly move outward related to the slide and this is resulting in a growing radial integrator voltage. Each time this voltage exceeds a certain value, a slide step is generated, resulting in a sudden outward movement of the slide and hence a radial error drop. Much more functionality is required during all kinds of non-linear operations, like starting up, catching track, jumping, playing across drop-outs, handling shocks and so on. All these operations require many additional switching functions which are provided in DSICR. These transfer function coefficients are programmed in the EEPROM.

3.2.4 The Wobble Processing

In the recording mode the normalized HF-signal (PPN) is lead to the wobble processing unit. Here the pregroove information has been decoded. The carrier frequency of the PPN signal (22.05 kHz) is compared to a reference frequency. The result is converted into an errorsignal that controls the turntable motor and the modulation on that carrier is demodulated to the time-code information.

In play-back mode of a pre-recorded disc the total wobble processing is switched off and the motorcontrol signal from Decoder is used to control the turntable motor.

3.2.5 The Servo microcontroller

The Servo microcontroller coordinates all functions of the laser control, servo-, AEGER-, Wobble-, Encoding- and Decoding-processing. The System controller actuates all those processings.

3.3 The Electrical part

The electrical part of the CD-Recorder/player can be split up in the arrangements of the incoming audio signal which should be prepared to be converted into the EFM-signal, and the EFM-signal which have been read should be converted into the audio output signal. The first function has been carried out by the input part with the encoder path, the second by the decoder path with the output part. Both parts are transporting the digital data in the set. That's why this bus is often called Data Path. On the overall blockdiagram at figure 13 all these units have been drawn.

3.3.1 The input part of the circuit with the ENCODER path

In the CD Audio Recorder is in recording mode the electrical input signal will be written to the disc. The encoder which takes care of coding into EFM format wants to get an I^2S digital input signal. That's why all input signals are converted into the I^2S format. The analogue signals are converted in an A/D converter into this format. The optical or electrical digital information at the input has to be converted to the I^2S signal too. This happens in the Digital In circuit.

3.3.1.1 Digital In

Digital signals (optical or electrical), according to the Digital Audio Interface, an IEC standard with bi-phase modulated information, are converted in the General Digital Input IC (GDIN) into the Datapath I^2S bus format. After this conversion all subcode information has been sent to the µP to generate a new subcode. On figure 25 the blockdiagram of this GDIN IC is shown. The IC is able to perform a sample rate conversion of digital signals. (SRC Mode) It can also read several serial input formats in the IEC958 digital audio format. For that a full Audio Digital Input Circuit (ADIC) is present. An internal digital PLL circuit clocks the incoming signal jitter free.

Blockdiagram

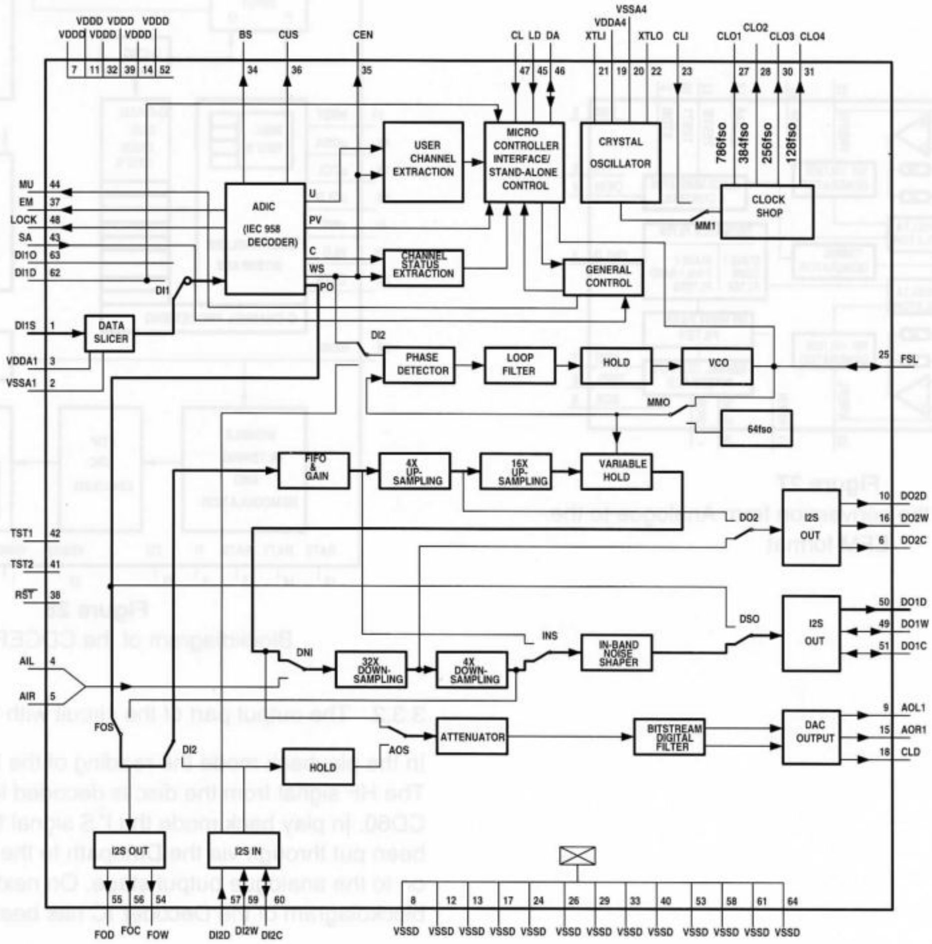


Figure 25

Blockdiagram of the General Digital Input

The Digital Audio Input/Output circuit (DAIO) calculates a new digital output signal. So digital Monitoring of the input signal is possible via this output signal. See figure 26.

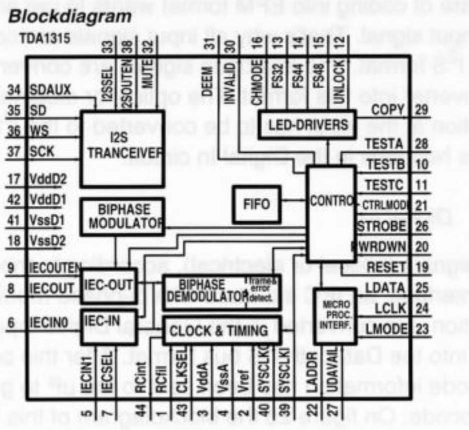


Figure 26

Blockdiagram of the Digital Audio input/output

3.3.1.2 Analogue Digital converter

The analogue input signal is converted in the Analogue/Digital converter IC (ADC) into the I^2S bus format. In figure 27 the blockdiagram of this IC is shown. Conversion is done via the Sigma/Delta modulator. After that the digital data is led to the CDCEP (Compact Disc CIRC Encoder Plus) via the datapath bus.

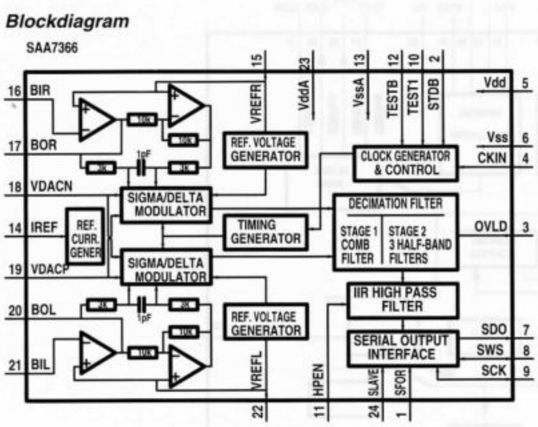


Figure 27

Blockdiagram of the conversion from Analogue to the EFM format

3.3.1.3 Cross Interleave Read/Solomon Code to Eight-to-Fourteen-Modulation (CIRC EFM) Encoder

In the CDCEP the I^2S signal will be converted into the EFM format. To get this format the data has been shifted into a RAM memory, split up in symbols and read out via the encoder pattern. In the CIRC circuit the error correction symbols will be added. Also the subcode information from the master µP will be prepared in the subcode shiftregister and the subcode bits are also added via CIRC to the EFM format. Here e.g. the copy bit information has been written to the disc. After that the conversion from the 8 bit symbols to the 14 bit has been done and 3 merging bits are added to each 14 bit pattern. Resulting in the writing EFM-signal. On figure 28 the blockdiagram of CDCEP encoder is shown.

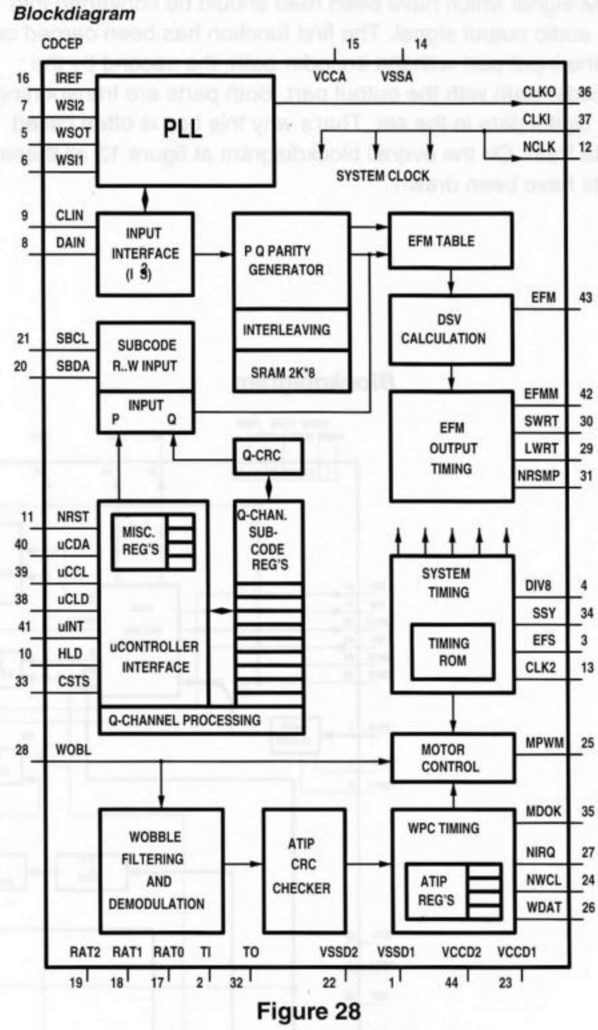


Figure 28

Blockdiagram of the CDCEP encoder

3.3.2 The output part of the circuit with the DECODER path

In the playback mode the reading of the EFM on disc is done. The HF signal from the disc is decoded in the Decoder IC CD60. In play back mode the I^2S signal from the decoder has been put through via the Datapath to the DAC IC and further on to the analogue output stage. On next figure the blockdiagram of the Decoder IC has been shown.

Block diagram

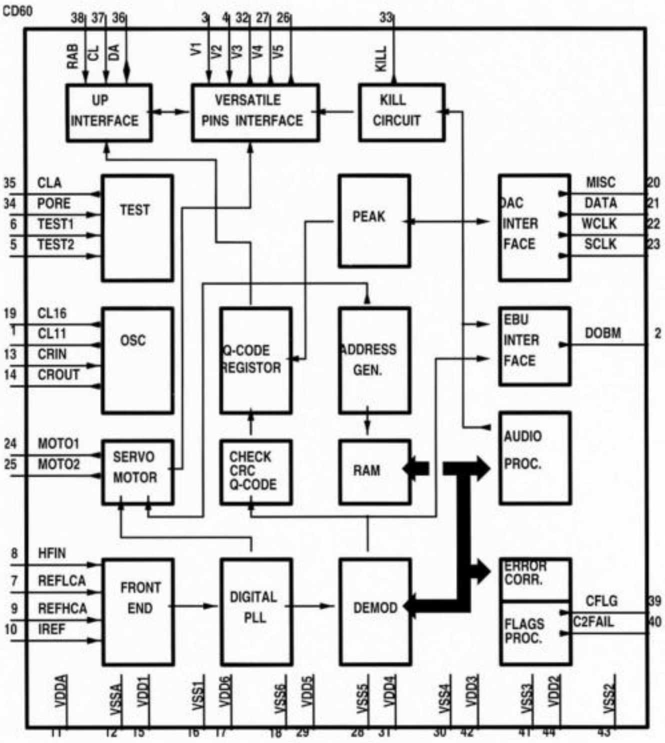


Figure 29
Blockdiagram of the CD60 decoder

3.3.2.1 DAC analogue output

The same Digital to Analogue Converter (DAC IC) as applied in the conventional CD player will be used in the CD-Audio Recorder/player.

3.3.2.2 Digital output

From Decoder CD60 is used the DOBM signal (IEC958 format) to connect this signal via an electronic switch to the digital output connector.

3.3.2.3 Monitoring

Monitoring of the input signal at I^2S level is possible via the direct digital out and analogue out generated from the same I^2S datapath information. However it is not possible to read and write at the same time the disc information. That's why the "monitor" signal does not proof the written signal.