TECHNICAL MANUAL

MINI DISC RECORDER

CONTENTS

1. Mini disc System: Features and General Overview

Features of the MD System

The features of the MD system can be summarized as follows:

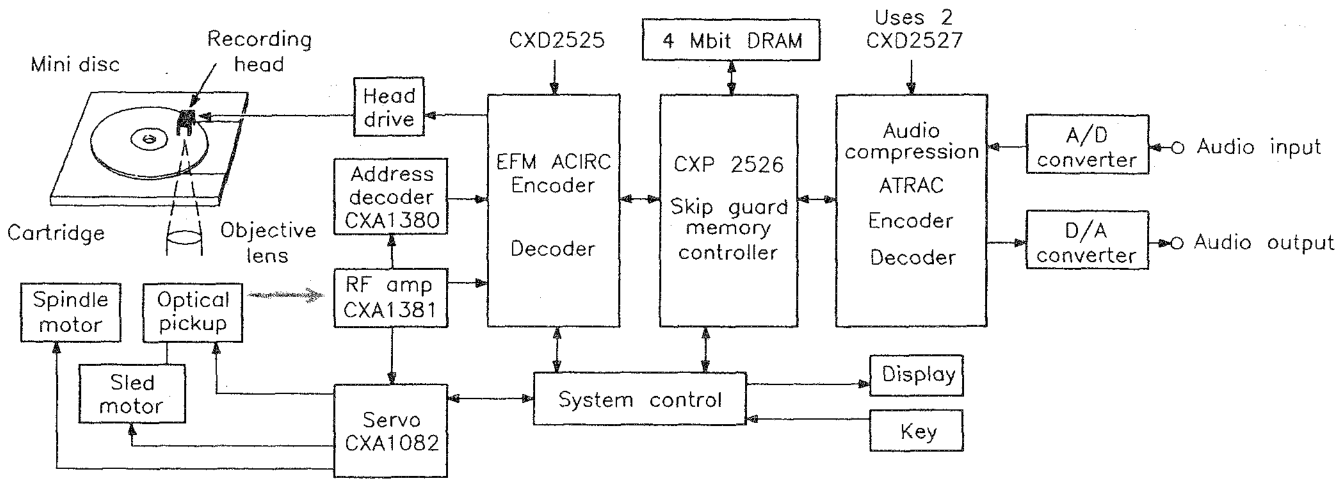
1) Similar to CDs, random access is possible.
2) Adopts an optical disc with a diameter of 64 mm housed in a cartridge.
3) Can be used with two types of optical discs.
   Can be used with special optical discs for playback of music software sold by record companies, and magneto-optical discs sold by media makers which allow the user to record on the disc.
4) Uses audio compression technology for high quality recording/playback of a maximum of 74 minutes of information.
5) Equips with anti-vibration technology by a semiconductor memory.

General Overview of MD System

Mini disc media include MDs for playback only and those for recording/playback. Playback MDs are created with basically the same process as that for CDs. As for recordable MDs, a magneto-optical disc is used and the magnetic modulation method is adopted for recording, thus allowing overwrite. Overwrite can be carried out more than 1 million times, and data life is on the same level as CDs. The discs are housed in cartridges with shutters for easy use.

(Details concerning disc and cartridge are found later in this paper).

The following is a block diagram of the MD system.



As can be seen from the chart below, the recording signal modulation method and error correction method are basically the same as those for the CD. Thus, reading from playback discs can make ample use of CD technology. On the other hand, the recording technology for recordable MDs is basically the same as that found in Part 1 of the "Orange Book" which has already been standardized by Sony and Phillips. In other words, technology involving the process where signals from the disc travel through the optical system for extraction and insertion of signals to the EFM and ACIRC encoder/decoder has as its basis the unified systems used by MO-CDs. By teaming this up with compression technology, the details are decided on.

Data structure is close to that of mode 2 of the CD-ROM. The 424-byte compression data is considered as 1 sound group. 11 sound groups are located within 2 sectors. Moreover, a total of 4 sub-data sectors and link sectors are added 32 sectors of compression data to produce 36 sectors which are known as a single cluster. Recording is always done in cluster units.

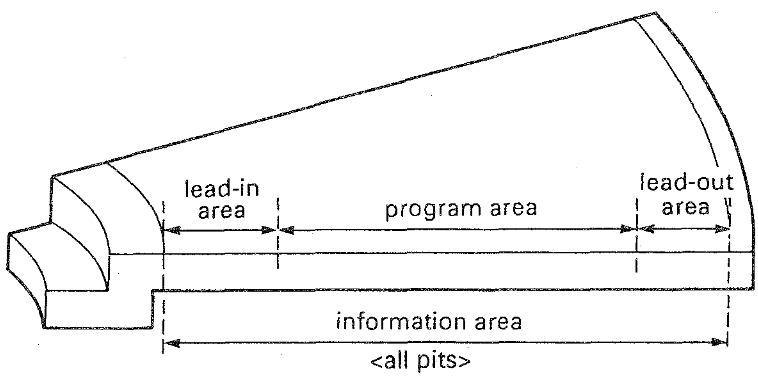
Having come to this point, however, following the EFM/ ACIRC encoder/decoder in the system, it is possible to handle digital compression signals. Because the compression rate is about 1/5 in relation to the actual reading rate of 1.4 Mbit/s from the disc, the transfer rate for transferring data to the ATRAC decoder is 300 kbit/s. Actually, this difference is the charm of it. The MD system makes skillful use of this to prevent skipping. If, for example, a 1 Mbit DRAM is inserted as a buffer between the EFM/ ACIRC decoder and ATRAC decoder, the compression data read from the disc fills the buffer in 0.9 seconds. Thus, even if it is not possible to read the data due to large vibration, for about 3 seconds (1 Mbit/0.3 Mbit/s) it is possible to continue sending data from the buffer to the ATRAC decoder. If the optical pickup returns to the original position on the disc during this 3 second period, there is no sound skipping.

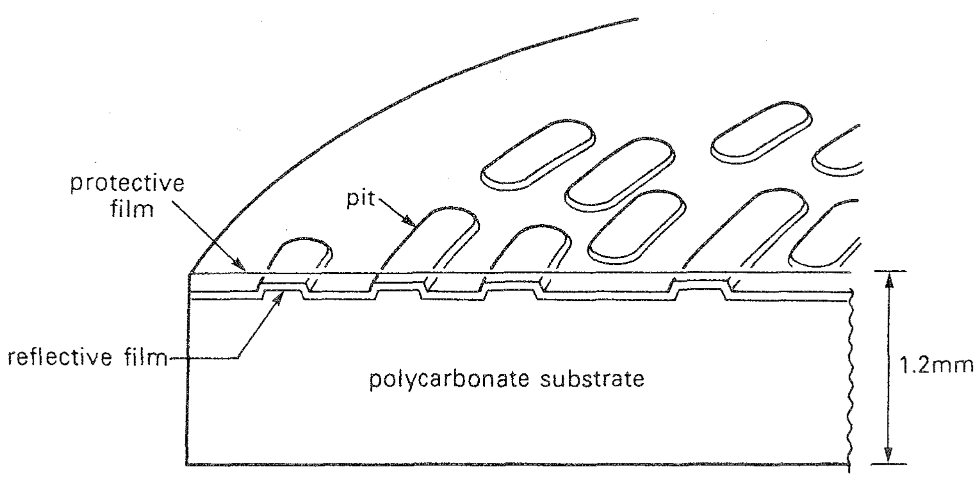
By means of compression, it is possible to achieve 74 minutes of recording/playback on a small, easy-to-use disc, and quick random access. The transfer rate difference generated by this system can be skillfully used to guard against the sound skipping which is a weak point on disc system.

●Main use	Recording -playback time Cartridge dimensions	Max. 74minutes 68 x 72 x 5mm
●Disc use	Diameter Thickness Hole diameter Diameter where program area starts Diameter where lead-in area starts Track pitch Disc linear velocity	64mm 1.2mm 11mm 32mm 29mm 1.6 μm 1.2-1.4mm/sec.
●Audio performance	Number of channels Frequency band Wow-flutter	2 channels (stereo) 5-20kHz Crystal oscillator accuracy
●Signal format	Sampling frequency High performance coding system Modulation system Error correction system	44.1kHz ATRAC EFM ACIRC
●Optical parameters	Laser wavelength Objective lens numerical aperture Recording power Recording method	Standard 780nm Standard 0.45 Max. 5mW Magnetic modulation system

MDs for playback only (premastered discs)
These are MDs containing music software and sold at record stores just like CDs and music tapes.

As with CDs, the data is recorded as pits, and high speed mass production is possible with the injection mold method.



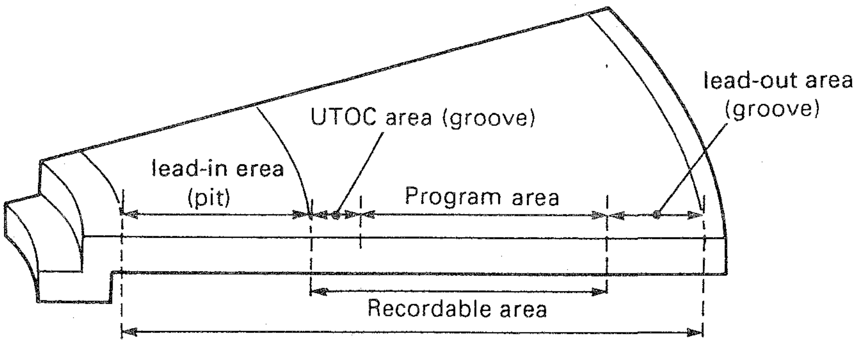


As the above figure shows, the disc inner circumference is the lead-in area and the outer circumference is the lead-out area.
There is no danger of jamming as is the case with cassette tapes and thus no danger of erasing data by mistake. The cartridge shutter window is only on the bottom side and the upper surface can be used for printing pictures of the artists, etc.

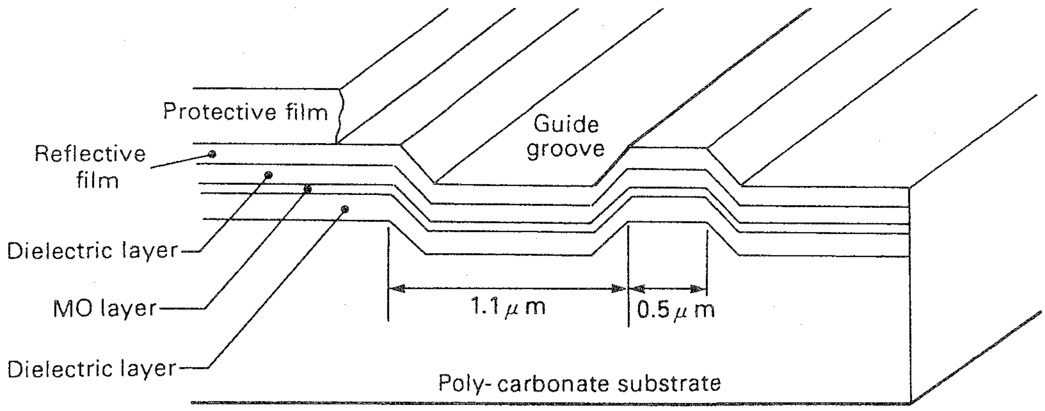
MDs for recording (magneto-optical discs)

Recordable MDs were developed as computer discs. There is also use of magneto-optical discs for which research has been continuing for use in CDs (CD-MO) which permit recording. Recordable MDs feature a design matching the magnetic modulation over-write, allowing more than 1 million times. The product life is already close to that of a CD.

As the following figure shows, the disc lead-in area has a pit structure. The recordable area and lead-out area feature a groove structure. When recording, laser light is projected from the lower side and there is imprinting of a magnetic field from the upper surface. For this reason, there is a shutter window on both sides of the cartridge.



Cross-sectional view of goove area



Margin distribution for disc and recorder

The MD system has been developed as a substitute for he compact cassette. In other words, it has been created for the purpose of allowing anybody to easily listen to fine quality music anywhere and at any time at an affordable price. The special features of the MD system which differ from existing systems are as follows:

1) It is not an industrial-use system but a private-use system.

→Low-priced and almost maintenance-free·········

The system is composed of a total of 7 media parts, thus reducing production costs. And, because the disc is housed in a hard case, it can be handled under rough handling.

→The high product quality is extremely important, and freedom was also important in design of media.·········

Regarding recordable MDs and pre-mastered MDs, there are almost no regulations concerning design. Thus, it is possible to freely design printing, coloring and configuration.

→Even users with no technical knowledge can use them easily. ·········

Even if the operator has no understanding of the hardware construction and operating system of the media/player of the Mini discs, they can be operated as a "black box."

2) The first optical disc system for which outdoor use has officially been recognized.

→The system can bear up under rough usage and is strong against dust, dirt and a wide humidity and temperature range.

3) High resistance to external vibration although it is an optical disc.

→The disc must be created to deal with vibration regardless of the environment so that it is possible to listen to music regardless of the time, place and occasion.······

The system is the result of audio compression technology and RAM digital technology. In terms of mechanisms, it is necessary to design to speed up rest of servo in response to external disturbance and to cut off the resonance source of the mechanism itself.

4) As the name "Mini disc" indicates, it has been possible to record 74 minutes on a small disc.

→The recording/playback time is determined by the following equation········

$T=K.\pi(D1^2-D2^2)/(4Tp.v)$

However,

track pitch $Tp \propto \lambda/NA$.

Non compression linear velocity $v \propto \lambda/NA$

- K : Audio compression rate
- λ : Wavelength
- D1 : External diameter
- NA : Objective lens numerical aperture
- D2 : Internal diameter

In making a small disc work over a long time, it becomes possible by realizing the following.

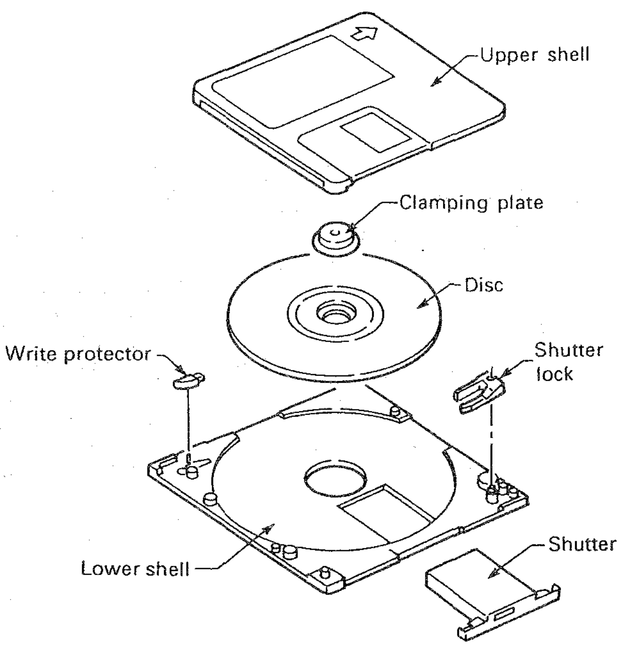
① Using a laser with a short wavelength.
② Increasing the NA value.
③ Decreasing the internal radius D2.
④ Increasing the compression rate.

However, a blue semiconductor laser has yet to reach the stage of actual use. If the NA value is increased, the focus depth becomes small. There is an increase in the mechanical precision in order to deal with an increase in the focus servo residual error and an increase in astigmation. This leads to an increase in production costs. If the value of D2 is made smaller, there is an increase in the instability of the tracking servo. The system becomes more susceptible to external disturbance. Also, there is a problem in that there is no space for the spindle motor and turntable.

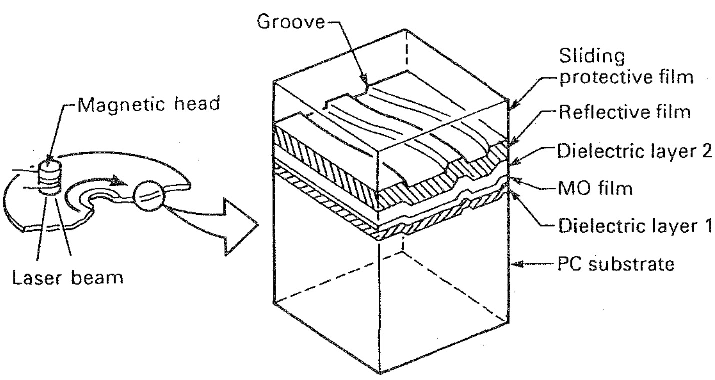
The MD system employs outstanding audio compression technology which is more than sufficient to create good sound: K=4.257, D1=61mm, D2=32mm, Tp=1.6 μm, v=1.2-1.4 m/s, λ=0.78 μm, NA=0.45

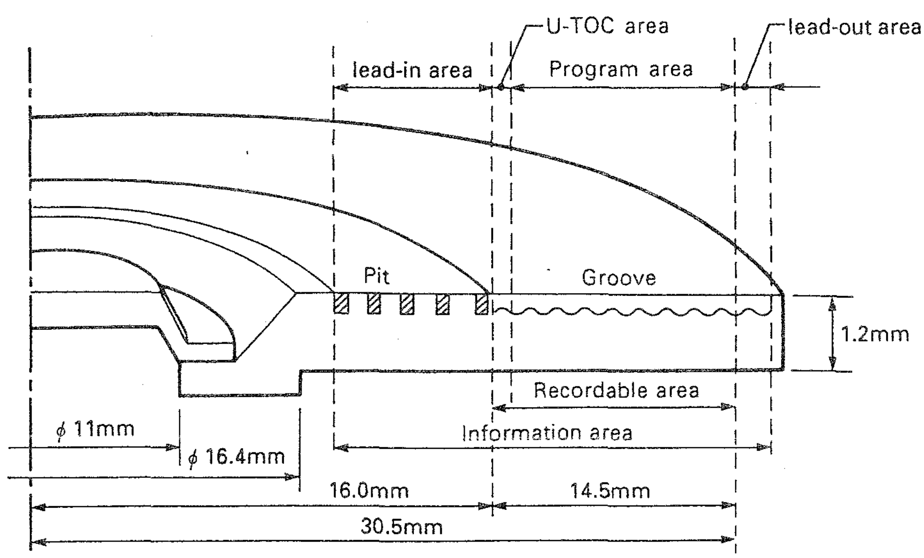
These specifications are ideally suited to mass production. That means it is possible to achieve low-cost stable quantity supply of systems.

<Total Structure of MD>



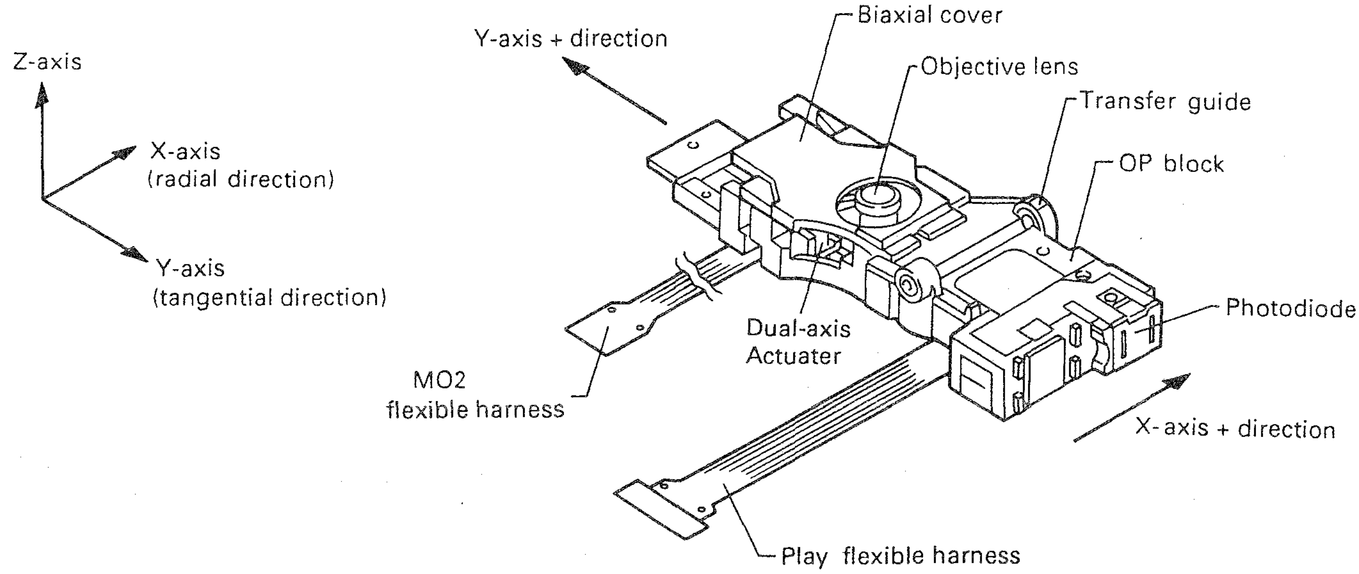
<Film Structure of Recording Medium for MD>





MD Optical Pickup

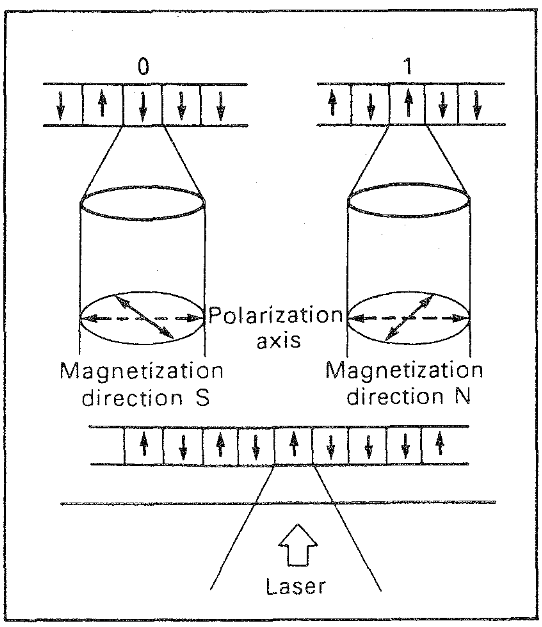
The following is a description of the optical pickup that was newly developed for the MD system. The external structure is as shown in the figure.



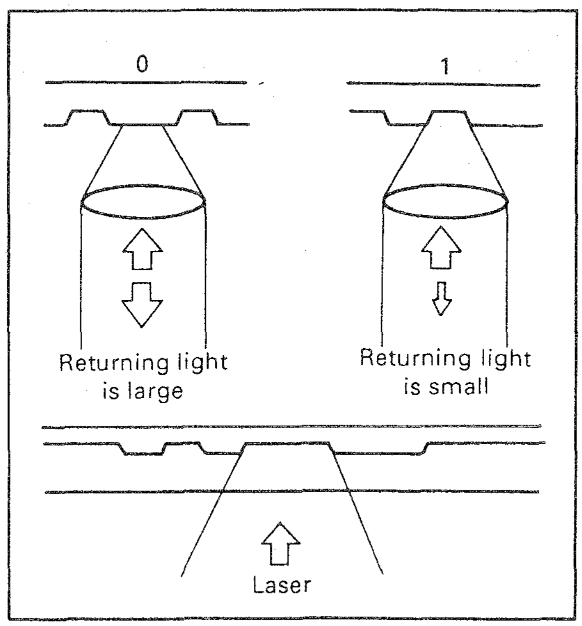
The following are the characteristics of the pickup.

1) Can reproduce music signals from both types of discs (2-way pickup) : pre-mastered discs (pit) and recordable discs (magneto-optical).
2) Can supply the necessary power and direct the required beam for recording on recordable MDs (with a pickup for recording use).
3) Compact size is ideally suited to the system and a large quantity production is possible.
4) Outstanding ease of use for system designers.

It has already been mentioned that there are two varities of media for MDs. The following explains why it is possible to read two types of media with a single pickup. With pre-mastered discs, as is the case with CDs, the presence or absence of pits on the disc surface is converted into signals representing the increase or decrease of reflected light from the disc. The recordable disc is a magneto-optical discs. Changes in light polarization direction (kerr effect) created by changes in the direction of magnetization on the disc are detected as signals. (The two types of signals used by the MD are shown in the figures below).

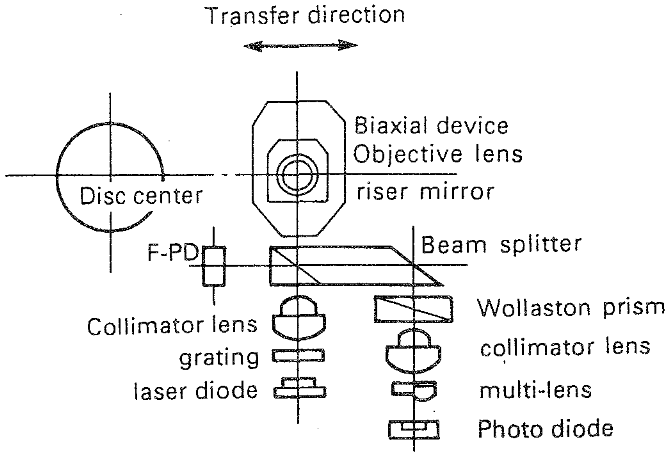


Minidisc capable of recording

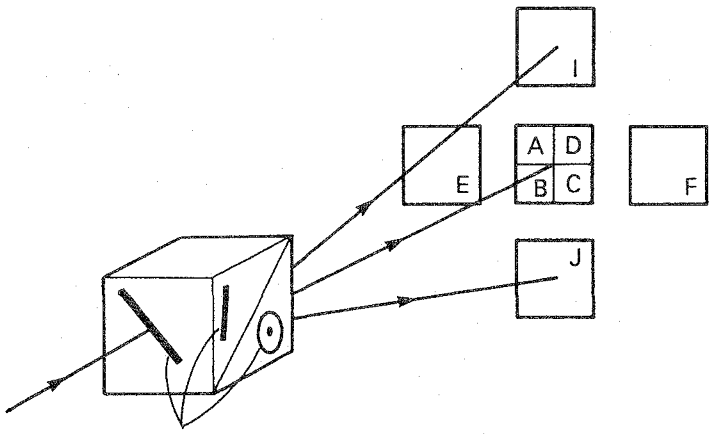


Minidisc used only for playback

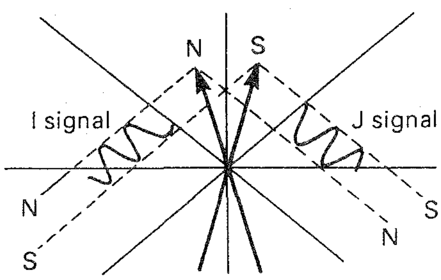
Detection of the polarization direction requires that the MD pickup include an optical element (analyzer) which was not included in conventional CD pickups. As the polarization analyzer, it was developed as an optical element known as a Wollaston prism which is included in the MD pickup. The structure of optical parts is as shown below:



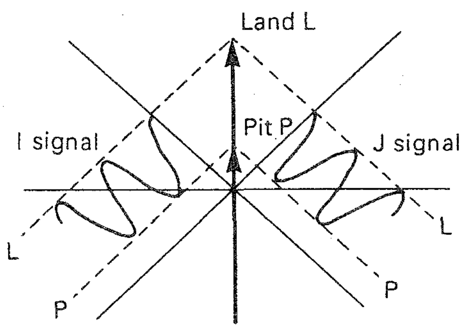
The three-beam Wollaston prism features two monoaxial crystals (crystal, calcite, etc.) pasted together. Due to differences in the polarization direction of reflected light, there is division of the beam in three directions as shown in the figure.



The three beams created by division form an image on the center section and on elements I and J of the photo-director. The magneto-optical signal section of signals gained from I and J are negative phase. Thus, if the difference between I and J is taken away, it is possible to obtain just the signal element. This is shown in the figure to the left.



(a) Magneto-optical signal



(b) Pit signal

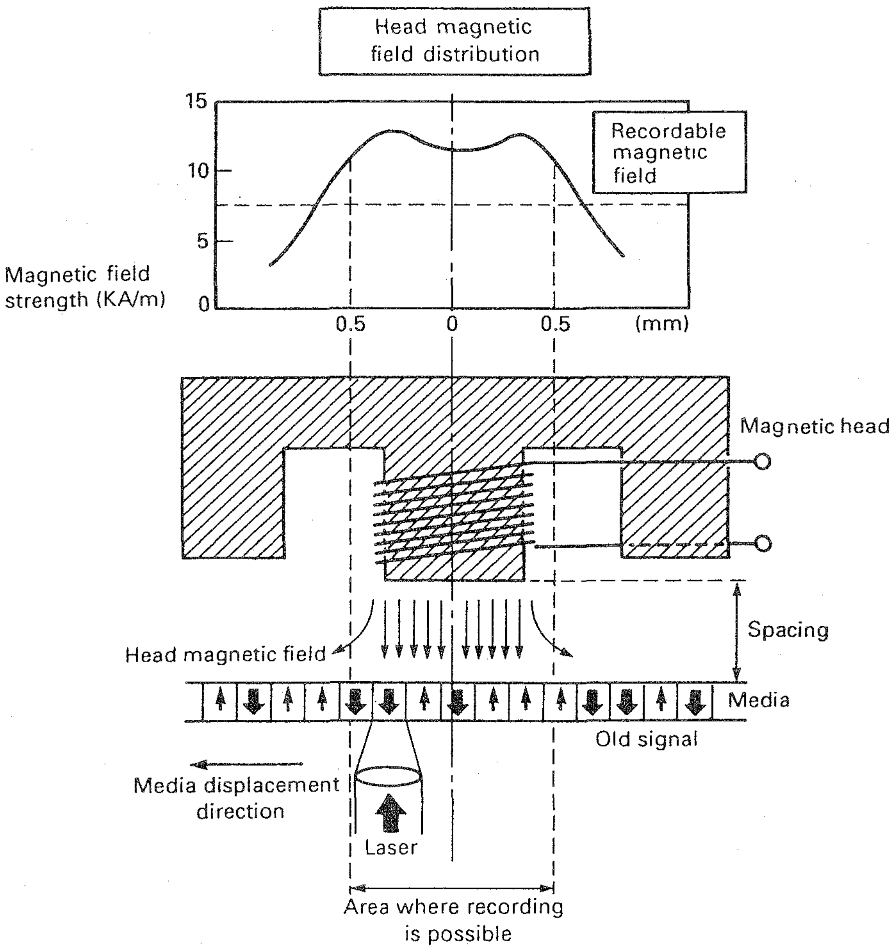
In the case of the pit signal in the figure to the right, there are changes in the strength of the light returning the detector, although the direction of polarization does not change. Thus, the signal elements derived from I and J are positive phase. It is possible to obtain the signal by the sum of I and J. In other words, with a pit signal, there is the sum signal of I and J; and with the magneto-optical signal, there is change to the difference signal of I and J, thus making it possible to read two different types of discs with the same one pickup.

Furthermore, the center beam is a light beam with half the light amount of the beam radiated through the 3-beam Wollaston prism. It is used for the focus servo. The tracking servo employs the three spot method so that the two wide beams are imaged on the elements E,F of the photo director. With the recordable disc, the recording tracks wobble at a set frequency. The wobbling signal is used to determine the disc servo and the abso-

lute address of the disc. This can be obtained by the push-pull signal { (A+B)-(C+D) } of the central beam.
In the case of a pickup capable of recording, because there is heating of the magneto-optical film of the recordable MD, it is necessary to radiate a beam spot on the disc having a power of about 5 mW. As a result, a high output (30 mW) laser diode is used so that the efficiency of the lens system is close to 20%.
The optical pickup that has now been developed has the above functions while offering a compact size and the possibility of quantity production. Furthermore, with this pickup, the maker designing the MD system does not have to be complicated and troublesome auxiliary electronic circuits. The electronic circuits of the laser drive system (high frequency superposed circuit) and optical signal system (PD-IC) which can be directly connected to ICs developed by Sony, can be included in the pickup, thus achieving an interface on a level with a CD-OP interface.

Magnetic Modulation Overwrite System

Signal recording with the MD system makes use of the magnetic modulation overwrite system. Please refer to the following figure.

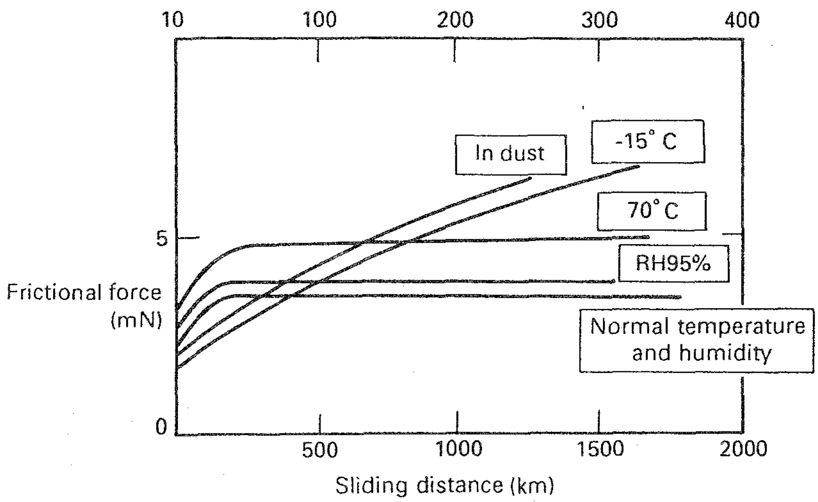


Let us assume that the media (magneto-optical magnetic film) moves from right to left on the paper. In other words, to the right side of the laser spot, there is processing of the data that was written beforehand. This is known as "writing while erasing." Consider the process that occurs during over-writing. The temperature increases in the area where the laser spot hits and exceeds the curie temperature of the magnetic film so that magnetization is eliminated. In other words, at this time the prior data is "erased." At the same time, the electrical current is directed to create either an upward or downward moving magnetic flux to the over-write head in response to 0 or 1 data to be written. The area where magnetization was lost when the spot hits it eventually moves away from the spot along with movement of media so that the curie temperature decreases. At this time, it receives the magnetic field from the head and becomes a small magnet. The polarity of the magnet is determined by the direction of the magnetic field from the head. In other words, it is according to whether the write-in data is 1 or 0. Furthermore, as the figure above shows, the range of the magnetic field of the magnetic head is sufficiently wide in relation to the size of the laser spot. Regarding lens movements due to the tracking servo, within a range of ±0.5 mm so that it is not necessary to move the head (although it follows the transfer mechanism), the design is such that a magnetic field strength of 8 kA/m or greater is secured.

Contact Sliding Head

One of the special features of the head is the contact sliding method. Although there are also non-contact methods depending on the type of servo system, their properties do not match well with needs in private-use equipment in terms of compactness, low consumed electric power and low cost.

Sliding properties



Sliding environment	Sliding time	Wear depth (μm)	
		Head	Disc
Normal temperature and humidity	400h	<1	0.01
70℃	300h	Same as above	0.03
−15℃	300h	Same as above	0.03
RH95%, 60℃	300h	Same as above	0.06
In dust JIS 15 types (normal temperature and humidity)	250h	Same as above	0.3

Wear Amount of Magnetic Head for Mini discs

The figures above show sliding properties. As the figure at left shows, the frictional force is low so the system is sufficiently stable. Even in dust, the increase is gradual so there are no problems with actual use. Furthermore, there are absolutely no problems in terms of the wear amount in the chart at the right. In actual usage conditions, considering that a disc can contain up to 74 minutes of data, the sliding reliability can be considered more than sufficient.

RF Servo Circuit

The pit signal is derived by obtaining the sum of the two RF signals sent from the optical pickup; the MO (magneto-optical) signal is obtained from the difference between the two signals. The two control inputs (RFSW0, RFSW1) achieve processing according to disc type.

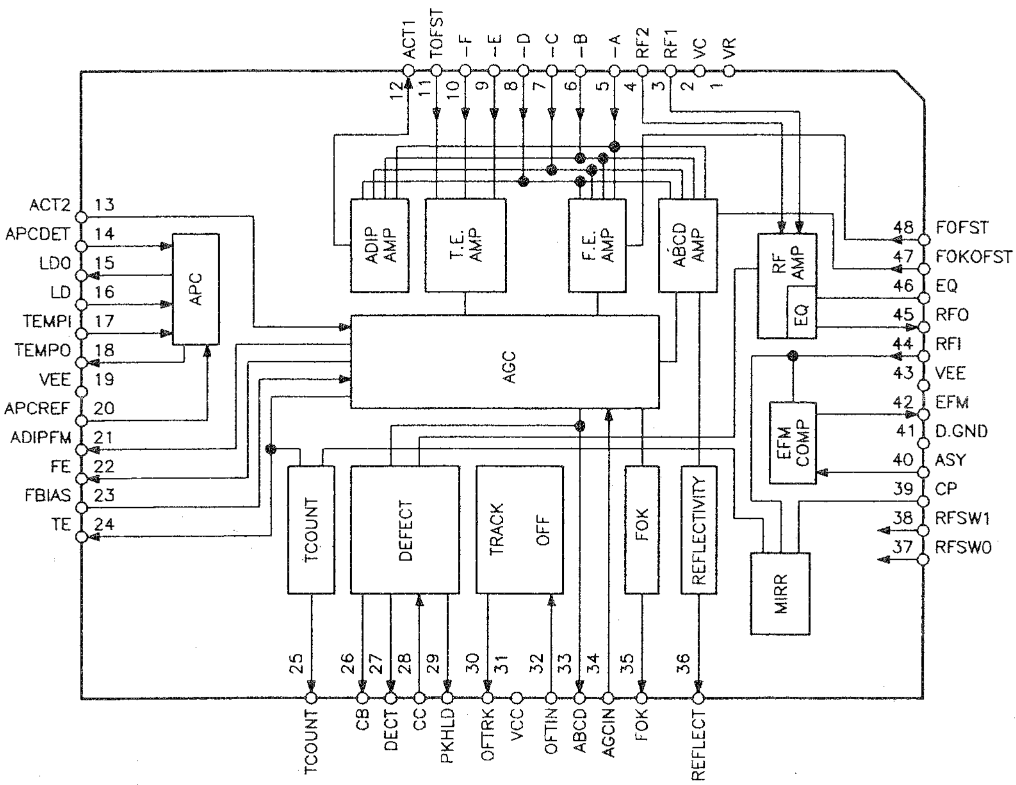
The RF signals become binary values after passing through the equalizer. At this time, due to the fact that the generation probability of the EFM signals 1,0 is 50%, each is employed to remove assymetry.

As for the servo signal, due to a matrix of six signals sent from the optical pickup, it is possible to obtain the light signal (ABCD), focus error, tracking error and ADIP-FM signal. These signals travel through a light feedback type AGC circuit before being output. Thanks to the AGC, it is possible to insure a stable servo operation regardless of the reflection rate and the amount of laser power during recording/playback.

The APC section is a block for carrying out auto-power control of the laser. The power is set according to the voltage input to the APCREF terminal.

In addition, the CXA1381 outputs the focus OK signal (FOK), the offtrack signal (OFTRK), the defect signal (DFCT) and traverse count signal (TCOUNT), thus functioning both as a servo and access.

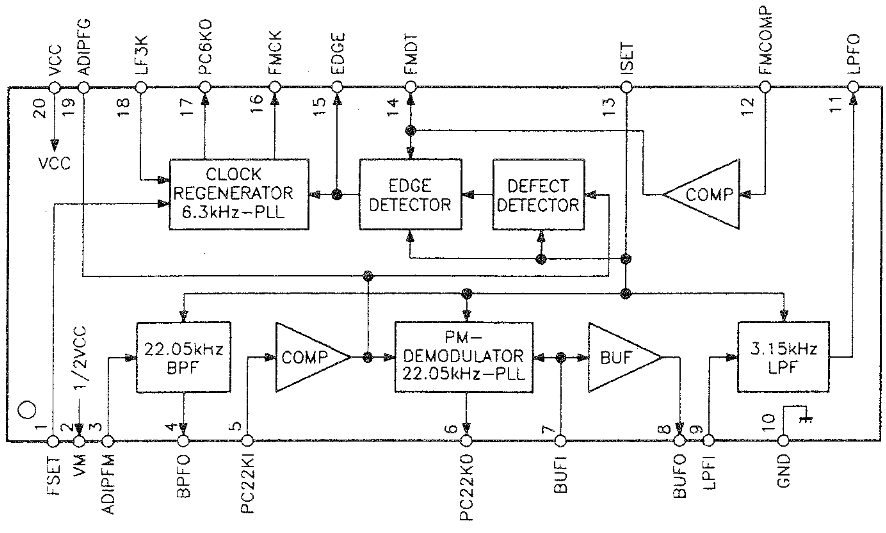
Because the servo circuit is the same as in that for CDs, use is made of the CXA1082 developed for CD use. The filters of the servo for the focus, tracking, sled, spindle are included inside. Furthermore, focus search and track jump are carried out according to serial commands from a microcomputer. The following shows a block diagram of the RF/matrix amp CXA1381.



ADIP Demodulation Circuit

With MO discs for recording/playback, there is groove wobbling to create FM demodulation and thus create the absolute address. This is known as ADIP (Address In Pregroove). ADIP is the address during access and is also used for control of the CLV (Constant Linear Velocity) of the spindle servo.

The following is a block diagram of the ADIP demodulation LSI CXA1380.

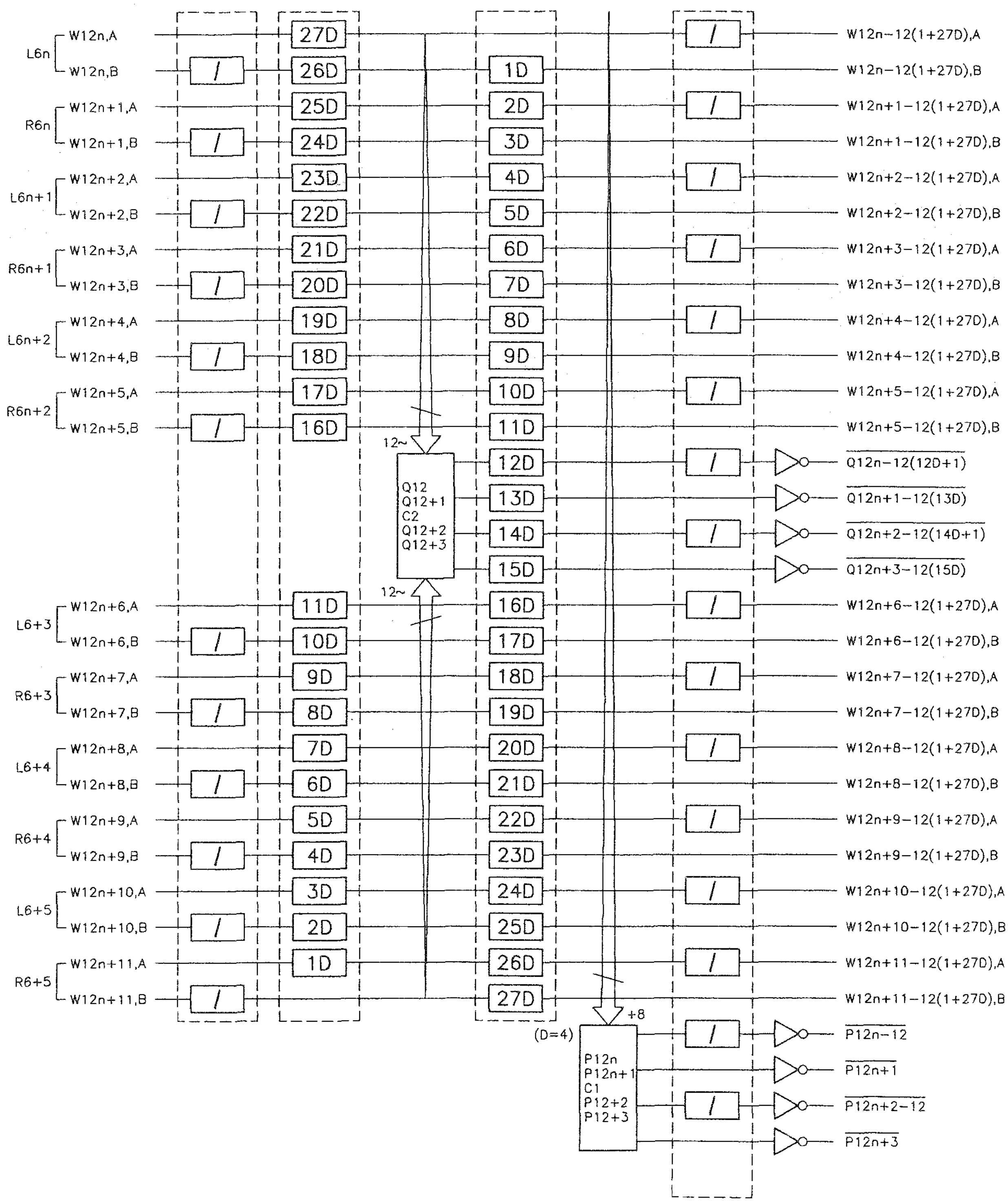


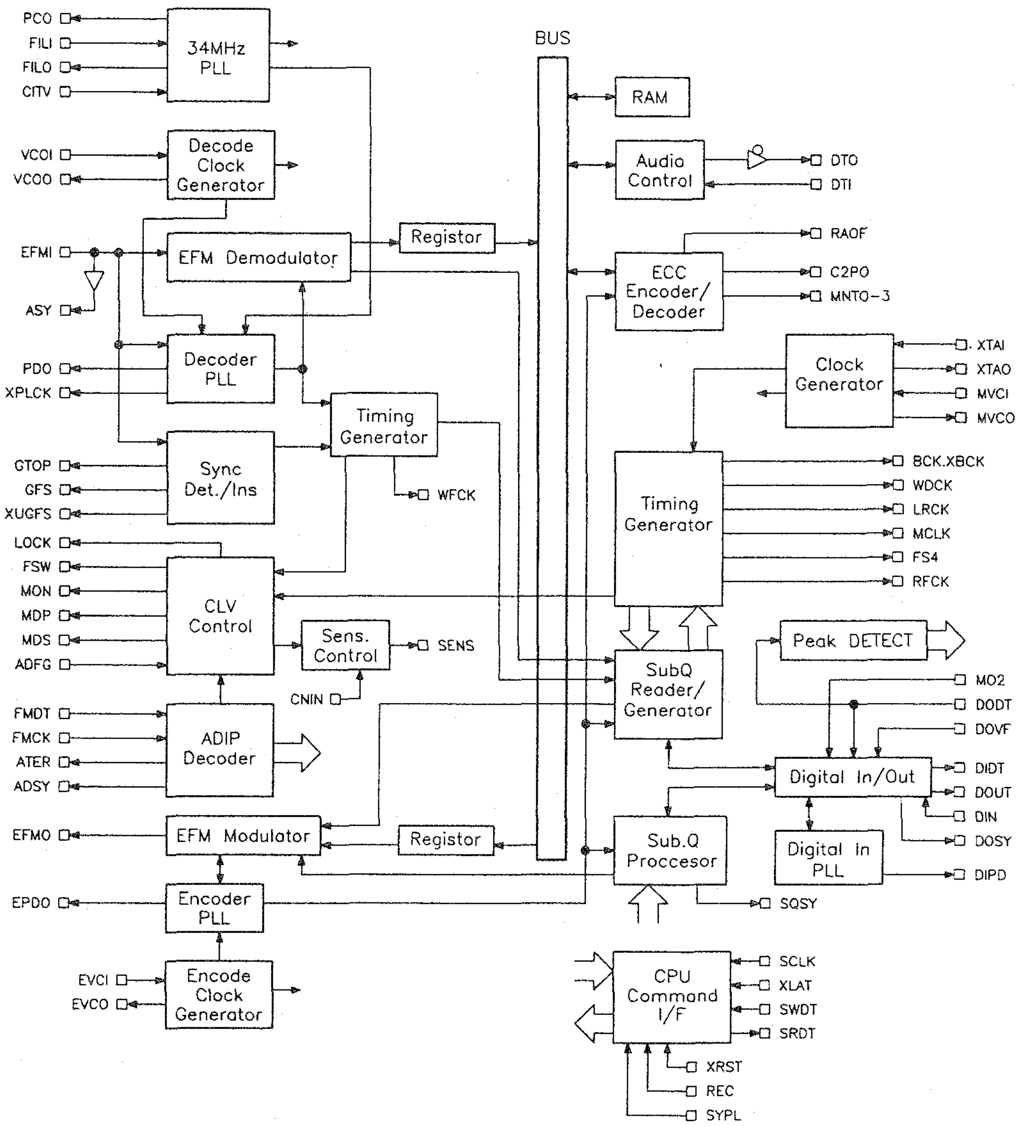
The ADIP-FM signal sent from the CXA1381 becomes a binary value after passing through the BPF. Bi-phase data is taken by means of PLL demodulation (FMDT output). Then there is reproduction of a 6.3 kHz clock from the biphase signal with the PLL (FMCK output). These outputs are sent to the CXD2525 where they are used as the decode of the ADIP data and spindle servo. If there is data missing from the ADIPFM signal, there is termination of phase comparison with the clock reproduction PLL in order to prevent negative influence on the spindle servo. Also, the ADIPFG signal obtained by creating a binary value of the ADIPFM signal is used as the rough servo when pulling in the spindle servo, thus realizing a wider pulling range.

EFM ACIRC Encode/Decode

The demodulation method of the recorded data is the same system as EFM (Eight to Fourteen Modulation) used with CD systems. As the error correction code, the CIRC (Cross Interleave Read Solomon Code) used in CD system is modified as the ACIRC (Advanced CIRC) which is suited to MD system. ACIRC has the same correction method (parity generation method) as the CIRC. There is no interleave of recording data with this method. When interleave/de-interleave is carried out and a burst error occurs during recording, the data for which correction was not possible is scattered for a long period. If the data is scattered in the case of a CD, it is easy to carry out interpolation so that noise is difficult to be heard. In the case of the MD, however, because compression data is used, it is not possible to carry out interpolation prior to data extension. Instead of errors being scattered over a long period, it is easier to concentrate them over a short period. For this reason, the ACIRC of which interleave is not used has been adopted.

As the LSI for carrying out encode/decode of the EFM and ACIRC, the CXD2525 was developed. Next, the ACIRC encoder's data flow is shown with a block diagram of the EFM/ACIRC encoder/decoder CXD2525.





The following is a list of the functions and features of the CXD2525.

1) EFM encode/decode
2) ACIRC encode/decode
3) ADIP encode

   The bi-phase data which was FM demodulated with the CXD1380 is read by the microcomputer after undergoing demodulation and decoding.
4) CLV control with the EFM/ADIP.

   With pit discs (playback only), an EFM signal is used to carry out CLV control of the spindle servo. With MO discs (MDs for recording), ADIP is used for such control.
5) Inclusion of an error-correction RAM

   The unit includes a 32 kbit RAM used for encode/decode of the ACIRC.
6) Playback-use PLL

   The unit includes a digital PLL to take the EFM signal during playback. As a result, it is possible to carry out a stable operation without an external circuit.
7) Sub-code playback

   Pre-mastered discs carry out access by means of a sub-code Q (SUBQ). As a result, it is possible to take the sub-code up from the playback signal for reading by the microcomputer.
8) Digital Audio Interface

   The unit processes digital in/out signals in response to the serial copy management system (SCMS). The audio data is taken from the digital-in signals input in the digital-in section, after which these are sent to the ATRAC LSI. It is also possible with the system for the microcomputer to read such data as channel status and user's bit. The digital-out section receives extended linear data from the ATRAC LSI for output to digital-out. Channel status and user's bit are written by the microcomputer. It is necessary at this time to write in conformity with the SCMS.
9) Powerful Error Correction

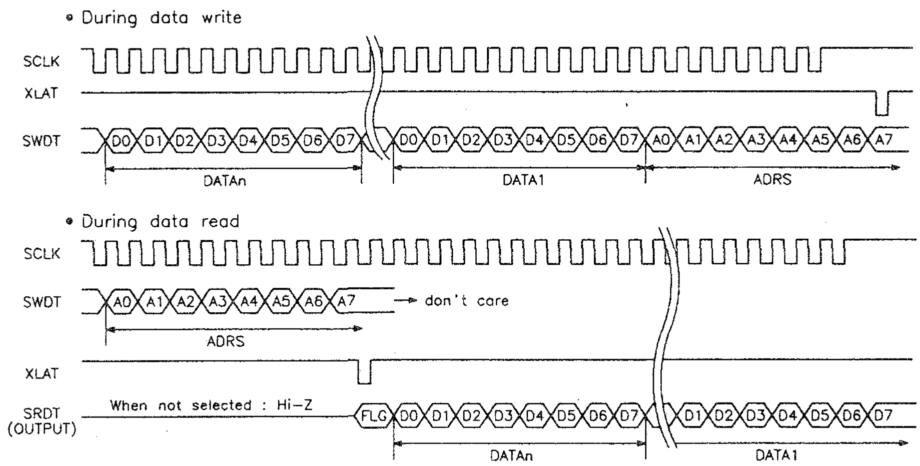
   Outstanding algorithms realize powerful error correction ability: C1: double correction/C2: quadratic correction
10) Peak level detection circuit

   Possible with the microcomputer to adjust data peak level during recording/playback.

11) Traverse Counter
Counting of the number of jumped tracks during access for reading by the microcomputer.

12) Microcomputer Interface with Serial Bus
Communication with the microcomputer by means of four interfaces. The interfaces can also be used with the other LSIs (CXD2526, CXD2527, CXA1082) as serial buses. The addresses are 8 bits and the data length can be changed.

The following shows the serial bus format.

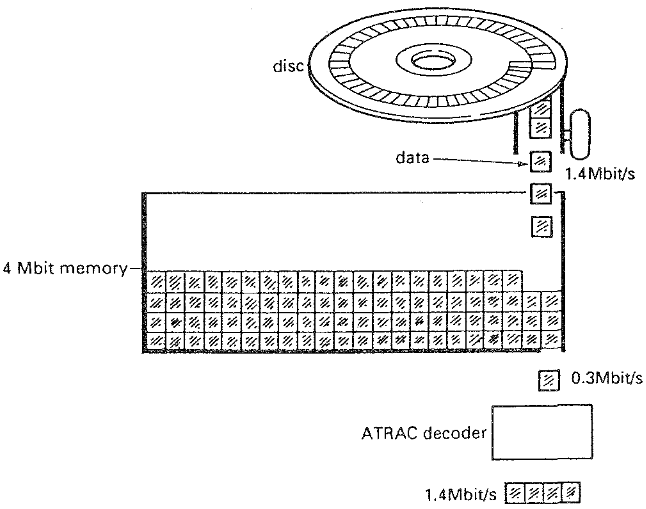


If there is latching of ADRS for which the WRITE ADRS or CHIP ADDRESS is different, SRDT becomes Hi-Z.

A7	A6	A5	A4	Assignment
1	0	0	X	CXD2525
1	0	1	X	CXD2526 Write register
1	1	0	X	CXD2526 Read register
1	1	1	0	CXD2527
0	X	X	X	CXD1082

Sound Skip Guard Memory

The following is a conceptual drawing of the sound skip guard memory.



One of the weak points of the optical disc is sound skipping or sound omission due to external interference such as vibration. The basic response is creating good countermeasures in the form of an anti-vibration mechanism such as a damper, thus preventing it with a servo. However, in cases of strong external disturbance where even such measures are of no use, a semiconductor memory is used to supplement data, thus obtaining sufficient anti-vibration properties for portable equipment. The optical pickup reads data from the disc at the same rate (1.4Mbit/s) as for CDs. However, because the ATRAC decoder is receiving compression data, the data rate only needs to be about 1/5 (292 kbit/s) of the former figure. In other words, because it is possible to read data from the disc at a rate that is much faster than the necessary data rate, if a semiconductor memory is placed between as a buffer, the data in the memory undergoes data reading control so that it is always above a set value. Thus, even if it is not possible to read data from the optical disc due to external disturbance, etc., as long as the data is not empty, it is possible to achieve continuous output of sound. It is possible to quickly reset the pickup and read the following data so that data is written at a fast rate, thus preventing generation of sound cuts. Because the compression data is stored in the memory, compared to cases of directly handling PCM data, the time compensated by the memory can be lengthened to the extent of the compression rate.
With MDs, data is stored at a rate of about 3 seconds with a 1 Mbit memory and about 12 seconds with a 4 Mbit

memory. The CXD2526 was developed as a memory controller IC for the sound skip guard memory. This IC is located between the EFM encoder/decoder (CXD2525) and the ATRAC encoder/decoder (CXD2527). It carries out buffering of the ATRAC data to a connected RAM. The signals read from the disc undergo decode/error correction by the CXD2525 and are sent to the CXD2526. The MD data has a CD-ROM structure. The CXD2526 first detects the sector sync from the data stream to carry out de-scramble. It reads the header and controls by inputting the data in sector units (2352 bytes) to the DRAM. As long as data is stored in the DRAM, the CXD2526 carries out control so that there is sending of data to the CXD2527 at regular intervals. The following is a brief summary of microcomputer control.

1) Based on data from the TOC, etc. there is access to just prior to the head sector for intake of data while reading the SUBQ or ADIP.
, The sector header is read to carry out data intake control starting with the intake start sector.
3) After storage of data to some degree, there is control of data transfer to the CXD2527. Then, there is regular transfer of data as long as data is stored.
4) If data is stored in the DRAM above the determined amount, intake of data is stopped. The pickup also goes to a pause state.
5) By transfer of data to the CXD2527 the data volume decreases. When the volume goes below the determined level, the pickup is accessed to the position that is the continuation of the former process and data intake is resumed.

Following this, steps 4 and 5 are repeated.

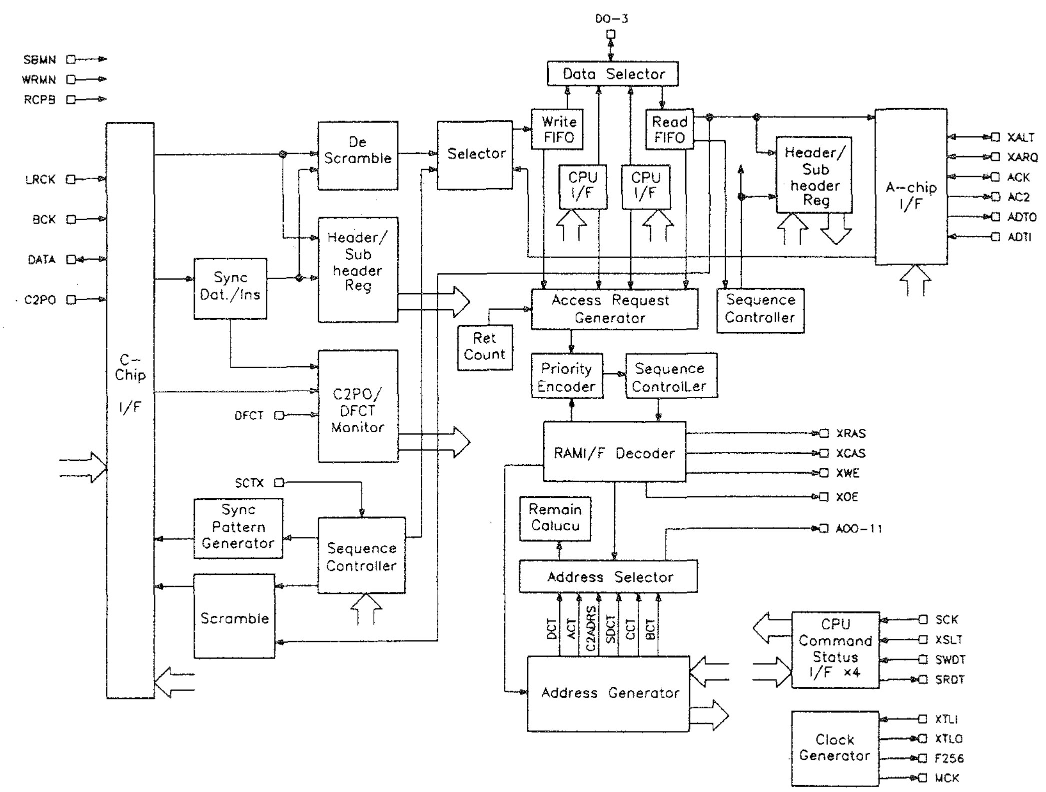
If the focus detects slips or track jumps, etc. in the process, it stops data intake immediately. After reset of the pickup, data intake resumes.

Also, during recording, the flow direction of data becomes the opposite direction and recording is carried out according to basically the same principle as playback.

The sound skip guard memory does not simply compensate for sound skips caused by external disturbance. If the user has carried out random recording and erasing of songs several times, the areas for recording on the disc are scattered in a discontinuous manner over the disc. In such a case as well, there is computation of the empty areas removed from each other which are considered as a single area in carrying out recording.

With the MD system, it is possible to record a single song (track) by jumping over several areas not connected with each other. Because recording is done with the burst method according to cluster units, even if the recording areas are discontinuous, due to random access and the sound jump guard memory, recording can be carried out with no problem. This is exactly the same during playback. As a result, the user does not need to worry at all about how much area is left on a single disc and where it is located. It is thus possible to make use of just about the entire area on the disc. It is also possible to carry out continuous playback of edited areas that were cut and spliced together. This is a superior aspect of discs that cannot be realized with tape media.

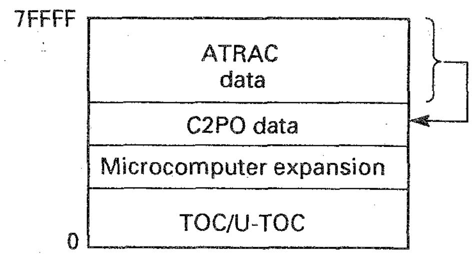
Next follows a block diagram of the CXD2526Q sound skip guard memory controller.



The data used by the CXD2526 is not just ATRAC data. It also includes the per-byte error information (C2PO) of the ATRAC data as well as TOC, and U-TOC (User's TOC) data. With the MD system, the TOC information is also included in the main data with a CD-ROM structure for control of the address information, data and name of the song title. The TOC information is too large in volume to be handled inside the microcomputer. Likewise, including a special RAM, etc. would make the system costly. Thus, one section of the sound skip guard memory (DRAM) connected to the CXD2526 is used for this purpose. The DRAM is roughly divided into the following areas: ATRAC data section, an error information section that is 1/8 the size of the former (C2PO data section), a TOC, UTOC section and an expanded working area for the microcomputer. The microcomputer acts via the CXD2526 to carry out read/write of arbitrary address data in the DRAM. As a result, the microcomputer can interpret the TOC data and edit UTOC information, etc.
The sector allocation of the TOC/U-TOC is as follows.

Sector 0	Basic information and selection start, finish address.
Sector 1	Title of disc and selection, artist's name (ASCII Code)
Sector 2	Recording date and duration of each selection.
Sector 3	Disc bar code and ISRC of each selection.
Sector 4	Title of disc and selection, artist's name (ISO-8859-1 or shift JIS code)

The figure at the right shows a division example of the sound skip guard memory RAM.

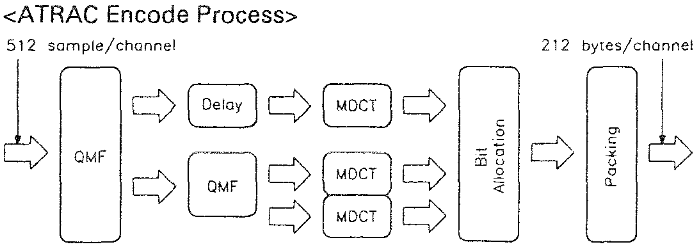


Audio High Performance Coding Method: ATRAC

The MD system employs a media size with a diameter of 64 mm. If recording density on a level with CDs is a prerequisite, a 44.1 kHz 16-bit audio signal cannot be used in order to sustain a playback time of 74 minutes. For MO systems, which makers foresee as the next-generation personal media to replace the analog compact cassette, the development and use of this coding method was a major key to success.

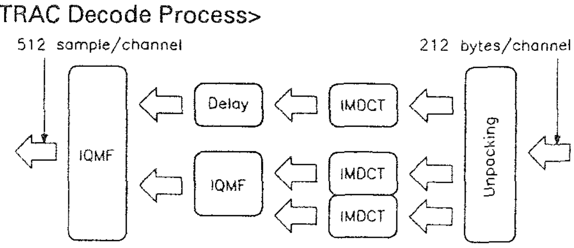
Of course, we are aware of several examples from the past of systems offering audio coding methods. Regarding the optical disc, the ADPCM method which combines predictive coding and block floating as the CD-I audio compression method has already undergone formatting. However, in order to obtain the playback time, a compression rate of approx. 1/5 must be achieved. With the ADPCM, a compression level of 1/4 is possible in CD-I Level B,. However, if the compression rate is increased beyond this figure, one cannot ignore the damage in terms of hearing sensitivity. Thus, the ATRAC (Adaptive Transform Acoustic Coding) system was developed as the compression system most suited to the MD system. Among compression methods there is the type in which coding is carried out on a time axis like the ADPCM. There is also the type known as the transform coding method in which coding is carried out by changing from the time axis to a frequency axis. ATRAC belongs to the latter. As will be explained below, the input/output signals on a time axis carried out with the ATRAC encoder/ decoder are not handled in terms of instantaneous compression. They are blocked and processed. The larger the block size, the higher the compression effectiveness and the more it is possible to prevent deterioration of hearing sensation. This is in inverse proportion to making more realistic LSI regulations for carrying out real time processing. In this sense, the ATRAC block size known as a "sound frame" has been determined as 512 samples/channel. This corresponds to about 11.6 msec on a time axis. The following chart shows the ATRAC encode/decode process.

<ATRAC Encode Process>



Encord process

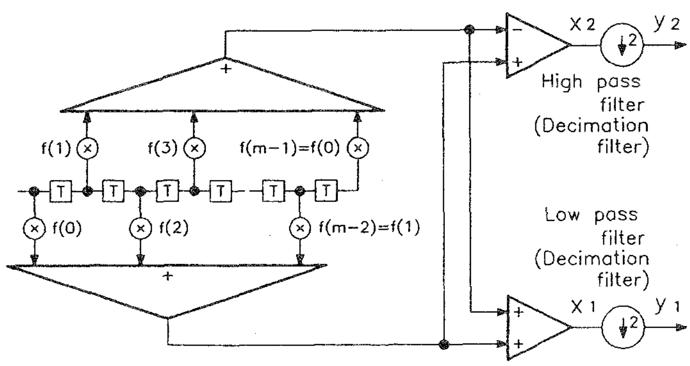
<ATRAC Decode Process>



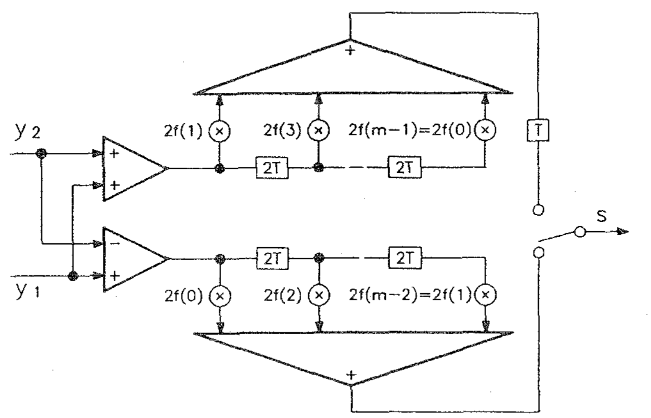
Decode process

As was mentioned above, this is one type of transform coding. One special feature is that, before and after conversion to the frequency axis, there is band division and synthesis with a filter. Due to this filter, which is known as a QMF (Quadrature Mirror Filter), because of encoding, the DC-22.05 kHz audio band is divided into three bands: DC-5.5125 kHz, 5.5125-11.025 kHz, 11.025 - 22.05 kHz. Because each band is 1/2 bandwidth in relation to the input band, the MDCT carries out decimation of the QMF output at half the rate to carry out sampling. On the other hand, because there is a discrepancy in comparison with an ideal filter, in the case of sampling at half the rate after splitting of the signal into two bandwidths, aliasing occurs. Regarding this point, the QMF composes three bands on the decode side to cancel the aliasing element.

As is shown in the figure below as an example of realizing a QMF, one can consider an even coefficient symmetry type FIR filter.

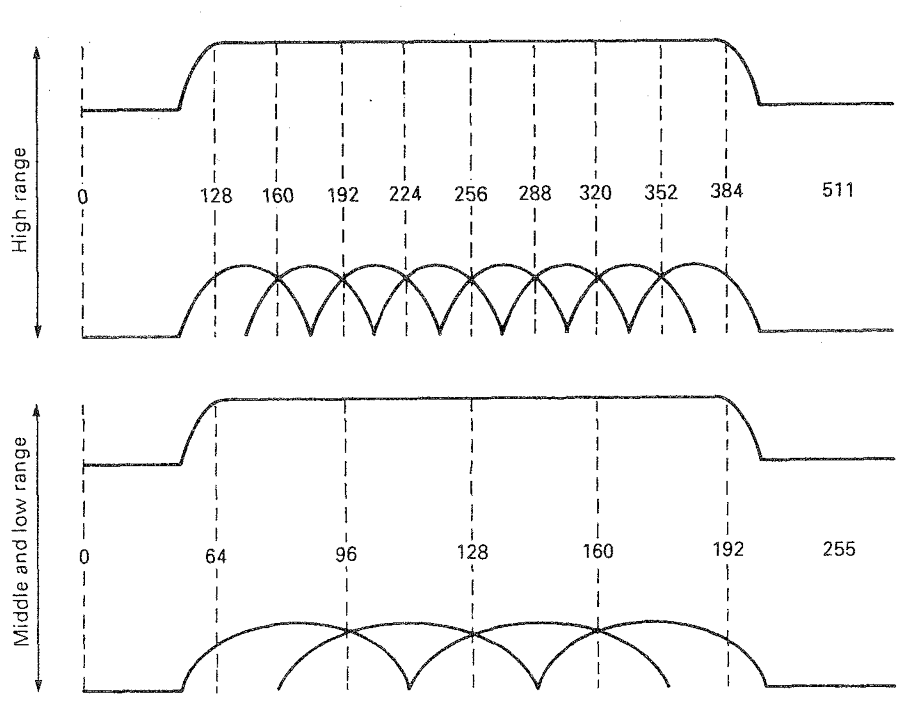


<Example of QMF Structure>

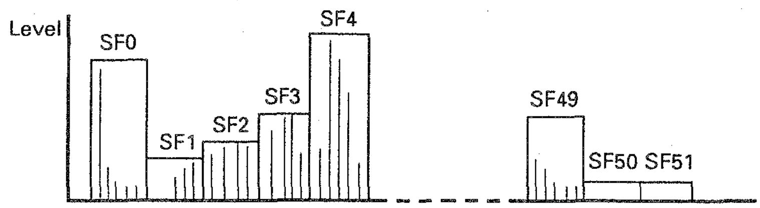


<Example of IQMF Structure>

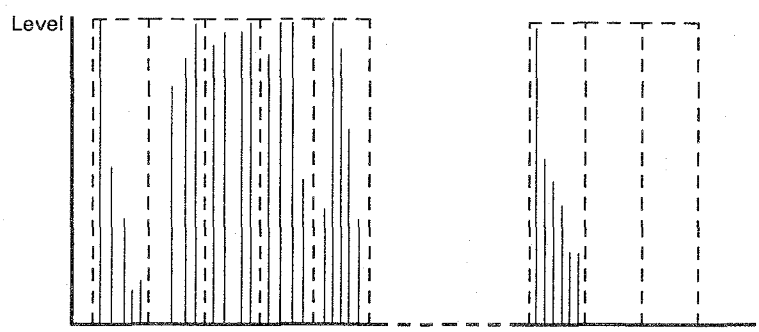
Next, by means of MDCT (Modified Discrete Cosine Transform), there is per-block conversion of spectrums of the time axis signals of each band. The block size M of MDCT is selected appropriately from the two modes of long or short for each band from the time series change. The sound frames are composed of 512 sample/channels. The block size decreases due to decimation following QMF. Compared to a method in which there is direct computation of spectrum without passing through a filter, it is possible to reduce the memory size required for the work area of the LSI carrying out real time processing. This is a major advantage. If the long mode is selected in each band, the block size is 256 in high bands, and 128 in middle and low bands. MDCT is carried out once for each sound frame. If the short mode is selected, the block length is 32 in all bands. MDCT is carried out 8 times per sound frame in high bands and 4 times per sound frame in middle and low bands. The following chart shows examples of the structures of the MDCT blocks.



As this shows, the individual blocks are not independent. Instead, after windows have been created between the neighboring blocks, there is overlapping to create blocks.
MDCT also makes us of high-speed Fourier conversion (FFT) for highly effective execution. Because the above-mentioned block length is a tap number the butterfly computation which is the main routine of FFT is executed in Log (H) levels. In the present case, by convolution of the coefficient of input and rotational factor, it is necessary to consider obtaining head room in computation and generation of requantization errors. Also, to make the memory size smaller, it is effective to use the in-place method for computation in relation to the work memory for FFT. To give the example of the long mode, with MDCT a total of 256 spectra are obtained in high ranges and a total of 128 spectra in medium and low ranges.
In the processes described above from QMF to MDCT, there is no compression of the information volume. Thus, by carrying out IMDCT-IQMF conversion on the decoder side, it is possible to completely restore the original signal. Actually, however, in the stage of standardization and requantization of the spectrum, there is compression to the desired bit rate. The spectra are arranged in 52 bands which are determined in terms of critical bands.
If the spectra are simply requantized in terms of low bits, the spectra with low power are ignored, creating a problem with hearing perception. For this reason, there is computation of the scale factor (largest value of spectra in a band) for each band, and block floating is carried out based on the scale factor. The following figures show grouping to critical bands and block floating.



<Division into critical bands>



<Block floating>

Next, there is requantization of the standardized spectra in terms of the bit number assigned to each band known as word length. With ADPCM, this is rounded out to the same bit number for all bands. With ATRAC this differs for each critical band. In the latter case, the requantization size is generated for each band. Controlling the bit length makes it possible to realize compression using the characteristics of human hearing.
Next, in addition to quantization sub-information such as the scale factor and word length for each band, the main information of compressed spectra undergoes packing to obtain 121 byte/channel data. There is decoding by means of a reverse process in the decoder. The sub-information is an especially important parameter. By carrying out double writing at the beginning and end of each bit stream there is protection against disc error.
The CXD2527 was developed as an LSI to process the above ATRAC sequence in real time. In terms of format, the bit assignment processing in the decoder is flexible so that we can expect an improvement in sound quality with better algorithms. For this reason, it was designed as an ASIC-DSP.

2. Kenwood First Generation MD System

The first generation of Kenwood MD systems included the three types that went on sale in the past: the DM-B9, the DM-1001 and the DM-E9. The following is a technical description of the contents of those products using the DM-E9 as a model.

Main devices and their functions

RF matrix amp CXA1381Q

→A first generation Sony device. Used for generation and processing of RF signal and servo signals used for storing and reproduction on Mini discs.

ADIP demodulator CXA1380M

→A first generation Sony device. Capable of reading the ADIP (Address in Pregroove) signal created in the Mini disc.

EFM/ACIRC encoder/decoder CXD2525Q

→A first generation Sony device. An EFM/ACIRC encoder/decoder created for the Mini disc format.

Shockproof Memory Controller CXD2526Q

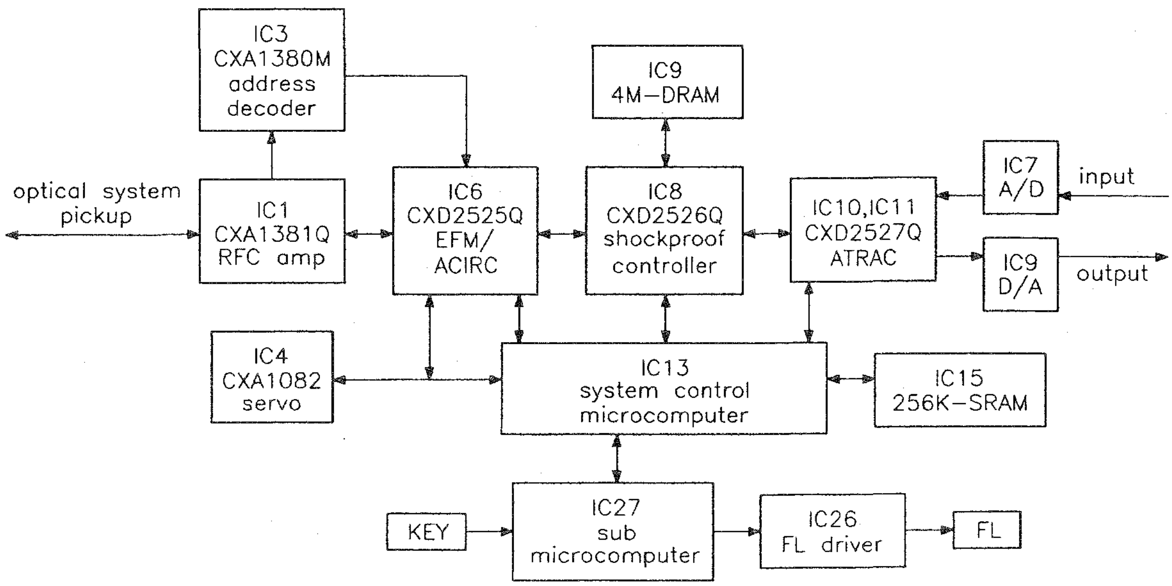
→A first generation Sony device. A memory controller for the sound skip guard memory controller structure found in the MD system. Controls encode/decode of MD format signals as well as main data, C2PO data, sub-data, system data for the microcomputer, and external input/output status.

Audio compression ATRAC encoder/decoder CXD2527R

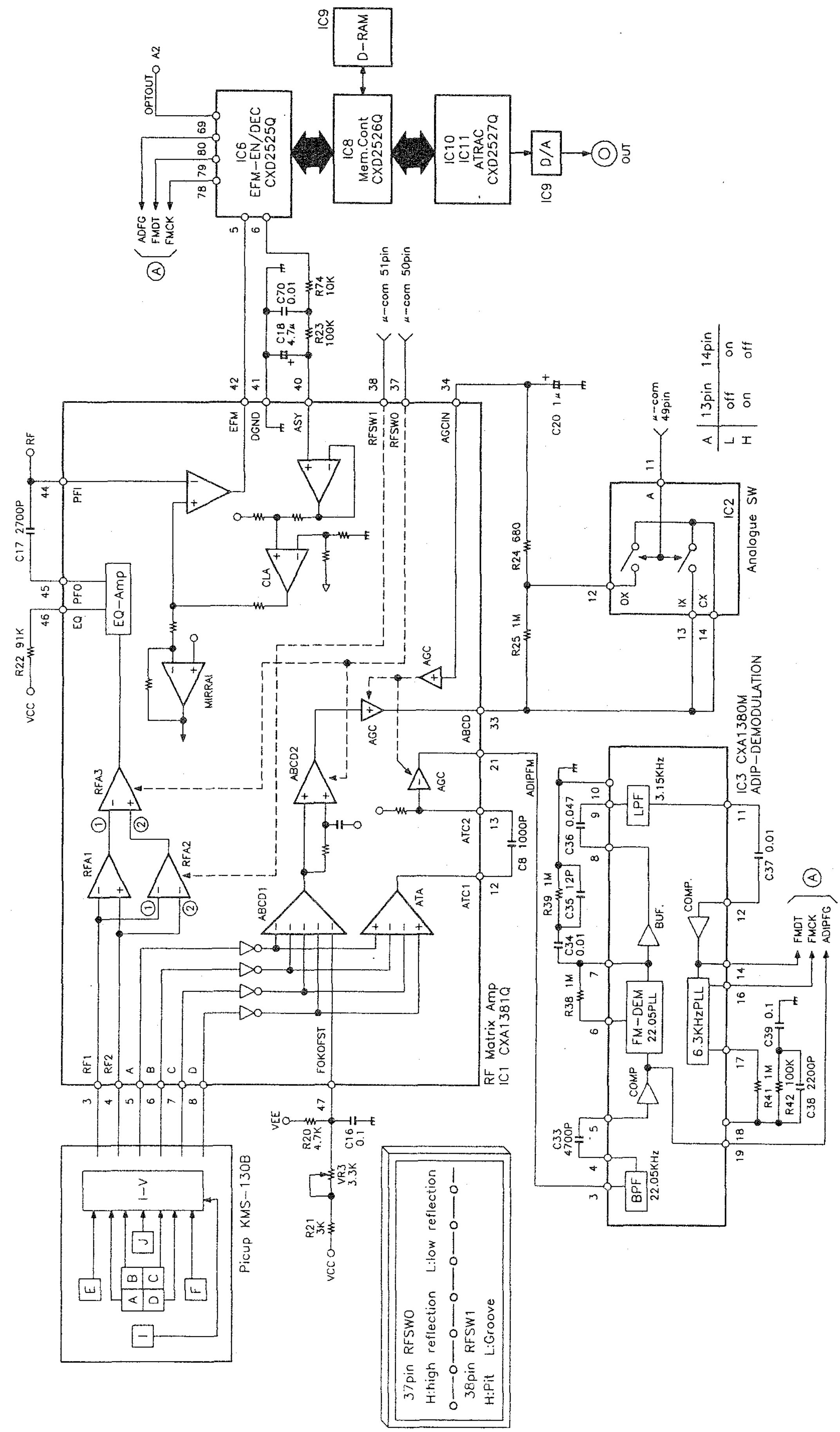
→A first generation Sony device. An LSI carrying out the process known as ATRAC (Adaptive Transform Acoustic Coding) for Mini disc recorders. In addition to including an A/D, D/A converter interface, it can be combined with a CXD2525Q and CXD2526Q for real time processing of band compression and extension.

In addition to the above five types of chip structures, there is inclusion of a servo signal processing IC (CXA1082) already known from use in CD players, as well as a 4-bit DRAM as a shock-proof memory, and a 256 kbit SRAM as a backup for TOC and UTOC. The main microcomputer carries out control with a sub-microcomputer for display and key input. The following is a block diagram of the system.

<Block Diagram of the DM-E9 System>



<FLow of playback system main signals of MD-E9>

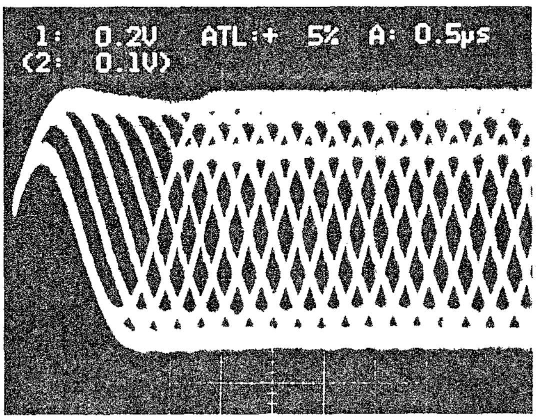


Description of the Flow of Playback System Main Signals

1) The main signal images I and J generated in the pickup undergo current/voltage conversion processing inside the pickup, and are output from the optical section as the signals RF1 and RF2. These are input to the 3,4 pins of the RF matrix amp IC1.
2) Regarding the two main input signals RF1 and RF2, the difference signal (MO signal) is obtained with the RFA1 amp, and the sum signal (PIT signal) is obtained with the RFA2 amp. The RFA2 and RFA3 amps are switch OP-amps. The output signals are determined according to the state of the RFSW0 and RFSW1 signals input from the IC1 27 and 38 pins. The RF signals set for each mode are input from the RFO terminal of the 45 pin as eye patterns after passing through the equalizer unit. (Observation at test point CN7-1 pin)

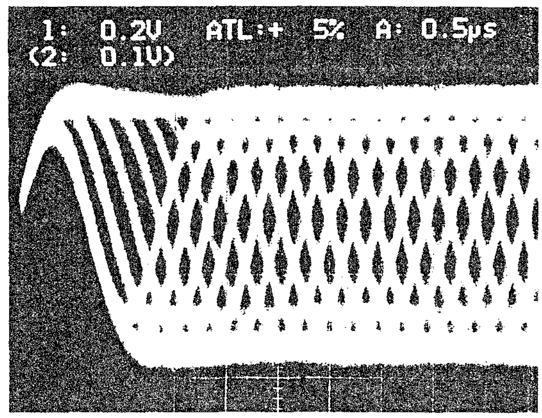
Premastered disc (playback disc)

●Eye Pattern

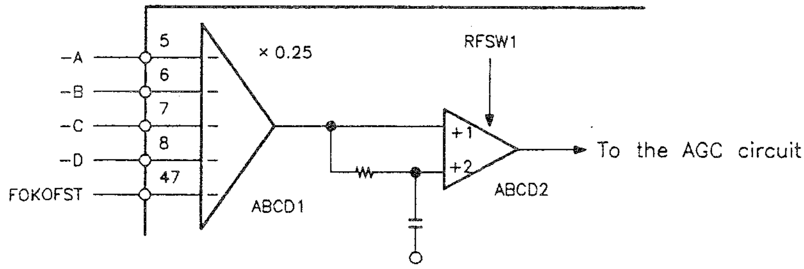


Recordable disc (recording disc)

●Eye Pattern

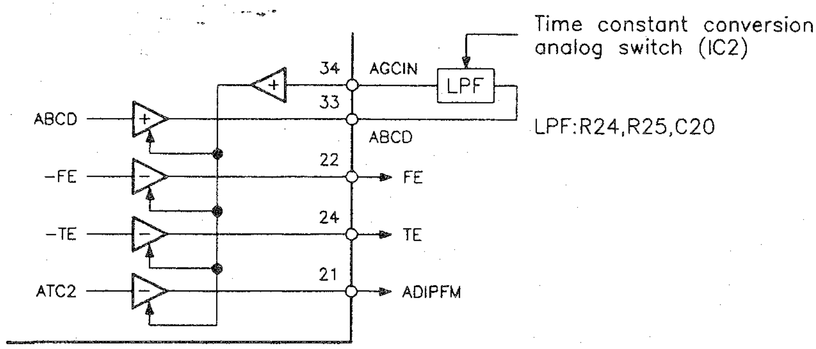


3) As the photographs above show, the RF signal output from the FRO terminal has an amplitude of approximately 1.0 Vpp. It passes through the AC coupling element (HPF) of C17 and is led again to the EFM comparator inside the RF matrix amp ICl. As is the case with CD players, it is necessary to distinguish H and L signals from the RF signal. However, if there is simply AC coupling of the RF signal, it is not possible to create a binary version of the signal. Thus, the fact that the generation rate of the EFM signal 1.0 is 50% is used to control the reference voltage of the EFM comparator and remove the assymetry section. R23, R74, C18 and C70 are LPF to obtain Vcc/2(v). In the present system, the cutoff frequency is set at fc=160 Hz. If the fc is large (500 Hz or greater) the leak of the low range factor of the EFM becomes larger causing a larger error rate.
4) The EFM signal which has undergone symmetry processing is demodulated in the EFM.ACIRC EN/DEC IC6 and is led to the IC8 memory controller at a speed of 1.4 Mbit/s, after which it is stored in the 4 Mbit memory (D-RAM). The subsequent ATRAC IC10, 11 only require an input signal speed of 292 kbit/s. This speed data is read from the D-RAM. The signals that have been read (compression signals) undergo extension processing by the ATRAC-IC. The digital data after extension is the signal obtained by carrying out 44.1 kHz sampling of the original analog signal and 16 bit quantization. One signal returns to the EFM EN/DEC of IC6 for conversion to the digital-out format and sending to the optical terminal. The other signal passes through the D/F D/A unit and is output to the analog out terminal as an audio signal.
5) With an MD recorder, the size of the signals input from the pickup to the RF matrix amp varies according to the disc. This is because the system responds to two types of discs which differ greatly in terms of reflection rate: the magneto-optic disc known as the low reflection disc and the premastered disc known as the high reflection disc. Moreover, a large laser power is set for recording on magneto-optic discs. In order that a stable signal and servo state can be maintained under all circumstances, an AGC circuit is included inside the RF matrix amp.



The block diagram above is a circuit to obtain the return light quantity of the main spot in the pickup so as to control the AGC circuit. The sum of four signals (-A, -B, -C and -D) which underwent I-V conversion with the head amp in the pickup are generated in the ABCD1 amp. ABCD2 is a switch OP-amp. It carries out time constant conversion when injecting to the AGC unit the SUM signal generated in the ABCD1 amp. When there are pits on the read signal surface of the disc, the EFM element is superimposed on the SUM signal so that the SUM signal level fluctuates. In order to prevent such level fluctuation, an LPF is added to remove the EFM element. When RFSW1 (38 pin) is "H" status, the LPF input is selected at the ABCD2 amp.

6) Due to the above circuit, a signal was generated to control the AGC circuit which is included to correctly obtain the signals (RF, ADIP, FE, TE).



The light amount sum signal from the ABCD amp is input to the AGC circuit and is output to the ABCD terminal of the 33 pin. This output passes through the external LPF and is input to AGCIN. As a result, even if the light amount entering the photodiode in the pickup should change, the ABCD terminal output is kept at DC 1 V.

In like manner, the amplitudes of the FE, TE and ADIPFM signals are maintained at a set value regardless of changes in light amount. Incidentally, the external LPF determines the band of the AGC loop.

During normal playback, the cut-off is set sufficiently low so that it does not respond to changes in return light amount during track jump or defect. Also, in order to speed up loop response during changes in laser power for Write-Read on magneto-optic discs or during focus search, the cut-off frequency is set high. Conversion of the LPF time constant is regulated by the analog switch IC2. The IC2 has the state indicated by the main microcomputer.

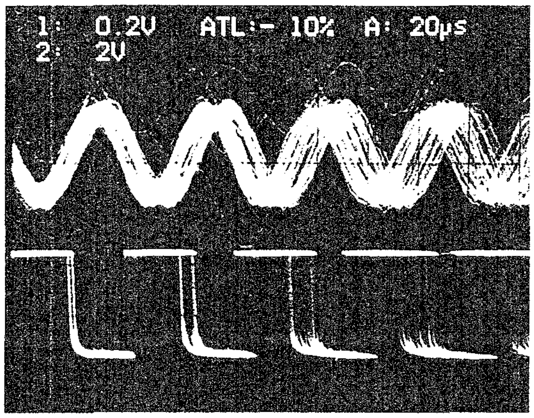
Special Signals When Playing Back Recordable Discs

With magneto-optic discs, in order to clarify the absolute position on the disc, address information is recorded beforehand. This address information is carved onto the magneto-optic discs by using FM demodulation for wobbling on the grooves in the disc. In other words, during playback of magneto-optic discs, this address information (absolute address) is extracted and becomes an indispensable signal acting in place of TOC to carry out data demodulation.

1) The ADIP signal is recorded beforehand as wobbling in the grooves on the disc. In other words, to obtain the ADIP signal, it is determined that is possible to use the photo detectors A,B,C,D in the pickup. Inside the RF matrix amp IC1, the ATA amp is used to create a (B+C)-(A+D) signal. The principle is the same as the method for generating the push-pull TE signal in a single-beam type CD player. The generated (B+C)-(A+D) signal undergoes AC coupling to obtain the ADIP signal which has undergone FM demodulation. This is then output to the 21 pin of the RF matrix amp IC1. (ADIPFM signal)

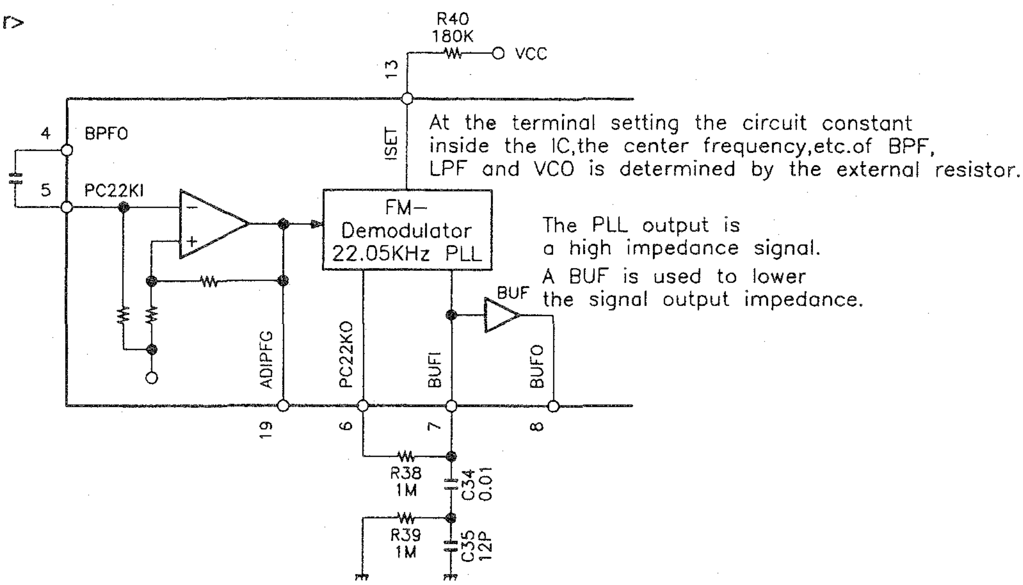
2) The ADIPFM signal that was generated by the RF matrix amp IC1 is input to the 3 pin of the IC3 ADIP demodulator and taken into the system's interior. The ADIPFM signal receives the information that the ADIP signal is modulated at 22.05 kHz ±1kHz and passes a BPF of 22.05 kHz (half-cycle of sampling frequency 44.1 kHz) to remove the noise element.

3) The ADIPFM signal which has undergone noise removal undergoes capacity coupling at C33. It then undergoes binarization by passing through the hysteresis comparator in IC3. The binarized signal known as an ADIPFG signal is output from the 19 pin. The signal of this terminal is used as the FG signal for CLV rough servo control. In the interior, the ADIPFG signal is set to a 22.05 kHz PLL to obtain a bi-phase signal.

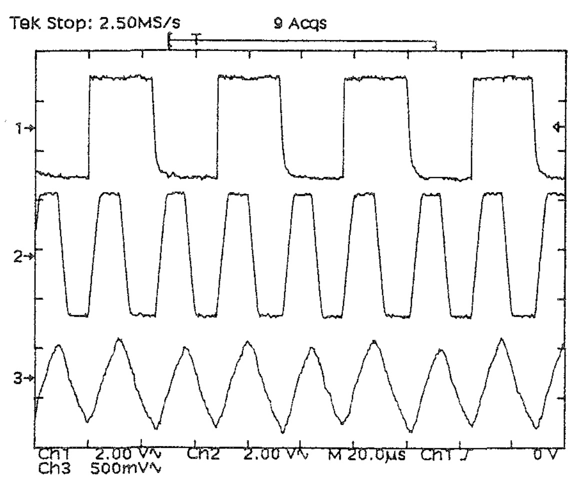


4) As the following figure shows, the ADIPFG signal which has already been binarization and the output of the internal VCO are applied to phase comparison and the compared signal (FC22KO) is returned via the external loop filter. As a result, there is control of the oscillation frequency of the internal VCO and PLL modulation. Thus, there is demodulation of the original bi-phase signal as the address signal.

<FM Demodulator>



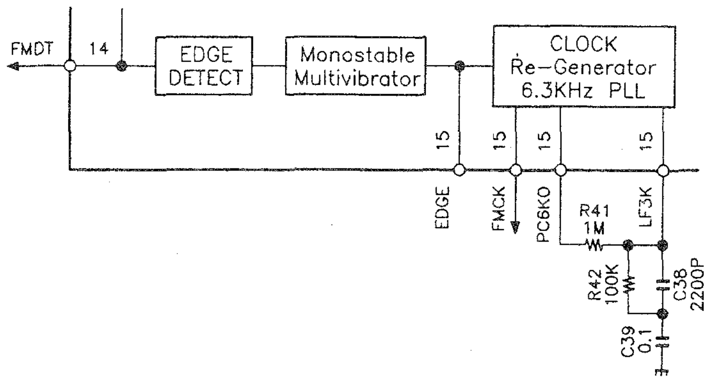
The following shows the waveforms around the 22.05 kHz PLL.



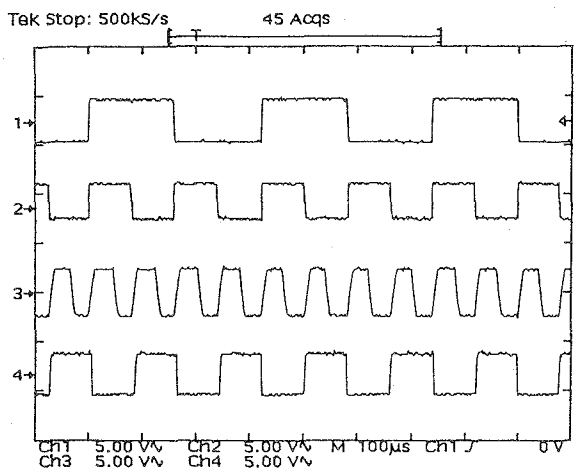
CH1: ADIPFG signal
CH2: PC22KO signal
CH3: BUFI signal

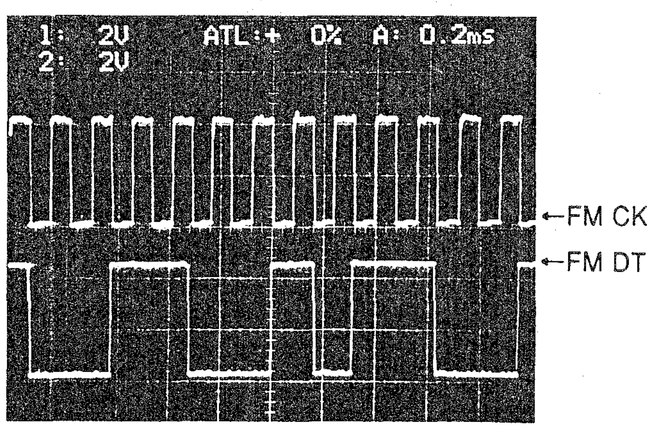
5) As shown in the block diagram above, a signal (BUF0 signal) including a bi-phase factor as an address signal is removed the 22.05 kHz carrier signal by the LPF (3.165 kHz). The signal that has undergone capacity coupling is injected to the comparator and is output as a digital signal (FMDT signal).

6) The data (FMDT) which has FM demodulated is a bi-phase data. The edge detection is carried to obtain a bi-phase bit clock. If there is an edge, there is generation of a 78 μs edge pulse by a monostable multivibrator. PLL modulation is carried out on the edge pulse obtained from this data to create a bit clock. The following is a block diagram of the related circuits and waveforms.



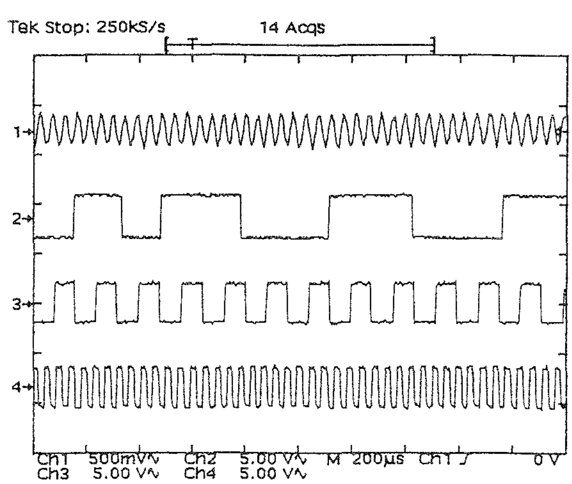
CH1, FMDT CH2, EDGE
CH3, PC6KO CH4, FMCK



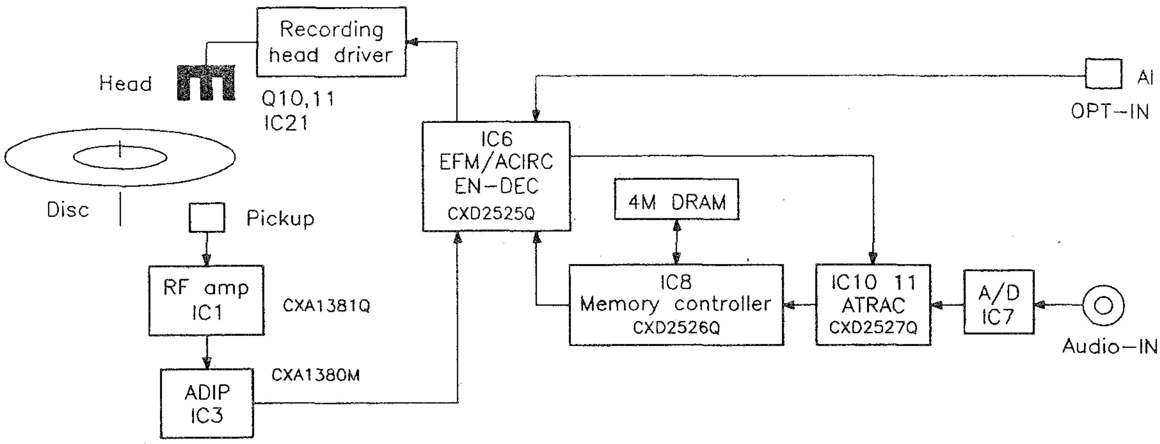


7) As shown above, the IC3 ADIP demodulator is used to extract address information from the recordable disc and to send data to the EFM/ACIRC DSP.

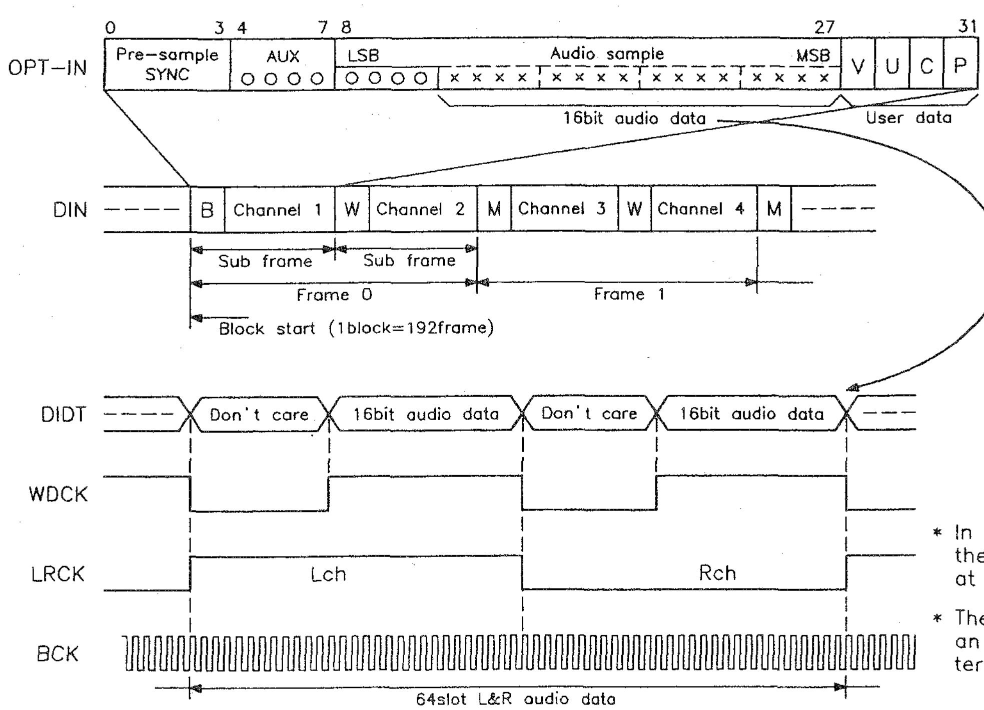
CH1, ADIPFM
CH2, FMDT
CH3, FMCK
CH4, ADIPFG



<Flow of DM-E9 Recording System Main Signals>



[1] Regarding the input configuration of the signal to be recorded, in the case of the DM-E9, there are two systems: optical digital input and analog input. The digital signal of the optical input is applied to the IC6 EFM/ACIRC IC so that synchronicity is obtained with the 512 fs PLL in this IC. Of the digital signals input to the DIN, the audio data is converted to the 64 slot format and is sent to the audio compression IC's (IC10, 11).

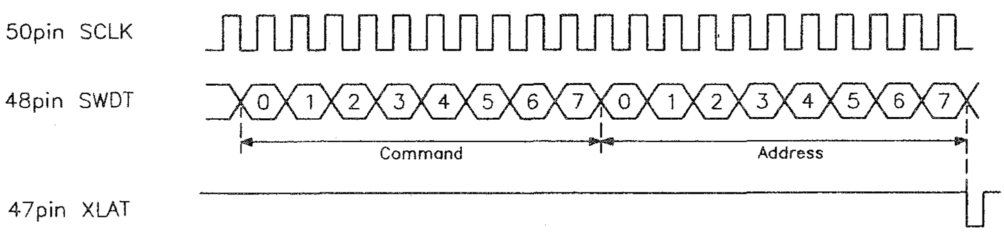


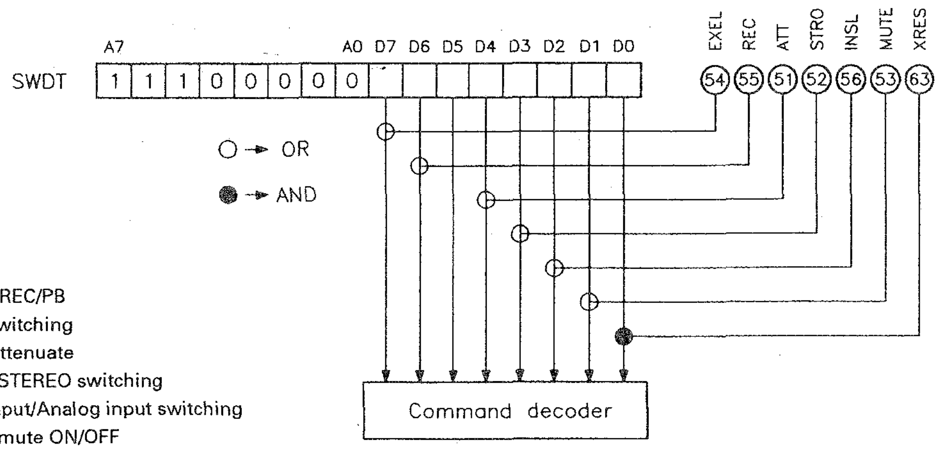
* In digital recording, the V bit is appeared at the C2PO terminal.
* The C bit is an 32bits output as an address indicated by the SRDT terminal.

2) The audio signal of the analog input undergoes Rec level (V1) adjustment. It then passes through the buffer for input to the A/D converter CS5339-KS of IC7 where it is converted into a digital signal. Regarding this digital output from the A/D converter, there is 16 bits of a 2's complement MSB fast, a 3-bit over/under scale flag and a 1-bit L/R flag to create a 20-bit audio sample which is obtained as 1 sub-frame from the pin 16 SDATA terminal. Then, as was the case with digital Rec in, it is led to the ATRAC-IC of IC 10, 11.

3) With the DM-E9 and other members of the first generation Kenwood MD systems, two ATRAC IC's are used independently: one for the Lch and another for the Rch. They also include the IC CXD2527R recording system/playback system. In other words, it is necessary to change the device mode according to the operation of the player. For mode-changing, control of 7 types of information from the main microcomputer is carried out either directly through the port or by serial transfer. In the present device, there is control by serial transfer. The following presents the concrete contents of the system.

<ATRAC ENCODE/DECODE IC CXD2575R CPU INTERFACE>

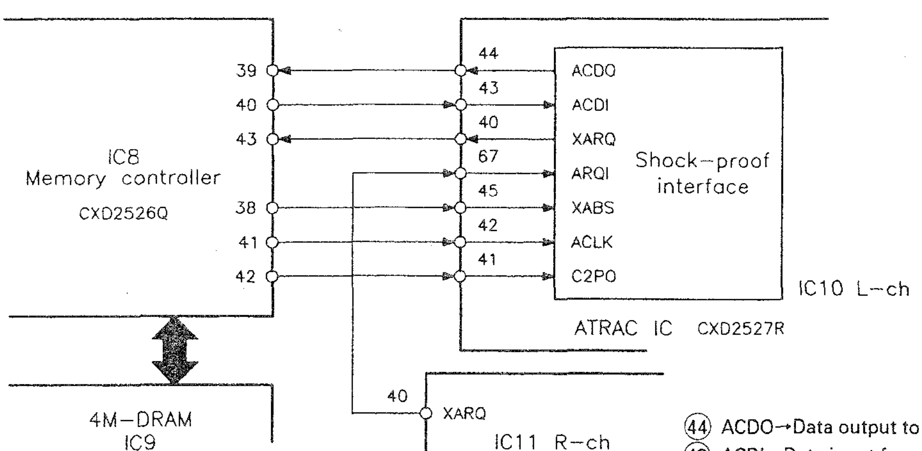




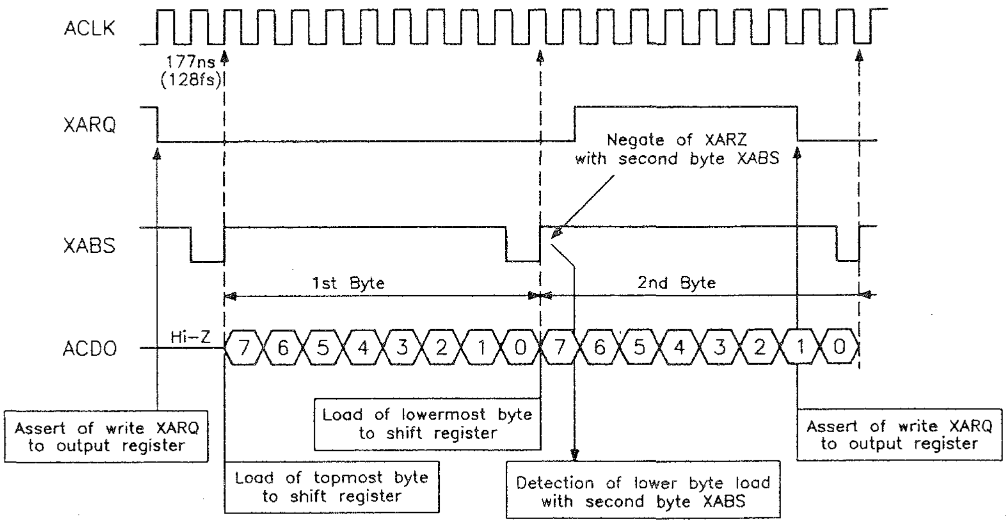
EXEC: Start of REC/PB
REC: REC/PB switching
ATAT: -12 db attenuate
STRO: MONO/STEREO switching
INSL: Digital input/Analog input switching
MUTE: Digital mute ON/OFF
XRES: Reset

4) The selected recording input is taken in at a rate of 44.1 kHz. Regarding the selected recording input, there is masking of the signal on the opposite channel by the CHSL command for each chip. For the recording monitor, the DODT (77 pin) of one channel (Rch) is connected to the DRI (69 pin) of the other channel for remixing of the Lch/Rch signals and fed to the D/A converter and CXD2525Q.

5) The following is a description of the recording interface with the shock-proof memory controller CXD2526Q.



44 ACDO→Data output to CXD2526Q.
43 ACDI→Data input from CXD2526Q.
40 XARQ→Request for data transfer to CXD2526Q.
67 ARQI→XARZ input on other channels.
45 XABSL→Synchronous pulse for serial transfer with CXD2526Q.
42 ACLK→Serial transfer clock with CXD2526Q.
41 C2PO→Error status of input data from CXD2526Q.

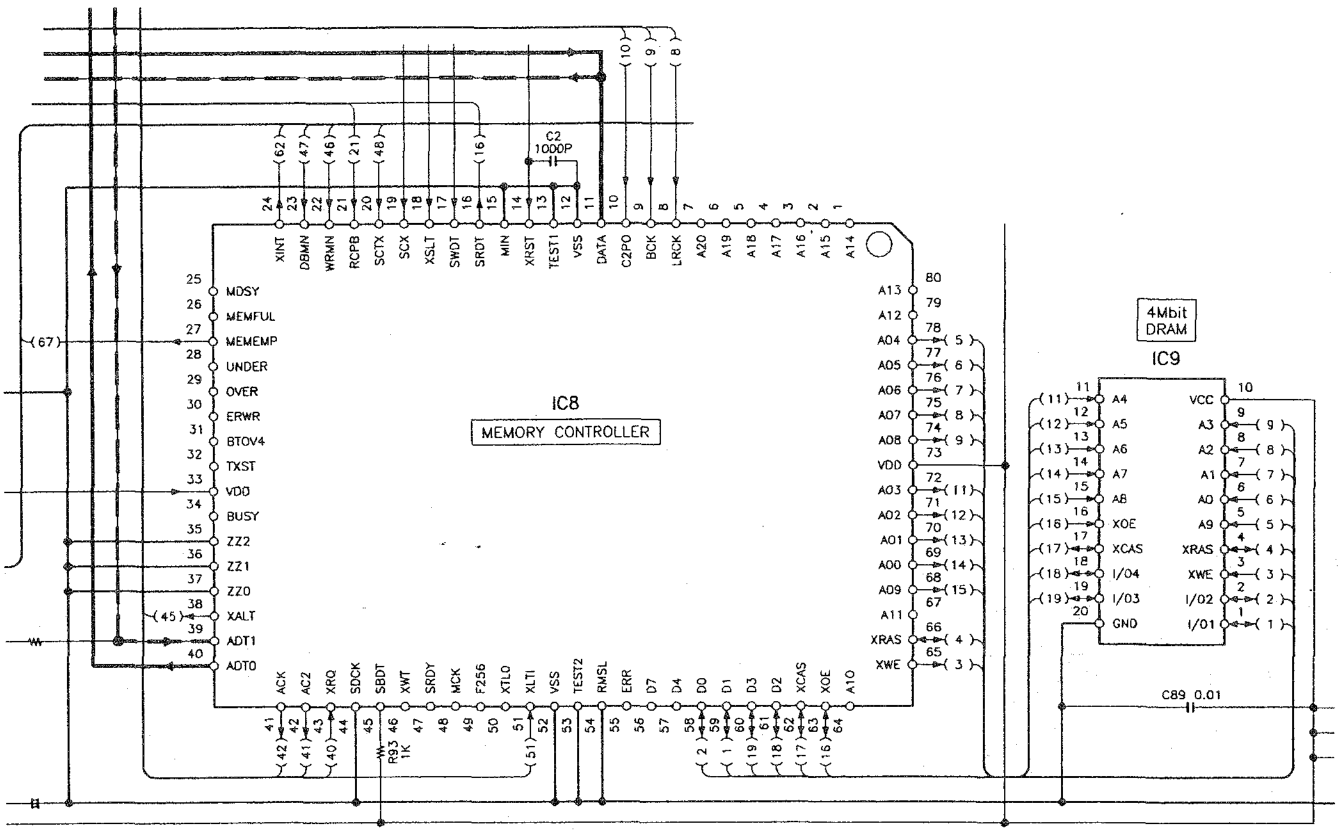


◆Transfer cycle corresponding to 1-word compression data. The compression data is 212 bytes so that the cycleis executed 106 times. Transfer of the compression data starts with L channel.

The ATRAC IC writes the compression data to the output register and asserts the transfer request XARQ. In response to the transfer request, the memory controller CXD2526Q makes the synchronous pulse XABS. Of the data written to the output register, there is loading of the upper byte and, synchronous with start of the transfer clock ACLK, there is output from the ACDO terminal. After transfer of 1 byte, there is loading of the lower byte of the data and output to the ACDC terminal in the same way. If XABS is not output immediately, after transferring the present transfer data, there is temporary termination of transfer and the system goes to a wait state. When it is confirmed by the system that the second byte XABS has started and that transfer is completed, the next compression data is written to the register and the transfer cycle starts corresponding to the next word. When the Lch chip completes transfer, transfer is permitted for the Rch chip. The ACDO terminals of the L, Rch are connected with wired OR. While one is transferring, the other terminal is in high impedance. The time required for transfer is 0.3 msec per channel.

For reference, operation of the playback system is basically the same as the recording operation described above. There are two differences: The compression data is input from the memory controller to the ACDI terminal. The pulse width of the serial transfer synchronous pulse changes to 4 ACLK. Also, there is inclusion of a C2PO signal expressing the compression input data error.

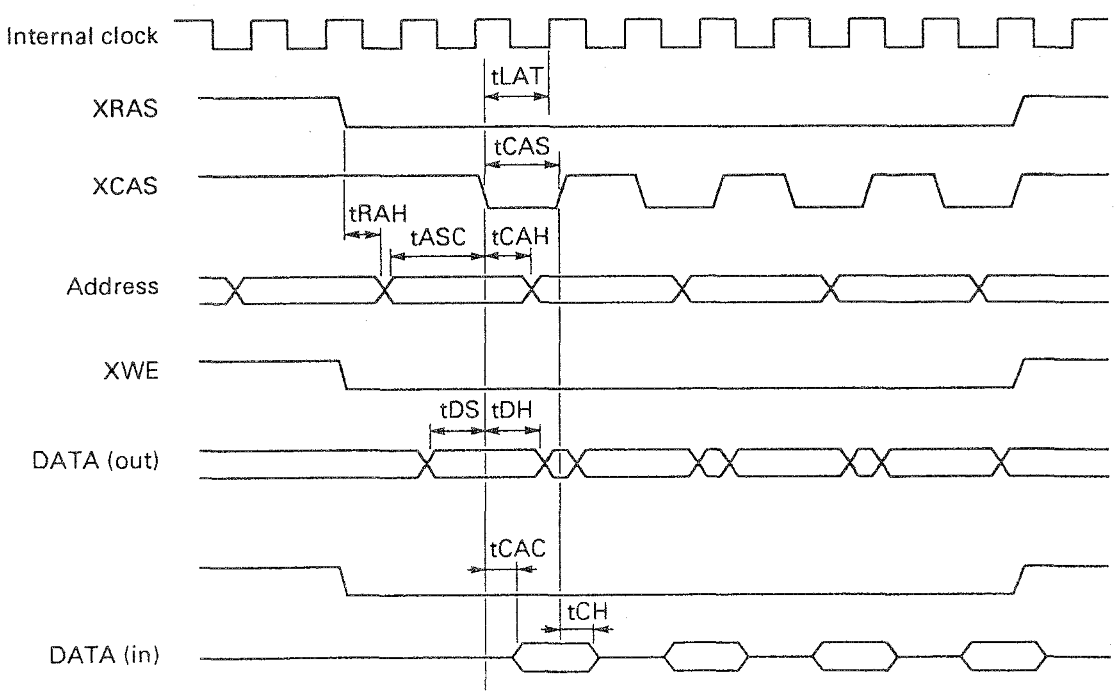
6) The compression data transferred from the ATRAC IC is written onto the 4-Mbit D-RAM IC7 by the IC8 memory controller CXD2526Q.



The interface between the memory controller and the D-RAM includes four terminals in addition to the address data. The following shows the timings.

IC8

62 pin	XCAS	→Chip select signal (column address intake signal during Read/write cycle).
63 pin	XOE	→Data output enable signal of RAM (output enable).
65 pin	XWE	→Data write enable signal to RAM (write enable).
66 pin	XRAS	→Low address strobe signal.



The basic operation of the memory controller during recording is as follows: Compression data from the ATRAC encoder immediately undergoes buffering. After a header, etc. are added, scrambling is carried out. Then a synch pattern is added and it is transferred to the EFM encoder (IC6). Incidentally, the per-sector transfer amount of main data to be sent in the case of the MD format is obtained by the following equation:

$$2352-\underbrace{12}_{\text{(synch pattern)}}-\underbrace{4}_{\text{(header)}}-\underbrace{4}_{\text{(sub-header)}} = 2332 \text{ bytes}$$

The following is a brief description of the CXD2526Q memory controller. The memory controller can roughly be divided into the following four blocks:

★DI Block (EFM encoder/decoder interface block)

Data input from the EFM decoder during playback undergoes internal synchronization in sector units by the synchronous detection circuit.

Synchronization is not simply detection of the input synch pattern. There is also guarding of detection errors, etc., with an interpolation circuit. Furthermore, even if there is synchronous aberration due to track jumping, etc. there is control so there is rapid recovery. Input data that has travelled through a descramble circuit and the C2PO data are sent to the RI block with the write mode. They are written onto the RAM according to the address generated by the counter in the CT block. During recording, this block encodes MD sector format data. It carries out generation of sync byte, reads the header time from the register and reads the necessary data from the memory. After passing through the scrambler, the data is supplied to the EFM encoder. There are 3 types of data as sector data. Depending on the microcomputer setting, there is generation of linking data, sub-data and main data.

★RI Block (RAM interface block)

Input/output requests are received from other blocks and there is RAM access control according to the following order of priority.

DI Block→AI Block→Refresh→CPU Access→Sub-Data Access

Thus, access of playback/recording data from the optical disc is in the order of highest priority. Data access from the CPU and external I/F is waited according to internal generation of requests.

★CT Block (Address Counter Block to RAM)

1) DCT: Address generation of read/write data with EFM encoder/decoder.
2) ACT: Address generation of transfer data with ATRAC encoder/decoder.
3) CCT: Generation of address accessed by the CPU.
4) SDCT: Address generation for memory access according to external sub-data I/F in addition to DCT.
5) BCT: Count operation of transfer data.

★AI Block (Interface Block with ATRAC Encoder/Decoder)

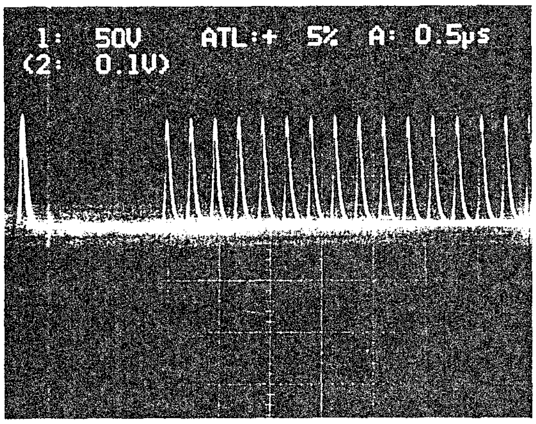
Carries out data input/output with ATRAC encoder/decoder and requests data reception to RI block.

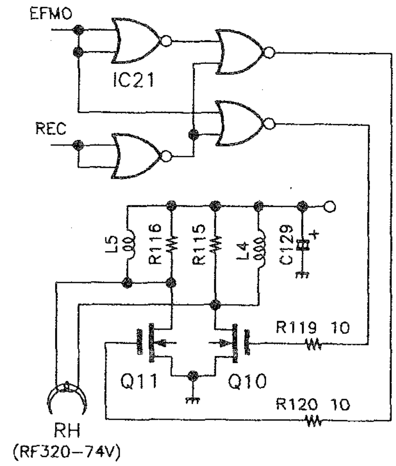
The following section is a description of the names of functions of particularly important terminals of the IC CXD2526Q memory controller.

Terminal NUmber	Terminal Code	I/O	Description of Terminal
1	A14	O	WFFUL terminal, Goes to "H" when the write FIFO is full.
2	A15	O	RFEMP terminal, Goes to "H" when the write FIFO is empty.
3	A16	O	WFOVF terminal, Goes to "H" when the write FIFO is overflow.
4	A17	O	WDTM terminal, outputs the timing of the window in the DI block.
5	A18	O	ZERO terminal, "H" is output when BCT=0.
6	A19	O	MDTSC terminal, Goes to "H" when the sector of the input data header is #00-1F.
7	A20	O	CMPSY terminal, Timing of interpolation sync.
20	SCTX	I	Enable signal input terminal for recording mode. Enable with "H".
21	RCPB	I	"L" Playback mode, "H" Recording mode.
22	WRMN	I	"H" Write mode, "L" Monitor mode.
25	MDSY	O	MD sync detection terminal of input data.
26	MEMFUL	O	Goes to "H" when the data in the main data area becomes full.
27	MEMEMP	O	Goes to "H" when the data in the main data area becomes empty.
28	UNDER	O	Goes to "H" when RMS<THUND.
29	OVER	O	Goes to "H" when RMS≧THOVR.
30	ERWR	O	Goes to "H" when data with H-C2PO is written onto the RAM.
48	MCK	O	128 fs output terminal.
49	F256	O	256 fs output terminal.
80	A13	O	SYOK terminal, Sync read signal output terminal for current header.

7) In the transfer mode of 1.4 Mb/s, the scrambled recording data is sent to the EFM encoder where there is EFM demodulation and assignment of error correction code (ACIRC). It is then output from the 13 pin EFMO of the IC6 and supplied to the recording head. When writing the EFM signal onto the disc, the sub-code in all cases must be 0.

●Recording Head (CN3)

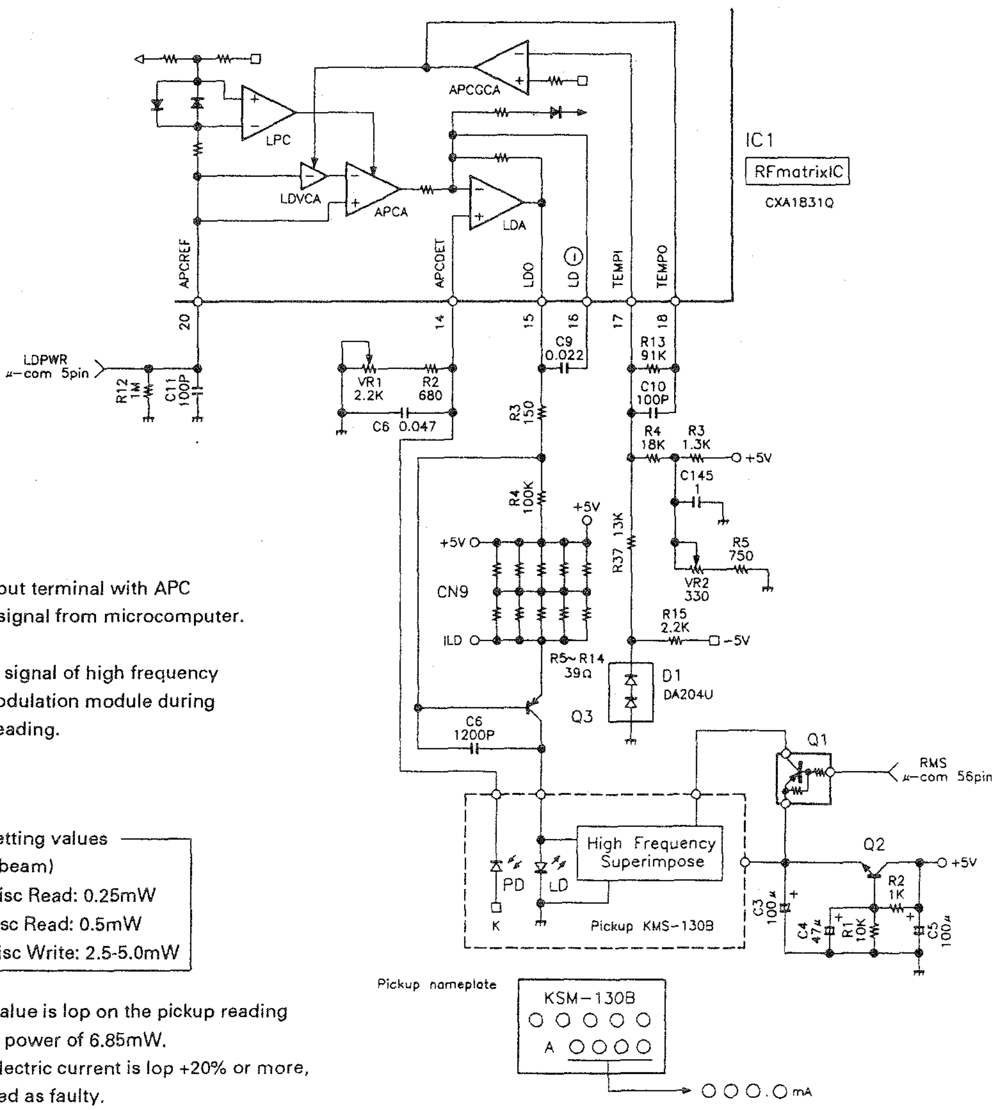




<Description of the DM-E9 Servo-Systems>

As can be understood from use of the servo IC CXA1083Q in the system, the basic structure of the servo systems is basically the same as that for a CD player. The following is a description of those servo systems. It is assumed that the reader has an understanding of the servo principles of a CD player.

1) APC Circuit (Automatic Laser Power Control Circuit)



Terminals

LDPWR→ D/A output terminal with APC control signal from microcomputer.

RMS→ ON/OFF signal of high frequency laser modulation module during signal reading.

LD power setting values (Main beam)
High reflection disc Read: 0.25mW
Low reflection disc Read: 0.5mW
Magneto-optic disc Write: 2.5-5.0mW

Normally the ILD value is Iop on the pickup reading during a radiation power of 6.85mW.
IF the measured electric current is Iop +20% or more, the pickup is judged as faulty.

With the APC circuit, the laser diode controls laser power without being influenced by ambient temperature in order to protect temperature characteristics. In the case of the MD recorder, there is an addition of a front monitor photodiode which is used as a laser amount detector for recording light. The back motor photo-diode inside the laser diode used in CD players, etc. cannot be used. This is because a front/back imbalance of the laser power radiation can easily occur (generation of scoop noise etc. because the laser return light volume is large).
In the case of either the magneto-optic disc or high reflection rate disc, during reading there is setting of the APCREF input to a setting below a set level {(Vcc-middle point electric potential)x4/26}. Then the voltage input to the APCREF as reference of the APC loop can be selected. To describe that operation, the comparator (LPC) output goes to "H" and, due to the SW amp (APCA), the voltage itself input to the APCREF is selected as the refe-ence for the APC loop.
For recording, the APCREF input is set above a set level {(Vcc - center point electric potential) x 4/26}. As the reference for the APC loop, the VCA (LDVCA) output is selected. The comparator (LPC) output becomes "L" and the SW amp (APCA) selects LDVCA.
LDVCA carries out compensation of the laser power during recording. The reason why it is necessary to compensate the laser power during recording is because the ideal disc write power changes according to frequency temperature (disc temperature). Although temperature detection is carried out fundamentally by measurement of disc temperature, because this is difficult to realize, there is detection of the ambient temperature with a temperature sensor and this is used in place of the disc temperature. During recording, the sensor diode changes of the voltage for D1 are used to control the LDVCA gain and thus compensate the APC loop reference to the ideal value in that temperature. The LDVCA control voltage is 0V at 25℃ and changes at a rate of ±1.6V at ±50℃. The LDVCA control voltage can be monitored with the TEMPO terminal.

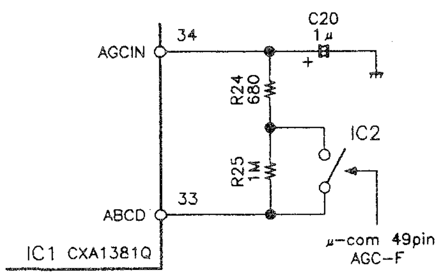
2) Microcomputer Control of the RF Matrix IC (CXA1381Q) (4 modes)

◎RFSW0, RFSW1 (disc type)

RFSW0 { 1: High reflection rate disc / 0: Low reflection rate disc }   RFSW1 { 1: Pit track / 0: Groove track }

Mode	RFSW0	RFSW1
Recording area on magneto-optic disc	0	0
Lead-in area in innermost periphery of magneto-optic disc	0	1
High reflection rate disc	1	1

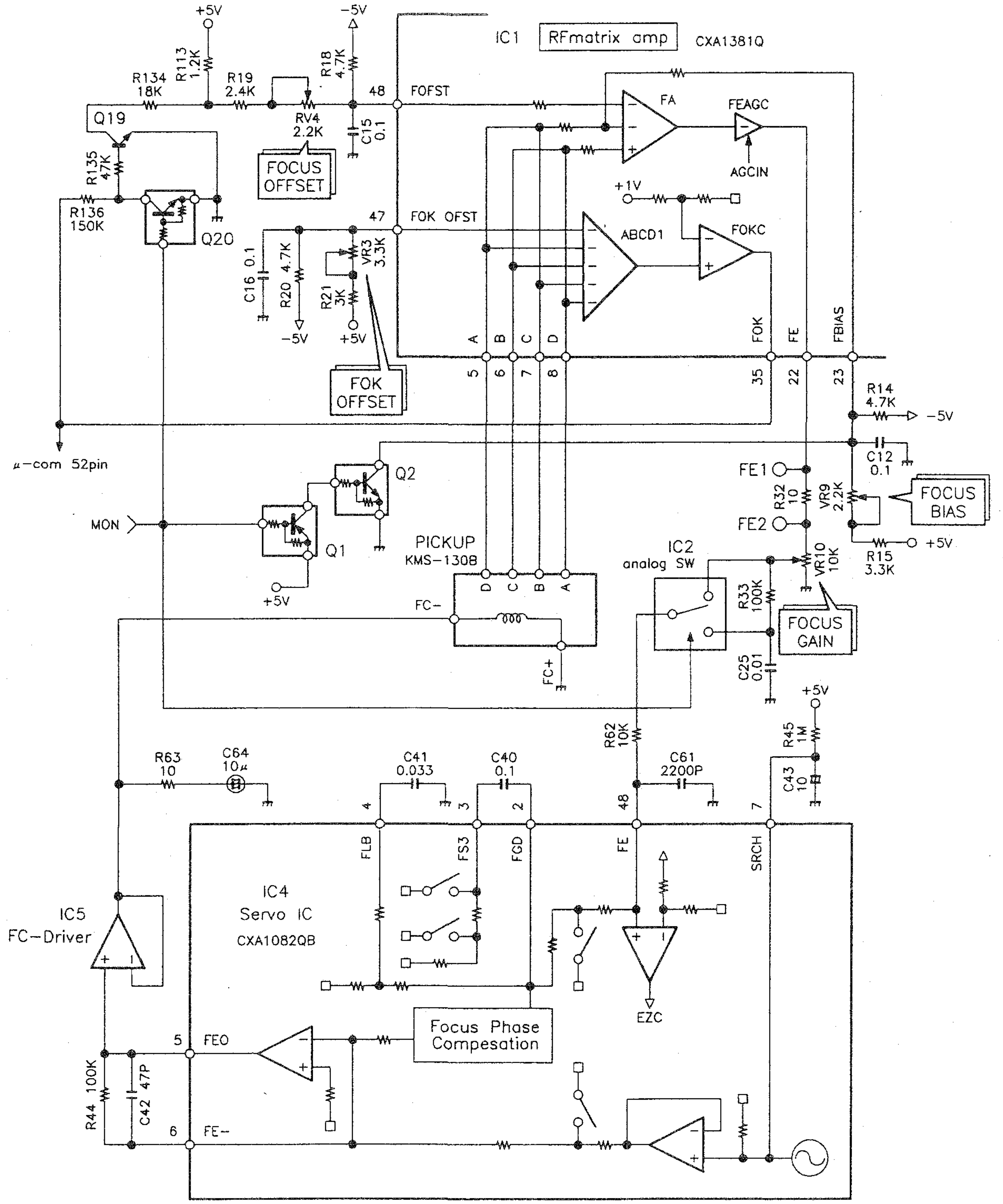
◎AGC time constant changing



→The analog SW IC2 is ON.
- During a period from focus search to focus servo start.
- During 30 msec period from when laser power was changed.

◎Laser power setting: APCREF terminal
◎High frequency laser module modulator ON/OFF:
Microcomputer 56 pin RMS terminal
→In the case of either disc, in order to remove unwanted laser noise during playback, this modulation module is ON.

3) Focus Servo System

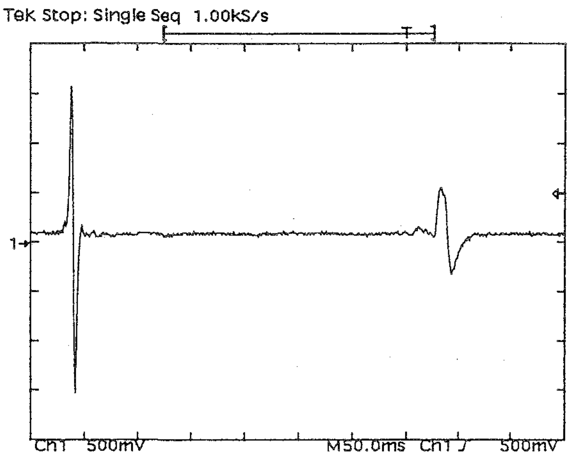


The basic operations and circuit structure of the focus system do not differ greatly from those for the CD player. As can be seen from the block diagram above, the servo IC is the CXA1082QB, a servo device with the incorporated sequencer that CD player users are already familiar with.

As is true with the CD, the system requires an FOK signal to create a window for the focus ON timing, an FE (S-shaped) signal to locate the focal point position, and an FZC signal (SENSE) to detect the focal point.

1) Focusing method

MDs include discs into which pits are made as with CDs (pre-mastered MDs) and magneto-optical discs with no pits (recordable MDs). The system must be usable for both types of discs which differ according to the laser reflection rate on the disc surface. Especially with magneto-optical discs, the reflection rate (15-30%) is lower than that of standard CDs so that the difference is small between the pseudo-reflected light on the disc surface and the original reflected light on the magneto-optical recording film. This makes it more difficult for the IC to distinguish between the two.



<Actual S-curve and pseudo-reflection S-curve>

Actually, the focus search is carried out from above (from location near the disc) which is the opposite of the conventional direction. This results in a phenomenon in which it is difficult for the focus servo to operate. The reason for this is that the speed of the up/down motion of the lens is often faster during focus down than during focus up (due to the influence of gravity and/or a characteristic of the charge/discharge curve of the search capacitor). As a result, the search speed is set so that the Tp-p of the S-curve signal during focus down is 2 ms or greater.

2) Actual circuit operation until focus servo ON.

When the focus search command ($OX) is input by means of serial communications (as is the case with operation of the servo IC on a CD player), the charge/discharge current of the capacitor C43 attached to the IC4 CXA1082QB 7-pin is used to cause the lens inside the pickup to move up and down. Together with up/down movement of the objective lens, the return light of the laser beam from the disc hits the main spot (A.B.C.D) so that signals A,B,C,D are generated and are injected to the IC1 RF matrix amp. Regarding the injected signals A,B,C,D, as is the case with CD players, the timing window signal FOK for focus ON and the error signal FE (S-curve) for detecting the focal point are generated in the CXA1381Q. As was described in the description before, in order to prevent faulty operation due to pseudo-reflected light in the case of the recordable desc, a variety of countermeasures are being carried out in the actual circuits.

First of all, in order to detect FZC (focus zero point) during focus search DOWN, it is necessary to "fool" the auto sequencer of the servo IC. This step differs from operations in CD players. The connection is changed for the inputs A (5 pin) and D (8 pin), B (6 pin) and C (7 pin) to the RF matrix IC. Furthermore, the polarity of the biaxial coil inside the pickup is wired in the opposite of the conventional manner. As a result, the polarity of the focus error signal becomes negative. In such a case, as is also true for conventional units, there is sending of the focus DOWN command (although the actuator of the pickup is actually UP) prior to the sequence command, so that the focus UP command (actuator goes DOWN) is executed with the search speed at minimum.

Secondly, even when the system operation of the focus search is changed as described above, it is extremely difficult to completely eliminate pseudo-reflected light. As a result, the transistor switch Q19 is used so that the offset position of the focus error signal is decreased when incorporating the FZC.

Thus, even if the FE S-signal due to pseudo-reflection is input, the servo IC cannot detect the FZC.

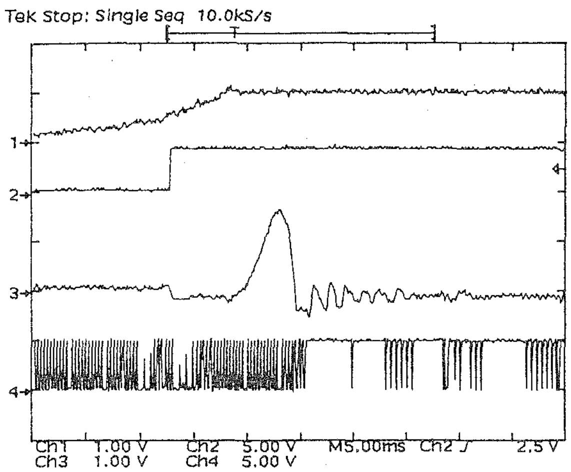
Also, due to Q1 and Q2, the bias setting of the focus error amp during search is made inoperable and the analog switch IC2 is changed to increase the insertion accuracy to the servo IC of the S-signal. At this time, the time constant of the AGC circuit in the RF matrix amp is shortened to speed up the response of the signals. As a result of this operation, the correct S-shaped FE signal is incorporated in the servo IC CXA1082QB so that FZC is got in the FOK window and the unit goes to focus ON. After focus ON, the disc starts rotating and, as is the case with CD players, the FE signal receives phase gain control so that the pickup lens is correctly controlled on the focal point position.

Furthermore, by rotating the disc motor, the MON signal gose H so that the transistor switch Q20 goes ON to return the focus offset amount to the regulation voltage. The focus bias/gain distribution is changed for closed loop use and focus search processing is terminated.

3) Related waveforms during focus search

The following shows the waveforms associated with focus search. These waveforms indicate that the ABCD signals of CH1 are attenuated to about 1 Vo-p due to functioning of the AGC circuit inside the IC.

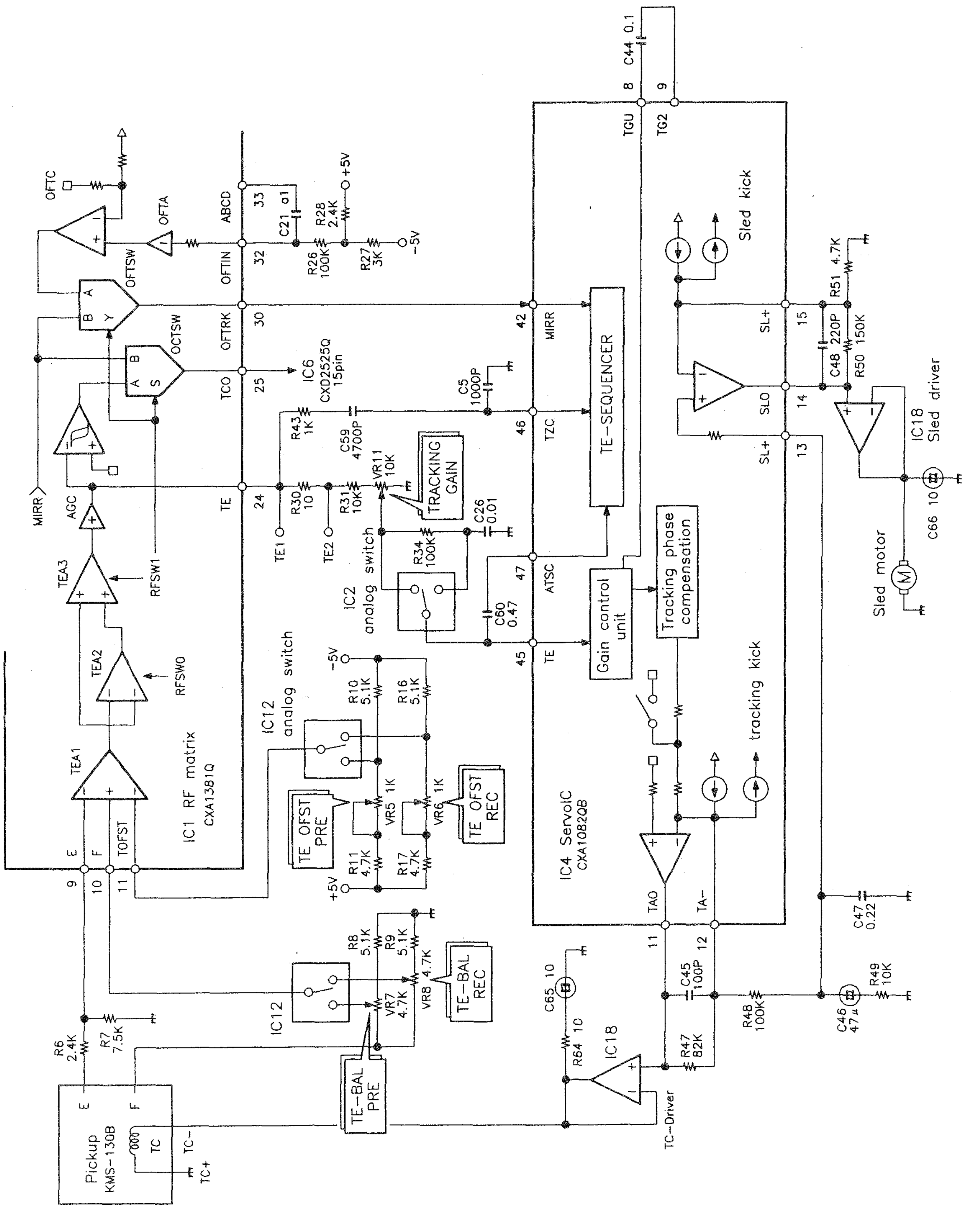
Also, the FOK signal of CH2 have started to rise as a result of the ABCD signals exceeding 0.5 V. In other words, it is understood that 0.5 V is the comparate level. It is also understood that, with the FE signal of CH3, the offset position declines as soon as FOK starts. As for the SENSE signal of CH4, it is understood that the data changes at the S-shaped central FZC point of FE. Moreover, the SENSE signal is connected to the SENSE terminal of the DSP IC. Because the SENSE terminal of DSP IC is for output of the state signal, the DSP state signal is constantly expressed.



CH1: ABCD
CH2: FOK
CH3: FE
CH4: SENSE

By the way, because the auto-sequencer inside the servo IC is used, the focus pull-in routine is automated. However, there is no automatic pulling-in when the focus is off. As a result, the microcomputer is constantly observing the FOK.

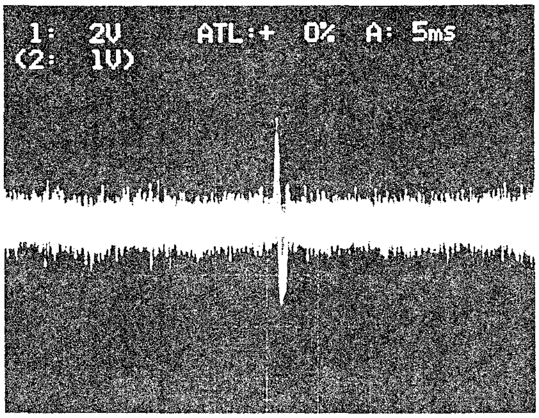
4) Tracking and Sled Servo System



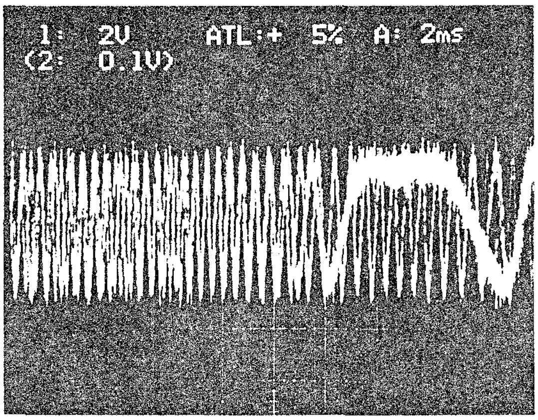
The basic operation of the tracking sled system is almost the same as that for the CD system. The subtracted signal of the two sub-spots E and F inside the pickup becomes an error signal, and the actuator in the pickup is controlled by the tracking coil so that the main beam is correctly located on the track.

The present device uses the RF head amp CXA1381Q. Because there is an internal AGC circuit, an adjustment-use semi-fixed volume control (VR5, VR6) is included in order to absorb the output offset of the AGC. Also, in order to handle the two different types of disc, a circuit is changed by the analog switch IC12 for offset and balance adjustment (VR7, VR8).

Tracking Error

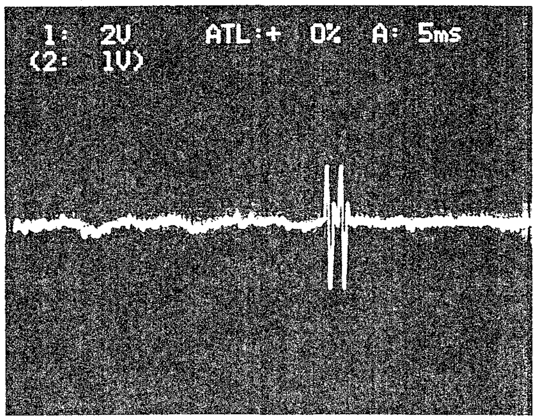


Tracking Error Balance

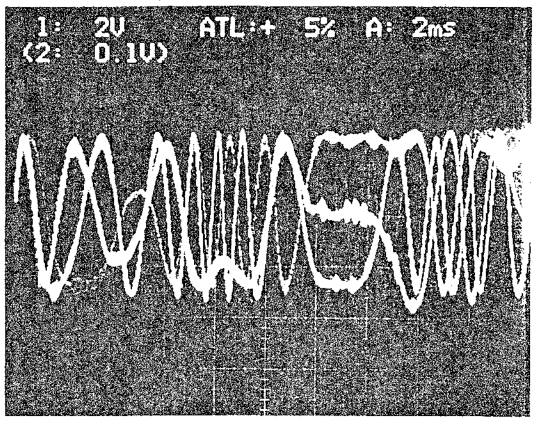


<Pre-mastered Disc>

Tracking Error



Tracking Error Balance



<Recordable Disc>

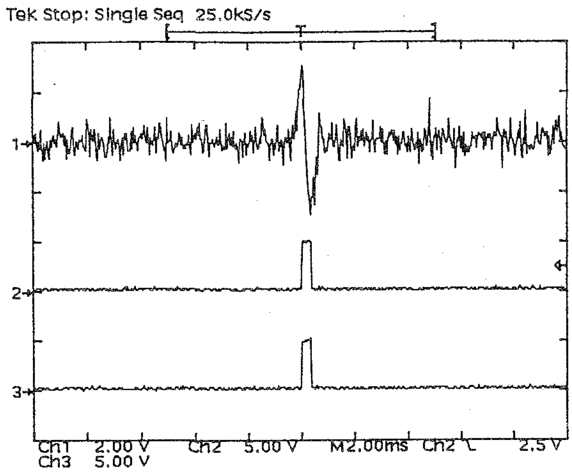
1) Actual circuit operation in the tracking system.
The current from the photodiode of the sub-spots undergoes I-V conversion in the pickup and is input to the RF matrix amp of IC1. In the IC, the amp TEA1 creates the TE signal. Due to the switch operation amps TEA2 and TEA3 in the next stage, there is changing of the signal polarity, gain and f-characteristics according to the type of disc. The TE signal that is obtained undergoes gain and phase compensation in the servo IC and then drives the tracking coil with the IC18 driver.

2) Off-track circuit and tracking count output

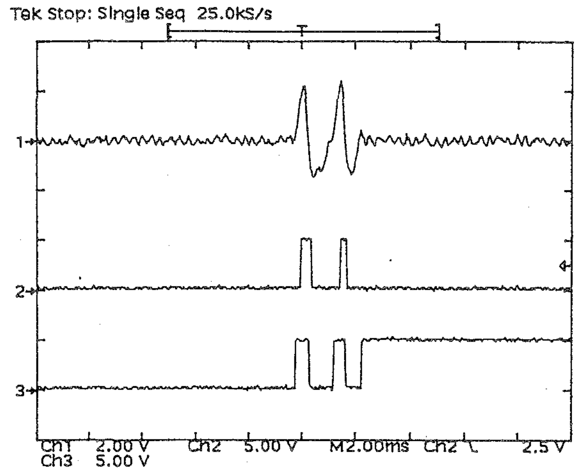
●Off-track circuit
A brake circuit is used to improve an accuracy of track jump. It creates the traverse signal required for this process. It also changes the circuit according to whether there are pits or grooves. In case of RFSW1=0 (signal surface is groove), the ABCD output of the 33 pin is amplified with AC coupling. There is comparison of that signal and a signal with offset. This is done in order to detect that the light amount on the track (groove center) has reached maximum. By adding an offset, the OFTRK signal goes to "L" even during normal tracking ON. The cutoff frequency for AC coupling is 160 Hz. (If the value is larger than 300 Hz the leakage of the ABCD signal becomes larger).
In case of RFSW1=1 (signal surface is pits), a mirror signal is sued. This is used so that the modulation of the RF signal on the track pits is maximum.
In either case of RFSW1, the OFTRK output becomes "L" on the tracks and "H" between the tracks.

●Tracking Count Output
This signal is used in counting the jump track number (in case of high speed access, etc.). In case of RFSW1=0, the tracking error signal is compared. Hysteresis is added at this time to remove the wobbling component on the groove.
In case of RFSW1=1, the TCO output becomes MIRR output.

<Waveform CH1: TE, CH2: OFTRK, CH3: TCO, normal playback>

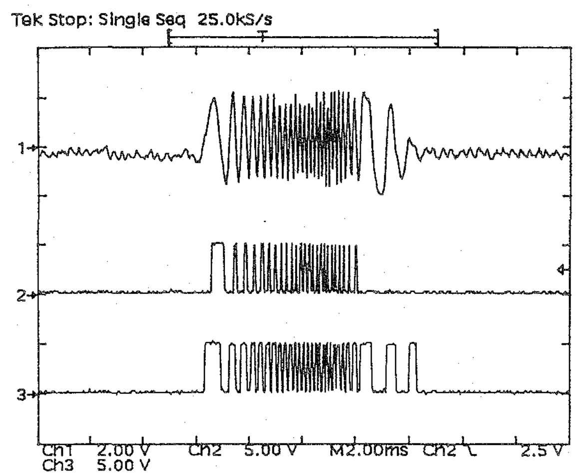


<Pre-mastered Disc>



<Recordable Disc>

Waveforms during long access with the recordable disc.



3) Search Processing

MDs have a disc diameter of 64 mm which is about half that of a CD. That means the movement distance during search is smaller. Also, the data read from the disc during search is only address. Information expressing lead-out and lead-in as with CDs is not written at all in the program area. In other words, information concerning the location on the disc is all managed according to the address information of the TOC.

During search processing (including intermittent operations during play) the area located four sectors before the actual target address (actually the D-RAM writing address) is considered the search target so that there is comparison with the address now being performed, to select the internal and external circumference direction, to convert the address into a track number and carry out track jump.

The servo control IC (CXA1082QB) has a maximum track jump number of 240 tracks. In the case of a 74-minute MD disc, there are about 9,000 tracks cut in the surface so that it is very difficult to carry out movement in terms of 240 tracks. Thus, when moving over long distances, the EFMIC (CXD2525Q) traverse counter is used to carry out these processes.

The search software inside the microcomputer computes the movement amount (track difference) and the kick level (KICLVL) is set according to the computation status. As a result, the servo IC and EFMIC are distinguished according to use. As search process conditions, the disc servo CLV is locked and the address can be read.

Track number (difference)		Kick Level		Track Jump Command
481 tracks or more	→	KICLVL 7	→	N track move of EFM IC
225 tracks or more	→	KICLVL 6	→	224 track move of servo IC
129 tracks or more	→	KICLVL 5	→	128 track move of servo IC
65 tracks or more	→	KICLVL 4	→	64 track move of servo IC
49 tracks or more	→	KICLVL 3	→	48 track move of servo IC
33 tracks or more	→	KICLVL 2	→	32 track move of servo IC
17 tracks or more	→	KICLVL 1	→	16 track move of servo IC
16 tracks or less	→	KICLVL 0	→	1 track move of servo IC

4) Setting of track number during N track move.
With a linear velocity of 1.2 m/s, 1 cluster is approximately 6 tracks on the internal circumference and approximately 3 tracks on the external circumfence. Thus, when setting the track number according to the address difference, 1 cluster is computed as 4 tracks. With a 74-minute disc or pre-mastered disc, where there is recording for more than 60 minutes, 1 cluster is computed as 3 track.

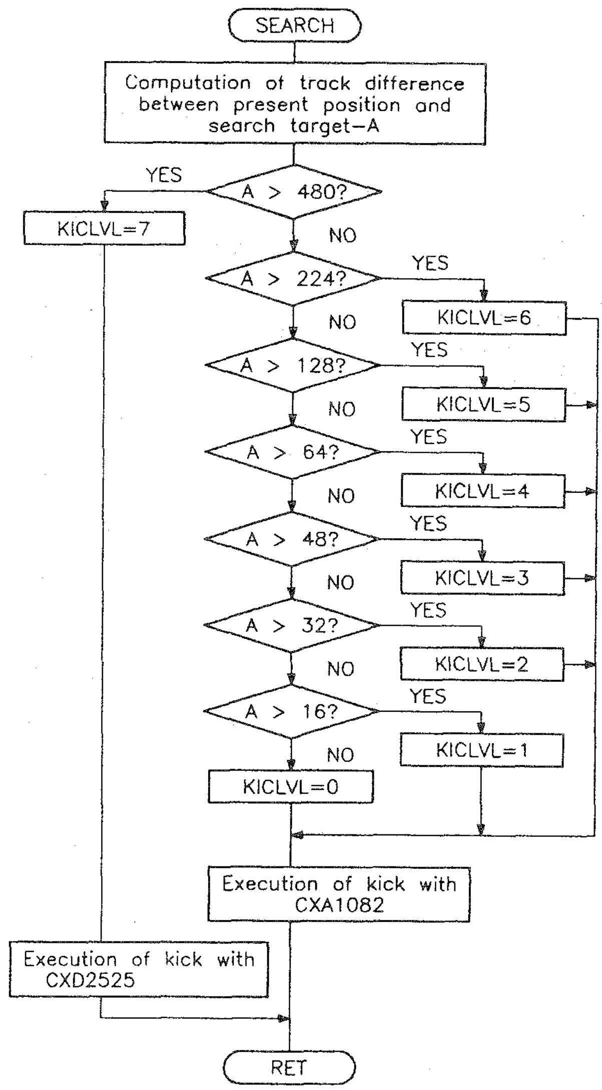
Track difference (address difference to search target) x 4 or 3

5) Setting of kick level near the external circumference
Search near the external circumference, especially in the direction of external circumference, is carried out on a level that is lower in relation to the selected kick level. This is done in order to control operations so that the beam spot does not stray from the disc during search.

6) Search Process During UTOC Read
During reading of UTOC, there is search near the internal circumference. As is the case with search on the external circumference, the set level is lowered one grade for execution. Because UTOC exists at a position that is extremely close to the lead-in area, if there is over-run during search, there is the danger that the beam spot will enter the lead-in area and the servo will run away. That means it is necessary to approach the target with as little movement as possible.
If the beam spot has entered the lead-in area during UTOC search, the disc servo will run away so that it will of course not be possible to read information from the disc. For this reason it is not possible to correct the reading position as is the case with CDs. In such a case, the pickup is initialized and the servo is started again.

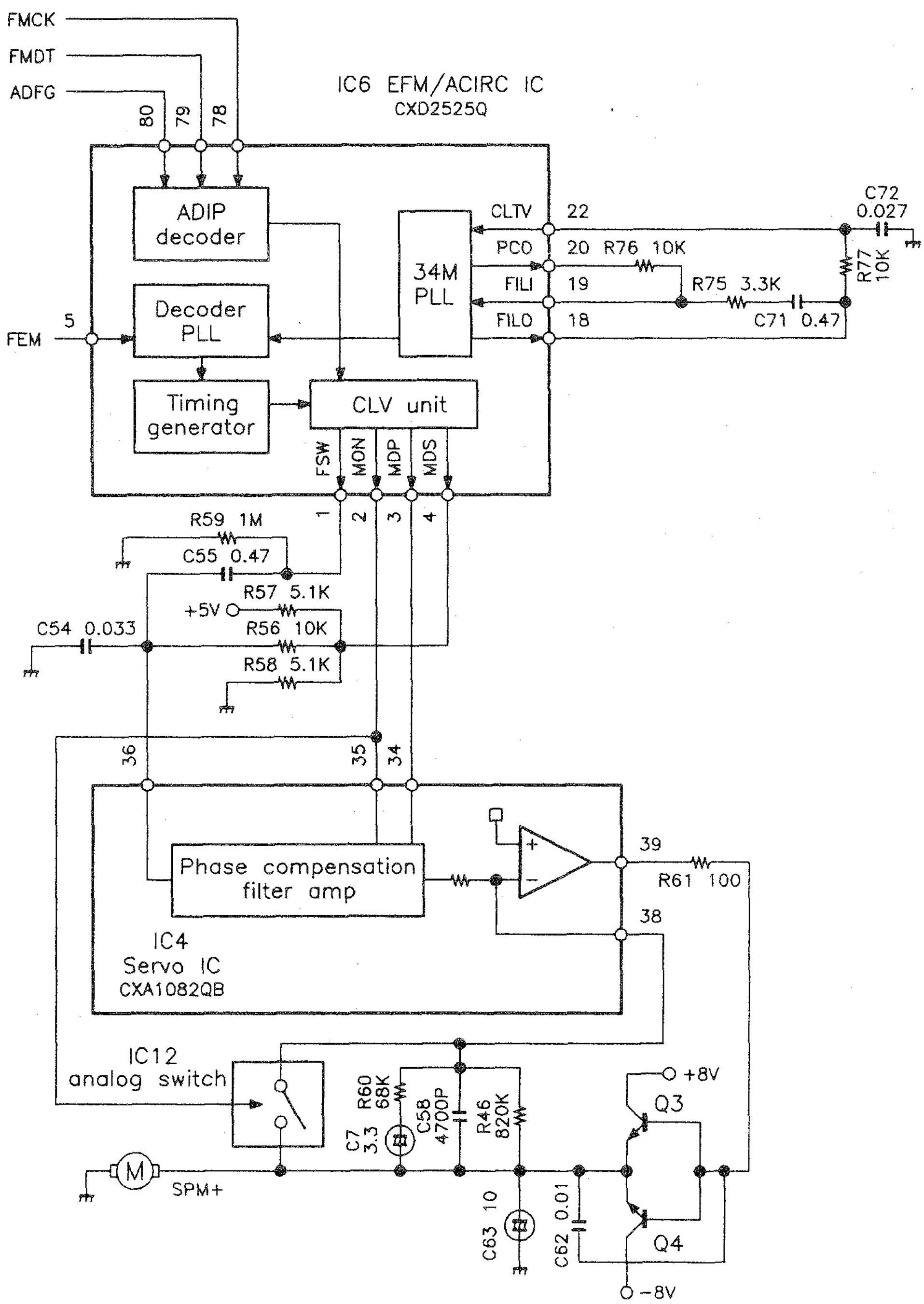
7) 1 track kick
As for 1 track jump in the direction of internal circumference, when a single track jump has finished, there is unconditional jumping of one more track. This is done because, following track jump, the servo stability wait timer operates for about 30 msec. This operation relates that there is time lag until actual start of decoding, Furthermore, a decode error can easily be generated just after jump. Data for which a decode error has been generated after jump is eliminated by the software. Thus, the data first stored by the software is on a position after the position of the end of jump. In other words, if this originally stored data is the same as the search goal or if it has already exceeded the goal, the search operation will continue on indefinitely. For this reason, if track jump is carried out two times so that there is jumping to a location slightly forward of the search point, the playback time becomes longer and the stability waiting time after jump is also included in this amount.
As the above shows, in the case of the MD, follow-up to the search point is not carried out when possible. Instead, there is jumping to a forward point and waiting until the target address appears during playback conditions since that method is more reliable.
With the present equipment, follow-up to the search point has been set roughly. If it drops inside the front 2 clusters, it is considered as the end of search.

8) General Flow of Search



5) CLV Disc Servo System and PLL Block

CLV disc servo control basically involves choice of two types according to the type of disc. With pre-mastered discs the EFM signal is used and for MO discs the ADIP signal is used. With the present device, there is control with a digital PLL circuit of the EFM IC and a CLV controller to control disc rotation.



The CLV mode and gain is set by the CLV unit inside the EFM IC (IC6).

☆Gain is variable over four stages from 0 to 18 dB.

☆Mode:

STOP : Stop spindle motor.
KICK : Forward rotation of spindle motor.
BRAKE : Reverse rotation of spindle motor.

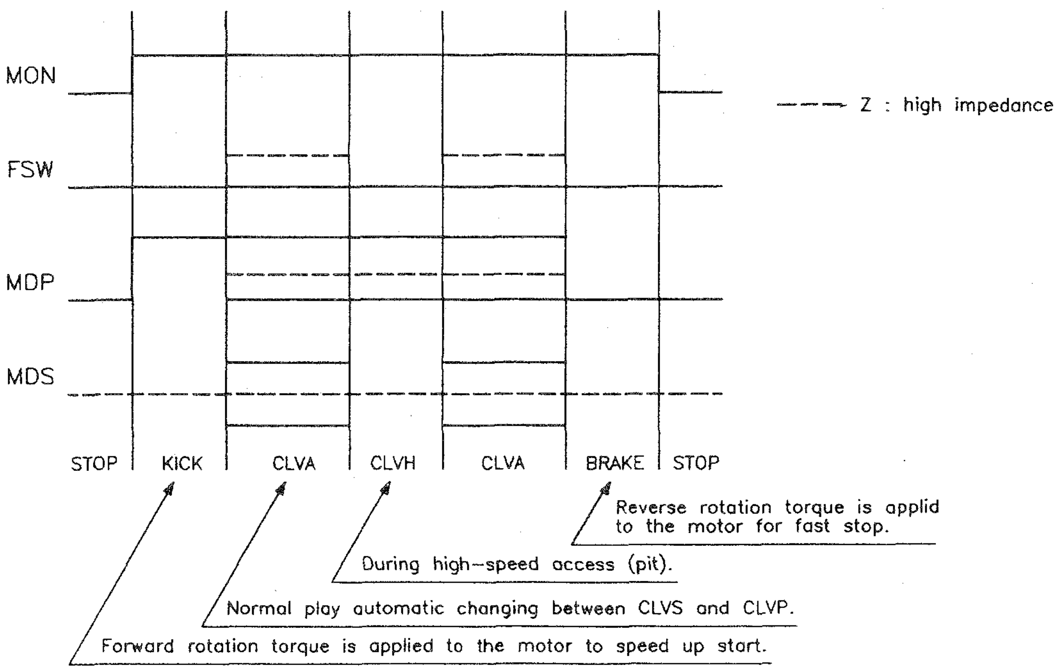
EFM
- CLVS : Rough servo mode for pulling in.
- CLVH : Rough servo mode for high-speed access.
- CLVP : PLL mode.
- CLVA : Auto mode.

There is sampling of the GFS signal at WFCK/16. If H, there is CLVP, if it is L with 8 continuous times, there is CLVS.

ADIP
- CLVS : Rough servo mode for pulling in.
- CLVP : PLL servo mode.
- CLVA3 : Auto mode 3.

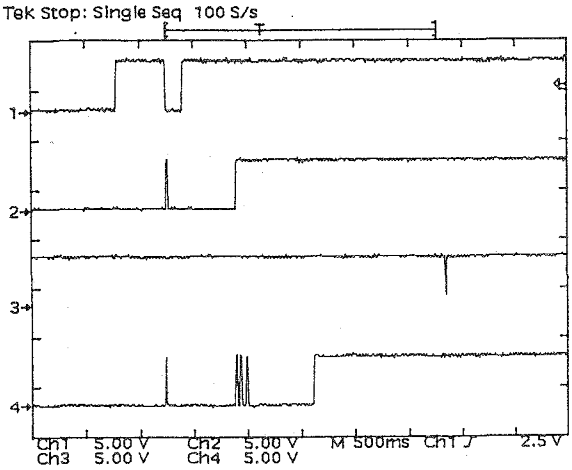
CRC check of ADIP is carried out two times and if OK, CLVP. If there is continuation for 10 frames NG, it becomes CLVS.

☆Examples of Spindle Motor Control



CLV related monitor terminals on the IC6 EFM/ACIRC IC.

2 pin MON : ON/OFF terminal of spindle motor. ON with H.
7 pin LOCK : Lock state monitor of spindle motor. LOCK with H.
45 pin XUGFS : Unguarded frame sync with L.
47 pin GFS : Frame sync OK with H.



<Waveforms during disc motor start-up>

CH1: MON
CH2: LOCK
CH3: XUGFS
CH4: GFS

Of these waveforms, the MON signal of CH1 goes ON and OFF and then ON again. This is in order to turn the focus servo ON correctly. Once FOK has appeared, the spindle motor is kicked and, after the focus servo has gone ON correctly, there is restarting of MON and movement to CLV operation. With a normal CD player, regarding FOK detection, after finishing several msec of chattering removal, there is kicking of the spindle motor after focus ON. This is a major difference from CD players. CH2 is a LOCK terminal and shows that CLV is locked. After locking there is start-up of GFS to show that data reading is possible. XUGFS of CH3 is the framing obtained from the EFM signal. It is a negative pulse prior to sync protection. With the MD, the frame sync is recorded about every 136 microseconds (7.35 kHz). This signal is the basis for knowing what data is inside a single frame. On the other hand, when it is not possible to select this framing, it is processed as error data and the playability worsens.

1) Digital PLL Circuit

A channel clock is required to demodulate the EFM signal reproduced from the optical system. The EFM signal is converted to the integral double value of T from 3 T to 11 T where there is synchronization with the channel clock. A channel clock is generated to read the information of the EFM signal. However, with actual players, rotational differences of the spindle cause changes in the pulse width of the EFM signal.
The PLL inside the IC is used in order to match this correctly. The inside is composed of a 2-stage PLL.
The 1st stage is used for generation of a high frequency wave clock. The 2nd stage is used for generation of a channel clock with the capture range of ±150 kHz. If there is a large discrepancy in the high frequency wave element of EFM, the frequency loop in the 2nd stage PLL is turned OFF to go to the mode with a capture range of 50 kHz.

2) Spindle Control with the Software in the Main Microcomputer

· Spindle Start-up

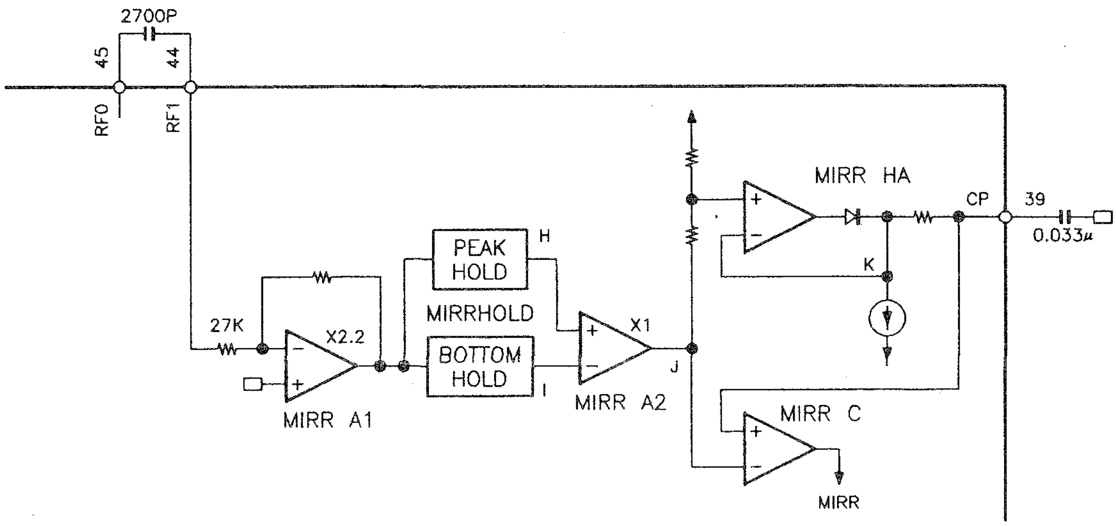
→For spindle start-up, After transfer of the pickup to the innermost circumference the focus search is oprerated. Even though the reflection rate differs from pre-mastered discs and recordable discs, there are pits there. For this reason, in the CLV mode, it is EFMCLVA. The unit checks whether the CLV lock signal is H or not. If it is lock, it goes to the state in which playback operation is possible (and reading of addresses is possible). If CLV does not lock even after 3 sec have elapsed during this check, the pickup position is reset and the operation starts again from focus search. This is because it is believed that, due to some trouble, the beam spot is positioned in an area where pits do not exist.

· CLV Control Mode During Long Distance Jump

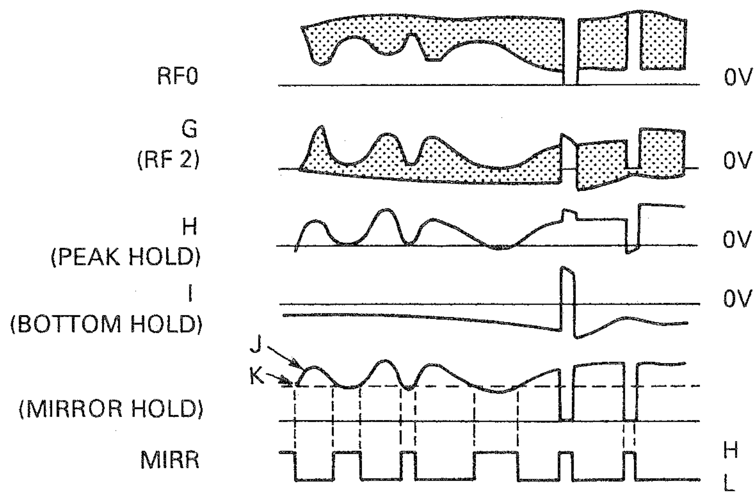
→This mode is used when using the traverse counter of the EFM IC CXD2525Q to carry out long distance moves. The CLV control mode changes to the rough servo mode. With pre-mastered MDs, as is the case with CDs, this should be done with the CLVH (rough servo for access). However, when using the travese counter, if set to the CLVH mode the CLV servo is unstable. As a result, in cases of an M track move of about 240 tracks with the auto-sequencer of the servo IC, it is the CLVH mode. In case of N track move (481 tracks or more) with the CXD2525Q, it remains in the CLVA mode.
In case of DM-B9, 1001, E9, it is in this fashion although the actual cause has not been made clear.

6) Disc Mirror Surface Detection and Scratch Detection

1) Mirror Circuit

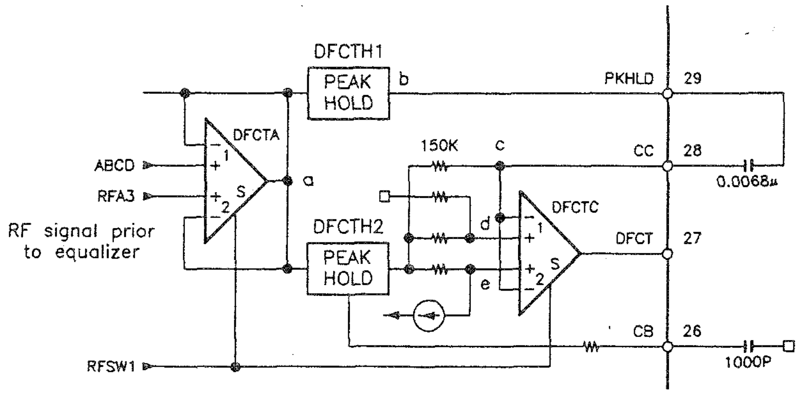


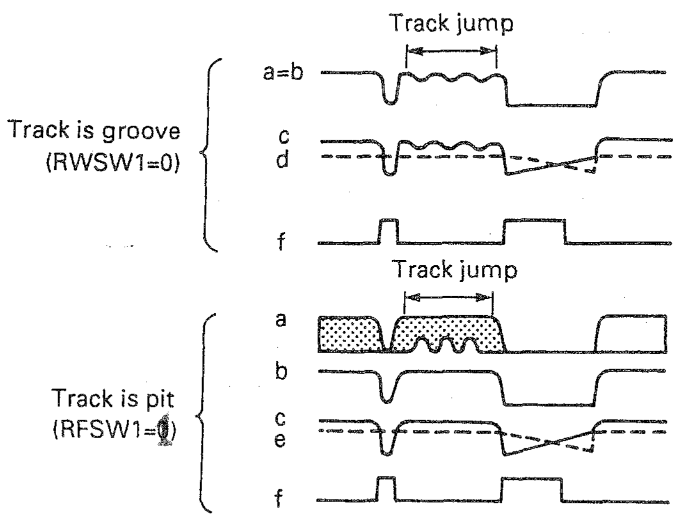
This circuit is for creating the traverse signal (MIRR) when crossing tracks in case of TOC of magneto-optical discs or playback of high reflection rate discs (i.e., in case of pit signals). If RFSW1=1, this MIRR signal is output from the TCOUNT terminal for tracking count and from the OFTRK terminal as the brake circuit of the servo.



After amplification of the RFI signal there is peak and bottom hold. Peak hold can follow a traverse of 30 kHz. On the other hand, bottom hold is held at a time constant at which it is possible to follow the envelope fluctuation of the mirror section of the rotational frequency.
A signal J which is the difference between the hold signals H,I is compared with signal K (signal obtained by peak hold with a large time constant at a level that is 2/3 of the J peak value), to obtain the mirror output MIRR. The mirror output is "L" on the tracks and "H" between the tracks (mirror section). Furthermore, when a defect is detected, there is output of "H". The mirror hold time constant must be sufficiently large in comparison with the traverse frequency.

2) Defect Circuit





This is a circuit for detecting defects on the disc.
The small time constant peak hold (upper side in figure) removes the RF component. It responds to defects. The large time constant peak hold (lower side in figure) removes the RF component and holds the light amount just prior to the defect (mirror surface level in case of pit).
In the groove mode, the light amount signal (ABCD) is used to carry out defect detection. If the light amount goes below 77% of the normal light amount, it is judged as a defect.
During the pit mode, the RF signal (RFA3) prior the equalizer is used and if the mirror level is below 100 mV, it is judged as a defect.
In case of either groove or pit, there is AC coupling to limit the maximum time width of the defect signal. Furthermore, the DFCT output is a digital signal for which the amplitude varies from Vcc to VEE.

<Operations with Software of Main Microcomputer μPD78054GC-359>

1) Summary of control with system control microcomputer

The microcomputer carries out main processing in a basically set cycle (approx. 4-5 msec).
This main processing is as listed below.

- Control of servo system.
- Control of operational mode.
- Control of serial reception from sub-microcomputer.
- Condition status generation of main microcomputer.
- Serial transfer processing to sub-microcomputer.
- Output control of Q-code.
- Reading of audio peak data.
- SCMS control.
- Data generation and output to digital I/F.
- Analysis of interrupt from memory controller CXD2526Q.
- Sync detection processing.

2) TOC read processing

The TOC of pre-mastered discs is repeatedly stored in sectors 00H to 04H of the FFXXH cluster in the lead-in area. The TOC is assigned to the area from 0 to 4 for recording of various data in these sectors. Incorporation of TOC/UTOC is the same operation as incorporation of normal audio data except for the following cases: (a) When using the sub-data counter, (b) When the SBMN terminal (microcomputer 47 pin) is "H" during write. With the DM-B9.1001.E9, there is only inporation of TOC0 and TOC1.
The indispensable information planted in TOC0 includes the type of disc, the optimum laser power value during recording, and addresses for lead-out and recordable area. In TOC1 is planted the disc/track name, etc. Regarding TOC2 and beyond which are not

supported in these equipments, there is planting of information of less importance such as the recording date.

The following shows the basic decode method for TOC0-4.

(1) Access to several sectors before TOC0.

(2) After acknowledgement of 1 sector before TOC0 (FFXHFFH), there is setting of the transfer write register SWDCT (data R.W address generation) and BCT (transfer byte counter) of the remote controller so that the 46 pin WRMN terminal goes to H and the 47 pin SBMN terminal goes to H.

(3) While incorporating the sector data of TOC0, there is monitoring of conditions according to the decode status (memory controller read register) SYOK and EIB, etc.

(4) Each time there is detection of MDSY (one of memory controller write registers which detects the sync pattern during the playback mode), there is repetition of step (3) above. Movement to TOC1.

(5) When incorporation has finished, there is checking of the error detection conditions for each sector. If there are no errors, the TOC information is copied to the SRAM (IC15). For copying from the DRAM to the SRAM, there is setting of the DRAM read address CCT (R/W address geneation for access by the CPU of the memory controller) and reading or writing as CPU data. When reading the TOC information component (1 sector), this operation is carried out 2352 times.

3) UTOC read processing

Recordable discs include UTOC in which information is recorded concerning the contents of information recorded by the user (TNO, title, etc.). Because TOC is unalterable data, it is always in areas in which it has been cut with pits. Because UTOC changes during recording or editing, it is necessary to constantly write the newest data. The area were UTOC exists is one part of the recordable area which is an area where no pits have been cut. In other words, when reading TOC it is necessary to set to a pit system, and when reading UTOC it is necessary to set to a system for magneto-optic discs.

The following shows the order of UTOC read processing starting with the end of TOC reading.

(1) There is reading of TOC and judging that the disc is a recordable disc.

(2) The tracking and sled servos go OFF and there is free run of CLV.

(3) RFSW is set to low reflection and groove.

(4) The pickup is moved in the direction of the external circumference at a setup time (156 msec).

(5) When transfer is finished, there is kicking of the CLV to start the 100 msec wait timer.

(6) After end of wait, the CLV has entered a range where lock is possible. The CLV mode is changed to ADIPCLVA3 and the tracking sled servo is turned ON.

(7) There is search to 1 sector before the UTOC start address written on the TOC.

(8) After search has finished, the UTOC data is planted in the DRAM and copied to the SRAM in the same order as for TOC reading.

The above is a summary of the UTOC read processing. However, in actual processing, there are protects to deal with a variety of troubles. Particularly regarding positional shifts when moving from the TOC area to the UTOC area, even if the movement time is set long at 150 msec, due to discrepancies in the mechanisms, it often happens that the movement time is not even.

The following shows the checks that are actually carried out to deal with these problems.

① Detection of Slip in Movement Position (TOC - UTOC)

Regarding this matter, because there is no method of knowing the pickup position, a method is adopted in which the pickup position is selected according to the lock state of the CLV. Because control of pit and groove discs is different in terms of tendency for positional slip, trouble occurs when the disc does not rotate normally and the information from the disc cannot be read at all.

When the position is not correct, there is a possibility of CLV control of grooves in the pit section or the opposite situation. In such a case, use the CLV lock detection timer to detect when the CLV does not lock within a defined period of time, rectifying the situation by starting with adjustment of reset position of the pickup. The retry operation is up to 4 times.

② Judgment of Virgin Disc

In case of a virgin disc, there is nothing recorded on the UTOC. Even if search is possible, it is not possible to plant the UTOC contents in the DRAM. Because the timing of start/finish of writing operations is carried out with the MDSY, in the case of virgin discs where no recording has been carried out, this MDSY is not output. Also, in cases where, although data was actually recoded but was destroyed due to problems during recording, the MDSY is output but the header cannot be read.

As a result, there is checking to see whether there has been recognition of the traces of even one recording. If such traces are recognized, there is inhibit of play as a disc error. If the trace has not been recognized at all, the disc is judged to be a virgin disc and the microcomputer sets the UTOC information in the SRAM as a blank disc. In such a state, the only operations allowed are editing, recording and record pause.

③ Error Check When Reading UTOC.

The UTOC information is repeatedly recorded in the three clusters known as clusters 0003H, 0004H and 0005H. If the unit fails to read a single cluster due to scratches or the like, the cluster for reading is shifted, and the unit attempts to read UTOC. If it is not possible to read the information after changing the cluster three times, it is judged to be a disc error.

Generally speaking, there is observation of TOC read processing so that the process stops within 20 seconds for TOC and UTOC.

4) Processing after reading of TOC

Although no particular troubles should occur with reading of TOC, because editing of UTOC is possible with the microcomputer, a variety of troubles can occur. Because the UTOC information has a very high level of important, there is a check to insure that there is nothing abnormal in the contents.

The most important matter to be careful about is management of Link P of UTOC0. Link P is a parameter that was conceived for processing of information which, although it may not be physically continuous on the disc, is nevertheless continuous during performance processing.

The microcomputer follows Link P for continuous processing of a single package. Thus, if there are problems with Link P it becomes endless in terms of processing. In order to prevent this from happening, there is checking of the Link P number in the first step. The maximum value of Link P according to regulations is 255 units. There is counting of link P in UTOC0 and if the number exceeds 255 units, it is judged as a disc error. In a second step there is checking of the relationship between the minimum and maximum number of selections for play. If there is an abnormality in that relationship it can cause problems in a variety of time computation processing routines.

If UTOC0 incorporation is OK, there is checking of UTOC1. If it was not possible to incorporate, the importance level of UTOC1 (disc/track name) is made low and playing is allowed as a disc that does not support a title.

When these checks are passed, TOC read is finished and the unit goes onto the next process. When TOC read is finished, the main microcomputer organizes the disc information and sends it to the sub-microcomputer. The contents of the information sent to the sub-microcomputer is as follows:

(1) Blank Disc? Y/N
(2) Character Support Disc? Y/N
(3) Disc Type
(4) Condition of write protect hole
(5) Read Out Start Address
(6) Remain Time Address
(7) Single time address for 1st track, total time address
(8) Minimum/maximum number of tracks for play
(9) Total address for whole play time on disc
(10) Disc title
(11) Remaining number of parts for use, remaining number of character parts for use (only on recordable discs)

5) TOC/UTOC Structural Diagram

SECTOR STRUCTURE of MD

TOC Sector=0 (mandatory)

	16 bit even m		16 bit add m		
	Wm B	Wm A	Wm B	Wm A	
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	
	d1 d8	d1 d8	d1 d8	d1 d8	
0	00000000	11111111	11111111	11111111	Header
1	11111111	11111111	11111111	11111111	Header
2	11111111	11111111	11111111	00000000	Header
3	cluster H	cluster L	00000000	00000010	Header
4	00000000	00000000	00000000	00000000	Data area (2336 Byte)
5	00000000	00000000	00000000	00000000	
6	"M"	"I"	"N"	"I"	
7	Disc type	*Rec power*	First TNO	Last TNO	
8	Lead-out start address			Used Sectors	
9	*Power cal area start address*			00000000	
10	*U-TOC start address*			00000000	
11	*Recordable user area start address*			00000000	
12	00000000	P-TNO 1	P-TNO 2	P-TNO 3	
13	P-TNO 4	P-TNO 5	P-TNO 6	P-TNO 7	
14	P-TNO 8	P-TNO 9	P-TNO 10	P-TNO 11	
15	P-TNO 12	P-TNO 13	P-TNO 14	P-TNO 15	
16	P-TNO 16				
17					
73					
74	P-TNO 248	P-TNO 249	P-TNO 250	P-TNO 251	
75	P-TNO 252	P-TNO 253	P-TNO 254	P-TNO 255	
76	00000000	00000000	00000000	00000000	
77	00000000	00000000	00000000	00000000	
78	Start address (Track 1)			Track mode	
79	End address			00000000	
80	Start address (Track 2)			Track mode	
81	End address			00000000	
82	Start address (Track 3)			Track mode	
83	End address			00000000	
84	Start address (Track 4)			Track mode	
85	End address			00000000	
86					
481					
482					
534					
535					
586	Start address (Track 255)			Track mode	
587	End address			00000000	
(X4 Byte)	1	2	3	4	

Remark: Bit order for scrambling is same as CD-ROM; LSBit first in ascending order from Byte 12 to Byte 2351.
Not used byte should be filled with 00h.

"M" "I" "N" "I" : System ID in ASCII code

Disc type=
- 3Dh : Pre-mastered MD
  following areas are zero
  Rec power
  Power cal area start address
  U-TOC start address
  Recordable area start address
- 3Eh : Recordable MD
  following area are zero
  First TNO, Last TNO
  P-TNO n, address table
- 3Fh : Hybrid MD

REC POWER mW	mW
00h = 2.5	08h = 3.6
01h = 2.6	09h = 3.75
02h = 2.7	0Ah = 3.95
03h = 2.85	0Bh = 4.15
04h = 3.0	0Ch = 4.35
05h = 3.15	0Dh = 4.55
06h = 3.3	0Eh = 4.75
07h = 3.45	0Fh = 5.0

Used sectors: used sector indicator
d8-d1 correspond to 0-7 sectors.
If a sector is used the corresponding bit should be 1.

Lead-out, PCA, UTOC, Recordable user area start address should be indicated as cluster (16bits) and sector (8bits).

P-TNO n (n= 1 to 255) :
(pointer for track n start address)
The value of P-TNO n indicates the byte position that gives start address of TNO n
Byte position
= 76 x 4 + (P-TNO n) x8

Start and End address of the Tracks:

Cluster 14 bit
Sector 6bit
Sound Gp. 4 bit

Track mode
- d1 = 0
- d2 = 0: copy right protected
  = 1: not protected
- d3 = 0
- d4 = 0: audio
  = 1: reserved
- d5 = 0 ┐ normal audio
- d6 = 1 ┘ else reserved
- d7 = 0: mono
  = 1: stereo
- d8 = 0: emphasis off
  = 1: emphasis 50/15 μs

SECTOR STRUCTURE of MD TOC Sector=1 (option)

(If not used, Byte 16- Byte 2351 should be all zero.)

	16 bit even m		16 bit odd m		
	Wm B	Wm A	Wm B	Wm A	
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	
	d1 d8	d1 d8	d1 d8	d1 d8	
0	00000000	11111111	11111111	11111111	Header
1	11111111	11111111	11111111	11111111	
2	11111111	11111111	11111111	00000000	
3	cluster H	cluster L	00000001	00000010	
4	00000000	00000000	00000000	00000000	Data area (2336 Byte)
5	00000000	00000000	00000000	00000000	
6	"M"	"I"	"N"	"I"	
7	Disc type	00000000	00000000	00000000	
8	00000000	00000000	00000000	00000000	
9	00000000	00000000	00000000	00000000	
10	00000000	00000000	00000000	00000000	
11	00000000	00000000	00000000	00000000	
12	00000000	P-TNA 1	P-TNA 2	P-TNA 3	
13	P-TNA 4	P-TNA 5	P-TNA 6	P-TNA 7	
14	P-TNA 8	P-TNA 9	P-TNA 10	P-TNA 11	
15	P-TNA 12	P-TNA 13	P-TNA 14	P-TNA 15	
16	P-TNA 16				
17					
73					
74	P-TNA 248	P-TNA 249	P-TNA 250	P-TNA 251	
75	P-TNA 252	P-TNA 253	P-TNA 254	P-TNA 255	
76	Disc name				
77	Disc name				
78	Disc name or Track name				
79	Disc name or Track name				
80	Disc name or Track name				
81	Disc name or Track name				
82	Disc name or Track name				
83	Disc name or Track name				
84	Disc name or Track name				
85	Disc name or Track name				
86					
481					
482					
534					
535					
586	Disc name or Track name				
587	Disc name or Track name				
(X4 Byte)	1	2	3	4	

"M" "I" "N" "I" : System ID in ASCII code

Disc type=

3Dh : Pre-mastered MD

3Fh : Hybrid MD

P-TNA n :
(pointer for the name of track n)
The value of P-TNA n indicates the byte position of the Name-slot for TNOn.

Byte position
= 76 x 4 + (P-TNA n) x8

Disc name, Track name slots

ASCII code should be used.
See Table 11.1.
Last character of each name should be null (00h). MSB is first.

The table should be sequential according to TNO.
The length of each name is variable at the unit of 8 bytes though total length should be less than 2048 bytes.

example

"Test disc type 1"

Remark: Bit order for scrambling is same as CD-ROM; LSBit first in ascending order from Byte 12 to Byte 2351.
Not used byte should be filled with 00h.

SECTOR STRUCTURE of MD TOC Sector=2 (option)

	16 bit even m		16 bit odd m		
	Wm B	Wm A	Wm B	Wm A	
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	
	d1 d8	d1 d8	d1 d8	d1 d8	
0	00000000	11111111	11111111	11111111	Header
1	11111111	11111111	11111111	11111111	Header
2	11111111	11111111	11111111	00000000	Header
3	cluster H	cluster L	00000010	00000010	Header
4	00000000	00000000	00000000	00000000	Data area (2336 Byte)
5	00000000	00000000	00000000	00000000	
6	"M"	"I"	"N"	"I"	
7	Disc type	00000000	00000000	00000000	
8	00000000	00000000	00000000	00000000	
9	00000000	00000000	00000000	00000000	
10	00000000	00000000	00000000	00000000	
11	00000000	00000000	00000000	00000000	
12	00000000	P-TRD 1	P-TRD 2	P-TRD 3	
13	P-TRD 4	P-TRD 5	P-TRD 6	P-TRD 7	
14	P-TRD 8	P-TRD 9	P-TRD 10	P-TRD 11	
15	P-TRD 12	P-TRD 13	P-TRD 14	P-TRD 15	
16	P-TRD 16				
17					
73					
74	P-TRD 248	P-TRD 249	P-TRD 250	P-TRD 251	
75	P-TRD 252	P-TRD 253	P-TRD 254	P-TRD 255	
76	Disc rec date and time				
77			00000000	00000000	
78	Track rec date and time (Track 1)				
79			00000000	00000000	
80	Track rec date and time (Track 2)				
81			00000000	00000000	
82	Track rec date and time (Track 3)				
83			00000000	00000000	
84	Track rec date and time (Track 4)				
85			00000000	00000000	
86					
481					
482					
534					
535					
586	Track rec date and time (Track 255)				
587			00000000	00000000	
(X4 Byte)	1	2	3	4	

(If not used, Byte 16- Byte 2351 should be all zero.)

"M" "I" "N" "I" : System ID in ASCII code

Disc type=
3Dh : Pre-mastered MD
3Fh : Hybrid MD

P-TRD n:
(pointer for the recording date and time of track n)
The value of P-TRD n indicate the byte position of recording date and time-slot for TNOn.

Byte position
= 76 x 4 + (P-TRD n) x8

Recording date and time-slots:
Each slot uses 12 digits BCD for each track, MSB is first.

example

Year	: 91
Month	: 08
Date	: 10
Hour	: 13
Minute	: 22
Second	: 30

Remark: Bit order for scrambling is same as CD-ROM; LSBit first in ascending order from Byte 12 to Byte 2351.
Not used byte should be filled with 00h.

SECTOR STRUCTURE of MD   TOC Sector=3 (option)

(If not used, Byte 16- Byte 2351 should be all zero.)

	16 bit even m: Wm B (MSB d1 – LSB d8)	16 bit even m: Wm A (MSB d1 – LSB d8)	16 bit odd m: Wm B (MSB d1 – LSB d8)	16 bit odd m: Wm A (MSB d1 – LSB d8)	
0	00000000	11111111	11111111	11111111	Header
1	11111111	11111111	11111111	11111111	Header
2	11111111	11111111	11111111	00000000	Header
3	cluster H	cluster L	00000011	00000010	Header
4	00000000	00000000	00000000	00000000	Data area (2336 Byte)
5	00000000	00000000	00000000	00000000	
6	"M"	"I"	"N"	"I"	
7	Disc type	00000000	00000000	00000000	
8	00000000	00000000	00000000	00000000	
9	00000000	00000000	00000000	00000000	
10	00000000	00000000	00000000	00000000	
11	00000000	00000000	00000000	00000000	
12	00000000	P-TCD 1	P-TCD 2	P-TCD 3	
13	P-TCD 4	P-TCD 5	P-TCD 6	P-TCD 7	
14	P-TCD 8	P-TCD 9	P-TCD 10	P-TCD 11	
15	P-TCD 12	P-TCD 13	P-TCD 14	P-TCD 15	
16	P-TCD 16				
17					
73					
74	P-TCD 248	P-TCD 249	P-TCD 250	P-TCD 251	
75	P-TCD 252	P-TCD 253	P-TCD 254	P-TCD 255	
76	Catalogue Number				
77					
78	ISRC (Track 1)				
79					
80	ISRC (Track 2)				
81					
82	ISRC (Track 3)				
83					
84	ISRC (Track 4)				
85					
86					
481					
482					
534					
535					
586	ISRC (Track 255)				
587					
(X4 Byte)	1	2	3	4	

"M" "I" "N" "I" : System ID in ASCII code

Disc type=
3Dh : Pre-mastered MD
3Fh : Hybrid MD

P-TCD n:
(pointer for the ISRC of track n)
The value of P-TCD n indicate the byte position of the slot that gives ISRC fo TNOn.

Byte position
= 76 x 4 + (P-TCD n) x8

Catalogue Number
(UPC/EAN/JAN-code)

N1-N13	4bit BCD	52bit
Zero		12bit

MSB is first. See IEC-908.

ISRC (DIN-31-621 or ISO-3901)

I1-I5	6bit format	30bit
Zero		2bit
I6-I12	4bit BCD	28bit
Zero		4bit

MSB is first. See IEC-908.
Also see Table 11.2.

Remark: Bit order for scrambling is same as CD-ROM; LSBit first in ascending order from Byte 12 to Byte 2351.
Not used byte should be filled with 00h.

SECTOR STRUCTURE of MD

TOC Sector=4 (option)

	16 bit even m		16 bit odd m		
	Wm B	Wm A	Wm B	Wm A	
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	
	d1 d8	d1 d8	d1 d8	d1 d8	
0	00000000	11111111	11111111	11111111	Header
1	11111111	11111111	11111111	11111111	Header
2	11111111	11111111	11111111	00000000	Header
3	cluster H	cluster L	00000100	00000010	Header
4	00000000	00000000	00000000	00000000	Data area (2336 Byte)
5	00000000	00000000	00000000	00000000	
6	"M"	"I"	"N"	"I"	
7	Disc type	00000000	00000000	00000000	
8	00000000	00000000	00000000	00000000	
9	00000000	00000000	00000000	00000000	
10	00000000	00000000	00000000	Char. code	
11	00000000	00000000	00000000	00000000	
12	00000000	P-TNA 1	P-TNA 2	P-TNA 3	
13	P-TNA 4	P-TNA 5	P-TNA 6	P-TNA 7	
14	P-TNA 8	P-TNA 9	P-TNA 10	P-TNA 11	
15	P-TNA 12	P-TNA 13	P-TNA 14	P-TNA 15	
16	P-TNA 16				
17					
73					
74	P-TNA 248	P-TNA 249	P-TNA 250	P-TNA 251	
75	P-TNA 252	P-TNA 253	P-TNA 254	P-TNA 255	
76	Disc name				
77	Disc name				
78	Disc name or Track name				
79	Disc name or Track name				
80	Disc name or Track name				
81	Disc name or Track name				
82	Disc name or Track name				
83	Disc name or Track name				
84	Disc name or Track name				
85	Disc name or Track name				
86					
481					
482					
534					
535					
586	Disc name or Track name				
587	Disc name or Track name				
(X4 Byte)	1	2	3	4	

Remark: Bit order for scrambling is same as CD-ROM; LSBit first in ascending order from Byte 12 to Byte 2351.
Not used byte should be filled with 00h.

(If not used, Byte 16- Byte 2351 should be all zero.)

(If this sector is encoded, TOC Sector 1 is strongly recommended to encode for a simple display.)

"M" "I" "N" "I" : System ID in ASCII code

Disc type=
- 3Dh : Pre-mastered MD
- 3Fh : Hybrid MD

Character code=
- 01h : ISO-8859-1
- 02h : Shifted JIS

P-TNA n:
(pointer for the name track n)
The value of P-TNA n indicates the byte position of the Name-slot for TNO n.

Byte position
= 76 x 4 + (P-TNA n) x8

Disc name, Track name slots

Last character of each name should be null (00h for 1 byte-code, 0000h for 2 bytes-code). MSB is first.

The table should be sequential according to TNO.
The length of each name is variable at the unit of 8 bytes though total length should be less than 2048 bytes.

example

"Test disc type 1"

SECTOR STRUCTURE of MD UTOC Sector=0 (mandatory)

	16 bit even m		16 bit odd m	
	Wm B	Wm A	Wm B	Wm A
	MSB LSB	MSB LSB	MSB LSB	MSB LSB
	d1 d8	d1 d8	d1 d8	d1 d8
0	00000000	11111111	11111111	11111111
1	11111111	11111111	11111111	11111111
2	11111111	11111111	11111111	00000000
3	cluster H	cluster L	00000000	00000010
4	00000000	00000000	00000000	00000000
5	00000000	00000000	00000000	00000000
6	00000000	00000000	00000000	00000000
7	Maker code	Model code	First TNO	Last TNO
8	00000000	00000000	00000000	Used Sectors
9	00000000	00000000	00000000	00000000
10	00000000	00000000	00000000	Disc Serial No
11	DISC-	ID	P-DFA	P-EMPTY
12	P-FRA	P-TNO 1	P-TNO 2	P-TNO 3
13	P-TNO 4	P-TNO 5	P-TNO 6	P-TNO 7
14	P-TNO 8	P-TNO 9	P-TNO 10	P-TNO 11
15	P-TNO 12	P-TNO 13	P-TNO 14	P-TNO 15
16	P-TNO 16			
17				
73				
74	P-TNO 248	P-TNO 249	P-TNO 250	P-TNO 251
75	P-TNO 252	P-TNO 253	P-TNO 254	P-TNO 255
76	00000000	00000000	00000000	00000000
77	00000000	00000000	00000000	00000000
78	Start address			Track mode
79	End address			Link-P
80	Start address			Track mode
81	End address			Link-P
82	Start address			Track mode
83	End address			Link-P
84	Start address			Track mode
85	End address			Link-P
86				
481				
482				
534				
535				
586	Start address			Track mode
587	End address			Link-P
(X4 Byte)	1	2	3	4

Header (rows 0–3)

Data area (2336 Byte) (rows 4–587)

Remark: Bit order for scrambling is same as CD-ROM; LSBit first in ascending order from Byte 12 to Byte 2351.

Maker and Model code:
See chapter 11. 5. 3. 1.

Used sectors
d8-d1 correspond to 0-7 sectors. If a sector is used, the corresponding bit should be 1.

Disc Serial No.: option, 8bit binary
(Disc Serial Number)

Disc-ID: option, 16bit binary
(Disc Identification Number)

Byte position of Pointers
= 76 x 4 + (Pointer) x8

P-DFA: option
(pointer for the start address of the defective area)

P-EMPTY
(pointer for the first empty slot on the parts table)

P-FRA:
(pointer for the start address of the freely recordable area)

P-TNO n:
(pointer for the start address of track n)
The value of P-TNO n indicates the byte position that gives the start address of TNO-n

Start and End address of the Parts:

Cluster 14 bit
Sector 6bit
Sound Gp. 4 bit

Track mode
- d1 = 0: Write protected
  - = 1: Write permitted
- d2 = 0: copy right protected
  - = 1: not protected
- d3 = 0: original
  - = 1: 1st or higher generation
- d4 = 0: audio
  - = 1: reserved
- d5 = 0, d6 = 1: normal audio; else reserved
- d7 = 0: mono
  - = 1: stereo
- d8 = 0: emphasis off
  - = 1: emphasis 50/15 μs

Link-P
The value of Link-P indicates the byte position that gives the next Part-descriptor of the same track. If the value is 00h, the track ends with the End address.

Byte position of the next Part-descriptor
= 76 x 4 + (Link-P) x8

SECTOR STRUCTURE of MD UTOC Sector=1 (option)

	16 bit even m		16 bit odd m		
	Wm B	Wm A	Wm B	Wm A	
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	
	d1 d8	d1 d8	d1 d8	d1 d8	
0	00000000	11111111	11111111	11111111	Header
1	11111111	11111111	11111111	11111111	Header
2	11111111	11111111	11111111	00000000	Header
3	cluster H	cluster L	00000001	00000010	Header
4	00000000	00000000	00000000	00000000	Data area (2336 Byte)
5	00000000	00000000	00000000	00000000	
6	00000000	00000000	00000000	00000000	
7	00000000	00000000	00000000	00000000	
8	00000000	00000000	00000000	00000000	
9	00000000	00000000	00000000	00000000	
10	00000000	00000000	00000000	00000000	
11	00000000	00000000	00000000	P-EMPTY	
12	00000000	P-TNA 1	P-TNA 2	P-TNA 3	
13	P-TNA 4	P-TNA 5	P-TNA 6	P-TNA 7	
14	P-TNA 8	P-TNA 9	P-TNA 10	P-TNA 11	
15	P-TNA 12	P-TNA 13	P-TNA 14	P-TNA 15	
16	P-TNA 16				
17					
73					
74	P-TNA 248	P-TNA 249	P-TNA 250	P-TNA 251	
75	P-TNA 252	P-TNA 253	P-TNA 254	P-TNA 255	
76	Disc name				
77	Disc name			Link-P	
78	Disc name or Track name				
79	Disc name or Track name			Link-P	
80	Disc name or Track name				
81	Disc name or Track name			Link-P	
82	Disc name or Track name				
83	Disc name or Track name			Link-P	
84	Disc name or Track name				
85	Disc name or Track name			Link-P	
86					
481					
482					
534					
535					
586	Disc name or Track name				
587	Disc name or Track name			Link-P	
(X4 Byte)	1	2	3	4	

Remark: Bit order for scrambling is same as CD-ROM; LSBit first in ascending order from Byte 12 to Byte 2351.

P-EMPTY:
(pointer for the first empty slot on name table)

P-TNA n:
(pointer for track n name table)
The value of P-TNA n indicates the byte position of the Name-slot for TNOn.

Byte position
= 76 x 4 + (P-TNA n) x8

Disk name, Track name slots

ASCII-code should be used.
See Table 11. 1.
Last character of each name should be null (00h). MSB is first.
The byte length of each name is variable at the unit of 7 bytes though total bytes length should be less than or equal to 1792 byte excluding Link-Ps.

example

"Test disc type 1"

Link-P
The value of Link-P indicates the byte position of the next slot of the same track.
If the value is 00h, the track name ends before 00h.

Byte position of the next slot
= 76 x 4 + (Link-P) x8

SECTOR STRUCTURE of MD UTOC Sector=2 (option)

	16 bit even m		16 bit odd m		
	Wm B	Wm A	Wm B	Wm A	
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	
	d1 d8	d1 d8	d1 d8	d1 d8	
0	00000000	11111111	11111111	11111111	Header
1	11111111	11111111	11111111	11111111	
2	11111111	11111111	11111111	00000000	
3	cluster H	cluster L	00000010	00000010	
4	00000000	00000000	00000000	00000000	Data area (2336 Byte)
5	00000000	00000000	00000000	00000000	
6	00000000	00000000	00000000	00000000	
7	00000000	00000000	00000000	00000000	
8	00000000	00000000	00000000	00000000	
9	00000000	00000000	00000000	00000000	
10	00000000	00000000	00000000	00000000	
11	00000000	00000000	00000000	P-EMPTY	
12	00000000	P-TRD 1	P-TRD 2	P-TRD 3	
13	P-TRD 4	P-TRD 5	P-TRD 6	P-TRD 7	
14	P-TRD 8	P-TRD 9	P-TRD 10	P-TRD 11	
15	P-TRD 12	P-TRD 13	P-TRD 14	P-TRD 15	
16	P-TRD 16				
17					
73					
74	P-TRD 248	P-TRD 249	P-TRD 250	P-TRD 251	
75	P-TRD 252	P-TRD 253	P-TRD 254	P-TRD 255	
76	Disk rec date and time				
77			Maker code	Model code	
78	Track rec date and time				
79			Maker code	Model code	
80	Track rec date and time				
81			Maker code	Model code	
82	Track rec date and time				
83			Maker code	Model code	
84	Track rec date and time				
85				(Link-P)	
86					
481					
482					
534					
535					
586	Track rec date and time				
587				(Link-P)	
(X4 Byte)	1	2	3	4	

Remark: Bit order for scrambling is same as CD-ROM; LSBit first in ascending order from Byte 12 to Byte 2351.

P-EMPTY:
(pointer for the first empty slot on recording date and time table)

P-TRD:
(pointer for the recording date and time of TNO n)
The value of P-TRD n indicates the byte position of the recording date and time-slot for TNO n.

Byte position
= 76 x 4 + (P-TRD n) x8

Recording date and time slots:
Each slot uses 12 digits BCD for date and time and 2 bytes Binary for Maker and Model codes. (MSB is first)

example

Year	: 91
Month	: 08
Date	: 10
Hour	: 13
Minute	: 22
Second	: 30
Maker code	
Model code	

For Maker and Model codes, See chapter 11. 5. 5. 2.

Link-P
Link-P exists only in the empty slot.
The value of Link-P indicates the byte position of the next empty slot.
If the value is 00h, there is no more empty slot.

Byte position of the next slot
= 76 x 4 + (Link-P) x8

SECTOR STRUCTURE of MD UTOC Sector=4 (option)

	16 bit even m		16 bit odd m		
	Wm B	Wm A	Wm B	Wm A	
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	
	d1 d8	d1 d8	d1 d8	d1 d8	
0	00000000	11111111	11111111	11111111	Header
1	11111111	11111111	11111111	11111111	Header
2	11111111	11111111	11111111	00000000	Header
3	cluster H	cluster L	00000100	00000010	Header
4	00000000	00000000	00000000	00000000	Data area (2336 Byte)
5	00000000	00000000	00000000	00000000	
6	00000000	00000000	00000000	00000000	
7	00000000	00000000	00000000	00000000	
8	00000000	00000000	00000000	00000000	
9	00000000	00000000	00000000	00000000	
10	00000000	00000000	00000000	Char. code	
11	00000000	00000000	00000000	P-EMPTY	
12	00000000	P-TNA 1	P-TNA 2	P-TNA 3	
13	P-TNA 4	P-TNA 5	P-TNA 6	P-TNA 7	
14	P-TNA 8	P-TNA 9	P-TNA 10	P-TNA 11	
15	P-TNA 12	P-TNA 13	P-TNA 14	P-TNA 15	
16	P-TNA 16				
17					
73					
74	P-TNA 248	P-TNA 249	P-TNA 250	P-TNA 251	
75	P-TNA 252	P-TNA 253	P-TNA 254	P-TNA 255	
76	Disc name				
77	Disc name			Link-P	
78	Disc name or Track name				
79	Disc name or Track name			Link-P	
80	Disc name or Track name				
81	Disc name or Track name			Link-P	
82	Disc name or Track name				
83	Disc name or Track name			Link-P	
84	Disc name or Track name				
85	Disc name or Track name			Link-P	
86					
481					
482					
534					
535					
586	Disc name or Track name				
587	Disc name or Track name			Link-P	
(X4 Byte)	1	2	3	4	

Remark: Bit order for scrambling is same as CD-ROM; LSBit first in ascending order from Byte 12 to Byte 2351.

Character code=
01h : ISO-8859-1
02h : Shifted JIS

P-EMPTY:
(pointer for the first empty slot on name table)

P-TNA n:
(pointer for track n name table)
The value of P-TNA n indicates the byte position of the Name-slot for TNO n.

Byte position
= 76 x 4 + (P-TNA n) x8

Disc name, Track name slots

Last character of each name should be null (00h for 1 byte-code, 0000h for 2 bytes-code).
MSB is first.
The byte length of each name is variable at the unit of 7 bytes though total bytes length should be less than or equal to 1792 bytes excluding Link-Ps.

example

"Test disc type 1"

Link-P
The value of Link-P indicates the byte position of the next slot of the same track.
If the value is null (00h for 1 byte-code, 0000h for 2 bytes-code), the track name ends before null.

Byte position of the next slot
= 76 x 4 + (Link-P) x8

3. Kenwood Second Generation MD System

As the second generation of Kenwood MD systems, the three types known as the DM-F9, DM-F70 and DM-7080 will go on sale in succession starting in summer of 1995. The following text uses the DM-F70 as an example in carrying out a technical description of the interior of the products.

Description of the Functions of the DM-F70

1) Features

1. Basic Functions

(1) PLAY

Playback of signals recorded on the disc. Playback of pre-mastered discs and recordable discs. Does not operate with hybrid discs. Monaural playback is also possible.

(2) REC

Records audio signals on the discs. Can only record on recordable discs for which there is no write protect. Does not operate with hybrid discs. Monaural recording is not possible.

2. Basic Auxiliary Functions

(1) FF/FB

FF/FB refers to fast-forward and fast-return. It only operates during playback (including pause). With FF/FB during playback (in conditions where sound is produced), the fast-forward or fast-return is operative while sound is being produced. During playback pause (in conditions where no sound is produced), the fast-forward or fast-return is carried with no sound. When carrying out FF/FB with the JOG dial, there is fast-forward or fast-return according to a set speed that does not depend on the rotational speed of the JOG dial. Furthermore, on the 1st generation of Kenwood MD recorders, sound production during FF/FB was not possible regardless of conditions.

(2) SKIP UP/DOWN

SKIP UP refers to search for the head of the track after the track presently being played followed by playback. When playing the last track, this function becomes invalid.

SKIP DOWN refers either to returning to the head of the track now being played and then playback or returning to the prior track and playback. If the playback type of the track now being played is less than 1 second, the unit returns to the previous track. If there is playing for more than 1 second, it returns to the head of the track now being played. If there is playback of less than a second in the first track for playback, SKIP DOWN becomes invalid.

(3) PLAY Mode

The Play Mode includes two types: the track mode and program mode. With the track mode, there is play in order starting with track number TNO=001. With the program mode, there is playing only of the tracks set arbitrarily by the user in order of setting. When the final track is finished, the unit stops. It is possible to program as many as 25 tracks.

(4) REPEAT PLAY

Function for repeating play regardless of the track mode and program mode.

(5) REC INPUT (ANALOG/DIGITAL)

Selects the type of input signal for recording in terms of Analog/Digital. If Analog is selected, the signals input from the analog input terminal are unconditionally recorded. If Digital is selected, there is recording according to the regulations of the various Digital recording instruments. If it is not possible to lock the standard clock during Digital input (UNLOCK), the recording operations are stopped (only reception of fs= 44.1 kHz).

(6) AUTO/MANUAL

During recording with Analog input, there is detection of the soundless sections and automatic determination of whether to assign a tracking number or not. AUTO refers to AUTO MARKING. There is detection of soundless sections and automatic assigning of TNo with the rise of the next sound. If Manual is selected, unless the user deliberately makes TNo, that TNo does not change. However, if there is recording with Digital input, with the conditions of the sub-code, etc. automatic writting of TNo is made.

3. Track Editing Functions

(1) DIVIDE (function for dividing track) → TNo insert on DM-E9.

It is possible to divide a single track into two at an arbitrary position. This function can only be carried out with recordable discs. This function is valid during playback (including pause) and recording. A new track starts at the point that DIVIDE command is applied.

(2) COMBINE (function for combining tracks) → TNo cancel on DM-E9.

It is possible to connect two continuous tracks and turn them into a single track. This can only be carried out on recordable discs. This function is valid during playback (including pause) and stop. During playback, it combines the playback track (including pause) and the next track).

During stop it selects an arbitrary track and combines the selected track and the next track.

(3) MOVE (function for moving the track) →

New feature that is not included on the DM-E9.

Possible to take an arbitrary track and move it to another location. This can only be carried out with recordable discs. The function is only valid during stop. There is selection of an arbitrary track as well as selection of the movement destination. The track that was already at the destination is placed behind the track that was moved.

(4) ERASE (function for erasing tracks) →
Track Delete on DM-E9.
This function is valid during play (including pause) and stop. During play (including pause) there is erasing of the track being played (including pause). During stop, it is possible to choose an arbitrary track. It is also possible to erase the entire disc to create a blank disc. This function is only valid on recordable discs.

4. QUICK MOVE

It is possible with this function to carry out changing of track order for a maximum of 40 selections at the same time. The function is only valid on recordable discs. The function only operates during stop.
There is selection of a new track order and final checking to change the order of preference. Also, prior to choosing the order, it is possible to indicate OFFSET (TNO of heads within the range for changing order).

5. Title Editing Function

Titles can be assigned to discs and to all existing tracks. It is possible to record a total of 1792 bytes of ASCII codes (7 bit ASCII) to the total disc. There are 1792 bytes for displays. It is possible to handle as much as 80 bytes during editing. As a result, the maximum character number of titles assigned to a single track or to a disc is 80 ASCII code characters. Also, regarding the J-destinations for this equipment (for domestic use in Japan), displays and editing with the katakana syllabary are also possible.
Due to MD standards, it is not possible to record katakana data. Instead, processing is done by changing to ASCII code. Due to this conversion, a buffer area is required and there is a limit to the number of katakana characters that can be edited.

2) Main Microcomputer (μPD78056GC-092) Control Targets
Carries out control of the panel keys, remote control, 16-bit serial input and displays. Drive of the peripheral ICs and mechanisms is controlled with the Mecha-Control CPU (MB-MI, M37610 MD) from Sony Corp.
This main microcomputer controls the Sony mecha-control CPU with communications.

- Fluorescent display (FL) tube (FIP15XM2AA)
  A large FL tube with a grid number of 32 and a segment number of 70 and two display drivers are used.
- Display Driver (LC75710E)
  5x7 dot matrix for 16 column display.
- Disc loading system
  Slot-in type
- MD System IC
  Sony 3rd Generation MD Package IC
  1 RF matrix amp → CXA1981AR
  2 Digital servo processor included
  EFM/ACIRC encoder/decoder → CXD2535BR
  3 Memory controllor included ATRAC encoder/decoder → CXD2536AR

  The 6-chip structure found in the first generation has become a 3-chip structure in the 3rd generation.

3) Situation according to model and destination.
The main microcomputer has destination port switches on three terminals. By changing the port logic, the destination and model are chosen.

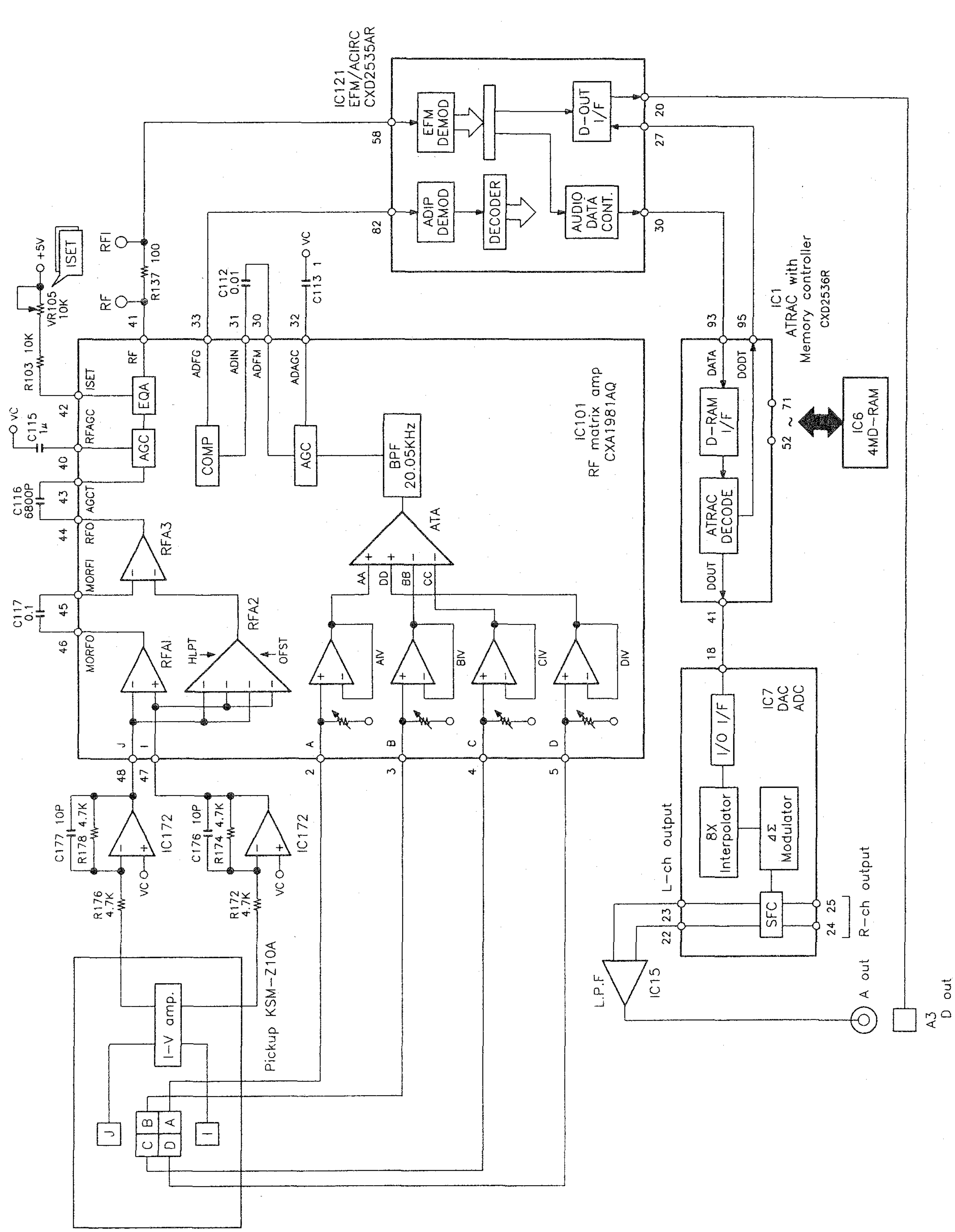
1. Differences according to destination
Domestic → Characters that can be used for title editing: A-Z, a-z, 0-9, special symbols, katakana
Overseas → Characters that can be used for title editing: A-Z, a-z, 0-9, special symbols

2. Differences according to model

Model	Difference	
DM-F9 (XK-7)	Power source	: Supplied by parallel cable from receiver. During UTOC write, the power does not go OFF on the receiver side.
	Timer operation	: Operation according to system.
	Power conditions	: After reset there is definitely rise with power OFF.
	Rec input	: DIGITAL/ANALOG changing is possible only when the selector is CD. In other selector modes there is ANALOG fixed.
	Remote control	: There is no opt, receiving unit. Only operates with system remote control.
DM-F70 (Allora, UD system optional) DM-7080 (separate component)	Power source	: An internal transformer so that the supply source is a power receptacle.
	Timer operation	: Can respond both to slide switch (main unit) and system.
	Power conditions	: Rise with the last state prior to power OFF after reset.
	Rec input	: Free switching between DIGITAL/ANALOG.
	Remote control	: There is a opt, receiving unit for operation with individual remote control and system remote control.

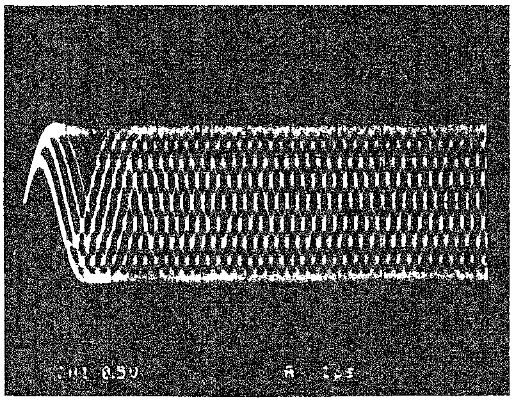
※All models operate with 16-bit serial communications. There is no reception of 8-bit serial communications.

<Main signal flow of DM-F70 playback system>

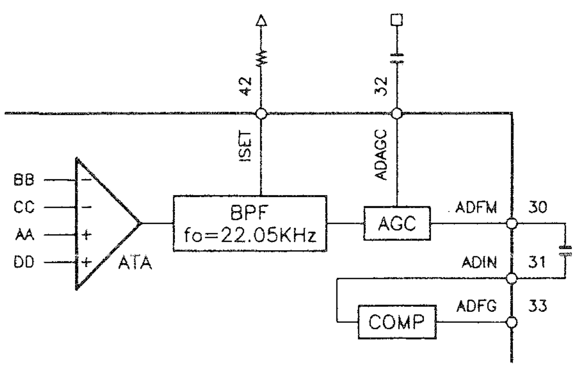


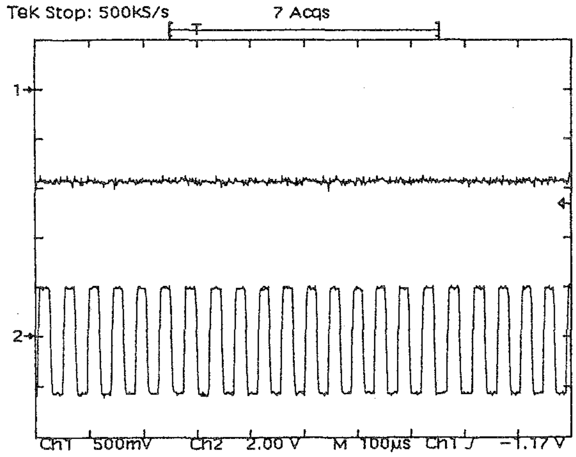
Description of main signal flow of DM-F70 playback system

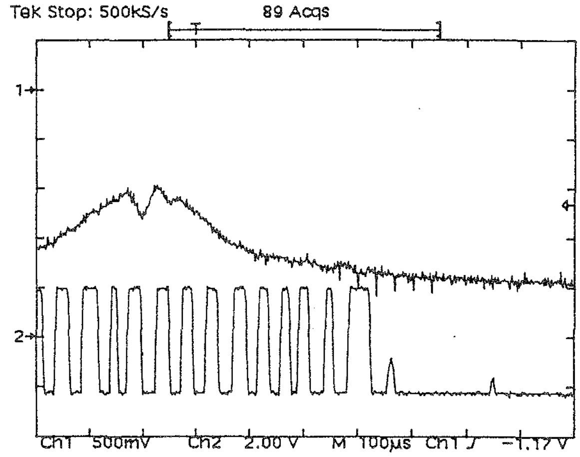
1) The reflected light from the disc is detected by the photodetector in the pickup and there is voltage conversion in the pickup of I and J as the music signal demodulation main signals. The I and J signals pass through the buffer amp and are guided to the IC101 RF matrix IC.
2) Regarding the I and J signals which have undergone I-V conversion, a difference signal (groove signal) is created in the amp RFA1 in the RF matrix IC and a sum signal (pit signal) is created in the amp RFA2. As for the groove signal generated in RFA1, there is AC coupling between the two terminals MORFO and MORFI in order to remove DC offset. In amp RFA2, in order to remove the DC element of the pit signal, an offset (OFST) is added to RFA2. Because the pre-mastered disc signal and recording disc signal are both input to the RFA2 amp, to handle the difference in the reflection rate of the two types of discs, the amp gain is also selected (HLPT). RFA3 is a switch OP amp in which there is selection of either pit signal or groove signal. Changing of gain and switch in this IC is all carried out through serial commands from the mechanism control microcomputer.
3) Regarding the RF signal from the RF0 terminal (44 pin), there is capacitive coupling to remove the DC element so that it is incorporated inside the IC from the AGCI terminal. There is AGC equalizer processing and output from the RF terminal (41 pin).



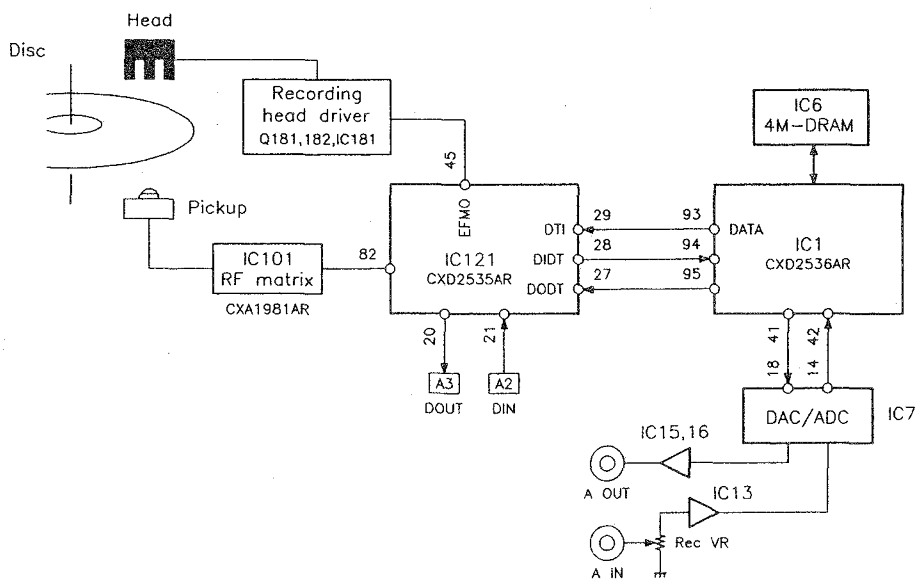
4) The main signal RF output from the RF matrix IC is input to the 58 pin of the EFM/ACIRC decoder in the IC121. EFM demodulation and error correction ACIRC processing are carried out in the IC and there is output from the 30 pin DTO terminal.
5) The digital signal from the DTO terminal enters the 93 pin DATA terminal of the IC1 ATRAC decoder. It passes through the sound skip guard memory inside. The compressed data is melted by means of ATRAC processing. The melted data is output in a single block from the 41 pin DOUT terminal to the DAC circuit (IC7) as analog output. On the other side, the data is returned from the 95 pin DODT to IC121 as digital output.
6) The ADIP signal for recordable disc playback is extracted as the photodetector A,B,C,D push-pull signal inside the pickup. In the IC101 RF matrix amp there is gain adjustment and reception as a (A+D)-(B+C) signal. A 22.05 kHz FM signal is removed from this signal for comparison. The removed FM signal undergoes binarization and is sent from the ADFG terminal to the IC121 EFM decoder. There is demodulation of the ADIP signal inside the IC and extraction of address data together with use as disc servo signal.
7) The figure below shows actual waveforms of the ADFG signal. CH1 is an ABCD signal and CH2 is an ADFG signal. Moreover, the left side is normal play back and the right side is abnormal state. As the chart shows, due to defects in the ABCD signal, the timing of the ADFG signal deteriorates.







<Main signal flow of DM-F70 recording system>



1) The digital signal input to the OPT input module A2 passes through the digital I/F inside IC121 and is input to the ATRAC IC of IC1 (IC121 28 pin to IC1 94 pin). After compression processing inside IC1, it is returned again to the IC121 29 pin as a recording signal. The signal that has undergone compression processing is applied to EFM modulation in IC121 and is input to the recording magnetic head from the 45 pin via the head driver.
2) The analog signal input from the RCA pin undergoes adjustment of recording level before entering the ADC unit of IC7. Here the analog signal is digitized and the resulting digital signal is guided to the ATRAC IC of IC1 for compression. The compressed signal is delivered to EFM demodulation as described above and moves toward the recording head.
3) In order to carry out Rec monitor during recording, the DAC circuit after the ATRAC IC also operates. Also, in order to carry out peak detection of the input signal and output the signals from the digital out terminal, the digital data is transferred from the ATRAC to IC121 27pin.

In the DM-F9 series, there is use of a Sony 3rd generation MD chip set to reduce the size of the circuit. Nevertheless, it is simply a multiplication of the Sony 1st generation chip set as found in the description above of the DM-E9. There is no change in the concrete processing method for recording and playback. In other words, clock processing of the EFM signal, PLL, frame sync protection and sub-Q code processing is almost the same as on the earlier model. On the other hand, the major differences are digitization of the servo system processing, serial commands from the mechanism microcomputer and the internal sequencer. Next follows a description of the digital servo.

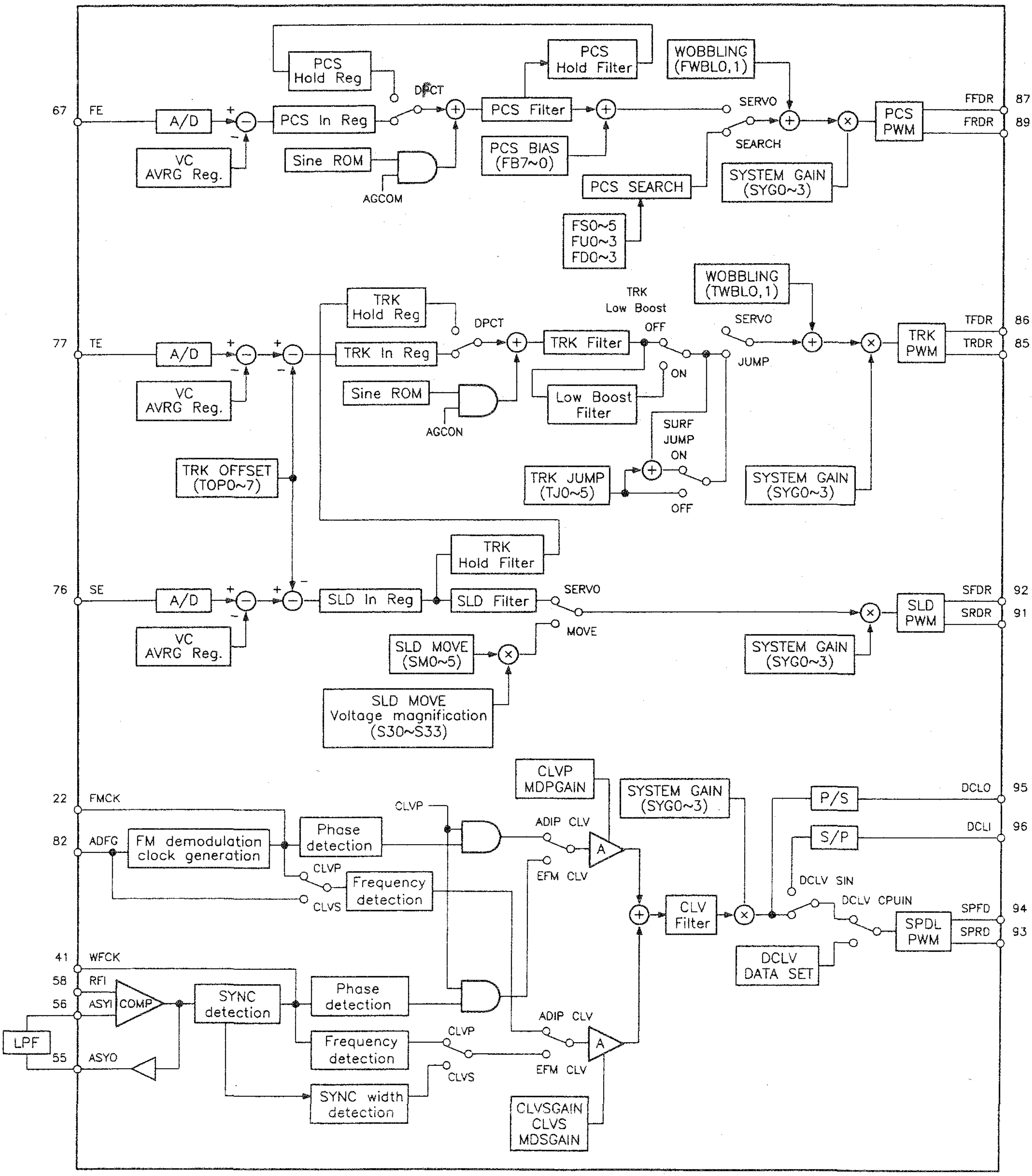
<Description of the digital servo function of the EFM/ACIRC Device>

The EFM/ACIRC encoder/decoder used with the DM-F70 also includes an auto digital servo processor. By combining this with the RF head amp CXA1981AQ, the input servo signals undergo digital conversion so that, with serial commands from the mechanism control, gain and phase compensation are carried out. The controlled servo systems are as follows:

- Offset compensation (VC, FE, ABCD)
- Focus servo
- Tracking sled servo
- Spindle servo (CLV)
- AGC control (Automatic Gain Control)
- System Gain Setting
- Defect countermeasures
- Shock detection
- Pit detection

The following shows the structure of the digital servo circuit. The following description is based on the block diagram below.

<Block diagram of CX2535AR digital servo>

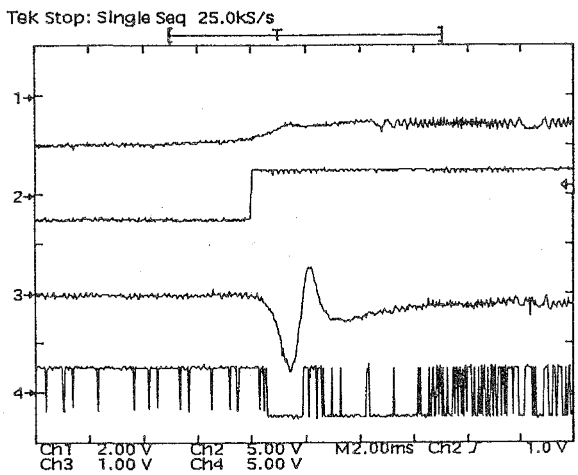


1) Offset compensation

The analog input terminals VC, FE and ABCD include circuits for compensation of DC offset. The power source of the MD system is turned on and, after reset, the input voltage during no signals is measured 256 times to obtain the average value (average voltage). Compensation is carried out by subtracting that average value. VC is the reference voltage that is generated at the RF head amp CXA1981A.

VC=(Vcc+GND of CXA1981)/2

All A/D input signals are processed with this VC voltage as standard.



DC offset compensation of FE is carried out in order to take accurate focus search operations. DC offset compensation of ABCD is for to accurate FOK comparison.

2) Focus Servo

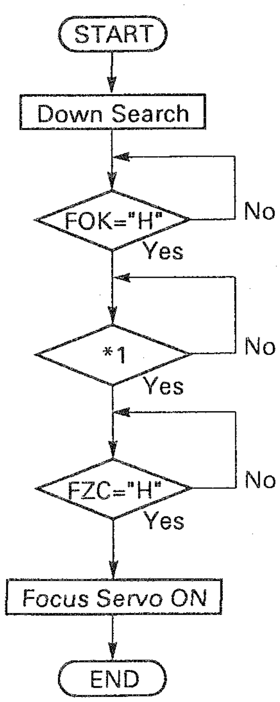
To prevent focus from mistakenly hitting the disc surface due to pseudo-reflection when applying the focus servo on a low reflection disc, the focus servo is ON from down search. As for high reflection discs, there is no problem either in down search or up search order. The following diagram shows waveforms during down search.

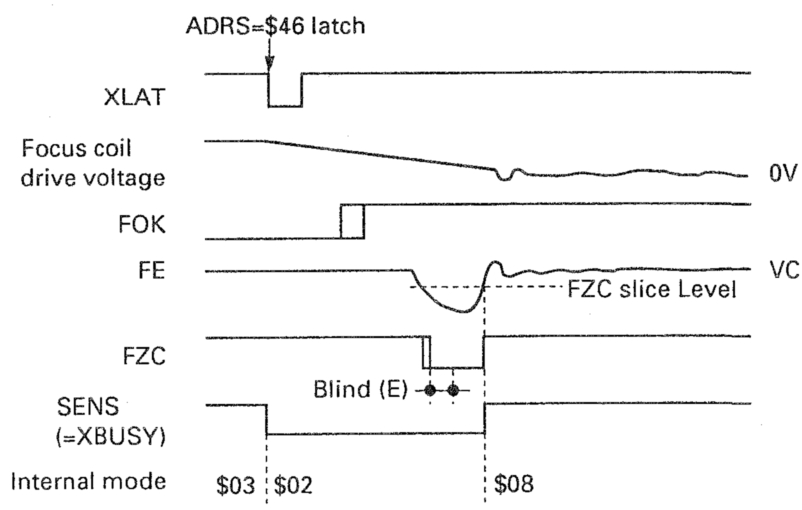
CH1: ABCD
CH2: FOK
CH3: FE (S-shaped curve)
CH4: SENSE

※The GND terminal of the oscilloscope is connected to the VC point to obtain the waveforms.

Due to operation of the auto-sequencer, pull-in of the focus servo is completed inside the IC. All operations (focus search, lens UP, search voltage, speed, etc.) are determined by serial commands.

In case of Auto Focus (Down Search)



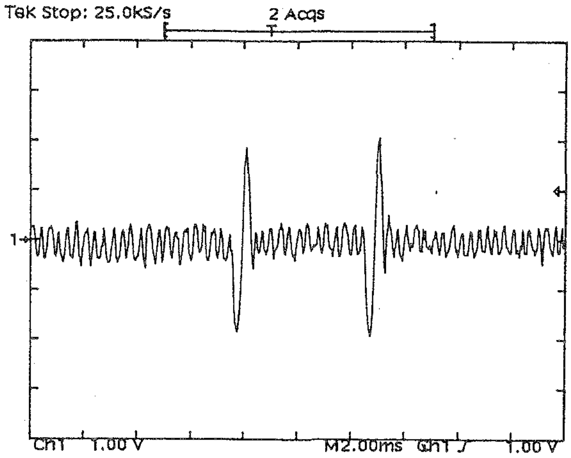


1 FZC="L" time≧Blind(E)

Blind (E) in the above diagram is a timer command of the sequence inside the auto-focus servo. The FZC edge during Blind (E) is masked to insure FZC incorporation at the correct position.

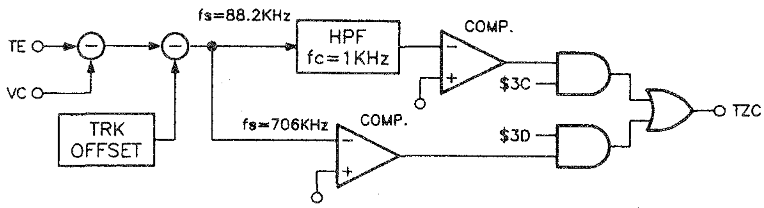
3) Tracking Sled Servo

Control of the servo of the tracking sled system is carried out by serial commands. The following is a description of the signals generated in that IC. The auto sequencer easily operates track jump. The figure at right shows the waveform of the TE signal input to this IC.



●TZC (Tracking Zero Cross) Signal

This signal is used for brake pulse switching during track jump and generation of the COUT signal. The signal can be generated by the two methods listed below. In either case, the polarity of the generated TZC signal is the reverse of the TE signal.



a) HPTZC (command address = $3C)

There is sampling of the TE signal at 88.2 kHz and passing through a 1 kHz HPF and insertion in the zero comparator. In case of a track jump, for example, when the frequency fluctuation of the TE signal is low, integration improves after jump. However, in cases of multi-track jump where the TE frequency is high, the sampling frequency is low so that there is a possibility of faulty operation.

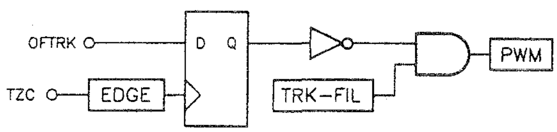
b) STZC (command address = $3D)

There is sampling of the TE signal at 706 kHz and injection in the zero comparator. Because the sampling frequency is high, it is effective during high-speed sending (multi-track jump).

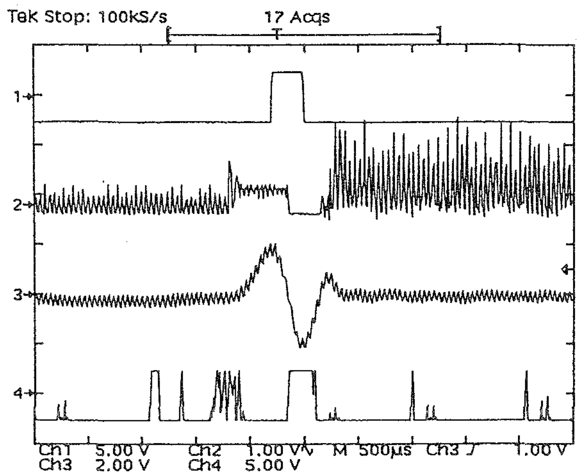
●Brake Circuit

This circuit is included to improve integration after long access such as 10-track or 100-track jumps.

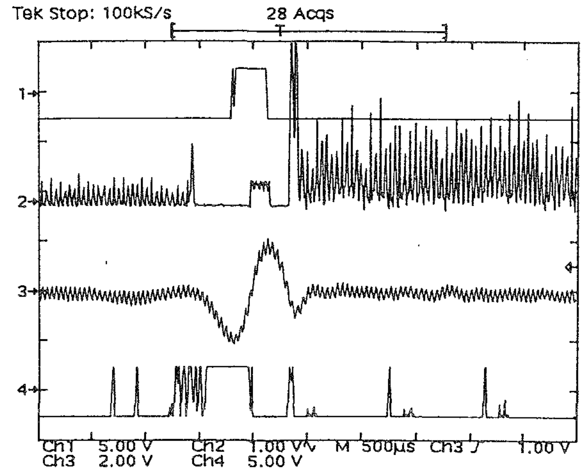
The fact that the phase relationship between the OFTRK signal and TZC signal changes by 180° is used to drive the tracking drive output signal in a direction to stop the actuator.



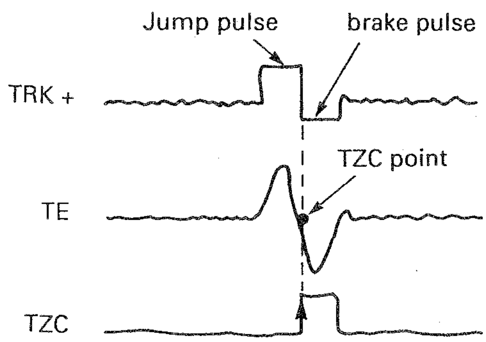
The following shows the TZC pulse and brake signal during 1 track jump.



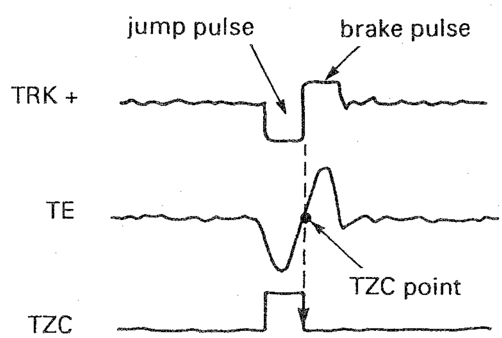
<Forward Jump>



<Reverse Jump>



Due to rise of TZC during off track, the polarity of the tracking coil drive signal is inverted to cause braking.



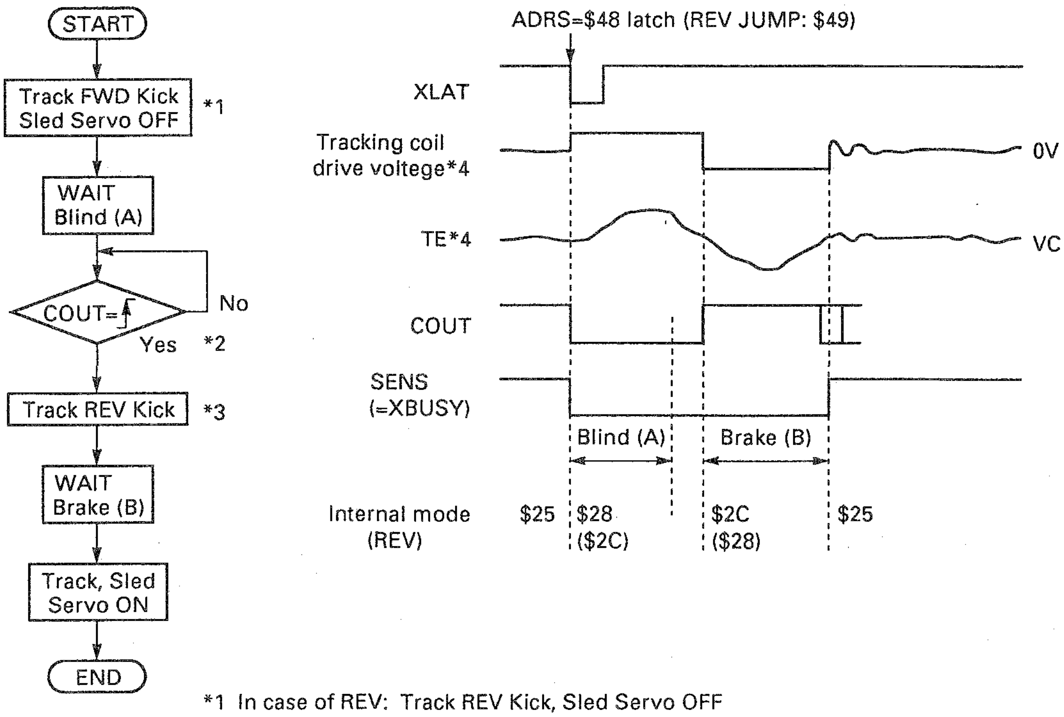
Due to fall of TZC during off track, the polarity of the tracking coil drive signal is inverted to cause braking.

CH1: OFTRK
CH2: TRK+ (AC coupling)
CH3: TE
CH4: SENSE (TZC signal)

※The GND terminal of the oscilloscope is connected to the VC point on the circuit to obtain the waveform.

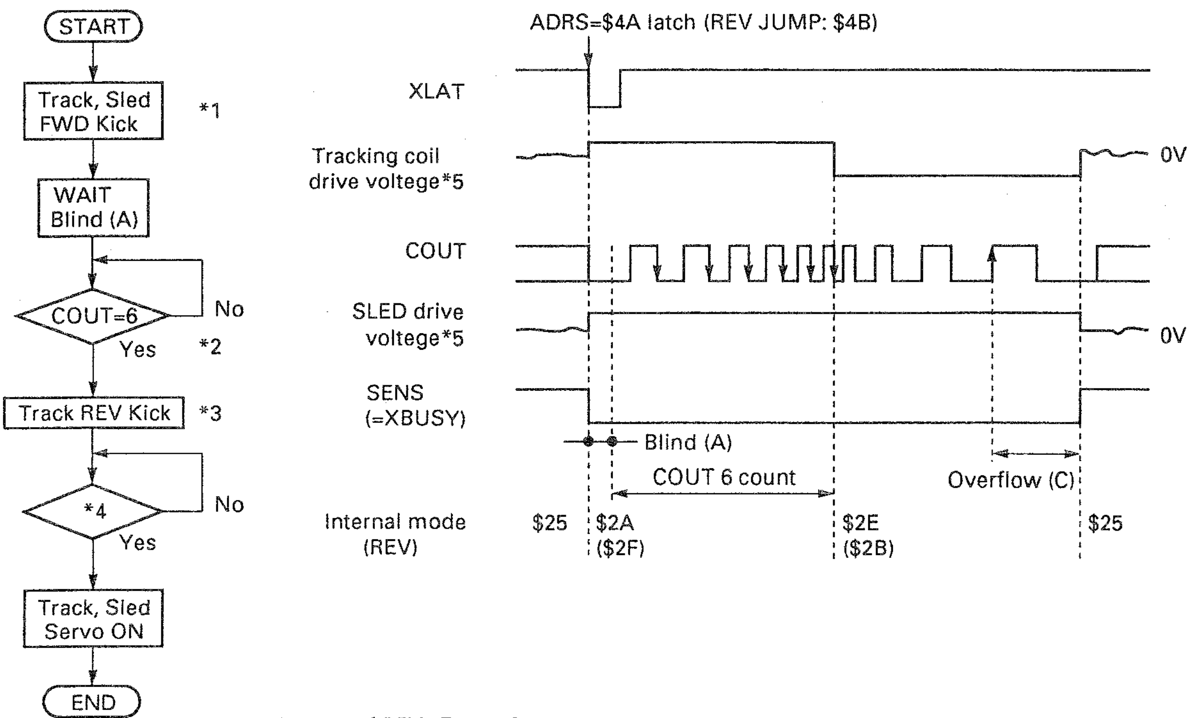
●Track Jump With Internal Auto Sequencer

In case of 1 Track Jump (Forward)



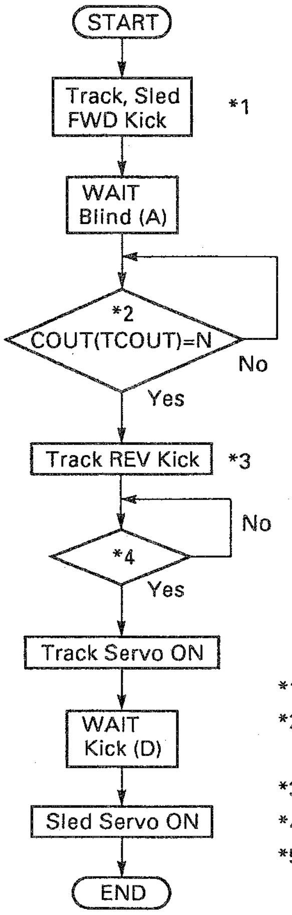
*1 In case of REV: Track REV Kick, Sled Servo OFF
*2 In case of REV: COUT fall edge
*3 In case of REV: Track FWD Kick
*4 In case of REV: Negative phase

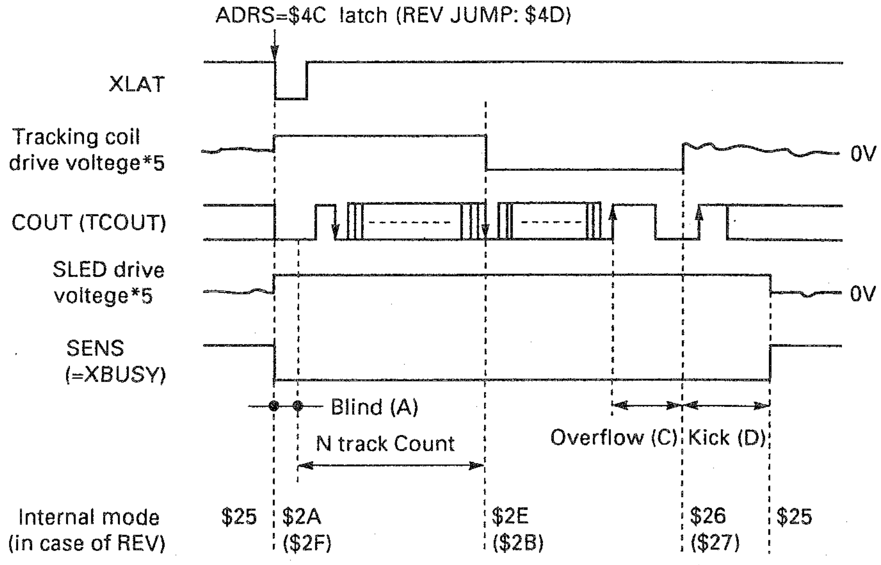
In case of 10 Track Jump (Forward)



*1 In case of REV: Track, Sled FWD Kick
*2 COUT fall: 6 count
*3 In case of REV: Track FWD Kick
*4 COUT cycle is longer than Overflow (C)
*5 In case of REV: Negative phase

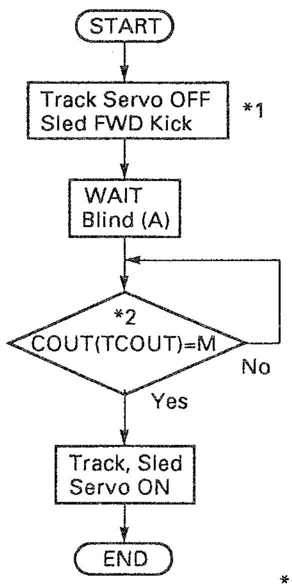
In case of 2N Track Jump (Forward)

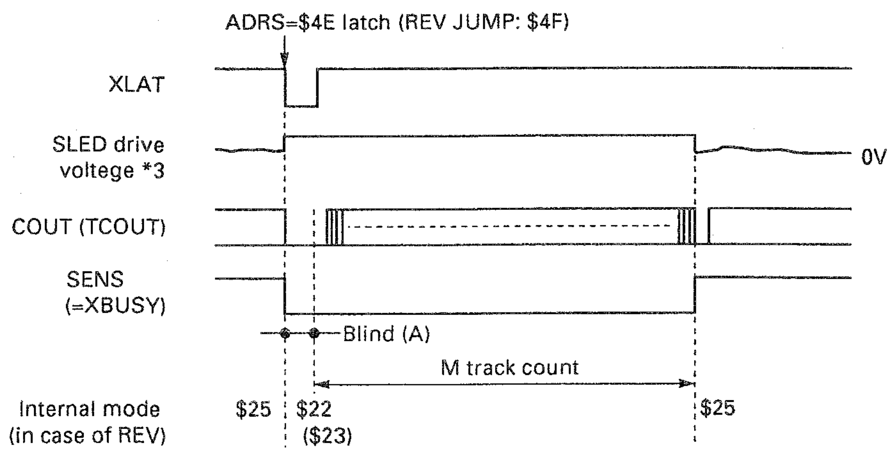




*1 In case of REV: Track, Sled REV Kick
*2 Count of COUT for first 15 tracks,
then count of TCOUT in subsequent tracks
*3 In case of REV: Track FWD Kick
*4 COUT cycle is longer than Overflow (C)
*5 In case of REV: Negative phase

In case of M Track Move (Forward)





*1 In case of REV: Track Servo OFF, Sled REV Kick
*2 Count of COUT for first 15 tracks,
then count of TCOUT in subsequent tracks
*3 In case of REV: Negative phase

4) Spindle Servo (CLV)

Control of spindle servo is also carried out with the address command. The following explains the modes of the CLV system in which the IC are found.

STOP : Stops the spindle motor (drive output = 0V)

KICK : Forward rotation of spindle motor (drive output = + full scale).

BRAKE: Reverse rotation of spindle motor (drive output = - full scale).

EFM-CLV Mode

The playback EFM signal input from the RFI terminal is used for activating the CLV servo.

Effective when activating the CLV servo in the disc pit area.

EFM-CLVS : Rough servo for pull-in.

EFM-CLVH : Rough servo mode during high-speed access (used during track jump).

EFM-CLVP : PLL Servo

EFM-CLVA : Auto Mode (Automatic switching of CLVP and CLVS).

ADIP-CLV Mode

The signal input from the ADFG terminal is used as the basis for activating the CLV servo. Effective when activating the CLV servo in the disc groove area.

ADIP-CLVS : Rough servo for pull-in.

ADIP-CLVP : PLL servo.

ADIP-CLVA : Auto Mode (Automatic switching of CLVP and CLVS).

Lock detection of spindle servo is as described below. Unfortunately, in the case of this IC there is no special terminal for the CLV Lock monitor. Confirmation of lock state is carried out with the address data or with the SENSE terminal.

EFM-CLV Mode : Judged according to the state of the GFS terminal.

ADIP-CLV mode : Judged according to the state of the ATER terminal.

When the spindle servo is in unlock state, in order to prevent servo runaway, the tracking gain is automatically increased and the sled servo goes OFF.

5) ACG Control (Automatic Gain Control)

In order to obtain the correct gain in the servo loop of focus, tracking, an AGC function which automatically adjusts the gain in the filter is included. This does not only respond to discrepancies in the sensitivity of the actuator and diode; it is also possible to obtain the ideal gain for each disc. In a condition in which all servos are ON, the servo filter of the focus and tracking is normal gain, and the anti-shock circuit is OFF, there is setting by the serial command.

The AGC related settings are as follows:

- Indication of focus convergence gain setting value (FG).
- Indication of tracking convergence gain setting value (TG).
- Setting of amplitude of internal generation sine wave (AGF).
- Setting of amplitude of internal generation sine wave (AGT).
- AGC sensitivity 1 (high sensitivity adjustment)
- AGC sensitivity 2 (low sensitivity adjustment)

By setting of FG and TG, the converging servo gain value is expressed. In case of default, FG and TG both become 0 dB aim at 1 kHz.

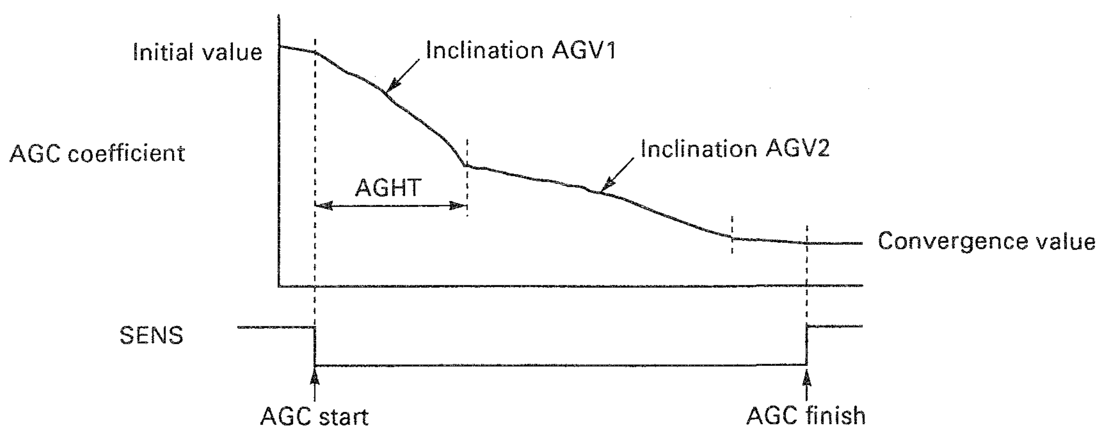
●AGC Operation

1st Stage

In the time set with the AGHT (128 ms or 256 ms) there is high sensitivity adjustment to bring the AGC coefficient closer to the appropriate value. The sensitivity at this time is AGV1.

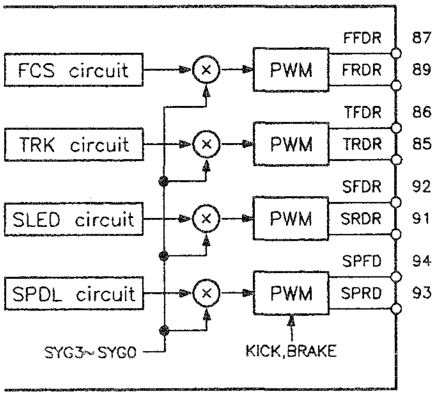
2nd Stage

At a relatively low sensitivity the AGC coefficient is guided to the appropriate value. The sensitivity at this time is AGV2, and the process ends automatically at the point where there is convergence of the AGC coefficient.



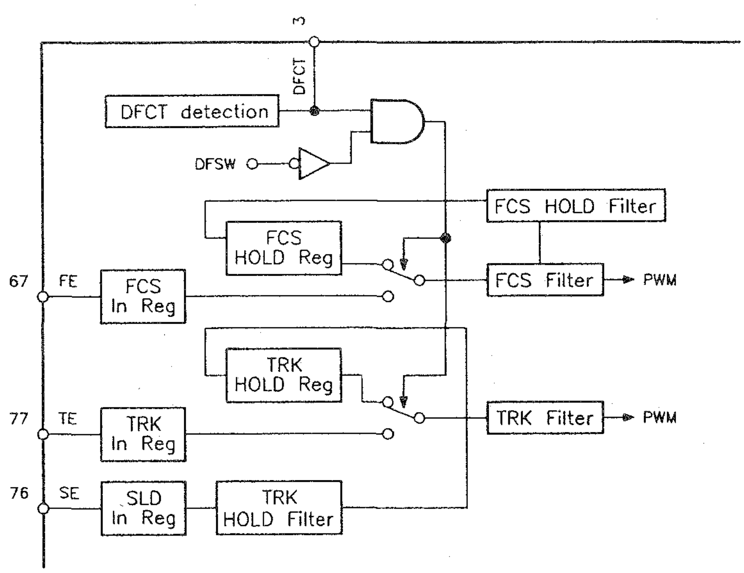
6) System Gain Setting

The gain of the PWM output of all servo systems is set simultaneously with the serial command.



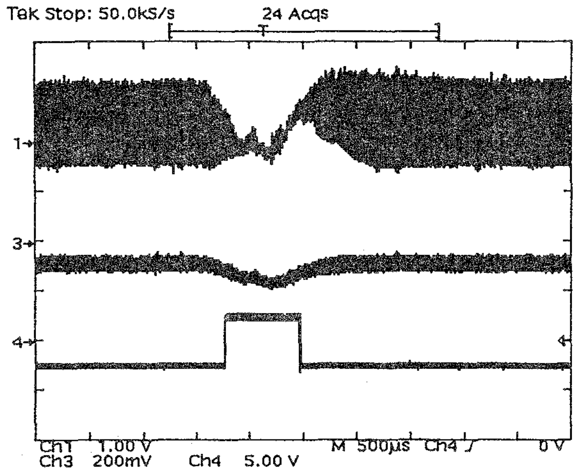
, Defect Countermeasure Circuit

The Defect Countermeasure Circuit is the circuit to prevent the focus servo and tracking servo from straying as a result of scratches and defects on the disc. There is detection of scratches and defects with the DFCT signal generation circuit. If DFCT="H", then instead of FE and TE, there is substitution to the FCS and TRK filters of the DC component of FE, TE until just before DFCT="H". If DFCT="L", then FE and TE are input to the filter. As a result, the laser spot does not follow the scratches and defects on the disc, thus in suring a stable servo.

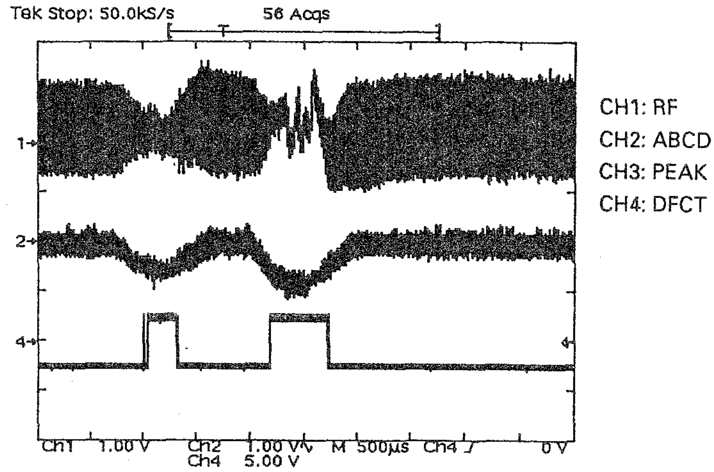


The DFCT signal expresses scratches and defects on the disc. If a defect occurs, this signal is generated by making use of the reduction in the reflected light of the laser beam.

When accessing the groove area, use the ABCD signal. When accessing the pit area, there is use of the PEAK signal in which the RF signal (I+J) has undergone peak hold.



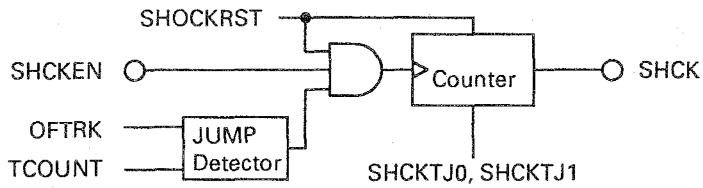
<Pre-mastered disc>

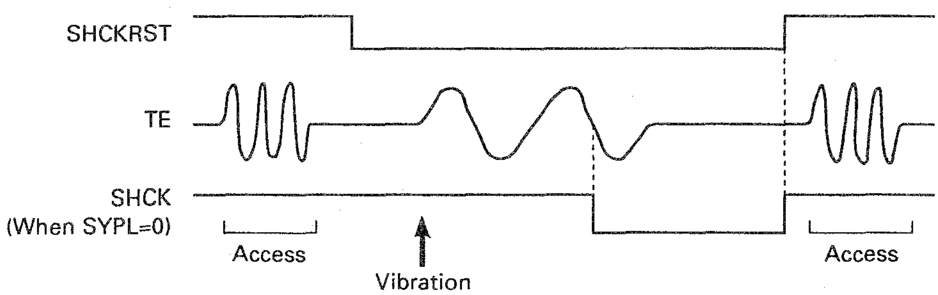


<Recordable disc>

8) Shock Detection Circuit

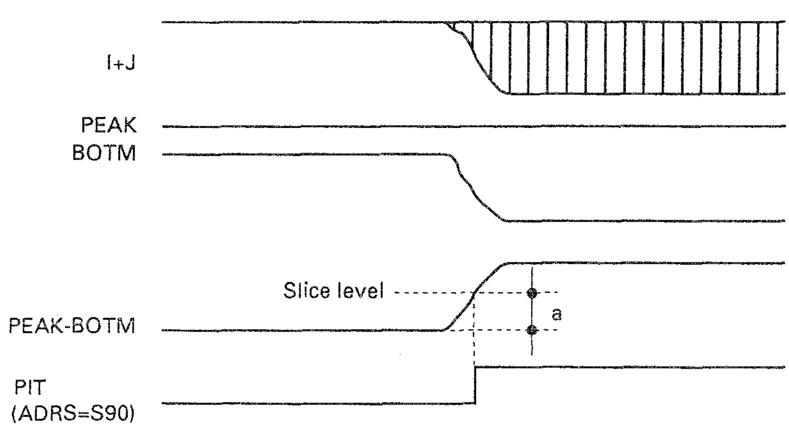
This indicates when a track jump has occurred during tracking and tracing. In order to prevent false detection, there is use of the OFTRK signal and TCOUNT signal to indicate that there has been crossing of a track. There is detection of the fluctuation for the TE signals in other modes.





9) Pit Detection Circuit

Regarding the PEAK signal and BOTM signal generated from the (I+J) signal inside the CXA1981A of the RF head amp, there is almost no difference in terms of groove area. In the pit area an envelope is generated so that a difference occurs in the level. This is used to generated the PIT signal.



Test Mode of the DM-F70

1) Adjustment Test Mode

After pressing the TITLE INPUT key, turn on the power. This unit will start in the test mode for adjustments. Once the test mode has been entered, release of the test mode is not possible other than by turning the AC power source OFF.

●Operation and Control of the Adjustment Test Mode.

→The test modes include the following 8 varieties. There is rotation of the encoders for selection and execution by pressing the ENTER key.

① TEMP ADJUST

The temperature at the time of adjustment is saved in the EEP-ROM as 25℃ standard data. This adjustment is carried out when the ambient temperature is 22-28℃. In addition, this is carried out immediately after the power is turned on in order that the internal temperature of the product is the same as the ambient temperature.

② LDPWR ADJUST

For adjustments, a laser power meter is used to adjust the semifixed volume of the Laser APC to that the required laser power is obtained when the APC-REF is 1/2 Write. It determines that the value is correct during Read and Write.

<Display>

LDPWR ADJUST

↓

LD$0F=0.7mW (READ)

↓

LD$4B=3.5mW (1/2 WRITE)

↓

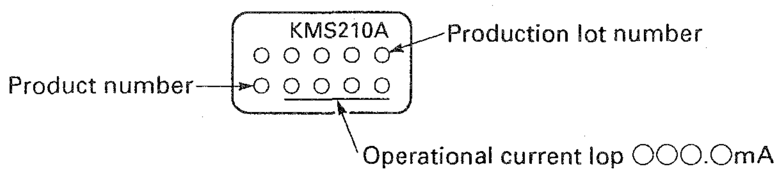
LD$96=7.0mW (WRITE)

When the display reads LD$4B=3.5mW, the semifixed volume is adjusted so that the reading of the laser power meter is 3.4mW.

Regulation

LDP=7.0±0.3mW
lop=pickup label value

<Pickup Label Display>



Pressing the ERASE key during this mode makes it possible to stop laser emission of the pickup and return to the LDPWR ADJUST display.

③ EFBAL ADJUST

The EF balance semifixed volume of the RF head amp CXA1981 is adjusted (EF balance of laser beam write power). Adjust for groove read and pit read on a recordable disc and EF balance on a pre-mastered disc and save those values in the EEP-ROM.

<Display>

EFBAL ADJUST	· Select EFBAL ADJUST with the encoder and press the ENTER key.
↓ EFBAL MO-W	· Use the semifixed volume VR101 to adjust the EF balance. Press the ENTER keywhen the adjustment is correct (recordable disc).
↓ EFB=$X MO-R	· Use the rotary encoder to adjust the data lead-in EFBAL for the groove area ona recordable disc. Press the ENTER key.
↓ EFB=$X SAVE	· The data to be saved is determined and displayed.
↓ EFBAL MO-P	· Press the ENTER key so that the pickup moves to the PTOC area.
↓ EFB=$X MO-P	· Use the rotary encoder to adjust the EF balance in the pit area on the recordabledisc. Press the ENTER key to save the data and turn the servo OFF.
↓ EFB=$X SAVE	· Save display.
↓ EFBAL CD	· Change the disc to the pre-mastered type and press the ENTER key.
↓ EFB=$X CD	· Use the rotary encoder to adjust the EF balance. Press the ENTER key after adjustment to save the data.
↓ EFB=$X SAVE	· Save display.

Note 1. If a disc which has been recorded on is used with these adjustments, the data will be erased during MO writing. It will prove beneficial to use the CREC mode (to be described later) to prepare a special disc for adjustments.

Note 2. If the TE balance waveforms cannot be observed on the oscilloscope, adding an LPF will make them easier to see. (R: 330 kΩ, C: 10 pF)

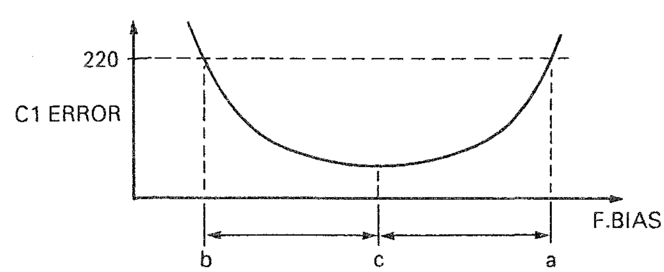
④ FBIAS ADJUST

Change the Focus Bias while observing the error rate, and determine the points (2 locations) where the C1 error = 220. Use the points within that range in which interior division is at 1:1 and save that data.

※Error rate display C1ER/ADER

<Display>

FBIAS ADJUST	· Use the rotary encoder to select FBIAS ADJUST and press the ENTER key.
↓ XXXX/XX a=XX	· Use the rotary encoder to adjust so that C1ER≒220 and press the ENTER key.
↓ XXXX/XX b=XX	· Use the rotary encoder to adjust so that C1ER≒220 and press the ENTER key.
↓ XXXX/XX c=XX	· Confirm at this time that the C1 error rate is 50 or less and the ADER is 00 and press the ENTER key.
↓ XX-XX-XX (XX)	· Displays the adjustment results (b point-c point-a point). Confirm that (XX) is 20 or greater and press the ENTER key.



Note 1: The relationship between the C1 error and the F.BIAS amount is as shown in the figure above. For adjustment, take points a and b and obtain point c from calculation. Save that value.

Note 2: The C1 error rate changes. Carry out so that the average value is 220.

⑤ FBIAS CHECK

While monitoring the error rate, move the Focus Bias only the required value on the "a point" side and "b point" side and confirm that the Focus Bias has been correctly adjusted.

CIER < 220 and ADER≒00 even when the FBIAS has been moved (point a, point b).

⑥ CPLAY MODE

Carry out continuous play by pressing the ENTER key so that the display changes from IN (0020 cl) to MID (0300 cl) to OUT (0700 cl) each time the key is pressed.

Each time the DISPLAY key is pressed the display changes from Mode display to Address display to Error Rate display in that order.

⑦ CREC MODE

Carry out continuous recording by pressing the ENTER key so that there is access in the order of IN (0020 cl) - MID (0300 cl) - OUT (0700 cl) each time the key is pressed.

⑧ EEP MODE

This is the mode for reading and writing with the EEP-ROM. It is normally not used.

Cautions in Using the Test Mode

1. The loading-related operations operate with no relation to the test mode operations. Be sure to confirm that the disc has stopped and carry out disc unload and load.
2. During the test mode, there is no detection of the write protect hole of the disc. As a result, recorded data is erased if the EFBAL, LDPWR and CRC modes are carried out.

2) Power ON for service stage

Because the DM-F9 does not include a Power key, here is the following means of starting the power using power source instruments: "Turn on the AC while pressing the STOP key" in order to turn the power on.

3) Initialization of the microcomputer

If the power is turned on while pressing the ENTER key, all the systems are initialized.

4) Special Processes

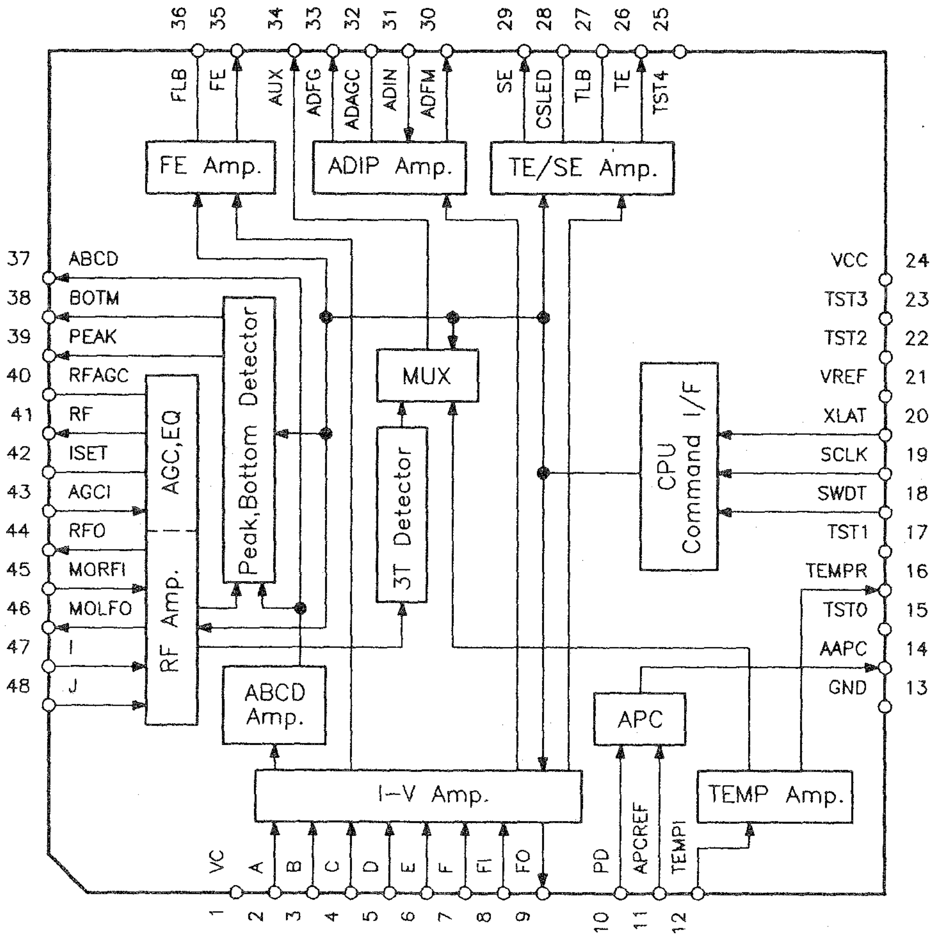
- Soft Reset→ If the REPEAT key is pressed for more than 3 seconds while the power is ON, then communication between the microcomputer and the mecha-controller microcomputer is initialized. At this time, the UTOC information is retained.
- Hard Reset→ If the AUTO/MANUAL key is pressed for more than 5 seconds while the power is ON, then communication between the microcomputer and the mecha-controller microcomputer is initialized. At this time, the UTOC information is not retained and the system is cleared.

5) Other key functions during the test mode

Name of Function	Contents
▶ "PLAY"	If this key is pressed during STOP, there is continuous play. If this key is pressed during continuous play, there is ON/OFF of the tracking servo.
■ "STOP"	Stops continuous playback and recording.
▶▶| "SKIP UP"	Sled moves toward outer circumference as long as the button is pressed.
|◀◀ "SKIP DOWN"	Sled moves toward inner circumference as long as the button is pressed.
● "REC"	If this key is pressed during continuous play, there is recording ON/OFF.
"TITLE SEARCH"	The unit changes back and forth betwwen pit and groove mode each time the button is pressed.
"TITLE INPUT"	Changing of spindle servo. (CLVA ←→ CLVS)

<Sony 3rd Generation MD Chip Set>

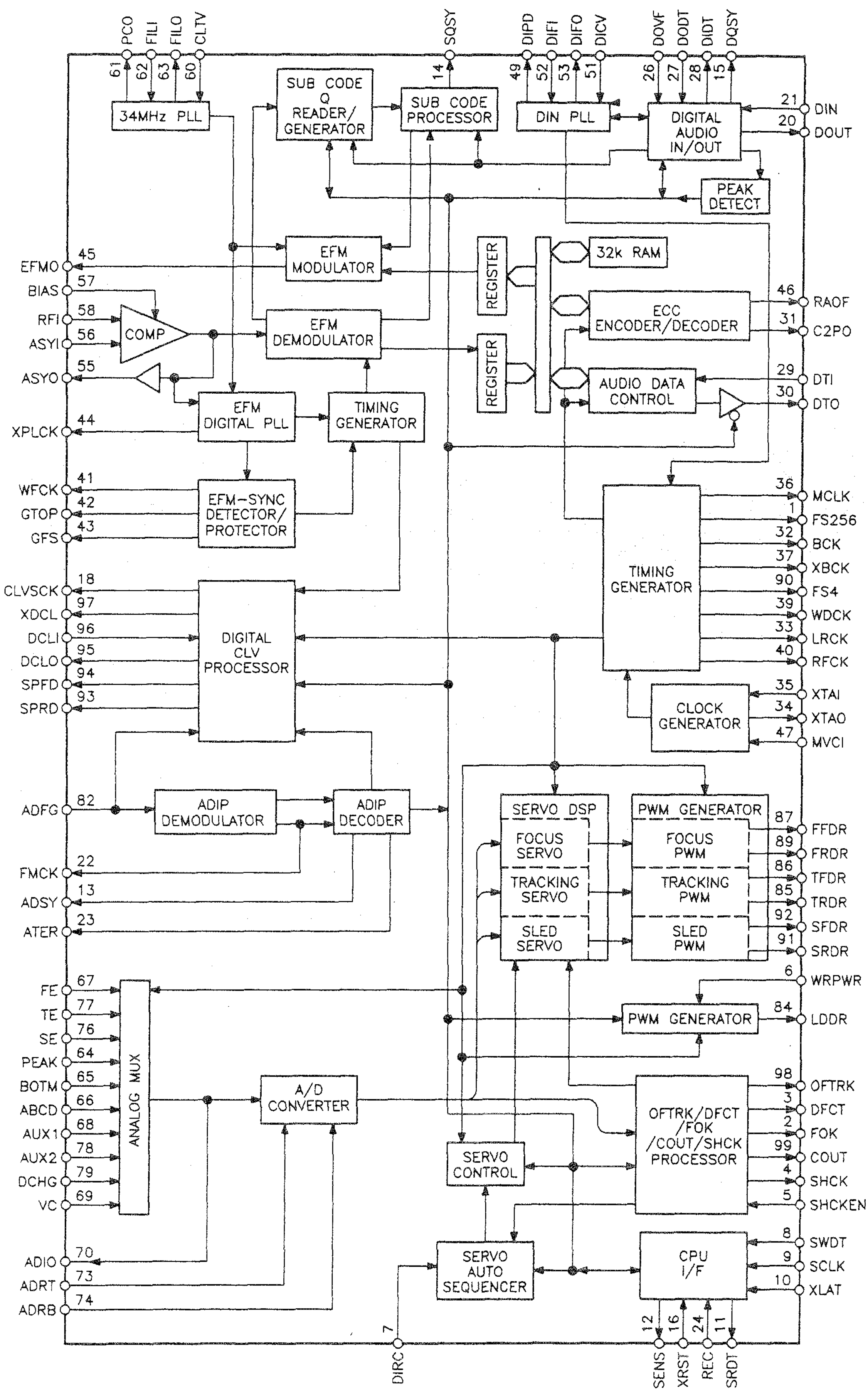
1)RF matrix amp CXA1981AQ/AR



Description of Terminals

Terminal No.	Symbol	I/O	Description of Terminal
1	VC	O	VCC/2 voltage output terminal.
2	A	I	Current input terminal of main beam servo signal A.
3	B	I	Current input terminal of main beam servo signal B.
4	C	I	Current input terminal of main beam servo signal C.
5	D	I	Current input terminal of main beam servo signal D.
6	E	I	Current input terminal of main beam servo signal E.
7	F	I	Current input terminal of main beam servo signal F.
8	FI	I	EF balance adjustment terminal.
9	FO	O	EF balance adjustment terminal.
10	PD	I	Light amount monitor signal input terminal.
11	APCREF	I	Laser power setting reference voltage input terminal.
12	TEMPI	I	Temperature sensor connecting terminal.
13	GND	—	Grounding terminal.
14	AAPC	O	APC output terminal.
15	TST0	O	Test terminal. Should be left open.
16	TEMPR	O	Temperature sensor reference voltage output terminal.
17	TST1	I	Test terminal. Connect to VCC.
18	SWDT	I	Microcomputer serial interface data input terminal.
19	SCLK	I	Microcomputer serial interface shift clock input terminal.
20	XLAT	I	Microcomputer serial interface latch input terminal. Latch with "L".
21	VREF	O	Standard voltage input terminal.
22	TST2	O	Test terminal. Should be left open.
23	TST3	—	Test terminal. Should be left open.
24	VCC	—	Power source voltage.
25	TST4	I	Test terminal. Connect to VC.
26	TE	O	Tracking error signal output terminal.
27	TLB	—	Tracking error signal low boost capacitor connecting terminal.
28	CSLED	—	Sled error signal LPF capacitor connecting terminal.
29	SE	O	Sled error signal output terminal.
30	ADFM	O	ADIP FM signal output terminal.
31	ADIN	I	ADIP signal comparator input terminal.
32	ADAGC	—	ADIPAG capacitor connecting terminal.
33	ADFG	O	ADIP 2 binarization signal output terminal.
34	AUX	O	I3 output/temperature signal output terminal.
35	FE	O	Focus error signal output terminal.
36	FLB	—	Focus error signal low boost capacitor connecting terminal.
37	ABCD	O	Main beam servo detector light quantity signal output terminal.
38	BOTM	O	RF/ABCD bottom signal output terminal.
39	PEAK	O	RF/ABCD peak signal output terminal.
40	RFAGC	—	RFAGC capacitor connecting terminal.
41	RF	O	RF equalizer output terminal.
42	ISET	—	BPF (fo=720kHz, 22kHz) and RF equalizer setting terminal.
43	AGCI	I	RFAGC input terminal.
44	RFO	O	RF amp output terminal. Eye pattern check point.
45	MORFI	I	Terminal where groove RF signal undergoes AC coupling and is input.
46	MORFO	O	Groove RF signal output terminal.
47	I	I	Input terminal for RF signal I whitch has undergone I-V convertion.
48	J	I	Input terminal for RF signal J whitch has undergone I-V convertion.

2) EFM/ACIRC Encoder/Decoder CXD2535BR Included in Digital Servo Processor

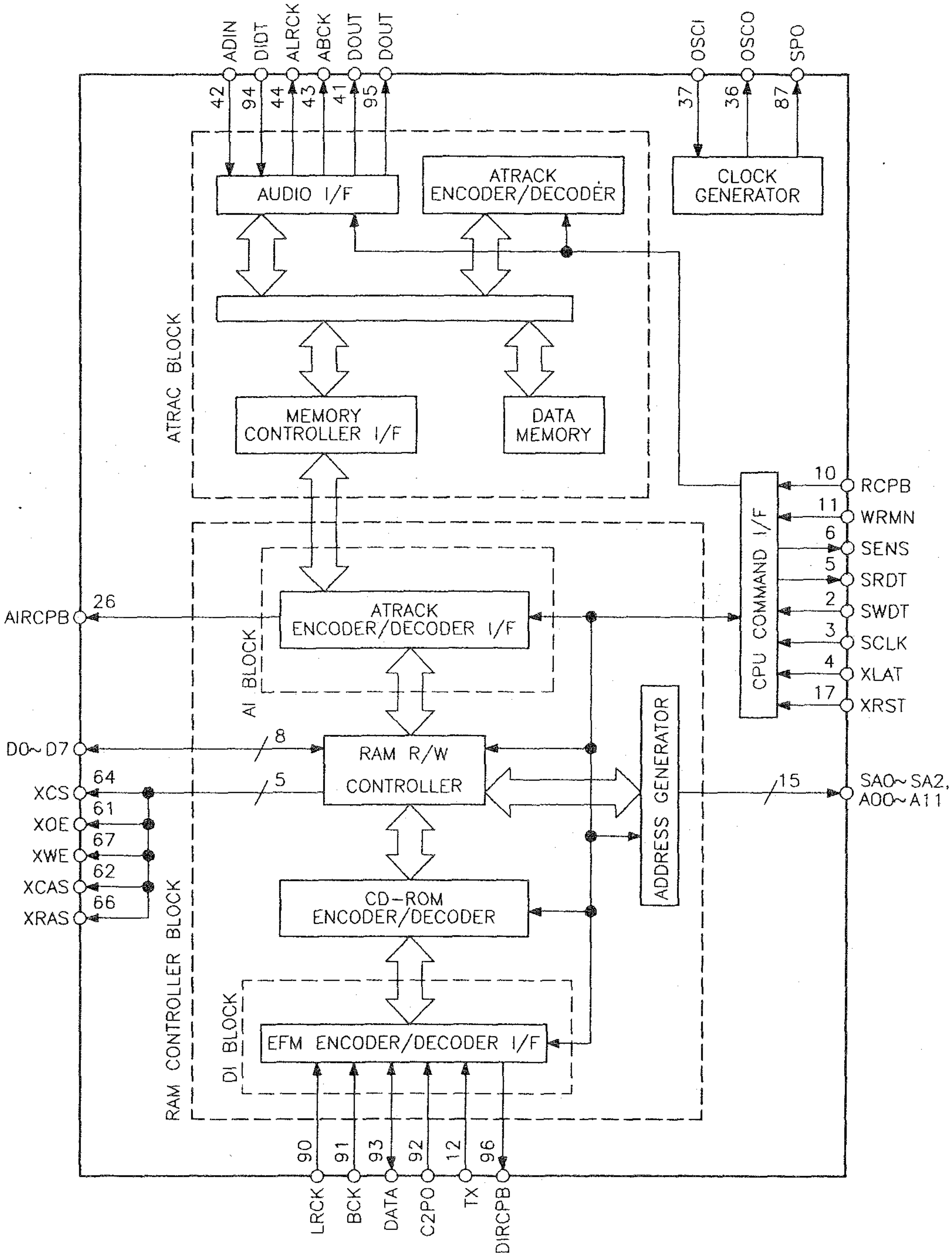


Description of Terminals

Terminal No.	Symbol	I/O		Description of Terminal
1	FS256	O	H,L	256 Fs output (11.2896MHz).
2	FOK	O	H,L	Focus OK signal output. Focus OK when "H".
3	DFCT	O	H,L	Defect detection output. Defect when "H".
4	SHCK	O	H,L	Track jump detection output.
5	SHCKEN	I		Track jump detection enable input. Enable when "H".
6	WRPWR	I		Laser power switching input. Recording power when "H". Playback power when "L".
7	DIRC	I		Track jump control signal.
8	SWDT	I		Microcomputer serial interface data input.
9	SCLK	I		Microcomputer serial interface shift clock input.
10	XLAT	I		Microcomputer serial interface latch input.Latch with fall.
11	SRDT	O	H,Z,L	Microcomputer serial interface data output.
12	SENS	O	H,Z,L	Terminal for outputting internal starter in response to microcomputer serial interface address.
13	ADSY	O	H,L	ADIP synch output.
14	SQSY	O	H,L	Disc sub-code Q-synch/ADIP synch output.
15	DQSY	O	H,L	Ubit CD or MD format Sub-code Q-synch output when digital in source is CD or MD.
16	XRST	I		Reset input. Reset with "L".
17	TEST4	I		Reset terminal. Connect to GND.
18	CLVSCK	O	H,L	Spindle servo evaluation clock output (5.6448MHz).
19	TEST5	I		Test terminal. Connect to GND.
20	DOUT	O	H,L	Digital audio interface signal output.
21	DIN	I		Digital audio interface signal input.
22	FMCK	O	H,L	ADIP FM demodulation clock output.
23	ATER	O	H,L	ADIP CRC flag output. Error with "H".
24	REC	I		Recording/Playback changing. Recording with "H". Playback with "L".
25	DVSS			Digital GND.
26	DOVF	I		Vbit input of signal output from DOUT terminal.
27	DODT	I		Audio data input for detection of signal output from DOUT terminal and peak level.
28	DIDT	O	H,L	Audio data output of signal input from DIN terminal.
29	DTI	I		Recording data input from CXD25326A.
30	DTO	O	H,Z,L	Output of playback data to CXD2536A during playback. "Z" during recording.
31	C2PO	O	H,L	Output of C2 pointer of playback data during playback. Output of digital in Vbit during digital recording. "L" during Analog Rec.
32	BCK	O	H,L	64 Fs output (2.8224MHz).
33	LRCK	O	H,L	Fs output (44.1kHz).
34	XTAO	O		Crystal oscillator circuit output terminal (inverse output of XTAI terminal).
35	XTAI	I		Crystal oscillator circuit input terminal (512 Fs= 22.5792MHz).
36	MCLK	O	H,L	Master clock output (512 Fs= 22.5792MHz).
37	XBCK	O	H,L	BCK inverted output.
38	DVDD			Digital power source.
39	WDCK	O	H,L	2Fs output (88.2kHz).
40	RFCK	O	H,L	Read Frame Clock output (Fs/6).
41	WFCK	O	H,L	Write Frame Clock output.
42	GTOP	O	H,L	Monitor of operational state of frame synch protect window. Release of frame synch protect window during "H".
43	GFS	O	H,L	Frame synch OK with "H".
44	XPLCK	O	H,L	PLL clock output of EFM Decoder (98 Fs= 4.3218MHz).
45	EFMO	O	H,L	"L" during playback. EFM (encode data) output during recording.
46	RAOF	O	H,L	RAM overflow output during playback.
47	MVCI	I		Digital in PLL external VCO clock input.
48	TEST2	I		Test terminal. Connect to GND.
49	DIPD	O	H,Z,L	Digital in PLL phase comparison output.

Terminal No.	Symbol	I/O		Description of Terminal
50	DVSS			Digital GND.
51	DICV	I	Analog	Digital in PLL internal VCO control voltage input.
52	DIFI	I	Analog	Filter input when using digital in PLL internal VCO.
53	DIFO	O	Analog	Filter output when using digital in PLL internal VCO.
54	AVDD			Analog power source.
55	ASYO	O	H,L	Playback EFM full swing output ("L"= VSS, "H"=VDD).
56	ASYI	I	Analog	Playback EFM comparator slice voltage input.
57	BIAS	I	Analog	Playback comparator bias current input.
58	RFI	I	Analog	Playback EFM RF signal input.
59	AVSS			Analog GND.
60	CLTV	I	Analog	Master PLL of playback digital PLL and internal VCO control voltage inpit for recording EFM PLL.
61	PCO	O	H,Z,L	Phase comparison output for playback digital PLL master PLL and recording EFM PLL.
62	FILI	I	Analog	Filter input for playback digital PLL master PLL and recording EFM PLL.
63	FILO	O	Analog	Filter output for playback digital PLL master PLL and recording EFM PLL.
64	PEAK	I	Analog	Light quantity peak hold signal input.
65	BOTM	I	Analog	Light quantity bottom hold signal input.
66	ABCD	I	Analog	Light quantity signal input.
67	FE	I	Analog	Focus error signal input.
68	AUX1	I	Analog	Auxiliary input 1.
69	VC	I	Analog	Middle point voltage input.
70	ADIO	O	Analog	Monitor output for A/D converter input signal.
71	TEST3			Test terminal. Connect to GND.
72	AVDD			Analog power source.
73	ADRT	I	Analog	A/D converter operational range upper limit voltage input.
74	ADRB	I	Analog	A/D converter operational range lower limit voltage input.
75	AVSS			Analog GND.
76	SE	I	Analog	Sled error signal input.
77	TE	I	Analog	Tracking error signal input.
78	AUX2	I	Analog	Auxiliary input 2.
79	DCHG	I		Connect to GND.
80	TEST6	I		Test terminal. Connect to GND.
81	TEST1	I		Test terminal. Connect to GND.
82	ADFG	I		ADIP binary FM signal (22.05±1kHz) input.
83	TS25	I		Test terminal. Connect to GND.
84	LDDR	O	H,L	Laser drive output.
85	TRDR	O	H,L	Tracking servo drive output. (−)
86	TFDR	O	H,L	Tracking servo drive output. (+)
87	FFDR	O	H,L	Focus servo drive output. (+)
88	DVDD			Digital power source.
89	FRDR	O	H,L	Focus servo drive output. (−)
90	FS4	O	H,L	4Fs output (176.4kHz).
91	SRDR	O	H,L	Sled servo drive output. (−)
92	SFDR	O	H,L	Sled servo drive output. (+)
93	SPRD	O	H,L	Spindle servo drive output. (−)
94	SPFD	O	H,L	Spindle servo drive output. (+)
95	DCLO	O	H,L	Spindle servo evaluation serial data output.
96	DCLI	I		Spindle servo evaluation serial data input.
97	XDCL	O	H,L	Spindle servo evaluation serial data load signal output.
98	OFTRK	O	H,L	Offtrack signal output. Offtrack when "H".
99	COUT	O	H,L	Track jump number count signal output.
100	DVSS			Digital GND.

3) ATRAC Encoder/Decoder CXD2536AR in Memory Controller



Description of Terminals

Terminal No.	Symbol	I/O		Description of Terminal
1	VDD			Power source terminal.
2	SWDT	I		Microcomputer serial interface data input.
3	SCLK	I		Microcomputer serial interface shift clock input.
4	XLAT	I		Microcomputer serial interface latch input. Latch with fall.
5	SRDT	O	H,Z,L	Microcomputer serial interface data output.
6	SENS	O	H,Z,L	Terminal for outputting internal status in response to microcomputer serial interface address.
7	SMD0	I		Serial command control mode.
8	SMD1	I		Serial command control mode.
9	XINT	O	H,L	Interrupt request output terminal. Goes to "L" with generation of interrupt status.
10	RCPB	I		"H" recording mode/ "L" playback mode.
11	WRMN	I		"H" write mode/ "L" monitor mode.
12	TX	I		Enable signal input terminal for recording data output. Enable with "H".
13	VSS			Connect to GND.
14	TST0	I		Test terminal. Connect to GND.
15	TST1	I		Test terminal. Connect to GND.
16	TST2	I		Test terminal. Connect to GND.
17	XRST	I		Reset input. Reset with "L".
18	TS0	I		Test terminal. Connect to GND.
19	TS1	I		Test terminal. Connect to GND.
20	TS2	I		Test terminal. Connect to GND.
21	TS3	I		Test terminal. Connect to GND.
22	TST3	I		Test terminal. Connect to GND.
23	TST4	I		Test terminal. Connect to GND.
24	TST5	I		Test terminal. Connect to GND.
25	VSS			Connect to GND.
26	AIRCPB	O	H,L	ATRAC block recording/playback mode output. Recording mode with "H". Playback mode with "L".
27	TST6	O		Test terminal. Leave open.
28	TST7	O		Test terminal. Leave open.
29	TST8	O		Test terminal. Leave open.
30	TST9	O		Test terminal. Leave open.
31	TST10	O		Test terminal. Leave open.
32	TST11	O		Test terminal. Leave open.
33	TST12	O		Test terminal. Leave open.
34	TST13	O		Test terminal. Leave open.
35	TST14	O		Test terminal. Leave open.
36	OSCO	O		Crystal oscillator circuit output terminal (1024Fs).
37	OSCI	I		Crystal oscillator circuit input terminal (1024Fs).
38	VSS			Connect to GND.
39	TST15	O		Test terminal. Leave open.
40	TST16	O		Test terminal. Leave open.
41	DOUT	O	H,L	REC monitor output/decode audio data output.
42	ADIN	I		Analog recording input terminal (connect external A/D converter output).
43	ABCK	O	H,L	XBCK (64Fs) output terminal to external audio block.
44	ALRCK	O	H,L	LRCK (Fs) output terminal to external audio block.
45	SA2	O	H,L	SRAM address bus.
46	SA1	O	H,L	SRAM address bus.
47	SA0	O	H,L	SRAM address bus.
48	A11	O	H,L	RAM address bus.
49	A10	O	H,L	RAM address bus.
50	VSS			Connect to GND.
51	VDD			Power source terminal.

Terminal No.	Symbol	I/O		Description of Terminal
52	A03	O	H,L	RAM address bus.
53	A02	O	H,L	RAM address bus.
54	A01	O	H,L	RAM address bus.
55	A00	O	H,L	RAM address bus.
56	A04	O	H,L	RAM address bus.
57	A05	O	H,L	RAM address bus.
58	A06	O	H,L	RAM address bus.
59	A07	O	H,L	RAM address bus.
60	A08	O	H,L	RAM address bus.
61	XOE	O	H,L	RAM output enable.
62	XCAS	O	H,L	DRAM CAS output.
63	VSS			Connect to GND.
64	XCS	O	H,L	RAM chip select. DRAM with "H". SRAM with "L".
65	A09	O	H,L	RAM address bus.
66	XRAS	O	H,L	DRAM RAS output.
67	XWE	O	H,L	RAM write enable.
68	D1	I/O	H,L	RAM data bus.
69	D0	I/O	H,L	RAM data bus.
70	D2	I/O	H,L	RAM data bus.
71	D3	I/O	H,L	RAM data bus.
72	D4	I/O	H,L	RAM data bus.
73	D5	I/O	H,L	RAM data bus.
74	D6	I/O	H,L	RAM data bus.
75	VSS			Connect to GND.
76	D7	I/O	H,L	RAM data bus.
77	ERR	I/O	H,L	Data input/output terminal to C2PO RAM.
78	EXTC2R	I		Selection of C2PO RAM. "H" when used. "L" when not used.
79	BUSY	O	H,L	RAM access busy output. RAM access with "H".
80	EMP	O	H,L	Signal output to indicate ATRAC data empty or just before full.
81	FUL	O	H,L	Signal output to indicate ATRAC data empty full or just before empty.
82	EQL	O	H,L	ATRAC data empty ("H" if ASAC=DSC).
83	MDLK	O	H,L	Indicates main/sub of recording/playback data. Sub or linking with "H". Main with "L".
84	CPSY	O	H,L	Interpolation synch output.
85	CTMD1	O	H,L	Internal counter mode output.
86	CTMD0	O	H,L	Internal counter mode output.
87	SPO	O	H,L	512 Fs output.
88	VSS			Connect to GND.
89	MDSY	O	H,L	Main data synch detection output.
90	LRCK	I		LRCK (Fs) input terminal from EFM encoder/decoder.
91	BCK	I		BCK (64Fs) input terminal from EFM encoder/decoder.
92	C2PO	I		C2PO input terminal from EFM encoder/decoder.
93	DATA	I/O	H,L	Data input/output from EFM encoder/decoder.
94	DIDT	I		Digital recording input terminal.
95	DODT	O	H,L	REC monitor output. decode audio data output.
96	DIRCPB	O	H,L	Recording/playback mode output to EFM encoder/decoder. Recording mode with "H". Playback mode with "L".
97	MIN	I		External monitor signal input terminal. Input the signal you want to monitor.
98	TST17	I		Test terminal. Connect to VDD.
99	TST18	O		Test terminal. Leave open.
100	VSS			Connect to GND.

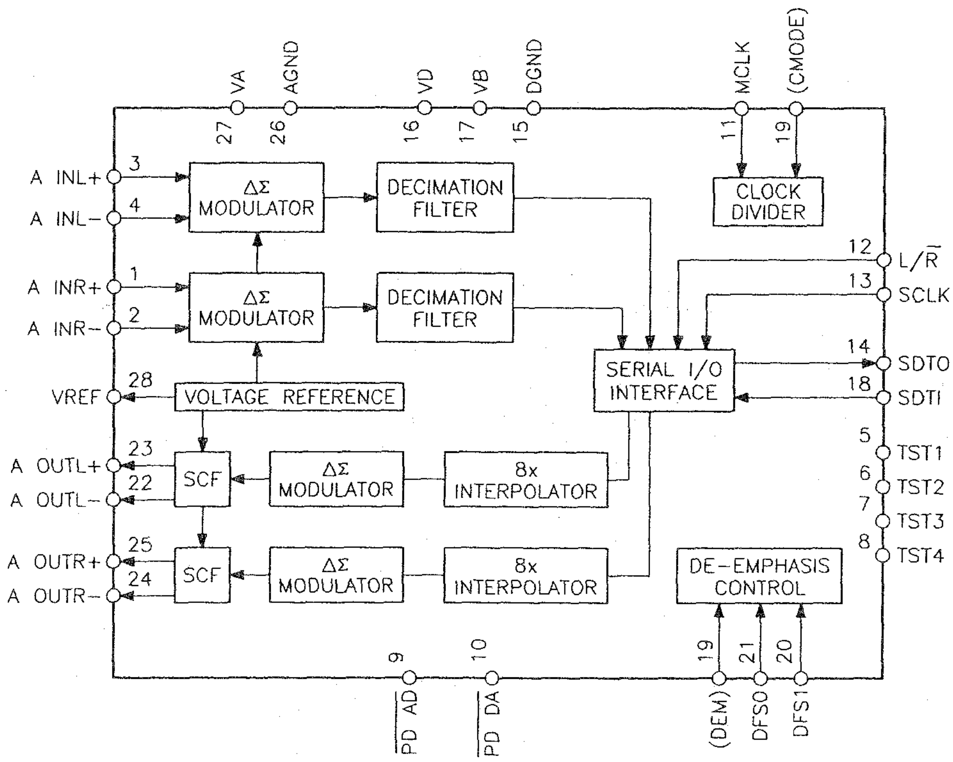
<16-bit 2ch delta-sigma method ADC/DAC AK-4506-VS>

□Quadratic Δ Σ ADC
- 64-time oversampling
- Includes folded digital filter to prevent noise.
- S/N: 90 dB

□Quadratic Δ Σ DAC
- 64-time oversampling
- Includes 8-time interpolation filter
- Includes secondary post filter (SCF).
- S/N: 92 dB
- Includes digital de-emphasis (32 kHz, 44.1 kHz, 48 kHz)

□Strong jitter resistance.

□Low consumed power: 125 mW



Pin No.	Pin name	I/O	Function
1	AINR+	I	Rch analog positive input pin.
2	AINR−	I	Rch analog negative input pin.
3	AINL+	I	Lch analog positive input pin.
4	AINL−	I	Lch analog negative input pin.
5 6	TST1 TST2	I	Test pin (pull-down pin) Open or connect to AGND pin.
7 8	TST3 TST4	O	Test pin Use with pin open.
9 10	$\overline{\text{PD AD}}$ $\overline{\text{PD DA}}$	I I	Power down pin $\overline{\text{PD AD}}$: ADC section power down pin. $\overline{\text{PD DA}}$: DAC section power down pin. The section corresponding when the pins are "L" is in the power down mode. When turning the power on, be sure to carry out reset and calibration once. Reset is carried out when $\overline{\text{PD AD}}$ and $\overline{\text{PD DA}}$ are "L" simultaneously.
11	MCLK	I	Master clock input pin.
12	L/$\overline{\text{R}}$	I	Input channel selection pin. Inputs the fs clock. "H" : Lch, "L" : Rch
13	SCLK	I	Serial data clock pin. When the pin is in the down position, there is 1 bit output of the output data.
14	SDTO	O	Serial data output pin. The data is output with 2's complement, MSB first and 16-bit forward setting. After 16-bit output, "L" is output. During power down ($\overline{\text{PD AD}}$= "L") is "L".
15	DGND	—	Digital section ground pin.
16	VD	—	Digital section power source pin, +5V.
17	VB	—	Silicon substrate, power source pin, +5V.
18	SDTI	I	Serial data input pin. The data is input with 2's complement, MSB first and 16-bit forward setting.
19	CMODE (AK4506)	I	Master clock selection pin (pull-down pin) "L" : MCLK=256fs, "H" : MCLK=384fs
20 21	DFS1 DFS0	I I	De-emphasis frequency selection pin. Corresponds to 3 frequency.
22	AOUTL−	O	Lch analog negative output pin.
23	AOUTL+	O	Lch analog positive output pin.
24	AOUTR−	O	Rch analog negative output pin.
25	AOUTR+	O	Rch analog positive output pin.
26	AGND	—	Analog ground pin.
27	VA	—	Analog power source pin, +5V.
28	VREF	O	Standard voltage output pin, VA-3.0V Output with VA standard. Connect electrolysis capacitor of 10 μF or less with VA and 0.1 μF ceramic capacitor in space to VA.

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