Announcing the disc format that everyone has been waiting for.

MiniDisc

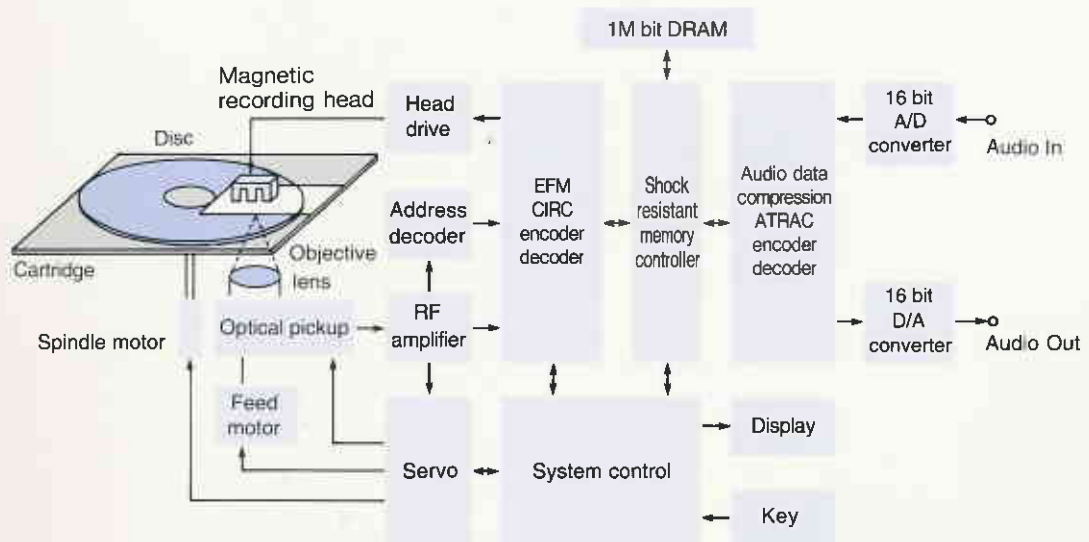
MINIDISC: THE ULTIMATE MUSIC FORMAT IS NOW A REALITY.

MiniDisc System
Preliminary Specifications

Channels:	2 (stereo)
Frequency Response	5-20,000 Hz
Dynamic Range	105 dB
Wow-and-Flutter	Unmeasurable
Sampling Frequency	44.1 kHz
Coding System	ATRAC system
Modulation System	EFM
Error Correction System:	CIRC
Disc Speed:	1.2-1.4 m/s (CLV)
Record/Playback Time	Up to 74 min.
Cartridge Size	72x68x5 mm
Disc Diameter	64 mm

In the creation of the MiniDisc, virtually every need of those who enjoy music has been taken into account. MiniDisc enables digital quality playback **and recording**, and because it is a disc, it allows quick random access just like CD. MiniDisc is also extremely compact for the convenience of portable applications. The crystallization of advanced technology in a broad variety of fields, MiniDisc is the ultimate in versatility, sound quality, and convenience. Truly the optimum portable digital recording format for the future, MiniDisc is here.

Block diagram of the MiniDisc System



IT'S A DISC.

MiniDisc is a recordable digital optical disc with 74 minutes of playing time.

The significant advantages of MiniDisc are possible only from a disc format.

Because it is a disc, MiniDisc offers superior operation convenience, including quick random access to any music selection. Permanently housed in a protective cartridge like a computer disc, MiniDisc is thin, compact, and easy to handle.

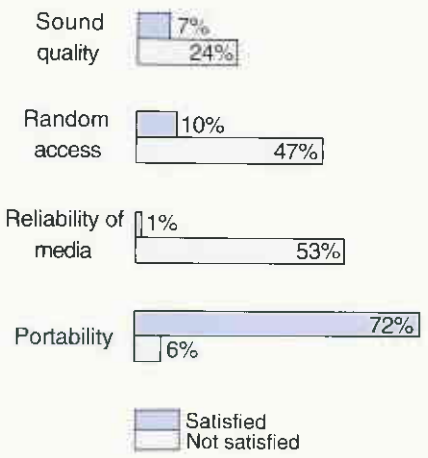
Because it is a disc that enables digital recording and playback, MiniDisc delivers sound quality comparable to CD, combined with the advantage of personal digital recording.

Because it is a disc read by a non-contact laser, MiniDisc offers durability and reliability that far surpasses conventional tape formats. There is no sound degradation from repeated playings.

There is no possibility of accidentally recording over playback-only MiniDiscs. There is no worry over the influence of strong magnetic fields. There is no physical degradation during long-term storage. And, best of all, there is no tape to twist, stretch, or become tangled.

In short, MiniDisc is a convenient, durable, and highly reliable music medium offering consistently high quality sound.

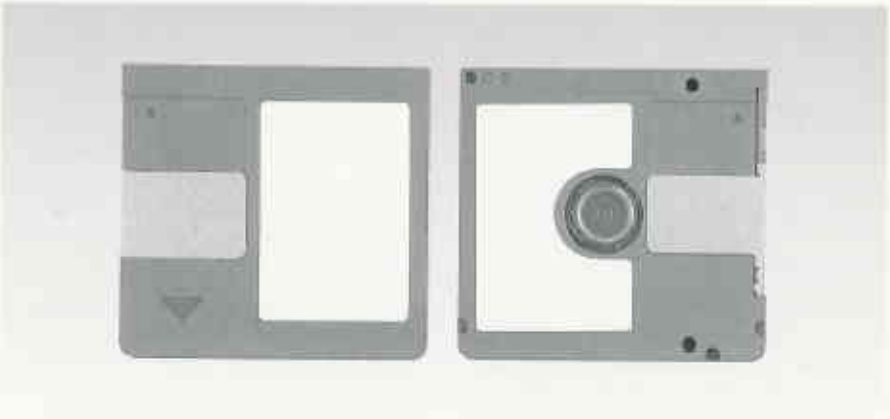
Analog Cassette Survey



A recent survey on user satisfaction with conventional analog cassette reveals that while a majority is satisfied with the format's portability, very few are satisfied with analog cassette in terms of sound quality, reliability, and random access capability. MiniDisc, however, excels in these areas. Sound quality, reliability, and random access capability are on par with CD, while the potential of portability is equal to analog cassette.

The MiniDisc Format Uses Two Types of Discs

PLAYBACK-ONLY MINIDISCS *are designed specifically for music by your favorite artists. The front can be fully utilized for the album's artwork, while the reverse side has a shutter that is opened by the player to expose a portion of the disc. With the shutter open, the disc is rotated by the clamping plate, while the laser reads the pits on the disc in a virtually identical manner to CD. When the MiniDisc is out of the player, the shutter remains closed to protect the disc. Note that it is not possible to record on a playback-only MiniDisc to insure against accidental loss of your favorite music.*



RECORDABLE MINIDISCS *have a shutter that opens to expose both sides of the disc. With the shutter open, recording is performed with a magnetic recording head on the upper side and a laser beam focused on the corresponding position on the other side. After recording, playback is by laser pickup only. A portion of each side has a label which may be marked by the user to indicate the recorded program. Thanks to Magnetic-field Modulation Overwrite System technology, a Recordable MiniDisc may be re-recorded an unlimited number of times.*

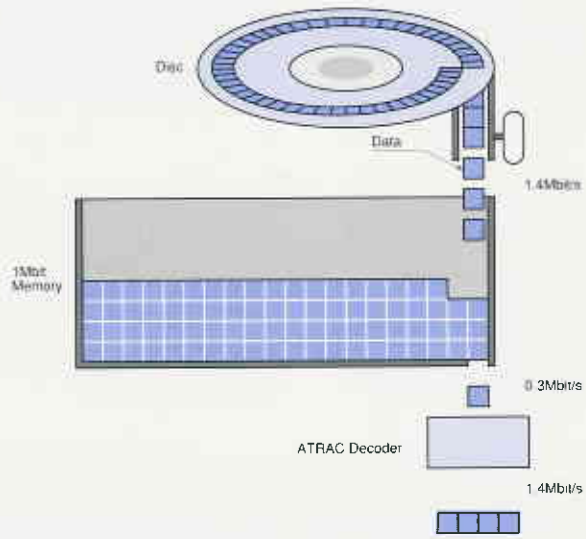
IT'S COMPACT, CONVENIENT. . .

MiniDisc assures fidelity and convenience, even in portable applications.

Compact Disc has become the standard format for high quality audio, yet it remains underutilized as a portable format. While users report dissatisfaction with analog cassette for several reasons, a majority are satisfied with its portability. Taking this into account, MiniDisc was designed from the start to not only deliver high fidelity and convenience, but also to deliver it in portable applications.

To accomplish this, the MiniDisc itself first had to be engineered at least as small as an analog cassette, yet still offer the same 74 minute maximum playing time as CD. The MiniDisc itself measures only 64 mm in diameter, and is contained in a protective cartridge measuring just 72 x 68 mm, and only 5 mm thick. By virtue of its small size, MiniDisc is not only easier to store and carry, it also creates the potential for smaller playback equipment.

But there was another important requirement. MiniDisc also had to be designed for perfect functioning during the shock and movement normally encountered in portable situations. Thus, countermeasures against skipping and sound dropouts were required.



Shock Resistant Memory

In this system, the laser pickup reads digital data from the disc at the rate of up to 1.4 Mb/s (mega-bits per second). This data is sent into a buffer memory in the form of a 1 Mbit D-RAM (Dynamic Random Access Memory), with the output fed into the ATRAC decoder at a steady, and much slower, rate of 0.3 Mb/s.

It takes less than a second of uninterrupted laser pickup operation to fill the Shock Resistant Memory to capacity. Then, if shock occurs which interrupts pickup operation, the contents of the memory continue to be fed into the ATRAC decoder, and playback will continue for up to three seconds until the data in the memory is exhausted.

Shock during actual use, however, is usually momentary. The pick-up will resume operation almost immediately thanks to highly responsive servo control, whereby the position of the pickup is continuously monitored by the premastered address locations on the disc so that the point where skipping began can instantly be detected. At the 1.4 Mb/s reading rate, it takes no longer than 0.9 seconds for the memory to be replenished.

In this way, skipping and dropouts are virtually eliminated during movement and shock normally encountered in portable situations.

Smaller Disc Size

If the 64 mm MiniDisc were recorded in the same way as a 120 mm CD, only about 10 minutes of playing time would be possible. Rather than increase pit density, which would result in tradeoffs with other technical difficulties, it was decided that an efficient form of digital data compression could be achieved which would allow sound reproduction with less data, without sacrificing fidelity.

The compression system adopted for MiniDisc is ATRAC—Adaptive TRansform Acoustic Coding. In simple terms, this system takes advantage of psychoacoustic principles to render unnecessary all digital signals for sounds which are effectively inaudible to the human ear. This includes sounds which are below the threshold of hearing, as well as sounds which are "simultaneously masked" by louder sounds on adjoining frequencies.

In use, ATRAC enables digital reproduction of only those sounds which can actually be detected by the human ear. As a result, digital data is reduced to 1/5 of that required by CD. This enables the disc to be made considerably smaller, yet offer the same playing time.

Another benefit of ATRAC is that data can be read from the disc at a rate nearly five times faster than is required for normal playback. This makes possible the high performance functioning of the Shock Resistant Memory.

Shock Resistant Operation

During portable operation, sharp movement or shock can displace the laser pickup, resulting in skipping of the music or sound dropouts. Prevention of this, therefore, is an absolute necessity for

AND PORTABLE.

high performance portable audio.

Since the ATRAC system makes it possible for data to be read from the disc at a much faster rate than playback requires, it is possible for the pickup to "read ahead" so that a certain amount of music data can be stored in an electronic memory, which is not affected by shock or movement.

MiniDisc uses a 1 mega-bit D-RAM (Dynamic Random Access Memory) which holds up to three seconds of music "in reserve" so that even if the player is jarred momentarily, the music will continue while the pickup reestablishes its position and resumes the reading of digital data.

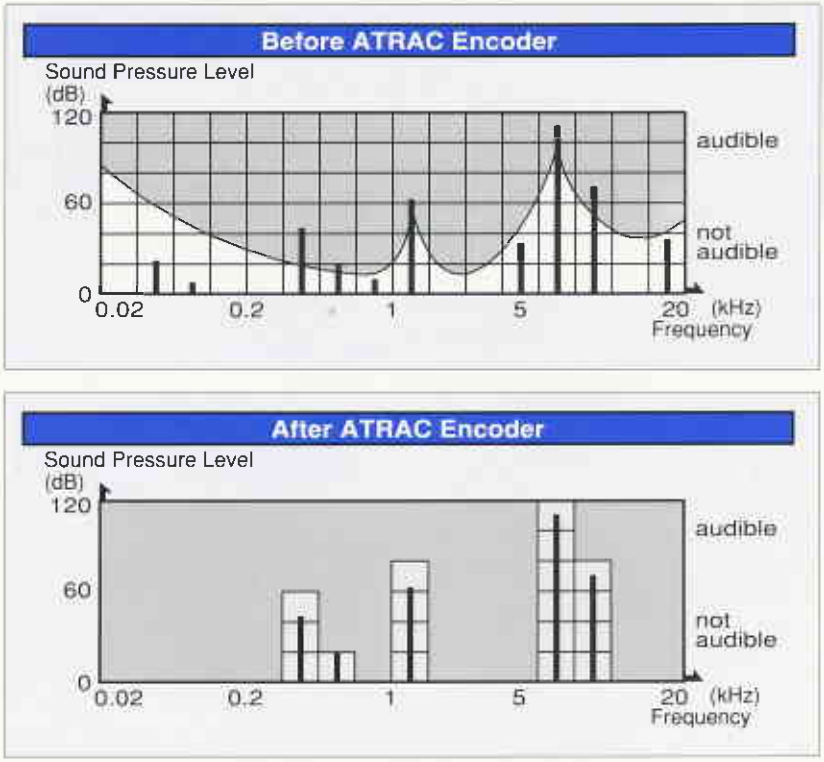
Quick Random Access

The ease of quick random access to any music selection is one of the great benefits of Compact Disc.

This same quick random access operation is offered by both playback-only and recordable MiniDiscs. In playback-only MiniDiscs, random title selection is exactly like that of CD.

With recordable MiniDiscs, however, random selection is possible thanks to microscopic pre-grooves which contain location information at 13.3 millisecond intervals. Thus, locations are permanently marked on the disc, allowing quick random access to any point on the disc.

This system also allows a variety of operation features such as playback order programming. This is made possible by a "user table of contents" (UTOC) area on the disc, which is similar to the directory management system of floppy discs. Starting and ending addresses for all music tracks are stored in the UTOC area, and by simple rewriting of these addresses, reprogramming of the tracks in a different order is possible.



ATRAC Digital Data Compression

To give the MiniDisc the same 74-minute capacity as CD, a method was required that would enable comparable sound reproduction using far less digital data. For this purpose, the Adaptive TRansform Acoustic Coding (ATRAC) system was developed.

While CD uses 16 bits of data for every 0.02 millisecond sample, regardless of the signal amplitude (or even if there is no signal), ATRAC analyzes the same 16-bit digital data for waveform content, and extracts and encodes only those frequency components which are actually audible.

During ATRAC encoding, this data is divided into time segments of up to 11.6 msec., depending upon the signal, in 0.02 msec. increments. MDCT (Modified Discrete Cosine Transform) analysis is then applied to the waveform of each segment, whereby approximately 500 changes in amplitude are analyzed as single-frequency waveforms. During this analysis, two different psychoacoustic principles — threshold of hearing and simultaneous masking — are taken into account to identify those components of each segment which are audible.

Threshold of Hearing: the sensitivity of the human ear varies with frequency, being most sensitive to sound at around 4 kHz. Sensitivity decreases as frequency decreases and increases away from this point. Thus, sounds below the lowest audible limit can be removed without affecting the perceivable sound quality.

Simultaneous Masking: this occurs when a sound becomes inaudible due to the presence of a louder sound at an adjoining frequency, providing that it is within a range called the critical bandwidth. The closer the two frequencies are, of course, the greater the masking effect.

Thus, only these audible sound components are assigned bits by amplitude (sound level). As a result, the signal can be represented with adequate resolution by only 1/5th the amount of data required by the 16-bit linear method of CD. During playback, these frequency components are recomposed by the ATRAC decoder, which reconstructs the time segments into digital waveform data. This data can then be processed by a conventional 16-bit D/A converter.

IT OFFERS DIGITAL RECORDING

MiniDisc is the first consumer-use optical disc that enables digital recording and playback of music

The MiniDisc format has two types of discs because it does two different things: digital recording, and digital playback.

Playback-only MiniDiscs have been created exclusively for pre-recorded music software. They are played in virtually the same way as CD, with the laser pickup sensing the presence or absence of pits on the disc.

Recordable MiniDiscs are recorded magnetically with the use of both a magnetic recording head and a laser beam, and are played back optically using only a laser pickup.

MMO System Recording

The MiniDisc format uses the Magnetic-field Modulation Overwrite system for recording. The disc has a stable magnetic layer that enables magnetic flux reversal with a low-power magnetic head. The polarity ("north" or "south") of magnetic flux at each point on the disc enables the creation of magnetic fields of differing length. These are comparable to the pits found in playback-only MiniDiscs.

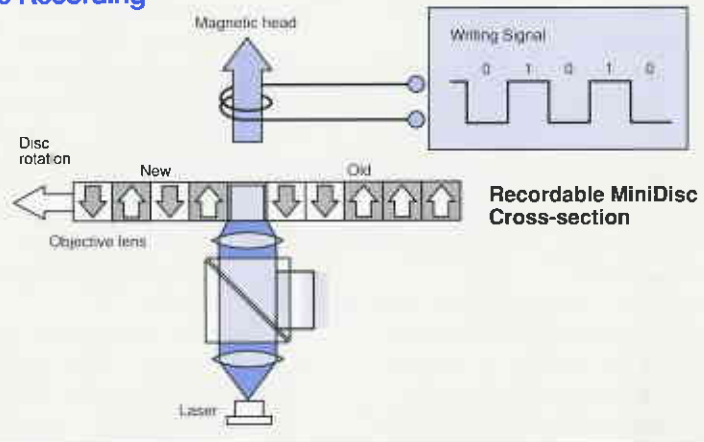
A magnetic head works in tandem with a laser, with the head on the upper side of the disc and the laser on the corresponding spot on the other side. The laser heats up a specific spot on which it is focused to 180 degrees C. As soon as the laser spot passes by, the spot temperature drops. This process is repeated, and when a specific polarity is applied by the magnetic head at this spot, a polarity which simulates either the presence or absence of a pit is produced.

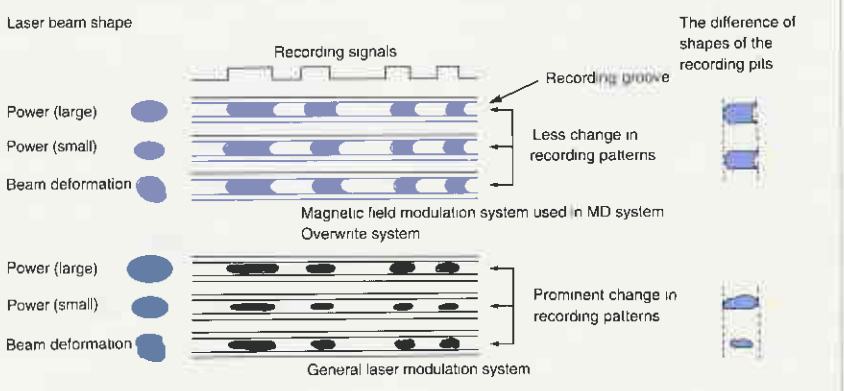
Re-Recording is Possible

With this MMO system recording, the same disc can be recorded a virtually unlimited number of times, unlike WO (write-once) systems that allow recording on a disc only once.

Another MMO system benefit is a larger recording power margin, which minimizes distortion in the position of recording start and/or finish, a cause of time-axis jitter. In addition, the MMO system is also highly resistant to disc tilt, in which the shape of the magnetized spot can become distorted, also a cause of jitter. Since the laser is used only to raise the temperature of the magnetic layer, it has less effect on the magnetic spot shape.

MiniDisc Recording





Magnetic-Field Modulation Overwrite System

Compared to the recording patterns produced by a general laser modulation system, which records according to the level of applied laser power, those produced by the MMO system are far more uniform and symmetrical, resulting in greater reliability when the disc is played back. Furthermore, this system achieves the same high recording density as CD.

AND PLAYBACK.

Dual Function Pickup

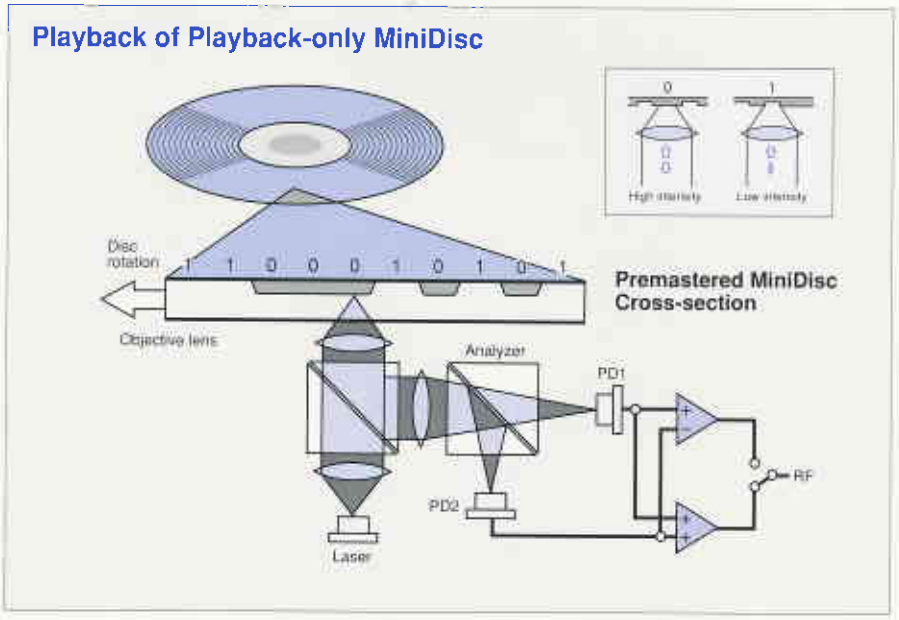
Since playback-only MiniDiscs and recordable MiniDiscs are "read" in different ways, they cannot be played back with the same pickup. For this reason, the MiniDisc format makes use of an innovative Dual Function Pickup in which both types of discs can be played back on the same equipment.

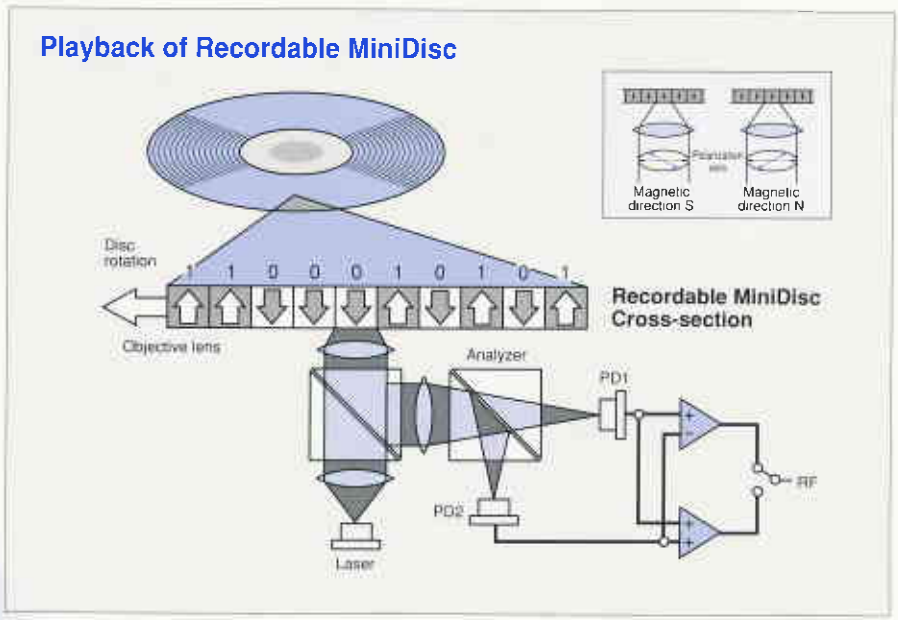
The Dual Function Pickup is based on the conventional CD player pickup, but has been modified to contain a polarized beam splitter to detect magneto-optical playback signals as well. Accordingly, it has two photo detectors, one for each type of signal.

As mentioned previously, the playback-only MiniDisc is read by a laser pickup in much the same was as a CD. Light reflected directly back indicates the absence of a pit, while in the presence of a pit, the light is diffracted, and a lower level is reflected back to the laser. These light level fluctuations correspond to the "0" and "1" digital signals.

Playback of a recordable MiniDisc is also by laser, but is performed in a somewhat different manner. Upon striking a specific portion of the disc, the polarized light will be reflected back along one of two opposing directions, with the polarization plane rotating slightly in a forward or reverse direction in accordance with the direction of the magnetic signal. The fact that light reflected from the disc differs according to magnetic orientation is central to the recording/playback capability of MiniDisc.

A polarized beam splitter distributes the reflected light between two photo detectors, the ratio of which varies according to the direction of polarization. Each photo detector converts the light received into an electrical signal. From this, signals of "0" and "1" can be derived from the difference in the levels of the two electrical signals from the two photo detectors.





Produced by the MD Group

Published by
SONY CORPORATION
1-7-4, Kounan, Minato-ku, Tokyo 108, Japan
(Fax: 03-3458-7917)

PRINTED IN JAPAN
0592/1