

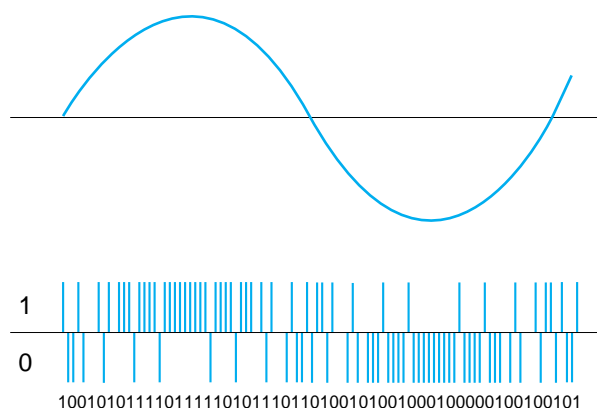
Key Chip for Next Generation of Audio

Super Audio CD DSD Decoder

- SACD playback signal processing
- Watermark (electronic watermark) decoding
- Decryption function for decoding encrypted data
- DSD audio data and TOC information decoding
- DSD signal fade processing

Sony and Royal Philips Electronics have proposed the “Super Audio CD” (SACD) as the next generation in audio. SACD achieves the ultrahigh fidelity of a 100 kHz bandwidth with a 120 dB dynamic range. At the same time as reproducing every nuance and even the ambiance of the performance, this technology provides a high level of copyright protection. The two key technologies that support SACD are DSD (Direct Stream Digital) and digital watermarking.

The creation of SACD players requires not only the development of these key technologies, but also special-purpose LSI devices that perform many unique parallel-processing operations. The CXD2750AQ is the result of a joint development effort carried out and completed by several companies and research laboratories.



■ Figure 1 DSD (Direct Stream Digital)

■ Table 1 Conventional CD and SACD Specifications

	Conventional CD	SACD (HD layer)
Diameter	12 cm	12 cm
Data capacity	780M bytes	4.7G bytes
Data word length	16 bits	1 bit
Sampling frequency	44.1 kHz	2.82 MHz (64 times that of CD)
Frequency response	DC to 20 kHz	DC to 100 kHz
Dynamic range	96 dB (audio band)	120 dB (audio band)
Playing time	74 minutes	109 minutes (for 2-channel program material)

Direct Stream Digital

1) DSD provides superb audio fidelity

DSD (Direct Stream Digital) adopts a sampling frequency of 2.82 MHz, 64 times that used by conventional CDs, yet uses a data word length of only one bit. The reason that DSD provides superb audio fidelity is that it records the 2.82 MHz 1-bit data stream output from a 1-bit A/D converter directly without any modification. (See table 1 and figure 1.)

2) DSD is close to analog

Although this 1-bit data stream is a digital signal, it is extremely close to the analog signal that is the original audio material. Simply by passing the signal

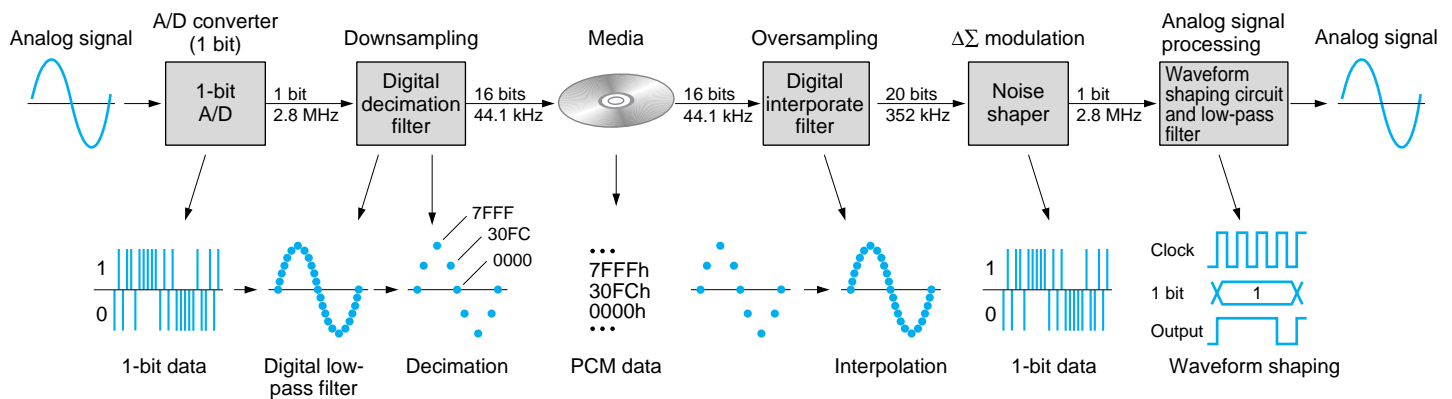
through waveform shaping and low-pass filter circuits DSD is able to reproduce the original audio signal faithfully.

3) Differences between DSD and conventional PCM

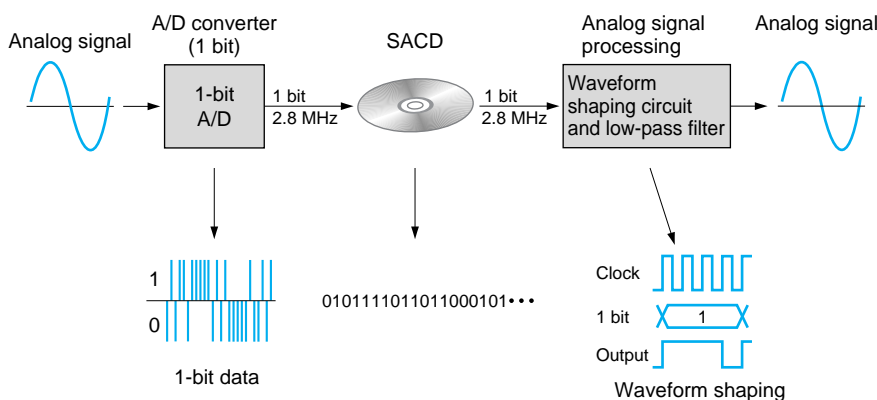
The 1-bit A/D converter has become the mainstream recording technology, even in conventional PCM recording. However, in the PCM technique, digital low-pass filter calculations and decimation processing are used to downconvert to the required sampling frequency. This processing discards the high-frequency components present in the original signal. Furthermore, PCM playback uses interpolation processing and noise shaping. These can subtly modify the sound quality since they are implemented as digital processing. (See figure 2.) In contrast, DSD uses none of this processing. (See figure 3.)

4) DSD respects sound quality beyond the technical specifications

As you can see from the above, DSD is not merely a modified conventional technique with a longer word length and a higher sampling frequency, but rather is a technique that, by performing direct recording and playback without any filter processing, provides an improved degree of “fidelity to the original” beyond that expressed in specifications while at the same time meeting the requirements of stringent specifications. This allows DSD to communicate the performers’ subtle nuances and the ambience of the performance in an extremely natural manner.



■ Figure 2 Conventional PCM Recording and Playback



■ Figure 3 DSD (Direct Stream Digital) Recording and Playback

Watermarking (Electronic Watermark)

1) A watermark that does not change the data

Electronic watermarks are added to SACD discs using PSP (pit signal processing) technology. This watermark is created without modifying the digital data on the disc in any way by applying unique processing to the pits. This means that nothing is added to the DSD signal, and the music can be enjoyed in its pure state.

2) Copying is extremely difficult

This means that the watermark itself cannot be read just by reading the data on the disc. Furthermore, it is extremely difficult to reproduce a watermark correctly, even by taking a mold of the disc and reproducing the disc mechanically.

3) Two types of watermark

There are two types of watermark:

- Visible watermark, and
- Invisible watermark.

The former allows visual recognition of illegally manufactured discs, and the latter is detected by SACD players, which will not play back a disc with an incorrect watermark.

4) Encryption

Encryption can be applied to the SACD audio data. When the watermark cannot be correctly recognized, it will be impossible to correctly decrypt the encrypted data.

The combination of these technologies can protect the artist and the recording company from illegal copying.

CXD2750AQ DSD Decoder LSI Device

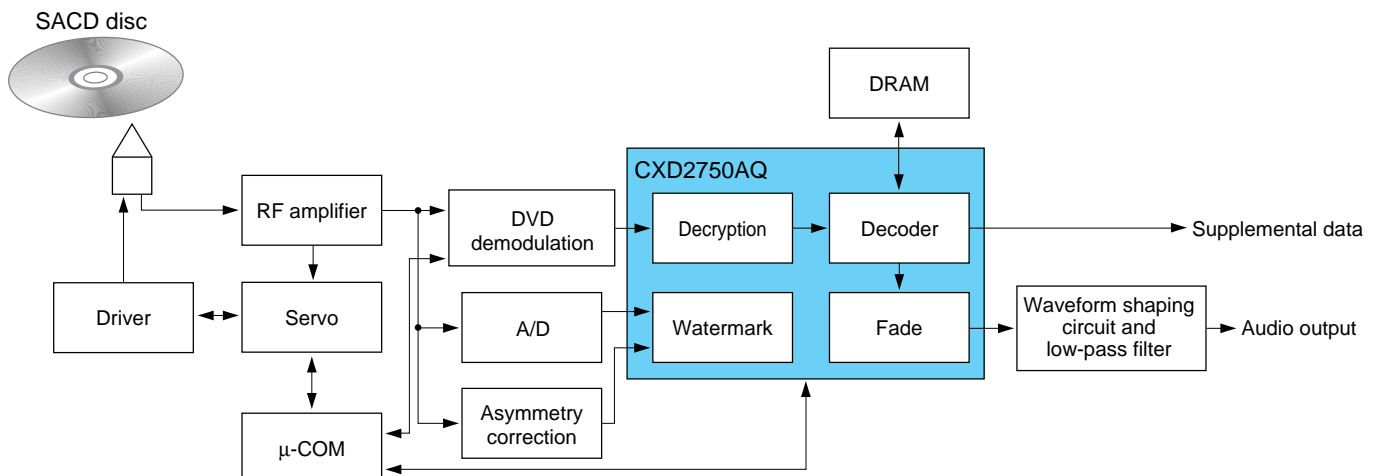
1) SACD system

Figure 4 shows the system structure of an SACD player, which consists of a pickup, an RF amplifier, a servo control system, a DVD demodulator, a DSD decoder (CXD2750AQ), DRAM, A/D converters, low-pass filters, and other components.

2) CXD2750AQ

In this SACD player, the special-purpose DSD decoder LSI device that supports the two major technologies mentioned previously is the CXD2750AQ. (See photograph 1.) The CXD2750AQ provides two main function systems:

- Main signal playback processing, and
- Watermark identifier processing.



■ Figure 4 SACD System

Main Signal Playback Processing

1) Decoding

The DVD demodulation IC first applies error correction and other processing to the data read from an SACD disc, and then outputs that data to the CXD2750AQ. The CXD2750AQ stores this data to, and retrieves it from DRAM according to the playback rate, and generates the following data:

- TOC data (disc information, track information, etc.),
- DSD data (the audio data), and
- Supplementary data (still pictures, etc.).

The generated data is output from the corresponding interface to the control microcomputer, D/A converters, or other circuits.

2) Fade processing

The CXD2750AQ also performs soft muting of the data associated with the start and stop of playback and errors in the data. This is a fade in/fade out function that takes a few milliseconds and prevents click and other transient noise. (See figure 5.)

3) Special-purpose parallel-processing circuit

Since the DSD data is a 1-bit data stream, special signal-processing is required. Furthermore, the data rate is extremely high due to a sampling frequency that is 64 times that used in conventional CDs. For these reasons, the CXD2750AQ uses a special-purpose parallel-processing circuit.

Watermark Identifier Processing

1) Automatic identification of invisible watermarks

The RF signal read from the SACD disc is converted from analog to digital and output to the CXD2750AQ. The CXD2750AQ analyses this data and automatically detects a correct invisible watermark if one is present in the input. The main signal playback functions described above are enabled if a correct invisible watermark is detected.

2) Decryption processing

The CXD2750AQ will decrypt data from a disc that has been encrypted only if a correct invisible watermark is detected.

These operations allow watermarks to be identified and TOC information and audio data to be decoded, and thus enable the playback of SACD discs. In addition, to maintain the high audio fidelity inherent in SACD discs, the CXD2750AQ aggressively switches unused circuit blocks to the standby state so that unnecessary digital noise is not generated.

Thus the CXD2750AQ supports the core technologies of next generation audio. We hope that you will soon be able to experience the sound produced by an SACD player based on the CXD2750AQ.

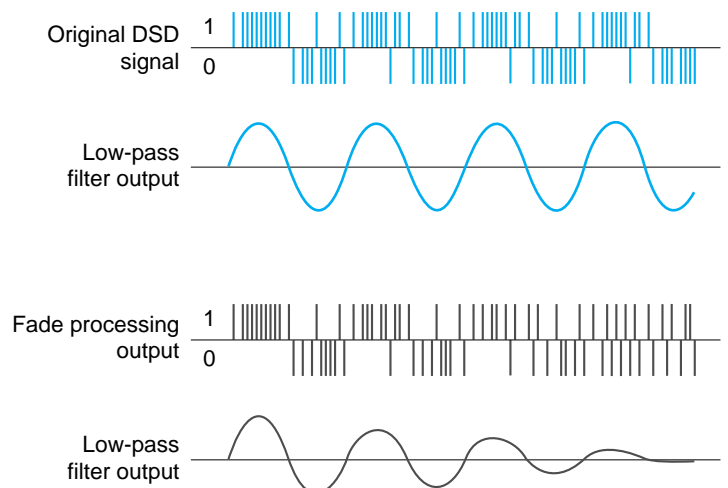
Additionally, to further increase the functionality and audio fidelity provided by SACD, Sony is planning to develop the following devices:

- An LSI device that includes a “DST - direct stream transfer” function that expands audio data compressed using a lossless compression technique,
- An LSI device that supports multi-channel playback, and
- An LSI device that integrates the peripheral signal-processing devices on a single chip.

You can look forward to many exciting future developments from Sony in the SACD area.



■ Photograph 1



■ Figure 5 DSD Fade Processing