CD Quality Audio Achieved with Digital IR Transmission

Digital Infrared Audio Transmission System: DIAT

- **Wireless digital audio interface**
- **Can be used at the same time as conventional infrared systems**
  — Progress towards international standardization is underway —
- **Two modes for different types of application**
- **Powerful error correction capabilities**
- **Chipset for easy system implementation**

Sony has developed DIAT (Digital Infrared Audio Transmission system), a new system for transmitting digital audio throughout a local area using infrared light as the carrier.

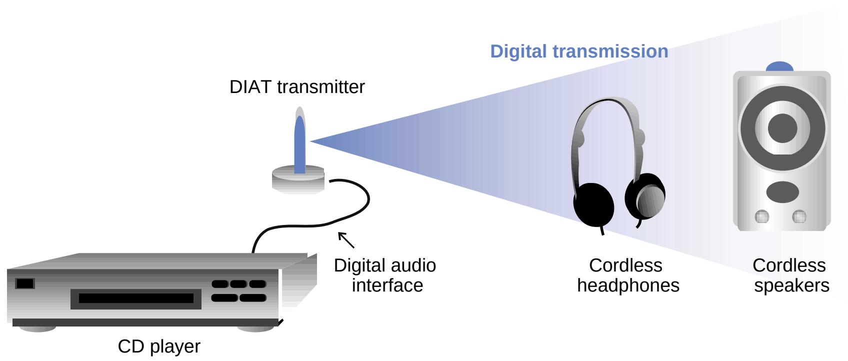
Systems that transmit audio signals throughout a local area using infrared light, mainly using analog modulation, have been developed and used in wireless headphone products. These headphones allow the user to enjoy music without the bother and inconvenience of using a cord. However, high-quality audio sources are now taken for granted, not only from audio equipment, but also, due to the success of the DVD, in video equipment as well, and these systems, which use analog modulation (FM modulation) are no longer appropriate for the current generation of audio technology.

Given this background, Sony began research and development on the DIAT digital audio transmission system, which uses QPSK digital modulation, and released the MDR-DS8000 digital surround headphone system that uses this system as a commercial product in November of last year.

In this article, we present an overview of the DIAT format and ICs.

Wireless Digital Audio Interface

The DIAT system was developed based on the concept of a wireless version of the digital audio interface (international standard: IEC 60958), which is used in CD and MD players. This meant that the DIAT system would not only handle audio signals, but would also be able to transmit, at the same time, the main subsidiary information handled by the digital audio interface. The DIAT system supports the same sampling rates as the digital audio interface: 32, 44.1, and 48 kHz.



■ Figure 1 Product Concept Examples

A System That Can Be Used at the Same Time as Conventional Infrared Systems
–– Progress towards international standardization is underway ––

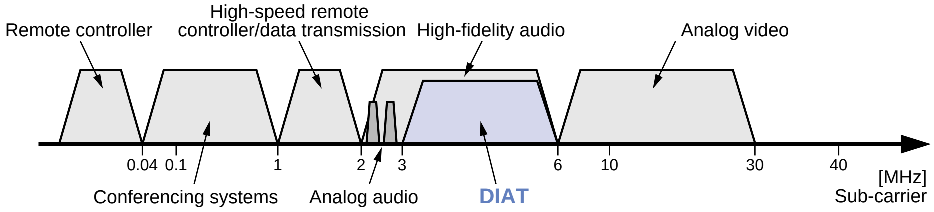
The wireless remote control is a familiar device that uses infrared light. Other IR equipment includes wireless headphones and wireless mouse and pointing devices for PCs. This IR equipment normally uses IR light in the 800 to 1000 nm wavelength range, and changes the brightness of the IR light (intensity modulation) to transmit information. To allow, for example, users to change TV channels with the remote control while using a wireless headphone set, the frequencies (subcarrier frequency) that are intensity modulated are allocated for each application. This is a kind of frequency division multiplexing. The IEC (International Electrotechnical Commission) determines this allocation for consumer products. Figure 2 shows this subcarrier frequency allocation. In the example discussed above, remote controls use the band up to 40 kHz, wireless mouse and pointing devices use the 1 MHz to 2 MHz band, and wireless headphones use the 2 MHz to 3 MHz band.

Since the DIAT system uses the 3 MHz to 6 MHz band, DIAT can be used at the same time as the equipment discussed above. Sony is active in the IEC and is working to acquire the allocation of this band. The current status of these activities is as follows. The proposal reached the CDV (committee draft for vote) stage in December of 2001 and is expected to be voted on by national representatives in May of 2002.

Two Modes for Different Applications

The DIAT system provides two modes so that the most appropriate mode can be selected for the application. These modes are the full-band mode and the half-band mode. In full-band mode, the whole allocated band is used directly as shown in figure 3 (a). In this mode, a DIAT system can transmit up to 24 bits of digital audio data as well as all the sub-data handled by the digital audio interface.

In half-band mode, the allocated band is divided into two smaller bands and each of those bands can be used independently as shown in figure 3 (b). In this mode, a DIAT system can transmit up to 16 bits of digital audio data. Only the absolute minimum amount of digital audio interface sub-data can be handled in this mode. However, this mode has the advantage that it allows transmission over distances 1.4 times longer than would be possible with full-band mode with the same power. Table 1 presents the features of these modes. For example, if one wanted to create a wireless headphone that provided the same audio quality as CD, one could select half-band mode, which in exchange for using only 16 bits of data and only handling the minimal amount of sub-data allows a wider service area to be covered. If one wanted to create a system for wireless dubbing between CD and MD systems, one would choose full-band mode, since it can transmit all of the information recorded between tracks on CDs and MDs.

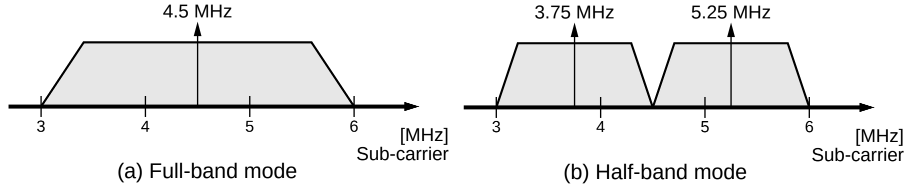


■ **Figure 2 Subcarrier Frequency Allocation**

■ **Table 1 Full-Band Mode and Half-Band Mode Features**

	Full-band mode	Half-band mode
Main data rate	3.072M bits/s	1.536M bits/s
Sub-data rate	80K bits/s	40K bits/s
Occupied bandwidth	2.5 MHz	1.25 MHz
Subcarrier frequency	4.5 MHz	3.75 MHz 5.25 MHz

*: When the sampling frequency is 48 kHz.



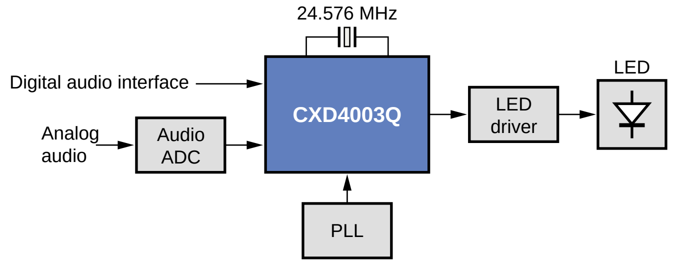
■ **Figure 3 Full-Band Mode and Half-Band Mode Bandwidths**

Powerful Error Correction Capabilities

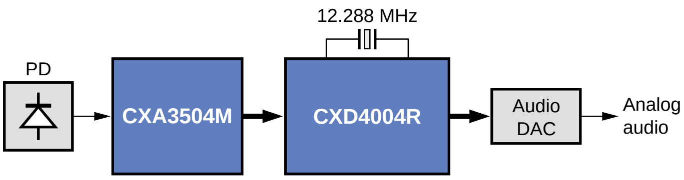
Digital audio transmission has the problem that the reception of data with incorrect values due to noise in the transmission path can result in extremely loud audio noise that can even lead to speaker damage. DIAT adopts a Reed-Solomon coding based error correction technique that provides high reliability even when the transmission path is affected by noise. This technique adds an extra 10 bytes of error correction and parity data for every 48 bytes of signal data. The use of error correction codes makes it possible to either recover the original data if a limited amount of transmission path noise has entered the signal or to protect the abnormal sound generation by muting the output if noise in excess of the error correction capability has entered the signal.

Chipset for Easy System Implementation

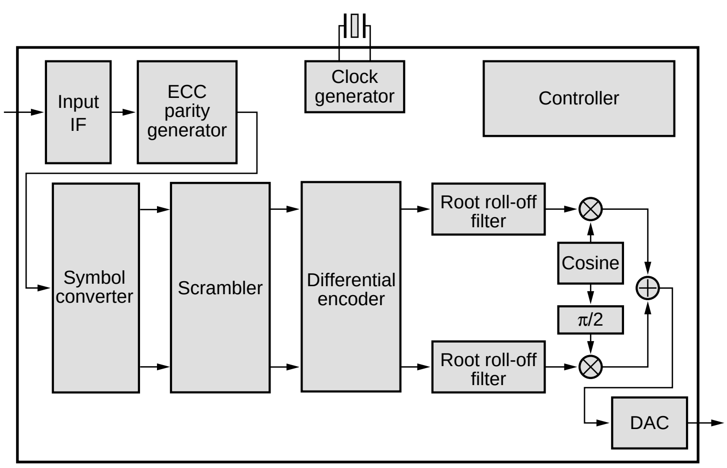
Figure 4 shows an example of a transmission system implementation, and figure 5 shows an example of a reception system implementation. The CXD4003Q, CXA3504M, and CXD4004R are the three chips in the chip set Sony developed to implement the DIAT system.
While the CXD4003Q is a signal-processing LSI that provides functions for both transmission and reception in the DIAT system, the system shown in figure 4 only uses the transmission functions provided by this device.
Figure 6 shows the block diagram of the CXD4003Q functions used for transmission. While the main modes can all be set up and controlled from input pins, the IC can also be set up and controlled over a 3-wire serial interface. The CXD4003Q has two input interface systems: a digital audio interface and an audio A/D converter interface. These can be switched using the mode setup. The CXD4003Q generates the parity for error correction and performs the digital signal modulation. The DIAT modulated signal is converted to analog with a D/A converter and transmitted spatially as an infrared signal by an LED driver. Since the CXD4003Q performs all operations (such as root roll-off filtering and subcarrier generation) used for modulation digitally, no adjustment steps are required in the end-product manufacturing line, and these operations have no temperature dependencies and are not subject to variations over time. Thus the CXD4003Q provides extremely stable modulation.
Figure 7 shows the CXA3504M block diagram. The CXA3504M IC performs the DIAT receiver analog signal processing. It accepts the current output (the DIAT modulated signal) from the photodiode (PD), and provides the following circuit blocks: an I/V amplifier that converts the current signal to a voltage signal and amplifies it, a first stage AGC amplifier, a second stage AGC amplifier, a bandpass filter that removes out-of-band noise, and a buffer amplifier. One notable feature of the CXA3504M is that the first stage AGC amplifier includes a shunt



■ **Figure 4 Transmission System Structure Example**



■ **Figure 5 Reception System Structure Example**



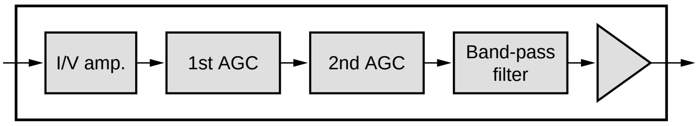
Package: 176-pin QFP, Supply voltage: 3.3 V

■ **Figure 6 CXD4003Q Block Diagram (Transmission functions only)** circuit so that the signal does not saturate, even if the light source (LED) is extremely close to the receiver. The CXA3504M also uses a two-stage structure in its AGC system to achieve an extremely wide total AGC dynamic range of about 90 dB.

Figure 8 shows the CXD4004R block diagram. The CXD4004R is a specially-designed digital signal-processing IC for DIAT system reception. It features low power consumption (approximately 35 mW: approximately 1/10 that of the CXD4003Q) for use in battery powered equipment and a miniature package. While the main modes can all be set up and controlled from input pins, the IC can also be set up and controlled over a 3-wire serial interface. The CXD4004R accepts the DIAT modulated signal that was processed as an analog signal by the CXA3504M and converts that signal to digital using a built-in A/D converter. The CXD4004R then demodulates and applies error correction to that signal using digital signal processing. If the result of error correction still has large numbers of errors that would interfere with audio signal reproduction, it outputs a muted signal from the output pin. Since the CXD4004R integrates the PLL circuit required for sampling frequency generation, an external PLL circuit is not required and the audio signal can be produced simply by connecting an audio D/A converter. The CXD4004R is able to provide stable demodulation since it performs all demodulation processing, including subcarrier reproduction, using digital signal processing.

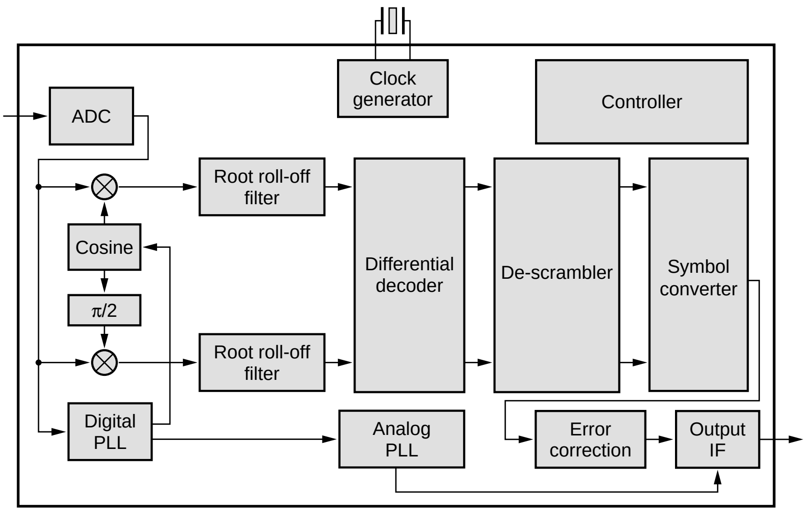
Future Developments

We expect the DIAT system for IR transmission of digital audio to become widely used in convenient high-fidelity cordless headphones and cordless speakers. Furthermore, since DIAT is a system that transmits digital signals, it can also be used for signals other than audio signals. For example, a full-duplex data communication system could be implemented by using two DIAT channels in half-band mode. Thus we are hoping that DIAT will find wide use in applications other than audio in the future.



Package: 28-pin SOP, Supply voltage: 2.5 V

■ Figure 7 CXA3504M Block Diagram



Package: 64-pin QFP, Supply voltage: I/O: 2.5 V, Internal: 1.5 V

■ Figure 8 CXD4004R Block Diagram