

A CONSUMER DIGITAL VCR FOR DIGITAL BROADCASTING

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ABSTRACT

IRD built-in VCR for recording digital broadcast has been developed. This VCR is based on the D-VHS standard and records digital bit-stream data broadcasted digitally. For this VCR, we have developed the one-chip digital signal processing LSI, the interface LSI and the digital/analog compatible head.

1. INTRODUCTION

In recent years, the digital broadcasting service is spreading all over the world. In Japan, there are over a half million subscribers. So, there is a strong demand in the market to expect an early appearance of the digital recording VCR for the digital broadcast with a reasonable price.

On the other hand, there is a huge amount of video tapes already recorded by current analog VHS VCRs. And the current analog broadcasting service will continue for the time being.

Therefore the consumer use digital VCR for digital broadcasting is required to satisfy two requirements. One requirement is to record and playback current analog video tapes, and another

requirement is the VCR must be of reasonable price. To meet these requirements, we have developed the digital VCR using the current VHS mechanism and digital/analog compatible head.

2. BASIC SPECIFICATIONS

This VCR is based on the D-VHS standard. The VCR has a capability of recording the digital bit-stream of the digital broadcasting, and a compatibility with the current VHS VCR.

Table 1 shows the basic specifications of the VCR. This VCR uses 1/2-inch oxide tape for digital recording. A maximum data rate is 14.1Mbps and a maximum recording time is five hours.

Figure 1 shows the block diagram of the VCR. The VCR consists of the digital recording and reproducing circuit, the analog recording and reproducing circuit and the IRD (Integrated Receiver and Decoder).

To realize this VCR, three key devices have been developed. The first one is the one-chip digital signal processing LSI. This LSI records and reproduces the digital broadcasting bit-stream data based on the D-VHS format. The second one is the interface LSI to connect the IRD with the digital recording and reproducing circuit. This LSI has a function to convert the transport stream of the digital broadcasting into a recordable stream. The third one is the analog/digital compatible head. The head shows good recording performance for digital signal as well as the Hi-Fi audio signal.

Table 1 Specifications of the Digital VCR

Tape Speed	16.67 mm/s
Track Pitch	29 μ m
Input signal rate	14.1 Mbps
Recording rate	19.13856 Mbps
Modulation	SI-NRZI
Recording Time	5 hours

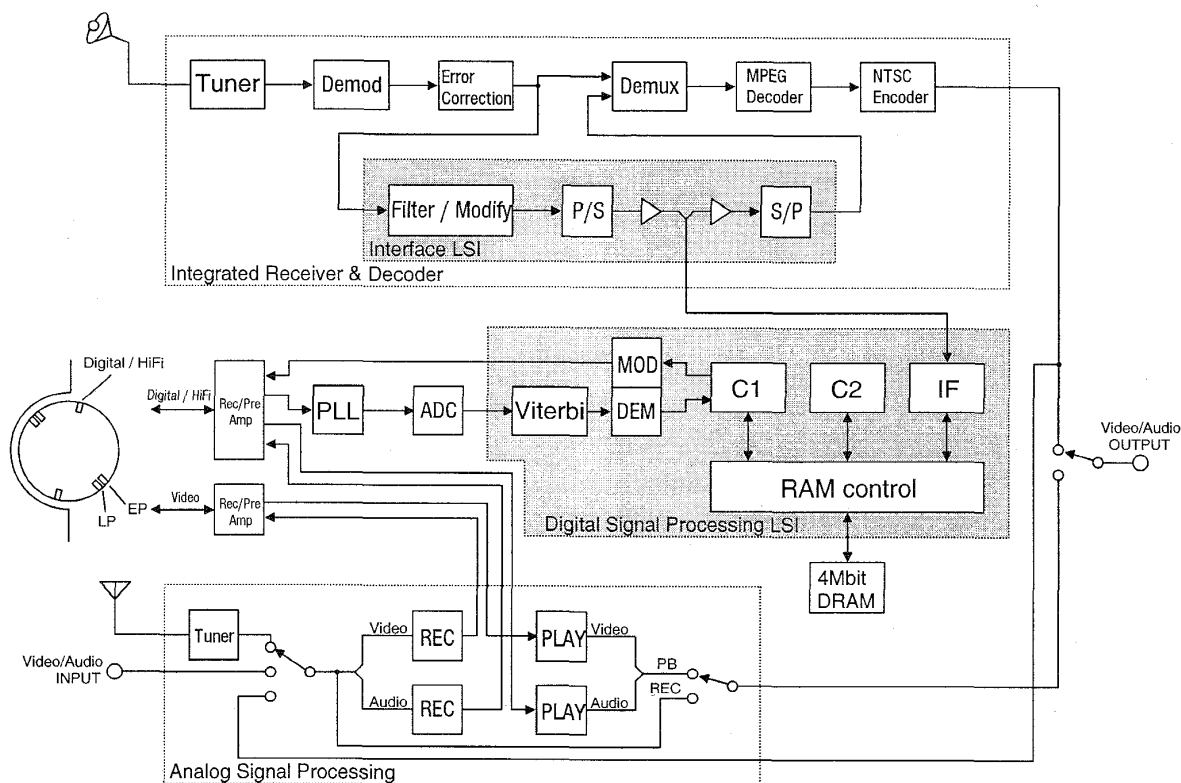


Fig.1 Block Diagram of the Digital VCR

3. DIGITAL SIGNAL PROCESSING LSI

There are several kind of digital broadcasting standards in the world. Table 2 shows the features of broadcasting standards. One of the major standards is the DVB (Digital Video Broadcast) standard. The DVB uses the MPEG transport stream packet of 188 bytes, and recommends usage of the IEEE1394 interface. The other is the DSS (Digital Satellite System) standard. The DSS uses the interface of SDAV (Simplified Digital AV Bus), and the SDAV uses packet of 144 bytes which consists of time stamp of 4 bytes and the packet data of 140 bytes. Figure 2 shows packet form of the DVB and the DSS.

Therefore the digital signal processing LSI is designed for the both types of packet format.

Figure 3 shows the allocations of the MPEG packet data on the sync blocks. For the MPEG packet

recording, a time stamp is added on each packet to recover the interval of reproduced packets. The time stamp has the length of 4 bytes. A sync block on the tape has a data area of 96 bytes, and the 192 bytes data (4 bytes time stamp and 188 bytes packet data) are

Table 2 Features of broadcasting services

Service	Structure	Interface
DVB etc.	188 bytes	IEEE1394
DSS	140 + Time Stamp	SDAV

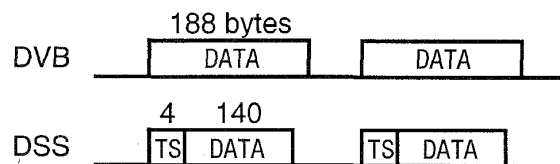


Fig.2 Data form of packets

TS: Time Stamp

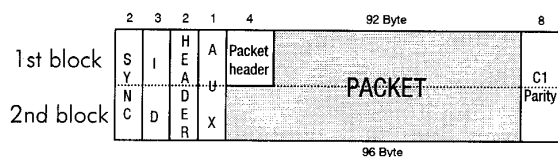


Fig.3 Data allocation for MPEG packet

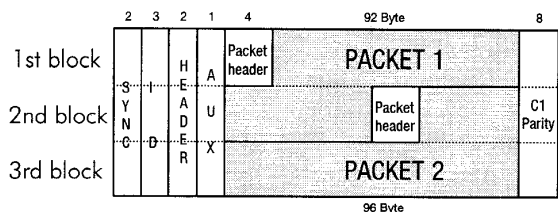


Fig.4 Data allocation for DSS packet

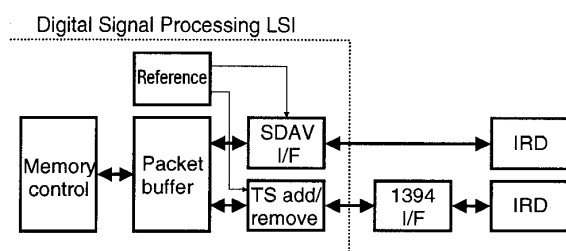


Fig.5 Block diagram of Interface circuit

allocated to two sync blocks. For the playback, the time stamp is compared with the reference time stamp of the LSI. Thus the 188 bytes packet data are transferred with the same interval as received interval.

Figure 4 shows the allocation of the DSS packet data on the sync blocks. For the DSS packet recording, packet data are received with time stamp. So the packets are recorded directly. Two packets data are allocated to three sync blocks. For the playback, the time stamp and the packet data are transferred with the same interval as received interval.

Figure 5 shows the block diagram of an interface circuit of the LSI.

As shown above, this digital signal processing LSI can record two kinds of digital broadcasting signal. This LSI consists of serial interface, error correction circuits, modulator, demodulator, viterbi detector and RAM controller.

4. INTERFACE LSI

The transport stream of the digital broadcasting contains a number of programs. To record a program, it is necessary to generate one program stream which is called the partial stream. The interface LSI makes the partial stream by filtering transport stream.

Figure 6 shows the block diagram of the interface LSI. And figure 7 shows the generation timing of partial stream. A transport stream consists of a number of program streams, PAT (Program Association Table) and service information. Each program stream consists of packets of video, audio and PMT (Program Map Table). To generate partial stream, the interface LSI selects packets according to PID (Packet ID) of each packets, and modifies PMT and PAT adapting to selected program.

At playback, the interface LSI receives the reproduced packet data from the VCR, and the received data are forwarded to MPEG decoder.

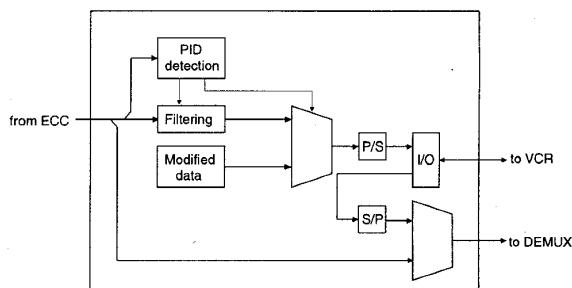


Fig.6 Block diagram of interface LSI

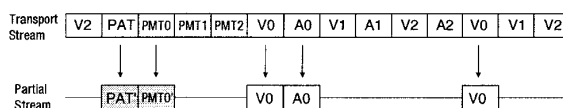


Fig.7 Generation timing of partial stream

5. HEAD FOR DIGITAL RECORDING & Hi-Fi AUDIO RECORDING

A current VHS VCR has six heads which are two SP (Standard Play) video heads, two EP (Extended Play) video heads and two Hi-Fi audio heads. And two heads are required for recording the digital signal. But,

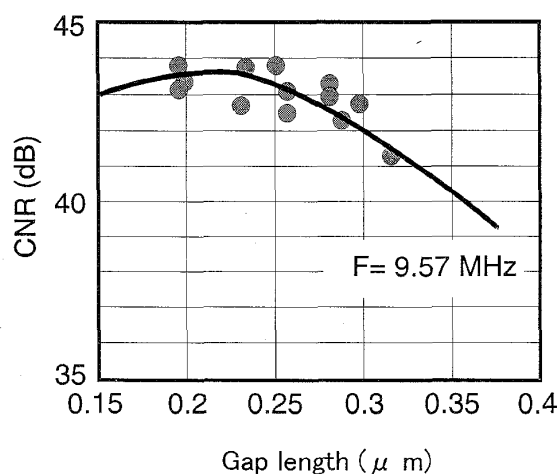


Fig. 8 CNR characteristics of Digital signal

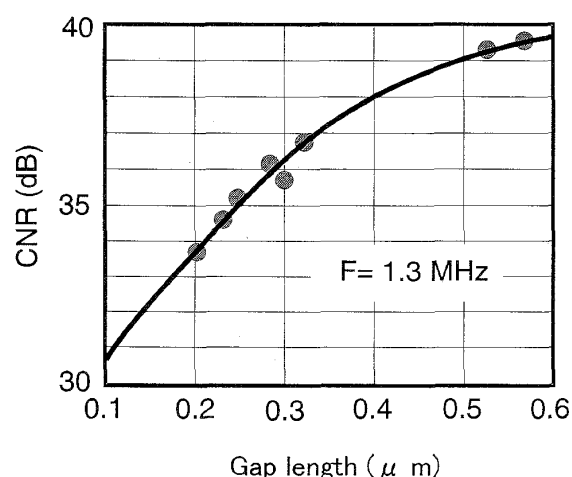


Fig. 9 CNR characteristics of Hi-Fi audio signal

additional digital recording will raise the production cost. So we have developed digital/analog compatible head.

The video heads are not suitable for digital recording because of their small azimuth. To the contrary, the Hi-Fi audio head has azimuth of 30 degree and is usable for digital recording. Therefore we have studied recording of the digital signal using the 30 degree azimuth head.

Characteristics of the digital recording signal are different from that of the Hi-Fi audio signal.

Table 3 Specifications of the Digital Head

Structure	Metal in Gap
Azimuth angle	± 30 deg
Gap length	$0.28 \mu\text{m}$
Head width	$32 \mu\text{m}$

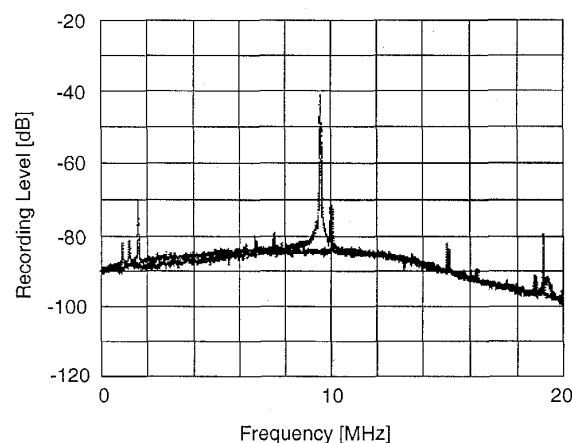


Fig. 10 Spectrum of reproduced digital signal

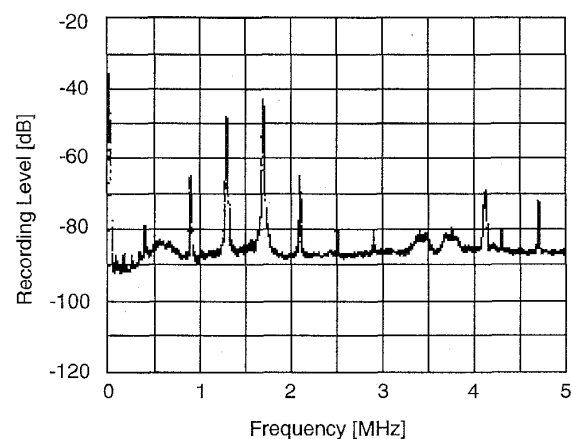


Fig. 11 Spectrum of reproduced Hi-Fi audio signal

The maximum frequency of the digital recording signal is 9.57 MHz, but a carrier frequency of the Hi-Fi audio signal is 1.3 MHz and 1.7 MHz. A gap of head should be narrowed to improve frequency response of the head. However, the small head gap will decrease the magnetic power for recording of the Hi-Fi audio signal. To solve this problem, we

employed the MIG (Metal in Gap) head.

Figure 8 shows the CNR characteristics of digital signal (9.57 MHz). To keep the error rate less than 10^{-4} , it is necessary to maintain the CNR of more than 42 dB. It means that the gap length less than $0.3 \mu\text{m}$ is required. Figure 9 shows the CNR of reproduced Hi-Fi audio signal (1.3 MHz). To keep quality of the Hi-Fi audio signal, it is necessary to maintain the CNR greater than 35 dB. It means that the gap length is larger than $0.25 \mu\text{m}$ is required.

To realize compatible head for the digital signal and the Hi-Fi audio signal, the gap length should be controlled in a range from $0.25 \mu\text{m}$ to $0.3 \mu\text{m}$. Therefore we have determined the gap length of $0.28 \mu\text{m}$. Table 3 shows the specifications of the digital head.

Figure 10 shows the spectrum of reproduced digital signal. CNR of 42.5 dB at frequency of 9.57 MHz has been obtained. And a byte error rate of 1.3×10^{-6} using the Viterbi decoder has been achieved.

Figure 11 shows the spectrum of reproduced Hi-Fi audio signal. CNR of 38 dB at frequency of 1.3 MHz and 42 dB at frequency of 1.7 MHz have been obtained.

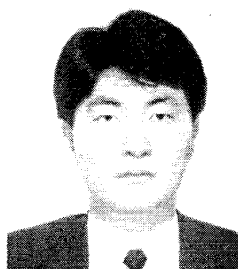
6. CONCLUSION

IRD built in digital VCR for digital broadcasting has been developed. To realize the VCR, we have developed two LSIs and digital recording head. The one-chip digital signal processing LSI can record and reproduce two kinds of digital broadcasting signals. The interface LSI generates the partial stream from the transport stream of digital broadcasting. The digital/analog compatible head can record not only digital signal but also Hi-Fi audio signal. The head has a structure of metal in gap and the gap length is $0.28 \mu\text{m}$. Using this head, byte error rate of 1.3×10^{-6} has been achieved using the Viterbi decoder.

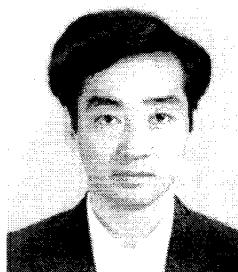
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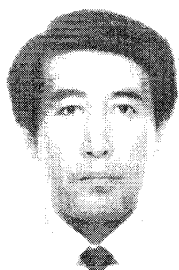
BIOGRAPHIES



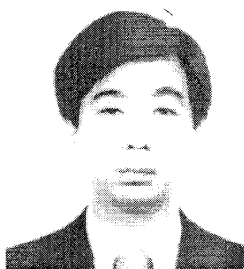
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