A CONSUMER DIGITAL VCR FOR ADVANCED TELEVISION

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ABSTRACT

A prototype of a consumer digital VCR for ATV has been developed. This VCR can record a compressed digital HDTV signal for 4 hours whose data rate is about 20 Mbps.

1. Introduction

The development of Advanced Television (ATV) system is now in progress. To meet the demand for an early realization of a VCR for the ATV system, we have developed a prototype consumer digital VCR for the ATV system which can be implemented by the current VCR technology. This VCR records a compressed digital HDTV signal whose data rate is 21.6 Mbps. At playback, the reproduced signal is decompressed to the HDTV signal by an ATV decoder.

In this paper, the technology adopted in the prototype VCR is described.

Table 1 Concept of the Digital VCR for ATV System

Item	Specification
Tape Width	1/2 inch
Tape Material	γ - Fe_2O_3
Drum Diameter	62 mm
Recording Time	4 hour

2. Basic Concept

Table 1 shows the basic concept of the digital VCR for the ATV system. To realize a low cost digital VCR, we focused on technology transfer from current analog VCRs. Although, we have adopted a 1/2-inch oxide tape and a drum diameter of 62 mm because they are widely used in the current analog VCRs, our goal for the recording time is more than four hours.

Because the main issue for this concept is the possible recording bit rate, we have done experiments on a various recording bit rate.

3. Examination of The Recording Bit Rate

Fig.1 shows the relation between the symbol error rate (1 symbol = 8 bits) and the signal-to-noise ratio (Vpp/Nrms) which is measured by a transmission characteristic simulator. It is necessary for the digital VCR to attain the symbol error rate of less than 1×10^{-5}. Therefore, the signal-to-noise ratio should be higher than 24 dB.

Fig.2 shows the relation between the signal-to-noise ratio and the recording bit rate with both oxide (γ -Fe_2O_3) tape and metal powder tape on the conditions that the scanning speed is 5.8m/s and the track pitch is 19 μ m. According to this figure, the

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recording bit rate of 20 Mbps is possible with oxide tape.

This means that the VCR can record the signal whose data rate is as high as 40 Mbps with the two-channel recording, because of simultaneous recording with two heads. And, four-hour recording would be possible when we use an equivalent cassette size as VHS and a tape thickness of 15 μm.

Therefore, we have adopted a recording format described in the next section for the digital VCR whose recording bit rate is about 40 Mbps.

4. Recording Format

The digital VCR records the compressed digital HDTV data of the ATV system.

This data is transmitted as two priority classes which are for high priority (HP) data and for standard priority (SP) data. Fig.3(a) shows the packet format of the HP and SP data. The packet consists of 148-byte data including a packet sync code, header data and a forward error correction code. Data transmission rates are 4.32 Mbps for the HP data and 17.28 Mbps for the SP data. Total

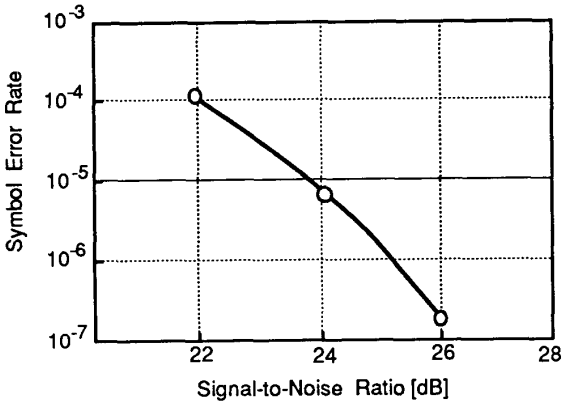

Fig.1 Symbol Error Rate vs. Signal-to-Noise Ratio

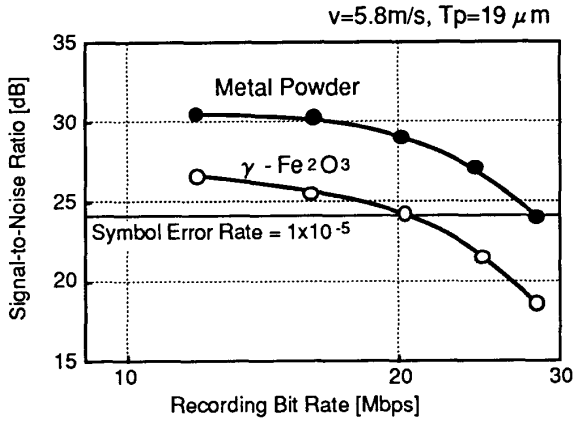

Fig.2 Signal-to-Noise Ratio vs. Recording Bit Rate

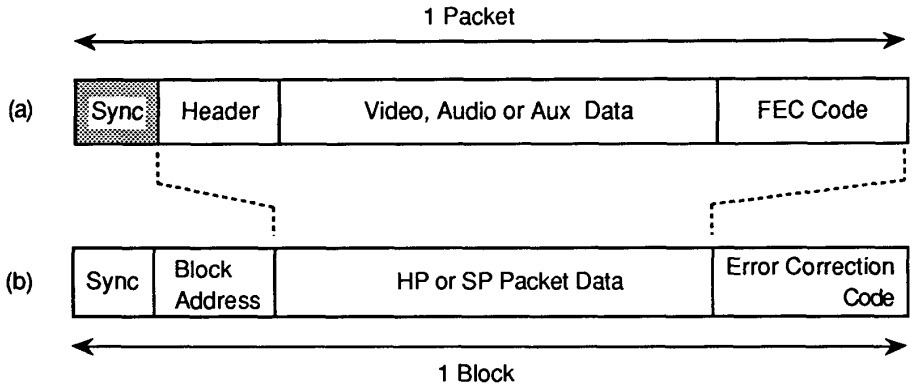

Fig.3 Data Recording Format of Digital VCR

transmission rate is 21.6 Mbps.

The VCR records these packet data with a block format. Fig.3(b) shows the block format of the recording data. A block consists of one packet data with a block sync code, block address data and error correction code.

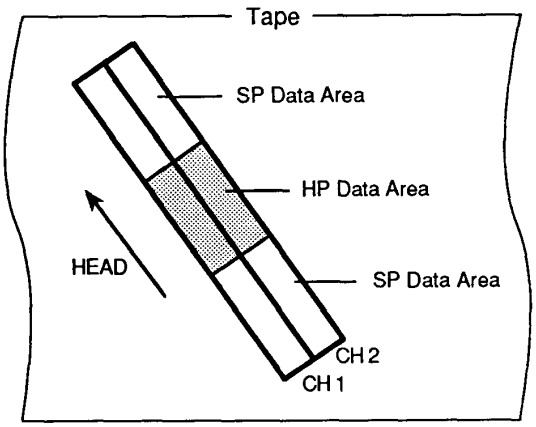

Fig.4 Track Format of Digital VCR

Table 2 Specifications of the Digital VCR

Item	Specification
Drum Speed	1824.3 min^{-1}
Number of Heads	4
Transmission Rate	21.6 Mbps
Error Correction Code	Reed-Solomon Code
Modulation Method	8-10 Modulation
Recording Bit Rate	36.8 Mbps
Tape Speed	22.24 mm/s
Track Pitch	19 μm
Minimum Wave Length	0.64 μm

The VCR records 180 block (packet) data in a track. Fig.4 shows the track format. A track consists of three areas that are one HP data area and two SP data areas. The VCR records 60 block data in each area. Considering dropouts on the tape and reduction in quantity of reproduced data at trick play, we have recorded the HP data doubly in the HP data area.

5. Main Specifications

Table 2 shows main specifications of the digital VCR for the ATV system.

A drum speed is 1824.3 revolutions per minute. This drum speed comes from the packet data rate of the ATV signal. At this speed, the VCR can record 180 packet data in each track.

The VCR uses the Reed-Solomon code for error correction.

Recording data are modulated based on an 8-10 modulation method which is the same method as that of the Digital Audio Tape (DAT) system. This method is suitable for magnetic recording, because a low frequency component of recording signal is reduced. The recording bit rate after modulation is 18.4 Mbps per channel. The total recording bit rate is 36.8 Mbps because of two channel recording.

A tape speed is 22.24 mm/s and a track pitch is 19 μm. A minimum wave length is 0.64 μm.

6. Recording and Reproducing Characteristics

Fig.5 shows the power spectrum of the reproduced signal. Fig.5(a) shows the power spectrum of the system noise. Fig.5(b) shows the power spectrum of the reproduced signal

when a maximum recording frequency (9.2 MHz) signal is recorded. Fig.5(c) shows the power spectrum of the reproduced signal when 8-10 modulated signal is recorded. A head width is 23 μm. A signal-to-noise ratio of 27.2 dB (Spp/Nrms, Signal freq.= 9.2 MHz) has been obtained.

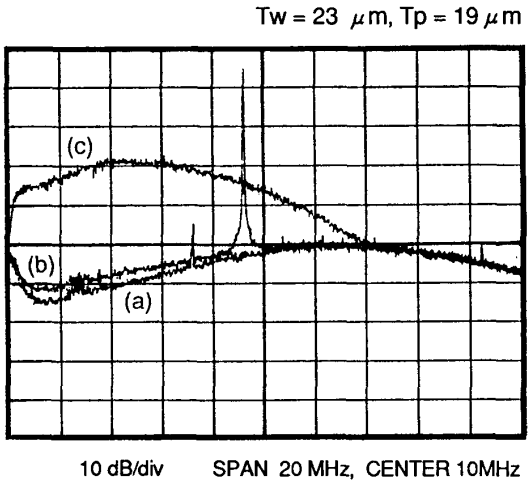

Fig.5 Power Spectrum of Reproduced Signal

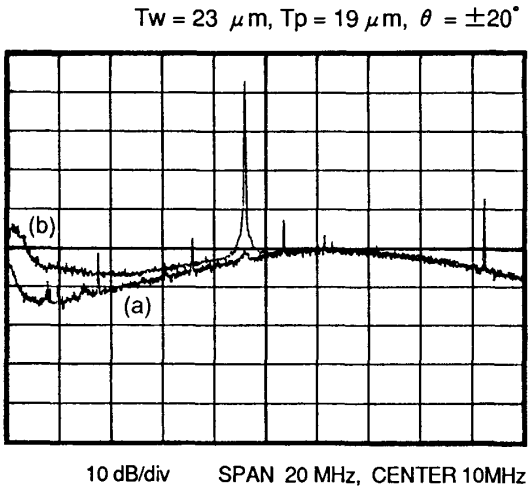

Fig.6 Power Spectrum of Cross Talk

Fig.6 shows the power spectrum of a cross talk signal from an adjacent track. Fig.6(b) shows the power spectrum of the reproduced signal when 9.2 MHz signal is recorded on the measured track and 8-10 modulated signal is recorded on the adjacent track. An azimuth angle of the head is ± 20 degree. This cross talk signal degrades the signal-to-noise ratio of about 2 dB. Therefore, the total signal-to-noise ratio is 25.2 dB.

Fig.7 shows an eye pattern of the reproduced signal. We have obtained a symbol error rate of less than 3×10^{-6}.

7. Structure of The Digital VCR

Fig.8 shows a block diagram of the digital VCR for the ATV system.

A recording circuit of the VCR consists of an interface circuit, a memory and two channel encoders. A reproducing circuit of the VCR consists of two channel PLL circuits, two channel decoders, a memory and an interface circuit.

At recording, the ATV decoder sends the demodulated packet data to the VCR. The interface circuit of the VCR receives this data, and stores in the memory. Encoders read

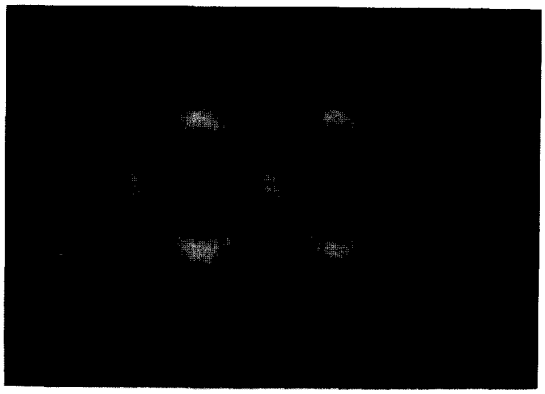

Fig.7 Eye Pattern of Reproduced Signal

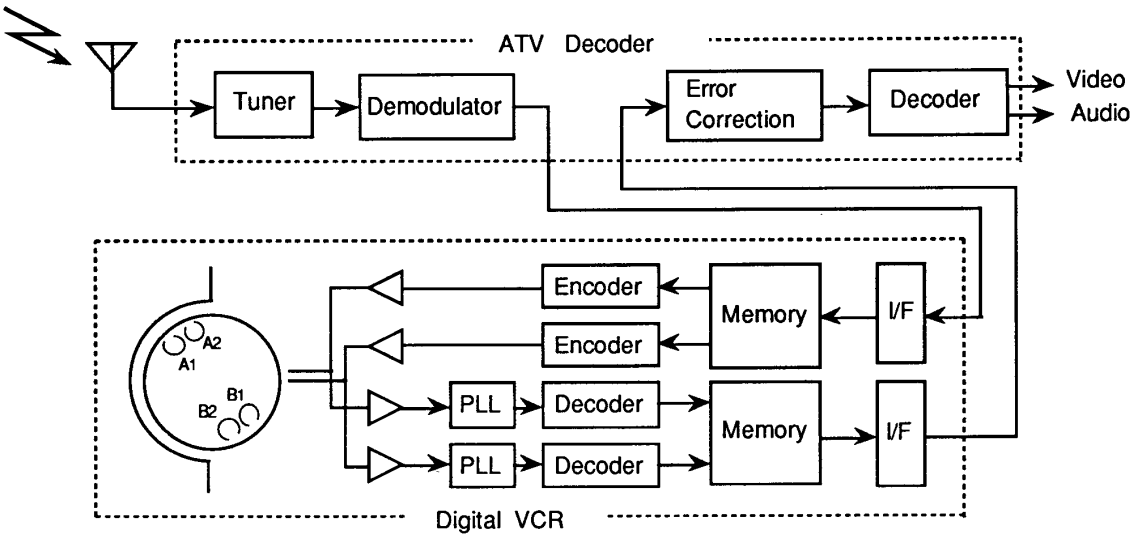

Fig.8 Block Diagram of the Digital VCR

packet data from the memory, and convert this data into the block format of the VCR. These block structured data are recorded on the tape by two rotary heads simultaneously.

At playback, the decoders of the VCR correct errors of the reproduced data by Reed-Solomon code. After correction, the decoders convert the data into the packet format of the ATV system, and store these data in the memory. The interface circuit reads the packet data from the memory, and sends these data to the ATV decoder. The ATV decoder decompresses the received packet data to the HDTV signal and audio signal.

7. Conclusions

(1) A prototype of digital VCR for the ATV system has been developed.

(2) This VCR records the compressed digital HDTV signal of the ATV system.

(3) The total recording bit rate is 36.8 Mbps (18.4 Mbps per channel) and the maximum recording time is 4 hours with oxide tape.

(4) We have confirmed that it is possible to produce a low cost consumer digital VCR for the ATV system with the current VCR technology.

ACKNOWLEDGMENT

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