A CONSUMER DIGITAL VCR FOR DIGITAL BROADCASTING

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ABSTRACT

A consumer use digital VCR for the digital broadcasting has been developed. This VCR can record the compressed digital video signal. The maximum recording data rate is 25 Mbps.

1. Introduction

The digital broadcasting service using MPEG2 as the picture compression technology started in the United States last year. This movement has a momentum spreading to all over the world.

There is a strong demand in the market to expect an early appearance of the digital recording VCR for the digital broadcasting at an affordable price for consumers. Although the digital broadcasting service has started, this does not mean the current analog broadcasting service will soon disappear. Instead, it is believed that both analog and digital services will coexist for a long time.

Furthermore, compatibility of the rental video tape and the recorded tape library is essential.

Based on these market requirements, we have concluded the new digital VCR needs to have the function of recording the broadcasting signal digitally on the tape, retaining all the analog functions current analog VCRs have. We have successfully developed this new digital VCR using various distinctive technologies.

In this paper, the new digital VCR concept and the key technology developed for the digital VCR are described.

2. Basic Concept

In order to keep interoperability as an analog VCR, the new digital VCR needs to have compatibility with conventional VCRs.

In order to realize a consumer affordable price, the specifications of the mechanism, tape and heads should be as close to the current analog VCR as possible.

Considering these two conditions, we have concluded the best solution is the bit stream recording. The definition of the bit stream recording is that it records the input digital bit stream digitally on the tape and reproduces the same digital bit stream. This is a transparent recording and it does not depend on the digital broadcasting system, assuring the expandability to various multimedia applications.

The digital VCR records the packet data which is transmitted from the receiver, and is sent back to the receiver with the same format and the same interval as the recording data at playback.

Table 1 shows the recording mode of the digital VCR. The VCR works at several recording data rate modes without changing a drum

Table 1 Recording Mode of the Digital VCR

Mode	Recording data rate	Maximum recording time	Recording data
I	6.25 Mbps	8 hours	MPEG bit stream
II	12.5 Mbps	4 hours	MPEG bit stream
III	25 Mbps	2 hours	ATV bit stream or Time compression data

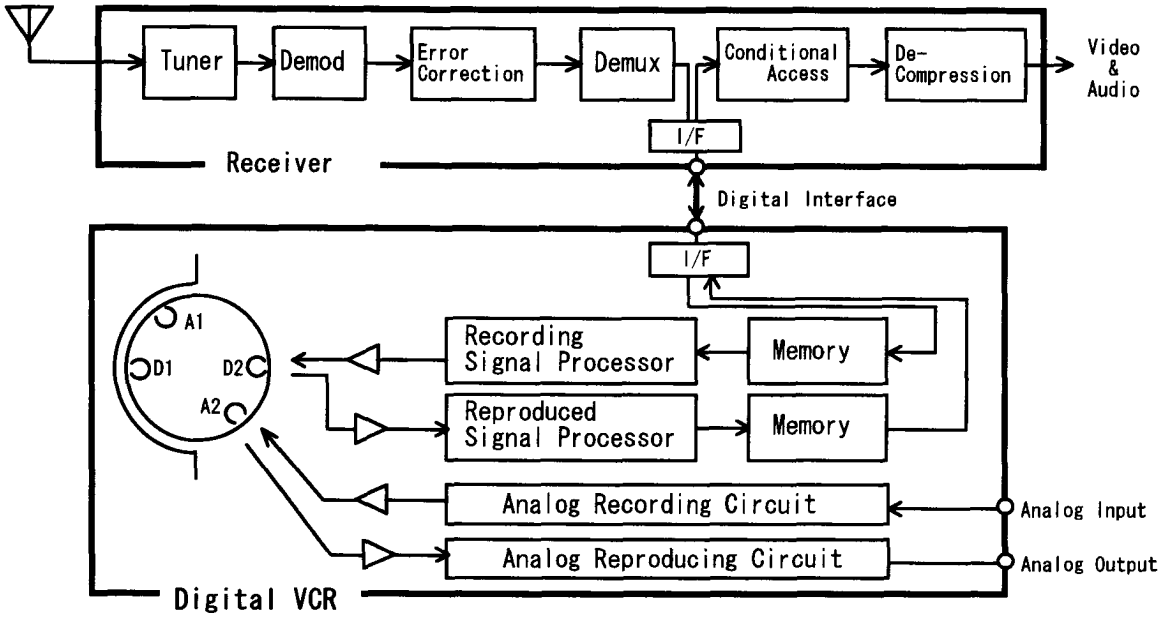

Fig. 1 The Digital VCR for The Digital Broadcasting System

revolution speed. Therefore this VCR can record various digital signals. The mode I is the long play mode. The mode II is the mode for recording the current digital broadcasting signal. And the mode III is the mode for recording the digital HDTV (ATV) broadcasting signal. The maximum recording data rate is 25 Mbps at the mode III. A maximum recording time is eight hours at the mode I.

3. Structure of The Digital VCR

We have realized the transparent recording digital VCR using the current analog VCR and the digital recording and reproducing circuits. To realize the compatibility with the current analog VCRs, 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.

The main issue of the transparent recording is that the VCR must transmit the reproduced packet data with the same timing as the received data. Therefore we regenerate the interval of the reproduced packet data using the time stamp which is added to the received packet data.

Fig. 1 shows a block diagram of the digital VCR and the digital broadcasting receiver.

At recording, the receiver sends the packet data to the VCR through the digital interface. Fig. 2 shows the configuration of the recording packet data. The packet data is transmitted with the packet time stamp which indicates the interval of the packets.

The recording signal processor converts the received packet data into track format data of the VCR. The track format comprises several blocks. These block data are recorded on the tape by the rotary heads.

At playback, the VCR corrects the errors which occurred at reproducing and converts the data back into the packet format. After that, the interface circuit of the VCR regenerates the interval of the reproduced packet data using the time stamp and sends it back to the receiver through the digital interface.

The receiver decompresses the received packet data to the video signal and audio signal the same as the case that decompresses the broadcasting signal.

Furthermore, this VCR can record and reproduce the analog video signal like a current VCR.

Fig. 2 Packet Configuration

4. Synchronization at Recording

To regenerate the interval of the packet data, the recording rate of the VCR must be synchronized with the packet transmission rate. Therefore the VCR synchronizes the recording rate and the drum speed with the packet transmission rate using the time stamp.

Fig. 3 shows the recording circuit of the digital VCR.

At first, the interface circuit detects the time stamp in the received packet data and sends

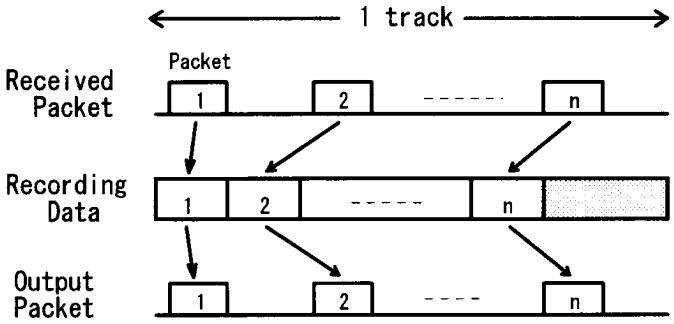

Fig. 4 Packet Transmission Timing

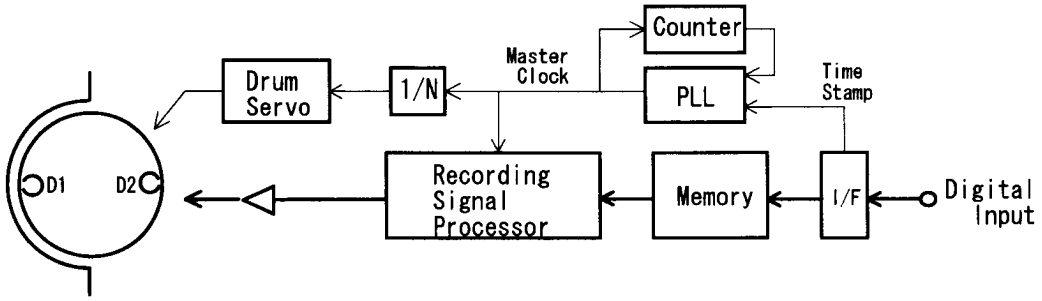

Fig. 3 Recording Circuit of the Digital VCR

it to the PLL circuit. The PLL circuit generates the recording master clock for the recording signal processor and the drum servo circuit using this time stamp. This master clock is synchronized with the packet time stamp rate. Therefore the recording signal processor and the drum rotation of the VCR are synchronized with the transmission rate of the packet.

Fig. 4 shows the transmission timing of the packet. The packets data received in the half rotation of the drum is recorded in one track.

At playback, the interface circuit of the VCR regenerates the interval of the reproduced packet data using the time stamp and the local oscillator which oscillates the same frequency as the time stamp rate. Therefore the transmission timing is completely regenerated the same as the received timing.

4. Recording Format

The configuration of the packet data depends on the digital broadcasting system. Therefore the VCR adopts several packet configurations. In case that the size of the packet is 188 bytes, one packet data is allocated in two blocks. And, in case that the size is less than 140 byte, two packet data is allocated in three blocks. Fig. 5 shows the block configuration. The block consists of sync. code, ID code, the packet data and error correction codes.

Fig. 6 shows the error correction code configuration. At the MPEG data recording system, an error correction capability is very important. Because, if an uncorrectable error is occurred in the intra frame data at playback, several frames of the data can not be decoded. Therefore we adopt the triply encoded Reed-Solomon code for error correction. The C1 code consists of one block data. The C2 code consists of one track data. And the C3 code consists of 12 tracks data. Fig. 7 shows the error correction

Fig. 5 Block Configuration

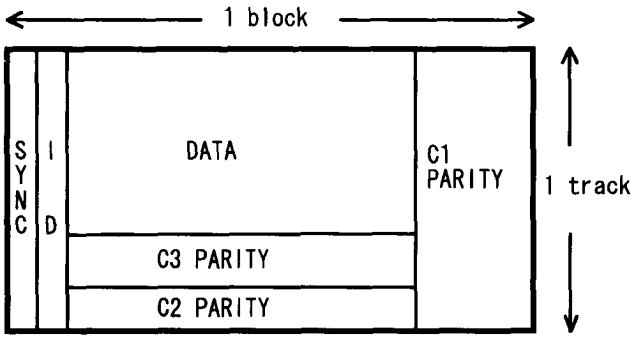

Fig. 6 Error Correction Code Configuration

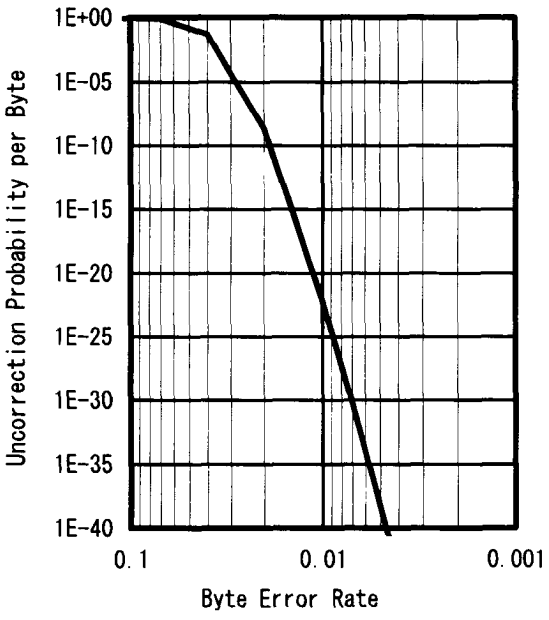

Fig. 7 Error Correction Capability

Fig. 8 Track Format

probability of the random error. An uncorrectable error probability of less than 1×10^{-20} has been obtained when a byte error rate is 1×10^{-2}. Furthermore a burst error of 0.67 track can be corrected.

Fig. 8 shows the track format. A track consists of the auxiliary data area, the packet data area and the subcode data area. This track data are modulated based on scrambled NRZI. Total recording bit rate after modulation is 19 Mbps per channel.

5. Specifications of The VCR

Table 2 shows the specifications of the digital VCR. This VCR has three modes. In any mode, a drum speed is 1800 revolutions per minute.

The mode I is the long play mode. At this mode, a tape speed is 16.68 mm/s. The VCR records two tracks per two drum revolutions. A maximum recording rate is 6.25 Mbps and a maximum recording time is 8 hours.

The mode II is the mode for the current digital broadcasting system. At this mode, a tape speed is 33.35 mm/s. The VCR records two tracks per one drum revolution. A maximum recording rate is 12.5 Mbps and a maximum recording time is 4 hours.

The mode III is the mode for the HDTV digital broadcasting system like the ATV system. At this mode, a tape speed is 66.7 mm/s. The VCR records four tracks per one drum revolution using

Table 2 Specifications of the Digital VCR

Item	Mode I	Mode II	Mode III
Tape	1/2 inch Oxide Tape		
Drum Speed	1800 min^{-1}		
Tape Speed	16.68 mm/s	33.35 mm/s	66.70 mm/s
Number of Heads	2	2	4
Transmission Rate	6.25 Mbps	12.5 Mbps	25.0 Mbps
Error Correction Code	Triply Encoded Reed-Solomon Code		
Modulation Method	S-NRZI		
Recording Bit Rate	19 Mbps/ch		
Track Pitch	29 μ m		
Minimum Wave Length	0.63 μ m		

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