3D HDTV VIDEODISC SYSTEM

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Abstract

We developed new 3D HDTV videodisc System. This system realized high quality picture with two different disc, one for the image coming from the right eye and the other for the left. Each one of the discs records the Hi-Vision signal for each eye. And we use 2 videodisc players which enable synchronized replaying to reproduce 3D images. A 6 tube-type projector with 2 way RGB input is adopted for display. This system is designed to improve the 3D effect and to widen its applicability in various fields.

1. Preface

Recently, thanks to the diversification of the packaged media and the technical development of computers and Liquid crystal device, recording and replaying of 3 dimension scenography have become much easier. As a result, it is widening its applicability in the fields of computer graphics, medical and industrial uses in addition to its use in the amusement fields.

Previously, we have presented the 3D NTSC videodisc system that replays 3D images by time-division multiplexing. Now, we have developed a new videodisc system that is capable of presenting High Definition 3D image even on large scale screens.

This is a report on this new system.

2. Method of Binocular Vision

The primary factor that enables us to see objects stereoscopically is the parallax of our two eyes. As we see objects with our two eyes, about 6 cm apart, two images with a small difference are reflected on our retina. The principle of binocular vision with the effect of parallax is shown in Fig. 1. There are two ways of recording this binocular vision caused by the parallax of the two eyes. One is to double the recording capacity compared to the case of single eye image, and the other is to decrease the amount of the images collected by each eye to half the amount.

Our new 3D HDTV Videodisc System realized high quality picture with two different disc, one for the right image and the other for the left. Each one of the discs records the Hi-Vision signal for each eye. A 6 tube-type projector with 2 way RGB input is adopted for replaying. This system is designed to improve the three dimesional effect and to widen its applicability in various fields.

3. MUSE Hi-Vision Videodisc Player

3-1. Recording Signal Format

The original Hi-Vision signal has so much information that we can not record it on a disc for a long time. The MUSE signal, originally developed for broadcasting via satellite, is being used for effective and long-time recording of discs. It is partially commercialized.

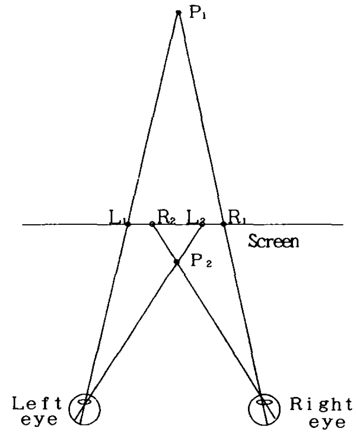

Fig. 1 Binocular Vision caused by Parallax of two eyes.

Table 1 shows the Hi-Vision standard format and Table 2 shows specifications on the bandwidth-compression technique (MUSE) to transmit the Hi-Vision signal.

Scanning lines	1125
Aspect ratio	16 : 9
Interlace	2 : 1
Field frequency	60Hz
Frequency bandwidth (Studio standard)	Y : 30MHz P_b : 30MHz P_r : 30MHz

Table 1 HDTV (Hi-Vision) format

In this Hi-vision disc system, the MUSE signal is frequency modulated. The FM signal, the pilot signal for motor-control at the time of replay, and the digital sound signal are frequency-division multiplexed and recorded. (See Fig. 2) In addition, the sound signal time-division multiplexed within the vertical-blanking-period used at the time of broadcasting via satellite, is also recorded simultaneously.

Major specifications of the recording signal for the Hi-Vision Videodisc are shown in Table 3.

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System		Motion-compensated multiple subsampling system (Multiplexing of C signal is TCI format)
Scanning		1125／60 2：1
Bandwidth of transmission baseband signal		8．1MHz (−6dB)
Resampling clock rate		16．2MHz
Horizontal bandwidth	(Y)	20～22MHz (for stationary portion of the picture) 12．5MHz (for moving portion of the pictire)
	(C)	7．0MHz (for stationary portion of the picture) 3．1MHz (for moving portion of the pictire)
Synchronization		Positive digital sync

Table 2 Characteristics of bandwidth-compressed signal (MUSE)

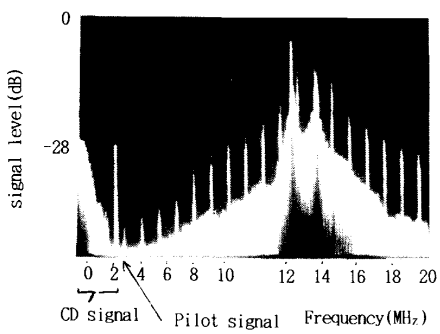

Fig.2 Spectrum of Recording signals on the disc

Video Signal	Recording signal : MUSE signal Modulation : FM FM Allocation : 12.5 ~ 15.5 MHz (Black~White)
Pilot Signal	Frequency : 2.278125 MHz (67.5f_H) Recording Level : -28dB
Audio Signal	(1)Frequency-division multiplexing :44.1kHz, 16bit, 2ch (2)Time-division multiplexing :48kHz, 16/11 DPCM, 2ch or 32kHz, 15/8 DPCM, 4ch

Table 3 Recording signal of Hi-Vision Disc

3-2. Hi-Vision Videodisc Player

To cope with the wider band recording signal, the videodisc player is improved in its performances concerning servo system, rotation speed of disc, and in wide-band characteristics of video circuit. As the sync signal of the MUSE signal is positive, the sync signal can not be separated in a simple circuit. Therefore, instead of the sync signal, the pilot signal, which is multiplxd with the video signal, is used to make Jitter Compensation and to control the disc rotation.

3-3. Specifications of the Disc and the player

With this Hi-Vision Disc player, one-side maximum replay is for 30 min (CLV :Constant Linear Velocity). The disc does not deteriorate even after repeated replay, it can easily be replayed by a relatively compact system, which makes it very useful to a stand alone replaying system.

The specifications of this disc is shown in Table 4 and the specifications of this player is shown in Table 5.

	CAV	CLV
Disc diameter (mm)	300	300
Recording Radius (mm)	95 ~ 145	55 ~ 145
Disc rotation (rpm)	1800	3300 ~ 1250
Linear Velocity (m/sec)	18 ~ 27	18 ~ 21
Tracking pitch (μm)	1.60 ~ 1.65	1.60 ~ 1.65
Recording Time (min/side)	17	30

Table 4 Specifications of Disc

Laser diode	Wave length (nm)	780
	Power (mw)	5
Objective lens	NA	0.53
Tracking detect	Three beam method	
Focus detect	Astigmatic method	
Sensor	PIN photo diode	

Table 5 Characteristics of pickup

4. Synchronized Hi-Vision videodisc player

In order to synchronize the two Hi-Vision videodisc players for presenting 3D video, it is necessary to solve the following three problems.

(1) Sync separation within the player.
(2) Phase-synchronization with the external standard synchronizing signal.
(3) To control the replayed frame address by external command.

This time, we have performed the synchronized play of the two players in the following method, and have realized 3D images.

4-1. Sync Separation

Inside the player, the signal taken out from the disc is frequency modulated and the MUSE signal is demodulated.

But as the sync signal of this MUSE signal is positive, the simple method of sync-separation using NTSC signal is not applicable. In addition, the sync-separation method taking part within the MUSE decoder, is very complex. Therefore, it is difficult to use the sync detector in the simple player.

To solve this problem, we use the address signal which is multiplexed at the beginning of every frame of the MUSE signal. This address signal is bi-phase modulated in each frame and base-band recorded. It can be detected even when the motor-speed of the player varies within ±20%. This time, we have developed and adopted a new address detection IC that enables sync-separation. The block diagram of this IC is shown in Fig. 3. This IC uses the pilot signal as main clock. First, the pilot signal taken out from the disc is transformed into $2f_P$, doubling the frequency in the PLL (Phase Locked Loop) circuit. By dividing this $2f_P$ clock by 135, the horizontal sync-frequency of fH can be obtained. By using the address signal detected from the MUSE signal as the reset signal within this divisor, the horizontal sync-signal HD, which is synchronized with the video signal can be obtained. Accordingly, the detection of the vertical sync-signal VD can also be detected by dividing HD and resetting the divider with the address signal.

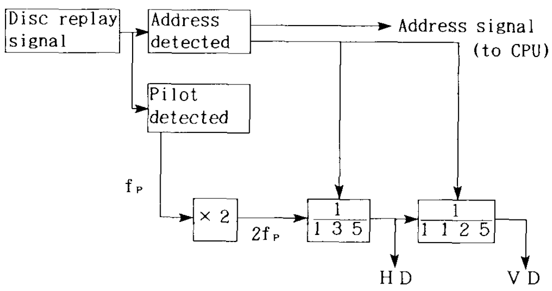

Fig. 3 Block diagram of Sync separation.

4-2. Disc Phase Control by External Synchronization

The phase synchronization of the sync signal of the replayed MUSE signal and the external standard sync signal is done according to the built-in line memory of the TBC (Time Base Corrector) circuit and the spindle motor control. Frame memory is not used as it is not economical. Here, the block diagram of the motor-controlled sync phase circuit is shown in Fig.4.

CLK generator in the player is set to $4f_P$, 4 times the pilot signal. The clock which is made by dividing this clock by 1350 is used for the control of the spindle motor. This clock is equivalent to 1/5 the horizontal sync frequency. The phase comparison between the horizontal sync signal of the disc, taken out by the sync-separation at the IC, and the external standard sync signal, enables the control of the spindle motor.

The phase comparator is equipped with a counter that detects frame phase. The detection is done by means of counting the phase difference of the frame pulse detected from the MUSE signal and the frame pulse of the external standard sync signal. It is counted by the horizontal sync signal. This phase difference is input into CPU to control player. Inside the CPU, the frame phase is advanced or delayed by changing the divisor of the motor control standard clock generator, according to the phase difference. For example, if the dividing ratio is changed from 1/1350 to

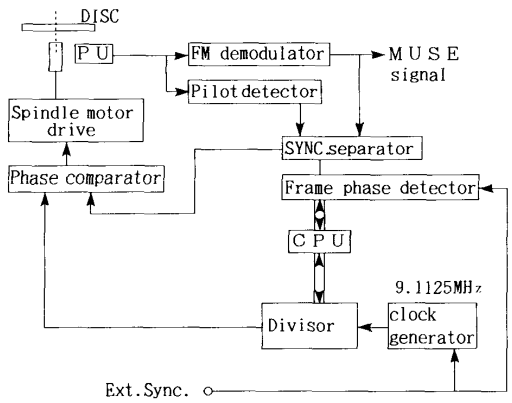

Fig. 4 Disc Phase Control

1/1351, the MUSE signal is delayed by 1125/1350 = 5/6H (H:horizontal sync frequency) per 1 frame. Larger changes of this ratio lead to larger transfer of the phase, but the changes should be kept within the ability of the motor control. Therefore the frame phase transfer is done by changing the dividing ratio 1 by 1 for each frame. And the CPU transfers the frame phase by fixing the pattern of the smallest ratio changes according to the phase difference data. This is done within the range where the dividing ratio returns to 1/1350 in case when the frame phase difference is 0. At the time of maximum frame phase difference, the operation time to synchronize is 1.7 sec.

With this phase transfer operation of the spindle motor, the phase difference of the MUSE signal and the external standard signal is kept below a few μ sec of the jitter range of the motor control. The compensation of this motor jitter is done by the digital TBC circuit.

4-3. Frame Control

The Hi-Vision Disc Player of this system is equipped with RS-232C interface, and the player operation can be controlled externally, such as by a personal computer.

The address signal multi-recorded in the MUSE signal is used for control of the play backed frame.

To synchronize the frame addresses of two players, a controller with a built-in CPU for commanding the operations of these two players will be needed. The two players will be connected by the RS-232C interface.

The flow chart for the parallel operation of two players commanded by this controller is shown in Fig. 5.

First of all, keep the two players in the still position at the start frame. After confirming the agreement of address numbers of the two players, start the synchronized replay using the external play-command. In addition, check the replay-video addresses of the two players using the address request command periodically.

5. 3D System Structure

We have succeeded in solving the three problems and developed a player capable of external synchronization, and applied it to the Hi-Vision 3D system to synchronize the two players. This system are as follows and the structure is shown in Fig. 6.

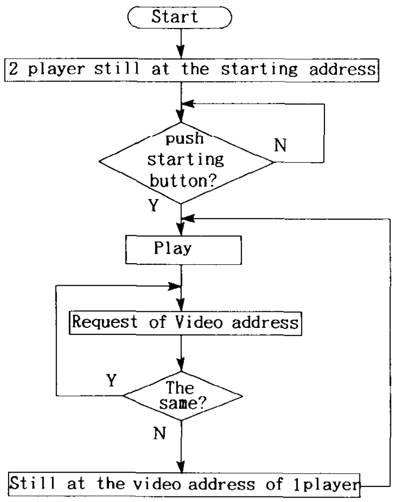

Fig. 5 Frame Control Flow Chart

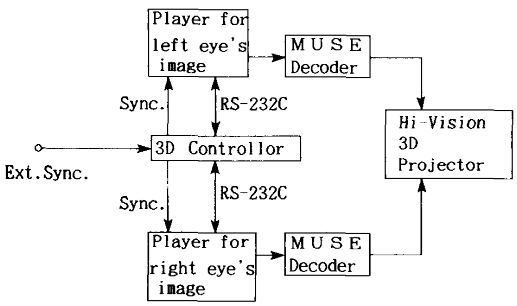

Fig. 6 Structure of the Hi-Vision 3D System

(1) MUSE Video disc and Video disc Player
(2) MUSE Decoder
(3) 3D Controller
(4) Hi-Vision 3D Projector

This system is an application of binocular vision, using two discs each recording the video image for the right eye or left eye. The address number recorded in the two video discs are designed to accord each other at the same time frame. The 3D controller commands the player to replay the frame-synchronized images. These images are passed on to the MUSE decoder where the time-accorded Hi-Vision base-band signals for the right eye and the left eye are obtained.

Specifications of the Hi-Vision 3D Projector is shown in Table 6.

Hi-Vision 3D projector is a 6 tube-type that projects two groups of RGB signals using three CRT tubes for each group. Polarizer is in front of each projecting lense so that the right eye image and the left eye image of different polarized light, are projected. The viewers watch the video on the screen with a polarizing glasses. The left eye sees only the image for the left eye and the right eye sees only the image for the right eye. These two different images are made into a 3D image.

The 3D Video System of NTSC method has already been developed, but this Hi-Vision 3D System provides us better and larger scale 3D video due to improved high resolution and good reproduction of colors.

Input Signal	R,G,B or Y,P_B,P_R
No.of scanning lines	1125
Interlace ratio	2 : 1
Scanning frequency	Horizontal:15.0 ~ 34.0 kHz Vertical :50 ~ 120 Hz
Resolution	Horizontal:800TVlines Vertical :750TVlines
Brightness	270 Ft-L (white peak)

Table 6 Specification of Hi-Vision Projector

6. Practical Use of Hi-Vision 3D System

The Hi-Vision 3D System has many advantageous characteristics such as high resolution and clear images, high-speed accessibility of laser disc players and no deterioration of image quality.
Therefore it is highly applicable in various fields.

6-1. Practical Use in the Medical Field

Today in many cases, video is used for recording surgery. Especially in the domain of micro neuro surgery and ophthalmology where most of the important operations are done under microscopes, video is useful for academic presentations and techniques of operations. But in case of micro neuro surgery which is performed deep in the brain, the 3D video image is of great value. Now, the method of applicating this Hi-Vision 3D is being researched. For example, the micro neuro surgery team of Shinshu University, NHK Enterprise and Sanyo Electric Co. have shown 3D Hi-Vision video using the Hi-Vision projector at The 2nd International Workshop on Intracranial Aneurysm 1989 on Nagoya in Japan and have gained a favorable reception of people from all over the world.

By this method, the precise situations of the operation can later be shown to many more people, which enables wider propagation of operation techniques. The stereo scopic image that can only be seen by those who have taken part in the operation in ordinary cases, can be shown to many other medical student with the video which would be a very effective lecture.

6-2. Applications for Amusements

Recently, many of the exhibitions and fairs take advantages of the theater because they attract many people. Here, the Hi-Vision 3D System would be very effectively used because it can provide high definition pictures even on large scale screens. Above all, the 3D underwater pictures are of excellence, so the audience can experience a feeling just as if they were really in the water.

6-3. Simulation

By watching 3D pictures which have much presence, more advanced and more excellent training can be aquired. This means that excellent technicians can be trained with easier trainings.

7. Conclusion

This time, we have succeeded in developing Hi-Vision 3D System with two MUSE Videodisc Players and a 6 tube-type projector.

The characteristics of this system are as follows;

(1) By using the Hi-Vision picture, excellent 3D video pictures can be presented on large scale screens.
(2) With large amount of video image, high definition 3D images can be expressed.
(3) By using laser discs, long time consecutive video replay is possible.
(4) In case of replaying without 3 D characteristics, long time replay or repeated replay of two different Hi-Vision program can be presented by operating the two players alternatively.

At present, Hi-Vision attracts a great deal of attention as it is a new type of scenography. Much are expected to the future development of its practical uses. The system that we have developed proposes a new possibility of Hi-Vision, and it is one of the significant examples of many practical uses of the Hi-Vision. We can expect larger range of its application by extending the playing time of the MUSE discs and by speeding-up the access speed.

As it has the synchronizing function with others, the video disc player itself is capable of widening its range of applications. For example, it would be easy to compose a Hi-Vision Multi-Screen System.

Last but not least, we deeply express our gratitude to those who have led us and co-operated with us for the development of this system.

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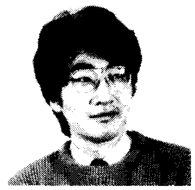

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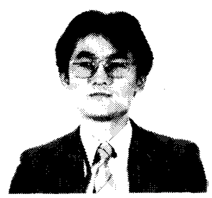

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