A NEW VIDEO SIGNAL PROCESSOR FOR HIGH-END PROFESSIONAL LASERVISION/CD VIDEO PLAYERS

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ABSTRACT

A new IC has been designed to process the signal from the HF photodiode into a standard colour TV signal. The IC, which requires a supply of only 5V, incorporates a number of features necessary for the video signal processing.

INTRODUCTION

In a LaserVision or CD Video player, the information stored on the disc is read using a laser beam. The reflected light falls on a photodetector and converts the modulated light into an electrical HF signal. Demodulation of the signal is separated into audio signal processing and video signal processing as shown in Fig.1. A control unit is also necesary because some of the control functions in the player have to be managed with the highest precision. For example, focusing and tracking of the laser beam and the timing control.

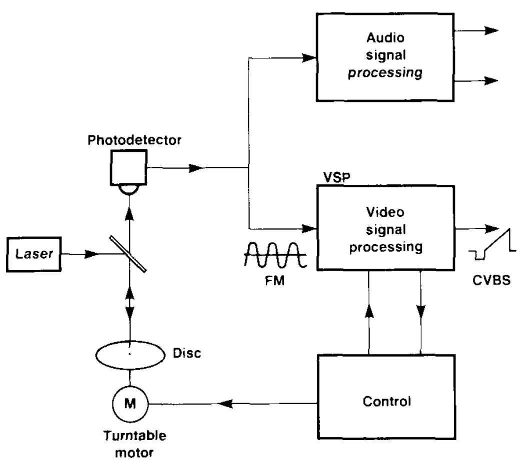

Fig.1 Simplified block diagram of a LaserVision/CD video player

Since home HI-FI and video systems are becoming more and more complex and yet still need to be easy to use, much more complex circuitry is required. This leads to the development of compact circuits with very dense integration.

This paper describes a new Video Signal Processor (VSP) IC we have designed to convert the HF signal from the photodiode directly into a CVBS signal suitable for a colour TV receiver. The bipolar IC requires about 45 mA from a 5 V supply and incorporates the following features:

- MTF compensation
- de-emphasis
- dropout compensation
- noise reduction
- separation of signals for timing control
- picture insertion
- data slicer
- NTSC/PAL system selector

DESCRIPTION OF THE SIGNAL PATH THROUGH THE IC

Figure 2 is a block diagram of the VSP and includes the peripheral circuitry for the video signal processing. The pulse-width modulated HF signal from the pre-amplifier is fed, via a DC-blocking capacitor, into the IC at the input to the Modulation Transfer Function (MTF) circuit which compensates for the characteristic of the optical reading system.

MTF compensation

Due to the finite diameter of the laser beam spot and the tangential velocity of the track of pits on the disc, the MTF of the optical system acts like a disc radius-dependent low-pass filter for the FM input signal. Although the video signal can be recovered without compensation, the ratio of the amplitudes of the chrominance and luminance signals would not then be the same at the innermost and outermost parts of the disc. This can be seen from the simplified frequency spectrum shown in Fig.3.

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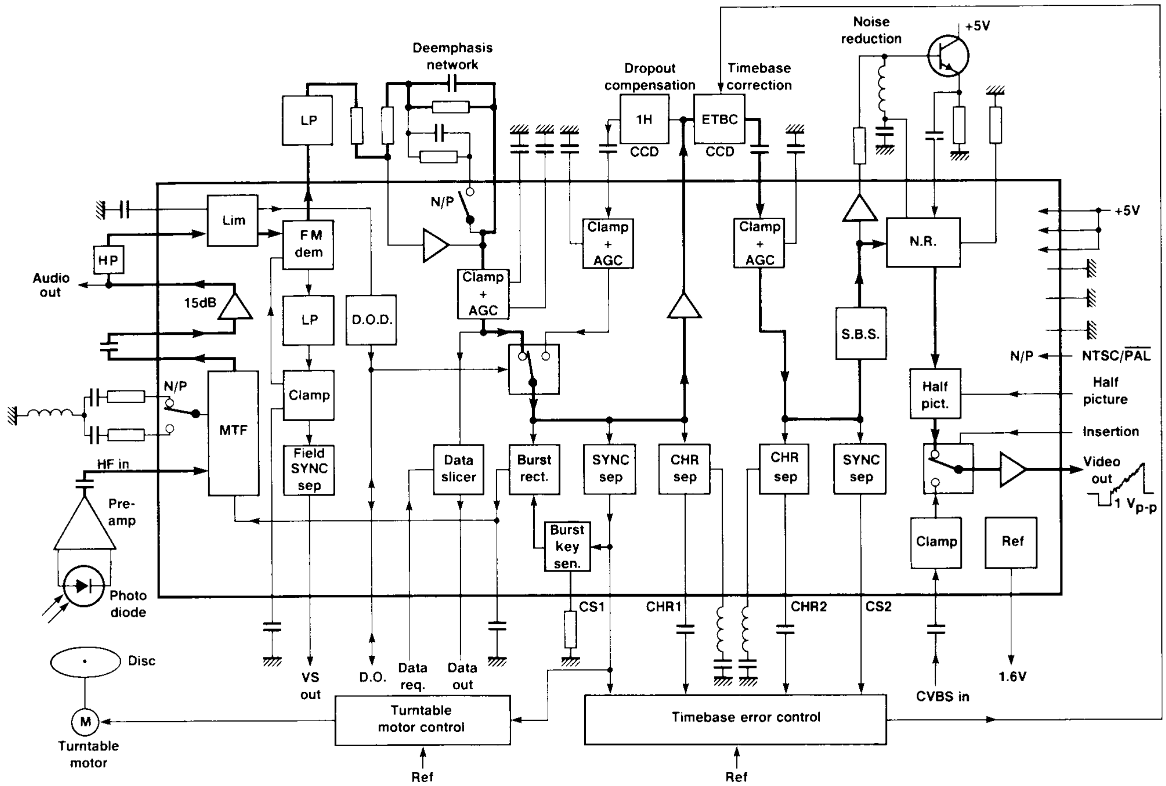

Fig.2 Block diagram of the Video Signal Processor

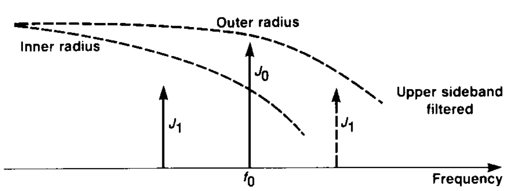

Fig.3 Influence of the MTF on the FM carrier and the first-order sideband

If the magnitude of J_0 (carrier) represents the luminance signal, and the magnitude of J_1 (first order chroma sideband) represents the chrominance signal, it is obvious that the ratio J_1/J_0 is larger at the inner radius than it is at the outer radius. This will demodulate as an increased chroma signal at the inner radius (see Ref).

This influence of the disc radius is automatically compensated by the Video Signal processor. The principle of compensation is to use the deviation of the demodulated burst signal to generate an error voltage to control the frequency selective MTF-circuit. The burst measurement operates as follows; A burst-key generator with an external timing resistor is triggered by the line synchronization pulse (CS1) to generate a burst-key pulse which activates a full-wave rectifier stage during the burst interval of the video signal. The DC content of its output current pulse is directly proportional to the burst amplitude. The error current is compared with a reference current, and the output is fed into an external capacitor.

The integrated error voltage, which is present at the control input of the MTF circuit, increases or decreases until the burst amplitude has reached its nominal level. The selectivity of the MTF circuit is determined by external resonant circuits. In the LaserVision system the carrier frequency in the PAL format is different to that in the NTSC format, so two resonant circuits are required. They are selected by the NTSC/PAL system selector pin.

The resonant circuits are tuned somewhat above the carrier frequency J_0. At the resonant frequency, the gain

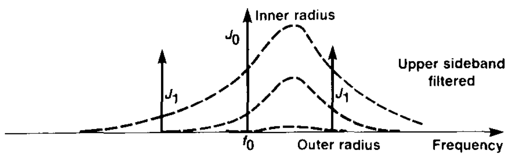

Fig.4 MTF compensation in the Video Signal Processor

of the MTF-circuit is controlled fom 0 to 12 dB by the error voltage. If the external components have a suitable Q-factor, the resonance curve will compensate for the influence of the disc radius. This is illustrated in Fig.4.

The MTF-corrected HF signal is amplified by 15 dB and fed, via an external high-pass filter which removes the audio frequency components from the signal, into the demodulator stage.

Demodulation

The FM signal is first fed into a limiter circuit with automatic slicing level control to suppress the main carrier in the demodulated signal. The demodulator has two outputs. The first clamps the demodulated video signal on tip-sync by controlling the transconductance of the demodulator. The FM signal can now be demodulated during disc start-up, thereby facilitating fast run-in. The second output signal from the demodulator is passed through an external 5 MHz low-pass filter to extract the CVBS signal. The CVBS signal is then fed into the de-emphasis network to compensate for the pre-emphasis of the video signal recorded on the disc.

Field Sync Separator

Referring back to the clamp circuit in Fig.2, a field sync separator is included so that a vertical blanking interval synchronization pulse (VS) can be provided. The frequency of the frame pulse relative to that of the line sync pulses (CS1) allows immediate identification of NTSC or PAL system discs (50/60Hz frame). The player can therefore automatically set its NTSC/PAL system switches without the intervention of the user.

De-emphasis

The de-emphasis circuit consists of an internal inverting amplifier and an external RC feedback network. Since the pre-emphasis on the disc in the PAL format is different from that in the NTSC format, the time-constants must be switchable. We designed an amplifier with an output switch. When PAL is selected, the first arm of the feedback network is active, otherwise both arms work in parallel.

The de-emphasized video signal is fed into an AGC stage where it is clamped on its black level and amplitude-controlled to a constant level. The signal is then fed into the data slicer and the dropout switch.

Data slicer

There are coded signals on the video disc which provide information used by the player to control special functions and provide information about picture frame or running time. These signals are inserted in selected video lines during the vertical blacking interval in a similar manner to the inserted text lines of normal transmitted television (Fig.5). They are extracted by the data slicer when the Data Request input is activated.

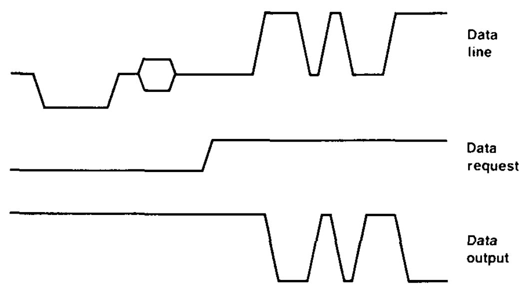

Fig.5 Data separation of the data slicer

Dropout compensation

It's very important for applications to include means of correcting for video disc dropouts. When a video FM-signal is recorded, a disc dropout usually causes one or more missing half-cycles which would be demodulated as a "blacker than black" or "whiter than white" video signal. During playback, this would, for example, be interpreted as a sync pulse.

The dropout detector (D.O.D) in the IC is triggered by every positive or negative transition of the FM signal and detects a dropout when the half-cycle period is outside the limits. Protection against a dropout is achieved by use of a video signal delayed by one line. The signal at the output of the dropout switch is fed out of the IC via a buffer and then through a delaying device (we used a CCD: Charge-Coupled Device) before being fed back into the IC. The delayed video signal appears at the input of an AGC circuit to compensate for gain tolerances of the delay line and avoids the need for an external adjustment. The delayed signal is fed into the second input of the dropout switch. There is thus a video signal at each input of the switch. When a dropout is detected, the dropout detector activates the video switch so that the information in the preceding line is substituted for the dropout.

The dropout pulse is also present at the D.O. pin of the IC and can be used for different purposes. This pin can also act as an input to control the dropout switch externally for test purposes.

Time error compensation

In a videodisc player we are faced with a number of problems caused by the fact that the linear speed of the track isn't constant. The causes of this difficulty are deviations of the rotational speed of the motor, imperfections in the disc and unavoidable tolerances in the centering of the disc on the turntable. Track eccentricity is the main cause of timing errors.

If the centre of the disc is shifted by ΔR with respect to the desired centre, due to incorrect hole punching for example, there will be spurious modulation of the readout signal. This modulated radius is

$$R(t) = R + \Delta R \cos(\omega t)$$

where $\omega = 2\pi f$ is the angular frequency of disc rotation This causes the linear speed of the track to vary with respect to the scanning beam. Since the player/disc combination allows for a maximum eccentricity of 100 µm (only a tenth of a mm !), it can be calculated that the resulting timing error is

$$\Delta t = \Delta R/(\omega R) = 10 \ \mu s$$

where $\omega = 2\pi \ 30$ Hz

R = inner radius = 55 mm.

A television picture consists of lines that have to be written in an exactly defined time interval. Deviations result in a distorted picture and, moreover, in phase errors in the colour signal which might cause loss of colour. A maximum timing error of 5 ns can be permitted to ensure satisfactory performance in combination with any TV receiver, so a reduction of 66 dB is required (see Ref.).

To minimize timing errors, it's necessary in the first place to keep the rotational speed of the disc as constant as possible. Referring back to the output of the dropout switch in Fig.2, the video signal is also fed into a sync separator and a chroma separator with its external resonant circuit tuned to the chroma subcarrier frequency. The phase of the line synchronization pulses (CS1) delivered by the sync separator is compared with that of a crystal-controlled oscillator. The signal derived by the motor speed control circuit controls the turntable motor.

However, with this method it is not possible to obtain an acceptable reduction of timing errors for frequencies of 25 Hz and above. To reduce the errors, use is made of an Electronic Time Base Corrector (ETBC) which functions as a variable delay line driven by an error signal from the Timebase Error Control circuit. The error signal is obtained by comparing the phase of a crystal-controlled reference signal with that of the line synchronization pulses of the video signal. Since the line sync pulses (CS1) delivered by the sync separator are not suitable for making an accurate enough measurement of the time difference, use is made of the 3.58 MHz burst signal derived from chrominance signal CHR1. If the same zero crossing of the burst signal is used in every line, the actual time can be measured with sufficient accuracy.

The video signal leaving the ETBC might still have small timing errors due to residual control error. A second (feedback) loop is therefore required. The video signal is fed into an AGC circuit that compensates for gain tolerances in the ETBC. As in the first loop, the line synchronization pulses (CS2) and the chrominance signal (CHR2) are derived from the video signal by using second sync and a chroma separators. The error signal obtained by comparison in this feedback loop is added to the error signal obtained in the first loop. This timebase correction facility makes it possible to connect the player to any type of TV receiver.

Using the burst signal for accurate measurements is a problem in the PAL format due to its alternating phase. A special 3.75 MHz ($240f_H$) burst has therefore been added to the video signal recorded on the PAL disc. This burst is inserted on the tip level of the line sync pulses. In dual-standard applications, the resonant circuits of the chroma separators should be tuned to 3.67 MHz to ensure good separation of the special burst or the chroma subcarrier. When the timebase-corrected video signal has bypassed the second sync and chroma separators, it reaches the special burst suppressor (S.B.S.) which removes the special burst. The signal is then fed into the noise reduction circuit (N.R.).

Noise reduction

A noise reduction circuit can be used to improve the apparent picture quality of a noisy signal. It works as follows: The timebase corrected video signal is first

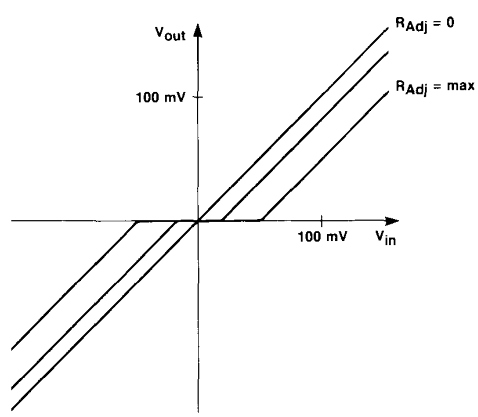

Fig.6 Characteristics of the noise reduction circuit

buffered and then fed into an external network which removes the chroma subcarrier and all the low-frequency components. It is then fed into a limiter which ensures that only small amplitudes (mainly noise) are removed.

The chroma subcarrier trap is switched to either the PAL subcarrier frequency (4.43 MHz) or to the NTSC subcarrier frequency (3.58 MHz) by the NTSC/PAL system selector using the additional small capacitor. An external resistor is included so that manufacturers can select their preferred level of noise reduction, or none at all, by grounding the pin. Fig.6 shows the characteristic of the noise reduction circuit.

Picture insertion

A further feature of the Video Signal Processor is the facility for picture insertion. An example of picture insertion is to superimpose a function display on the TV screen to provide status information at a glance. Also, picture numbers, chapter numbers etc. stored on the disc and extracted by the data slicer and can be displayed on the screen.

The video signal containing the information to be displayed is applied to the CVBS IN input. A clamp circuit ensures that the black level of this signal is the same as that of the main signal from the noise reduction circuit. Both signals are applied to the insertion switch.

When, for example, a character is to be displayed the half picture circuit is first activated to generate a reduced contrast background area around the character. The half picture circuit reduces the amplitude of the video with respect to the black level so that the original picture is still visible. Next, the insertion switch is activated and the character appears at the output. By switching back to the original picture, the procedure operates in the reverse sequence. Figure 7 clearly illustrates the technique. Other examples of the picture insertion facility are displaying a background picture during start-up of the machine or the use of picture-in-picture.

When coloured displays or pictures are superimposed, the phase of the chroma subcarrier of the inserted signal must be synchronized to avoid colour errors. The phase of the burst signal is available at CHR2 to provide the reference.

A buffer is provided at the video output (Video out) which delivers a black-level-clamped CVBS signal, the peak-to-peak amplitude of which is controlled at 1 V.

Reference voltage

A 1.6 V reference is provided by a bandgap circuit with an output voltage which is independent of temperature and supply variations. Internally, all control circuits are provided with this reference voltage. Externally, the voltage can be used for various purposes.

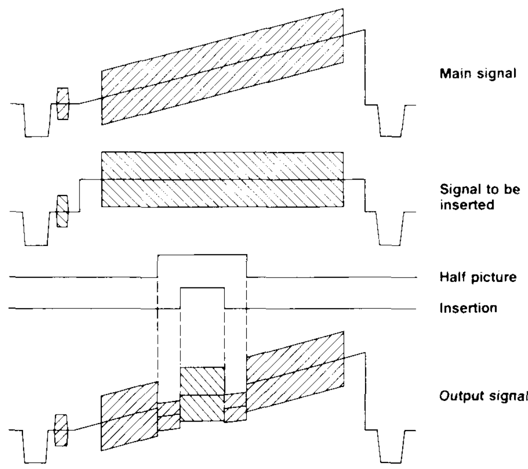

Fig.7 Picture insertion principle

CONCLUSION

The Video Signal Processor we have designed is a compact IC which forms the heart of a high-performance and yet low cost circuit for future CD video and Laser-Vision players.

REFERENCE

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Biography

Günter Hildebrandt was born in Bremervörde, West Germany in 1957. He received his Dipl. Ing. degree in Communications Engineering from the Fach-hochschule of Hamburg in 1984. Since then he has been a member of the Philips Semiconductor Factory in Hamburg designing bipolar integrated circuits.