SIGNAL PROCESSING FOR A VIDEO DISC SYSTEM (VLP)

G. C. Kenney
Philips Laboratories
Briarcliff Manor
A. H. Hoogendijk
N. V. Philips' Gloeilampenfabrieken
Eindhoven. The Netherlands

Introduction

The Philips VLP, Video Long Play, is a system for storage and playback of a 30 minute color television program on a plastic disc similar to a gramophone record (figure 1).

Fig. 1

All necessary video and audio information is encoded on a single spiral track consisting of pits or depressions in the plastic surface as shown in the microphotograph, figure 2. With the recording technique employed, the only signal encoding parameters are pit length and spacing.

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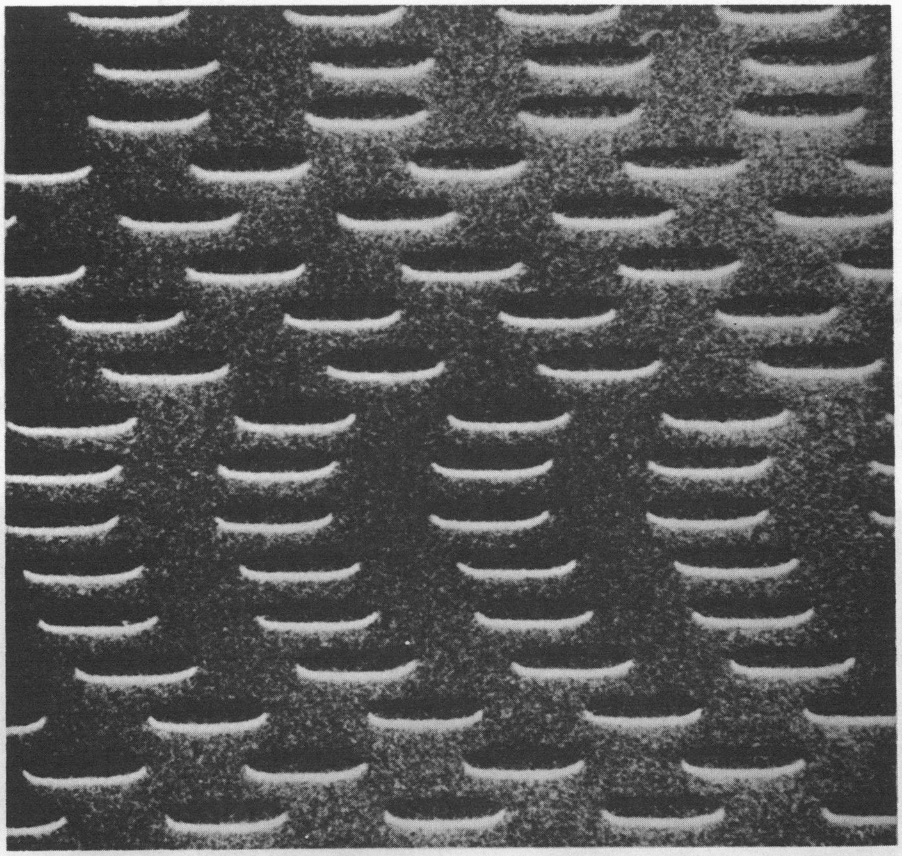

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Fig. 2

Fig. 3 shows a diagram of the VLP player. The reflectively coated plastic disc rotates at 30 RPS, while the complete pick up unit moves on rails below it to follow the spiral track. Since the complete optical system including servos for tracking and focusing has already been adequately described ,
a further discussion will not be included here.

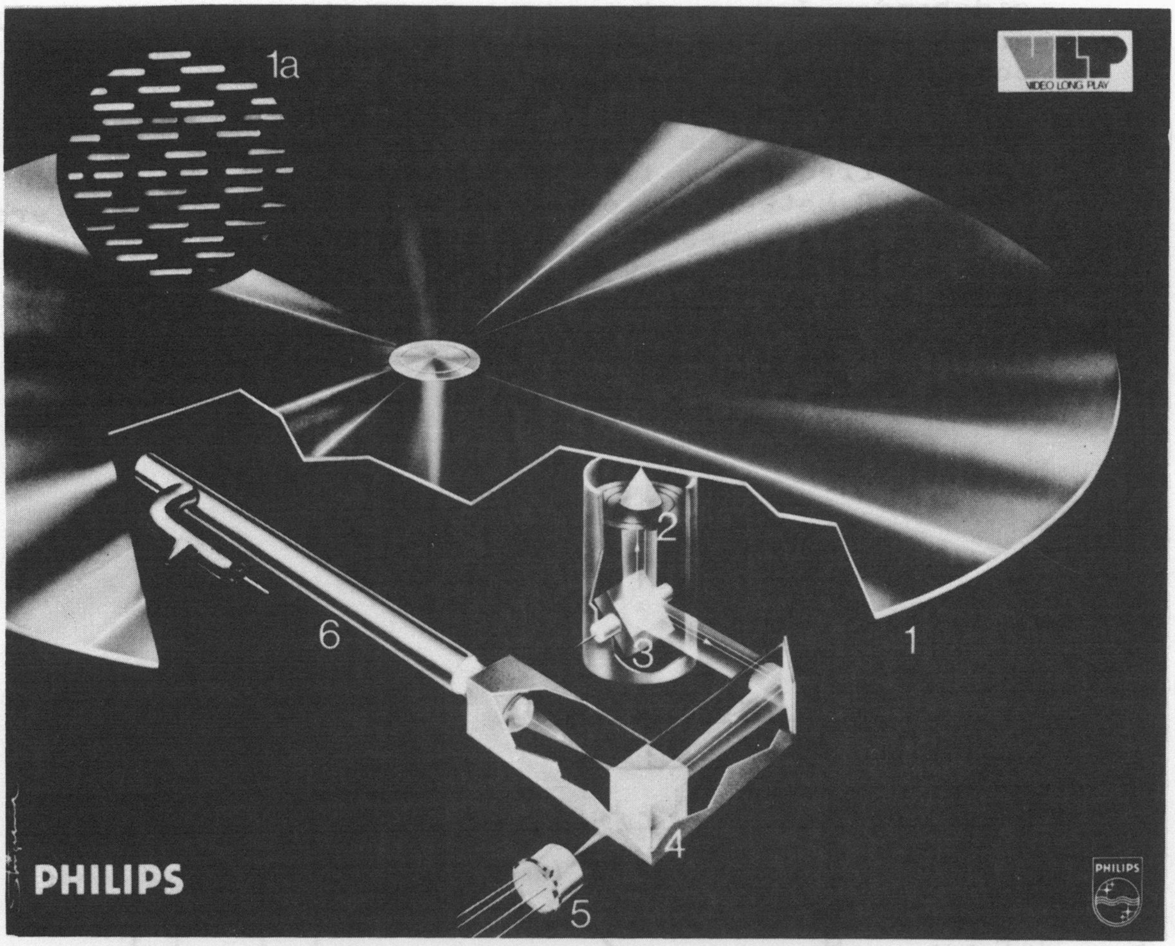


Fig. 3

A spot of light scans the track and the reflected light is modulated by the pit pattern. The modulated light falls on a photo diode whose output, after processing, yields a color picture suitable for viewing on a normal T.V. set.

Recorded spectrum

The available recording spectrum of the VLP disc is not too different from that of a good quality video tape recorder, and therefore the reasons for choosing the recording techniques here employed are well known [2].

Figure 4 shows the recorded spectrum on the VLP disc for the NTSC crossband system. A crossband system of special color and luminance recording similar to the Philips Video Cassette Recorder (VCR) was choosen [3]. The luminance, Y, bandlimited to 3.2 MHz, frequency modulates a 6.5 MHz carrier. The sync tip is 5.6 MHz and peak white frequency of 7.0 MHz. The modulation index is small enough that only the first lower sidebands, J_1, are important, leaving a free spectral area below 3.3 MHz. The color is first seperated by combing from the luminance, band limited to 1 MHz, and then translated onto a lower frequency carrier for recording. The choice of this special color carrier frequency, 1.68 MHz, represents a subtle trade off between color noise and luminance interference as will be discussed later. A color pilot, .56 MHz, and two high fidelity FM audio channels at .425 and .7 MHz are also recorded.

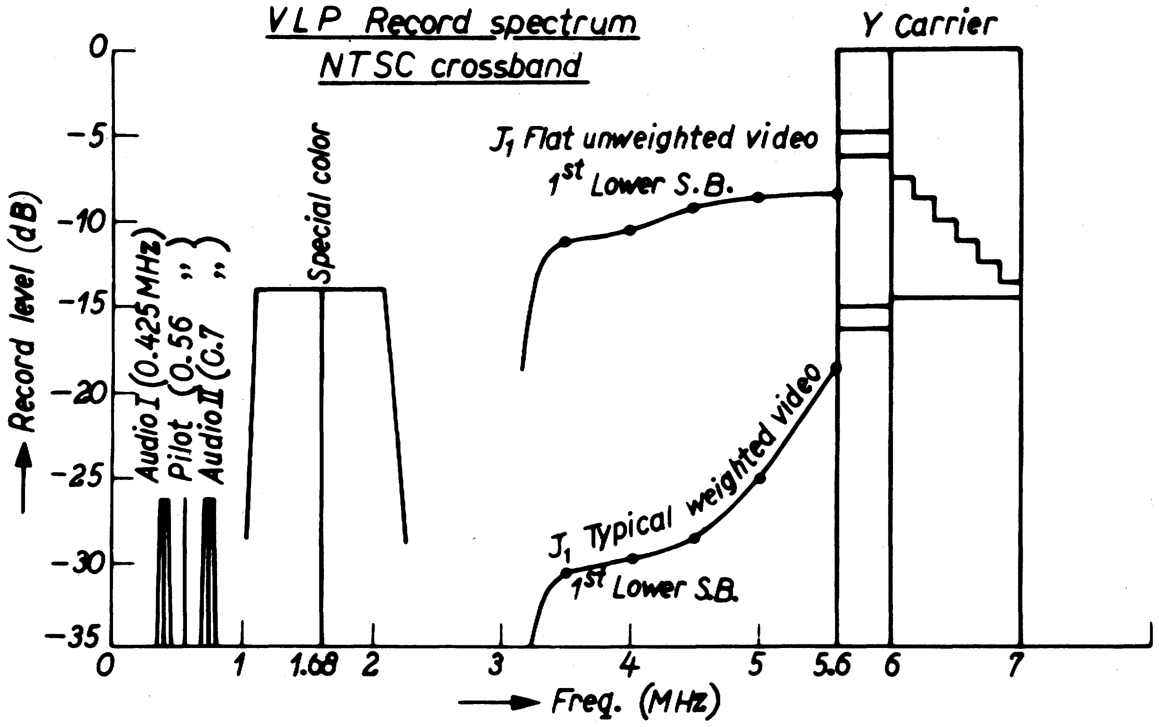
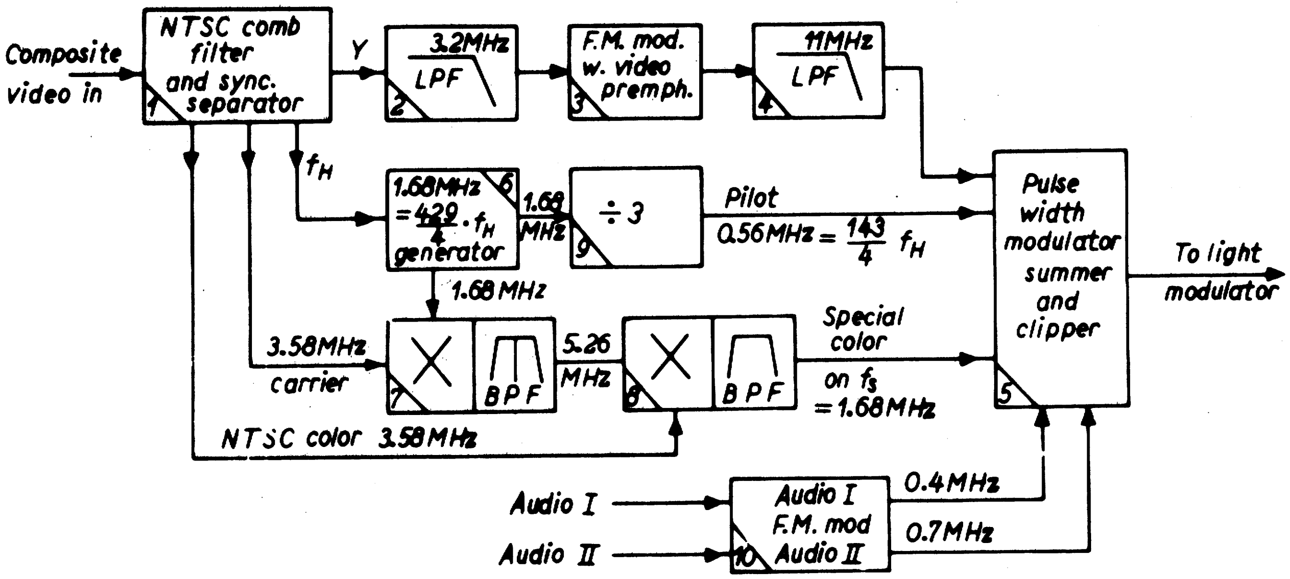


Fig. 4

The audio, pilot, and special color are summed with the luminance F.M. signal. The resultant signal is then symmetrically limited giving the amplitude ratios as shown in figure 4. This clipping gives rectangular pulses in which the luminance is contained as frequency modulation and the color and sound contained as pulse width modulation. Such a signal with all the information present in its zero crossings is suitable for recording the pits on the VLP disc.

Record Signal Processing



Block diagram NTSC crossband record

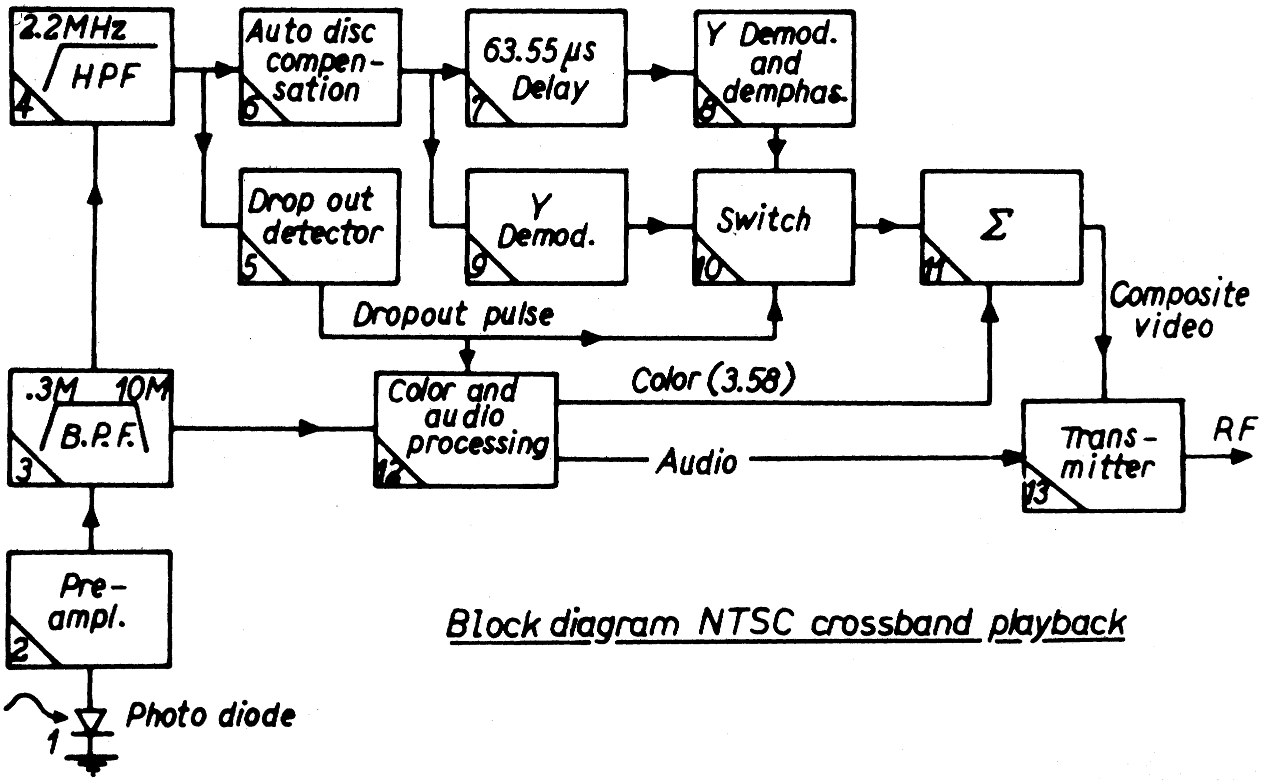
Fig. 5

Figure 5 is a block diagram of the record signal processing. A key element is the Comb filter (1) which allows separation of the luminance and color without band limiting. Normal filtering techniques would require a luminance bandwidth below 2.8 MHz for good color rejection. A video premphasis of .318 us and .106 us is employed before FM modulation (3). After luminance modulation, the F.M. signal is bandlimited to 11 MHz (4) so as to make the signal almost sinusoidal. This makes it easier to pulse width modulate the carrier and also reduces the 2nd harmonics of the F.M. modulator.

The normal 3.58 MHz color must be translated to a new carrier of 1.68 MHz = 429/4 f_H. This is accomplished by mixing (7) a 1.68 MHz carrier (6) with the 3.58 MHz carrier yielding a 5.26 MHz signal. The 5.26 MHz is then mixed (8) with the normal color (3.58 MHz) resulting in a special color on the desire frequency, 1.68 MHz. At this point the special color is also band limited to 1 MHz. The pilot frequency .56 MHz is 143/4 f_H and is derived from the 1.68 special carrier by three dividing (9). The audio channels are F.M. modulated (10) on carriers of .425 MHz and .7 MHz. A frequency deviation of ± 50 KHz and premphasis time constants of 50 ms. are choosen similar to the European F.M. broadcasting standards.

The two audios, pilot, and special color are summed with the F.M. carrier and then clipped in the pulse width modulator (5). The output, whose spectrum is figure 4, is then used to intensity modulate a light beam during the disc mastering process.

Playback Signal Processing



Block diagram NTSC crossband playback

Fig. 6

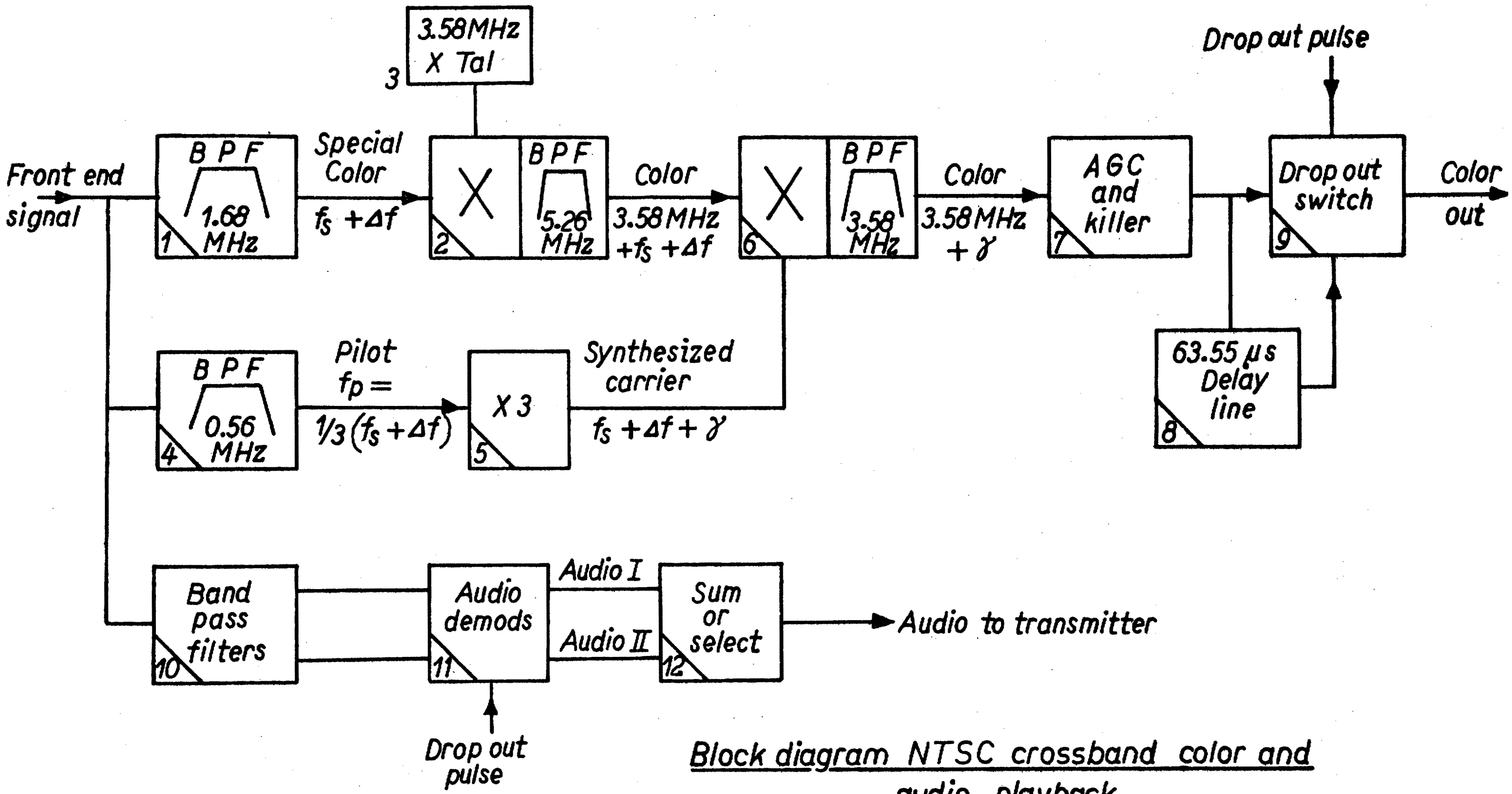
Light reflected from the disc falls on a photodiode whose output signal must be processed for final viewing on a monitor or television set. Luminance and sound demodulation, color retransformation and phase correction, and picture fault or drop out correction are the most important operations.

Figure 6 is a block diagram of the luminance processing. After preamplification (2) of the photodiode (1) output, the signal is band limited (3). The signal is then split such that frequencies above 2.2 MHz (4) are used for luminance decoding, and those lower for audio and color decoding (13). Because the amplitude and phase characteristics of the disc are not ideal, compensation (6) is desirable to give a better luminance S/N ratio and a more uniform frequency response. The amount of compensation is automatically controlled by the ratio of the carrier to pilot amplitude such that variations from track to track and disc to disc are minimized.

After compensation, the F.M. signal is demodulated (9) by the pulse counting technique. The same F.M. signal is delayed one horizontal line time (7) and then again demodulated.

A luminance switch (10) normally selects the undelayed luminance except during the presence of a dropout or picture fault. During a dropout, the switch selects the delayed channel for 3 us. The detection (5) of dropouts can be accomplished in many ways either by monitoring the F.M. signal or the demodulated luminance or both. The dropouts are caused by distorted or missing edges of the F.M. signal. The sensitivity of a dropout detector is generally related to its complexity and length of time required for detection. A realistic compromise of 200 ns to detect a 50 IEEE unit video fault is employed. Detectors sensitive to 10 IEEE faults with delays of 800 ns are realizable, but more costly.

The luminance is now ready for summation (11) with the color to reform composite video. The video and audio are then feed to a RF transmitter (13) whose output is suitable for viewing on a normal television.



Block diagram NTSC crossband color and audio playback

Fig. 7

Due to the eccentricity and speed variations of the disc during playback, the special color information is not on exactly $f_s = 1.68$ MHz, but $f_s \pm \Delta f$. The color playback electronics shown in fig. 7, correct this error and retranslate the color to its normal 3.58 MHz carrier.

The pilot is extracted from the front end signal by a narrow bandpass filter (4) on .56 MHz. It is desirable to limit the bandwidth to less than 7 KHz to minimize disturbing interference components at half the horizontal line frequency. After filtering, the pilot frequency is $f_p = \frac{1}{3}(f_s \pm \Delta f)$. A times three multiplier (5) yields a carrier of $f_s \pm \Delta f + \gamma$, γ being the phase error between this synthesized carrier and the actual special color. These residual errors, γ, can be attributed to the group delay of filter (4) and the multiplier (5). By proper design γ is minimized to provide nearly complete color correction. There are alternate ways to derive, f_s. Either the horizontal sync edge or the special color burst could be used to derive a synthetic color subcarrier $f_s \pm \Delta f + \gamma$. It can be shown[4] however that the min γ for use of a single sync pulse is 25°. The γ for burst lock derivation is tolerable but there are other disadvantages, such as side locking and increased susceptibility to dropouts.

The special color on a carrier frequency of $f_s \pm \Delta f \cong 1.68$ MHz is extracted by means of a bandpass filter (1). This color is mixed (2) with a stable 3.58 MHz (3) resulting in color on a carrier of 3.58 MHz + $f_s \pm \Delta f \cong 5.26$ MHz. This color is now mixed (6) with the synthesized carrier at $f_s \pm \Delta f + \gamma$. The resulting color is on a proper NTSC carrier of 3.58 MHz with some residual phase error γ. For semi-professional use γ is less than 10°.

The color is now gain corrected (1) and then fed to a dropout switch (9). The color input to the color dropout switch is the color delayed (8) from the last field line. The operation is similar to the luminance correction except that the switch is held on longer as the color dropouts are lengthened due to the smaller bandwidth of the color filters. The output color is now ready for summation with the luminance to form composite video suitable for viewing.

The audio decoding employs standard bandpass filtering (10) and demodulation (11). During a dropout the audio is held for the duration of the disturbance. After demphasis the disturbance is smoothed over. The two audios are either summed or selected (12) for combination in the T.V. transmitter. If seperate audio playback equipment is available, both audio channels may be used to produce stereo sound.

Choice of special color carrier

As stated, the special color carrier, f_s, is choosen to be an odd quarter multiple of the horizontal line frequency, f_H, i.e. $f_s = \frac{429}{4} f_H \cong 1.68$ MHz.

The choice of the carrier frequency and its relationship to the line frequency represents a trade off between playback color noise and luminance interference.

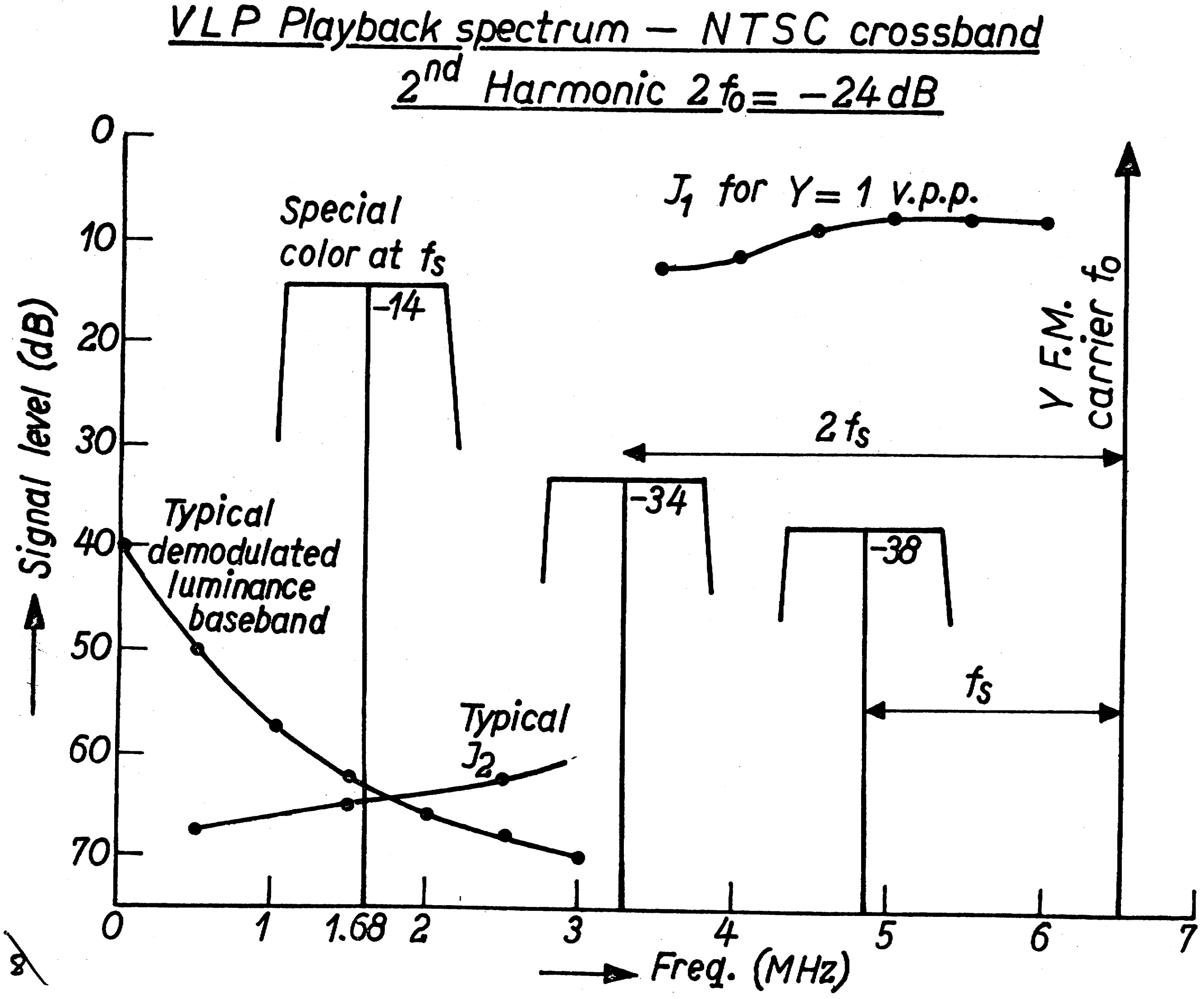


Fig. 8

Figure 8 shows a playback frequency spectrum with interference in the color and luminance areas. Due to the nature of pulsewidth modulation two unwanted side bands appear in the luminance F.M. spectral area at frequencies of $f_o \pm f_s$ and $f_o \pm 2 f_s$. (f_o= luminance F.M. carrier).

These side bands demodulate into the luminance at interfering frequencies of f_s and 2 f_s. Both interferences are dependent on the recorded level of the special color, but f_s is also strongly dependent on the 2nd harmonic of f_o. To minimize the visibility of f_s and 2 f_s, odd/quarter line locking for f_s was choosen which gives odd/half line locking for 2 f_s. If odd/half line locking is choosen for f_s, then its visibility is minimized even further; but the 2 f_s interference will be line locked and maximally visible.

One can therefore appreciate that the choice of special color subcarrier frequency, f_s, and the type of locking employed are not independent. If $\frac{1}{2}$ line locked f_s is choosen, the 2 f_s interference must be sufficiently out of the playback luminance passband to insure reduced visibility. With careful filtering and/or band reject trapping, it is possible to tolerate a line locked 2 f_s interference at 4 MHz. Therefore a $\frac{1}{2}$ line locked f_s is only advantageous at frequencies above 2 MHz, while $\frac{1}{4}$ line locking is best below 2 MHz. The pilot is also choosen to be $\frac{1}{4}$ line locked for the same reasons.

When the 2nd harmonic distortion is sufficiently controlled and the recorded color level is less than 14 dB below the level of f_o, then the f_s visibility is tolerable.

A second problem resulting from second harmonic distortion is the unwanted demodulation of luminance baseband components which can contaminate the special color as well as the audios and pilot. In this case odd/half line locking of the f_s is the best because it will serve to minimize the visibility of luminance side bands in the color. Since the average luminance energy decreases rapidly above 1 MHz it is desirable to choose the color, f_s, as high as possible with the obvious restriction of spectral separation from the lower luminance F.M. side bands. Also, one must be careful of interference from the 2nd lower F.M. side bands, J_2, especially with video premphasis.

When these color and luminance disturbances are controlled, then the crossband system can provide for suitable recording of a color picture using less bandwidth than a direct composite recording.

Alternate Recording System

Parallel to the development of the above described system, Philips has been evaluating possible alternate recording formats. Our aim is to provide a high quality picture and sound compatible with reasonable playing time (i.e. 30 mins). In general the alternate systems require more bandwidth, and therefore all other things kept equal yield less playing time.

One obviously attractive recording format is to directly encode the full composite video on to an F.M. carrier of say 7.5 MHz. This system coupled with time base correction by tangential servos and/or electrical means (variable delay lines) is presently under consideration as a possible alternative to the crossband system.

The authors wish to thank the members of VLP team especially Erik Schylander for their efforts on the NTSC crossband system.

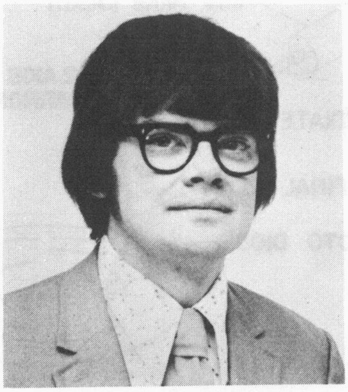
References

1. P. Kramer and K. Compaan, "T.V. Programs on the Disc", IEEE Technical Paper Session 39, May 26-30 1973.

2/3. Van den Bussche, Hoogendijk, Wessels, "Signal Processing in Philips "VLP" System", Philips Techn. Review 33, 181-185, 1973 No. 7.

4. S.M. Edwardson, "Digital Timing Correction of Video Tape Recorded Colour Television Signals", IERE Conference No. 26, July '73.

BIOGRAPHIES



George C. Kenney

George C. Kenney, Electronic Engineer, has been with Philips Laboratories, Briarcliff Manor, New York, since 1970. He earned his BSEE degree from Rensselaer Polytechnic Institute, Troy, New York, in 1966 and his MSEE degree from Stanford University, Palo Alto, California, in 1968. His principal fields of interest at Philips Laboratories have been analog and digital circuit design and video systems design.

His other experience includes the management and technical supervision of the development of a line of computer-controlled digital measuring instruments. He also developed a system for increasing the recording density of disc and drums utilizing auto-correlation recovery techniques and has designed VHF counters and time interval meters.

Mr. Kenney was formerly Project Manager, Ardis Inc.; Manager, R & D Laboratory (and co-founder), Digital Measurement Co., and Staff Engineer Frequency and Time Division, Hewlett Packard Co.

Mr. Kenney holds a patent and has several pending. He is also the author of four publications and is a member of Tau Beta Pi and Eta Kappa Nu.

A. H. Hoogendijk

A. H. Hoogendijk, a member of the Audio Group, N. V. Philips' Gloeilampenfabrieken, Eindhoven, The Netherlands, received a bachelor's degree in electronics from Hilversum Institute in 1959. At the present time his responsibility in the Audio Group is signal processing for the PAL system of the Video Long Play program.

Between 1963 and 1972 Mr. Hoogendijk performed similar work for VCR color tape recorders and other video tape recorders.

Mr. Hoogendijk is a co-author of an article appearing in the *Philips Technical Review*, Vol. 33, No. 7, 1973, entitled "Signal Processing in the Philips VLP System."

*Philips Laboratories, Briarcliff Manor, New York.

**N. V. Philips' GloeilampenfabrieKen, Eindhoven, The Netherlands