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VIII

THE MARK VIII COLOUR CAMERA—APERTURE CORRECTION FACILITIES

INTRODUCTION

This article continues the detail description of the Mark VIII Colour Camera Channel. After an examination of the principles of Aperture Correction and 'Combing', the article describes the manner in which the various correction functions have been implemented.

APERTURE CORRECTION

All television camera tubes suffer from aperture loss which gives rise to a lack of definition in the picture. The effect is normally attributed to the finite size of the scanning electron beam in the tube. However, optical scatter and charge redistribution on the target can also contribute to this loss of definition.

Correction for aperture loss has been applied in the horizontal direction for many years, but the application of vertical aperture correction is a comparatively recent innovation. Figure 1 shows one method of producing a correction signal. A signal E_0 is fed to a pair of identical delay lines connected in tandem. The second line is terminated in its characteristic impedance so that there is no reflection. The output from the second line (E_2) and that from the first line (E_1) are combined to form the correction signal as indicated in the diagram. The frequency response of this arrangement has the form $(1 - \cos \omega t_D)$ where ω is the input angular velocity and t_D the delay of the lines used. The circuit shown can be used for both horizontal and vertical correction, but the delay times involved are three orders different. Also, the horizontal corrector is only used below or just past the first response maximum, whereas the vertical corrector operates over some hundred or more maxima. However, in the case of horizontal correction it is convenient to use just one delay (Fig.2). Here E_1 is supplied by the collector current of VT1 after passing through the delay line. VT2 supplies the E_0 signal directly and E_2 is the part of the current that has travelled down the delay line and then returned to the terminated end after a further delay. The output signal of this circuit consists of the original signal plus an amount of correction set by RV1. This type of corrector gives the symmetrical (equal preshoots and overshoots) correction that is required to compensate for aperture loss.

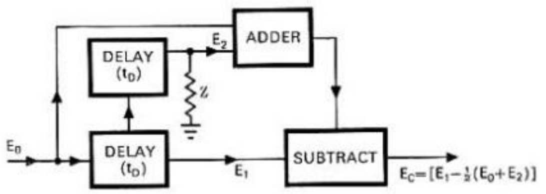

Fig.1(a) Basic Aperture Corrector.

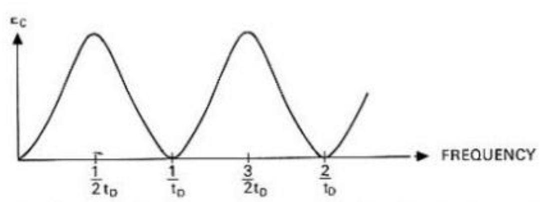

Fig.1(b) The frequency response of the circuit shown in figure 1(a).

When performing vertical correction the delay time required is one television line period, approximately 64μs. This necessitates the use of sonic delay lines made from special glass, suitable transducers being fitted to generate and receive the sound wave. Due to the nature of these delay lines it is, unfortunately, impossible to use just one line, and the circuit arrangement is therefore as figure 1. A vertical correction signal is formed by comparing detail in one picture line with that in the lines preceding and following it. This principle is demonstrated in figure 3. The height of each of the series of lines represents the signal amplitude found in a vertical cross-section of part of a single television field. The time interval between each of the lines is one television line period. By delaying the original signal (E_0) by one line period the signal E_1 is obtained (this signal will normally be used as the main uncorrected signal). After a further delay E_2 is obtained. The correction signal E_c is formed by combining E_0, E_1 and E_2 as indicated in figure 1. Referring again to figure 3, E_c is shown four times the

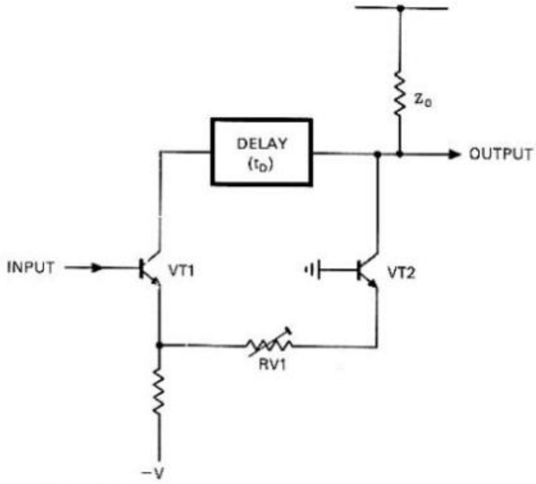

Fig.2 Basic Horizontal Aperture Corrector

correct amplitude for clarity. This signal represents the line-to-line differences in the vertical detail in the picture. It can be seen from the lower part of figure 3 that the addition of the correction signal to the uncorrected signal has enhanced the vertical detail.

COMBING

For the purpose of the following explanation a television signal will be taken to consist of short bursts of energy at frequencies ranging from a few kilohertz to the upper limit of the video band. It is inevitable that some of these bursts of information will have frequencies lying within the band of colour subcarrier frequencies. These are decoded at the display device and give rise to the spurious colour signals known as cross-colour. It is obviously desirable to remove or at least reduce this effect. One method of decreasing cross-colour is to employ a notch filter, but this technique tends to give more loss of definition than is desirable. A better method of improving cross-colour effects is that which has become known as 'combing'. The circuitry is made to function as a comb-filter with

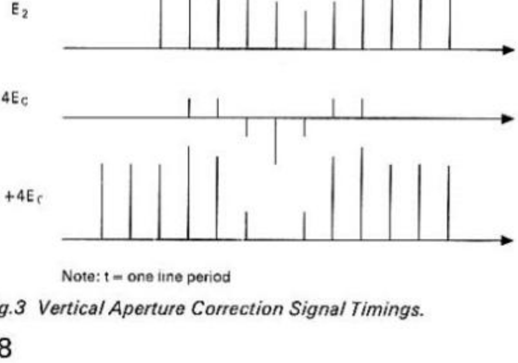

Fig.3 Vertical Aperture Correction Signal Timings.

response maxima at all line harmonics – hence the name combing. The circuit required to achieve this is as shown in figure 1 except that all signals are added so that the circuit output is $V_{out}=\frac{1}{2}\left(E_1+\frac{1}{2}(E_0+E_2)\right)$.

Other writers[1] have explained the operation of combing using Fourier Analysis. While this method is very instructive, it is felt that the following may be more easily understood without a need to appreciate the complex harmonic structure of a television signal.

First it is necessary to consider the cause of cross-colour and the effect of a pattern of vertical bars having a repetition rate equal to that of colour subcarrier must be examined. Figure 4A shows such a pattern with a NTSC subcarrier superimposed for comparison. As can be seen the phase of the bars shifts 180° relative to the subcarrier on alternate lines. For NTSC the pattern will be decoded giving complementary colours on alternate lines. The result is that, to a large extent, the cross-colour tends to be self-cancelling.[2] If, however, the bar pattern is slanting, as in figure 4B, it is possible for it to be exactly in phase with subcarrier. This will then give rise to clearly visible cross-colour effects. In the case of PAL the relationship between subcarrier and line period is rather more complex and it is sufficient to say that vertical patterns will give cross-colour but the cancellation is better than for NTSC. Again, slanting patterns give rise to strong cross-colour for the PAL system. In general it is the patterns which exhibit vertical detail which give the most objectionable cross-colour and there is obviously a range of spacings and angles which can give this effect. As already mentioned, the 'combed' signal is made by adding the delayed signals used to produce vertical correction. Referring again to figure 4B, if E_0 is considered to be line 3, E_1 will be line 2 and E_2 line 1. At the instant when the scanning beam has reached section line AA, E_1 will be high, E_0 and E_2 will be low. If signals are displaced equally above or below some arbitrary level V by an amount V1 then the output will be $V_{out}=\frac{1}{2}\left(E_1+\frac{1}{2}(E_0+E_2)\right)=\frac{1}{2}\left(V+V1+\frac{1}{2}(2V-2V1)\right)=V$.

It can easily be seen that this holds for any point while the pattern is being scanned. It follows that the pattern has completely disappeared from the output signal and has been replaced by a level equal to the d.c component. This cancellation will exist whenever the input signal to the comb filter fulfils the condition that its phase shifts by half a cycle on alternately scanned lines. If the signal appears in the same phase on each line the output will be a maximum. Output levels for signals which fall between these two extremes may be calculated by performing the appropriate vector addition.

Another feature of the combing circuit is that, as the noise in the E_0, E_1 and E_2 is uncorrelated, the output noise power is reduced. If we take the noise power of each signal as unity we have:

$$\text{Total noise power}=\Sigma\,(\text{noise voltage})^2$$
$$=\tfrac{1}{2}^2+\tfrac{1}{4}^2+\tfrac{1}{4}^2=\tfrac{3}{8}$$

that is, a 4·26dB improvement.

It may appear at this stage that the combing is

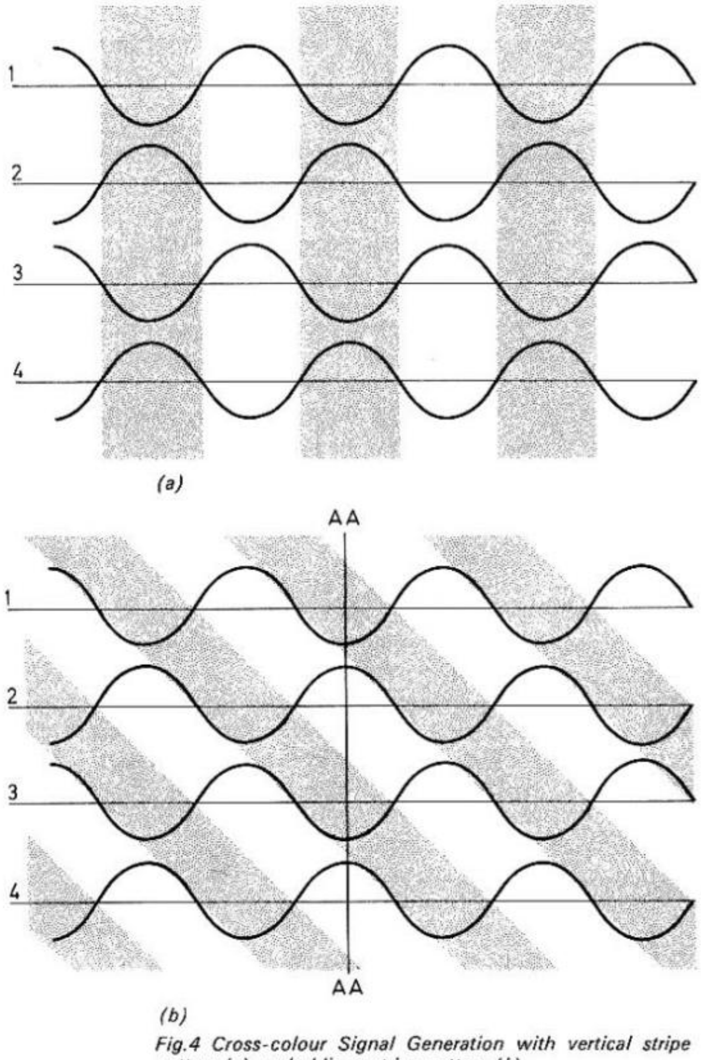

Fig.4 Cross-colour Signal Generation with vertical stripe pattern (a) and oblique stripe pattern (b).

also removing vertical detail where this may be undesirable. However, it will be seen later than the operating bandwidth of the combing is restricted.

IMPLEMENTATION

General

Occupying a 2in (5cm) deep tray and drawing its power from the main power supply unit, the corrector is fully integrated into the camera control unit. All circuitry is on plug-in printed wiring boards. The corrector not only provides aperture correction, but also performs the separation of high-frequency detail essential to the signal processing system which the Mark VIII utilizes.

The circuitry has been divided into simple blocks which do not interact. It is therefore possible to change any block without readjustment within any of the other blocks. A block diagram of the corrector is shown in figure 5.

First Horizontal Corrector

Wideband video signals from the video A board (after corrections for cable loss and flare, and the adjustment of lift and Master Black level) are first passed to the Horizontal Corrector board. The corrector is a delay line type as already described with the circuit shown in figure 2. The delay time is 50ns giving a theoretical first response maximum at 10MHz. Correction to give up to 12dB boost at 5MHz is available. After correction, a.g.c reference pulses are added (the a.g.c system is to be described later), and the signal is d.c clamped before feeding to the modulator.

Modulator

Because the glass delay lines are not capable of being used over the normal video bandwidth it is necessary for the video signals to modulate a 20MHz carrier. Amplitude modulation has been chosen for this purpose as it gives the best noise performance in this application. The crystal oscillator which feeds the modulator is mounted on the modulator board and the whole is screened to decrease radiation. The modulator itself is of simple design giving excellent linearity and stability. All components are preset and should not require adjustment during the service life of the unit.

Line Delay System

As already explained, it is necessary to delay the video signal by two complete line periods to produce the vertical correction signal. To do this sonic delay lines made from glass are used. This type of delay has an attenuation of between 50dB and 60dB when operated over the wide band needed. It is thus necessary to drive the sonic lines at a reasonably high level to avoid a noise problem at the receiving end. The r.f drive to the line has therefore

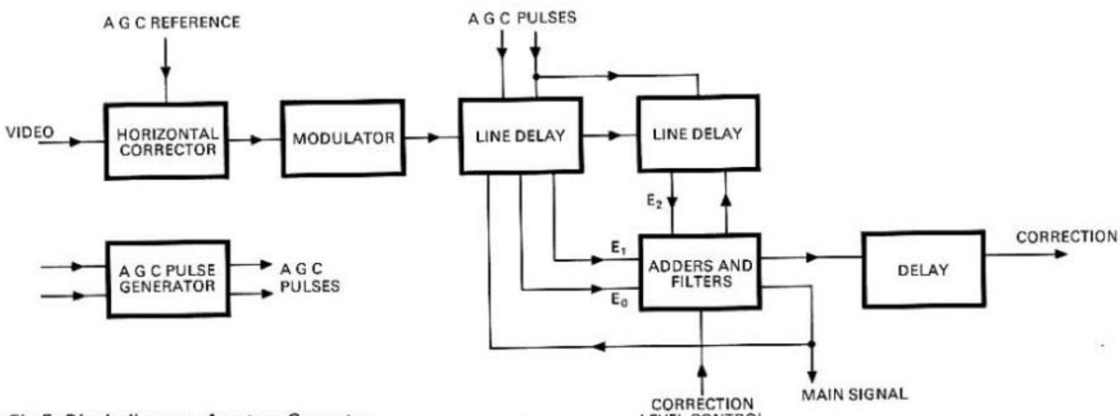

Fig.5 Block diagram, Aperture Corrector.

been made as high as possible consistent with power requirements and physical size of the driving transistors. The drive of 10V peak-to-peak then gives approximately 10mV at the receiving end of the line. The r.f signal is amplified by a pair of integrated circuits and then fed to the demodulation circuits. Automatic gain control (a.g.c) is achieved by detecting the level of the reference pulses inserted on the horizontal corrector board. The a.g.c feed is taken at the Main-Signal (low-frequency) output and the error signal is applied to the integrated circuit r.f amplifiers. Extremely good stability is thereby obtained. The sonic delay lines are cut so that the delay is very close to one television line period, thus eliminating the need for introducing any significant delay external to the sonic lines for trimming purposes and minimizing any 'third-time-round' effects. Because of this it is necessary to take the undelayed E_0 signal from the r.f line driver and demodulate. A simple tapped delay line is included on the board to take up tolerances in the glass delay line. The two line delay boards used in the corrector are identical, but in the case of the second delay the a.g.c maintains a correct balance on the vertical correction signal. There are two editions of delay board, one for 625-line working and the other for 525-line systems.

Adders and Filters

A block diagram of this board is shown in figure 6. The one-line-delayed (E_1) signal is passed through a phase-corrected 1·5MHz low-pass filter and becomes the MAIN Green video which is fed to the Matrix unit. A feed for the a.g.c system is taken at the output point of this signal. The vertical correction signal is formed by a combination of E_0, E_1 and E_2 signals as described previously. The correction signal is fed to a 1·5MHz low-pass filter and also to the a.g.c system of the second line delay board. The 'combed' signal formed by the addition of E_1, E_2 and E_0 is passed via a level dependent (black clipping) circuit to the HIGHS extractor and the In-Band Peaker circuit. The filter used in the HIGHS extraction is identical to that used in the MAIN signal path. Thus a high-pass characteristic, which is the exact complement of the MAIN signal characteristic, is obtained. The in-band peaker circuit is another horizontal corrector of the type shown in figure 2. Here the delay is 140ns and this gives a correction peak at 3·6MHz. It is intended that this corrector is used to give the picture added sparkle and that the first horizontal corrector (10MHz peak) is set to give a flat response with the in-band peaker switched out. The signal from the peaker is fed via a delay line to time it correctly before addition to the vertical correction. The combined correction signal is first connected to a coarse level control and then to a remotely controlled amplifier. The gain of this amplifier, and hence the amount of correction, may be controlled from the camera remote control panel. A maximum of 12dB vertical and 6dB in-band correction is available. Another level dependent circuit is inserted after the control amplifier so that the system signal-to-noise ratio may be improved. The signal at this point swings equally positive and negative about its mean level and the circuit is designed to remove the centre 'core' from the signal. The correction signals are then combined with the Combed Highs and fed to the CORRECTION DELAY board. This board makes the necessary timing correction to allow for the delay of the MAIN signal in the masking and other circuits prior to addition of HIGHS.

CONCLUSION

By careful design and by the use of a.g.c, extremely good gain stability has been obtained. The unwanted delay line 'third time round' effect has been

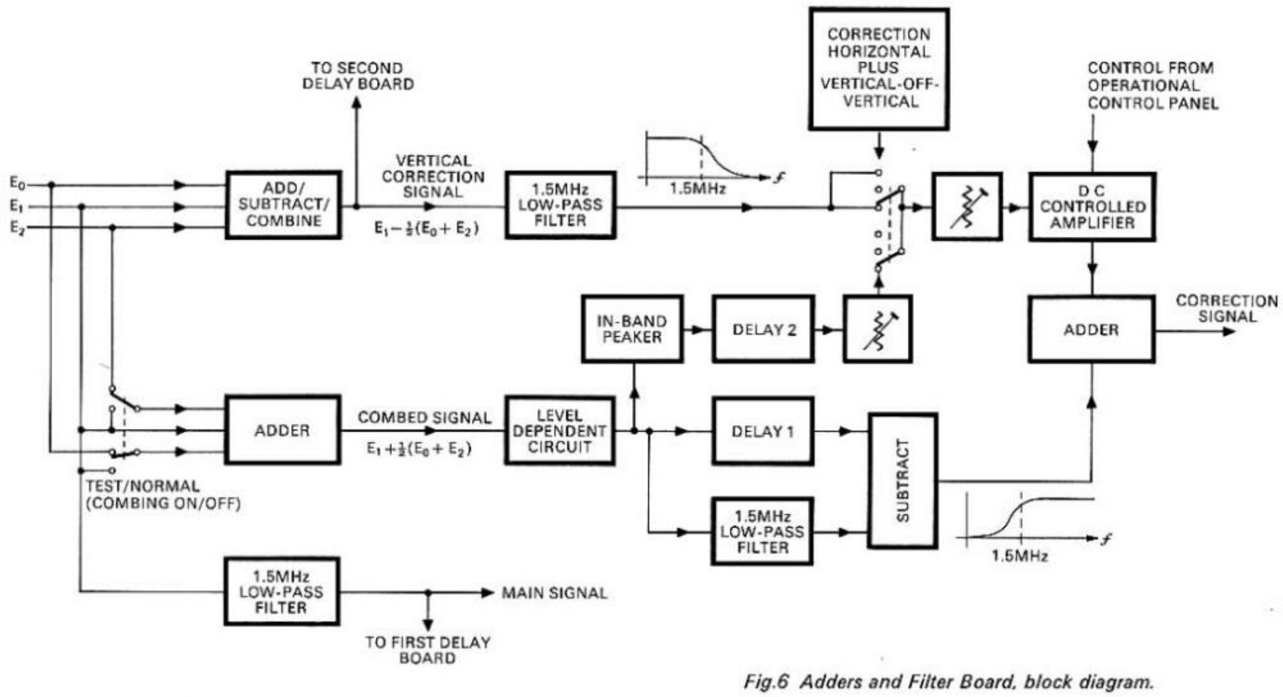

Fig.6 Adders and Filter Board, block diagram.

reduced to negligible proportions by optimizing the delay line design and by choosing a delay almost exactly equal to the line period. The signal-to-noise ratio of the corrector, which is excellent, is further increased by the wide-band 'combing' employed. The over-all design concept has been to make the equipment simple to operate, and the complicated maintenance procedure sometime associated with this type of unit has thus been illiminated.

REFERENCES

1 R. R. Brooks and W. J. Cosgrove: Combed Aperture Equalization for Colour Television Cameras: *Journal of the SMPTE*, January 1970.

2 P. S. Carnt and G. B. Townsend: *Colour Television*, Vol.2, ch.8; Iliffe Books Ltd.