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INTEGRATED CIRCUIT COLOUR CODER

INTRODUCTION

The first point in a television station at which a colour signal in a form suitable for transmission appears is at the output of a coder. Since the station output can be no better than the coder output it is critical to achieve an exceptionally high standard of performance in the coder. Performance here is to be understood in its widest sense, including (*inter-alia*) stability, reliability and simplicity of operation. The new Coder being described utilizes modern components, including integrated circuits, to achieve an improvement on existing designs.

CONSTRUCTION

The mechanical construction is shown in figure 1. Occupying only 1·75in of 19in rack space the coder may be withdrawn on its integral sliding runners and in this position the unit may be tilted either upwards or downwards. Thus excellent access is provided, both to the circuitry, which is contained on five printed boards which are mounted horizontally on either side of the central metal chassis plate, and to the power supply.

All setting-up controls are mounted on the printed boards which are readily accessible when the unit is withdrawn on its runners. The block diagram, figure 2, shows the basic circuit functions of the PAL version and the way in which the unit is split into its four printed circuit boards, the fifth board being the colour bar generator which will be discussed later. The main frame of the coder is common to both NTSC and PAL colour systems, the two systems being catered for by changing the printed boards.

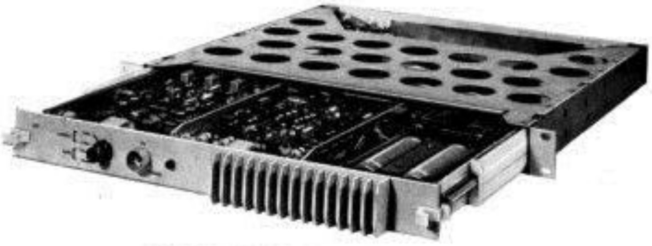

Fig.1 The B3373 Colour Coder which occupies only 1.75in of 19in rack space.

Although linear integrated circuits at present available do not in general lend themselves to their use in video amplifiers, integrated circuit monolithic modulators have shown themselves to be superior to diode ring modulators. Digital integrated circuits have proved invaluable in the pulse circuitry, for it is most unlikely that features such as the colour bar generator, internal PAL V axis switching signal generation and internal NTSC burst gating pulse generation could have been included in a unit of this size had integrated circuits not been used.

MATRIXING

The matrix follows fairly conventional practice, sealed relays being used to select either the camera inputs or the colour bar inputs. These are followed by a high input impedance, unity gain, isolation amplifier which drives the matrixing resistors, as shown in figure 2. A simplified circuit diagram of the matrixing amplifier is shown in figure 3. The low impedance presented by the emitter of VT1, which is further reduced by negative feedback, means that any one matrixing resistor will not be affected by the presence of the other two resistors. Thus the matrix coefficients are almost entirely a function of the resistors, which are 0·1% tolerance and of low temperature coefficient, since the resistor values can be made many orders of magnitude greater than the amplifier input impedance. This arrangement has the further advantage that the frequency response is not affected by the high resistor values.

In the formation of the U and V signals for PAL it is convenient, and makes for considerable simplification, to add a burst pulse at the matrix in addition to the red, green and blue signals. This technique cannot be used for NTSC since the two components of burst which in this case would be on the I and Q signals are, unlike PAL, filtered to dissimilar bandwidths. This would result in a burst the phase of which changes during the rather long rise and fall times.

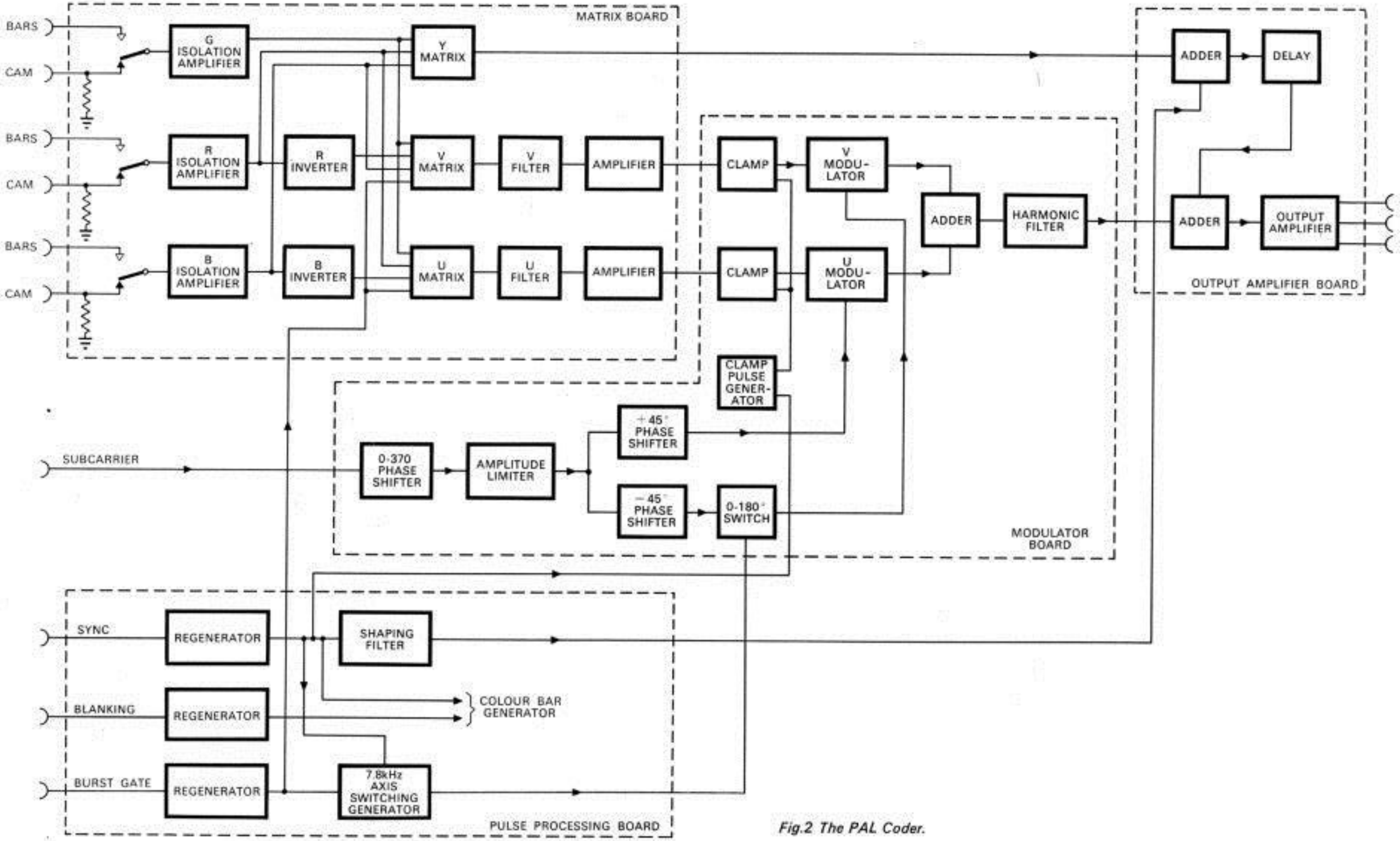

Fig.2 The PAL Coder.

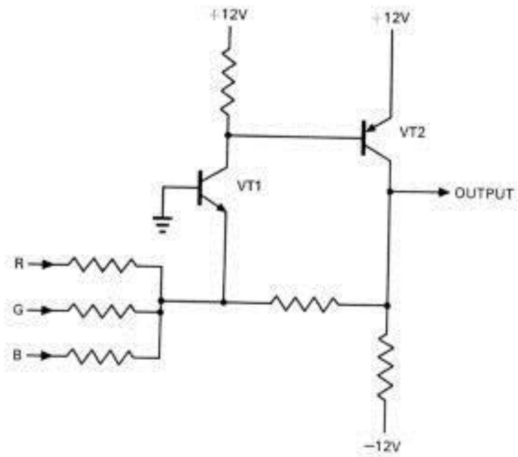

Fig.3 Matrixing Amplifier.

The colour difference signals formed in the matrix, U and V for PAL, I and Q for NTSC, are then passed through band limiting filters according to the system specification. The PAL filters have a Gaussian amplitude characteristic together with an almost linear phase characteristic, resulting in a well shaped pulse response with almost no overshoot.

The NTSC I channel specification calls for a filter with a sharper cut-off than for PAL which results in a pulse response with some overshoot. A single section constant k filter is used together with a phase correcting network which redistributes the overshoot by introducing some preshoot. The constant k section comprising the Q filter is not phase corrected since this would result in a relatively long overall coder delay approaching 2μs, which is considered unacceptable. The filtered I signal is then delayed so that it is time coincident with the Q signal. The two components of burst pulse are then added to the I and Q signals to form a resultant burst at the output in the −(B−Y) phase.

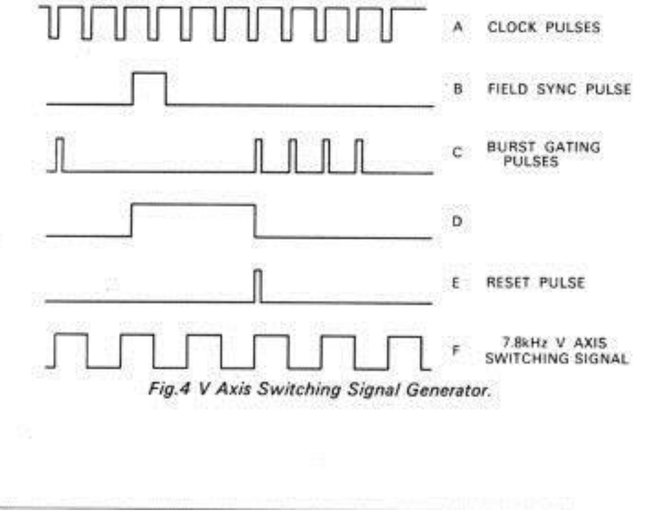

Fig.4 V Axis Switching Signal Generator.

SUBCARRIER

The colour subcarrier is passed through a 0° to 370° phase shifter. This consists of a coarse adjustment in 90° steps and a continuous adjustment with a range of 0° to 100°, thus giving an overlap at each step of coarse adjustment. In order to define the subcarrier level driving the modulators, an amplitude limiter is incorporated following the phase shifter. This allows a range of subcarrier input levels to be accommodated without adjustment. After limiting and filtering to a sinusoid the subcarrier is split into two paths, one via a +45° phase shifting network to one modulator and the other via a −45° phase shifting network to a phase reversing switch operating at half line frequency and thence to the second modulator.

The two colour difference signals are clamped during line blanking to establish a d.c level corresponding to zero carrier. The clamping action is performed by a field effect transistor. This has an 'on' resistance of about twenty ohms and has the advantage over conventional bipolar transistor clamps that, provided gate current does not flow, there is no offset voltage which can vary with temperature and hence change the clamping potential. A temperature compensated emitter follower follows the clamp to provide the necessary high input impedance and the low output impedance to drive the modulator.

After a careful evaluation of both the diode ring and integrated circuit modulators it was found that the latter had considerable advantages. The subcarrier and modulating signal drive power requirements are considerably lower. Balance may be adjusted with one control compared with four or five controls used in a ring modulator since it is usually necessary to balance the diodes resistively and capacitively. Carrier balance is much more stable with temperature due to the close matching and good thermal tracking inherent in a monolithic device. The modulators are followed by a harmonic filter which has particularly high attenuation at the second harmonic of sub-carrier frequency. The presence of significant amounts of second harmonic in the output waveform may make accurate setting up of the coder difficult, particularly if the 'twitter' method referred to later is used for setting quadrature.

The modulated chrominance subcarrier is fed to the output amplifier where it is added to the luminance signal which has been delayed by a lumped-constant delay line to bring it into time coincidence with the narrow-band chroma signals. The two signals are added in a resistive pad driven from low impedance sources, thus eliminating level dependent phase and gain problems which can be introduced by some adding systems. The only part of the coder handling the composite colour signal is the output amplifier which provides three source terminated outputs at standard level into 75 ohms. This is a high input impedance feedback amplifier with a shunt regulated emitter follower output stage.

PULSE PROCESSING

The pulse inputs to the coder, i.e blanking, sync

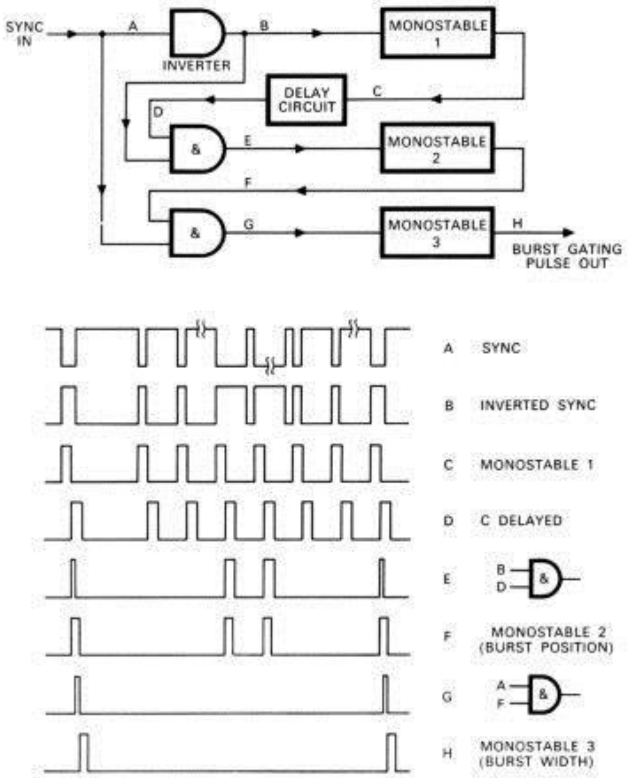

Fig.5 Burst Gating Pulse Generator (Field sync interval drawn with reduced number of equalizing and broad pulses).

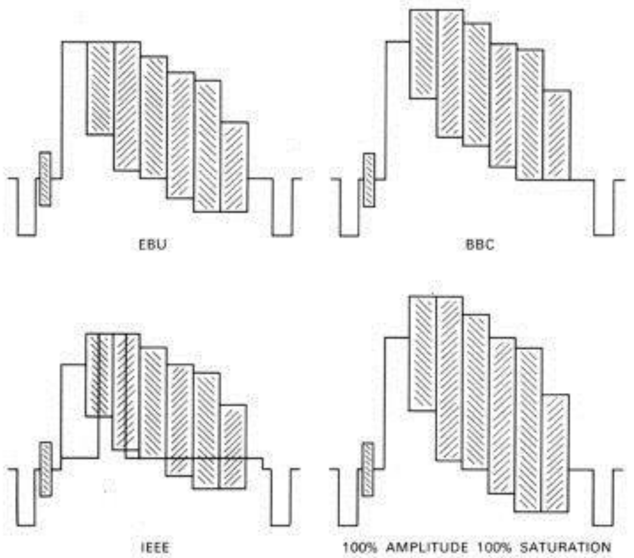

Fig.6 Coded waveforms obtainable using built-in Colour Bar Generator.

and burst gate, or in the case of NTSC blanking and sync only, are processed to remove hum and to ensure that any variations of input level do not appear as changes of level at the output. The pulses are also shaped to an approximate sine squared form before addition to the output signal. An external feed of PAL V axis switching signals is not required as this is generated internally using information contained in the burst blanking sequence to establish the correct sequence. Apart from the obvious simplification in pulse distribution, internal generation of the switching signal has the advantage that the unit does not have to be designed to cater for both the 7·8kHz square wave widely used in the United Kingdom and the 7·8kHz pulse used in Europe. The axis switching signal is generated by a bistable which is clocked by line-frequency pulses derived from syncs. In establishing the correct sequence of the bistable, use is made of the fact that the first burst of each field is always in the same phase and corresponds to the +V direction. A pulse corresponding to the first burst gating pulse of each field is derived and used to reset the bistable. The resetting operation will only occur immediately after switch-on or if the synchronizing pulses are interrupted. A block diagram together with associated waveforms is shown in figure 4.

In the NTSC version of the coder the burst gating pulses are generated internally from the incoming synchronizing waveform thus simplifying pulse distribution and timing. Figure 5 shows the waveform produced to eliminate the burst pulse during the field sync interval. Incoming synchronizing pulses trigger a monostable multivibrator having a period longer than equalizing pulse width but shorter than line sync pulse width. These pulses are then delayed and gated with syncs to eliminate the equalizing pulses, the pulses produced being used to trigger a further multivibrator.

The trailing edge of the pulse generated by the second multivibrator corresponds to the leading edge of the burst gating pulse. These pulses are then gated with syncs to eliminate field sync information and the resultant output is used to trigger a third monostable multivibrator which determines the width of the burst gating pulse. Integrated circuit monostables are used for the above functions which result in a burst with an exceptionally stable position and width.

COLOUR BAR GENERATOR

A colour bar generator is built-in to the coder and is capable of generating bars to any one of four standards with the option of a split-field display on any one of these standards, some of the more common variations being shown in figure 6. The bars are derived from the outputs of a synchronous counter which consist of four bistables, one being for each colour and the fourth for either black or white depending on the bar standard chosen. Provision is made for stopping the colour bars during the lower quarter of the picture and replacing them with a white pulse on a black back-

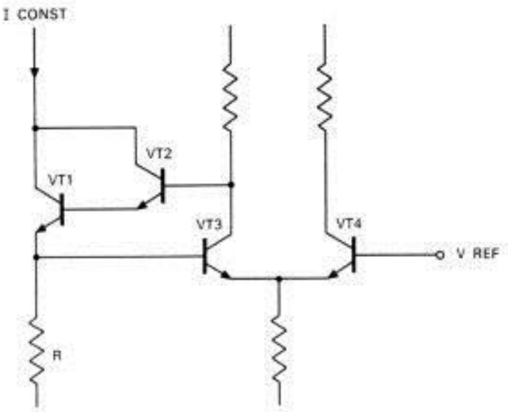

Fig.7 Constant Current Generator.

ground. There are no setting up controls on the colour bar generator, apart from one which adjusts bar width, the output levels being determined by the current from high accuracy constant current generators flowing in precision resistors. The currents through the resistors are switched on or off by the outputs of the synchronous counter which uses transistor-transistor logic elements, via diodes. Several current sources may be switched with various waveforms through a common load resistor using this technique, the limit being reached when the sum of the diode leakage currents becomes significant compared with the current sources.

The circuit diagram of the current generator is shown in figure 7. The current through R, which approximates very closely to the combined collector current of VT1 and VT2 because of the Darlington connection, produces a voltage across R which is compared in the long tailed pair comparator VT3 and VT4 with a reference voltage.

Transistors VT3 and VT4 are on a common substrate which results in very close matching of the base-emitter voltages and good thermal tracking. The circuit thus provides a constant current source the accuracy of which is almost entirely dependent on the resistor R which is a precision metal film type, and the reference voltage. The voltage reference is common to all the current sources in the colour bar generator and is derived from the −12V supply which is regulated by an integrated circuit voltage regulator containing a temperature compensated voltage reference.

SETTING UP

All setting up of the coder can be carried out using an oscilloscope or waveform monitor. After adjustments of carrier balance and white balance have been made, the quadrature can be adjusted using the 'twitter' method on a colour bar signal. It can be seen from the diagram of figure 8 how the vector amplitude corresponding to a particular colour will change in amplitude from line to line as one axis is alternated if a quadrature error is present. If the oscilloscope is suitably triggered the colour bar display will appear to 'twitter' until the quadrature error is adjusted to be zero. The PAL system lends itself to this method since one axis is always alternating in phase whereas in the NTSC system the alternation is introduced solely for setting up. The amplitudes of the U and V or I and Q signals relative to luminance can be adjusted such that the positive excursions of the envelopes of the yellow and cyan bars are at the same level, and the negative excursion of the envelope of the green bar is at black level.

The burst phase in PAL does not require any adjustment, the angle between succeeding lines being determined by the matrix resistors. Since in NTSC the burst pulse cannot be introduced in to the matrix for reasons explained earlier, it is introduced after the filters and a burst phase control is necessary. For setting up purposes, however, a burst pulse can be added at the matrix using precision resistors and this can be arranged to cancel the transmission burst when the burst phase control is correctly adjusted. To enable this adjustment to be made more easily, provision has been made for temporarily widening the burst pulse to avoid any problems due to the slow risetime of the Q channel.

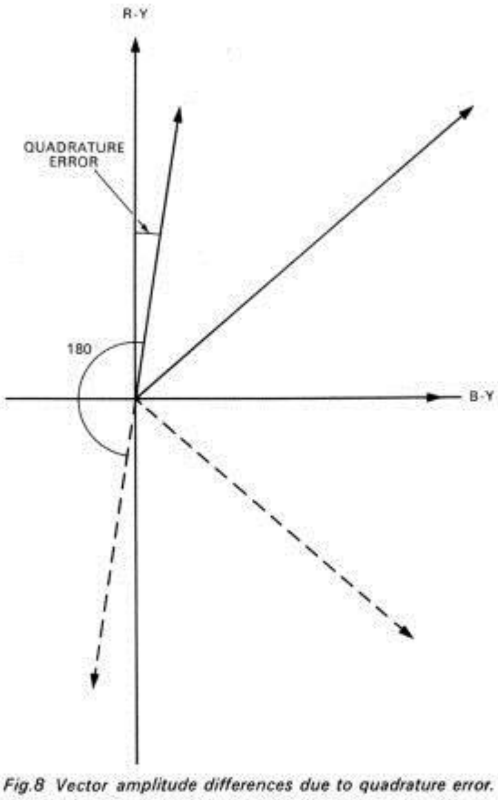

Fig.8 Vector amplitude differences due to quadrature error.