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TELEVISION SIGNAL CODING (PRACTICALS)

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INTRODUCTION TO PRACTICALS

There are two pieces of practical equipment associated with the Television Signal Coding package. The first unit to be used is a Low Frequency Coder demonstration (**LFC**), and the second is a demonstration of colour television signal CODing (**COD**).

The Low Frequency Coder

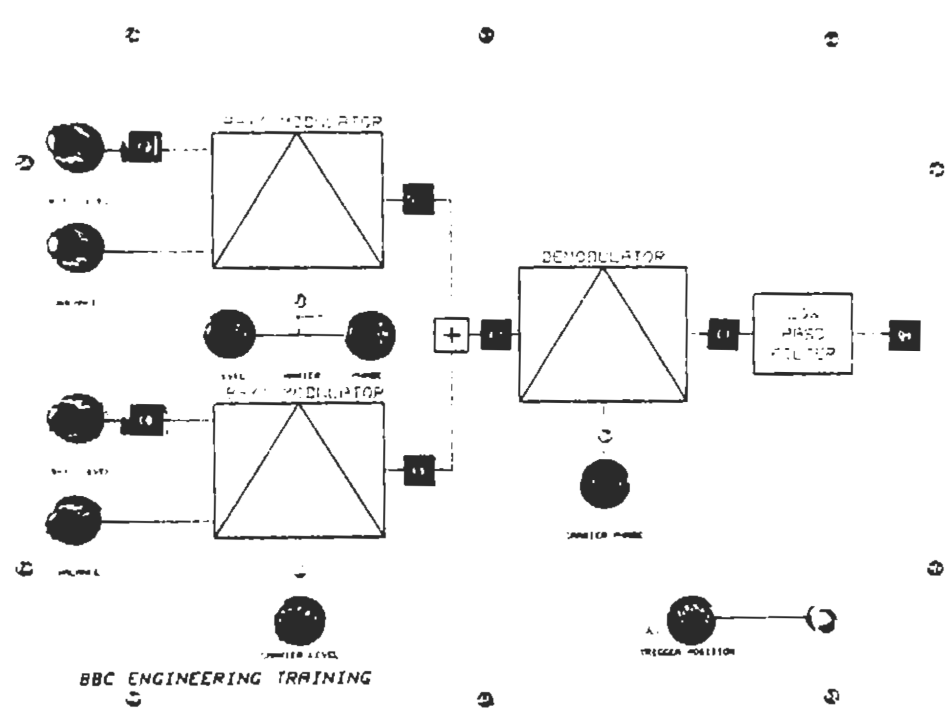
This unit consists of two suppressed carrier modulators using a low frequency carrier. The use of a low frequency carrier enables the moduated waveform to be examined more easily on an oscilloscope. The modulating signal inputs to the two modulators represent the two colour difference signals that are required to be transmitted.

The input waveform to modulator 1 is a steady d.c. during the active line time. This signal may be varied either positive or negative with respect to the blanking level which is at 0 volts. The input to the second modulator is a 4-step function, the first two steps are negative going and the second two are positive. The overall amplitude of this signal again may be varied from its maximum value to zero (blanking level).

The outputs of the two modulators are combined to represent the chrominance component of a coded colour television signal. This combined signal is then fed to a synchronous suppressed carrier demodulator. The phase of the reference demodulator subcarrier can be varied to enable either of the original modulating signals to be recovered. The demodulator output is finally passed through a low pass filter to remove the subcarrier components.

At various points throughout the signal path monitoring points are available to enable the waveforms to be examined in detail. An oscilloscope external trigger feed is also available (bottom right hand corner of the demonstration). The position of this trigger pulse can be varied to enable various parts of the waveform to be examined in detail using a fast oscilloscope timebase speed.

The layout of the front panel is shown below.



LIST OF PRACTICALS

LFC 1 Comparison of amplitude of modulating signal with that of carrier.
Importance of balance control to ensure no carrier for no signal input.

LFC 2 Experiment to show 180° phase change of modulator output when the input polarity is reversed.

RETURN TO TEXT - SECTION 2.5

LFC 3 Examination of waveforms using one modulator at,

(a) Modulator output

(b) Demodulator output before filtering

(c) Demodulator output after filtering

(d) Demodulator output (before and after filter) if phase of reference demodulator is 180° phase shifted. (include zero output at 90°)

RETURN TO TEXT - SECTION 2.8

LFC 4 Examination of combined outputs of modulators.

LFC 5 Examination of how varying demodulator reference phase can cause the demodulator output to be either modulator input.

LFC 6 Experiment to set up the reference phases to the modulators and demodulator.

RETURN TO TEXT - SECTION 3.1

LFC 1.

This investigation only uses one of the modulators. Consider Modulator 1 located in the top left corner of your equipment. It has four controls associated with it. viz

(a) LEVEL

(b) BALANCE

(c) CARRIER LEVEL

(d) CARRIER PHASE.

Start your investigations with all four controls turned fully clockwise.

There are three monitoring points which enable you to examine the associated waveforms; these are located at the modulators,

(a) SIGNAL INPUT

(b) CARRIER INPUT

(c) OUTPUT.

Monitor the SIGNAL INPUT and OUTPUT on an oscilloscope. Use an oscilloscope timebase speed of 0.5mS/DIV and trigger the scope externally from the trigger output socket on the demonstration unit. Turn the trigger position control fully anticlockwise. Select DC for both input amplifiers and a sensitivity of 1 volt/div.

Observe the effect on the output of decreasing the input level control until there is no input signal.

As you have seen in the text, for this condition there should be no residual carrier. This can be eliminated (or nearly so) by adjusting the balance control. (NOTE - to ensure that no signal is present from the other modulator, it is advisable to reduce the MODULATOR 2 LEVEL and CARRIER to minimum - fully anticlockwise.).

LFC 2.

Having balanced the modulator for minimum residual carrier output for zero input signal, the effect of positive and negative input signals can be observed.

Adjust the oscilloscope timebase speed to 20μ sec/div. and whilst observing the modulator output waveform, adjust the TRIGGER POSITION control until individual cycles of carrier can be observed. Note the effect on the output as the signal is varied from its maximum positive value to its maximum negative value.

With a maximum input signal, note the effect on the output of varying the input carrier amplitude and phase. Remember the input carrier is basically being used as a switching signal.

When you are satisfied that you understand the characteristics of a single suppressed carrier modulator, return to the text.

LFC 3.

This investigation examines the complete modulation and demodulation process using one modulator.

Ensure that the INPUT LEVEL and CARRIER LEVEL controls of modulator 2 are turned to minimum. Set the CARRIER LEVEL of MODULATOR 1 to maximum and check that it is correctly balanced for zero input signal.

Vary the INPUT control between its two limits and note the effect at the following points.

(a) MODULATOR 1 INPUT

(b) MODULATOR 1 OUTPUT

(c) DEMODULATOR OUTPUT - See NOTE 1.

(d) LOW PASS FILTER OUTPUT - See NOTE 2.

NOTE 1. When examining the demodulator output waveform, use the modulator output or demodulator input as a reference on the other trace of the oscilloscope. The effects will best be observed by using a timebase speed of at least 10μsec. per division.

NOTE 2. When examining the LPF output, use a slower timebase speed, e.g. 0.2 m-sec/div. and use the modulator input signal as a reference.

Feed the MODULATOR INPUT with the maximum positive signal.

Investigate the effect of varying the DEMODULATOR CARRIER PHASE control on

(a) The DEMODULATOR OUTPUT and

(b) the LOW PASS FILTER OUTPUT.

Note also the effect of varying the modulator's reference carrier phase. For zero demodulator output signal, compare the phases of the modulator and demodulator reference carriers.

RETURN TO TEXT.

LFC 4.

The effect of adding two modulator outputs can now be observed.

Using the same procedure as in LFC 1, observe the input and output waveforms of MODULATOR 2. Balance the modulator as before.

Examine the output of Modulator 2 in detail at the point where the input signal changes from negative to positive. This will be observed more easily if a an oscilloscope timebase speed of about 50μsec/div is used and the TRIGGER POSITION control adjusted to display the relevant part of the modulator output waveform.

Monitor the mixing point of the two modulator outputs (i.e. the demodulator input). Note the effect of varying the inputs to both modulators. (n.b. a less distorted waveform may be obtained at the mixing point if the individual modulator CARRIER AMPLITUDES are slightly reduced.)

LRC 5.

The demodulation of the combined signal can now be examined.

Feed both modulators with their maximum input signals and check that they are correctly balanced.

Monitor the DEMODULATOR output and the L.P.F output. Observe the effect of varying the demodulator reference carrier phase.

There are four critical positions for the DEMODULATOR CARRIER PHASE. These correspond to:-

(a) maximum output of Modulator 1 modulating signal.

(b) zero output of Modulator 1 modulating signal.

(c) maximum output of Modulator 2 modulating signal.

(d) zero output of Modulator 2 modulating signal.

A convenient method of finding these positions is to slowly vary the demodulator carrier phase whilst rocking the input control to the relevent modulator. Comparisons between the L.P.F. output and the relevent modulator input should enable the four condidtions above to be found.

Try to find a position of the demodulator phase which will simultaneously give conditions (a) and (d) above. Then try to find another position which will correspond to both conditions (b) and (c). Suggest any reasons why this may not be possible.

LFC 6.

Quadrature conditions can now be set up.

If you were unable to completely eliminate one signal at the phase giving maximum output of the other, this is because the MODULATOR reference phases were not in quadrature, i.e. not exactly 90° apart.

Carefully adjust the reference phase to the demodulator to the point where zero output is produced from the modulator 2 signal. Adjust the reference phase to modulator 1 to produce maximum output signal from the demodulator. What is the phase difference between the two modulator reference carriers?

Find the two positions of the demodulator reference phase which correspond to complete isolation of the two modulating signals when monitoring the L.P.F. output.

For each of these conditions compare the demodulator carrier phase with the phases of the two modulators.

The suppressed carrier quadrature modulation/demodulation process has now been set up as it would be used to code the two colour difference signals, U & V, in a colour television system coder and decoder.

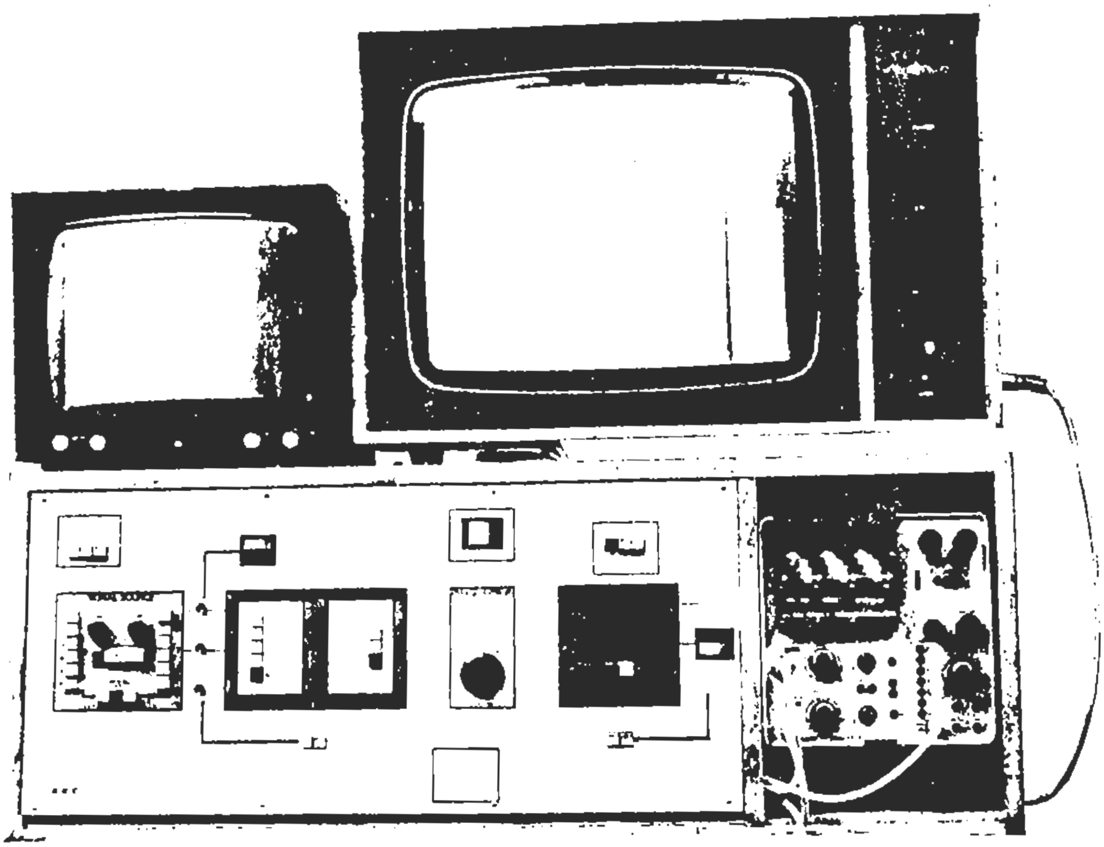
If there are any features of this practical that you have not understood, consult your supervisor now, otherwise return to the text.

THE CODING DEMONSTRATION UNIT

This unit demonstrates the complete colour television coding process. It may be operated in three modes (NTSC, PAL-S and PAL-D) and a choice of three subcarrier frequencies are available (NTSC, PAL-25Hz and PAL). Monitoring throughout the signal chain is on the integral oscilloscope which may be used either in a line repetitive mode or as a vector display.

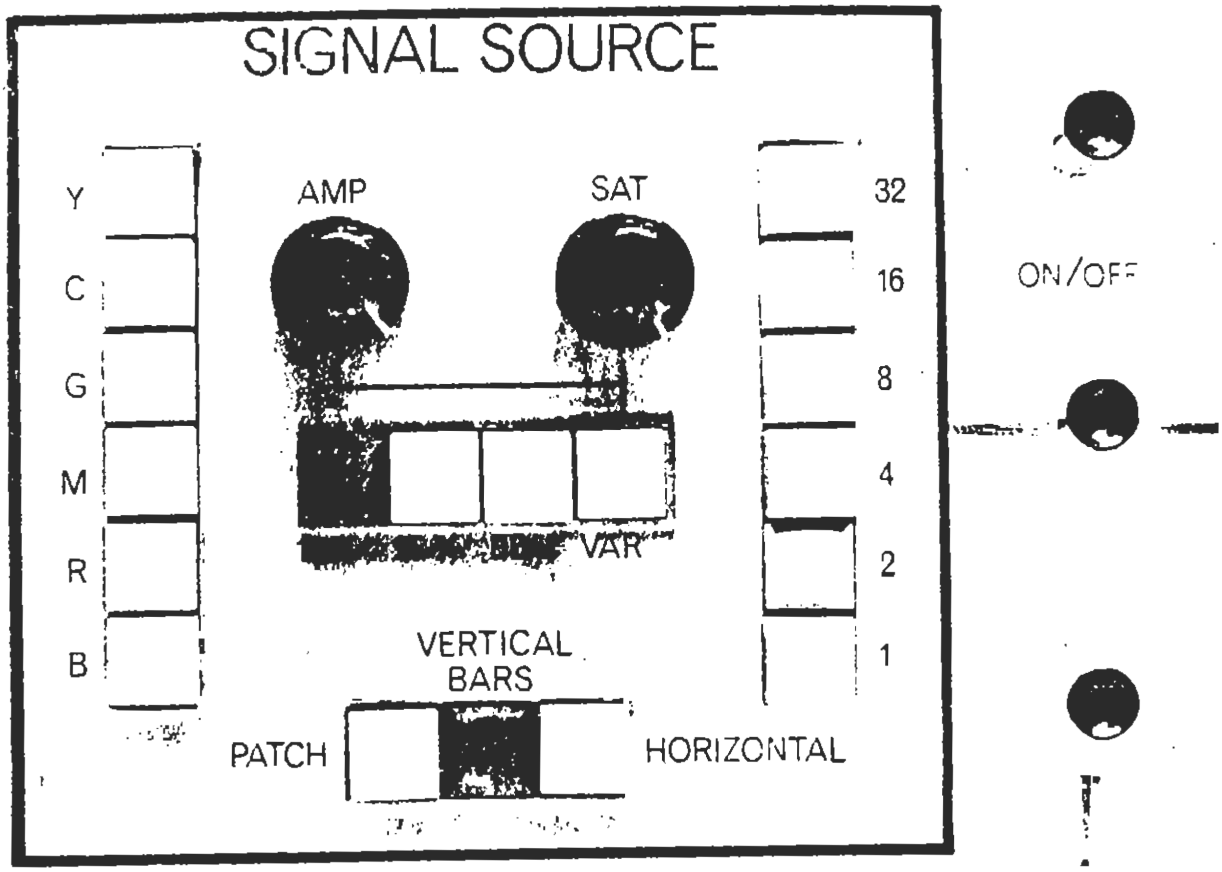
The coding process involves coding the three colour signals (R,G and B) into a luminance (Y) signal and the addition of a chrominance signal derived from the two colour difference signals (R - Y) and (B - Y) and then adding mixed syncs and a colour burst. This composite coded video signal is then decoded to reconsitute the original R, G and B signals. To enable a comparison between the original and the decoded signals to be made the top half of the colour monitor is fed with the original R, G and B signals and the bottom half with the decoder output signals. A monochrome monitor is also provided. This is fed with the coder output and represents the picture that would be obtained by a viewer with a monochrome receiver. This is particularly useful to examine the effects the added subcarrier would have on such a picture.

The complete unit is shown below.



The main demonstration panel has four main units.

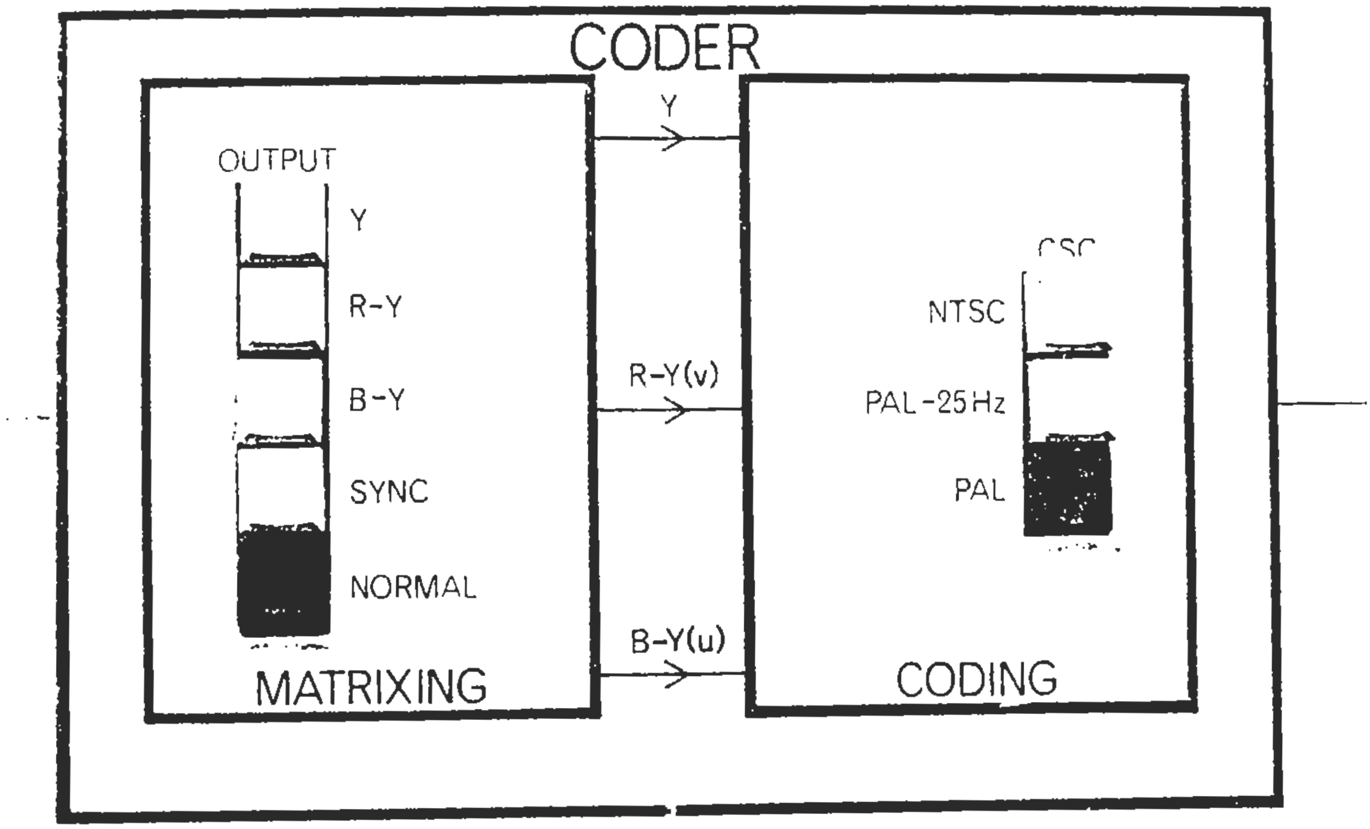
1. SIGNAL SOURCE



The signal source can either provide a PATCH of any colour selected by the left hand buttons, vertical colour bars or horizontal colour bars. Three types of vertical bars are available (100%, 95% and E.B.U.) and if horizontal bars are displayed the buttons on the right hand side of the panel select how many lines of each colour are displayed.

Selecting VARiable enables the AMPlitude and SATuration of the signal source to be varied.

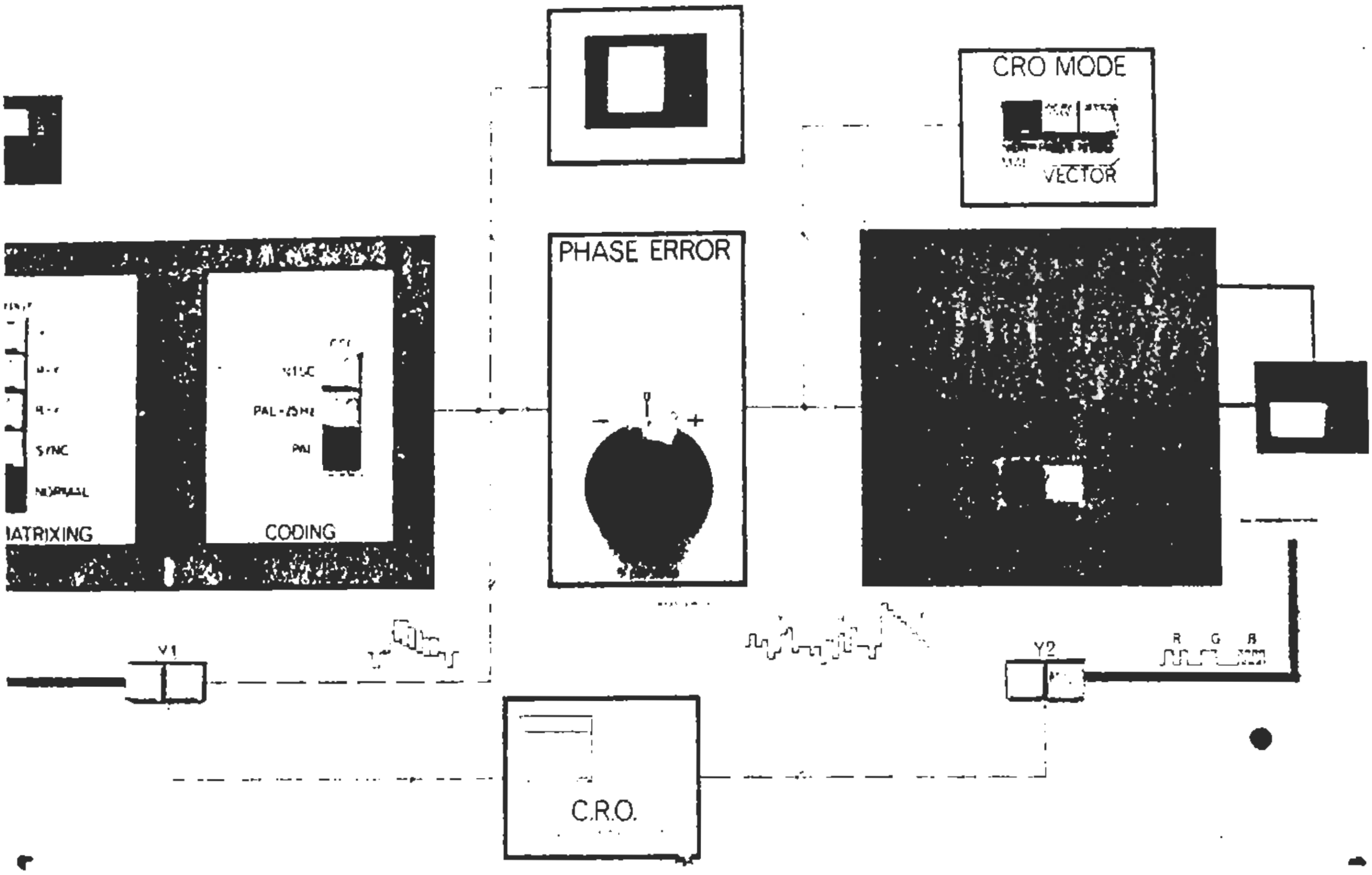
2. CODER



The Red, Green and Blue outputs of the Signal Source are fed via switches to the CODER. In the Coder these three signals are matrixed to provide separate luminance (Y) and colour difference signals, (R - Y) and (B - Y). Any one of these three may be used or the NORMAL operation adds the modulated colour differences signals to the luminance. The frequency of the subcarrier used in the modulators can be switched on the right hand (CODING) section of the Coder.

3. PHASE ERROR

The output of the coder is fed to a PHASE ERROR unit which adds phase error to the coded video in 8° steps.



4. DECODER

Finally the DECODER separates the luminance and chrominance components to enable Red, Green and Blue outputs to be obtained for feeding to the lower half of the colour monitor screen and the oscilloscope Y2 input (when selected on the Y2 buttons).

MODE SELECTION AND MONITORING

There are two mode selection sub-panels on the unit. The buttons located in the top left hand corner in the MODE box are used to select the type of coding and decoding used (NTSC, PAL-S or PAL-D). The buttons located in the top right hand corner of the unit are used to select the mode of operation of the oscilloscope (CRT MODE). Selecting NORMAL causes a line display to be examined and selecting either of the VECTOR buttons causes the oscilloscope Y amplifier to be fed with the demodulated (R - Y) signal and the X amplifier to be fed with the demodulated (B - Y) signal. The PAL button in the CRO MODE box adds a V Axis Switch to the (R - Y) signal.

The two sets of buttons at the bottom of the panel (Y1 and Y2) are used to select the inputs to the Y1 and Y2 inputs to the oscilloscope as shown on the front panel.

LIST OF PRACTICALS (2)

SIGNAL SOURCE.

COD 1 Examination of R, G & B waveforms of Colour Bars and Saturated Colours.

COD 2 Examination of (R - Y), (B - Y), U & V waveforms of Colour Bars.

CODER OUTPUT.

COD 3 Examination of waveforms (and picture) of coder output for Y, (R - Y), (B - Y) and composite.

VECTOR REPRESENTATION

COD 4 Examination of vectors of (R - Y), (B - Y) and the saturated colours.

COD 5 Effect of variation of saturation on vectors and picture.

COD 6 Comparison between R G B and coded.

COD 7 Effect of Phase Distortion on NTSC signal.

RETURN TO TEXT - SECTION 6.1

COD 8 Effect of 24° of Phase Error in Simple PAL on vector and picture monitor.

RETURN TO TEXT - SECTION 7.7.

COD 9 Effect of Delay Line on Phase Errors.

COD 10 Effect of Delay Line without phase errors on Horizontal bars.

RETURN TO TEXT - SECTION 7.13

COD 11 Effect of Subcarrier Frequency on MONOCHROME monitor for NTSC

RETURN TO TEXT - SECTION 8.03

COD 12 Effect of NTSC frequency in PAL.

RETURN TO TEXT - SECTION 6.04

COD 13 Dot pattern of PAL-25Hz and f-PAL.

COD 14 Luminance - Chrominance Crosstalk.

COD 1. EXAMINATION OF R, G & B WAVEFORMS OF COLOUR BARS AND SATURATED COLOURS

Before commencing this practical investigation, set the demonstration unit as follows:-

(a) Select all the black push button positions.

(b) Switch PHASE ERROR to central position (0)

(c) Select R, G, B inputs to c.r.o. inputs Y1 & Y2.

(d) Check that you have six colours plus white and black on the colour monitor. If this is not the case, check that the three ON/OFF switches between the SIGNAL SOURCE and CODER are switched on.

(e) Select NTSC on the MODE panel.

Set the c.r.o. controls as follows:-

(a) Channel 1 (Y1 input) to D.C., 0.5 volts/DIV and CH1 to ON.

(b) Channel 2 (Y2 input):- CH2 to OFF.

(c) TIME/DIV:- 20µs (calibrated).

(d) All the trigger control buttons should be OUT.

The c.r.o. should now be displaying one line of the RED signal, followed by one line of the GREEN, and one line of the BLUE. Check this by operating in turn the three ON/OFF buttons betweens the SIGNAL SOURCE and CODER. For each input in turn note the resulting picture in addition to the waveform. Note also the various combinations of any two of the colours. These are the waveforms and resulting pictures from the three components of the 100% Colour Bars.

Select PATCH on the SIGNAL SOURCE. This produces white on the left hand side of the picture and the relevant selected colour on the right. For each colour, note the displayed picture and justify the R, G & B waveforms for each.

Select VARiable on the SIGNAL SOURCE. This enables the AMPlitude and SATuration of the signals to be varied. Note the effect on the picture and the c.r.o. of varying these two controls.

Examine the picture and waveforms for 95% and E.B.U. bars, and compare these with those described in the text. Note the changes in brightness and saturation on the displayed picture compared with their actual values. Pay particular attention to the desaturation produced by the 95% Bars.

Another test signal available on the SIGNAL SOURCE is HORIZontal Bars. These are not normally encountered in the broadcasting chain, but they will be used to examine certain system defects later. Select HORIZontal Bars and 32. This displays 32 consecutive lines as laid down of each colour combination. The picture as viewed thus contains 64 consecutive lines of each colour owing to the interlaced scanning.

You have now examined the R, G & B inputs available to the colour system demonstration.

COD 2. NTSC CODER MATRIX WAVEFORMS.

The first stage in the colour television transmission chain is the coding process. Prior to modulation, the R, G & B signals are matrixed in the coder. The matrix output waveforms can now be examined.

Select the V, U, Y input to the c.r.o. Y2 input. Switch the c.r.o. CH2 to ON and select D.C. on CH2 input and ALTernate display. Select 2 VOLTS/DIV on the Channel 2 Y amplifier.

The second channel c.r.o. input now displays one line of the V matrix, followed by one line of the U matrix and then one line of the Y matrix output.

For various signal inputs note the V, U and Y waveforms produced.

What waveform would you expect on the U matrix output for 100% bars if the Blue input to the coder is switched off? Check your answer.

COD 3. NTSC CODER OUTPUT WAVEFORMS.

The Coder output waveform may now be examined on Channel 2 on the c.r.o. by selecting the other Y1 input on the demonstration unit. Reduce the Channel 1 sensitivity on the c.r.o. to 1 VOLT/DIV.

For various test signal inputs to the coder note the coded output waveform.

Observe the effect on the coded video of removing one or more of the R, G & B inputs to the coder.

For 100% Vertical Colour Bars, note the output obtained if only the (R - Y) or (B - Y) matrix is used. These 'chrominance' waveforms will be observed frequently when lining up coders.

With either (R - Y) or (B - Y) selected on the coder, adjust the variable sensitivity and vertical centering of the c.r.o. Channel 2 to superimpose the colour difference signal on the peaks of the coder chrominance. Note that this relationship holds for any input.

Return the demonstration unit to normal by pressing all the black buttons and return the oscilloscope controls to normal as set in COD 1 and COD 2.

COD 4. VECTOR REPRESENTATION OF CHROMINANCE.

The vector representation of the chrominance signal can be displayed on an oscilloscope. To obtain this, the U signal (or B - Y) is fed to the c.r.o. as an external X input via the Channel 2 Y amplifier and the V (or R - Y) signal is fed to the Channel 1 input.

Select PAL VECTOR on the CRO MODE panel. Select 0.2 VOLTS/DIV on both c.r.o. channels and adjust the two channel shift controls to centre the display. The NTSC vectors should now be displayed. Compare the display with that in Figure 3-2 in the text, and identify each vector. Explain the cause of the lines connecting the vectors when 100% Vertical Bars are displayed. Note the difference when Horizontal Bars are displayed.

Examine the vector display for various signal inputs.

COD 5. EFFECT OF DESATURATION ON THE VECTORS

The angle of the vector represents the hue of the colour and its amplitude (distance from the centre of the display) represents the saturation of the colour and the picture brightness.

For various signal inputs, vary the AMPlitude and SATuration controls and note the effect on the vectors.

Restore the c.r.o. display to normal.

COD 6. EFFECTS OF CODING AND DECODING

The test signals generated in the SIGNAL SOURCE are high quality full bandwidth (5.5 MHz) R, G and B signals. These are displayed on the top half of the colour monitor. The bottom half of the monitor screen is fed with the R, G and B outputs of the decoder.

Select NORMAL operation of the demonstration unit by pressing all the black buttons and ensure that the PHASE ERROR control is at 0. Select R, G and B inputs to both Y1 and Y2 inputs to the c.r.o.

The picture monitor and the c.r.o. should both now be displaying the R, G, and B signals, both before and after the coding/decoding process. Examine both the picture and waveforms and list the main features that you notice.

COD 7. EFFECT OF PHASE DISTORTION ON THE NTSC SIGNAL

The demonstration unit has the facility to add various amounts of overall phase error to the coded signal. The PHASE ERROR control can advance or delay the reference colour burst in 8° steps from the -(B - Y) axis. The effect is best observed on the c.r.o. in the PAL VECTOR mode as set up in COD 4.

The effect of the phase errors can be observed both on the picture monitor and on the vector display on the c.r.o. Note how much phase error is necessary to produce an unacceptable result with the NTSC system.

If the c.r.o. is returned to NORMAL, the decoded R, G, and B display will show the effect of demodulating off the true axes on the demodulated signals.

You can now return to the text to examine how the PAL system overcomes the effects of these phase errors. If there are any parts of the practicals that you have not understood, consult your supervisor before continuing with the text.

COD 8. EFFECT OF PHASE ERRORS IN THE PAL SYSTEM

Check that the demonstration unit is set up for normal operation (black buttons pressed and zero phase error). Select PAL VECTOR on the c.r.o. MODE panel and centre the display. With no phase error in the system, switch the demonstration mode to PAL-S.

What changes have occured on the picture monitor and the vector display.

Insert various amounts of overall phase error into the coded signal and note the effect on the picture monitor.

How much phase error is required to produce an unacceptable result in PAL-S. Compare this result with that for NTSC in the last investigation.

Select 24° of phase error (3 steps). Note the difference between NTSC and PAL-S.

You have observed in this practical investigation how the PAL system reverses any phase errors on alternate lines, which after being layed down as two interlaced fields in a picture, produces two line pairs known as Hanover Bars. Taking Magenta as an example, the Hanover Bars consist of two lines of reddish-magenta adjacent to two lines of bluish-magenta. It is then left to the eye and brain to average these together. With 24° of phase error, examine the brightness changes of the Hanover Bars closely and then see how far away from the monitor you have to move before the eye cannot resolve the structure of the Hanover Bars.

It would be better if the errors could be electronically averaged instead of relying on the eyes resolution.

If you now return to the text, you will see how a PAL delay line decoder achieves this.

COD 9. EFFECT OF DELAY LINE DECODER ON PHASE ERRORS

Display 100% Colour Bars with 24° of overall phase error in PAL-S mode, Monitor the R, G, B input and output waveforms. Switch to PAL-D and note the effect of using a delay line decoder both on the picture and on the output R, G & B waveforms. For various amounts of phase error, compare the three modes taking note of how much overall phase error you could tolerate on a picture for each mode.

In the text, it was shown that a delay line decoder produced desaturation from phase errors. If the decoder output waveforms are examined, it can be seen that increasing phase errors to the coded signal, converts all three output waveforms nearer to the luminance step wedge. This would be complete desaturation, which would occur in a delay line decoder fed with a signal with a 90° overall phase error.

COD 10. DISADVANTAGES OF PAL-D

Delay line PAL Decoders operate by averaging the chrominance information on adjacent lines. Conventional vertical colour bars are line repetitive, but what would happen to a signal which was not. The delay line decoder would be averaging two signals which were not intended to be the same. This problem, however, is not as objectionable as may be expected.

Display Horizontal Bars with 16 lines of each colour using PAL-D and no phase error, 15 of these lines will be perfect. The first line of each colour band, however, will be an average of its true colour and the colour of the last line of the previous colour. It is most noticeable on the transition between Green and Magenta. Can you explain why this should be so?

You may find it difficult to identify these errors, but switching between PAL-D and PAL-S should outline the effect of the delay line averaging.

If the extreme case of one line per colour is taken, then every line will be incorrect. Confirm this on your colour monitor.

If there are any parts of the practicals you have not understood so far, please consult your supervisor now, otherwise return to Section 8 of the text for an examination of the effects of the choice of the subcarrier frequency.

COD 11. DOT PATTERN PRODUCED BY NTSC SUBCARRIER.

To observe the subcarrier dot pattern on the monochrome monitor, select normal operation of the demonstration unit (black buttons pressed) and display 100% Colour Bars. Select NTSC both for the MODE and for the CSC frequency in the CODER.

The subcarrier frequency now being used is (567/2) x line frequency (4.4296875 MHz).

Observe the dot patterning produced on the monochrome monitor. The patterning may become more obvious if adjustments are made to the monitor BRIGHTNESS and CONTRAST controls.

If the dot pattern you observe is not similar to your answer to CPQ 21 try and justify the observed effect.

If you are in any doubt, an example of the dot pattern you have on your monitor is shown later in the text in Figure 8-3.

When you have satisfied yourself that the NTSC dot pattern is displayed as you would expect, return to the text.

COD 12. EFFECT OF THE PAL SWITCH ON THE NTSC PATTERN.

With the demonstration unit set up as for COD 11, select PAL-S for the MODE. The system is still using the same subcarrier frequency [(567/2) x line frequency] but the effect the PAL system has on the patterning can now be observed.

Observe the dot patterning on the Cyan bar (still on the monochrome monitor) and check that it is the same as your answer to CPQ 22.

Note that for colours which have very little V component, e.g. yellow, the dot pattern is still similar to that produced for NTSC

Return to the text to examine how the subcarrier frequency may now be modified to overcome this effect.

COD 13. DOT PATTERN OF PAL-25Hz AND f-PAL.

With the demonstration unit set up as before, the effect of further modification to the subcarrier frequency can be observed.

When PAL-25 is selected on the CODER, this adds a quarter cycle of subcarrier from each line making the frequency (567/2 + 1/4) x line frequency.

Selecting PAL subcarrier frequency on the CODER then adds the 25Hz PRECISION OFFSET to give the final PAL frequency relationship of

$$f\text{-}pal = (567/2 + 1/4 + 1/625) \times 15.625 \text{ KHz}$$
$$= 4..43361875 \text{ MHz.}$$

Examine the dot pattern produced with both these subcarrier frequencies, both on colours with a predominantly V component and those which only have a small V component.

COD 14. EFFECT OF LUMINANCE - CHROMINANCE CROSSTALK.

Select normal operation of demonstration unit.

Selecting MULTIBURST on the DECODER feeds the decoder input with a variable frequency sweep instead of the coded bars produced by the coder.

Observe the effect of the higher frequency luminance components of this multiburst signal being decoded as chrominance for the three subcarrier frequencies available.

Note the objectionable coloured patterning produced from the NTSC frequency and how the Precision Offset reduces the effect compared with PAL-25Hz.