

**TELEVISION
SIGNAL CODING**

**VOL 3 OF THE
TELEVISION PRINCIPLES
MODULE
(PRACTICALS)
G.G. WINTER**



ENGINEERING TRAINING

DEPARTMENT

THE TELEVISION SIGNAL CODING DEMONSTRATION EQUIPMENT

Introduction to the equipment	<i>page</i>
Signal Source Panel	2
Coder Panel	3
Phase Error Panel	4
Decoder Panel	4
Mode Selection and Monitoring Sub-panels	5
List of Demonstrations	
Examination of R, G, and B Waveforms for Colour Bars and Saturated Colours (Dem. 3.1)	6
NTSC Coder Matrix Waveforms (Dem. 3.2)	7
NTSC Coder Output Waveforms (Dem. 3.3)	8
Phasor Representation of Chrominance (Dem. 3.4)	9
Effect of Desaturation on Phasors and Picture (Dem. 3.5)	10
Effects of Coding and Decoding (Dem. 4.1)	11
Effects of Phase Distortion on the NTSC Signal (Dem. 4.2)	12
Effects of Phase Errors in the Simple PAL System (Dem. 6.1)	13
Phase Errors with Vector Display (Dem. 6.2)	14
Effect of Delay Line Decoder on Phase Errors (Dem. 6.3)	15
Disadvantages of PAL-D (Dem. 6.4)	16
Choice of Subcarrier Frequency (Dem. 6.5)	17
Effect of Fine Detail on the Decoded Picture (Dem. 6.6)	18

Note:

The first figure of the Demonstration number refers to the associated Section of the Theory text. For example, Demonstration 3.1 is the first demonstration in Section 3 of the theory text.

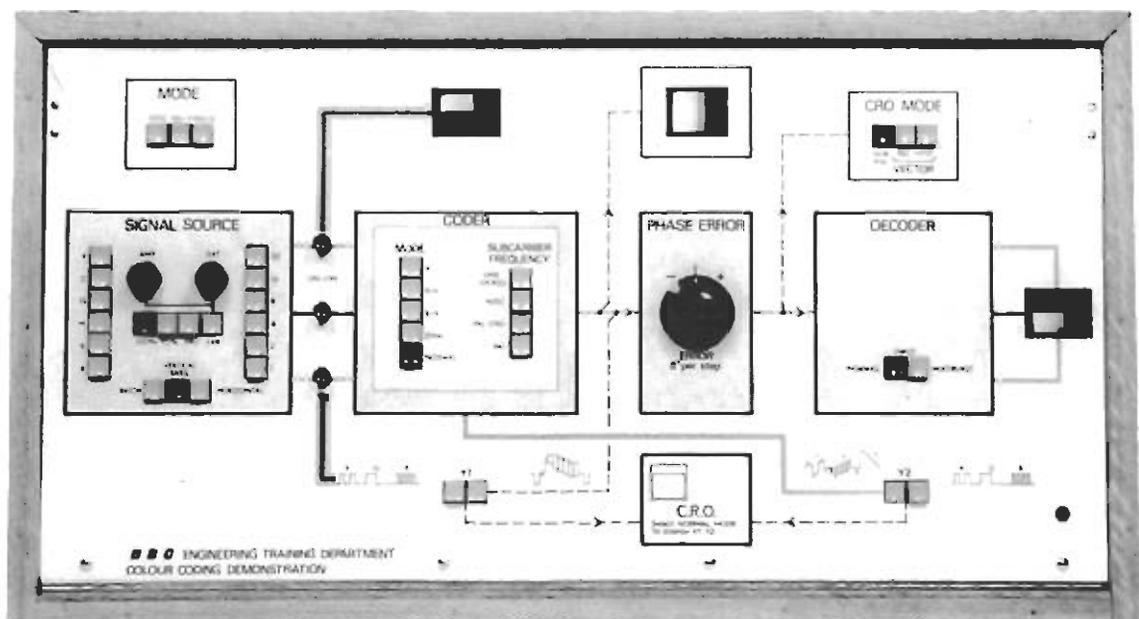
INTRODUCTION TO THE EQUIPMENT

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

The coding process entails matrixing the three colour signals (R, G and B) into a luminance (Y) signal to which is added a chrominance signal derived from the two colour difference signals (R - Y) and (B - Y). The signal is completed by the addition of mixed syncs and a colour burst. This composite coded video signal is then decoded to recover 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, and the bottom half with the decoded output signals. A monochrome monitor is also provided. This is fed with the coder output and displays the picture that would be obtained by a viewer with a monochrome receiver. This is particularly useful when examining the effects that the added subcarrier would have on such a picture.

The complete unit is shown below.

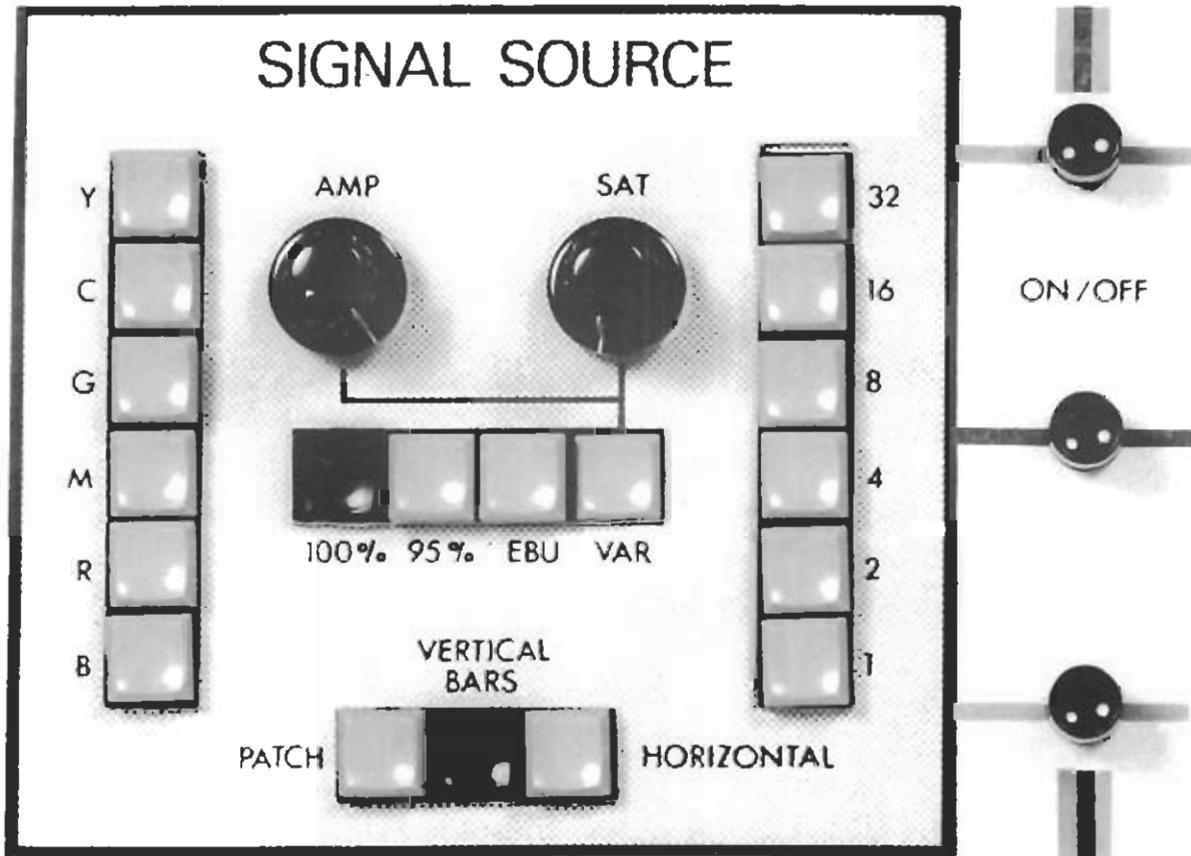
The main demonstration panel comprises four principal sections.



1. Signal Source Panel

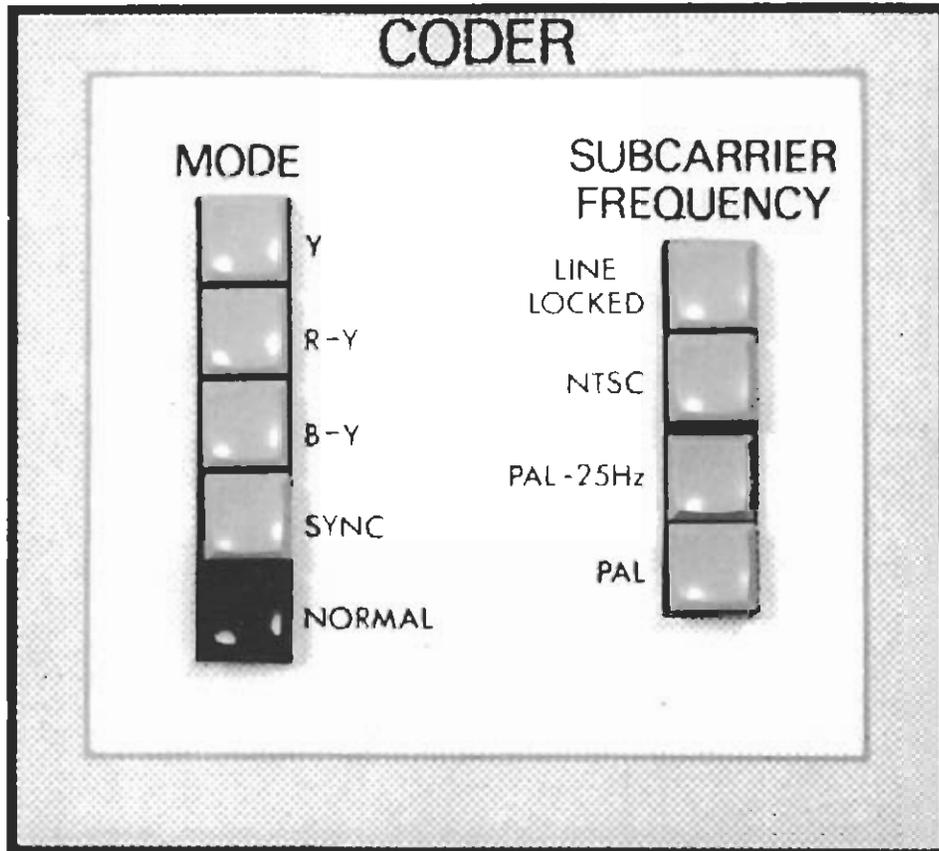
The RGB signal source normally provides vertical colour bars. However, a coloured patch (selected by the left-hand buttons) or horizontal bars may be selected instead. If horizontal bars are required the buttons on the right-hand side of the panel select how many lines of each colour are displayed.

The amplitude and saturation of the signals can be pre-selected to normal standards (100%, 95% or E.B.U.) or the VARIable mode can be used. Selecting VARIable enables the AMPLitude and SATuration of the signal source to be changed.



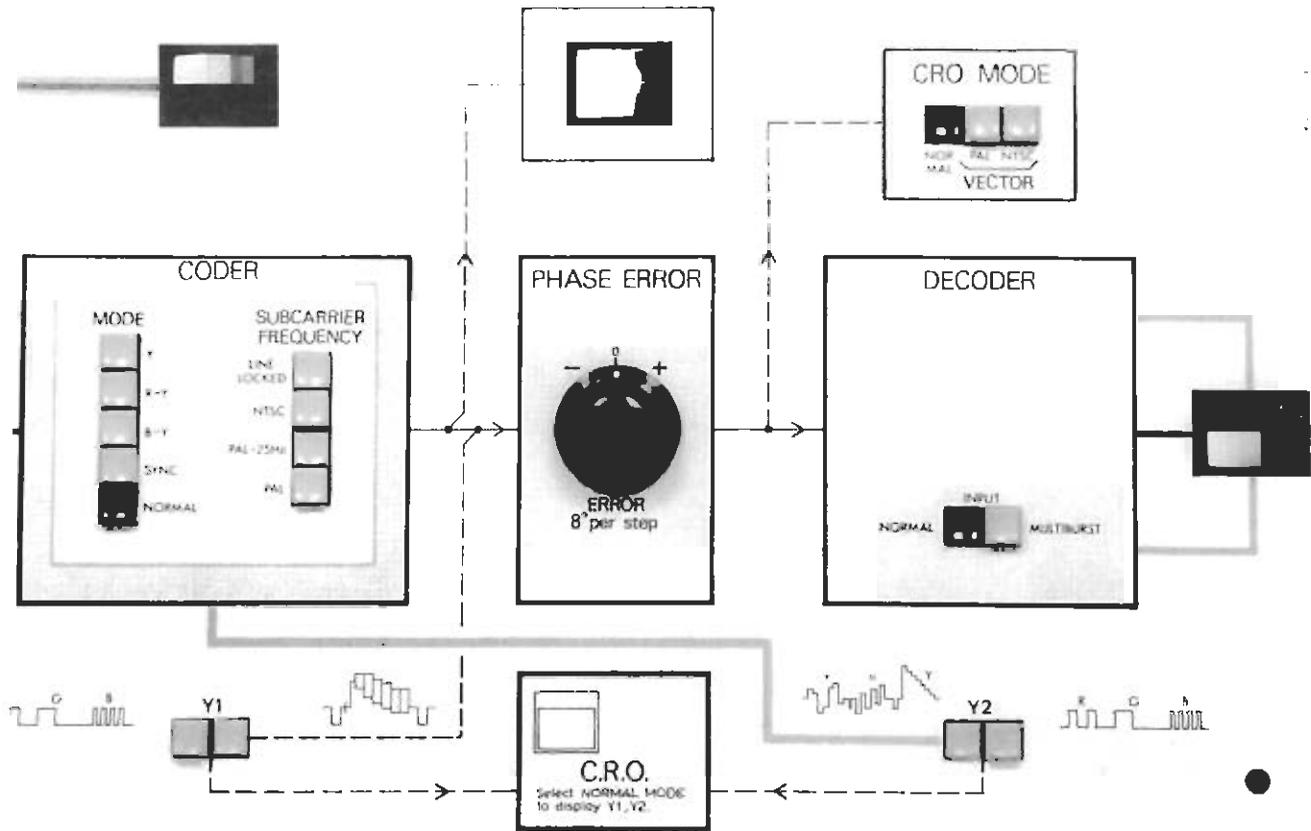
2. Coder Panel

The Red, Green and Blue outputs of the Signal Source are fed via On/Off switches to the CODER. In the Coder these three signals are matrixed to provide separate luminance (Y) and colour difference (R - Y) and (B - Y) signals. NORMAL mode is generally used and selects a conventional coded output. For test and monitoring purposes the Y, R-Y and B-Y buttons can be used to select these components separately. The frequency of the subcarrier used in the modulators can be switched on the right-hand section of the Coder.



3. Phase Error Panel

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



4. Decoder Panel

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

Mode Selecting and Monitoring Sub-Panels

There are two mode selection sub-panels on the unit. The buttons located in the top left-hand corner (the MODE box), 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 select the mode of operation of the oscilloscope (CRO MODE). Selecting NORMAL causes a line display to be presented, 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 NTSC button in the CRO MODE box adds a V-Axis switch to the (R - Y) signal. When either vector mode is selected the oscilloscope should be used in its X - Y 'Plot' mode in order to present a vector display to the viewer.

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

DEMONSTRATION 3.1: EXAMINATION OF R, G, & B WAVEFORMS FOR 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 oscilloscope inputs Y1 & Y2.
- d) Check that you have six colours, plus white and black, on the colour monitor. If not, 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 oscilloscope 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:- $20\mu\text{s}$ (calibrated)
- d) EXTERNAL trigger, -ve slope, DC. (EXT \div 10 on Phillips 3215.)

The oscilloscope should now display 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 between 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 colours. These are the waveforms and resulting pictures from the three components of 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 oscilloscope of varying these two controls.

Examine the picture and waveforms for 95% and E.B.U. bars, and compare them 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 visible effect of the desaturation produced by the 95% Bars and the brightness change for EBU bars.

Another test signal available on the SIGNAL SOURCE is HORIZONTAL Bars. This test signal is not normally encountered in the broadcasting chain, but 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.

Return to Section 3.8 of the main text.

DEMONSTRATION 3.2: 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 oscilloscope Y2 input. Switch the Oscilloscope CH2 to ON and select D.C. on CH2 input and ALTERNATE display. Select 2 VOLTS/DIV on the Channel 2 Y amplifier.

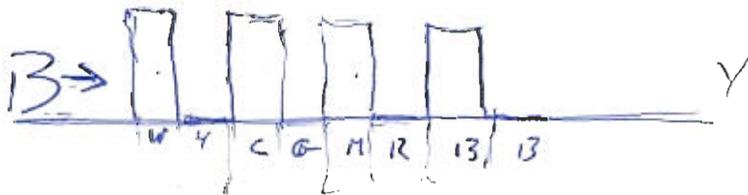
The Channel 2 input now displays one line of the V signal, followed by one line of U and one line of Y.

Note the V, U and Y waveforms produced for the various signal inputs.

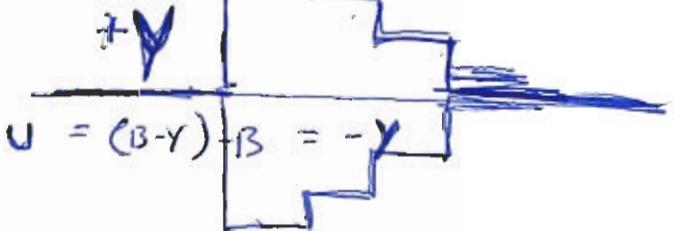
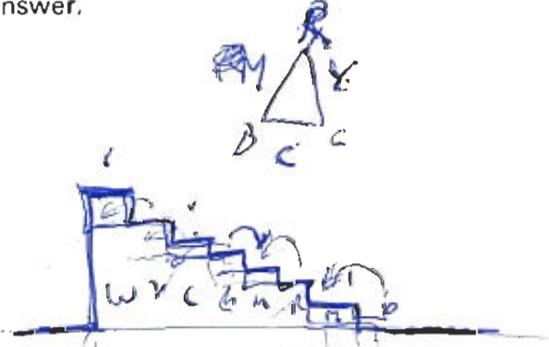
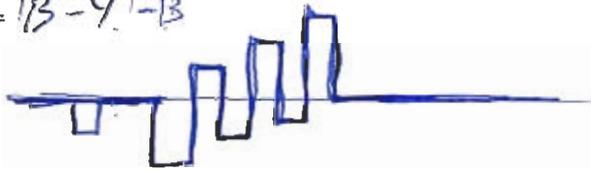
Sketch the waveform you would expect on the U matrix output for 100% bars if the Blue input to the coder is switched off. Check your answer.

W Y C G H R B

NOTES



$$U = (B - Y) - B$$



DEMONSTRATION 3.3: NTSC CODER OUTPUT WAVEFORMS

The Coder output waveform can now be examined on oscilloscope Channel 1, by selecting the other Y1 input on the demonstration unit.

Reduce the sensitivity of oscilloscope Channel 1 to 1 VOLT/DIV. Apply various test signals to the coder (particularly 100%, 95% and E.B.U. bars) and note the coded output waveform.

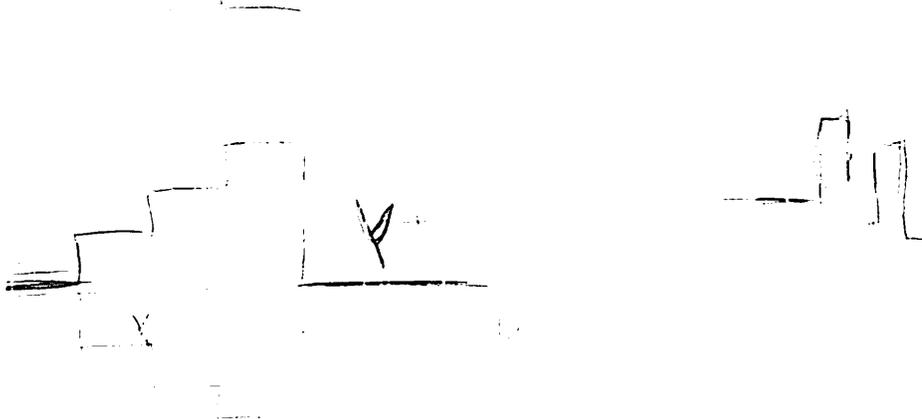
Observe the effect on the coded video of removing one or more of the R, G & B inputs to the coder.

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

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

Return the demonstration unit to normal by pressing all the black buttons and return the oscilloscope controls to normal as described in 3.1 and 3.2.

NOTES



DEMONSTRATION 3.4: PHASOR REPRESENTATION OF CHROMINANCE

The phasor representation of the chrominance signal can be displayed on an oscilloscope. To do this the U (or B - Y) signal is fed to the horizontal deflection system (usually via the Channel 2 or B input amplifier) and the V (or B - Y) signal is applied to the vertical deflection system.

Select PAL VECTOR on the CRO MODE panel. Put the oscilloscope into its X - Y plot mode. Select EXTernal X on the Time/Div. control and B on the Trigger input selector, as shown in the photograph below.

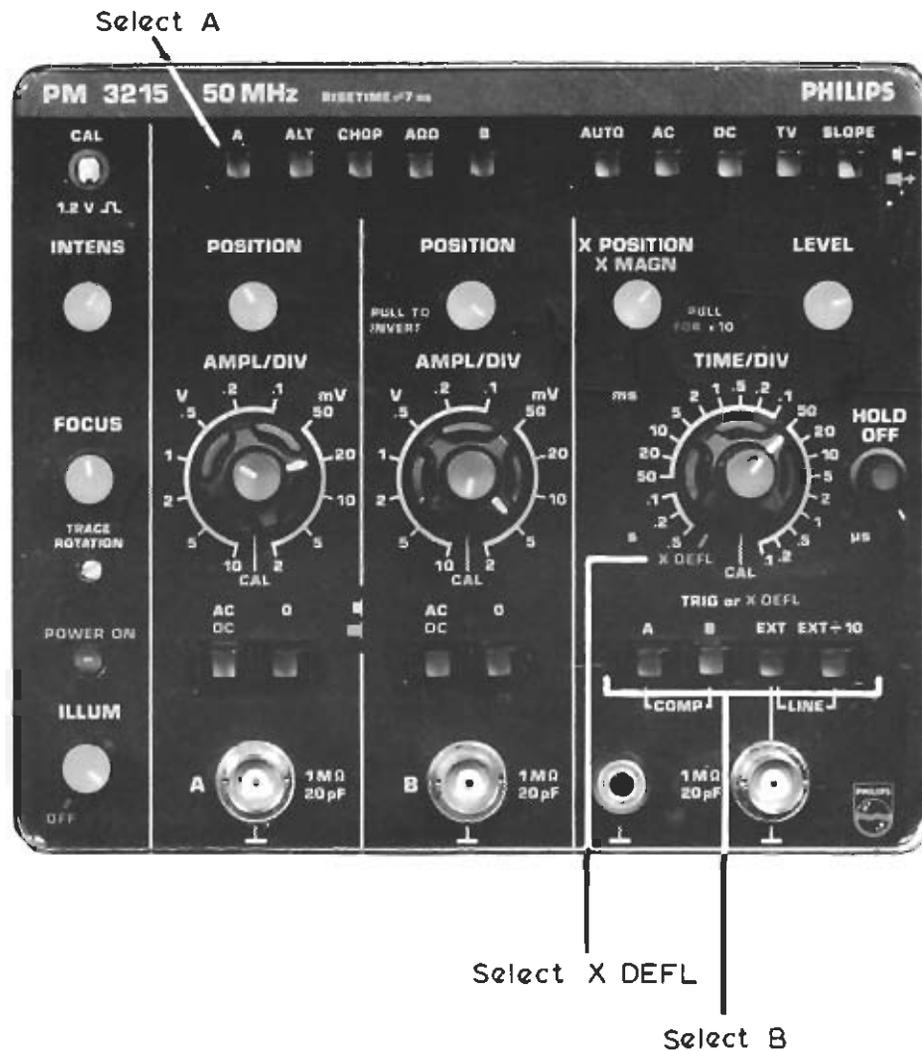
Select 0.2 VOLTS/DIV on both oscilloscope channels and adjust the shift controls to centre the display. The NTSC phasors should now be displayed. Compare the display with that shown in figure 2.2 in the text, and identify each phasor.

Explain the cause of the lines connecting the phasors when 100% Vertical Bars are displayed. Note the difference when Horizontal Bars are displayed.

Examine the phasor display for various input signals.

Note:

On those units with a built-in oscilloscope the X - Y plot mode is automatically selected when vector displays are used.



DEMONSTRATION 3.5: EFFECT OF DESATURATION ON PHASORS AND PICTURE

The angle of a phasor represents the hue of the associated 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 phasors and the picture.

Restore the display to normal $20\mu\text{s}/\text{div}$ and EXT trigger.

Now return to Section 4 of the main text.

NOTES

DEMONSTRATION 4.1: EFFECTS OF CODING AND DECODING

The test signals generated in the SIGNAL SOURCE are 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 oscilloscope inputs.

The picture monitor and the oscilloscope should both display the R, G, and B signals, before and after the coding/decoding process. Examine the picture and waveforms and list the main features that you notice, with particular regard to any obvious degradation of the decoded signal.

NOTES

DEMONSTRATION 4.2: EFFECT OF PHASE DISTORTION ON THE NTSC SIGNAL

The demonstration unit can be used to add various amounts of overall phase error (burst phase error) to the coded signal. The PHASE ERROR control can either advance or delay the reference colour burst in 8° steps from the $-(B - Y)$ axis. The effect is best observed with the oscilloscope in the PAL VECTOR mode as set up in 3.4.

The effect of phase errors can be observed both on the picture monitor and on the vector display on the oscilloscope. Note how little phase error is needed to produce an unacceptable result with the NTSC system.

If the oscilloscope 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.

Now return to Section 5 of 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.

NOTES

DEMONSTRATION 6.1: EFFECT OF PHASE ERRORS IN THE SIMPLE PAL SYSTEM

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

What changes have occurred 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 demonstration.

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

You have observed in this demonstration how the PAL system reverses any phase errors on alternate lines, which after being laid 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 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, then note 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 eye.

DEMONSTRATION 6.2: PHASE ERRORS WITH VECTOR DISPLAY

You have now observed the effect on the display of different phase errors. In this investigation the actual phase error can be observed on the vector monitor.

Set up the demonstration equipment as for demonstration 3.4. You can now observe the changes that occur when a phase error is introduced. Try it for both NTSC and PAL modes.

The vector monitor can also be used to show how the PAL system cancels out the effects of a phase error. To do this select PAL mode with a NTSC vector display. This causes the vector monitor V-axis to be reversed on alternate lines. Introducing a phase error now will show how the error on one line is made to be equal and opposite to that on the next.

Note:

The labelling of the vector monitor display modes often confuses, however it follows the practice of the more sophisticated instruments used in broadcasting. Both display modes refer to a PAL signal fed to the vector monitor. With PAL display mode selected a PAL vector display (six colours together with their V-axis switched counterparts) results. If NTSC display is selected only six vectors are seen (assuming no phase error) consequently the display is the same as that for a conventional NTSC signal. (Actually there is still one small dissimilarity – can you identify it?)

Return to Section 6.8 of the main text to see how a PAL delay line decoder electronically averages the effects of a phase error.

DEMONSTRATION 6.3: 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 R, G & B output waveforms. Compare the three modes for various amounts of phase error, note 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 and brightness changes from phase errors. If the decoder output waveforms are examined it can be seen that increasing phase errors to the coded signal makes all three output waveforms appear more like the luminance step wedge. This would be complete desaturation and would occur in a delay line decoder fed with a signal having a 90° overall phase error.

Now return to Section 6.11 of the main text.

NOTES

DEMONSTRATION 6.4: 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 average two signals which were not intended to be the same. This disadvantage 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. Taking interlace into account the first two lines of each colour band will be an average of the correct colour and the previous bar. This effect 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 emphasise the effect of the delay line averaging.

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

If there are any parts of the practicals you have not understood so far, please consult your supervisor, otherwise return to Section 6.11 of the text for a summary of the effects of Phase and Amplitude variations.

DEMONSTRATION 6.5: CHOICE OF SUBCARRIER FREQUENCY

The subcarrier is a high-frequency signal superimposed onto the luminance (monochrome) waveform. If steps are not taken to filter the signal before the display, then this high-frequency carrier will be treated as if it were luminance.

High-frequency luminance corresponds to fine detail in a scene, consequently any subcarrier present is displayed as a fine pattern superimposed on the picture. Although we are not, at this stage, concerned with the *precise* relationship between the subcarrier and line frequencies you can observe the effect of the subcarrier.

Select normal operation with NTSC mode and 100% colour bars. Select LINE-LOCKED subcarrier and observe the pattern displayed on the monochrome monitor. Now select NTSC, (the correct subcarrier frequency for this mode) and notice how less objectionable the pattern appears.

Unfortunately the correct subcarrier frequency for NTSC is not the same as that for PAL. Without changing the frequency select PAL mode and notice the effect on the monochrome monitor. Now select PAL subcarrier, again with the correct frequency the visibility of the pattern is much reduced.

NOTES

DEMONSTRATION 6.6: EFFECT OF FINE DETAIL ON THE DECODED PICTURE

In 6.5 you observed how the subcarrier is displayed as fine detail on the monochrome monitor. Even worse is the fact that *fine luminance detail* is interpreted as *subcarrier frequency* by the decoder. This means that, for example, black and white vertical stripes of the correct pitch could result in spurious colours appearing on the colour display. The effect is colloquially known as 'cross-colour' and can be demonstrated by selecting the MULTIBURST input to the decoder.

The decoder input is now a monochrome frequency sweep signal which in one line sweeps from over 5 MHz to about 1 MHz. Notice how the lower half of the colour monitor display, which should be monochrome, shows colours at a certain point on the line. What do you think this point corresponds to?

Repeat the investigation made in 6.5, this time observe the cross-colour as well as the monochrome monitor patterning. Notice how the most objectionable cross-colour also corresponds to the worst patterning.

Now return to the Summary at the end of the main text.

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