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TELEVISION SIGNAL CODING

SUPPLEMENTARY INFORMATION

This volume contains information that is supplementary to that contained in the Television Coding package, and should be read after you have completed that volume.

SUBCARRIER FREQUENCY

1.1 FACTORS AFFECTING THE CHOICE OF SUBCARRIER FREQUENCY

In order to minimise the visual effect of the subcarrier, it should be as high in frequency as possible, bearing in mind that the chrominance sidebands should still lie within the luminance spectrum. What are the effects of adding the chrominance signal to the luminance?

1.2 BRIGHTNESS ERRORS

Any signal which has a high-frequency sine wave added to it will experience an increase in brightness from its true value. This is due to the non-linearity of the tube.

Consider a steady luminance d.c. signal with a superimposed chrominance signal. The effect can be seen in Figure 1.1

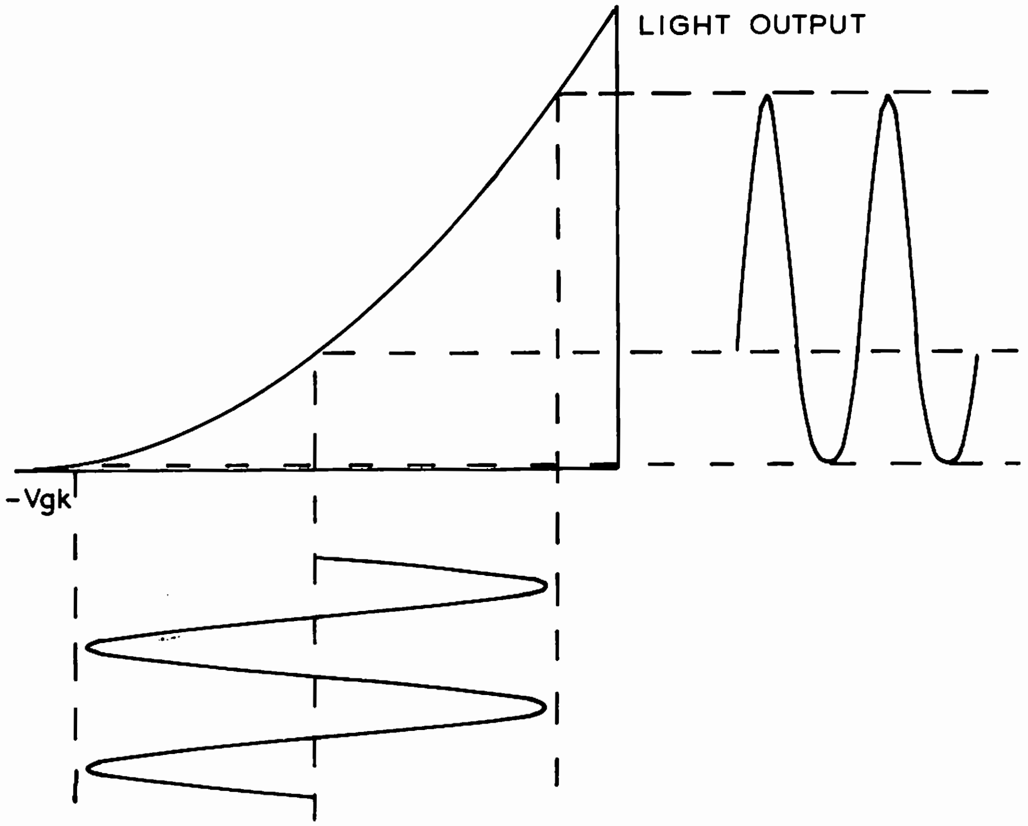


Figure 1.1 Effect of Subcarrier on Mean Luminance Level

The light output from the tube is not exactly sinusoidal, but its visual effect is very close to that of a slightly higher mean luminance level with a superimposed sine wave. The effect is sometimes known as subcarrier rectification. The long term or mean brightness error is the same whatever subcarrier frequency is used, but what about the short term errors?

1.3 DOT PATTERNING CAUSED BY SUBCARRIER

As a line is scanned on the picture display tube, the subcarrier superimposed on the luminance signal is treated as if it were a high frequency luminance component. The effect this brightness modulation produces depends on:-

(a) the viewing distance, and
(b) the interfering subcarrier frequency

We have no control on the viewing distance, but, provided the chrominance frequency is high enough, the eye will not resolve it at an average viewing distance to a sufficient extent to find it objectionable.

For an average scene, the degree of saturation is usually fairly low so the amplitude of the colour difference signals, and hence the chrominance signal, is also low. A subcarrier notch filter in the luminance chain reduces the effect, but at the expense of loss of fine detail.

How is the interference affected by the subcarrier to line frequency relationship?

Consider the result of having the subcarrier at an exact multiple of line frequency, e.g. 4.00 MHz, which is 256 × line frequency. This would mean that, at any time, the phase of the subcarrier would be exactly the same as the corresponding point on the previous line. For scenes with a high chrominance component, this would produce a pattern of vertical stripes as shown in figure 1.2, where a small part of the picture is reproduced for clarity.

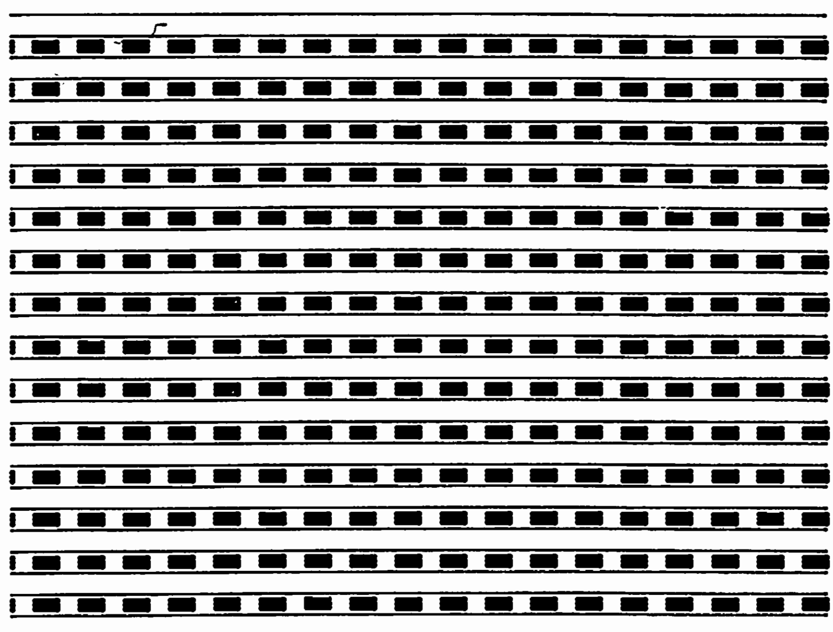


Figure 1.2 Effect of Subcarrier Patterning on a Small Part of the Picture

What effect would the chrominance produce on the luminance output if its frequency was made an odd multiple of half-line frequency. (It may help you to first consider a very low odd multiple, e.g. $\frac{3}{2}$ × line frequency, for one field and then add the effect of the interlaced field.)

Investigation

The subcarrier dot pattern can be observed on the monochrome monitor. To do this select normal operation of the demonstration unit (black buttons pressed) and display 100% Colour Bars. Select NTSC mode, and NTSC subcarrier on the coder unit.

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 you are in any doubt, an example of the dot pattern you have on your monitor is shown later in the text in figure 1.3. Also observe the line-locked pattern, which is an integer number of cycles per line.

This is the method adopted by the NTSC system. The actual multiple chosen for a 625 line 50 Hz NTSC system is 283½ times line frequency, i.e. 4.4296875 MHz. Using an odd multiple of half line frequency results in a chrominance dot pattern as shown in figure 1.3. Interlacing the two fields causes the pattern to appear as pairs of dots.

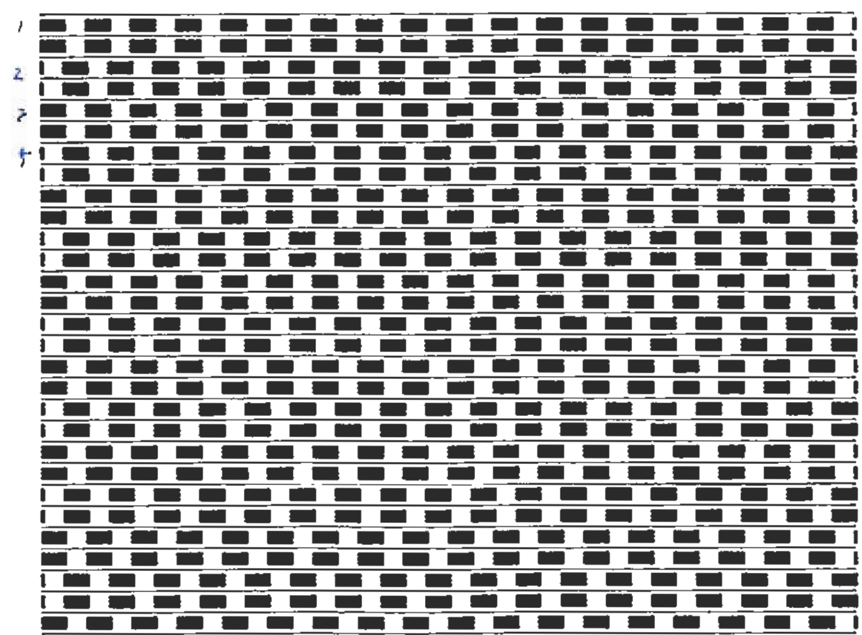


Figure 1.3 NTSC Chrominance Dot Patterning

1.4 EFFECT OF PAL SWITCHING ON THE NTSC DOT PATTERN

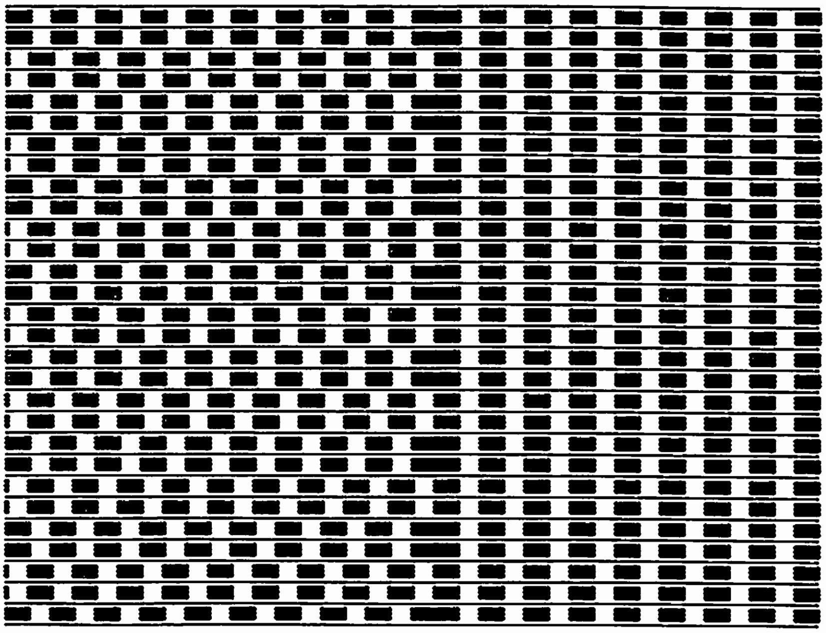
The PAL system inverts the phase of the V component on alternate lines as displayed. Consider a colour such as red or cyan. It will be remembered that these two colours have a large V component and only a small U component.

Sketch the pattern which results from a chrominance signal lying on the V axis. Include the effect of interlace.

Repeat the investigation you made above, this time using the PAL mode.

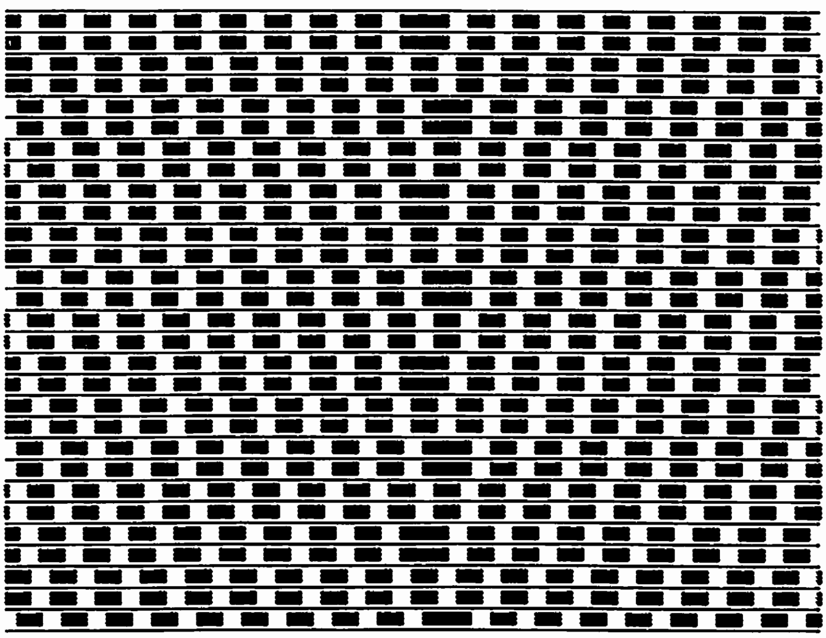
1.5 PAL SUBCARRIER OFFSETS

The PAL system overcomes this defect by modifying the relationship of subcarrier to line frequency by adding an extra quarter cycle per line. This makes the relationship 283¾ times line frequency. Figure 1.4 shows the effect of having an odd number of half cycles in each line and figure 1.5 an odd number of quarter cycles. Each figure shows the patterning effect produced when PAL switching is present by a chrominance signal with (a) a very small V component (e.g. Yellow) and (b) a high V component (e.g. Cyan).



(a) (b)

Figure 1.4 Effect of PAL switch on chrominance signals which are (a) predominantly U (e.g. yellow) (b) predominantly V (e.g. cyan) using NTSC subcarrier frequency



(a) (b)

Figure 1.5 Effect of PAL switch on chrominance signals which are (a) predominantly U (e.g. yellow) (b) predominantly V (e.g. cyan) using a modified subcarrier frequency

The result is a pattern which shifts to the left or right by a quarter cycle per line. The pattern appears to the viewer as a series of diagonal lines which move slowly up or down the picture.

Why does the pattern appear to move?

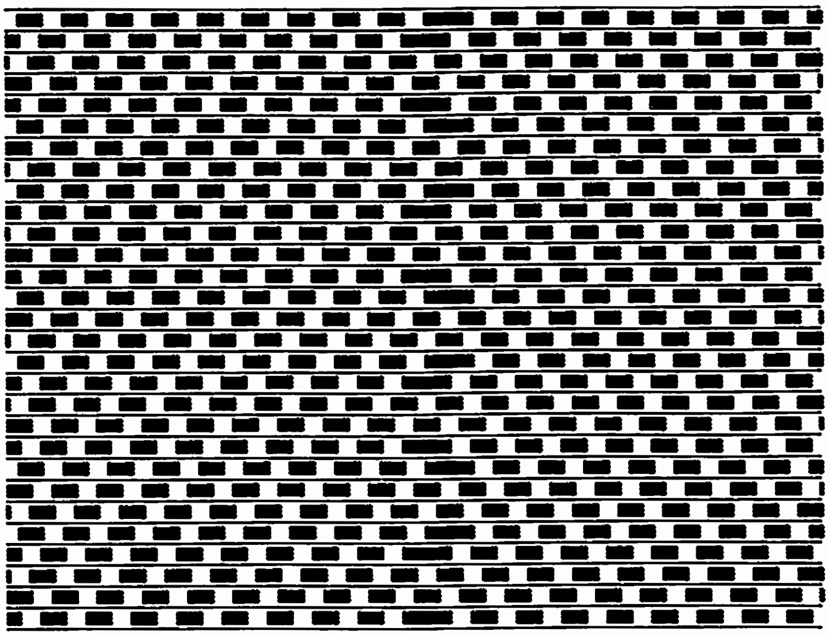
1.6 PAL SUBCARRIER FREQUENCY

The final modification to the frequency used is the addition of 25 Hz (or $\frac{1}{625}$ × line frequency). This is known as a precision offset. This effectively inverts the phase of the subcarrier at the corresponding point on the adjacent field and results in its brightness modulation being averaged to zero over several pictures.

The final frequency of PAL subcarrier is:

$$\begin{aligned} fcsc &= (283\ \tfrac{1}{2} + \tfrac{1}{4} + \tfrac{1}{625}) \times f_{line} \\ &= (283\ \tfrac{3}{4} + \tfrac{1}{625}) \times 15.625\ \text{KHz} \\ &= 4.43361875\ \text{MHz} \end{aligned}$$

The resulting pattern is shown in figure 1.6.



(a) (b)

Figure 1.6 Dot pattern resulting from
(a) U-axis and (b) V-axis chrominance signals using PAL subcarrier

1.7 THE PAL EIGHT-FIELD SEQUENCE

The basic monochrome signal has a sequence which repeats itself every two fields. The PAL system however, incorporates V axis switching at half-line frequency, so taking four fields to repeat its sequence. For most requirements the PAL system can be considered as repeating in a four-field sequence, but this does not take into account the subcarrier to line frequency relationship. There is also an eight-field sequence which is of particular importance in digital synchronisers, and video tape editing.

So far only the relationship between subcarrier and line frequency has been discussed. Consider however, its relationship to the *field* frequency:

$$\begin{aligned} fcsc &= (283\ \tfrac{3}{4} + \tfrac{1}{625}) \times (625 \div 2) \times f_{field} \\ &= (709379 \div 8) \times f_{field} \end{aligned}$$

This means that an integral number of cycles of subcarrier will only occur after an eight-field period. The PAL system therefore, strictly speaking, has an eight-field and not a four-field sequence.

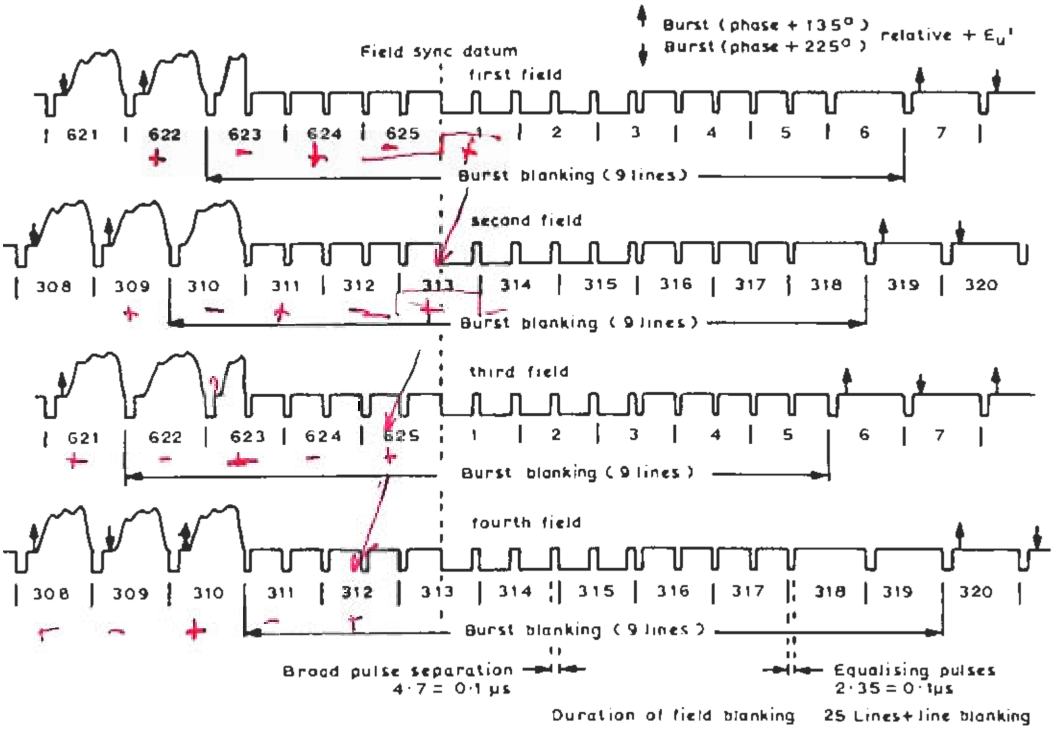


Figure 1.7 Field Sync Waveform Showing Bruch Blanking

1.8 BRUCH BLANKING

It is necessary to remove the burst during the field sync interval. Although all present day decoders could easily cope with the burst being blanked for the same group of lines on all fields, there was some doubt as to whether very early colour receivers could lock their carrier oscillators sufficiently quickly following the re-appearance of the burst.

Because incorrectly locked oscillators would lead to phase errors, and even a possible loss of regenerated V-axis switching signal, it was decided to try and eliminate the problem. The work was carried out by Dr. Bruch, a member of the original committee on PAL. The result of this is that the burst is always blanked for 9 lines, however the actual 9 lines are different for each of the four fields. This results in the first and last bursts of each field always having the same instantaneous phase, i.e. that which corresponds to a normal V-axis polarity.

Some modern equipment, e.g. video cassette recorders and most coders, actually make use of Bruch Blanking to identify the PAL sequence.

(The Bruch Blanking sequence is imposed on the burst gate signal, which explains how a coder is able to derive its V axis switch information from burst gate and mixed syncs.)

The video waveforms around the field sync interval with Bruch Blanking are shown in figure 1.7.

1.9 LUMINANCE TO CHROMINANCE CROSSTALK

Another side effect of the actual chrominance frequency used is that of luminance to chrominance crosstalk. Any luminance signal whose frequency falls within the chrominance spectrum will be decoded as colour information.

A luminance signal which has a frequency of 4.3 MHz is decoded as chrominance, producing colour difference signals at about 100 kHz. Such a signal could be produced from a fine check material (e.g. a man's jacket). If the subcarrier phase relationship on adjacent lines were the same, or very close, the effect of this would be a strongly coloured, almost stationary, interfering pattern. The quarter cycle and 25 Hz offsets help to reduce this effect.

(A possible solution to this problem would be to remove the high frequency luminance component from the coded video signal and transmit it separately).

Dot Pattern of PAL-25 Hz 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 to each line making the frequency 283 $\frac{3}{4}$ × line frequency.

Selecting PAL subcarrier frequency on the coder then adds the 25 Hz precision offset to give the final PAL frequency relationship of:

$$\text{f-pal} = 283\ \tfrac{3}{4} + \tfrac{1}{625} \times 15.625\ \text{KHz}$$
$$= 4.43361875\ \text{MHz}$$

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.

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 deocoded as chrominance for the three subcarrier frequencies available and both PAL and NTSC modes.

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

NOTES