TECHNICAL INSTRUCTION
P.8

WAVEFORMS

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AMENDMENT RECORD

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SECTION 1

TELEVISION STANDARD WAVEFORMS IN STUDIO AND NETWORK DISTRIBUTION CIRCUITS

405-LINE MONOCHROME WAVEFORMS

405-line Monochrome Waveforms

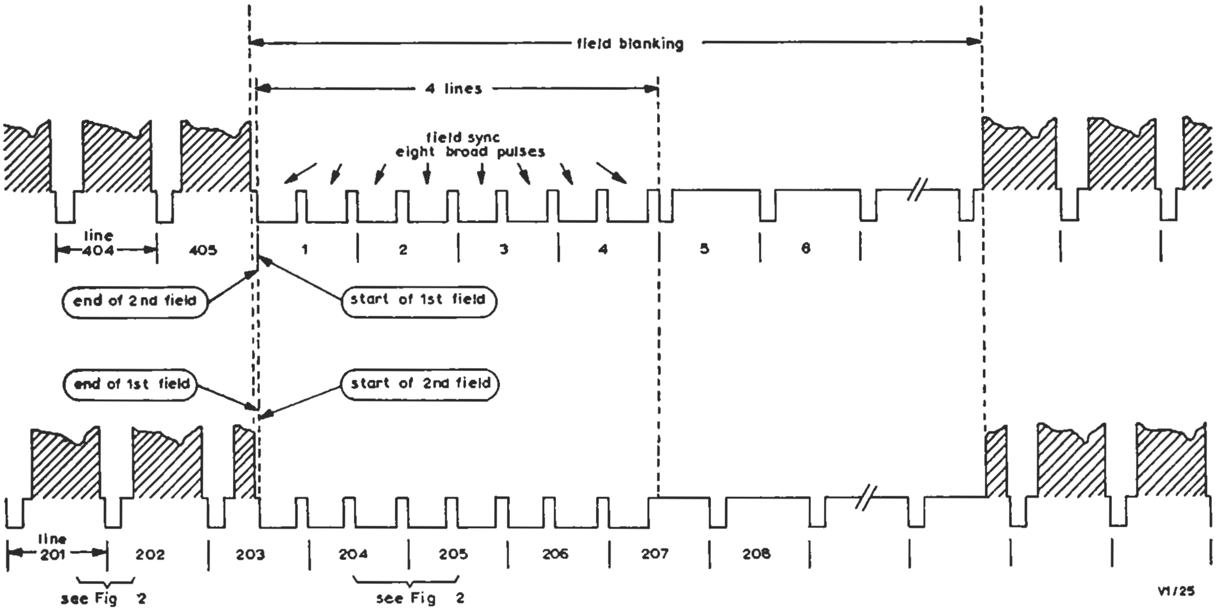

Fig. 1 405-line Waveforms: Commencement of the First and Second Fields in Each Picture

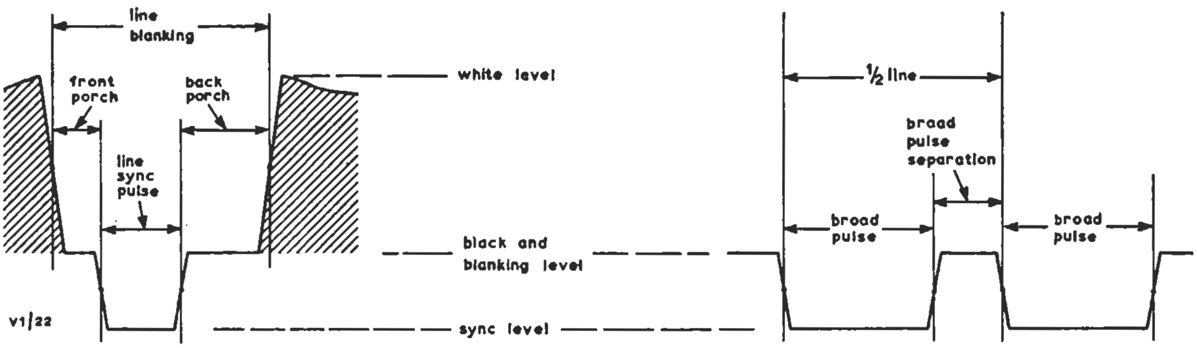

Fig. 2 405-line Waveforms: Line-sync Interval (left) and Field-sync Broad Pulse (right)

405-Line Monochrome Waveforms

Waveform Durations (*between half-amplitude points*)

Line period	98·8 μs nominal
Line blanking	17·5-19·0 μs
Front porch	1·5-2·0 μs
Line sync pulse	8·0-10·0 μs
Line sync pulse + back porch	16·0-17·0 μs
Field period	20 ms
Field blanking	13-15½ lines + 18·25 μs (See Note 2)
Separation between field sync broad pulses	7·4-11·4 μs

Times of Rise and Fall (*10-90% full amplitude*)

Line sync pulse	0·25 μs max
Field sync broad pulse	0·25 μs max
Line blanking	0·25-0·5 μs
Field blanking	0·25-0·5 μs

Amplitudes, Relative to Blanking Level

White level	+0·7 V
Sync level	−0·3 V

Line and Field Frequencies

Line frequency	10,125 Hz
Field frequency	50 Hz

Signals in Field Blanking

At present, lines 12 and 214 may contain test signals. It is intended that these will be transferred to lines 13 and 215.

Notes

1. The preceding data giving waveform durations and times of rise and fall correspond to the values given for the 405-line system in C.C.I.R. Report 308-1 (Oslo 1966).
2. In a 405-line waveform that comes from an electronic standards converter, one or two lines before and after the true field blanking period may contain only low-level spurious signal.

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525-LINE MONOCHROME AND NTSC COLOUR WAVEFORMS

525-line Monochrome and NTSC Colour Waveforms

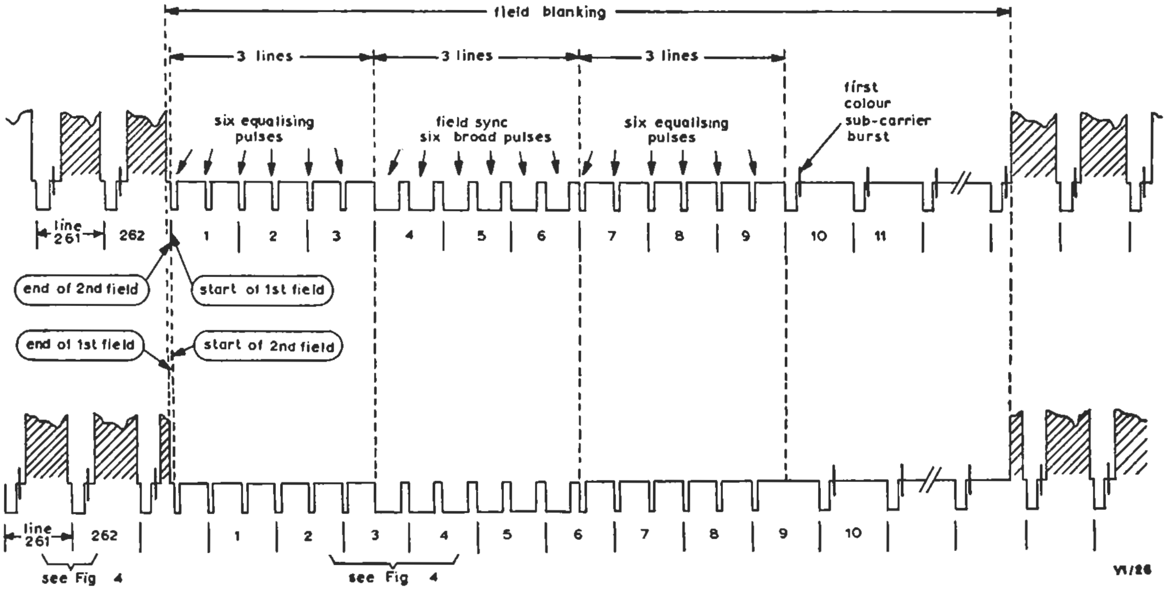

Fig. 3 525-line Waveforms: Commencement of First and Second Fields in Each Picture. Bursts are not present in a monochrome signal. Fields and lines are numbered as in U.S.A.; in the second field, line 1 starts with the second equalising pulse

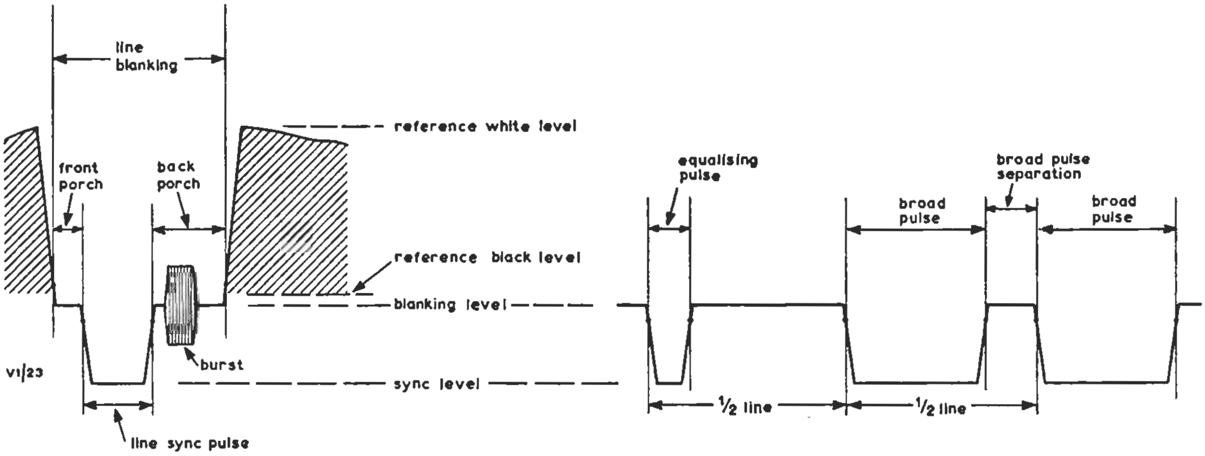

Fig. 4 525-line Waveforms: Line-sync Interval (left), Equalising Pulse and Field-sync Broad Pulse (right)

525-line Monochrome and NTSC Colour Waveforms

(*See Note 11*)

Waveform Durations (*See Note 12*)

	Monochrome	*Colour*
Line period	63·5 μs	63·556 μs
Line blanking	10·2-11·4 μs	10·5-11·4 μs
Front porch	1·27-2·54 μs	1·27 μs min.
Line sync pulse	4·2-5·7 μs	4·2-5·1 μs
Line sync pulse + back porch	8·9-10·2 μs	8·06-10·2 μs (See Note 13)
Field period	16·667 ms	16·683 ms
Field blanking	19-21 lines +10·7 μs	1,168-1,335 μs (approx. 18-21 lines)
Equalising pulse	2·29-2·54 μs	2·29-2·54 μs (See Note 14)
Separation between field sync broad pulses	3·8-5·6 μs	3·8-5·6 μs

Times of Rise and Fall
(*10-90% full amplitude*)

Line sync pulse	0·25 μs max.	0·25 μs max.
Field sync broad pulse	0·25 μs max.	0·25 μs max.
Line blanking	0·64 μs max.	0·48 μs max.
Field blanking	6·35 μs max.	6·36 μs max.

Amplitudes, Relative to Blanking Level
(*See Note 15*)

Reference white	+100 ±4 units	+100 ±4 units
Reference black (set up)	+7·5 ±2·5 units	+7·5 ±2·5 units
Sync level	−40 ±4 units	−40 ±4 units

Line and Field Frequencies

Line (f_L)	15,750 Hz	15,734·264 Hz
Field (f_F)	60 Hz	$\frac{2}{525} \times f_L$ (approx. 59·94 Hz)

Burst Parameters (*Colour Waveform*)

Waveform	At least 8 cycles of colour subcarrier at 3·579545 MHz ±10 Hz.
Start	At least 0·38 μs after the trailing edge of the line sync pulse. The phase of the subcarrier wave has no specified relationship with the line sync pulse.
Finish	Not more than 7·94 μs after the leading edge of the line sync pulse.
Amplitude	0·9 to 1·1 times the blanking to sync-level amplitude, p-p.

Burst Blanking (*Colour Waveform*)
Bursts are omitted during the 9-line interval occupied by equalising pulses and field sync broad pulses.

Phase Reference (*Colour Waveform*)
Phase of burst plus 180 degrees.

Colour Signal Phase Angle (*Colour Waveform*)
The phase angles of signals representing primary and complementary colours, relative to phase reference, are the same as those tabulated for odd lines of the first and second fields in the 625-line PAL system.

Notes

11. Figs. 3 and 4, and the associated data for monochrome or colour, conform to monochrome system M or the U.S.A. colour system as detailed in C.C.I.R. Reports 308-1 and 407 (Oslo 1966), except where any of the following notes specify otherwise.
12. The durations quoted for 525-line waveforms usually refer, in accordance with U.S.A. practice, to intervals between points where leading and trailing edges have reached 10% of their final amplitude relative to blanking level.
13. Some U.S.A. and Canadian sources specify 9·22 μs minimum for line sync pulse plus back porch.
14. C.C.I.R. Report 407 only gives the single value 2·29 μs for the equalising pulse duration in the colour waveform. Other sources specify up to 2·54 μs.
15. The amplitudes are specified in units on a scale originated by the I.E.E.E. (U.S.A.) and are derived from a number of U.S.A. and Canadian sources. The widest tolerances given are quoted here. In a particular system, the relationship of units to voltage may be defined: e.g., where the composite signal is 1 volt p-p, 100 units (reference white level) is 0·71 volt.

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625-LINE MONOCHROME AND PAL COLOUR WAVEFORMS

625-line Monochrome and PAL Colour Waveforms

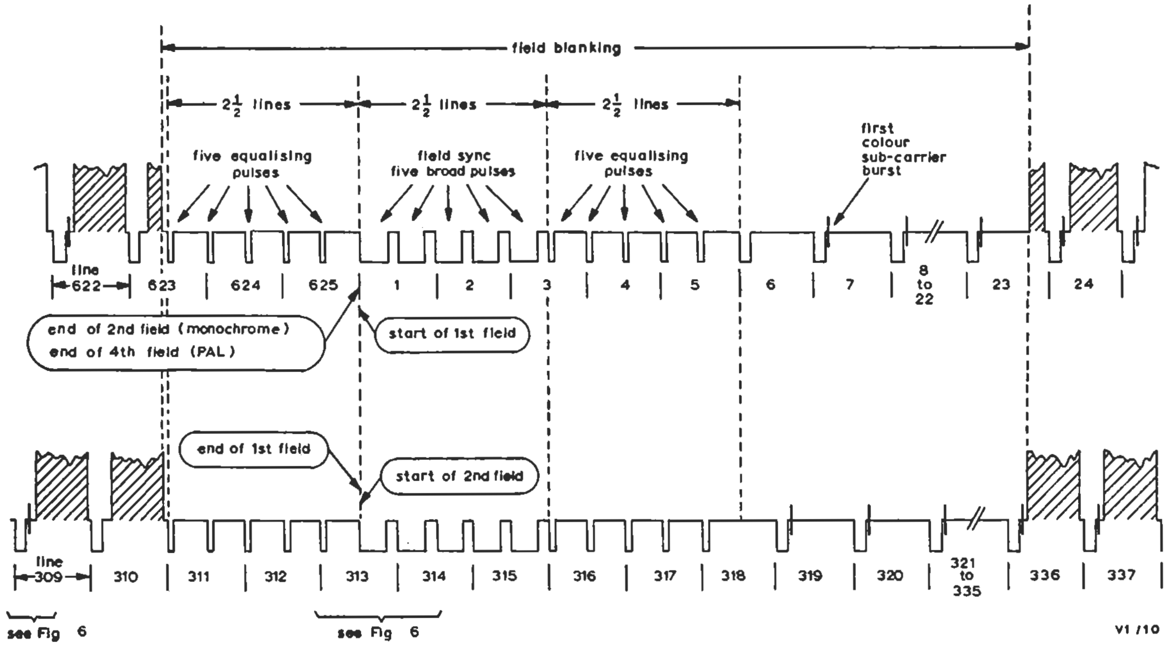

Fig. 5 625-line Waveforms: Commencement of First and Second Fields. The two waveforms recur in each pair of fields making a picture, except for the bursts included in a colour signal. The timing of burst blanking is repetitive in series of four fields

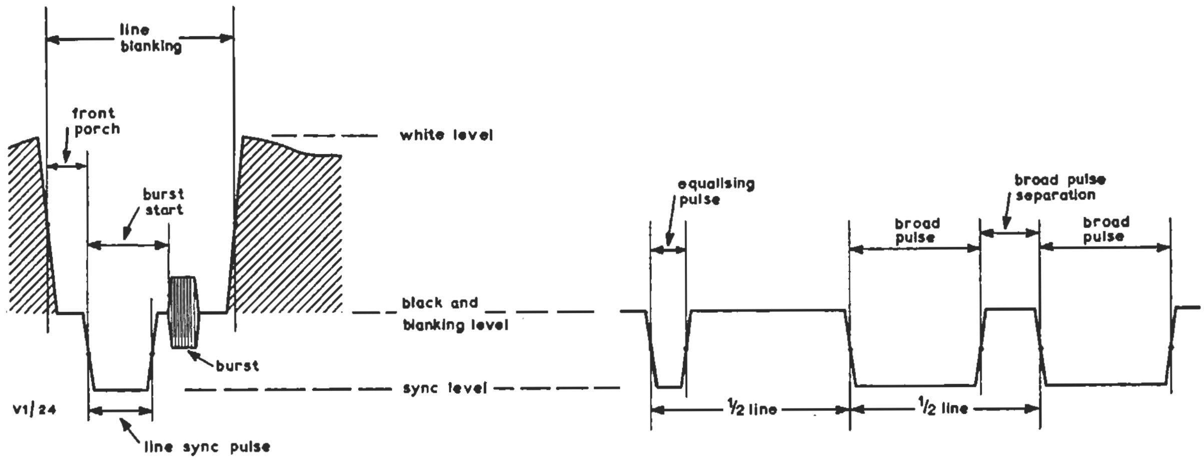

Fig. 6 625-line Waveforms: Line-sync Interval (left), Equalising Pulse and Field-sync Broad Pulse (right)

625-line Monochrome and PAL Colour Waveforms
(*See Note 21.*)

Waveform Durations (*between half-amplitude points*)

Line period	64 μs nominal
Line blanking	12·05 ±0·25 μs
Front porch	1·55 ±0·25 μs (See Note 27.)
Line sync pulse	4·7 ±0·1 μs (See Note 22.)
Field period	20 ms
Field blanking	25 lines + 12·05 μs (See Note 23.)
Equalising pulse	2·35 ±0·1 μs (See Note 23.)
Separation between field sync broad pulses	4·7 ±0·1 μs (See Note 22.)

Times of Rise and Fall (*10-90% full amplitude*)

Line sync pulse	0·25 ±0·05 μs (See Note 24.)
Equalising pulse	0·25 ±0·05 μs (See Note 24.)
Field sync broad pulse	0·25 ±0·05 μs (See Note 24.)
Line blanking	0·3 ±0·1 μs
Field blanking	0·3 ±0·1 μs (See Note 23.)

Amplitudes, Relative to Blanking Level

White level	+0·7 V ±0·25 dB.
Sync level	—0·3 V ±0·25 dB.

Frequencies

Colour subcarrier (*f*SC)	4,433,618·75 ± 1 Hz. (See Note 25.)
Line (*f*L)	$fsc \div (\frac{567}{2} + \frac{1}{4} + \frac{1}{625})$ = 15,625 Hz. (See Note 26.)
Field (*f*F)	$2 fL \div 625 = 50$ Hz.

Burst Parameters (*Colour Waveform*)

Waveform	10 ± 1 cycles of colour subcarrier.
Start	5·6 ± 0·1 μs after the leading edge of the line sync pulse. (See Notes 24 and 28.) The phase of the subcarrier wave has no specified relationship with the line sync pulse.
Amplitude	0·3 V p-p ±0·25 dB. (See Note 22).

Burst Blanking and Burst Phase Sequence (*Colour Waveform*)

Bursts are omitted from nine-line periods commencing in advance of or coincident with field blanking, and are introduced in successive series of four fields as follows:

First field:	on lines 7 to 309
Second field:	on lines 319 to 621
Third field:	on lines 6 to 310
Fourth field:	on lines 320 to 622

The first burst waveform in each field is at 135 degrees relative to phase reference, and following bursts are alternately at 225 (i.e. —135) degrees and 135 degrees.

The bursts are also specified as being at 45 ±0·5 degrees each side of a 'burst mean phase axis' which is at 180 ±2 degrees relative to phase reference. (See Note 24.)

Phase Reference (*Colour Waveform*)

B—Y axis. (Corresponds in position to the U axis in the PAL system.)

Bandwidth (*Colour Waveform*)

Luminance	D.C. to 5·5 MHz; flat except if modified at *f*SC by a notch filter.
Chrominance	Less than 3 dB down at 1·3 MHz, more than 20 dB down at 4 MHz, relative to low frequencies. (See Note 24.)

Signals in Field Blanking

Lines 16 and 329 may contain international identification and control signals.

Lines 17, 18, 330, 331 may contain international test signals.

Lines 19, 20, 332 and 333 may contain national test signals.

Colour Signal Phase Angle, after Coder

Signal	*Angles of Burst and of Signals Representing Primary and Complementary Colours, Relative to Phase Reference*	
	On Odd Lines of 1st and 2nd Fields *On Even Lines of 3rd and 4th Fields*	*On Even Lines of 1st and 2nd Fields* *On Odd Lines of 3rd and 4th Fields*
Burst	135°	225°
Yellow	167·2°	192·8°
Cyan	283·5°	76·5°
Green	240·7°	119·3°
Magenta	60·7°	299·3°
Red	103·5°	256·5°
Blue	347·2°	12·8°

This table is based on information in Designs Department Technical Memorandum No. 8.222(66)

Notes

21. Figs. 5 and 6, and the associated data, conform to monochrome system I and the PAL system in C.C.I.R. Reports 308-1 and 407 (Oslo 1966) except where any of the following notes specify otherwise.
22. The tolerance is that adopted in the BBC. See Designs Dept. Technical Memorandum 8.258(68).
23. The field-blanking and equalising-pulse durations, and the field blanking times of rise and fall, conform to C.C.I.R. Report 310-1 (Oslo 1966).
24. Values adopted in the BBC. See Designs Dept. Technical Memorandum 8.258(68).
25. f_{SC} may have a tolerance of ± 5 Hz in a PAL signal originating outside the U.K.
26. The relationship of f_L to f_{SC} may not be exact while a signal is (a) in the process of synchronisation or (b) derived by standards conversion. At these times $f_L = 15{,}625$ Hz $\pm$ 0·01%.
27. A front porch of 1·65 ±0·1 μs has been found necessary for optimum operation of video tape machines.
28. The burst may be at 5·5 ±0·2 μs in a PAL signal originating outside the BBC.

625-LINE SYSTEM–L MONOCHROME AND SECAM III COLOUR WAVEFORMS

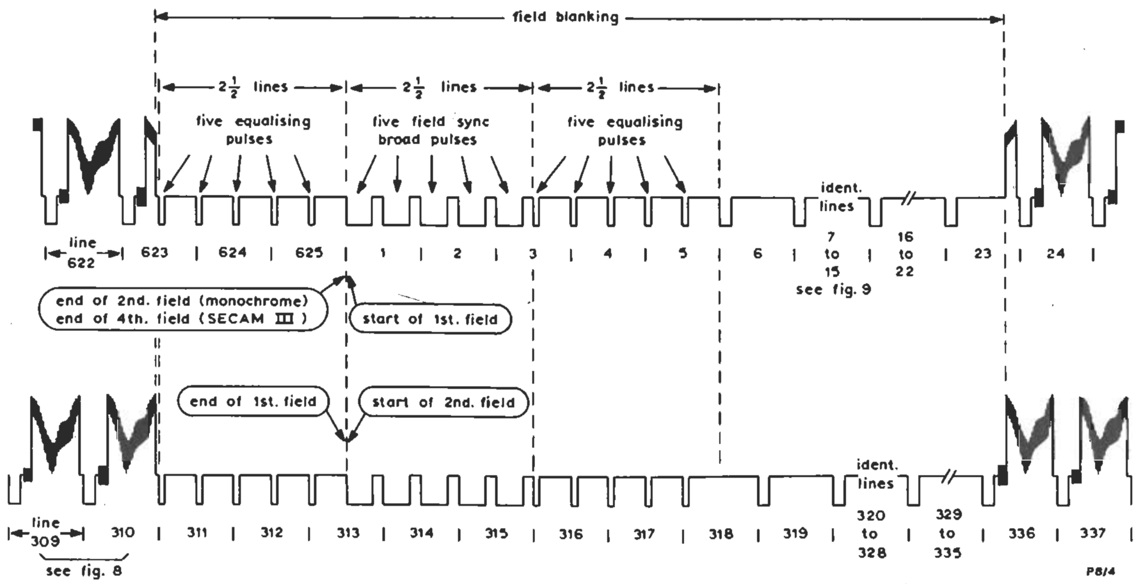

Fig. 7 625-line System L and SECAM III Waveforms: Commencement of First and Second Fields

The two waveforms shown recur in each pair of fields which make a picture, except that alternation of subcarrier frequency and amplitude creates a cycle of four fields (and reversal of subcarrier phase a cycle of twelve fields).

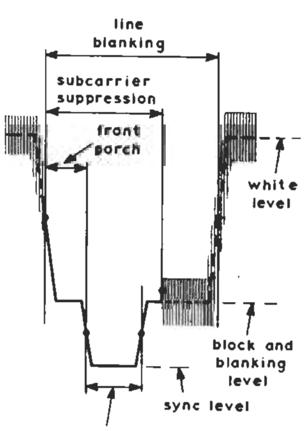

Fig. 8 SECAM III Line-sync Interval

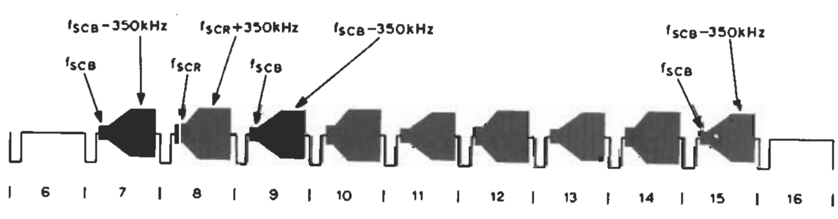

Fig. 9 A Sequence of SECAM III Ident Lines

625-line System-L Monodrome and SECAM III Colour Waveforms
(See Note 31.)

Waveform Durations **(between half-amplitude Points)**

Line period	64 μs nominal
Line blanking	12·0 ±0·3 μs
Front porch	1·5 ±0·3 μs
Line sync pulse	4·7 ±0·2 μs
Field period	20 ms nominal
Field blanking	25 lines + 12·0 μs
Equalising pulse	2·35 ±0·1 μs
Separation between field sync broad pulses	4·7 ±0·2 μs

Times of Rise and Fall **(10 – 90 % full amplitude)**

Line sync pulse	0·15 ±0·05 μs (See Note 32.)
Equalising pulse	0·15 ±0·05 μs
Field sync broad pulse	0·15 ±0·05 μs
Line blanking	0·3 ±0·1 μs (See Notes 32 and 33.)
Field blanking	0·3 ±0·1 μs (See Note 32.)

Amplitude, Relative to Blanking Level

White level (luminance signal)	0·7 V
Black level (luminance signal)	At, or close to, blanking level
Sync level	– 0·3 V

Line and Field Frequencies

Line (f_L)	15,625 Hz
Field (f_F)	$f_L \div 625 = 50$ Hz (independent of mains frequency).

Chrominance Subcarrier

Frequencies

On successive lines the unmodulated subcarrier is alternately at

$f_{SCR} = 282f_L = 4{\cdot}40625$ MHz

$f_{SCB} = 272f_L = 4{\cdot}25000$ MHz

within ±2 kHz of reference signals of $282f_L$ and $272f_L$, respectively, to which the subcarrier is initially locked during line blanking.

Phase

The subcarrier is locked in phase, or 180 degrees out of phase, with the reference signals. Pairs of lines in which the subcarrier is locked in one mode alternate with single lines in which the subcarrier is locked in the other mode. The sequence is reversed in each field and is also staggered in successive fields so that a complete cycle of subcarrier frequency and phase changes occupies 12 fields.

Ident lines

The sequence of f_{SCR} and f_{SCB} is established in each field blanking period by nine alternate ident lines, i.e. lines 7 to 15 and 320 to 328 in each picture.

In f_{SCR} ident lines the subcarrier deviates linearly, in 15 $\pm$5 μs, from f_{SCR} (206 mV p-p) to f_{SCR} + 350 kHz (535 mV p-p), at which the subcarrier remains for the remainder of the line.

In f_{SCB} ident lines the subcarrier deviates linearly, in 20 $\pm$10 μs, from f_{SCB} (166 mV p-p) to f_{SCB} – 350 kHz (501 mV p-p), at which the subcarrier remains.

In ident lines the luminance signal is zero.

Subcarrier suppression

Beginning with line blanking, for 6·7 to 7·8 μs. (See Note 34.)

Throughout field blanking, except in the ident lines.

Subcarrier Modulation

Two modulating signals are formed by subjecting the gamma-corrected red and blue colour difference signals ($E'_R - E'_Y$) and ($E'_B - E'_Y$) to individual weighting factors and to video-frequency pre-emphasis with bandwidth limitation. (See Note 35.) These two signals linearly frequency modulate the subcarrier when it is f_{SCR} and f_{SCB} respectively, on alternate lines.

Modulation of f_{SCR} due to ($E'_R - E'_Y$) signal

Unit modulating signal (corresponding to the steady level for red and cyan in EBU colour bars) produces 280 kHz deviation, down or up for positive or negative values of ($E'_R - E'_Y$) respectively. See Table of Signal Values.

Modulation of f_{SCB} due to ($E'_B - E'_Y$) signal

Unit modulating signal (corresponding to the steady level for blue and yellow in EBU colour bars) produces 230 kHz deviation, up or down for positive or negative values of ($E'_B - E'_Y$) respectively. See Table of Signal Values.

Deviation limits (See Note 35.)

f_{SCB} +350 kHz and –500 kHz,

f_{SCB} +500 kHz and –350 kHz,

i.e., on both f_{SCR} and f_{SCB} lines the subcarrier deviation is limited at about 4·75 MHz and 3·90 MHz.

Modulated subcarrier pre-emphasis (See Note 35.)

Before addition to the luminance signal, the modulated subcarrier is subject to the transmission factor

$$\frac{1 + j16F}{1 + j1{\cdot}26F}$$

where $F = \frac{f}{fo} - \frac{fo}{f}$

and fo = 4·28600 MHz

Bandwidth

Luminance	D.C. to 6·0 MHz
Chrominance	From 2·8 to 5·8 MHz approximately

Signals in Field Blanking

Lines 7 to 15 and 320 to 328 are subcarrier frequency ident lines.

Lines 16 to 22 and 329 to 335 are reserved for test and control signals.

Table of Signal Values

Steady-state values (after transients due to pre-emphasis) of the subcarrier modulating signal and modulated subcarrier for EBU colour bars (100 % amplitude white bar, 75 % amplitude primary and secondary colour bars), and for levels reached in ident lines.

Colour	*Colour Signals* Relative Amplitudes			*Luminance Signal*	*Modulating Signal* Relative Amplitudes		*Subcarrier Deviation* (kHz)		*Subcarrier Amplitude* (mV** p-p)	
	Red	Green	Blue							
	E'_R	E'_R	E'_B	E'_Y*	f_{SCR} lines	f_{SCB} lines	f_{SCR} lines	f_{SCB} lines	f_{SCR} lines	f_{SCB} lines
White	1·00	1:00	1·00	1·00	0	0	0	0	206	166
Yellow	0·75	0·75	0	0·66	−0·16	−1·00	−45	−230	184	350
Cyan	0	0:75	0·75	0·53	+1·00	+0·34	+280	+78	457	170
Green	0	0·75	0	0·44	+0·84	−0·66	+235	−152	418	270
Magenta	0·75	0	0·75	0·31	−0·84	+0·66	−235	+152	206	204
Red	0·75	0	0	0·23	−1·00	−0·34	−280	−78	242	206
Blue	0	0	0·75	0·09	+0·16	+1·00	+45	+230	245	266
Black	0	0	0	0	0	0	0	0	206	166
Ident				0	+1·25	−1·52	+350	−350	535	501

* $E'_Y = 0{\cdot}30E'_R + 0{\cdot}59E'_G + 0{\cdot}11E'_B$

** Corresponding to a black-to-white luminance amplitude of 700 mV

Notes

31. Figs. 7, 8 and 9, and the following data, conform to the C.C.I.R. monochrome system L and the optimised SECAM III colour system, as detailed in Designs Department Technical Memorandum 11.38(67), translated from ORTF specification SN 043A (January 1967), except where any of the further notes specify otherwise.

32. Maximum overshoot allowable is 5%.

33. Measured with a signal at white level at the end and beginning of lines.

34. From a C.C.I.R. draft report, September 1969. The earlier value in D.D.T.M. 11.38(67) for the end of subcarrier suppression was 5·7 ±0·3 μs after the leading edge of line sync.

35. The video-frequency pre-emphasis and the subcarrier pre-emphasis are also known as the low-frequency and high-frequency pre-emphasis, correction, or pre-correction. The first can cause overshoots in the modulating signal at transitions of level in the colour difference signals and, for increases of level, may cause the frequency modulation to reach, and be curtailed at, the deviation limits. The subcarrier pre-emphasis results in an increase in subcarrier amplitude as it deviates away from 4·286 MHz, and the chrominance signal may include overshoots or rounded edges on its envelope at colour signal transitions, as may be evident on the waveform for colour bars.

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SECTION 2

COLOUR BARS

Introduction

A colour bar signal is a standardised colour test waveform which, when viewed on a picture monitor or television receiver, consists of vertical or horizontal bars of different colours. It is usual for these colours to include the three primary colours (red, green and blue) and the secondary colours which are the additive mixtures of pairs of the primaries (namely yellow, cyan and magenta) as well as white and black. For each colour, the luminance level and both the amplitude and phase of the chrominance component in the waveform are specified. The commonest arrangement consists of vertical bars of the eight colours in descending order of luminance, and various forms of this arrangement are the subject of fuller descriptions which follow. The 'deluge' waveform, containing fewer colour bars, is also described.

Initially, in the BBC, the signal was intended to facilitate coder alignment, in which coders are fed and adjusted so that a colour bar waveform satisfying various requirements is obtained as output. However, in addition, coded colour bar signals are used in adjusting other equipment and are commonly examined at intermediate points in systems as a quick transmission check. A colour bar signal, alone or inserted at the top of the colour test card, is radiated by the BBC in trade tests.

In some instances, including the alignment of coders, the chrominance signals in the coded colour bars have maximum amplitude and, with the associated luminance levels, represent 100 per cent saturation. These are designated 100/0/100/0 bars (in accordance with nomenclature detailed later), and are also known as 100 per cent bars. Such a signal may be applied to decoders and other equipment for testing purposes, where it is available locally, or the 'deluge' signal produced by a decoder line-up generator may be employed.

For other purposes, particularly for transmission through the television system and radiation, a lower amplitude coded colour bar waveform that still provides a stringent test is generated by the BBC. In this, the chrominance amplitudes and luminance levels correspond to decoded colour signals that are of full amplitude but produce a saturation of 95 per cent for a display gamma of 2·2 (a value which was once standard). These are known as 100/0/100/25 bars or 95 per cent bars. They are regarded as very representative of the luminance and chrominance values obtained from colour cameras in normal operation.

Other forms of colour bar signal may be encountered, particularly in international-network and videotape operations, and the commoner of these are included in the details that follow.

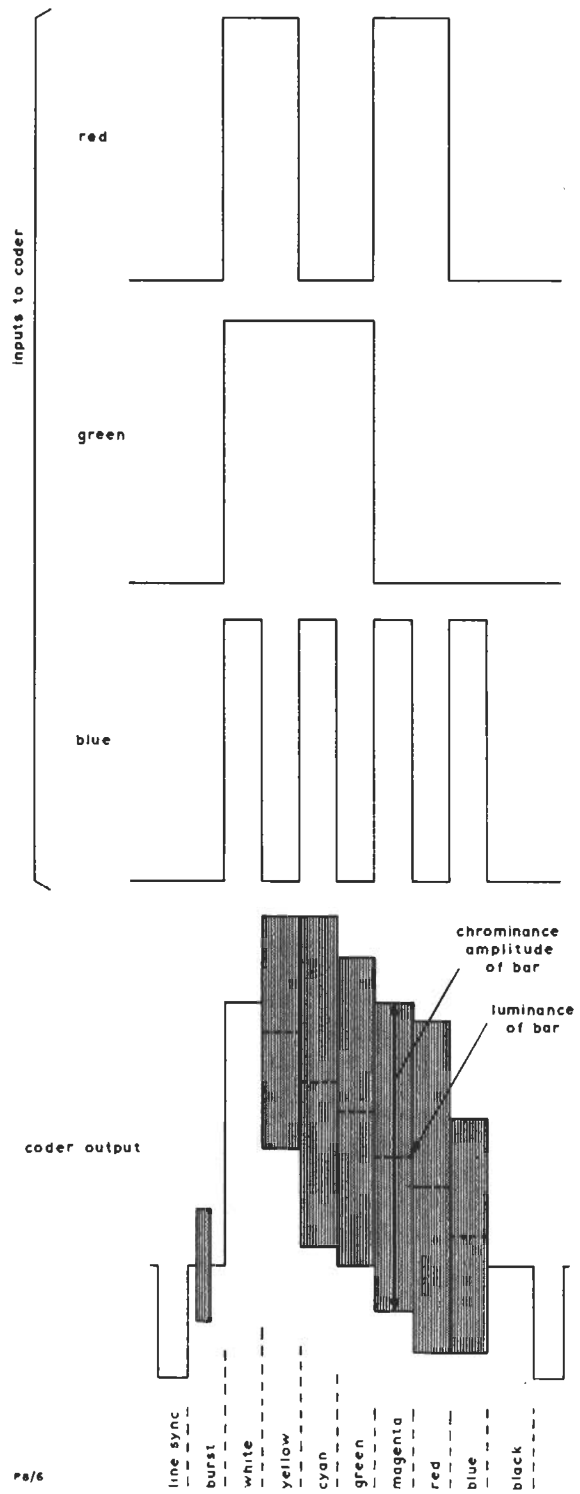


Fig. 2.1 Generation of a Coded Colour-bar Signal
Typical RGB inputs to a coder and composite output over one line period

Generation

In the alignment of a coder, a colour bar signal is produced at the output as a result of feeding into the coder separate R, G and B signals consisting of one or more rectangular waves per line. (These are sometimes also called colour bar signals.) Adjustments are made so that the coded colour bar waveform produced is satisfactory.

When a coded colour bar waveform is required for transmission through a system and for radiation, the same method of generation is usually employed, using the coder at the head of the system. The RGB signals are modified, if necessary, so that the colour bar waveform is of the type suitable for these purposes and can be handled by the system when correctly set up.

As a rule, the RGB rectangular waves are applied to the coder from a vertical colour bar generator, such as a GE4/523. The RGB waveforms are blanked and are of equal amplitude, as shown in the example in Fig. 2.1. Their full amplitude is +0·7 volt relative to blanking level, for application to coders normally fed with 0·7 volt (maximum) RGB signals from camera channels. The G output of the generator consists of one complete rectangular wave per line, the R output two waves per line and the B output four waves per line.

The rectangular waves are related to each other in time so that at the beginning of a line they are at their upper level simultaneously, resulting in a white (or grey), luminance only, signal from the coder. Subsequently, during the line, the rectangular waves are at their upper level in pairs or alone in a sequence which causes the coder to produce signals representing the primary and secondary colours in descending order of luminance. (Luminance = 0·299R + 0·587G + 0·114B.)

Providing that the lower level to which the RGB rectangular waves drop in turn is zero, the coder output following the white (or grey) bar is purely the result of the two waves, or one wave, at the upper level at a particular time, and the luminance and chrominance components in the coded waveform correspond to 100 per cent saturation. If the lower level of the RGB rectangular waves is at some voltage above zero, then the simultaneous existence of this voltage in all three RGB inputs (alone or as part of the upper level amplitude) causes the coder output to have a luminance pedestal, and only the relative amplitude of the RGB waves above the lower level generates chrominance signals: as a result the chrominance amplitudes are reduced and the luminance pedestal either causes an increase in the luminance component in the colour bars (causing desaturation) or may form a specified black level, above blanking level. (A black-level pedestal is not normal in BBC practice, but is standard in some countries, mainly those using 525-line signals).

The deluge waveform is a coded colour bar waveform produced, without the use of a separate coder, by a decoder line-up generator. The one currently in use, the GE4M/524, generates white, yellow, red and black bars. It requires only a video input containing mixed sync-pulses and, preferably, colour bursts.

Nomenclature

A system of nomenclature for identifying colour bar signals has been agreed between authorities concerned with television broadcasting in the United Kingdom, including the BBC, and is the subject of a recommendation to C.C.I.R. This nomenclature assumes that colour bar signals are generated by the application of RGB signals in the form of rectangular waves to a coder, as described previously, and identifies any particular colour bar waveform by a group of four numbers that refer to the RGB signals required. These numbers are the levels of the RGB waveforms, expressed as percentages of the full RGB amplitude that can be applied, corresponding to four conditions, as follows:—

The first number specifies:
: the level of the RGB waves during generation of the white (or grey) bar.

The second number specifies:
: the level of the RGB waves during generation of the black bar.

The third number specifies:
: the upper level of the RGB waves during the generation of the primary and secondary-colour bars.

The fourth number specifies:
: the lower level of the RGB waves during the generation of the primary and secondary-colour bars.

Consideration shows that the first number indicates whether the 'white' bar has full amplitude, that is, maximum luminance, and therefore whether it represents white or a grey. The second number normally represents black level, and is zero except for waveforms in which black level is above blanking level. The third number, minus the fourth number if it is not zero, indicates the amplitude (relative to maximum) of the chrominance signals in the primary and secondary colour bars. The fourth number, if not zero, indicates the generation of a pedestal in the primary and secondary colour bars: the fourth number is the same as the second if the pedestal represents black level, but is greater than the second if a desaturating pedestal is generated in the primary and secondary colour bars.

As an example, the colour bars usually generated in coder alignment have

(a) the white bar at maximum luminance
(b) the black bar at blanking level
(c) the chrominance amplitudes at maximum
(d) no desaturation

These are 100/0/100/0 bars.

This system of identifying colour bars has the advantage that it does not refer directly to saturation values, which become misleading when based on a value of display gamma that has been superseded.

100/0/100/0 Colour Bars
(Known as 100 % Colour Bars)

As shown in Fig. 2.2, the generating RGB signals are at maximum value at their upper level and are at zero at their lower level.

In the generated coded waveform, the white and black bars are formed by the luminance signal at white level and at blanking level respectively.

The primary and secondary colour bars contain chrominance signals at maximum amplitude for the colours represented. The corresponding luminance levels are at the maxima produced by R, G and B signals in pairs and alone. There is no luminance component which would result from a simultaneous R, G and B voltage, and the colours are 100 per cent saturated when displayed.

The luminance levels, chrominance signal amplitudes and chrominance signal phase angles for these bars are given in the Appendix.

Looking at the coded waveform, the following features are of interest:

(a) In both the yellow and cyan bars, the positive peaks of the chrominance signal reach the same level (above white level).
(b) In both the red and blue bars, the negative peaks of the chrominance signal reach the same level (below blanking level).
(c) In the magenta bar, the positive peaks of the chrominance signal are at white level.
(d) In the green bar, the negative peaks of the chrominance signal are at black level (i.e. blanking level).

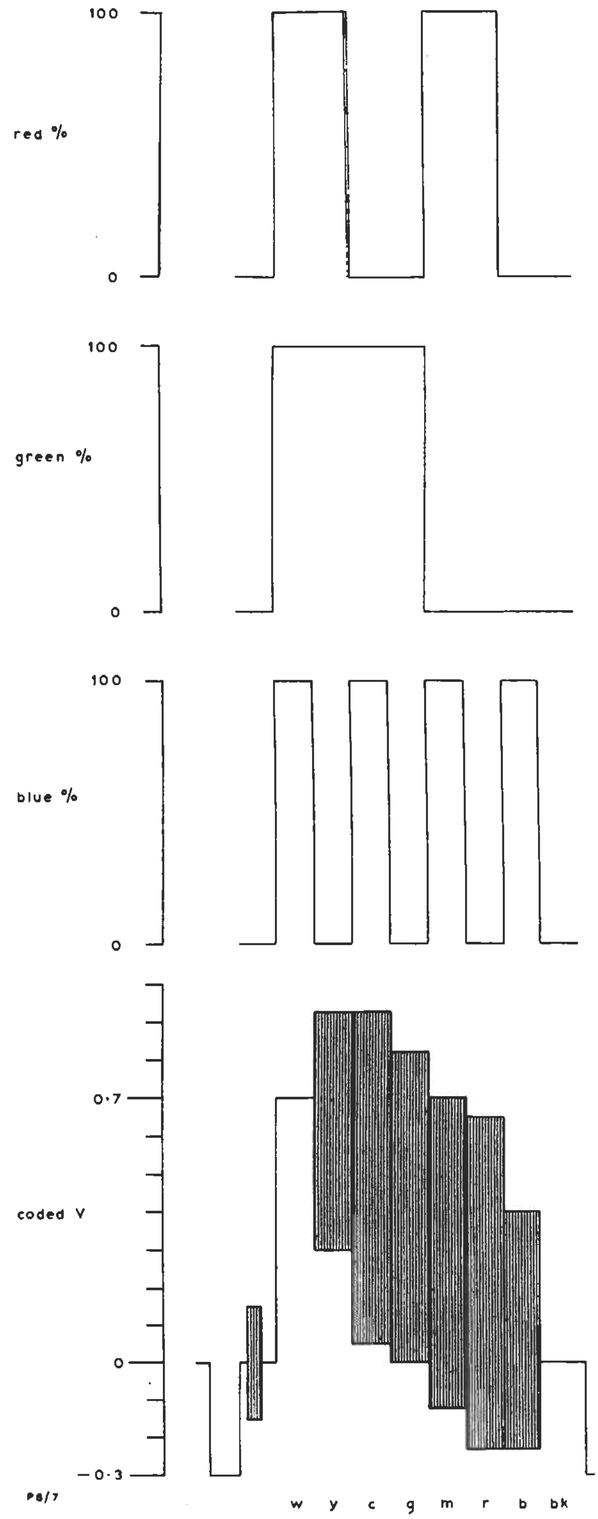


Fig. 2.2 100/0/100/0 Colour Bars
RGB inputs and composite output of coder

100/0/100/25 Colour Bars
(Known as 95 % Colour Bars)

As shown in Fig. 2.3, the generating RGB signals are at the maximum value at their upper level and are at 25 per cent of maximum at their lower level, except that during the period for the black bar they drop to zero.

In the generated coded waveform, the white and black bars are formed by the luminance signal at white level and blanking level respectively.

The primary and secondary colour bars contain chrominance signals at 75 per cent of the amplitude in 100/0/100/0 bars. The corresponding luminance levels consist of 75 per cent of the levels in 100/0/100/0 bars added to a luminance pedestal at 25 per cent of white level.

The luminance levels, chrominance signal amplitudes and chrominance signal phase angles for these bars are given in the Appendix.

Looking at the coded waveform, the following features are of interest:

(a) In both the yellow and cyan bars, the positive peaks of the chrominance signal reach the same level (above white level).

(b) In both the red and blue bars, the negative peaks of the chrominance signal reach black level (i.e. blanking level).

(c) In the magenta bar, the positive peaks of the chrominance signal are at white level.

If this colour bar signal is decoded faithfully, the RGB rectangular waves originally applied to the coder are reproduced as inputs for a colour picture tube. The simultaneous existence of a voltage at 25 per cent of maximum in the three signals applied to a picture tube causes desaturation in the colour bars displayed. However, owing to the non-linearity of picture tubes, the desaturation is not directly proportional to the 25 per cent level in the decoded RGB signals, but is usually much less. The value of saturation is

$$100\,[1 - (E_{min}/E_{max})^{\gamma}] \text{ per cent}$$

where E_{min} and E_{max} are the minimum and maximum values, relative to blanking level, of the RGB signals, and γ is the gamma value of the picture tube. Thus, for a gamma of 2·2, which was once the standard value, the saturation of 100/0/100/25 colour bar is

$$100\,(1 - 0{\cdot}25^{2{\cdot}2}) = 95 \text{ per cent}$$

but for a gamma of 2·8, the value now adopted, the saturation is approximately 98 per cent.

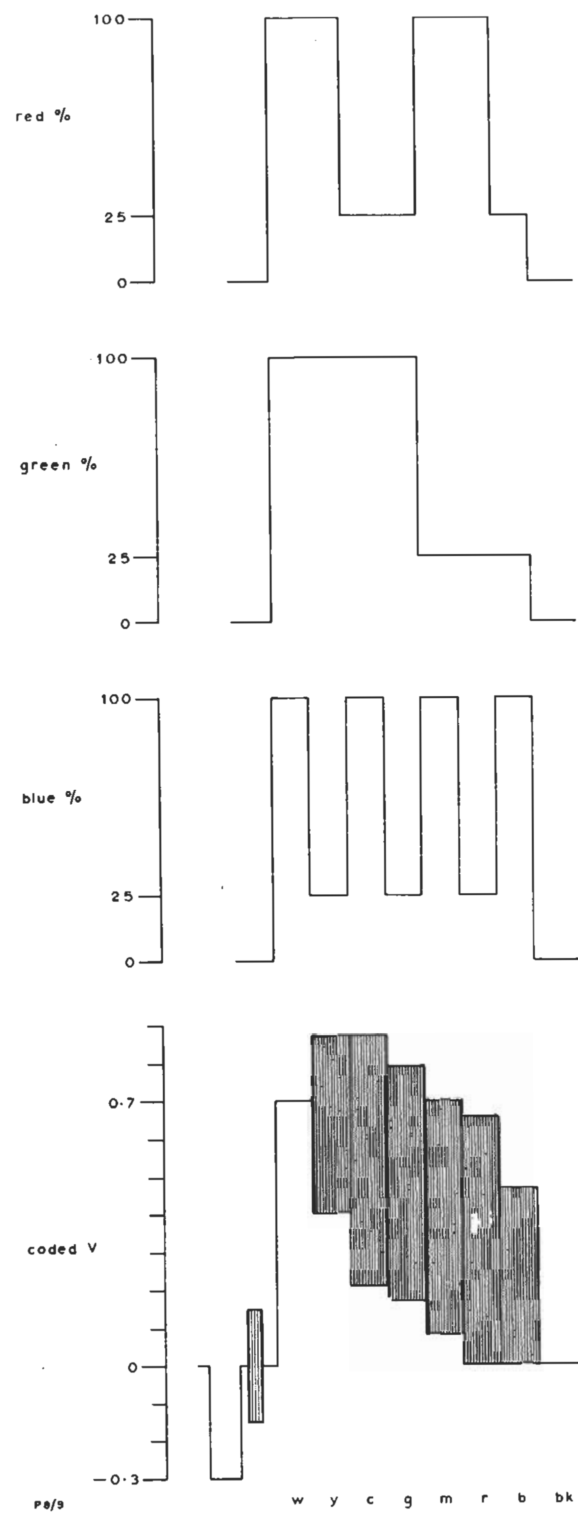


Fig. 2.3 100/0/100/25 Colour Bars
RGB inputs and composite output of coder

100/0/75/0 Colour Bars

(Known as EBU Colour Bars)

As shown in Fig. 2.4, the generating RGB signals are at 75 per cent of maximum value at their upper level and are at zero at their lower level, except that during the period for generating the white bar they are at maximum.

In the generated coded waveform, the white and black bars are formed by the luminance signal at white level and at blanking level respectively.

The primary and secondary colour bars contain chrominance signals at 75 per cent of the maximum amplitude for the colours represented, that is 75 per cent of the amplitudes in 100/0/100/0 bars. The luminance levels are also at 75 per cent of the levels in 100/0/100/0 bars. There is no luminance component which would result from a simultaneous R, G and B voltage, and the colours are 100 per cent saturated when displayed.

The luminance levels, chrominance signal amplitudes and chrominance signal phase angles for these bars are given in the Appendix.

Looking at the coded waveform, the following features are of interest:

(a) In both the yellow and cyan bars, the positive peaks of the chrominance signal reach white level.

(b) In both the red and blue bars, the negative peaks of the chrominance signal reach the same level (below blanking level).

(c) In the green bar, the negative peaks of the chrominance signal are at black level (i.e., blanking level).

This colour bar waveform is widely used by European broadcasting authorities other than the BBC. Because, until recently, many of these organisations employed a pedestal in their standard television waveform, a pedestal has often been encountered in the EBU colour bar waveform. Commonly, the pedestal has been at 0·05 volt (i.e. 7·14 per cent) in a signal with white level at 0·7 volt above blanking level. Such a pedestal is generated in the colour bar waveform by feeding to the coder RGB waves in which the lower level is 7·14 per cent above zero. With the upper levels of the RGB waves still at 75 per cent, for the primary and secondary colour bars, the resulting chrominance signals have less amplitude. It should be noted that the pedestal is under all the bars, including the white and black bars, for the purpose of providing a black level above blanking level, and that the bars are not desaturated when displayed, providing the receiver or picture monitor is correctly adjusted.

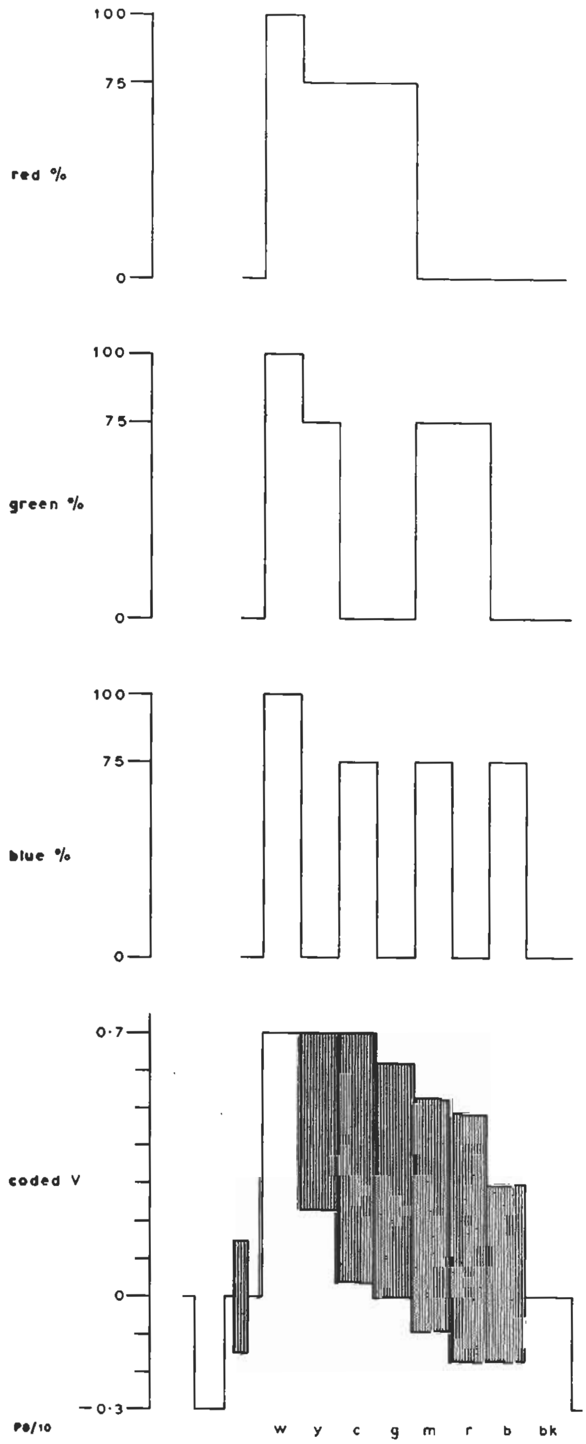


Fig. 2.4. 100/0/75/0 Colour Bars
RGB inputs and composite output of coder.

525-line System Colour Bars

The colour bar signal commonly used in the U.S.A. and Canada is a split-field waveform which consists of a sequence of only seven colour bars (grey and the six primary and secondary colours) spaced over the lines occupying three-quarters of the display period of each field, and a sequence of –I, white level, Q and black level signals on the lines in the remainder of the display period of the field.

The colour bars occupying the first three-quarters of a field correspond to the RGB inputs to a coder shown in Fig. 2.5. The RGB rectangular waves are at 77 per cent of maximum at their upper level and at 7·5 per cent of maximum at their lower level. (The value 77 per cent is nominal; basically this level is at 75 per cent of the range from the 7·5 per cent level up to maximum.)

The coded waveform sits on a pedestal, known as the setup, at 7·5 per cent of white level above blanking level. This pedestal represents black level. The grey bar is formed by a luminance signal at 77 per cent above blanking level (i.e. 75 per cent up the range above the pedestal). The primary and secondary colour bars contain chrominance signals which have 75 per cent of the maximum possible amplitudes after allowance for the black pedestal; that is, the chrominance amplitudes are 0·75 (100 – 7·5) per cent, equals 69·37 per cent, of the values that would be obtained in 100/0/100/0 bars. Because the pedestal represents black level it should not introduce desaturation, and in a correctly adjusted display the colour bars in this signal are 100 per cent saturated.

In the lines occupying the last quarter of the display period of each field, a – I subcarrier signal at black level commences after line blanking, as shown in Fig. 2.6. A white level, 100 per cent luminance, signal follows, and then a Q subcarrier signal. Each of these three signals has a duration of 1·25 times the duration of each of the preceding seven colour bars. The remainder of these lines is occupied by a black level (pedestal level) luminance signal.

The luminance and chrominance voltage values in this signal depend on the standard video peak-to-peak voltage that is employed and on the picture/sync ratio. Usually in 525-line operations the video voltage is one volt peak-to-peak and the picture/sync ratio is 100/40, resulting in white level being at +0·714 volt and sync level being at –0·286 volt. Luminance levels and chrominance amplitudes related to these values are given, together with chrominance phase angles, in the Appendix.

The result of viewing the waveform in the lines occupying the last quarter of each field superimposed on the waveform of the seven colour bars is shown in Fig. 2.7. The following features are of interest:

(a) In both the yellow and cyan bars, the positive peaks of the chrominance signal reach white level.
(b) In both the red and blue bars, the negative peaks of the chrominance signal reach the same level (below blanking level).
(c) In the magenta bar, the positive peaks of the chrominance signal reach the level of the grey bar
(d) In the green bar, the negative peaks of the chrominance signal reach black level (not blanking level).

Other versions of the colour bar signal are known to be used in 525-line operations. Full-field eight-bar waveforms including a black bar are sometimes employed. In these the amplitudes may be as in the first three-quarters of the split-field signal detailed previously, giving a 77/7·5/77/7·5 signal, or the white bar, or all the bars, may be at maximum amplitude, subject to allowance for the black-level pedestal.

In any of the waveforms described, the black-level pedestal or setup may occasionally be at 10 per cent instead of 7·5 per cent, resulting in slightly greater luminance levels (relative to blanking) and smaller chrominance amplitudes in the bars.

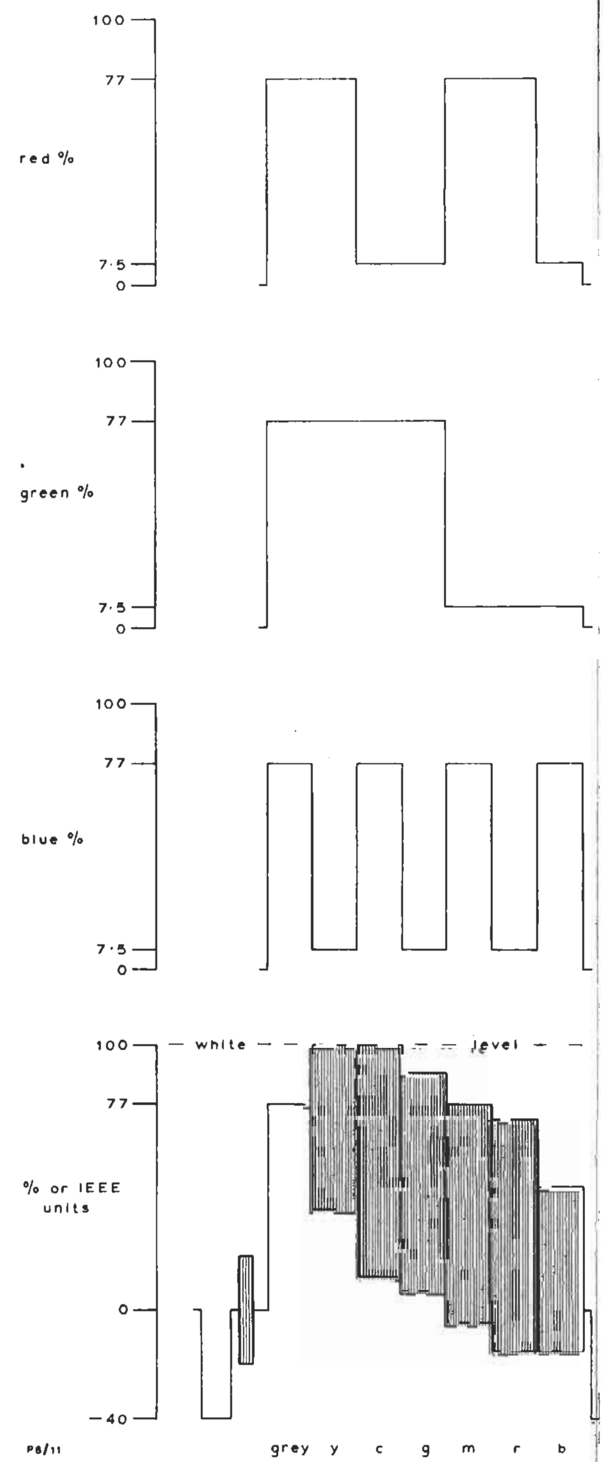


Fig. 2.5 77/7·5/77/7·5 Bars in a 525-line Split-field Colour-bar Signal and (above) the Corresponding RGB Signals

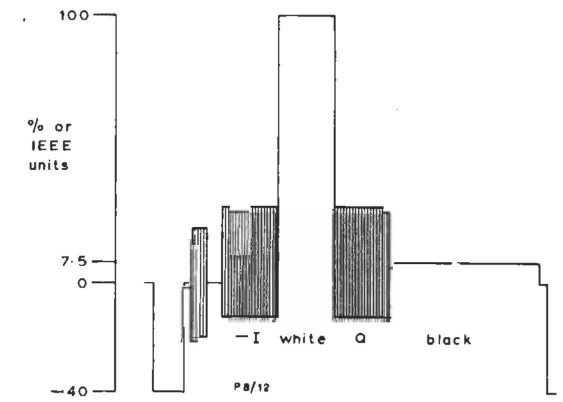


Fig 2.6 The Sequence of – I, White, Q and Black Waveforms in a 525-line Split-field Colour-bar Signal

Fig. 2.7 The Line Waveforms of Figs. 2.5 and 2.6 Superimposed in a Complete Field

Deluge Waveforms

The name of these waveforms is derived from that of their source, decoder line-up generators. The waveform described here is the one produced by the decoder line-up generator currently in use in the BBC, the GE4M/524.

The GE4M/524 requires a video input signal which must contain mixed sync-pulses, and preferably should include colour bursts. It produces a simple full-field composite colour bar waveform, shown in Fig. 2.8, in which each line contains, after a burst and the end of line blanking, four equal parts as follows:–

In 1st quarter of line:
a luminance signal at maximum, i.e. white level.
In 2nd quarter of line:
a yellow chrominance signal at maximum amplitude, with the associated luminance level, corresponding to 100 per cent saturation.
In 3rd quarter of line:
a red chrominance signal at maximum amplitude, with the associated luminance level, corresponding to 100 per cent saturation.
In 4th quarter of line:
a luminance signal at zero, i.e. black level.

The values of the luminance levels and chrominance signals in these four bars are the same as those for the white, yellow, red and black bars in the 100/0/100/0 colour bar waveform.

Summary of the Uses of Colour Bars

Adjustment of Coders

A colour bar generator, set for 100/0/100/0 bars (100 per cent bars), is connected to provide RGB inputs to the coder, and the output of the coder is examined on a wideband oscilloscope. The procedure for setting up a particular type of coder is usually the subject of detailed information available for the coder. Typically, on a PAL coder, the following outputs are checked and, if necessary, adjusted:

Spurious subcarrier; with RGB bar inputs off at coder
Spurious subcarrier; with RGB bar inputs paralleled (therefore exactly equal, corresponding to pure white or grey) at coder chrominance unit
Amplitudes of (B – Y) and (R – Y) signals; with RGB inputs normal
Fluctuation (twitter) between successive lines, indicating state of accuracy of (B – Y) and (R – Y) quadrature; with RGB inputs normal
Luminance levels; with RGB inputs normal
Sync and burst amplitudes

It is an advantage to use a coder calibrator in

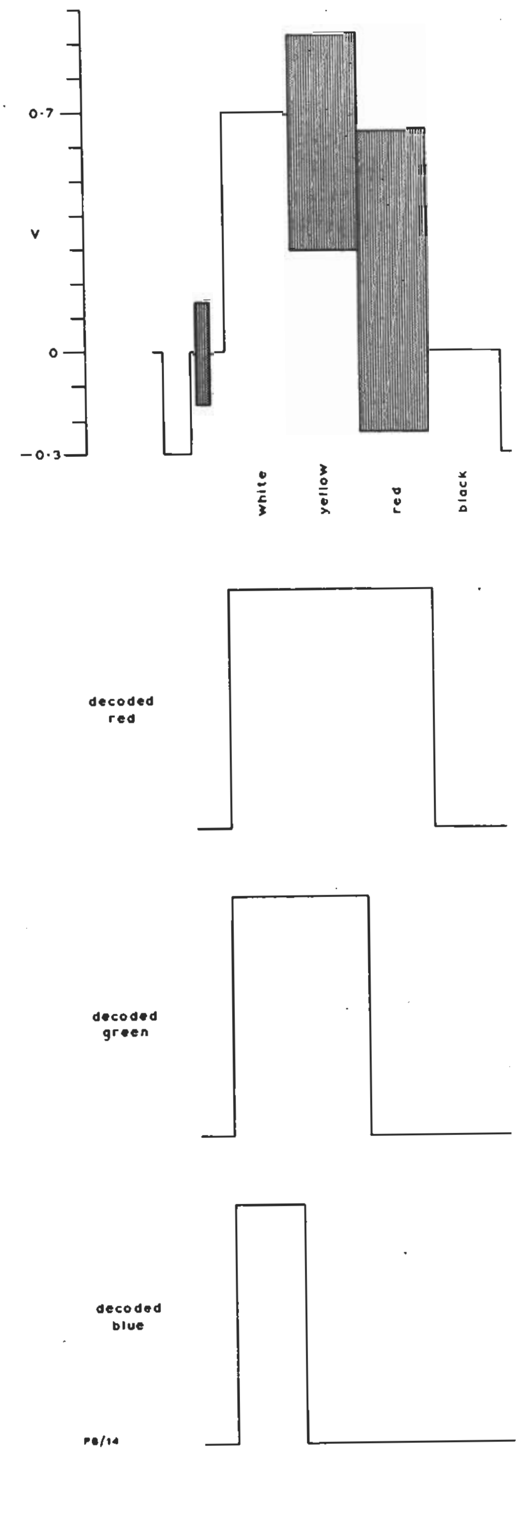


Fig. 2.8 The Deluge Waveform and Decoded RGB Signals

conjunction with the oscilloscope. See the Instructions for coder GE1/526 and coder calibrators UN2M/505 and UN2L/505.

Adjustment of Decoders

This is the subject of detailed information applying to each type of decoder. In general, a 100/0/100/0 coded colour bar waveform (if available) or a deluge waveform is applied to the decoder. Typically, a PAL decoder is set to the simple mode and the following are checked and, if necessary, adjusted:

Luminance and sync output amplitudes
Phase of local demodulating subcarrier
Saturation (chrominance amplitude)
(R – Y) amplitude
RGB amplitudes

Tests on Other Equipment and Transmission Systems

If a colour bar waveform is passed through an equipment or transmission system, the extent to which certain features of the waveform are modified as a result may be checked as an indication of the performance of the equipment or system.

When a 100/0/100/0 (100 per cent) waveform, a 100/0/75/0 (EBU) waveform, or a 525-line waveform is applied to an equipment or system, a loss in the higher video frequencies is indicated if the negative envelope of the green bar is seen to be above black level on a wideband oscilloscope connected to a check point. Similarly, high-frequency loss is shown with 100/0/100/25 bars if the positive envelope of the magenta bar is below white and the negative envelope of the red and blue bars is above black level.

As a quick check of differential gain, the chrominance amplitudes of the yellow and blue bars, which should be the same as each other in any colour bar waveform, may be compared at test points.

As a quick check of differential phase, the angle between the yellow and blue chrominance signals, which should be 180 degrees, may be examined on a vectorscope connected to test points.

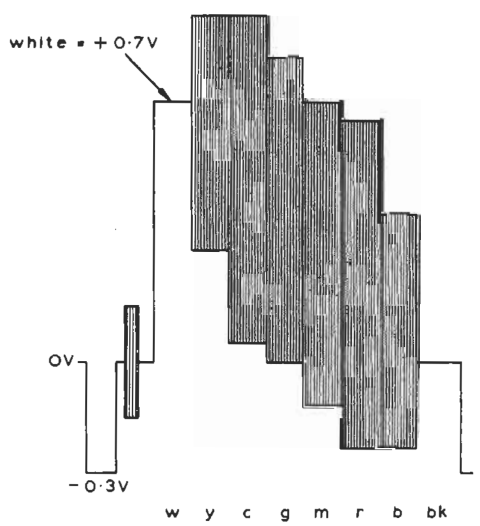
Modified Colour Bar Signal in Video Tape Operations

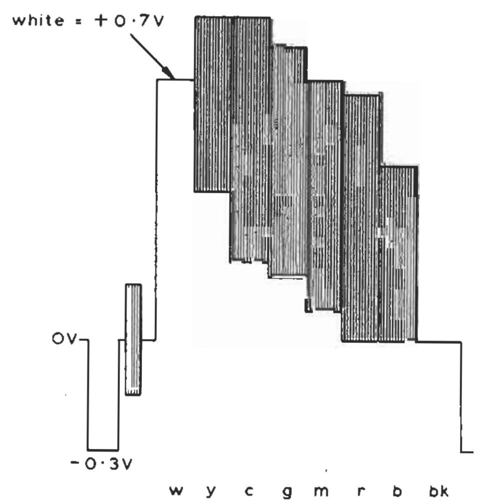
During video tape recording and reproduction of colour signals, it is useful to have some simple test signal with both a burst and chrominance information. A colour bar signal, being familiar to video tape and other operational staff, is convenient for this purpose, providing a ready means of checking amplitude and phase using waveform, vector and picture displays. However, in the conventional form it is not fully satisfactory. Both chrominance and luminance vary along each line and this renders it difficult to distinguish the effects of velocity and pressure variations as the video heads sweep the tape. The area occupied by any one test colour, as conveyed by one head channel on one sweep of the head, is small, making it difficult to judge the effect of these variations on the complete picture. However, it has been found that the alteration of colour saturation due to small errors becomes very noticeable in large areas of fairly uniform colour (such as faces in close-up, backgrounds of simple sets), particularly when the colour is near red and magenta.

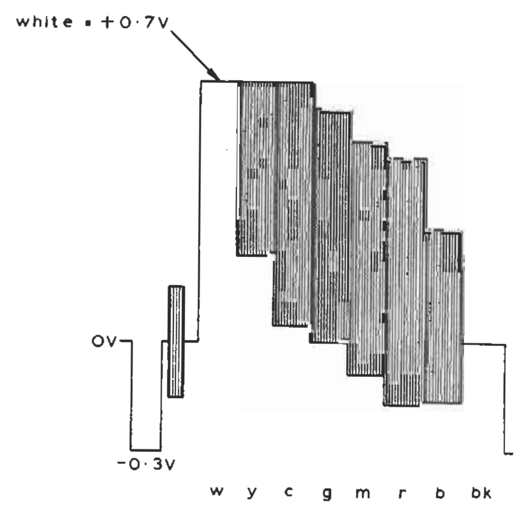
To provide a test signal to check this, colour bar generators in BBC video tape areas have been modified to provide, during approximately the last third of each field, a uniform chrominance signal throughout most of the active period of each line. For simplicity, this has been made a red signal having the same characteristics as the red bar of the colour bar signal occupying the first two-thirds of the field, which is normally the 100/0/100/0 signal.

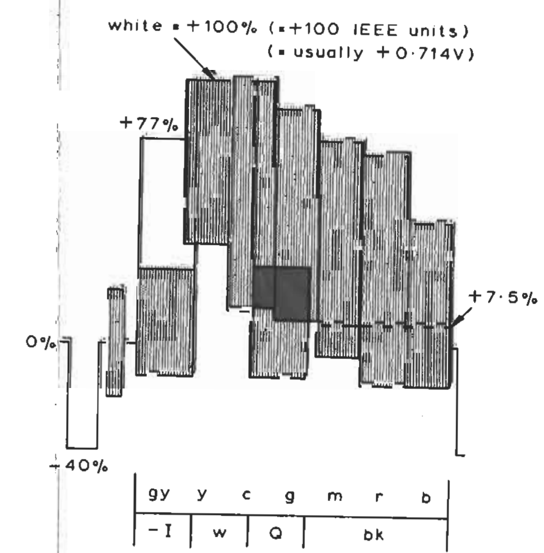
Chart of Main Features

Colour	*100/0/100/0 Bars* (Known as 100% Bars)	*100/0/100/25 Bars* (Know as 95% Bars)	*100/0/75/0 Bars* (Known as EBU Bars)	*525-line Split-field Bars* (Used in U.S.A. and Canada)
White or Grey	Luminance at white level	Luminance at white level	Luminance at white level	Luminance at 77% relative to blanking in first 3/4 of field and at white level in last 1/4
Yellow and Cyan	Positive chrominance peaks at same level, above white	Positive chrominance peaks at same level, above white	Positive chrominance peaks at white level	Positive chrominance peaks at white level
Green	Negative chrominance peaks at black level	Negative chrominance peaks above black level	Negative chrominance peaks at black level	Negative chrominance peaks at black, above blanking level
Magenta	Positive chrominance peaks at white level	Positive chrominance peaks at white level	Positive chrominance peaks below white level	Positive chrominance peaks at the grey bar level (77%)
Red and Blue	Negative chrominance peaks at same level, below black	Negative chrominance peaks at black level	Negative chrominance peaks at same level, below black	Negative chrominance peaks at same level, below blanking
Black	At blanking level	At blanking level	At blanking level	7.5% above blanking level









Appendix: Luminance and Chrominance Signal Values

The following tabulated values of luminance and chrominance in 100/0/100/0, 100/0/100/25 and 100/0/75/0 bars are taken from Appendix 1 in Designs Department Technical Memorandum 8.242(67), Colour Bars. The values in 525-line bars at 75 per cent amplitude, after allowing for the 7·5 per cent black pedestal, are derived from Appendix 2 of the same Technical Memorandum by calculating 69·37 per cent of the values given for 100 per cent NTSC bars, by adding 0·0525 volt (i.e. 7·5 per cent of 0·700 volt) to obtain luminance values relative to blanking, and by modifying all values obtained so that they are on a scale in which white level is at 0·714 volt instead of 0·700 volt.

100/0/100/0 Bars (Known as 100% Bars)

COLOUR BAR	*LUMINANCE* Volts above blanking	*CHROMINANCE* Volts p-p *U*	*V*	*Total*	*CHROMINANCE ANGLE* rel. to (B − Y) axis *Degrees* In lines with 135° burst	In lines with 225° burst
White	0·700	0	0	0		
Yellow	0·620	0·612	0·140	0·627	167	193
Cyan	0·491	0·206	0·861	0·885	283·5	76·5
Green	0·411	0·405	0·721	0·827	240·5	119·5
Magenta	0·289	0·405	0·721	0·827	60·5	299·5
Red	0·209	0·206	0·861	0·885	103·5	256·5
Blue	0·080	0·612	0·140	0·627	347	13

100/0/100/25 Bars (Known as 95% Bars)

COLOUR BAR	*LUMINANCE* Volts above blanking	*CHROMINANCE* Volts p-p *U*	*V*	*Total*	*CHROMINANCE ANGLE* rel. to (B – Y) axis *Degrees* In lines with 135° burst	In lines with 225° burst
White	0·700	0	0	0		
Yellow	0·640	0·459	0·105	0·470	167	193
Cyan	0·543	0·155	0·646	0·664	283·5	76·5
Green	0·483	0·304	0·541	0·620	240·5	119·5
Magenta	0·392	0·304	0·541	0·620	60·5	299·5
Red	0·332	0·155	0·646	0·664	103·5	256·5
Blue	0·235	0·459	0·105	0·470	347	13

100/0/75/0 Bars (Known as EBU Bars)

COLOUR BAR	*LUMINANCE* Volts above blanking	*CHROMINANCE* Volts p-p *U*	*V*	*Total*	*CHROMINANCE ANGLE* rel. to (B – Y) axis *Degrees* In lines with 135° burst	In lines with 225° burst
White	0·700	0	0	0		
Yellow	0·465	0·459	0·105	0·470	167	193
Cyan	0·368	0·155	0·646	0·664	283·5	76·5
Green	0·308	0·304	0·541	0·620	240·5	119·5
Magenta	0·217	0·304	0·541	0·620	60·5	299·5
Red	0·157	0·155	0·646	0·664	103·5	256·5
Blue	0·060	0·459	0·105	0·470	347	13

525-line Split-field Bars (75% amplitude, on a 7·5% black pedestal)

COLOUR BAR or SIGNAL	LUMINANCE Volts (and IEEE Units)* rel. to Blanking	CHROMINANCE Volts (and IEEE Units)* p-p			Chrominance Angle rel. to (B – Y) axis
		I	*Q*	*Total*	*Degrees*
Grey	0·549 (77)	0	0	0	
Yellow	0·493 (69)	0·319	0·309	0·444 (62)	167
Cyan	0·401 (56)	0·590	0·209	0·626 (88)	283·5
Green	0·344 (48)	0·273	0·518	0·585 (82)	240·5
Magenta	0·258 (36)	0·273	0·518	0·585 (82)	60·5
Red	0·202 (28)	0·590	0·209	0·626 (88)	103·5
Blue	0·110 (15)	0·319	0·309	0·444 (62)	347
–I	0·054 (7·5)	0·286	0	0·286 (40)	303
White	0·714 (100)	0	0	0	
Q	0·054 (7.5)	0	0·286	0·286 (40)	33
Black	0·054 (7.5)	0	0	0	
Burst	0			0·286 (40)	180
Sync	–0·286 (–40)				

* The voltages apply to a signal in which white level is at 0·714 volt above blanking level. In U.S.A. and Canadian practice, video amplitudes are expressed in IEEE units, where 100 IEEE units corresponds to 100 % luminance (i.e. white level) relative to blanking: nominal IEEE values are shown in brackets.

DPEB 10/70