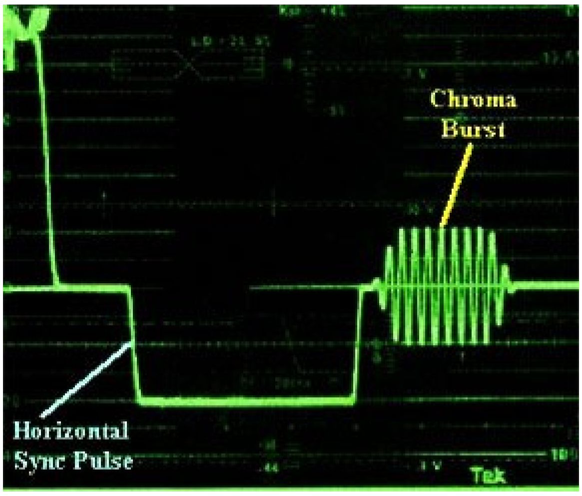
COLOUR FRAMING

What does it mean, and why won't it go away?



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FOREWORD

This document was originally written in 1982/3. At the time I was working as a VT Editor for Molinare in London, UK. Our edit suites were being upgraded with the CMX 340X system, and in 1981 I had attend an Operations Course at the CMX/Orrox plant in Santa Clara, California. While on the course I gave an explanation of PAL Colour Framing which was well received, and it was suggested that I should write it up in a briefing paper. I spent several months researching the subject, and this document is the result.

Early in my research I found that there was some confusion as to the origin of the problem, and that some solutions had been arrived at almost by trial and error. My intention was to gather together information that defined the various colour systems, and then explain how this brought about the need for Colour Framing in the recording and editing process. As far as I could tell this information had never been assembled into a single concise document, and this became my goal.

Although this new version has been extensively reformatted (see below), I decided not to make any major updates to the text, apart from a new historical paragraph at the beginning. Please keep this in mind as you read.

Although Digital Component recording is now the norm, and the majority of editing is done on computers with the video encoded as JPEG or MPEG files, composite VT is still in use and will be for some time. In addition the majority of TV receivers are Composite and again this will be the norm for at least another decade. Eventually the problem will go away, but will always be archive material that hasn't been converted to the current format, and in the developing world the use of both composite recording and tape editing will continue.

Even today, compatibility is a necessity. Transmitter channel spacing can only be changed with difficulty due to the very large investment in existing hardware, so new enhanced scanning systems such as Wide-screen and HiDef, must either fit into the existing bandwidth or be transmitted in new frequency bands. Direct satellite transmission, and digital encoding are however making this simpler, but do require the viewer to invest in new hardware.

If only as a historical record, I hope the reader will find this interesting. I had fun doing the original research, and was very pleased to find that apart from CMX, the paper had been of use to Ampex, Calaway and others in their implementation of Colour Framing correction.

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DOCUMENT HISTORY

The text of the original document was written using the VIEW wordprocessor on a BBC B Micro, and printed on an Epson MX-80 dot matrix printer. The diagrams were made up by cutting and pasting photocopies from various books on Colour TV theory.

In 1986 I re-typed the text using ClarisWorks on a Mac, and remade some of the diagrams using its graphics package.

In 1991, I converted the text from MAC to PC and corrected it using XyWrite on a PC. This version was updated in 1996 using ClarisWorks for Windows..

In 2002 I again remade the diagrams using Adobe Photoshop, and reformatted the text in MS Word.

This 2005 version has been completely reformatted in OpenOffice 1.1 on a PC running Linux 2.4.26. Figures 7 & 8 were rescanned from earlier artwork, and all the diagrams have been remade using GIMP 2.0.2. Previous versions, had the diagrams in a separate document, but for this version they have been inserted into the appropriate places in the text, and all the captions redone. The final version was exported from OpenOffice as an Adobe Acrobat PDF file for publication.

In 2015 I again reformatted it in LibreOffice and re-exported to PDF.

VIDEO TAPE EDITING, TIMECODE, AND THE COLOUR FRAMING PROBLEM.

Colour Framing, what does it mean, and why won't it go away?

The Colour Framing problem can probably be blamed on the marketing department at RCA. Their research lab had developed two different colour transmission systems, one was compatible with existing transmission and receiving equipment, and the other, thought it produced higher quality pictures, was not. For commercial reasons the first system was chosen, as it would require less investment in new distribution hardware and transmitters, and viewers could watch the new transmissions in monochrome on their existing TV sets.

In spite of the sophistication of VTR's and editing systems now in use, colour framing can still cause problems. Either the system keeps aborting edits, or "invisibles" shift and hop. Why this should be, requires an examination of the basic structure of the colour video signal. Some of the explanations are quite technical, but I will try to keep the maths to a minimum.

To make descriptions simpler I have used TRANSMISSION to mean all forms of video distribution to the end user/viewer, and have assumed a knowledge of some of the basic details of the television transmission system.

1. COMPOSITE v COMPONENT.

Colour video signals come in two forms, composite and component, and recordings can also be analogue or digital.

The original signal, whether from an electronic camera, film on a telecine, or a computer graphics system, starts off as three separate Red, Green & Blue COMPONENT's (RGB) which then have to be combined into one COMPOSITE for transmission. During the 1980's distribution and recording systems were developed which effectively kept the component signals apart until the last stages before transmission. These are known as COMPONENT systems and although they have no inherent colour framing there can be problems when they are used in a composite environment, as we shall see later.

2. COMPOSITE SIGNALS.

The three colour television systems currently in use are NTSC, PAL, & SECAM. Historically NTSC, the acronym of the National Television Standards Commission, came first, and in fact PAL & SECAM are modifications rather than separate systems. However all three were designed to be COMPATIBLE with the then existing monochrome television systems. Colour signals had to be viewable on unmodified monochrome equipment, and use no extra bandwidth for recording, distribution, and transmission.

3. ENCODING.

Luckily the human eye sees fine definition mainly in the brightness information of an image. The chosen solution involved extracting the brightness information from the original colour image and transmitting it in the same form as the equivalent monochrome image. The colour information (shade or HUE, & purity or SATURATION) could then be formed into a second, subsidiary signal, to be added to the brightness signal. This process is called ENCODING. The signal containing the brightness information was called LUMINANCE, while the colour information was called CHROMINANCE. The trick was to put these two signals together in such a way that they wouldn't interfere with each other, and could still be easily separated.

4. FREQUENCY INTERLEAVING

Researchers in the 1930's & 40's found an elegant and practicable solution to squeezing more information into a limited space. To enable the encoded colour signal to fit into the same bandwidth as a monochrome signal, the Chrominance is first modulated onto a SUB-CARRIER signal. Use can then be made of a principle called FREQUENCY INTERLEAVING. When the energy of the Luminance signal is measured against frequency, it can be seen that the spectrum is not continuous. It clumps together at multiples of the horizontal scanning frequency (Fh) as shown in fig.1 below. At frequencies half-way between the peaks there is almost no energy, so it was realised that a second signal could be superimposed if its peaks interleaved with those of the first. The fact that only the Luminance signal needed to be full bandwidth maked this possible, as otherwise the sub-carrier side-bands would not have fitted into the transmission channel.

Fig.1 - Interleaving the Luminance & Chrominance signals.

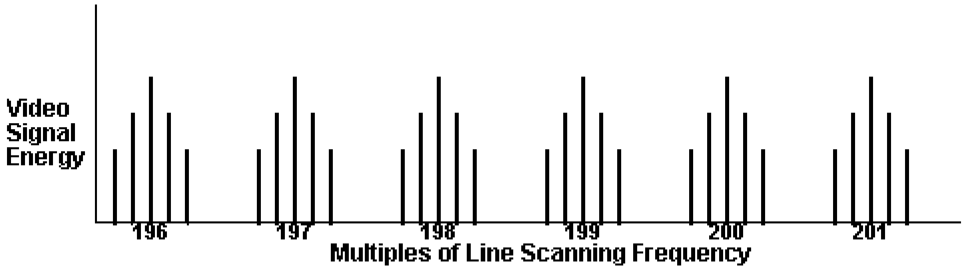


Fig 1a - The Luminance Signal.

Graph of Signal Energy against Frequency shows "clumping" at multiples of Horizontal Scanning Frequency (Fh). Each "clump" consists of a spike of energy at a multiple of Fh, with adjacent side-bands separated by multiples of the Vertical Scanning Frequency (Fv).

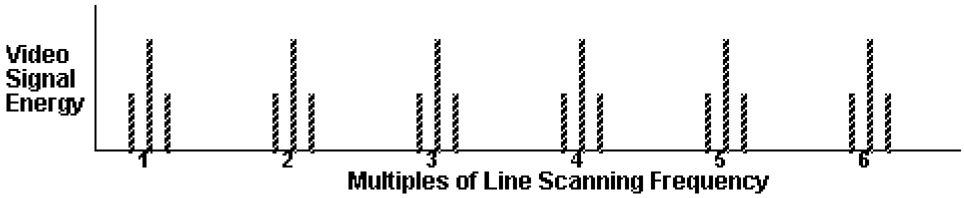


Fig 1b - The Chrominance Signal.

This spectrum shows a similar structure to that of the Luminance signal. The Chrominance Sub-carrier Frequency (Fsc) was chosen to be a multiple of half the Horizontal Scanning Frequency.

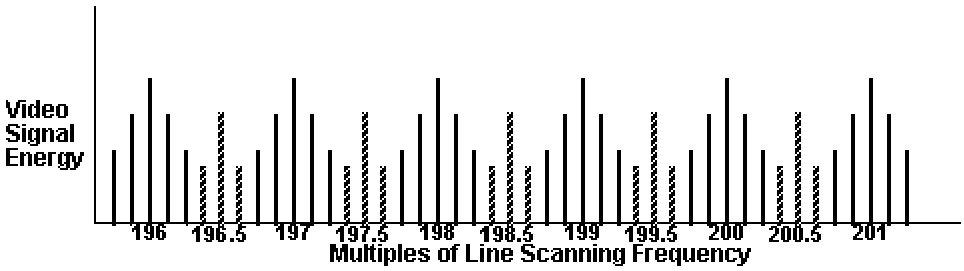


Fig 1c - The Composite Pal Signal.

This shows how the two signals can be interleaved when Fsc = N x Fh/2, allowing the composite signals to occupy the same bandwidth. This interleaving is known as the half line offset. For the PAL 625 system, Fh = 15,625 Hz and Fv = 50. Fsc = (Fh/2 x 567) + Fh/4 + Fv/2. The additional terms provide further offsets to conceal Chrominance Sub-carrier patterning on areas of saturated colour, by cancellation due to the ensuing differences between successive fields.

5. CHOOSING A FREQUENCY.

Two constraints governed the choice of the Colour Sub-carrier Frequency, Fsc. Firstly to satisfy the need for interleaving, Fsc must be an odd multiple of half Fh. Secondly, notice must be taken of the spacing between the carrier frequencies of the transmitted sound and vision signals. This spacing must be accurately maintained to enable the receiver to separate the two signals, and is a major factor in determining the bandwidth of the Composite signal and in the spacing of transmitted channels. To minimise interference between the sound carrier and the colour sub-carrier, the sound to vision carrier spacing must be an even multiple of Fh.

We can examine the principal by looking at the NTSC 525 line, 30 frame per second system, though we will need to indulge in some arithmetic.

6. NTSC SUB-CARRIER FREQUENCY.

The value of Fh for 525/30 monochrome transmissions was 15,750Hz, and the sound to vision carrier spacing was fixed at 4.5MHz, which is not a multiple. For colour transmissions Fh was changed to 15,734.265Hz, so that Fh x 286 = 4.5MHz. This is close enough to the monochrome value that no modification was required for existing receivers.

This is a good place to digress slightly, and note that the numbers for the various frequencies may be complicated, but the ratios between them are simple, as they were chosen to have small prime factors. In addition, to minimise interference, and maintain the accuracy of the transmitted signal, it is necessary that the various carrier frequencies be locked together. This requirement is fulfilled by dividing down from some master frequency, usually a multiple of the colour sub-carrier frequency. It must be remembered that this design work took place between the late 1930's and the early 50's. The approach was very much dictated by the available technology, and division by small prime numbers was the order of the day.

The new value of Fh had an unexpected and unfortunate side effect on 525 NTSC VT editing. To maintain 525 lines per frame, the frame rate, Fv, must be such that Fh = 525 x Fv, giving a value for Fv of 29.97002996Hz. This is usually given as 29.97Hz. It is a very unfriendly number and is the direct cause of the dreaded DROP-FRAME timecode!

The NTSC luminance signal has a bandwidth of 4MHz, and the encoded chrominance signal a bandwidth of 0.5MHz. The higher the value of Fsc the less the interference, so a frequency of around 3.5MHz was looked for.

The value chosen was 3.579545MHz, which gives Fsc = 455/2 x Fh, where 455 = 5 x 7 x 13. This figure is generally referred to as "358".

7. PAL SUB-CARRIER FREQUENCY.

Fixing the NTSC sub-carrier frequency at a multiple of half the horizontal scanning frequency is referred to as a HALF-LINE OFFSET. For reasons to due with the detailed structure of the Chrominance signal, this is not possible with PAL.

A full explanation is outside the scope of this paper, but the problem is tied to the alternating phase of the R-Y signal as described later.

There are currently three variants of PAL in worldwide use. Full details of these, together with variants of SECAM & NTSC may be found in Appendix 1.

For 625 line PAL systems a QUARTER-LINE PLUS 25Hz OFFSET is used, while 525 PAL requires only the QUARTER-LINE OFFSET. The ratios between Fsc and Fh for European and N/PAL look unwieldy compared to NTSC and M/PAL (Appendix 1), but whereas NTSC was originally implemented with 1940's technology, PAL was able to use more developed 1960's circuitry which could handle the more complex division ratios.

8. SECAM SUB-CARRIER FREQUENCY.

For accurate recovery of the colour information by the receiving equipment, the PAL and NTSC systems require the colour sub-carrier to be locked to the scanning rate. SECAM does not require this same relationship, although one is imposed for reasons given later.

9. THE CHROMINANCE SIGNAL.

Since the Luminance signal is made by adding the RGB signals together, only two of the colours need be transmitted. The Chrominance signal is made up of two components which represent the Red and Blue content of the original scene, and the Green signal is recovered by a simple subtraction in the decoder.

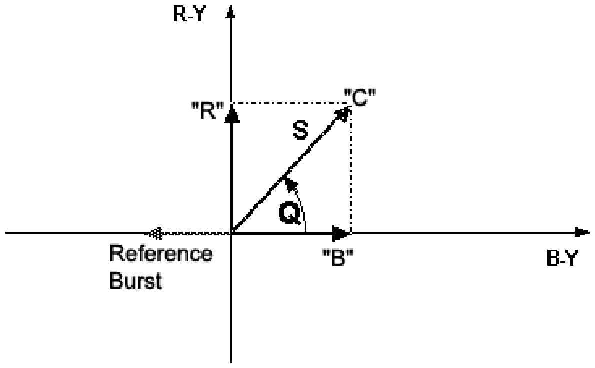
To improve the signal-to-noise ration of the transmitted signal, the Red and Blue signals are not used directly, but rather the difference between each and the Luminance signal. Luminance is normally represented by the letter Y, so the COLOUR DIFFERENCE COMPONENTS are denoted R-Y & B-Y respectively.

In NTSC the R-Y and B-Y signals are modulated onto the sub-carrier in such a way that the amplitude represents the Saturation and the phase represents the Hue, as shown in Fig.2 below.

PAL is a modification of NTSC, with the phase of the R-Y signal being inverted on alternate lines. If a PAL signal was displayed in the manner of fig.2, we would see that on every other line, positive signed R-Y vectors point downwards. PAL is an acronym for Phase Alternating Line-by-line.

Unlike PAL and NTSC, SECAM does not combine R-Y and B-Y into one chrominance signal, but transmits them separately on alternate lines. Thus if one particular line carries an R-Y signal, the immediately preceding and following lines will carry B-Y signals. The receiver requires a single line delay or memory to bring the R-Y and B-Y together again, hence the name SECAM which is an acronym for "sequentiel-à-mèmoire" (sequential-to-memory).

FIG. 2



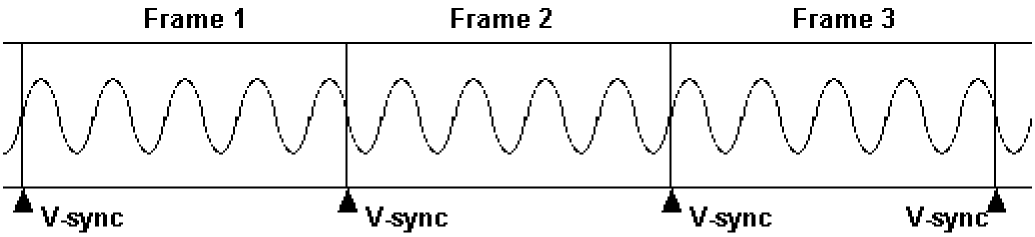
Vector diagram of R-Y & B-Y components of modulated NTSC Sub-carrier, showing derivation of parameters for Colour "C". SATURATION is shown by S , & HUE by phase angle Q. Zero Phase reference for NTSC is along the negative B-Y axis.

The feature of both PAL & NTSC, where the colour difference signals are modulated with a fixed 90% phase difference, enables them to be combined and separated with relative ease. However this requires the absolute phase reference to be maintained with a high degree of accuracy.

10. RELATIONSHIP OF SUB-CARRIER PHASE TO HORIZONTAL TIMING.

As referred to earlier, both PAL and NTSC carry information in the absolute phase of their sub-carriers. This requires that the sub-carrier reference phase be maintained to a very close tolerance relative to the horizontal scan rate. This relationship is generally denoted by the term SC/H (Sub-Carrier to Horizontal) Phase. Fig.3 shows a simplification with a low frequency sub-carrier. Note the extra half-cycle at the end of each frame, which is the result of a HALF-LINE OFFSET. In the case of 525 line System M NTSC there are 119,437.5 cycles of sub-carrier per frame.

FIG. 3



Simplified video signal showing the relationship between a continuous low frequency sub-carrier and frame edge markers. It can be seen that because of the odd half-cycle at the end of each frame, to maintain a correct sequence, frames must be be edited ODD to EVEN, or EVEN to ODD. Editing ODD to ODD, or EVEN to EVEN, would produce a discontinuity.

It is vital for the SC/H relationship to be maintained throughout recording and editing, to ensure that the transmitted signal contains an accurate representation of the colour of the original scene. This process is called COLOUR FRAMING, and attempts to preserve a continuous SC/H relationship throughout an edited tape.

SECAM does not carry information in the phase of it's sub-carrier and so has no need of a fixed SC/H relationship. However one is imposed to minimise the visibility of the sub-carrier on monochrome receivers, although there is no real necessity for this to be accurately maintained.

11. NTSC COLOUR FRAMING.

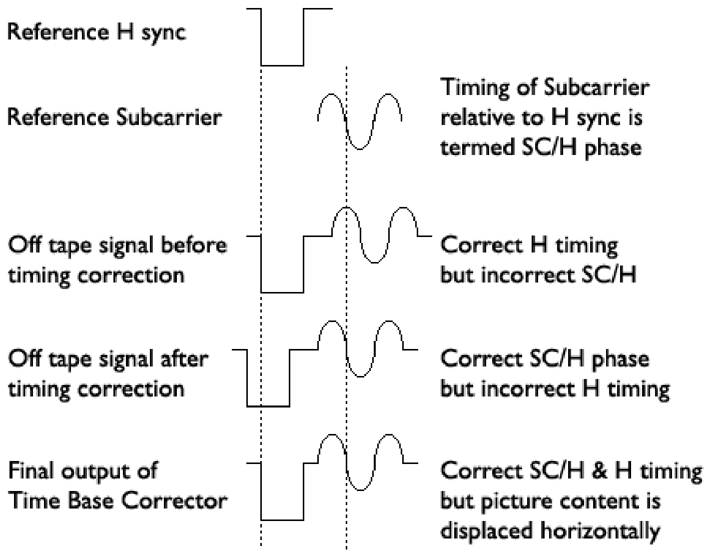
Although colour framing sequences are conventionally referred to as "4-field" or "8-field", it is important to note that edits must always preserve the field interlace, so it is more accurate to talk of "2-frame" or "4-frame" sequences.

The Half-line Offset imposes a 4-Field (2-Frame) Sequence on the encoded NTSC signal analogous to that shown in fig.3.

The results of a Non Colour-Framed edit depend on the picture content and the nature of the VTR's playback processing. Composite TBC's use digital memory with sampling clocks locked to 3 or 4 times Fsc, therefore the fixed SC/H phase relationship will put constraints on the correction of errors.

Fig.4 below, represents a "bad" edit. The off-tape sub-carrier after the edit has the wrong SC/H which the TBC corrects by adjusting a delay relative to the horizontal sync timing. The effect is to shift the whole picture sideways to restore the "lost" 1/2 cycle of sub-carrier. If the edit involves a shot change then this shift will not be seen except as a change in the horizontal blanking. However, if it is an "invisible" or "match-frame" into a dissolve or DVE move, then it will be unacceptably obtrusive.

Fig. 4 - Time Base Correction of incorrect SC/H recording.



Time Base Correction is used to compensate for playback errors in the off-tape signal. These errors can be of several types, but the one that concerns us here is a composite signal recorded with the wrong SC/H phase.

The TBC is essentially a delay line and makes corrections by re timing the off-tape signal relative to the new syncs applied at it's output. All current broadcast TBC's use digital technology and sample at some multiple of Fsc. To correct the SC/H phase, the sampling clock is adjusted. Depending on the type of error, this can lead to horizontal and/or vertical displacement of the off-tape signal relative to the new syncs.

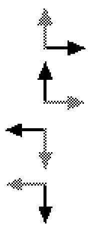
12. PAL COLOUR FRAMING.

The relationship between Fsc and Fh for PAL (see Appendix 1) involves a Quarter-line Offset, which imposes an 8-field (4-frame) Colour Frame Sequence. However the line-by-line inversion of the R-Y component introduces an additional complication.

If the 4-frame (8-field) sequence is taken as referring to the phase of the B-Y component, with the R-Y component alternately leading and lagging by 90 degrees, then we find that when the reference phase of the same numbered line is examined on successive similar fields, a 2-frame R-Y reference sequence is superimposed on the overall 4-frame B-Y reference sequence. This is illustrated in fig.5 which shows the reference phase for B-Y and R-Y on the same numbered line of successive odd numbered fields. This R-Y phase switching is known as the V-AXIS or PAL SWITCH ("Vertical" axis from its direction on the phase diagram).

Fig. 5 - The PAL 4 & 8 FIELD SEQUENCES.

Field	B-Y Phase	R-Y Relative to B-Y	Vectors	PAL PAIR	COLOUR FRAME
1	0°	+90°		ODD	A
3	+90°	-90°		EVEN	A
5	+180°	+90°		ODD	B
7	+270°	-90°		EVEN	B



This table shows the relationship of B-Y & R-Y reference phase on the same numbered line of consecutive odd numbered fields. The "clock's" show B-Y in grey.

PAL PAIR & COLOUR FRAME refer to the notation on the right hand side of Fig 7 (Bruch Blanking sequence), and show that the PAL 8-Field COLOUR FRAME Sequence is made up of two pairs of 4-Field PAL PAIR sequences.

By convention, the 2-frame (4-field) sequence is referred to as the BRUCH (Dr. Bruch of Telefunken holds some of the patents for the system), PAL SWITCH or PAL PAIR sequence, and the complete 4-frames are called the COLOUR FRAME sequence. The 4-frame sequence should be thought of as consisting of pairs of PAL PAIRS.

Bad edits in PAL are of two types. A NON COLOUR-FRAMED edit preserves the PAL PAIR sequence but not the COLOUR FRAME sequence. Such an edit is treated in the same way as a bad edit in NTSC as shown in fig.4.

The other type breaks the PAL PAIR sequence and has no counterpart in NTSC. A broken PAL PAIR sequence cannot be fixed by a correction of SC/H phase as it is not just a 1/4 cycle out of step. In fact until the advent of digital Time Base Correctors such errors could not be corrected at all, and even the latest generation can only make such a correction if it occurs at a shot change.

13. PAL COLOUR FRAMING ERRORS.

As with NTSC, PAL TBC's correct their output SC/H phase by re timing the picture relative to H-sync. However there are two types of "shifts" that can occur. A "NON COLOUR-FRAMED" edit will be a 1/2 cycle out, which can be corrected with horizontal timing only. On the other hand if the edit has an R-Y switch error as well, then the correction is 1/4 cycle horizontally plus one line upwards producing a "hop". Since the R-Y line-by-line switching is now in the wrong phase, a "MISS-PAIRED" edit can only be corrected if the TBC can either decoded to component form and re-code the Chrominance into the new sequence, or if it is able, discard a whole line of the first field after the edit. Either process will restore the correct V-axis switching sequence. Again, neither correction will be visible if it occurs at a shot change, so long as the time base corrector can make this correction during the vertical blanking interval. However not all Composite TBC's can accomplish this within the time allowed by the Vertical Blanking and some sort of disturbance may occur. With early 1" VT's this would appear as a white flash at the top of the picture.

14. SECAM COLOUR FRAMING.

In SECAM the line-by-line alternation of R-Y and B-Y generates a 2-frame sequence similar to the Pal Pair sequence. However there is no fixed SC/H phase relationship to be maintained as the Chrominance information is frequency modulated onto the sub-carrier. Information which unambiguously identifies the correct line switching sequence is transmitted with the picture information. Originally this was a sequence of subcarrier bursts in the same sequence as the picture information, but transmitted during the vertical blanking. The current EBU standard is to transmit unmodulated sub-carrier of the appropriate frequency (see Appendix 1) during the "back-porch" following the horizontal sync pulse. The unmodulated or "white" frequency is different for the R-Y and B-Y components and both are multiples of Fh, so it is quite simple to identify the switching sequence on a line-by-line basis.

The form of SECAM which uses identification in the vertical interval is known as VERTICAL-LOCK, or V-SECAM, and has no fixed phase relationship between Fh and Fsc. The other, and now preferred form, is called HORIZONTAL-LOCK, or H-SECAM. The unmodulated Fsc for R-Y is 4.40625MHz (282 x Fh) and for B-Y is 4.25MHz (272 x Fh). The tolerance for these frequencies is +/- 2KHz and the only phase relationship is intended to reduce the visibility of sub-carrier patterning in large areas of saturated colour on monochrome receivers. This imposed phase relationship has an overall 6-frame (12-field) cycle, but cannot be considered to be a colour framing sequence as it carries no information. In fact because of the modulation system used and the method used to identify the line switching sequence, there is no need for a SECAM colour framing sequence so long as the VTR always records and replays the ident signals in the correct relationship to the picture. For H-SECAM this only requires that the active line period be considered to start from the trailing edge of the H-sync pulse rather than the edge of the blanking, as with NTSC and PAL. SECAM editing can therefore work to 1-frame accuracy at all times, although a 2-frame (4-field) sequence is maintained for "invisibles" and animation sequences to minimise the possibility of "glitches" on replay.

15. COLOUR FRAMED EDITING.

Having established the origin of and need for the SC/H phase relationship we now come to the problem of maintaining it through the editing process.

By adopting a standard for the SC/H relationship it is possible to identify and mark the Colour Frame (CF) Sequence of source material. These marks can then be used to synchronise the CF sequence of the Record VTR to the source whether this is another VTR or a camera or vision mixer output. The source VTR's may also be Colour Framed to an external reference so that disturbance free transitions can be performed between 2 or more sources.

This marking can be done in two ways. COLOUR IDENT or EDIT FLAG pulses are added to the control track, and SMPTE/EBU timecode is generated so that particular combinations of timecode numbers identify specific frames in the CF sequence.

All transmission systems use the same convention for defining a complete frame:

1) *ODD FIELDS begin with line number 1, such that the horizontal sync edge coincides with the vertical sync edge at the start of the first BROAD PULSE.*
2) *A complete FRAME consists of an ODD field followed by an EVEN field.*
3) *ODD fields and frames are defined as those which are ODD NUMBERED.*

The NTSC Colour Frame Sequence is defined thus by the RS-170-A Standard:

> *"Frame A of the sequence is that frame where the phase of the reference sub-carrier undergoes a positive going zero-crossing coincident with the leading edge of the H-sync pulse preceding line number 10."*

This is illustrated below.

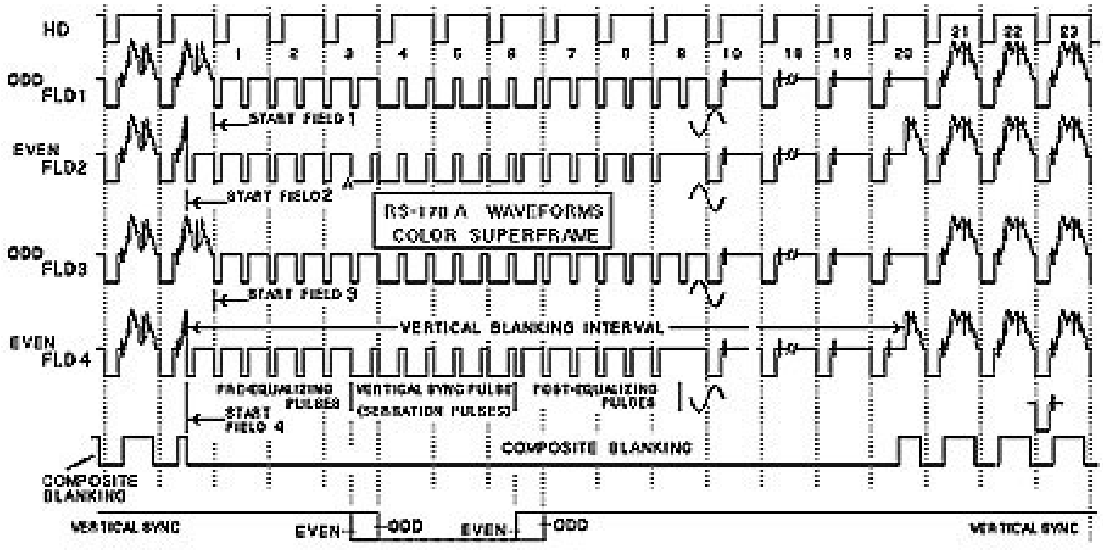


Fig. 6 - RS-170-A synchronizing waveforms *(525 lines, System M/NTSC)*

Frame A is then marked by an EDIT FLAG pulse on the control track, and by the following timecode relationship as defined by the SMPTE:

> *"...the even units of frame numbers shall identify Frame A....as defined in the EIA Standard RS-170-A."*

The PAL Colour Frame sequence is defined and marked in the same way, although the relationships are more complex. The details are published in EBU Statement D14-1978 and CCIR Draft Report 624-1 (Mod F). The latter document also covers SECAM, M/NTSC, M/PAL & N/PAL.

The SC/H phase relationship for PAL is measured at the H-sync reference edge for line 1 of field 1, and the definition states that the B-Y component of the reference sub-carrier must undergo a positive going zero-crossing at this point, with a tolerance of +/- 20 degrees. This defines the start of the 8-field sequence as shown in fig.7.

The control track will have a pulse marking this frame, and a similar rule to that for NTSC is used to fixed the timecode relationship. The EBU specification for PAL timecode states:

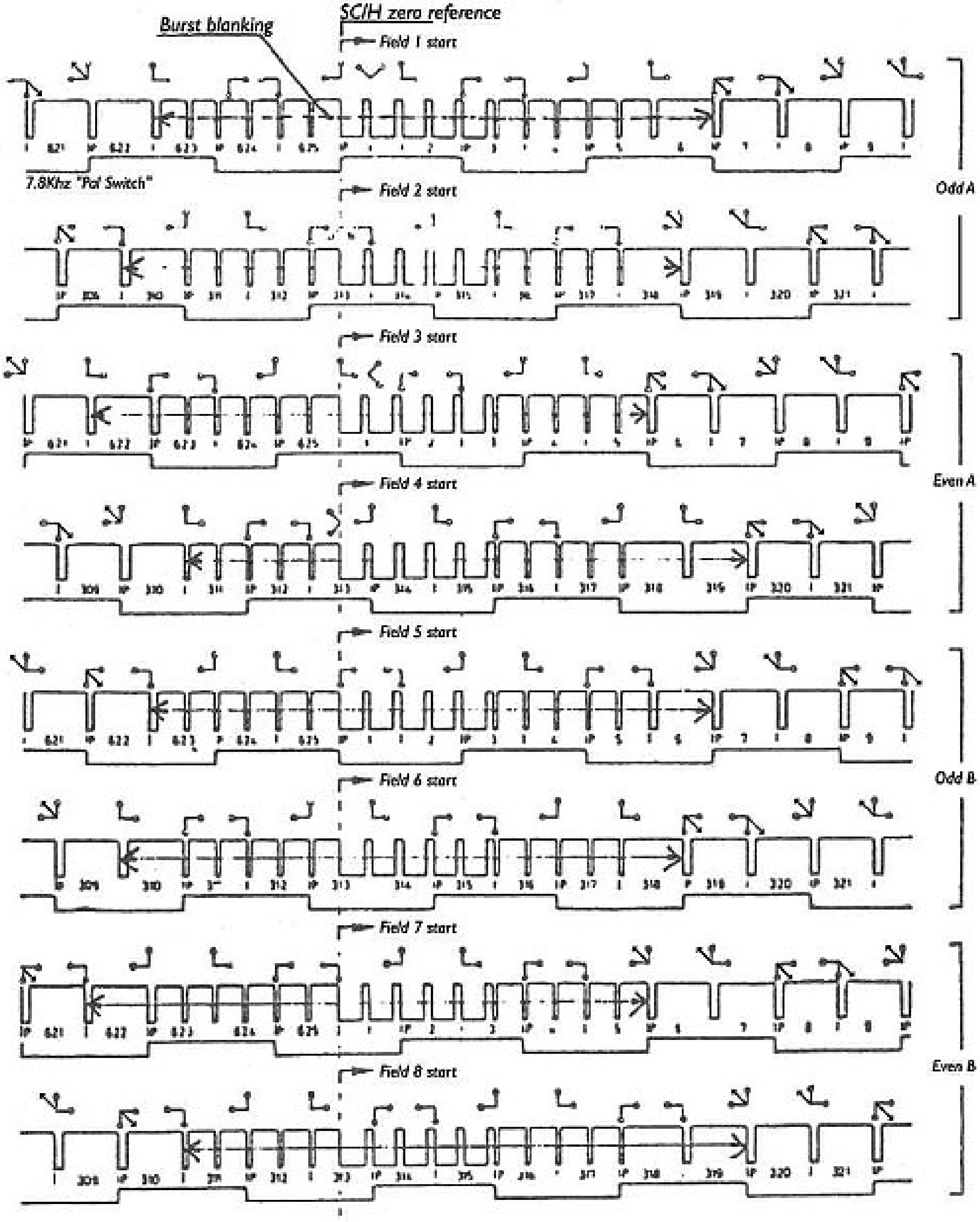
> *"When the timecode is displayed in decimal numbers, with S and P designating the seconds and frames respectively,*
>
> *Then; a) S + P is ODD for COLOUR FRAMES 1 and 3, and EVEN for COLOUR FRAMES 2 and 4,*
>
> *and; b) The remainder after dividing S + P by 4 is:*
> *0 for Colour Frame 4,*
> *1 for Colour Frame 1,*
> *2 for Colour Frame 2,*
> *and, 3 for Colour Frame 3."*

Rule "a)" defines the 4-field PAL PAIR (R-Y SWITCH) sequence, and "b)" the overall 8-field COLOUR FRAME sequence.

Fig. 7 - PAL 8-field sequence & Bruch Blanking

The notation down the right side of the diagram indicates the 8-field (4-frame) PAL sequence. ***Odd/Even*** *indicate 4-field PAL Pairs, with* ***A/B*** *indicating the combination off two Pairs to make the complete 8-field sequence.*

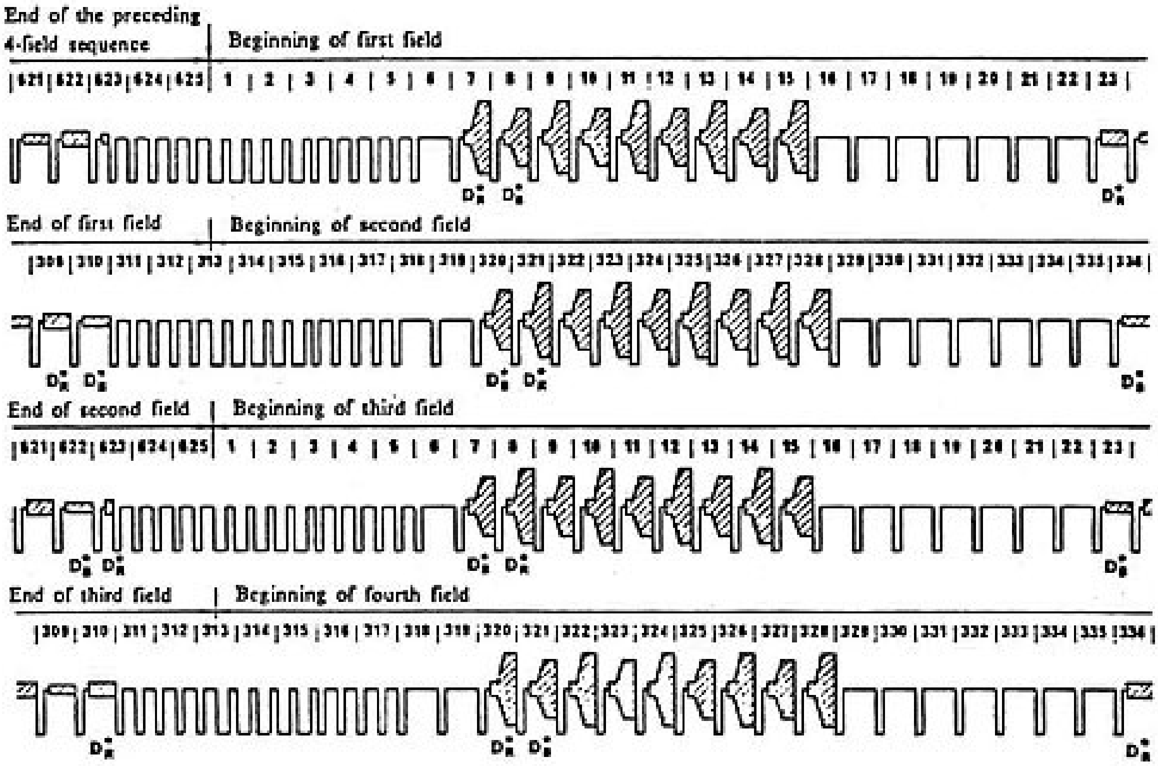
The small clocks show the R-Y & B-Y reference phase for each line, with the arrow showing the derived burst phase.



Although, as explained before, SECAM does not need a Colour Frame sequence, a standard has been adopted which defines a 4-field cycle analogous to the PAL PAIR. Frame 1 of this sequence is identified as beginning with a line 1 that would contain R-Y information in the absence of any Chrominance blanking, as shown in fig.8a. Fig 8b details the reference "bottles" used for V-lock SECAM, and fig 8c shows that for H-lock SCAM.

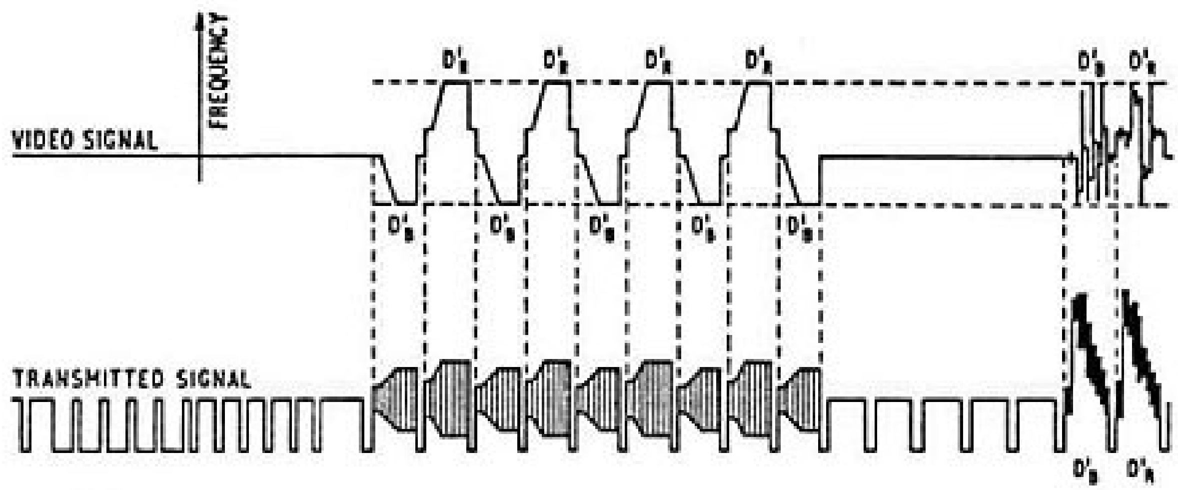
The timecode relationship for SECAM is as defined by rule "a)" for PAL.

Fig. 8a



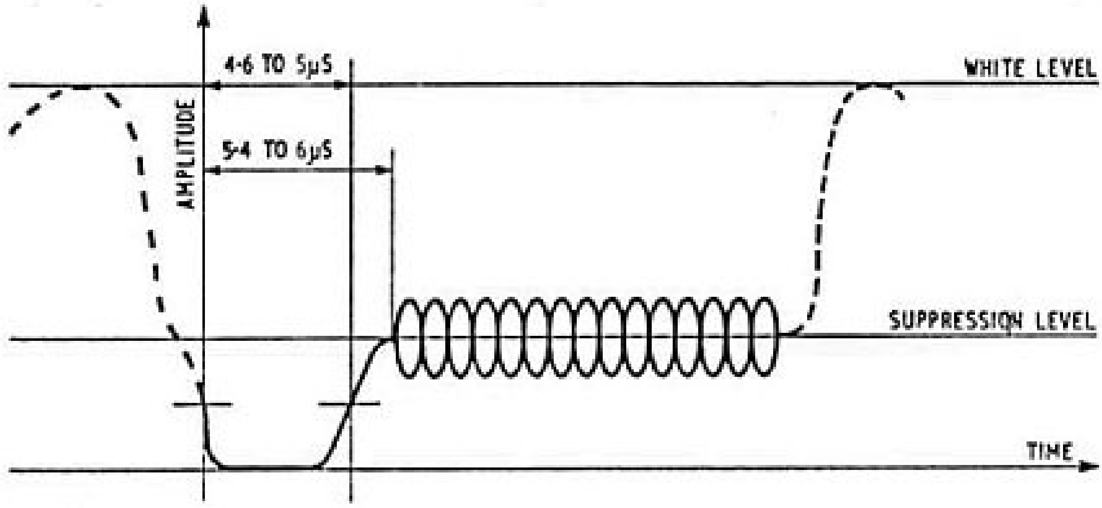
SECAM sequence of V interval subcarrier identification signal ("bottles") over four consecutive fields. ***D_R*** *&* ***D_B*** *denote lines with R-Y & B-Y respectively.*

Fig 8b



The V- interval colour identification "bottles", correspond to negative colour-difference signals on each line. (SECAM subcarrier is Frequency Modulated)

Fig 8c



The subcarrier is suppressed at the beginning of each line-blanking period, but not during the back-porch when undeviated subcarrier is transmitted.

16. CONCLUSIONS.

Where does all this leave us? The requirement for Colour Television signals to fit into existing transmission bandwidths, and be viewable on existing Monochrome receivers has left us with some awkward compromises.

The Colour Framing sequences for all systems have now been fully defined, and manufacturers can now produce fool-proof colour frame detectors for sync pulse and timecode generators. Given that this equipment is correctly operated and maintained, generation of correctly identified and marked source material should no longer be a problem. The use of EDIT FLAG's on control track, Colour Framed timecode, and computerised edit control systems has improved matters to the extent that there are now very few excuses for producing a "bad" edit.

The fact that problems still occur is generally due to an inadequate understanding of the origins and purpose of the Colour Frame sequence. Hopefully this paper goes some way towards clarifying the situation.

I firmly believe that the better we understand the medium with which we work, the easier we can manipulate it with accuracy and confidence. This applies to manufacturers as much as to users. We need equipment which provides the editor with transparent control of his source material allowing him to give full attention to the programme rather than the hardware. Editing systems and VTR's should be able to handle incorrectly recorded timecode and Edit Flags, and should offer the editor a range of manual and automatic error-checking and correction options.

17. THE FUTURE.

When I first wrote this paper in 1981, the imminent arrival of COMPONENT ANALOGUE and DIGITAL recording promised that Colour Framing would no longer be a problem. Unfortunately this has not turned out to be the case.

As long as the signal, whether Analogue or Digital, is handled in fully component form at all stages of processing, then it will have no Colour Framing for editors to worry about. However if the original source was Composite then the signal will have to be decoded before it can be recorded in Analogue or Digital Component form. The nature of the encoding process introduces what can best be thought of as "texture" to the video signal. If the signal is kept in composite form throughout recording and processing, this "texture", which is caused by the Chrominance Subcarrier, will be concealed by the decoding process in the final receiver. However if a PAL composite source is recorded on a component recorder, then it will have to be decoded to Y, R-Y & B-Y either in the recorder or by an external decoder. Any residual subcarrier "texture" in the R-Y will retain its V-Axis switch. If this is then played back and re-encoded in the wrong Pal phase, some image definition can be lost. The solution involves recording 4 or 8 field Colour Framing flags which are later used by the TBC to correctly re-encode on playback. This means that editing with component recordings of composite source material requires Colour Framing to be checked.

Digital recording has only confused things even more. D1, DCT, D5 & Digital Betacam, are fully Component recording systems. However if they are used in a Composite environment the same care needs to be taken as for Analogue Component. D2 & D3 are Composite recording systems and require the same attention to Colour Framing as 1" C format.

The advent of component transmission systems and compressed video has added yet more complexity. Direct Satellite Broadcasting allows for a fully component signal to be delivered directly into the viewers home, and in theory compression technology allows the distribution of component signals over "single wire" systems. However once again if the original signal came from a composite source, and was not decoded to Y/U/V or RGB components before digitising, then problems can still occur.

The moral is that unfortunately Video Tape Editors and the manufacturers of their equipment will need to continue to address this problem for the foreseeable future.

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NOTE: The “texture” problem noted above shows itself in some recording formats as a loss of vertical definition if the playback has locked up with the “wrong” phase.

Bibliography

Detailed data can be found in the following documents:

- EIA Standard RS-170-A
- EBU Statement D14-1978
- CCIR Draft Report 624-1 (Mod F)

Recommended reading on Colour TV standards:

- CARNT, P.S. & TOWNSEND, G.B., “Colour Television. N.T.S.C. System, Principles, and Practice”, Iliffe Books Ltd., London, 1961.
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- SIMS H.V., "Principles of PAL Colour Television and Related Systems", Newnes-Butterworths 1969 (reprinted 1970,1974). ISBN 0-592-05970-7
- HUTSON, GEOFFREY, “Colour Television Theory”, McGraw-Hill, London, 1971.
- KING, GORDON J., “Beginner's Guide to Colour Television”, Newnes-Butterworth, 1973.

APPENDIX 1

STANDARD PARAMETERS FOR COLOUR TELEVISION TRANSMISSION SYSTEMS.

Summary of CCIR Draft Report 624-1 (MOD F)

a) TRANSMISSION SYSTEMS

	M	N	B	G & H	I
Line Standard (Lines)	525	625	625	625	625
Frame Scan (Fv) - Hz	29.97	25	25	25	25
Line Scan (Fh) - Hz	15,734.264	15,625	15,625	15,625	15,625
Video Bandwidth - MHz	4.2	4.2	5	5	5.5
Channel Spacing - MHz	6	6	7	8	8
Sound-to Vision Carrier Spacing - MHz	4.5	4.5	5.5	5.5	6

Systems G & H differ slightly in the form of the transmitted signal.

b) ENCODING SYSTEMS

	SUB-CARRIER FREQUENCY Fsc(Hz)	RATIO OF Fsc to Fh
525 NTSC (M)	3,579,545.0 (±10Hz)	455/2 x Fh
525 PAL (M)	3,575,611.49 (± 10Hz)	909/4 x Fh
625 PAL (N)	3,582,056.25 (± 5Hz)	(917/4 + 1/625) x Fh
625 PAL (B,G,H & I)	4,433,618.75 (± 5Hz)	(1135/4 + 1/625) x Fh
625 SECAM	R-Y = 4,406,250 B-Y = 4,250,000 (± 2KHz)	R-Y = 282 x Fh B-Y = 272 x Fh

System N, 625 PAL was designed to fit within the same channel spacing and bandwidth as System M, 525 NTSC & 525 PAL. It is found in some South American countries.

SECAM details shown are for the H-LOCK version. SECAM transmissions also use systems D, K, & L parameters. Full details can be found in CCIR Draft Report 624-1 (MOD F).