BBC ENGINEERING TRAINING
information sheet

TELEVISION STANDARDS CONVERSION

1. TELEVISION STANDARDS, A BRIEF REVIEW OF THE MAIN DIFFERENCES

		625 PAL	625 SECAM	525 NTSC
Lines/picture		625	625	525
Field Freq.	Hz	50	50	60*
Lines/Field		312.5	312.52	262.5
Line Freq.	Hz	15 625	15 625	15 750*
Line Period	µs	64	64	63.5
Active line period	µs	52	52	52-53
No. of active lines/field		287.5	287.5	241.5-243.5
Video bandwidth width	MHz	5.5	6.0	4.2
Colour subcarrier freq.	MHz	4.433	approx 4.4 MHz	3.58
Relation to sync Freq.		283.75 fh + ½ fv	F.M.	227 ½ fh
Chrominance bandwidth	MHz	1.2	1.2	1.5/0.6

*These are the values for monochrome. For NTSC color the frequencies are 0.1% lower.

In 625 SECAM the sync and luminance components are similar to PAL but the frequency stability requirement is less rigid, ± 2pt in 10^4 is specified. The subcarrier, being frequency modulated, cannot be precisely related to sync frequency.

The 525 line system has <u>almost</u> the same line frequency and active line period as the 625 but has 50 more lines per field. The field frequency is very slightly less than 60Hz. (59.94Hz) for NTSC colour. The video and chrominance bandwidths are less and so the horizontal resolution is inferior. The sync waveform differs in detail.

2. THE NEED FOR STORAGE

2.1 Consider a standards converter with picture monitors connected to both the input and output as in Fig. 2.1. The pictures displayed should appear identical. The scanning speeds would be different however, so at any instant the beam spot on the two monitors would, almst certainly, be in different parts of the picture and the signal appearing at the output must have been applied at the input sometime earlier. The converter primarily, therefore, must be a store (or it could be regarded as an adjustable delay) taking the signal as it appears at the input and holding it until it is required by the output scan. In general the output field frequency, and hence timing, will be different from that of the input and the store must hold at least one field hence the name "field-store converter" though in practice more storage than this will be required.

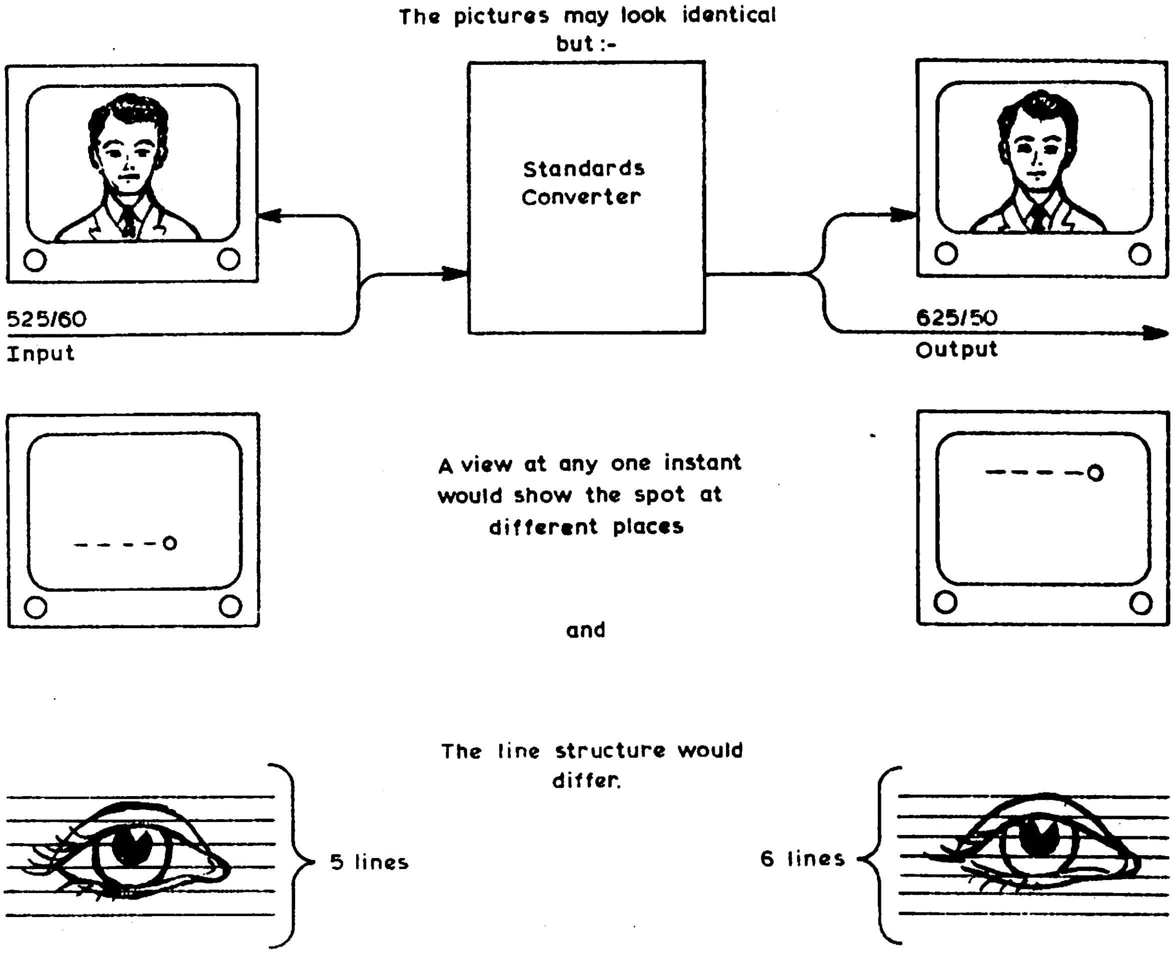
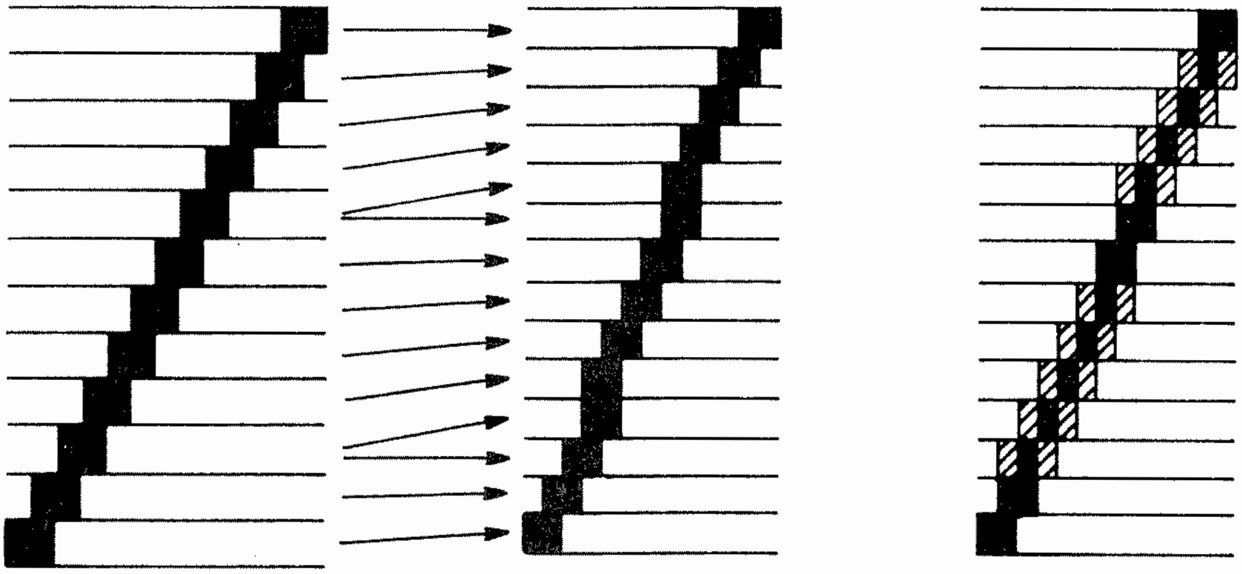


Fig. 2.1. Basic Requirements of Standards Conversion

3. INTERPOLATION

3.1 To understand the principles of interpolation it is perhaps helpful to consider the conversion of a 525 line 60 field/sec signal to the 625 line 50 field/sec standard without the use of this process.

3.2 The most obvious difference between the input and the output, present even of the picture is a stationary scene, is that the output picture is divided into more scanning lines and they are more closely spaced than on the input. The simplest way for a converter to increase the number of lines would be to repeat about every fifth input line. This would be satisfactory if the picture area was plain or consisted only of vertical edges, one line would be very much the same as the next in this case. But if, for example, the input picture consisted of a diagonal line then the closing up of the scanning lines and the repetition of every fifth causes the diagonal line of the picture to become jagged as shown in Fig. 3.1.



525 line input

625 line signal
without interpolation

625 line picture
with interpolation

Fig. 3.1. Line or Vertical Interpolation

3.3 If we examine the input and output line structures we see that few, if any, of the output lines occupy precisely the same locations in the picture as any particular input line and it is important to realise that the correct picture information for the output lines does not actually exist on any input line. It is therefore necessary to make an estimation of the most suitable signal by taking a suitable mixture of picture information presented on lines of input signal adjacent to the position that the output line will occupy.

3.4. This process of estimation is called "interpolation". Where it is concerned with the generation of extra lines it is called "line" interpolaton.

3.5 Fig. 3.2. shows how this interpolation could be achieved. At the instant that an output line is required the input and output of the one-line delay give the information of two successive input lines, and from suitable proportions of these lines the output line is produced. The "suitable proportions" could be found by considering the position of the output line; if it sat midway between two input lines then a 50 : 50 mixture might be suitable, if it sat very close to an input line above it then a 20 : 80 mixture might be more appropriate.

3.6 The actual value of the co-efficients (that is, the proportions used) can be determined by measuring the timing of the output line relative to the input lines and referring to the interpolation aperture of Fig. 3.3. In practice the values for each line of the picture could be stored in a ROM.

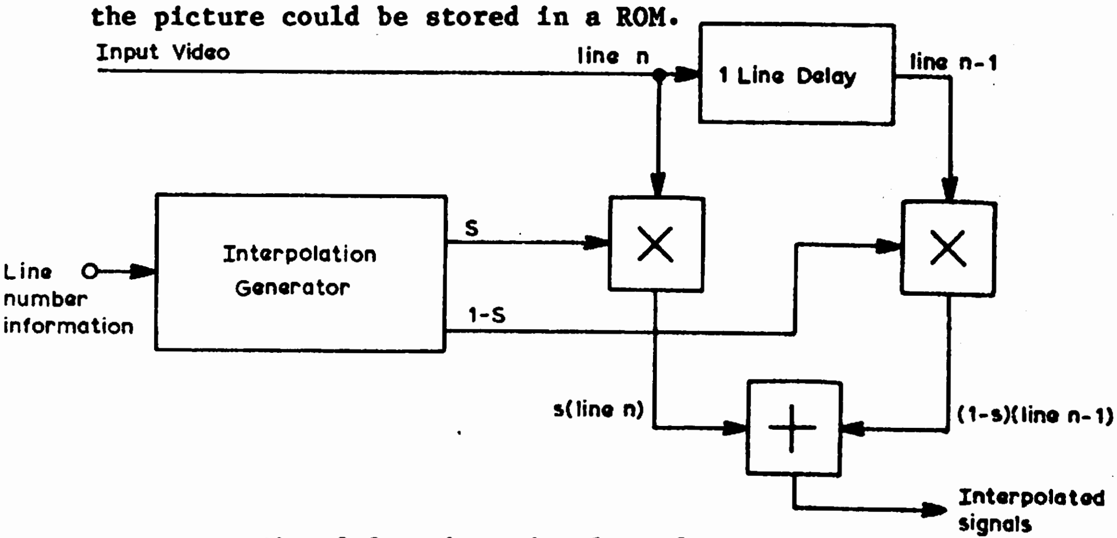


Fig. 3.2. The Princples of Interpolation

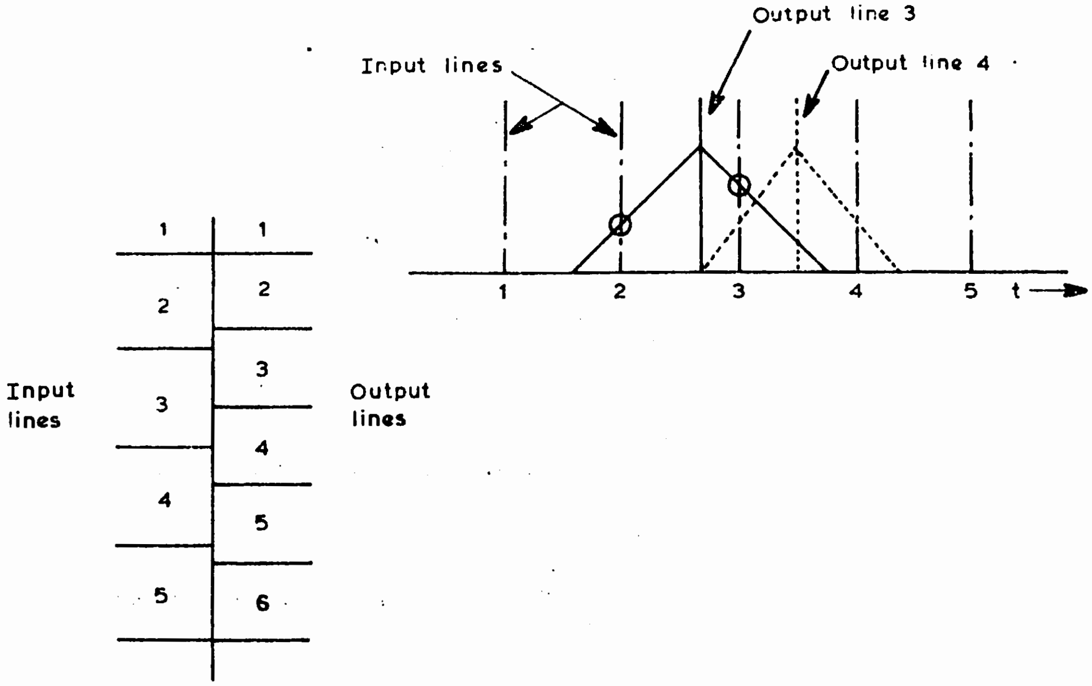


Fig. 3.3. Simple 2 line Interpolation

3.7 It should be clear that this interpolation does not give the "correct" information for a point on the output picture, just a mixture of the signals above and below. A better approximation would be made by taking four lines of input and applying the interpolation aperture shown in Fig. 3.4. The negative lobes imply a form of vertical aperture correction.

3.8 There may be a compromise betwen removing the jagged edges and loss of vertical resolution. The latter can be improved by using a one-field delay to present the interlace field of scanning lines.

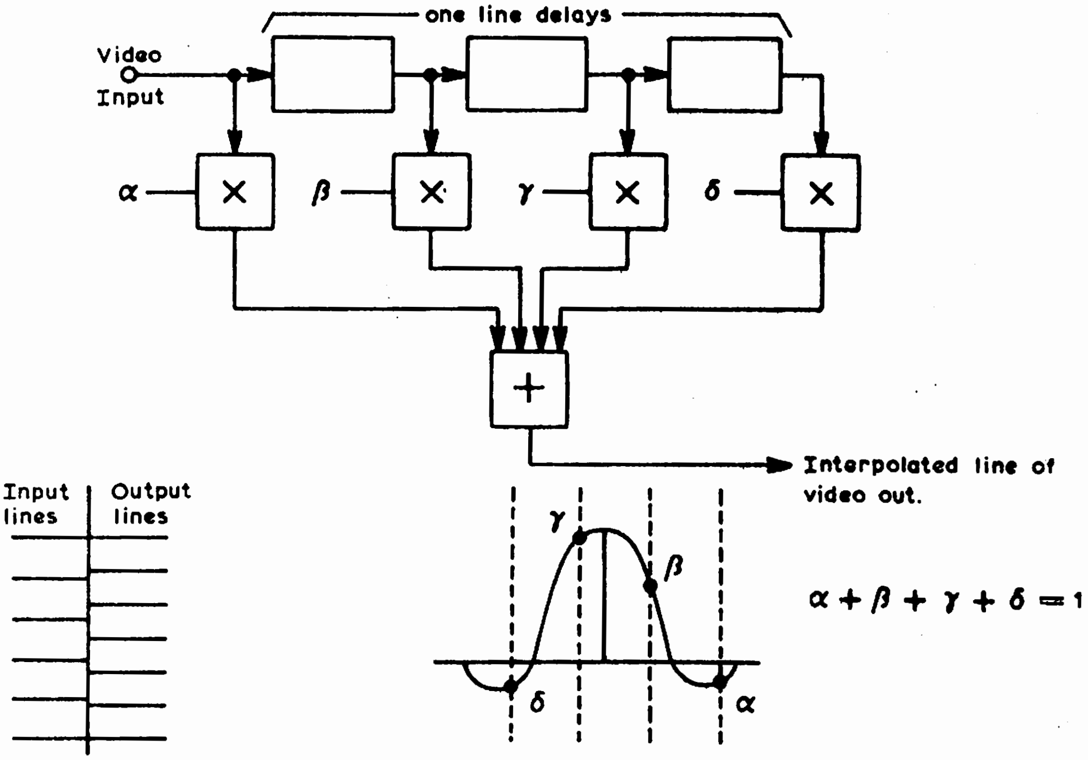


Fig. 3.4. Four-line Interpolation

3.9. Movement (or field) Interpolation See Fig. 3.5.

When converting a 60 field/sec input to a 50 field/sec output the simplest method would simply be to omit every sixth input field and ~~show~~ SLOW down the remaining five. This would be satisfactory with a stationary scene but a steadily moving scene, for example, would move slowly for five fields then jerk forwards when seen on the output, giving a 10Hz "judder" which in practice is very objectionable.

3.10 The effect can be compared with the line structure problem and is overcome in a similar way, by making up the output signal from a mixture of two or more successive fields of the input. In practice some compromise between judder and blurring may be involved.

4. CLASSIFICATION OF STANDARDS CONVERTORS

They can be classified by type of storage and form of interpolation.

4.1 Optical types use a long persistance picture monitor in front of the camera, they are largely obsolete.

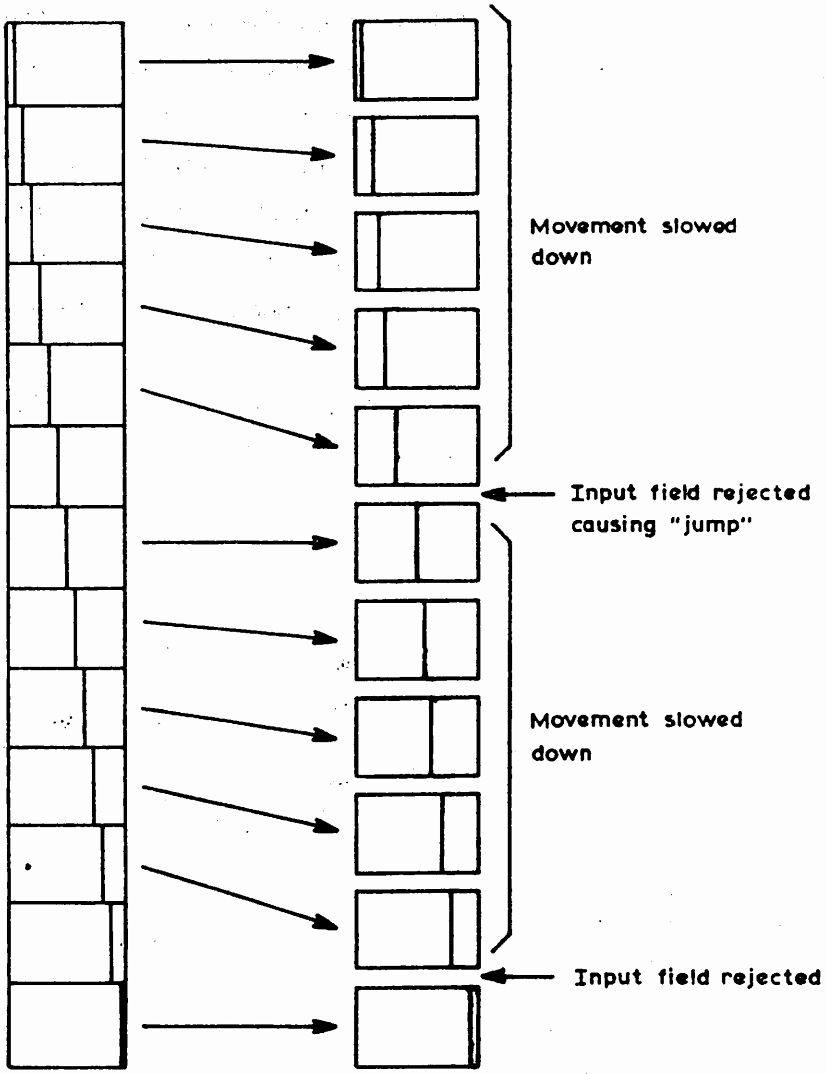


Fig. 3.5. Movement Rendering in a 60 field/sec to 50 field/sec Conversion without Interpolation

4.2 The earliest electronic types either stored the signal as a series of analogue voltage samples in a bank of capacitors (e.g. line-store types) or used quartz ultrasonic delays switched in and out of circuit as required. They are all obsolesent.

4.3 Digital storage of video signals is now normally used, 8 bit pcm samples can be stored in shift registers or RAM. This is now the cheapest method and it's use is universal for new time-base correctors, synchronisers and standards converters.

4.4 Transcoders simply de-code the colour information and re-code it on a different standard without any change of timing or scan standard. A simple Secam - PAL transcoder is shown in Fig. 4.1. Because the sync timing and frequency is not altered it may not be within the PAL frequency specification and hence two alternative outputs are possible; one with the wrong mathematical relationship between sub-carrier and sync which must not be recorded, the other with the wrong sub-carrier frequency which must not be transmitted.

If the SECAM input is from a local VT replay locked to the normal PAL sync, then this problem will not arise and both outputs would be identical.

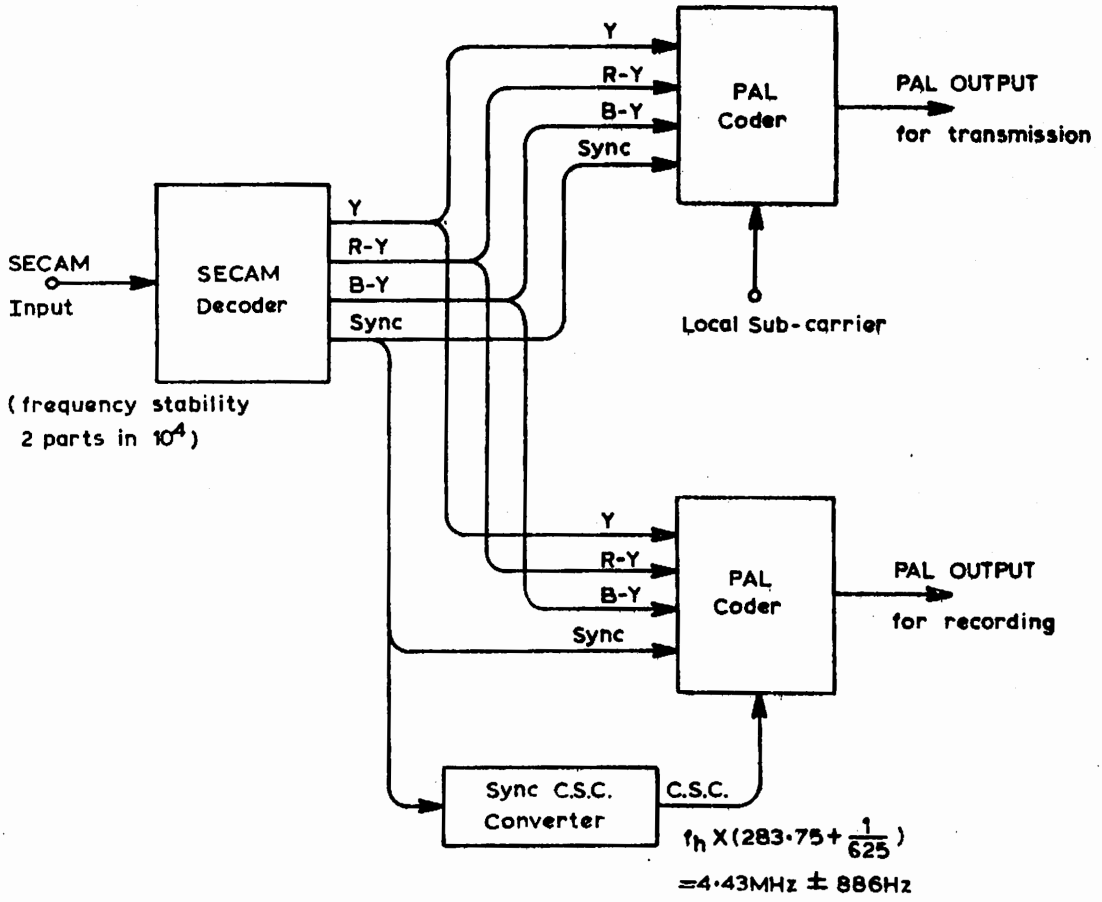


Fig. 4.1. SECAM - PAL TRANSCODING
(without field-store synchroniser)

4.5 Synchronisers simply delay a signal enough to make it synchronous with a reference source.

Non-decoding types are the simplest and give least picture degradation but can only handle a "standard" PAL input. Using a one-field store the input can be delayed to make its field timing match the reference source, then adjusting by either half or one line period to make it match the line timing and VAS of the reference, and it's timing then finally trimmed to make colour sub-carrier phase match the reference. The result is a synchronous output but with the picture information shifted, relative to sync, by up to 1 line vertically and up to ± 112µs (180° of CSC) horizontally. If the input signal is, for example, slightly higher in frequency than the reference then the delay introduced must be gradually increased then suddently reduced by one field as the input and output go through field synchronism. At this instant one input field will be omitted and the output picture will hop vertically and horizontally.

Providing signals are within the very tight PAL frequency tolerance this should happen only very in-frequently and hysteris is provided to prevent repeated hopping with an input that is hovering near field synchronism.

A more serious problem is the erosion of active picture by the re-blanking of the signal particularly if synchronisers are used in cascade.

Decoding types of synchroniser, using two fields of storage of Y, U, V signals, can handle Secam or "non-mathematical" PAL, and eliminate the picture shift and non-standard blanking problems but do cause slight image degradation.

4.6 Timebase Correctors are simpler than synchronisers in that they require less storage because the VT can be servo controlled to adjust video timing close to that of reference sync; but more complex in that they have to cope with a jittery and noisy signal which may also be non-standard.

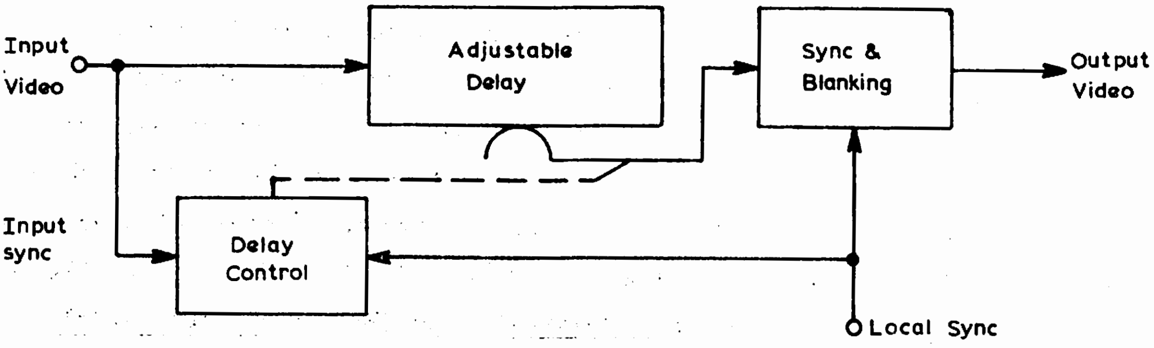


Fig. 4.2. Basic Principle of Timebase corrector or Synchroniser

5. IMAGE-TRANSFER (OR OPTICAL) STANDARDS CONVERTERS

In the simplest terms these consist of a camera placed in front of a picture monitor. They were used from the earliest days but have been largely sperceded by all-electronic types because :

a. they introduce some loss in image quality

b. they require frequency attention.

They have the advantage of accepting a wide range of input signals however, anything which can lock a picture monitor can be converted and interruptions to the input cannot affect the sync waveform of the output.

Though obsolete, they justify a brief study to illustrate the principles of standards converstion. The principles of a monochrome converters operating in 525 - 625 direction will be considered first.

5.1 Consider first a 525 line signal applied tio a short persistence CRT which is then focussed onto the target of a camera tube which, let us suppose, does not employ the charge storage principle; that is, it produces an output proportional to the light on the target only at the instant each element is scanned. The output picture would only be an occasional twinkle of light when the input spot from the CRT happened to be in the same position as the camera scanning beam. Quite useless!

This problem can be overcome by using a long-persistence CRT phosphor, ideally with pefect persistence for one field, or one picture period, and then a sudden cut off. Such a phosphor would ensure there was always just one complete picture on the CRT at all times. Unfortunately such a phospor does not exist and one with a longer decay time is used together with the charge storage effects of the vidicon or plumbicon camera tube. Too short a persistence gives excessive flicker at the difference between the field frequencies (10Hz in this case) and too long a persistence gives blurring on moving pictures.

5.2 Spot Wobble. If both the CRT and camera beams were very sharply focussed then the camera beam would sometimes scan between the two lines from the CRT raster resulting in little or no signal. "Spot Wobble" is a high frequency sinusoidal vertical deflection added to the CRT to give controlled vertical spreading of the beam, broadening the lines to fill the space available.

5.3 **Line Interpolation** Suppose the camera beam is very sharply focussed and a 525 line input is being converted to 625 line. The lines of the camera scan are more closely spaced then those of the input from the CRT which results in about every fifth input line being used twice. This gives a lack of interpolation and the undesirable effect on, for example, diagonal lines in the converted picture as discussed earlier.

If the camera beam is now defocussed slightly in a vertical direction then the beam is no longer examining a "point" on its target but rather an "aperture" the size and shape of which depends on the degree of defocussing. The output signal will be a mixture of one or more input lines depending on the position of the input lines with respect to the output line, i.e. the CRT scanning lines relative to the camera scanning line.

The above illustrates the principle of line interpolation, the beam "aperture" determines the form of interpolation, if it is too large then vertical resolution suffers.

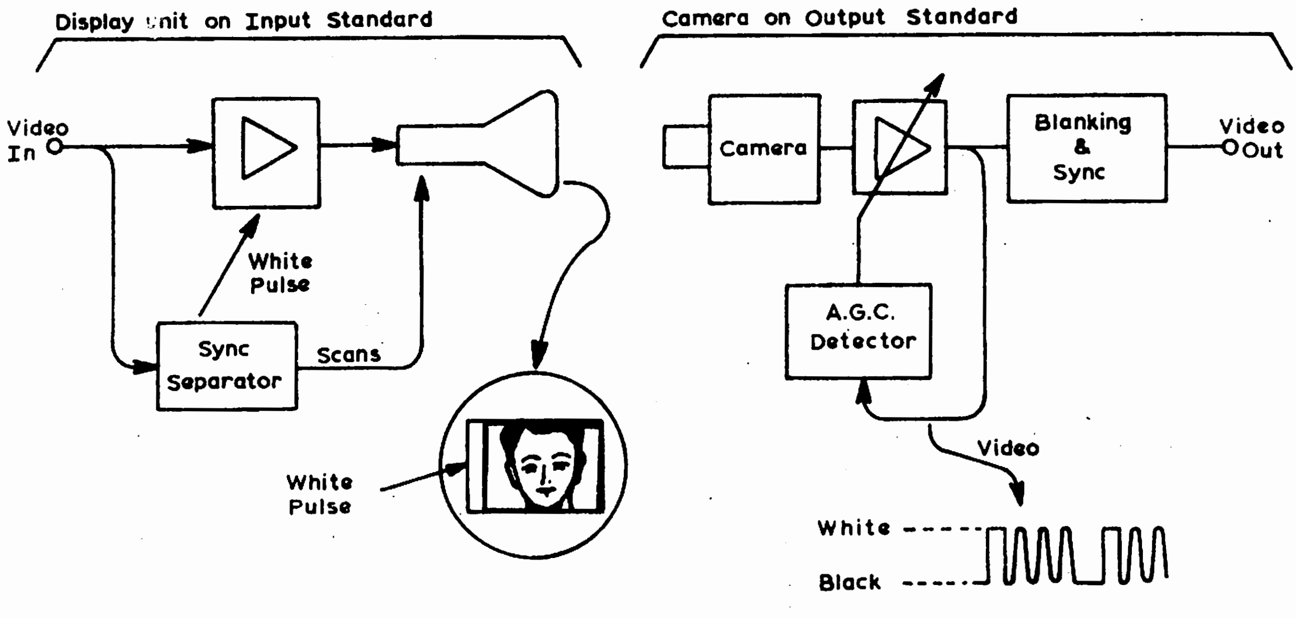


Fig. 5.1. Optical Standards-Converter

5.4 **Movement (Field) Interpolation.** This is provided rather haphazardly by the phosphor persistence which results in the output picture having information from several previous fields. This causes blurring and multiple imaging with moving scenes which at least has the benefit of disguising movement judder.

5.5 Flicker Reduction

In practice the output suffers a flicker at the difference between the input and output field frequencies which can be reduced by modulation of the gain of the camera video amplifier by a fast-acting a.g.c. system. The reference for this is a white level pulse added to the video input just before the start of active picture and displayed on the left side of the CRT as shown in Fig. 5.1. and detected in the camera output prior to line blanking. Both CRT and camera scans must have flyback periods shorted than the line blanking periods of the standards used.

5.6 Colour Image Transfer Standards Converters

The substitution of a shadow mask CRT and colour camera for the monochrome types need not be considered further for serious standards conversion.

An alternative is to decode the input and apply it to three separate monochrome converter sets handling R G and B or perhaps Y U and V signals.

The only system in common use, made by Bosch- Fernseh uses two monochrome converters. One handles the Y signal the other a specially re-coded chrominance signal. It is shown in Fig. 5.2. The chrominance component is separated from the input and converted to an NTSC like signal, but with sub-carrier at a multiple of the input line-frequency and about 1MHz, and displayed on one CRT.

The displayed "picture" would consist of vertical lines in coloured areas, the camera output would effectively by NTSC type sub-carrier, amplitude and phase depending on the hue and saturation. This is decoded to U and V signals and re-coded on the output standard.

In the chrominance conversion process the sub-carrier frequency would be altered, and would also be affected by scan linearity.

To assist in the de-coding a pilot in the form of a 1MHz pulse is added to the chrominance input to the CRT. It is extracted from the camera output by filtering and used in lieu of an burst-locked oscillator in the decoder.

Because the displayed sub-carrier is a multiple of line frequency the phase of the chrominance is the same, for a given colour, on consecutive lines and interpolation is achieved just as with the luminance signal.

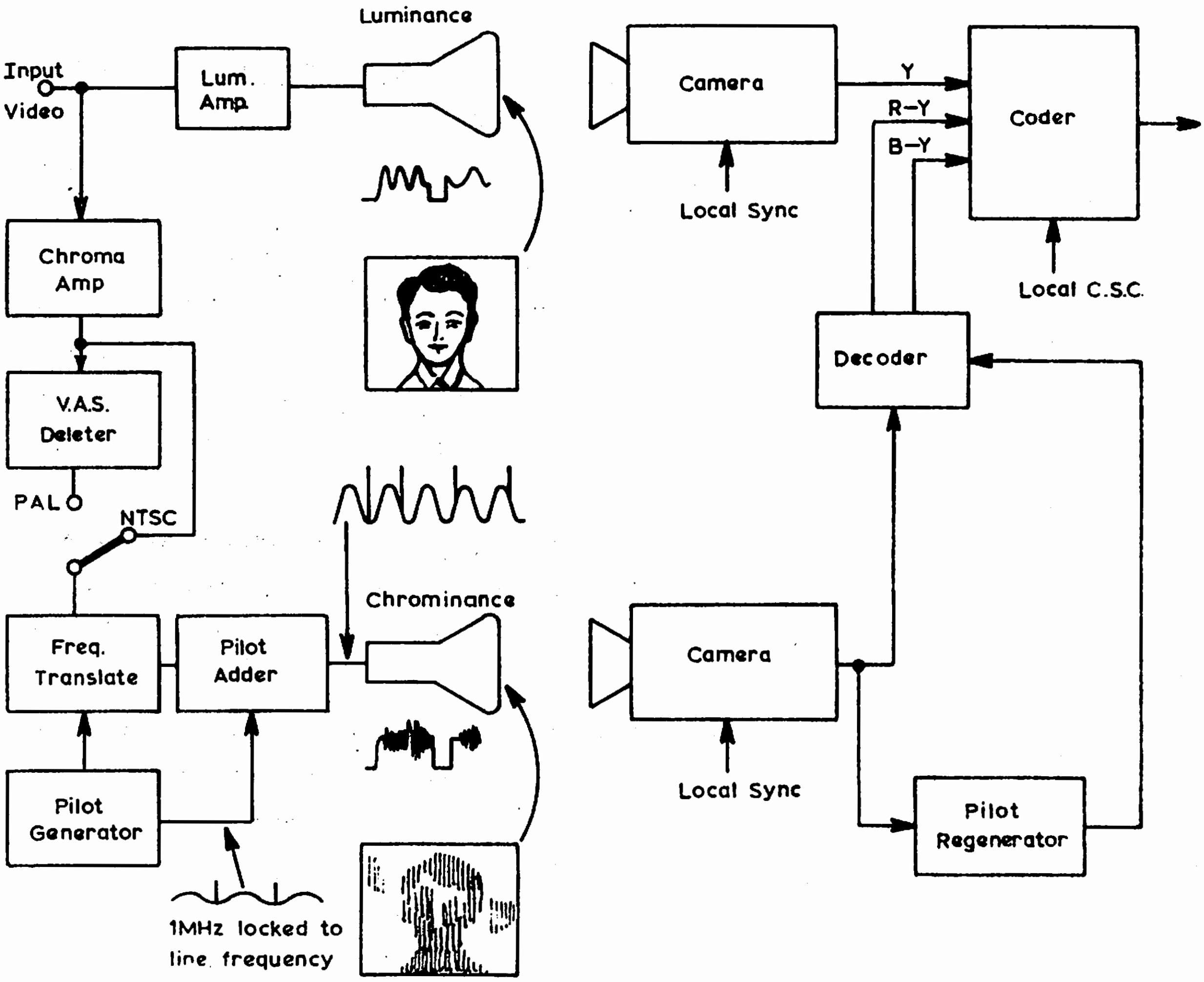


Fig. 5.2. Colour Image Transfer Standards Converter

6. THE DIGITAL FIELD-STORE CONVERTER/SYHCHRONISER (Advanced Conversion Equipment or ACE)

Two of these devices have been built by Designs Department and more have been built commercially under licence. They offer bothway 625-525 operation with minimum maintenance attention or loss in quality. In the synchroniser mode they de-code/re-code and can handle SECAM or "non-standard PAL".

6.1 Operation in Convert Mode See Fig. 6.1.

The input is first de-coded to three signals, Y, U and V. Each analogue signal is converted to 8-bit p.c.m. digital form using a clock frequency locked to a multiple of the input line frequency.

The coded samples of the signals are arranged in sequential form Y U Y V Y. The resulting signal has 8 wires and a bit rate of 16 Mb/s on each.

The main store consists of RAM. It is convenient if the reading and writing clocks can take place at the same frequency so that the two processes can take place on alternate clock cycles, though of course at different addresses.

This requires the same number of samples to be taken from the active line periods of both input and output signals.

Unfortunately the 525 line period is very slightly shorter. The difference is accommodated by the "buffer" store, a "first in first out" register system which is emptied at the start of each input 525 line signal and gradually fills up as the data is supplied at a very slightly higher frequency than it is clocked out. The clocking of the RAM can then take place at the Read Clock Frequency. The buffer store has a capacity of 128 bits, i.e. 8μs.

Four fields of the input are written into appropriate locations in the four field stores, so the four previous fields of input signal are always available. At any instant only one store is being written.

The read addresses are determined by the local output sync, but at any instant 4 successive lines are read from each of the four field stores, 16 signals in all, each is an 8 bit p.c.m. signal of Y U Y V Y sequence. Suitable proportions of these 16 signals are then taken, digitally added to produce a single 8 bit sequential Y U Y V Y signal, which is then split into Y U Y, converted to analogue signals and re-coded onto the output standard.

6.2 Operation in Synchronise Mode

This is basically similar to the convert mode except that greater bandwidth is required but no interpolation is needed.

This synchroniser always de-codes the signal to Y, U and V. This involves a slight loss of quality but enables it to handle SECAM and "non-mathematical" PAL.

The Y ADC is clocked at 16MHz the U and V at 8MHz each locked to a multiple of line frequency. Only two fields of storage are required, so the four field-store units WXY and Z are rearranged, W and X providing 2 fields of Y singal storage, the U and V signals are multiplexed and 2 fields are stored in UUVV sequence in stores Y and Z. Each of the stores is therefore still handling 16 Mb/s data.

The effective Y sampling rate is then 16mHz and the U and V signals are sampled at 8mHz. These frequencies are somewhat higher than fundamentally necessary but involve minimum change for the "convert" mode.

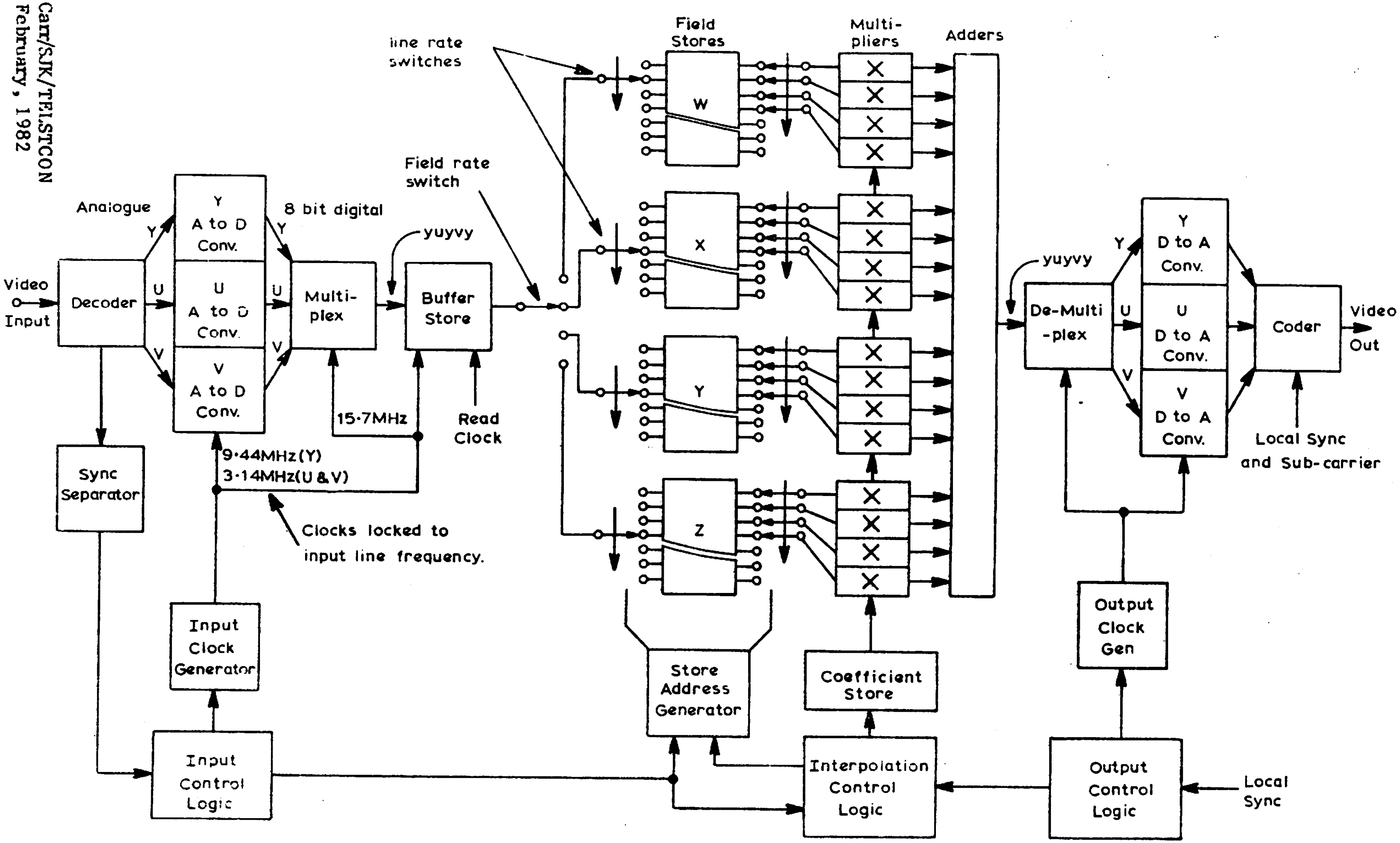


Fig. 6.1. Digital Field-Store Standards Converter/Synchroniser

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ENGINEER TELEVISION COURSE

TELEVISION STANDARDS CONVERSION

1. (i) State the principal differences between the 625 PAL, 625 SECAM and 525 NTSC television standards. (6)
   (ii) Briefly compare the merits of the three systems. (4)

2. Describe the following features of a standards converter when operating in the 525 - 625 mode.
   - i) the amount of signal stored, (2)
   - ii) the form of the signals in the store, (3)
   - iii) the signals used by the interpolation section and how it forms the output signal. (5)

3. Describe the main differences in principles of operation between the "Convert" and "Synchronise" modes of operation of the BBC designed Digital Field-Store Standards Converter. (10)

4. Explain what is meant by the term "interpolation" when applied to a field-store standards converter. Illustrate your answer by describing the effects seen on a 625 line picture converted from a 525 line standard input if:-
   a. line,
   b. field
   interpolation were not used. (10)

5 Why is a Buffer Store provided in the ACE standards converter?

Describe why 1% or 2% overscan may be needed when converting from 625/50 to 525/60 standards.
How can this be achieved in the a) Vertical
b) Horizontal axis.

6 Compare the relative merits of I-PAL a M NTSC TV systems.

Explain why many would judge that 525 pictures converted from a 625 source would be better quality than 625 pictures converted from a 525 source.

RC. Feb 15 1984