COLOUR TV SYNC PULSE GENERATOR

by

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ABSTRACT

In this thesis study, the synchronizing signals which are used in the transmitter systems of the television that is the most common mass communication means of today have been studied and a practical studio pulse generator which produces necessary synchronizing signals for both black and white and colour television systems, have been realized.

In this study, the PAL system which is currently being used in Turkey and is about to change into colour system has been emphasized and all the output signals of the generator have been presented according to the requirements of this system.

In the study, at first, general information related to colour television system, has been given, and then the detailed structure of the pulse generator has been presented. By means of this pulse generator, the students who are interested in the subject of television or those who attend television courses, have been shown and made known in laboratory, the black-and-white and colour fundamental synchronizing signals, and thus the subject of synchronisation has been aimed at being better understood.

ÖZETÇE

Bu tez çalışmasında günümüzün en yaygın kitle iletişim aracı olan televizyonun, verici sistemlerinde kullanılan senkronize sinyalleri incelenmiş ve hem siyah beyaz, hem de renkli televizyon sistemleri için gerekli senkronize sinyallerini veren pratik bir stüdyo darbe üreteci gerçekleştirilmiştir.

Çalışmada, renkli televizyon sistemine geçmek üzere olan ülkemizde kullanılan PAL sistemine ağırlık verilmiş ve gerçekleştirilen üretecin tüm çıkış sinyalleri bu sistemin gerektirdiği ölçülerde sunulmuştur.

Tez çalışmasında, önce renkli televizyon sistemi ile ilgili genel bilgiler verilmiş, daha sonra gerçekleştirilen darbe üretecinin ayrıntılı yapısı sunulmuştur. Yapılan bu darbe üreteci vasıtasıyla televizyon dersi alan yada televizyon konusuna ilgi duyan öğrencilere laboratuvarda renkli ve siyah beyaz temel senkronize sinyallerinin gösterilerek tanıtılması ve böylece senkronizasyon konusunun daha iyi anlaşılması amaçlanmıştır.

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INTRODUCTION

Sync Pulse Generator designed in this thesis study is the central item of equipment in studio and field operations. It establishes the timing of the line and field scanning for both transmitter and receiver. The object of this thesis is to design a practical Sync Pulse Generator that can be used in laboratory as a teaching device. It contains both black and white, and colour television pulses used in transmitter systems.

All colour television systems at present in use owe their origin to the NTSC (National Television System Committee) system, which was invented and developed in the United States of America, but most of the emphasis in this thesis - since it is used in Turkey - is necessarily devoted to the PAL (Phase Alternation Line) system, which was developed to reduce the effects of phase distortion of the colour signal. The third system, which falls outside of the scope of this study is known as SECAM (Séquentiel Couleur à Mémoire).

The thesis study consists of eight chapters. Chapter 1 gives the function of Sync Pulse Generator and its output signals, Chapters 2-5 include the general colour information and the principles of PAL colour television system, Chapters 6-7 cover the presentation of Sync Pulse Generator's design details and circuit diagrams. Finally in Chapter 8, a conclusion is presented. Greater detail of the subjects discussed in Chapters 1-7 can be found in references section given at the end of the thesis.

CHAPTER 1

INTRODUCTION

1.1. NECESSITY FOR SYNC PULSE GENERATOR

In all television broadcasting systems it is usual to synchronise all picture sources feeding a studio from the same synchronising pulse generator. Sync pulse generator, which supplies the various pulses necessary for operating a TV studio is the central equipment of both black and white, and colour television transmitter systems. Generally, it has a controlled oscillator at twice line frequency (e.g., $2f_h = 31250$ Hz) and counts down from this frequency to line, field and picture frequencies. Four sets of station pulses are distributed to picture-generating sources: (1) Composite synchronising pulses, comprising the horizontal, equalizing and vertical pulses [1], (2) Horizontal driving pulses, (3) Vertical driving pulses, (4) Composite blanking pulses.

The time of arrival of the pulses at the camera, or other source, has to be adjusted so that all pictures arrive at the control-room mixer in time synchronism. For PAL colour television, it is necessary to distribute three further sets of signals, so that all coders can produce similar colour pictures at the inputs to the vision mixer. (5) A continuous subcarrier reference sinewave is distributed so that all balanced modulators are fed with precisely the same subcarrier frequency. (6) A burst-flag pulse is also distributed, so that all coders key-out the colour burst from the continuous reference sinewave at the same time. (7) A third pulse train is required to ensure that the PAL alternation sequence is the same in all coders.

These extra pulse trains, and the twice line frequency needed for generating the other studio pulses, are derived from a crystal-controlled oscillator of very high stability which produces the continuous reference sinewave. The detailed specifications of the sync, driving, blanking, and extra station pulses are shown in Fig. 1.1 and Fig. 1.2 .

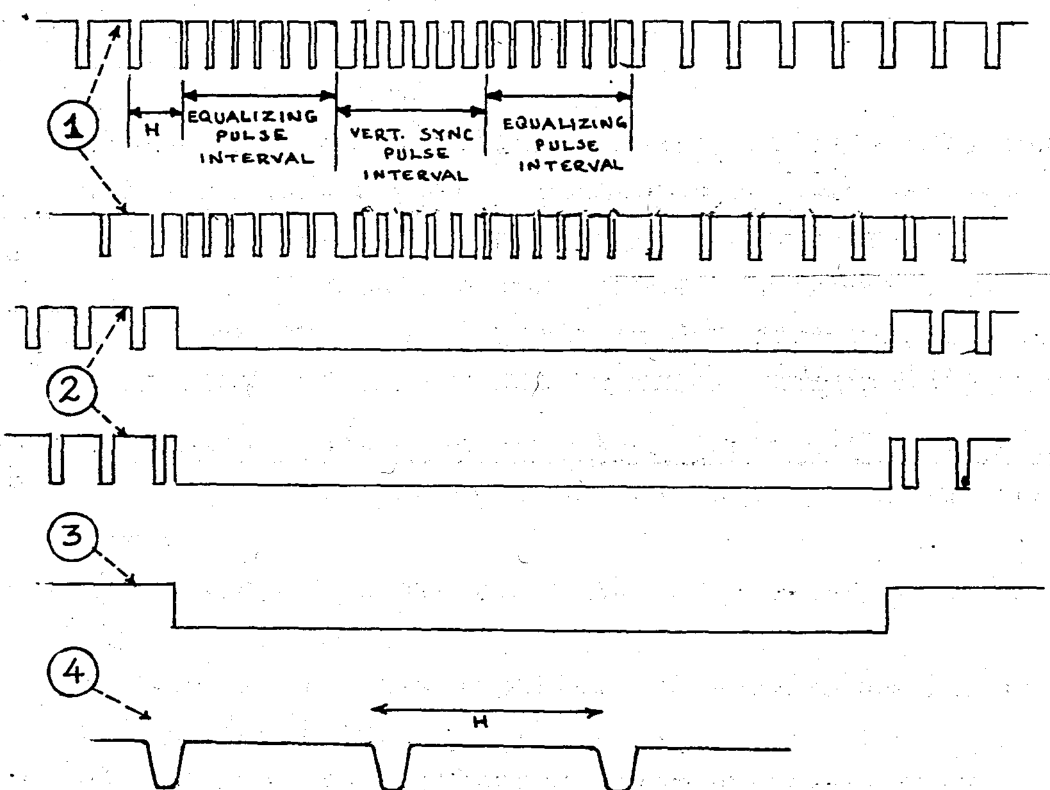


Fig.1.1

1- SYNCHRONIZING SIGNAL 2- BLANKING SIGNAL 3- VERTICAL DRIVING SIGNAL

4- HORIZONTAL DRIVING SIGNAL

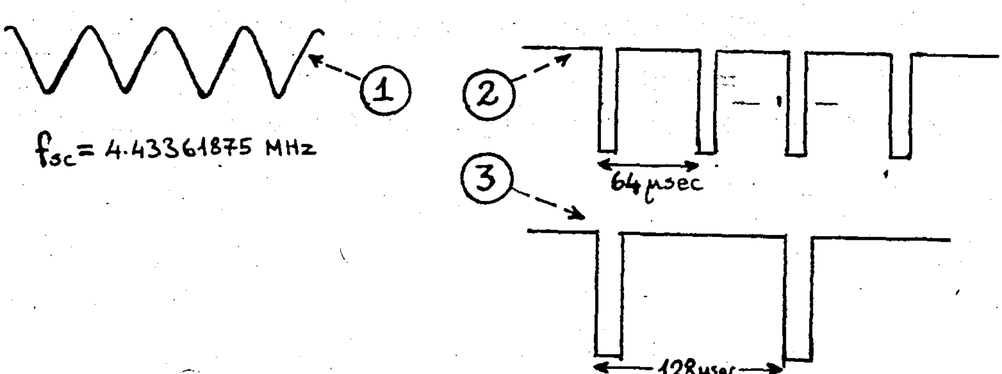


Fig. 1.2

1- REFERENCE SUBCARRIER 2- BURST-FLAG PULSE 3- PAL-FLAG PULSE

1.2 BASIC REQUIREMENTS OF A COLOUR TELEVISION SYSTEM

It is helpful to summarize the main properties which a colour television system should possess.

The system must produce a picture of realistic colour, adequate brightness and good definition. In designing it due account must be taken of the properties and limitations of the human eye.

Compatibility

a) The colour television signal must produce a normal black and white picture on a monochrome receiver and do so without any modification to the receiver circuitry.

b) A colour receiver must be able to produce a black and white picture from a normal monochrome signal. This is sometimes referred to as "reverse compatibility".

Conditions Necessary to Establish Compatibility

To be fully compatible the colour television signal must:

a) Occupy the same bandwidth as the corresponding monochrome signal.

b) Employ the same location and spacing of the sound and vision carriers.

c) Use the same deflection frequencies.

d) Employ the same line and field synchronizing signals

e) Contain the same fundemantal brightness (i.e., luminance) information as would a monochrome signal transmitting the same scene.

f) Contain additional colour information together with the ancillary signals needed to allow this to be decoded.

g) Carry the colour information in such a way that no visible sign of it appears on a monochrome receiver's picture.

CHAPTER 2

COLOUR PERCEPTION

2.1 COLOUR VISION AND COLOUR MIXING

The human eye is not uniformly sensitive over the visible spectrum. Fig. 2.1 shows the relative response of the "average eye" to light of constant luminance projected at various wavelengths throughout the spectrum. The curve peaks in the yellow-green region and it is interesting to note that a curve showing the distribution of energy in sunlight, peaks in this same area. The full-line curve shows the average observer's subjective impression of brightness under daylight conditions. As shown by the second curve, under near dark conditions the response curve shifts to the left. Light of a single wavelength is said to be monochromatic. Our ability to distinguish a variety of different colours might be supposed to indicate the presence of an equal number of different types of cones in retina; each type being "tuned" to only a small band of frequencies. If the cones were monochromatic in this way, then a given colour impression could "only" be produced by e.m. energy having the appropriate wave-length. This is not, however, true. Shining monochromatic light on the retina is not the only way of creating a given colour impression. For example, some monochromatic yellows may be matched by the simultaneous arrival at the retina of red and green light. Almost all colours can be matched by mixing only three coloured lights; red, green, and blue.(Primary Colours).

This behaviour of the eye is consistent with there being three types of cones only, each having a different response curve; the three response curves overlapping in such a way that all spectral colours are beneath either one only, or else partly under two, of the three curves.

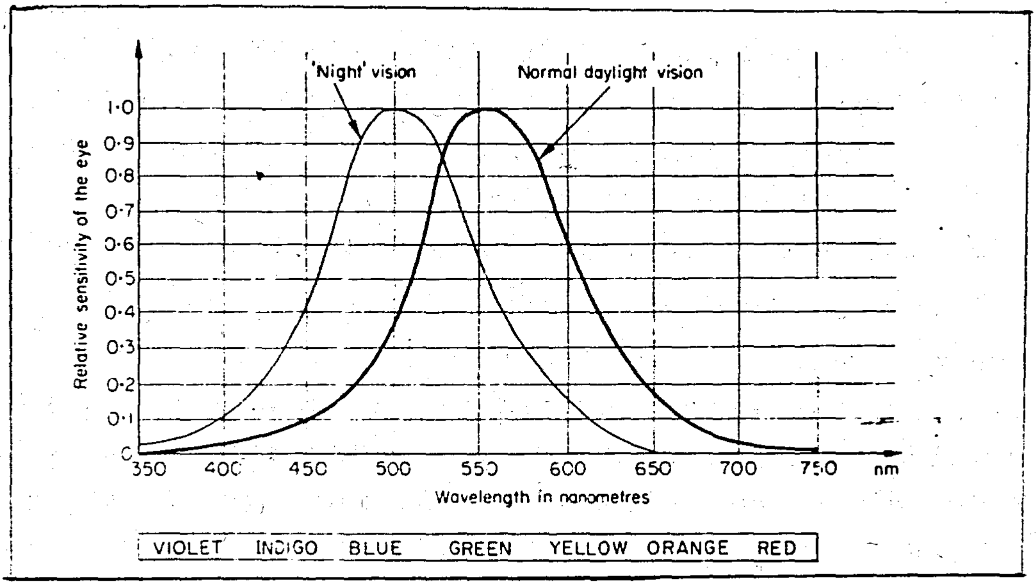


Fig. 2.1

Approximate relative sensitivity of the average human eye to different wavelengths.

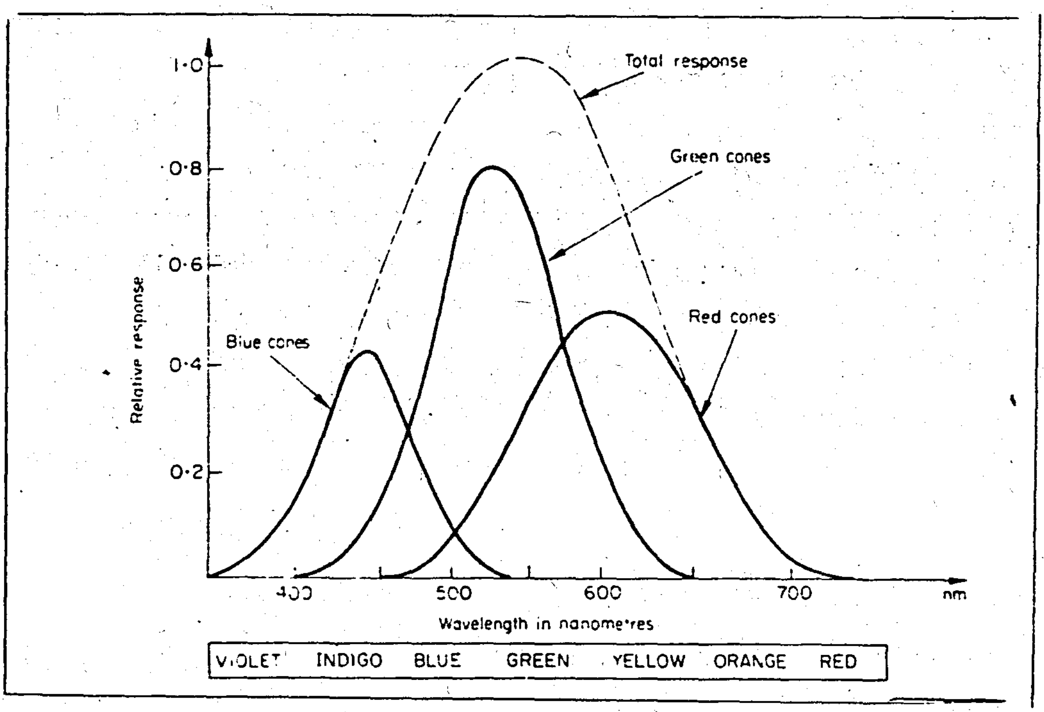


Fig. 2.2

Hypothetical relative sensitivities of the suggested three types of cones in the retina.

Fig. 2.2 illustrates this. It will be seen that yellow activates both red and green cones. It is logical to deduce that when red and green light reaches the retina at the same time, the simultaneous excitation of the red and green cones gives a mental impression which is indistinguishable from monochromatic yellow.

In order for colour to be seen, e.m. energy has to reach the eye. An object is seen by the light reflected from it. If it looks green in daylight, then this must imply that although it is bathed in "white" sunlight, it is only reflecting the green part of the light back to our eyes. The remainder of the spectrum is "absorbed". An object therefore looks coloured because it only reflects part of the visible spectrum and absorbs the rest. The colour stems from the incident light.

The colour of an object is determined by pigments. These are chemicals which create a given colour by subtracting parts of the spectrum of the incident white lihgt. The remaining light is reflected and this gives the object its characteristic colour. Making colours by mixing paint pigments may therefore be described as a process of "subtractive mixing", since each added pigment subtracts more from the white light and leaves less to to reflected to the eye. Conversely, it is possible to create colours by the addition of coloured lights. This is known as "Additive mixing". These two distinctly different processes are now discussed in turn.

Additive Mixing

Additive mixing is simpler to remember than the theory of subtractive mixing. A colour television receiver does not create colour by starting with white light and subtracting parts from it. Here colours are created by mixing red, green and blue lights. The process used in this system is shown in Plate I.

Red + Green = Yellow

Red + Blue = Magenta

Blue + Green = Cyan

Red + Blue + Green = White

Red, green, and blue are called primary colours, while yellow, magenta, and cyan are known as complementaries. If a complementary is added in appropriate proportions to the one primary which it itself does not contain (e.g., yellow + blue), white is produced.

Subtractive Mixing

This may be demonstrated by imagining that various colour pigments are superimposed one upon another. Plate II illustrates the result when the three complementary colours, yellow, magenta, and cyan are used. These are shown partially overlapping so that the effects of any combination of them may be seen. It must be remembered that it is no longer light sources that are being considered. White light is shining down on the pigments which then absorb parts of the spectrum and reflect the rest. The results are summarized below:

Yellow = White - Blue

Magenta = White - Green

Cyan = White - Red

Yellow and Magenta = White - Blue - Green = Red

Yellow and Cyan = White - Blue - Red = Green

Magenta and Cyan = White - Green - Red = Blue

low and Magenta and Cyan = White - Blue - Green - Red = Black

This expressions are intended to show the sequence of events when the pigments are added in turn. For example, yellow on its own merely subtracts blue light leaving the red and green parts of the spectrum which when seen together look yellow. Magenta on the other hand, takes out green leaving only red and blue which is seen as Magenta. When

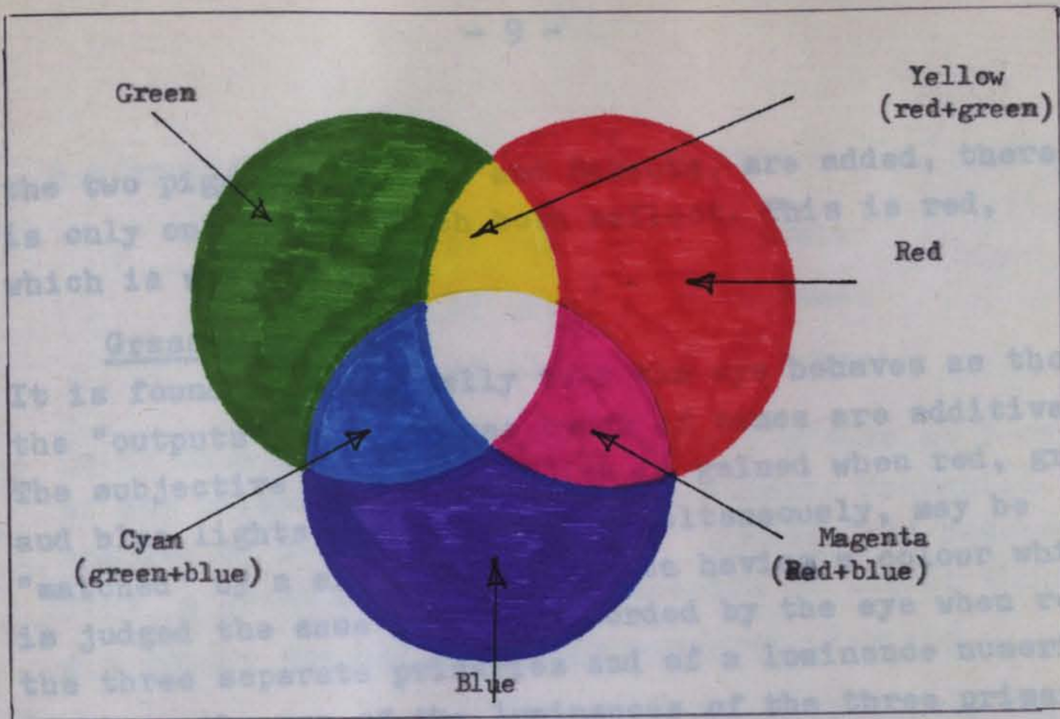
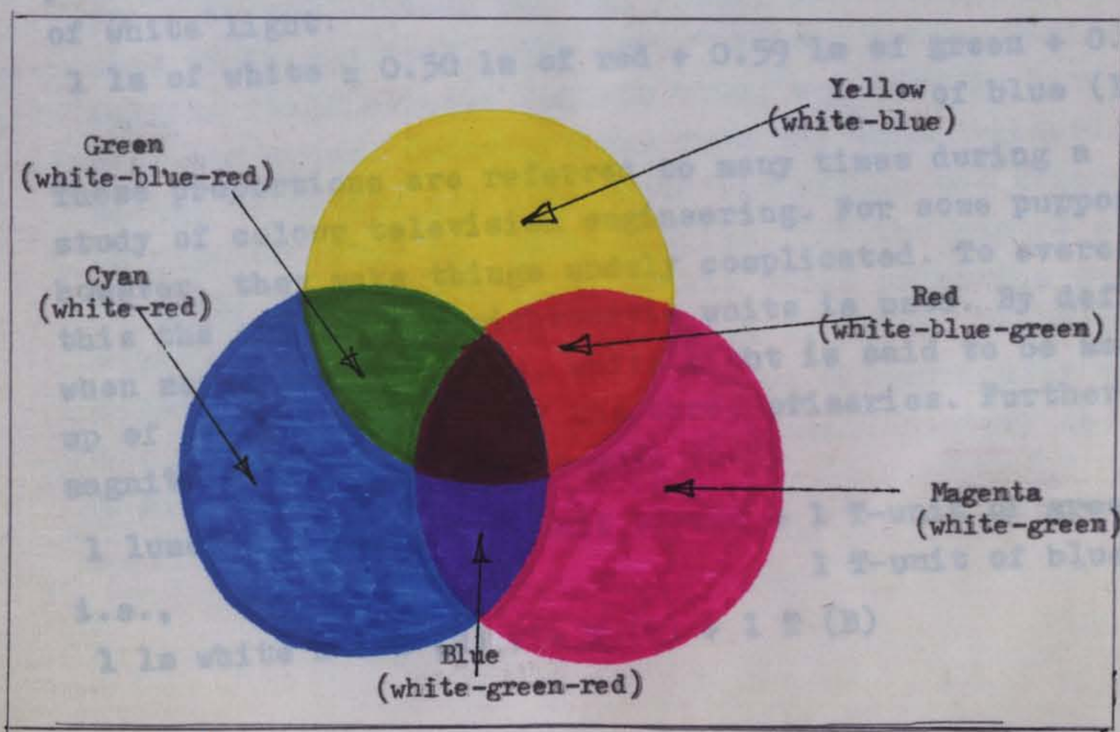


Plate 1

Additive colour mixing

Plate 2

Subtractive colour mixing



the two pigments, yellow and Magenta, are added, there is only one colour which both reflect. This is red, which is what is seen.

Grassman's Law

It is found experimentally that the eye behaves as though the "outputs" of the three types of cones are additive. The subjective impression which is gained when red, green, and blue lights reach the eye simultaneously, may be "matched" by a single light source having a colour which is judged the same as that recorded by the eye when receiving the three separate primaries and of a luminance numerically equal to the sum of the luminances of the three primaries. This apparent property of the eye of producing a response which depends upon the algebraic sum of the red, green, and blue inputs is referred to as Grassman's law.

Trichromatic Units

The following luminance equation expresses the approximate quantities of the three colour television primaries, which are necessary to produce one lumen (the quantity of luminous flux which falls per second upon a surface of unit area placed unit distance from a light source of one candela) of white light:

1 lm of white = 0.30 lm of red + 0.59 lm of green + 0.11 lm of blue (1)

These proportions are referred to many times during a study of colour television engineering. For some purposes however, they make things unduly complicated. To overcome this the concept of trichromatic units is used. By definition, when measured in T-units, white light is said to be made up of equal quantities of the three primaries. Further, the magnitude of the T-unit is such that:

1 lumen of white = 1 T-unit of red + 1 T-unit of green + 1 T-unit of blue (2)

i.e.,

1 lm white = 1 T (R) + 1 T (G) + 1 T (B)

A comparison of (1) and (2) shows that:

1 T-unit of red = 0.3 lumen

1 T-unit of green = 0.59 lumen

1 T-unit of blue = 0.11 lumen

It is thus easy to translate a given number of T-units of any primary into lumens if necessary. Meanwhile, by the use of T-units, the awkward numbers are removed from a great deal of the discussion of colour theory.

2.2 COLOUR TRIANGLES AND CHROMATICITY DIAGRAMS

A colour triangle is a diagram which allows the relationship between given chosen primaries and the colours which may be obtained by mixing them, to be portrayed in a simple and convenient form. Carried to their most sophisticated form (e.g., in the C.I.E. chromaticity diagram), they become devices which allow any colour to be precisely designated numerically in terms of co-ordinates on the diagram. Fig. 2.3 shows an equilateral triangle with the three primaries in the corners. The colours formed by mixing red and green are shown along the side R.G. Yellow falls midway between red and green, with orange on one side of it and "yellowish green" on the other. Similarly magenta falls between red and blue, and cyan is between blue and green. Contributions from all three primaries are needed to create all hues which lie within the triangle, as distinct from on its boundaries. At the centre of the triangle the contributions of the three primaries are equal so that this is the position of white. The two colours connected by any straight line drawn diametrically across the triangle to pass through W are complementary colours; i.e., together they form white.

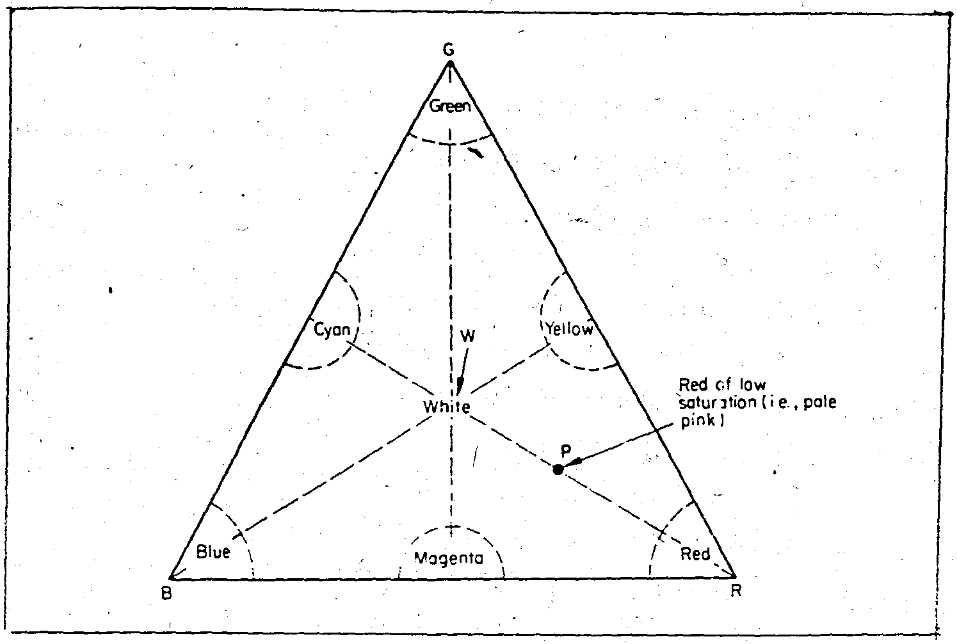


Fig. 2.3

Additive mixing colour triangle

Hue and Saturation

At point R, red is completely pure and is said to be "fully saturated". On moving towards W on the line RW, the red becomes diluted with white so that the pure red changes to a pastel shade of red (pink) and finally the red tint dissapears altogether at point W.

A colour is said to be "desaturated" when white is added to it. In colour technology, the word "hue" is used to describe the characteristic which normally is known as colour. To describe a given colour impression, three qualities have to be considered. These are brightness (i.e., luminance), hue, and saturation. A colour triangle is only two dimensional and shows hue and saturation but not brightness. In Fig. 2.3 point P represents a red hue of low saturation. Another dimension (e.g., out of the paper, along a line perpendicular to point P) would be needed to show the brightness of the red hue at P. However, in a television signal, it has already been pointed out that the brightness of a colour is transmitted as the "luminance" signal. The other two qualities of "hue" and "saturation", hence represent the extra information which has to be transmitted in a colour television signal. A colour triangle is therefore helpful in demonstrating what it is that has to be accommodated by the "chrominance" (i.e. colour-bearing) signal which, when transmitted with the luminance signal, will provide the colour receiver with a complete description of the colour in the scene, i.e., its hue, saturation, and brightness.

The diagram becomes more useful if it allows the proportions of the three primaries which are needed to create a given hue to be read off and also allows the position of the hue to be designated simply by quoting co-ordinates. It is possible to use an equilateral triangle for this purpose but a right-angled triangle is simpler and more convenient to use.

Fig. 2.4 shows such a triangle. Let the quantity of each hue shown, be 1 T-unit. Red is plotted along the x axis and green along the y axis. The amount of blue present in a given hue is deduced by a simple application of Grassman's Law. Since 1 T-unit of each hue has been specified, the sum of the red green, and blue components of a given hue is unity. Hence the number of T-units of blue is found by subtracting the sum of the red and green T-units from 1.

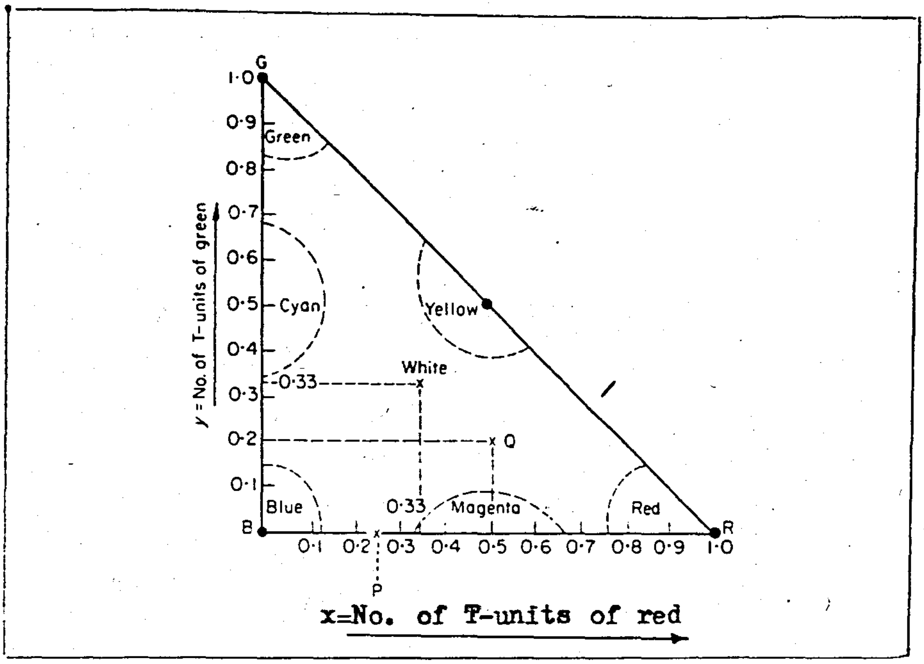


Fig. 2.4

Additive mixing colour triangle

Two examples will serve to show how the triangle is used:
(a) The hue 'Q': This hue is located by quoting the co-ordinates R=0.5, G=0.2. These numbers also indicate that 1 T-unit of the hue 'Q' contains 0.5 T-units of red and 0.2 T-units of green. It follows that the amount of blue is 1 − (0.5+0.2) = 0.3 T-units, i.e., 1 T-unit of Q:

A = 0.5 T(R) + 0.2 T(G) + 0.3 T(B).

(b) The hue 'P': This hue is located on the x axis. Its co-ordinates are x = 0.25, y = 0. One T-unit of the hue at P thus consists of 0.25 T-units of red, 0 T-units of green, and 1 − 0.25 = 0.75 T-units of blue.

CHAPTER 3

COLOUR TELEVISION SIGNALS

3.1 INTRODUCTION

As it is seen earlier, the picture information in a compatible transmitted signal consists of two parts; a "luminance" signal representative of the brightness of the element being scanned and a "chrominance" signal which bears the extra data on hue and saturation necessary for a complete description of the colour of the picture element. The luminance signal alone serves the needs of a monochrome receiver, producing at the c.r.t. a voltage proportional to picture brightness. In a colour receiver, the ultimate requirement at the display device is three voltages proportional to the red, green, and blue content of the scanned element.

The red, green, blue, and luminance voltages are often written as E_R, E_G, E_B and E_Y. As a simplification, the prefix E is omitted and the symbols R, G, B and Y represent these voltages directly. These usually appear 'primed' as R', G', B', and Y', which indicates that the voltages have been "Gamma corrected".

3.2 GAMMA (γ) CORRECTION

Regarded overall a television system ought (as a first approximation) to be linear; i.e., the light emitted from the receiver should be directly proportional to the light falling upon the camera target plate. However, a receiver c.r.t. does not emit light in direct proportion to the voltage applied between grid and cathode. This is chiefly due to the non-linearity of the beam current against grid voltage characteristic, rather than the light output against beam current characteristic, which is largely linear. If the luminance (L) of the screen is plotted against the grid-to-cathode input voltage (V_g), the curve (for low values of V_g) is roughly parabolic, i.e., $L \propto (V_g)^2$. In general terms the non-linear relationship between light output and voltage input may be expressed by writing $L \propto (V_g)^{\gamma}$. To compensate for this non-linearity at the receiver c.r.t., an opposite distortion, referred to as gamma correction, is introducted at the picture source. If E is the camera voltage resulting from a given light input (L), then a gamma corrected voltage of $E^{1/\gamma}$ will yield a light output at the receiver which is directly proportional to the light input at the camera. Hence:

$$\text{Receiver light output} \propto (V_g)^{\gamma} \propto (E^{1/\gamma})^{\gamma} \propto E$$

Fig. 3.1 shows a plot of both the transmitter and receiver characteristics.

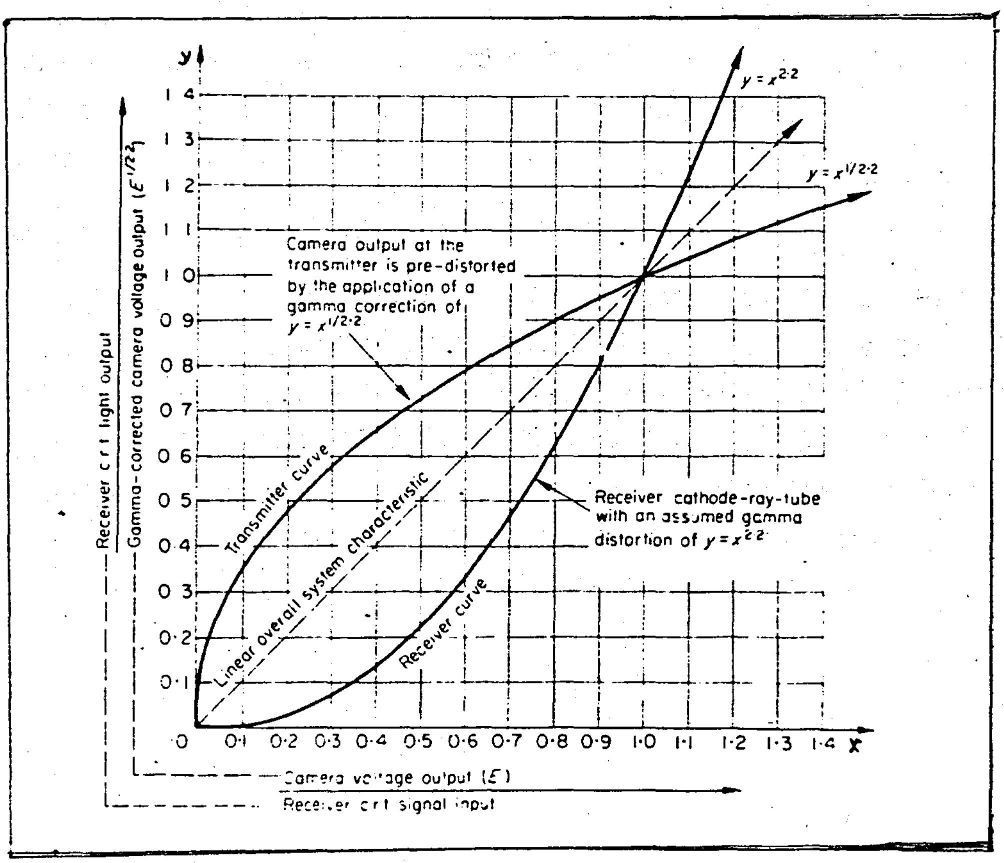


Fig. 3.1

Transmitter and receiver 'gamma' curves
(for γ =2.2)

It is presupposed that the camera voltage E has been arranged to be linearly related to the light input. The chosen value for γ is 2.2 i.e., the transmitted signal is said to have a gamma of 1/2.2 = 0.45.

For the transmitter, the x axis is the camera voltage output, and the y axis is the gamma-corrected version of this voltage (i.e., $y = x^{1/\gamma} = x^{1/2.2}$). For the receiver the x axis is the voltage input to the c.r.t. and the y axis is the c.r.t.'s light output. Both axes are scaled in relative amplitudes, from 0 to 1.0; i.e., 1.0 represents the maximum value the quantity may have and all other levels then fall between 0 and 1.0.

In a more general sense the words "system gamma" are used to express the relationship between the light output at the receiver and the light input at the camera, i.e., to describe the overall "light characteristic" of the entire system.

3.3 COLOUR DIFFERENCE VOLTAGES

To drive a colour receiver c.r.t. (e.g., a shadow mask tube) the voltages R', G', and B' are required. A voltage Y' is available from the demodulated luminance signal. By providing three other voltages (R'-Y'), (G'-Y'), and (B'-Y'), referred to as colour-difference voltages, the required R', G', and B' colour voltages are obtained by simple algebraic addition. Thus:

$$(R'-Y') + Y' = R'$$
$$(G'-Y') + Y' = G'$$
$$(B'-Y') + Y' = B'$$

Production of Luminance and Colour-Difference Voltages

Fig. 3.2 shows how these voltages may be derived at the transmitter. The scene is analysed into its red, green and blue content by passing images of it through red, green, and blue filters to three cameras. On white, these three cameras are adjusted to give equal output voltages. On "peak-white" (i.e., maximum brightness) let the common level be taken as unity, e.g., 1V. On greys (i.e., on whites of lower brightness) the three voltages remain equal but have a level of less than 1V.

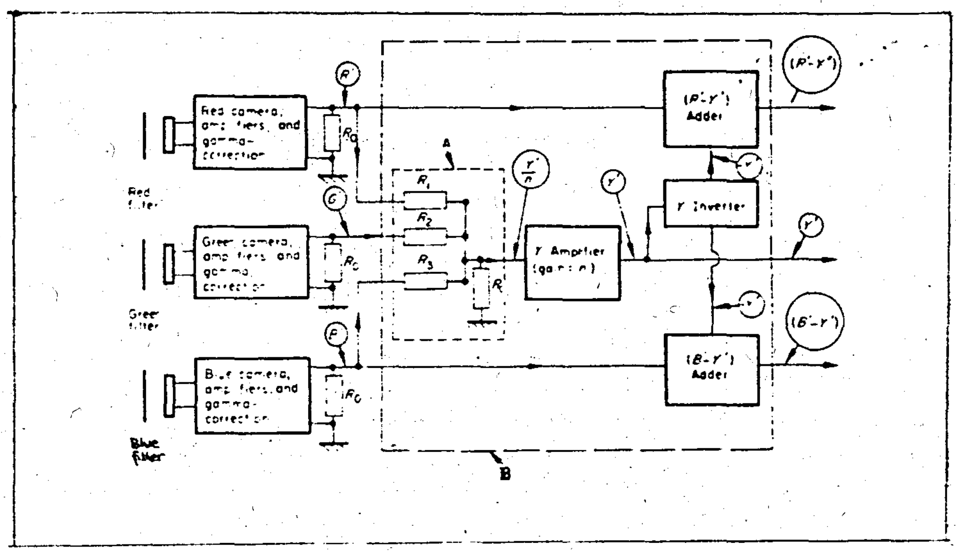


Fig. 3.2

Production of luminance and colour-difference voltages

To produce a voltage representative of the luminance of the scene, the proportions 0.30, 0.59, and 0.11 of R', G', and B' respectively are added. Then:

$$Y' = 0.3R' + 0.59G' + 0.11B'$$

Colour difference voltages are derived by substracting the luminance from the colour voltages. Only (R'-Y') and (B'-Y') are produced. It is only necessary to transmit two of the three colour-difference signals since the third may be derived from the other two.

A circuit in which signals are combined in given required proportions is called a matrix. The essential properties of a matrix are that it must:

(a) operate upon the input signals to establish them with the relative amplitudes and polarities needed for the combined signal.

(b) provide a method of combination which prohibits interaction (i.e., cross-talk) between the various signal sources.

Often a matrix may consist simply of resistors which act as attenuators to set the input signals at the necessary relative amplitudes. It may, however, include non-inverting and/or inverting amplifiers. In Fig. 3.2, the dotted box marked A includes a simple resistor matrix for establishing the R', G', and B' signals in the approximate proportions 0.3, 0.59, and 0.11. If the output impedances R_o of the cameras are low and R_1, R_2, and R_3 are all made much larger than both R_o and the common resistor R_c across which the Y' signal is developed, then cross-talk is minimized. If "peak-white" is assumed to be present and the camera voltages are all at 1V, the required immunity from cross-talk may be arrived at by reducing the Y' voltage across R_c to a level much lower than 1V, and then passing the Y' signal through an amplifier to establish Y' at 1V. This makes R_c small compared with R_1, R_2 and R_3.

The resistor values for the three potential dividers R_1R_c, R_2R_c, and R_3R_c are therefore calculated not only to achieve the correct R', G', and B' relative levels of 0.3, 0.59, and 0.11 but also to scale down these three voltages by a factor n equal to the gain of the amplifier. In this way the resistors R_1, R_2, and R_3 serve the dual purpose of adjusting the relative amplitudes of the R', G', and B' signals and of isolating the cameras from one another. To obtain (R'-Y') and (B'-Y'), the Y' signal output from the Y' amplifier is first inverted (so that + Y' becomes -Y') and then added to R' and B'.

The Chrominance Signal

The two colour-difference signals are modulated on to sub-carriers and combined to form what is then called the chrominance signal. It is the method of modulated which marks the difference between the NTSC, PAL, and SECAM systems . . In the broadest sense the quality of "chrominance" defines the difference between a coloured area and a neutral grey of the same luminance, and the expression "chrominance information" embraces that part of a video signal which enables a colour receiver to describe an area in colour rather than in monochrome.

Disappearance of Colour-Difference Signals on "Whites"

The colour-difference signals equal zero when greys or whites are being transmitted. That this must be so, is easily seen .

(a) on peak-white.

Here $R' = G' = B' = 1.0$ but

$Y' = 0.3R' + 0.59G' + 0.11B' = 0.3(1) + 0.59(1) + 0.11(1) = 1$

hence

$(R'-Y') = (1-1) = 0$ and $(B'-Y') = (1-1) = 0$

(b) On greys

Again $R' = G' = B'$ but the level is less than 1. In general case, let the common voltage be V, then

$Y' = 0.3R' + 0.59G' + 0.11B' = 0.3V + 0.59V + 0.11V = V(1) = V$

hence

$(R'-Y') = (V-V) = 0$ and $(B'-Y') = (V-V) = 0$

The disappearance of the colour difference signals during the grey or white content of a colour scene, or completely during a monochrome transmission, is an aid to compatibility in the NTSC and PAL systems.

Values of Luminance and Colour-Difference Signals on Colours

On colours, the voltages R', G', and B' are not equal. The Y' signal still represents the monochrome equivalent of the colour since the proportions 0.3, 0.59, and 0.11 taken of R', G', and B' respectively, represent the contributions which red, green, and blue light make to the luminance of the colour. Let's see an example for a desaturated purple: The word desaturated indicates the presence of some white light so that R', G', and B' voltages must all be produced. The hue, however is purple which implies a mixture of red and blue. Hence R' and B' predominate and both must be of greater amplitude than G'. Suppose $R' = 0.7$, $G' = 0.15$, and $B' = 0.6$. The white content is represented by equal quantities of the three primaries and the actual amount must therefore be indicated by the smallest of the three; i.e., in this example G'. Thus white is due to 0.15R', 0.15G', and 0.15B'. The remaining 0.55R' and 0.45B' together represent the magenta hue.

(i) To calculate the luminance signal

$$Y' = 0.3R' + 0.59G' + 0.11B'$$

$$= 0.3(0.7) + 0.59(0.15) + 0.11(0.6)$$

$$= 0.21 + 0.0885 + 0.066 = 0.3645$$

(ii) To calculate the colour-difference signals

$$(R'-Y') = (0.7-0.3645) = +\ 0.3355$$

$$(B'-Y') = (0.6-0.3645) = +\ 0.2355$$

(iii) Reception by a colour set.

In a colour receiver these three signals (i.e., the luminance at (i) and the two colour-difference signals at (ii) are recovered. The missing (G'-Y') colour-difference signal is recovered by combining suitable proportions of (R'-Y') and (B'-Y'), clearly (G'-Y') = (0.15-0.3645) = - 0.2145.

Then, by a process of matrixing, the required original colour voltages are obtained. Thus:

$$R' = (R'-Y') + Y' = 0.3355 + 0.3645 = 0.7$$

$$G' = (G'-Y') + Y' = -0.2145 + 0.3645 = 0.15$$

$$B' = (B'-Y') + Y' = 0.2355 + 0.3645 = 0.6$$

(iv) Reception by a monochrome set.

In a monochrome receiver only the luminance signal Y' = 0.3645 is recovered. Since peak white to the same relative scale would be 1.0, it is clear that the purple colour described, shows up only as a fairly dull grey in a black-and-white picture. This is as would be expected for this colour.

Polarity of Colour-Difference Signals

In the example above, it is seen at (ii) that both (R'-Y') and (B'-Y') are positive. Whereas, both (R'-Y') and (B'-Y') may be either positive or negative, depending upon the hue they represent. Table 3.1 shows their polarities for various groups of hues.

Hue	*Polarity of* $(R' - Y')$	*Polarity of* $(B' - Y')$
Purples (magentas)	+	+
Red, orange, yellow	+	−
Yellow-green, green	−	−
Blue-green (cyan), blue	−	+

Table 3.1

Colour-difference signal polarities for various hues

3.4 CHOICE OF CHROMINANCE SUB-CARRIER FREQUENCY

To meet the requirements of compatibility the chrominance signal has to be contained within the existing bandwidth of the corresponding monochrome signal.

In the U.K. 625 - line system video frequencies extend from 0 to 5.5 MHz. The chrominance signal has to fit within this bandwidth. It is a self-contained signal and is simply added to normal picture information (i.e., the "luminance" detail) to become part of the video signal which modulates the vision carrier. Fig. 3.3 (a) shows the bandwidth of the normal 625 - line vision signal. In Fig. 3.3 (b) the chrominance signal is added as a shaded area approximately centred on a sub-carrier frequency shown as f_{sc}, where f_{sc}= 4.43361875 MHz. (PAL system)

It is helpful to summarize some of the factors which govern the choice of the subcarrier frequency f_{sc}:

(a) For minimum interference, f_{sc} must be as high as possible

(b) Having specified a bandwidth of approximately 1 MHz for the colour-difference signals which modulate the

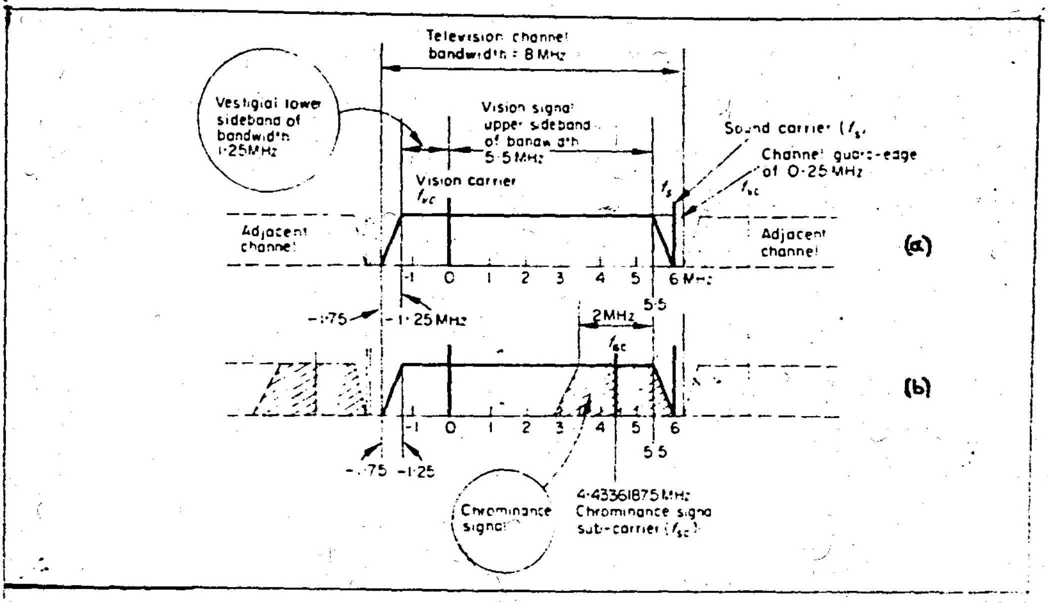


Fig. 3.3

U.K. 625-line television signals showing frequencies expressed relative to the vision carrier (f_{vc})

(a) Shows a normal monochrome signal

(b) Shows the corresponding colour signal

sub-carrier, it must be sufficiently below 5.5 MHz to allow in the upper sideband of the chrominance signal.

(c) In the PAL system, the chrominance signal is amplitude modulated and "equiband" (i.e., its two parts are of equal bandwidth). It requires a total bandwidth of 2 MHz centred on the sub-carrier. The highest possible value for f_{sc} is hence (5.5 - 1) = 4.5 MHz, if both sidebands are to be fully accomodated.

(d) Cross-talk between chrominance and luminance information must be minimized.

(e) Since the sub-carrier falls in the normal video frequency spectrum it will pass through the video amplifiers in monochrome receivers.

As it is a high frequency it will give rise to a 'dot-pattern' along each raster line. The numerical relationship between f_{sc} and the line frequency f_h must be chosen so that the dot-pattern shifts horizontally on successive raster lines in such a way the visibility of this interference is minimized. As a conclusion, it is found that the most suitable place for the subcarrier is between the 283 and 284 th harmonics of the video carrier.

Frequency Interleaving

When the spectrum of a television vision signal is analysed, it is found that the energy is not uniformly distributed throughout the channel bandwidth but exists in bunches of frequencies centred on harmonics of the line frequency. The reason for this is easily seen. For simplicity, suppose that the vision carrier f_{vc} is modulated by a video signal of the form shown in Fig. 3.4 (a). This represents 'black' raster lines. Fig. 3.4 (b) shows the negatively modulated vision signal bearing this information. For every frequency component in the modulating waveform, there will be a pair of side-frequencies one lying above and the other below f_{vc}. But the fundemental frequency of the modulating waveform is 15,625 Hz, i.e., f_h. Because it is a 'square' type shape, of an unequal mark-to-space ratio, this waveform is equivalent to the sum total of an infinite series of sine wave harmonics of f_h, i.e., f_h, $2f_h$, $3f_h$, etc.

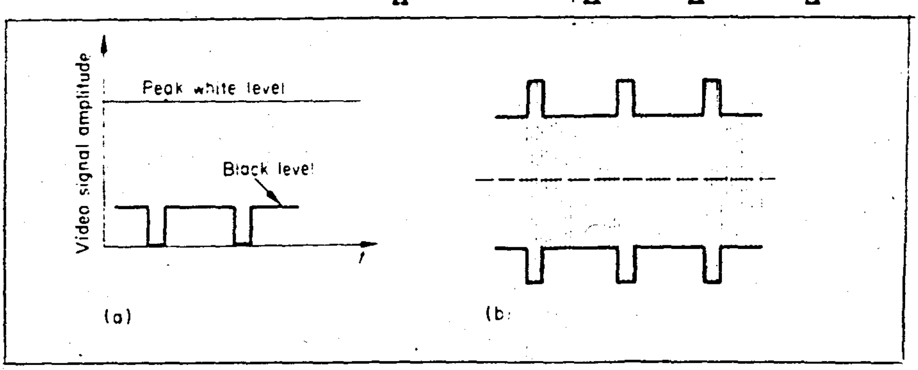


Fig. 3.4

(a) Shows the form of a monochrome system video signal on 'black' lines.

(b) Shows the form of the corresponding negatively modulated vision carrier

These sine waves grow progressively smaller in amplitude as the frequency gets higher. The spectrum of this vision signal is thus $f_{vc} \pm f_h$, $f_{vc} \pm 2f_h$, $f_{vc} \pm 3f_h$, ..., etc.

The highest harmonic accomodated in the vision signal is clearly:

$$(5.5\ \text{MHz} \div f_h) = 5.5 \times 10^6 \div 15625 = 352.$$

Fig. 3.5 (a) illustrates this distribution of line harmonics in the vision signal. If the video waveform on its own is considered, this itself is modulated by 50 Hz and 25 Hz components due to the field synchronizing signal. Each line harmonic therefore has groups of 'side-frequencies' around it, at 25 Hz intervals. For any static scene, since all detail repeats on successive pictures, the bunching is very marked. With normal pictures, where detail is constantly changing, the spectrum is more complex but there are still regularly spaced clusters of frequency components with intervening spaces which are only sparsely occupied. It is into these spaces that the chrominance signal is fitted.

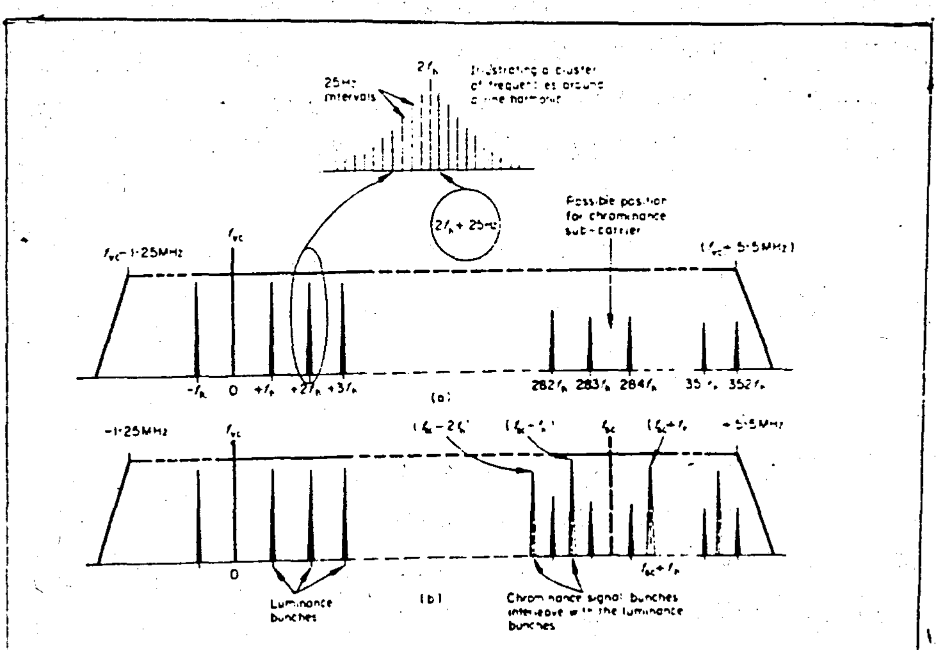


Fig. 3.5

Showing the principle of frequency interleaving

In the original NTSC system the chrominance sub-carrier was made to fit exactly between two line harmonics, i.e., its frequency was offset by half the line frequency from a line harmonic. This is known as 'half-line offset' and it involves choosing a subcarrier of frequency equal to an odd multiple of half the line frequency. In the U.S.A., $f_{sc} = 455 \times f_h/2$. Since the chrominance signal is itself an r.f. carrier which is interrupted at line frequency, it also, has a spectrum consisting of bunches of side frequencies spaced at intervals of f_h. These range on either side of f_{sc}. In the composite vision signal the chrominance bunches clearly interleave with those of the luminance signal. This is illustrated in Fig. 3.5 (b).

Dot-Patterns

The sub-carrier causes the brightness of a raster line to rise and fall sinusoidally from one end of the line to the other. If the positive and negative peaks are regarded as producing white and black dots it is possible to assess the overall pattern by working out how the white dots on successive lines are positioned relative to one another. The number of sub-carrier cycles per line is equal to f_{sc}/f_h. But in NTSC, $f_{sc} = n(f_h/2)$ where n is an odd number. Therefore

$$\frac{f_{sc}}{f_h} = \frac{nfh}{2} \div f_h = \frac{n}{2}$$

Since n is an odd number, there is therefore an odd number of half cycles on each line. On any two successively scanned lines of one field, the white dots move along by half a cycle. Vertically this tends to give cancellation since white and black dots fall beneath one another.

Since one line contains an odd number of half cycles, it takes two lines to contain an even number of full cycles. But one picture contains an odd number of lines so that on 'corresponding' lines of 'successive' pictures the sub-carrier is in antiphase, again tending to give cancellation. As it takes two pictures to contain an even number of cycles the dot pattern follows a two picture i.e., a four-field cycle. Working out the relative positions of sub-carrier cycles on raster lines over a four-field sequence, establishes that any remaining visible pattern is in the form of slanting black and white lines at an angle of about 45^{o}. This gives minimum interference since slanting patterns of dim closely packed lines are far less visible than similar vertical lines.

The nature of the PAL system is, however, such that if the sub-carrier were chosen on the basis of half-line offset, then -on certain hues- dots tend to line up vertically to give an annoying interference. To overcome this "quarter-line offset" is used i.e., f_{sc} is equal to an odd multiple of one quarter of the line frequency. For optimum results this is modified slightly by the addition of 25 Hz to create a phase reversal on each successive field and the actual relationship between f_{sc} and f_h in the PAL system is given by:

$$f_{sc} = f_h \left(284 - \frac{1}{4}\right) + \frac{fv}{2}$$

$$f_{sc} = 15625\ (283.75) + \frac{50}{2} = 4.43361875\ \text{MHz}$$

With quarter-line offset, four lines are needed to contain an even number of sub-carrier cycles and four 'pictures' are needed to produce a total number of lines which is divisible by four. The dot pattern therefore follows a four-picture or eight-field sequence. The pattern repeats once each 8/10 second, i.e., at the rate of 6.25 times per second.

3.5 CHROMINANCE SIGNAL BANDWIDTH

In the U.K. 625 - line system, with a video bandwidth of 5.5 MHz, the chrominance signal is double sideband up to 1.07 MHz (i.e., 5.50 - 4.43 = 1.07 MHz), but the attenuation of higher frequencies is thereafter more rapid in the upper sideband than in the lower.

Some other 625 - line systems (e.g., in Europe), have a video bandwidth of 5.0 MHz but use the same chrominance signal sub-carrier frequency as the U.K. for PAL colour television signals (i.e., f_{sc} = 4.43361875 MHz). Since the same colour difference signal bandwidth of 1 MHz is also used, the chrominance signal is of vestigial sideband teype. The upper sideband attenuation slope starts at 0.57 MHz (i.e., 5.0 - 4.43 = 0.57 MHz), but the lower sideband extends to 1.0 MHz before attenuation begins.

CHAPTER 4

COLOUR-BAR SIGNALS

4.1 INTRODUCTION

A standard colour-bar waveform produces on a colour receiver screen, eight vertical bars of uniform width. These include the three primaries, the three complementaries, white, and black. They are arranged in descending order of luminance from left to right. This places them in the order:

white yellow cyan green magenta red blue black

On a monochrome set this produces a peak-white stripe on the left of the screen, followed by grey stripes which grow progressively darker from left to right. Colour-bar signals are in practice entirely electronically generated so that actual light and cameras have no part in the formation of such signals. However, an electronically generated signal represents coded information about light and gives rise to the appropriate light output at the receiver. Each bar is treated in turn. The luminance and chrominance signal amplitudes are calculated and the composite video signal is then deduced by adding these two components to the line blanking period waveform.

4.2 QUADRATURE AMPLITUDE MODULATION (Q.A.M.)

PAL and NTSC systems both employ quadrature amplitude modulation (Q.A.M.) of the chrominance signal. The Q.A.M. chrominance signal may be resolved into two sine-waves of sub-carrier frequency at 90^o to one another (i.e., in quadrature). One of these is proportional in amplitude to the (R'-Y') colour-difference signal and the other to (B'-Y'). Each of the colour-difference signals may be either positive or negative. The subcarrier sine waves which represent (R'-Y') and (B'-Y') have to indicate what polarity these signals have as well as showing their amplitudes. This is achieved by making the polarity reversals of colour - difference signals cause the sine waves representing these signals to be inverted (i.e., to change phase by 180°).

Hence each sine wave may have one of two possible phases. The phase of the sine wave representing + (B'-Y') is taken as the reference phase of 0°; and this sine wave switches to a phase of +180° when (B'-Y') is negative. The other sine wave is at +90° when (R'-Y') is positive and +270° (i.e., -90°) when (R'-Y') is negative. This may be illustrated by a phasor (i.e., vector) diagram on which each of the subcarrier frequency signals is represented as a phasor. (Figure 4.1). The direction in which each phasor points and its length give a direct indication of the polarity and amplitude respectively of the colour-difference signal the sine wave represents.

In a PAL signal, the sub-carrier sine wave representing (R'-Y') is phase inverted on alternate lines. Suppose, for a particular hue (e.g., red), that in the NTSC signal the (R'-Y') component has a phase of +90°. In a PAL signal one line is identical to the NTSC signal but on the next the phase of this component is switched to +270°; returning again to 90° on the following line etc. This Phase Alternation Line - by-Line of the (R'-Y') component gives the system its name of PAL. The chrominance phasor may rest in any of the four quadrants of a circle because there are four possible combinations of polarity of its two components. Also when the (R'-Y') component is inverted on alternate lines in the PAL signal, the effect is to cause the chrominance phasor to switch across the 'x', i.e., (B'-Y') axis to the quadrant adjacent to the one it occupies on its normal NTSC phase.

These facts are summarized in Table 4.1 and the form of the corresponding chrominance signal phasor diagrams are shown in Fig. 4.1. Note that if a and b are the amplitudes of the sub-carrier frequency sine-waves bearing (R'-Y') and (B'-Y') colour-difference signal information respectively, then the amplitude C_h of the chrominance signal is given by:

$$C_h = \sqrt{a^2 + b^2}$$

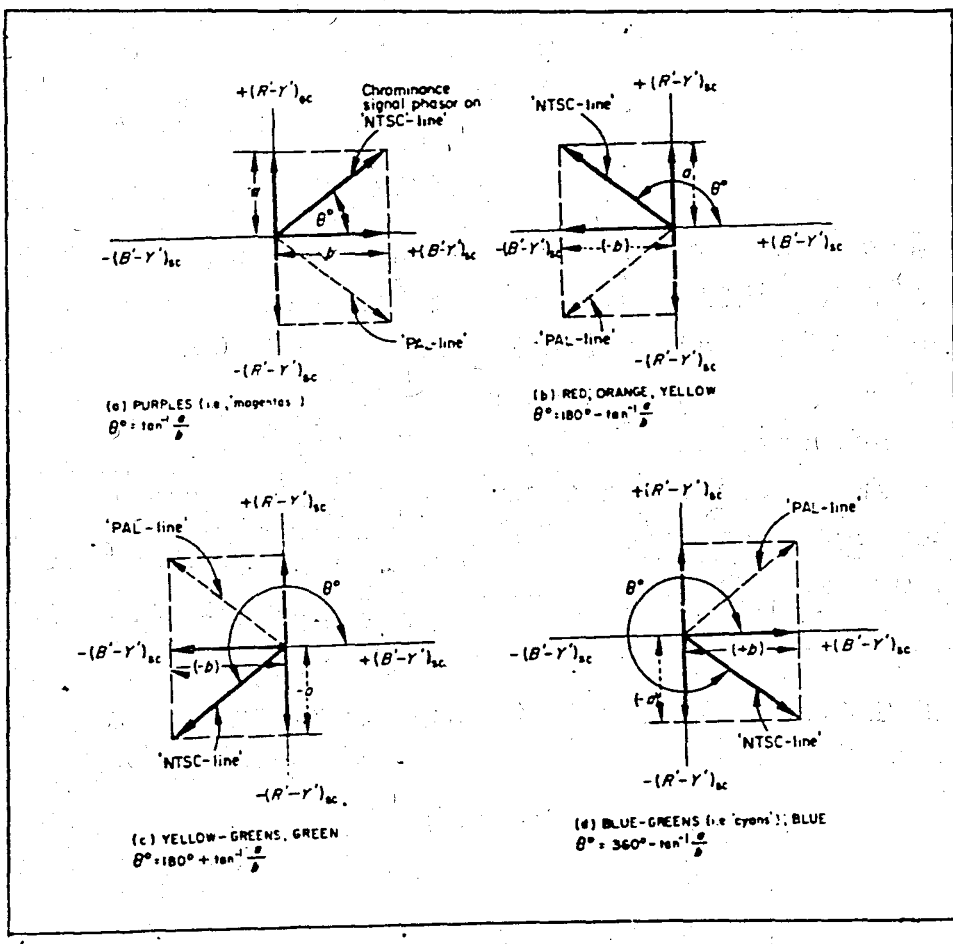


Fig. 4.1

Chrominance signal phasor diagrams

(see Table 4.1)

Hues	Colour-difference signal polarities		Sub-carrier phases		Chrominance signal	
	(B' − Y')	(R' − Y')	(B' − Y') sine wave	(R' − Y') sine wave	Quadrant in which phasor lies	Appearance of phasor diagrams
Purples	+	+ (−)	0°	90° (270°)	1st (4th)	see Fig. 4.1(a)
Red, orange, yellow	−	+ (−)	180°	90° (270°)	2nd (3rd)	see Fig. 4.1(b)
Yellow-greens, green	−	− (+)	180°	270° (90°)	3rd (2nd)	see Fig. 4.1(c)
Blue-greens, blue	+	− (+)	0°	270° (90°)	4th (1st)	see Fig. 4.1(d)

Table 4.1

(The figures in brackets show the polarities and the angles on the alternate 'PAL -lines'.)

4.3 SATURATION AND AMPLITUDE

Saturation and amplitude are the two parameters used to describe colour-bar signals (e.g., 100% sat., 100% amp.; 95% sat., 100% amp., etc.). The description 100% saturation indicates that each of the colour-bars is a pure hue, undiluted by white light; 95% saturation implies that each colour-bar consists of 95% of the given hue together with 5% of white light. The term 100% amplitude indicates that one (at least) of the three cameras is giving maximum output (e.g., 1 V)

4.4 100% SATURATED, 100% AMPLITUDE COLOUR-BAR SIGNAL (UNWEIGHTED)

Let us give an example for yellow bar:

Here $R = 1.0$; $G = 1.0$; $B = 0$

$R' = 1.0$; $G' = 1.0$; $B' = 0$

(i) Luminance signal

$$Y' = 0.30\,R' + 0.59\,G' + 0.11\,B' = 0.30 + 0.59 = 0.89$$

(ii) Colour - difference signals

$$(R'-Y') = (1-0.89) = +0.11$$

$$(B'-Y') = (0-0.89) = -0.89$$

(iii) The Q.A.M. chrominance signal.

Since (R'-Y') is positive, the sub-carrier frequency sine-wave representing it has a phase of $+90^{\circ}$ on 'NTSC - Lines' alternating to $+270^{\circ}$ on 'PAL - Lines'. Meanwhile (B'-Y') is negative so that the (B'-Y') subcarrier sine-wave has a phase of 180°. The amplitude of the chrominance signal is given by:

$$C_h = \sqrt{(B'-Y')^2_{sc} + (R'-Y')^2_{sc}} = \sqrt{(-0.89)^2 + (+0.11)^2}$$

$$= \sqrt{0.7921 + 0.0121} = \sqrt{0.8042} = 0.9$$

4.5 WEIGHTING FACTORS

The colour-difference signals are transmitted by amplitude modulation of the subcarrier. The subcarrier is then added to the compatible monochrome signal so that the peak excursion of the composite signal is greater than for monochrome. In order to limit the total excursion of the composite signal to an arbitrary maximum of 1.33, the colour-difference signals are reduced in amplitude before they are modulated onto the subcarrier;

$$V = \frac{R'-Y'}{1.14} = 0.877\,(R'-Y')$$

$$U = \frac{B'-Y'}{2.03} = 0.493\,(B'-Y')$$

4.6 100% SATURATED, 100% AMPLITUDE COLOUR-BAR SIGNAL (WEIGHTED)

Let us give an example again for YELLOW BAR:

$R = 1.0$, $G = 1.0$, $B = 0$;

$R' = 1.0$, $G' = 1.0$, $B' = 0$

(i) Luminance signal

$$Y' = 0.30 + 0.59 = 0.89$$

(ii) Colour-difference signals

$$(R'-Y') = (1.0-0.89) = 0.11$$
$$(B'-Y') = (0-0.89) = -0.89$$

(iii) Weighted colour-difference signals

$$U = 0.493\,(B'-Y') = 0.493\,(-0.89) = -\,0.4387$$
$$V = 0.877\,(R'-Y') = 0.877\,(+\,0.11) = +\,0.0965$$

(iv) Chrominance signal amplitude

$$C_h = \sqrt{U^2+V^2} = \sqrt{(-0.4387)^2 + (0.0965)^2} = 0.44$$

(v) Chrominance signal phase angle

on 'NTSC - lines' the phase angle is given by:

$$\theta = 180^\circ - \tan^{-1} V/U = 180^\circ - \tan^{-1} 0.0965/0.4387 = 167^\circ$$

In the PAL system, the chrominance signal phase angle on the alternate lines is deduced, by switching the 'NTSC-line' phasor across the U axis to its mirror-image position in the adjacent quadrant. For yellow, the angle on 'PAL-lines' is therefore:

$$\theta = 180^\circ + 13^\circ = 193^\circ$$

Proceeding in this way for the remaining colour-bars yields the result shown in Table 4.2.

Fig. 4.2 shows the composite video signal for the 100% amplitude 100% saturated weighted colour-bar signal and the corresponding vision carrier modulation levels are shown to the left of the diagram. 95% saturated; 100% amplitude colour-bar signal can also be calculated in detail as shown above [3].

Colour-bar	Y'	$(B'-Y')$	$(R'-Y')$	$U = 0{\cdot}493(B'-Y')$	$V = 0{\cdot}877(R'-Y')$	Chrom. amp $= \sqrt{U^2+V^2}$	Chrom. phase angle ('NTSC-line')
White	1·0	0	0	0	0	0	—
Yellow	0·89	−0·89	+0·11	−0·4388	0·0965	0·44	167°
Cyan	0·7	+0·3	−0·7	+0·1479	−0·6139	0·63	283°
Green	0·59	−0·59	−0·59	−0·2909	−0·5174	0·59	241°
Magenta	0·41	+0·59	+0·59	+0·2909	+0·5174	0·59	61°
Red	0·3	−0·3	+0·7	−0·1479	+0·6139	0·63	103°
Blue	0·11	+0·89	−0·11	+0·4388	−0·0965	0·44	347°
Black	0	0	0	0	0	0	—

Table 4.2

Details of a 100% amplitude, 100% saturated colour-bar signal when colour-difference signal weighting factors are employed

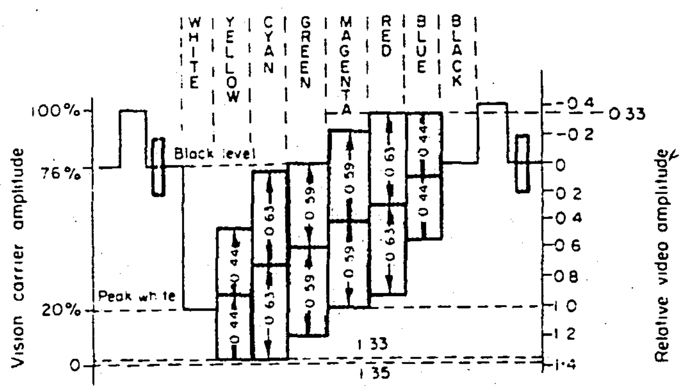


Fig. 4.2

100% saturated, 100% amplitude colour-bar signal in which the colour-difference signals are reduced by weighting factors to restrict the chrominance signal excursion to 0.33 beyond black and peak-white levels

4.7 COLOUR PHASE ANGLE CHART

Using the information in Table 4.2 a diagram may be drawn showing the chrominance phasor positions for the primary and complementary colours. This is shown in Fig. 4.3. It is easily seen that:

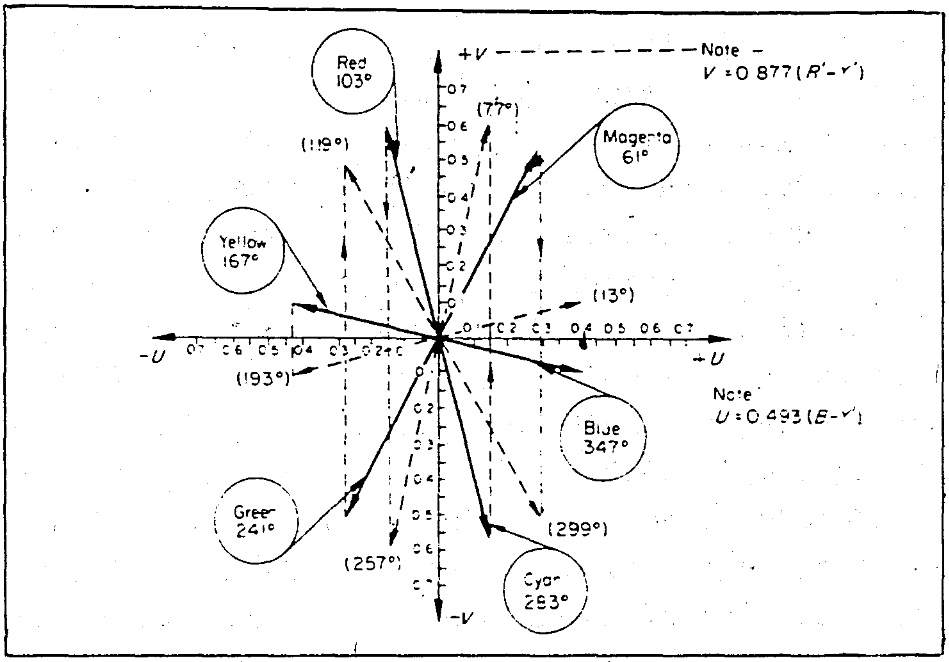


Fig. 4.3

Chrominance signal phasor positions for the primary and complementary colours

(a) Each compelentary hue is diametrically opposite its associated primary (e.g., yellow is opposite blue)
(b) The amplitudes of these opposite pairs of phasors are equal.
(c) Projection from a given phasor to the U and V axes shows the relative amplitudes of the weighted (B'-Y') and (R'-Y') subcarrier signals which together form the chrominance signal.
(d) The positions of the phasors on 'PAL-lines' may be found simply by switching the phasor to the opposite side of the U axis; i.e., PAL-line phasors are the mirror image of NTSC-line phasors.

CHAPTER 5

BASIC 'PAL' CODER AND TRANSMITTER ARRANGEMENTS

5.1 'PAL' VIDEO AND VISION SIGNALS

Fig. 5.1 shows the modulation levels for the negatively modulated 625-line vision carrier when bearing a 95% sat., 100% amp., colour-bar signal. Since the chrominance signal consists of two suppressed carrier signals, a replacement carrier has to be generated at the receiver. For the purpose of locking the frequency and phase of the re-inserted sub-carrier generated by the receiver's 'reference oscillator' a burst of subcarrier is transmitted during the back porch in the line-blanking period. (Fig. 5.2) This consists of 10±1 cycles. In an NTSC signal the burst phase is 180°. With PAL, however, the burst phase angle is switched on a line-by-line basis from 135° on 'NTSC-lines', to 225° on the alternate 'PAL-lines'. This is done to allow the receiver to identify NTSC and PAL lines.

In the PAL signal, since the burst switches in phase by 45° line-by-line, about 180°, its average phase is still 180° which is the same as that in the original NTSC system. This phase angle was chosen to give minimum interference during the line fly-back stroke in colour receivers. Although under normal operation the burst is gated out of the signal path to the chrominance demodulators and directed only to that part of the receiver where it is required (i.e., to the reference oscillator's automatic frequency and phase-controlling circuit), it is possible under fault conditions for the burst to get through to the demodulators. This gives rise to an output voltage which modulates the beam current during line fly-back and causes interference. The choice of a burst phase angle of 180° reduces this interference to a minimum.

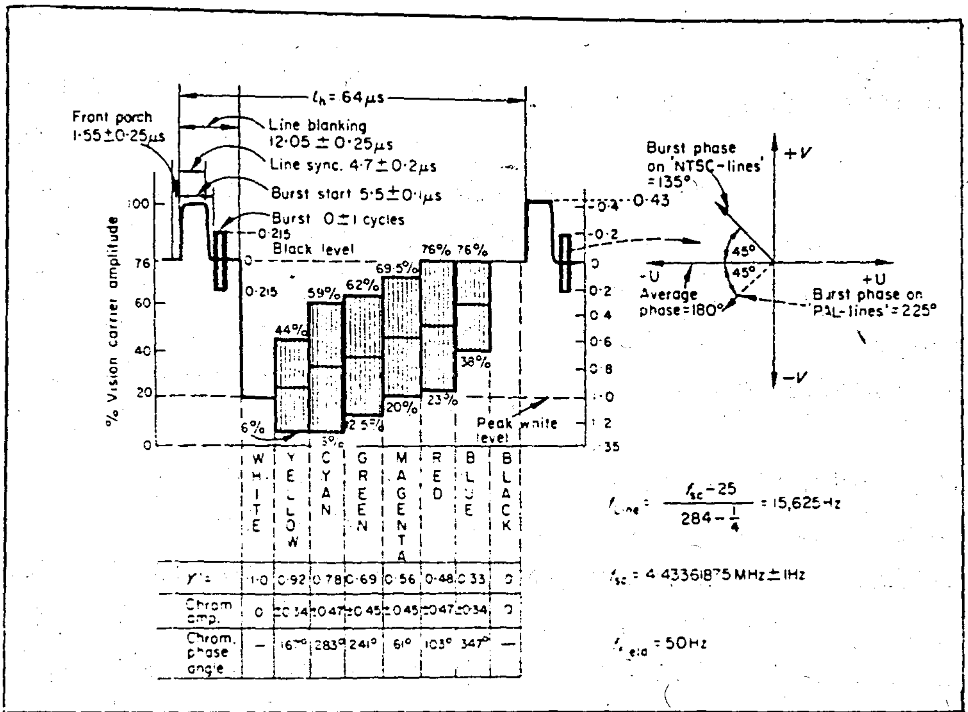


Fig. 5.1

Showing the video signal waveform and corresponding vision carrier modulation levels for a 95% saturated, 100% amplitude colour-bar signal

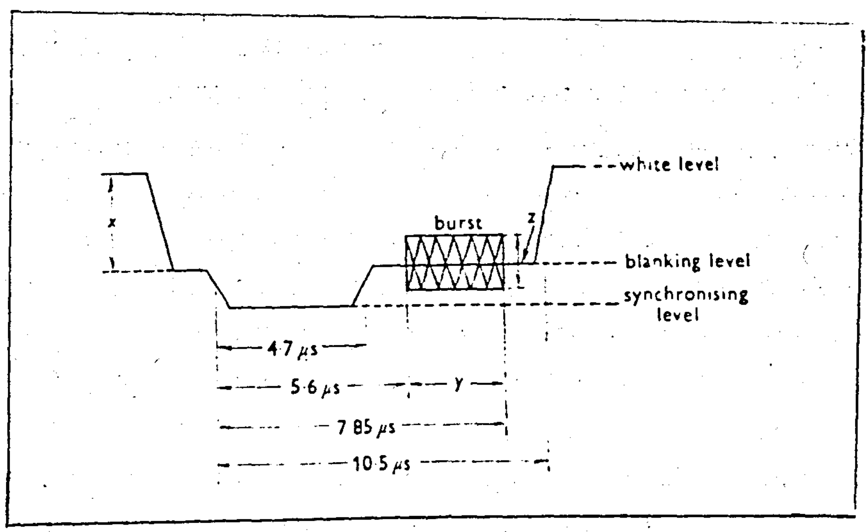


Fig. 5.2

The EBU specification of the PAL-burst position

It shows up as a very low amplitude green pattern towards the left of the screen.

It will be noted on Fig. 5.1 that the line frequency f_h is stated in terms of the subcarrier frequency f_{sc}. At the signal source f_{sc} is the standard frequency and f_h is derived from f_{sc} by count-down circuits so that the correct numerical relationship between f_{sc} and f_h is maintained at all times.

Although the field frequency f_v is equal to the nominal mains frequency of 50 Hz, it is not locked to the mains. The mains frequency varies slightly with loading and this would cause errors in the relationship between f_{sc}, f_h, and f_v, if f_v were mains-locked. To obviate this the field frequency is maintained accurately at 50 Hz independently of the mains. Since the system is not mains-synchronized it is said to be asynchronous.

A result of this is that any mains hum pattern on the screen is no longer stationary but drifts at a rate determined by the difference between the field and mains frequencies.

In Fig. 5.3 the video waveform during the field blanking period is shown. The burst is gated out of the transmitted signal during this interval. In the PAL signal, in order to make the burst phase start and stop in identical directions at the beginning and end of each field, the burst blanking pulse is shifted as shown, so that it follows a four-field cycle. If the burst blanking pulse were not staggered in this way but repeated at regular intervals of 1/50 s (i.e., at intervals of 312.5 lines precisely), the burst phases at the end of each field and the start of the next would be one direction for fields 1 and 4, but the opposite for fields 2 and 3. In some receiver circuits, it was found that these different start and stop phase sequences caused a flicker disturbance at the top of the screen when colours of high saturation were present there.

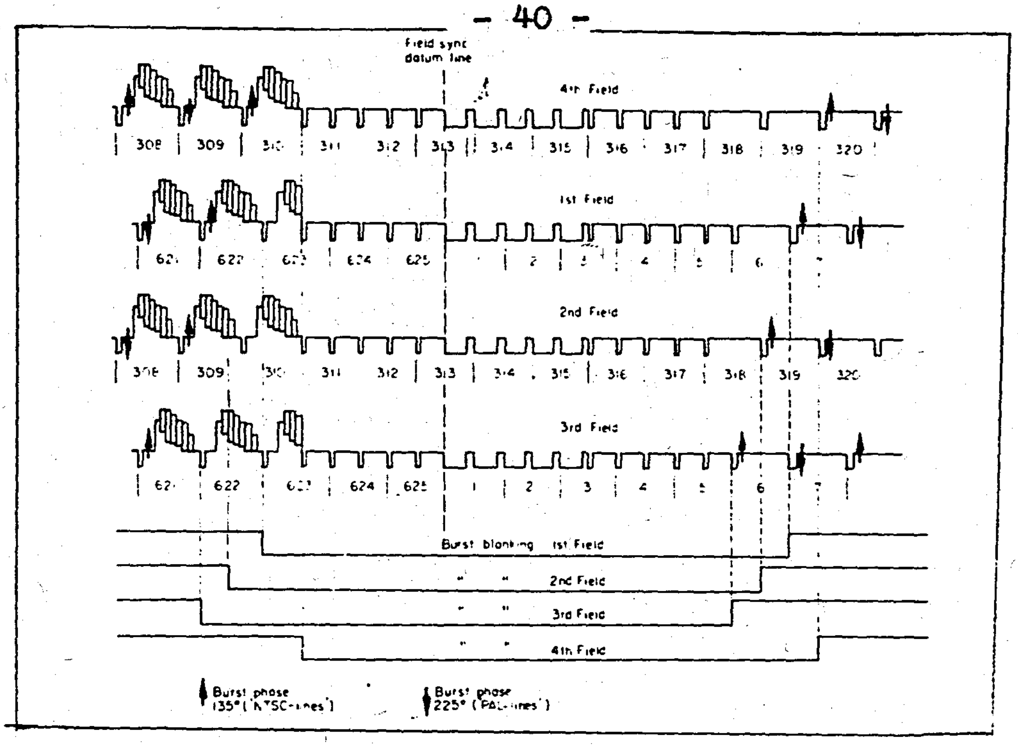


Fig. 5.3

Showing the waveform of the 625-line PAL video signal during the field blanking period

5.2 THE BASIC PAL CODING PROCESS

A basic PAL coder arrangement is shown in Fig. 5.4. The gamma-corrected R', G', and B' inputs to the matrix, give rise to Y', (R'-Y'), and (B'-Y') outputs. Because the colour-difference signals are bandwidth restricted by filters which pass the range 0 to 1 MHz, they suffer a small delay relative to the Y' signal which has a broader bandwidth of 5.5 MHz. To bring the Y' and chrominance signals into step at the point where they are added, it is necessary to insert a compensating delay into the Y' path.

The (R'-Y') and (B'-Y') signals pass to balanced modulators together with subcarrier inputs at appropriate phases. In the subcarrier path to the V modulator is a phase-switching circuit which passes to the modulator a subcarrier having a phase of 90^o on one line but 270^o on alternate lines.

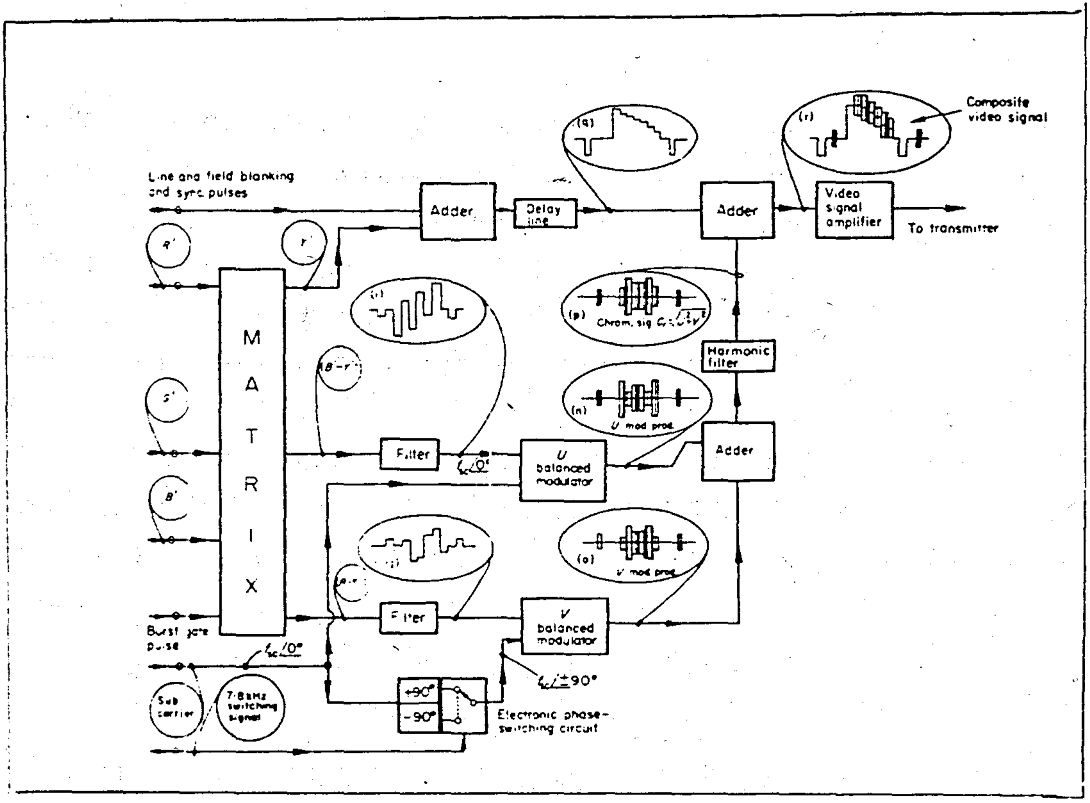


Fig. 5.4

Basic organization of a PAL coder

Since one switching cycle takes two lines, the square wave switching signal to the phase switch is of half-line frequency i.e., 7812.5 Hz.

The double-sideband suppressed carrier signals from the modulators are added to yield the Q.A.M. chrominance signal. This passes through a filter (which removes harmonics of the subcarrier frequency) and on to an adding circuit where it is combined with the luminance and blanking signals to form a composite video signal. This goes forward to the transmitter to modulate the vision carrier in the normal way.

In this diagram the weighting operation is assumed to be carried out in the modulator 'boxes', e.g., by attenuating the (B'-Y') and (R'-Y') inputs, or by corresponding adjustments of the modulator outputs. This weighting operation may be carried out in the main 'matrix' which will then deliver colour-difference signals of amplitudes U = 0.493 (B'-Y') and V = 0.877 (R'-Y'). The end product is the same, i.e., the chrominance signal subcarrier frequency sine-wave components have amplitudes in the ratio U:V, not (B'-Y') : (R'-Y').

The instantaneous amplitude of the composite video signal (i.e., of the modulating information) during the active part (i.e., the picture detail) of raster lines may be written as:

$$E_m = E'_Y + E'_U \sin\omega t \pm E'_V \cos\omega t$$

5.3 BASIC PAL TRANSMITTER ARRANGEMENTS

To summarize the basic principles of the production of a PAL colour television signal, a simplified diagram of a transmission system is shown in Fig. 5.5.

It will be noticed on both Fig. 5.4 and Fig. 5.5 that one of the inputs to the matrix is labelled 'burst gating signal'. This is a square type pulse at line frequency, timed to appear during the back-porch period. For its duration the matrix delivers to the two modulators inputs such that the (B'-Y') modulator yields a subcarrier burst at 180° while the (R'-Y') circuit gives a burst of the same amplitude but having a phase of 90° on one line and 270° on the next. The adder yields an output which is the vector sum of the two inputs, i.e., it delivers a subcarrier frequency sine-wave at 135° on one line and 225° on the next.

The matrix following the camera unit delivers the weighted colour-difference signals U=0.493 (B'-Y') and V=0.877 (R'-Y') to the U and V modulators, and the luminance signal Y' is passed via a luminance delay circuit to the video signal combining unit.

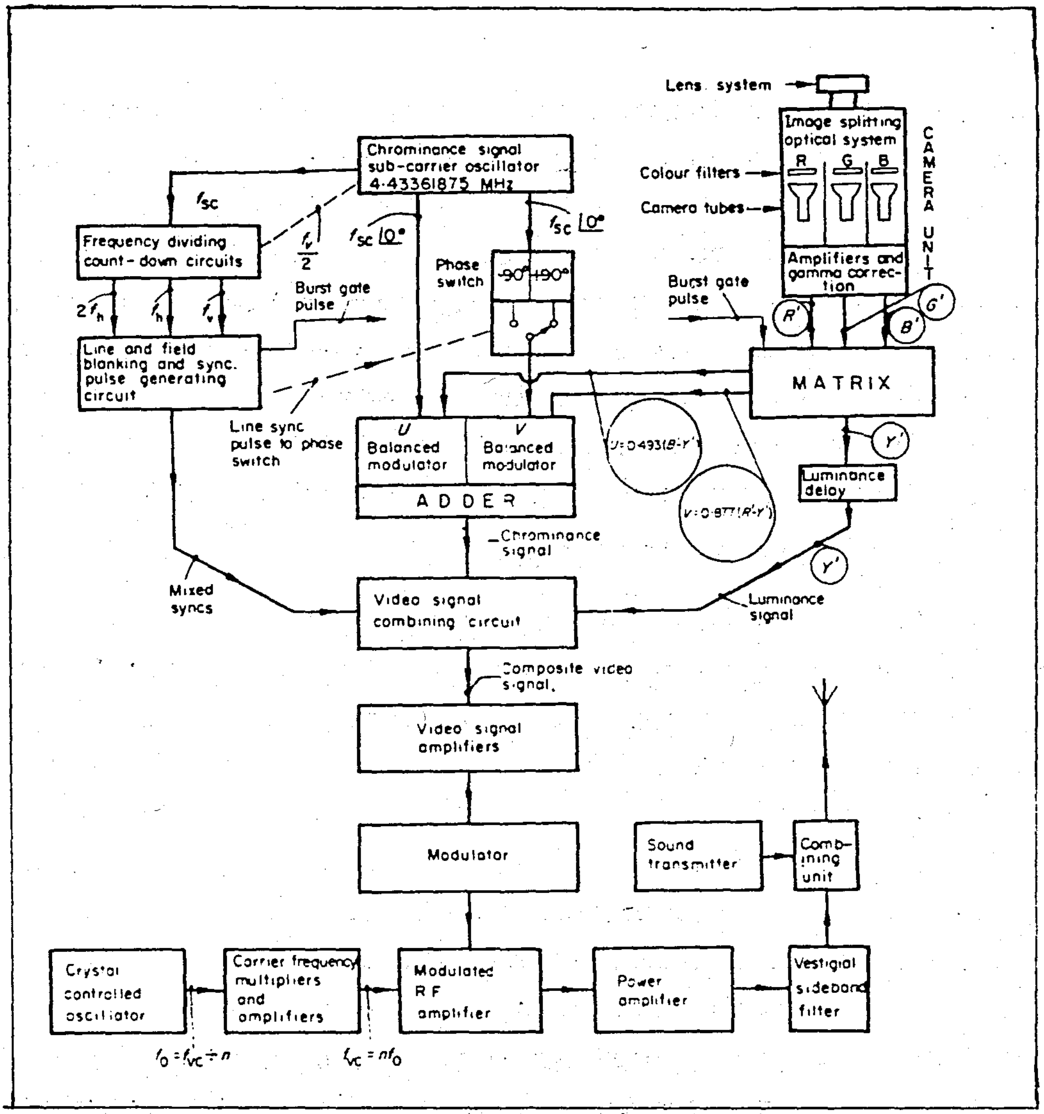


Fig. 5.5

Basic PAL-system transmission arrangement

In the simplified block diagram, the subcarrier is shown as being directly generated at 4.43361875 MHz and this is shown as passing to 'count down' circuits to produce the required synchronizing frequencies of $2f_h$, f_h, and f_v. (Note that a frequency of $2f_h$ is needed because this is the repetition rate of the half-line and equalizing pulses in the field blanking period.)

The numerical relationships are in fact such that it is easier to start off with a 'master-frequency' of 4.43361875 MHz - 25 Hz = 4.43359375 MHz. This frequency is (1135/4 x f_h) and may conveniently be counted down to yield $2f_h$, f_h, and f_v. Finally a component at $f_v/2$ = 25 Hz is derived and this is then added to the generated 'master frequency" to give the required chrominance subcarrier frequency of 4.43361875 MHz. In this sense f_{sc} is itself a 'derived frequency' with the standard frequency controlling the system being 4.43359375 MHz.

5.4 COMPARISON OF COLOUR TELEVISION SYSTEMS

The main world systems are NTSC, PAL and SECAM. All of these describe the picture in terms of luminance and colour-difference signals. It is the way in which the chrominance signal is modulated by the colour-difference signals which constitutes the main differences between these systems. NTSC and PAL are alike in employing quadrature amplitude modulation of the chrominance signal. PAL uses simple weighted (R'-Y') and (B'-Y') colour-difference signals of equal bandwidth to modulate the two quadrature phase (but equal frequency) subcarriers to form the two components which when added yield the chrominance signal. In NTSC the more complex I and Q colour-difference signals are used [2] . These have unequal bandwidths; the I being some three times broader than the Q.

In SECAM [4] it is again the simpler (R'-Y') and (B'-Y') colour-difference signals which are used but here the method of modulation is entirely different. Frequency modulation of the subcarrier is used and instead of both (R'-Y') and (B'-Y') information being present in the chrominance signal simultaneously (as is the case with NTSC and PAL), the subcarrier is modulated by (R'-Y') on one line and (B'-Y') on the next.

CHAPTER 6

INSTRUMENTATION

6.1 INTRODUCTION

Sync Pulse Generator realized in this thesis study is the timing heart of a television system. The signals generated in the pulse generating circuits control the sequence of operation of the entire system. All these signals are generated separately or their functions are combined in waveform groups. The functions and design details of the complete system will be given in Chapters 6 and 7. Chapter 6 deals with general black and white television signals, and Chapter 7 deals with PAL colour TV signals used in colour television transmitter system.

6.2 SYSTEM DESCRIPTION

The whole circuitry is mounted on seven printed circuit boards, hence the complete system consists of seven units. Each unit serves to produce various pulses which are necessary for operating a TV studio. These individual units are:

(1) Vertical Components Unit
(2) Horizontal Components Unit
(3) Power Supply and Output Stages Unit
(4) H/2 (Double Line Frequency) Oscillator and Divider Unit
(5) 25 Hz Offset Unit
(6) Subcarrier Generator and Encoder Flag Pulse Generator Unit
(7) Colour Burst Generator Unit

The abbreviations and symbols used in the following sections are shown below:

S	(SYNC)	: Composite Sync Train
H	(HOR)	: Horizontal Drive Pulse
V	(VERT)	: Vertical Drive Pulse
B	(BLANK)	: Composite Blanking
F	(SUBC), fsc	: Subcarrier (Colour carrier)
P	(PAL FLAG)	: PAL Flag Pulse
K	(BURST FLAG)	: Burst Flag Pulse
V_s		: Vertical Sync Pulse
V_{eq}		: Vertical Equalizing Pulse
V_B		: Internal Vertical Blanking Pulse
T_H		: Horizontal Gate Pulse
H/2		: Double Line Frequency ($2f_h$= 31250 Hz)
2 H		: Half-Line Frequency (7812.5 Hz)
I		: Integrated Circuit
Tr		: Transistor

The general block diagram of the complete system is shown in Fig. 6.1. As it is seen from the block diagram, the most important parts of the entire system are the H/2 oscillator and Crystal oscillator. Crystal oscillator has a property of high stability. 4.43361875 MHz sinewave oscillation generated from crystal oscillator, is connected to the 25 Hz offset unit. 25 Hz offset circuit is provided to generate a colour carrier shifted by -25 Hz which is necessary for a PAL system. Thus the colour carrier frequency is 4.43359375 MHz instead of 4.43361875 MHz. 4.43359375 MHz is divided by 1135 (= 5x 227), and double line frequency is divided by 8 so that both of the results are 3906 Hz. As a result, by means of phase comparison circuits the output of H/2 oscillator is kept constant. H/2 pulses are distributed to the both vertical and horizontal units. Vertical components unit produces vertical sync (V_s), vertical blanking (V_B), vertical equalizing (V_{eq}), and vertical drive pulses (V).

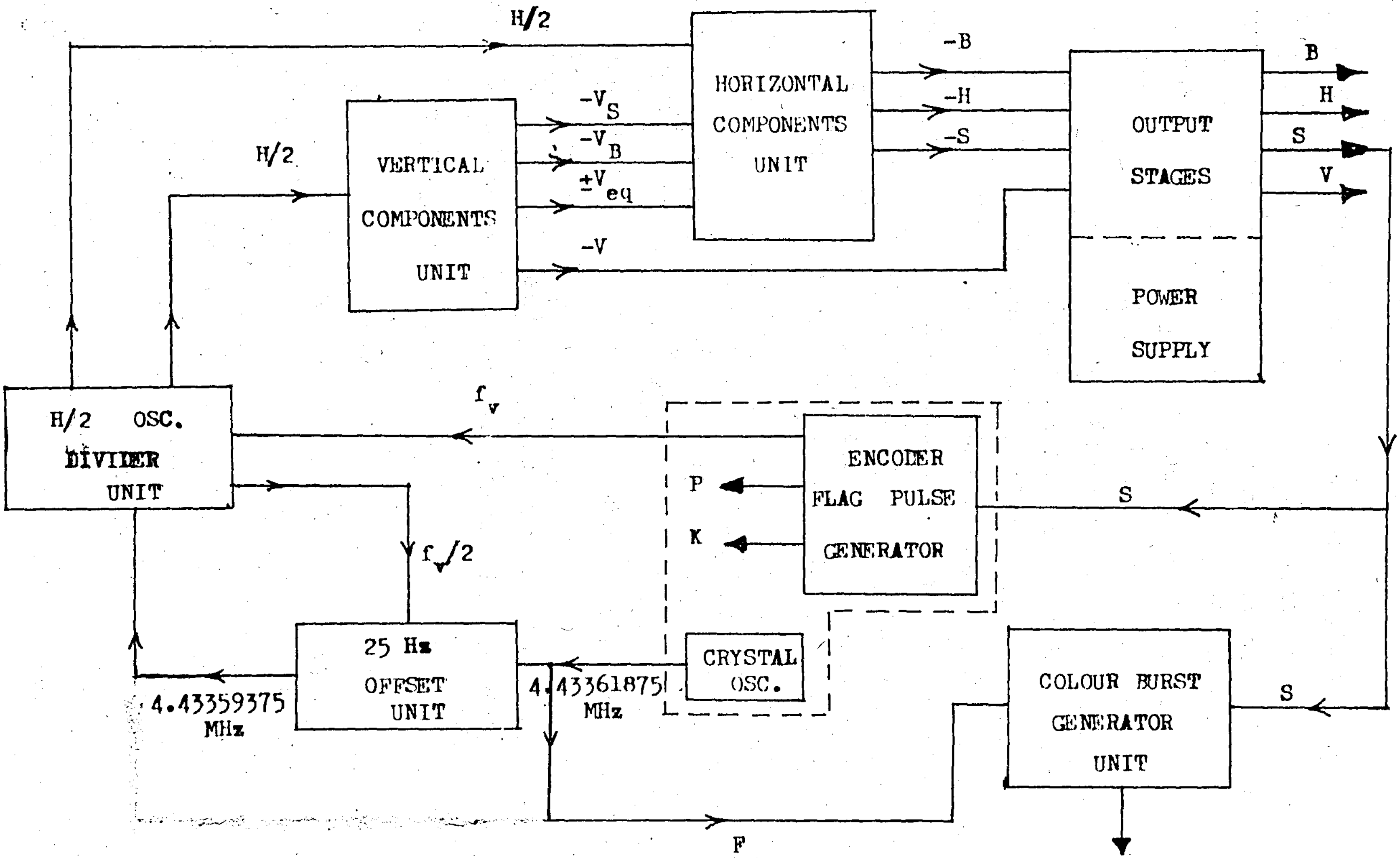


Fig. 6.1 General block diagram of the complete system

All of these pulses -except vertical drive pulse- are connected to the horizontal components unit. Finally, the minus values of outputs of horizontal components unit are converted to required waveforms in the output stages. The final signals produced in the output stages are:
Composite sync train (S), Composite blanking (B), Horizontal drive pulse (H), and Vertical drive pulses (V).

Composite sync train is distributed both to the Colour burst generator and Encoder flag pulse generator. Colour burst generator, produces the colour burst reference signal on the back porch of the line-synchronisation pulse, for the purpose of locking the frequency and phase of the re-inserted subcarrier generated by the receiver's reference oscillator. Finally, Encoder flag pulse generator unit produces two kinds of pulses, one of them is 'PAL flag pulse' (P) which is required to ensure that the PAL alternation sequence is the same in all coders. The other one is 'Burst flag pulse' (K), it is produced so that all coders key-out the colour burst from the continuous reference sinewave at the same time.

All the units and their output waveforms mentioned above will be discussed in detail in the following sections.

6.3 VERTICAL COMPONENTS UNIT

Vertical components unit generates the four outputs: Vertical drive pulse, vertical sync pulse, internal vertical blanking pulse, and vertical equalizing pulse. The vertical sync and blanking pulses control the vertical motion of the scanning beam and blank out the beam during the vertical retrace intervals. The equalizing pulses occur in two groups of six each, preceding and following each vertical sync pulse. The purpose of the equalizing pulses is to secure accurate interlacing by equalizing the energy content of the sync pulse waveform during successive vertical blanking intervals. Since the vertical frequency is 50 Hz, the period of the vertical pulses are 20 msec.

Fig. 6.2 shows the detailed circuit diagram of vertical components unit. The components used in the circuit are listed below:

I 1	:	MC851 (Monostable multivibrator)
I (3,5,6,7,9)	:	SN7400 (Quad 2-input NAND gate)
I (12,13,14)	:	SN7490 (Decade counter)
I (10,11)	:	SN7442 (BCD-to-decimal decoder)
I (2,4,8)	:	SN7402 (Quad 2-input NOR gate)

The H/2 pulses coming from H/2 oscillator are counted up to the number of 625 by the divide-by-ten counter I 12 (SN7490). (Units), I 13 (tens) and I 14 (hundreds). When the number 625 is decoded the reset pulse for the divide-by-ten counters is supplied through monostable multivibrator I 1. The units, tens and hundreds are decoded by I 11, I 10 and gate I 5/ (11,12,13). The zero hundred digit needs not be considered for resetting the flip-flops because -after having been reset- the flip-flops do not respond to further reset pulses (e.g., V_B at <u>1</u> 4 5, <u>2</u> 4 5 ...). To reset the V_S the zero tens must also be decoded, otherwise the set and reset pulses would arrive simultaneously.

The positions of the leading and trailing edges of the pulses V_B, V_{eq}, V_S and V must be as in Fig. 6.3. The pulses which are derived by decoding these numbers are used for setting and resetting the flip-flops I 6 and I 7.

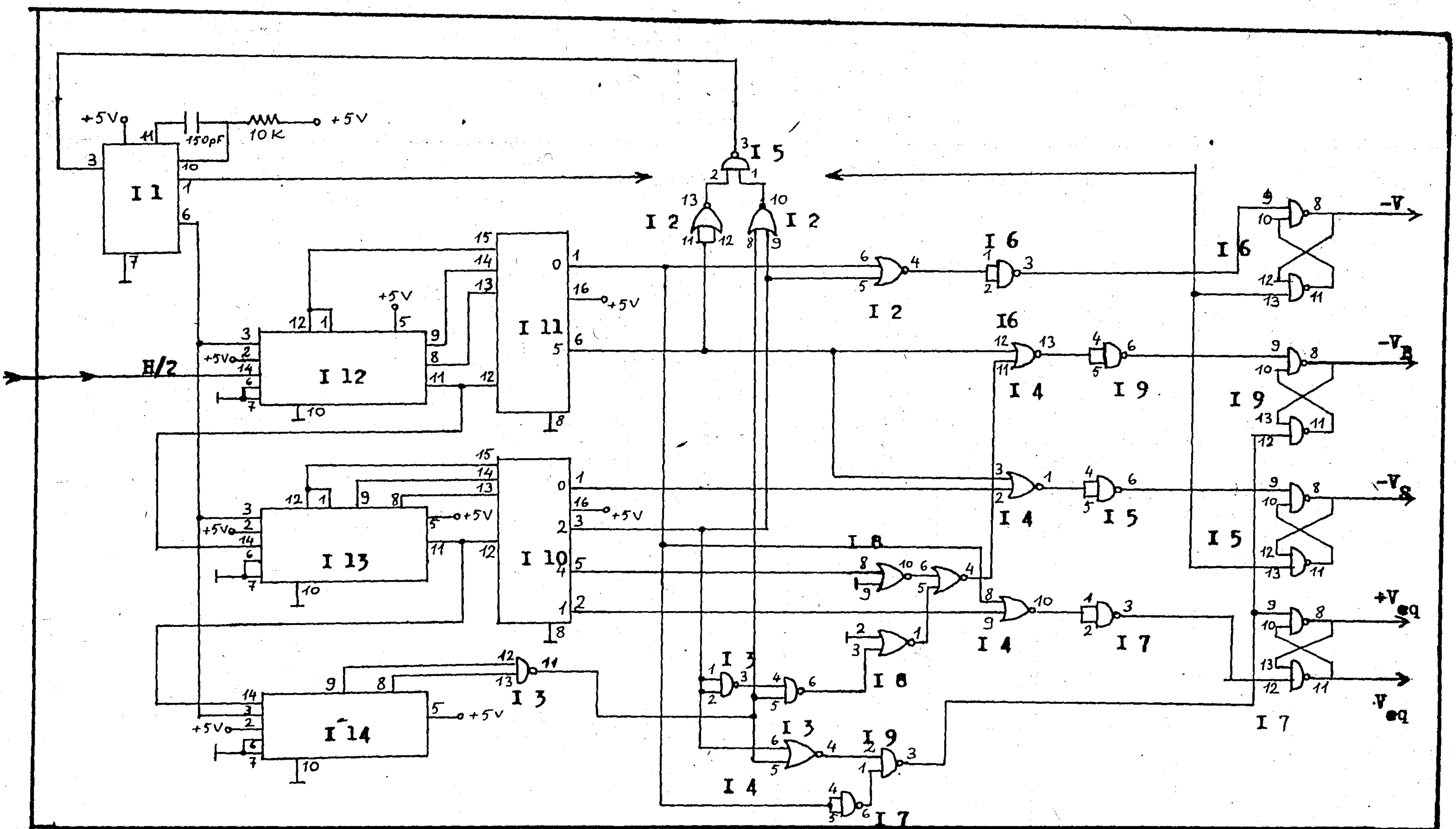
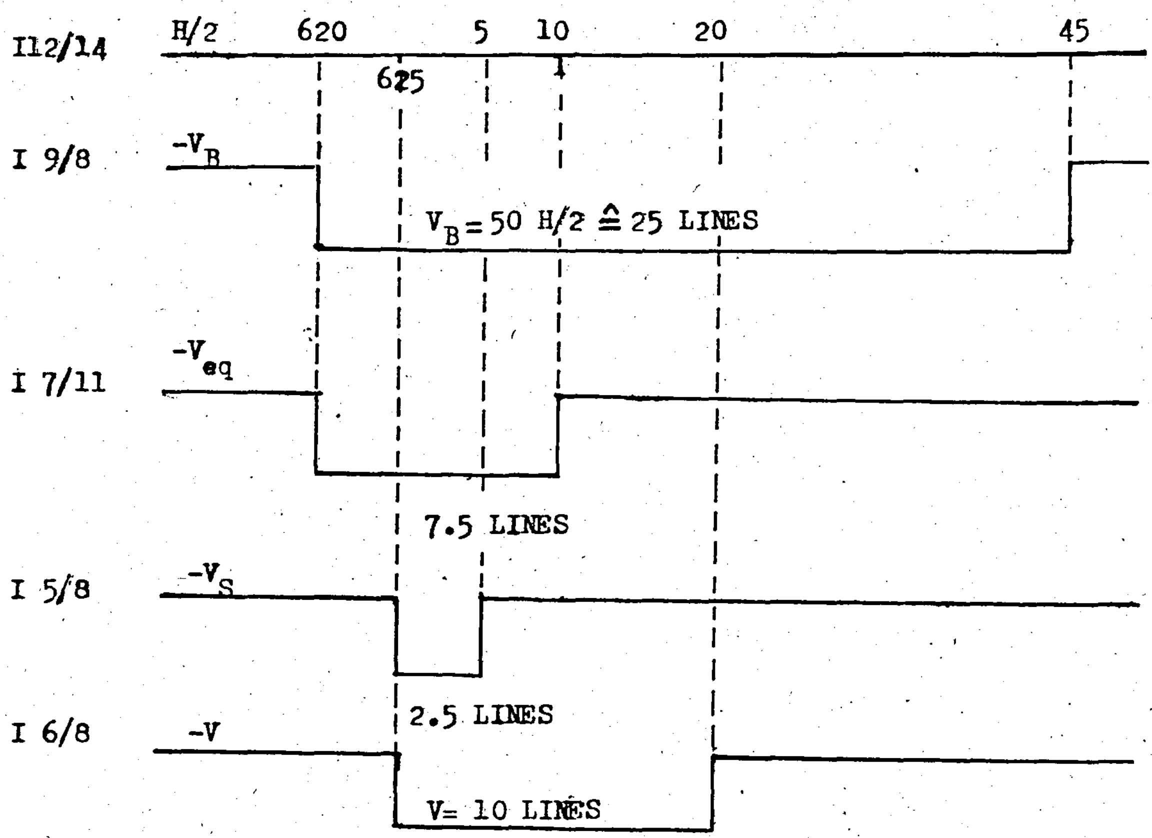


Fig. 6.2 Circuit diagram of vertical components unit



I12/14
H/2
620
625
5
10
20
45
I 9/8
-V_B
V_B = 50 H/2 ≙ 25 LINES
I 7/11
-V_eq
7.5 LINES
I 5/8
-V_S
2.5 LINES
I 6/8
-V
V= 10 LINES

Fig. 6.3

The desired outputs are obtained through flip-flops I6, I9, I5 and I7 as shown in Fig. 6.2. The output waveforms generated by vertical components unit are indicated in Fig. 6.4, the specifications conform to C.C.I.R. 625-line standards..

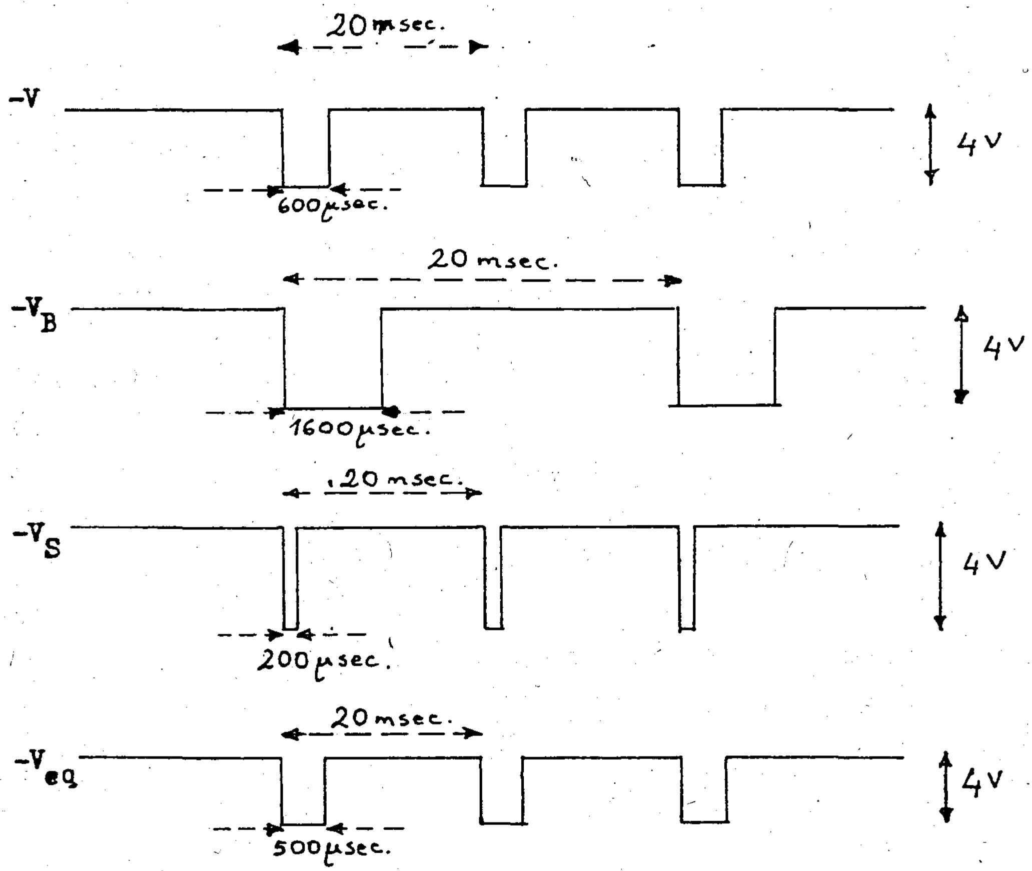


Fig. 6.4

The output waveforms of vertical components unit

6.4 HORIZONTAL COMPONENTS UNIT

Horizontal unit produces three outputs, these are: Composite sync train (S), Composite blanking (B), and Horizontal drive pulse (H). The horizontal sync and blanking pulses control the motion of the scanning beam as it moves horizontally across the screen and properly blanks the picture tube beam during the horizontal retrace period. Horizontal pulses have a frequency of 15625 Hz, so their periods are 1/15625 Hz = 64 µsec. As far as pulse widths are concerned, horizontal pulses are narrower than the vertical pulses. Fig. 6.5 indicates the block diagram and Fig. 6.6 shows the detailed circuit diagram of the horizontal components unit.

The components and their functions used in the circuit of horizontal unit are listed below:

I (1,10,12,13)	: SN 7400 (Quad 2-input NAND gate)
I (2,6)	: MC 851 (Monostable multivibrator)
I 4	: SN 7490 (Decade counter)
I 5	: SN 7473 (Dual J-K master-slave-flip-flop)
I 3	: CA 3046 (General-purpose transistor arrays)
I 11	: SN 7410 (Triple 3-input NAND gate)
I 7	: SN 7442 (BCD-to-decimal decoder)
I (8,9)	: SN 7402 (Quad 2-input NOR gate)
Tr 1	: 2N 3906 (General purpose PNP, Silicon, low frequency, transistor)

The H/2 pulse coming from H/2 oscillator unit is connected to the monostable multivibrator I 2, the other inputs of the circuit are the outputs of vertical unit except vertical drive pulse. All pulse widths existing in the horizontal and sync pulses can be derived from integral multiples of the period of an oscillation whose frequency is f=1.2766 MHz, T=0.783 usec.

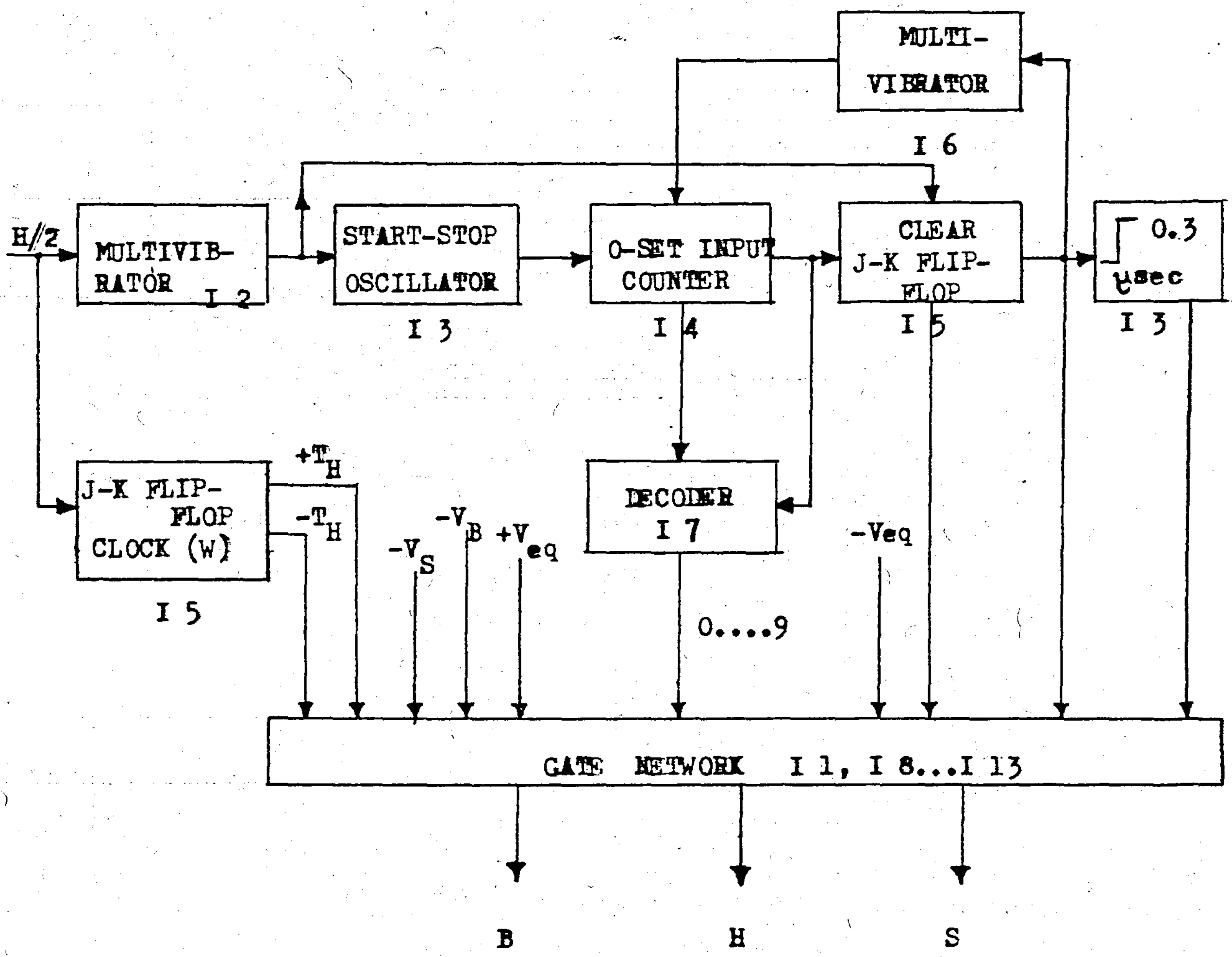


Fig. 6.5

Block diagram of horizontal components unit

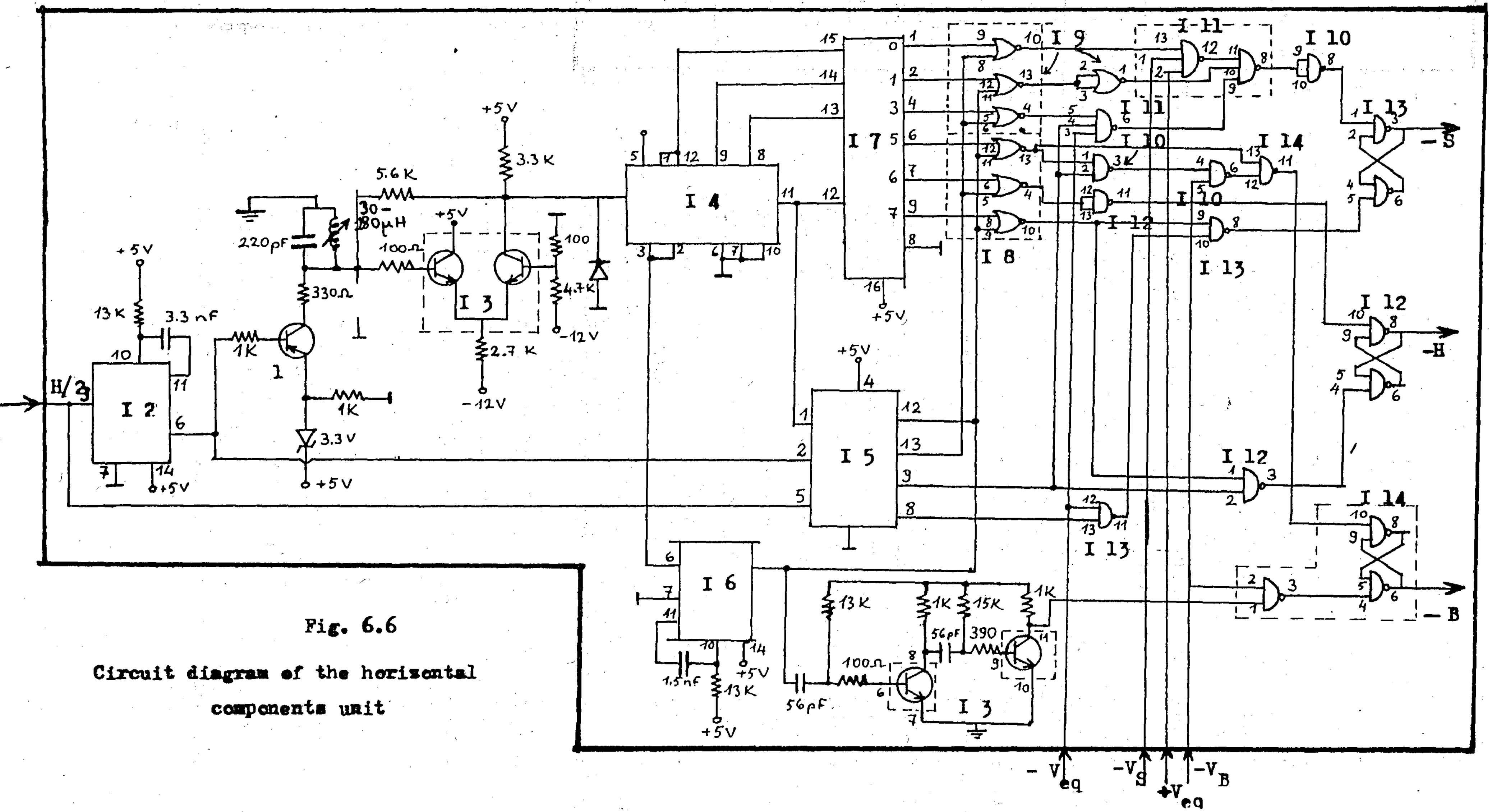


Fig. 6.6

Circuit diagram of the horizontal components unit

The blanking pulse is delayed by 0.3 usec. when passing through pulse shaper I3/6,7,8 and I 3/9,10,11. The leading and trailing edges of all pulses being shorter than half a line are within the first and 20th period of the 1.2766 MHz oscillator. Therefore a start-stop oscillator Tr 1, I3/1,2,3, I 3/3,4,5, keyed by the H/2 frequency, is used. The cycle of this oscillator ends after the 20th oscillation and before the H/2 pulse. The oscillations reach the divide-by-ten counter I4 and decoder I7. The J-K flip-flop I5 is triggered by the D-output of I4. The level of the Q output of I5 changes after the first ten oscillations and serves to distinguish the periods 1 ... 10 and 11 ... 20.

To obtain a definite switching position of flip-flop I5 output Q (I5/12) is set by I2 to 0 with the leading edge of the start-stop pulse. After the 20th oscillation the divide-by-ten counter I4 is set to 0 by Q via multivibrator I6. The reset pulse must have a greater width than the cycle of the oscillator and must be finished before the succeeding starting pulse (H/2) so that counting from 1 onwards can be started again.

The horizontal gate pulse ($\pm T_H$) with horizontal frequency necessary for suppressing the H/2 pulse, is supplied by the second J-K flip-flop of I5/8,9.

The set and reset pulses for the flip-flops I12, I13, I1 which supply the blanking, horizontal and sync. pulses are derived via the gates I8, I9, I10, I11 from the following pulses:
the $\pm T_H$ pulse,
the digits 0 ... 9 from decoder I7,
the Q and Q pulses from I5/12 and I 5/13,
the delay pulse derived from Q via I3/6,7,8 and I3/9,10,11,
the gate pulses $-V_S$, $-V_B$ and V_{eq} from vertical components unit. The positions of the waveforms discussed above are shown in Fig. 6.7.

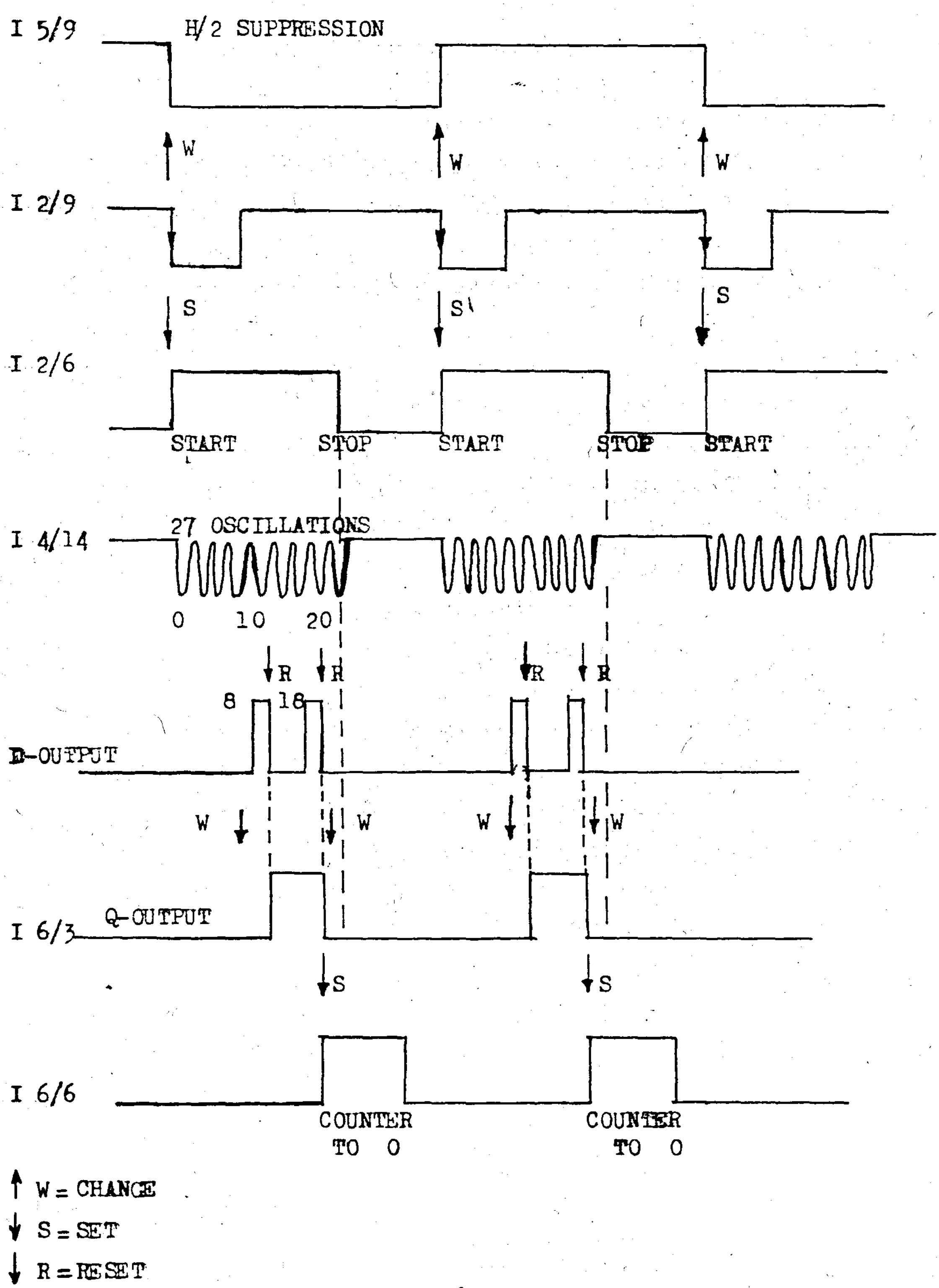

I 5/9
H/2 SUPPRESSION
W
I 2/9
S
I 2/6
START
STOP
I 4/14
27 OSCILLATIONS
0
10
20
R
8
18
D-OUTPUT
W
I 6/3
Q-OUTPUT
S
I 6/6
COUNTER
TO 0
W = CHANGE
S = SET
R = RESET

Fig. 6.7

6.5 POWER SUPPLY AND OUTPUT STAGES

All of the circuits, designed in this study are supplied by three kinds of D.C. voltage these are: +12 V, +5 V, and -12 V. Maximum current consumption is approximately 600 mA. Fig. 6.8 indicates the circuit configuration of power supply unit. In order to get exact voltage values, related potentiometers shown in figure can be adjusted to desired levels.

The components and their functions used in the power supply unit are listed below:

Tr (1,8,9)	: BC 177 (General purpose PNP silicon, low frequency, low current transistor)
Tr (4,5,12)	: BC 108 (General purpose NPN silicon low frequency, low current transistor)
Tr (2,10)	: 2N 2218 (General purpose NPN silicon high speed, medium power, switching transistor)
Tr 6	: 2N 2904 (General purpose, PNP silicon, medium power switching transistor)
Tr 7	: 2N 3740 (General purpose, PNP silicon, high frequency, high current transistor)
Tr (3,11)	: 2N 3055 (NPN silicon, low frequency, high current, high voltage transistor)

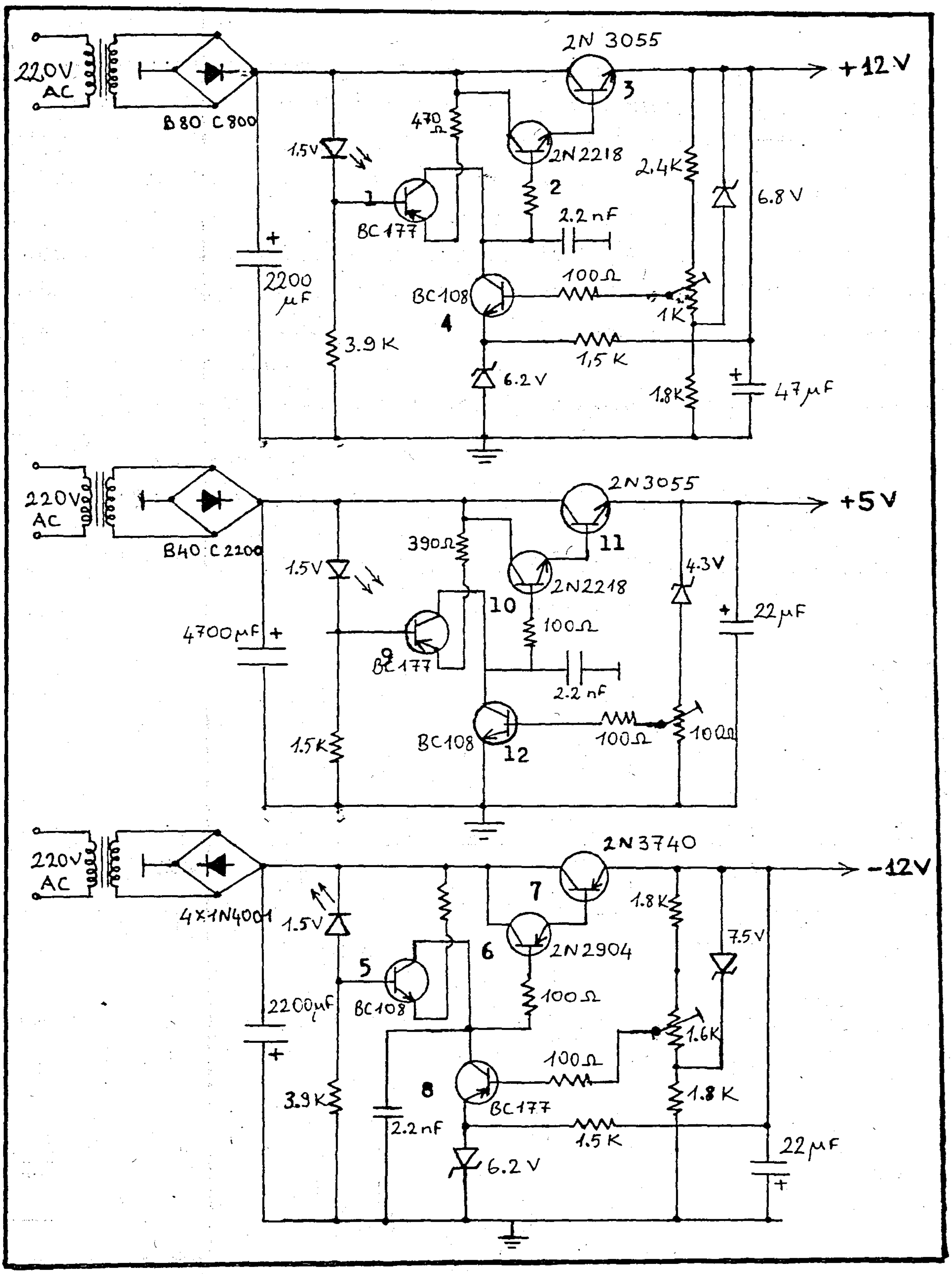


Fig. 6.8

Circuit configuration of power supply unit

The Output Stages, provide four signals: Composite sync train (S), Horizontal drive pulse (H), Composite blanking (B), Vertical drive pulse (V). Each stage consists of a clipper and two emitter followers. All of the four stages are symmetrical and the rise times and amplitudes of the each output can be adjusted with related coil and potentiometer. Fig. 6.9 shows the output waveforms obtained through the output stages and the circuit diagram of output stages is shown in Fig. 6.10.

The components used in the circuit of output stage unit are listed below:

Tr (13,14,16,17,19,20,22,23): 2N 3904 (NPN silicon low frequency, low current transistor)

Tr (15,18,21,24) : MD 6003 (NPN-PNP silicon dual transistor)

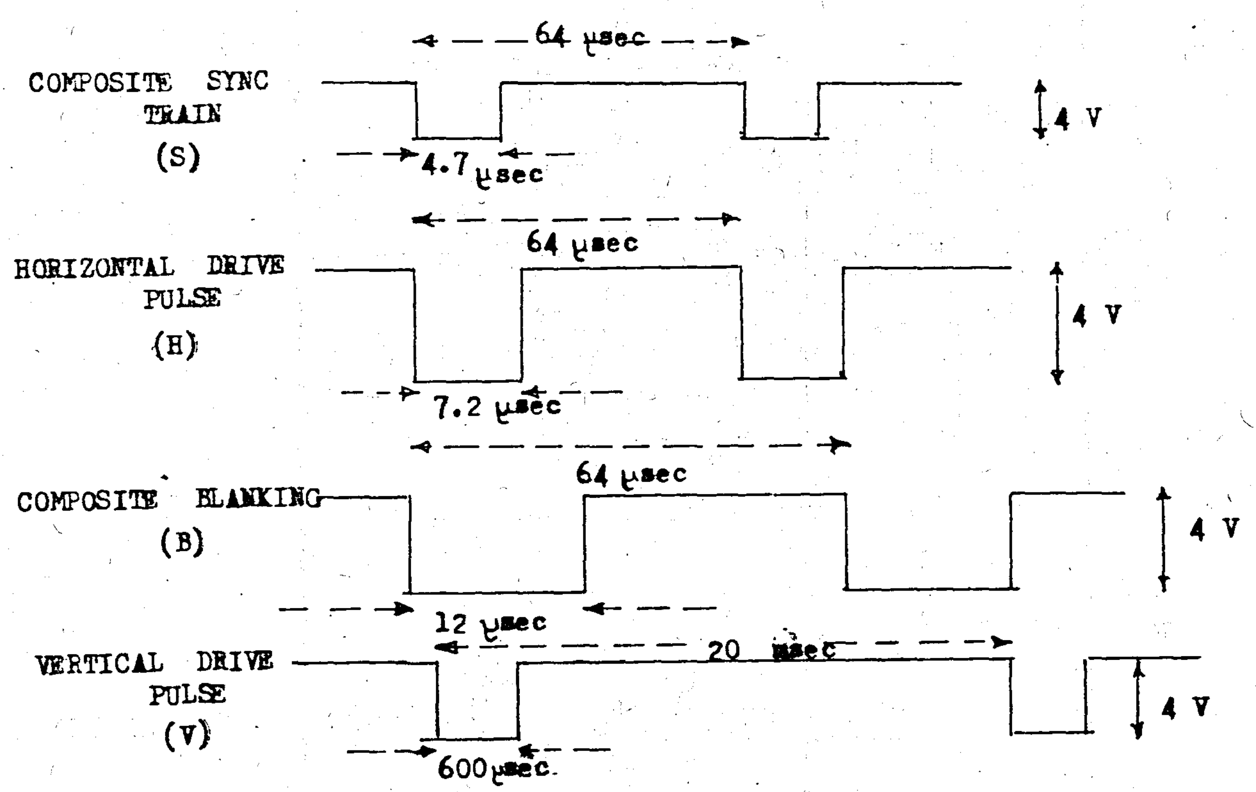


Fig. 6.9

The output waveforms obtained through output stages unit (dimensions not to scale)

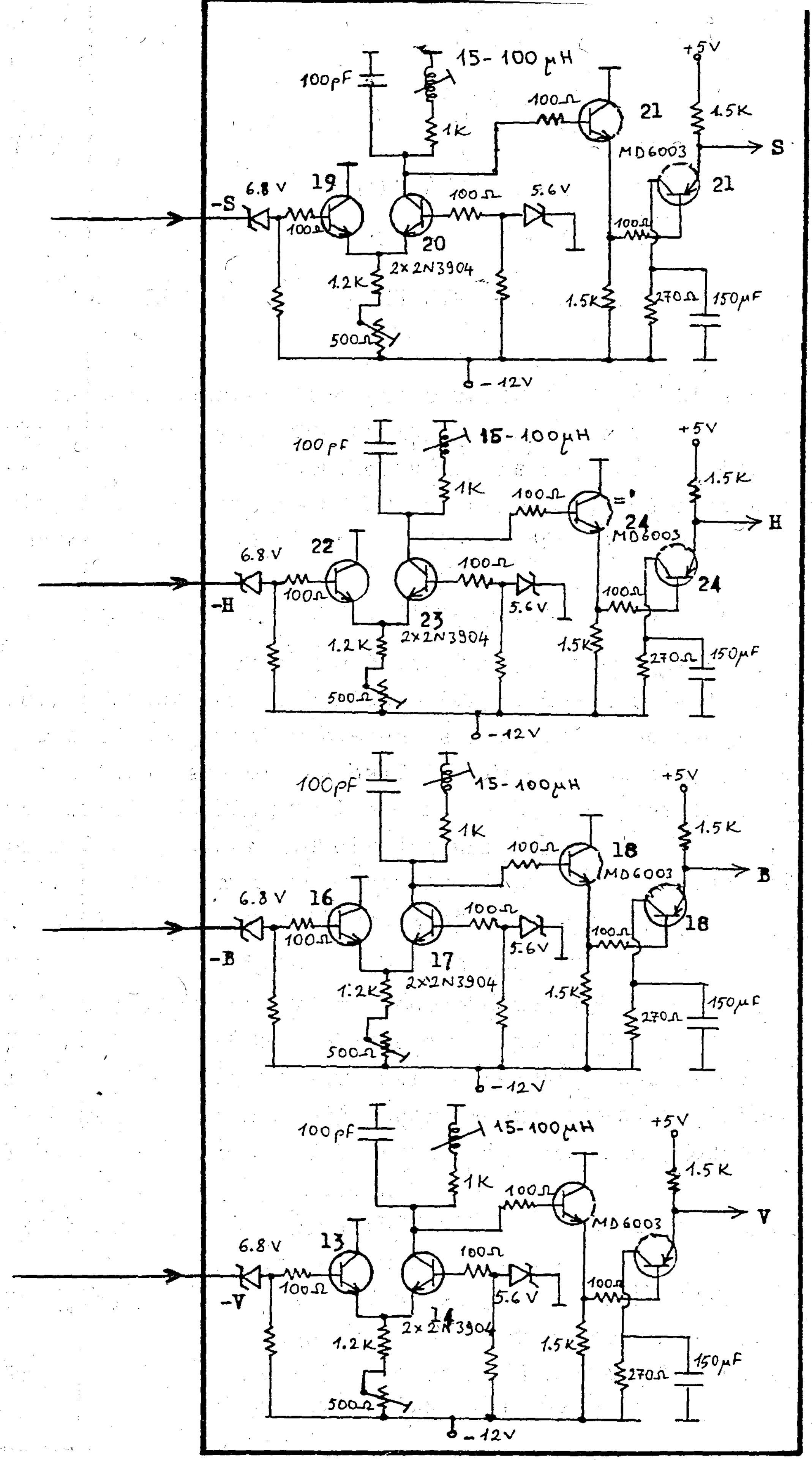


Fig. 6.10 Circuit diagram of output stages

CHAPTER 7

COLOUR SIGNAL UNITS OF SYNC PULSE GENERATOR

In this chapter, the other units of Sync Pulse Generator which are designed for producing the colour TV signals will be discussed. The detailed analysis and calculations of the circuits are not given but the brief explanations are presented to provide a clear understanding for their behaviours.

7.1 H/2 OSCILLATOR AND DIVIDER UNIT

H/2 oscillator generates the square-wave pulses which have a frequency of 31250 Hz ($2f_h$). The double line frequency for a TV transmitter system is necessary because this is the repetition rate of the half-line and equalizing pulses in the field blanking period. Fig. 7.1 shows the circuit diagram of H/2 oscillator and divider unit.

The components and their functions used in the H/2 oscillator and divider unit are listed below:

I 1	:	Delay Line (100 nsec.)
I (2,3,4,5)	:	SN 7490 (Decade counter)
I 6	:	SN 7402 (Quad 2-input NOR gate)
I 7	:	SN 7410 (Triple 3-input NAND gate)
I (8,9)	:	SN 7473 (Dual J-K master-slave flip-flop)
I 10	:	CA 3054 (Dual independent differential amplifiers)
Tr (1,2)	:	2N 3904 (NPN silicon, low frequency, low current transistor)
Tr (3,5)	:	BC 108 (General purpose NPN silicon, low frequency, low current transistor)
Tr 4	:	BF 245 (N-channel junction FET transistor for DC, AF and RF amplifiers)

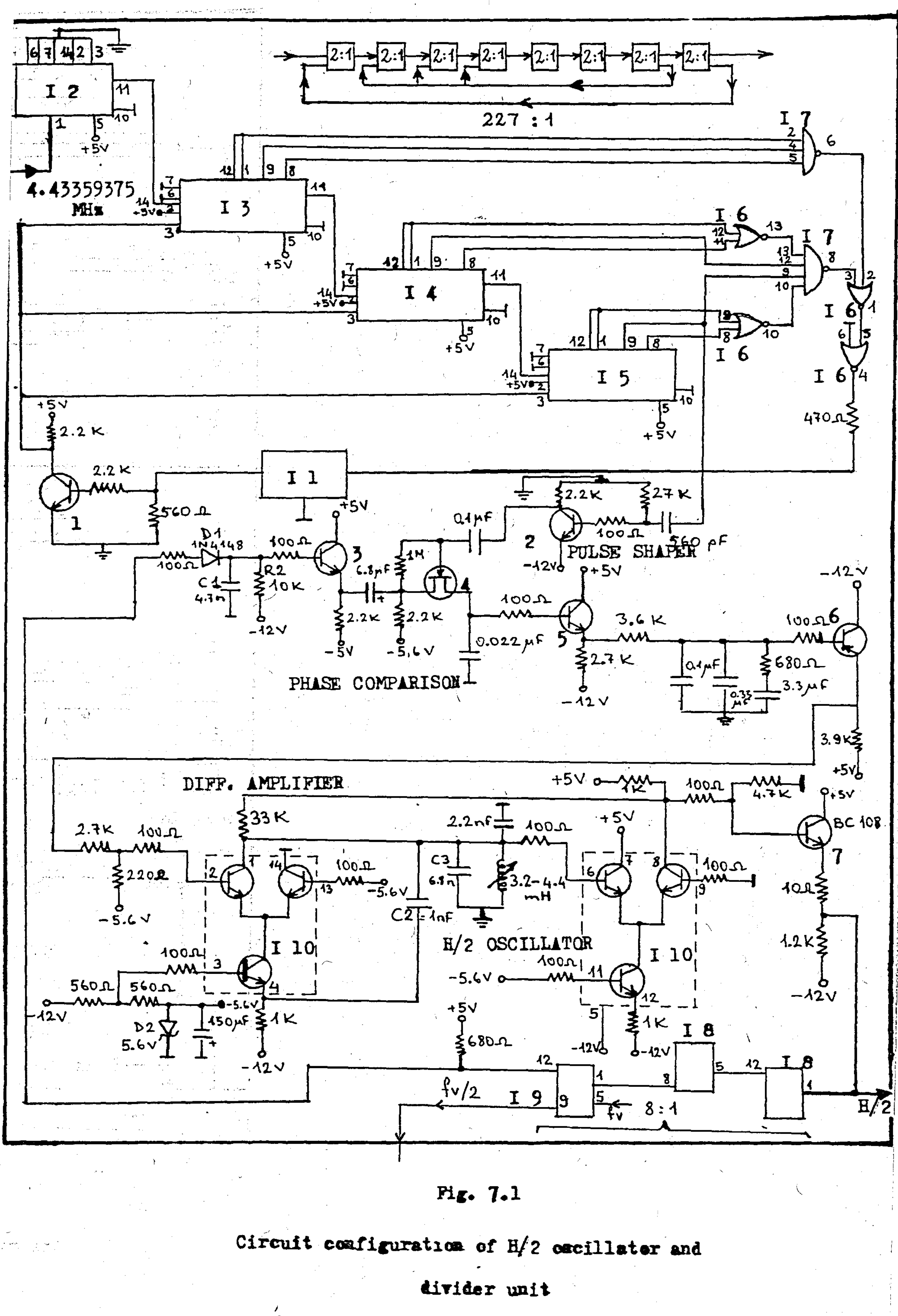


Fig. 7.1

Circuit configuration of H/2 oscillator and

divider unit

Tr 6 : BC 177 (General purpose PNP silicon, low frequency, low current transistor)

The colour carrier oscillation coming from 25 Hz offset unit (e.g., 4.43361875 MHz - 25 Hz = 4.43359375 MHz) is divided by 1135 (=5.227) in divide-by-ten counter I 2 and divide-by-ten counters I 3, I 4 and I 5. Then it is fed through pulse shaper transistor Tr2 to the phase comparison stage transistor Tr4 and decoded in I 6 and I 7. The output pulse, delayed in the delay network I 1 serves to reset the counters to 0.

The oscillations of the H/2 oscillator (I10/8,9, I 10/6,7, I 10/11,12) are divided by 8 in the J-K flip-flop I 8 and I 9/1,12. As a result a squarewave voltage having $f_h/4=$ 3906 Hz frequency arises. Its negative porch is shaped into a ramp by D1, C1 and R2. This reference pulse is fed through emitter follower transistor Tr3 to the second input of phase comparison stage transistor Tr4. The control voltage generated by the phase comparison stage is fed to transistor I 10/1,2 through emitter follower transistor Tr5, the following smoothing network and transistor Tr6.

Depending on the level of the control voltage, capacitor C2 is either short-circuited through I10/1,2 and I 10/3,4 or it is connected in parallel to oscillator circuit capacitor C 3 through I 10/13,14 and I 10/3,4. As a result the oscillator is retuned. The output waveform of H/2 oscillator unit is shown in Fig. 7.2.

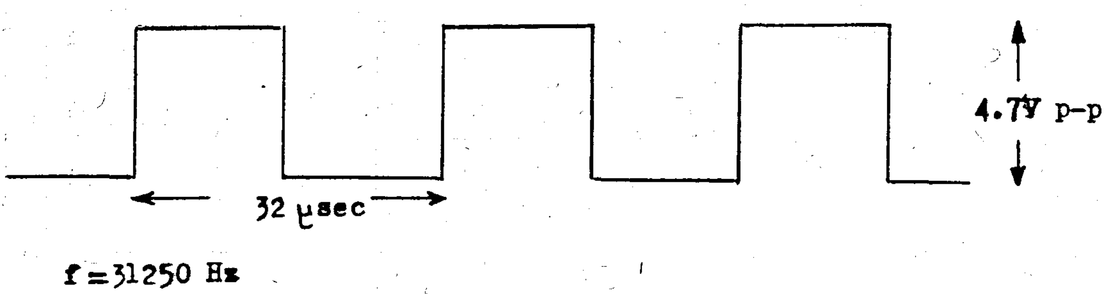


Fig. 7.2

7.2 25 Hz OFFSET UNIT

In PAL system the colour carrier frequency has to be modulated with a 25 Hz oscillation. The carrier and the upper sideband are suppressed in such a way that the desired frequency F-25 Hz results. (i.e., 4.43361875 MHz-25Hz= 4.43359375 MHz) If the 25 Hz is to be subtracted before the count down begins, then normal filters are inadequate for separating (f_{sc}-25), f_{sc} and (f_{sc}+25) Hz. The technique of single-side-band modulation has been used by W. Bruch. The method consists in adjusting the phases of two sub-carrier signals, each modulated, with suppressed carrier, by 25 Hz sinewaves in quadrature, so that a combination of the two modulated signals cancels the unwanted (f_{sc}+ 25) Hz. The block diagram of subtraction of 25Hz from the PAL frequency is indicated in Fig. 7.3. The alternative solutions can also be realized for 25Hz offset circuits [5] .

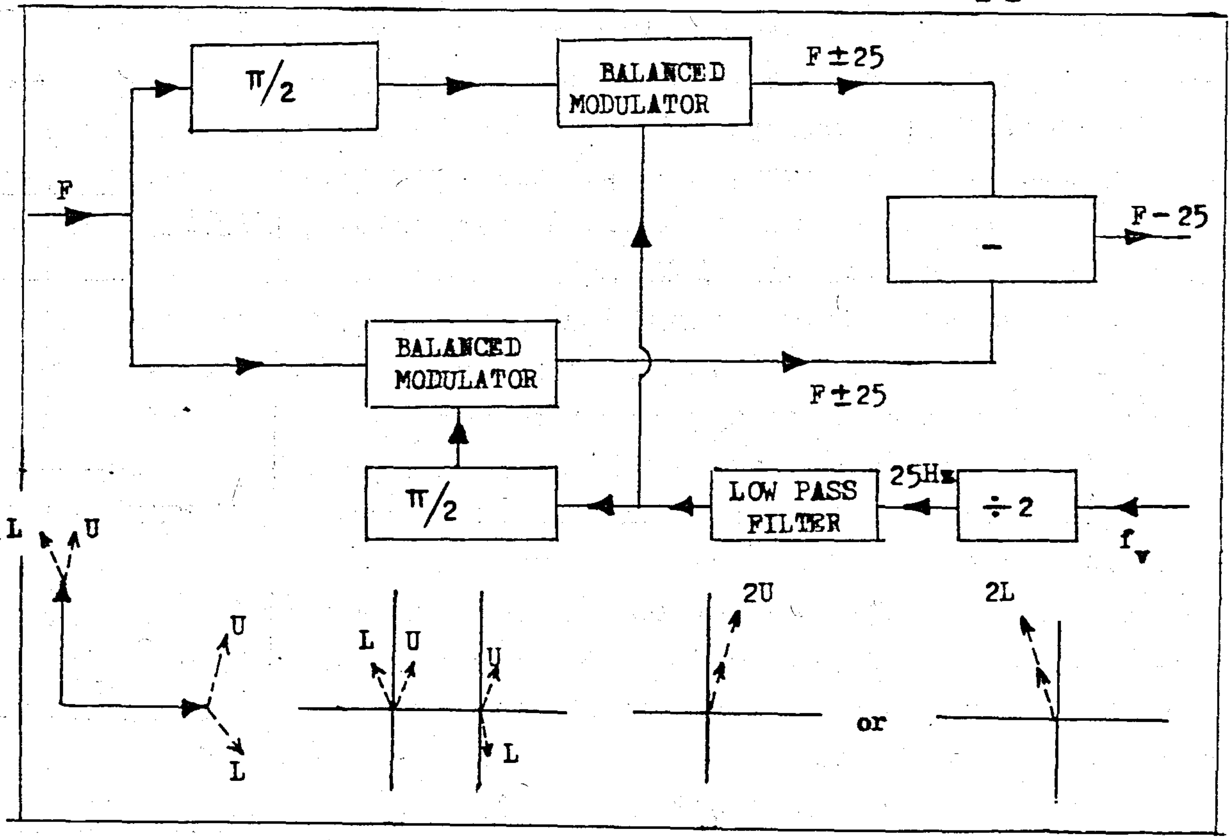


Fig. 7.3 Subtraction of 25 Hz from the PAL frequency: single-sideband modulation

The detailed circuit configuration of 25 Hz offset unit is shown in Fig. 7.4.

The components list used in the circuit of 25 Hz offset unit is given below:

I (1,2)	:	CA 3054 (Dual independent differential amplifiers)
Tr (1,2,3,4)	:	2N 3904 (NPN silicon, low frequency, low current transistor)
Tr (6,7,8)	:	BC 108 (General purpose NPN silicon low frequency, low current transistor)
Tr 5	:	2N 3906 (General purpose PNP silicon, low frequency transistor)

The 25 Hz offset unit is supplied with a colour carrier signals coming from crystal oscillator and a 25 Hz square-wave pulse (1/2 f_v), coming from H/2 oscillator-divider unit.

The 25 Hz pulse is fed through Tr 8 to an active resonant circuit C1, Tr 6,7 and shaped into a sinewave oscillation, which is fed, on the one hand, through emitter follower Tr 9 to the 90° modulation stage I 2 and, on the other hand, through Miller integrator Tr 10,11 to the 0° modulation stage I 1. In the 0° modulation stage I 1 the colour carrier is fed to the transistors I 1/1,2 and I 1/8,9, whereas the modulating audio frequency is fed to the transistors I 1/3,4 and I 1/11,12. The colour carrier signal at I 1/13,14 is in phase opposition to the colour carrier signal existing at I 1/8,9. As a result the colour carrier is suppressed by the addition of the currents of these two transistors if the amplitudes are equal. The same is effected in the 90° modulation stage (by the addition of the currents of I 2/6,7 and I 2/1,2) In this stage the colour carrier is shifted by 90° in L1, C2, and is fed to I 2/8,9 and I 2/1,2, whereas the AF oscillation is shifted by 90° and is fed to I 2/11,12 and I 2/3,4.

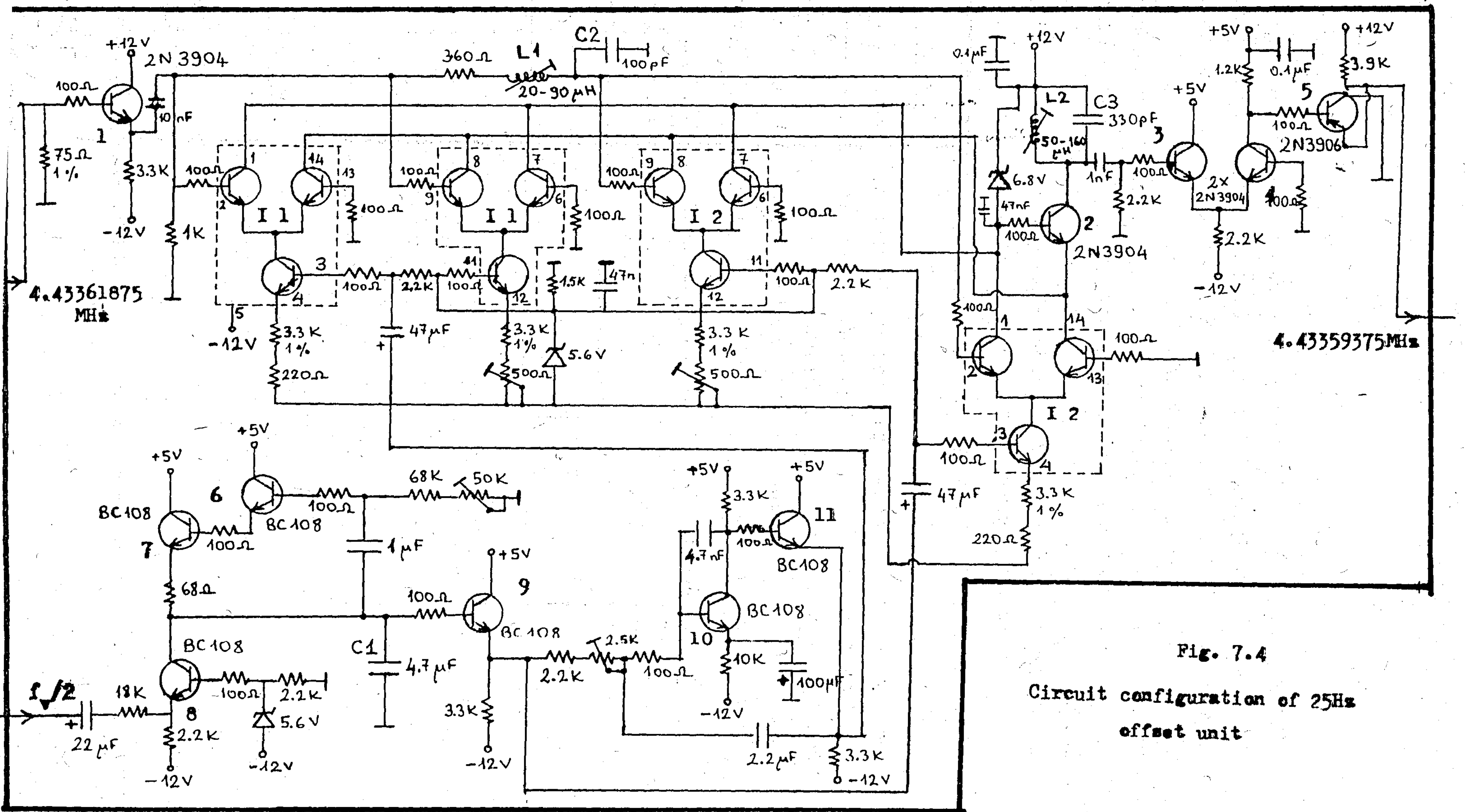


Fig. 7.4

Circuit configuration of 25Hz offset unit

If the currents coming from the 0° stage and from 90° stage (on the one hand I1/1,2 and I1/8,9 and on the other hand I2/6,7 and I2/8,9) are added, the upper sideband F+25 Hz is suppressed (An interchange of both the AF components results in the suppression of the lower sideband). Through Tr2, operating in a grounded-base configuration, the lower sideband F-25 Hz coming from resonant circuit L2, C3 is fed to the amplifier transistors 3 and 4 and from there through emitter follower Tr5 to the output.

7.3 SUBCARRIER GENERATOR AND ENCODER FLAG PULSE GENERATOR UNIT

Crystal oscillator, which generates the exact value of subcarrier sinewave oscillations and Encoder flag pulse generator circuits are mounted on the same printed circuit board. As discussed earlier, the subcarrier frequency is determined as follows:

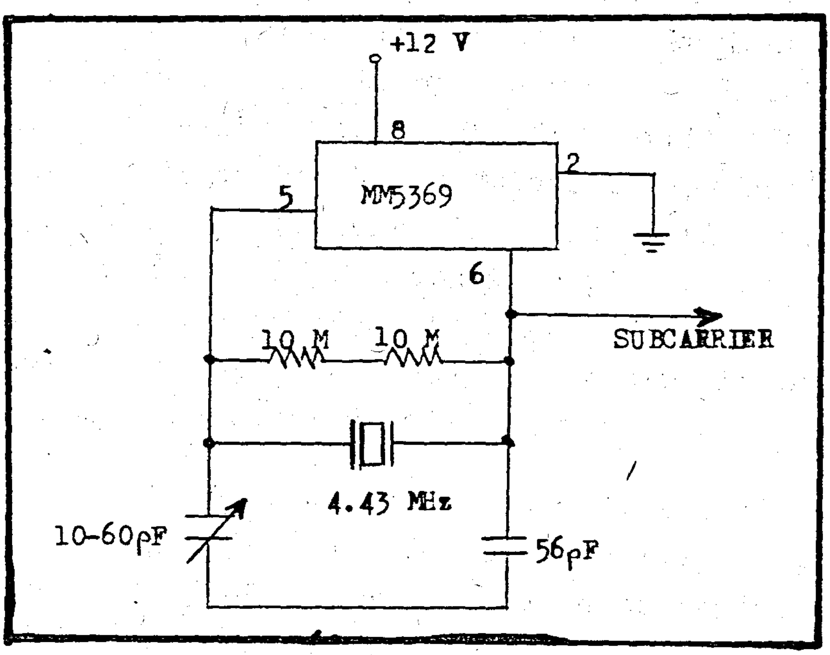


Fig. 7.5

Circuit configuration of crystal oscillator

$$f_{sc}=(284-\frac{1}{4})f_h+\frac{f_v}{2}=(1135\times\frac{f_h}{4})+\frac{f_v}{2}$$

$$=4.43361875 \text{ MHz}$$

where;

$f_h = 15625$ Hz, $f_v = 50$ Hz.

The circuit configuration of crystal oscillator is shown in Fig. 7.5. The crystal, which has a frequency of 4.433618 MHz is connected between the pins 5 and 6 of the integrated circuit MM5369 (17-stage programmable oscillator-divider). The variable capacitor serves to adjust the precise value of output frequency. The operating voltage of the circuit is +12 V and because of the crystal characteristics, the output has a high stability.

Encoder Flag Pulse Generator producer the PAL flag pulse (P) and burst flag pulse (K). Furthermore this unit is used for obtaining the vertical blanking pulse which is necessary for 25 Hz offset unit. The block diagram, indicating the functions of several components designed in this circuit, is shown in Fig. 7.6.

The detailed circuit configuration of encoder flag pulse generator is shown in Fig. 7.7.

The components list used in the circuit of encoder flag pulse generator unit is given below:

I 1 : MC 851 (Monostable multivibrator)
I 2 : SN 7473 (Dual J-K master-slave flip-flop)
I (3,6) : CA 3046 (General purpose transistor arrays)
I (4,11): SN 7402 (Quad 2-input NOR gate)
I (5,7) : SN 7400 (Quad 2-input NAND gate)

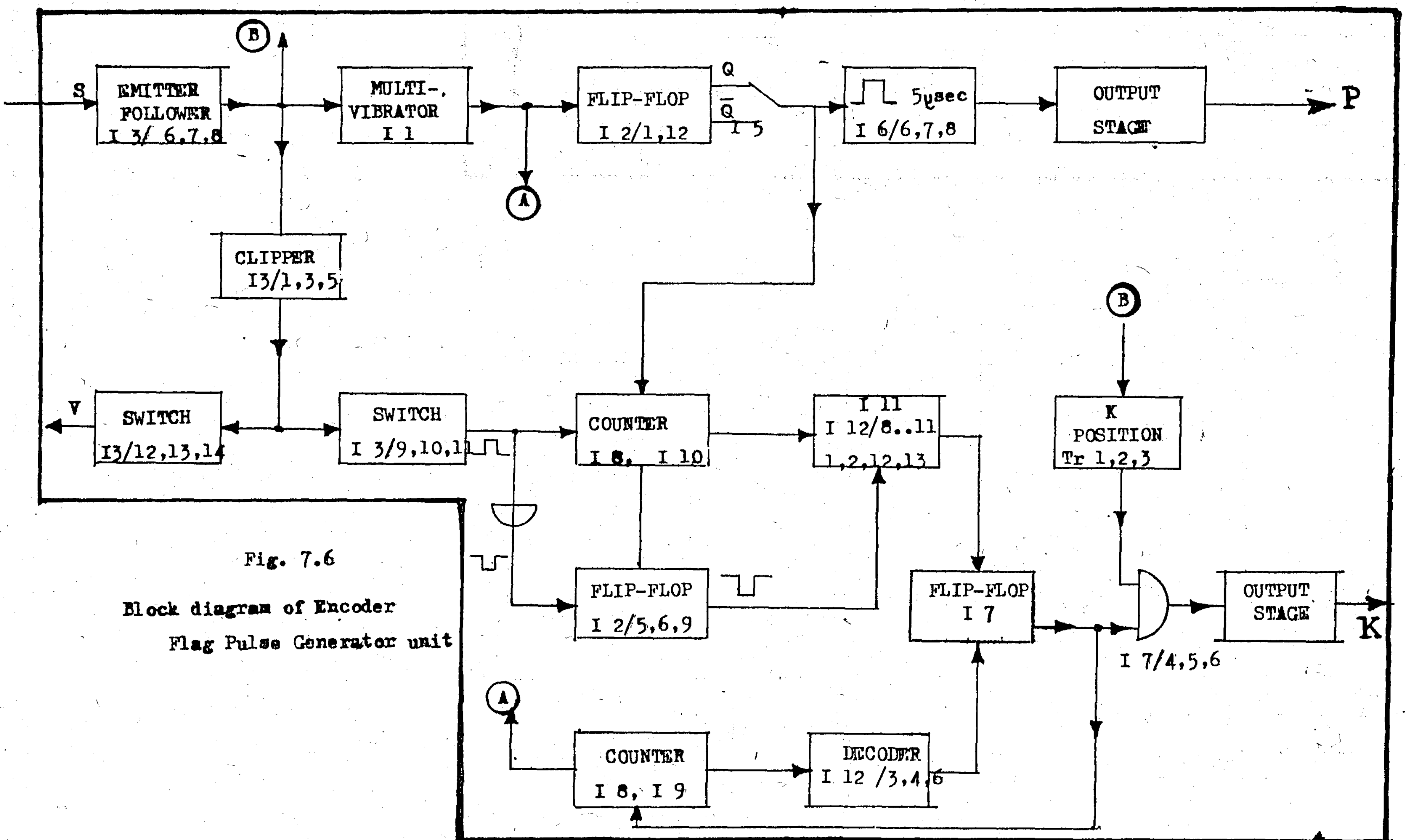


Fig. 7.6

Block diagram of Encoder

Flag Pulse Generator unit

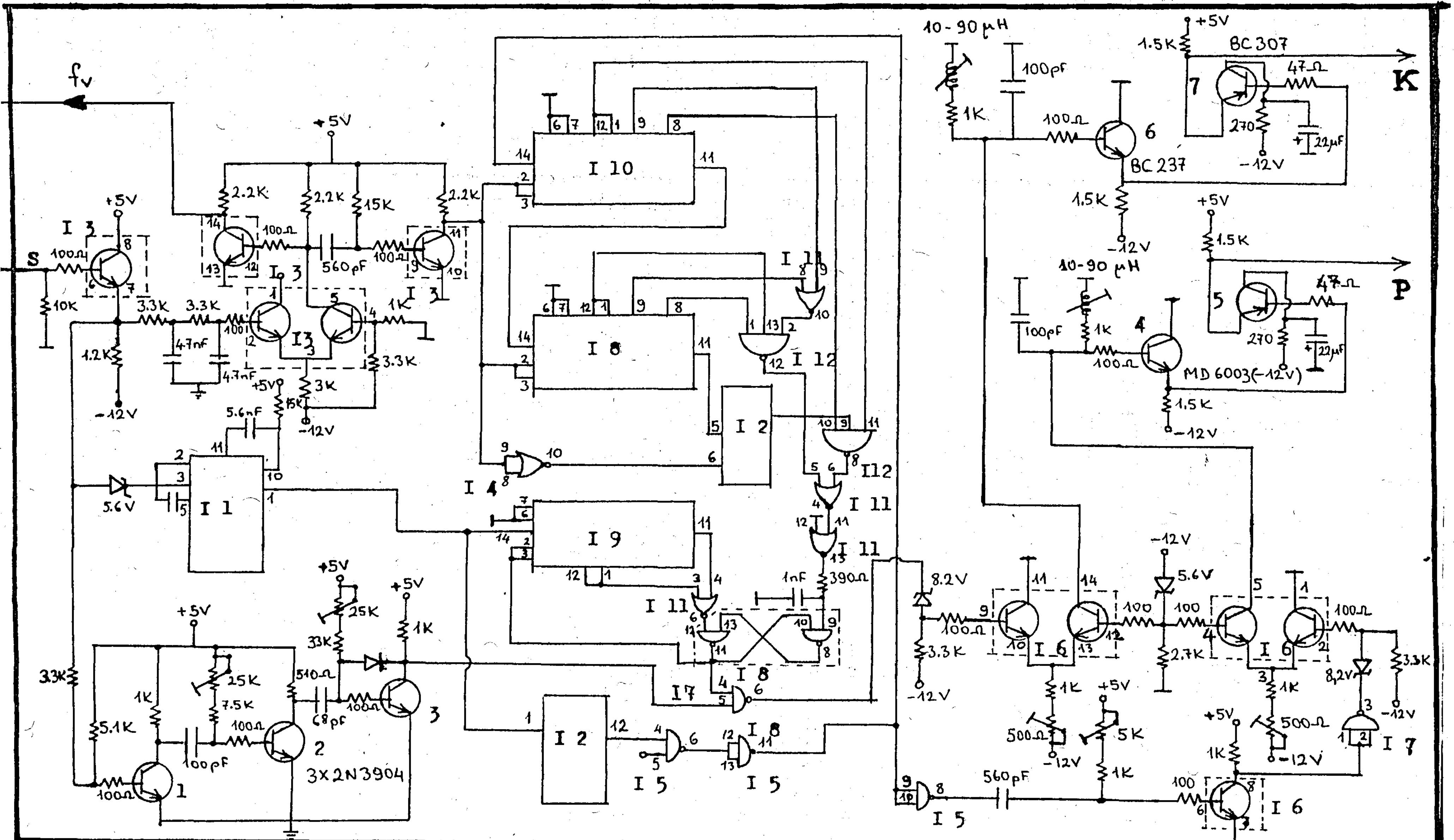


Fig. 7.7 Circuit configuration of Encoder Flag Pulse Generator unit

I (8,9,10)	: SN 7490 (Decade counter)
I 12	: SN 7410 (Triple 3-input NAND gate)
Tr (1,2,3)	: 2N 3904 (NPN silicon, low frequency, low current transistor)
Tr (4,5)	: MD 6003 (NPN-PNP dual transistor)
Tr 6	: BC 237 (NPN silicon AF input and driver stages transistor)
Tr 7	: BC 307 (PNP silicon AF input and driver stages transistor)

Generation of the P Flag Pulse

The P flag pulse consists of a continuous pulse sequence having 2-H frequency (2-H frequency-half the line frequency-78125 Hz). A sync pulse is fed through emitter follower I 3/ 6,7,8 to monostable multivibrator I 1 to suppress H/2 (H/2= 31250 Hz). The H pulse sequence derived by this measure is divided in flip-flop I 2/1,12 into a 2-H pulse sequence. In pulse shaper I 6/6,7,8 the width of the 2-H squarewave pulse is reduced to 5 usec. It is fed to the output through the output stage consisting of a clipper I 6/1,2,3,4,5 and two emitter follower transistors 4 and 5.

Generation of the Burst Flag Pulse K

The K pulse consists of a pulse sequence with H frequency having a blanking which alters during the vertical interval with a four-stroke cycle. The start of the blanking is anticipated by half a line during three fields succeeding one another; during the fourth field it jumps back by 3/2 lines. The horizontal pulse sequence is generated by three pulse shapers connected in series which are supplied with a sync pulse from I 3/6,7,8.

The pulse shapers are provided with controls allowing to adjust the start and the duration of a burst with respect to the sync pulse. The burst pulses as well as the pulses for the vertical blanking are fed to NAND gate I 7/4,5,6 and from there to the clipper I 6/9,10,11,12,13,14. Then, the output pulse of clipper goes to the output stage consisting of the two emitter follower transistors 6 and 7.

Vertical Blanking Pulse

In a double integrating network the vertical pulse is separated from the sync signal coming from I 3/6,7,8. From there it goes through switch I 3/12,13,14 to H/2 oscillator-divider unit and through switch I 3/9,10,11 to the reset inputs of the divide-by-ten counters I 10 and I 8 and to flip-flop I 2/5,6,9. During the 55th 2-H pulse the level at the output of this flip-flop is always different from that existing during the 155th 2-H pulse. By the vertical pulse, which starts shortly after the 155th 2-H pulse, the output is set to a defined logical 0-level.

By means of output Q and both the counters I 10 and I 8, it is possible to decode the 155 through gate I 11, I 12. The pulse derived serves to set flip-flop I 7. This pulse forms the start of the output pulse. Its duration must come up to 9 lines. For this reason the horizontal pulse sequence from I 1 is fed to divide-by-ten counter I 9 and the pulse derived by decoding the 9.(I12) is used to reset flip-flop I 7.

7.4 COLOUR BURST GENERATOR UNIT

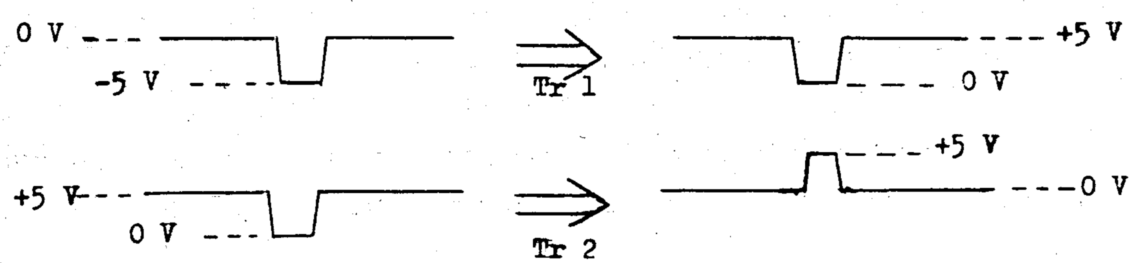
As mentioned earlier, Colour Burst is the portion of the composite colour signal, comprising a few cycles of a sinewave of chrominance subcarrier frequency which is used to establish a reference for demodulating the chrominance signal. In order to obtain the burst signals, the following circuit is designed in such a way that simplicity and reliability is emphasized through the design. The circuit configuration is given in Fig. 7.8.

The components used in the circuit are listed below:

I 1	: TL 74121	(Monostable multivibrator)
I 2	: SN 7400	(Quad 2-input NAND gate)
Tr (1,2,3,4,5):	BC 237	(NPN silicon AF input and driver stages transistor)

As a first step, by unchanging the pulse position, the negative level of sync pulse (0V, -5V) is shifted to the positive level (0V, +5V) with respect to ground line. In order to realize that, transistor 1 is biased so that, in steady state the voltage, existing between emitter and ground is zero. When the sync signal at zero level, the emitter voltage rises to +5 V, whereas when the sync signal at negative level, transistor is at cut off, hence the emitter voltage drops to zero.

Then, the shifted sync pulse is inverted in transistor 2 as shown below:



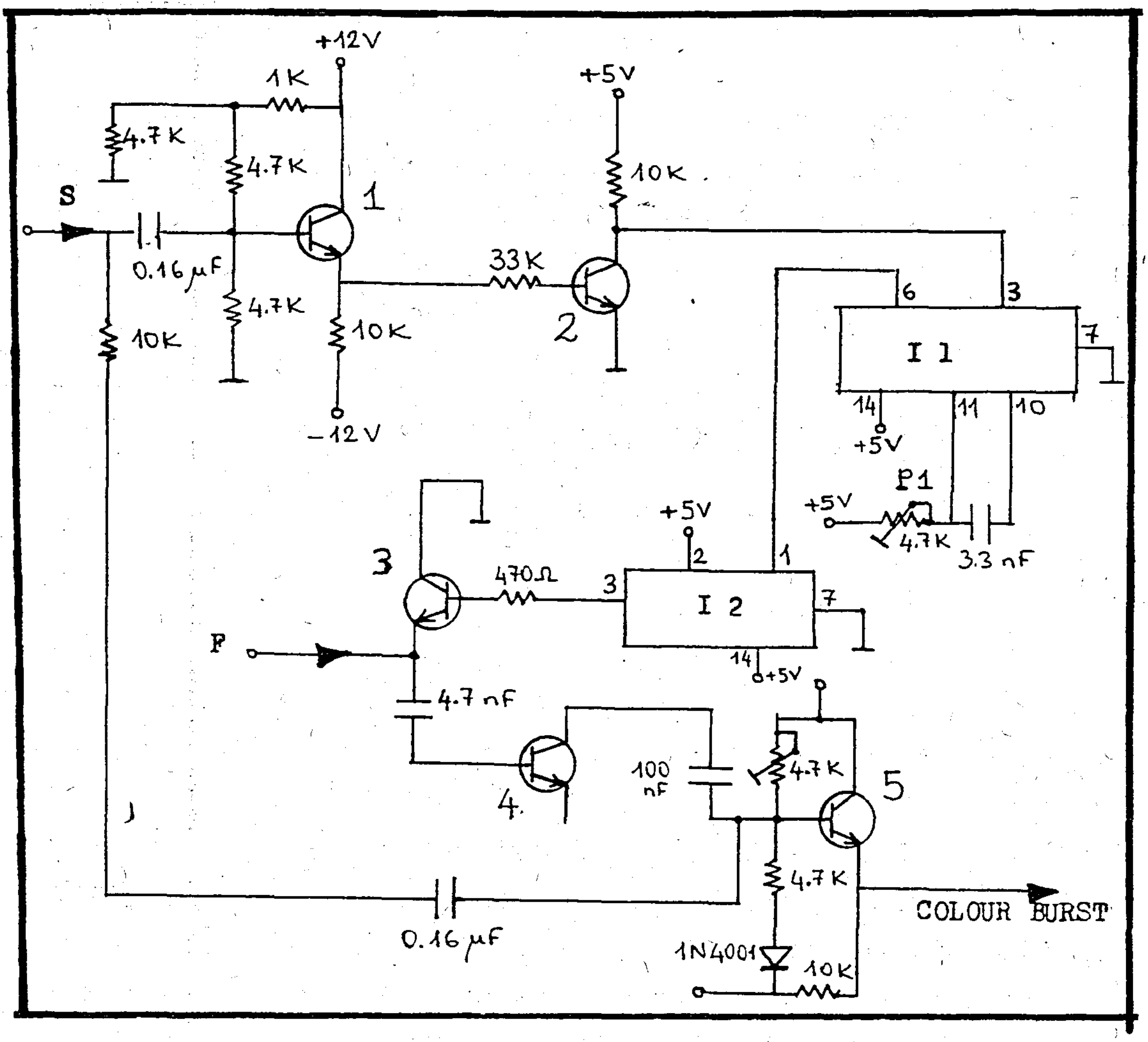
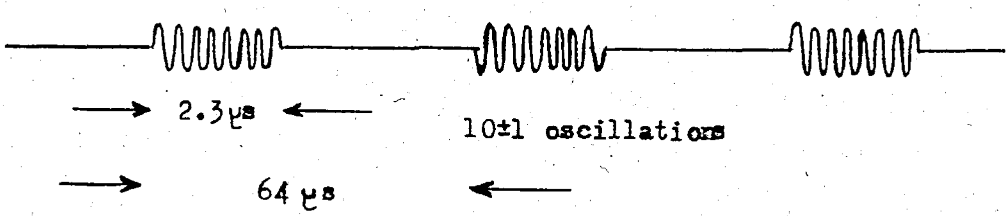


Fig. 7.8

Circuit configuration of Colour Burst Generator unit

The output of Tr 2 is connected to the monostable multivibrator I 1. The outputs of I 1 is given to the first inputs of integrated circuit I 2 . The output of NAND gate reaches the base of switching transistor Tr 3. The duration of the pulses are adjusted by potentiometer P 1 as 2,3 μsec (the width of the burst signal). If the subcarrier frequency -coming from subcarrier generator- is coupled to the emitter of the switching transistor Tr 3,

- the resulting shape of the subcarrier waveform is not a continuous sinewave oscillation but as shown below, it is a waveform consisting of discrete sinusoidal oscillations, which is known as burst.



The period of these repeated oscillations are 64 µsec and each oscillation lasts 2,3 µsec. After generating the burst signals, the second problem is to locate the burst signal on the back porch of sync signal. Transistor 4 is used as a diode for shifting the burst signals to the symmetrical position with respect to ground line. The sync pulse, coming from output stage of horizontal unit is fed to the base of transistor Tr 5 which is used a summing circuit for burst and sync signals. After superposing the two signals, the desired colour burst position is obtained as shown in Fig. 7.9.

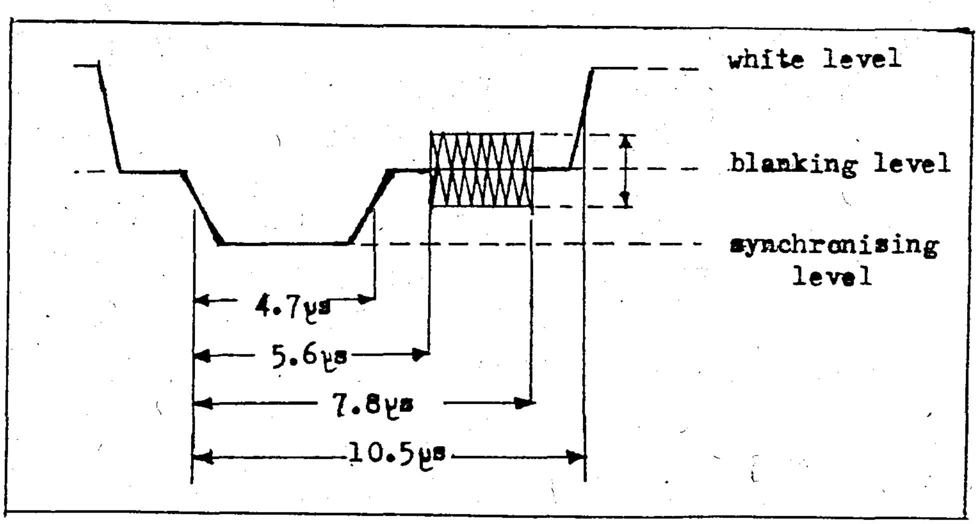


Fig. 7.9

CHAPTER 8

CONCLUSIONS

In this thesis study, a practical colour TV sync pulse generator which conforms to the standards of Turkey (625-line, 50 Hz) and operates according to the PAL colour TV system, has been realized. As pointed out earlier, sync pulse generator which is one of the most important parts of the television transmitter system provides the process of synchronisation between the transmitter and receiver.

If the synchronisation can not be done exactly, (i.e., if the successive field information can not be located into the desired place) a clear picture can not be obtained on the screen, and instead only the dark and bright spots are seen randomly.

In order to realize the synchronisation, line and field synchronisation pulses are placed on the blanking pulses of the video signal. Line and field synchronisation pulses indicate the beginning of a new line or field on the screen, being separated from the video signal in the receiver, they are used to control the average frequency of scanning networks oscillators which give the sawtooth current to the deflection coils.

The synchronisation pulses can not be seen on the picture tube screen since they are found in a place which is darker than black on the video signal. All the pulses which provide the synchronisation process and colour conformity, are produced by sync pulse generator in the television studios. So, it is clear that this device has much importance as far as broadcasting quality is concerned.

In this thesis, generally,the structure and properties of transmitter systems were emphasized. The characteristics of receivers were not mentioned. The study of thesis consists of two main parts: In the first part (chapters 1-5), there are general theoretical information about PAL colour TV and its basic signals, and in the second part (chapters 6-8), instrumentation and conclusions were given. In the theory section, much importance was placed on the PAL colour TV which is accepted in Turkey and a brief comparison was made with NTSC and SECAM systems. More detailed sources about these systems can be found in the references part.

The units which produce the required signals for colour TV system were designed according to the characteristics of PAL system and it was observed that, all the results which were seen on the oscilloscope were the same as the theoretical values.

In general, TTL logic gates were used in the circuit designs and in necessary places various transistors, diodes and coils were used. Some of the components which are much necessary for designing the circuits of device (4.43 MHz crystal etc.) were not available in Turkey so they had to be brought from abroad.

All the results were quite satisfactory, both in performance and display quality. This sync pulse generator was designed to be a demonstration instrument in the laboratory and thus the subject of colour television and synchronisation process was aimed to be better understood.

As a result, the colour TV sync pulse generator which is realized practically in this thesis study, may not be a perfect device to be used in a TV studio for direct broadcasting, but it is a much useful teaching device because of the many characteristics it possesses.

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