Video Engineering (EC0605)
Unit-3
B.Tech (Electronics and Communication)
Semester-VI

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Colour Signal Transmission and Reception

Television Signal Propagation

- Radio waves are electromagnetic waves, which when radiated from transmitting antennas, travel through space to distant places, where they are picked up by receiving antennas. Although space is the medium through which electromagnetic waves are propagated, but depending on their wavelengths, there are three distinctive methods by which propagation takes place. These are:

(a) ground wave or surface wave propagation

(b) Sky wave propagation

(c) space wave propagation.

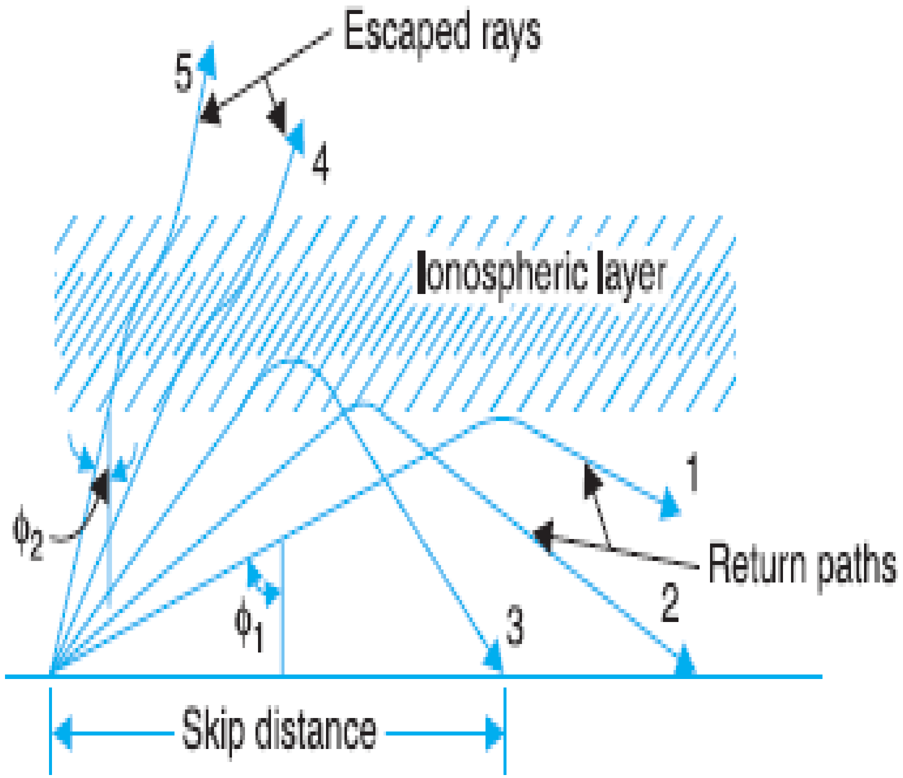
(a) Ground Wave Propagation

- Vertically polarized electromagnetic waves radiated at zero or small angles with ground, are guided by the conducting surface of the ground, along which they are propagated. Such waves are called ground or surface waves. The attenuation of ground waves, as they travel along the surface of the earth is proportional to frequency, and is reasonably low below 1500 kHz

(b) Sky Wave Propagation

- Ground wave propagation, above about 1600 kHz does not serve any useful purpose as the signal gets very much attenuated within a short distance of its transmission
- Therefore, most radio communication in short wave bands up to 30 MHz (11 metres) is carried out by sky waves. When such waves are transmitted high up in the sky, they travel in a straight line until the ionosphere is reached. This region which begins about 120 km above the surface of the earth, contains large concentrations of charged gaseous ions, free electrons and neutral molecules
- The ions and free electrons tend to bend all passing electromagnetic waves. The angle by which the wave deviates from its straight path depends on
  - *Frequency of the radio* wave
  - *Angle of incidence at which the wave enters the ionosphere*
  - *Density of the charged* particles in the ionosphere at the particular moment
  - *Thickness of the ionosphere at* the point

Ray paths for different angles of incidence (ϕ) at the ionosphere.

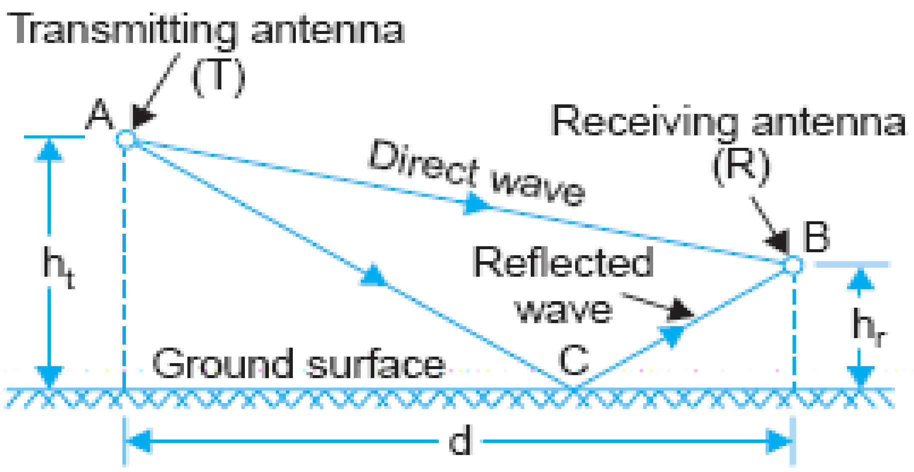


(c) Space Wave Propagation

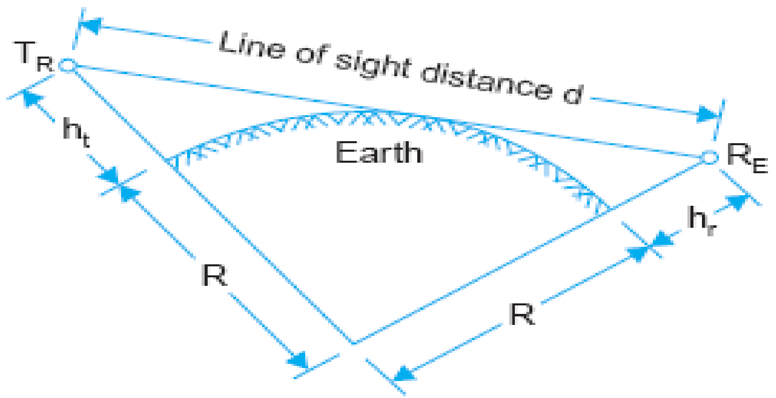
- As explained above, propagation of radio waves above about 40 MHz (which is the beginning of television transmission band) is not possible through either surface or sky wave propagation

- Thus, the only alternative for transmission in the VHF and UHF bands, despite large attenuation, is by radio waves which travel in a straight line from transmitter to receiver. This is known as space wave propagation. Its maximum range, because of the nature of propagation, is limited to the line of sight distance between the transmitter and receiver

- For not too large distances, the surface of the earth can be assumed to be flat and different rays of wave propagation can reach the receiver from transmitter as shown in Figure



Space wave propagation



Computation of line-of-sight

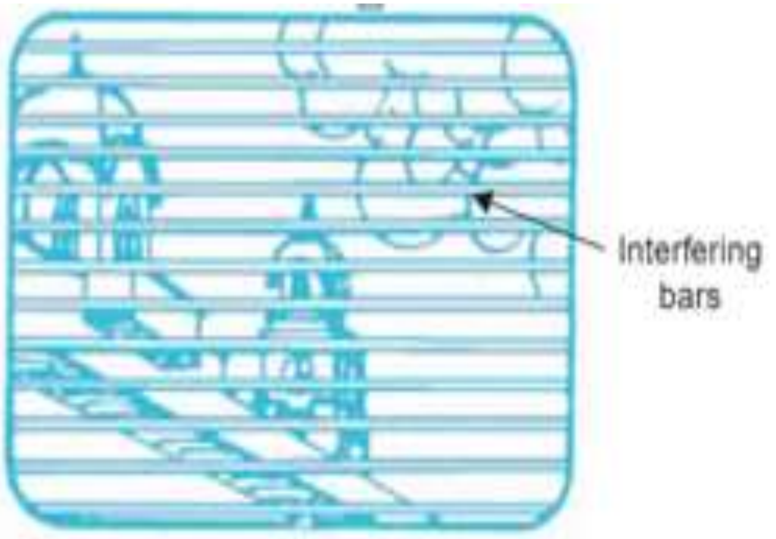
$$E^* = \frac{4\pi f h_t h_r}{d^2} \; E_0$$

- where *Eo is the field strength at unit distance from the transmitter, and f is the frequency of* the transmitted signal. The field strength varies inversely as the square of the distance between the two antennas but is directly proportional to their heights

Interference suffered by TV signals

(a) Co-channel Interference

- Two stations operating at the same carrier frequency, if located close by, will interfere with each other. This phenomenon which is common in fringe areas is called co-channel interference
- As the two signal strengths in any area almost equidistant from the two co-channel stations become equal, a phenomenon known as 'venetian-blind' interference occurs

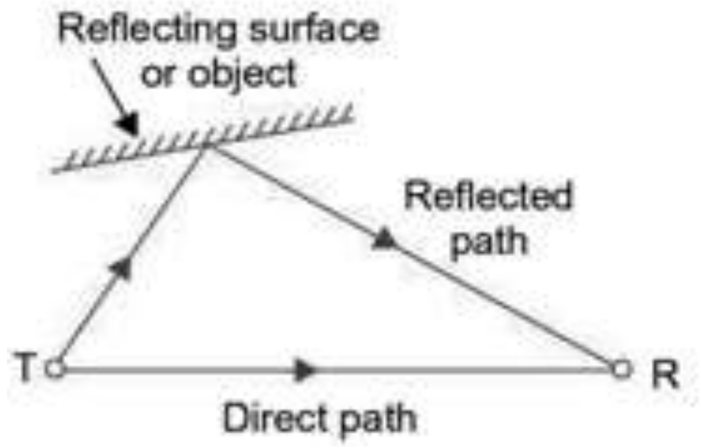


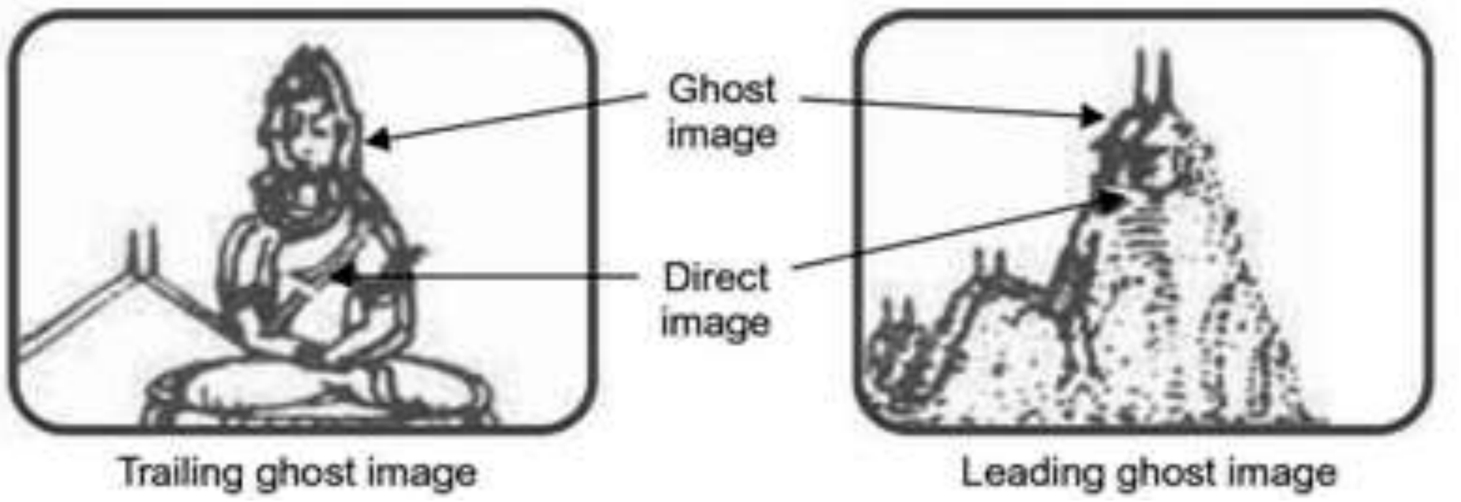
(b) Adjacent Channel Interference

- Adjacent channel interference may occur as a result of beats between any two of these frequencies or between a carrier and any sidebands

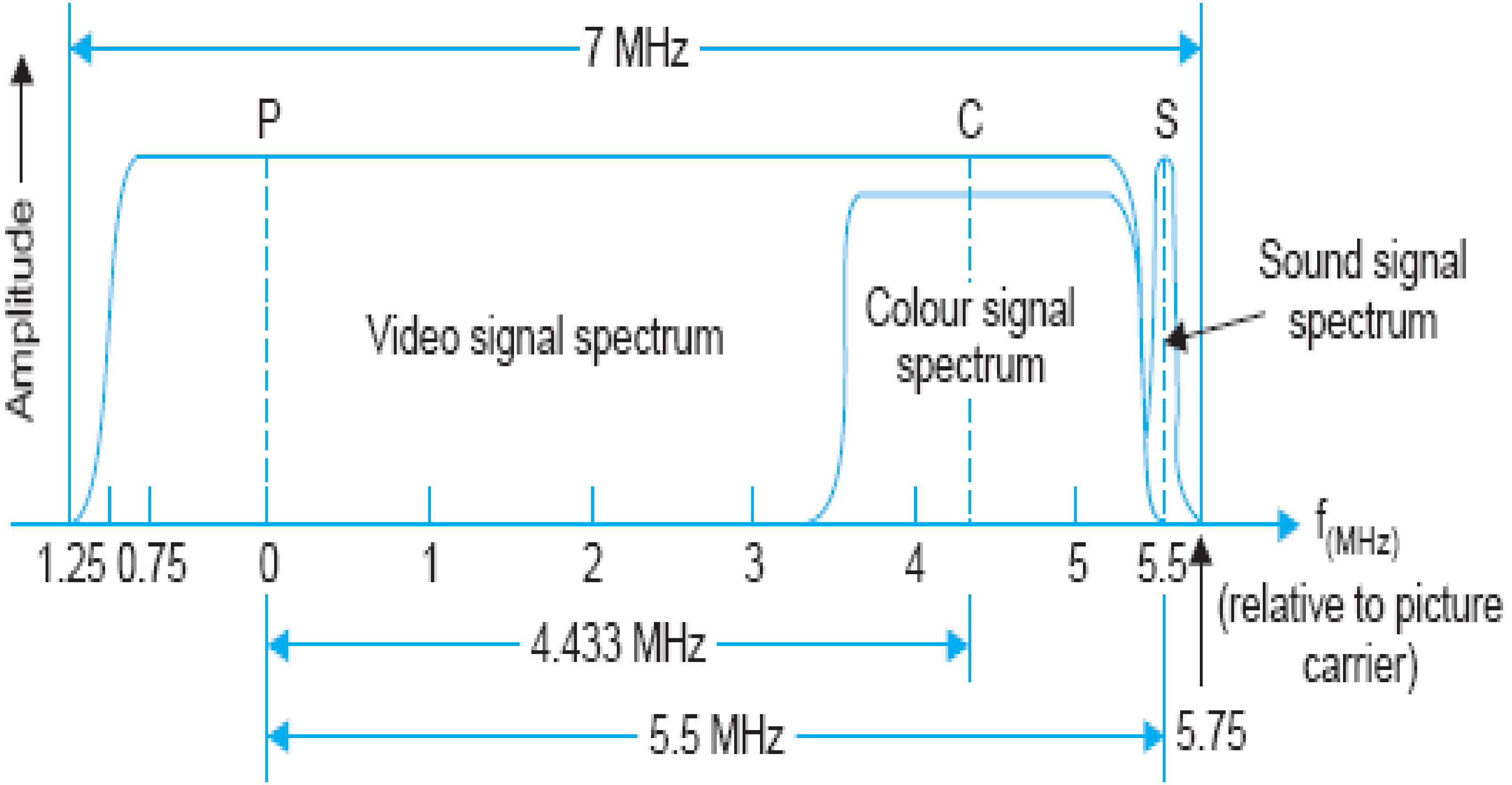
(c) Ghost Interference:

- Its arises as a result of discrete reflections of the signal from the surface of buildings, bridges, hills, towers ect





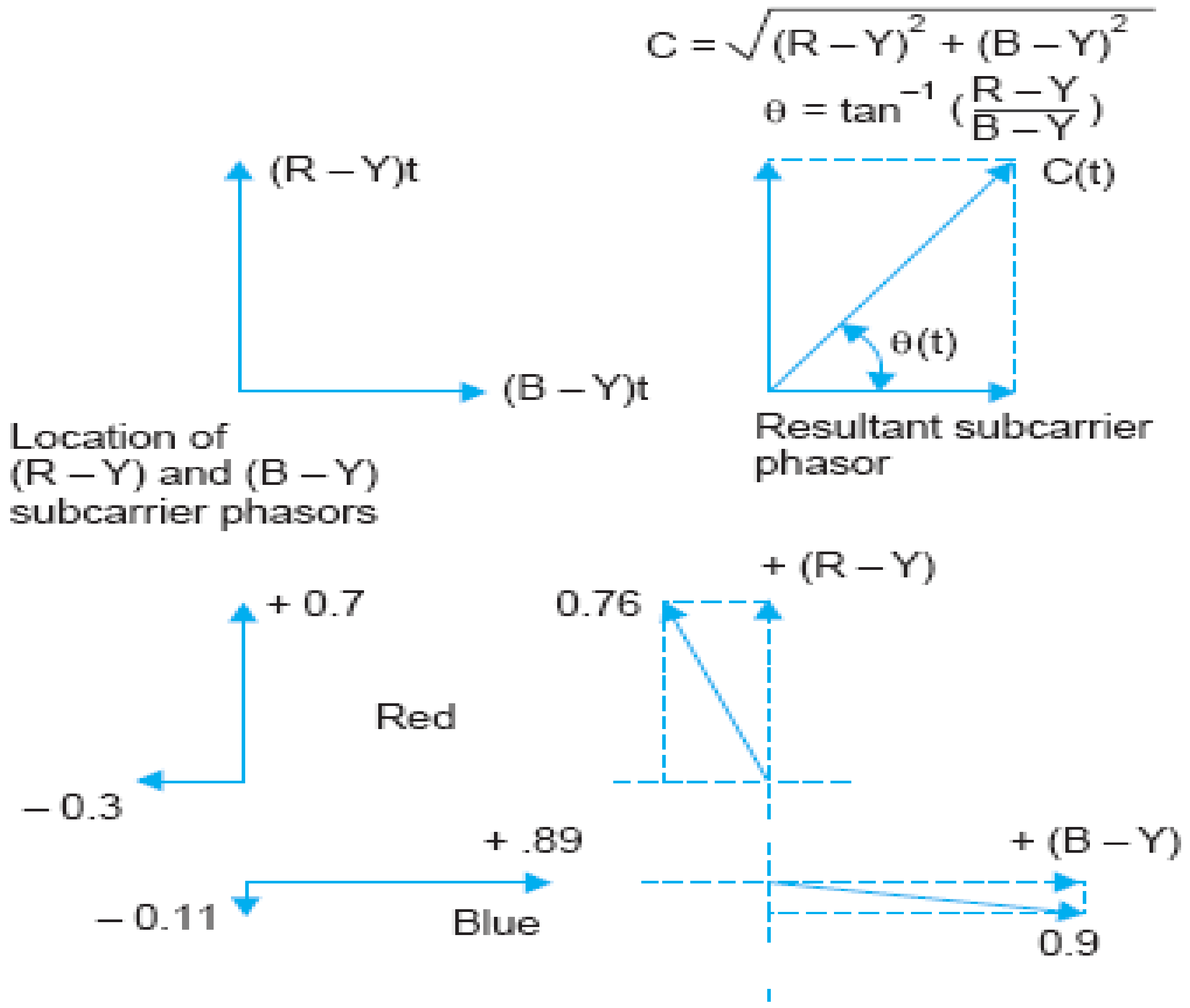
CHANNEL BANDWIDTH FOR COLOUR TRANSMISSION



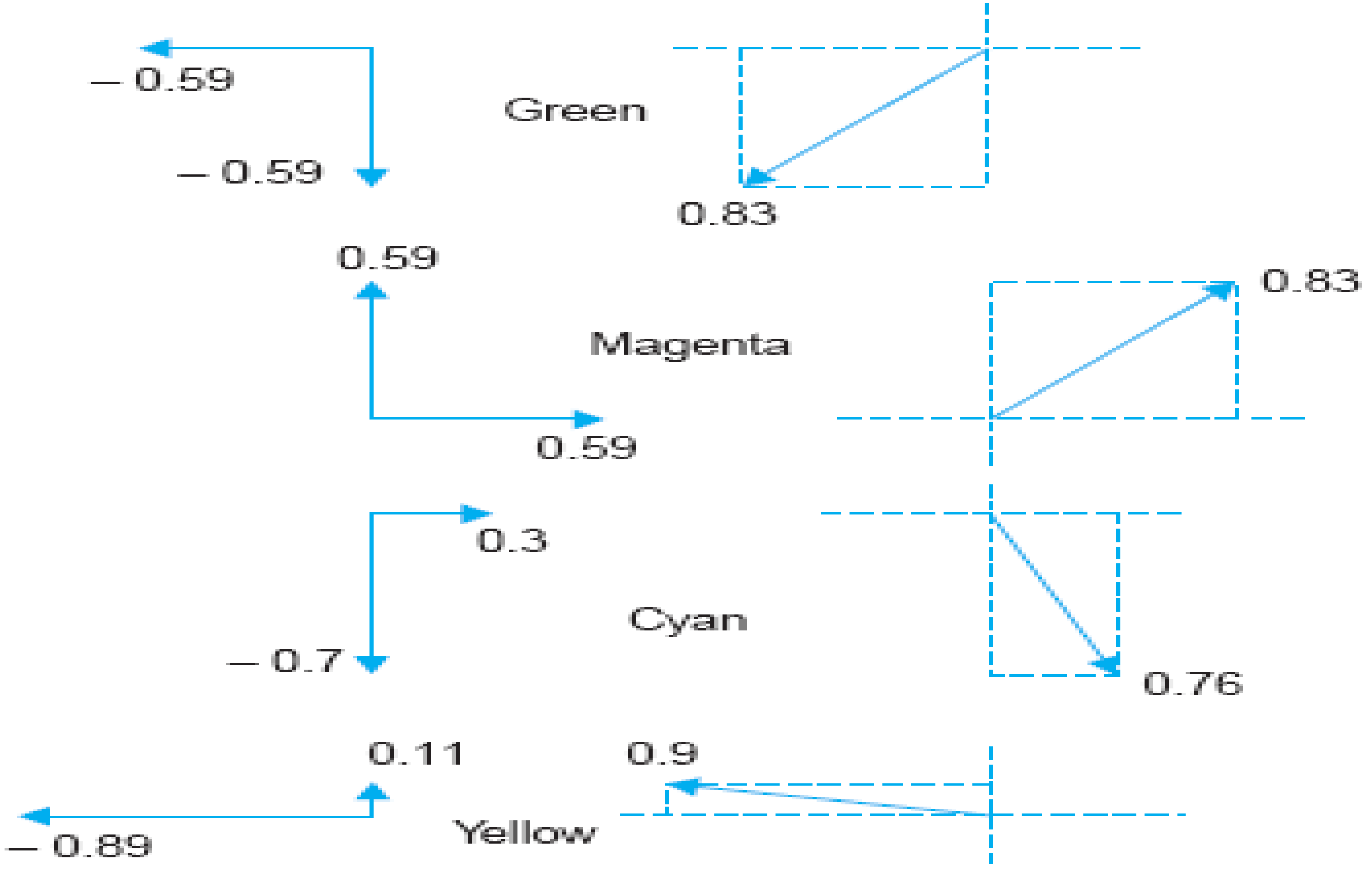
- TV pictures the colour video signal does not extend beyond about 1.5 MHz. Therefore, the colour information can be transmitted with a restricted bandwidth much less than 5 MHz. This feature allows the narrow band chrominance (colour) signal to be multiplexed with the wideband luminance (brightness) signal in the standard 7 MHz television channel. This is achieved by modulating the colour signal with a carrier frequency which lies within the normal channel bandwidth. This is called colour subcarrier frequency and is located towards the upper edge of the video frequencies to avoid interference with the monochrome signal
- In the PAL colour system which is compatible with the C.C.I.R. 625 line monochrome system the colour subcarrier frequency is located 4.433 MHz way from the picture carrier. The bandwidth of colour signals is restricted to about ± 1.2 MHz around the subcarrier

MODULATION OF COLOUR DIFFERENCE SIGNALS

- The problem of transmitting (B-Y) and (R-Y) video signals simultaneously with one carrier frequency is solved by creating two carrier frequencies from the same colour subcarrier without any change in its numerical value. Two separate modulators are used, one for the (B-Y) and the other for the (R-Y) signal. However, the carrier frequency fed to one modulator is given a relative phase shift of 90° with respect to the other before applying it to the modulator
- Thus, the two equal subcarrier frequencies which are obtained from a common generator are said to be in quadrature and the method of modulation is known as quadrature modulation



C = √((R – Y)² + (B – Y)²)
θ = tan⁻¹ ((R – Y)/(B – Y))
(R – Y)t
(B – Y)t
C(t)
θ(t)
Location of
(R – Y) and (B – Y)
subcarrier phasors
Resultant subcarrier
phasor
+ (R – Y)
+ 0.7
0.76
Red
– 0.3
+ .89
+ (B – Y)
– 0.11
Blue
0.9



Quadrature amplitude modulated colour difference signals and the position of resultant subcarrier phasor for the primary and complementary colours.

- After modulation the two outputs are combined to yield C, the resultant subcarrier phasor. Since the amplitude of C, the chrominance signal, corresponds to the magnitudes of colour difference signals, its instantaneous value represents colour saturation at that instant. Maximum amplitude corresponds to greatest saturation and zero amplitude to no saturation i.e. white
- Similarly, the instantaneous value of the C phasor angle (θ) which may vary from 0° to 360° represents hue of the colour at that moment. Thus the chrominance signal contains full information about saturation and hue of various colours

Example

- It would be necessary to first express (R-Y) and (B-Y) in terms of the three camera output voltages. This is done by substituting
- Y = 0.59G + 0.3R + 0.11B in these expressions. Thus (R-Y) becomes
- R – 0.59G – 0.3R – 0.11B
- R = 0.7R – 0.59G – 0.11B
- Similarly, (B-Y) becomes
- B – 0.59G – 0.3R – 0.11B
- B = 0.89B – 0.59G– 0.3R

Example for pure red

- Now suppose that only pure red colour is being scanned by the colour camera. This would result in an output from the red camera only, while the green and blue outputs will be zero
- Therefore, (R-Y) signal will become simply + 0.7R and (B-Y) signal will be reduced to – 0.3R
- The resultant location of the subcarrier phasor after modulation is illustrated in Fig

  Note that the resultant phasor is counter clockwise to the position of

  + (R-Y) phasor

Example for pure blue

- Next consider that the colour camera scans a pure blue colour scene.
- This yields (R-Y)= – 0.11B and (B-Y) = 0.89 B. The resultant phasor for this colour lags + (B-Y) vector by a small angle.
- Similarly the location and magnitude for any colour can be found out

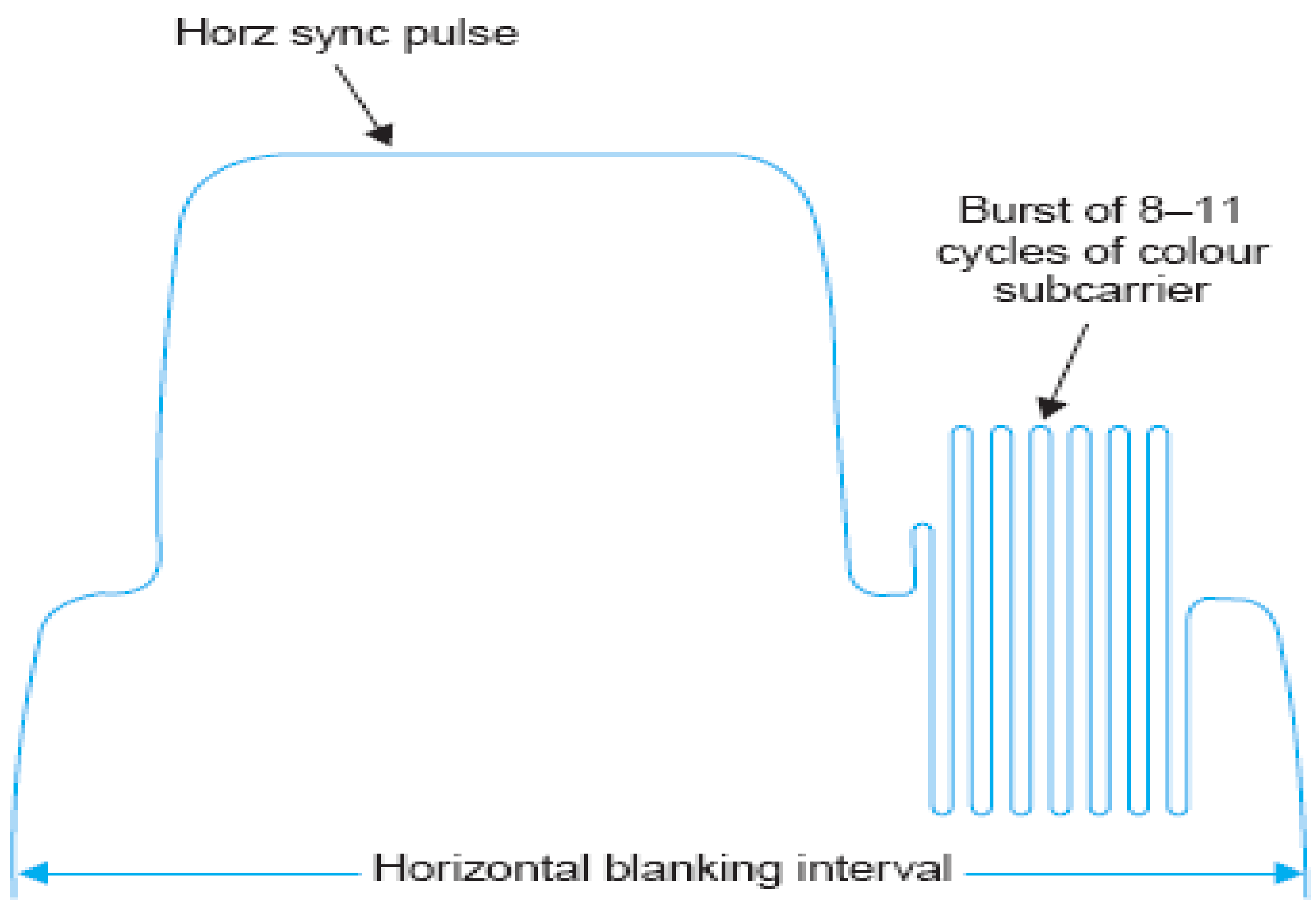
- Another point that needs attention is the effect of desaturation on the colour phasor
- Since desaturation results in reduction of the amplitudes of both (B-Y) and (R-Y) phasors, the resultant chrominance phasor accordingly changes its magnitude depending on the degree of desaturation. Thus any change in the purity of a colour is indicated by a change in the magnitude of the resultant subcarrier phasor

Colour Burst Signal

- Suppressed carrier double sideband working is the normal practice for modulating colour difference signals with the colour subcarrier frequency. This is achieved by employing balanced modulators. The carrier is suppressed to minimize interference produced by the chrominance signals both on monochrome receivers when they are receiving colour transmissions and in the luminance channel of colour receivers themselves

- However, even at 100% modulation two-thirds of the total power is in the carrier and only one-third is the useful sideband power. Thus suppressing the carrier clearly eliminates the main potential source of interference. In addition of this, the colour-difference signals which constitute the modulating information are zero when the picture detail is non-coloured(*i.e., grey, black or* white shades) and so at such times the sidebands also disappear leaving no chrominance component in the video signal
- The transmitted does not contain the subcarrier frequency but it is necessary to generate it in the receiver with correct frequency and phase relationship for proper detection of the colour sidebands. To ensure this, a short sample of the subcarrier oscillator, (8 to 11 cycles) called the ‘colour burst’ is sent to the receiver along with sync signals

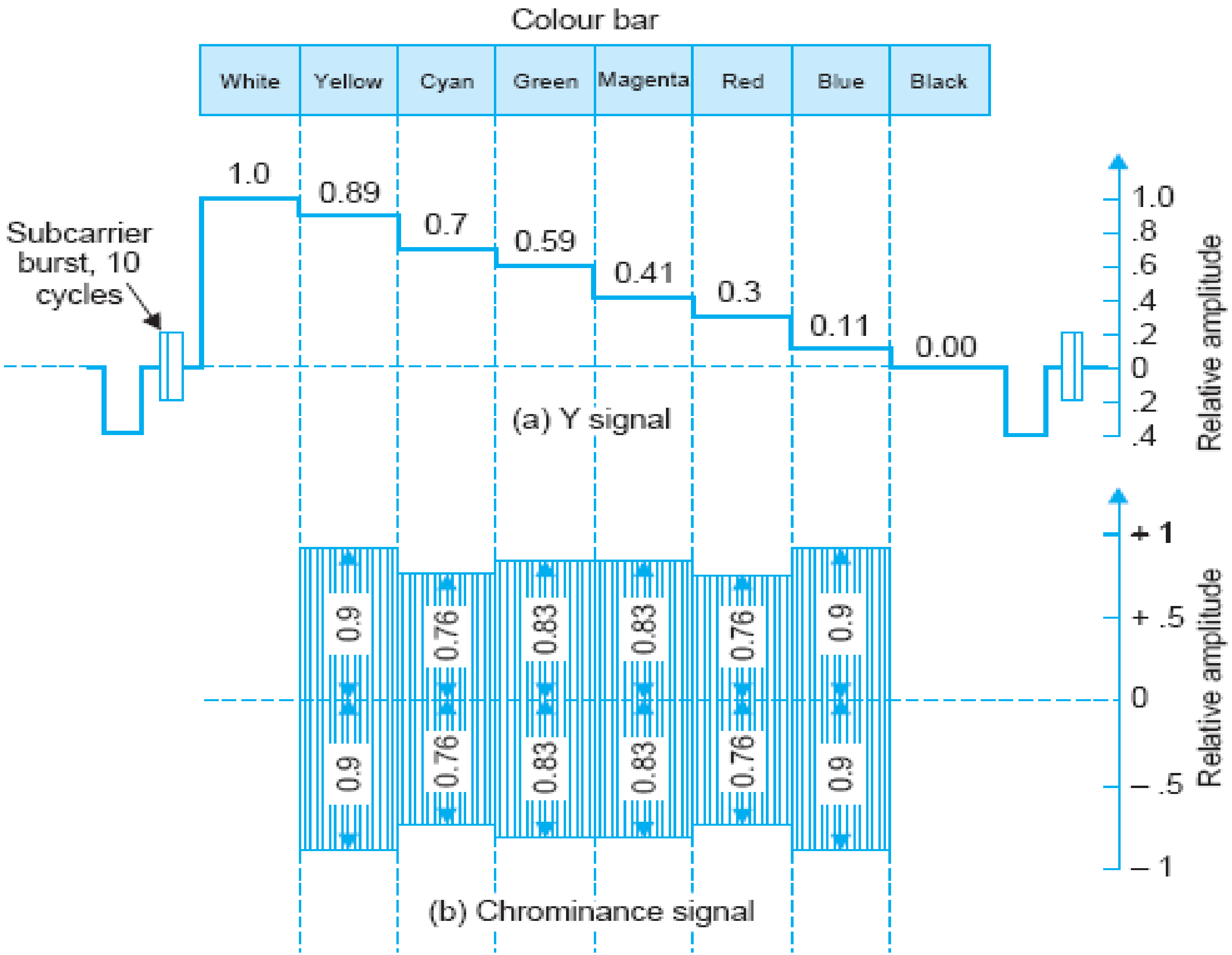
Colour Burst



WEIGHTING FACTORS

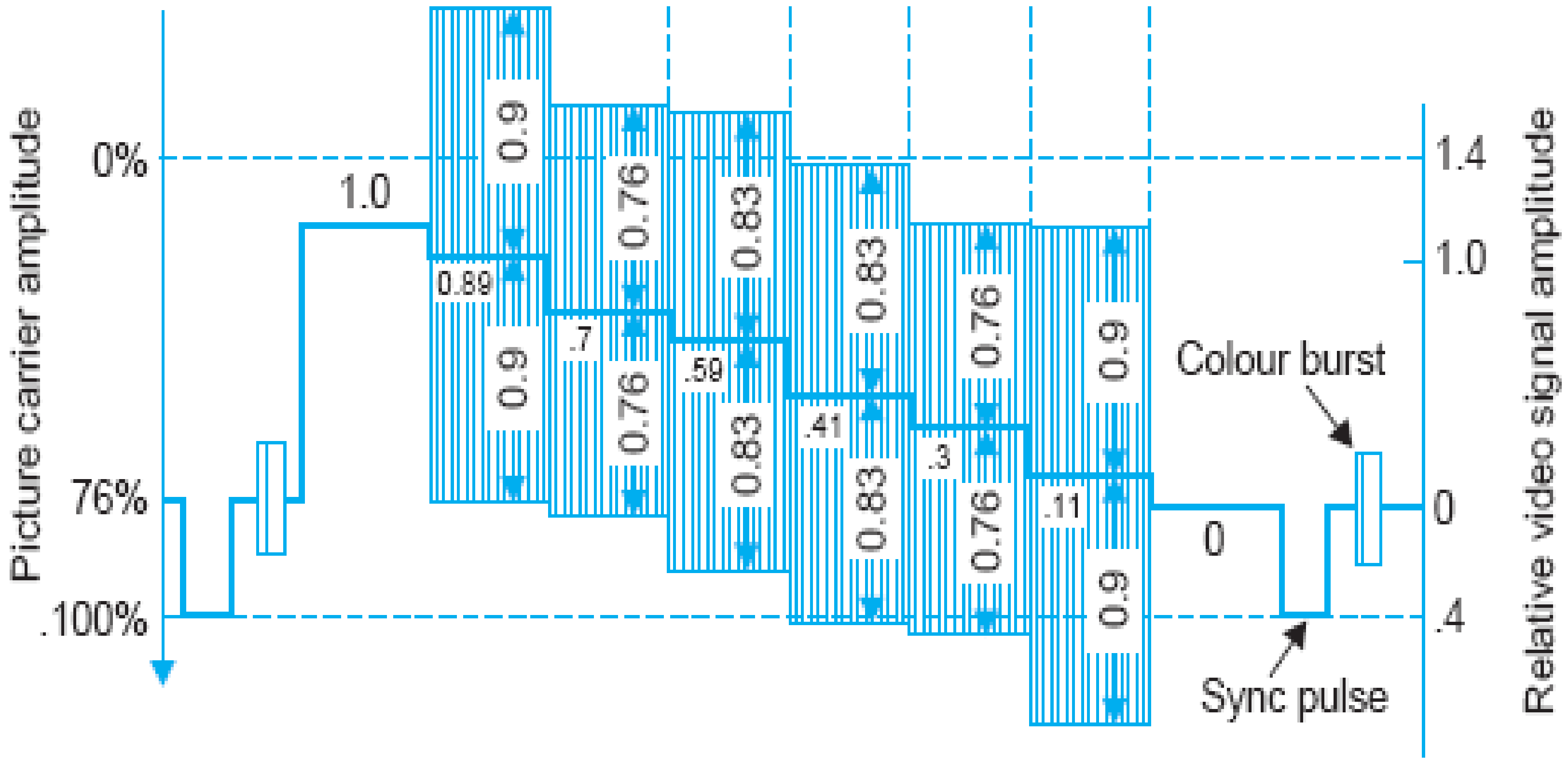
- The resultant chrominance signal phasor (C) is added to the luminance signal (Y) before modulating it with the channel carrier for transmission. The amplitude, i.e., level line of Y signal becomes the zero line for this purpose. Such an addition is illustrated in Fig. for a theoretical 100 percent saturated, 100 percent amplitude colour bar signal. The peak-to-peak amplitude of green signal (± 0.83) gets added to the corresponding luminance amplitude of 0.59. For the red signal the chrominance amplitude of ± 0.76 adds to its brightness of 0.3
- Similarly other colours add to their corresponding luminance values to form the chroma signal
- However, observe that it is not practicable to transmit this chroma waveform because the signal peaks would exceed the limits of 100 percent modulation

- This means that on modulation with the picture carrier some of the colour signal amplitudes would exceed the limits of maximum sync tips on one side and white level on the other. For example, in the case of magenta signal, the chrominance value of ± 0.83 when added to its luminance amplitude of 0.41 exceeds the limits of 100 percent modulation of both white and black levels. Similarly blue signal amplitude greatly exceeds the black level and will cause a high degree of over modulation.



Colour bar
White
Yellow
Cyan
Green
Magenta
Red
Blue
Black
1.0
0.89
0.7
0.59
0.41
0.3
0.11
0.00
Subcarrier burst, 10 cycles
(a) Y signal
1.0
.8
.6
.4
.2
0
.2
.4
Relative amplitude
0.9
0.76
0.83
0.83
0.76
0.9
0.9
0.76
0.83
0.83
0.76
0.9
+ 1
+ .5
0
– .5
– 1
Relative amplitude
(b) Chrominance signal

Generation of composite colour signal for a theoretical 100% saturated, 100% amplitude colour bar signal



(c) Composite colour signal (a - b)

- If over modulation is permitted the reproduced colours will get objectionably distorted
- Therefore, to avoid over modulation on 100 percent saturation colour values, it is necessary to reduce the amplitude of colour difference video signal before modulating them with the colour subcarrier. Accordingly, both (R–Y) and (B–Y) components of the colour video signal are scaled down by multiplying them with what are known as ‘weighting factors’. Those used are 0.877 for the (R–Y) component and 0.493 for the (B–Y) component

- The compensated values are obtained by using potentiometers at the outputs of (R–Y) and (B–Y) adders
- Note that no reduction is made in the amplitude of Y signal. It may also be noted that since the transmitter radiates weighted chrominance signal values, these must be increased to the uncompensated values at the colour TV receiver for proper reproduction of different hues.
- This is carried out by adjusting gains of the colour difference signal amplifiers. The un weighted and weighted values of colour difference signals are given below in Table

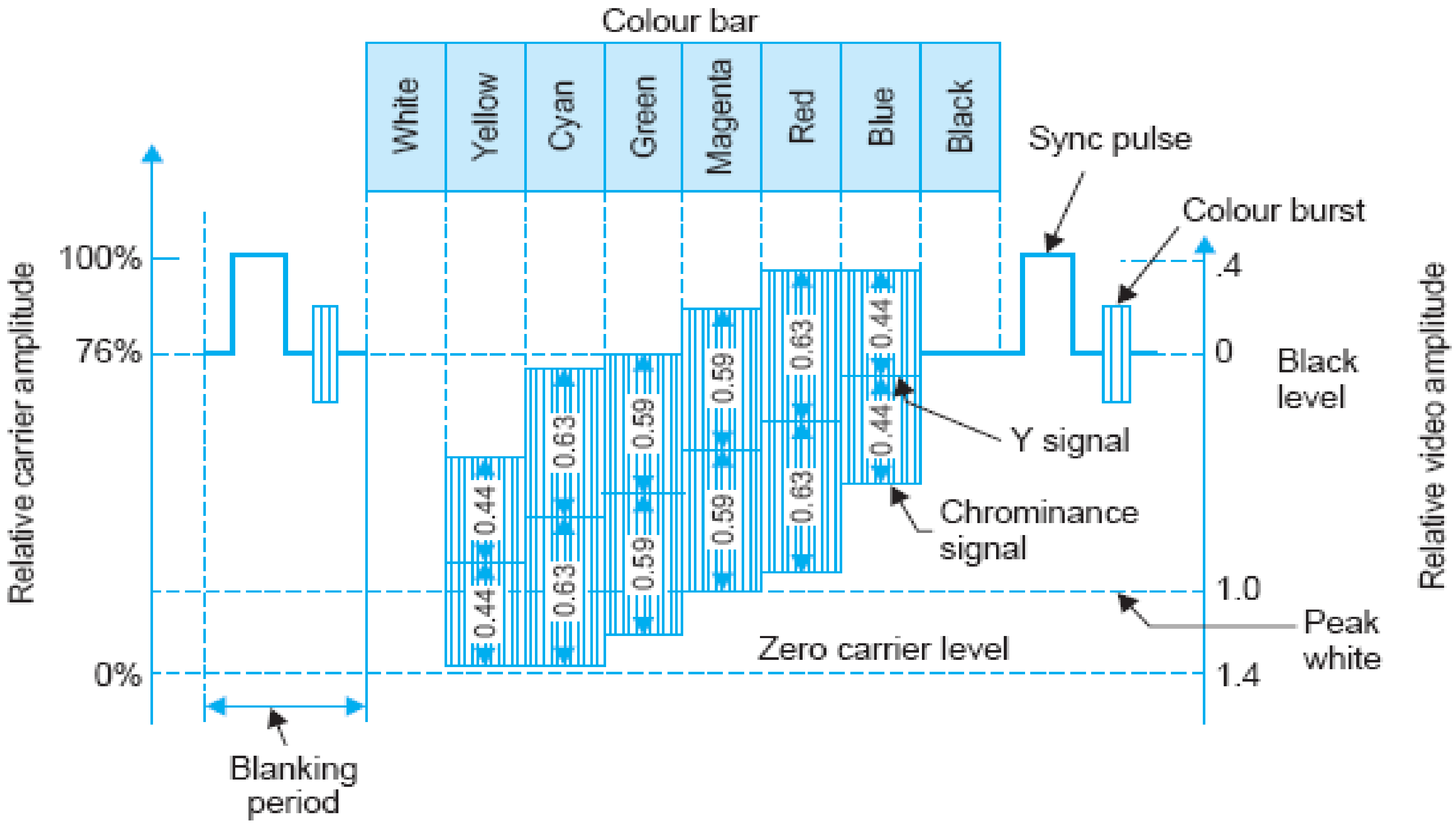
Colour	Luminance signal (λ)	B – Y	R – Y	G – Y	C_{SC}	B – Y	R – Y	C_{SC}
		Unweighted				Weighted		
White	1	0	0	0	0	0	0	0
Yellow	0.89	–.89	+.11	+.11	.9	–.4385	+.096	0.44
Cyan	0.7	+.3	–.7	+.3	.76	+.148	–.614	0.63
Green	0.59	–.59	–.59	+.41	.83	–.29	–.517	0.59
Magenta	0.41	+.59	+.59	–.41	.83	+.29	+.517	0.59
Red	0.3	–.3	+.7	–.3	.76	–.148	+.614	0.63
Blue	0.11	+.89	–.11	–.11	.9	+.4388	–.096	0.44
Black	0	0	0	0	0	0	0	0

$$C_{SC} = \sqrt{(B - Y)^2 + (R - Y)^2}$$

$(B - Y)$ weighted = 0.493 $(B - Y)$ unweighted

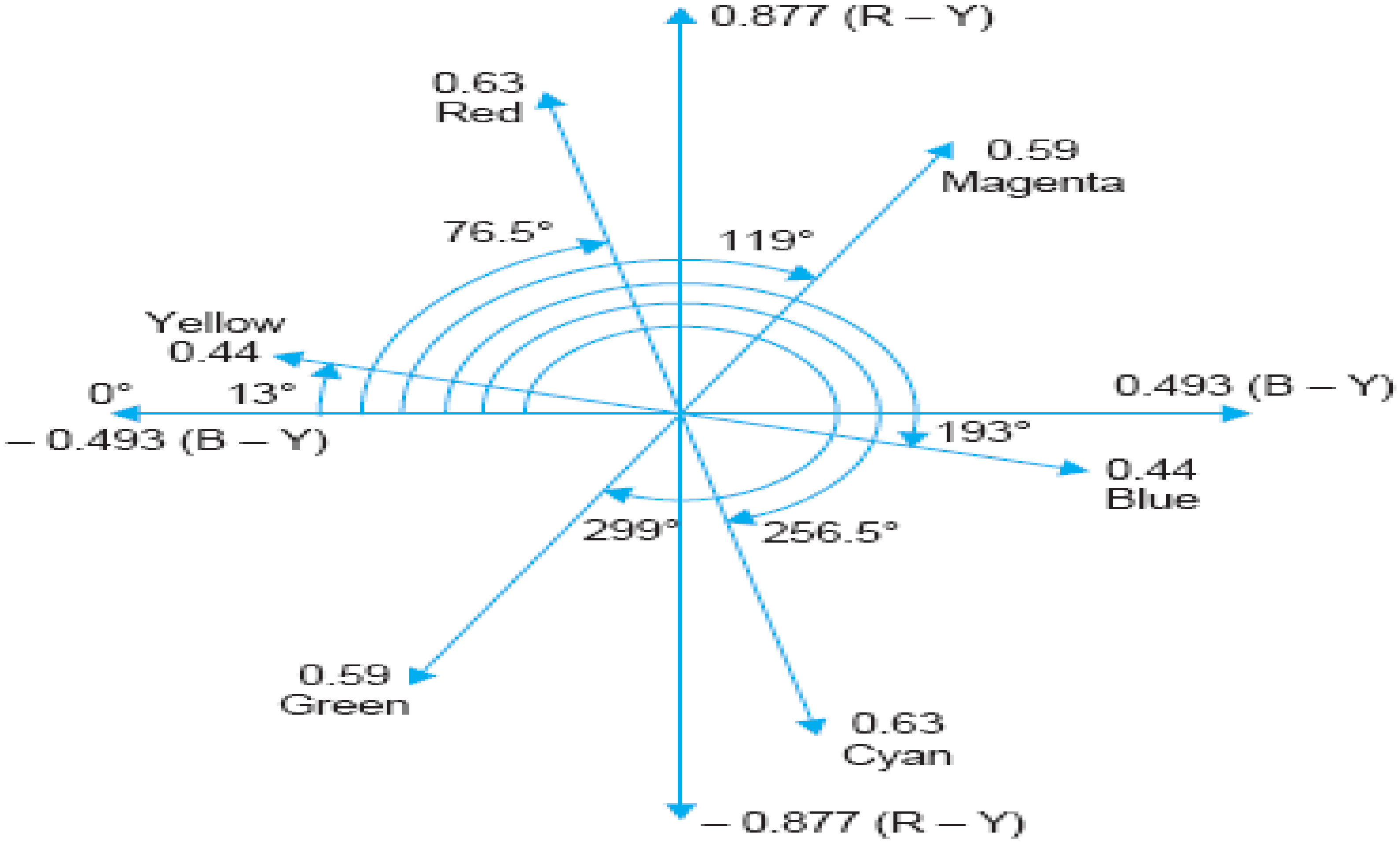
$(R - Y)$ weighted = 0.877 $(R - Y)$ unweighted

Formation of the Chrominance Signal

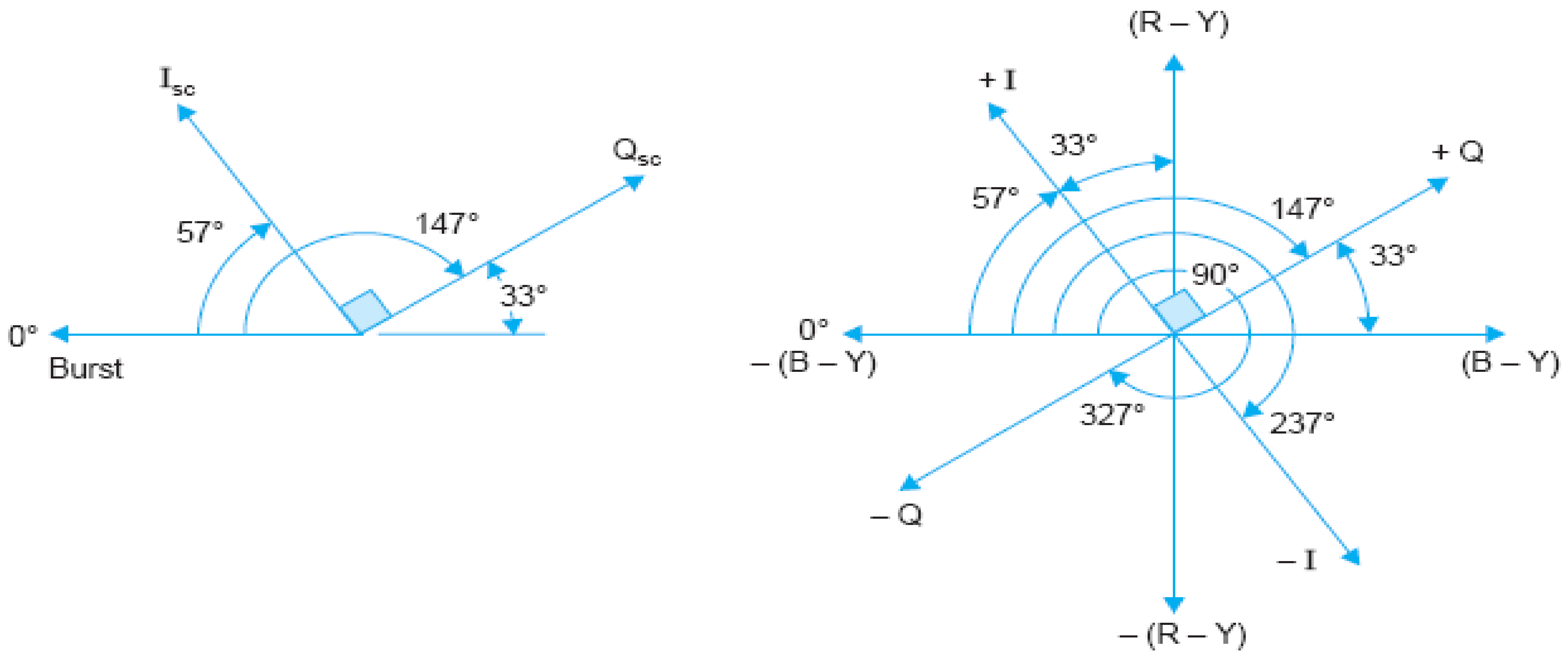


100% saturated, 100% amplitude colour-bar signal in which the colour difference signals are reduced by weighting factors to restrict the chrominance signal excursions to 33% beyond black and peak white levels.

Chroma Signal Phasor Diagram

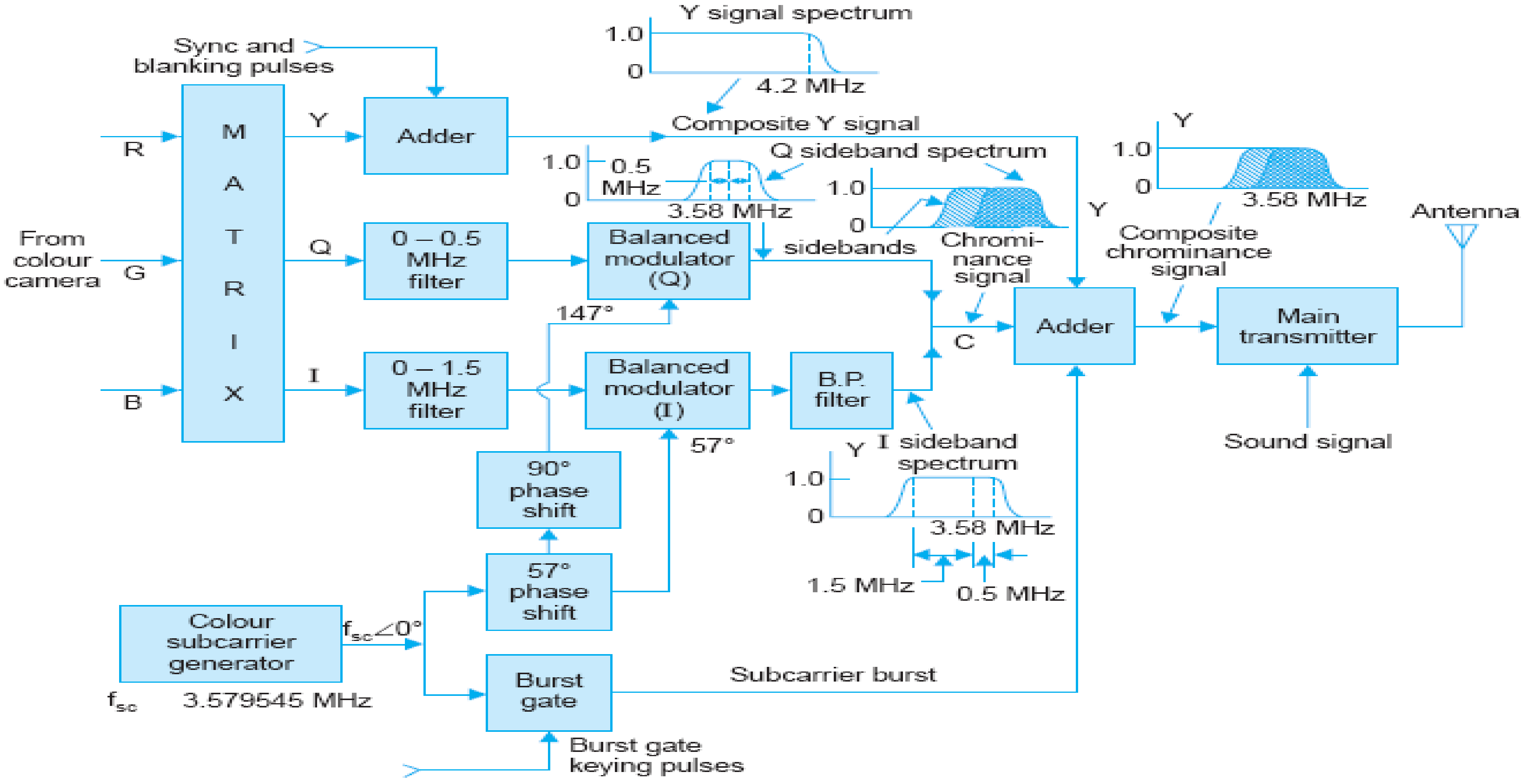


Magnitude and phase relationships of compensated chrominance signals for the primary and complementary colours.



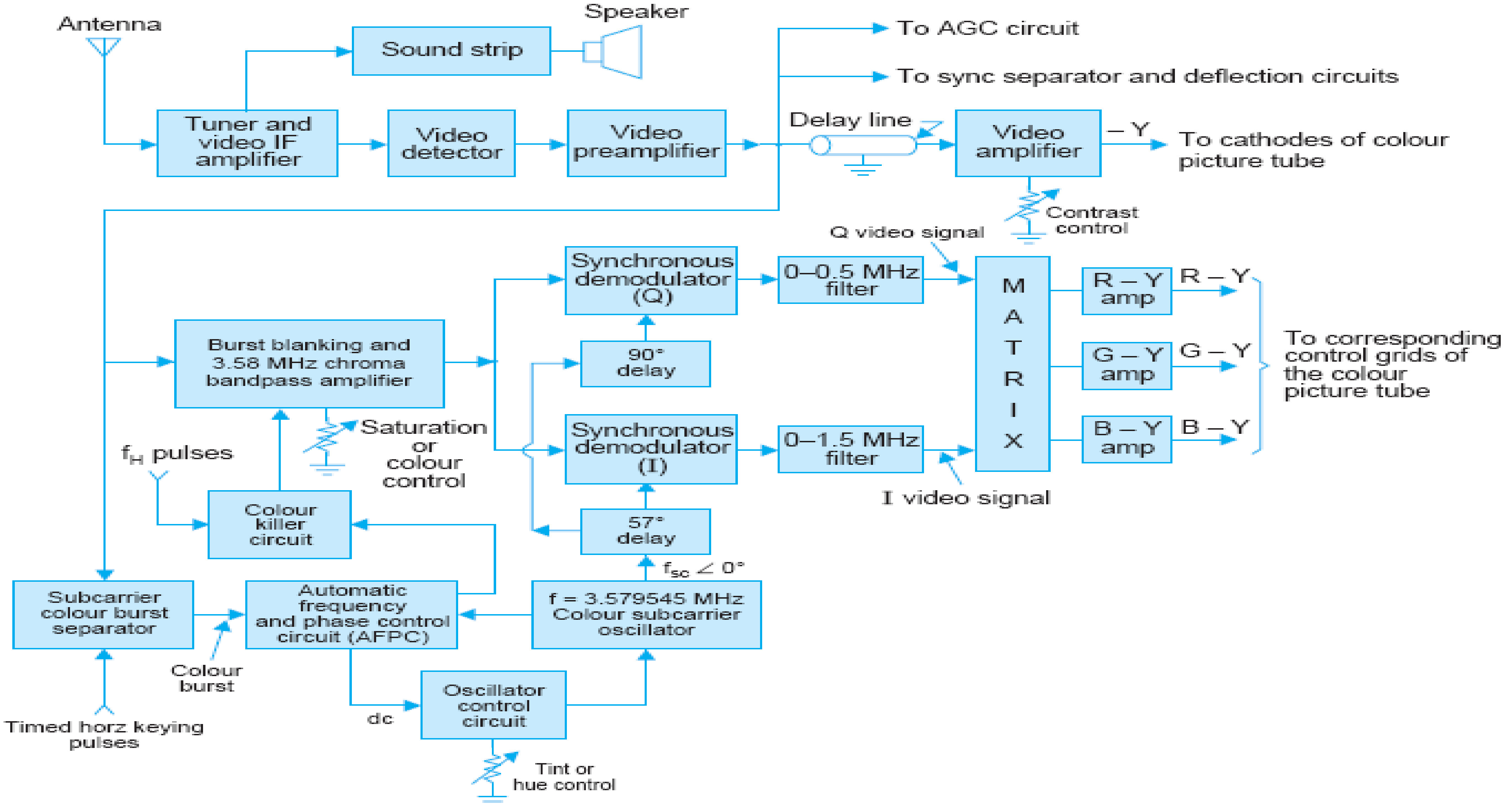
Phasor diagrams of the I and Q signals in the NTSC system.

Encoding of Colour Picture Information



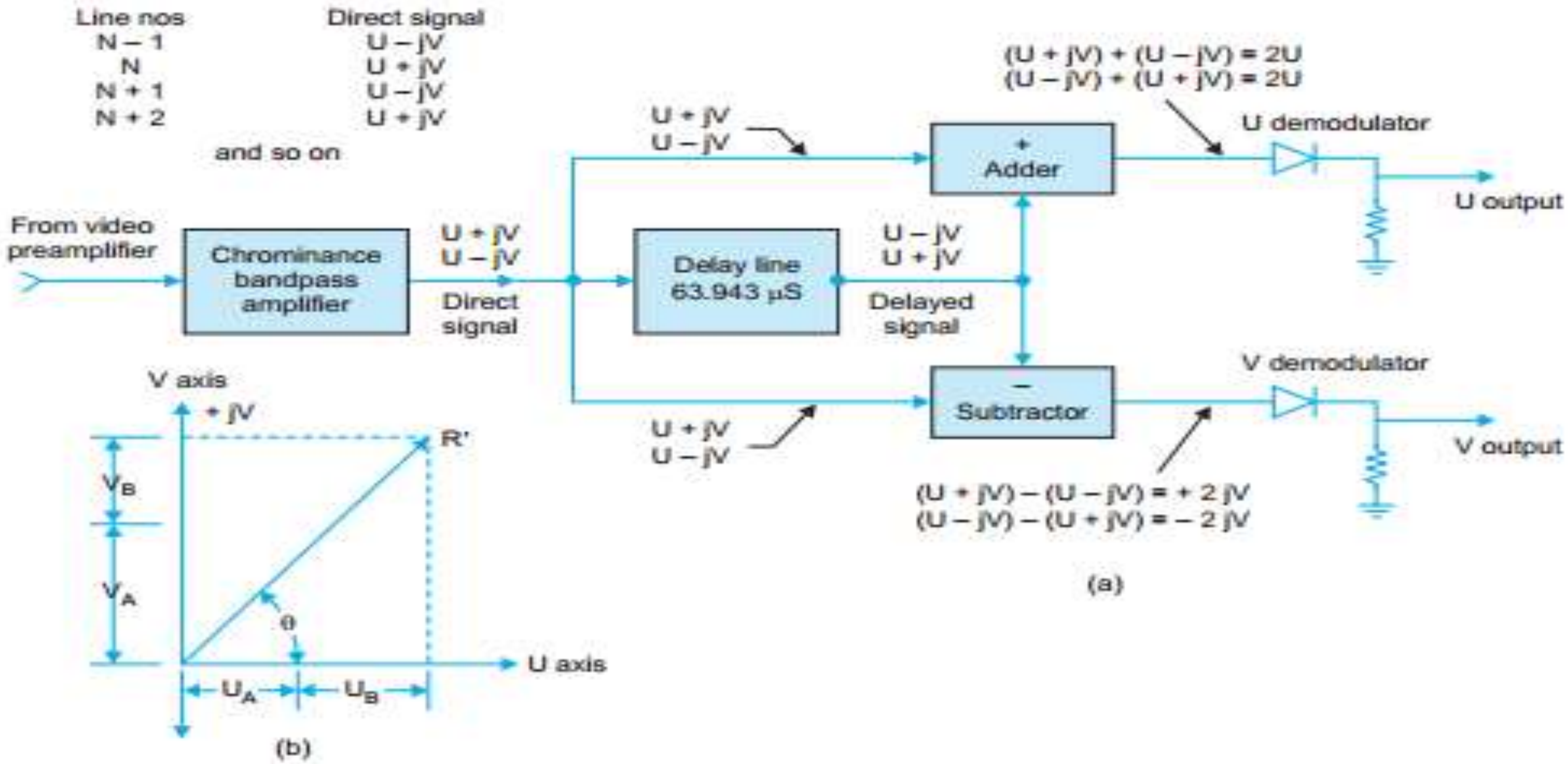
Functional diagram of a NTSC coder.

NTSC COLOUR RECEIVER

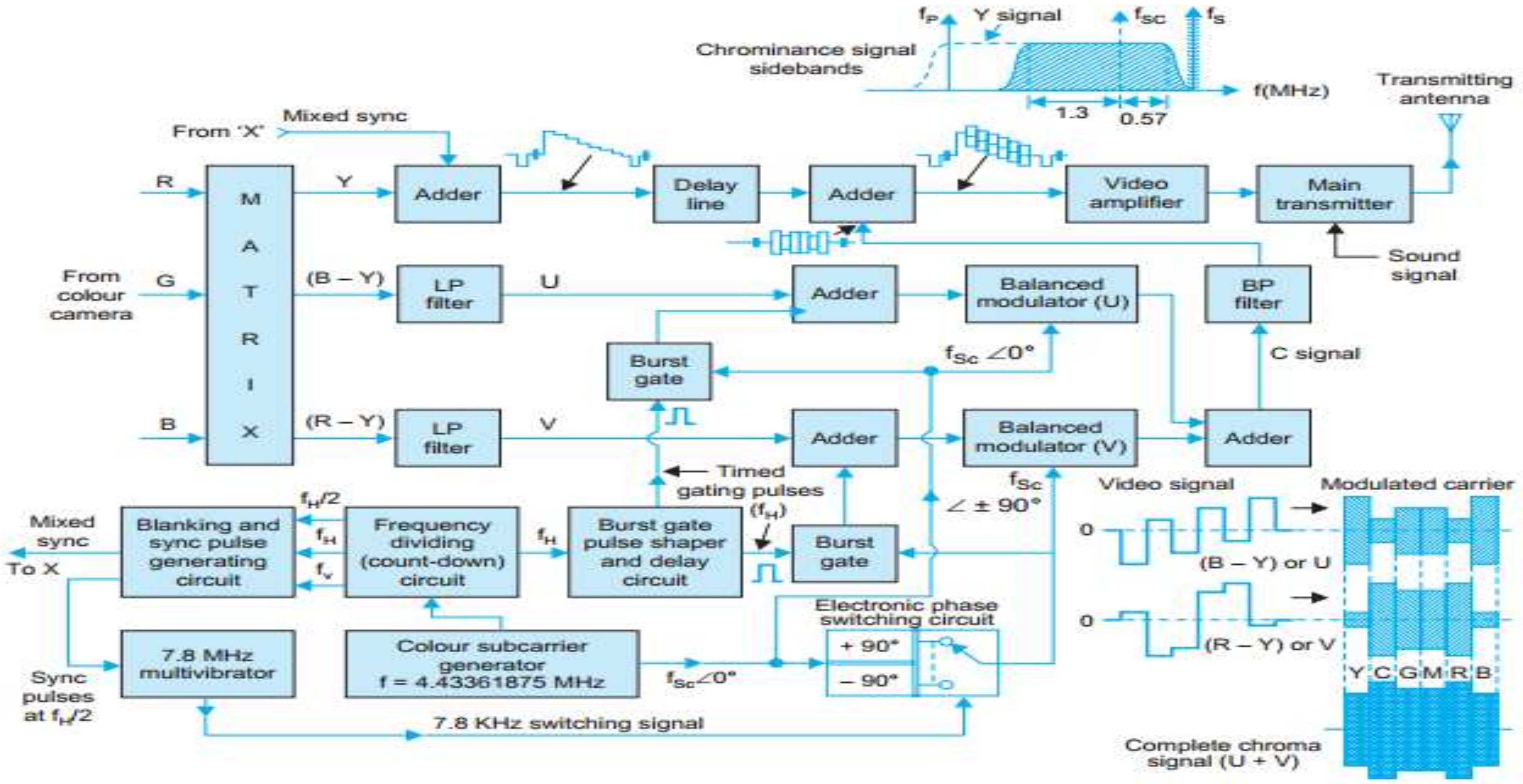


Simplified block diagram of a NTSC receiver

(a) Basic principle of Pal-D demodulation.
(b) Summation of consecutive line phasors in a PAL-D receiver



Block Diagram of PAL Coder



Seminar Topics

- Block diagram of PAL-D colour Receiver
- SECAM System

TELEVISION STANDARDS

Vision and Sound Signal Standards for the 625-B Monochrome System Adopted by India as Recommended by the International Radio Consultative Committee (C.C.I.R.)

Characteristics of the 625-B Monochrome TV System

No. of lines per picture (frame)	625
Field frequency (Fields/second)	50
Interlace ratio, *i.e.*, No. of fields/picture	2/1
Picture (frame) frequency, *i.e.*, Pictures/second	25
Line frequency and tolerance in lines/second, (when operated non-synchronously)	15625 ± 0.1%
Aspect Ratio (width/height)	4/3
Scanning sequence	(*i*) Line : Left to right (*ii*) Field : Top to bottom
System capable of operating independently of power supply frequency	YES
Approximate gamma of picture signal	0.5
Nominal video bandwidth, *i.e.*, highest video modulating frequency (MHz)	5
Nominal Radio frequency bandwidth, *i.e.*, channel bandwidth (MHz)	7
Sound carrier relative to vision carrier (MHz)	+ 5.5
Sound carrier relative to nearest edge of channel (MHz)	– 0.25
Nearest edge of channel relative to picture carrier (MHz)	– 1.25
Fully radiated sideband	Upper

Nominal width of main sideband (upper) (MHz)	5
Width of end-slope of full (Main) sideband (MHz)	0.5
Nominal width of vestigial sideband (MHz)	0.75
Vestigial (attenuated) sideband	Lower
Min : attenuation of vestigial sideband in db,	
(below the ideal demodulated curve)	(at 1.25 MHz) 20 db
	(at 4.43 MHz) 30 db
Width of end-slope of attenuated (vestigial) sideband (MHz)	0.5
Type and polarity of vision modulation	(A5C) Negative
Synchronizing level as a percentage of peak carrier	100
Blanking level as percentage of peak carrier	72.5 to 77.5
Difference between black and blanking level as a percentage of peak carrier	0 to 7
Peak white level as a percentage of peak carrier	10 to 12.5
Type of sound modulation	FM, ± 50 KHz
Pre-emphasis	50 μs
Resolution	400 max
Ratio of effective radiated powers of vision and sound	5/1 to 10/1

Details of Line-Blanking Intervals

Nominal duration of a horizontal line	= 64 μs = *H*
Line blanking interval	= 12 ± 0.3 μs
Front porch	= 1.5 ± 0.3 μs
Sync pulse width	= 4.7 ± 0.2 μs
Back porch	= 5.8 ± 0.3 μs
Build up time (10% to 90%) of line blanking edges	= 0.3 ± 0.1 μs
Interval between datum level and black edge of line blanking signal (average calculated time for information)	= 10.5 μs

Details of Field-Blanking Intervals

Field blanking period = 20 *H* (20 lines)	= 1280 µs
Pre sync equalizing pulses, 5 pulses of duration 1/2 *H*, *i.e.*, 32 µs, total time	= 160 µs
Equalizing pulses are narrow pulses with pulse width	= 2.35 ± 0.1 µs
Field sync pulses at $\frac{1}{2}H$ intervals, 5 such pulse, each pulsewidth	= 27.3 µs
Interval between field sync pulses	= 4.7 ± 0.2 µs
Interval between equalizing pulses	= 29.65 µs
Post-sync equalizing pulses, 5 pulses	same as for pre-sync. eq. pulses
Build up time of field blanking edges.	= 0.3 ± 0.1 µs
Build up time for field sync pulses	= 0.2 ± 0.1 µs

Principal Television System

Particulars	*Western Europe, Middle East, India and most Asian countries*	*North and South America including US, Canada, Mexico and Japan*	*England*	*USSR*	*France*
Lines per frame	625	525	625	625	625
Frames per second	25	30	25	25	25
Field frequency (Hz)	50	60	50	50	50
Line frequency (Hz)	15,625	15,750	15,625	15,625	15,625
Video bandwidth (MHz)	5 ot 6	4.2	5.5	6	6
Channel bandwidth (MHz)	7 or 8	6	8	8	8
Video modulation	Negative	Negative	Negative	Negative	Positive
Picture modulation	AM	AM	AM	AM	FM
Sound signal modulation	FM	FM	FM	FM	AM
Colour system	PAL	NTSC	PAL	SECAM	SECAM

Reference

- R.R. Gulati, “Modern Television Practice”, Third edition, New Age International Publishers