Tecnología de Servicios Audiovisuales
Introducción

Rafael Sotelo

https://www.statista.com/forecasts/1207931/tv-viewers-worldwide-number

Los hábitos van cambiando

- As television becomes more widespread and easily accessible, television viewing continues to increase, but as the younger generation adopts new forms of entertainment, television viewership has dropped in recent years. Television viewing peaked in 2020 due to the COVID-19 pandemic and has slightly decreased to an estimated 2 hours and 33 minutes daily in 2023.Although television viewership has declined over the years, people are still watching content on screens. People are watching more content on streaming platforms through their phones, tablets, and laptops, as opposed to a traditional television. Streaming service usage continues to grow, and from May 2021 to May 2022, it grew 21%, to now accounting for 32% of total television time.

https://en.wikipedia.org/wiki/Television_consumption

https://www.nielsen.com/es/insights/2022/streaming-usage-increases-21-in-a-year-to-now-account-for-nearly-one-third-of-total-tv-time/

Television Watching Statistics

Total Use of Television	Data
Average time spent watching television (U.S.)	5:11 hours
White	5:02
Black	7:12
Hispanic	4:35
Asian	3:14
Years the average person will have spent watching TV	9 years
Family Television Statistics	
Percentage of households that possess at least one television	99 %
Number of TV sets in the average U.S. household	2.24
Percentage of U.S. homes with three or more TV sets	65 %
Percentage of Americans that regularly watch television while eating dinner	67 %
Percentage of Americans who pay for cable TV	56 %
Number of videos rented daily in the U.S.	6 million
Percentage of Americans who say they watch too much TV	49 %

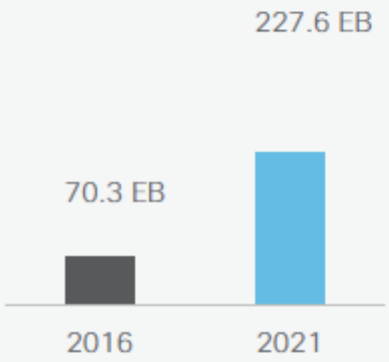
Fuente: http://www.statisticbrain.com/television-watching-statistics/ May 23, 2017

Percent of American adults who subscribe to the following Pay-TV services, by age				
Pay-TV Service	**Age 18-36**	**Age 37-48**	**Age 49-67**	**Age 68+**
Cable TV	46 %	48 %	55 %	63 %
Netflix	43 %	31 %	21 %	13 %
Satellite TV	16 %	30 %	28 %	25 %
Amazon Prime	17 %	15 %	10 %	6 %
Hulu Plus	8 %	5 %	3 %	1 %

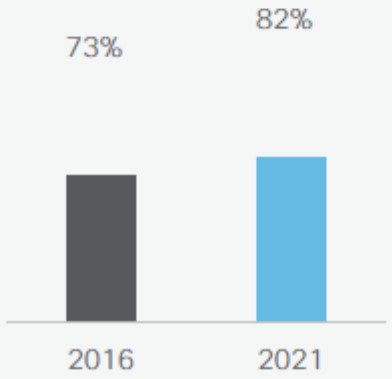
IP Video

View

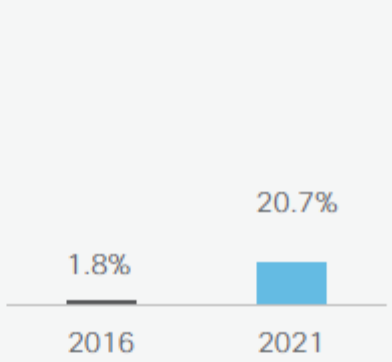
IP Video Traffic per Month



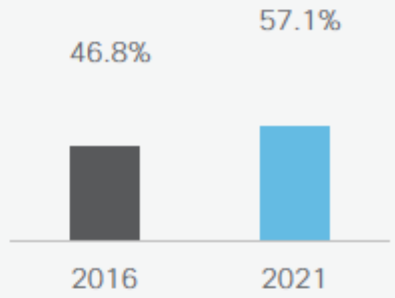
IP Video Share of IP Traffic



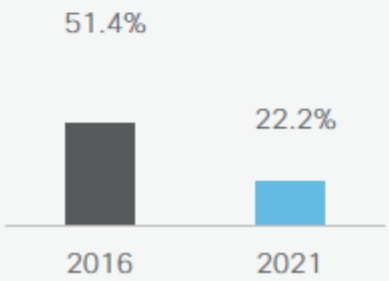
UHD Share of IP Video Traffic



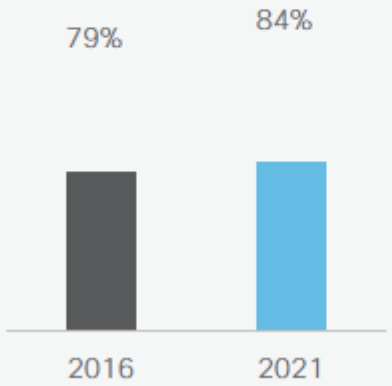
HD Share of IP Video Traffic



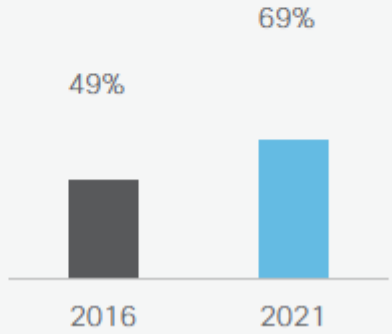
SD Share of IP Video Traffic



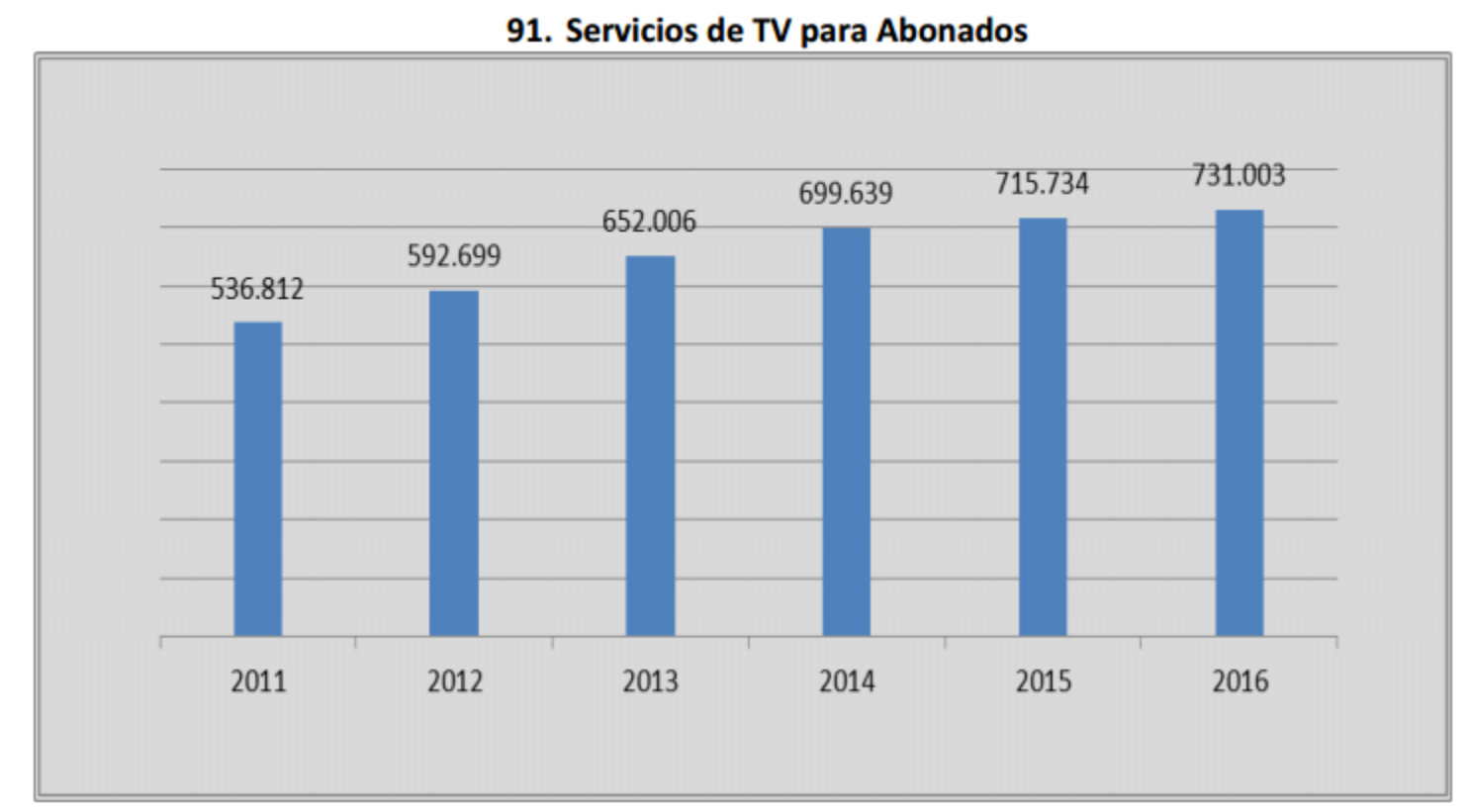
Consumer: IP Video Share of IP Traffic



Business: IP Video Share of IP Traffic

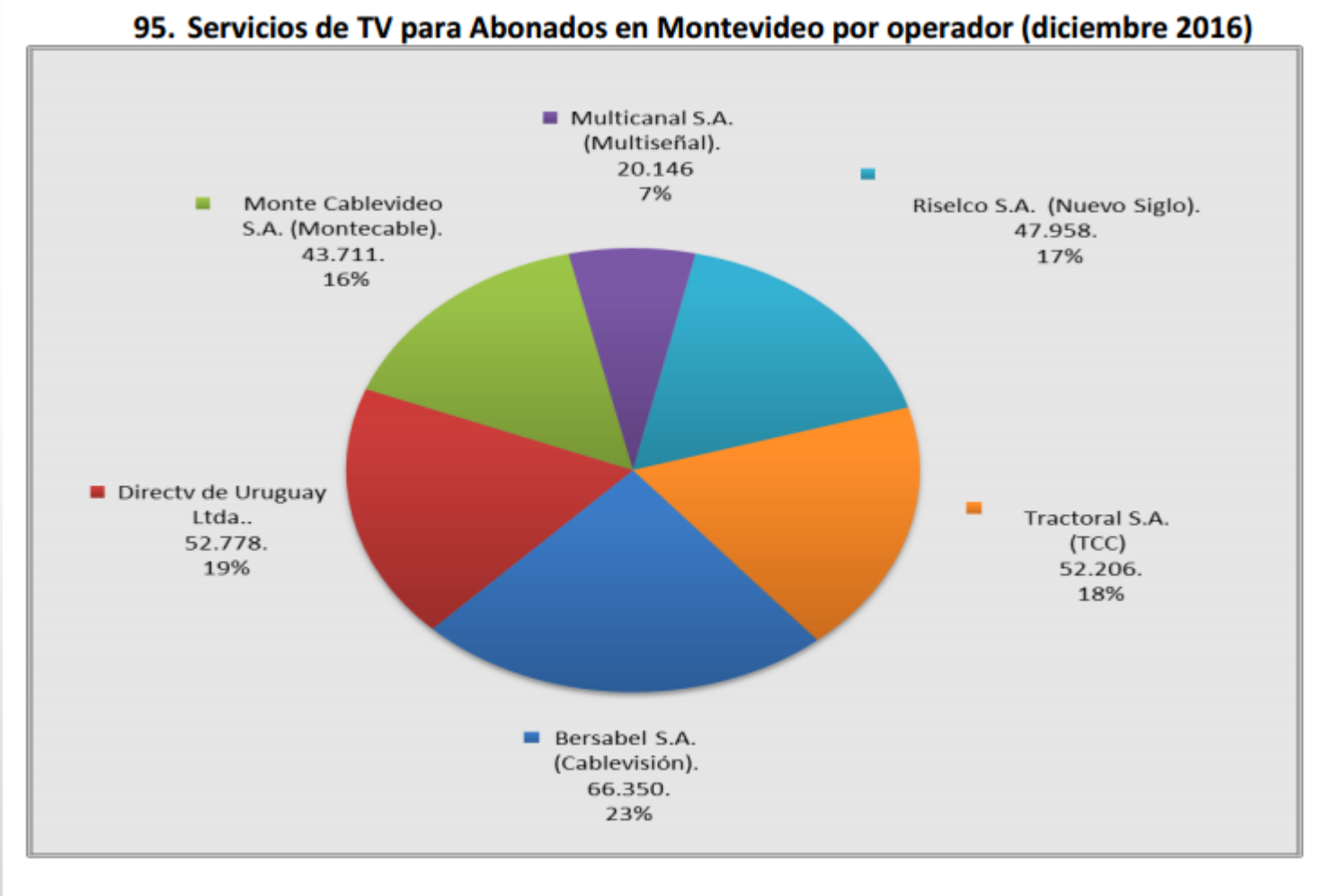


En Uruguay



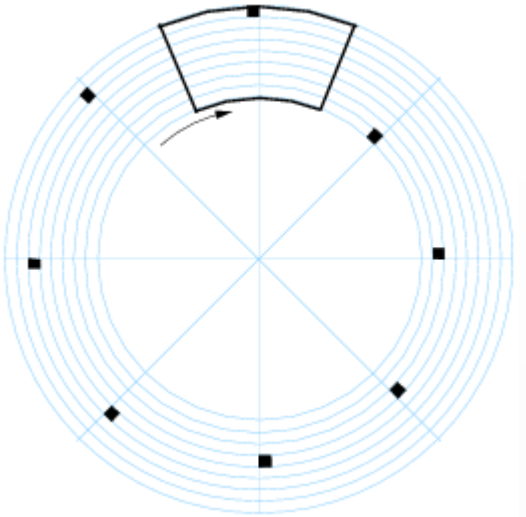
Fuente: EVOLUCIÓN DEL SECTOR TELECOMUNICACIONES EN URUGUAY – URSEC – DICIEMBRE 2016

En Uruguay

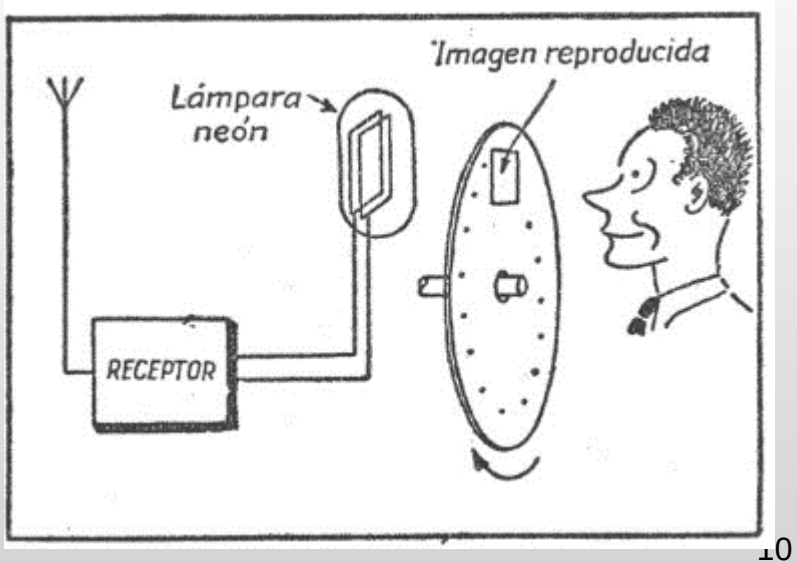


Fuente: EVOLUCIÓN DEL SECTOR TELECOMUNICACIONES EN URUGUAY – URSEC – DICIEMBRE 2016

Historia de la Televisión



- Televisión electromecánica
  - 1884 – Disco de Nipkow
  - 1924 – Baird, sistema práctico
    - 1936 – Inauguración de los XI Juegos Olímpicos de Berlín

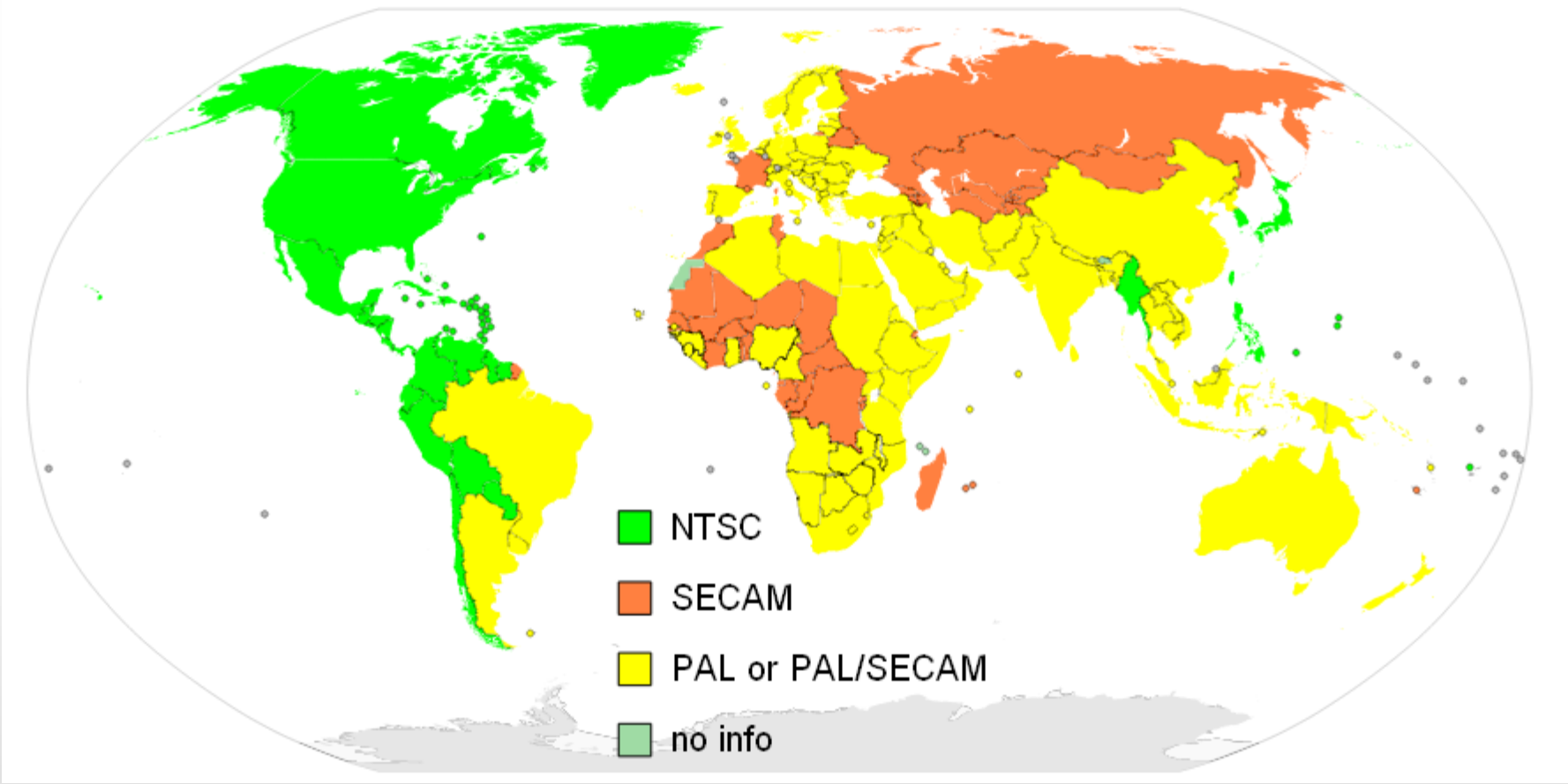


- Televisión electrónica
  - 1897 – Braun, Tubo de rayos catódicos
  - 1934 – Zworykin, Iconoscopio

- ’30 Primeras emisiones en EEUU, Gran Bretaña, Francia y Alemania
- En EEUU hacia 1952 había unas 108 emisoras y unos 21 millones de televisores. De una inversión publicitaria de un poco más de 10 millones de dólares, en 1950, se pasó a 1.500 millones, en 1960.

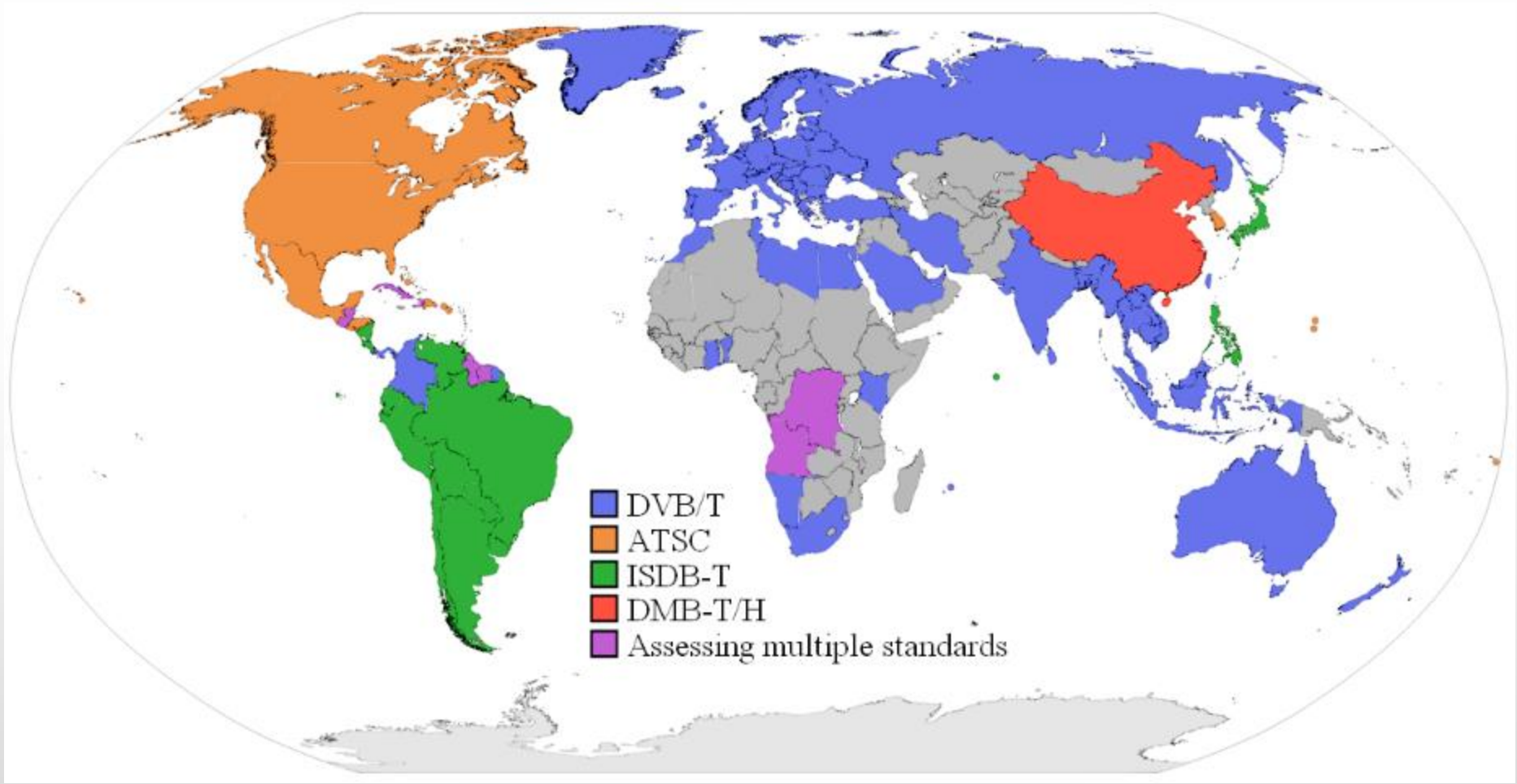
- TV blanco y negro:
  - Europa: 625 líneas por cuadro, 25 cuadros por segundo
  - Estados Unidos: 525 líneas por cuadro, 30 cuadros por segundo
- TV color:
  - NTSC
  - PAL
  - SECAM

Sistemas de televisión analógicos utilizados en el mundo



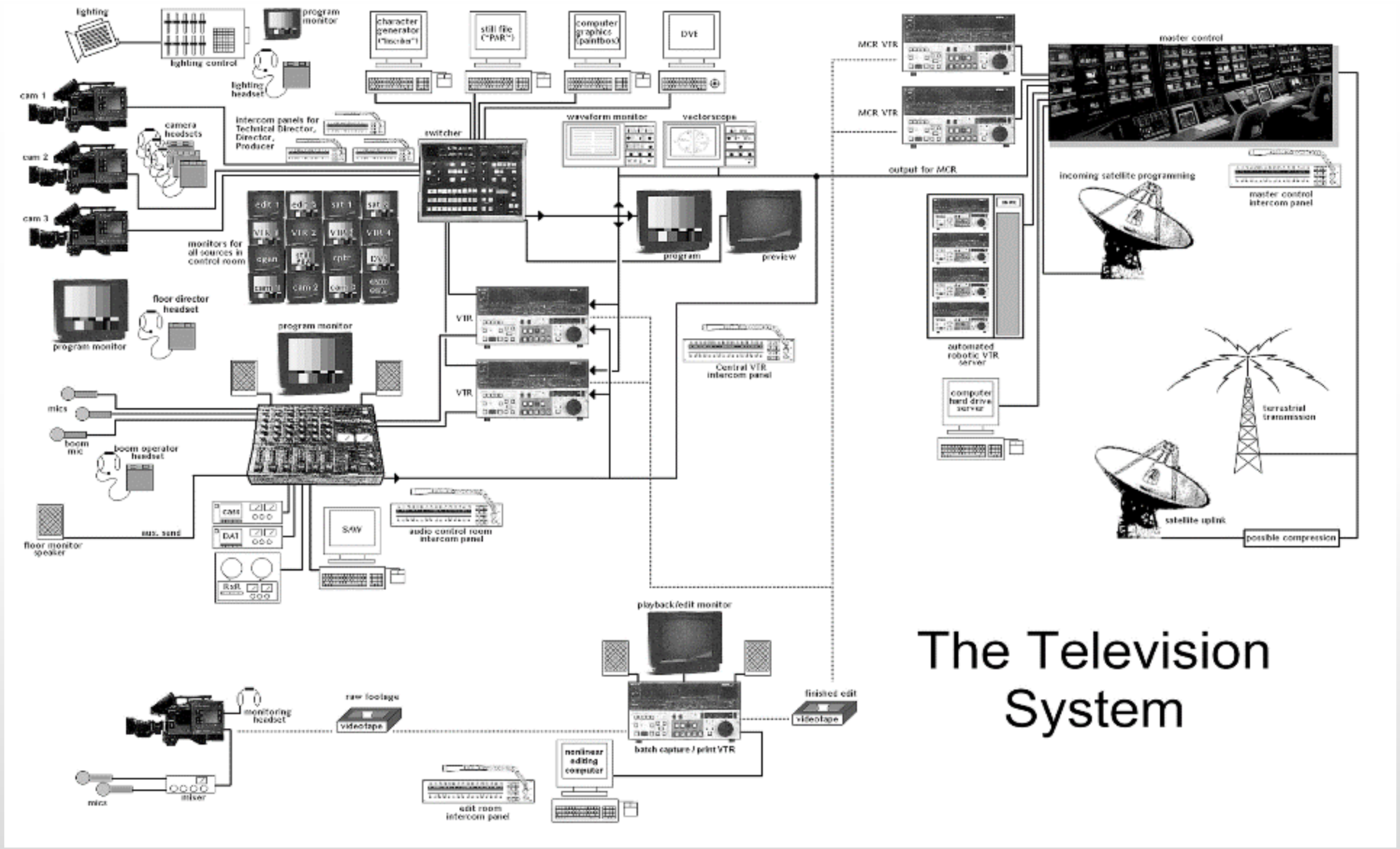
Ver: http://www.itu.int/pub/R-REP-BT.2043-2004/es

- ´60 transmisiones vía satélite
- ´70 videojuegos
- ´80 televisión por cable
- ´90 Internet, TV Digital
- Convergencia


DVB/T
ATSC
ISDB-T
DMB-T/H
Assessing multiple standards

Ventajas TV Digital

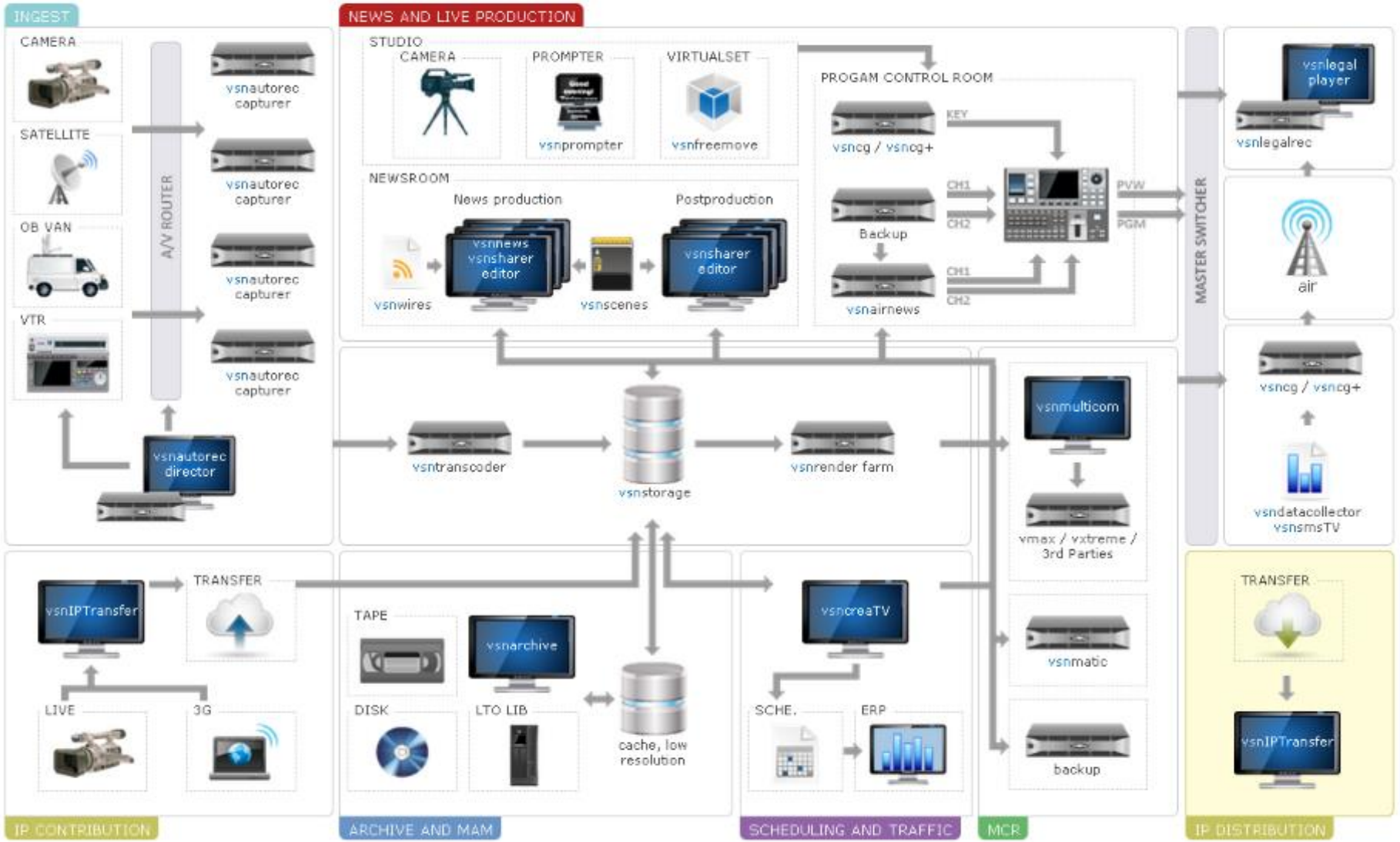
- Alta definición
- Más señales en el mismo ancho de banda
- Interactividad
- Movilidad
- Subtítulos
- Varios idiomas
- Mejor calidad de audio. 5+1
- Mejor calidad de video.
- Acceso condicional. Pay Per View.
- Otras facilidades:
  - mensajes personalizados
  - mensajes de emergencias
  - facilidades para discapacitados



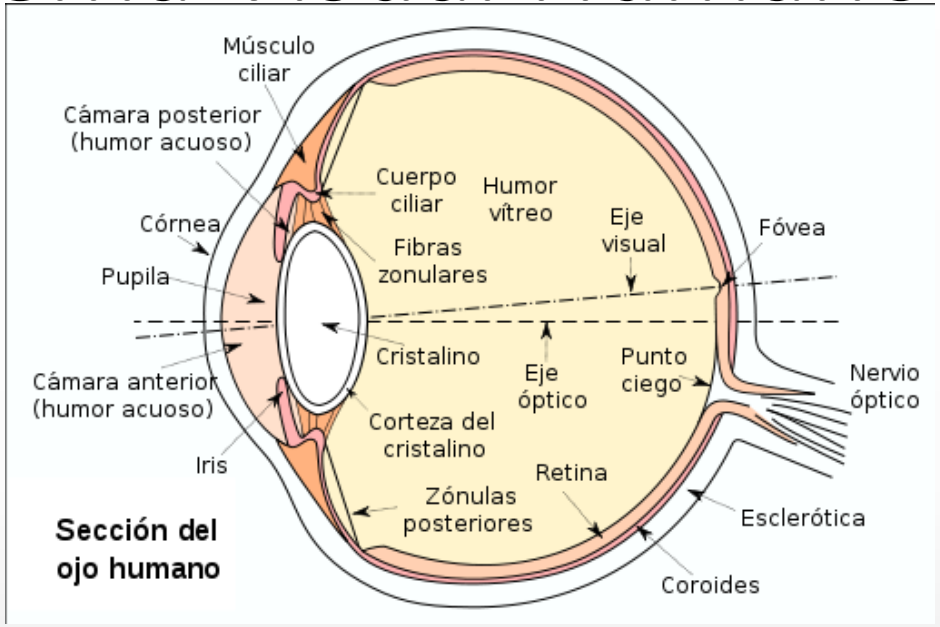
The Television System

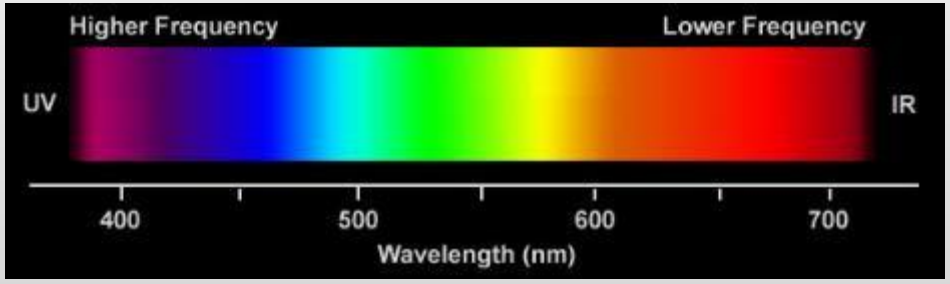
Workflow

All products



Sistema Visual Humano



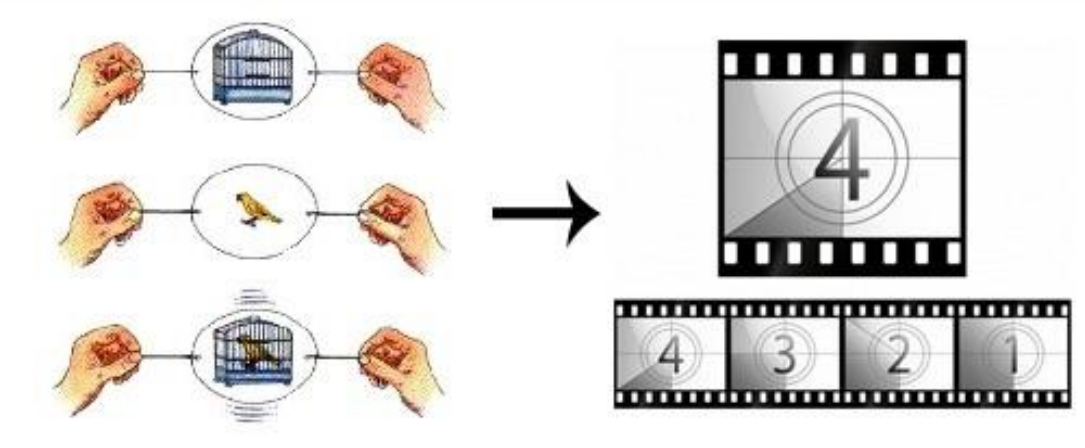


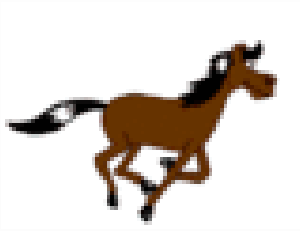
- Elementos sensores en la retina:
- CONOS
  - Responsables de visión color
  - Concentrados en el centro
  - Tres tipos sensibles a tres longitudes de onda
- BASTONES
  - Responsables de visión en baja luminosidad
  - No perciben color
  - Distribuidos uniformemente

Características del SVH

- Somos menos sensibles a los detalles finos (Altas frecuencias espaciales son menos visibles).
- Más sensible a cambios en el brillo que en los colores.
- Errores en regiones texturadas son difíciles de ver. Somos muy sensibles a errores en regiones uniformes.
- Errores cerca de los bordes son difíciles de ver.
- Persistencia temporal.

Persistencia temporal





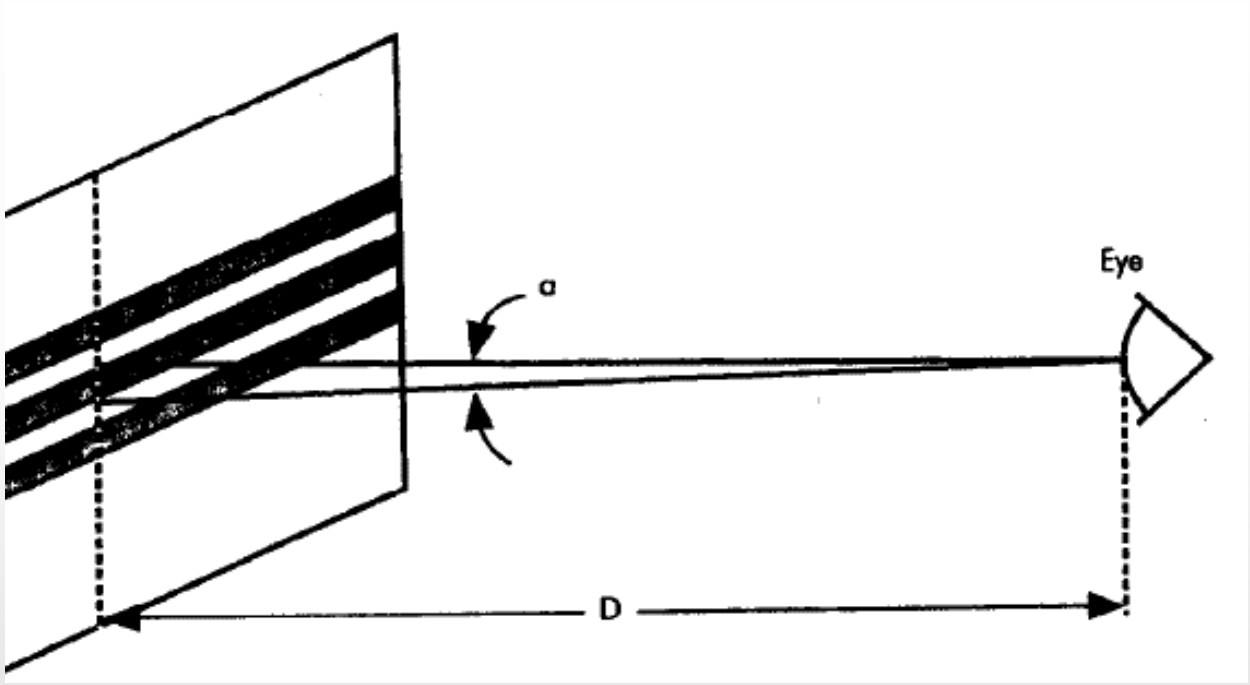
SE UTILIZA:
En Cine 24 cuadros por segundo
En televisión 25 o 30 cuadros por segundo

¿Cuál es el mínimo número de imágenes por segundo para crear la sensación de movimiento?

2	12	50	1000

Agudeza Visual

- Ángulo determinado por el ojo y el detalle más pequeño visible por el ojo.



¿Cuál es el mínimo ángulo α que podemos discriminar?

3º	1º	15’	1’

Agudeza Visual

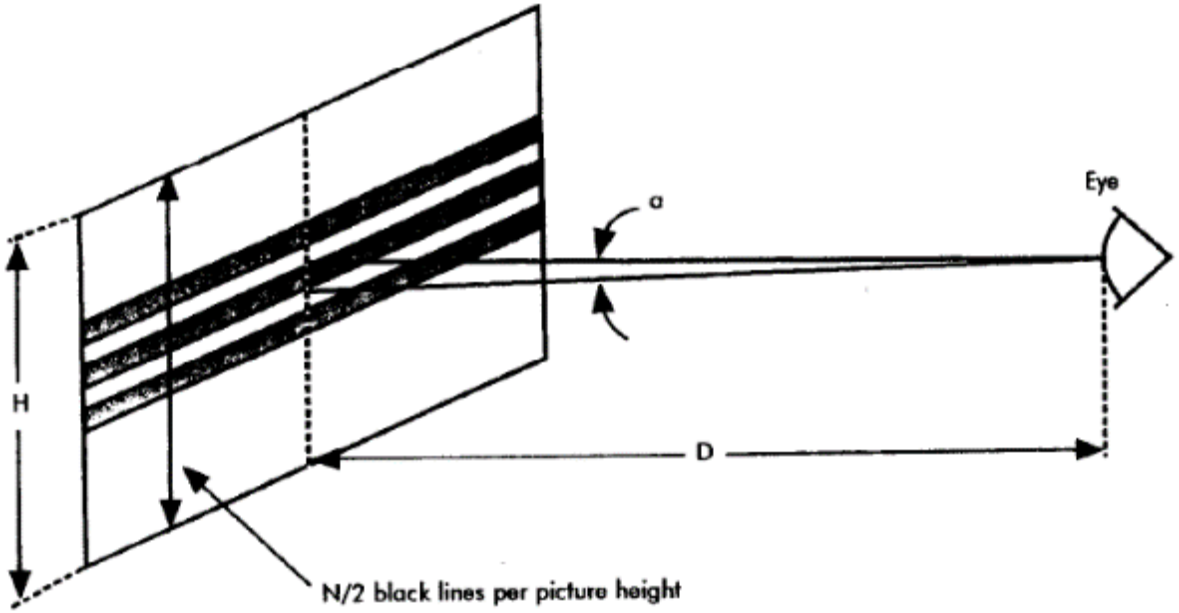


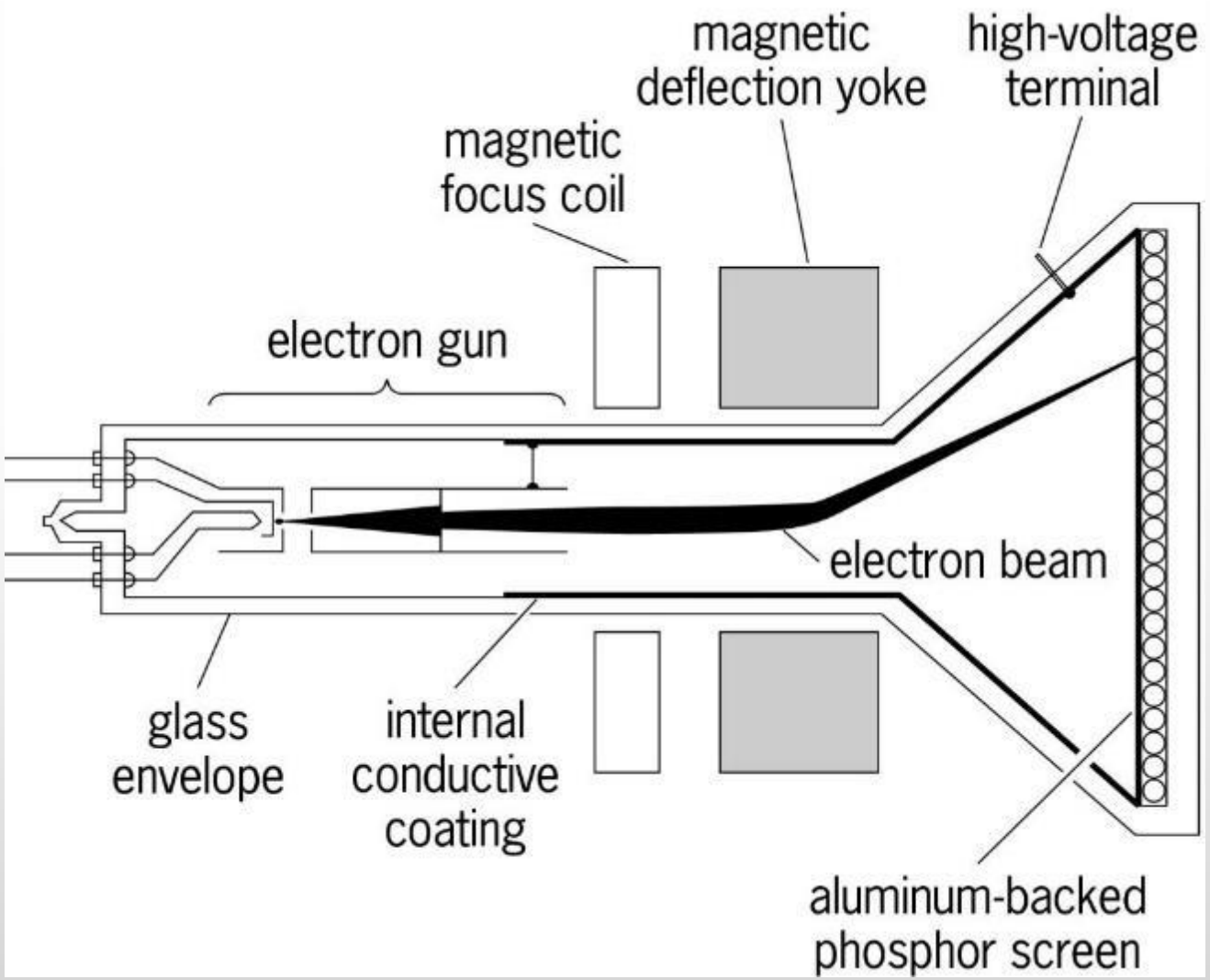
Figure 1.2 Visual acuity concept.

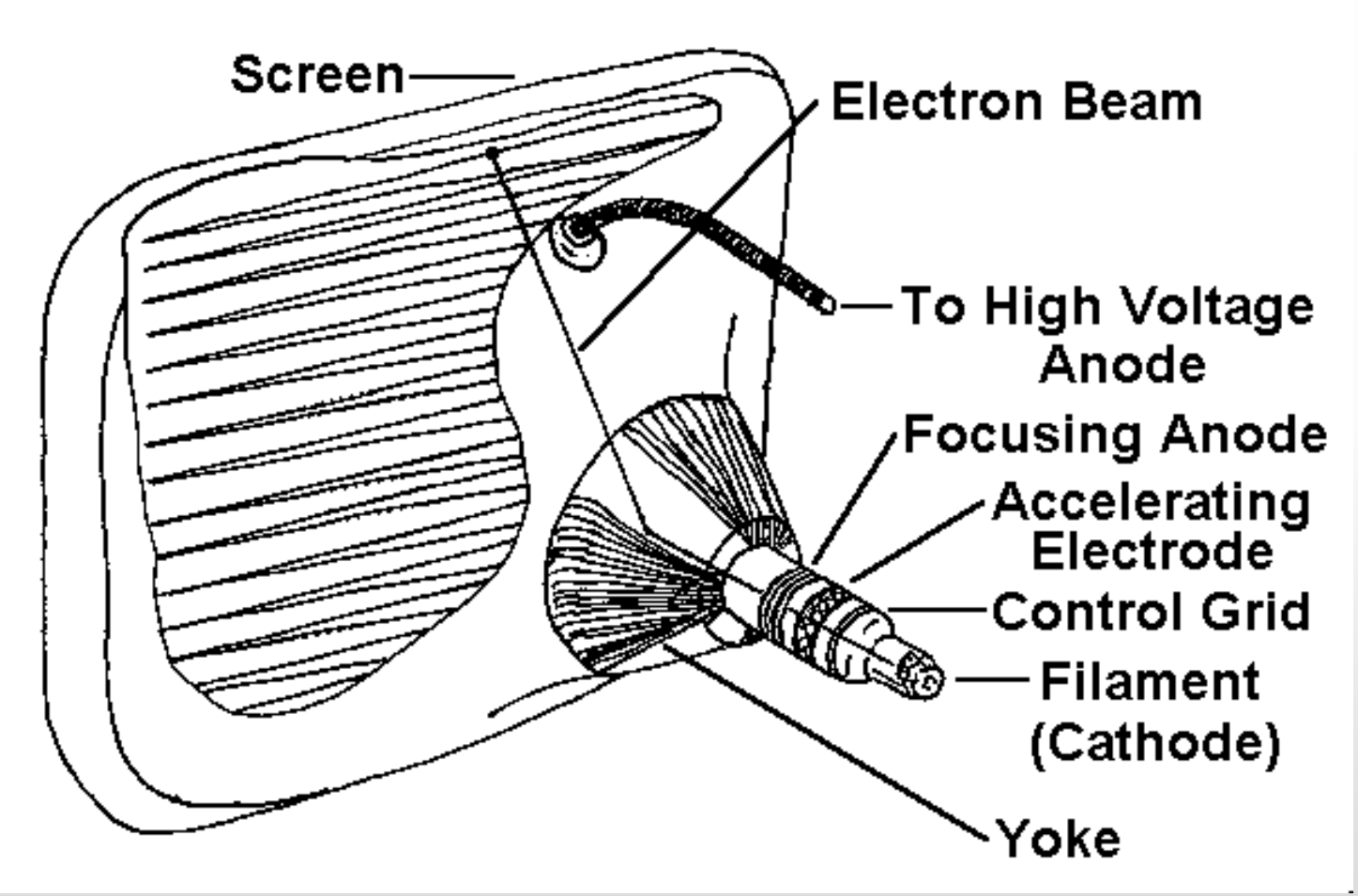
where N_v = Total number of elements to be resolved in the vertical direction
α = Minimum resolvable angle of the eye (in radians)
$n = D/H$ (viewing distance divided by picture height)

En definición estándar, n=6

¿Cuál es el número de líneas aproximado de la televisión SD?			
2000	1000	500	250

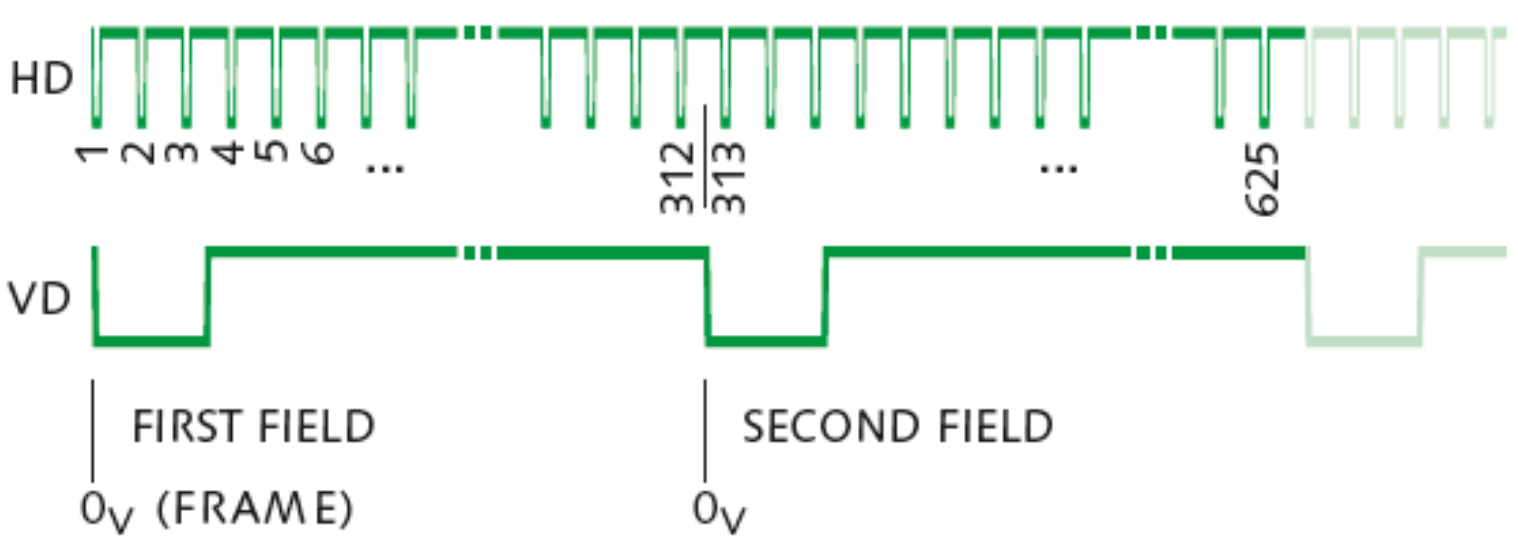
Tubo de rayos catódicos



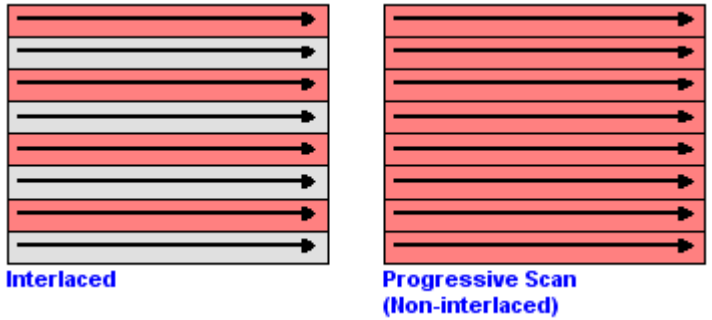

Screen
Electron Beam
To High Voltage Anode
Focusing Anode
Accelerating Electrode
Control Grid
Filament (Cathode)
Yoke

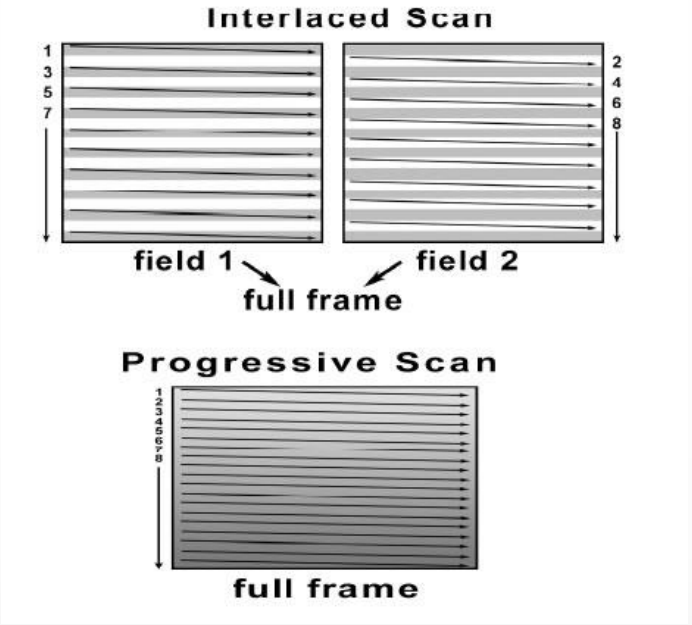
Barrido entrelazado

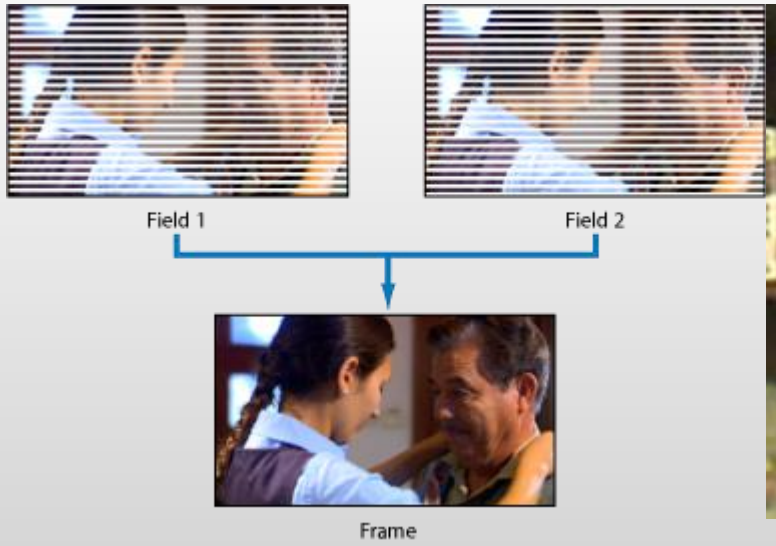
Figure 8.7 **Horizontal and vertical drive** pulses historically effected interlace in analog scanning. 0_V denotes the start of each field. The halfline offset of the second 0_V causes interlace. Here, *576i* scanning is shown.

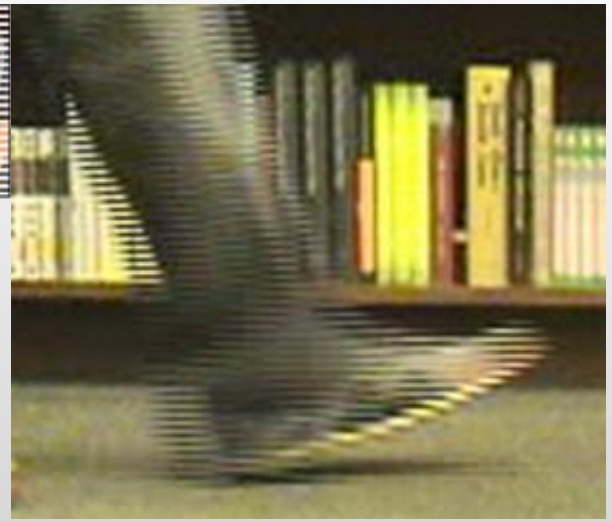


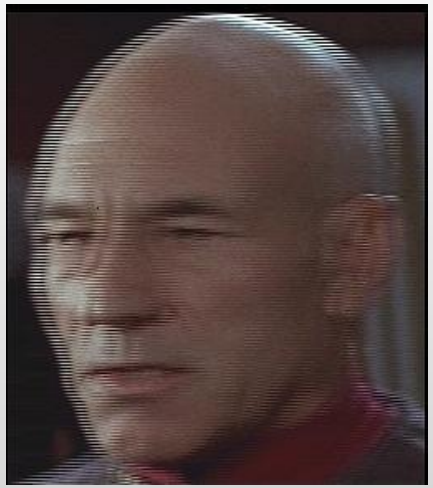
Barrido Progresivo y Entrelazado (Interlaced)











Período y frecuencia de línea

- Dos sistemas principales de barrido:
  - 525 líneas por cuadro @ 30 cuadros por segundo
  - 625 líneas por cuadro @ 25 cuadros por segundo

¿Cuántos campos por segundo tiene cada uno de ellos?

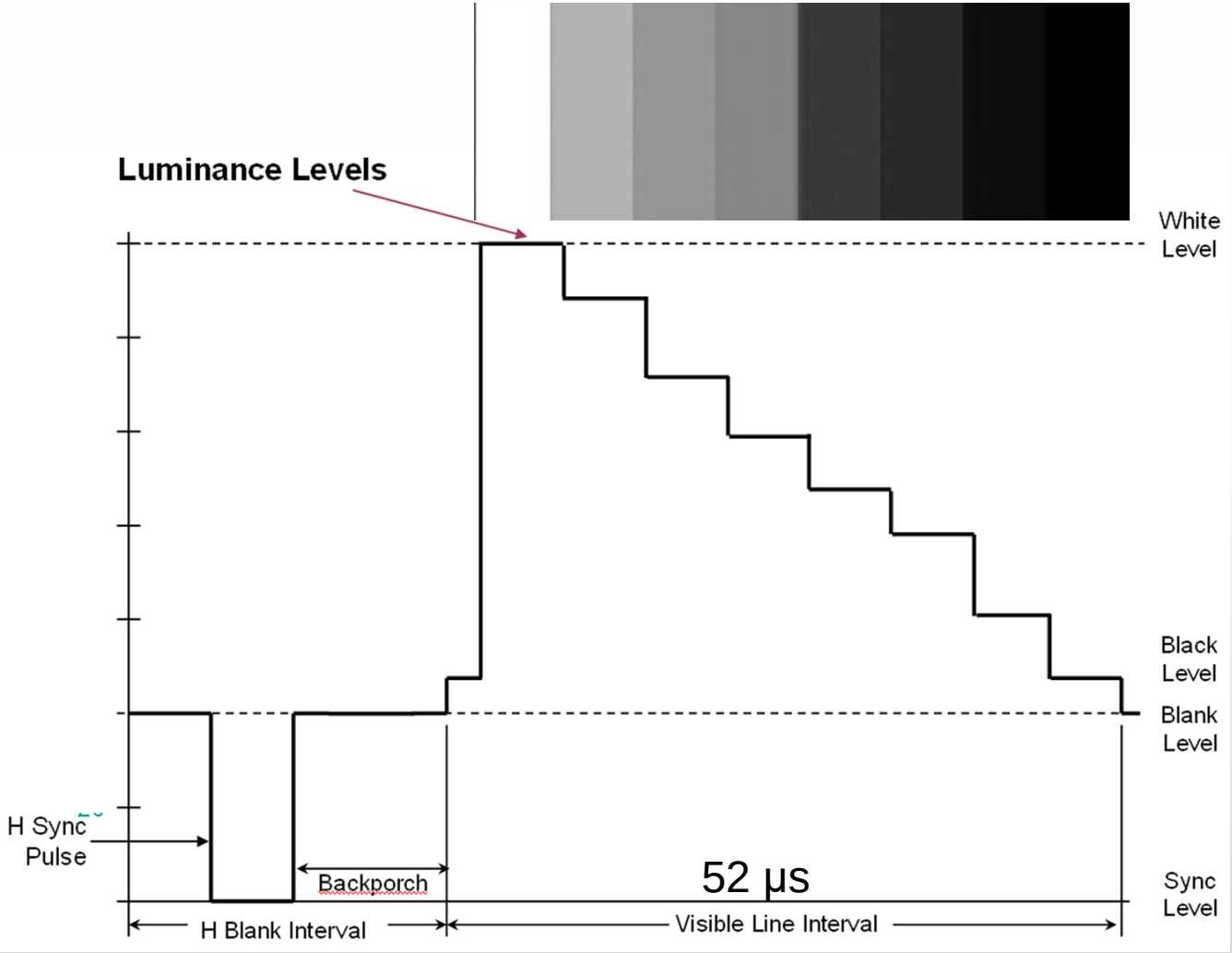
60//50	30//25	15//12,5	262,5//312,5

¿Cuál es el período de línea en el sistema 625@25?

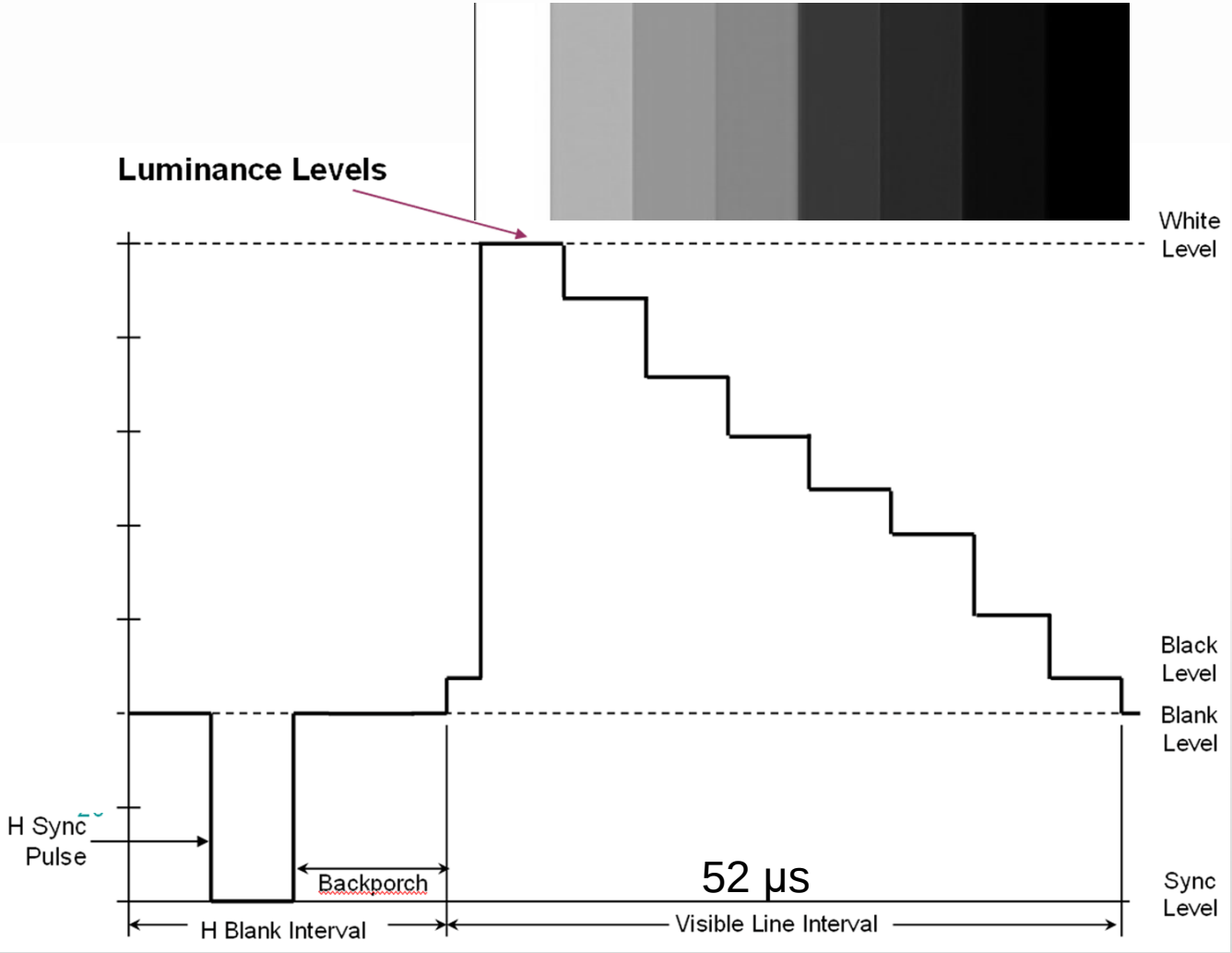
40ms	20ms	64µs	32µs

Barrido	T_H	f_H	T_V	f_V
525i@30	63,5µs	15750Hz	33,33ms	60Hz
625i@25	64µs	15625Hz	40ms	50Hz

Línea activa y borrado horizontal



Línea activa y borrado horizontal



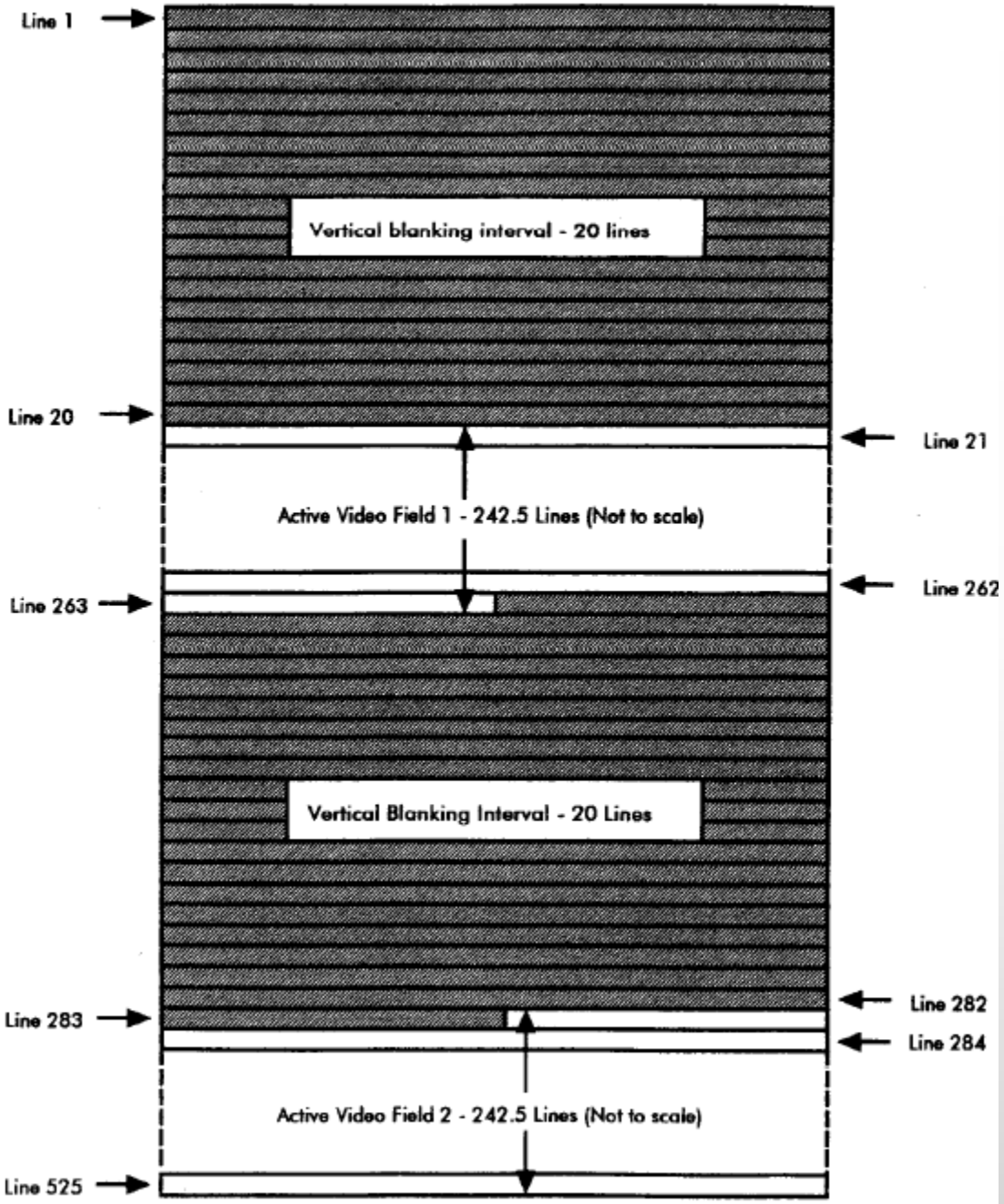


Figure 1.15 Vertical blanking interval details of 525/60 scanning standard.

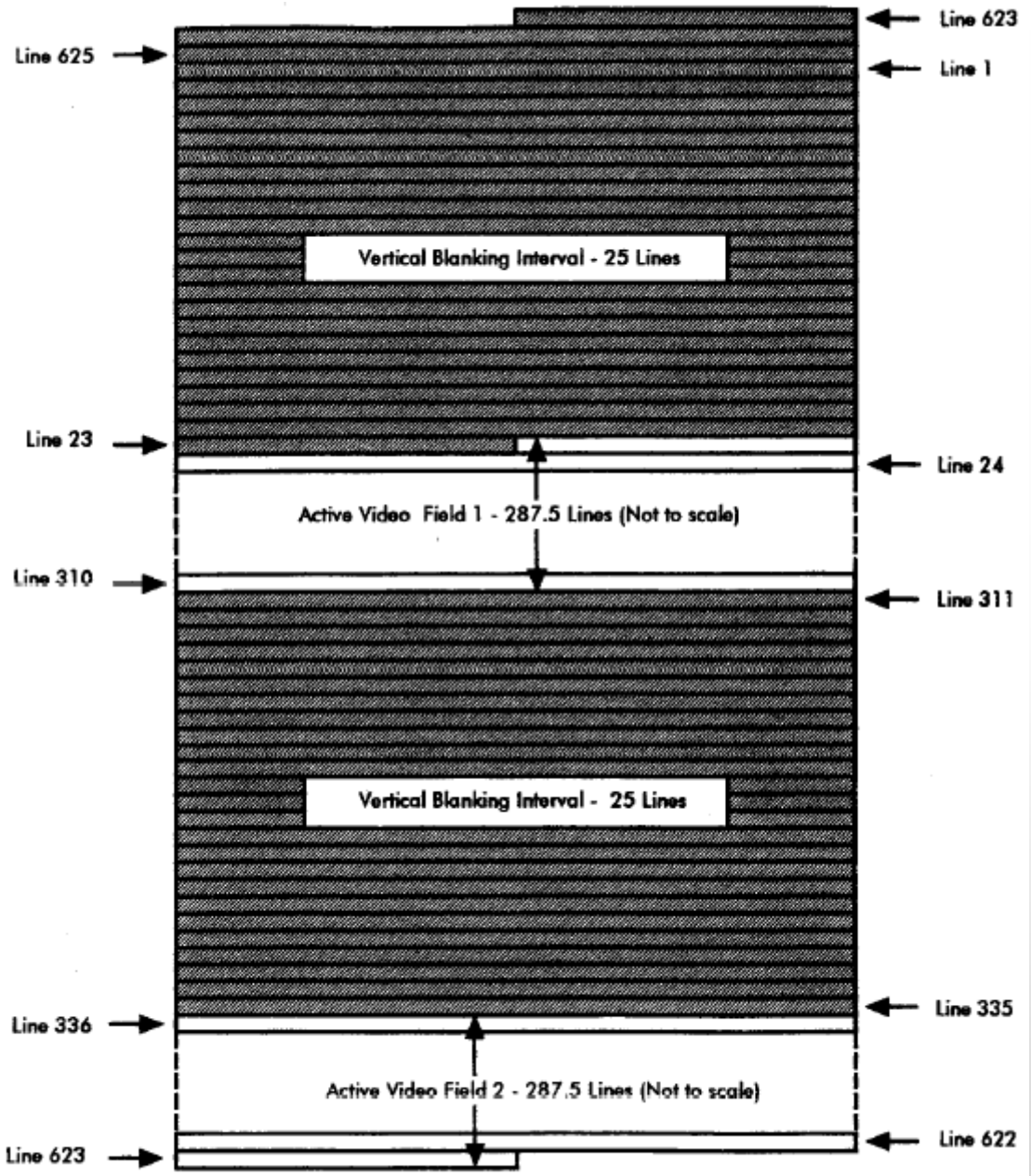
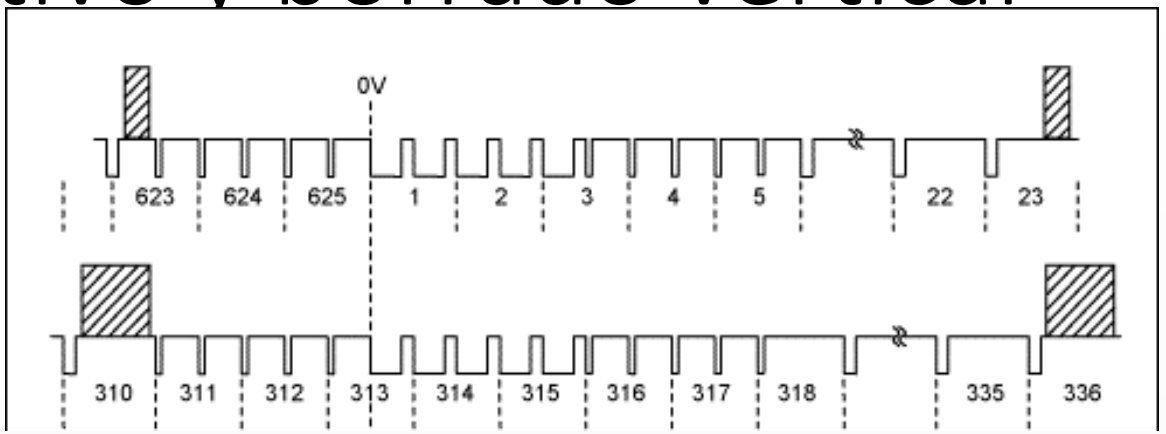
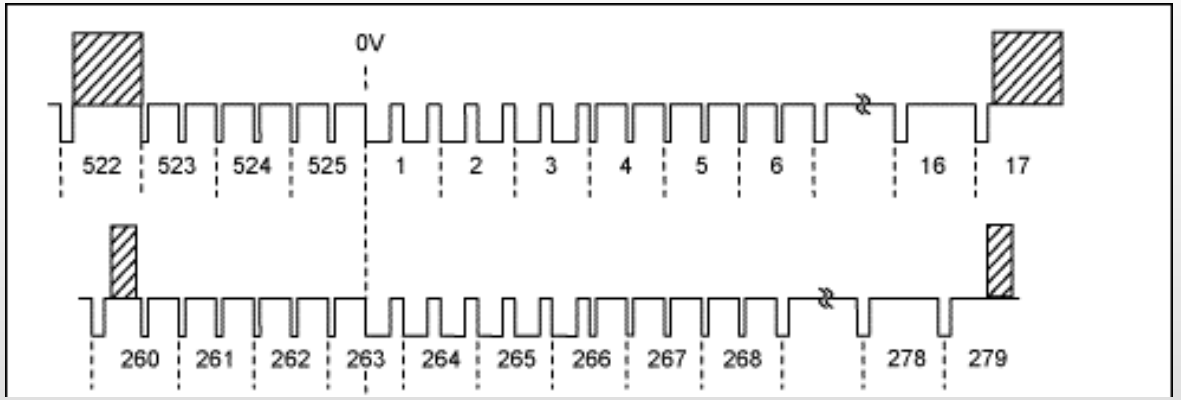


Figure 1.16 Vertical blanking interval details of 625/50 scanning standard.

Campo activo y borrado vertical





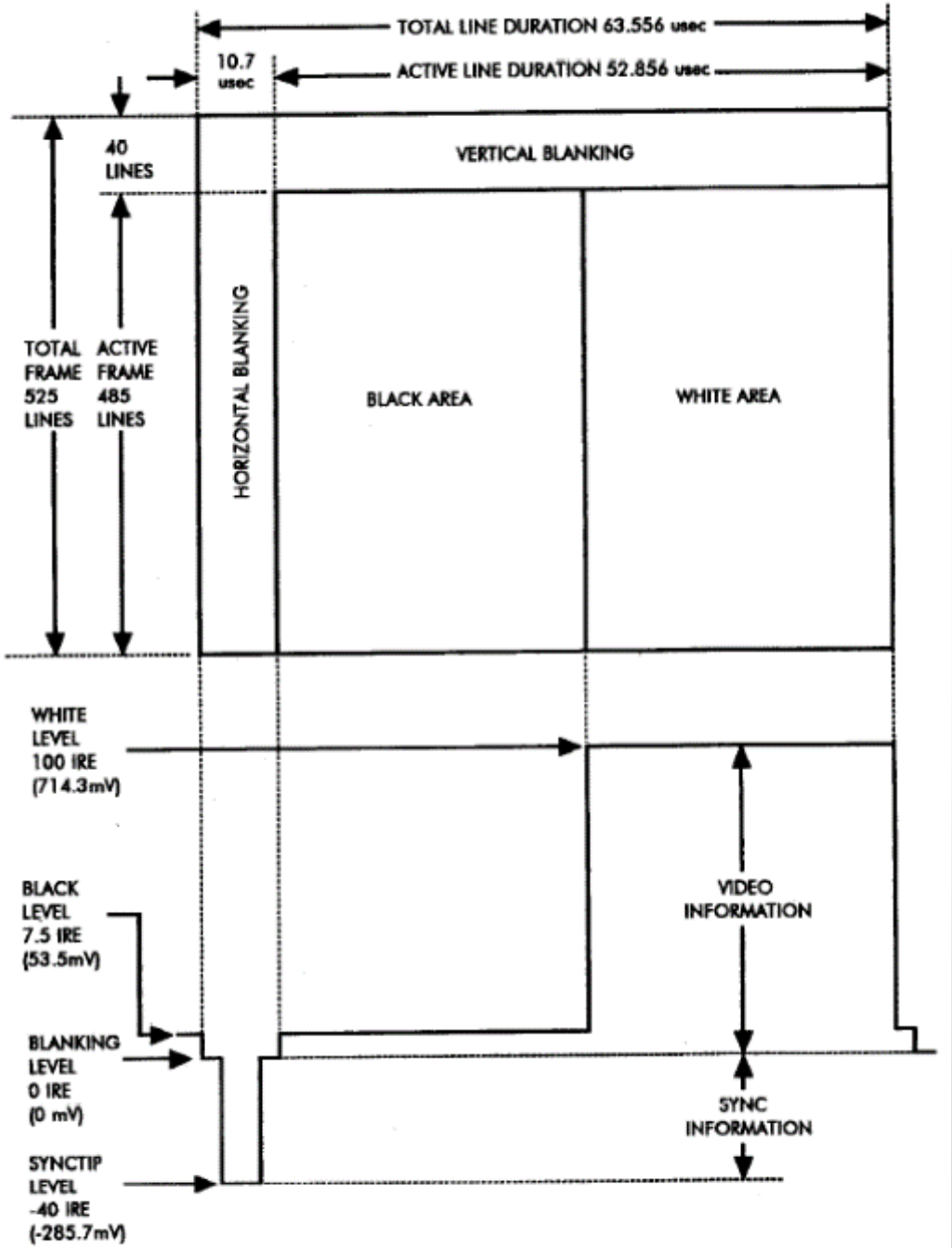


Figure 1.9 Significant amplitude and timing values of composite video signal relative to picture characteristics in 525/60 standard.

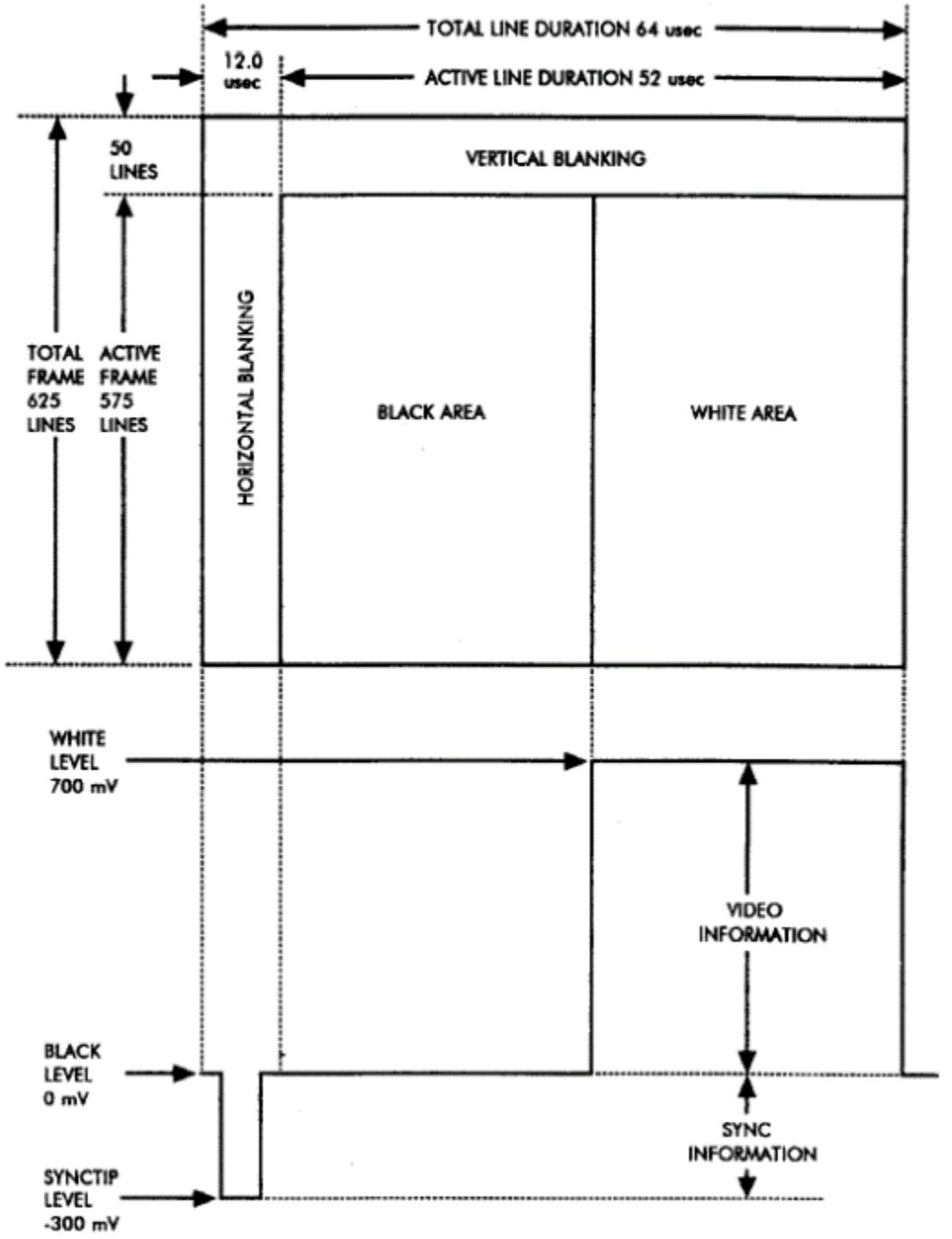


Figure 1.10 Significant amplitude and timing values of composite video signal relative to picture characteristics in 625/50 standard.

TABLE 1.5 Details of Line-Synchronizing Signals (See Figs. 1.11 and 1.12)

Symbol	Parameter	525/60 standard	625/50 standard
H	Nominal line period, μs	63.556	64
A	Line blanking interval, μs	10.7 (derived)	12.05 ± 0.25
B	Horizontal reference point to horizontal blanking end, μs	9.2 +0.2/−0.1	10.5 (derived)
C	Horizontal blanking start to horizontal reference point (front porch), μs	1.5 ± 0.1	1.5 ± 0.3
D	Horizontal synchronizing pulse duration, μs	4.7 ± 0.1	4.7 ± 0.1
E	Horizontal synchronizing pulse end to blanking pulse end (back porch), μs	4.5 (derived)	5.8 (derived)
F	Horizontal blanking pulse risetime, ns	140 ± 20	300 ± 100
G	Horizontal synchronizing pulse risetime, ns	140 ± 20	200 ± 100

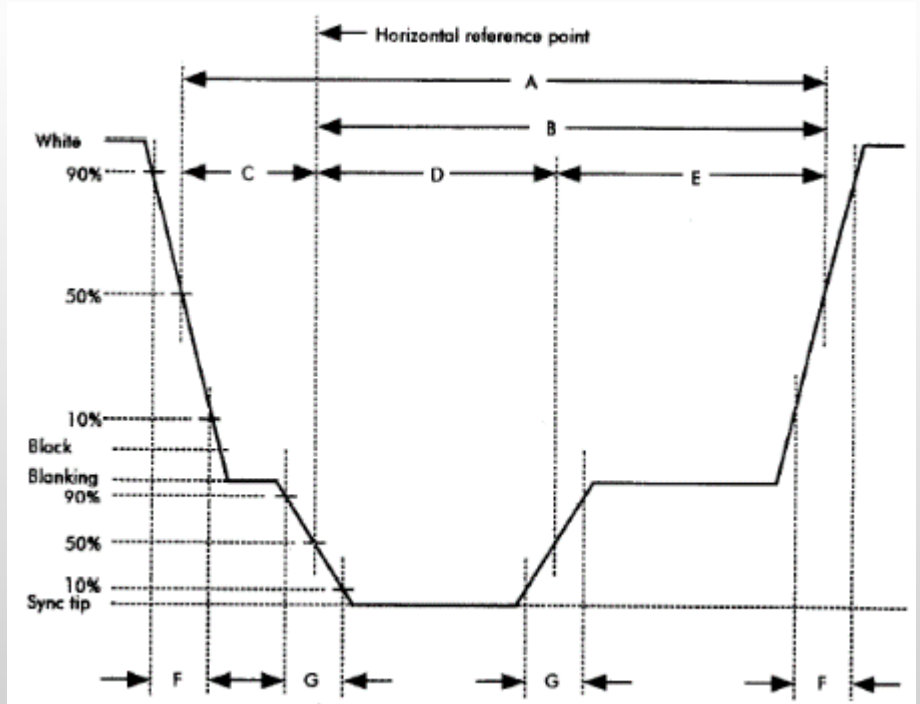


Figure 1.11 525/60 scanning standard details of horizontal blanking interval.

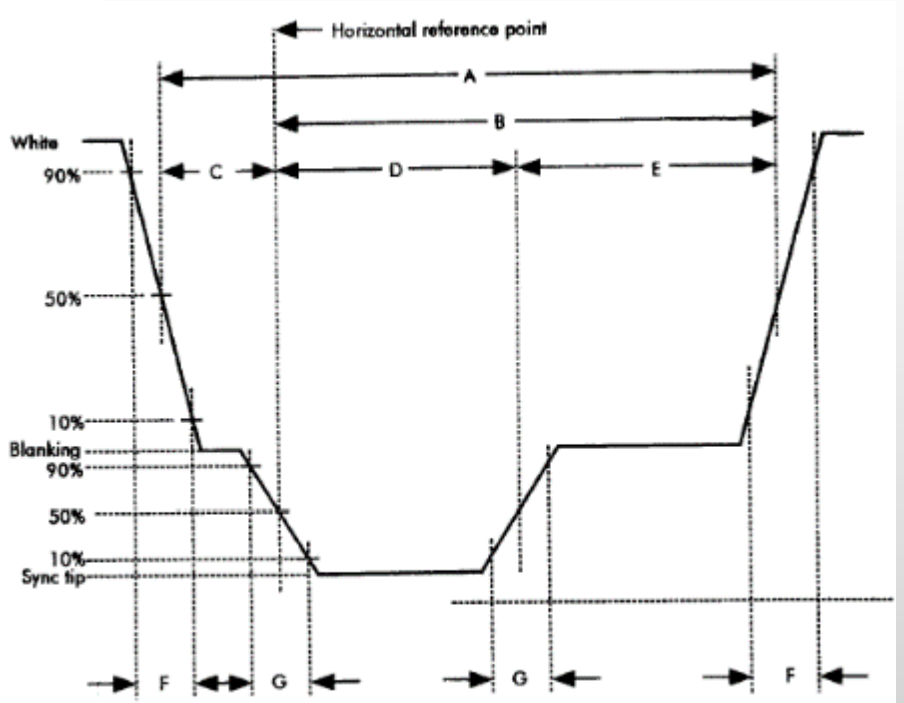


Figure 1.12 625/50 scanning standard details of horizontal blanking interval.

TABLE 1.6 Details of Field-Synchronizing Signals (See Figs. 1.13 and 1.14)

Parameter	525/60 standard	625/50 standard
Field period, ms	16.6833	20
Frame period, ms	33.3667	40
Vertical blanking start to front edge of first equalizing pulse, μs	1.5	Not specified
Vertical (field) blanking interval duration, lines	20 +1.5 μs	25
Preequalizing pulse sequence duration, lines	3	2.5
Preequalizing pulse width, μs	2.3 ± 0.1	2.35 ± 0.1
Vertical synchronizing pulse sequence duration, lines	3	2.5
Vertical serration pulse width, μs	4.7 ± 0.1	4.7 ± 0.2
Postequalization pulse duration, lines	3	2.5
Postequalizing pulse width, μs	2.3 ± 0.1	2.35 ± 0.1

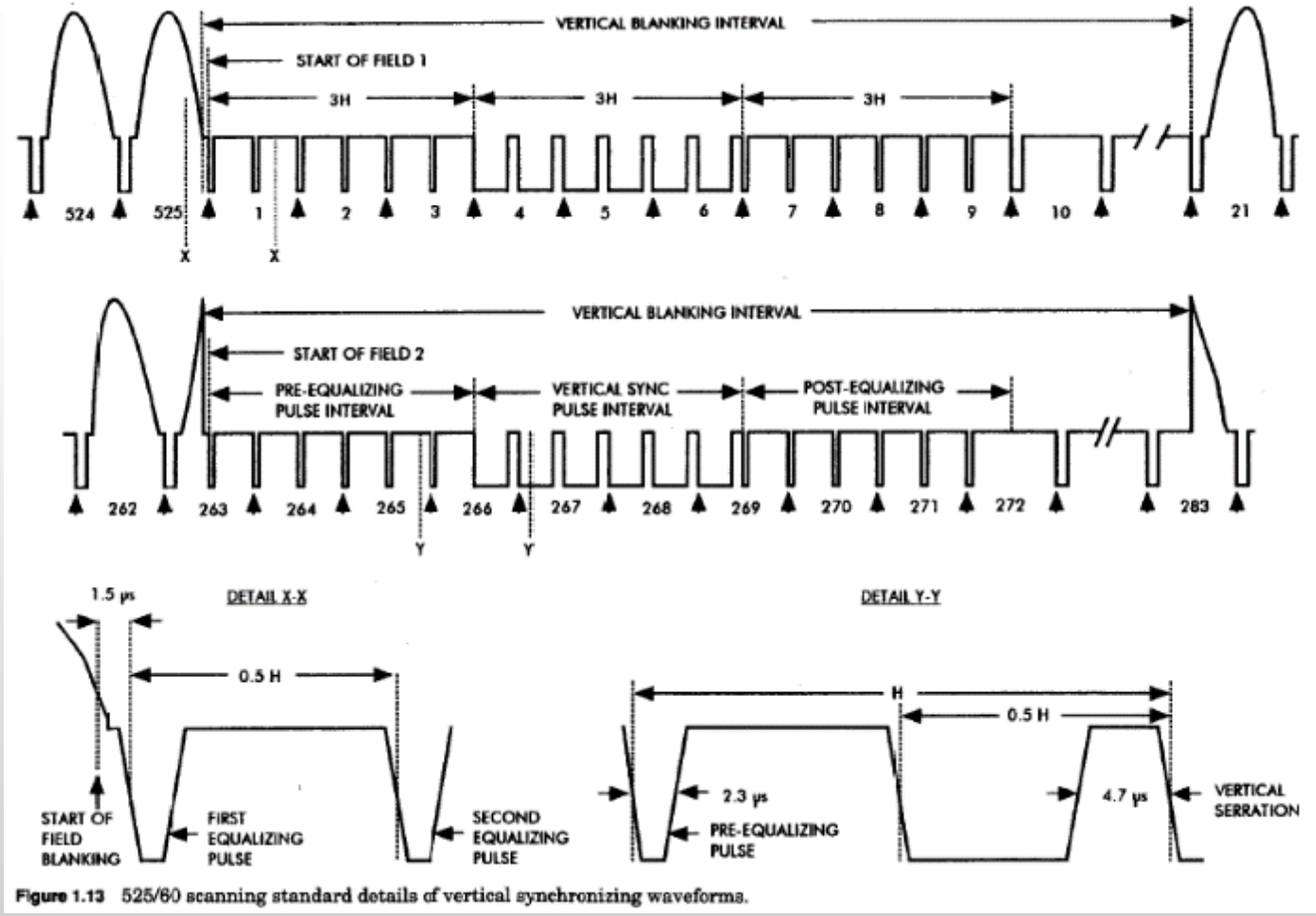


Figure 1.13 525/60 scanning standard details of vertical synchronizing waveforms.

TABLE 1.6 Details of Field-Synchronizing Signals (See Figs. 1.13 and 1.14)

Parameter	525/60 standard	625/50 standard
Field period, ms	16.6833	20
Frame period, ms	33.3667	40
Vertical blanking start to front edge of first equalizing pulse, μs	1.5	Not specified
Vertical (field) blanking interval duration, lines	20 +1.5 μs	25
Preequalizing pulse sequence duration, lines	3	2.5
Preequalizing pulse width, μs	2.3 ± 0.1	2.35 ± 0.1
Vertical synchronizing pulse sequence duration, lines	3	2.5
Vertical serration pulse width, μs	4.7 ± 0.1	4.7 ± 0.2
Postequalization pulse duration, lines	3	2.5
Postequalizing pulse width, μs	2.3 ± 0.1	2.35 ± 0.1

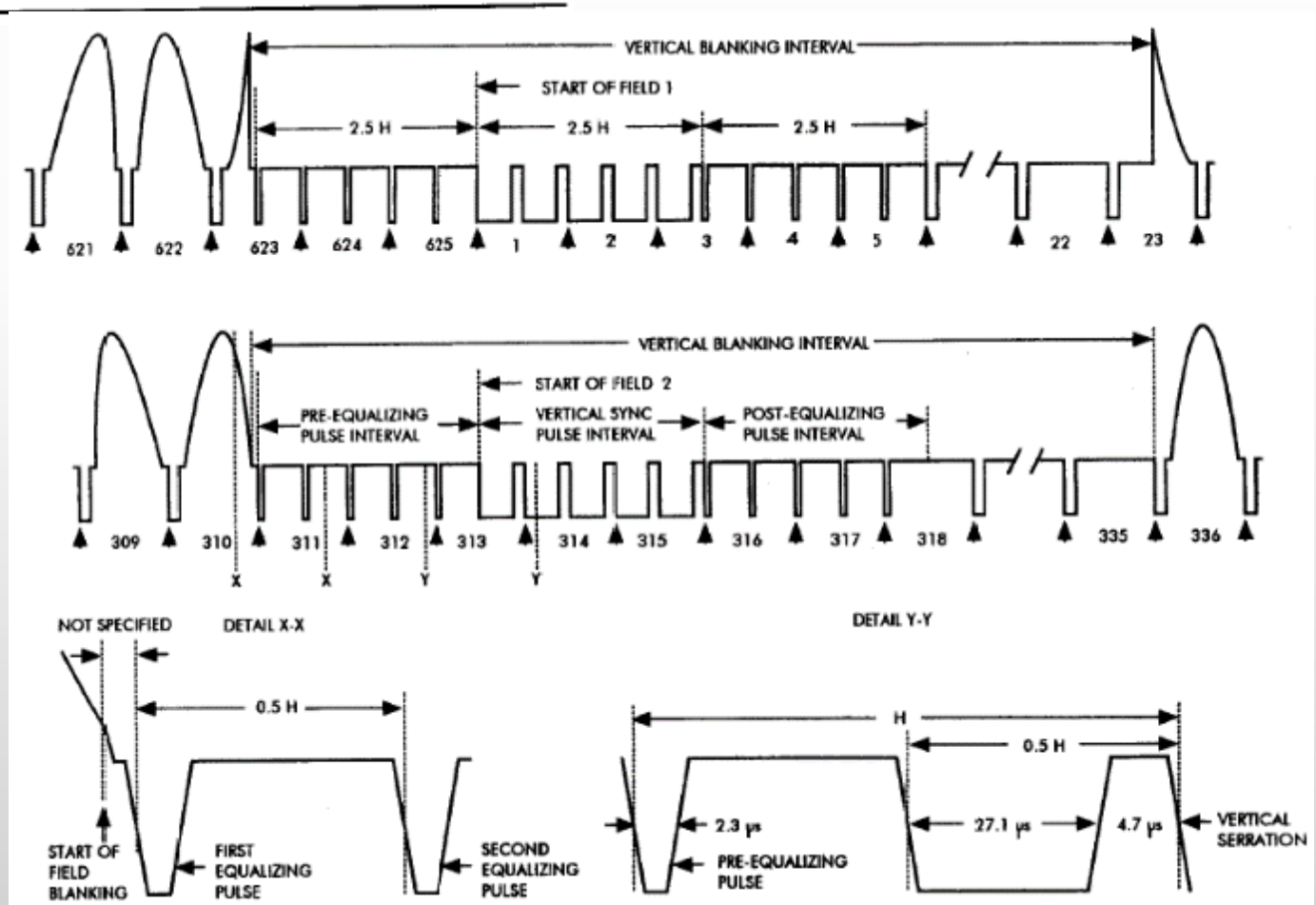


Figure 1.14 625/50 scanning standard details of vertical synchronizing waveforms.

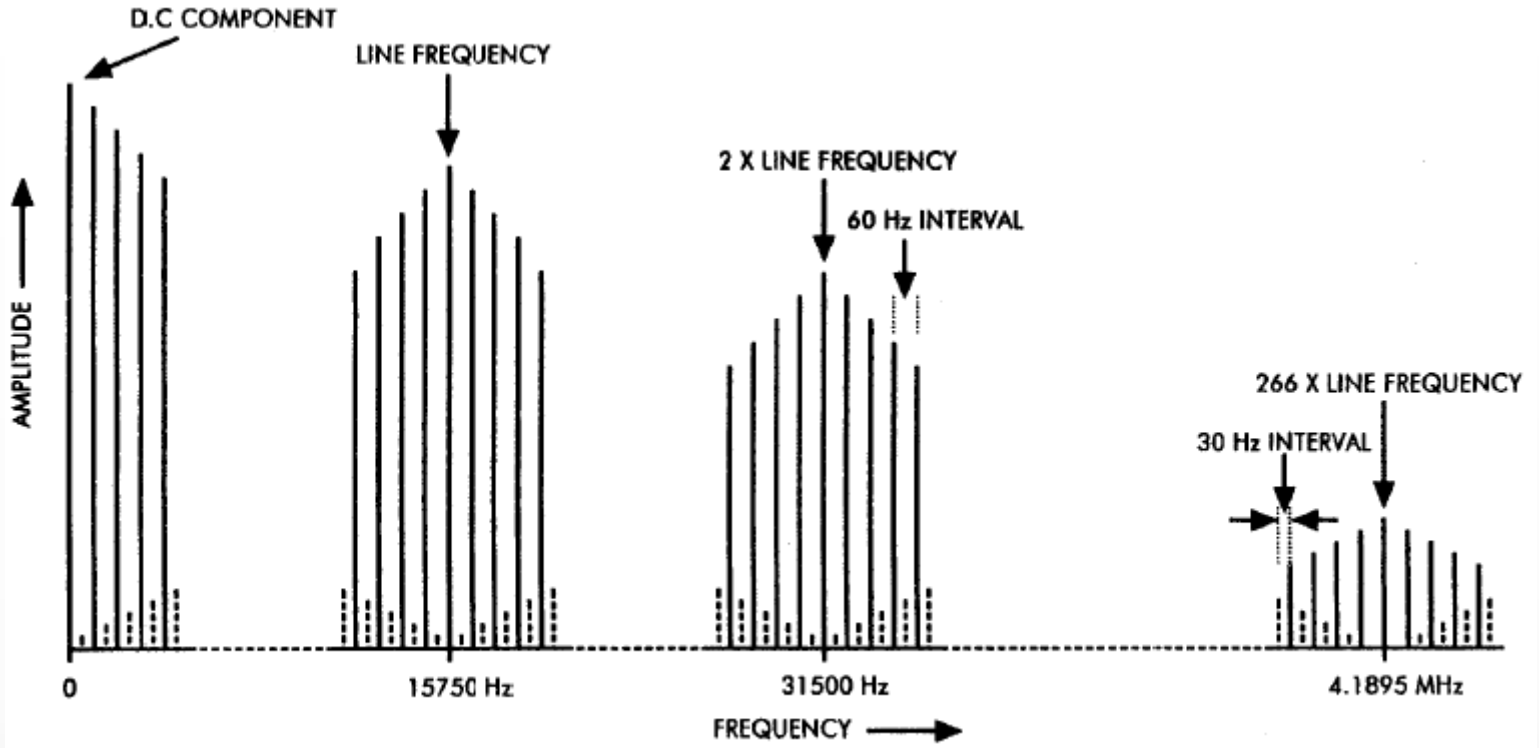


Figure 1.17 Simplified 525/60 monochrome video spectrum of a stationary scene.

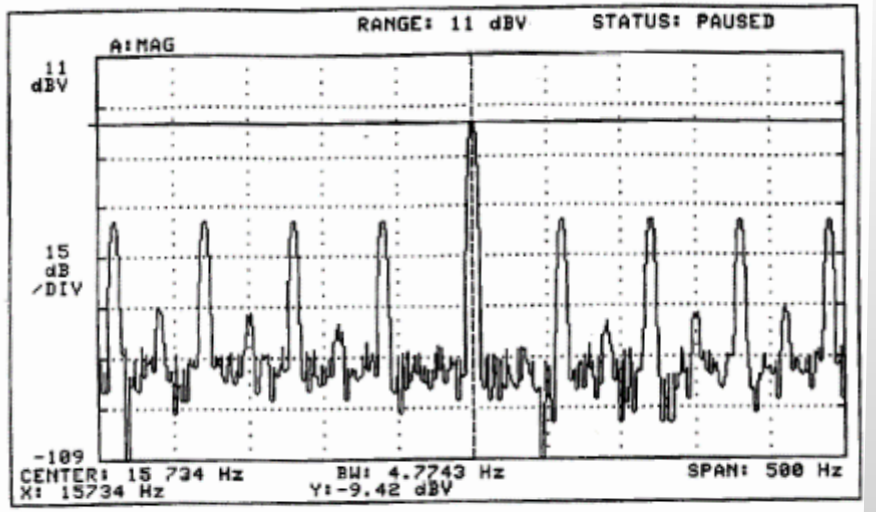


Figure 1.18 Details of 525/60 scanning system spectrum as seen on a spectrum analyzer. Center frequency, 15734 Hz; horizontal resolution, 50 Hz/division. Note sideband components at 59.94 Hz and 29.97 Hz intervals.

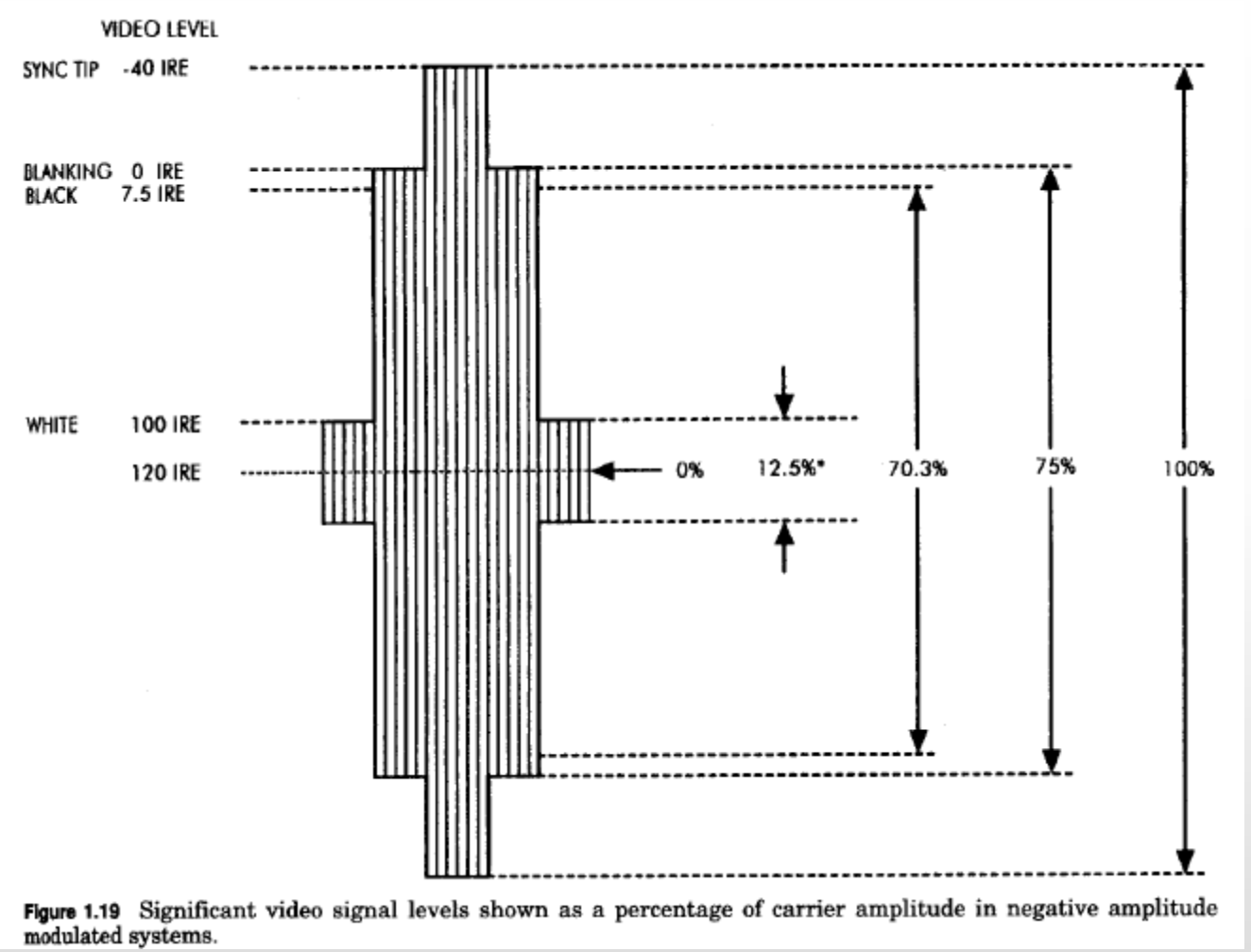


Figure 1.19 Significant video signal levels shown as a percentage of carrier amplitude in negative amplitude modulated systems.

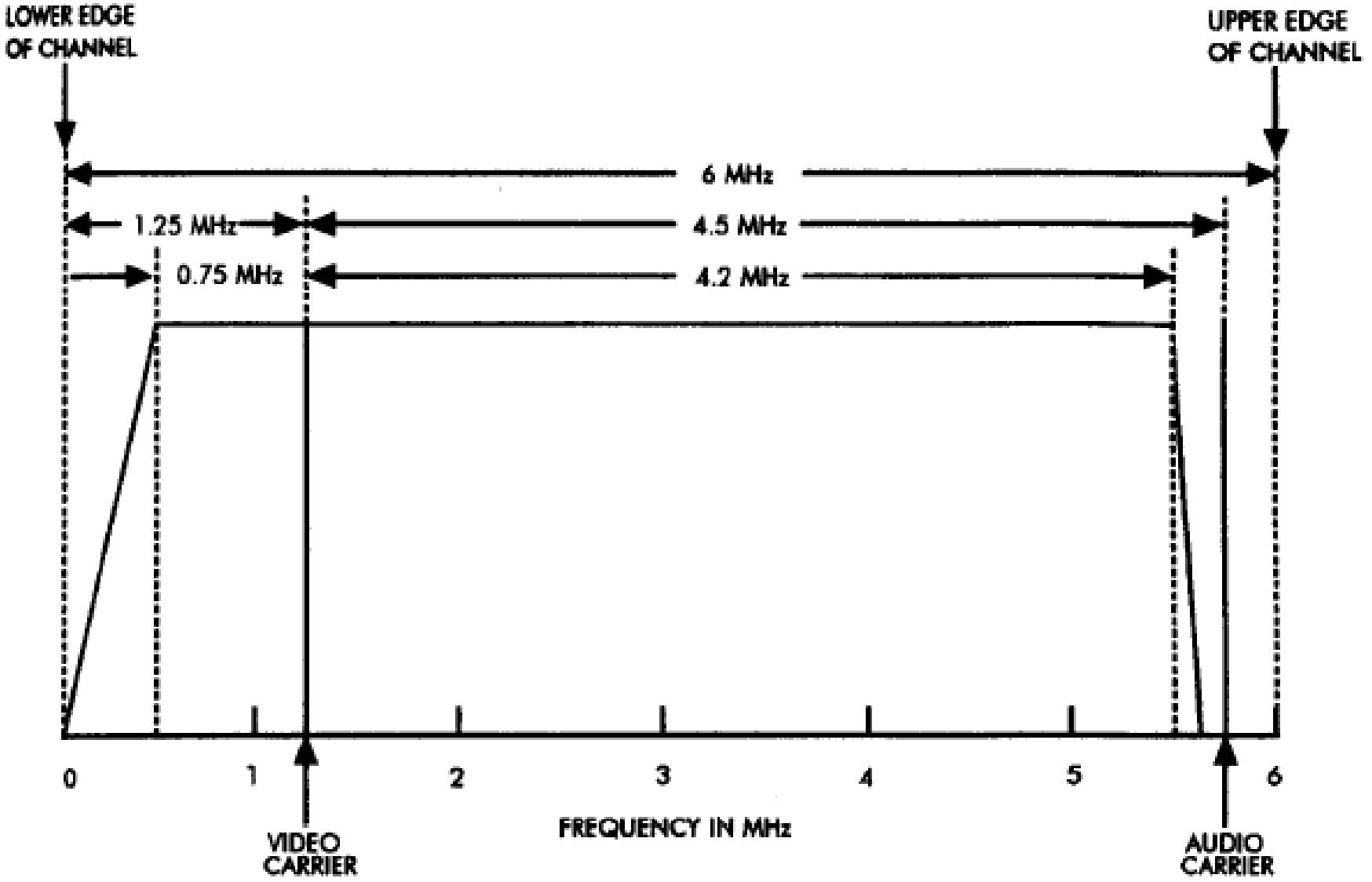


Figure 1.20 CCIR M Vestigial sideband characteristics and channel occupancy.

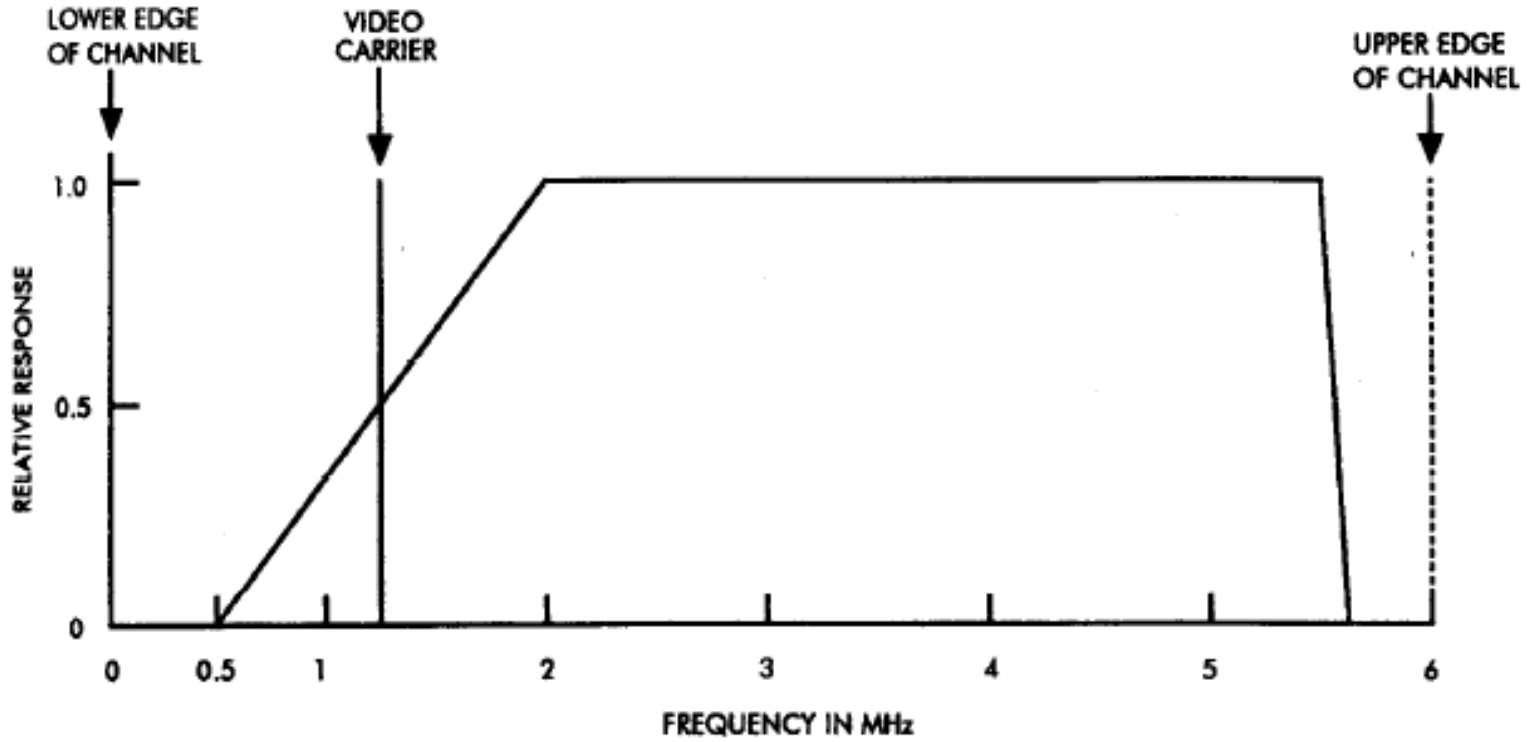


Figure 1.21 CCIR M Receiver selectivity characteristics to compensate for vestigial sideband effects.

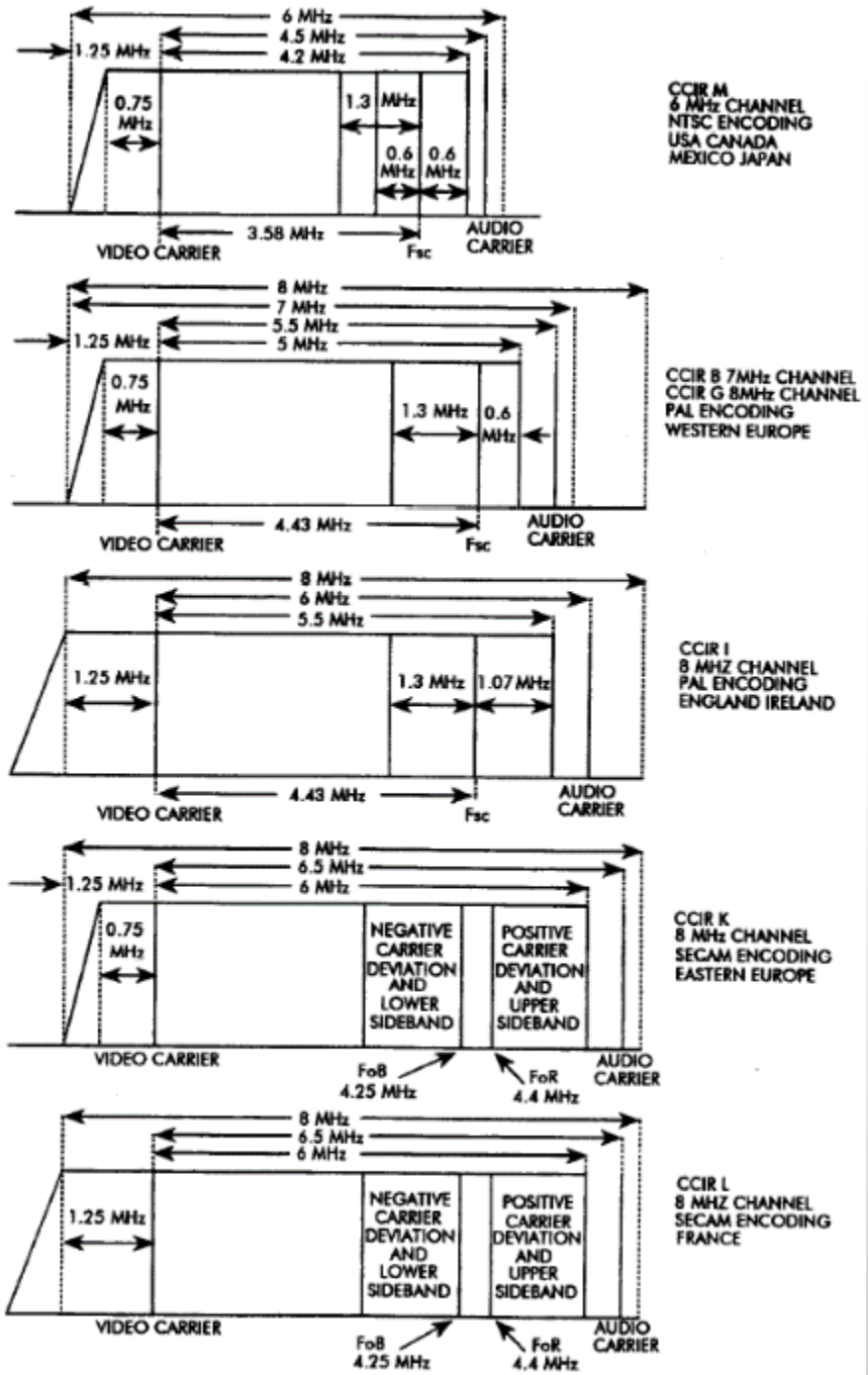


Figure 1.22 Transmission channel occupancy of several CCIR television systems.

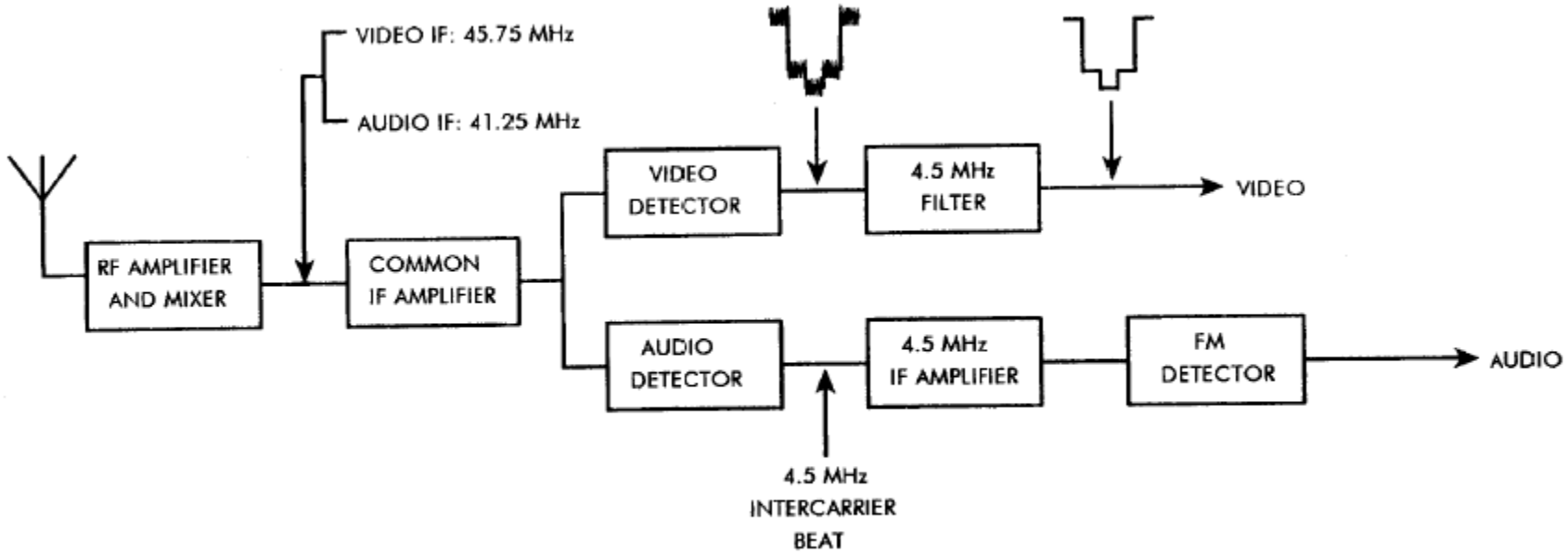
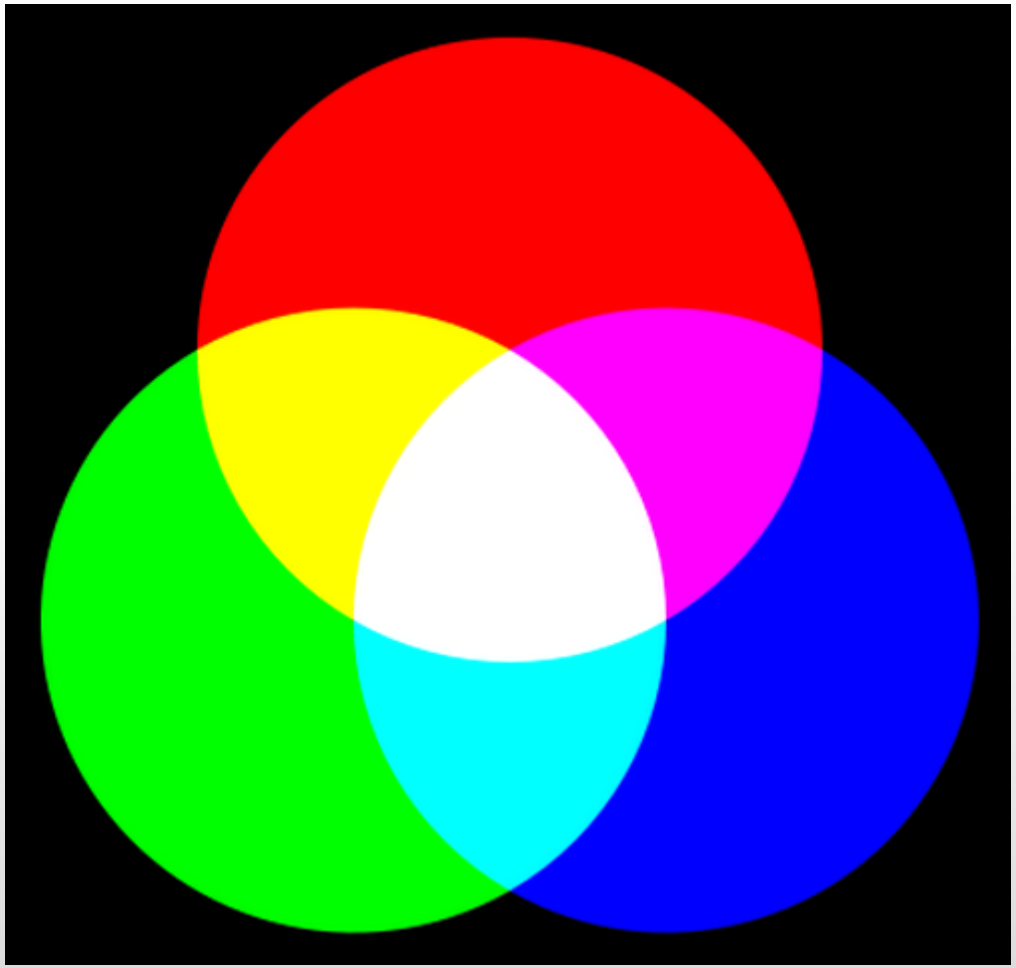
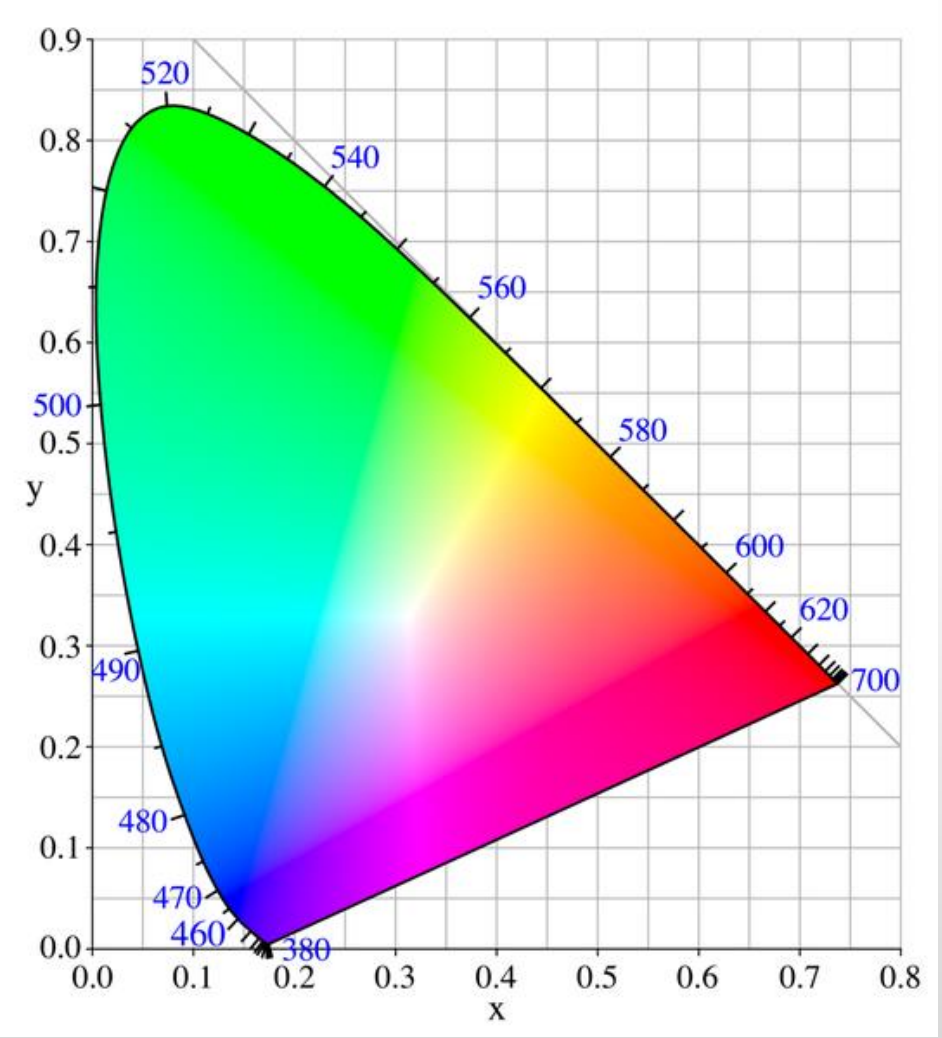


Figure 1.23 Simplified block diagram of CCIR M intercarrier receiver.

Colores Primarios



Espacio de color CIE



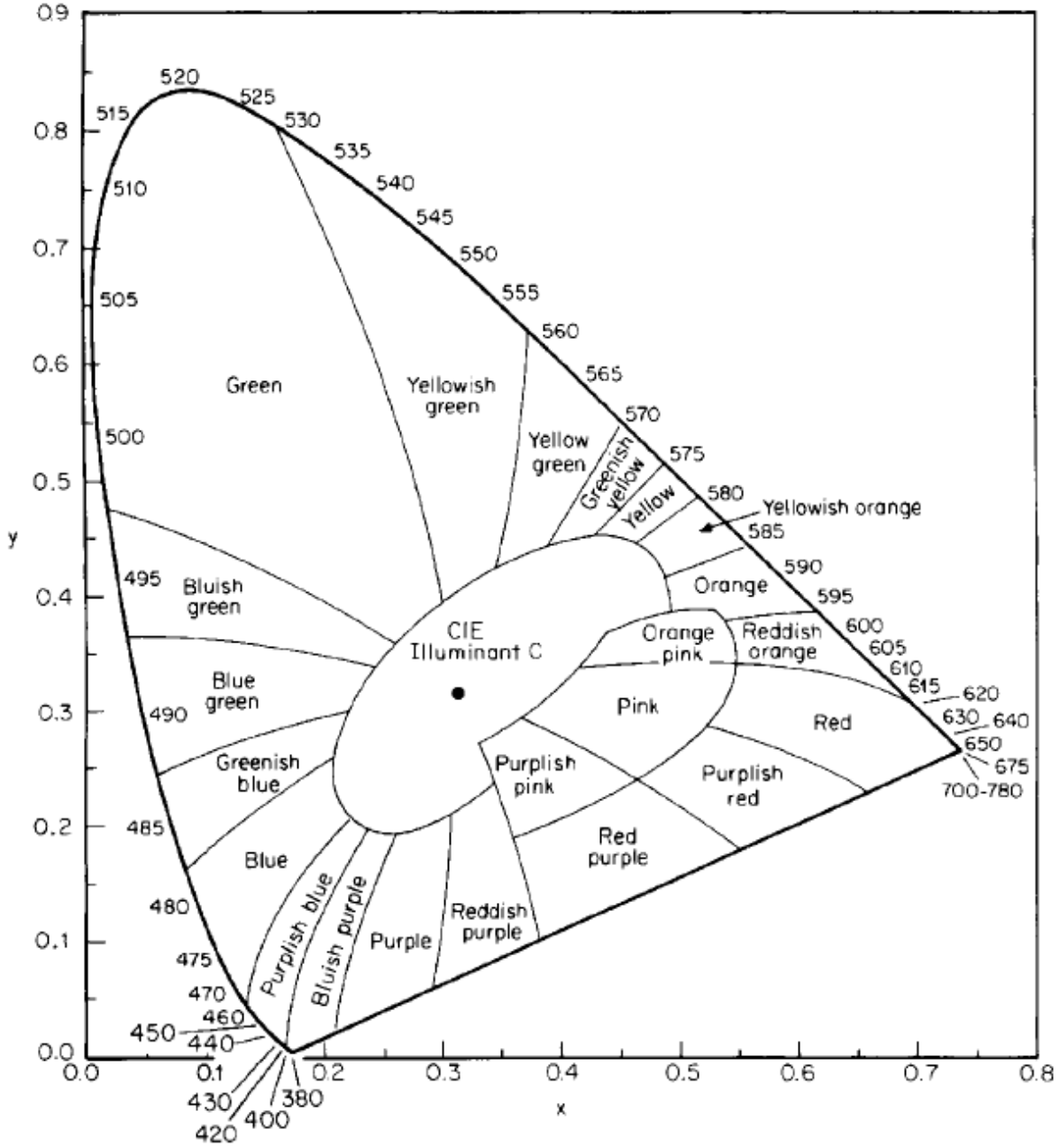


Figure 2.2.4 The CIE 1931 chromaticity diagram divided into various color names derived from observations of self-luminous areas against a dark background. (*After* [3].)

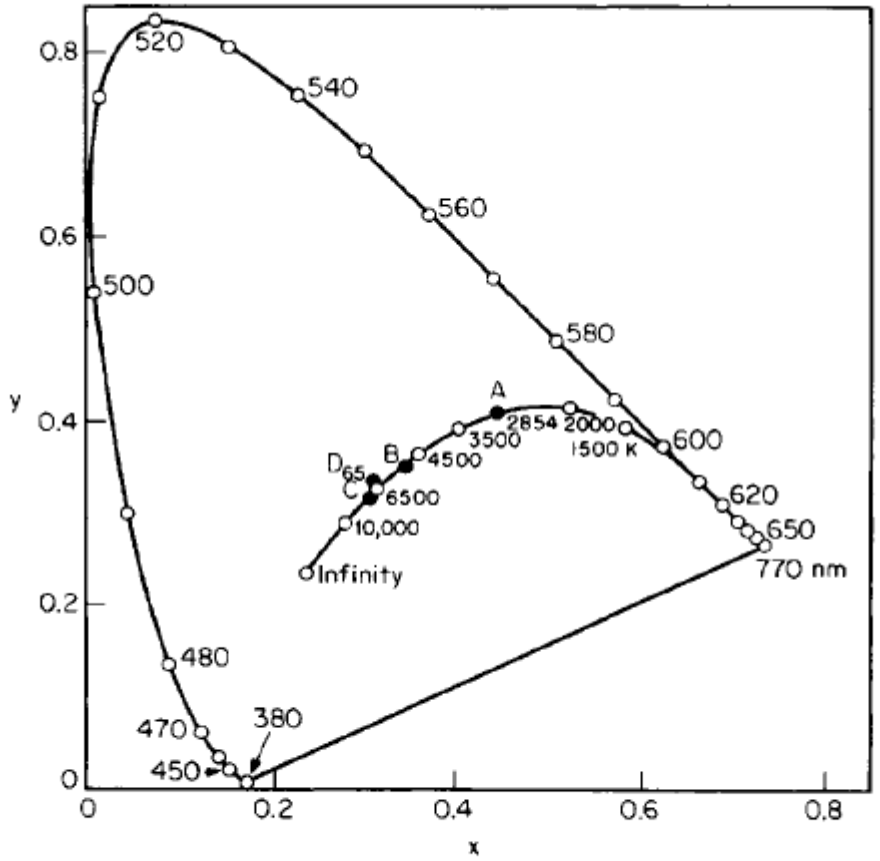
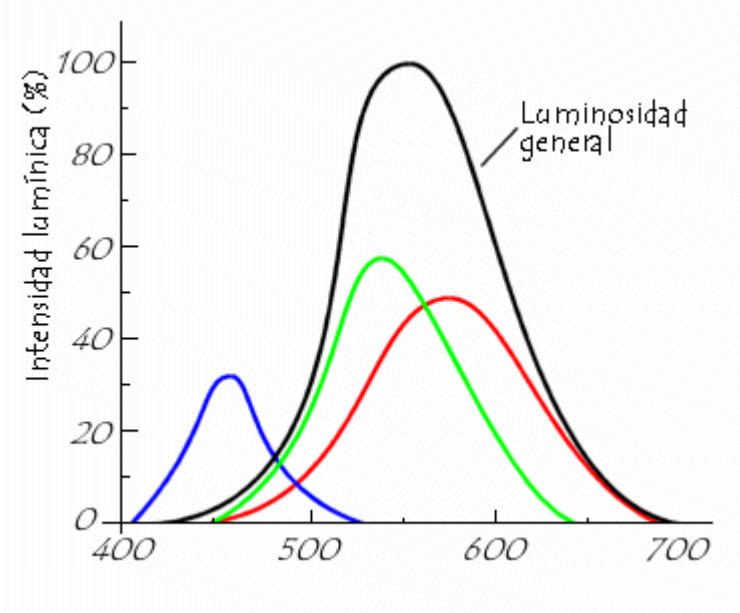


Figure 2.2.5 The relative spectral power distributions of CIE standard illuminants A, B, C, and D_{65}.


BH
HOSPITAL BRITANICO
Local
Local

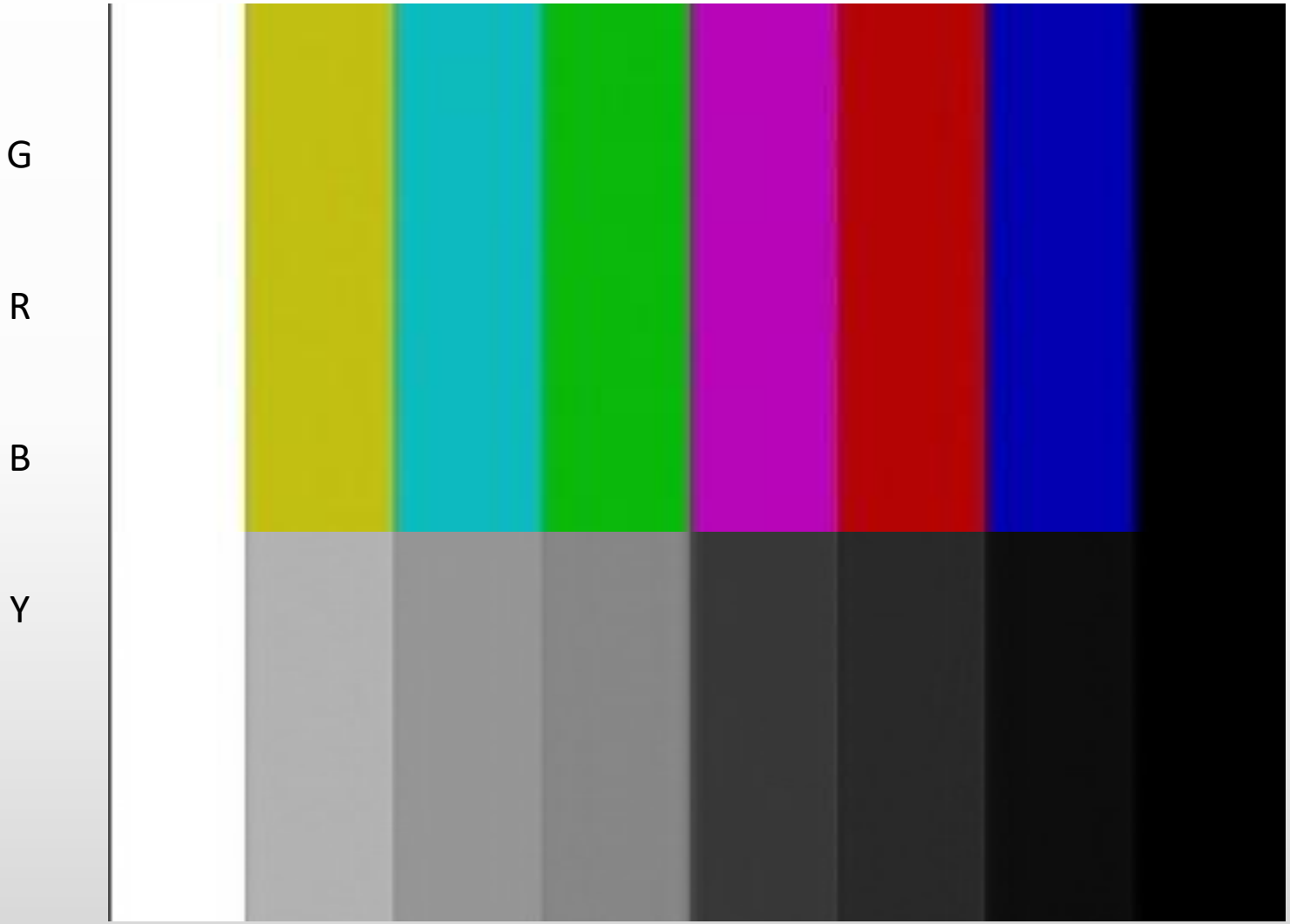
Sensibilidad del ojo a la luz

- Tres clases de conos:
- **Rojos:** principalmente sensibles a la radiación roja (570 nm)
- **Verdes:** principalmente sensibles a la radiación verde (535 nm)
- **Azules:** principalmente sensibles a la radiación azul (445 nm)

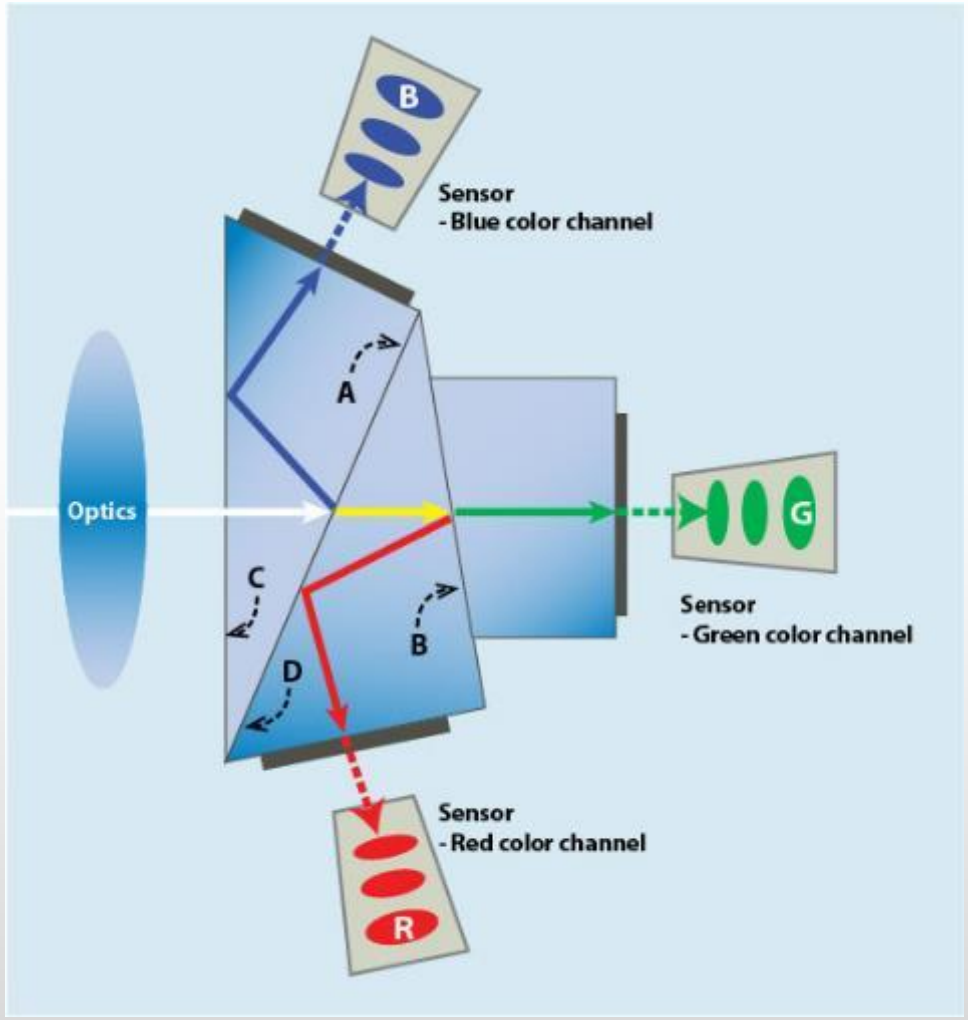


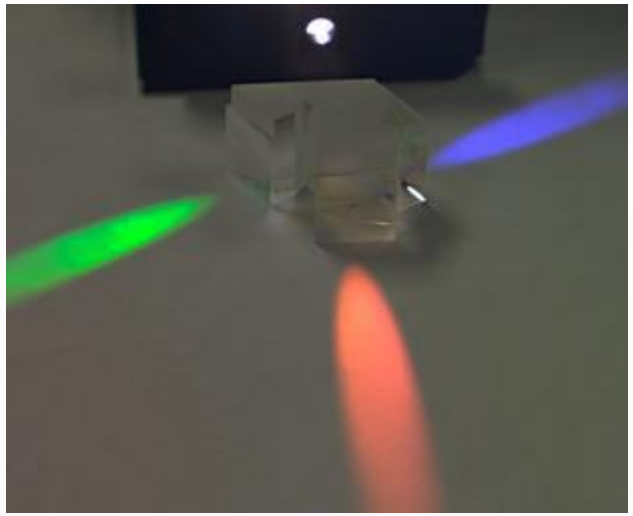
$$Y = 0{,}59\ G + 0{,}30\ R + 0{,}11\ B$$

Barras de color

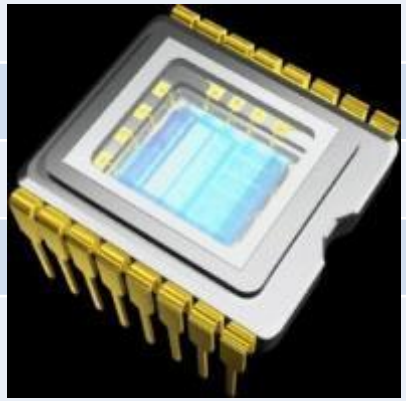


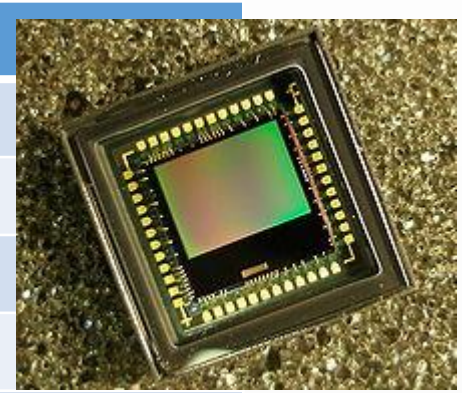
Obtención de RGB





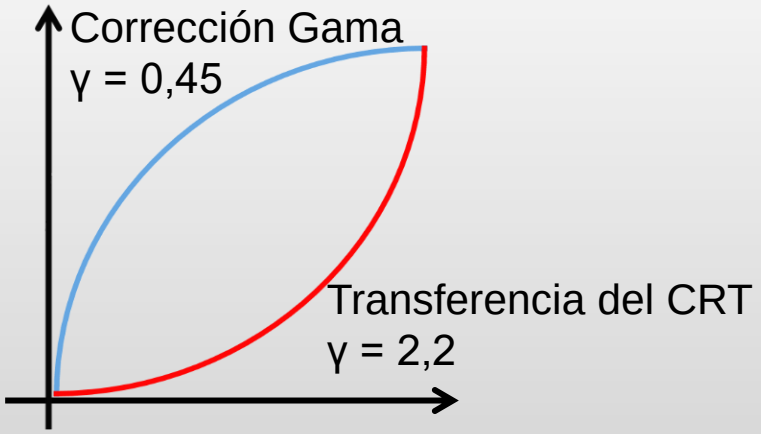
Sensores

CCD	CMOS
Tecnología más madura	
Mayor rango dinámico	
Menor ruido	
Respuesta más uniforme	
	Costo más bajo
	Mayor velocidad
	No tiene blooming
	Menor consumo
	Celdas independientes
	Circuitos accesorios más sencillos (digitalización en el pixel)
	Menores tensiones



Corrección Gama

- La relación entre la tensión de la señal eléctrica y la intensidad luminosa de los tubos de rayos catódicos no es lineal.
- Para evitar distorsiones se introduce la ‘Corrección Gama’



R → R’
G → G’
B → B’

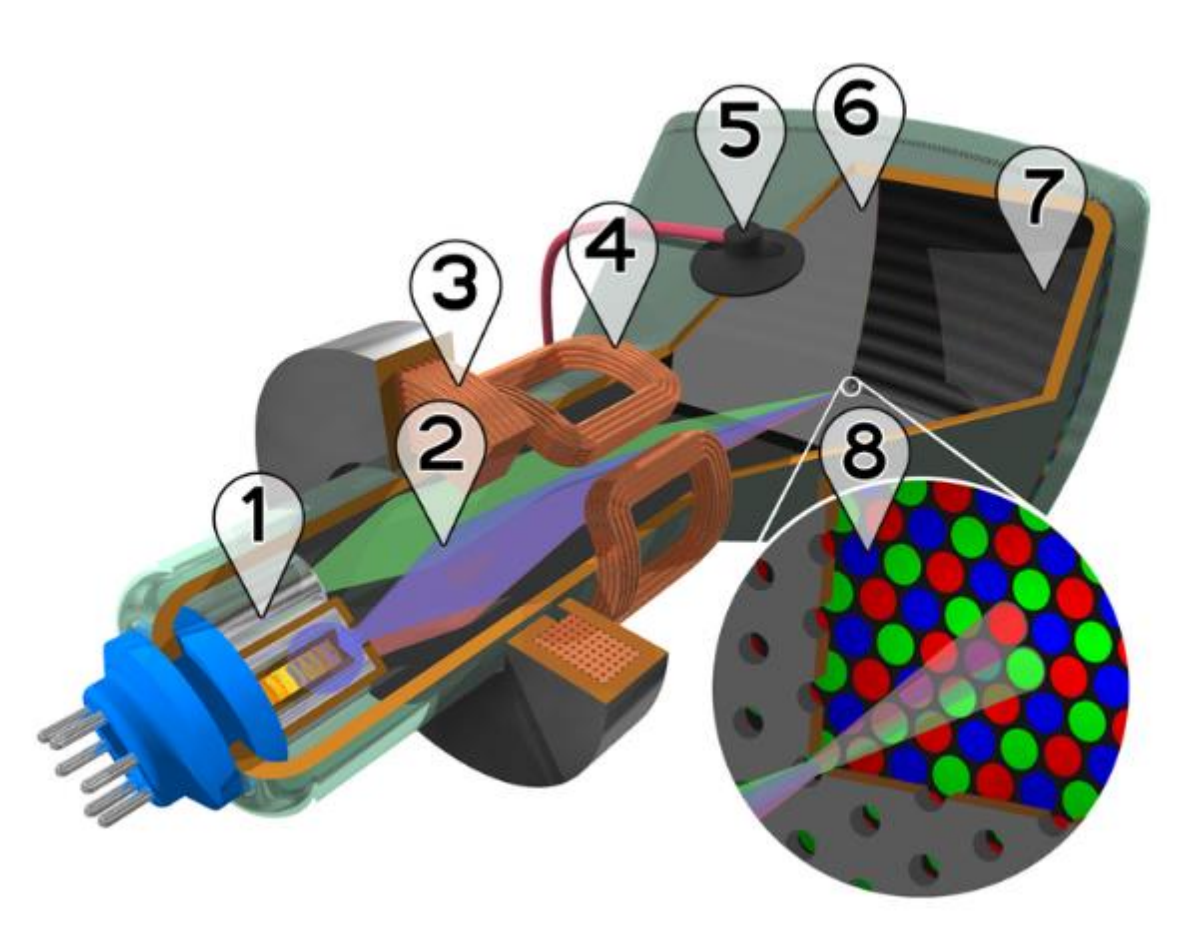
Señales de Componentes

- R
- G
- B

- Y = 0,59 G + 0,30 R + 0,11 B
- R-Y = – 0,59 G + 0,70 R – 0,11 B
- B-Y = – 0,59 G – 0,30 R + 0,89 B

- Y I Q YUV
- Y C_B C_R Y P_B P_R

Tubo de rayos catódicos tricromático



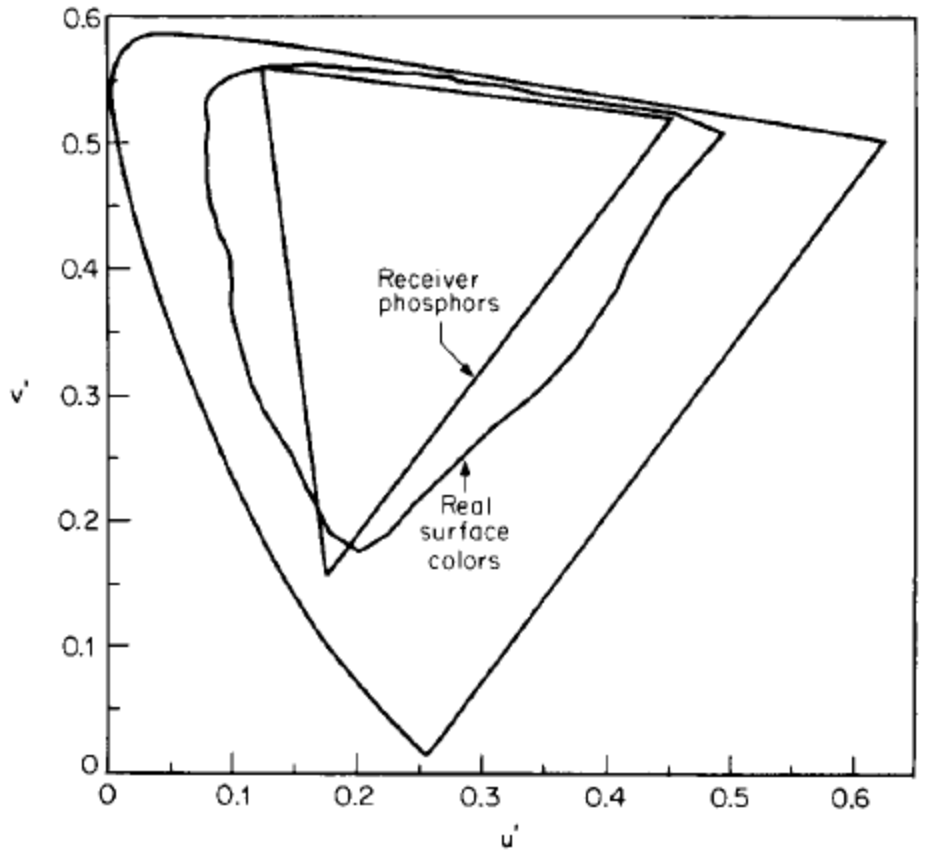
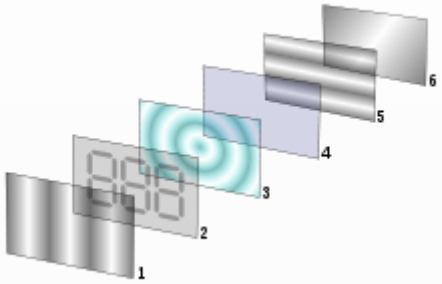
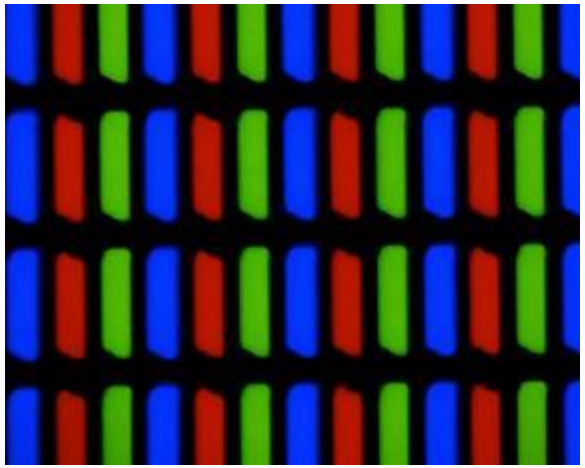
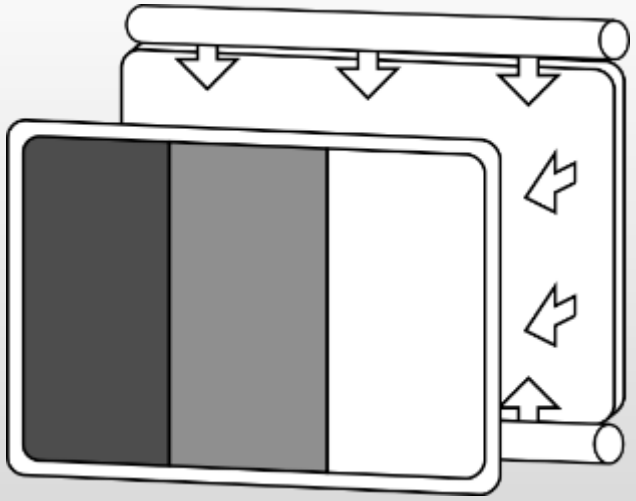


Figure 2.2.6 The color triangle defined by a standard test of color television receiver phosphors compared with the maximum real color gamut on a u′ , v′ chromaticity diagram. (*After* [6].)

Monitores LCD





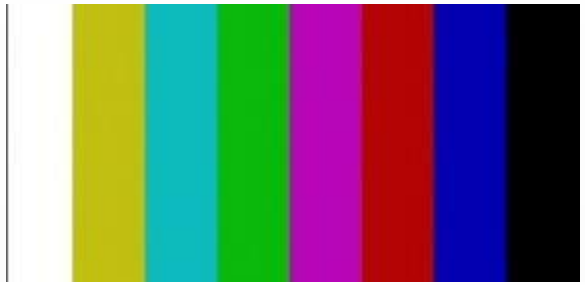


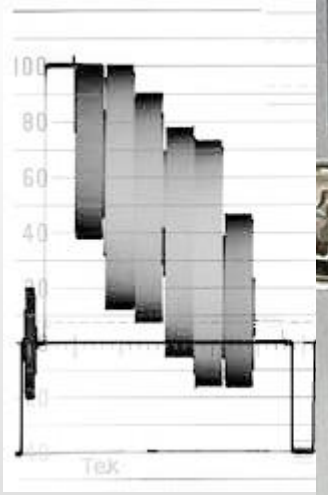
Retroiluminación con lámpara fluorescente

LED Backlight
- Edge LED
- Full-array LED
- Dyamic LED

- Más finos, mejor contraste dinámico, mayor gama de colores

La señal de video compuesto





Televisión Color

- Brillo
- Tinte
- Saturación

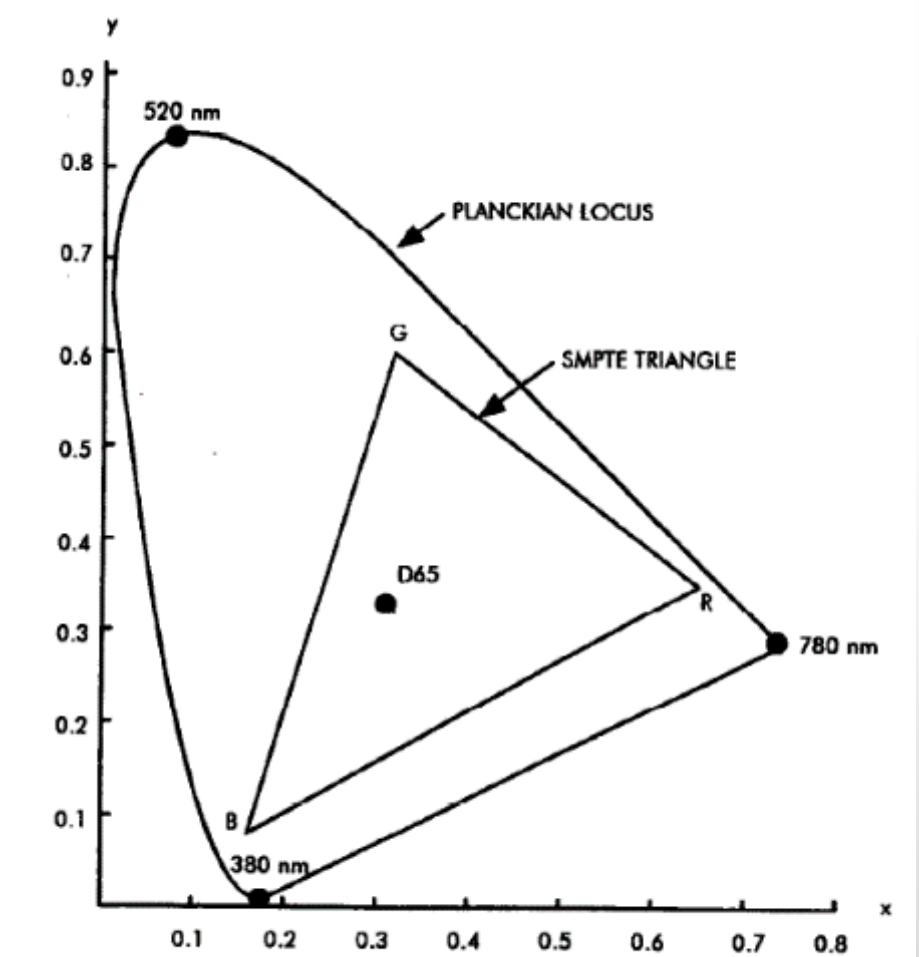


Figure 2.1 2D Planckian locus showing the location of the SMPTE phosphors and the D6500 reference white.

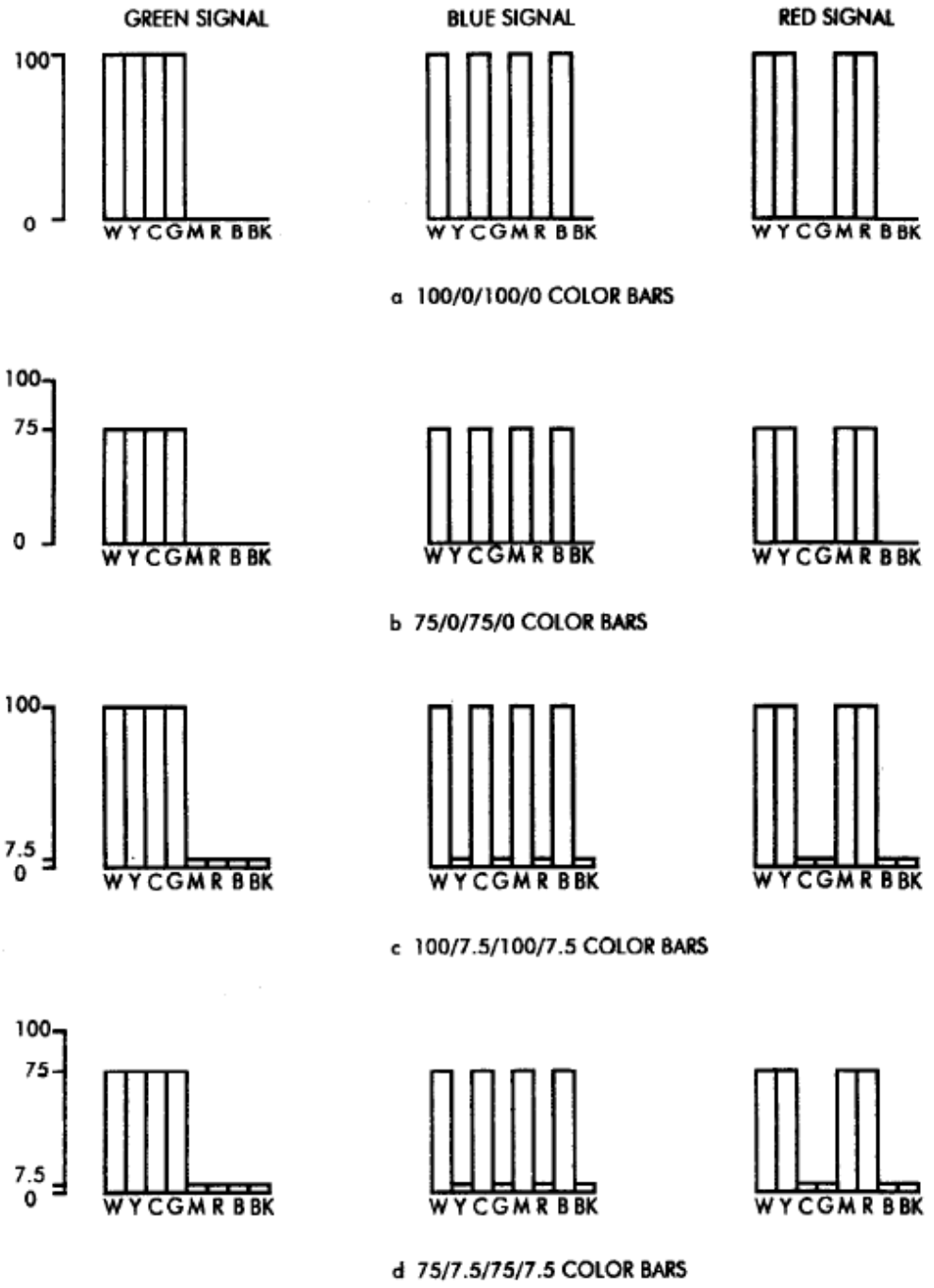


Figure 2.3 Relative amplitudes of components for four types of color bars.

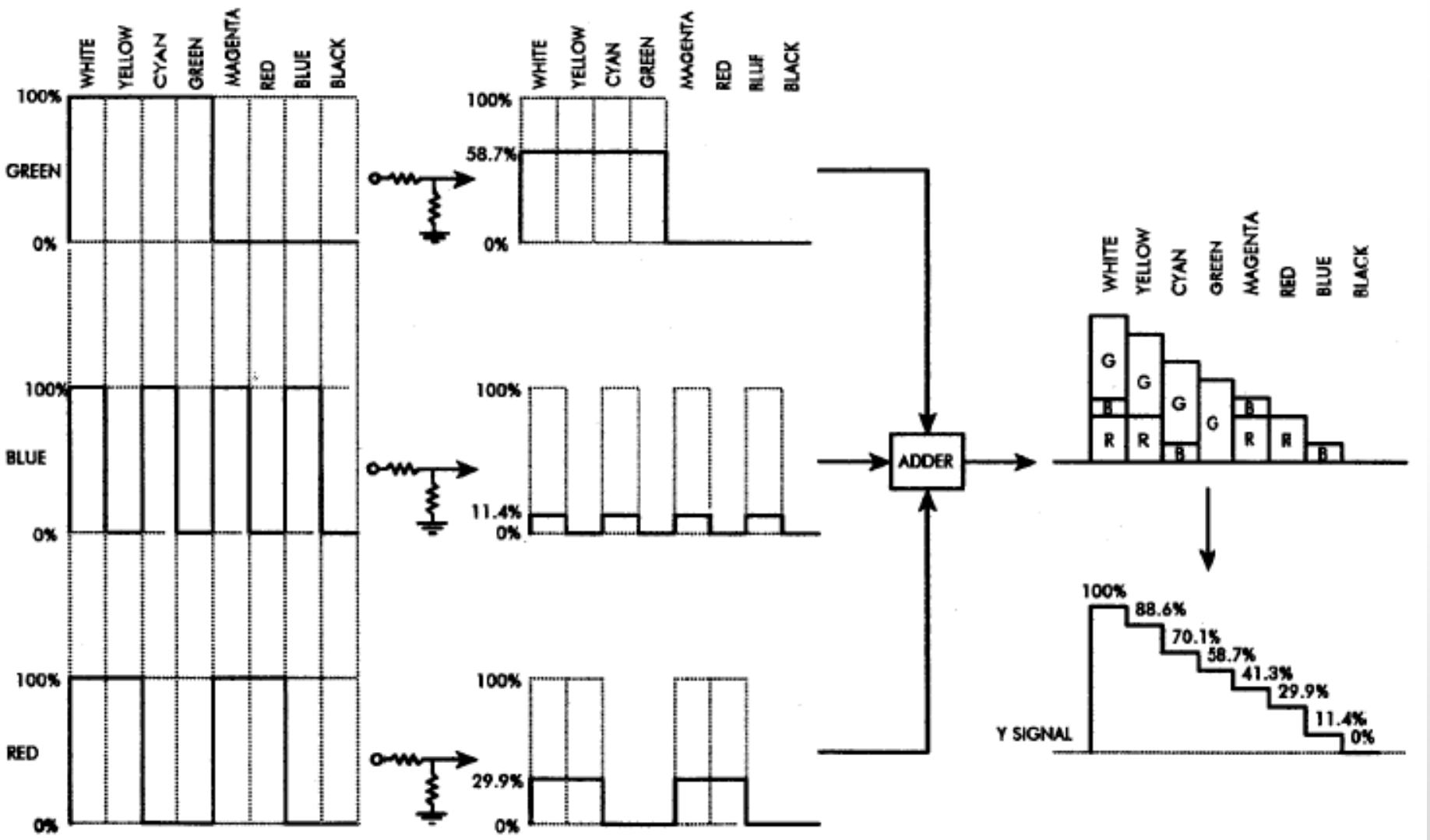


Figure 2.5 Graphic representation of the formation of 100/0/100/0 color bars Y signal from the primary green, blue, and red signals.

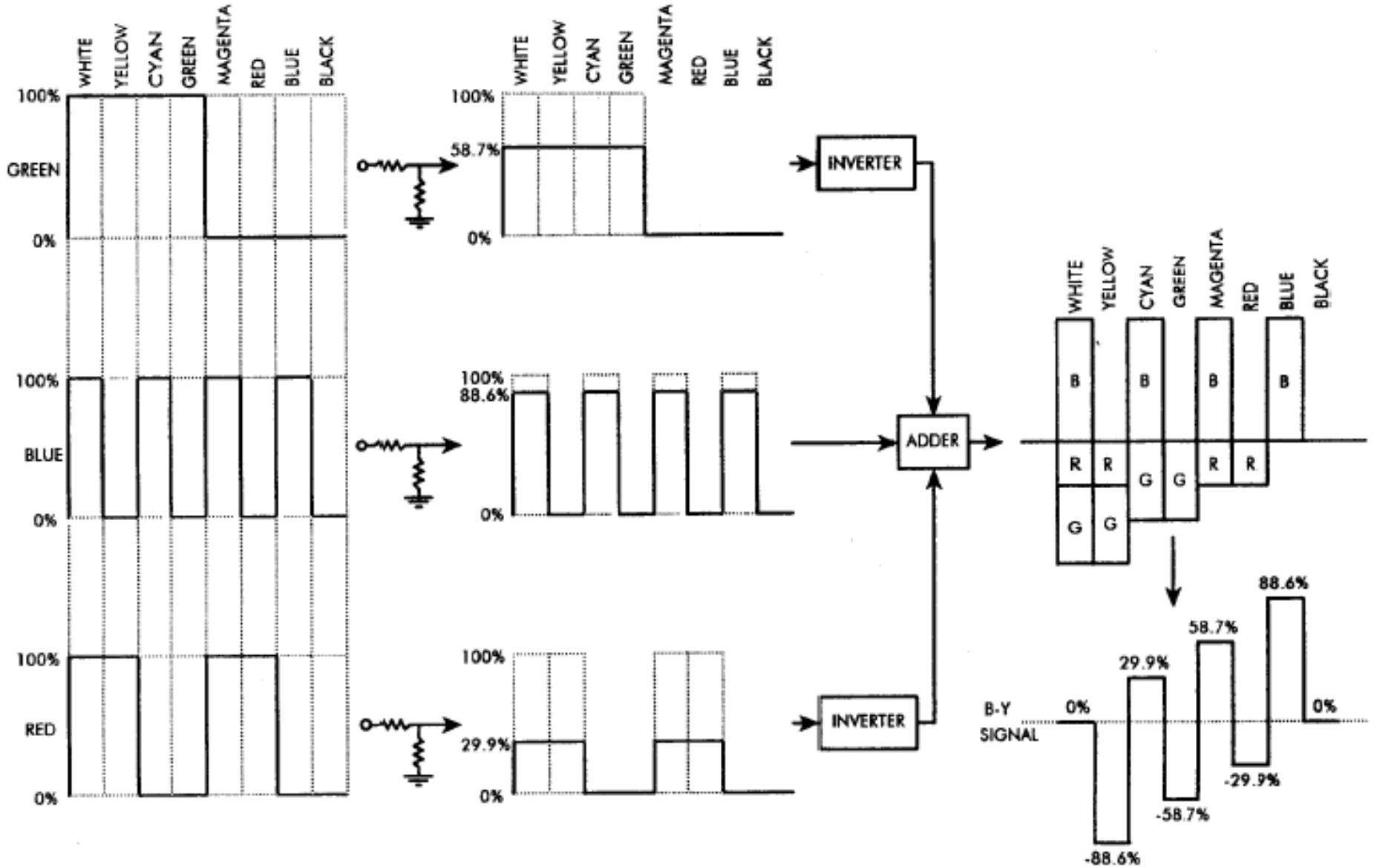


Figure 2.6 Graphic representation of the formation of 100/0/100/0 color bars blue color-difference signal from the primary green, blue, and red signals.

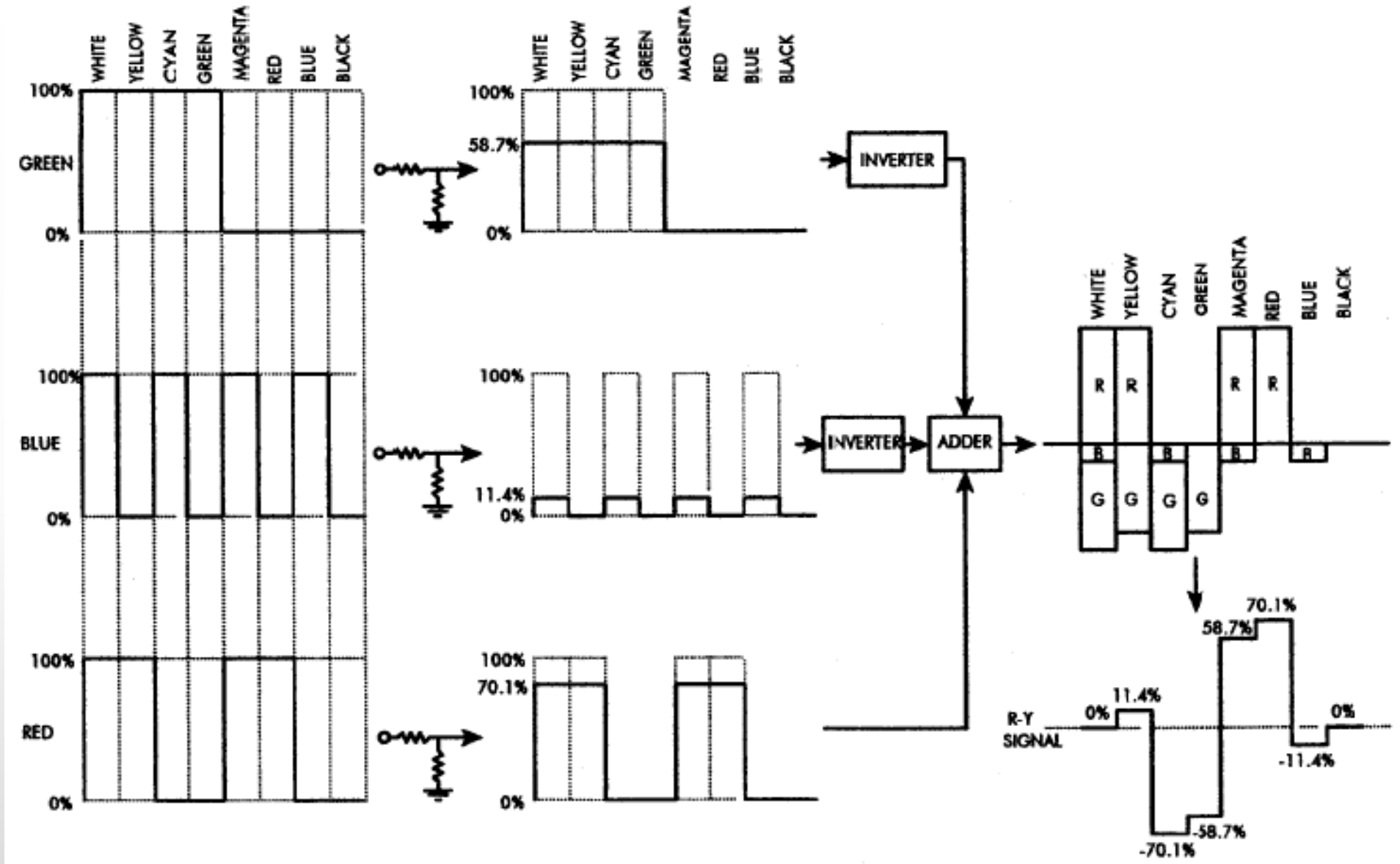


Figure 2.7 Graphic representation of the formation of 100/0/100/0 color bars red color-difference signal from the primary green, blue, and red signals.

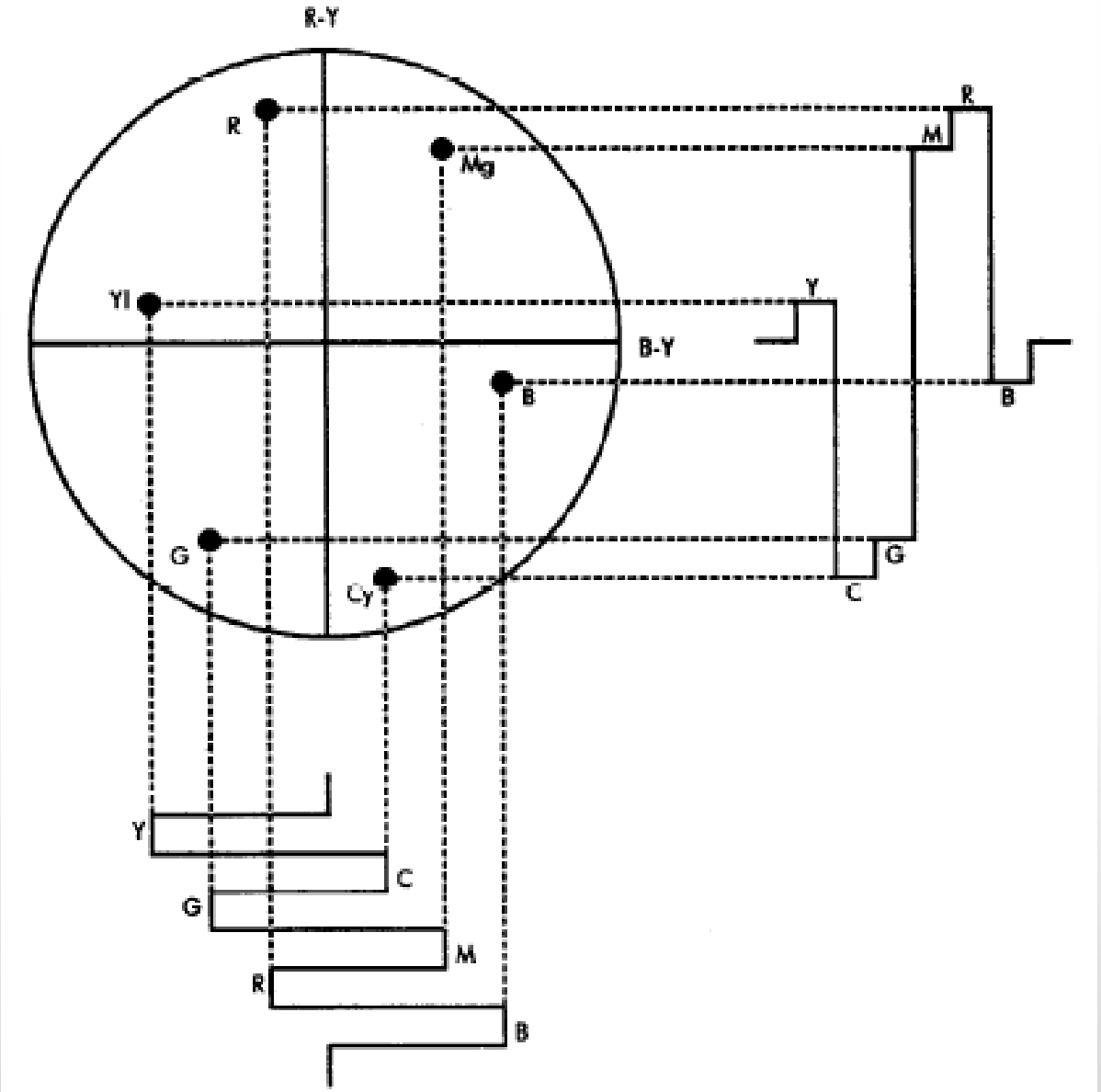
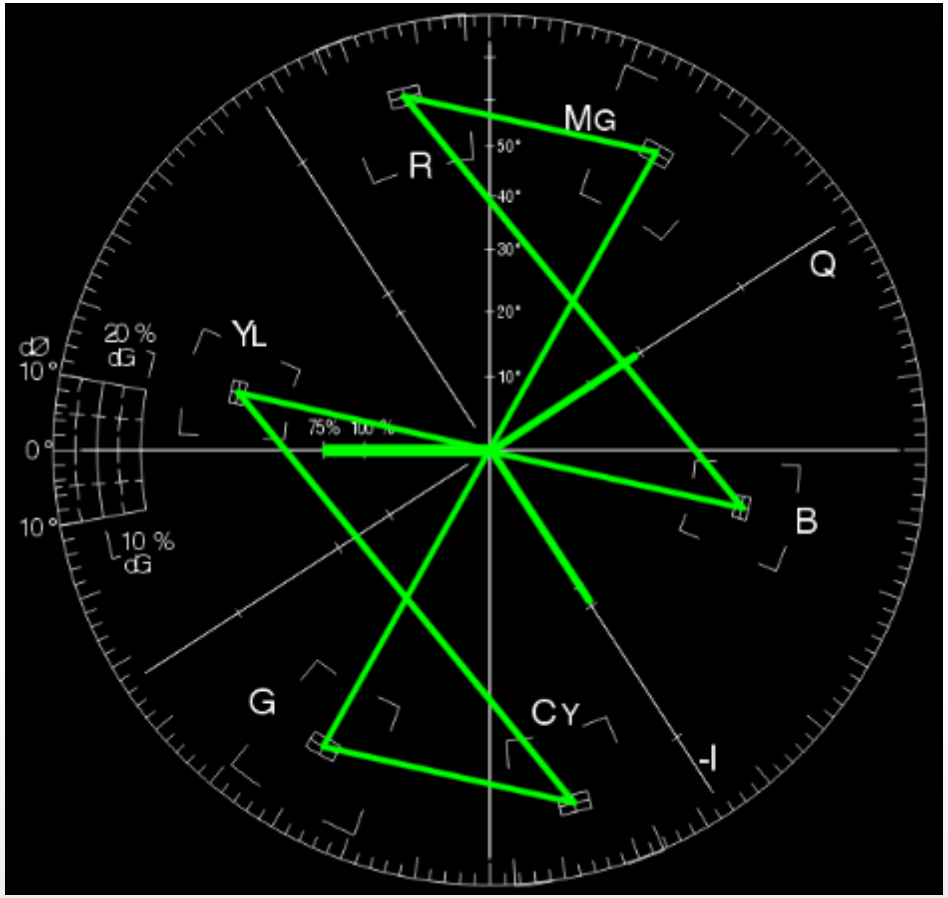
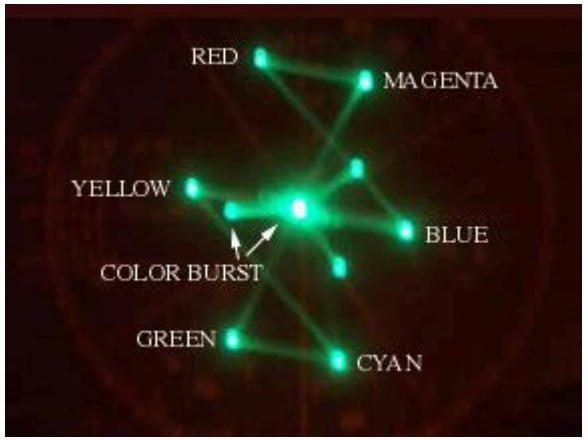
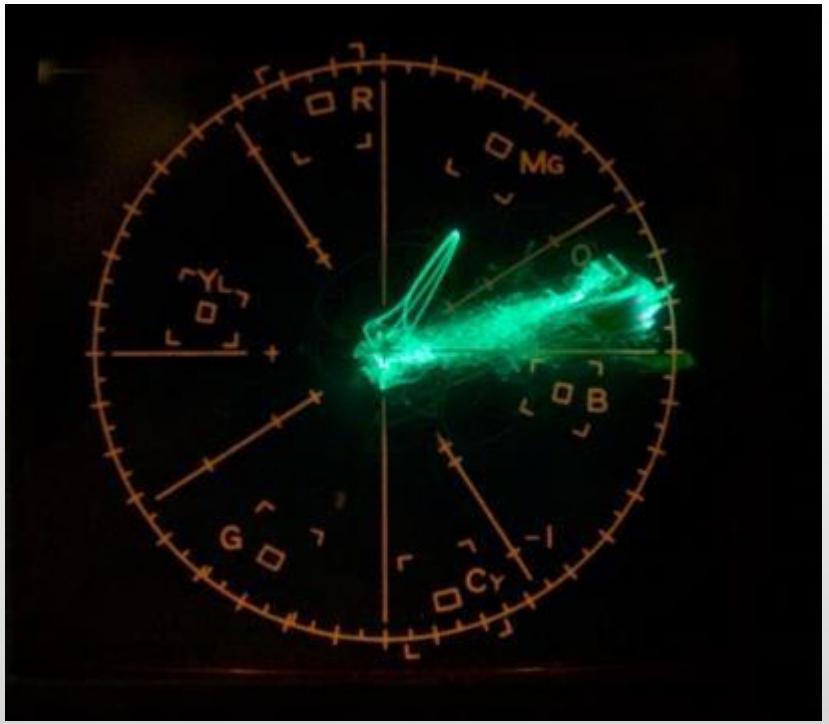


Figure 2.8 Graphic representation of the formation of a vector display of the 100/0/100/0 color bars chrominance components.


MG
R
Q
YL
B
G
CY
-I
dØ
10°
20 %
dG
0°
10°
10 %
dG
75%
50°
40°
30°
20°
10°


RED
MAGENTA
YELLOW
BLUE
COLOR BURST
GREEN
CYAN


R
MG
YL
B
G
CY
-I

Problema: enviar R, G y B o Y, R-Y y B-Y en el mismo ancho de banda que Y

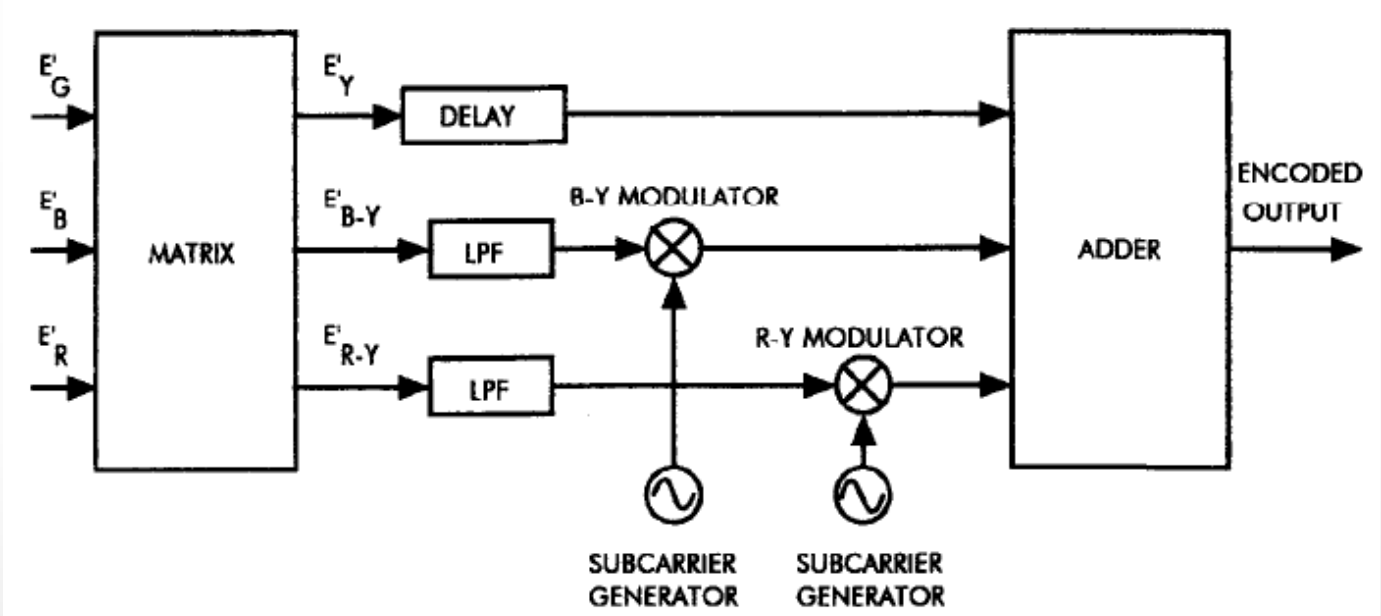


Figure 2.9 Simplified block diagram of generalized encoder.

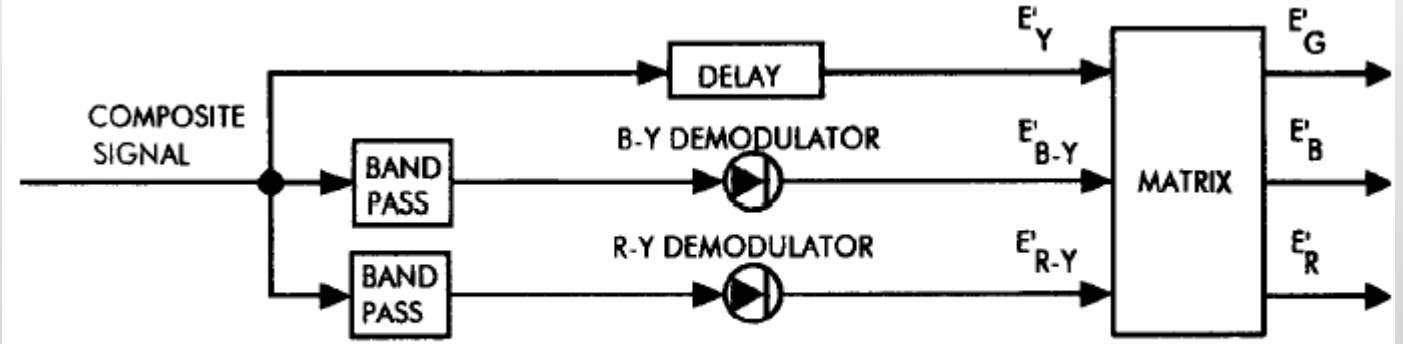


Figure 2.10 Simplified block diagram of generalized decoder.

El sistema NTSC
(National Television System Committee)

- Desarrollado originalmente para 525/60 (Estados Unidos)
- SMPTE 170M
- Las señales diferencias de color se transmiten en los «agujeros» que hay en el espectro de luminancia (que tiene un ancho de banda de 4,2 MHz)
- R-Y y B-Y (o I y Q) se modulan en cuadratura en modulación de amplitud con portadora suprimida (B-Y en fase y R-Y a 90º)
- Se modulan con ancho de banda de 600 KHz (transmisión) o 1,3 MHz (usado en Estudios)

$$f_{SC} = \frac{455}{2} f_H = 3{,}579{,}545 \pm 10 \text{ Hz}$$

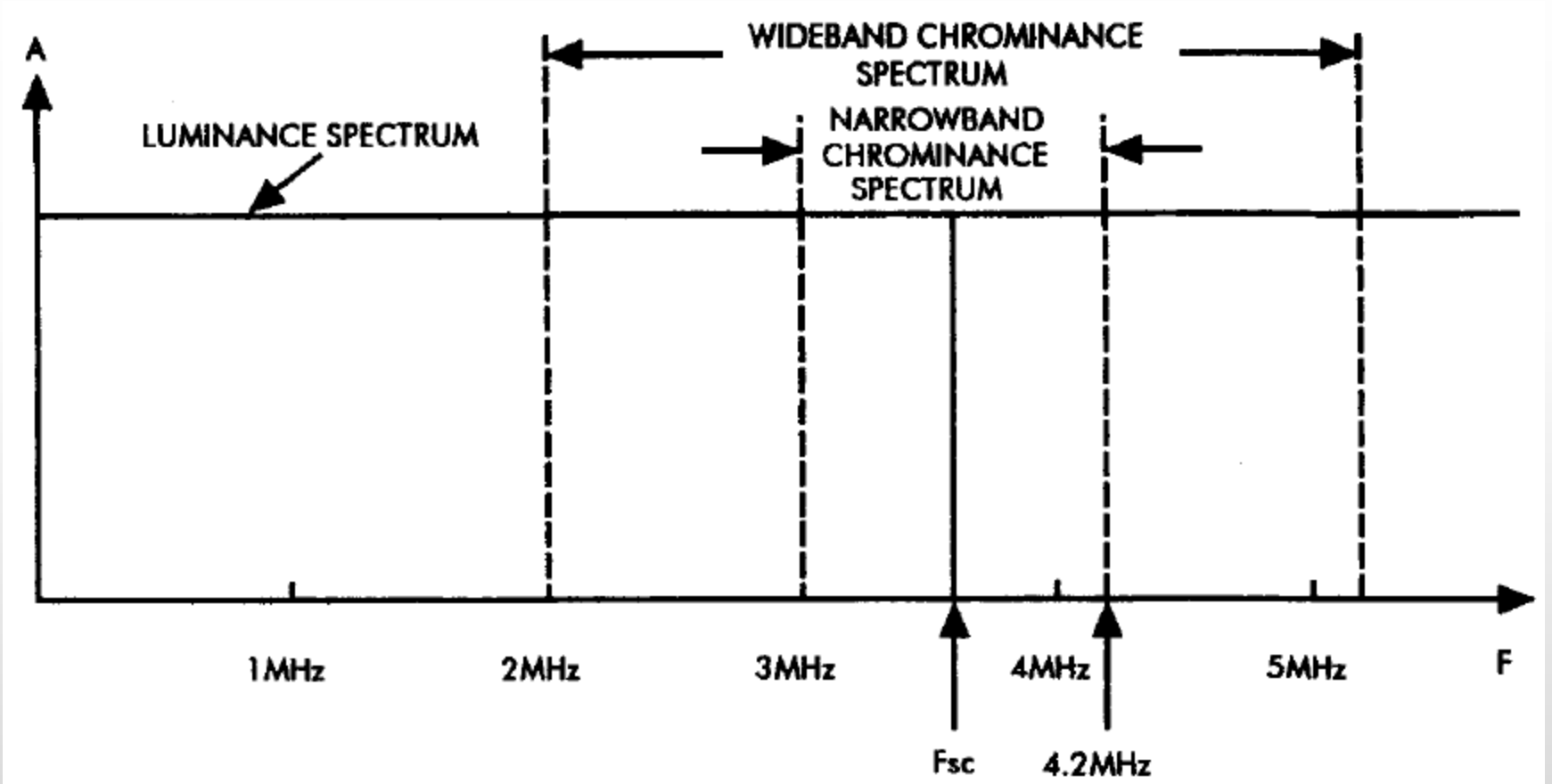


Figure 2.11 NTSC composite signal bandwidth.

TABLE 2.1 Summary of NTSC Signal Characteristics

1. Assumed chromaticity coordinates for primary colors of receiver	<table><tr><th></th><th>x</th><th>y</th></tr><tr><td>Green</td><td>0.310</td><td>0.596</td></tr><tr><td>Blue</td><td>0.155</td><td>0.070</td></tr><tr><td>Red</td><td>0.630</td><td>0.340</td></tr></table>
2. Chromaticity coordinates for equal primary signals	Illuminant D_{65}: $x = 0.3127$; $y = 0.3290$
3. Assumed receiver gamma value	2.2
4. Luminance signal	$E'_Y = 0.587\,E'_G + 0.114\,E'_B + 0.299\,E'_R$
5. Chrominance signals	$E'_{B\text{-}Y} = 0.493\,(E'_B - E'_Y)$ and $E'_{R\text{-}Y} = 0.877\,(E'_R - E'_Y)$ or $E'_Q = E'_{B\text{-}Y}\cos 33° + E'_{R\text{-}Y}\sin 33°$ and $E'_I = -E'_{B\text{-}Y}\sin 33° + E'_{R\text{-}Y}\cos 33°$
6. Equation of complete color signal	$E_M = 0.925\,E'_Y + 7.5 + 0.925\,E'_{B\text{-}Y}\sin(2\pi f_{SC}t) + 0.925\,E'_{R-Y}\cos(2\pi f_{SC}t)$ or $E_M = 0.925\,E'_Y + 7.5 + 0.925\,E'_Q\sin(2\pi f_{SC}t + 33°) + 0.925\,E'_I\cos(2\pi f_{SC}t + 33°)$
7. Type of chrominance subcarrier modulation	Suppressed-carrier amplitude modulation of two subcarriers in quadrature
8. Chrominance subcarrier frequency, Hz	Nominal value and tolerance: $f_{SC} = 3{,}579{,}545 \pm 10$ Relationship to line frequency f_H: $f_{SC} = (455/2)f_H$
9. Bandwidth of transmitted chrominance sidebands, kHz	$f_{SC} \pm 620$ or f_{SC} +620/−1300
10. Amplitude of chrominance subcarrier	$G = \sqrt{(E'^2_{B-Y} + E'^2_{R-Y})}$ or $G = \sqrt{(E'^2_I + E'^2_Q)}$
11. Synchronization of subcarrier	Subcarrier burst on blanking backporch

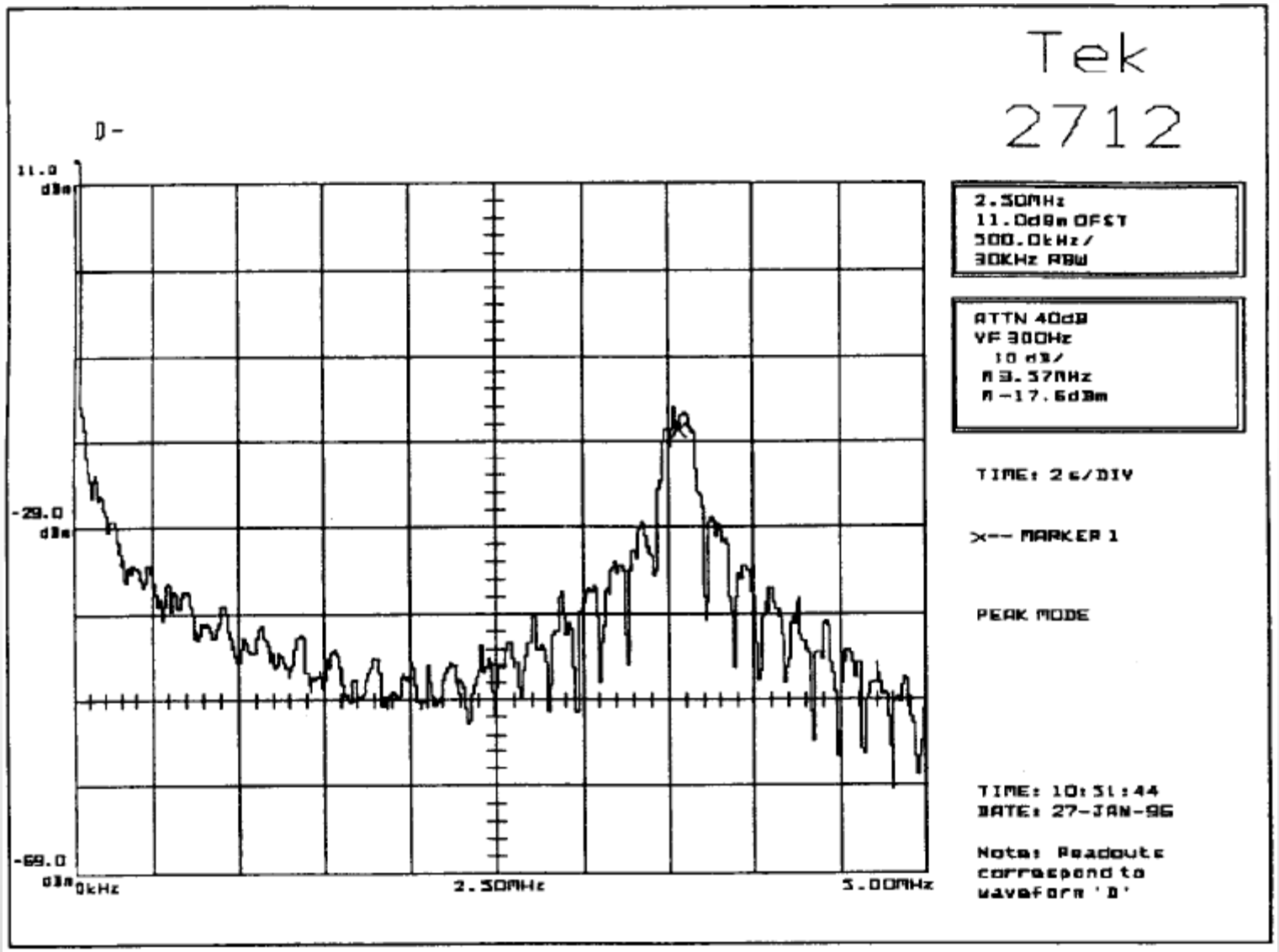


Figure 2.12 Spectrum of 100/7.5/100/7.5 NTSC color bars signal. Note a peak of energy around the suppressed 3.58-MHz subcarrier. Horizontal resolution: 500 kHz/division.

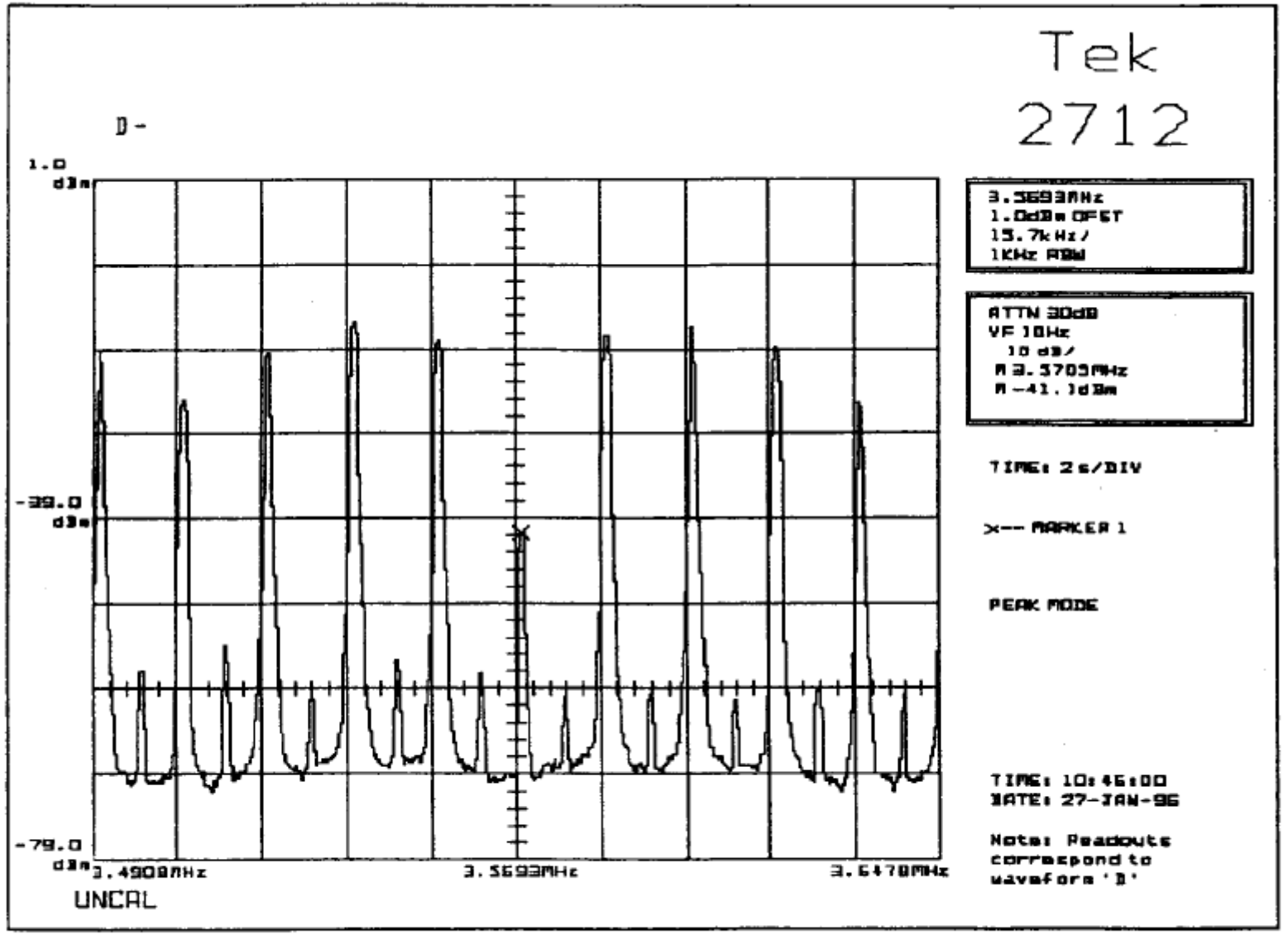


Figure 2.13 Detailed spectrum of NTSC 100/7.5/100/7.5 color bars signal around the suppressed chrominance subcarrier. Note chrominance sideband components at f_H intervals. Low level luminance spectrum components are interleaved at $f_H/2$ intervals. Horizontal resolution: 15.7 kHz/division.

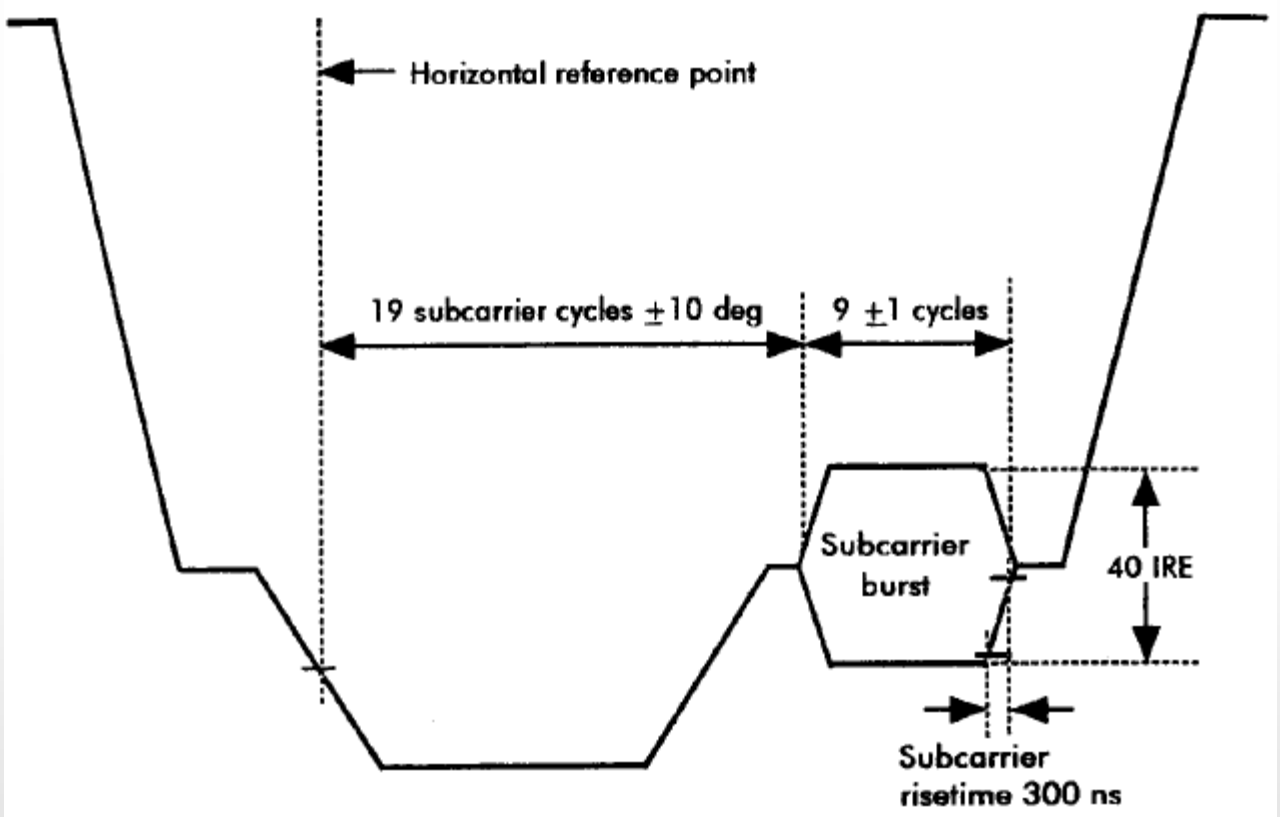


Figure 2.14 NTSC horizontal blanking interval showing details of color burst.

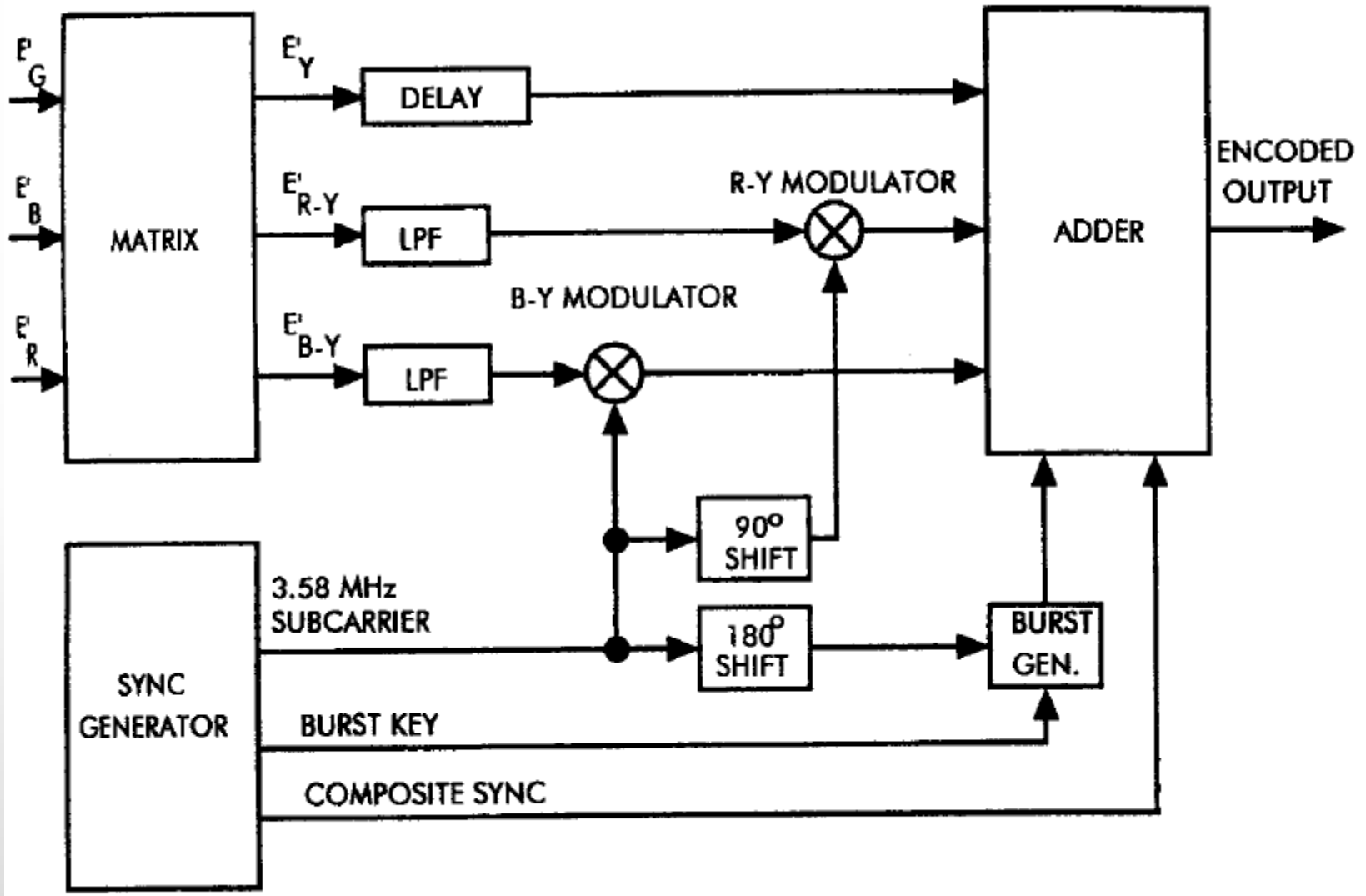


Figure 2.15 Simplified block diagram of NTSC B-Y/R-Y encoder.

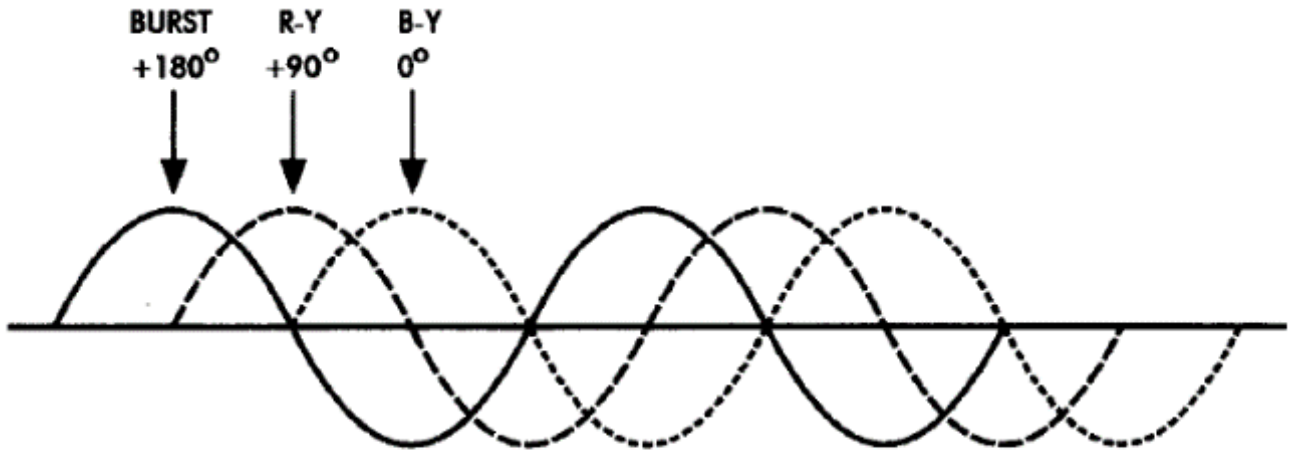


Figure 2.16 Phase domain representation of the two significant equal-frequency subcarriers. The third subcarrier represents the synchronizing burst.

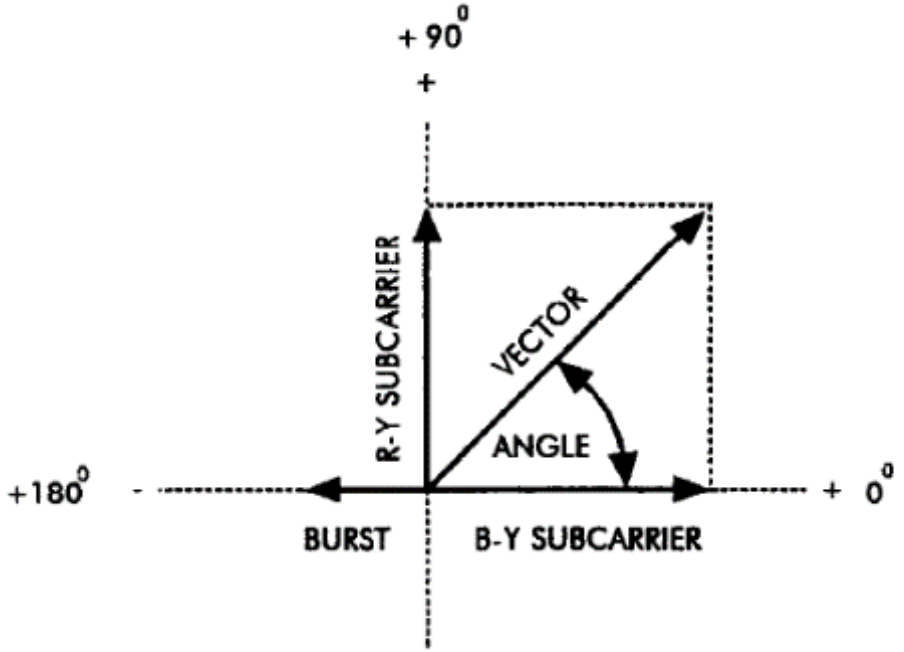


Figure 2.17 The instantaneous amplitudes of the subcarrier result in a vector whose amplitude represents saturation and phase represents hue.

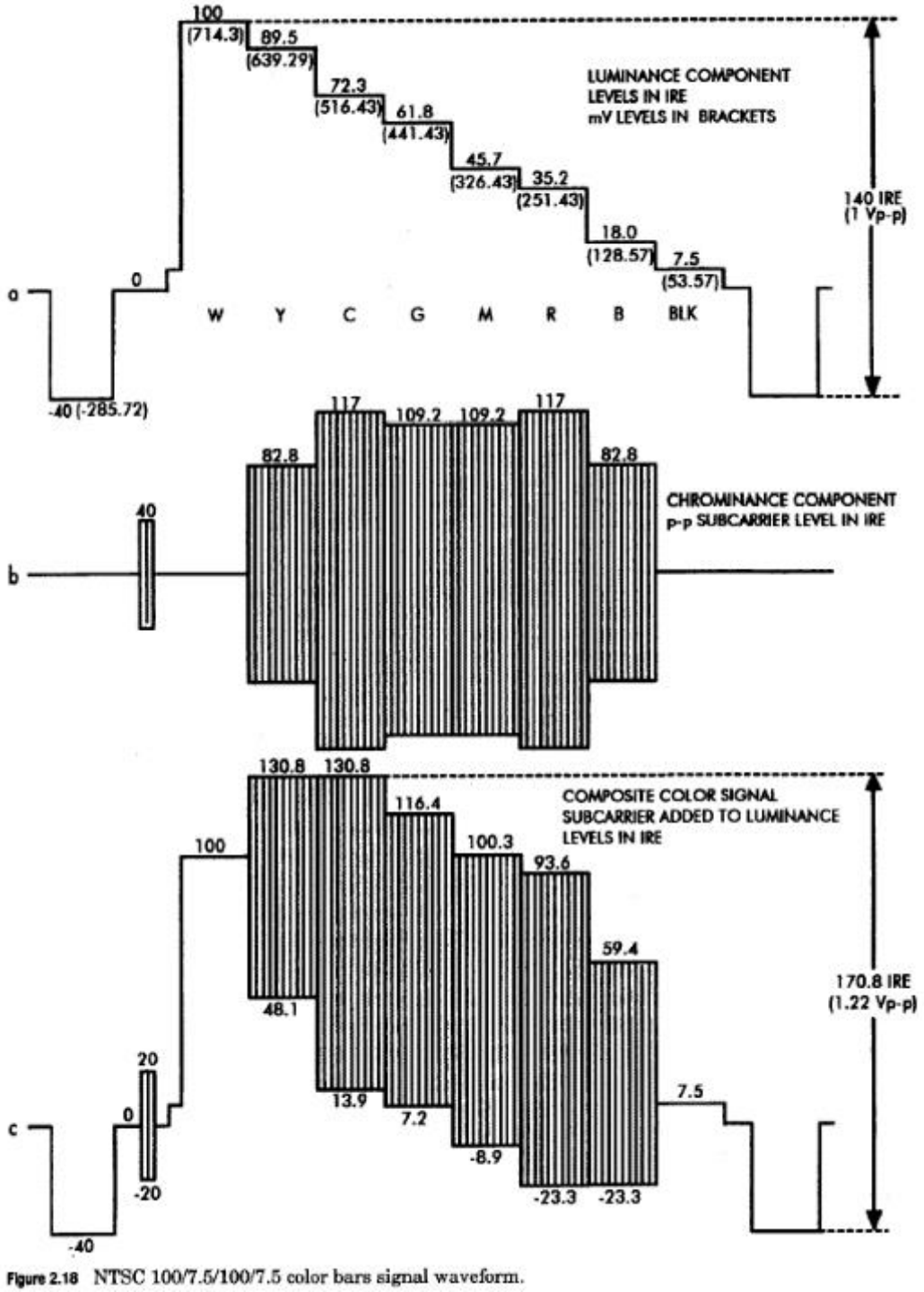


Figure 2.18 NTSC 100/7.5/100/7.5 color bars signal waveform.

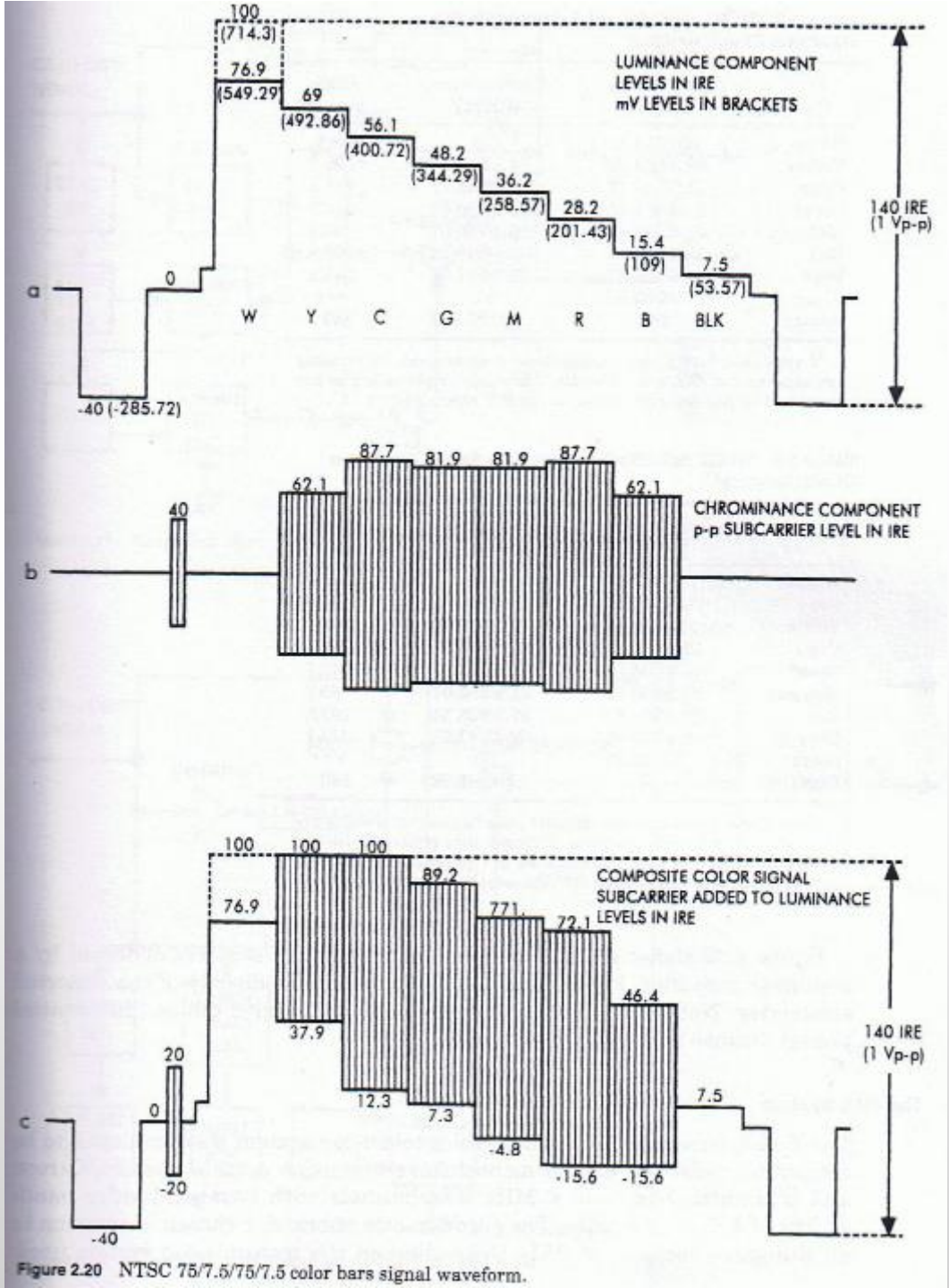


Figure 2.20 NTSC 75/7.5/75/7.5 color bars signal waveform.

TABLE 2.2 NTSC 100/7.5/100/7.5 Color Bars Signal Waveform Characteristics*

Color	Luminance, IRE/mV	Chrominance, IRE/mV	Angle, degrees
White	100/714.3	0/0	•••
Yellow	89.5/639.29	82.8/591.44	167.1
Cyan	72.3/516.43	117/835.73	283.5
Green	61.8/441.43	109.2/780.01	240.7
Magenta	45.7/326.43	109.2/780.01	60.7
Red	35.2/251.43	117/835.73	103.5
Blue	18/128.57	82.8/591.44	347.1
Black	7.5/53.57	0/0	•••
Burst	0/0	40/285.72	180

*Luminance levels and chrominance peak-to-peak amplitudes are expressed in IRE and millivolts. Chrominance phase angles are expressed in degrees with respect to the B-Y reference.

TABLE 2.3 NTSC 75/7.5/75/7.5 Color Bars Signal Waveform Characteristics*

Color	Luminance, IRE/mV	Chrominance, IRE/mV	Angle, degrees
White	100/714.3	0/0	•••
Gray	76.9/549.29	0/0	•••
Yellow	69/492.86	62.1/443.58	167.1
Cyan	56.1/400.72	87.7/626.44	283.5
Green	48.2/344.29	81.9/585.01	240.7
Magenta	36.2/258.57	81.9/585.01	60.7
Red	28.2/201.43	87.7/626.44	103.5
Blue	15.4/109.00	62.1/443.58	347.1
Black	7.5/53.57	0/0	•••
Burst	0/0	40/285.72	180

*Luminance levels and chrominance peak-to-peak amplitudes are expressed in IRE and millivolts. Chrominance phase angles are expressed in degrees with respect to the B-Y reference. The "white" bar is representative of a 100/7.5/75/7.5 color bars signal waveform.

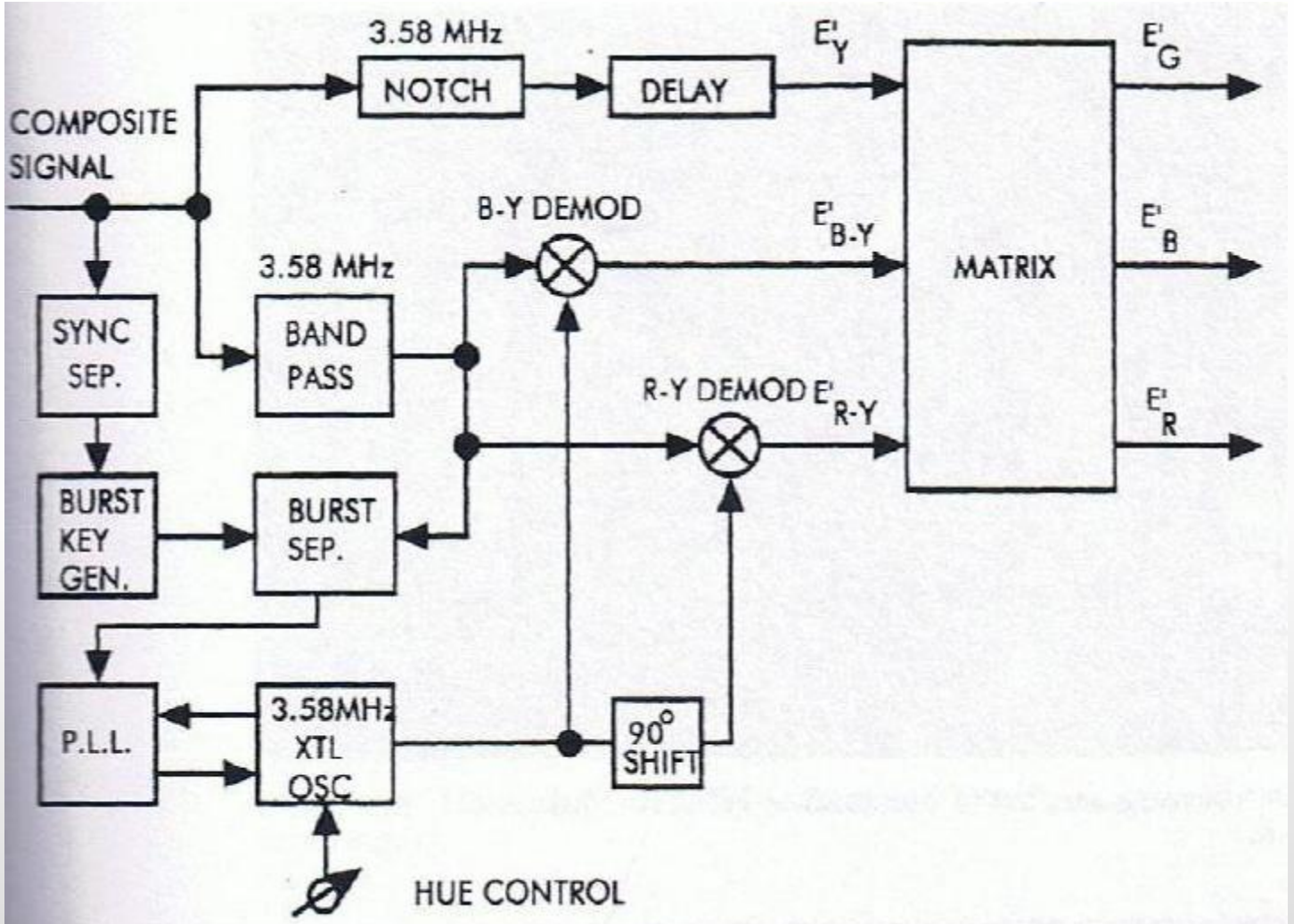


Figure 2.21 Simplified block diagram of NTSC B-Y/R-Y decoder.

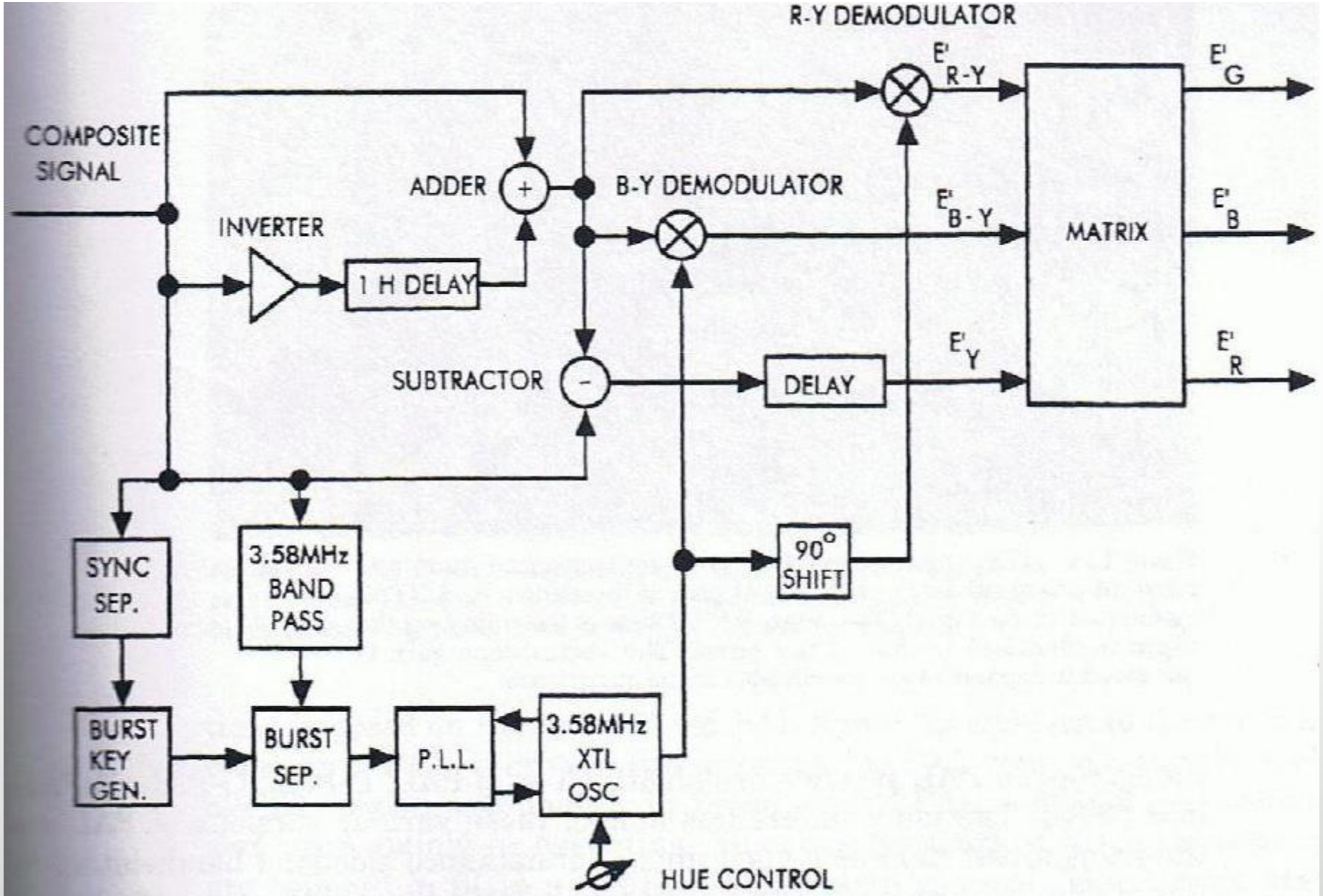


Figure 2.22 Simplified block diagram of NTSC decoder with comb filter.

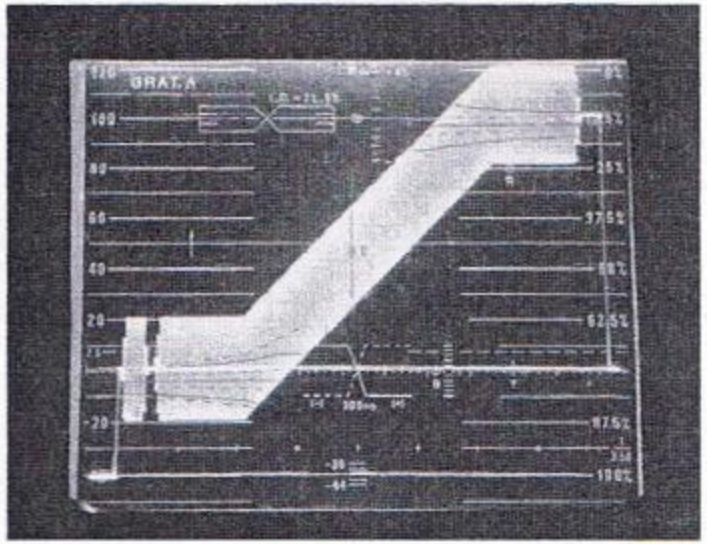


Figure 2.23 Oscilloscope display of undistorted NTSC modulated ramp signal.

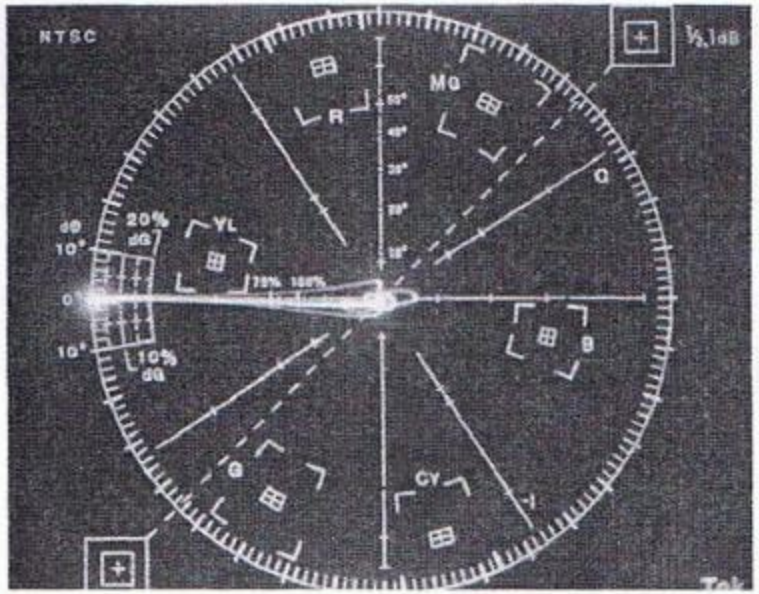


Figure 2.24 NTSC vectorscope display of constant-amplitude and constant-phase subcarrier component part of the undistorted NTSC modulated ramp signal. The phase of the subcarrier riding on the ramp is identical to that of the burst. The vectorscope gain is increased to expand vector amplitudes to the outer trace.

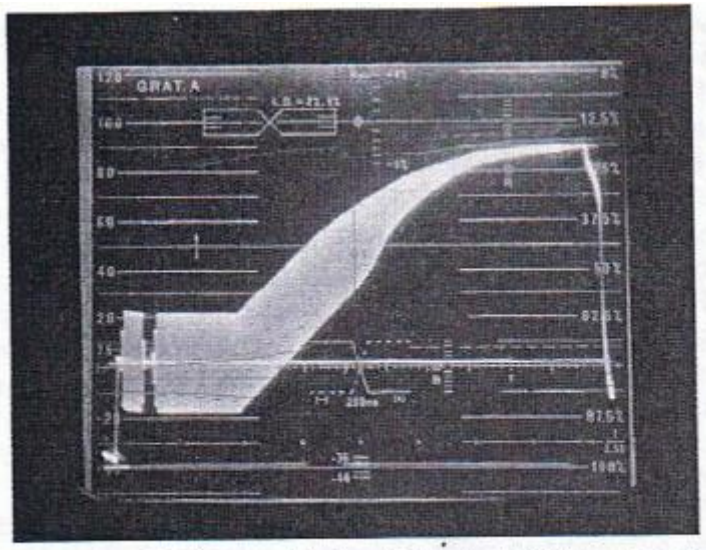


Figure 2.25 Oscilloscope display of distorted NTSC modulated ramp signal.

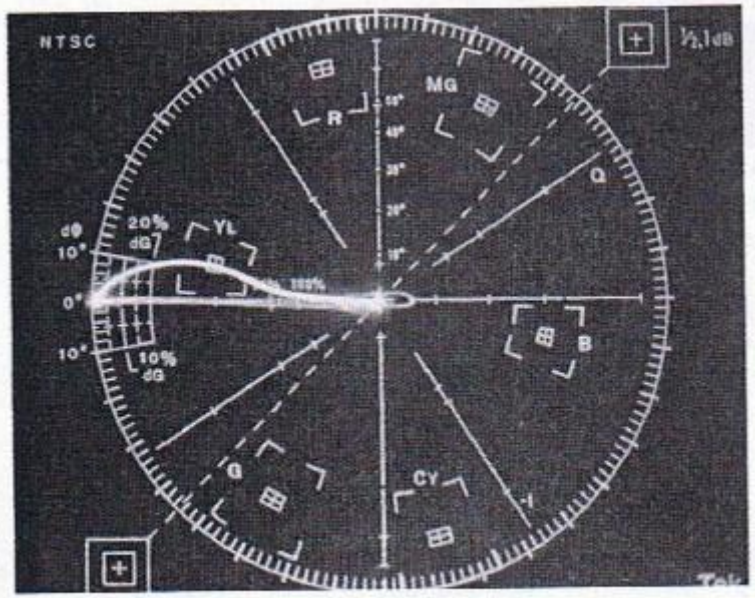


Figure 2.26 NTSC vectorscope display of distorted NTSC modulated ramp signal showing a subcarrier phase change relative to the burst phase. This phase change is called differential phase.

Error de fase diferencial

El sistema PAL
(Phase-Alternating Line)

- Desarrollado originalmente para 625/50 (Europa)
- Canal de transmisión de RF 7 u 8 MHz
- Banda base de 5 o 5,5 o 6 MHz
- Y con ancho de banda >= 5 MHz
- E_U y E_V idénticas a E_{B-Y} y E_{R-Y}

TABLE 2.4 Summary of PAL Signal's Characteristics

1. Assumed chromaticity coordinates for primary colors of receiver	x / y Green 0.29 / 0.60 Blue 0.15 / 0.06 Red 0.64 / 0.33
2. Chromaticity coordinates for equal primary signals	Illuminant D_{65}: $x = 0.3127$; $y = 0.3290$
3. Assumed receiver gamma value	2.8
4. Luminance signal	$E'_Y = 0.587E'_G + 0.144E'_B + 0.299E'_R$
5. Chrominance signals	$E'_U = 0.877\,(E'_B - E'_Y)$ and $E'_V = 0.493\,(E'_R - E'_Y)$
6. Equation of complete color signal	$E_M = E'_Y + E'_U \sin(2\pi f_{SC}t) \pm E'_V \cos(2\pi f_{SC}t)$
7. Type of chrominance subcarrier modulation	Suppressed-carrier amplitude modulation of two subcarriers in quadrature
8. Chrominance subcarrier frequency, Hz	Nominal value and tolerance: $f_{SC} = 4{,}433{,}618.75$ Hz $\pm$ 5 (CCIR B, D, G, H) $\pm$ 1 (CCIR I) Relationship to line frequency f_H: $f_{SC} = (1135/4 + 1/625)\,f_H$
9. Bandwidth of transmitted chrominance sidebands, kHz	f_{SC} +570/−1300 (CCIR B, D, G, H) f_{SC} +1066/−1300 (CCIR I)
10. Amplitude of chrominance subcarrier	$G = \sqrt{(E'^2_U + E'^2_V)}$
11. Synchronization of subcarrier	Subcarrier burst on blanking backporch

$$f_{SC} = (284 - \tfrac{1}{4})\, f_H + f_V \text{ Hz} = 4{,}443{,}618.75 \text{ Hz}$$

where $f_H = 15{,}625$ Hz

$f_V = 25$ Hz

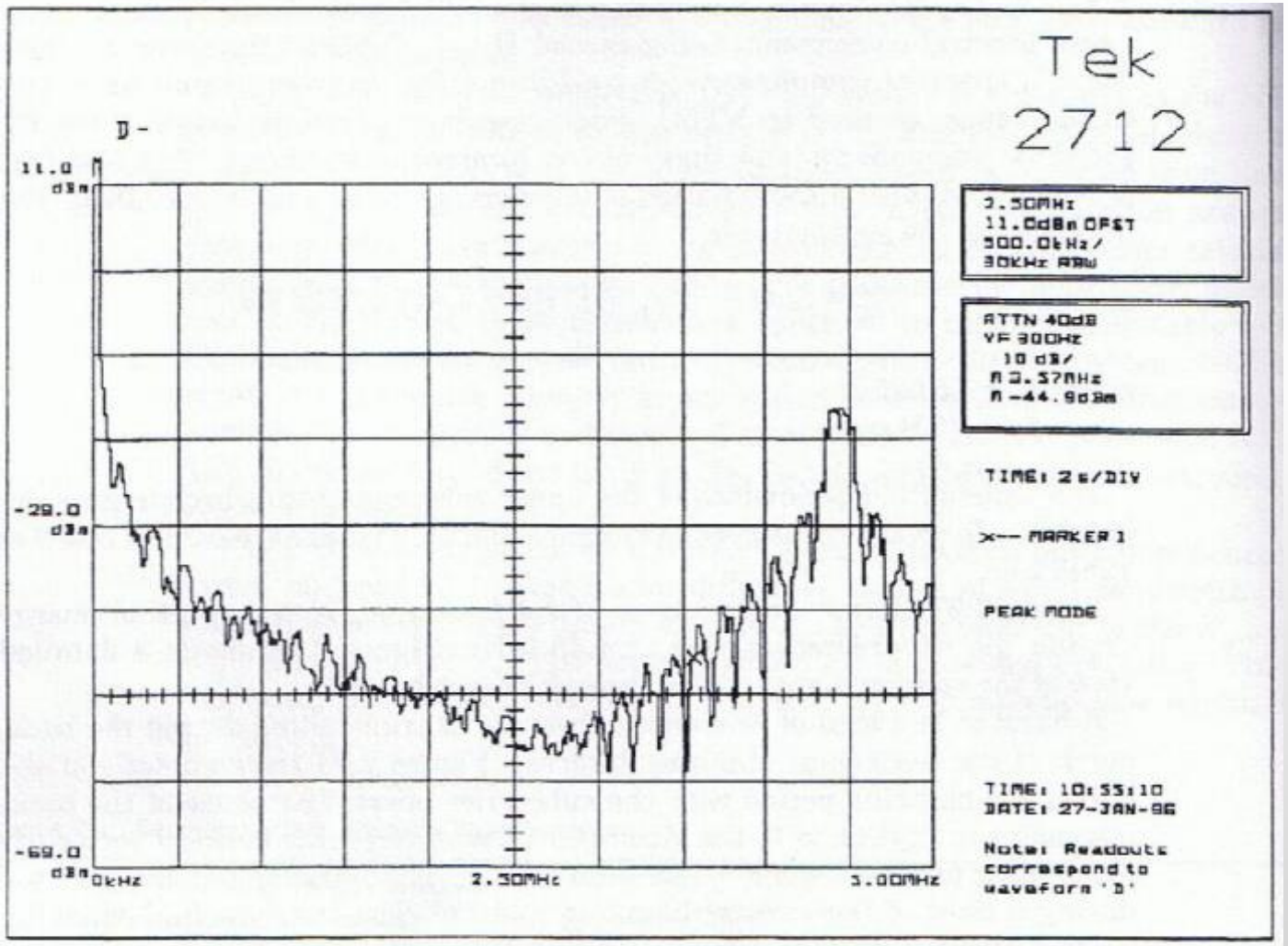


Figure 2.27 Spectrum of PAL 100/0/100/0 color bars signal. Note a peak of energy around the suppressed 4.43 MHz subcarrier. Horizontal resolution: 500 kHz/division.

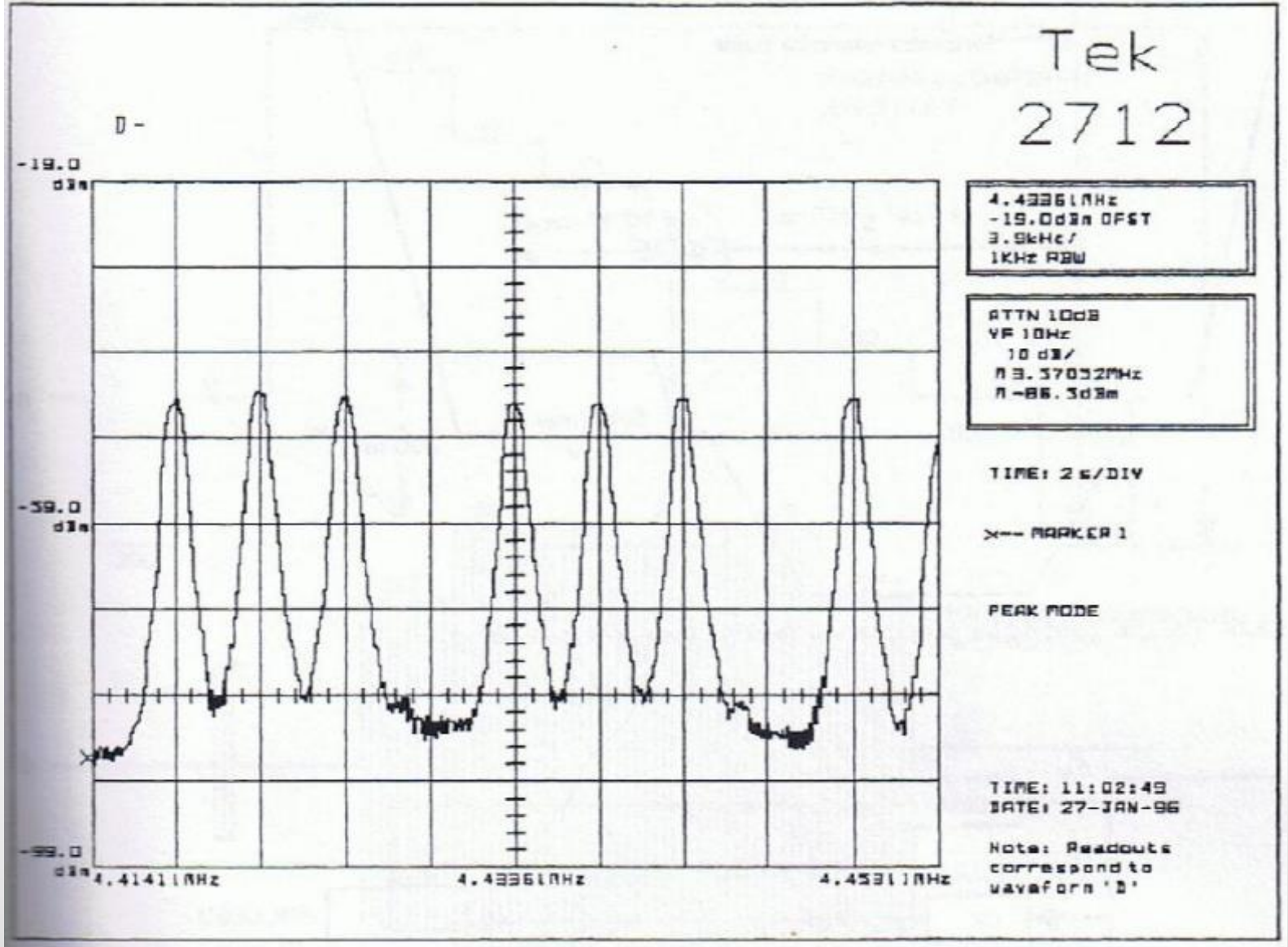


Figure 2.28 Detailed view of spectrum around the 4.43 MHz subcarrier. This picture was obtained with a synthetic signal and, therefore, the subcarrier is not suppressed in order to enhance the details of the spectrum. The spectrum is characterized by triplets consisting of the luminance (Y) in the center with the constant phase subcarrier (U) on its left (spaced at $-\frac{1}{4}f_H$) and the phase-alternating subcarrier (V) on its right (spaced at $+\frac{1}{4}f_H$). The spacing between the V component of one triplet (e.g., the third peak from the left) and the U component of the consecutive triplet (e.g., the fourth peak from the left) is $\frac{1}{2}f_H$. The horizontal resolution of the spectrum analyzer display is $\frac{1}{4}f_H = 3.9$ kHz/division.

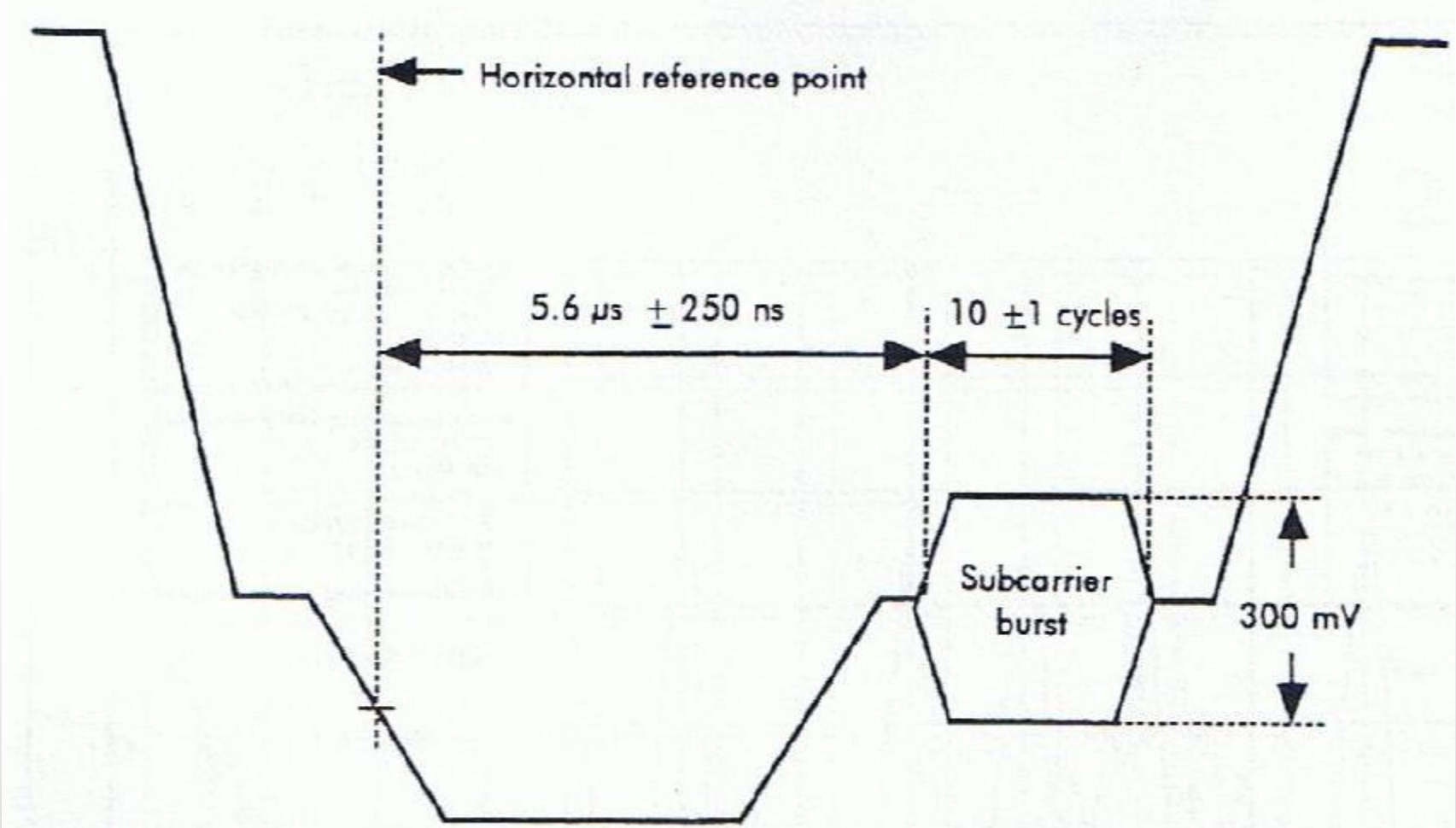


Figure 2.29 PAL horizontal blanking interval showing details of color burst.

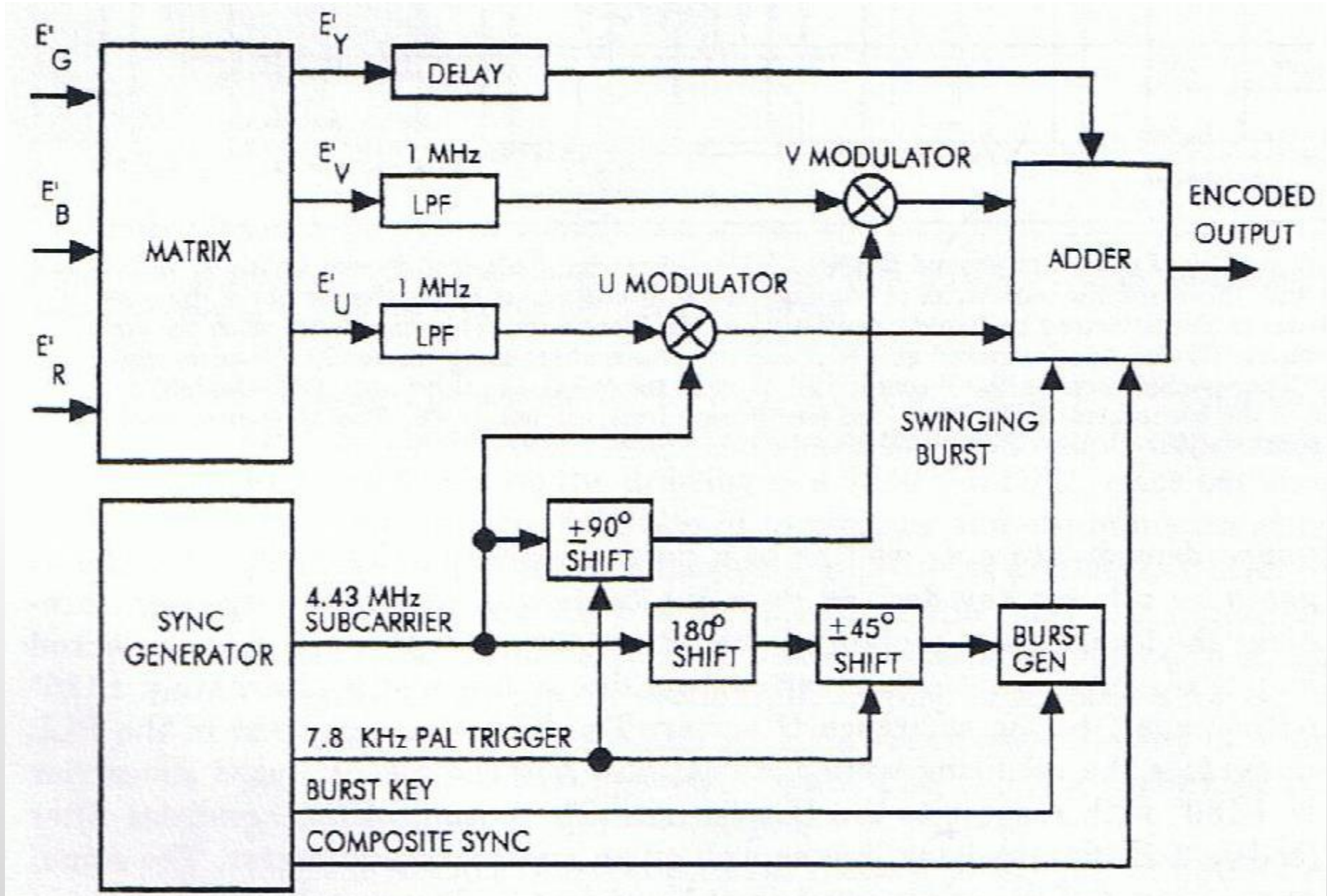
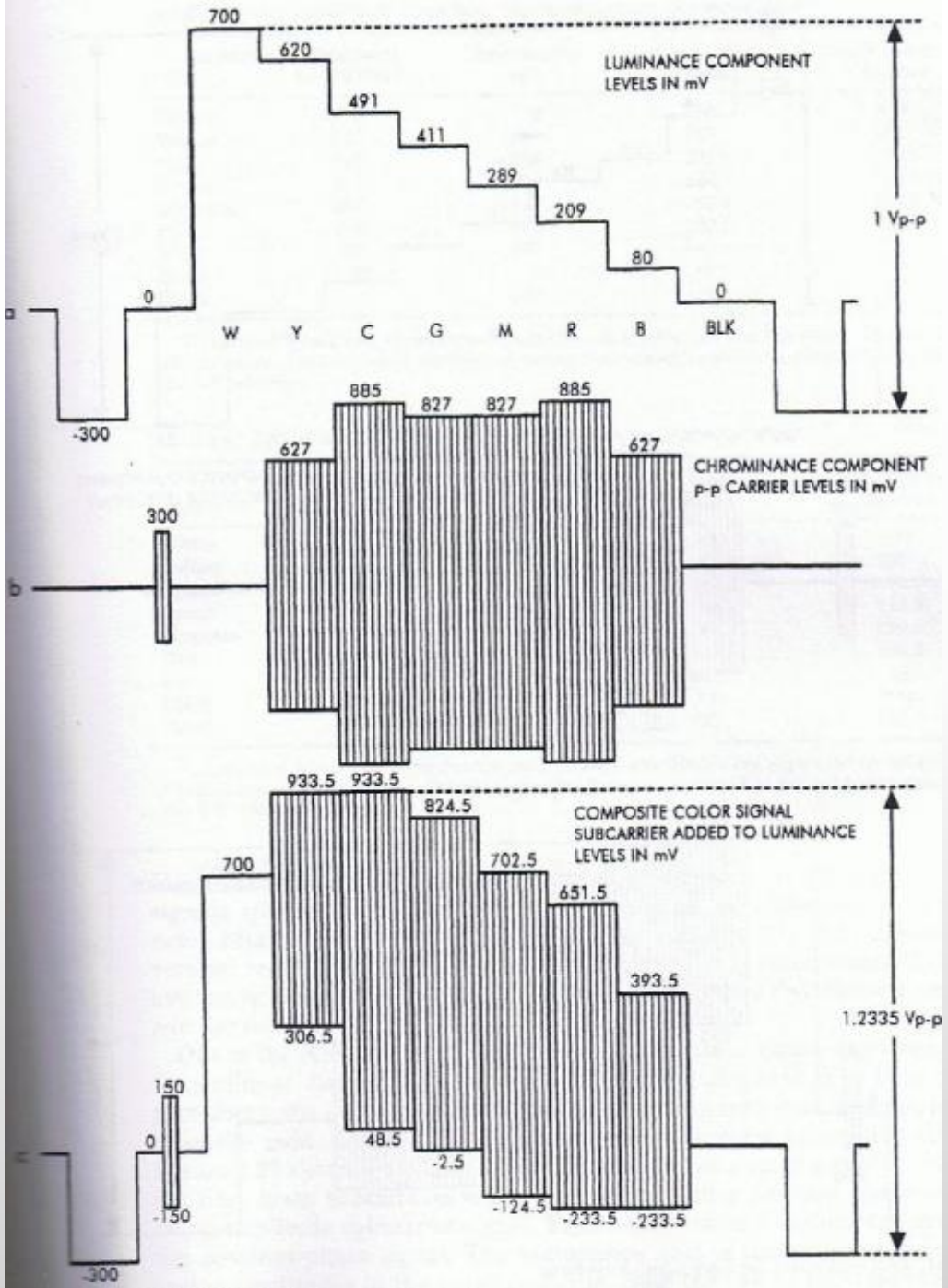


Figure 2.30 Simplified block diagram of PAL encoder.



PAL 100/0/100/0 color bars signal waveform.

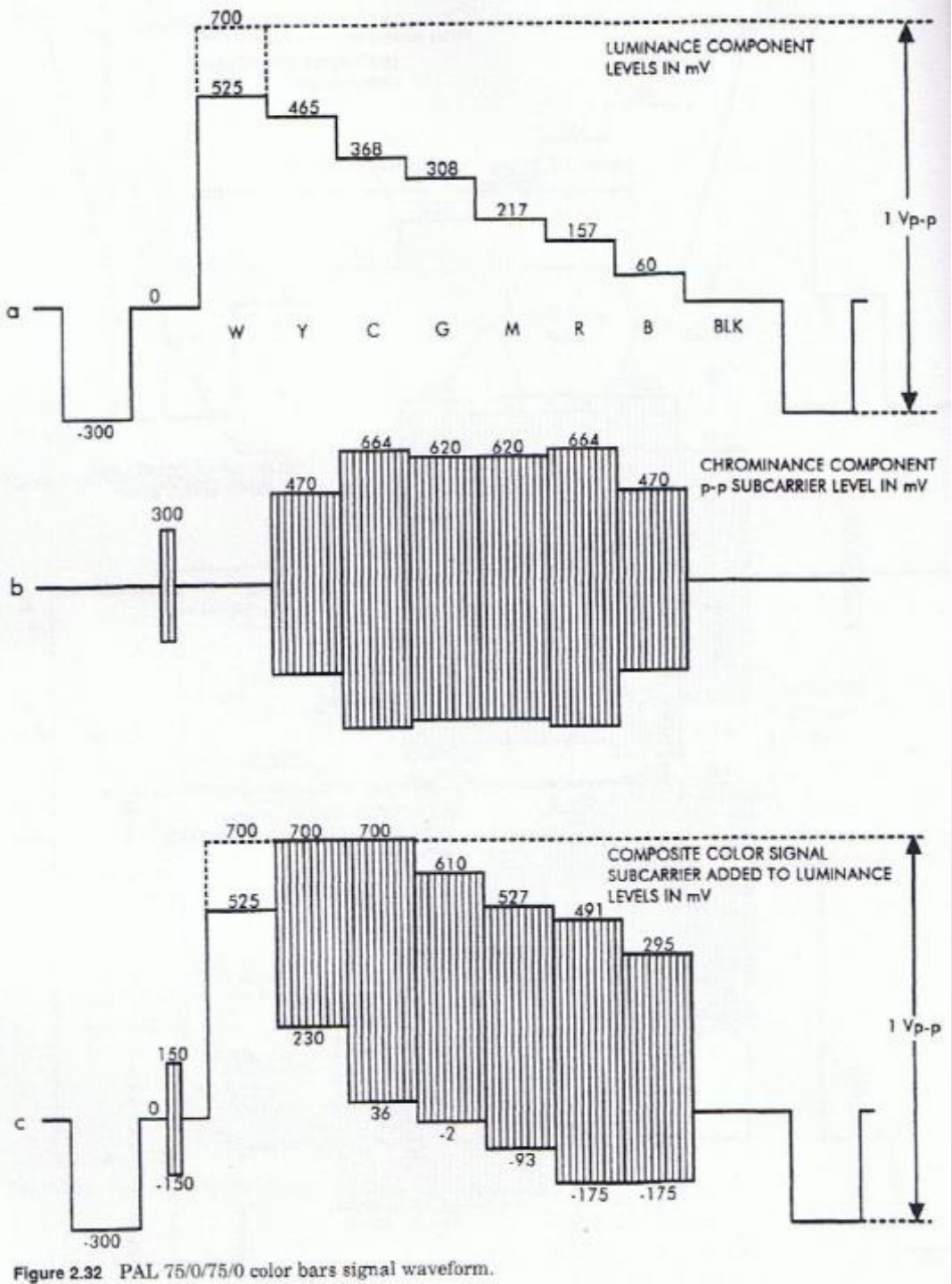


Figure 2.32 PAL 75/0/75/0 color bars signal waveform.

TABLE 2.5 PAL 100/0/100/0 Color Bars Signal Waveform Characteristics*

Color	Luminance, mV	Chrominance, mV	Angle line *n*, degrees	Angle line *n*+1, degrees
White	700	0	•••	•••
Yellow	620	627	167	193
Cyan	491	885	283.5	76.5
Green	411	827	240.5	119.5
Magenta	289	827	60.5	299.5
Red	209	885	103.5	256.5
Blue	80	627	347	13
Black	0	0	•••	•••
Burst	0	300	135	225

*Luminance levels and chrominance peak-to-peak amplitudes are expressed in millivolts. Chrominance phase angles on alternate scanning lines are expressed in degrees with respect to the B-Y reference.

TABLE 2.6 PAL 100/0/75/0 Color Bars Signal Waveform Characteristics*

Color	Luminance, mV	Chrominance, mV	Angle line *n*, degree	Angle line *n*+1, degrees
White	700	0	•••	•••
Yellow	465	470	167	193
Cyan	368	664	283.5	76.5
Green	308	620	240.5	119.5
Magenta	217	620	60.5	299.5
Red	157	664	103.5	256.5
Blue	60	470	347	13
Black	0	0	•••	•••
Burst	0	300	135	225

*Luminance levels and chrominance peak-to-peak amplitudes are expressed in millivolts. Chrominance phase angles on alternate scanning lines are expressed in degrees with respect to the B-Y reference.


525/625LINES
5212
INPUT
CH 1
CH 2
CH 3
EXT
MODE
VECT
DG
DP
X-Y
GAIN
BARS
MAG
VAR
INTEN
ROTATION
FOCUS
ILLUM
POWER
OFF
ON
PAL
REF CH1
SETUP
0%
PHASE
0.0°
LEADER
AUTO
PHASE
POSITION / PHASE
MENU
ENTER
RECALL
LEADER
NTSC/PAL VECTORSCOPE

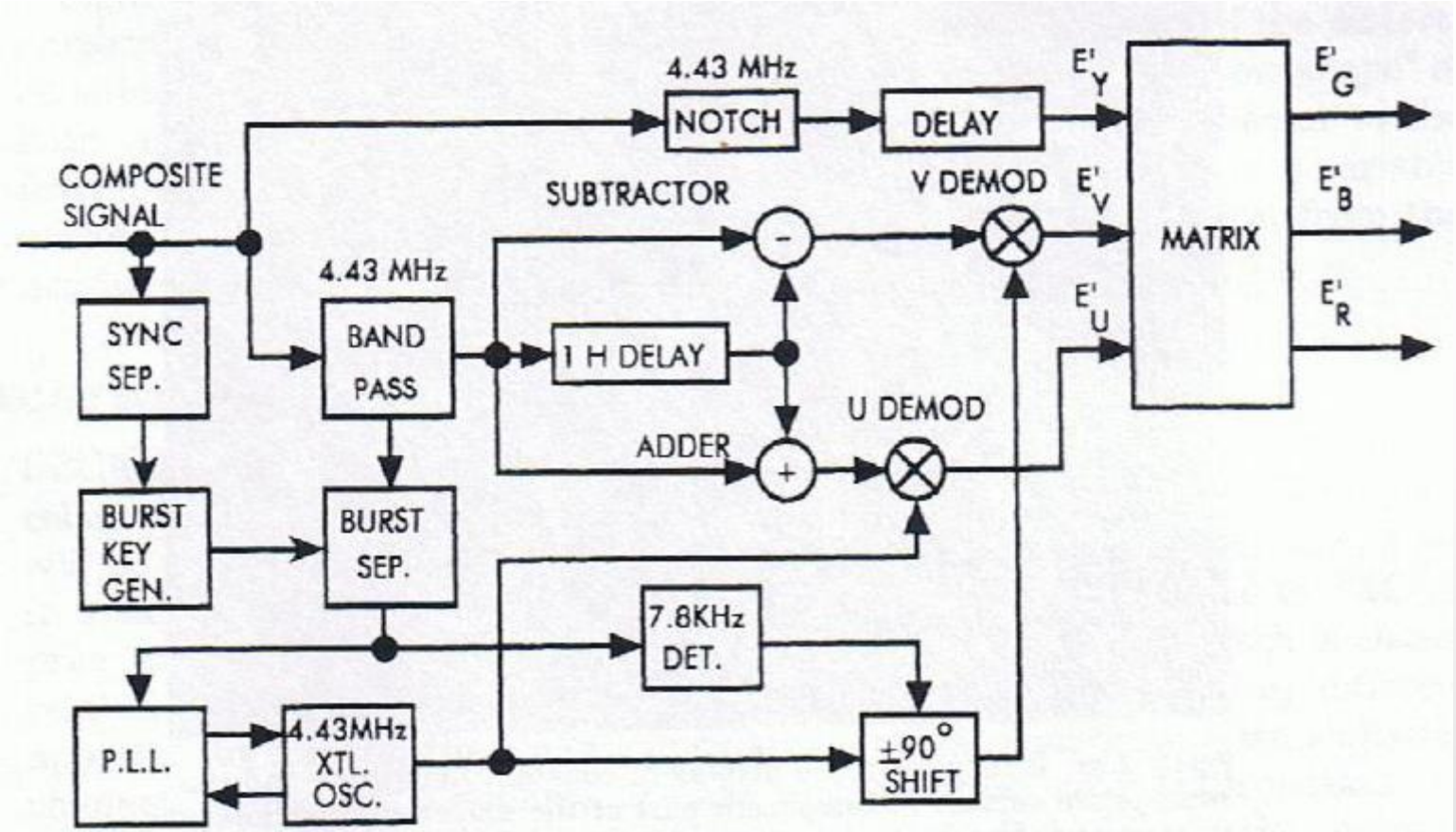


Figure 2.36 Simplified block diagram of PAL decoder.

PAL-N

- 625/50
- 6 MHz de ancho de banda de transmisión
- f_{sc}=3,58205625
- Ancho de banda de video 4,2 MHz
- Ancho de banda del canal de transmisión 6 MHz
- Uruguay, Argentina, Paraguay

PAL-M

- 525/60
- 6 MHz de ancho de banda de transmisión
- f_{sc}=3,57…
- Ancho de banda de video 4,2 MHz
- Ancho de banda del canal de transmisión 6 MHz
- Brasil