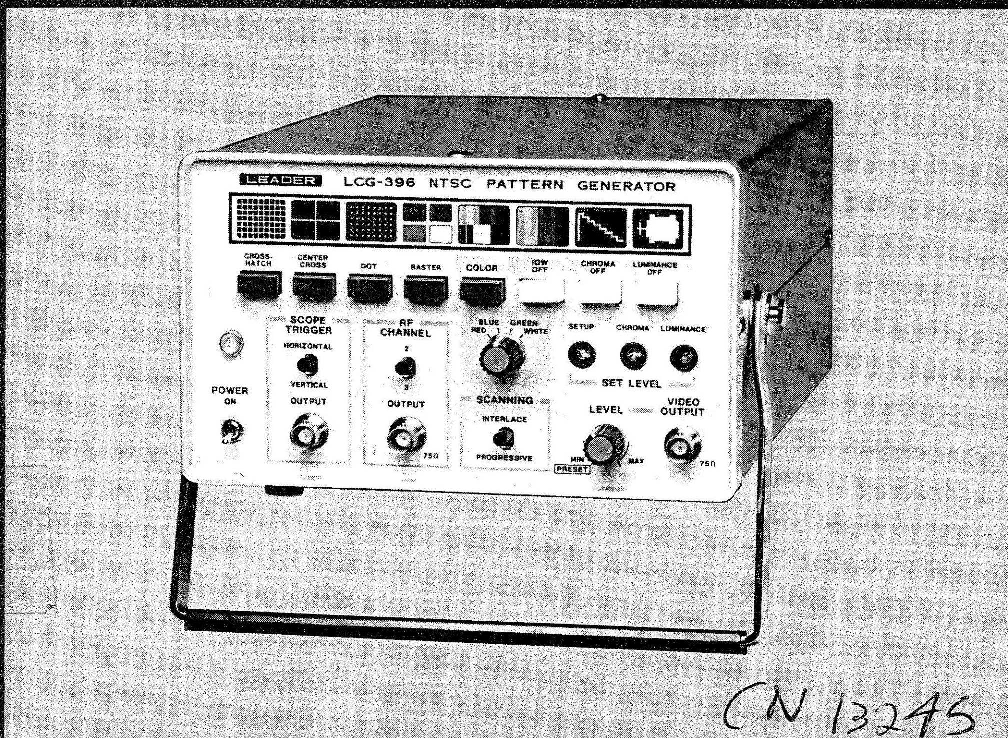
$15.00

LCG-396
NTSC pattern generator



instruction manual

When Quality Counts

LEADER Instruments Corporation

1. DESCRIPTION

The LCG-396 is a NTSC-M pattern generator designed to produce standard 75% color bars as well as other test signals for use in alignment and troubleshooting of video monitors and receivers, and video tape recorders.

Features

1. Standard split-field color bars with fully saturated 75% bars in the upper half, I, Q and 100% white bars in the lower half.

This signal facilitates simultaneous checks of luminance and chrominance values. Waveforms given for the video processing circuits in most VTR service manuals are given for the standard color-bar signal.

2. Standard sync and blanking intervals, as well as standard equalizing pulses and serrations permit accurate adjustments of picture size and VTR servo alignment.
3. Provision for front-panel alterations to setup, luminance and chrominance levels.
4. Provides standard video levels into a 75 ohm load.
5. Saturated primary-color rasters and white raster for purity checks without gun killers or altering CRT bias.
6. Dots, crosshatch and single-cross displays for size, linearity and convergence adjustments.
7. Scope trigger at both H and V rates to simplify scope triggering.
8. RF output on channels 5 or 6.
9. Selection of normal interlace or progressive interlace. The latter minimizes flicker in the horizontal lines of the convergence patterns.
10. All signals synthesized in digital form and converted to a standard form by D/A converters.

2. SPECIFICATIONS

2.1 Patterns

Color: NTSC 75% color bars

Top half: fully saturated 75% color bars in order of descending luminance value—white, yellow, cyan, green, magenta, red, blue, and black.

Lower half: Q—I—100% White

IQW OFF: Full field 75% color bars

CHROMA OFF: Luminance only

LUMINANCE OFF: 3.58 MHz chroma and sync only

Crosshatch: 21 vertical × 16 horizontal lines with single center dot

Dots: 20 vertical columns × 15 horizontal rows of white dots

Rasters: Red, blue, green and white

2.2 Signal Outputs

Video output: Preset, 1 V(p-p) into 75 ohms, variable 0-1.5 V(p-p) into 75 ohms

Video output impedance: 75 ohms

Video polarity: Positive (sync negative)

R-F output

Modulation: negative

Picture Carrier frequency: CH 5 77.25 MHz ± 0.5%

CH 6 83.25 MHz ± 0.5%

Output level: 10 mV, approx. (no load)

Output impedance: 75 ohms

Scope Trigger

Frequency: horizontal or vertical

Output level: 1 V(p-p) approx. (no load)

Output impedance: 75 ohms

Subcarrier output

Frequency: 3.579545 MHz ± 100 Hz setable to ±5 Hz

Output level: 1 V(p-p) approx. (no load)

Output impedance: 75 ohms

2.3 Synchronizing Signals

Horizontal scanning frequency: 15.734 kHz

Vertical scanning frequency: 59.94 Hz interlaced, 60.05 Hz progressive

Horizontal blanking: 11.3 μS

Vertical blanking: 1.24 mS interlaced, 1.21 mS progressive

Horizontal sync: 4.61 μS

Vertical sync: 3H

Front porch: 1.3 μS

Burst: 8 Hz, min

3. CONTROLS AND CONNECTORS

3.1 Front Panel

Figure 3-1. shows the location of front-panel controls and connectors.

(1) POWER switch – Turns power on and off.

(2) Pilot lamp – Lights when power is on.

(3) – (7) Pattern Selectors

(3) CROSS-HATCH

(4) CENTER CROSS

(5) DOT

(6) RASTER – RED, GREEN, BLUE or WHITE rasters are selected by switch (17)

(7) COLOR bars – Push for normal, split-field display. Push buttons 8, 9 and 10 control the color bar pattern as follows:

(8) IQW OFF switch – Turns off the I, Q and 100% white bars in the lower half of the display and provides full-field 75% color bars.

(9) CHROMA OFF SWITCH – Turns off all subcarrier to provide luminance only (descending-Y stairstep).

(10) LUMINANCE OFF switch—Turns off the luminance signal to provide chrominance, sync and burst only.

(11) CHROMA level control – Chrominance level can be varied approximately ± 20%. This variation applies to both the color bars and RGB raster display.

(12) LUMINANCE level control – Luminance level of all patterns can be varied approximately ± 20%.

(13) SETUP level control – Setup level for all patterns can be varied from zero to 10% (7.5% standard).

(14) VIDEO OUTPUT connector – This BNC jack supplies rated output into a 75-ohm load.

(15) VIDEO LEVEL control – Varies video output from zero to approximately 1.5 V(p-p), into a 75-ohm load. At the PRESET setting output level is 1 V(p-p) into a 75-ohm load. The setting of this control does not affect percentage of modulation for r-f output.

(16) SCANNING selector – Alters the synchronizing system to provide standard INTERLACE or PROGRESSIVE scanning. Interlaced scanning is used for color bar and raster displays; progressive scanning should be used for crosshatch, dot and single cross to minimize flicker in the horizontal lines.

(17) Raster selector – Selects RED, BLUE, GREEN or WHITE rasters when the RASTER button (6) has been depressed. This switch has no effect upon other displays.

(18) RF OUTPUT connector – BNC jack supplies r-f output on channel 5 or 6 into a 75-ohm load.

(19) CHANNEL selector – Switches the internal modulator to operate on channel 5 or 6.

(20) SCOPE TRIGGER output connector – BNC jack supplies trigger for external synchronization of oscilloscopes.

(21) Trigger selector – Selects either HORIZONTAL (15.734 kHz) or VERTICAL (59.94 Hz) trigger pulses.

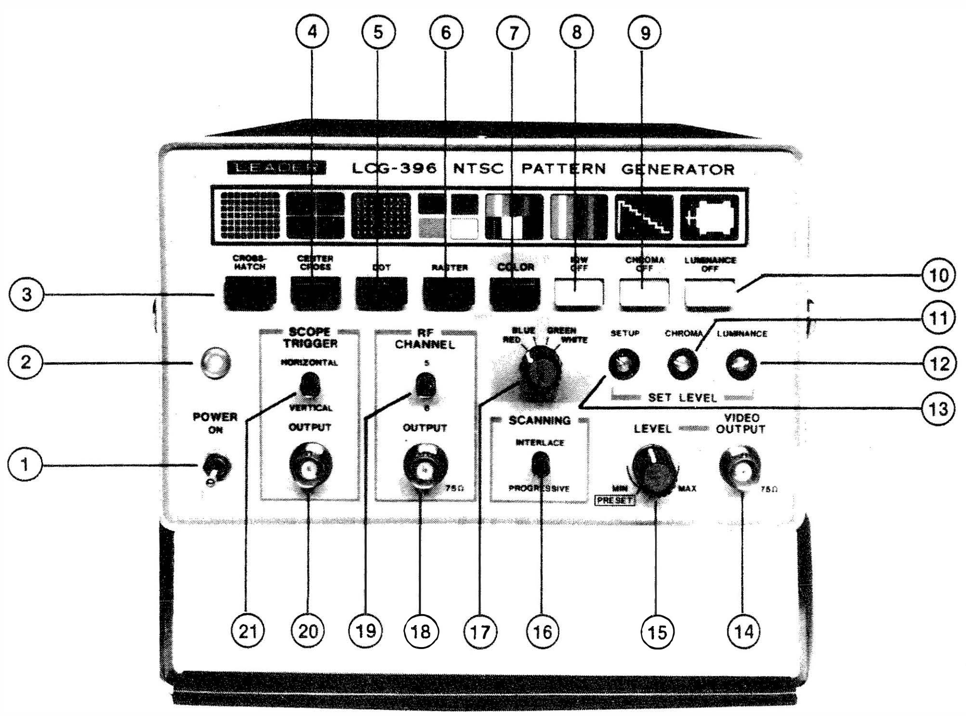


Fig. 3-1.

3.2 Rear Panel

Figure 3-2. shows the rear panel of the LCG-396.

(22) Instrument legs—Four legs permit the generator to stand vertically. They also facilitate winding and storing the power cord.

(23) Power cord

(24) Fuse holder—Contains a 0.3A slow-blow fuse.

(25) SUBCARRIER OUTPUT connector—BNC jack provides approximately 1 V(p-p) of CW subcarrier signal for the purpose of calibrating the instrument.

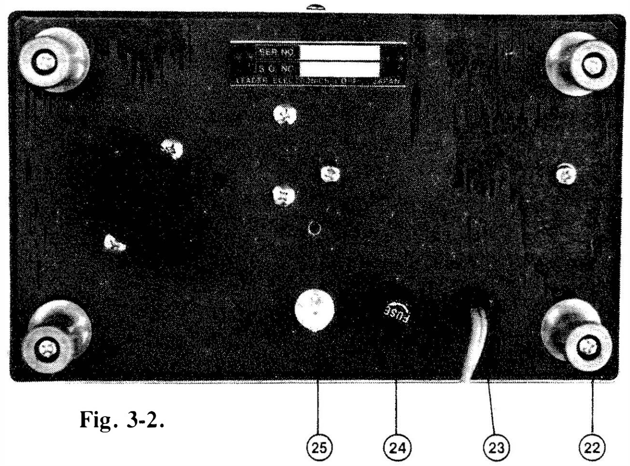


Fig. 3-2.

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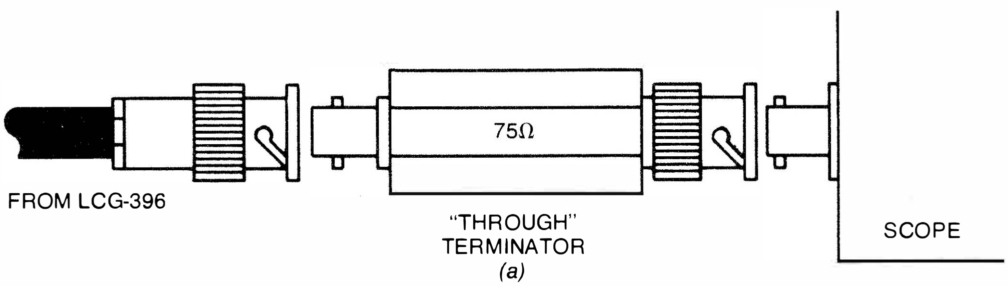
4. CONNECTIONS AND OPERATION



4.1 Operating Precautions

1. Line voltage should be within ± 10% of rated voltage (100 V, 117 V, 200 V or 234 V). Units shipped to the U.S.A. are set for 117 V.
2. Do not apply external voltages to the SCOPE TRIGGER OR SUBCARRIER output jacks.
3. Do not apply external voltages in excess of ± 20 V to the VIDEO OUTPUT jack.
4. When making connections to the video circuits of TV receivers, make sure the chassis is not "hot" (above AC ground). Plug hot-chassis receivers into an isolation transformer.
5. To prevent damage to the crystal oscillator be careful not to drop the unit or expose it to other forms of mechanical shock.
6. Operate the unit within 0° to 40°, C. Avoid temperature extremes.

4.2 Video Output

The LCG-396 is designed to provide a standard 1 V(p-p) signal across a 75-ohm load.

In those cases where the load does not present a 75-ohm termination, as when driving a scope or vectorscope, a 75 terminator should be added as shown in Fig. 4-1.

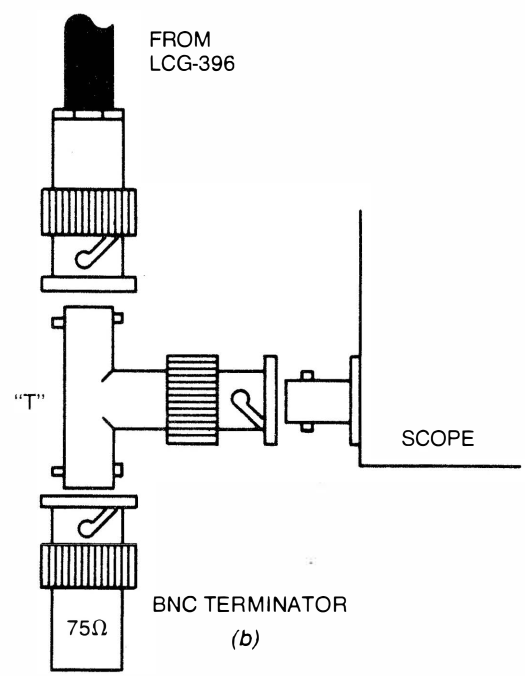


Fig. 4-1. Cable Terminations

4.3 R-F Output

An internal TV modulator provides r-f output on channel 5 or 6. Output is approximately 10 mV rms under open circuit conditions.

Where the receiver under test does not have a 75-ohm coaxial antenna converter, a balun should be added to the output cable to drive the 300-ohm balanced antenna terminals. See Fig. 4-2.

4.4 Scope Trigger

Connect the SCOPE TRIGGER OUTPUT terminal to the SYNC or TRIGGER INPUT of your SCOPE using 75-ohm coax with the appropriate connectors. HORIZONTAL or VERTICAL trigger may be selected. Trigger voltage under no load conditions is approximately 1 V(p-p).

4.5 Pattern Selection

CROSSHATCH

A pattern of 16 horizontal and 21 vertical lines with a single dot in the center. Use to adjust picture size and linearity as well as static and dynamic convergence.

CENTER CROSS

Provides a centered cross for making centering adjustments and static-convergence adjustments, also handy for locating center screen during purity (beam landing) adjustments.

DOTS

A pattern of 15 rows and 20 columns of white dots, useful for making static and dynamic convergence adjustments.

RASTERS

Red, blue and green rasters permit purity adjustments without altering CRT bias. The white raster is useful for final purity checks and the 100% white level is also useful for checking deviation in VTRs. A black raster can be produced by selecting the COLOR bar pattern and turning off CHROMA and LUMINANCE.

COLOR BARS

The color bar pattern is available in four patterns depending on the settings of the white buttons IQW OFF, CHROMA OFF and LUMINANCE OFF. With the three white buttons ON the upper half of the display is composed of fully-saturated 75% color bars. The lower half contains I and Q signals, with no luminance components plus a wide 100% white bar. This standard display is useful for chroma and ACC circuit adjustments in both receivers and VTRs. It is particularly useful in setting

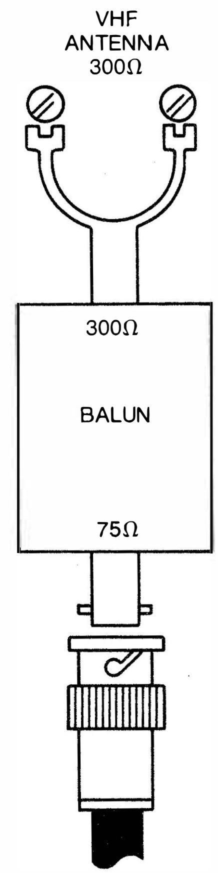


Fig. 4-2. Balun for 300−Ω balanced feed.

Y/C ratio in VTRs because the tops of the yellow and cyan bars are then even with the 100% white bar.

IQW OFF

This removes the lower half of the display to provide continuous 75% color bars from top to bottom. This is helpful in troubleshooting chroma circuits in both receivers and VTRs.

CHROMA OFF

This removes the 3.58 MHz chroma signal to provide the luminance stairstep only. This pattern is useful for checking video linearity and gray-scale tracking. It is also useful in setting FM deviation limits in VTRs.

LUMINANCE OFF

This provides 3.58 MHz chroma signals and sync only, no luminance values. It is useful in troubleshooting color-processing circuits.

5. LUMINANCE, CHROMA AND SETUP ADJUSTMENTS

Front-panel screwdriver adjustments are provided to permit setup, luminance and chrominance levels to be altered. To check the unit for proper calibration, proceed as follows:

EQUIPMENT REQUIRED

1. Triggered scope with 10 MHz or more vertical bandwidth (internal graticule preferred), or −
2. Vectorscope, Tektronix 520A, or equivalent.

CONNECTIONS

Connect the VIDEO OUTPUT of the LCG-396 to the scope or vectorscope using a 75-ohm terminator. Use D-C coupling in the scope to eliminate errors due to sag.

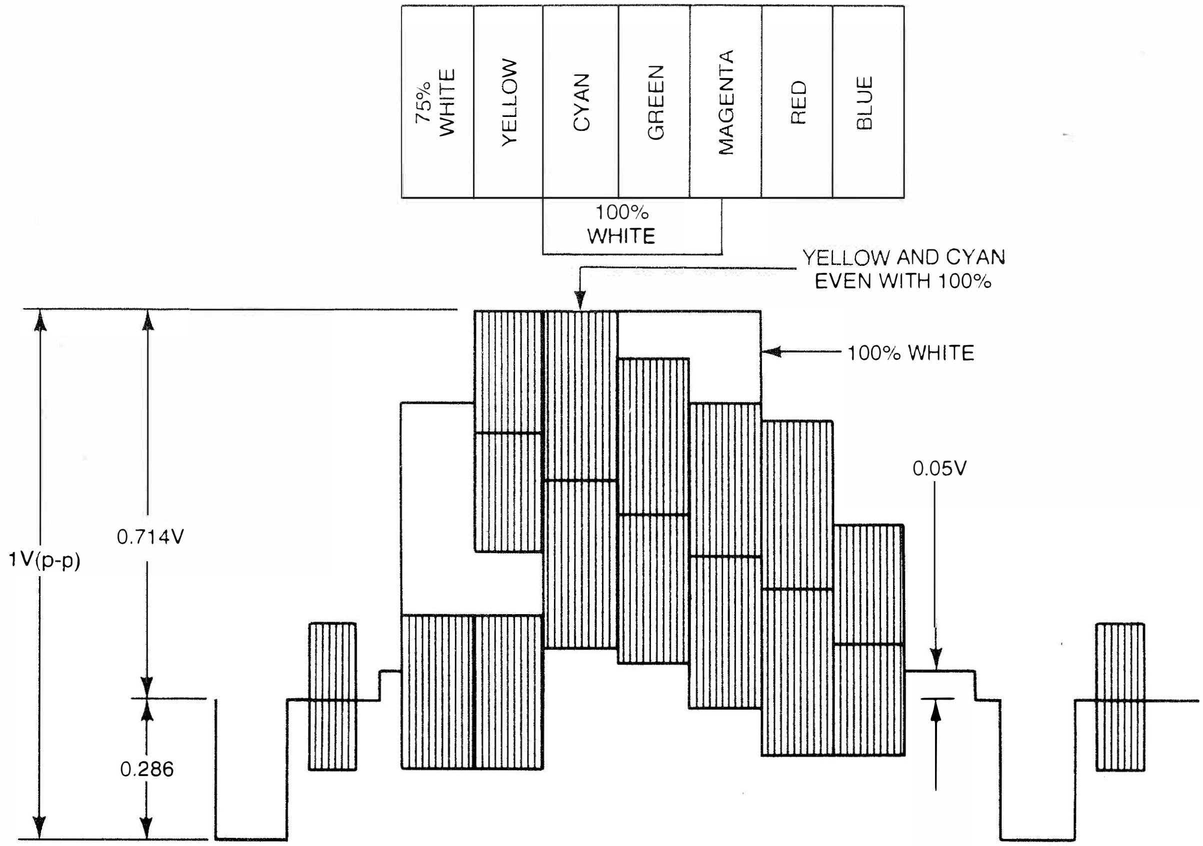


Fig. 5-1. Scope adjustment of LUMINANCE, CHROMA and SETUP

ADJUSTMENTS

1. Depress COLOR and set IGW, LUMINANCE and CHROMA ON.
2. Turn the VIDEO LEVEL control to PRESET.
3. Apply external trigger to the scope and set SCOPE TRIGGER to HORIZONTAL. Adjust scope controls to display one or two horizontal lines.
4. Adjust scope sensitivity for full-scale deflection.
5. Adjust SETUP for 7.5%, 0.05V above blanking. See Fig. 5-1.
6. Adjust LUMINANCE for 0.714 V or a peak-to-peak reading, including sync, of 1 V(p-p).
7. Adjust CHROMA to make the tops of the yellow and cyan bars even with 100% white bar.
8. When making adjustments with a vectorscope, set the vectorscope for 75% vector, luminance measurement. Set luminance and chrominance gain to CAL. The vectorscope has a graticule calibrated in IRE units. Set SETUP for 7.5 units and LUMINANCE for 100 units while observing the wide bar that is in the lower half of the display. See Fig. 5-2.
9. Switch the vectorscope from luminance to vector measurement and adjust CHROMA to place the peaks of the display inside the designated squares. See Fig. 5-3.

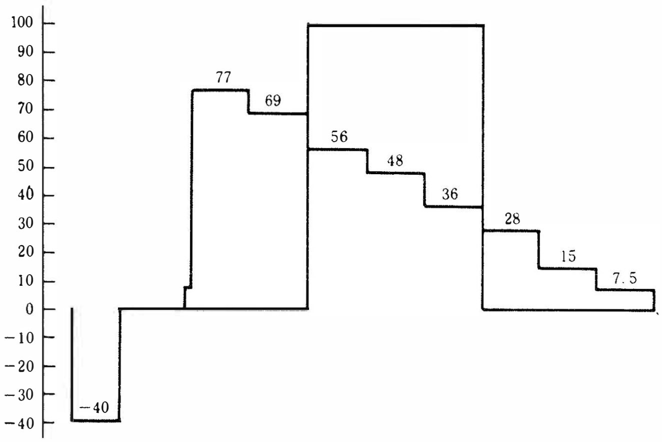


Fig. 5-2. Vectorscope LUMINANCE display

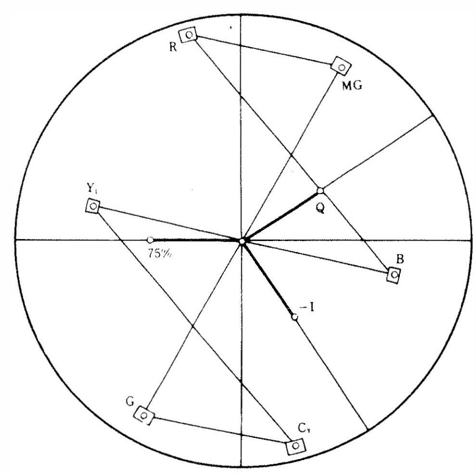


Fig. 5-3. Vectorscope display

6. REVIEW OF NTSC BASICS

The color TV system is based on the fact that the visual color values of practically all natural experience can be reproduced with appropriate mixtures of the light emitted by certain red, green and blue phosphors.

A perfectly acceptable system can be assembled with separate red, green, and blue transmission channels wherein camera pick-up tubes having spectral response similar to the radiation spectrum of the phosphors are used to drive each of the transmission channels. Such a system would require more r-f bandwidth than standard broadcast channels allow. Further, an early requirement of the NTSC system was that conventional monochrome receivers produce a normal black-and-white picture during color telecasts; that is, the system must be compatible with existing monochrome standards. For this reason a luminance or Y signal is developed from the RGB signals produced by the camera. The Y signal produces a monochrome picture with the same sort of gray-scale gradations produced by a monochrome camera whose spectral response closely matches that of human vision.

Human vision is not uniformly sensitive across the visible spectrum but peaks in the yellow-green area. See Fig. 6-1. In the NTSC system the effects of human response are simulated by adding 30% of the red signal, 59% of the green signal and 11% of the blue signal.

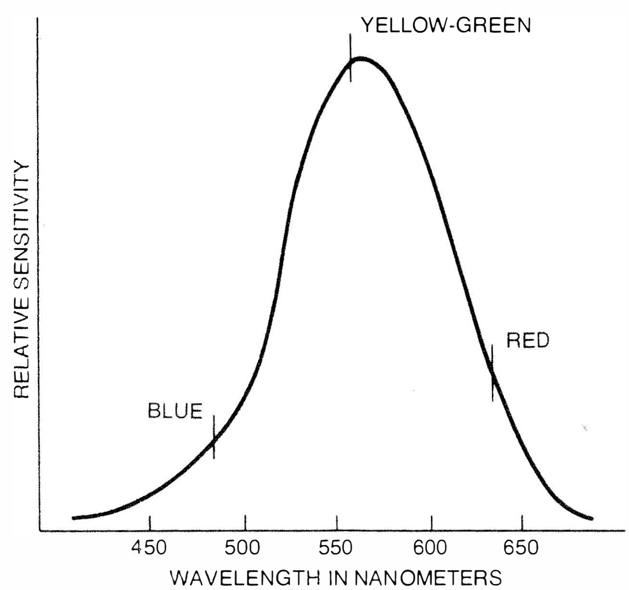


Fig. 6-1. Spectral response of human vision.

$$Y = 0.30R + 0.59G + 0.11B$$

This yields an acceptable gray scale. For example the American flag would look as we expect it to look in monochrome photos. A system having excessive sensitivity in blue would show black bars for the red stripes and a light gray background for the stars.

The Y signal is transmitted in the same way as in monochrome transmissions. To transmit chrominance (color) values, the Y signal is subtracted from each of the color signals to form the color-difference signals R-Y, B-Y, and G-Y. These are multiplexed within the video passband and decoded in color receivers where they are added back to the Y signal to restore R G and B signals.

MULTIPLEXING. To accommodate the color difference signals within the passband of a TV channel, advantage is taken of the fact that human visual acuity is not as good in distinguishing hue in small areas of the picture as it is in detecting variations in brightness. For this reason, chrominance information can be carried in a bandwidth of less than 600 kHz and still match the full color response of human vision. Further, it is not necessary to transmit all three color difference signals, because the third can be reconstructed from the two that are chosen.

The system chosen for multiplexing two color difference signals is *amplitude modulation* of two subcarrier signals that have the same frequency but are in phase quadrature (90° apart). Balanced modulators are used so that when both chrominance signals are zero (for neutral white or gray) no output subcarrier signal is produced. A subcarrier signal at approximately 3.58 MHz is chosen to permit retention of both upper and lower sidebands of the amplitude modulated signals. The precise selection of subcarrier and sync frequencies provide for minimum visual effect of the subcarrier signal on wideband monochrome receivers.

Vector addition of the output of both modulators results in a specific phase for each of the primary and complementary colors. See Fig. 6-2. The subcarrier signals so produced are added to the Y signal to form the composite video signal. A sample of the subcarrier signal at the −(B-Y) phase is keyed into the composite signal on the back porch of horizontal sync to serve as the reference for carrier regeneration in the receiver.

AMPLITUDE CORRECTIONS. The basic setup shown in Fig. 6-2 results in subcarrier excursions that exceed peak white by an excessive amount, during the transmission of fully-saturated colors having the highest Y values (yellow and cyan). To prevent desaturation of these colors due to signal clipping in normal transmission routes, it was decided to attenuate B-Y by the factor 0.493 and R-Y by the factor 0.877. See Fig. 6-3. However, to restore B-Y and R-Y to their correct relative values following the decoder in the receiver, the B-Y and R-Y channels must apply inverse gain factors.

I AND Q. To make full use of human visual acuity and suppress the visual effects of subcarrier phase errors due to sideband cutting, the NTSC system provides for altered modulation axes wherein one phase axis is aligned with the orange-cyan axis on the vector diagram. Human vision can discern orange and cyan in relatively small areas of the picture, corresponding to a video-bandwidth of approximately 1.2 MHz. The orange-cyan axis is rotated 33° from the R-Y axis as shown in Fig. 6-4. This signal, called the I signal is produced by taking appropriate values of R-Y, B-Y. The Q axis, roughly magenta-green, is at right angles to the I axis. In this system the Q signal is band-limited to 600 kHz in both the encoder and decoder. In the region above 600 kHz, where phase errors are likely due to loss of the upper

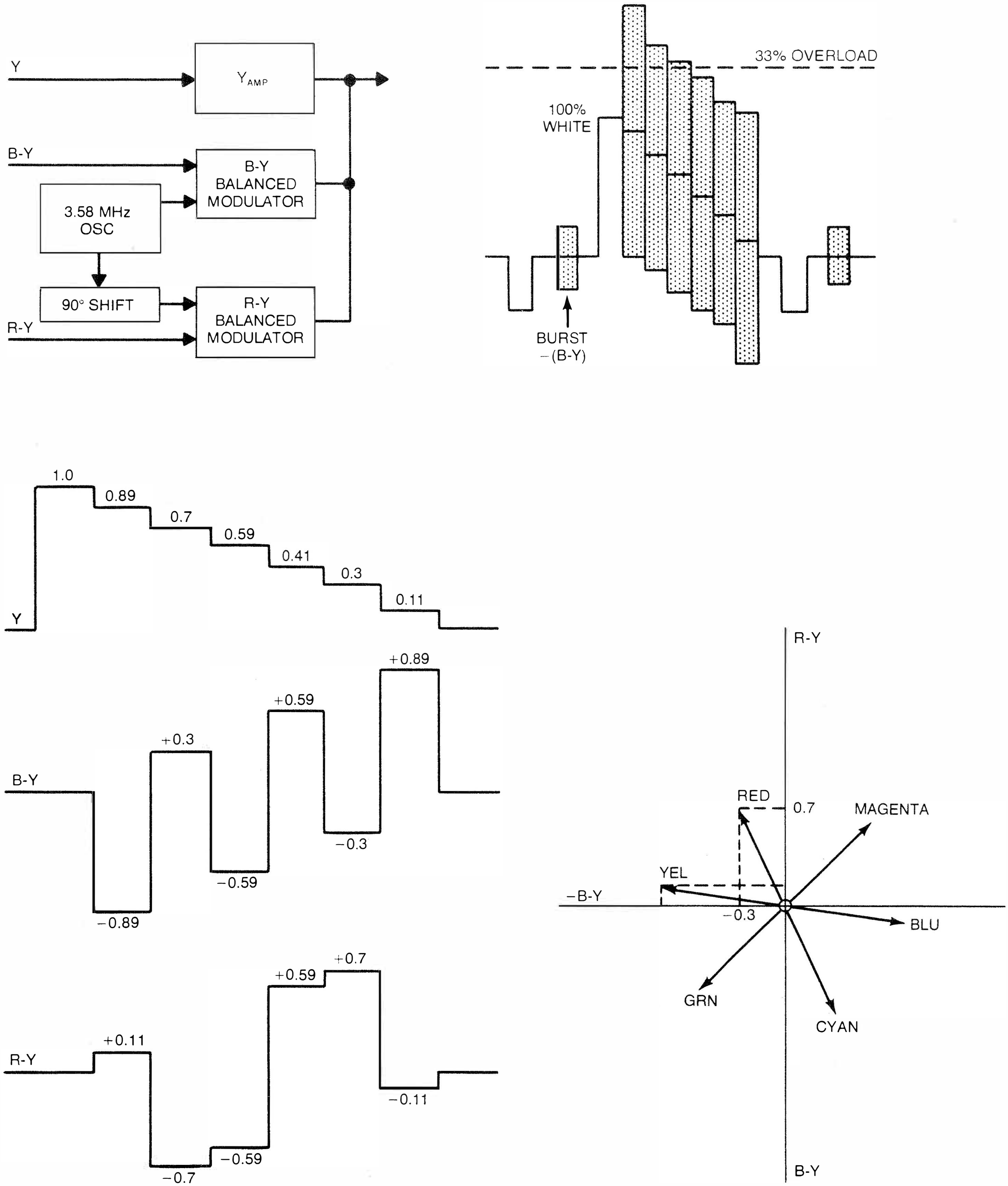


Fig. 6-2. Simplified Encoder using uncorrected values of R-Y and B-Y results in excessive subcarrier amplitudes.

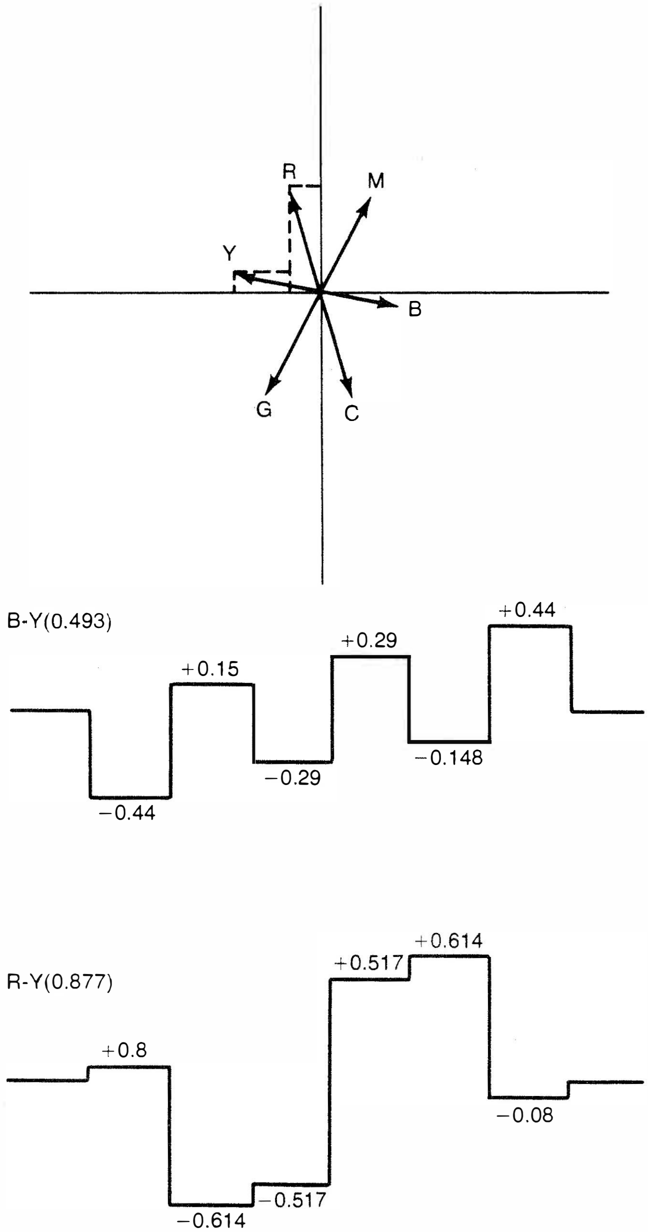


Fig. 6-3. Simplified Vector diagram for amplitude-corrected R-Y and B-Y

sideband, only the I demodulator is active. Here phase errors result only in minor variations in the amplitude, and hence saturation, of orange or cyan colors.

Below 600 kHz, all hues are transmitted. In this region, the decoder can be set to demodulate R-Y, B-Y and G-Y directly by appropriate rotation of the demodulation axes.

In the color-bar generator which deals with large areas of color only, the B-Y/R-Y axes can be used and result in precision location of all color vectors. Alignment on I/Q axes is needed only when the I channel is required to have the full I bandwidth of approximately 1.2 MHz. Below 600 kHz, each color vector can be resolved into the correct values of R-Y, B-Y and G-Y by demodulation on either R-Y/B-Y axes or I-Q axes. In the latter case, a matrix correction of relative amplitudes is needed to reconstruct R-Y, B-Y and G-Y. The encoder in the LCG-396 operates on R-Y/B-Y axes. Since the color bar generator presents large areas of color, there is no need to use the I and Q axes. Reference I and Q signals are provided in the lower part of the display, however.

75% COLOR BARS. Fully saturated color bars at 100% amplitude are seldom encountered in nature and present an unnecessarily stringent demand on signal processing and transmission systems. The reason is that the peak subcarrier excursions of the yellow and cyan bars extend some 33% above peak white while red and blue extend some 33% below the blanking level. To provide a more realistic test signal the standard pattern that has been adopted uses fully saturated colors at 75% of maximum amplitude. This means that the RGB signals into the encoder are at 75 IRE units rather than 100. See the left waveforms in Fig. 6-5. The Y signal is calculated from 75 IRE units using the formula: Y = .30R + .59G + .11B. To calculate Y for each bar also requires a consideration of setup (7.5 IRE units). As an example the Y value for the green bar is calculated as follows:

100 − 7.5 = 92.5 × 0.75 = 69.375G
69.375G × 0.59 = 40.93

This value must be added to the setup

40.93 + 7.5 = 48.43

The nominal value, 48 IRE units, is used for the Y value of the G bar.

Fig. 6-5 shows nominal values for Y values for each of the bars as calculated in the example for green.

Calculation of subcarrier amplitude and phase requires conversion to R-Y and B-Y followed by some simple trigonometry. Using the green bar as an example, during the green bar both R and B are zero (at the 7.5 setup level).

R-Y is then 7.5 − 48.43 = −40.93 where 48.43 is the Y value for green
The amplitude correction factor 0.877 must be applied to yield:
R-Y = − 40.93 × 0.877 − −35.896
B-Y is 7.5 − 48.43 = −40.93
The amplitude correction factor 0.493 must be applied to yield:
B-Y = −40.93 × 0.493 = −20.178

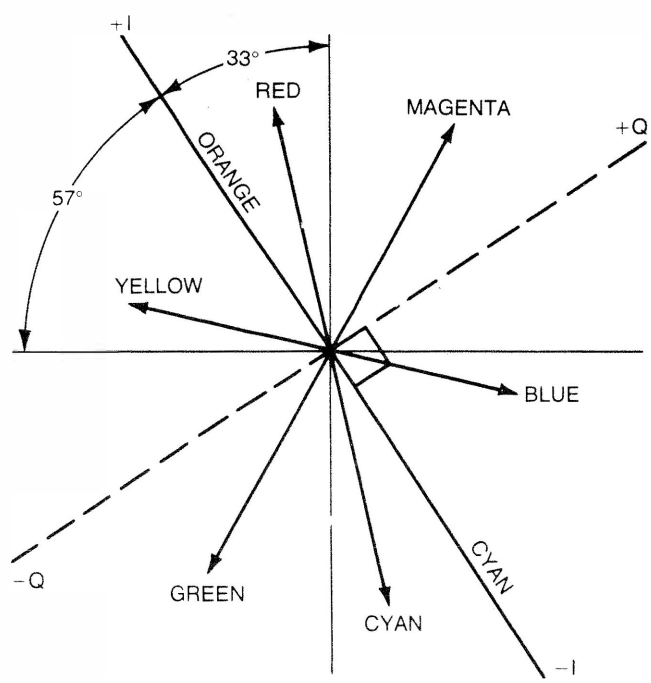


Fig. 6-4. I-Q axes

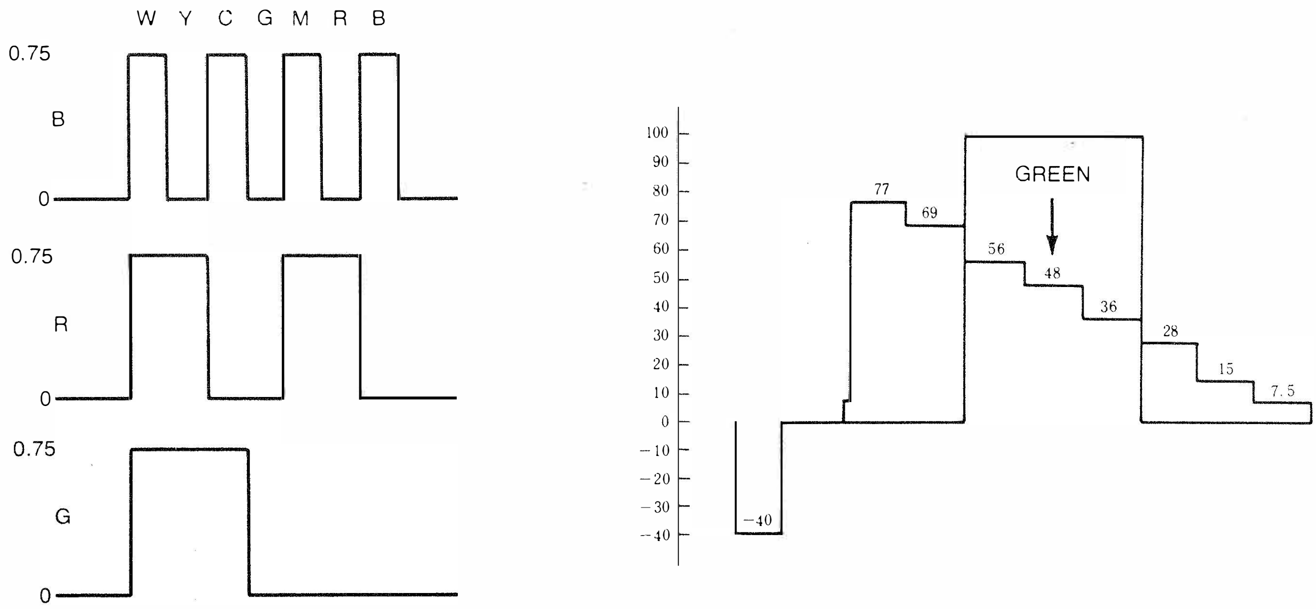


Fig. 6-5. Construction of the Y signal.

These values are plotted on the vector diagram of Fig. 6-6. The angle x is calculated as follows:

$$x = \text{arc tan} \frac{-20.178}{-35.876}$$

$$x = 29.34°$$

Since vector angles are measured ccw from B-Y the phase angle for green is:

270° − 29.3Y° = 240.66° = 241° nominal

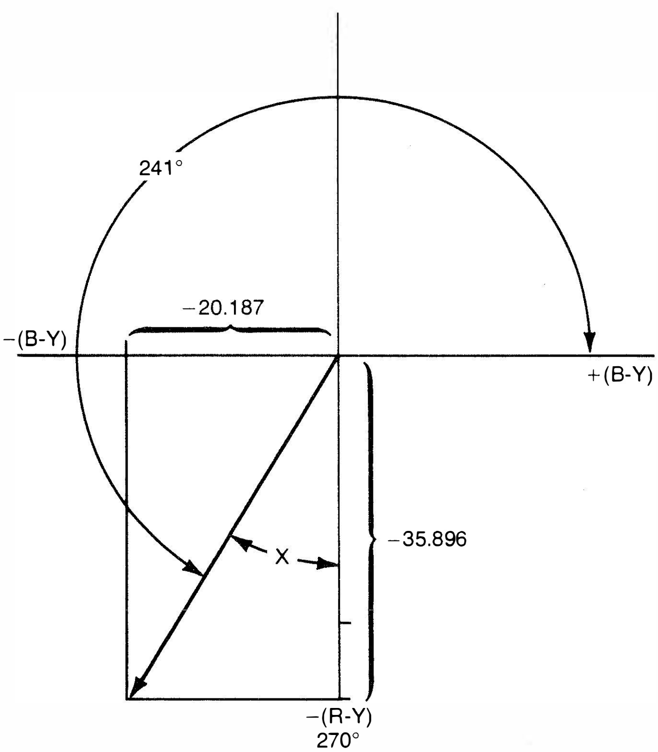


Fig. 6-6. Construction of the encoded green signal

The peak amplitude of the subcarrier signal for green is calculated as:

$$EG(\text{peak}) = \sqrt{20.178^2 + 35.896^2}$$
$$= 41.178$$

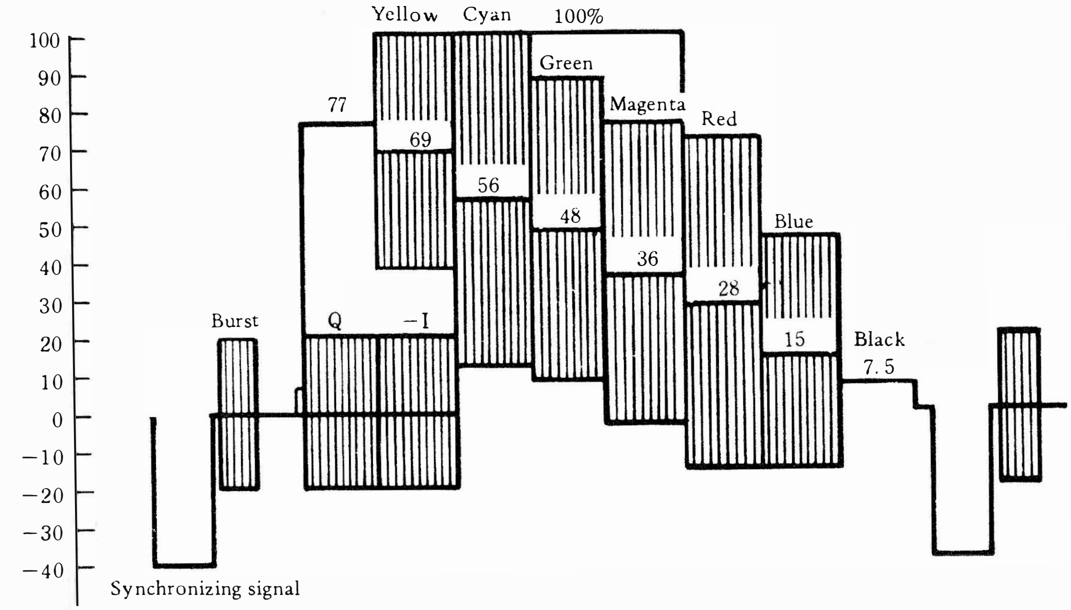
The peak-to-peak value is twice 41.178 or 82.35 = 82 nominal

Figure 6-7 shows the composite Y/C waveform and the vector diagram for each of the colors in the pattern.

For details and specifications for 75% NTSC color bars, refer to EIA standard RS-189A.

ADVANTAGES OF 75% BARS. The color bar display provided by the LCG-396 provides standard 75% bars in the top half of the display plus 100% white and I and Q in the lower half. This pattern provides instant recognition of correct relative values of luminance and chrominance. For example the positive peaks of the subcarrier for the yellow and cyan bars are at 100%. Thus they should be in line with the 100% white bar on the scope waveform. See Fig. 6-8. Further, the bottom excursion of the green bar is just about equal to the setup value. This makes it easy to set Y and C values in camera encoders or at the output of VTRs.

CHOICE OF THE SUBCARRIER FREQUENCY. Three factors affect the choice of the subcarrier signal. One is that about 600 kHz must be provided each side of the carrier for both sidebands of the Q signal. To allow room for the upper sideband, the carrier must be 600 kHz below 4.2 MHz or at approximately 3.6 MHz. Next the carrier must be related to the scanning frequency by an odd multiple of half the H rate. The factor employed is: $F_s = 455/2\ F_H$. This produces a interlaced dot pattern caused by subcarrier signal as shown in Fig. 6-9. Note that signals at the same points in alternate lines in the same field are 180° apart; a 1/4 cycle shift between odd and even fields is due to the odd number of lines (525) in the raster. The interleacing of subcarrier and scan rate results in a frequency interleaving wherein the



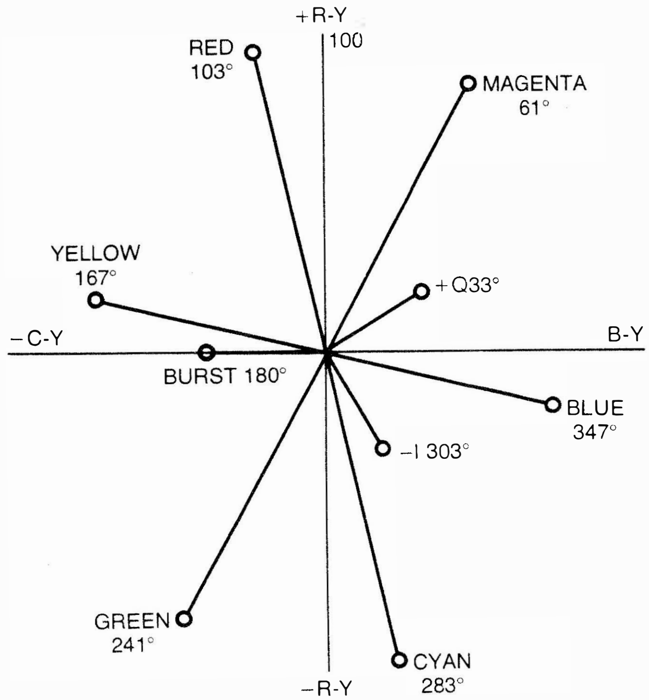


Fig. 6-7. Y and C Values for 75% color bars

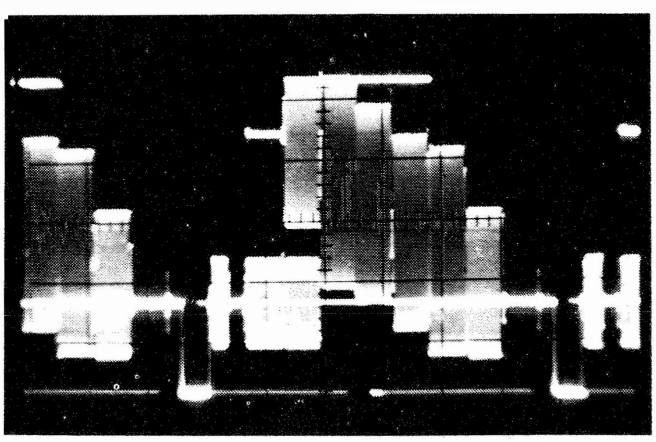


Fig. 6-8. Correct Y/C ratio

subcarrier sideband signals are frequency interleaved with the harmonics of the scan rate.

Finally the visual effects of the sound carrier were considered, and it was determined that the sound carrier should also be harmonically related to the scan rate. However, the harmonics of 15.75 kHz closest to the sound carrier fall at 4.48875 and 4.5045 MHz. This would require a major shift in the sound carrier frequency, a shift beyond the range of existing TV receivers at the time. Hence, the decision to keep the sound carrier at 4.5 MHz and alter the scan rate.

Thus the H rate is calculated as:

$$F_H = \frac{4.5 \times 10^6}{286} = 15{,}734.26 \text{ Hz}$$

The field rate then becomes:

$$F_F = \frac{FH}{525/2}$$

$$= 59.94 \text{ Hz}$$

Finally the subcarrier frequency is

$$F_S = \frac{FH\ 455}{2}$$

$$= 3.579545 \text{ MHz}$$

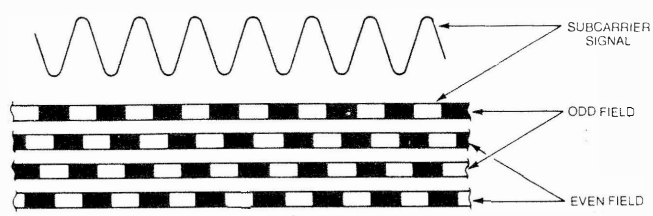


Fig. 6-9. Dot Pattern caused by color subcarrier.

7. TV-MONITOR APPLICATIONS

This section describes the use of the LCG-396 in TV receiver and monitor checks and alignment.

The selection of patterns available from the LCG-396 facilitates convenient checks of scanning size and linearity, beam landing, static and dynamic convergence. The NTSC color-bar display permits easy visual checks of gray-scale tracking, and precise checks of both luminance (black and white) and chrominance circuits.

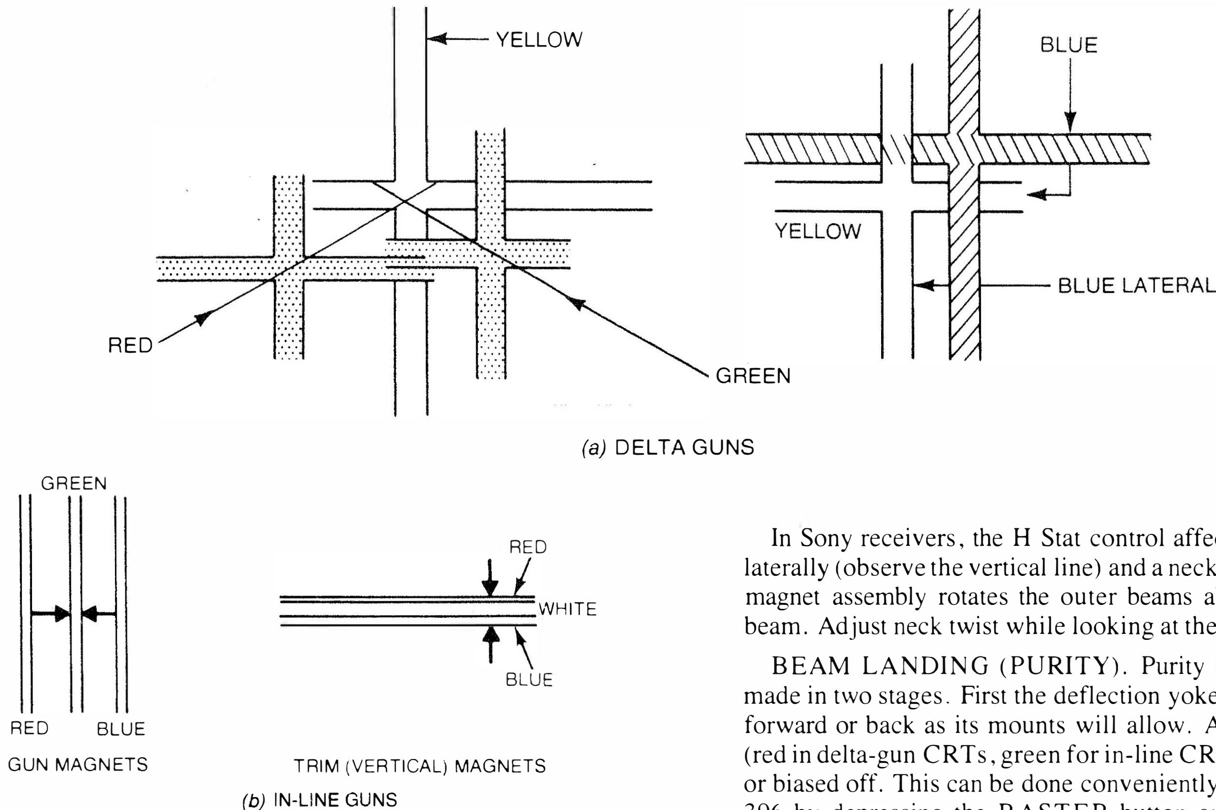


Fig. 7-1. Static Convergence

7.1 Purity and Convergence

Make a quick check of scanning size and linearity before attempting to correct beam landing or convergence. The accurate blanking periods provided by the LCG-396 permit precise size adjustments. Refer to section 7-2.

STATIC CONVERGENCE. Static convergence adjustments should be made to register the three primary-color beams at center screen before beam landing adjustments (purity adjustments) are made. To concentrate on center screen, depress CENTER CROSS to set up the single cross-hatch display.

For Delta-Gun CRTs, adjust the red and green gun magnets to register the red and green crosses. Move the blue cross vertically with the blue gun magnet, and laterally with the blue lateral adjustment until the blue cross registers with the yellow (red/green) cross. See Fig. 7-1*a*.

For In-Line CRTs, adjust the outer guns (usually red and blue) to move the corresponding color towards the central (green) vertical line. See Fig. 7-1*b*. Adjust the trim magnets to converge red and blue on the central green line while observing the horizontal line of the pattern.

In Sony receivers, the H Stat control affects convergence laterally (observe the vertical line) and a neck-twist control or magnet assembly rotates the outer beams about the central beam. Adjust neck twist while looking at the horizontal line.

BEAM LANDING (PURITY). Purity adjustments are made in two stages. First the deflection yoke is moved as far forward or back as its mounts will allow. All guns but one (red in delta-gun CRTs, green for in-line CRTs) are disabled or biased off. This can be done conveniently with the LCG-396 by depressing the RASTER button and selecting the RED or GREEN raster. Beam landing is then adjusted using the magnet assembly mounted on the neck of the CRT to center the "blob" or "cloud" of color produced by the active gun. See Fig 7-2*a*. Switch back to the CENTER CROSS momentarily to help identify the center of the screen.

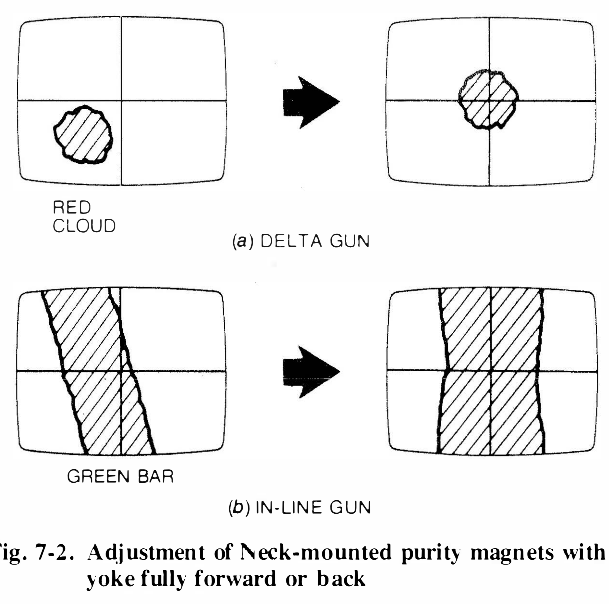


Fig. 7-2. Adjustment of Neck-mounted purity magnets with yoke fully forward or back

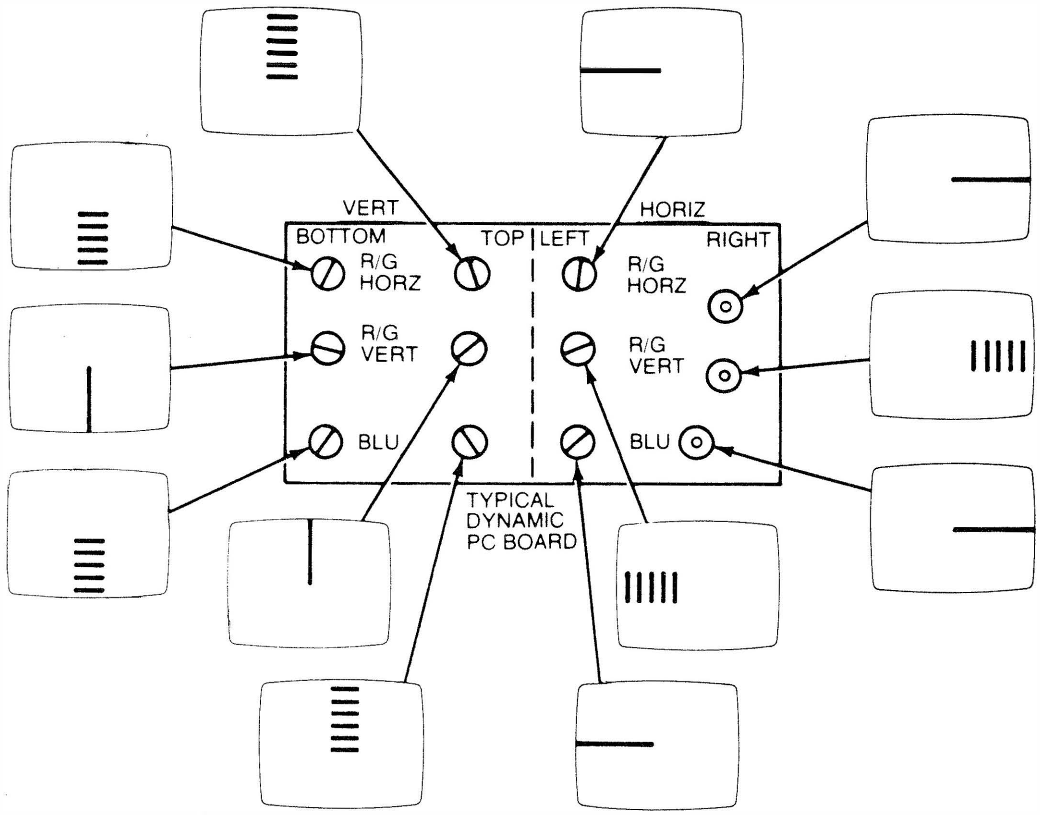


Fig. 7-3. Typical delta-gun dynamic convergence adjustments.

The yoke is then repositioned along the CRT neck to spread the color produced by the active gun over the entire screen surface. Recheck the remaining raster colors using the selector switch and touch up as necessary.

For slot-mask picture tubes the first step in the beam landing adjustment may produce a nearly vertical bar as shown in Fig. 7-2*b*. Adjust the neck-mounted controls to center the bar horizontally. Reposition the yoke so that the central bar of color spreads out uniformly and no impurity is seen at screen edges or corners. Re-check the remaining primary colors.

DYNAMIC CONVERGENCE. The 16 × 21 crosshatch pattern is useful for dynamic convergence adjustments.

For Delta-Gun CRTs the differential system used for dynamic convergence is based on the registry of red and green first, followed by blue. In cases of severe misconvergence, it helps to bias off the blue gun and concentrate on red and green. Dyanmic controls are labeled as to the affected area of the screen and the orientation of the lines that should be observed. For example "RG Top Vertical" identifies the control that converges the vertical red and green lines of the crosshatch pattern at the top of the picture. Refer to Fig. 7-3.

After red and green lines have been coverged over the entire screen area, restore operation of the blue gun and adjust the blue lines to converge with the yellow (red/green) lines. The action of the blue controls is to move the horizontal blue lines up and down at the screen areas designated top, bottom, left and right.

Dynamic convergence adjustments are minimal for In-Line systems, usually confined to a Horizontal Dynamic control which affects convergence of vertical lines of the crosshatch pattern at the sides of the screen.

7.2 Scanning Adjustments

The duration of horizontal and vertical blanking are accurately controlled in the LCG-396 so that picture size adjustments will match those required for broadcast signals.

PICTURE SIZE. In modern receivers using well regulated supplies, vertical size is adjusted for a small amount of overscan (blanking is not visible at the top or bottom of the screen). Horizontal deflection circuits are designed for maximum efficiency and seldom include a horizontal size control.

In older receivers that do not employ B+ regulators, scan size is usually adjusted to fill the mask at the lowest supply-line voltage to be expected. A typical value is 106 VAC. Size adjustments may be made considering the normal line voltage in the customer's home. For bench adjustment's, consider voltage difference in your shop if it is markedly different from that expected in the customer's home.

LINEARITY. Use the crosshatch pattern and adjust vertical size and linearity controls for uniform spacing of horizontal lines from top to bottom and the desired vertical size. Horizontal linearity controls are seldom found in late-model receivers.

PINCUSHION ADJUSTMENTS. Pincushion distortion causes the crosshatch pattern to appear as shown in Fig. 7-4*a*. Overcorrection results in the condition shown in *b* of the figure.

Side pincushion correction is achieved by modulating the horizontal scan current with a parabolic waveshape derived from the vertical deflection circuits. The SIDE PIN-AMP control is set to straighten vertical lines at both sides of the picture. In many cases side pin amplitude is not adjustable and components must be changed to effect proper correction.

Top and bottom pincushion correction is achieved by a balanced modulation system that adds a horizontal parabolic or sine-wave shaped current to the vertical deflection current. This horizontal component is maximum and opposite in phase at top and bottom but drops to zero at center screen. In most cases a PIN AMP control sets the degree of correction and a PIN PHASE control adjusts the lateral phase of the correction current. To adjust, set PIN AMP to maximum and adjust PIN PHASE to center the bowing or bulge in the horizontal lines of the crosshatch pattern at the top and bottom of the picture. Where a saturable reactor is used to develop the desired waveshape, a mechanical slider containing the PIN BIAS magnet, should be adjusted to equalize correction (bowing) at top and bottom. Reset PIN AMP for straight horizontal lines at top and bottom.

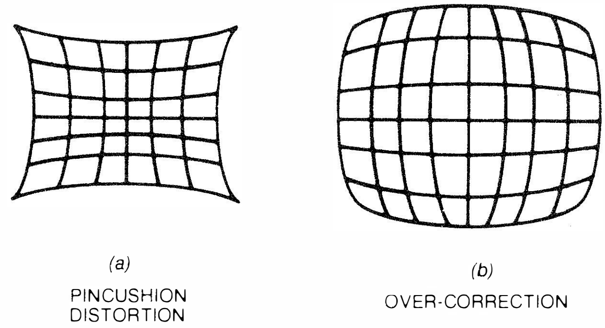


Fig. 7-4. Pincushion distortion and over correction

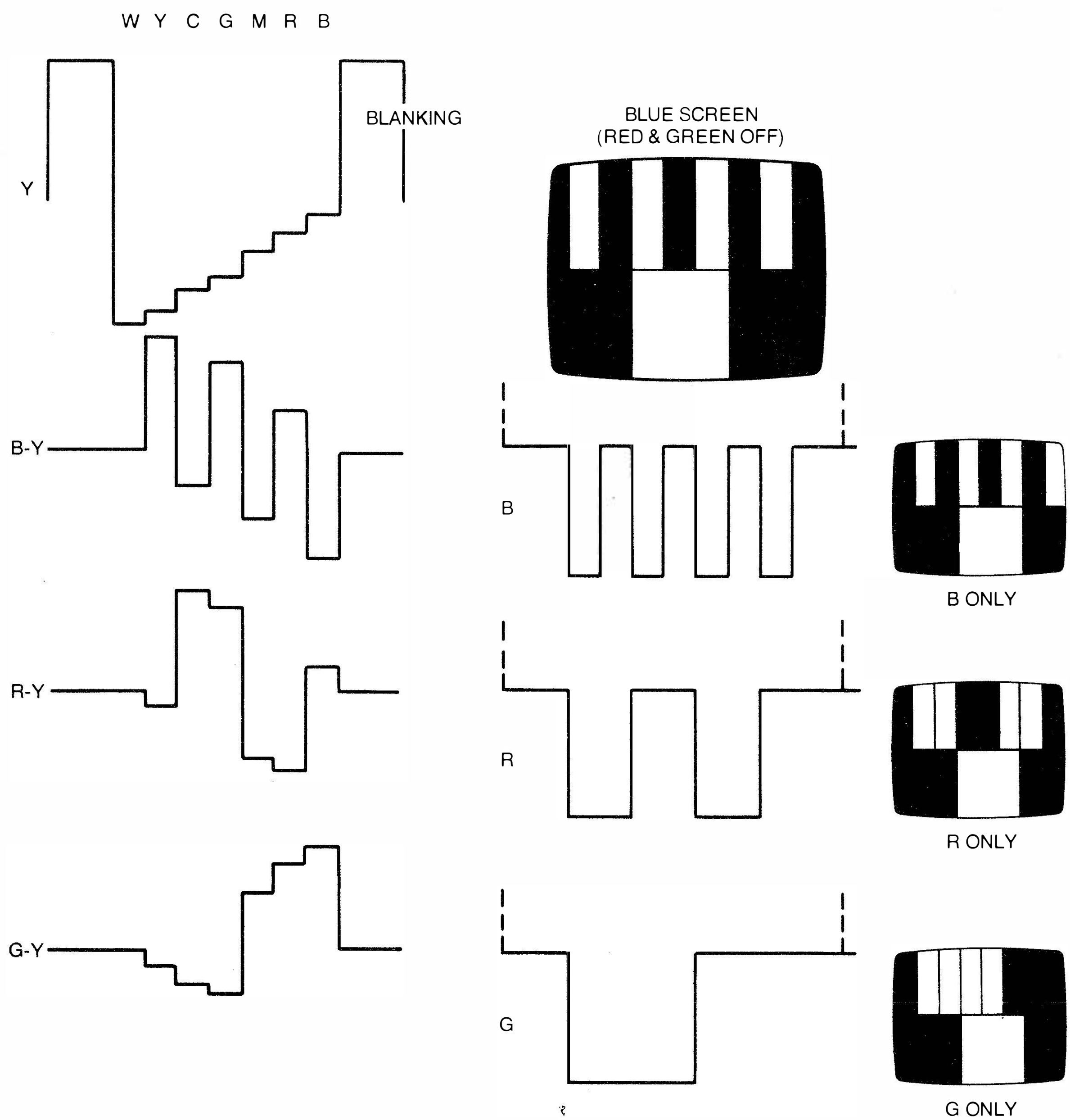


Fig. 7-5. NTSC Waveforms

7.3 Gray-Scale Tracking

The luminance part of the color bar signal provides a quick check of gray scale tracking. Select the COLOR display and depress the CHROMA OFF button. If gray-scale tracking is correct, none of the bars should show a predominant hue. All bars should be either neutral white or neutral gray.

For those CRTs that employ individual primary-color guns, the SCREEN controls affect color balance near cutoff (dark grays). A magenta hue in the darkest bar (at the far right) indicates that the green gun is closer to cutoff and green screen should be advanced. For single-gun CRTs that employ a common screen grid, red, green and blue BACKGROUND controls affect g-k bias to balance primary colors at low brightness levels.

VIDEO DRIVE controls are adjusted to balance primary colors for a neutral white in the peak-white parts of the picture (100% white bar in lower half of display). In many cases only two drive controls are provided. Drive to one gun (usually red) is fixed at maximum and drive to the remaining guns (blue and green) are set to produce a neutral peak white.

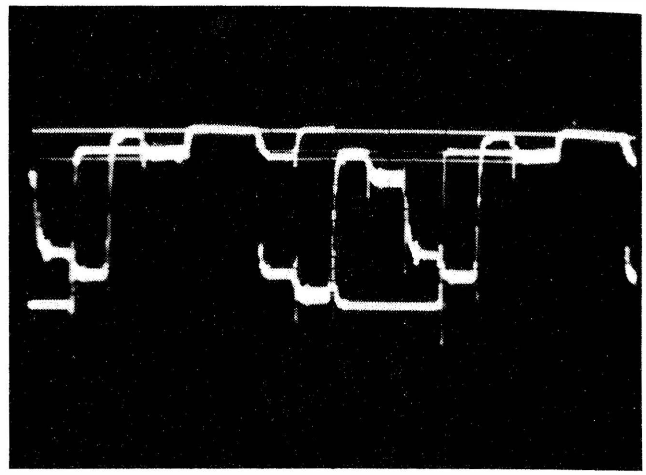
7.4 Color Checks and Adjustments

The fully-saturated primary and complementary color bars of the NTSC display provide an easy visual assessment of correct HUE or TINT (phase) and COLOR (saturation).

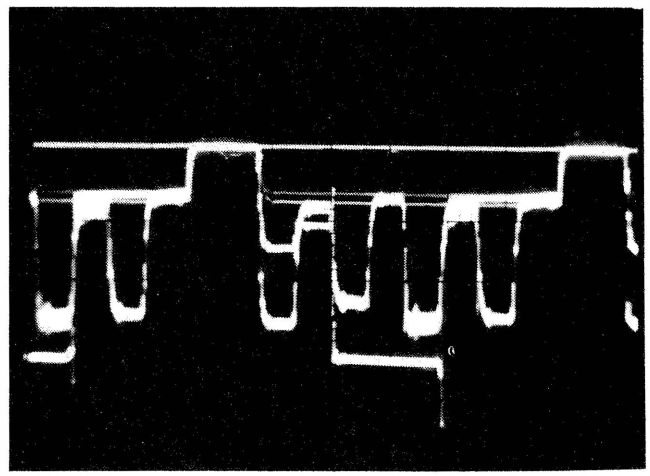
For correct reproduction of the NTSC display using the original NTSC primaries, each bar should be fully saturated. That is, one or two of the guns should be at cutoff for each of the color bars. For example, when looking at the blue drive waveform all colors containing blue (blue, cyan and magenta) should be at 75% while all other colors should be at reference black. See Fig. 7-5. Correct phase and saturation are achieved when the blue drive waveform shows the peaks of all bars containing blue at the same level and all bars not containing blue (red, yellow, green) at blanking. In those receivers where the addition of the Y and color-difference signals takes place in the CRT, the addition of Y and B-Y can be observed by biassing off the red and green guns. Then all bars containing blue should be of equal brightness; all bars not containing blue should be fully extinguished. Figure 7-5 shows the primary-drive waveforms, Y, the color difference signals and the appropriate screen displays for each primary. Note that the waveforms are shown inverted for cathode drive to the CRT. In older sets, when the color difference signals are applied to G1 the color-difference signals shown in Fig. 7-5 should be inverted.

Departures from the values shown in Fig. 7-5 are made to accommodate CRT phosphors other than the original NTSC primaries. In addition, attenuation of chrominance signals along the Q axis (green-magenta) is often used in receiver design to minimize objectionable flesh-tones due to overall-system phase errors. For this reason there are wide variations from the situation shown in Fig. 7-5 Figure 7-6 shows typical R G and B drive signals from a properly adjusted late-model receiver.

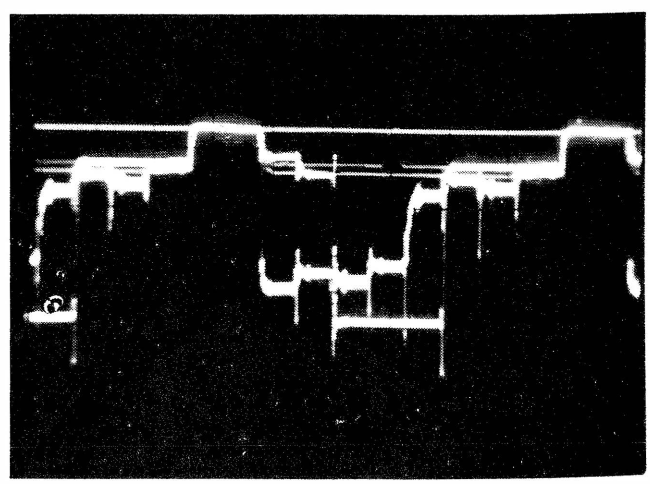
SIGNAL TRACING. Figure 7-7 shows key waveforms at various points in the TV receiver. Note that the amplitude of the chrominance signal at the video detector is about half the correct value. This is to be expected because the color subcarrier signal is at the 50% point on the I-F response curve. This loss of relative gain is made up in the chroma bandpass amplifier.



(a) RED



(b) BLUE



(c) GREEN

Fig. 7-6. Cathode Drive Waveforms in a late-model receiver

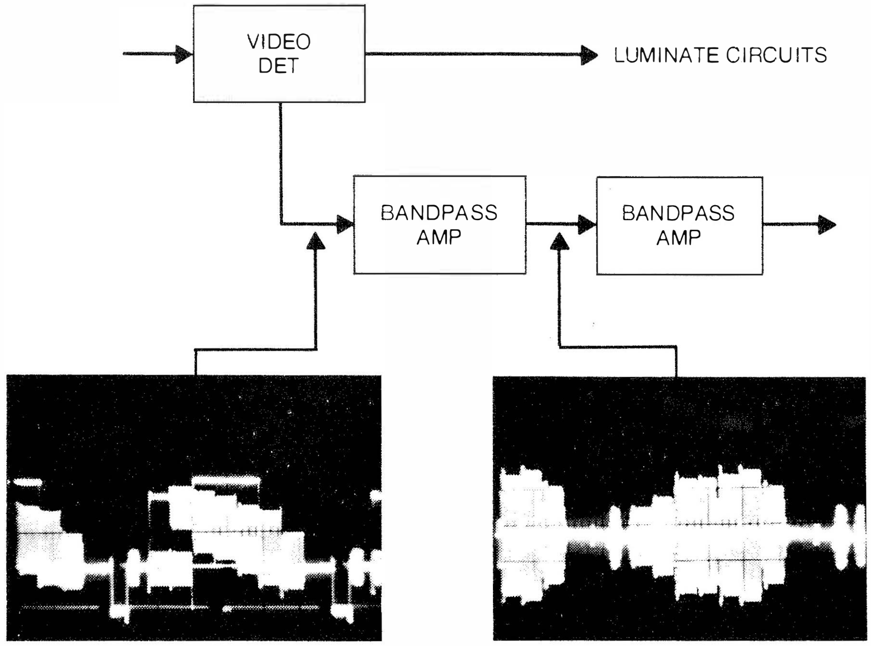


Fig. 7-7. Receiver chroma waveforms

8. VTR CHECKS AND ADJUSTMENTS

A basic philosophy applied by most VTR manufacturers is to make checks and adjustments of playback circuits using a factory supplied alignment tape, then to adjust record circuits to provide matching playback performance when using a standard signal source. The most useful source in this case is one that provides one of the signals commonly recorded on the alignment tape — 75% NTSC color bars with standard sync. Waveforms given in VTR service manuals are also shown for standard NTSC color bars.

In addition to correct chroma values, the NTSC color bar signal provides a 100% white bar, needed for luminance FM deviation and white-clip checks. Finally, correct servo adjustments require broadcast quality sync with correct sync and equalizing pulses, as well as correct blanking durations. The LCG-396 provides correct input for all luminance, chrominance and servo adjustments. The following outlines some examples of typical record-mode adjustments.

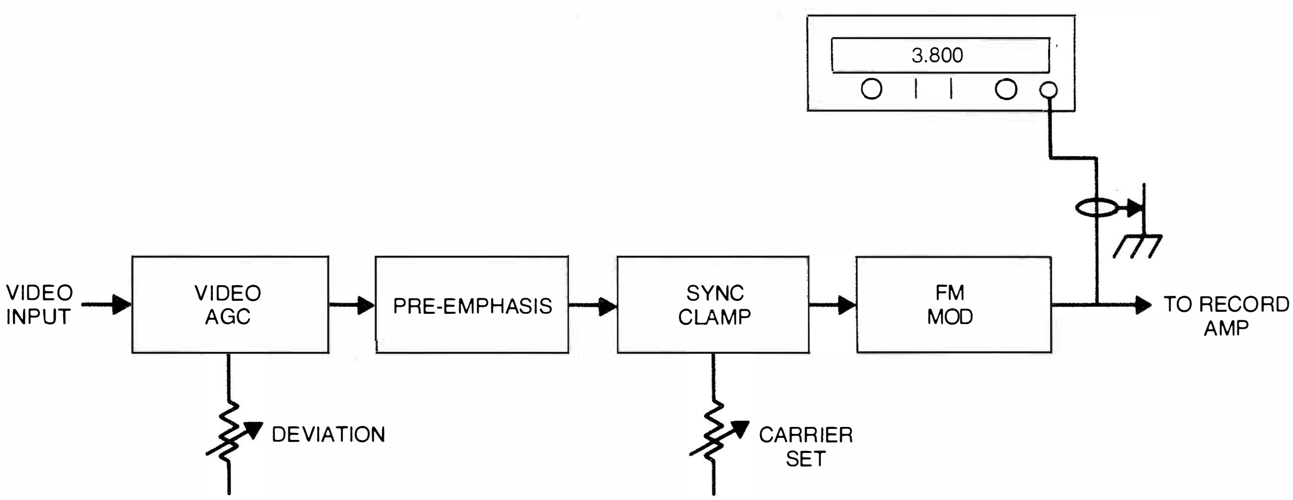


Fig. 8-1. Carrier set for sync-tip frequency

8.1 Luminance FM Deviation

Adjustment of the frequency-modulated luminance signal requires that the FM modulator swing between two fixed frequency limits that correspond to sync tip and peak white in the video signal.

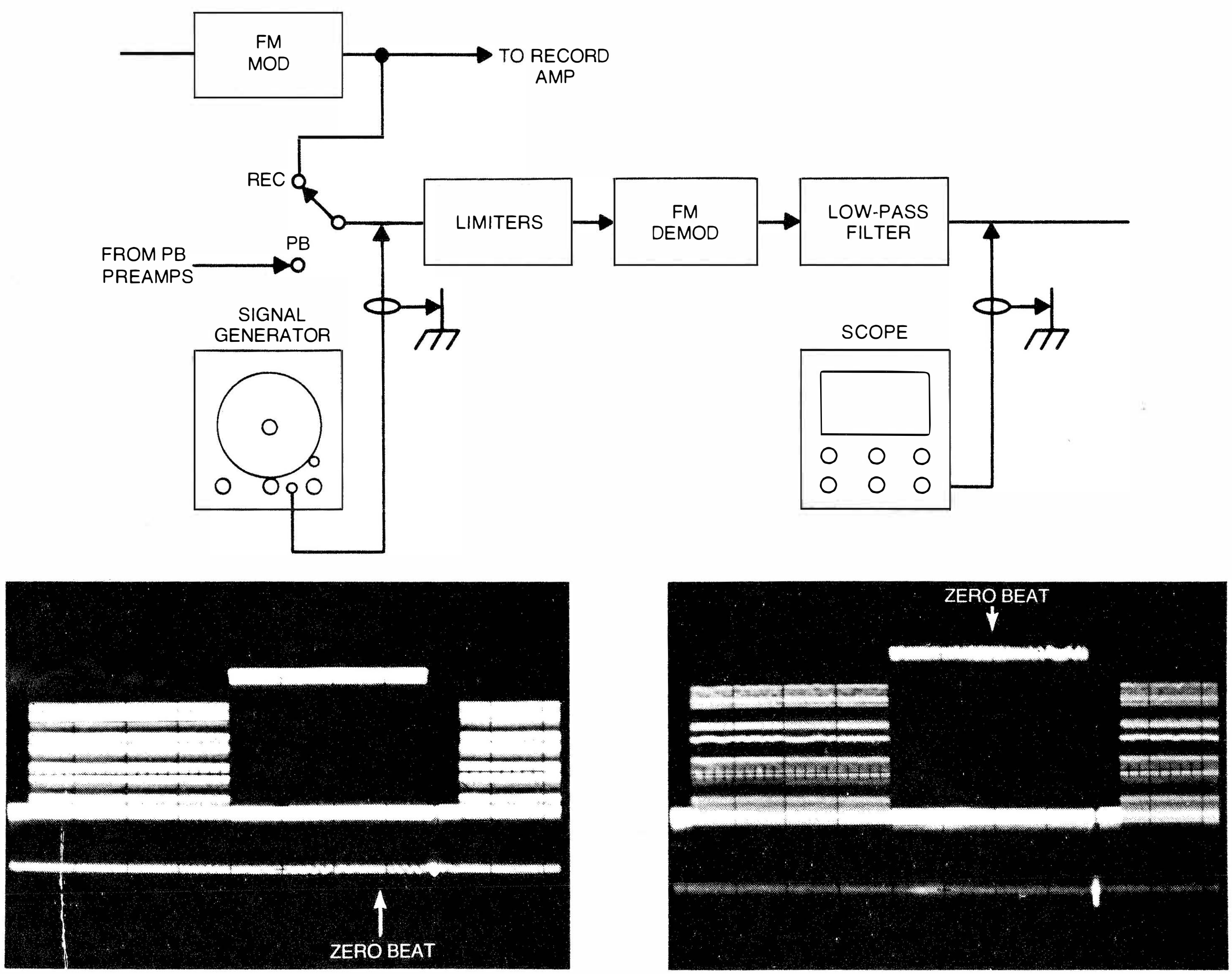
A common method requires playback video level to be set first to the standard output level of 1 volt peak-to-peak (output terminated in 75 ohms) using the factory alignment tape.

A preliminary adjustment is made to remove the action of the white clip circuit. Then sync-tip frequency is then set in the record or E-E mode with no input video applied. A frequency counter is connected as shown in Fig. 8-1 and the sync tip frequency set to the proper value. A standard video signal (with 100% peak white) is then applied and a trial recording is made. Deviation is increased in small increments while monitoring the peak-to-peak video into the modulator. A note is made of each value by voice on one of the audio tracks using a microphone. The trial recording is then played back and the input value that yields the correct, 1 V (p-p), output video value is noted. Deviation is then reset to the noted value.

An alternative method is shown in Fig. 8-2. This system must be used when keyed clamps are found at the input to the FM modulator, in which case the frequency of the modulator in the absence of input video is meaningless. For this system to work the VTR must have a true E-to-E signal path. That is output video in the record mode must have been through the full FM modulation-demodulation process. Many home-type videocassette machines do not have full E-to-E operation.

The machine is put into the E-to-E mode with the standard color bar signal applied. The scope is connected to monitor the output of the FM demodulator and set to observe one or two vertical fields.

A CW signal from a signal generator is injected into the luminance playback circuits just ahead of the limiters, and set to the sync tip value. (3.8 MHz for 3/4" machines). When the clamp level or sync tip frequency is set correctly in the modulator a zero beat will appear at the sync tip level as shown in waveform *a*. The generator is then set to the peak white value (5.4 MHz for 3/4" machines) and deviation (video amplitude) set in the machine to produce the zero beat at the peak white level. See waveform *b* in Fig. 8-2.



a *b*

Fig. 8-2. Heterodyne method of setting FM Deviation

8.2 White Clip Adjustment

Following the deviation adjustments to the FM modulator, the white clip adjustment must be reset to prevent the pre emphasis spikes at the leading edges of peak white signal excursions from driving the modulator too high in frequency (overdeviation). A signal source with a 100% peak white bar is needed. Figure 8-3 shows a typical white clip setting. The waveform is at the input to the FM modulator, and the allowable preemphasis spike is 40 units, considering the signal excursion from blanking to peak white to be 100 units. To make this adjustment, adjust scope gain for a 5 division spread between 100% peak white and blanking. Then adjust white clip until the preemphasis spikes extend 2 divisions above or below peak white.

The crosshatch or single cross display of the LGC-396 provides a good signal for revealing the effects of excessive FM deviation. The black smudges of noise, as shown in Fig. 8-4, appear at the vetical line in playback if deviation during record is excessive.

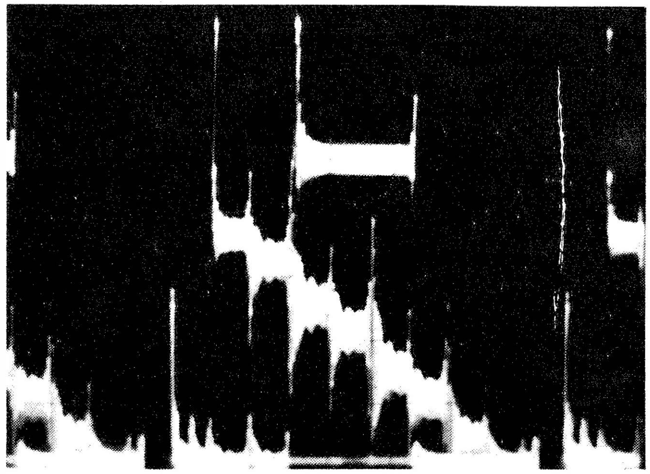


Fig. 8-3. White-clip setting

8.3 Chroma Circuit Adjustments

The chroma signal in helical-scan machines is not demodulated at any point, but is heterodyned down to a lower subcarrier center frequency during record (688 kHz in 3/4″ machines, for example). In playback an up conversion restores the subcarrier to its normal center frequency at 3.58 MHz. Because the chroma signal is not demodulated, circuit adjustments deal primarily with absolute or relative signal amplitudes. Although burst amplitude can be used as an amplitude reference, common sources of color video signals such as TV tuners or receiver monitors are subject to variations in burst amplitude and shape due to tuner/antenna influence and the effects of multipath.

For this reason most service manuals deal with 75% NTSC color bars, and reference chroma amplitude to the peak-to-peak value of the cyan and red bars. See Fig. 8-5*a*.

Where the relative value of Y and chroma must be set, as in E-to-E adjustments of luminance and chrominance values, the luminance value is set first for the standard output level of 1 V (p-p). Chroma amplitude is then set so that the tops of the yellow and cyan bars are even with the top of the 100% bar. See Fig. 8-5*b*.

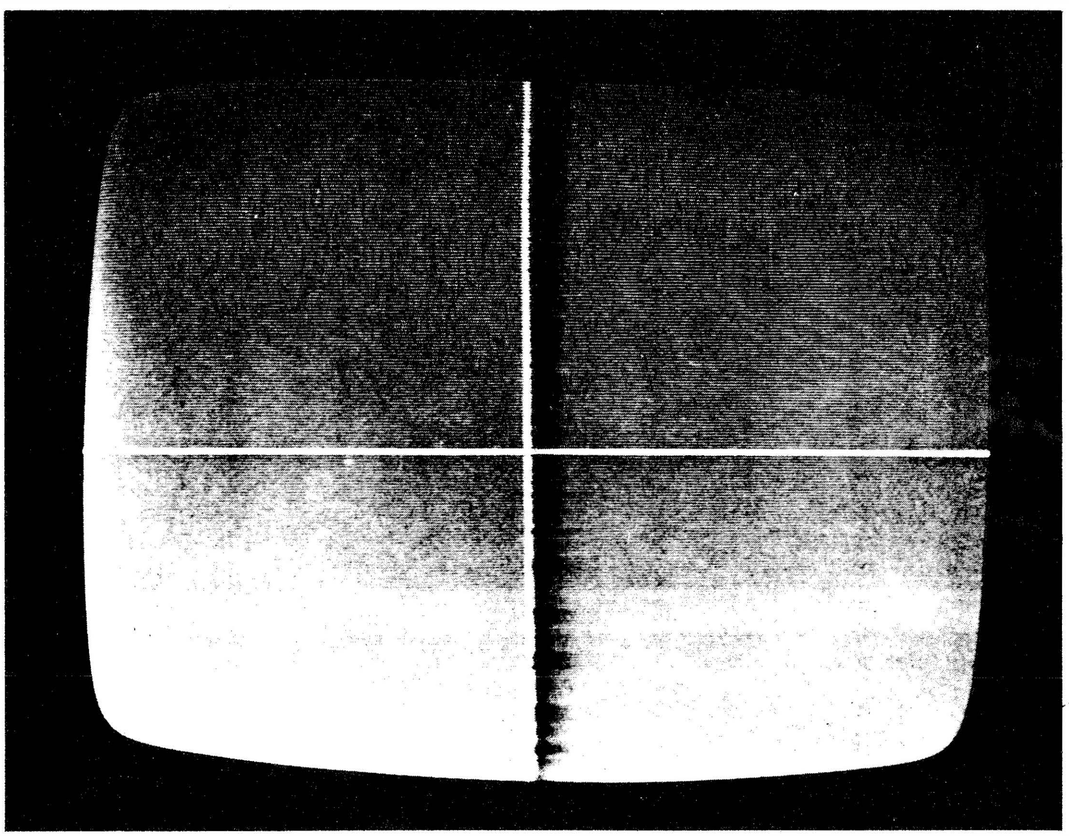


Fig. 8-4. Overdeviation noise

and components must be changed to effect proper correction.

Top and bottom pincushion correction is achieved by a balanced modulation system that adds a horizontal parabolic or sine-wave shaped current to the vertical deflection current. This horizontal component is maximum and opposite in phase at top and bottom but drops to zero at center screen. In most cases a PIN AMP control sets the degree of correction and a PIN PHASE control adjusts the lateral phase of the correction current. To adjust, set PIN AMP to maximum and adjust PIN PHASE to center the bowing or bulge in the horizontal lines of the crosshatch pattern at the top and bottom of the picture. Where a saturable reactor is used to develop the desired waveshape, a mechanical slider containing the PIN BIAS magnet, should be adjusted to equalize correction (bowing) at top and bottom. Reset PIN AMP for straight horizontal lines at top and bottom.

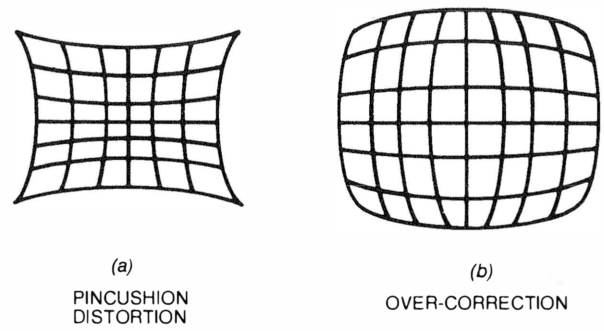


Fig. 7-4. Pincushion distortion and over correction

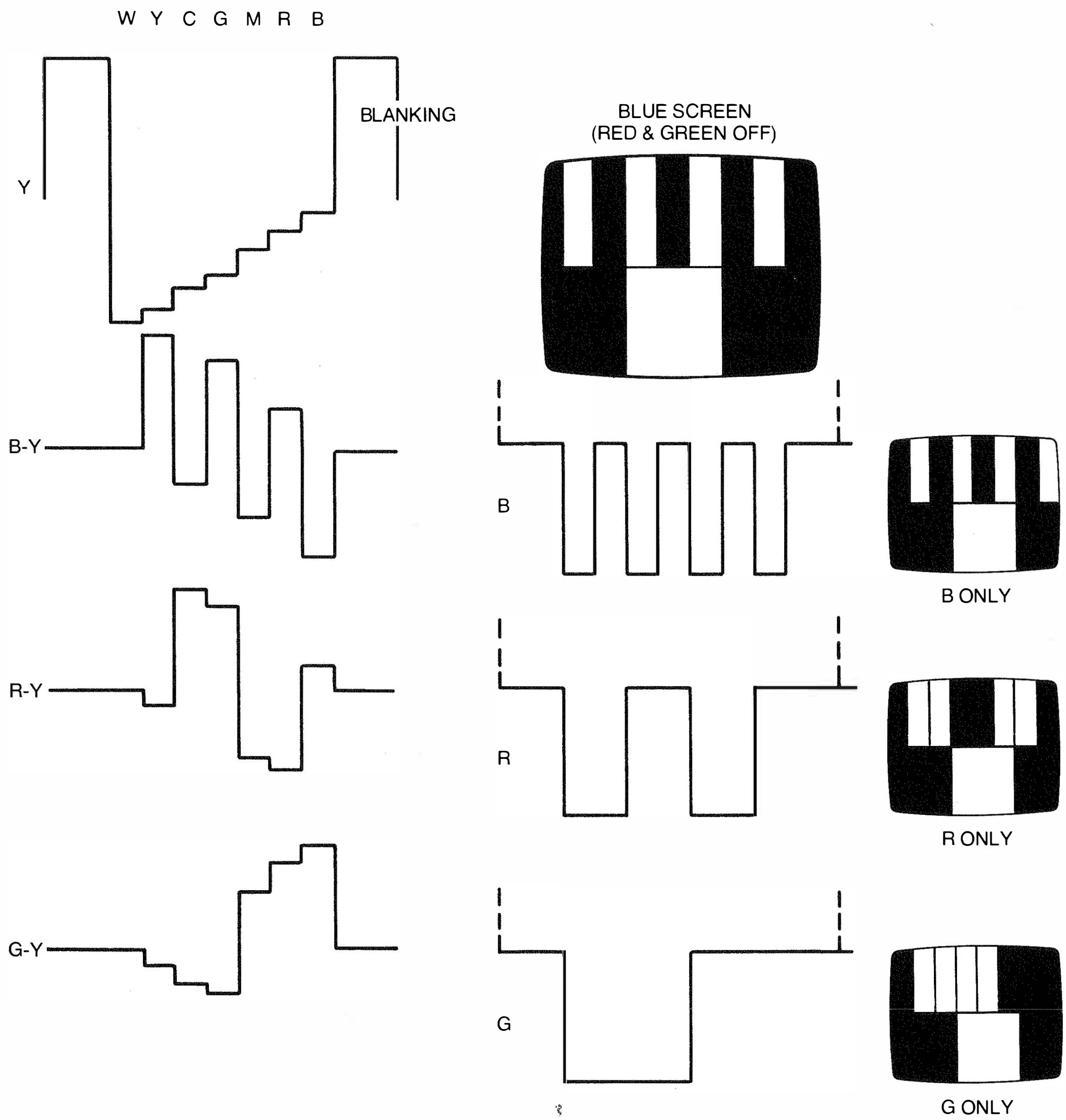


Fig. 7-5. NTSC Waveforms

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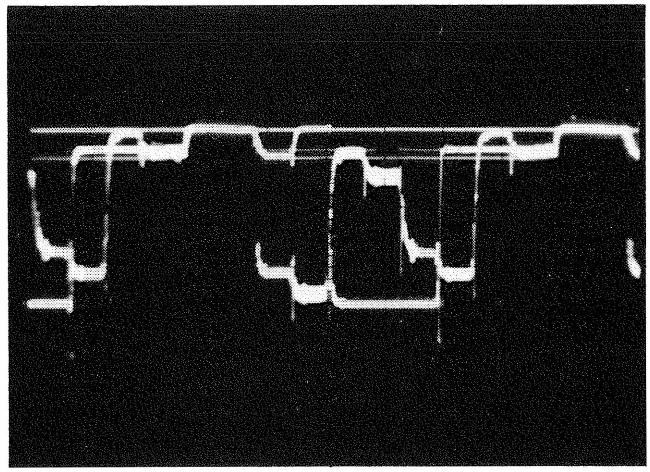
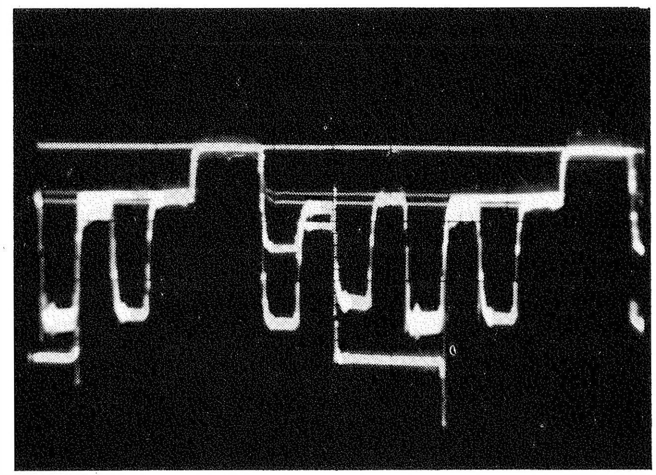
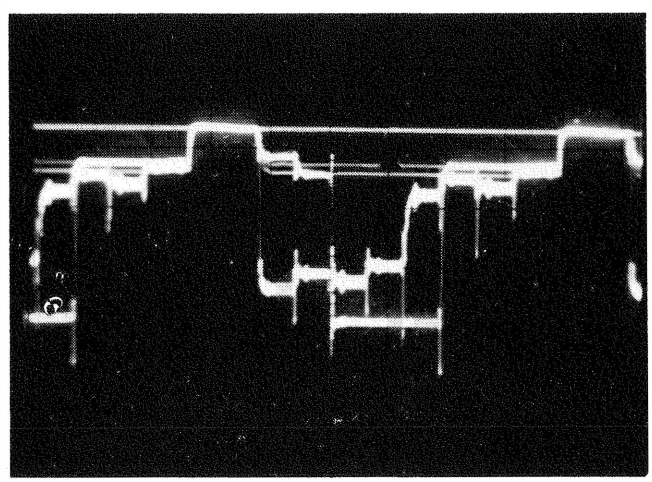
SIGNAL TRACING. Figure 7-7 shows key waveforms at various points in the TV receiver. Note that the amplitude of the chrominance signal at the video detector is about half the correct value. This is to be expected because the color subcarrier signal is at the 50% point on the I-F response curve. This loss of relative gain is made up in the chroma bandpass amplifier.



(a) RED



(b) BLUE



(c) GREEN

Fig. 7-6. Cathode Drive Waveforms in a late-model receiver

9. MAINTENANCE

This section covers adjustments that may be required following replacement of components or the effects of long-term component aging.

9.1 Equipment Required

1. Frequency Counter
   Min. Frequency: 10 MHz
   Input sensitivity: 50 mV rms
   Accuracy: 0.1 ppm
   Resolution: 1 Hz
2. Oscilloscope
   Minimum vertical bandwidth: 10 MHz
   Vertical sensitivity: 10 mV/cm
   or
   Vectorscope: Tektronix 520A or equivalent
3. DC Voltmeter: Minimum input impedance 1 M ohm
4. Heterodyne Frequency Meter or Counter capable of measuring frequency in the 70-90 MHz range.

9.2 Disassembly

The cabinet is in two halves divided lengthwise along the sides. To remove the top half remove the two screws at the top (front and rear) of the cabinet. Loosen the two screws on each side at the front and rear. Lift the top cabinet straight up.

To remove the lower cabinet half, turn the unit over and remove the two screws from the bottom half. Lift off the bottom cabinet.

9.3 Subcarrier Frequency

1. Connect the frequency counter to the SUBCARRIER jack on the rear panel.
2. Turn on all equipment and allow a half-hour warmup.
3. Adjust the trimmer, accessible through the hole on the left side of the cabinet for a frequency reading of ~~3.79545 MHz ± 5 Hz.~~
   3.579545 MHz ± 5 Hz
   2/11/88

9.4 Video Level, Chrominance Level and Setup

Refer to Section 5.

9.5 Sync Amplitude

Follow the procedure in Section 5. Then adjust VR-1 on PC board T1146 for a sync amplitude of 0.29 V ± 0.1 V. See Fig. 9-1. If a vectorscope is used, set sync for the 40 IRE units shown on the luminance graticule.

9.6 Modulator Balance

Monitor output video and adjust VR-3 and VR-4 for minimum subcarrier signal in the black areas of the waveform. If a vectorscope is used, switch to the vector display and adjust to center dot on the display.

9.7 Q, I and Burst Amplitude

Adjust VR-2, at the rear of the balanced modulators, for a burst level of 0.29V (equal to sync amplitude). This also sets I and Q amplitude. Reset CHROMA if needed. If a vectorscope is used, set VR-2 for burst, I and Q amplitude in accordance with the vector scales. Reset CHROMA if needed.

9.8 VHF Modulator

1. Place a d-c voltmeter across TP_1 and TP_2 on the T-1147 PC board.
2. Set VT 101 for a reading of 3.5 V.
3. To check carrier frequency, select color bars with LUMINANCE and CHROMA OFF. Connect a suitable counter or heterodyne frequency meter to the RF output jack. A preamp may be needed to drive the counter.

Channel	Adjust	Frequency
~~5~~ 3	C201	~~77.25~~ 65.25 MHz ± 0.5%
~~6~~ 4	C202	~~83.25~~ 71.25 MHz ± 0.5%

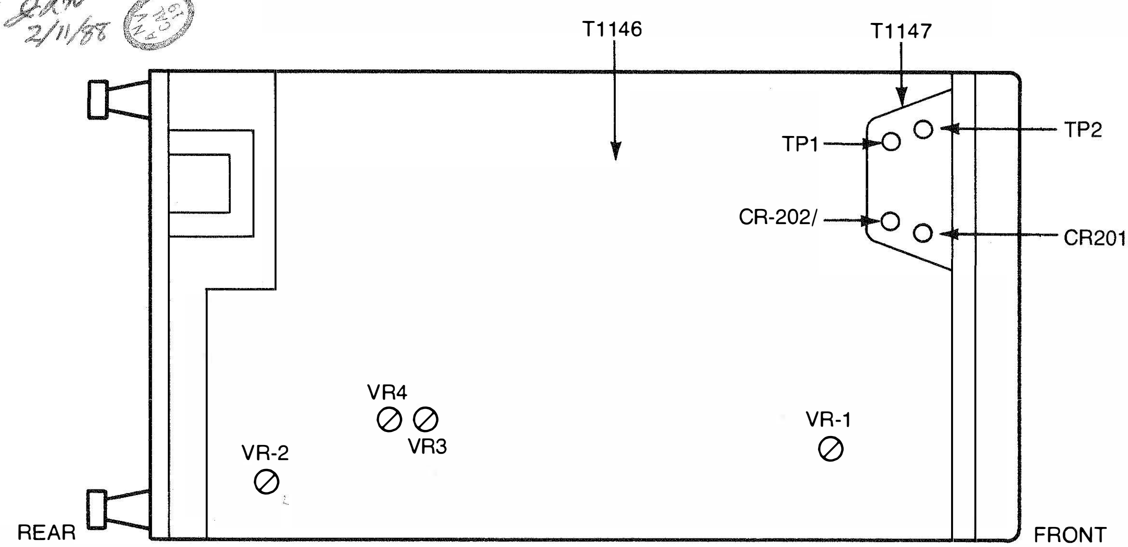


Fig. 9-1. Bottom view

10. CIRCUIT DESCRIPTION

The LCG-396 employs digital techniques to establish subcarrier, line and field rates, as well as pulse duration, signal levels, and quadrature subcarrier drive to the balanced modulators in the encoder. All video processing circuits are mounted on printed-circuit board T-1146. The VHF modulator is mounted on PC board number T-1147. Refer to the block and schematic diagrams at the end of this book.

10.1 Master Clock and Dividers

The crystal oscillator operates at four times the subcarrier frequency, 14.318 MHz. This signal is divided by 4 to form the subcarrier signal. In addition, by proper selection of 1/4 Hz delays, subcarrier signals in phase quadrature are produced for application to the balanced modulators in the encoder.

A signal at 1/2 the subcarrier frequency is applied to the line divider where it is further divided by 455 to form the line frequency of 15.734 kHz. An output from the line divider at twice the line frequency is then divided by 525 to form the field frequency at 59.94 Hz when interlaced scanning is selected. For progressive scanning the division is 524. Signals L1 to L11 and F1 to F10 from the line and field dividers are applied to the sync and pattern generators to synthesize these signals. Refer to the schematic diagrams.

10.2 Sync Generator

D/A converter B synthesizes line sync, field sync, equalizing pulses, serrations and blanking from the divider feeds L1 to L11 and F1 to F10 to form the composite sync signal.

10.3 Pattern Generator

Signals L1 to L11 and F1 to F10 are selected by the pattern selector switches and applied to D/A converter B to synthesize the luminance signal for all patterns. Digitized values are also applied to D/A converter B to develop the chrominance signals. These are applied to the Balanced Modulator to develop the 3.58 MHz chrominance signals.

10.4 Chroma Generator

Two subcarrier signals in phase-quadrature are developed in the divider by shift registers clocked at four times the subcarrier rate (each 1/4 cycle represents 90° phase increments). These are applied to balanced modulators IC 33 and IC 34 which produce the encoded subcarrier signal. The latter is then added to the luminance signal to form the composite video output signal.

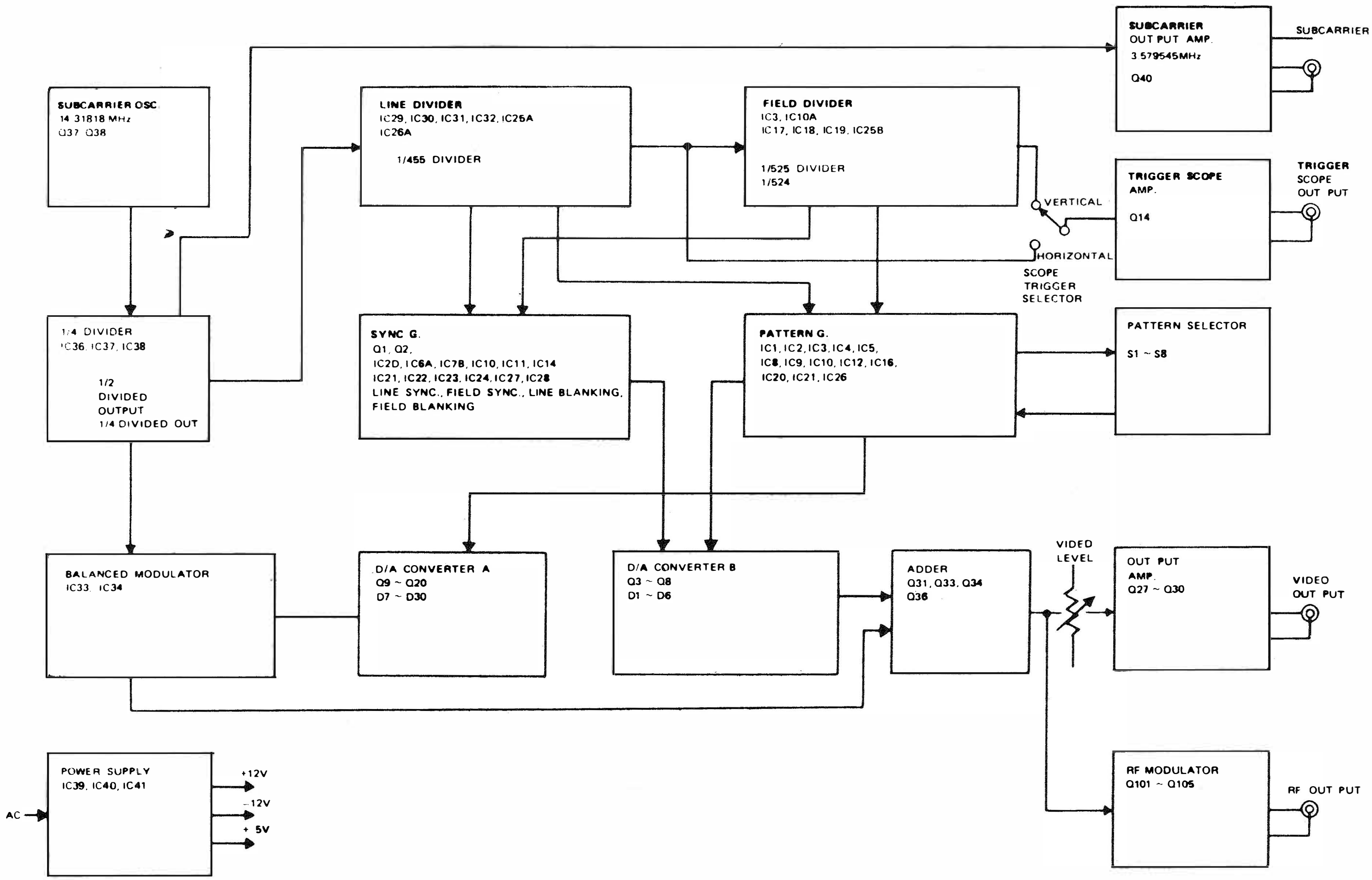
10.5 Output Circuits

Composite video is applied through the video level control to a push-pull output stage using emitter followers in the final stage to drive a 75 ohm load. A feed ahead of the level control feeds the VHF modulator.

Scope trigger is taken from L10 in the line divider and F9 in the field divider, selected by the trigger selector and applied to buffer Q 41 to supply the output jack.

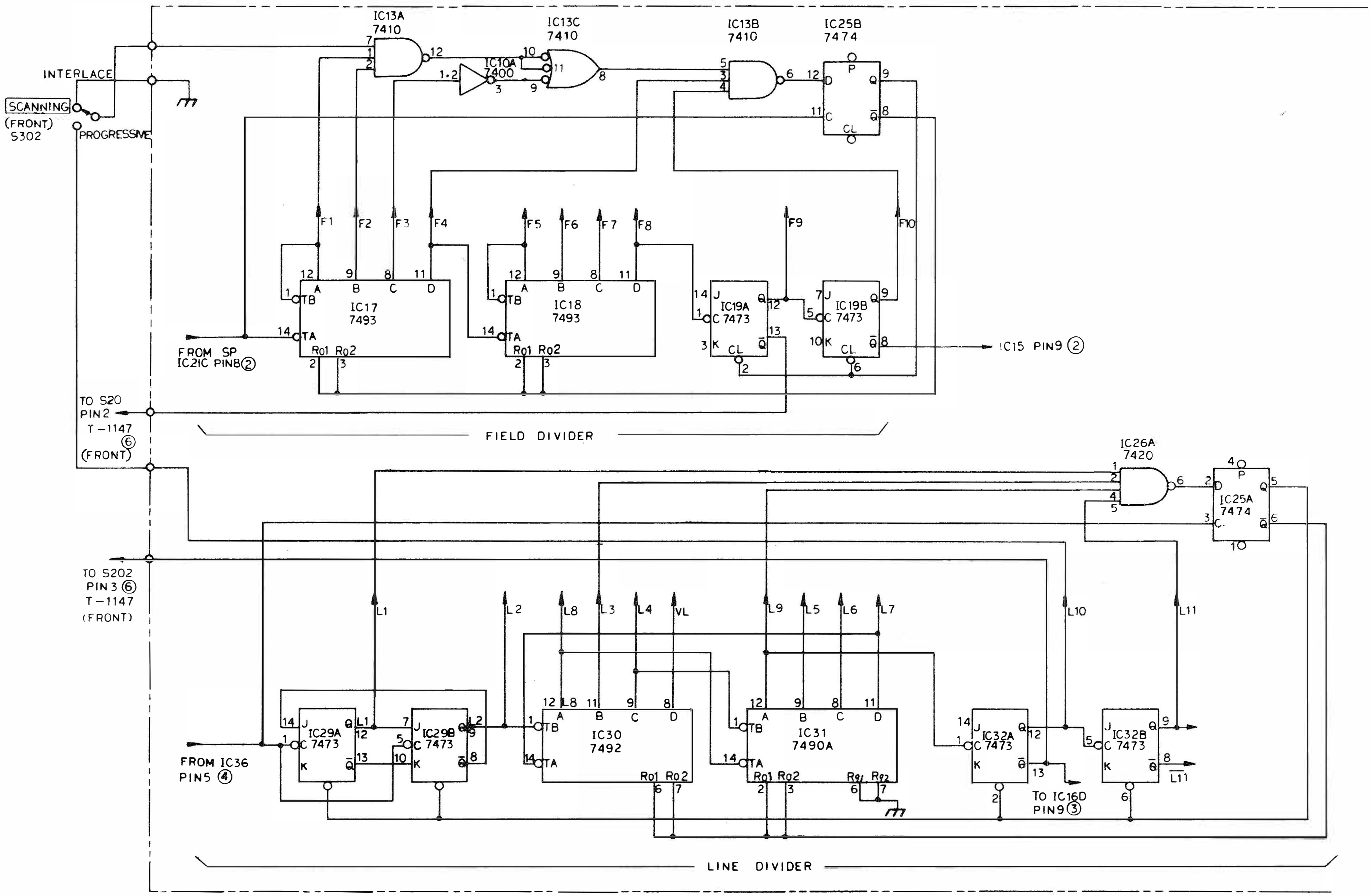
The VHF modulator board contains two crystals for CH5 or CH6 operation. Downward (negative) modulation is employed to produce the modulated visual carrier.

10.6 BLOCK DIAGRAM



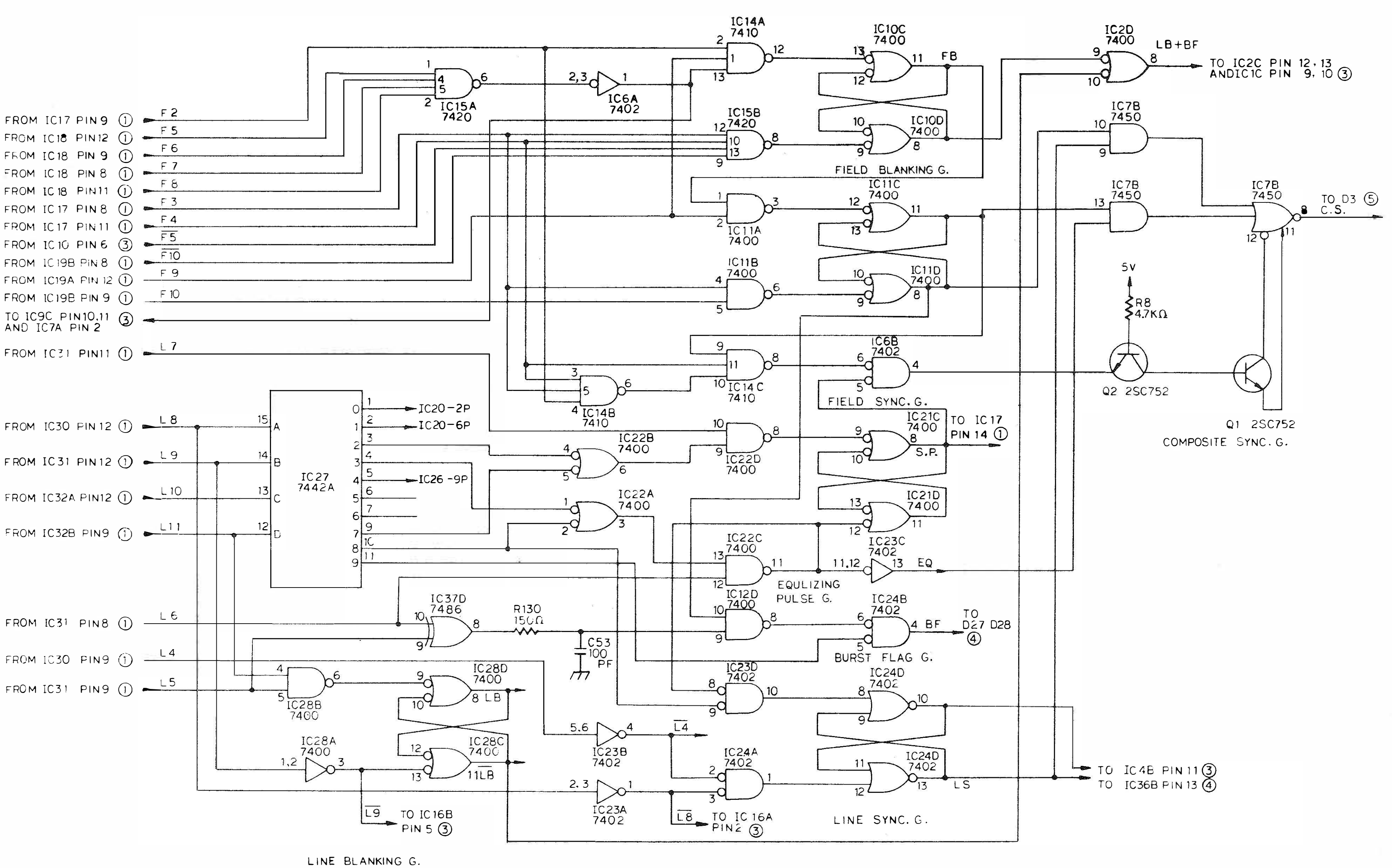
10.7 SCHEMATIC DIAGRAMS

① FIELD DIVIDER, LINE DIVIDER



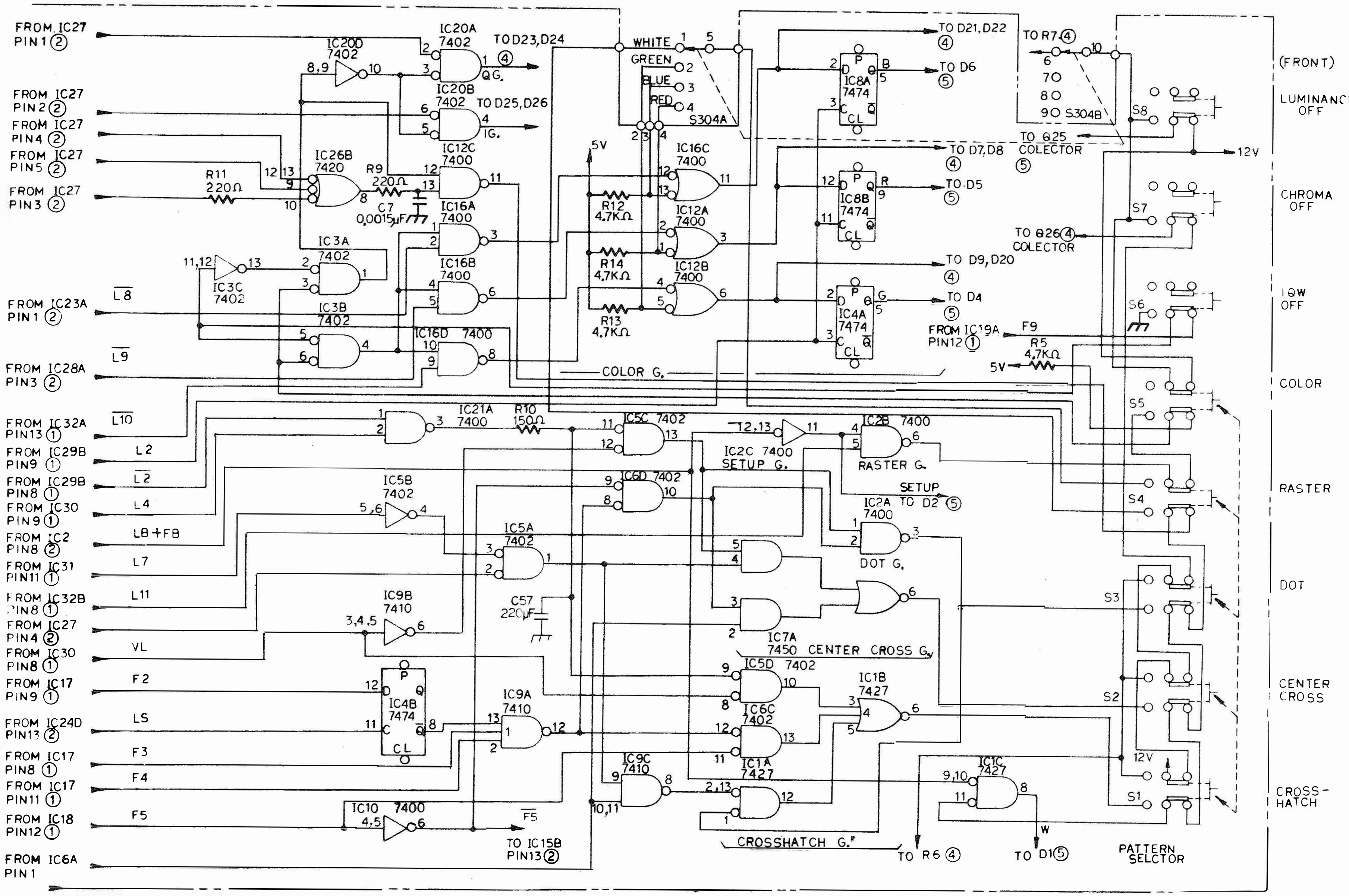
SCHEMATIC	Model LCG−396	0−936	(1/6)

② FIELD BLANKING G. FIELD SYNC.G COMPOSITE SYNC G. EQULIZING PULSE G. BURST FRAG.G. LINE BLANKING G. LINE SYNC G.



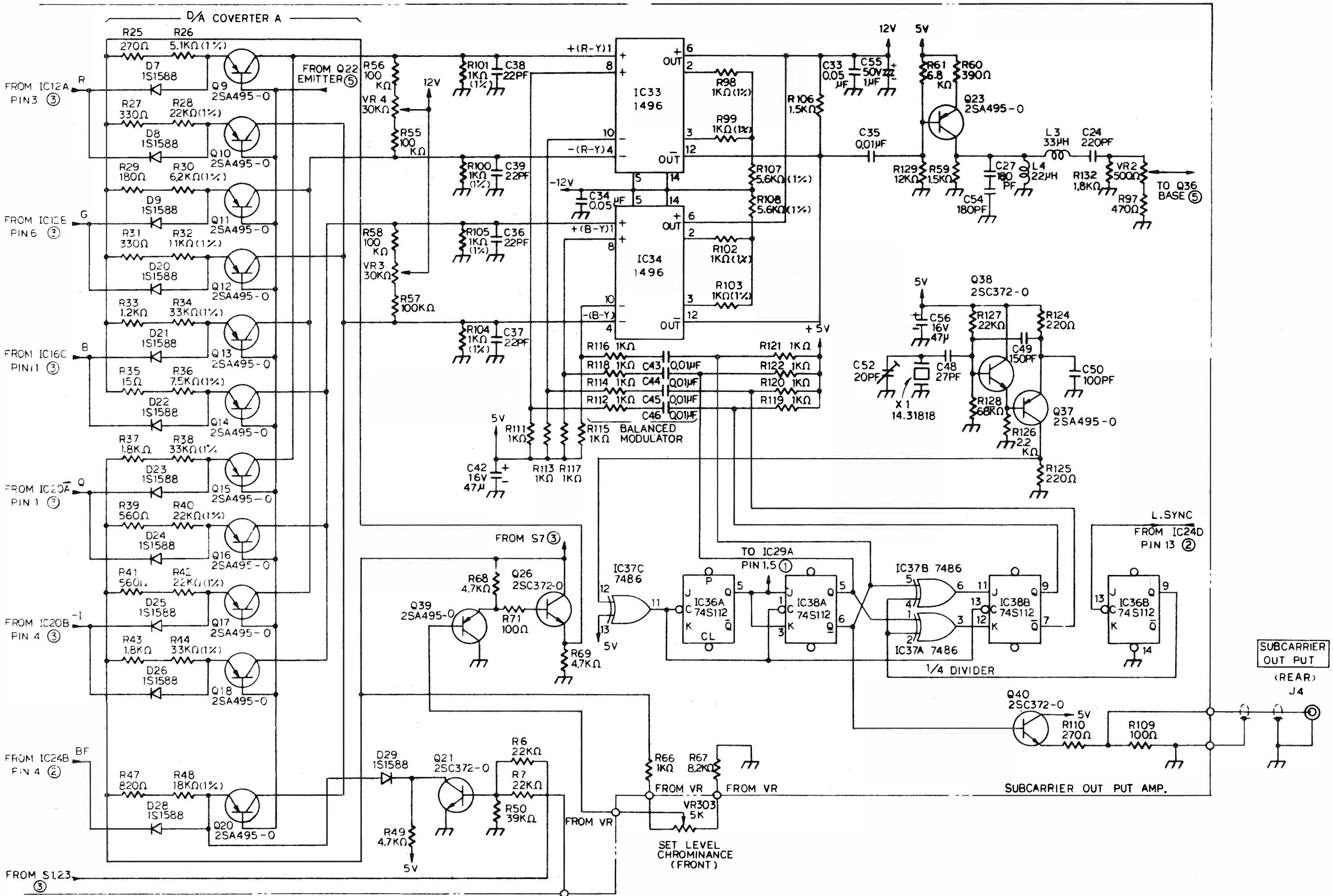
SCHEMATIC	Model LCG-396	0-936 (2/6)

③ COLOR G. RASTER G. DOT G.
CENTER CROSS G. CROSS HATCH G. PATTERN SELECTOR



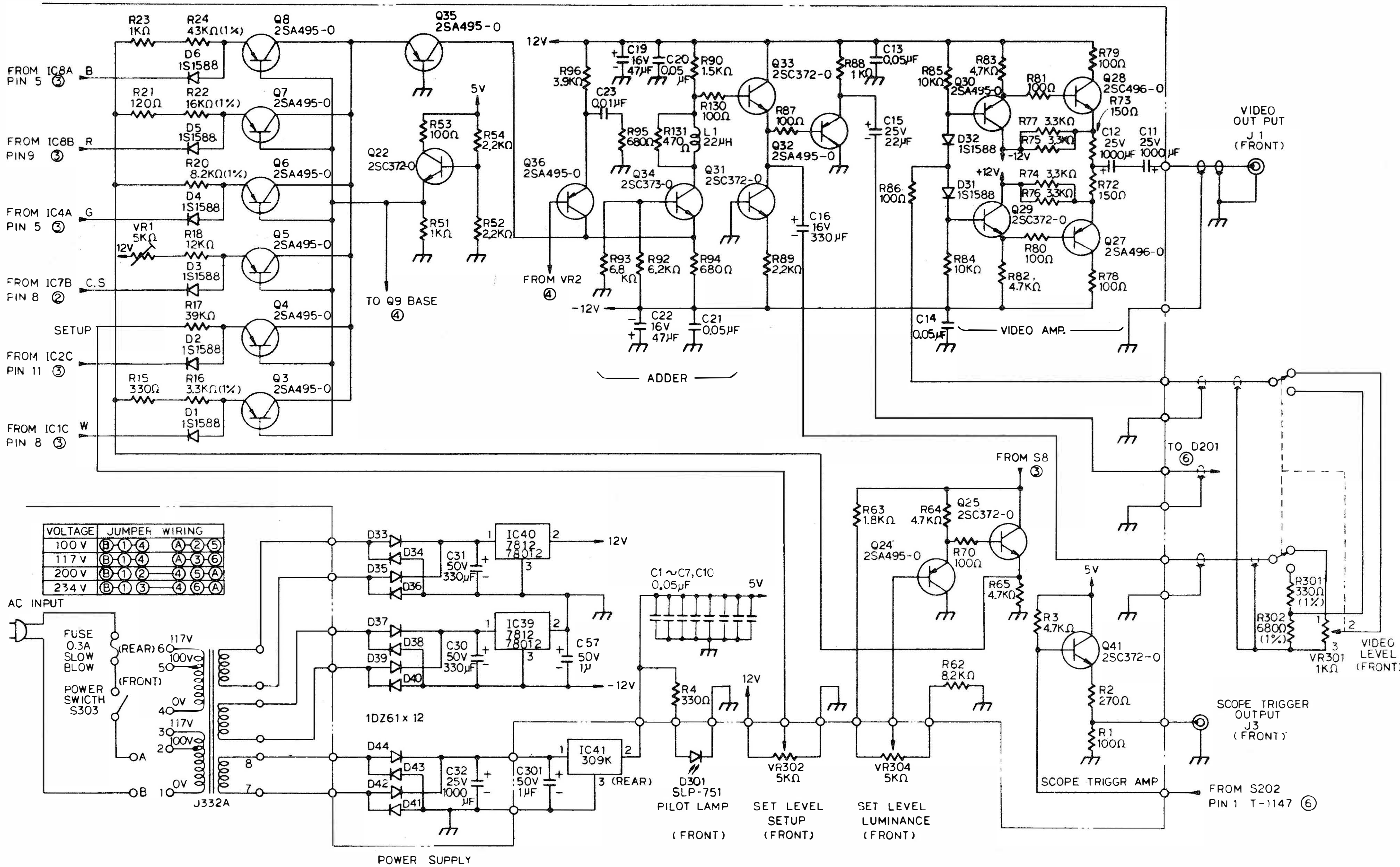
SCHEMATIC	Model LCG − 396	0-936 3/6

④ SUBCARRIER OSC. 1/4 DIVIDER BALANCED MODULATOR D/A CONVERTER A



SCHEMATIC	Model LCG-396	0-936 (4/6)

⑤ POWER SUPPLY D/A CONVERTER B ADDER VIDEO AMP SCOPE TRIGGER AMP.



VOLTAGE	JUMPER WIRING	
100 V	Ⓑ-①-④	Ⓐ-②-⑤
117 V	Ⓑ-①-④	Ⓐ-③-⑥
200 V	Ⓑ-①-②	④-⑤-Ⓐ
234 V	Ⓑ-①-③	④-⑥-Ⓐ

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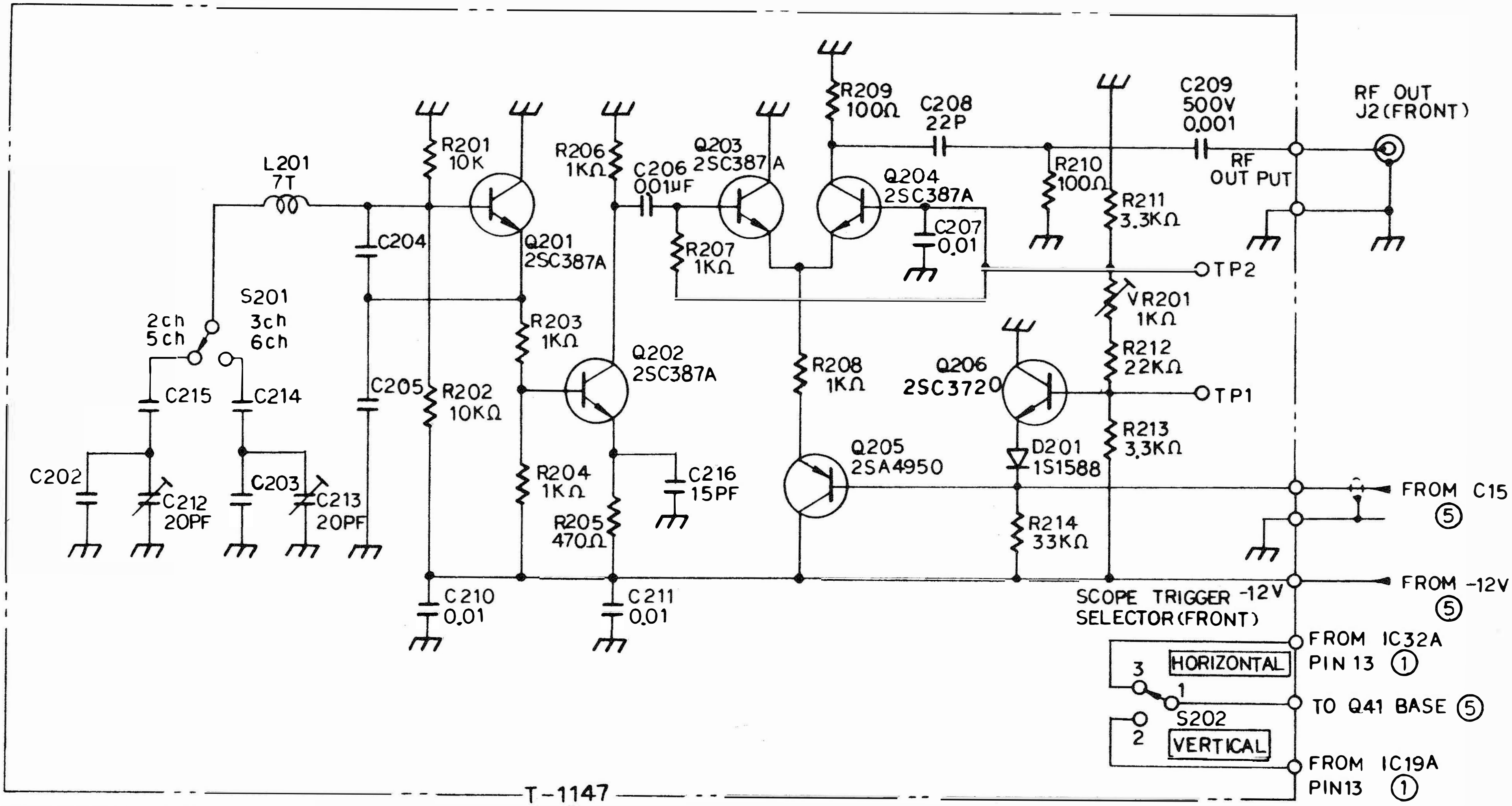
SCHEMATIC	Model LCG-396	0-936 (5/6)

⑥ LCG-396 VIDEO RF MODULATOR



ch	JAPAN		ch	USA	
	C204	22PF		C204	47PF
	C205	10PF		C205	22PF
2	C215	7PF	5	C215	27PF
	C202	3PF		C202	5PF
3	C214	5PF	6	C214	15PF
	C203			C203	5PF
	C216	15PF		C216	

SCHEMATIC	Model LCG-396	0-936 6/6
	VIDEO RF MOD	

11. REPLACEMENT PARTS LIST

Reference Designation	Description	Ordering Number
CAPACITORS		
C1	Ceramic Capacitor, 50V, 50,000 pF	RD209YM503
C2	Ceramic Capacitor, 50V, 50,000 pF	RD209YM503
C3	Ceramic Capacitor, 50V, 50,000 pF	RD209YM503
C4	Ceramic Capacitor, 50V, 50,000 pF	RD209YM503
C5	Ceramic Capacitor, 50V, 50,000 pF	RD209YM503
C6	Ceramic Capacitor, 50V, 50,000 pF	RD209YM503
C7	Plastic Film Capacitor, 50V, 1,500 pF	CQ92MB1H152K
C10	Ceramic Capacitor, 50V, 50,000 pF	RD209YM503
C11	Electrolytic, 25V, 1,000 μF	CE04W1E102
C12	Electrolytic, 25V, 1,000 μF	CE04W1E102
C13	Capacitor, 50V, 50,000 pF	RD209YM503
C14	Capacitor, 50V, 50,000 pF	RD209YM503
C15	Electrolytic, 25V, 22 μF	CE04W1E220
C16	Electrolytic, 16V, 330 μF	CE04W1C331
C19	Electrolytic, 16V, 47 μF	CE04W1C470
C20	Ceramic Capacitor, 50V, 50,000 pF	RD209YM503
C21	Ceramic Capacitor, 50V, 50,000 pF	RD209YM503
C22	Electrolytic, 16V, 47 μF	CE04W1C470
C24	Mica Capacitor, 50V, 220 pF	VFM092C221K05
C27	Capacitor (Temp, Compensation), 50V, 180 pF	DD380UJ180PF±10%5
C30	Electrolytic, 50V, 330 μF	CE04W1H331
C31	Electrolytic, 50V, 330 μF	CE04W1H331
C32	Electrolytic, 25V, 1,000 μF	CE04W1E102
C33	Capacitor, 50V, 50,000 pF	RD209YM503
C34	Capacitor, 50V, 50,000 pF	RD209YM503
C35	Capacitor, 50V, 50,000 pF	RD204YM103
C36	Mica Capacitor, 50V, 22 pF	FM05ZC220K5
C37	Mica Capacitor, 50V, 22 pF	FM05ZC220K5
C38	Mica Capacitor, 50V, 22 pF	FM05ZC220K5
C39	Mica Capacitor, 50V, 22 pF	FM05ZC220K5
C42	Electrolytic, 16V, 47 μF	CE04W1C470
C43	Ceramic Capacitor, 50V, 10,000 pF	RD204YM103
C44	Ceramic Capacitor, 50V, 10,000 pF	RD204YM103
C45	Ceramic Capacitor, 50V, 10,000 pF	RD204YM103
C46	Ceramic Capacitor, 50V, 10,000 pF	RD204YM103
C48	Mica Capacitor, 50V, 27 pF	FM07ZC270K5
C49	Mica Capacitor, 50V, 150 pF	VFM09ZC151K05
C50	Mica Capacitor, 50V, 100 pF	VFM07ZC101K05
C51	Electrolytic, 16V, 47 μF	CE04W1C470
C52	Variable Capacitor, 0 ~ 20 pF	TMC-710SWD20PF0.25
C53	Mica Capacitor, 50V, 100 pF	VFM07ZC101K05
C54	Capacitor (Temp, Compensation), 50V, 180 pF	DD380UJ180PF±10%
C55	Electrolytic, 50V, 1 μF	CE04W1H010
C56	Electrolytic, 16V, 47 μF	CE04W1C470
C57	Electrolytic, 50V, 1 μF	CE04W1H010
C202	Mica Capacitor, 50V, 5 pF	FM05ZC050K5
C203	Mica Capacitor, 50V, 5 pF	FM05ZC050K5
C204	Mica Capacitor, 50V, 47 pF	FM05ZC470K5
C205	Capacitor (Temp, Compensation), 50V, 22 pF	DD350UJ220J50V01
C206	Ceramic Capacitor, 50V, 10,000 pF	RD204YM103
C207	Ceramic Capacitor, 50V, 10,000 pF	RD204YM103
C208	Mica Capacitor, 50V, 22 pF	FM05ZC220K5

Reference Designation	Description	Ordering Number
C209	Ceramic Capacitor, 50V, 1,000 pF	CK62YZ102PZ500
C210	Ceramic Capacitor, 50V, 10,000 pF	RD204YM103
C211	Ceramic Capacitor, 50V, 10,000 pF	RD204YM103
C212	Variable Capacitor, 0-20 pF	ECV-12W20X32
C213	Variable Capacitor, 0-20 pF	ECV-12W20X32
C214	Mica Capacitor, 50V, 22 pF	FM05ZC150K5
C215	Mica Capacitor, 50V, 22 pF	FM05ZC270K5
C301	Electrolytic, 50V, 1μF	CE04W1H010
D1-D32	Diodes	1S1588
D33-D44	Diodes	1DZ61
D301	LED	SLP-751
D201	Diode	1S1588
IC1	Digital IC	SN7427N/M53227P
IC2	Digital IC	SN7400N/M53200P
IC3	Digital IC	SN7402N/M583202P
IC4	Digital IC	SN7474N/M53274P
IC5	Digital IC	SN7402N/M53202P
IC6	Digital IC	SN7402N/M53202P
IC7	Digital IC	SN7450N/M53250P
IC8	Digital IC	SN7474N/M53274P
IC9	Digital IC	SN7410N/M53210P
IC10	Digital IC	SN7400N/M53200P
IC11	Digital IC	SN7400N/M53200P
IC12	Digital IC	SN7400N/M53200P
IC13	Digital IC	SN7410N/M53210P
IC14	Digital IC	SN7410N/M53210P
IC15	Digital IC	SN7420N/M53220P
IC16	Digital IC	SN7400N/M53200P
IC17	Digital IC	SN7493AN/M53293P
IC18	Digital IC	SN7493AN/M53293P
IC19	Digital IC	SN7473N/M53273P
IC20	Digital IC	SN7402N/M53202P
IC21	Digital IC	SN7400N/M53200P
IC22	Digital IC	SN7400N/M53200P
IC23	Digital IC	SN7402N/M53202P
IC24	Digital IC	SN7402N/M53202P
IC25	Digital IC	SN7474N/M53274P
IC26	Digital IC	SN7420N/M53220P
IC27	Digital IC	SN7442AN/M53242P
IC28	Digital IC	SN7400N/M53200P
IC29	Digital IC	SN7450N/M53250P
IC30	Digital IC	SN7492AN/M53292P
IC31	Digital IC	SN7490AN/M53290P
IC32	Digital IC	SN7473N/M53273P
IC33	Linear IC	LM1496N/MC1496L
IC34	Linear IC	LM1496N/MC1496L
IC36	Digital IC	74S112N/M5S112P
IC37	Digital IC	SN7486N/M53286P
IC38	Digital IC	74S112N/M5S112P
IC39	IC, Power Supply	MC7812/TA78012P
IC40	IC, Power Supply	MC7812/TA78012P
IC41	IC, Power Supply	LM309K

Reference Designation	Description	Ordering Number
L1	Inductor, 22 μH	EL0710-220M
L3	Inductor, 33 μH	EL0710-330M
L4	Inductor, 22 μH	EL0710-220M
L201	Code No. L-482	
TRANSISTORS		
Q1	Transistor	2SC752
Q2	Transistor	2SC752
Q3-Q18	Transistor	2SA4950
Q20	Transistor	2SA4950
Q21	Transistor	2SC3720
Q22	Transistor	2SC3720
Q23	Transistor	2SA4950
Q24	Transistor	2SA4950
Q25	Transistor	2SC3720
Q26	Transistor	2SC3720
Q27	Transistor	2SA4960
Q28	Transistor	2SC4960
Q29	Transistor	2SC3720
Q30	Transistor	2SA4950
Q31	Transistor	2SC3720
Q32	Transistor	2SA4950
Q33	Transistor	2SC3720
Q34	Transistor	2SC373
Q35,36,37	Transistor	2SA4950
Q38	Transistor	2SC3720
Q39	Transistor	2SA4950
Q40,41	Transistor	2SC3720
Q201	Transistor	2SC387A
Q202,203,204	Transistor	2SC387A
Q205	Transistor	2SA495-0
Q206	Transistor	2SC372-0
R1	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J
R2	Resistor, 270 ohm, ¼ W, 5%	RD¼PNY270J
R3	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R4	Resistor, 330 ohm, ¼ W, 5%	RD¼PNY330J
R5	Resistor, 270 ohm, ¼ W, 5%	RD¼PNY4.7KJ
R6	Resistor, 22 Kohm, ¼ W, 5%	RD¼PNY22KJ
R7	Resistor, 22 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R8	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R9	Resistor, 220 ohm, ¼ W, 5%	RD¼PNY220J
R10	Resistor, 150 ohm, ¼ W, 5%	RD¼PNY150J
R11	Resistor, 220 ohm, ¼ W, 5%	RD¼PNY220J
R12	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R13	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R14	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R15	Resistor, 330 ohm, ¼ W, 5%	RD¼PNY330J
R16	Resistor, 3.3 Kohm, ¼ W, 1%	SN14K2E3.3KF
R17	Resistor, 39 Kohm, ¼ W, 5%	RD¼PNY39KJ
R18	Resistor, 12 Kohm, ¼ W, 5%	RD¼PNY12KJ
R20	Resistor, 8.2 Kohm, ¼ W, 1%	SN14K2E8.2KF
R21	Resistor, 120 ohm, ¼ W, 5%	RD¼PNY120J
R22	Resistor, 16 Kohm, ¼ W, 1%	SN14K2E16KF

Reference Designation	Description	Ordering Number
R23	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R24	Resistor, 43 Kohm, ¼ W, 1%	SN14K2E43KF
R25	Resistor, 270 ohm, ¼ W, 5%	RD¼PNY270J
R26	Resistor, 5.1 Kohm, ¼ W, 1%	SN14K2E5.1KF
R27	Resistor, 330 ohm, ¼ W, 5%	RD¼PNY330J
R28	Resistor, 22 Kohm, ¼ W, 1%	SN14K2E22KF
R29	Resistor, 180 ohm, ¼ W, 5%	RD¼PNY180J
R30	Resistor, 6.2 Kohm, ¼ W, 1%	SN14K2E6.2KF
R31	Resistor, 330 ohm, ¼ W, 5%	RD¼PNY330J
R32	Resistor, 11 Kohm, ¼ W, 1%	SN14K2E11KF
R33	Resistor, 1.2 Kohm, ¼ W, 5%	RD¼PNY1.2KJ
R34	Resistor, 33 Kohm, ¼ W, 1%	SN14K2E33KF
R35	Resistor, 15 ohm, ¼ W, 5%	RD¼PNY15J
R36	Resistor, 7.5 Kohm, ¼ W, 1%	SN14K2E7.5KF
R37	Resistor, 1.8 Kohm, ¼ W, 5%	RD¼PNY1.8KJ
R38	Resistor, 33 Kohm, ¼ W, 1%	SN14K2E33KF
R39	Resistor, 560 ohm, ¼ W, 5%	RD¼PNY560J
R40	Resistor, 22 Kohm, ¼ W, 1%	SN14K2E22KF
R41	Resistor, 560 ohm, ¼ W, 5%	RD¼PNY560J
R42	Resistor, 22 Kohm, ¼ W, 1%	SN14K2E22KF
R43	Resistor, 1.8 Kohm, ¼ W, 5%	RD¼PNY1.8KJ
R44	Resistor, 33 Kohm, ¼ W, 1%	SN14K2E33KF
R47	Resistor, 820 ohm, ¼ W, 5%	RD¼PNY820J
R48	Resistor, 18 Kohm, ¼ W, 1%	SN14K2E18KF
R49	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R50	Resistor, 39 Kohm, ¼ W, 5%	RD¼PNY39KJ
R51	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R52	Resistor, 2.2 Kohm, ¼ W, 5%	RD¼PNY2.2KJ
R53	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J
R54	Resistor, 2.2 Kohm, ¼ W, 5%	RD¼PNY2.2KJ
R55	Resistor, 100 Kohm, ¼ W, 5%	RD¼PNY100KJ
R56	Resistor, 100 Kohm, ¼ W, 5%	RD¼PNY100KJ
R57	Resistor, 100 Kohm, ¼ W, 5%	RD¼PNY100KJ
R58	Resistor, 100 Kohm, ¼ W, 5%	RD¼PNY100KJ
R59	Resistor, 1.5KJ, ¼ W, 5%	RD¼PNY1.5KJ
R60	Resistor, 390 ohm, ¼ W, 5%	RD¼PNY390J
R61	Resistor, 6.8 Kohm, ¼ W, 5%	RD¼PNY6.8KJ
R62	Resistor, 8.2 Kohm, ¼ W, 5%	RD¼PNY8.2KJ
R63	Resistor, 1.8 Kohm, ¼ W, 5%	RD¼PNY1.8KJ
R64	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R65	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R66	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R67	Resistor, 8.2 Kohm, ¼ W, 5%	RD¼PNY8.2KJ
R68	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R69	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R70	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J
R71	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J
R72	Resistor, 150 ohm, ¼ W, 5%	RD¼PNY150J
R73	Resistor, 150 ohm, ¼ W, 5%	RD¼PNY150J
R74	Resistor, 33 Kohm, ¼ W, 5%	RD¼PNY33KJ
R75	Resistor, 33 Kohm, ¼ W, 5%	RD¼PNY33KJ
R76	Resistor, 33 Kohm, ¼ W, 5%	RD¼PNY33KJ
R77	Resistor, 33 Kohm, ¼ W, 5%	RD¼PNY33KJ
R78	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J

Reference Designation	Description	Ordering Number
R79	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J
R80	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J
R81	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J
R82	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R83	Resistor, 4.7 Kohm, ¼ W, 5%	RD¼PNY4.7KJ
R84	Resistor, 10 Kohm, ¼ W, 5%	RD¼PNY10KJ
R85	Resistor, 10 Kohm, ¼ W, 5%	RD¼PNY10KJ
R86	Resistor, 15 ohm, ¼ W, 5%	RD¼PNY15J
R87	Resistor, 15 ohm, ¼ W, 5%	RD¼PNY15J
R88	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R89	Resistor, 2.2 Kohm, ¼ W, 5%	RD¼PNY2.2KJ
R90	Resistor, 1.5 Kohm, ¼ W, 5%	RD¼PNY1.5KJ
R92	Resistor, 6.2 Kohm, ¼ W, 1%	SN14K2E6.2KF
R93	Resistor, 6.8 Kohm, ¼ W, 5%	RD¼PNY6.8KJ
R94	Resistor, 680 ohm, ¼ W, 5%	RD¼PNY680J
R95	Resistor, 680 ohm, ¼ W, 5%	RD¼PNY680J
R96	Resistor, 3.9 Kohm, ¼ W, 5%	RD¼PNY3.9KJ
R97	Resistor, 470 ohm, ¼ W, 5%	RD¼PNY470J
R98	Resistor, 1 Kohm, ¼ W, 1%	SN14K2E1KF
R99	Resistor, 1 Kohm, ¼ W, 1%	SN14K2E1KF
R100	Resistor, 1 Kohm, ¼ W, 1%	SN14K2E1KF
R101	Resistor, 1 Kohm, ¼ W, 1%	SN14K2E1KF
R102	Resistor, 1 Kohm, ¼ W, 1%	SN14K2E1KF
R103	Resistor, 1 Kohm, ¼ W, 1%	SN14K2E1KF
R104	Resistor, 1 Kohm, ¼ W, 1%	SN14K2E1KF
R105	Resistor, 1 Kohm, ¼ W, 1%	SN14K2E1KF
R106	Resistor, 1.5 Kohm, ¼ W, 5%	RD¼PNY1.5KJ
R107	Resistor, 5.6 Kohm, ¼ W, 1%	SN14K2E5.6KF
R108	Resistor, 5.6 Kohm, ¼ W, 1%	SN14K2E5.6KF
R109	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J
R110	Resistor, 270 ohm, ¼ W, 5%	RD¼PNY270J
R111	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R112	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R113	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R114	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R115	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R116	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R117	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R118	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R119	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R120	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R121	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R122	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R124	Resistor, 220 ohm, ¼ W, 5%	RD¼PNY220J
R125	Resistor, 220 ohm, ¼ W, 5%	RD¼PNY220J
R126	Resistor, 2.2 Kohm, ¼ W, 5%	RD¼PNY2.2KJ
R127	Resistor, 22 Kohm, ¼ W, 5%	RD¼PNY22KJ
R128	Resistor, 68 Kohm, ¼ W, 5%	RD¼PNY68KJ
R129	Resistor, 12 Kohm, ¼ W, 5%	RD¼PNY12KJ
R130	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J
R131	Resistor, 470 ohm, ¼ W, 5%	RD¼PNY470J
R132	Resistor, 1.8 Kohm, ¼ W, 5%	RD¼PNY1.8KJ
R201	Resistor, 10 Kohm, ¼ W, 5%	RD¼PNY10KJ
R202	Resistor, 10 Kohm, ¼ W, 5%	RD¼PNY10KJ

Reference Designation	Description	Ordering Number
R203	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R204	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R205	Resistor, 470 ohm, ¼ W, 5%	RD¼PNY470J
R206	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R207	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R208	Resistor, 1 Kohm, ¼ W, 5%	RD¼PNY1KJ
R209	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J
R210	Resistor, 100 ohm, ¼ W, 5%	RD¼PNY100J
R211	Resistor, 3.3 Kohm, ¼ W, 5%	RD¼PNY3.3KJ
R212	Resistor, 2.2 Kohm, ¼ W, 5%	RD¼PNY2.2KJ
R213	Resistor, 3.3 Kohm, ¼ W, 5%	RD¼PNY3.3KJ
R214	Resistor, 33 Kohm, ¼ W, 5%	RD¼PNY33KJ
R301	Resistor, 330 ohm, ¼ W, 1%	SN14K2E330F
R302	Resistor, 680 ohm, ¼ W, 1%	SN14K2E680F
S1-S8	Push Switch	S-8-6
S201,202	Switch	SLE12251
S302	Switch	SLE12251
S303	Switch	ST1106D/8A1011
S304	Switch	SRM34SR-15
VARIABLE RESISTORS		
VR1	Variable Resistor, 5 Kohm	TM10PVB5KB
VR2	Variable Resistor, 500 ohm	TM10PVB500B
VR3	Variable Resistor, 100 Kohm	TM10PVB100KB
VR4	Variable Resistor, 100 Kohm	TM10PVB100KB
VR201	Variable Resistor, 1 Kohm	TM10PVB1KB
VR301	Variable Resistor, 1 Kohm	VM11A-5M1222-15S1KB
VR302	Variable Resistor, 5 Kohm	V16L4N15SB5K
VR303	Variable Resistor, 5 Kohm	V16L4N15SB5K
VR304	Variable Resistor, 5 Kohm	V16L4N15SB5K