



# COLOR BAR GENERATOR

**Build this inexpensive color-bar test generator and brush up on your video skills.**

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IF YOU'RE INVOLVED IN TV SERVICING and repair, or just enjoy tinkering around with video or amateur television, you'll be interested in this color-bar test generator. This convenient device produces an NTSC color-bar pattern that can be used for video performance testing and monitor adjustments. For added flexibility, just the encoder section can be used to generate composite video from your computer's RGB and sync outputs. With a dedicated color-bar generator, you can eliminate the need for a test tape or your camera—all for under \$70!

Before we delve into the theory behind the color-bar generator,

let's briefly discuss the various components that make up the composite NTSC video signal: synchronization, luminance, and chrominance information.

### The NTSC signal

A typical NTSC composite color video signal is shown in Fig. 1-a. (NTSC is the National Television Systems Committee, who has set the standards for color encoding and decoding systems in the U.S. since 1953.) The picture on a color TV is formed by three electron beams of varying amplitudes and phases: red, blue, and green. Each of those beams are scanned horizontally and ver-

tically over the screen. As the beams scan, their currents and amplitudes change to create the light and dark areas on the picture-tube face and form the image that you see displayed on the screen.

The composite video signal is made up of three basic components: the scan control information called the synchronizing pulses (Fig. 1-b), the luminance signal, which is the brightness information and is often referred to as the Y signal (Fig. 1-c), and the color information called the chrominance signal (Fig. 1-d). Let's briefly discuss each type of video information.



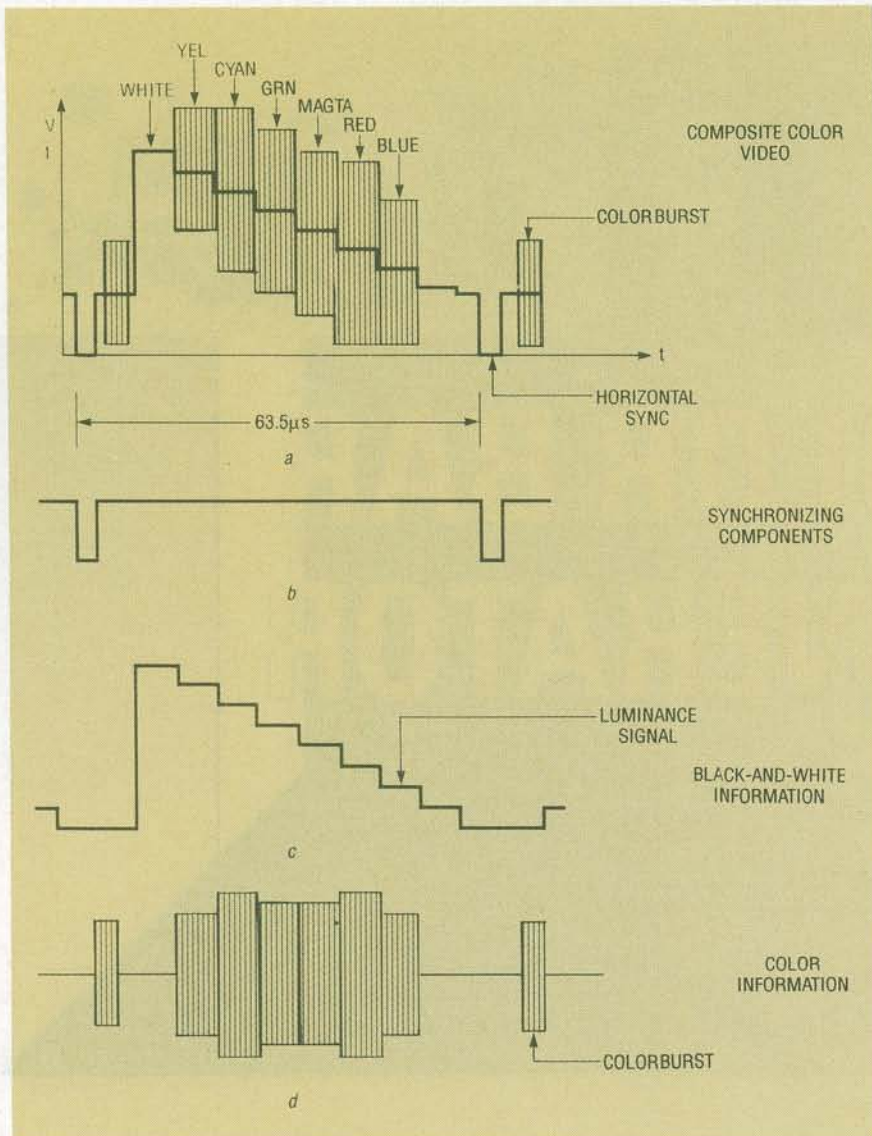


FIG. 1—A COMPOSITE VIDEO SIGNAL (a) includes sync pulses (b), black-and-white information (c), and the colorburst signal (d).

### Synchronizing components

In order for a picture to be reproduced properly, the TV receiver must scan its screen exactly in step with the camera in the studio. To make sure the camera and the receiver are synchronized, a series of pulses are

sent to the camera telling it when to start at the top of the screen and when to begin a new line at the left of the screen. Those same pulses are sent to the receiver along with the video information. The signals that tell the camera and receiver when to

start at the top are called vertical sync pulses, while those that start scanning each line at the left are known as horizontal sync pulses.

In the NTSC system, each frame, of complete video image, contains 525 lines. That is accomplished by horizontally scanning at approximately 15,750 lines per second, and vertically scanning at 30 frames per second. (The vertical scan rate is actually 60 Hz, but it takes two trips, or fields, down the screen to complete one frame.) The process of returning to start a new scan is called retrace or flyback.

### Luminance

Black and white information is contained in the Y or luminance signal, which determines the instantaneous brightness of the electron beams as they scan over the screen. In fact, it is all that is used for the single electron beam in a black-and-white TV set. A negative-going video detector detects a luminance signal in which the negative signal extremes correspond to bright areas of the picture. The waveform shown in Fig. 1-c would, therefore, produce vertical bars of decreasing brightness from left to right. Note that the output is black during retrace so the electron beams will not be seen.

In the NTSC color system, the Y signal is made from the red, green, and blue cameras by an additive technique: 30% of the red signal, 59% of the green signal, and 11% of the blue signal are added together to form the Y signal. The luminance signal can also be expressed as

$$E_Y = .30E_R + .59E_G + .11E_B$$

where  $E_R$ ,  $E_G$ , and  $E_B$  are the voltages of the red, blue, and green signals, respectively.

The combination of different amplitudes of color signals is what determines the various shades of gray in a monochrome receiver—white having a luminance of one, black a luminance of zero. The ability of a receiver to determine a corresponding level of gray from color levels is an important feature in the compatibility of color and monochrome TV's because the black-and-white signals can be obtained from the three primary color signals.

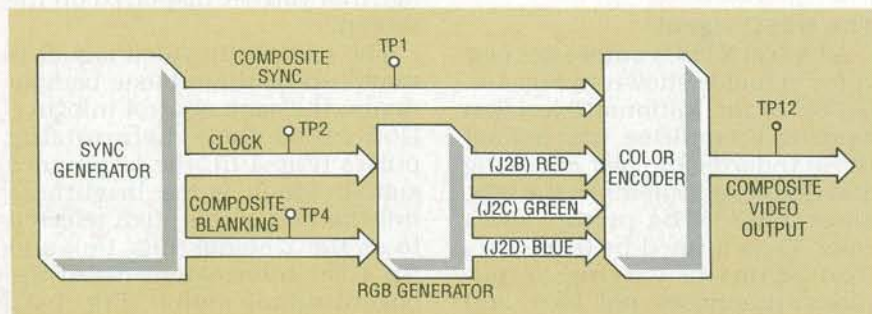


FIG. 2—A BLOCK DIAGRAM of the color-bar generator shows the main components of the circuit: RCA's CD22402E sync generator and Motorola's MC1377P color encoder.



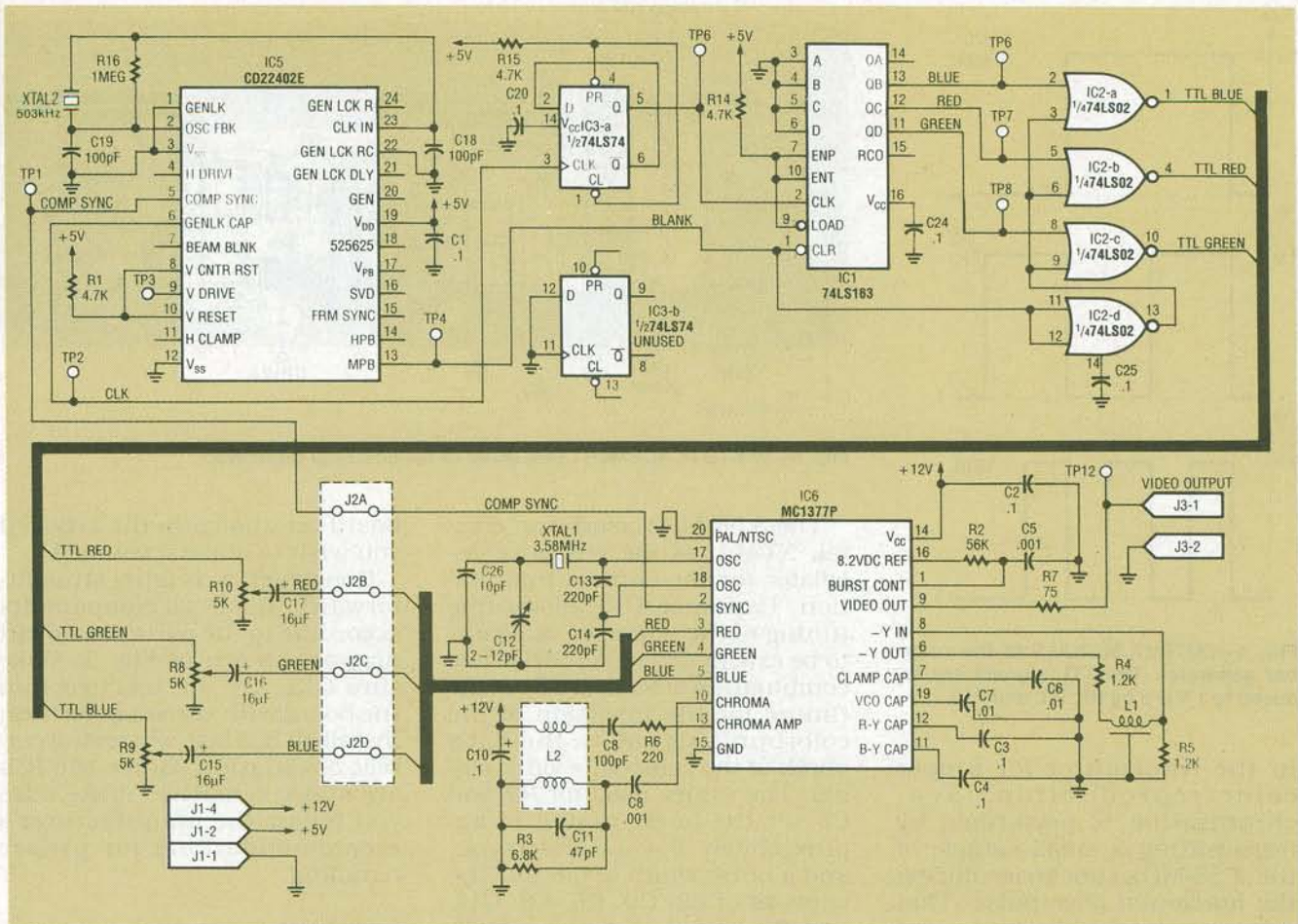


FIG. 3—SCHEMATIC OF THE COLOR-BAR GENERATOR. Sync generator IC5 provides the composite-sync timing signals, color encoder IC6 takes the separate red, green, and blue video signals and composite sync to generate the composite video signal.

All resistors are ¼-watt, 5%, unless otherwise indicated.

- R1, R14, R15—4700 ohms
- R2—56,000 ohms
- R3—6800 ohms
- R4, R5—1200 ohms
- R6—220 ohms
- R7—75 ohms
- R8—R10—5000-ohm potentiometer
- R16—1 megohm

**Capacitors**

- C1—C4, C10, C20, C24, C25—0.1 µF, bi-polar electrolytic
- C5, C8—1000 pF, mica
- C6, C7—0.01 µF, bi-polar electrolytic
- C9, C18, C19—100 pF, mica
- C11—47 pF, mica
- C12—2–12 pF variable ceramic capacitor
- C26—10 pF, mica
- C13, C14—220 pF, mica
- C15—C17—15 µF, electrolytic

**Semiconductors**

- IC1—74LS163 counter
- IC2—74L02 quad NOR gate
- IC3—74LS74 flip-flop
- IC4—not used
- IC5—CD22402 sync generator, RCA
- IC6—MC1377 color encoder,

**Motorola Other components**

- L1—400-ns delay line (TK1001)
- L2—30 µH, 2.52-MHz transformer (TK1603)

- XTAL1—3.58-MHz colorburst crystal
- XTAL2—503-kHz ceramic resonator

**Miscellaneous:** enclosure, standoffs for mounting circuit board, 4-pin friction-lock connector for J2, straight-header connector for J1, 2-pin friction-lock connector for J3, four shorting jumpers, wire, solder, etc.

**Note:** The following items are available from Geko Labs, 13019 250th Place SE., Issaquah, WA 98027-6730, (206) 392-0638: etched, drilled and plated-through PC board \$30.00; a complete kit including all parts, PC board, and assembly instructions \$80.00; a complete assembled and tested unit \$125. Add \$5.00 S & H with any order. Washington residents add 8.1% sales tax.

**Chrominance**

The color information, or chrominance, (which is ignored in a black-and-white TV) is made up of red, blue, and green signals required to drive the picture tube, minus the luminance signal. Those "color-difference" signals are designated as R-Y (red minus Y), and B-Y (blue minus Y). Color-difference signals are used solely for color reproduction. A special matrix circuit in the receiver can extract a G-Y (green minus Y) signal from the B-Y and R-Y signals. The advantage of changing the color signals into color-difference signals is the reduction of three color signals into two.

The R-Y, B-Y, and G-Y signals are decoded at the receiver by adding the Y signal back to each of the difference signals. A 3.58-MHz subcarrier is sent by the transmitter and used in the receiver to restore the original color information.

The frequency and phase angle of the 3.58-MHz subcarrier in the receiver must be the same as that



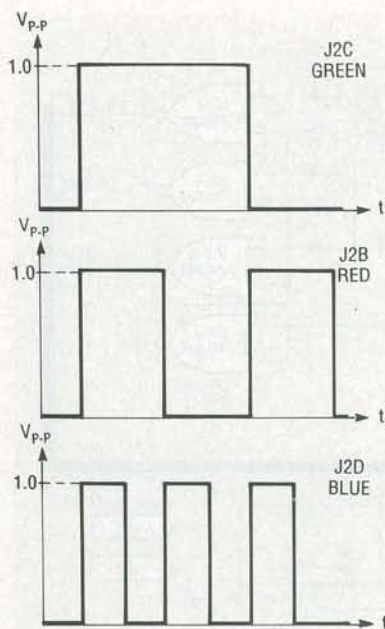


FIG. 4—OUTPUT SIGNALS of the color-bar generator. The TTL signals are reduced to 1 V p-p by R8, R9, and R10.

in the transmitter for proper color reproduction. Synchronization is performed by transmitting a small sample of the 3.58-MHz subcarrier during the horizontal sync pulse. That color sync interval is also known as the colorburst. The colorburst signal is used as a reference to synchronize the phase and amplitude of the color subcarrier. The colorburst also determines the tint and saturation of the color that is displayed.

### Theory of operation

Figure 2 shows a block diagram, and Fig. 3 a schematic of our video generator. Sync generator IC5 is used to provide the composite-sync timing signals. The outputs are composite sync, composite blanking, and a buffered output of the sync oscillator. The sync generator uses a 503-kHz ceramic resonator (XTAL2) as a base oscillator. The 503-kHz frequency is divided by 32 for the horizontal sync, and is further divided to derive the vertical sync-timing signals. Those signals are all combined into the composite-sync signal which is sent to the MC131377 color encoder (IC6). The color encoder takes the separate red, green, and blue video signals and composite sync to generate the composite-video signal.

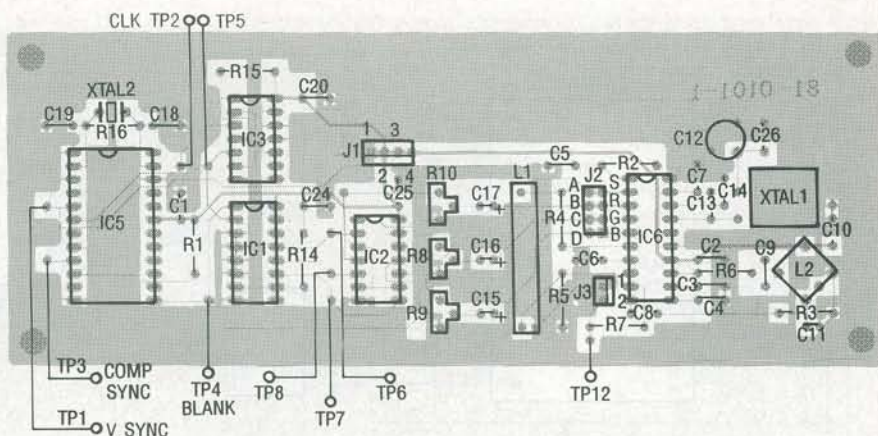


FIG. 5—PARTS PLACEMENT DIAGRAM of the color-bar generator.

The 3.58-MHz colorburst crystal, XTAL1, is the reference oscillator for the chroma information. Capacitor C12 allows fine tuning of the reference oscillator to be exactly 3.579545 MHz. The combination of R2 and C5 set the timing for the insertion of the colorburst signal on the back porch of the composite video signal. The values used for R2 and C5 set the burst timing to approximately 0.4  $\mu$ s after sync, and a burst width of 0.6  $\mu$ s. The network of L2, C9, R6, C8, C11, and R3 provide bandpass filtering for the chroma component. A delay for the luminance channel (-Y) is provided by R4, L1, and R5 to compensate for the internal delay of the chroma signal.

RGB generators IC1, IC2, and IC3 make up the red, green, and blue video signals that drive the video encoder section to make the color bars. One half of IC1 is used as a divide-by-2 counter, which generates the 252-kHz clock for the four-bit counter IC1. The non-inverted blue, red, and green signals are the divide-by-4, -8, and -16 outputs of IC1, respectively. The blue, red, and green signals are inverted, and blanking is added by IC2. The TTL level is reduced to 1 volt p-p by R8, R9, and R10, as shown in Fig. 4.

### Construction

The video generator uses a double-sided PC board that is available from the source mentioned in the parts list. We recommend that you use a PC board for this project because the frequencies involved require a large ground plane. Both the component and the solder side of the PC

board are shown in the article if you wish to make it yourself.

Construction is fairly straightforward. Install all components according to the parts placement diagram shown in Fig. 5. Make sure C15-C17 are inserted into the board with correct polarities. Install all IC's last, observing correct orientation. Since the IC's are static sensitive, make sure you follow the manufacturer's recommendations for proper handling.

### Checkout

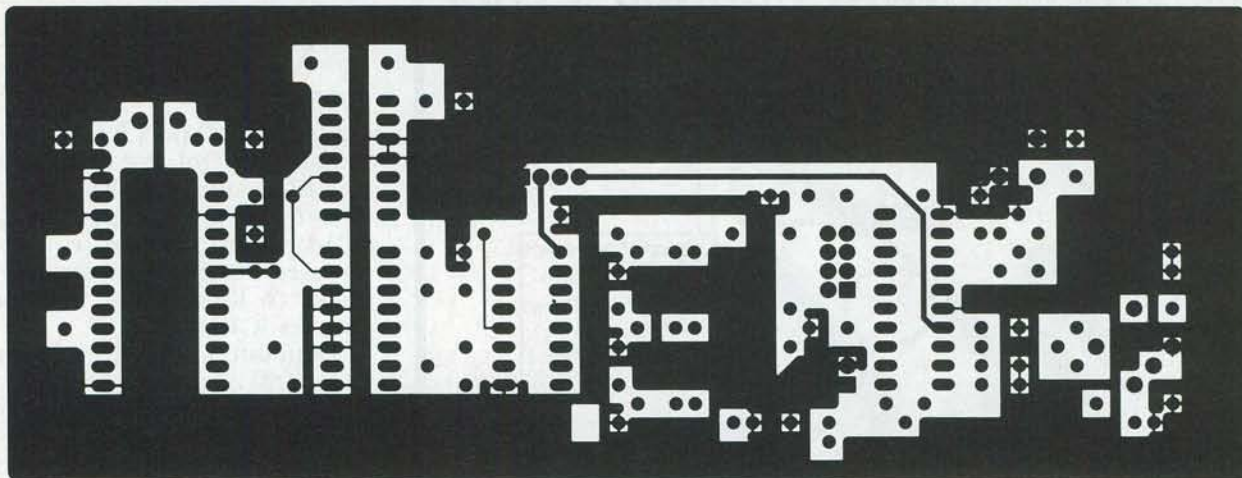
The measurements listed in this section will help to make sure the video generator is working properly. The power on tests should be made with the +12- and +5-V power sources on. Set R8, R9, and R10 to mid range. If you are the impatient type you can go right to the video output test point TP12 and see what you get. If you're lucky you'll have a video signal that probably needs some adjustments. If that's the case you can proceed directly to the video adjustments section. If not, proceed slowly through the following steps to isolate the problem and verify each of the listed voltages, frequencies and waveforms. Keep in mind that you will need an oscilloscope for the video level adjustments.

- Pin 2 of J1 and +5 V  $\rightarrow$  2000 ohms (power off)
- Pin 4 of J1 and +12 V  $\rightarrow$  1 megohm (power off)

### Power-on Tests

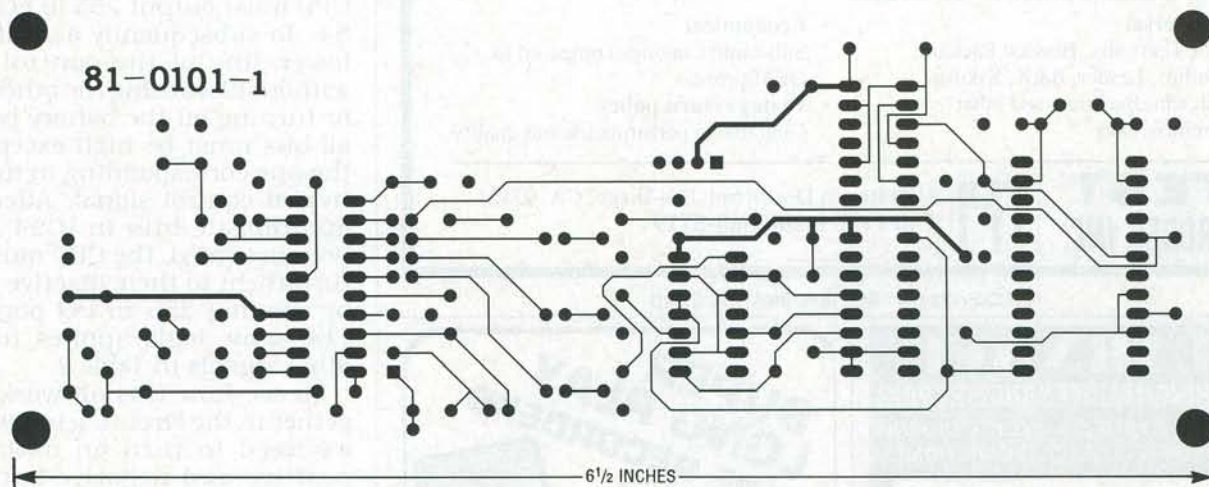
- +12-V supply—57 mA
- +5-V supply—29 mA
- IC1 pin 16—+5 V
- IC2 pin 14—+5 V
- IC3 pin 14—+5 V





6 1/2 INCHES

FOIL PATTERN OF THE COMPONENT side of the double-sided PC board.



6 1/2 INCHES

FOIL PATTERN OF THE SOLDER SIDE of the PC board.

- IC5 pin 19—+5 V
- IC5 pin 6 (TP2)—2.504-kHz, 5-V p-p (TTL level) square wave
- IC5 pin 5 (TP1)—TTL-level composite-sync signal
- IC5 pin 13 (TP4)—TTL-level blanking signal
- IC3 pin 5 (TP5)—252-kHz signal
- IC1 pins 11–13 (TP6, 7, 8)—Divided down signals

#### Sync Generator

- IC5 pin 19—+5 V
- IC5 pin 5 (TP1)—TTL-level composite-sync signal
- IC5 pin 6 (TP2)—504-kHz, 5-V p-p TTL-level square wave
- IC5 pin 13 (TP4)—TTL-level blanking signal

#### RGB Generator

- IC1 pin 16—+5 V
- IC2 pin 14—+5 V
- IC3 pin 14—+5 V
- IC3 pin 5 (TP5)—252-kHz signal

- IC1 pins 11–13 (TP6, 7 and 8)—Divided down signals as shown in Fig. 4

#### Color Encoder

- IC6 pin 14—+12 V
- IC6 pin 2—TTL-level composite-sync signal (Fig. 1-b)

- IC6 pins 3–5—1 V p-p signal
- IC6 pins 17 and 18—3.58-MHz oscillator signal
- IC6 pin 16—8.2 VDC
- IC6 pin 1—Ramp signal
- IC6 pins 10 and 13—Chroma signal (Fig. 1-d)
- IC6 pins 6 and 8—Luminance signal (Fig. 1-c)
- IC6 pin 9—2 V p-p (Fig. 1-a signal)

#### Video Level Adjustments

- IC6 pin 4 (J2C)—Adjust R8 to 1 V p-p
- IC6 pin 3 (J2B)—Adjust R10 to 1 V p-p
- IC6 pin 5 (J2D)—Adjust R9 to 1 V p-p
- J3 pin 1—Terminate into a 75-ohm connector
- Video Output (TP12)—Composite 1-V p-p signal. If you can't get this signal, adjust R8 for the proper peak level and null out the

*continued on page 79*

#### Amateur Television Quarterly

This article originally appeared in ATVQ magazine. ATVQ is a quarterly publication featuring technical articles on subjects related to ham radio, including VHF, UHF, amateur TV (ATV), computer programs, and repeater projects. ATVQ is enjoyed by hams of all levels, from beginner to Extra class. A subscription to this magazine is available for \$15 per year, \$4.00 for a sample copy (Visa and Mastercard are accepted). For more information contact

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chroma on the white bar (the first bar after horizontal sync) with R10 and R9.

### **Adjustment with Monitor**

If you have a monitor, hook up the video output of the video generator to the monitor's video in-

put and do all the adjustments looking at the white color bar on the left side of the screen. If the red, green, and blue video levels are set up properly the white bar should be full brightness and white. If it is not, adjust R8 for the overall brightness and then adjust R10 and R9 for a pure white bar.

We hope you've learned some-

thing about color video from this project. Everything is neatly broken into fairly simple blocks so you can be assured of success. If you have an IBM Clone computer with a CGA board (or other video card with NTSC-compatible sync) you can use just the encoder section to generate NTSC-compatible sync and RGB video outputs.

R-E