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BUILD A COLOR-BAR TEST GENERATOR
Test and troubleshoot your video equipment.
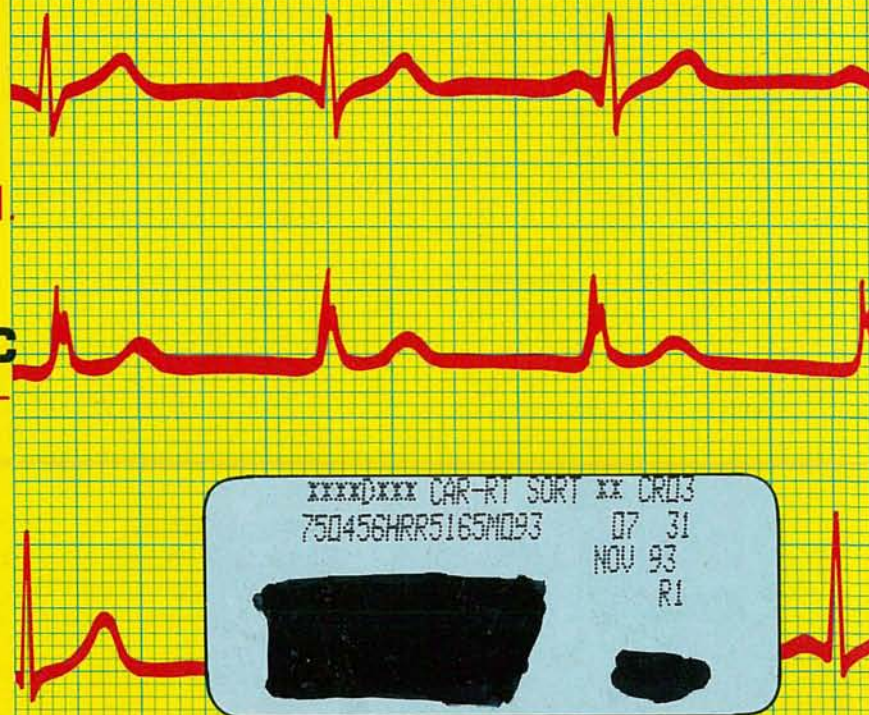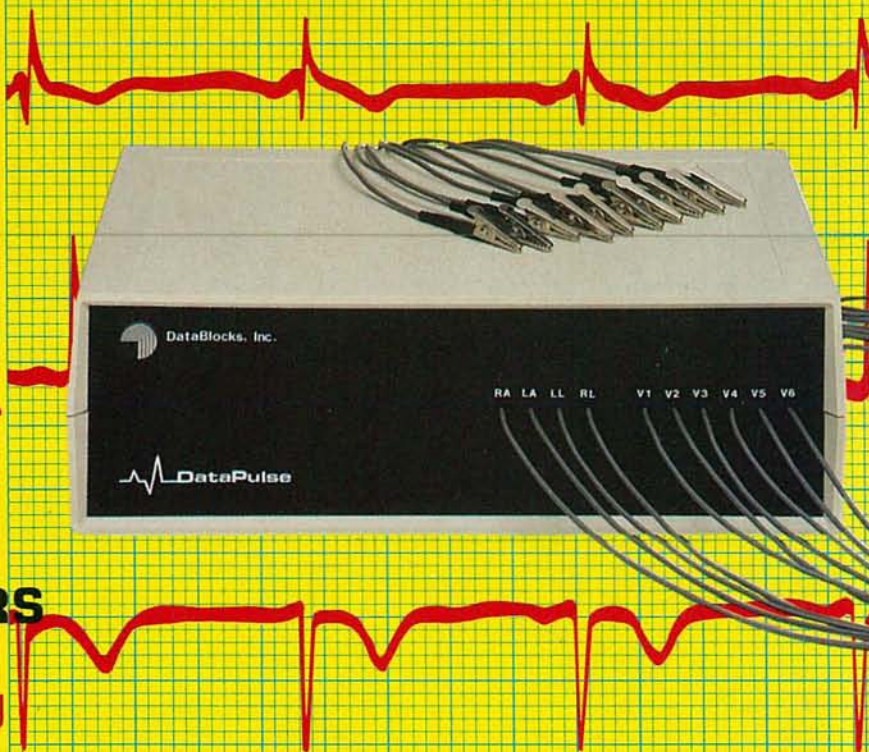
D/A and A/D CONVERTERS
A look at the chips that bring the digital and analog worlds together.

BUILD A LOGIC ANALYZER
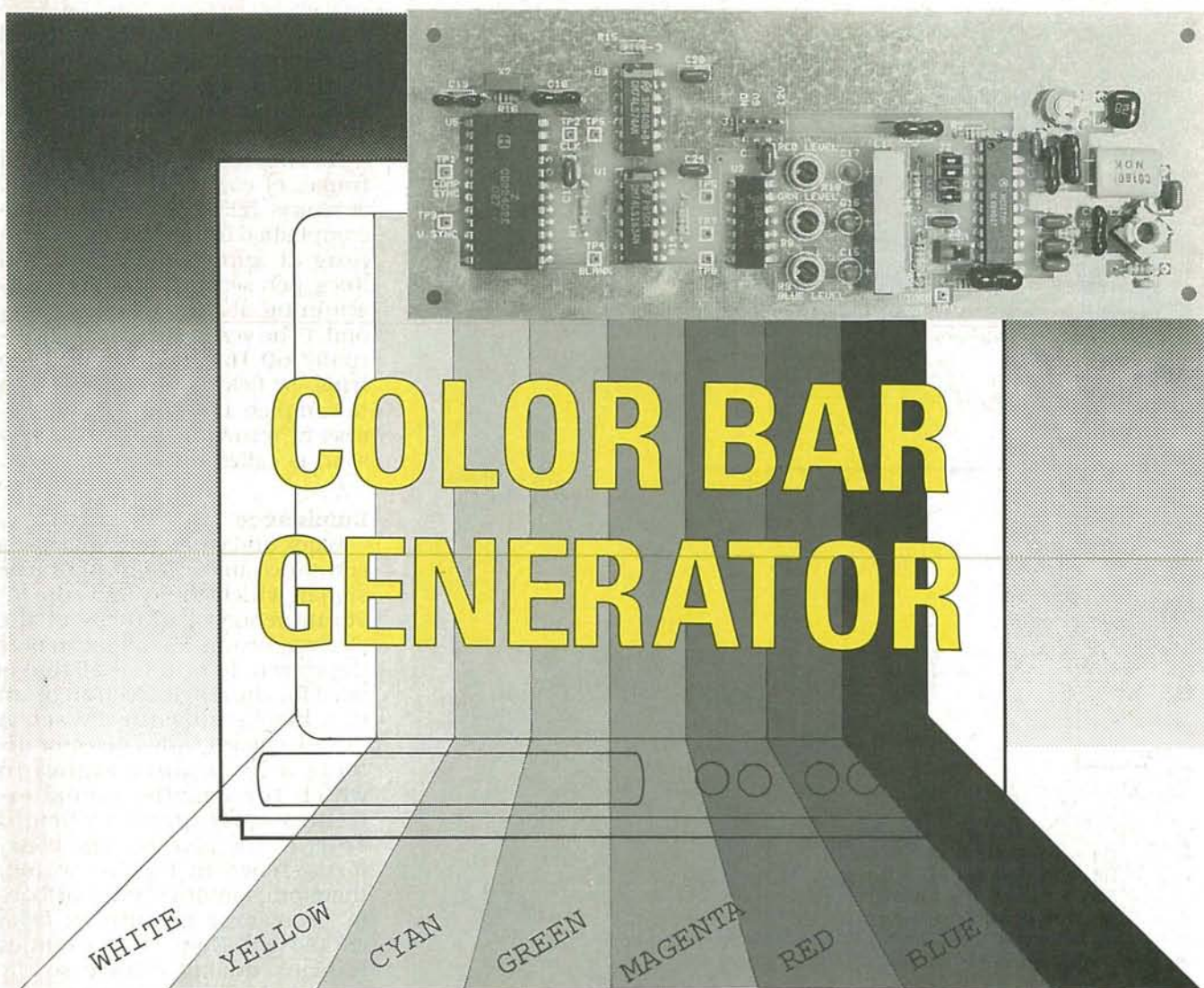A 16-channel, 50-MHz digital troubleshooting tool.

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PUBLICATION

COLOR BAR GENERATOR

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

THOMAS GOULD WB6P

WHITE   YELLOW   CYAN   GREEN   MAGENTA   RED   BLUE

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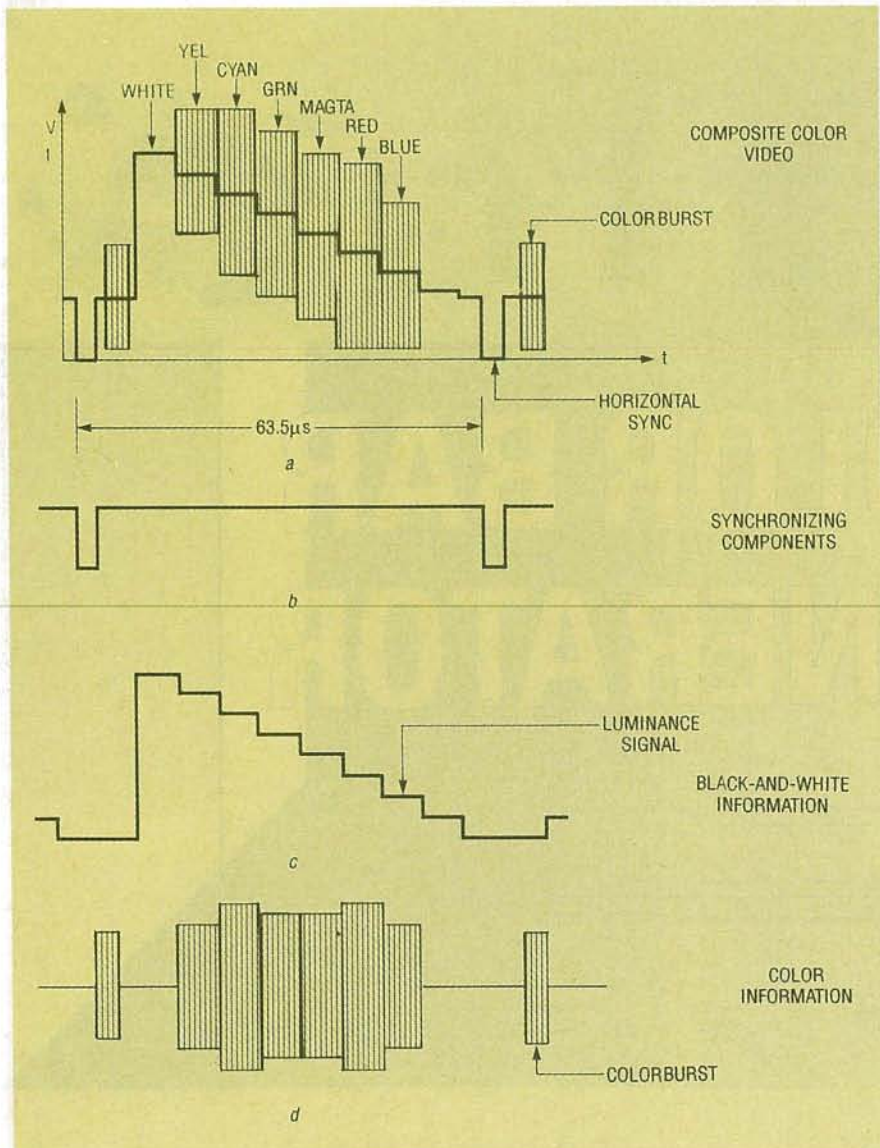
FIG. 1—A COMPOSITE VIDEO SIGNAL (a) includes sync pulses (b), black-and-white information (c), and the colorburst signal (d).

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.

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
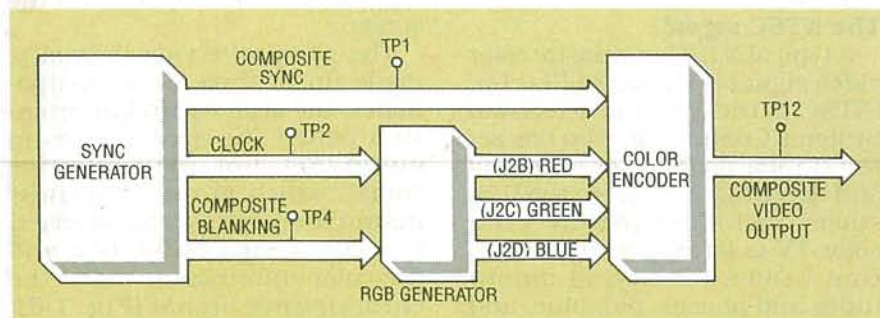

FIG. 2—A BLOCK DIAGRAM of the color-bar generator shows the main components of the circuit: RCA's CD22402E sync generator and Motorola's MC1377P color encoder.
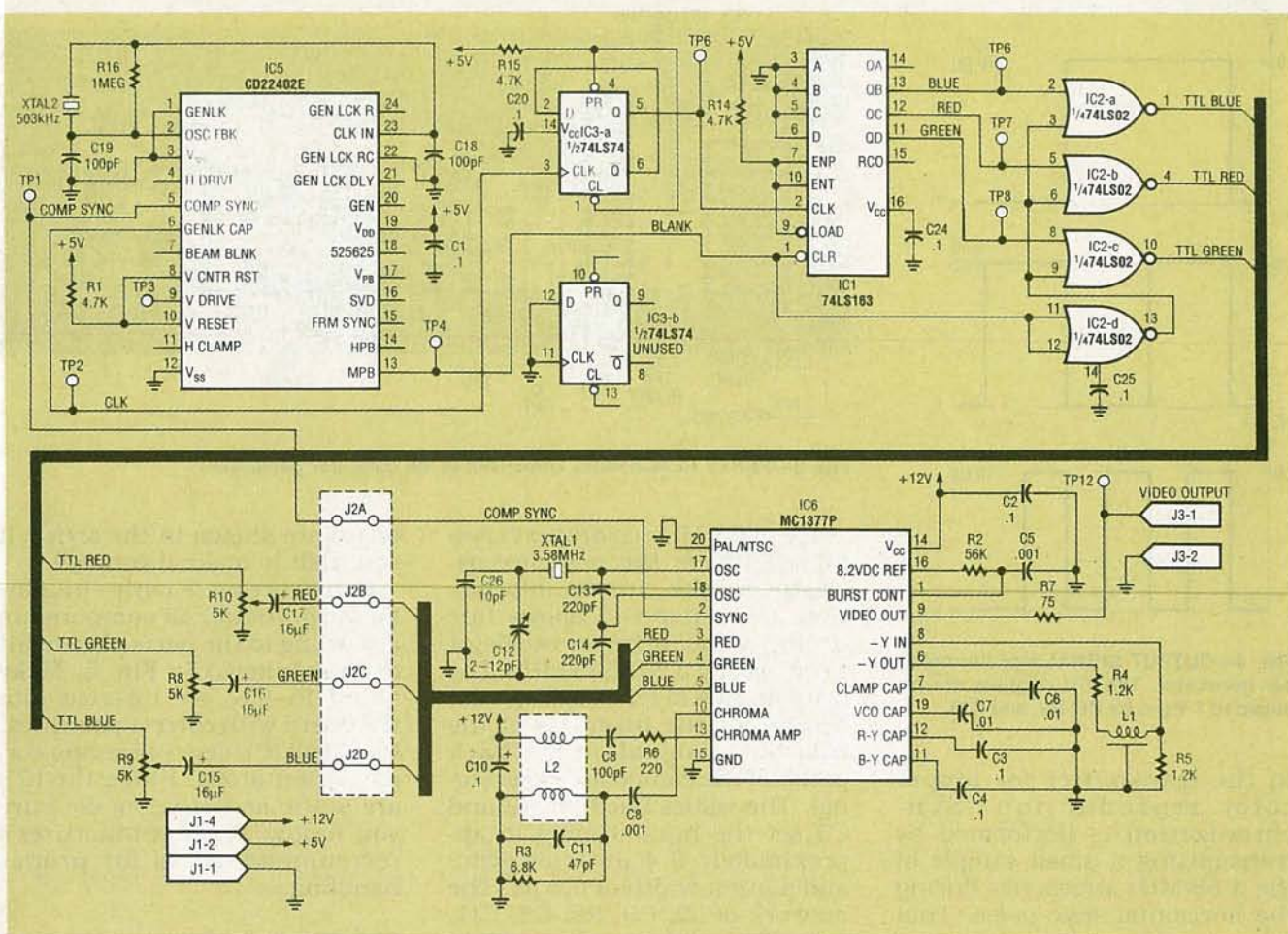
FIG. 3—SCHEMATIC OF THE COLOR-BAR GENERATOR. Sync generator IC5 provides the composite-sync timing signals, color encoder IC6 takes the separate red, green, and blue video signals and composite sync to generate the composite video signal.

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, bipolar 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 J1, straight-header connector for J2, 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
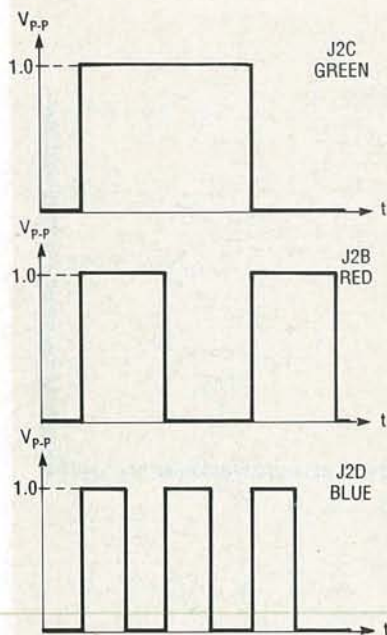
FIG. 4—OUTPUT SIGNALS of the color-bar generator. The TTL signals are reduced to 1 V p-p by R8, R9, and R10.

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

in the transmitter for proper color reproduction. Synchronization is performed by transmitting a small sample of the 3.58-MHz subcarrier during the horizontal snyc 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.
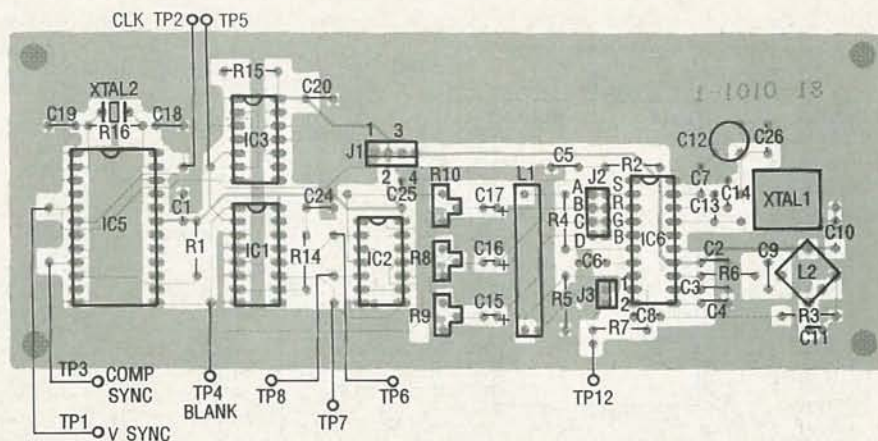
The 3.58-MHz colorburst crystal, XTAL1, is the reference oscillator for the chroma information. Capacitor C12 allows fine tuning of the reference oscillator to be exactly 3.579545 MHz. The combination of R2 and C5 set the timing for the insertion of the colorburst signal on the back porch of the composite video signal. The values used for R2 and C5 set the burst timing to approximately 0.4 μs after sync, and a burst width of 0.6 μs. 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.
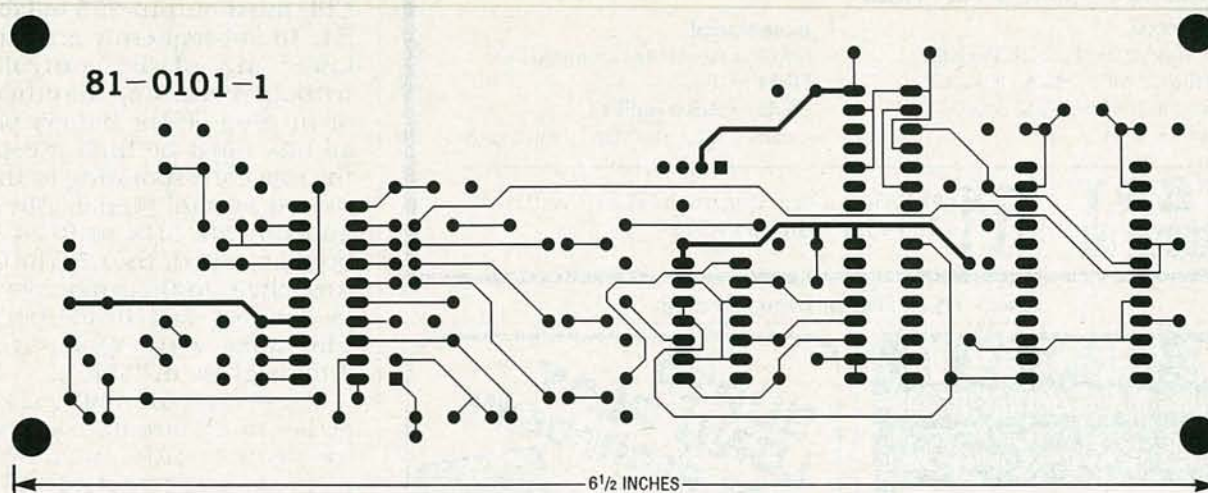
- Pin 2 of J1 and +5 V—> 2000 ohms (power off)
- Pin 4 of J1 and +12 V—> 1 megohm (power off)

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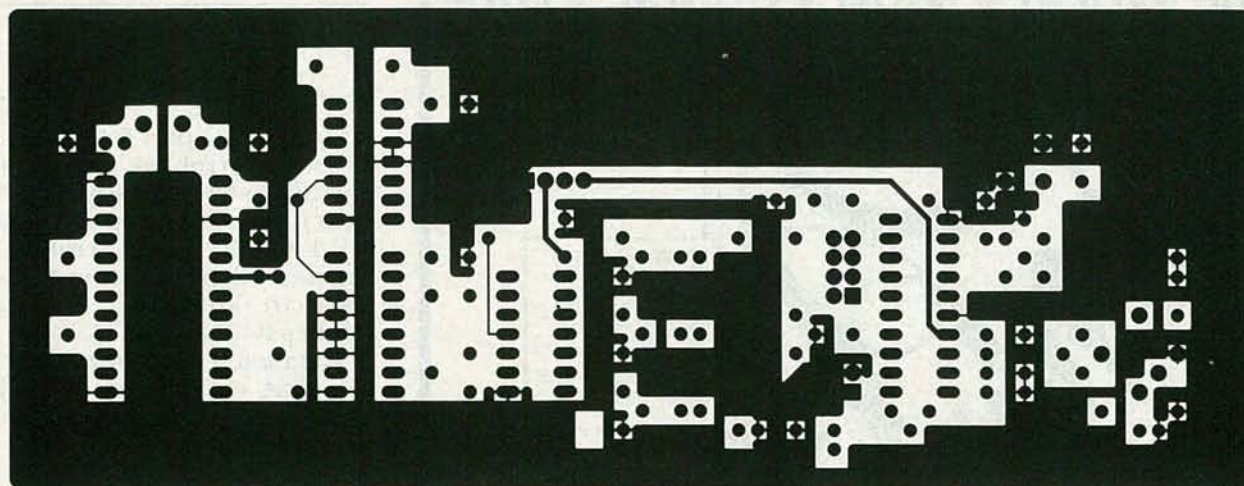
FOIL PATTERN OF THE COMPONENT side of the double-sided PC board.

81-0101-1

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

this environment; as the premier supplier of object-oriented programming tools, this is exciting news.

A related development is Unicode, a consortium of leading computer vendors (IBM, Apple, Microsoft, Sun, Next, Novell, and others) that has begun the process of defining the successor to the ASCII character set. ASCII is a seven-bit code, limited to 128 characters. By contrast, Unicode is a 16-bit code, allowing 64K characters, enough to represent all western languages unambiguously, and a good start on eastern languages as well.

News bits

Recession? What recession? After hitting an all-time low in November of 1990, semiconductor sales are on the rise again. The first two months of 1991 set an all-time record, and the Semiconductor Industry Association is optimistic that the industry could grow by about 10% this year. **MacClones?** Apple's continually shrinking market share has finally forced Sculley and crew to understand that they're in business to sell computers, not religion. The company recently acknowledged interest in licensing the Mac operating system to vendors of other hardware platforms, most likely including some flavor of Intel chips. With the rapidly increasing popularity of the 386/486, technical problems should be few, as the advanced Intel processors overcome the limitations of earlier processors that used to make the Motorola family attractive. **PolyGlot PostScript.** Adobe Systems is expected to announce a PostScript-based utility that allows transparent data sharing across multiple platforms. **OS Soup.** IBM will try to ease skepticism about OS/2 with a marketing blitz designed to promote understanding of the operating system, applications for it, DOS and Windows compatibility, and futures. Watch for OS/2 2.0 to sweep the industry just like Windows 3.0 has.

486 blues

Just when 386-based systems start to become affordable, the 486 moves in as the new high-end option. However, the 486 may penetrate the market much quicker than did the 386. Intel is poised to release several updated 486's, a 50-MHz unit, and a "crippled" or de-featured unit (variously called the P23 and the 486SX) that comes without the math coprocessor, and that runs slower (20 MHz) than a full 486. Remember that even running at the same clock speed, a 486 is about twice as fast as a 386. Several vendors have already announced P23 systems priced under $3000.

The P23 isn't stopping American Micro Devices, which is shipping 40-MHz versions of its 386 clone. Also, Chips & Technologies and Cyrix have introduced system logic and math coprocessors, respectively, that support the new device. Intel's not scared, however; the company has shown a 486 running at 100 MHz. **R-E**

COLOR BAR GENERATOR

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 input 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 something 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**