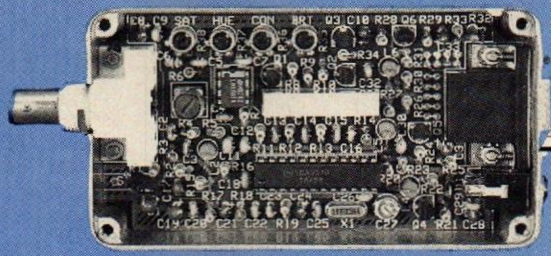


# NTSC → RGB CONVERTER

## *Put a TV in your VGA monitor.*

JIM HARRIGFELD

AT BOTTOM, A TV AND A COMPUTER monitor are more alike than they are different. As a matter of fact, a monitor is really just a TV in disguise less a few circuit boards and knobs.

At one time, when computers used teletypewriters for display, television pictures were considered high-resolution. Today, even the best TV sets cannot compare with the latest breed of computer monitors in terms of resolution, stability, convergence, and fidelity. So wouldn't it be nice if you could simply connect a VCR or camcorder to your monitor and enjoy some of that extra fidelity?

This article will show you how to build a simple decoder that will take any standard NTSC video signal (from a VCR, camera, tuner, or what have you), and convert it into the analog RGB signals that computer monitors work with. The circuit costs well under $100 to build, and requires no fancy test equipment to align. In addition, if you would like to build one, partial and complete kits are available.

### Some basics

A color monitor has a simple interface. It generally requires four separate signals to operate: red, green, blue, and sync. Sync tells the monitor where and when to start each scan line, and the RGB signals determine how much red, green, or blue to display in the picture at any instant in time.

The composite video signal used in a television is more complicated, because it combines all the RGB signals, as well as other timing information, into a single high-frequency signal. In the United States, this signal is based on the NTSC/RS-170A video standard.

The disadvantage of composite video is that a great amount of processing is required to combine and encode the separate signals into one composite signal. The advantage of composite video, of course, is that the signal may be broadcast over the air or sent down a single piece of coaxial cable. But to be displayed, eventually the signal must be broken down into its individual red, green, blue, and sync components. By contrast, the advantage of the RGB system is that no decoding circuitry is required, so circuit designs are simpler and cheaper. The disadvantage of the RGB system is that several wires and multi-pin connectors are required to make connections.

Given the similarity between a television and a monitor, what exactly is required to display NTSC video on an RGB monitor? First and foremost, we need an analog monitor that is capable of scanning at standard NTSC video rates (60 Hz vertical, 15,750 Hz horizontal). That requirement immediately eliminates most fixed-frequency (digital) monitors—i.e., most CGA and EGA types. However, most multi-frequency type monitors work beautifully.

We also need a video source. You can choose any VCR, video camera, camcorder, or component tuner that has a video output in the NTSC/RS-170A format. Those devices usually have some kind of audio output that you can use to drive a pair of headphones or your home stereo system.

Of course, there's still one thing missing: a gadget that can be used to convert the composite video from your source device into the separate RGB signals that your monitor understands.

### About the circuit

Figure 1 shows a block diagram of the circuit, and Fig. 2 shows the complete schematic. The heart of the circuit is IC2, a TDA3330. That highly integrated Motorola IC is specifically designed to break a composite video signal down into its individual components. The TDA3330 requires three inputs to operate: chroma (color information), luminance (brightness information), and burst flag (timing information).

The other major component is IC1, an LM1881 video-sync separator made by National Semiconductor. It extracts most of the important timing information

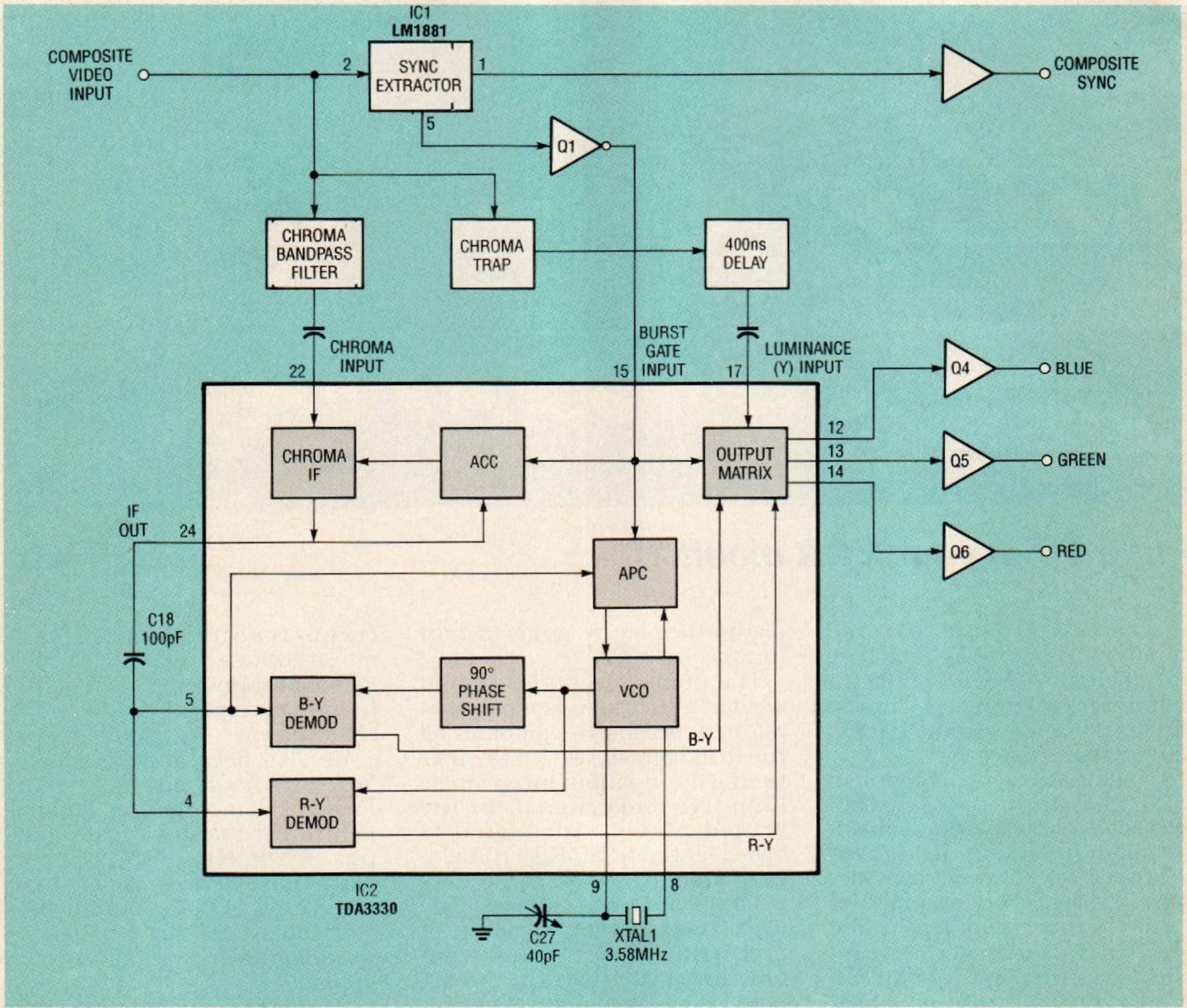



**FIG. 1—BLOCK DIAGRAM. IC1 derives the sync signal and timing information. IC2 uses the latter to decode the red, green, and blue outputs.**

from a standard video signal, and it needs only three external (passive) components to operate. Our circuit uses two of its three outputs: composite sync, which after buffering becomes one of our outputs; and the burst flag, which is inverted by Q1 to furnish the necessary timing information to IC2.

The other signals that are needed by IC2 are derived from the composite video input signal by means of several passive filters. The chroma bandpass filter consists of R2, L2, C11, and C12. That circuit works by allowing only 3.58-MHz signals to pass into pin 22 of IC2, while blocking all others. The luminance input (pin 17) is just the opposite, in that the 3.58-MHz component must be blocked and all other frequencies allowed to pass through. That is accomplished with the chroma trap consisting of L1, R3, R4, C2, and C3. Basically, the output of the chroma trap is monochrome video. To meet NTSC timing requirements, that signal must also be delayed (by R5, R14, and L3) before entering IC2.

With proper input signals, IC2 requires only a few more passive components to enable it to lock on to the incoming signals. Once locked, the IC performs all I/Q demodulation, quadrature decoding, R−Y, and B−Y processing, and it then delivers red, green, and blue signals at pins 14, 13, and 12, respectively. Those signals are buffered in turn by Q4, Q5, and Q6, which are set up as emitter followers designed to drive 75-ohm loads.

The circuit has four controls for setting operational characteristics. The brightness control (R35) sets the black level of the RGB outputs; for most applications, it should be set at minimum. The three other controls (hue, R37; saturation, R38; and contrast, R36) work much like their counterparts on a standard TV. After they have been properly adjusted, none of those controls should require operator intervention. The brightness control shifts the black level without affecting the overall peak-to-peak amplitude of the signal. On the other hand, the contrast control varies the peak-to-peak amplitude without affecting the black level.

Figure 3 shows several waveforms and timing relationships for a color-bar input signal at several points in the circuit: (*a*) The

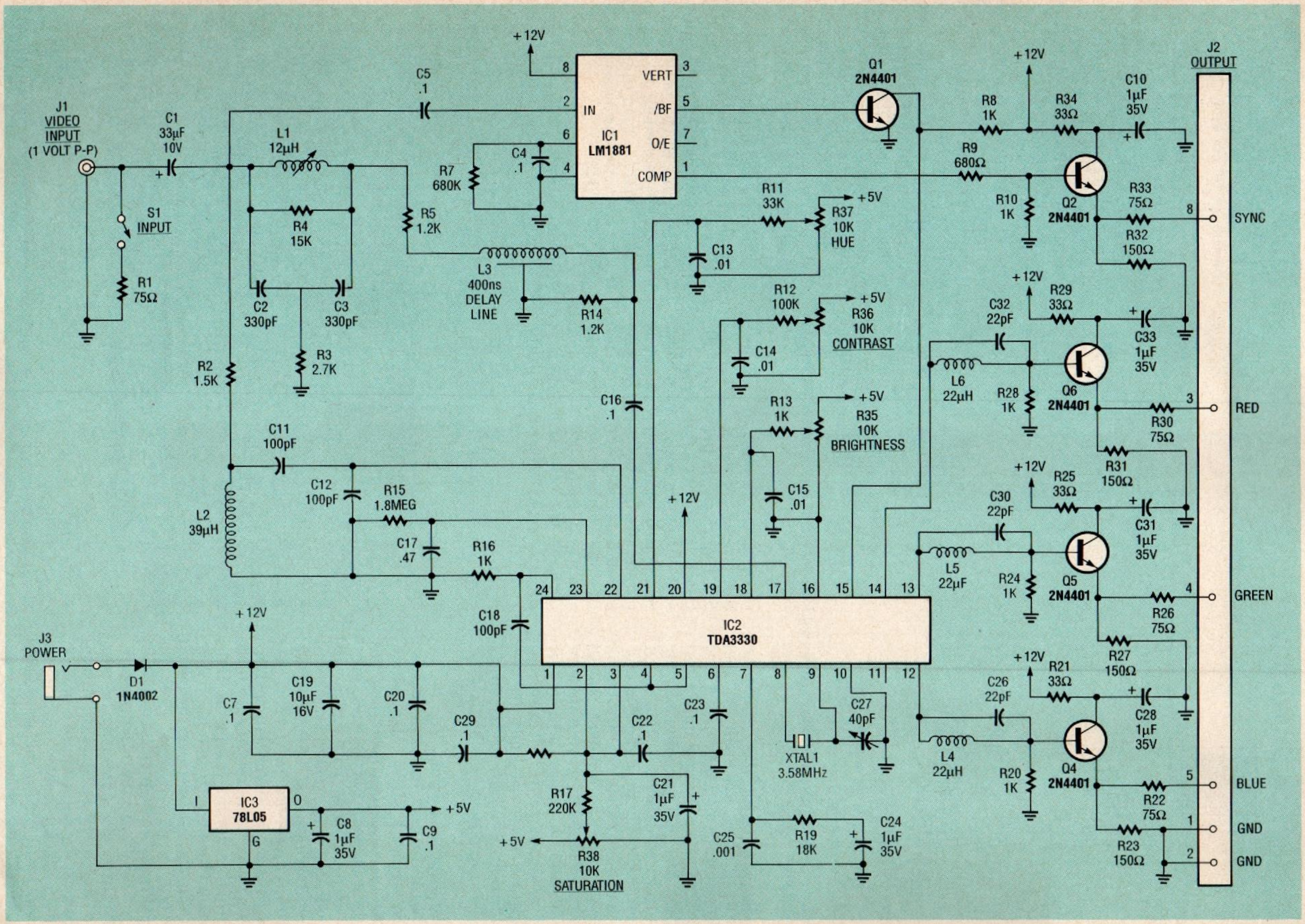



**FIG. 2—COMPLETE SCHEMATIC. The circuit accepts a 1-volt peak-to-peak composite input, and delivers RGB and sync outputs, also with a swing of 1 volt peak-to-peak.**

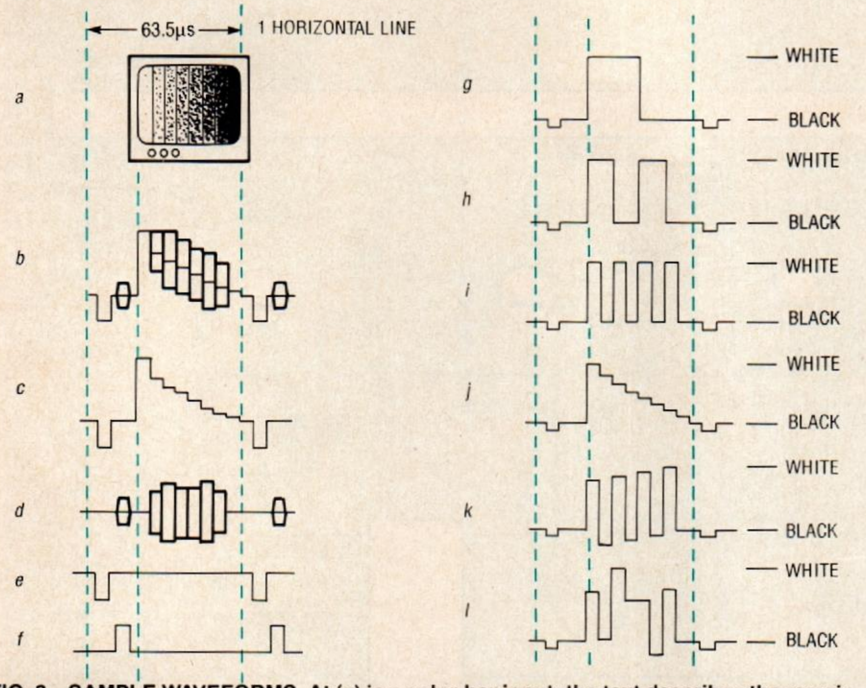



**FIG. 3—SAMPLE WAVEFORMS. At (*a*) is a color-bar input; the text describes the remaining signals.**

color-bar input. (*b*) Composite video across one scan line. (*c*) The luminance input (pin 17) of IC2. (*d*) The chroma input (pin 22) of IC2. (*e*) The composite sync output. (*f*) The burst-flag input (pin 15) of IC2. (*g*) The green output (Q5). (*h*) The red output (Q6). (*i*) The blue output (Q4). (*j*) All outputs with the saturation control (R38) at minimum. (*k*) The blue output with the saturation control (R38) too high. (*l*) The blue output with the hue control (R37) improperly adjusted.

## Building the circuit

With the high frequencies that are involved, stray capacitance and crosstalk will almost certainly cause problems with most breadboarding and wirewrap techniques. Therefore, we recommend that you use a PC board for the project. Patterns for the board are provided if you wish to make your own; boards are also available commercially, as discussed in the parts list. If you use our board, Fig. 4 shows the parts layout.

All parts except possibly IC2 (the TDA3330) are readily available from the mail-order houses advertising in **Radio-Electronics.** If you purchase a partial kit, be careful in selecting capacitors. Only tantalum or monolithic DIP types are suitable, as electrolytic, Mylar, or ceramic disc types may not fit in the allotted space on the printed circuit board. Also note that resistors and inductors are mounted vertically. Bend one of the leads back parallel to the body of the part and mount the body of the part in the hole with the circle around it, and then pass the bent lead through the other hole. Mount the inductors (except L3) in the same manner. This method saves space and also furnishes you with good debug/test points.

We also strongly recommend the use of IC sockets. If you are unable to locate a 24-pin socket for IC2, you can use 16- and 8-pin sockets mounted end-to-end. The pads around the trimmer potentiometers have been laid out so that several types of trimmers may be installed. Just be sure to mount the trimmer's wiper arm in the correct pad.

The board was designed to accept PC-mounted connectors for J1 (input), J2 (output), and J3 (power). However, you may not want or need these types. Our prototype uses a BNC connector for J1, but a simple RCA jack may suffice. Likewise, J2 and J3 may be eliminated entirely or changed depending on what your particular application involves. Switch S1 may be replaced with a simple jumper/header combination for most setups.

For best operation, the board should be installed in a shielded enclosure. The template in Fig. 5 shows hole locations for mounting the board in the project box that is mentioned in the parts list. The board is held in place in the box by the connector hardware (J1–J3).

## Hooking it up

Regardless of the type of con-

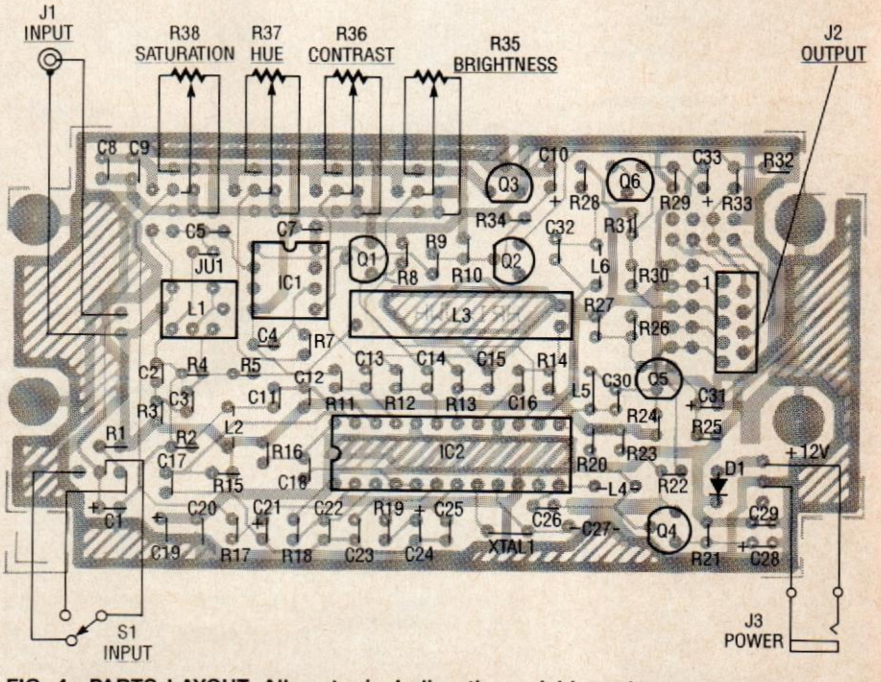



**FIG. 4—PARTS LAYOUT. All parts, including the variable resistors and the I/O jacks, mount on the board.**

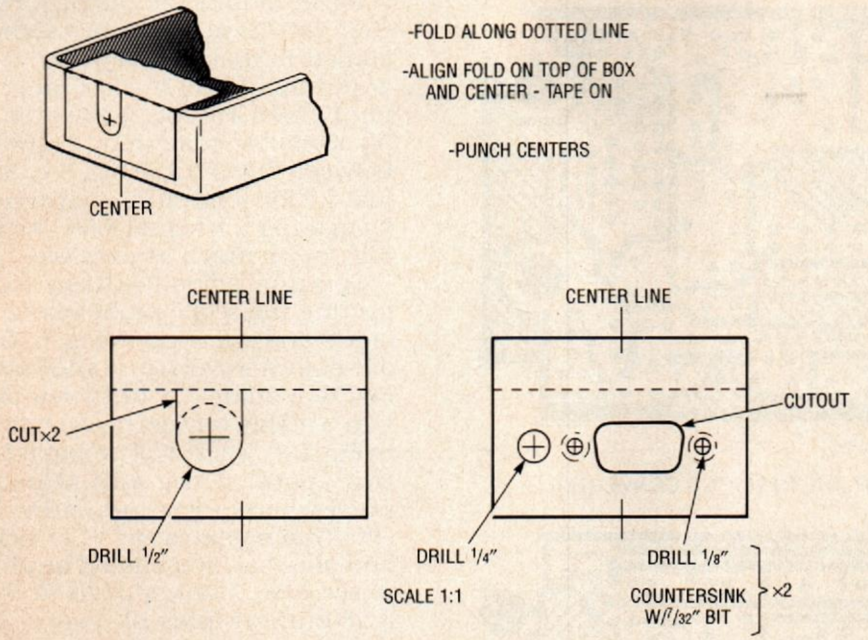



**FIG. 5—DRILLING TEMPLATE. If you use our board and the box mentioned in the parts list, drill the box as shown here.**

## PARTS LIST

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

R1, R22, R26, R30, R33—75 ohms
R2—1500 ohms
R3—2700 ohms
R4—15,000 ohms
R5, R14—1200 ohms
R6—not used
R7—680,000 ohms
R8, R10, R13, R16, R20, R24, R28—1000 ohms
R9—680 ohms
R11, R18—33,000 ohms
R12—100,000 ohms
R15—1.8 megohms
R17—220,000 ohms
R19—18,000 ohms
R21, R25, R29, R34—33 ohms
R23, R27, R31, R32—150 ohms
R35–R38—10,000 ohms, cermet potentiometer, Panasonic #SOGAO1B1

**Capacitors**
C1—33 µF, 10 volts, tantalum
C2, C3—330 pf, 50 volts, monolithic
C4, C5, C7, C9, C16, C20, C22, C23, C29—0.1 µF, 50 volts, monolithic
C6—not used
C8, C10, C21, C24, C28, C31, C33—1 µF, 35 volts, tantalum
C11, C12, C18—100 pF, 50 volts, monolithic
C13–C15—0.01 µF, 50 volts, monolithic
C17—0.47 µF, 50 volts, monolithic
C19—10 µF, 16 volts, tantalum
C25—0.001 µF, 50 volts, monolithic
C26, C30, C32—22 pf, 50 volts, monolithic
C27—5–30 pF, trimmer

**Semiconductors**
IC1—LM1881N video sync separator (National)
IC2—TDA3330 NTSC to RGB decoder (Motorola)
IC3—78L05 low-power 5-volt regulator
Q1, Q2, Q4–Q6—2N4401
Q3—not used
D1—1N4002 rectifier diode

**Other components**
J1—PC-mount BNC connector (AMP #226978-1)
J2—9-pin D connector, female, PC mount
J3—3.5mm mono phone jack
L1—12 µH variable inductor (Toko #A119ANS-T1034)
L2—47 µH fixed inductor(Toko #348LS-470K)
L3—400 ns delay line (Toko #H321LNP-1436P)
L4–L6—22 µH fixed inductor (Toko #348LS-220K)
S1—SPST, PC board right-angle mount
XTAL1—3.579-MHz crystal
**Miscellaneous:** Metal case—(Hammond #1590B), 12-volt regulated wall transformer, solder, etc..

**Note: The following items are available from Harmonic Research, Inc., 193 Villanova Drive, Paramus, NJ 07652 (201) 652-3277: Complete kit including PC board and all parts except wall transformer, $95.95; Partial kit including all parts except box, S1 and J1, $81.50; Etched, drilled, and silk-screened PC board, $20; TDA3330 (IC2), $4.75. All orders add $2.50 for shipping and handling. New Jersey residents add appropriate sales tax.**

nectors that you use, the input should be wired using high-quality coaxial cable for best results. Your VCR or camera may have come from the factory with a cable of this type. Otherwise you can buy or build an input cable with RG59U coax and either BNC or RCA connectors.

The output cable depends on your application and use. Refer to your monitor's manual to determine its input wiring requirements. The decoder's output (J3) is a DB-9 connector that conforms to the PC standard. Many multi-frequency monitors adhere to that standard; but it's a good idea to check the manual just to be sure. With a little luck, you should be able to unplug the cable from the display adapter in your PC and plug it directly into the decoder.

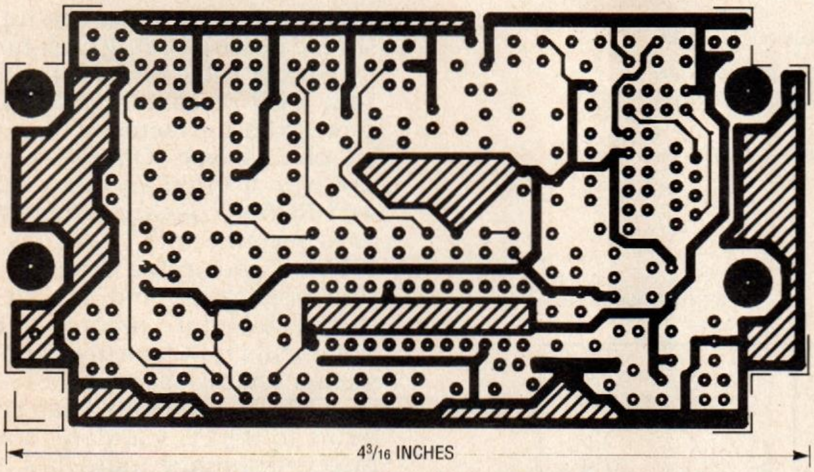
If you're not so lucky, you'll have to wire up a cable or an adapter. In addition, we left a row of pads just behind J2 on the PC board; you might find it easier to simply cut the traces between the two rows and add jumpers to reconfigure the pinout of J2. That could save you from having to modify a cable.

The power supply for the NTSC converter can be any well-regulated 12-volt supply that is capable of furnishing 250 mA of current on a continuous basis. Apply power to J3 through a ⅛" phono plug with positive tip and grounded shield.

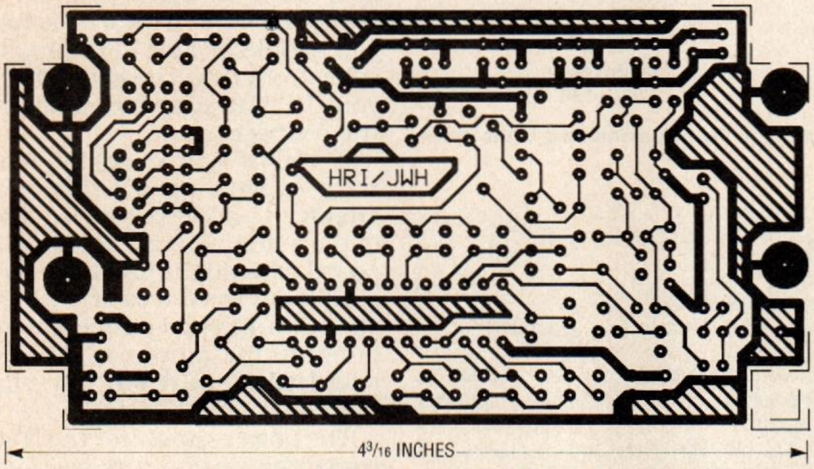
### Testing and adjustment

Before applying power, check the PC board for solder splashes, bad or shorted connections, etc.. Do not install the IC's in their sockets yet; rather, first apply power to the circuit and check for smoke and overheated components. Using a DMM, verify that pins 1 and 20 of IC2, and pin 8 of IC1, are all about +12 volts. In addition, verify that the positive side of C8 is +5 volts.

After everything checks out, remove power from the board, install the IC's in their sockets, and make the external connections. A color-bar generator is nice for making the adjustments, but if you don't have access to one, any stable video signal will do. Use a camera or an off-the-air signal; don't try to set up from a tape. Turn the saturation, hue, and




HERE'S THE COMPONENT SIDE OF THE NTSC/RGB CONVERTER




HERE'S THE SOLDER SIDE OF THE NTSC/RGB CONVERTER.

contrast controls (R36–R38) to maximum, and the brightness control (R35) to minimum.

**Adjusting without test equipment.** With everything hooked up and the monitor on, plug in the power supply. You should immediately see some kind of picture, although it will probably be black and white and possibly flashing on and off. Adjust C27 with a small screwdriver for the most stable picture and the best color. You may find two spots where performance seems equal: either will do. Next, adjust L1 for the deepest, richest color. Then adjust the saturation, hue, and contrast controls for the most natural look, just as you would on a normal television. You should leave the brightness control set at minimum unless you have a specific reason for wanting the black level set higher than it already is. That's all it takes to adjust the unit, and you will probably be very close to the optimum settings.

**Adjustment with color-bar generator and oscilloscope.** With S1 closed, verify with the scope that you have a 1-volt peak-to-peak signal similar to that shown in Fig. 3-*a* at the input connector. Next, verify that a burst-flag pulse is present at pin 15 of IC2. That signal should look like the waveform shown in Fig. 3-*f*, and must be at least eight

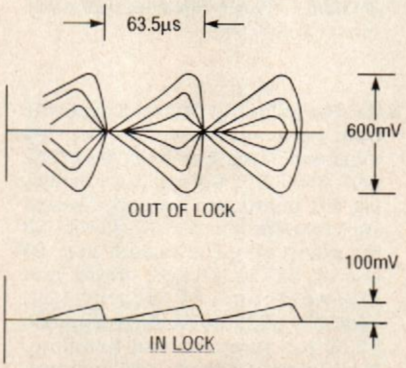



**FIG. 6—VCO LOCK AT PIN 7 OF IC2.** In (*a*) is an incorrectly adjusted signal; (*b*) shows the correct waveshape.

volts in amplitude. Also, verify that you have a chroma signal similar to that shown in Fig. 3-*d* at pin 22 of IC2. If you examine pin 17 with a scope, it will probably resemble something halfway between Fig. 3-*b* and Fig. 3-*c*. Adjust L1 for minimum subcarrier by making the signal look like in Fig. 3-*c* as much as possible.

Continue adjustments by connecting the scope probe to pin 7 of IC2 and referring to Fig. 6. An out-of-lock waveform is shown in Fig. 6-*a*; adjust C1 until you obtain a stable waveform as shown in Fig. 6-*b*. There will probably be two spots in the adjustment range where lock occurs; either is OK. That signal is the VCO lock, and once set, you should be able to see nice, stable signals at the RGB outputs (pins 12–14 of IC2). Refer to the output waveforms in Fig. 3 and watch your monitor while adjusting the saturation, hue, and contrast controls to your liking. Outputs should be set anywhere from 0.7 to 1.0 volt peak-to-peak.

**I want my MTV/2!**

After making all of the adjustments to the unit itself, leave them alone; instead use the brightness and contrast controls on your monitor to compensate for ambient lighting. The decoder should be able to lock on to anything that comes anywhere close to NTSC video, but it can't deal with some of the copy-protection schemes that many prerecorded tapes use. However, you may be able to compensate by running the composite video signal through a descrambler or stabilizer first.

You may notice that some video looks better on your monitor than on a TV, whereas other video looks worse. The reason is that a high-resolution display cannot improve a low-resolution input, and in some cases the high resolution might even bring out some unwanted artifact that a low-resolution display would cover up.

Some day, with all the hoopla over HDTV and multimedia, video and graphics displays will most likely merge. We will be running our CAD program on the same screen that we sit back and watch STAR WARS 15 on. Until then, projects like this will inch us a little closer. **R-E**