PC-TO-TV CONVERTER

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Put PC power into home videos with this VGA to NTSC television adapter.

WITH OUR VGA TO NTSC VIDEO CONVERTER, you can have video production right at your fingertips. A part of multimedia is connecting your computer to the outside video world. In the past, $100,000 computer-controlled video consoles were required to produce many video effects you see today. Now with animation software, a video tape recorder, and this video converter board we present here, it's possible to turn your PC into a home video production studio!

You don't even need the latest equipment. If you have a VCR and a PC that's compatible with a video graphics array (VGA) video card, you're on your way. Creating your own TV video productions, insert-editing titles on home videos, or playing computer games over a projection TV are

just some of the many exciting possibilities that await you if you build our video converter.

Displaying a computer video picture on a VCR requires a VGA-to-NTSC signal converter. The converter board mounts in the computer and is connected in line with the computer's VGA monitor cable. A memory-resident software program monitors the VGA board, and with a key stroke on the computer, it can be turned on or off.

When conversion is off, the computer monitor displays normal VGA video. When conversion is on, the board converts the VGA monitor display and outputs NTSC broadcast-quality signals for recording. The conversion is in real time and is fast enough to display full-action computer games.

Computer video

In the early days of personal computers, video monitoring suffered because the circuit designs had to use low-density, high-cost memory components. Various innovative display formats were developed in order to store video text and video graphics with less memory. That need for efficiency started the computer graphics monitor design down a path of noncompatibility with standard broadcast video.

Lately, the VGA standard has become widely accepted. With VGA, a picture is displayed on a video monitor in a serial fashion. Figure 1-*a* shows how the picture is painted one line at a time. The picture starts at the top of the screen and traces, line by line, until reaching the bottom of the picture. That is repeated fast
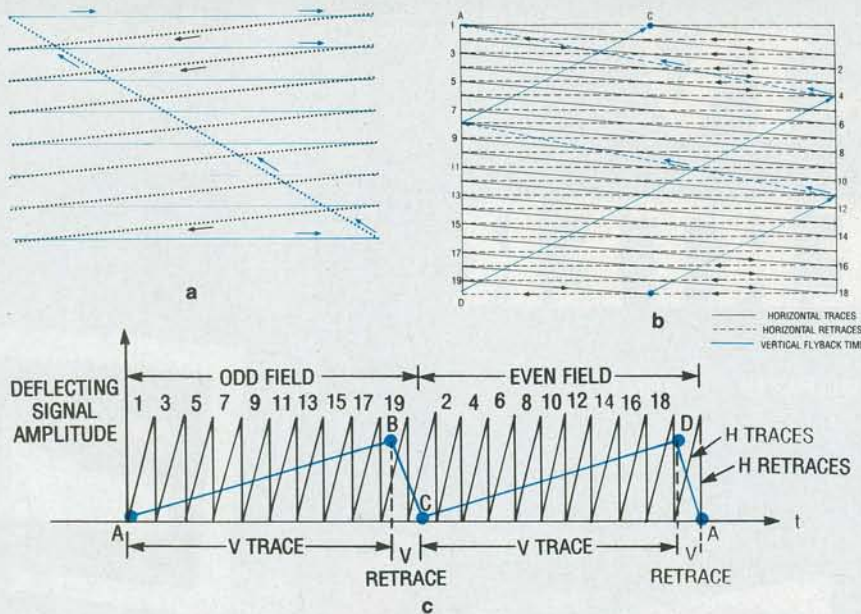
FIG. 1—DOT SCANNING OF THE PICTURE TUBE creates the image that you see. VGA uses a noninterlaced technique which scans once to make a complete picture (*a*), NTSC uses an interlaced method to scan twice to make a complete picture (+*hbib* +*hb*). The amplitude of the deflected signal versus time is shown in *c*.

enough so the eye sees a continuous picture without flicker. Control, or sync signals are also sent to the monitor to align the picture properly on the screen. An NTSC signal scans twice in an interlaced mode to make a complete picture (Fig. 1-*b*).

The difference in the control and sync signals between VGA and NTSC makes it impossible to display a VGA picture on standard television without a format converter. Conversion from VGA to NTSC is not an easy task. Let's see how those systems work.

VGA versus NTSC standards

VGA boards have become very popular in recent years. The VGA standard has several modes of operation for compatibility with existing software. Those different modes define the control signals that generate the horizontal, vertical, and pixel clocking rates. The horizontal rate is the time it takes to paint one line from left to right across the face of the video monitor. The pixel clock sets the dots of resolution for each horizontal line. The vertical timing sets how many horizontal lines that make up the whole picture from the top to the bottom of the display.

PC video standards and operating frequencies can differ greatly, depending on the type of monitor used. For instance, a 640×X400 mono/color VGA monitor has a video bandwidth (dot rate) of 25.175 MHz with a horizontal scan rate of 31.5 kHz, while a 640×X350 EGA monitor has a 16.257-MHz bandwidth with a 21.85-kHz horizontal scan rate. Other mono and color monitors, such as CGA, MDA, HGC, and MCGA also have different video bandwidths and horizontal and vertical scan rates. The VGA signaling to the computer monitor consists of multiple signal lines. Figure 2 shows that three independent signal lines carry the actual analog video in a red, green, and blue (RGB) format, one color per line. One other line carries the horizontal sync pulses, and another line carries the vertical sync pulses. Some of the various VGA modes are indicated by the polarity of the two sync signals. Table 1 shows the relationship between sync polarity and the VGA mode. As we will see, VGA technology differs greatly from the NTSC broadcast standard.

NTSC is the standard used by television broadcasters in the United States. Video cassette recorders (VCR's) and cameras/ camcorders also use that same standard. The NTSC signal is a composite of all the signals necessary to generate a broadcast quality picture. The three analog color signals are combined together with the horizontal and vertical sync signals and color subcarrier to make up the total NTSC signal.

The NTSC sync signals and color subcarrier are fixed in their frequencies; the horizontal scanning frequency is 15,734.26 Hz,

TABLE 1—SYNC POLARITY AND VGA MODE RELATIONSHIP

Fixed-Frequency Monitor				
Display Mode	Horizontal Sync Frequency	Polarity	Vertical Sync Frequency	Polarity
350 lines	31.5 kHz	+	70.1 Hz	−
200 lines	31.5 kHz	−	70.1 Hz	+
400 lines	31.5 kHz	−	70.1 Hz	+
480 lines	31.5 kHz	−	59.9 Hz	−
132 columns	31.5 kHz	−	70.0 Hz	+
Multi-Frequency Monitor				
350 lines	31.5 kHz	+	62.3 Hz	−
200 lines	31.5 kHz	−	62.3 Hz	+
400 lines	28.0 kHz	−	62.3 Hz	+
480 lines	31.5 kHz	−	59.9 Hz	−
132 columns	27.6 kHz	−	61.5 Hz	+
600**	35.2 kHz	−	56.2 Hz	−
768†	35.5 kHz	+	86.9 Hz	+

**800×600 Graphics
† 1024×768 interlaced graphics

Video Signals
Black level = 0V
Full intensity level = +0.7V

VGA MONITOR CABLE PIN OUTS

PIN	FUNCTION	SIGNAL
1	RED VIDEO	
2	GREEN VIDEO	
3	BLUE VIDEO	
5		
6		
7	GROUNDS	
8		
10		
13	HORIZONTAL SYNC	
14	VERTICAL SYNC	

FIG. 2—THESE ARE THE PINOUTS OF A VGA MONITOR CABLE, with their corresponding signals. Note that pin 15 is not used.
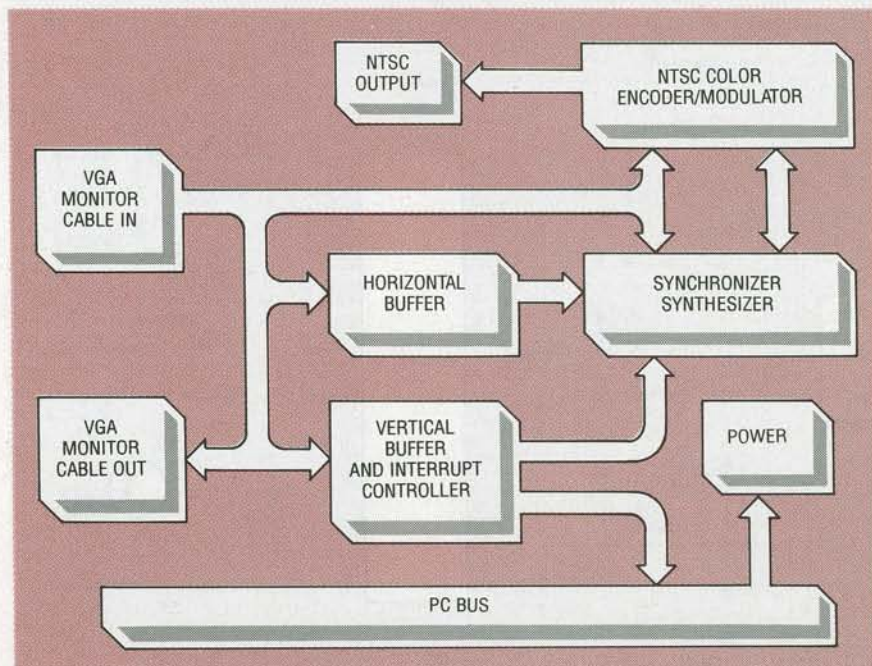

FIG. 3—BLOCK DIAGRAM OF THE BROADCAST VIDEO CONVERTER. The unit consists of two main sections; an NTSC color encoder/modulator and an NTSC synchronizer synthesizer.

the vertical scanning frequency is 59.94 Hz, and the color subcarrier frequency is 3.579545 MHz. By contrast, the different VGA modes have different horizontal and vertical timing rates, depending on the video mode chosen.

Another difference between VGA and NTSC is the field scanning. NTSC uses interlacing, which scans the picture tube twice per picture (Fig. 1-b). There is one scan for the even lines and another scan to fill in between

the evens with the odd numbered lines, making one complete picture. Most modes in VGA, on the other hand, use noninterlaced scanning, where the complete picture is painted in only one pass over the face of the picture tube.

The challenge of converting from VGA to NTSC standards involves stripping off the VGA horizontal and vertical control signals, changing the video timing, and recombining properly generated NTSC horizontal and ver-

tical sync. The three color signals are then mixed and added to the color subcarrier, finishing the job.

About the circuit

The video converter's power and software-interrupt control signals are supplied directly from the PC bus. The video signals from the VGA board are connected to the converter using the VGA monitor cable. The computer monitor is then plugged into the converter board by another VGA monitor cable. An RCA jack on the converter board is used to supply the NTSC video signal output.

Figure 3 shows a block diagram of the video converter, and the schematic is shown in Fig. 4. The circuit consists of two main parts: an NTSC color encoder/modulator, IC1, and the NTSC sync generator, IC2. Horizontal and vertical VGA sync signals from the VGA connector (pins 4 and 5 of P1) are buffered by R32, R33, IC3-a, -b, and -d before driving IC2. The vertical sync is also conditioned by R10, R11, C12, and IC3-c. Those conditioned signals are narrow pulses, which drive Q2. The collector of Q2 and R17 are wired ORED to the PC bus interrupt request input (IRQ2), which tells the computer when conversion begins.

Two input clocks are required by IC2: The 14.31818-MHz crystal, XTAL1, and components R19–R21, C21–C23, and D1 make up a phase-locked oscillator clock that's generates the color subcarrier and runs the internal workings of IC2. Components L4, C25–C28, R24–R26, and D2 make up the second clock oscillator, which is used to combine all the necessary sync signals together.

The output of IC2 is the composite NTSC synchronizing signal (pin 21) and the color subcarrier (pin 27). The subcarrier signal is buffered by R31 and IC3-e. Components R12, C16, and C33 reduce the subcarrier amplitude to match IC1's input. The NTSC composite sync and color subcarrier signals are then applied to the NTSC color encoder/modulator.

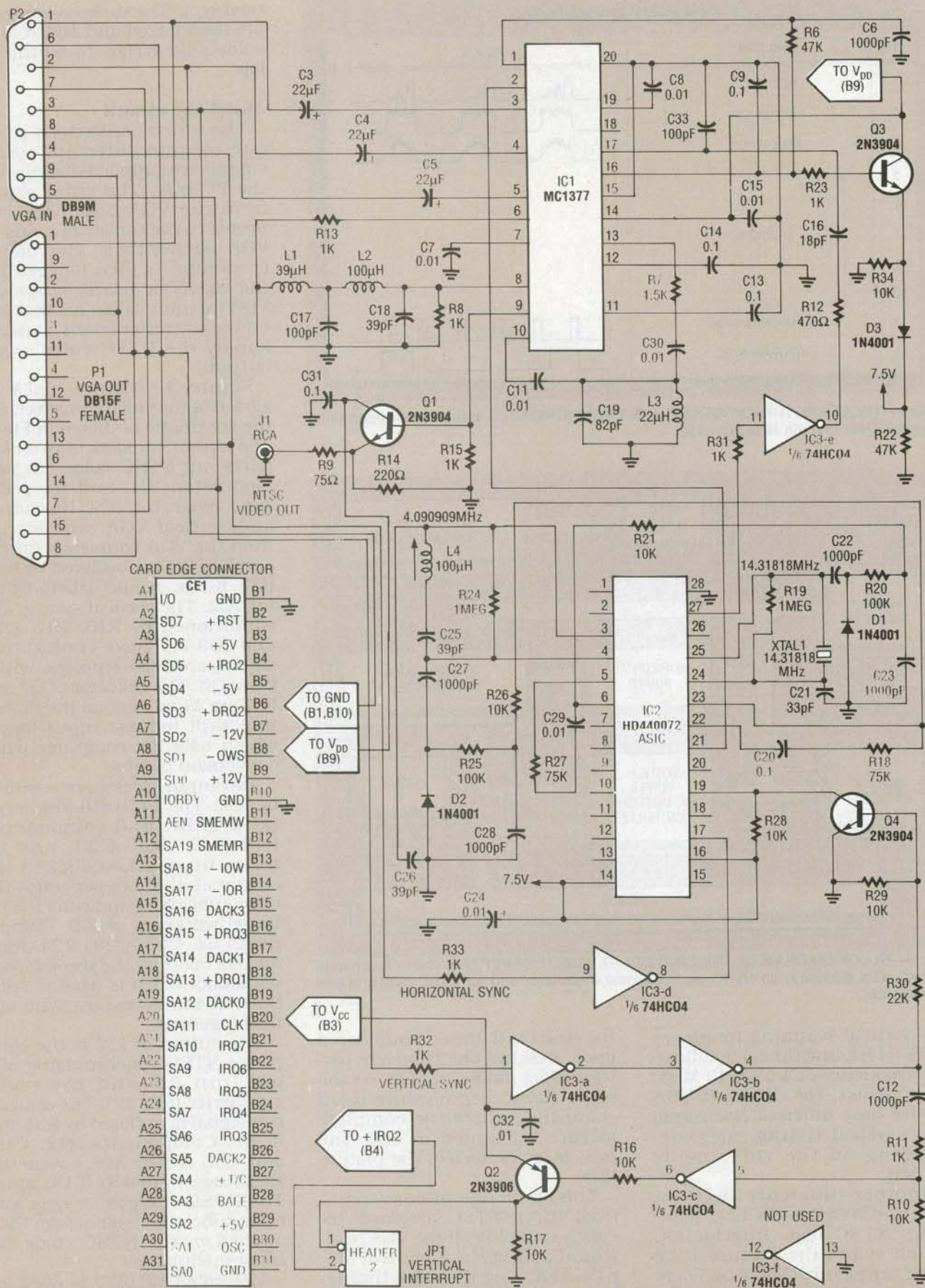Motorola's MC1377 is used for the NTSC modulator, IC1. The VGA RGB signals are applied

FIG. 4—THE SCHEMATIC OF THE VIDEO CONVERTER. IC2 is used for computer control, as an NTSC signal synthesizer, and for NTSC composite sync and subcarrier output. IC1 is an NTSC modulator; a 200 µs-delay circuit is used to align the luminance part of the picture with the chrominance part.
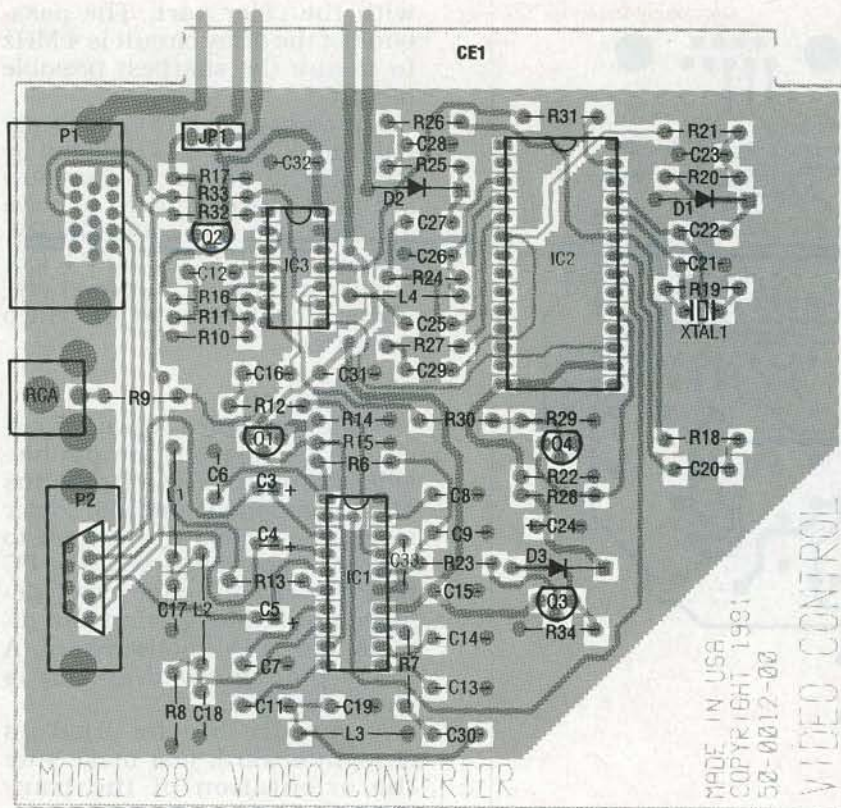
FIG. 5—PARTS PLACEMENT DIAGRAM. The square pads on the PC board indicate the positive leads for polarized capacitors, the cathode of diodes, and pin 1 of the IC's.

through the VGA connector pins 1–3. Components C3–C5 block any DC on the video. A chrominance bandpass filter consisting of R7, C11, C19, C30, and L3 reduces mixing harmonics. That filter introduces a 200-µs delay to the color image. A 200-µs delay circuit consisting of R8, R13, C17, C18, L1, and L2 was added in the luminance path to match the delay of the chrominance circuit, which makes the black and white part of the picture line up

VGA CABLE WIRING	
15 PIN	9 PIN
1	3
2	4
3	5
4	(NO CONNECTION)
5	(NO CONNECTION)
6	2
7	6
8	7
9	(NO CONNECTION)
10	1
11	1
12	(NO CONNECTION)
13	8
14	9
15	(NO CONNECTION)
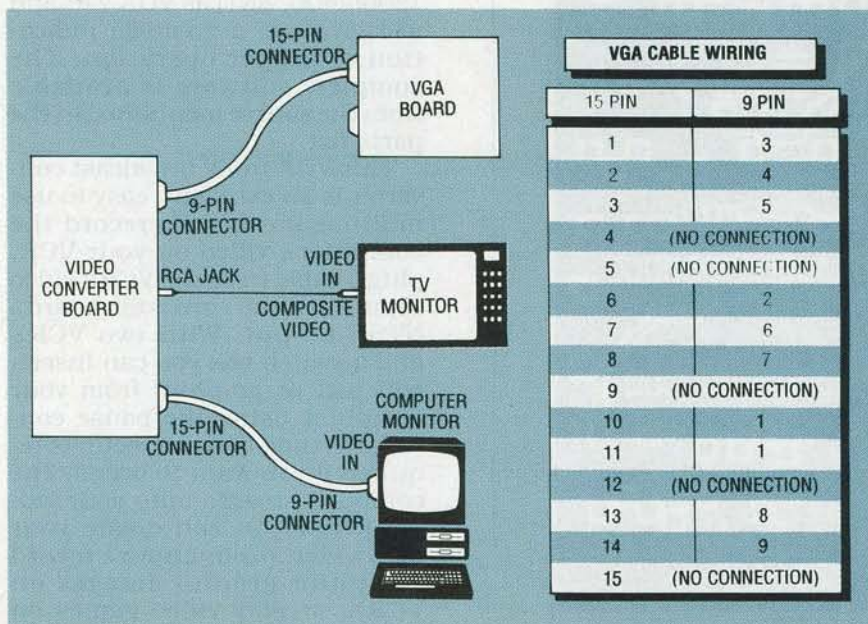
FIG. 6—HERE IS THE HOOKUP DIAGRAM for the video converter.

4¼ INCHES

THIS IS THE FOIL PATTERN of the component side of the PC board.

MODEL 28 VIDEO CONVERTER

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VIDEO CONTROL
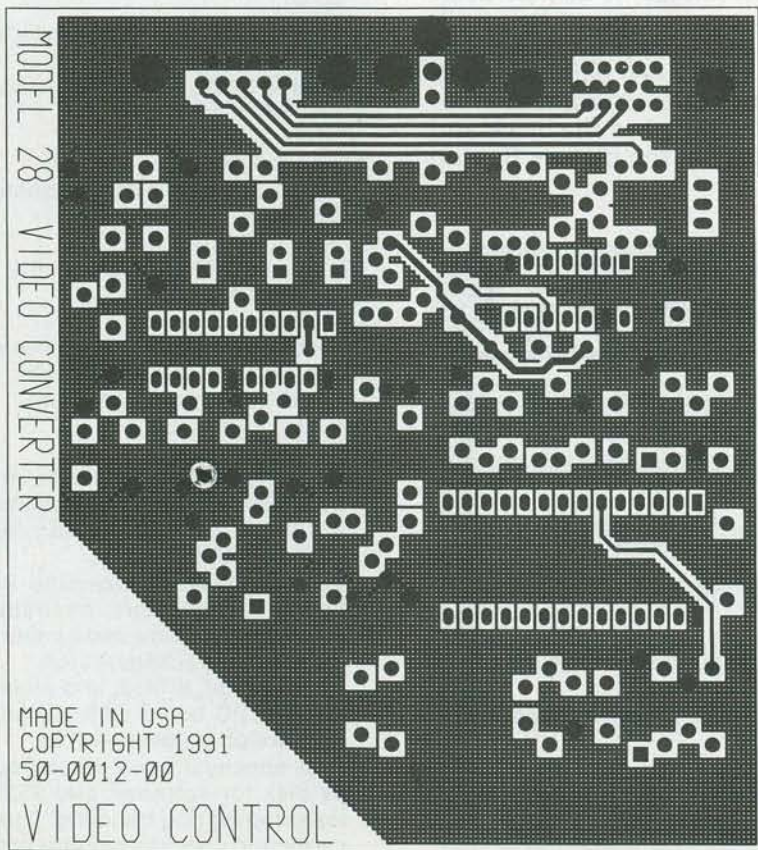
4¼ INCHES

RADIO-ELECTRONICS

HERE IS THE FOIL PATTERN of the solder side of the PC board.

with the color part. The pass-band of the delay circuit is 4 MHz to ensure the sharpest possible picture.

The composite NTSC video signal from IC1 pin 9 is buffered by R14, R15, and Q1. A 75-ohm output impedance required to drive a video cable is provided by R9. Components R22, R23, R34, Q3, and D3 make up IC2's power regulator. Now let's build the video converter.

Construction

The entire video converter circuit is located on one double-sided PC board. The foil patterns of the component side and solder side are provided if you wish to make the board yourself. The PC board is a card-edge type, designed to fit into a short slot directly into a PC motherboard. A parts-placement diagram is shown in Fig 5.

Assembly of the unit is straightforward, just make sure the orientation of the transistors, diodes, electrolytic capacitors, and IC's is correct. The positive (+) leads for polarized capacitors, the cathode of diodes, and pin 1 of the IC's are identified by a square pad on the board. After soldering, visually inspect it to make sure there are no solder bridges between closely spaced traces.

To test the board, hook it up as shown in Fig. 6. A test program is available on the **Radio-Electronics** BBS (516-293-2283, 1200/2400, 8N1) as VGA.ZIP, and will give you a go/no-go indication of proper operation. The complete software is available from the source mentioned in the parts list.

This VGA to TV broadcast converter is an excellent, easy to use multimedia tool. To record the computer's video on your VCR, plug a cable from the VCR's video input into the converter board's NTSC output. With two VCR's and a switch box you can insert-edit text or graphics from your computer using the pause controls. (A time-base corrector is required if you want to overlay the computer images onto your videos.) Now you can create your own video productions, record computer graphic images on VCR's, or play video games on projection TV. **R-E**