AUDIO/VIDEO SWITCHER

Eliminate the mess and confusion of wires that lurks behind your audio and video equipment with this easy to build switcher.

TOD T. TEMPLIN

HAS YOUR VIDEO SYSTEM BECOME OVER-run with a tangle of patch cords, jumper cables, and wires? Do you have to grope around in the restricted space behind your VCR when you want to make a dub? Have you ever wanted to view one program while copying another? If the rat's nest of wires is keeping you from getting the most out of your equipment, then you need the same type of equipment-interconnection system used by professional video operations and television stations. You need an audio/video routing switcher.

We'll show you how to build a 4 × 1 electronic stereo-audio and video crosspoint switcher. It will enable you to select one out of four signal sources (consisting of a video signal and a stereo-audio signal), and connect it to an output bus which can supply an input signal for up to four additional devices. That, of course, can be done by merely pressing a button. You'll never have to touch another cable or jumper again. This device is not a simple mechanical RF-type switcher. This switcher was originally designed to expand the number of inputs on professional videotape recorders and monitors in a commercial television studio. Also, the technical specifications (shown in Table 1) are so good that the device is virtually transparent to any signal passing through it.

TABLE 1—SPECIFICATIONS

Audio Section	
Frequency Response	−1, +0dB 30Hz - 20KHz
S/N Ratio	75dB at 5V Input Level
Cross-Channel Isolation	62dB
Input Impedance	Greater than 50 Kilohms
Output Impedance	Kilohm
THD	.07% at 20Hz .04% at 1KHz .03% at 20KHz
Video Section	
Frequency Response	DC - 8MHz
Cross-Channel Isolation	70dB
Input Impedance	75 ohms
Output Impedance	75 ohms
Differential Phase	−0, +3 degrees
Differential Gain	Less than 3%

Consumer VCR's and monitors rarely have more than one set of inputs and outputs. But consumers often have several signal sources, including a second VCR, a video disc or CD-video player, an image enhancer or noise reducer, or perhaps a special effects generator. If your system has several signal sources and you want to drive more than one monitor or VCR simultaneously, there is no simple way to connect them all together into an easy to use, versatile, and functional system. Just making a simple A to B dub may result in a maze of patch cables, Y-adapters, and double-terminated signals. And, since most VCR's and monitors have their input/output jacks located on the rear panel, getting to the connections can be a difficult and frustrating task.

The 4 × 1 switcher eliminates those problems by allowing all of your audio and video equipment to be connected together in one totally-integrated, "patchless" system. That is accomplished by placing one 4 × 1 switcher at the input of each device that must receive a signal from more than one source, and then connecting each device's output to the inputs of each switcher. Each switcher has a four-output bus, so that any signal can be connected to four devices. Operation of the switcher is very simple. By pressing any one of the switches (S1–S4), the corresponding signal source is connected to the output bus. Because each switcher has a built-in distribution amplifier, up to four loads can be connected to the output bus. The block diagram for the device shown in Fig. 1 clearly shows how the four signal sources are multiplexed to one output bus.

Until recently, it would have been impossible to build a switcher of such

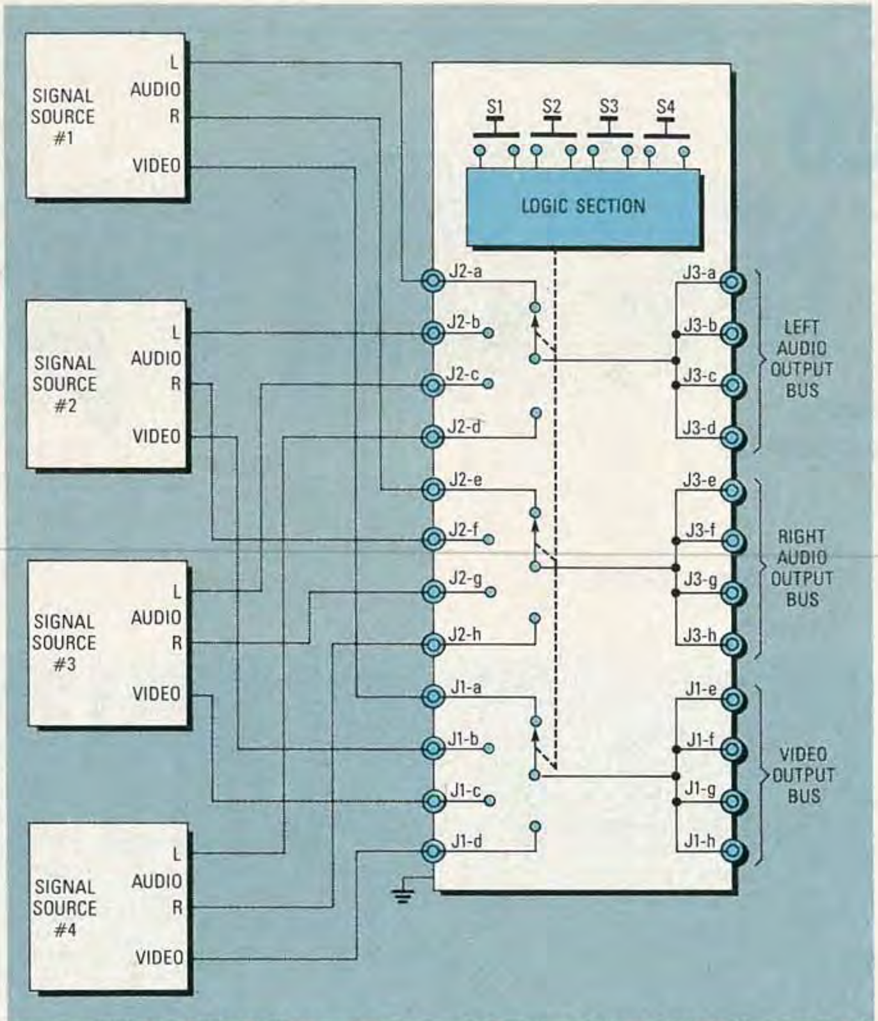

FIG. 1—THIS BLOCK DIAGRAM shows how one out of four signal sources can be switched to one output bus.

high quality using so few parts. However, new IC's are now available, which are specifically designed for audio and video switching. The MAX454 from Maxim Integrated Products (510 N. Pastoria Ave. Sunnyvale, CA 95054 408-737-7600) combines a CMOS 50-MHz video amplifier and 4-channel multiplexer in a single package. The TDA1029 from Signetics does the same for stereo-audio signals. It contains two 4-channel multiplexers plus input and output buffer amplifiers designed for audio frequencies.

Logic circuit

The complete schematic for the 4 × 1 audio/video switcher is shown in Fig. 2; we'll begin our analysis with the logic section. Selector switches S1–S4 are connected via diodes D1–D8 to the four NAND gates in IC1. Those gates are configured as a cross-coupled SET/RESET flip flop (latch) and a 2-bit *B*inary *C*oded *D*ecimal (BCD) encoder. The outputs of IC1 are connected to the inputs of IC2 (another quad NAND gate), which decodes the latched information from IC1 back to decimal format, where it is used to light the LED of the selected channel and to drive the audio-channel-selector pins of IC5. The BCD information from IC1 is used to drive the video-channel-selector pins of IC3. Note that IC5 requires decimal information while IC3 requires BCD information.

To understand the operation of the logic circuit, suppose you have just pressed S4. A low (ground) signal is routed simultaneously through D7 and D8 to IC1-a and IC1-c. A low on either input of the gate will cause its output to go high, so we now have highs on the outputs of IC1-a and IC1-c. Those high levels are cross-connected to one set of inputs of IC1-b and IC1-d, and the other set of inputs are being pulled high by resistors R2 and R4. That action causes the outputs of IC1-b and IC1-d to go low. Those low signals are again cross connected to the other set of inputs of IC1-a and IC1-c. We now have lows at both inputs of IC1-a and IC1-c, and highs at both inputs of IC1-b and IC1-d. That results in a steady state or "latched" condition in the circuit. The entire sequence, which happens almost instantaneously, also serves to de-bounce the switches. The two high outputs from IC1-a and IC1-b now also appear at both inputs of NAND gate IC1-b, causing its output to go low and light LED4 as well as select channel 4 of the audio switcher, IC5. The outputs of IC1-a and IC1-c also make up a 2 bit BCD "word" which defines the condition of the latch. Because both IC1-a and IC1-c outputs are now high, channel 4 is selected by the video switcher, IC3.

Audio circuit

The audio section of the switcher is contained entirely in IC5, a complete stereo-audio, 4-channel switcher. Based on information fed to pins 11–13 from the logic section, it selects a pair of inputs and passes them through an on-chip op-amp buffer to the audio-output bus. DC decoupling for the inputs is provided by C11–C18, which also establish the low-frequency cut-off point of the circuit. The outputs are decoupled by C19 and C20. Technical specifications for the audio section include a frequency response from 30 Hz to 20 kHz, a S/N ratio of 75 dB with an input level of 0.5 volts, and a cross-channel isolation of 62 dB. The input impedance is greater than 50K, and the output impedance is about 1K. The total harmonic distortion for the audio section is 0.07% at 20 Hz, 0.04% at 1 kHz, and 0.03% at 20 kHz.

Video circuit

The video section of the switcher is made up of two IC's connected in a unity-gain feedback loop. IC3 is a 4-channel CMOS video switch which also has an on-chip buffer amplifier. Because IC3 can drive only one 75-ohm load, a wideband power op-amp (IC4) was added to the circuit to increase the number of video outputs. BCD information from the logic section determines which of the 4 inputs is passed via IC3 to IC4. The buffer amp in IC3 is loaded by R11, while R10 and R12 set the entire circuit to unity gain. The output impedance of

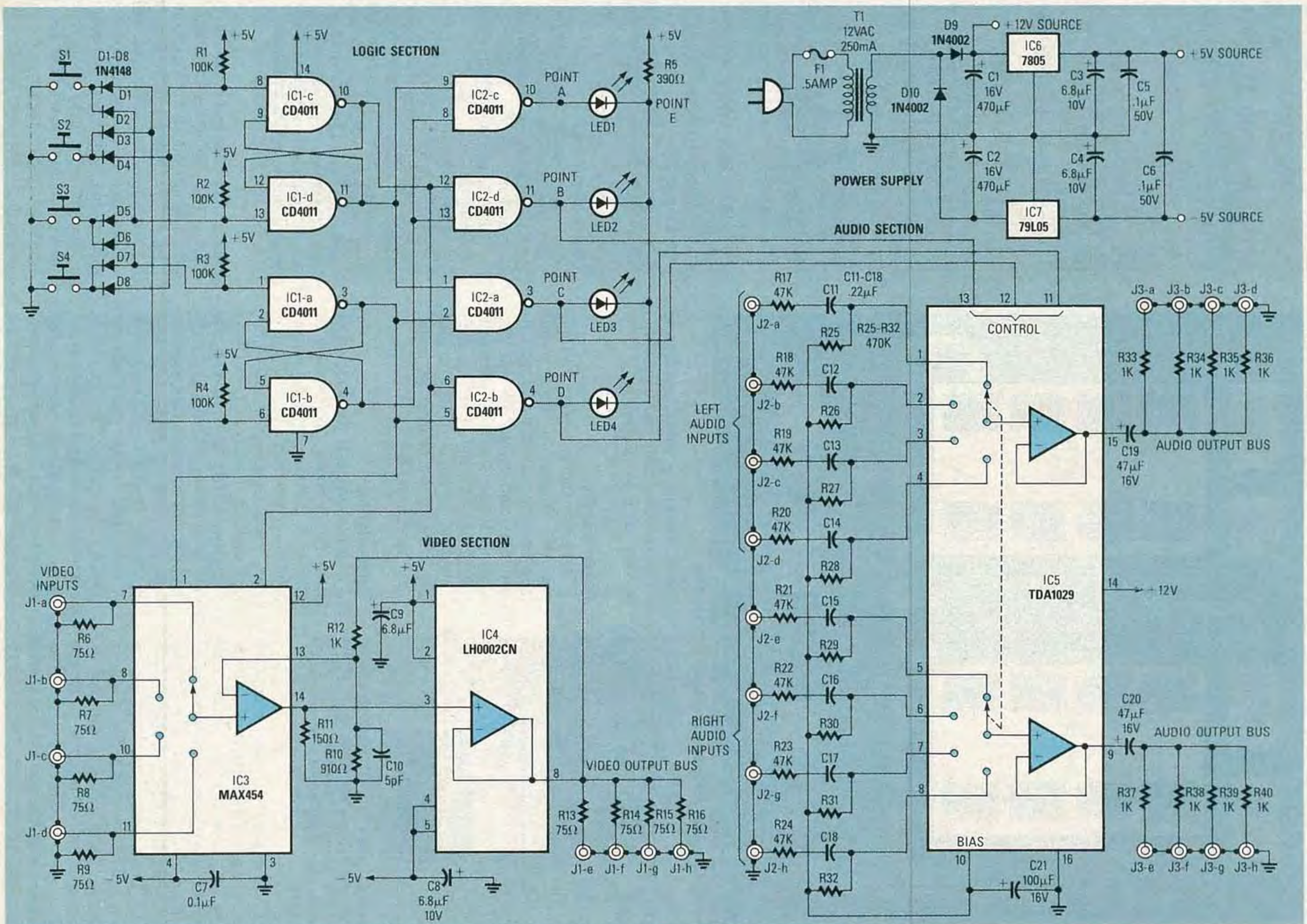

FIG. 2—THIS COMPLETE SCHEMATIC for the 4×1 switcher contains the three different sections, and the power supply.

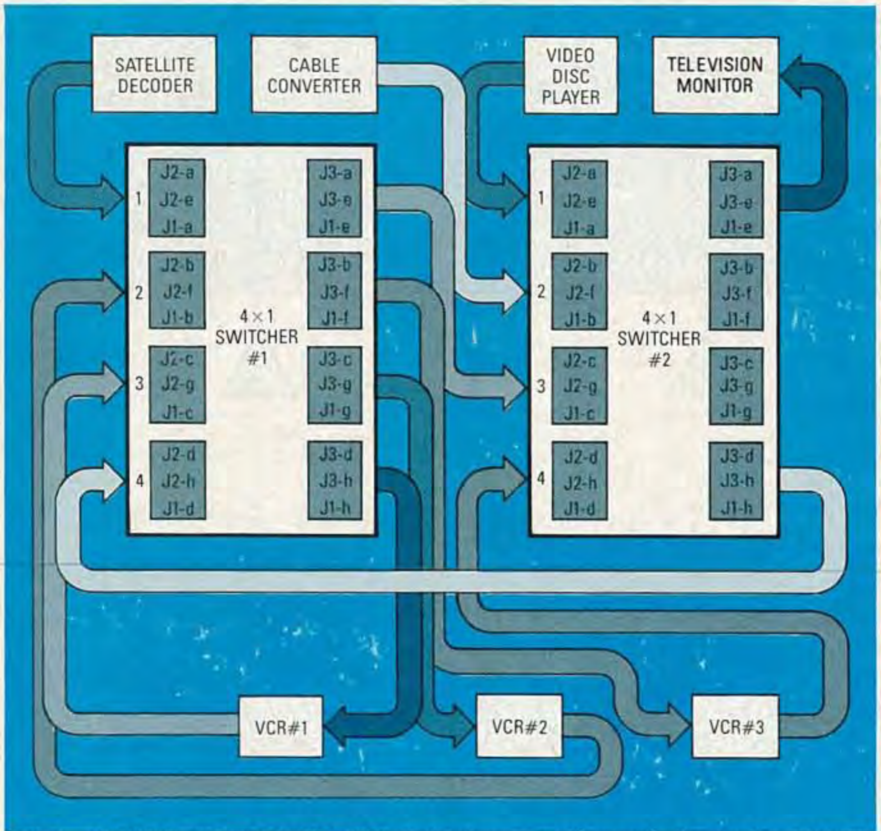

FIG. 3—ALMOST ANY COMBINATION of viewing, recording, or both, can be achieved using this setup which contains two 4×1 switchers.

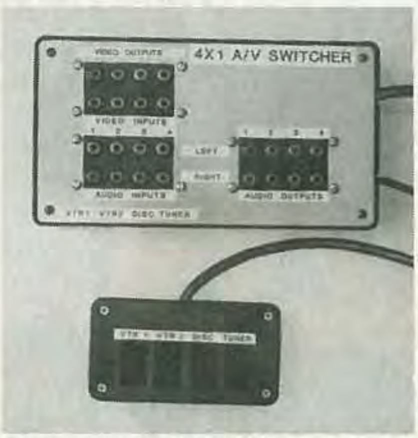

FIG. 4—THIS 4×1 SWITCHER has a separate control box which allows all of the messy wiring to be hidden out of sight, while controlling it from a convenient location.

IC4 is so low that its output approximates a zero-impedance voltage source. Consequently, loads connected to the output resistors have no effect on one another. The 75-ohm resistors, R13–R16, establish the correct drive-source impedance for 75-ohm cable as well as short-circuit protection for IC4. C10 establishes the upper-frequency response of the circuit. With C10 being 5 pF, the frequency response for the video section is virtually flat from DC to about 8MHz. The cross-channel isolation is 70 dB, and the input and output impedance are both 75 ohms.

Power supply

The power supply is not at all complicated. 12 volts AC from a wall transformer is rectified by D9 and D10 into plus and minus 12-volt DC sources. Ripple filtering is provided by C1 and C2, and +12V is then tapped off to supply IC5. The plus and minus 5-volt sources are regulated by IC6 and IC7.

Video signals

It is important that you understand a few basics about video signals in general. Standard composite video is defined as *1 volt from sync tip to maximum white level*, across a 75-ohm load, and contains signals from DC to as high as 5 MHz. Because of those high frequencies, video signals require special attention; they must always be connected between devices by 75-ohm shielded cable, and must be terminated into a 75-ohm load impedance. If a constant 75-ohm impedance is not maintained throughout the system, an impedance mismatch between the source and load will occur, causing some of the video signal to be reflected back from the load to the source. The visible result of that is reflections or "ghosts" in the picture.

Each 4×1 switcher has four inputs and one output bus. Therefore, only one out of four inputs may be connected to the output bus, and supply an input signal for up to four devices. Chances are that one switcher will be sufficient for the average person's video system. However, by building two

PARTS LIST

All resistors ¼-watt, 5% unless otherwise noted
R1–R4—100,000 ohms
R5—390 ohms
R6–R9, R13–R16—75 ohms
R10—910 ohms
R11—150 ohms
R12, R33–R40—1,000 ohms
R17–R24—47,000 ohms
R25–R32—470,000 ohms

Capacitors
C1, C2—470 μF, 16 volts, radial electrolytic
C3, C4, C8, C9—6.8 μF, 10 volts, radial tantalum
C5–C7—0.1 μF, metal film
C10—5 pF, mica or disc (see text)
C11–C18—0.22 μF, metal film
C19, C20—47 μF, 16 volts axial electrolytic
C21—100 μF, 16 volts, radial electrolytic

Semiconductors
D1–D8—1N4148 diode
D9, D10—1N4002 diode
IC1, IC2—CD4011 CMOS quad NAND
IC3—MAX454 video switch/amplifier (Maxim)
IC4—LH0002CN power op-amp (National)
IC5—TDA1029 audio switch/amplifier (Signetics)
IC6—7805 positive voltage regulator
IC7—79L05 negative voltage regulator
LED 1–LED 4—red LED's

Other components
J1–J3—octal-type RCA jacks, or select jacks to suit needs
S1–S4—SPST momentary push button switch
T1—12VAC, 250 mA, plug-in wall transformer

Miscellaneous
1 chassis of your choice

NOTE: The following items are available from T3 Research, 5329 N. Navajo Ave., Glendale WI 53217-5036: 4×1 PC board, $10.00 postpaid; MAX454, LH0002CN, and TDA1029N (1 of each type), $18.50 postpaid; Wisconsin residents must add 5% sales tax.

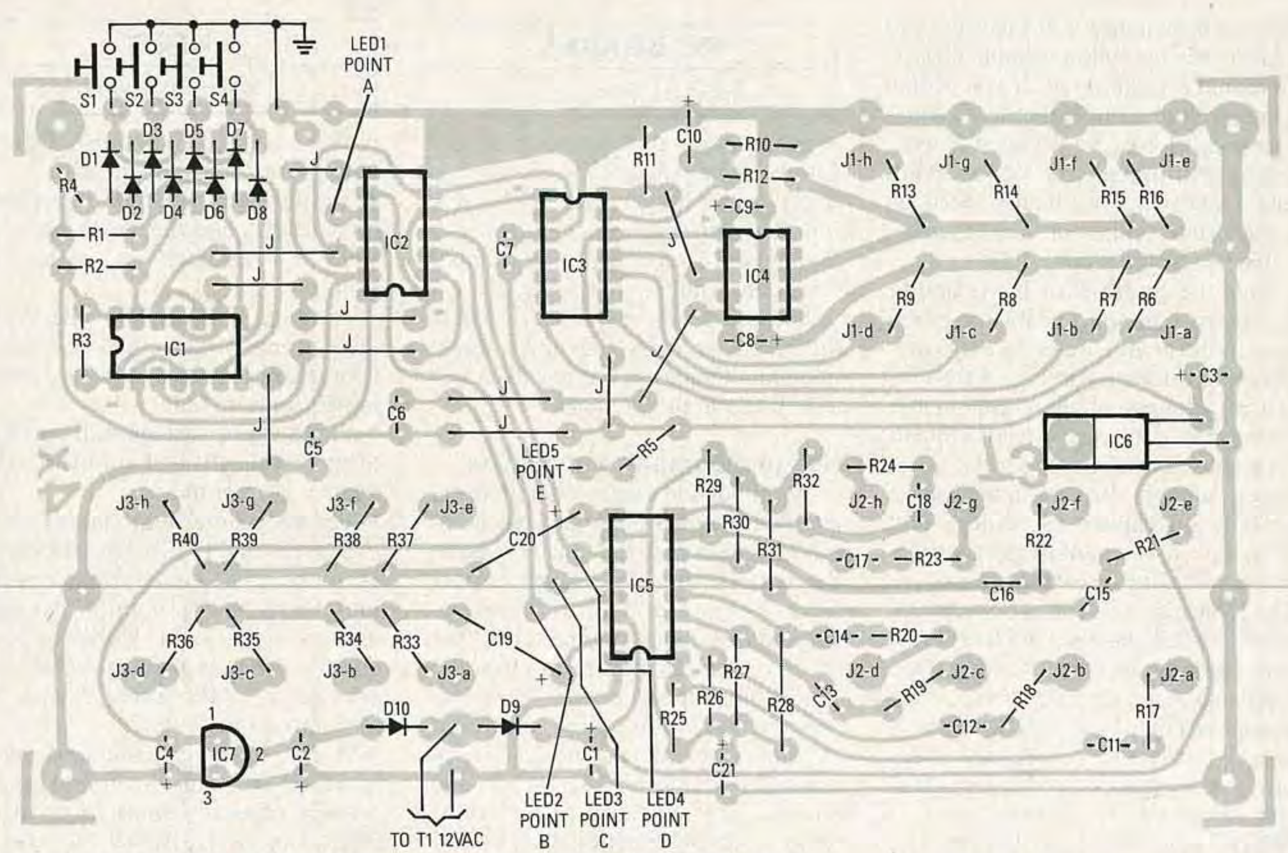

FIG. 5—REFER TO THIS parts-placement diagram when assembling the PC board.

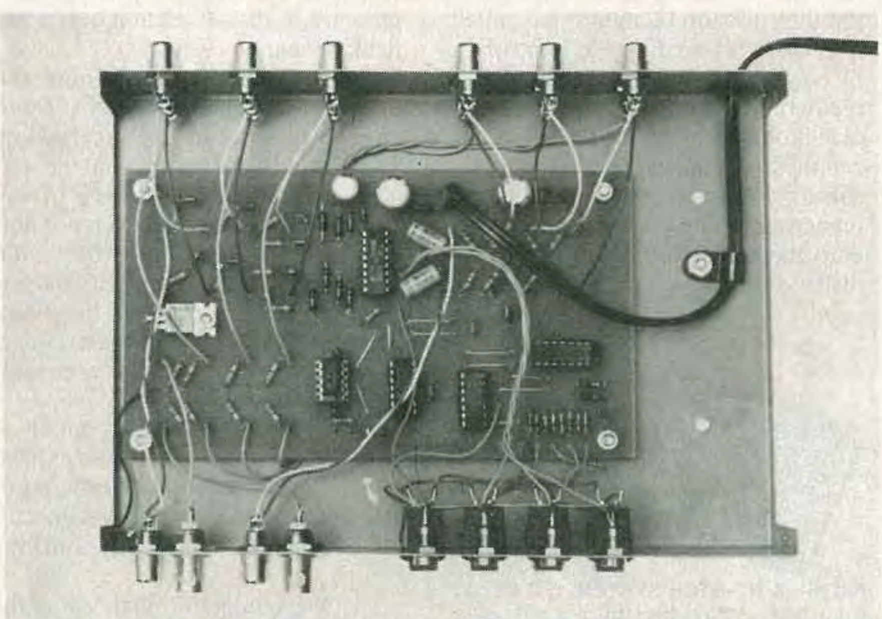

FIG. 6—YOU CAN MOUNT the completed PC board on the bottom of the chassis, and wire the jacks on the sides as shown.

or more 4 × 1 switchers, you can put together a system similar to that in Fig. 3. That system provides for just about any possible combination of viewing, recording, or both. Of course, the number of switchers you'll need and how you wire them together depends on your particular system's requirements.

Construction

Before assembling your switcher, it's a good idea to sketch out how you want to connect your equipment together. You probably require only one 4 × 1 switcher. But, if you have a more complex system, make a diagram like that of Fig. 3, to see how many switchers you'll need. During actual construction, you can then install as many switchers as you need in one chassis of an appropriate size. Note that a PC board can be purchased from the source mentioned in the parts list, or one can be made using the foil pattern shown in the PC Service. Remember, you'll need one 4 × 1 circuit board, and complete set of components for each switcher that you build.

There are two ways that the 4 × 1 switcher can be assembled. Although they perform identically, they are quite different in concept. In one model, shown in the opening of this article, the circuit board, input/output jacks, and selector switches are all mounted in a conventional chassis. That arrangement brings all of your system's interconnecting cables to wherever your switcher is located. That is certainly fine if you only need one switcher. In the other model, the selector switches and LED's are located in a separate control box and connected to the switcher by a 10-conductor cable, as shown in Fig. 4. In the cable, four conductors and one common are used for the switches, and the same goes for the LED's. That allows the main chassis to be located behind your equipment.

After you decide what configuration your switcher will take on, you must come up with a suitable chassis to mount everything in. If you decide to go with the model that has a separate control box, you'll need a separate case to mount the four switches and LED's in. You'll also need an appropriate length of 10-conductor cable to reach the control box.

Start the construction by mounting all of the components flush against the circuit board. Refer to the parts-placement diagram in Fig. 5 for correct positioning of the components. Save some of the excess leads clipped from those components for the 11 required jumpers. Be certain to observe polarity on capacitors, diodes and IC's, and use standard precautions when handling the static-sensitive IC's. Note that you can use 8-pin (octal) RCA-jack panels, which cost less than separate RCA jacks. Also, they can be soldered directly to the circuit board, eliminating a good deal of wiring. If you choose octal jacks, make sure that the jacks are the *last* items you install on the board. Also, be certain you wire together all the ground tabs on each jack before you solder it down to the board. Leave enough wire on the end tab so that it can reach down to the ground hole on the circuit board.

Once the board is complete, all that is left to do is to mount it in the chosen chassis, and add the appropriate wiring. When finished, it should look similar to the one shown in Fig. 6. (Note that Fig. 6 shows the unit in which everything is contained in one chassis.) It is then ready to be hooked up to your video system and tested. Should any problems arise, go back and check your work.

Normally, if the 4×1 switcher is built totally from fixed-value components, it will perform as indicated in the specification chart, with no adjustments required. However, increasing the value of C10 (in the video section) will cause the video frequency response to tilt upwards. It is possible to compensate for high-frequency roll-off, caused by extremely long cable runs, by replacing C10 with a 5–20pf trimmer capacitor. That creates what is known as an equalizing DA (*D*istribution *A*mplifier). While observing a multiburst test signal, C10 is adjusted for a flat response. Don't be concerned about the problem of roll-off if your cables are less than 250 feet long. **R-E**

PC SERVICE

One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

We've moved all the foil patterns to this new section where they're printed by themselves, full sized, with nothing on the back side of the page. What that means for you is that the printed page can be used directly to produce PC boards!

Note: The patterns provided can be used directly only for *direct positive photoresist methods.*

In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and/or on a light table. Look for breaks in the traces, bridges between traces, and in general, all the kinds of things you look for in the final etched board. You can clean up the published artwork the same way you clean up you own artwork. Drafting tape and graphic aids can fix incomplete traces and doughnuts, and you can use a hobby knife to get rid of bridges and dirt.

An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper transluscent. Don't get any on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are used to.

We can't tell you exactly how long an exposure time you will need as it depends on many factors but, as a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method for you. And once you find it, stick with it.

Finally, we would like to hear how you make out using our method. Write and tell us of your successes, and failures, and what techniques work best for you. Address your letters to:

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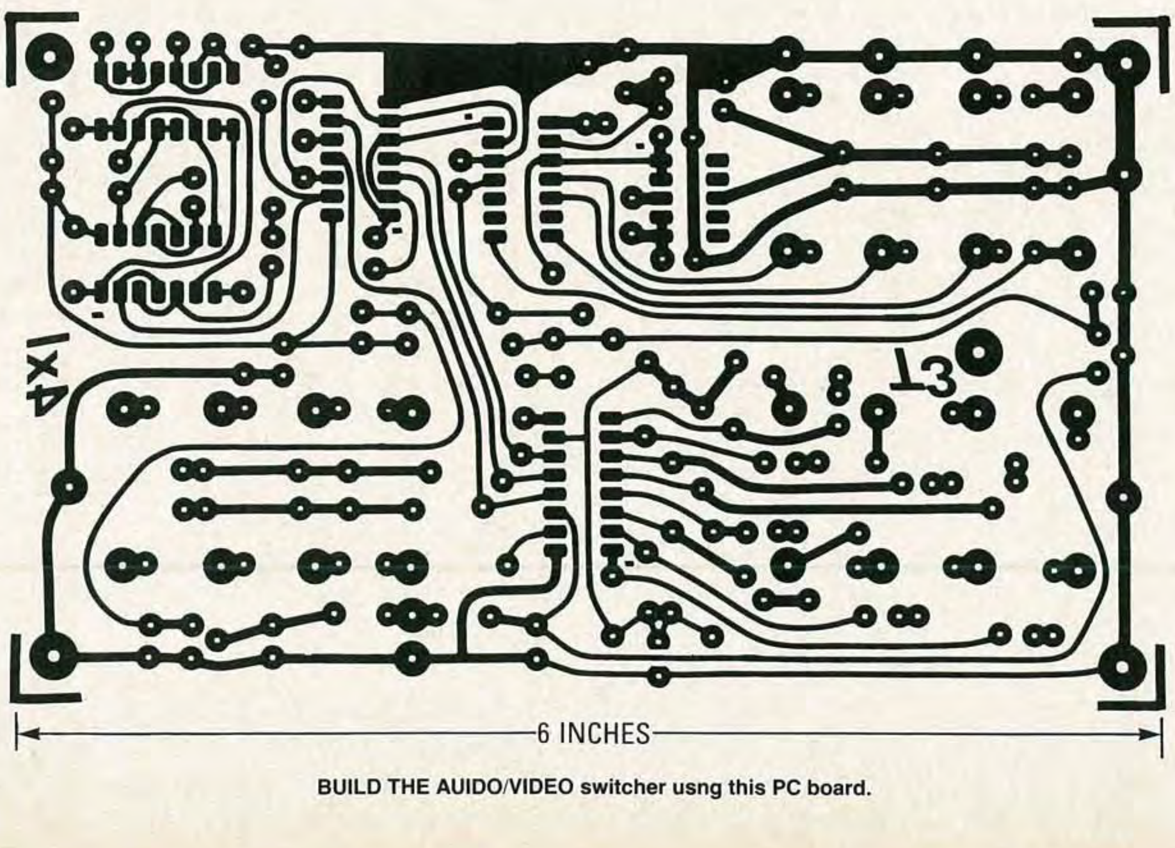

BUILD THE AUIDO/VIDEO switcher usng this PC board.