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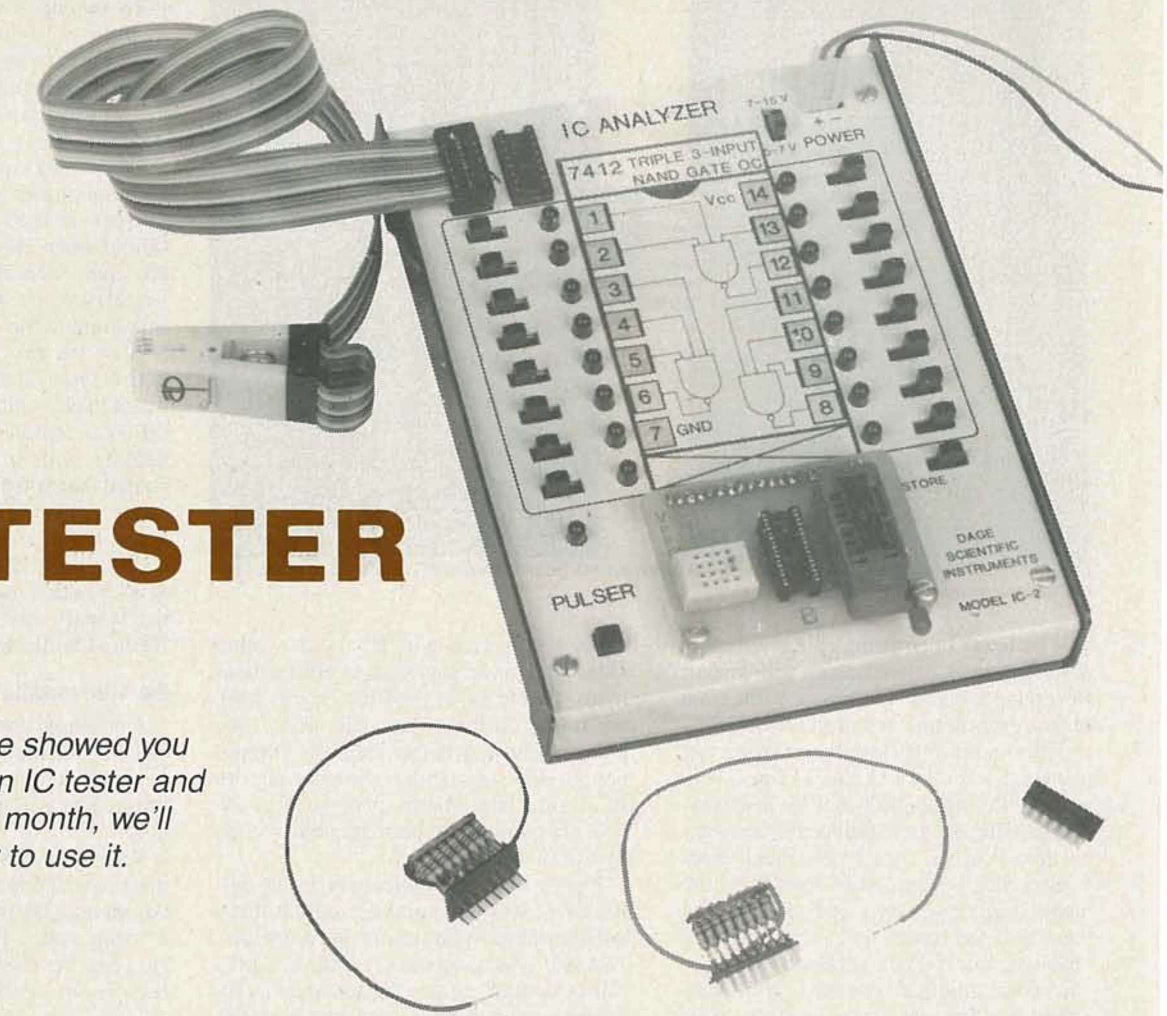

IC TESTER

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Last month, we showed you how to build an IC tester and analyzer. This month, we'll show you how to use it.

Part 2

WHEN WE LEFT OFF last month, we had put the IC analyzer or tester together and had just finished checking its various functions. This month, we'll show you how to put the tester to work. Before we get started, we should mention that the foil pattern for the solder side of the main board was not shown in the "PC Service" section because of space restrictions. It does, however, appear this month. (See page 83)

IC pinout cards

When using the IC analyzer as a monitor or tester, you must know how the IC is supposed to function, i.e., how the input pins affect the output pins. The IC pinout cards supply that information.

While the pinout cards cannot supply all the information that you would expect to find on data sheets, they can come surprisingly close. For example, see Fig. 12-*a*, which shows the pinout card for a 7400 quad NAND gate. To use the IC tester in its comparator mode, set each switch either IN (for an input) or OUT (for an output). Setting up the analyzer can be done quickly and easily if each pin on the card is marked appropriately.

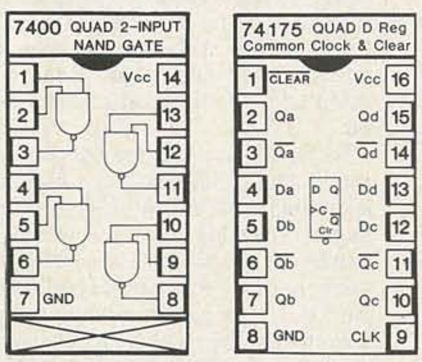


FIG. 12—THE PINOUT CARDS should contain as much information as possible.

A set of pinout cards for the 74xx series of ICs is available from the source mentioned in the Parts List. If you make up your own set, you'll want to include on the cards an easy way to distinguish between inputs and outputs. Our convention is to mark inputs with a bold line toward the inside of the card, and outputs with a bold line toward the edge. You'll also want to indicate which inputs and outputs are numerically weighted, etc.

To monitor and check an IC, we need to know how its inputs affect its outputs. For the most part, that information will be obtained from reading the IC cards, and using a little prior knowledge. The 7400 card is an example of simple gates shown in symbols. Prior knowledge of gate operation is necessary in order to know that when pins 1 and 2 are high, the output at pin 3 will be low.

As another example, look at the 74175 quad D flip-flop with common clock and clear shown in Fig. 12-*b*. You may already know that a D-type flip-flop stores the data on its D input when clocked and that it may be preset (set) or cleared (reset). The data stored is available at the Q output, and it's complement is available at the $\overline{Q}$ output. The 74175 flip-flop can be cleared, but no preset is available. To clear the flip-flop, a low level signal is required (as indicated by the tiny circle). The flip-flop is clocked with a rising edge.

The title "quad D flip-flop with common clock and clear" indicates that there are four separate flip-flops that are clocked and cleared together. The four inputs, the four true outputs, and the four complimented outputs are designated with subscripts a, b, c, and d.

Putting all that together in words and using the pin designations on the card we have; data on pins 4, 5, 12, and 13 will be stored when pin 9 (clock) goes high providing pin 1 is high and remains high. This data will be present on pins 2, 7, 10, 15 and its compliment on pins 3, 6, 11, 14 respectively. After pin 1 goes low, outputs on pins 2, 7, 10, and 15 will go low and pins 3, 6, 11 and 14 will go high.

Using the analyzer

The IC analyzer requires an external source of between 5 and 15 volts DC. It draws approximately 300 mA with all LED's lit. If possible, you should power the analyzer from the circuit under test. For safety's sake, first connect the power cable to the circuit, and then measure the voltage magnitude and polarity at the cable connector. Place the power switch to the proper range, and only then connect the cable to the analyzer.

If the external circuit cannot supply the 300 mA needed, you'll have to use a separate power source. If you do that, *it is important that the two supplies have a common ground (or that the individual grounds remain within 1/2 volt of each other).*

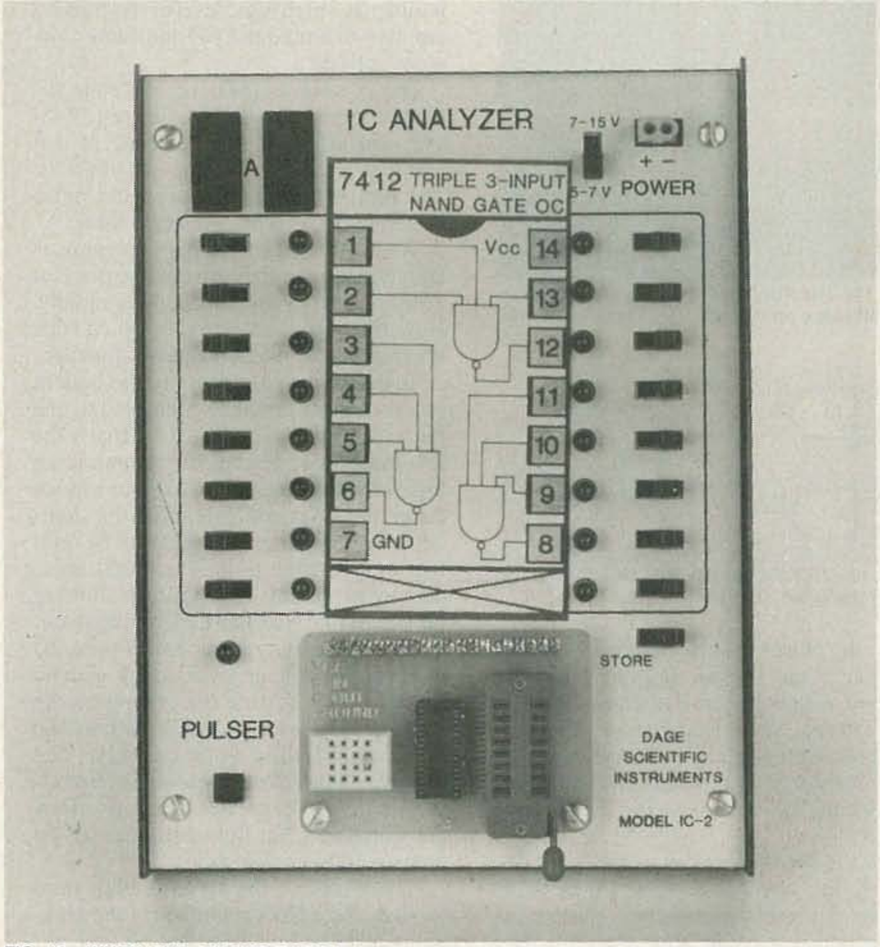


FIG. 13—WHEN THE PINOUT CARD is mounted on the front panel, the function of each switch becomes apparent. And since each IC has its own card, no numbering confusion exists between 14 and 16 pin IC's.

The pinout card corresponding to the IC under test should be inserted in the analyzer, and all switches should be initially in the OUT position, as shown in Fig. 13. However, if you're testing 14-pin IC's, you may want to switch the two bottom (unused) switches to the IN position so that the LED's will stay off and won't be distracting.

The DISPLAY STORE switch should also be left in the OUT (not stored) position until needed. When installing IC's or the DIP clip, always orient pin 1 correctly. Pin 1 is always at the top left—even when installing 14 pin devices.

Be aware of the voltages present on an in-circuit IC before connecting the DIP clip. Many IC's operate as input or output buffers and their pins may not be at logic voltage levels. Any IC with open-collector outputs should be suspect. Remember to orient the DIP clip to pin one.

Using the pulse stretcher

Connection to the pulse stretcher is made at the second row of SO3, the solderless breadboard. Any transition from high to low (or low to high) greater than 20 ns will cause the pulse-stretcher LED to blink on for about 50 ms. Rapid pulse activity below 50 MHz will cause the LED to blink continually. Connecting the pulse stretcher to an in-circuit IC is usually made by connecting the IC to one of the A sockets (using the DIP clip) and connecting the pulse stretcher input from socket B to socket A using an 8-inch length of 24-gauge solid wire stripped at both ends.

The pulser

The pulser or pulse generator is accessed at the third row of the solderless connector, SO3, and it can be connected to an in-circuit IC in the same manner as described for the pulse stretcher. The pulse generator senses the external logic level, and when the PULSER pushbutton (S19) is pressed, it will drive the circuit to the opposite state. If S19 is held closed for more than 2 seconds, the generator will deliver a 100-pps pulse train as shown in the oscilloscope photograph of Fig. 14.

Let's see how we would use the pulse generator to troubleshoot the circuit shown in Fig. 15. Suppose we want to verify that the AND gate IC1-a is operating properly, and suppose that an initial check shows that pin 2 is high and pin 1 is low. In order to see if the gate is operating correctly, we have to override the low level output from IC1-c. The pulse generator output is connected to pin 1 of IC1-a and is activated. If the circuit is operating properly, pin 3 should change state. If it doesn't, both pin 1 and pin 3 must be monitored.

If pin 1 is shorted to ground (and therefore cannot be pulsed), monitoring pin 3 is useless. So let's assume at this point that pin 1 did go high when pulsed, but pin 3 stayed low. One of the internal components of the gate could be faulty, holding pin 3 low. Let's label this a "logic short," which is typically several ohms. Pin 3, on the other hand, could be shorted externally by a solder bridge or an unetched PC trace. Let's label this kind of a short as a "hard short," which is typically less than an ohm.

The pulser can change the level of a logic short but not of a hard short. If you verify that pin 1 pulsed high but pin 3 did

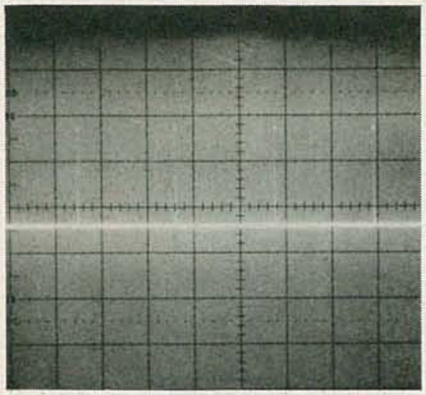


FIG. 14—THE PULSER OUTPUT is shown on this oscilloscope photograph. (Courtesy Tektronix.)

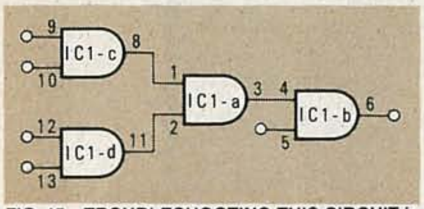


FIG. 15—TROUBLESHOOTING THIS CIRCUIT is easy using the IC tester.

not, the pulser should then be connected to pin 3 and pulsed. If pin 3 can't be pulsed with the pulse generator, look for an external short first before replacing gate A. By using the pulse generator in this manner it is possible to distinguish between logic shorts and hard-wire shorts.

While hard shorts can occur in IC devices, they are not as common as logic shorts. To complicate matters, shorts may exist between inputs (pin 1 and 2), between outputs, outputs to inputs, and circuits shown here to circuits on the other side of a schematic. When using the pulse generator along with the monitor, observe any input or output that changes.

If both pins 1 and 2 are low, they could be connected together and pulsed. The pulse generator has plenty of power to pulse several inputs at once. By tying pins 1 and 2 together, output pins 8 and 11 are also tied together. Should pin 11 change state, it would be shorted through output pin 8. Diodes can be used to pulse more than one input while maintaining output isolation. Use diodes with a low forward drop, such as germanium or Schottky diodes.

Using the in-circuit monitor

To use the IC analyzer as an in-circuit monitor, it should be set up as follows:

- Connect power from circuit under test (or a separate supply)
- Connect jumper cable to socket "A".
- Connect shorting plug to socket "B" and ground at solderless connector.
- Place all IC switches, including the DISPLAY STORE switch, to the OUT position.

Select the appropriate IC card, insert it into the IC analyzer, and connect the DIP clip to the in-circuit IC. If an LED is off, then the corresponding pin is at a low logic level. If the LED is on, then the pin is either at a high logic level or it is pulsing rapidly. A blinking LED indicates slow pulse activity.

The A sockets (SO1 or SO2) are directly connected to the IC under test. Voltage measurements can be made at that point with an oscilloscope or voltmeter. The built-in pulse generator and pulse stretcher can also be connected there.

When an LED is on, its meaning is ambiguous—it can mean that the pin is at a steady state or that it is pulsing rapidly. However, you can determine which state it's really in by using the pulse stretcher.

To determine pulse activity, the built in pulser detector could be connected to one pin at a time at socket "A". That's the recommended procedure when tracing logic or using the pulser. However a much faster method is available. With the shorting plug grounded, the LED will be on if the logic voltage is high or rapid pulse activity is present. If you lift the shorting plug's ground and the LED remains on, rapid pulse activity is present. If the LED goes off, the voltage level is high with no pulse activity. Lifting the ground on the shorting plug to observe pulse activity can be accomplished very quickly. The monitor circuit alone is capable of detecting single pulses greater than 1 μs. They are stored in a flip-flop until reset by the internal 100-pps generator.

If you remove the shorting plug from ground, the LED's will display the complement logic, i.e. on for low, off for high. That is useful when observing complemented inputs or outputs. As an example, the 7447 decoder that is driving a 7 segment display will have active low output when displaying a segment. By using the compliment a lighted LED will correspond to a display segment that is on.

Pull-up plugs

For TTL devices, a floating input is considered to be high. However, depending on internal leakage, its voltage could fall into the undefined area of 1.7 volts or so. Since many designers choose to leave unused TTL inputs floating, incorrect monitoring may result.

That problem can be eliminated by using the pull up plug. Insert it into the A socket and connect its lead to $+V_{CC}$ at the solderless connector.

CMOS devices have very high input impedances, and their inputs must not be left unconnected (floating). A floating CMOS input can, and will, switch from one state to the other. For new designs, that can make troubleshooting difficult.

The pull-up plug can be installed in one of the A sockets and alternately connected from $+V_{CC}$ to ground at the solderless connector. Any input which changes

ORDERING INFORMATION

The following are available from Dage Scientific Instruments, P.O. Box 144, Valley Springs, CA 95252: Plated-thru PC boards, IC pin-out cards and detailed instructions (order number IC-18), $30.00 plus $2.00 shipping. Complete kit of parts less chassis, DIP-clip cable, and sockets (order number IC-20), $79.95 plus $3.00 shipping. Complete kit, includes assembled dip-clip cable, zero insertion force socket, even solder (order number IC-22) $119.00 plus $4.00 shipping. California residents please add sales tax. Countries other than U.S.A. and Canada, please add $8.00

when the pull up plug is changed should be examined more closely. The pull-up plug is not needed for normal CMOS operations, and should be removed from the circuit after checking the inputs.

The in-circuit comparator

To use the in-circuit comparator:

- Connect power from the above circuit.
- Connect the jumper cable with DIP clip to socket A.
- Place all switches in the OUT position.

Select the proper card and insert it in the tester. Then connect the DIP clip to the in-circuit IC and install a good IC in socket B. You are then ready to put the switches for ground, power, and the inputs to the IN position.

All the LED's should remain off if the in-circuit IC is operating properly. If an output LED blinks or stays on, something is wrong. If an input LED blinks or stays on, the input is probably floating and should be ignored. To catch and hold single momentary faults, switch S17 to the STORE position. To clear, press S19, the PULSER switch.

Output LED's will go on if an output pin on one IC changes more than 800 ns before the same pin on the other. The old style CMOS outputs called A-Series do not have the drive capabilities that the newer B-Series devices have. It is possible that the A-Series device is driving a large capacitive load and may take longer than 800 ns to switch. The analyzer's good IC is driving practically no load at all and therefore switches very rapidly. Viewing the output on a scope should reveal such timing problems.

For the comparison test to work, both IC's must be synchronized. As an example, assume that a 4060, 14-stage ripple counter is used as a simple divider and that the circuit does not require the divider to be reset or start from zero. To reset this device, pin 12 must be made high. If pin 12 is held low with a resistor, the pulse generator can reset both the in-circuit and the known good IC. They will now run in

continued on page 115

IC TESTER

continued from page 82

unison. More than likely, the circuit will tie pin 12 directly to signal ground. In that case, there is no easy way to get the two devices synchronized, and the comparison test will not work.

Testing IC's

To test out-of-circuit ICs:

- Connect power from external source
- Connect a grounded shorting plug to socket A
- Place all IC switches in the OUT position.

Select the appropriate IC card and insert it into the IC analyzer. Then insert the IC in the right-hand B socket (SO5). Use short jumpers of 22-gauge solid wire to make power and ground connections from the solderless connector to one of the B sockets.

The inputs can be tied low by putting the switches to the IN position. Do not switch the outputs, power, or ground pins. The pulser can be connected at the B socket, and should be used to test clocked logic. The pulse generator pushbutton is not debounced, so occasionally a double output pulse may result. **R-E**

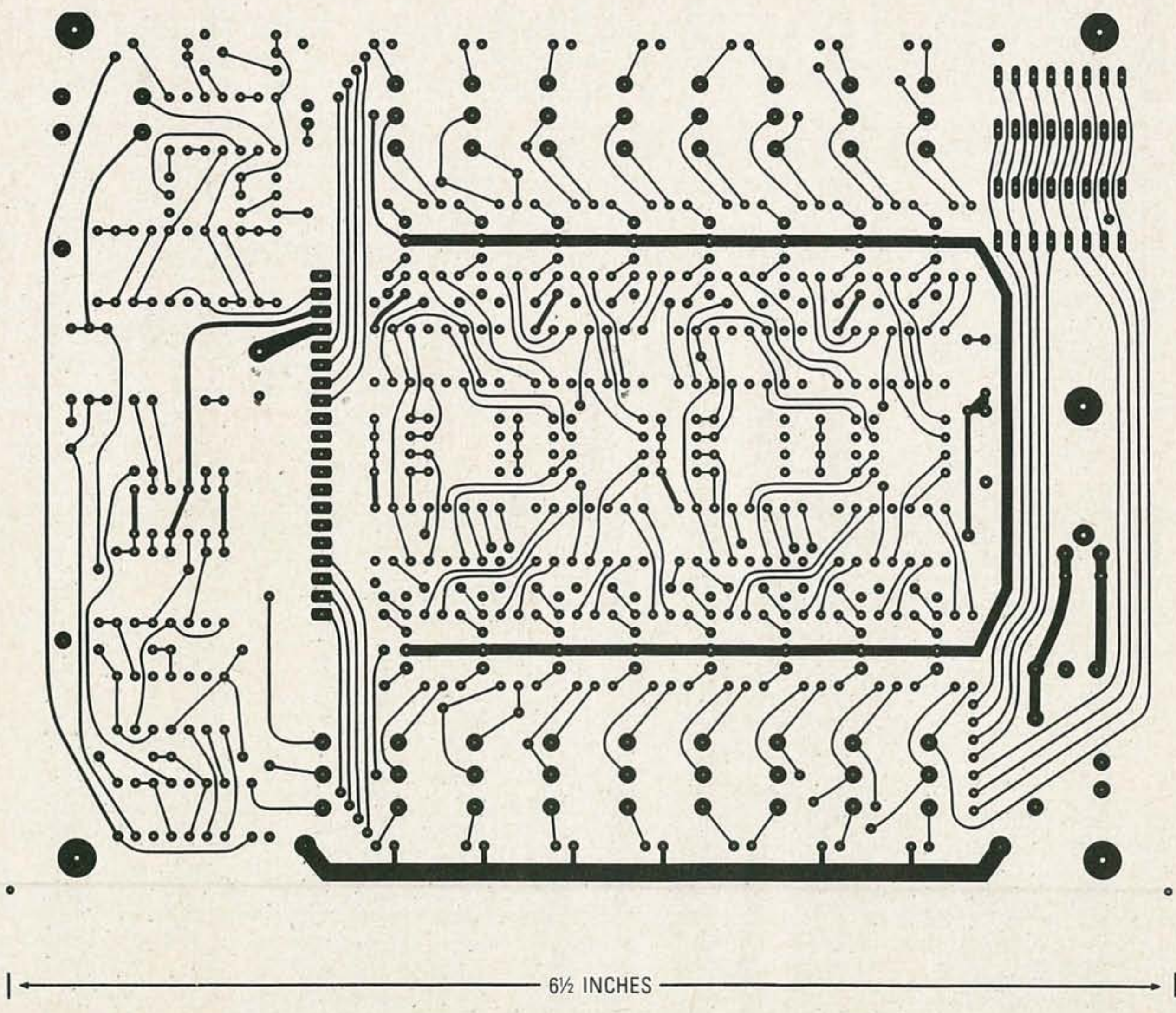
PC SERVICE

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!

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 oil 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



THE SOLDER SIDE OF THE IC TESTER BOARD. See page 80 for more information.

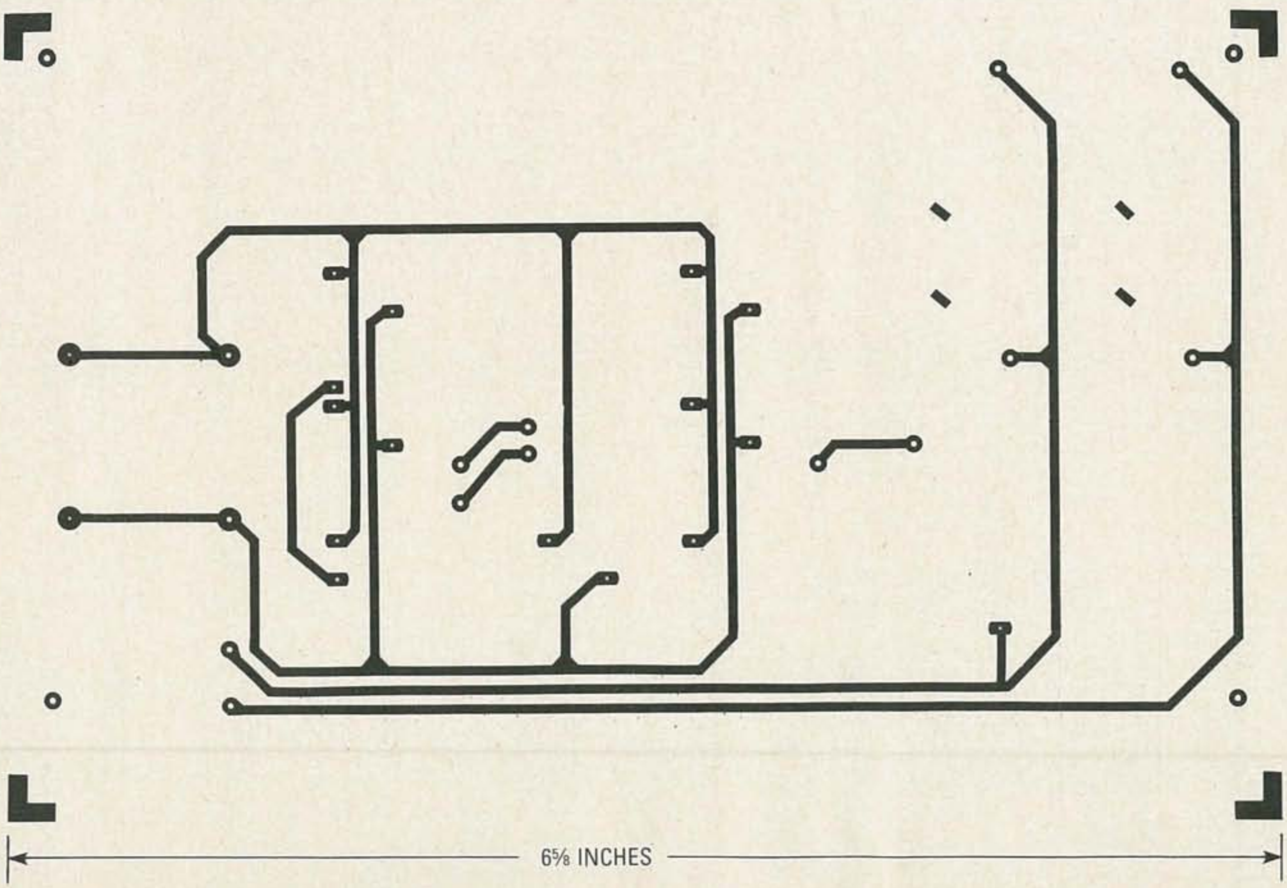
PC SERVICE

blank, and make the exposure. You'll probably have to use a longer exposure time than you are used to.

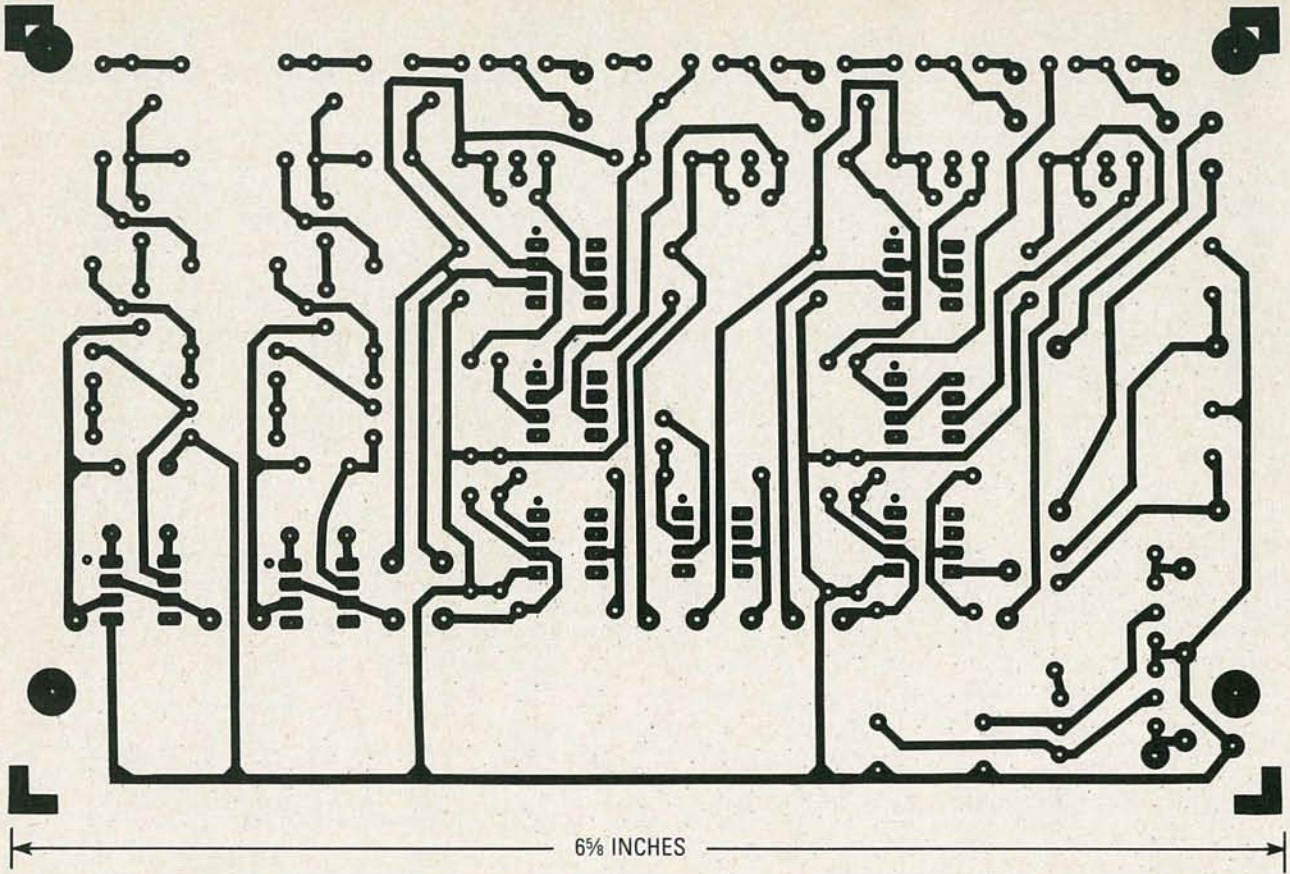
We can't tell you exactly how long an exposure time you will need because we don't know what kind of light source you use. As a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method to use with the chemicals you're familiar with. And once you find it, stick with it. Don't forget the "three C's" of making PC boards—care, cleanliness, and consistency.

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:

Radio-Electronics
Department PCB
200 Park Avenue South
New York, NY 10003



FOIL PATTERN for the Versatile Power Supply. The component side of the board is shown here.



SOLDER SIDE of the "Versatile Power Supply" PC board is shown here. For more information on the project, see page 53.