

# A 16-Channel Digital IC Tester

*An easy-to-build project that simplifies troubleshooting digital circuits*

By David Leithauser

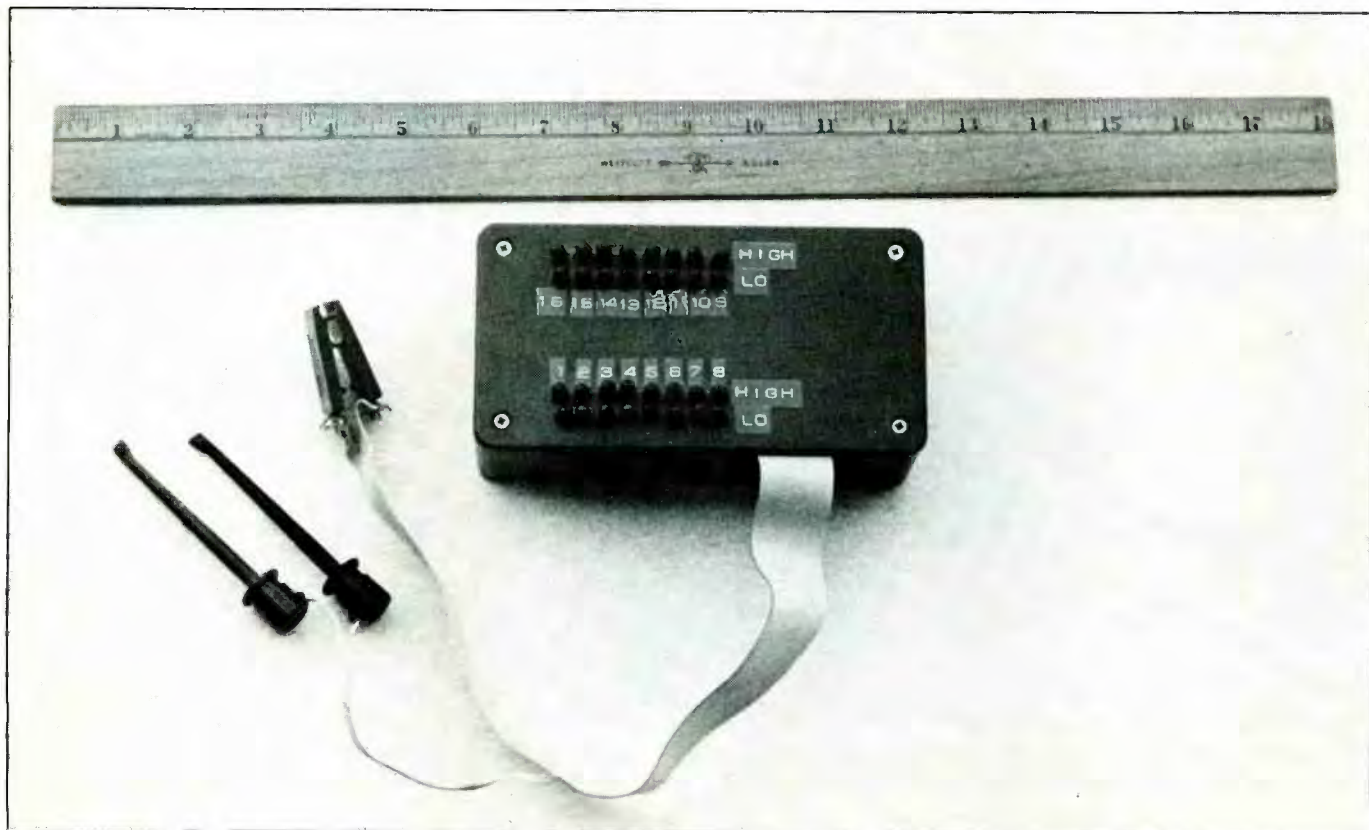
When you build and test a project that uses digital integrated circuits, chances are that the test you perform most frequently is determining whether a given input or output is high or low. If you're like most of us, you use either an oscilloscope or a logic probe to perform this test. While

both instruments are good in their own ways, a far more informative instrument is a multi-channel logic analyzer like the 16-channel tester described here. This type of instrument can monitor and report on the status of all 16 pins of a typical digital IC simultaneously. With about two hours at your workbench and an investment of around \$15, you can make this instrument. Moreover, it can be expanded for use with 20-, 24- and

even 40-pin digital ICs at little extra cost.

## About the Circuit

Our 16-channel digital IC tester consists of a series of 16 independent but identical logic probes. Each of these "probes" consists of a simple inverter/buffer, two light-emitting diodes and two resistors with some convenient type of input connector. Because all 16 probes are identical, the circuit



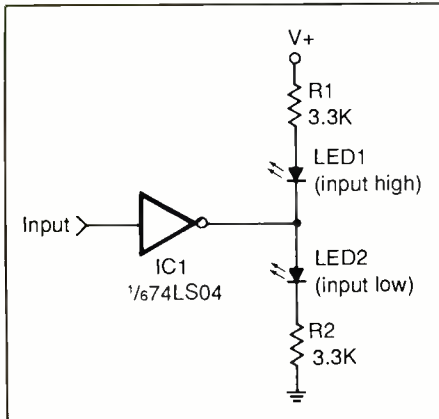


Fig. 1. Schematic diagram of only one of the 16 (or more—see text) logic “probes” that make up the digital IC tester.

shown in the schematic diagram for one probe is all that’s needed to explain project operation.

A basic version of this tester would have 16 channels. Since there are six inverter/buffers in a single 74LS04 IC, you need a minimum of three such ICs, which leaves two extra inverter/buffers that aren’t used. If you wanted to build a 20-, 24- or 40-pin tester, you would have to add extra probe channels, each with their own inverter/LED/resistor arrangement. For a 20- or 24-pin tester, you need four 74LS04s (all inverter/buffers used for the latter but four not used for the former); for a 40-pin tester, you need seven 74LS04s (two inverter/buffers not used). Inputs to the buffers would be made through a ribbon cable terminated in a clip-on connector with contacts for all pins of an IC under test. There would also be two extra leads, one terminated in a red alligator clip or ball-type hook connector for the +5-volt power input and the other terminated in a similar black connector for power (and signal since both share the same electrical point) ground.

Not shown in the schematic diagram are the +5-volt and ground connection points in the circuit. These go to pins 14 (+5 volts) and 7

(ground) for all 74LS04 inverter/buffer packages used.

The red and black connectors tie to the +5-volt and ground points of the circuit of the IC to be tested to provide power for the project. With the connector clipped onto the IC to be tested, each conductor of the ribbon cable serves as an input line to each of the inverter/buffers that are active. If an input of any given tester channel is high, the output of the inverter/buffer for that channel will be low, which will turn on *LED1*. Conversely, if the input is low, the output of the inverter buffer will be high and *LED2* will turn on. If there is no output at a given IC pin, the signal will be at neither +5 volts nor near ground potential, which will result in neither LED for that channel lighting.

Power monitoring is automatically taken care of when the ribbon-cable connector is clipped onto the IC under test and power is applied. Whichever pin has the steady +5 volts applied to it will deliver to the project a constant +5 volts that will cause *LED1* for that channel to light. Conversely, the pin that serves as power and signal ground will be at 0 volt so that *LED2* for that channel will be on continuously.

Because this tester has separate

## PARTS LIST

IC1—74LS04 hex low-power Schottky inverter/buffer

LED1,LED2—Jumbo red light-emitting diodes (two per channel)

R1,R2—3,300-ohm, ¼-watt, 10% tolerance resistors (one for each LED used)

Misc.—One each red and black miniature alligator clips or spring-loaded ball-type hook connectors (see text); IC test clip (16-, 20-, 24- or 40-pin; see text); printed-circuit board or perforated board and suitable soldering or Wire Wrap hardware; sockets for ICs; 24-inch length of multi-con-

ductor ribbon cable (number of conductors depends on number of lines needed for test clip); two small alligator clips or spring-loaded ball-type hook connectors; one each red- and black-insulated 24-inch length of stranded hookup wire or test-lead wire; suitable plastic enclosure; insulating tubing; machine hardware; hookup wire; solder; etc.

**Note:** The number of ICs, IC sockets, LEDs, dropping resistors, contacts on IC test clip and conductors in ribbon cable depends on how many channels are used. See text for details.

HIGH and LOW LEDs for each channel, brief pulses are easier to spot than with some costly commercial models, which usually have only one LED per channel. If both LEDs in a given channel appear to be on at the same time, this is an indication of rapid high/low transitions. If the LEDs are well-matched, you can even estimate the signal’s duty cycle by observing the relative brightnesses of the two LEDs.

Though the schematic diagram and the Parts List both specify 74LS04 inverter/buffers, you can use standard 7404 TTL devices. However, the “LS” (low-power Schottky) devices specified will draw less power from the circuit of the device being tested and, more importantly, will cause less interference with the IC under test.

## Construction

Since there’s nothing critical about component mounting and layout, you can use any traditional method of wiring for the ICs and resistors that suits you. For example, you can design and fabricate your own printed-circuit board or use perforated board with holes on 0.1-inch centers and suitable soldering or Wire Wrap hardware. In either case,

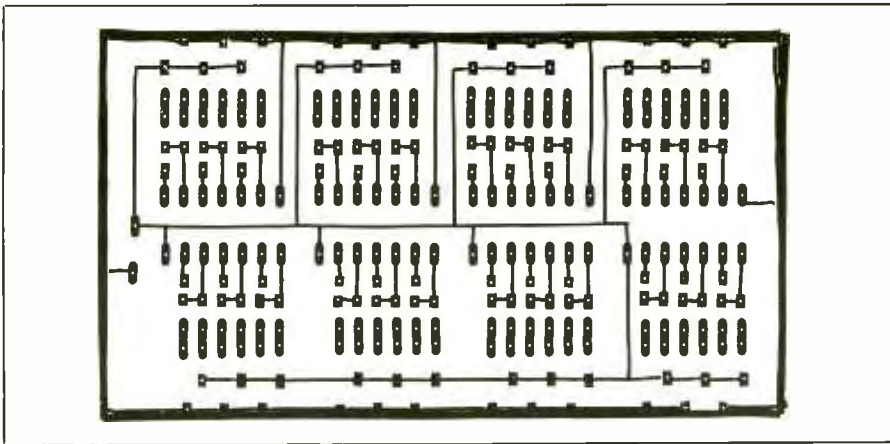


Fig. 2. Actual-size etching-and-drilling guide for up to 24-channel tester. Two boards are needed for a 40-pin device tester.

it's a good idea to use sockets for all integrated circuits.

Note that the Fig. 2 etching-and-drilling guide and Fig. 3 wiring diagram show a layout for up to a 24-pin tester. If you wish to test only 14- and 16-pin ICs, you can leave out one IC and the resistors and LEDs that go with it. For a 24-pin tester, include *all* four IC stages, resistors and LEDs. For a 40-pin tester, you need two of the Fig. 2 boards, one fully populated and the other lacking only one IC and its associated components.

Note, too, in Fig. 3 that all resistors mount upright on the board, with the bodies mounted directly over the circled holes. This is done to

conserve space to make as compact a unit as possible.

Wire the boards exactly as shown in Fig. 3, installing and soldering into place first the IC sockets and then the resistors. Trim  $\frac{1}{4}$  inch of insulation from both ends of as many 3-inch lengths of hookup wire as needed to make the connections to the off-the-board LEDs. Use black-insulated wires for the cathodes and red-insulated wires for the anodes. Plug one end of each of the black-insulated wires into the holes labeled K and solder into place. Similarly, plug one end of the red-insulated wires into the LED holes that are not labeled and and solder into place.

Next, separate the conductors at one end of a 24- to 36-inch ribbon cable a distance of 1 inch and trim from all conductors  $\frac{1}{4}$  inch of insulation. Separate the conductors at the other end of the cable a distance of 3 inches and trim from each  $\frac{1}{4}$  inch of insulation. Tightly twist together the fine wires of each conductor and sparingly tin with solder. Connect and solder the conductors at the 1-inch separated end to the solder pins of the IC test clip. Then, working with an ohmmeter and referring to Fig. 1, plug into the appropriate holes in the board the conductors at the other end of the cable and solder each into place as you go.

Strip  $\frac{1}{4}$  inch of insulation from both ends of 24-inch-long red- and black-insulated wires. Twist together the fine wires at both ends and tin with solder. Plug one end of these wires into the +5V (red insulation) and GND (black insulation) holes and solder into place.

Mount the LEDs on the lid of the selected enclosure. You have either of two options for LED mounting. One is to drill a single suitably sized hole in which to friction mount each LED from the rear of the panel so that only the LED's domed top protrudes through the front of the panel. The other is to drill two  $\frac{1}{16}$ -inch holes 0.1 inch apart for each LED's leads and plug the leads into the holes so that the entire LED housing is external to the box. A piece of perforated board with holes on 0.1-inch centers serves as a good drilling guide for this. Both approaches are suitable, though with the latter, it's a good idea to apply a very small drop of fast-set clear epoxy between the bottom of each LED and the front panel to secure the LEDs into place.

Arrange your LED layout on the panel to emulate the pin arrangement of the type of IC the project is designed to test. That is, you should have two parallel rows of LED pairs, as shown in the lead photo. As a finishing touch, you might want to

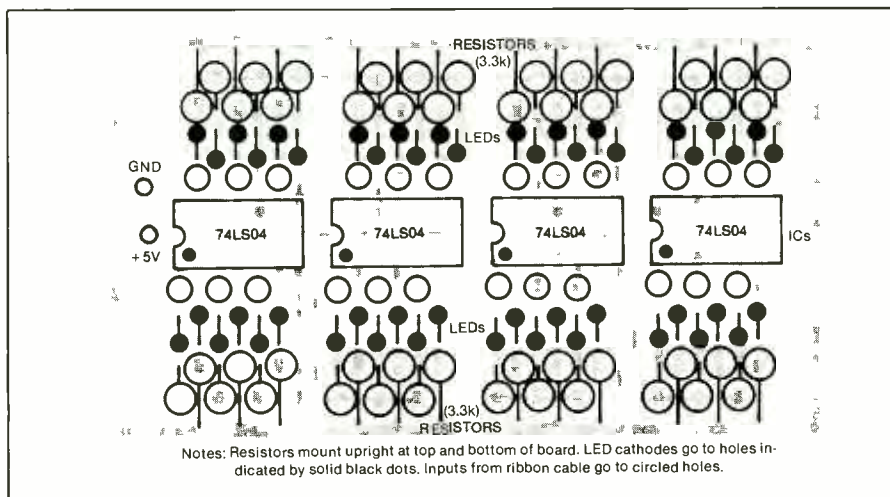


Fig. 3. Wiring guide for printed-circuit board.



paint onto the panel the traditional IC case outline and number each pin location.

Slide a 1-inch length of small-diameter insulating plastic tubing over each of the LED wires on the circuit-board assembly. Then identify the anode leads of all LEDs and trim each to 3/4 inch long and form a small hook in each. Identify the wires on the board that are to connect to the anodes of the LEDs and form a small hook in each of these. Connect and solder the free ends of the wires to the anode leads of the LEDs. Make sure you connect each wire to the correct LED anode before soldering the connections. When all anode wires have been connected and soldered to the LED anode leads push the insulating tubing up over the connections until it sits flush against the bottom of the LED or panel. Do the same for the cathode leads and wires.

Notch both halves of the plastic box in which the project is to be housed to provide exits for the ribbon cable and +5-volt and ground wires. Mount the circuit-board assembly in place. Then assemble the box with the ribbon cable and power leads routed through their slots. Finally, terminate the free ends of the power leads in miniature alligator clips or spring-loaded ball-type hook connectors.

### Using the Tester

Use of the tester is simple and straightforward. Simply connect the red and black power leads to any +5-volt and ground points, respectively, in the circuit containing the IC to be tested. Then place the IC clip on the IC, observing orientation to make sure the pin arrangement matches the numbering on the project. Finally, turn on the power to the circuit containing the IC to be tested and observe the activity of the project's LEDs. Compare this activity with what would be expected from a good integrated circuit under the condi-

tions that exist in the circuit.

Though the lowest level tester described is for 16-pin digital ICs, the project can be used on DIP (dual in-line package) ICs with fewer pins. To simplify interpreting LED activity, it's a good idea to always align the pin 1 contact of the IC clip with pin 1

of the IC, regardless of the number of pins on the latter. You can, of course, place the clip on the IC anywhere all pins will make contact, since the project is neither pin nor orientation sensitive. Whatever IC clip contacts aren't needed will simply overhang the IC being tested. **ME**

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