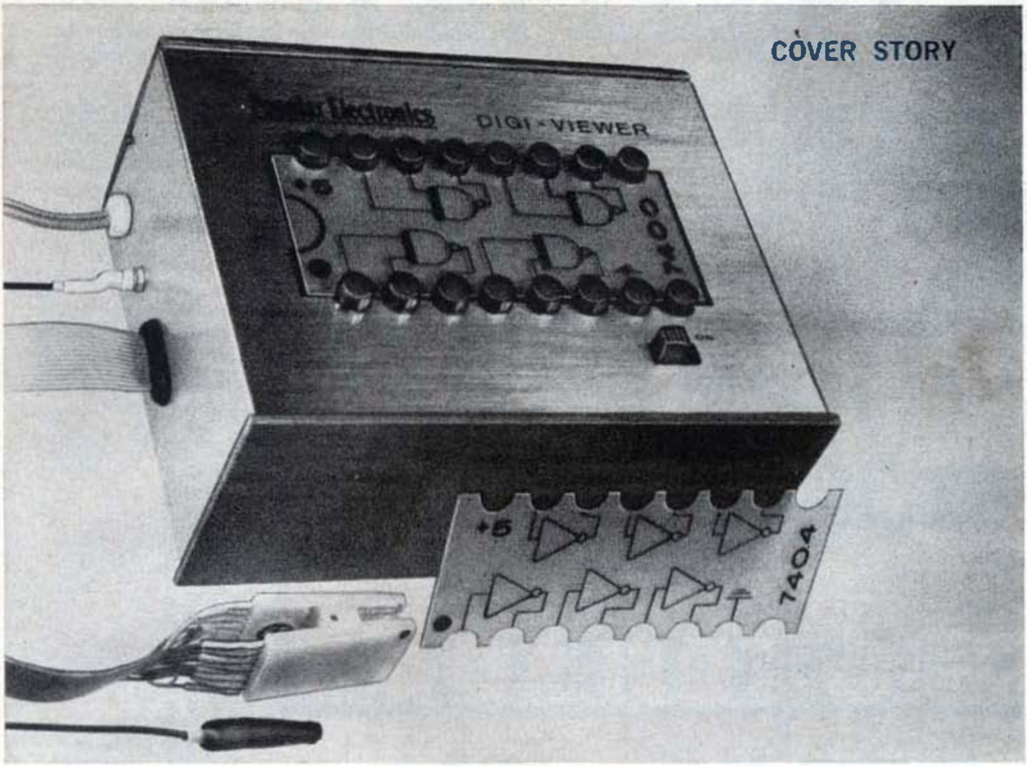
COVER STORY



Build a DIGI-VIEWER

AUTOMATIC IN-OPERATION TESTING OF DIGITAL IC'S

Using simple Darlington pair transistor amplifiers, this handy digital IC tester can be built for under $20 and will be a boon to the experimenter or technician who can't afford complex commercial equipment. At the same time, it is much more practical than simple one-circuit probes. By tying the IC's circuit in with the tester, a complete unit can be checked visually in a matter of seconds.

THAT OLD BUGABOO, testing in-circuit digital IC's, has finally been conquered for the experimenter/technician. (Assuming he's tired of one-lamp probes and can't afford a complex computer system.) The Digi-Viewer, which can be built for under $20, is a simple visual display that indicates immediately the state of every stage of an IC while it is operating in the circuit.

The Digi-Viewer consists of 16 indicator lamps driven by 16 Darlington pair transistor amplifiers. When these circuits are attached to the pins of an IC through a special clip-on connector, the lamps light or don't light depending on whether the potential on the respective pin is over or under 1.4 volts—thus indicating the "on" or "off" logic state. To identify which lights are which for specific IC's, a transparent overlay of the circuit arrangement is slipped between the rows of lights on the top of the Digi-Viewer and the faulty circuit can be located at once.

The Digi-Viewer can be used on any 14- or 16-pin dual in-line package, including RTL, DTL, TTL, and most of the newer MOS types. Due to the extremely low loading factor, there is no need to worry about overload-

BY DON LANCASTER

ing the IC. By substituting an IC in a circuit that is known to be good (using a socket), you can perform use tests and also find out whether or not the IC is good.

Construction. The schematic of the Digi-Viewer is shown in Fig. 1. The diodes, resistors, and transistors are mounted on a printed circuit board as shown in Fig. 2. As shown, the Digi-Viewer is designed to handle 16-pin IC packages. If you have no need for the 16-pin version, two of the Darlington circuits (at one end) and their associated lamps may be omitted.

Any type of chassis may be used; the prototype was built in a 6" × 4½" × 2½" cabinet. The important thing is the placement of the lamps on the top surface. Space the lamps on

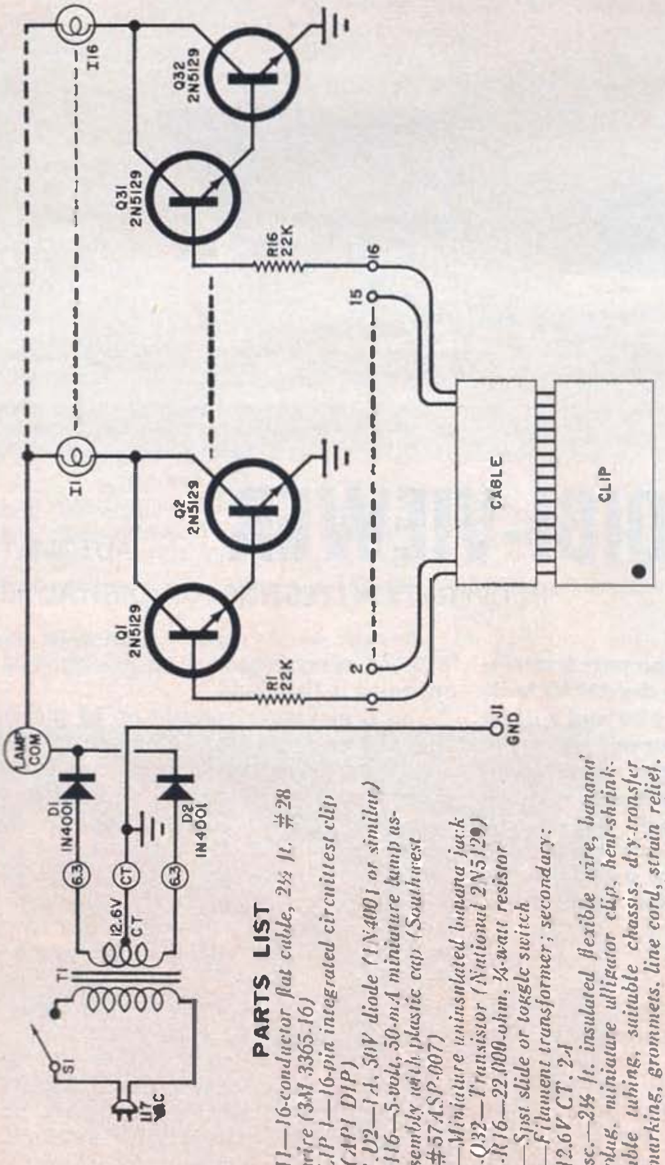
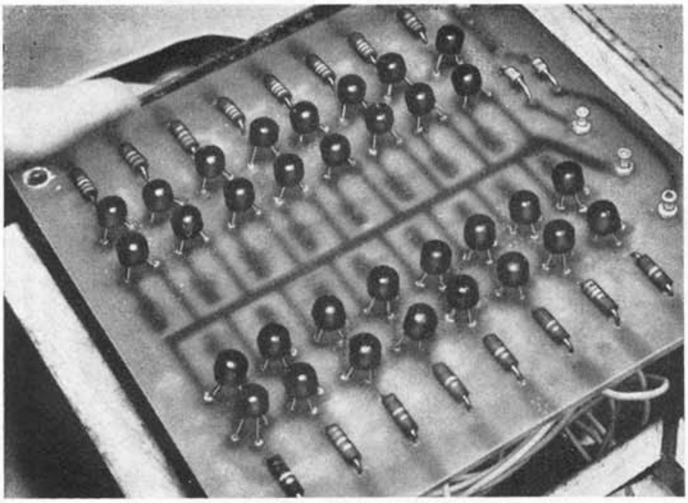


Fig. 1. A lamp goes on when the input exceeds 1.4 volts and goes off under that level. Input current is about 20-μA therefore tested IC's are not loaded. Input capacitance is about 20-pF per line enabling use on all but highest speed circuits.

PARTS LIST

CA1—16-conductor flat cable, 2½ ft. #28 wire (3M 3365-16)
CLIP 1—16-pin integrated circuit test clip (AP1 DIP)
D1,D2—1A, 50V diode (1N4001 or similar)
I1-I16—5-volt, 50-mA miniature lamp assembly with plastic cap (Southwest #57ASP-007)
J1—Miniature uninsulated banana jack
Q1-Q32—Transistor (National 2N5129)
R1-R16—22,000-ohm, ¼-watt resistor
S1—Spst slide or toggle switch
T1—Filament transformer; secondary: 12.6V CT, 2A
Misc.—2½ ft. insulated flexible wire, banana plug, miniature alligator clip, heat-shrinkable tubing, suitable chassis, dry-transfer marking, grommets, line cord, strain relief, spacers, mounting hardware, plastic and ink for slides, etc.
Note—The following are available from Southwest Technical Products, Box 16297, San Antonio, TX 78216: drilled and etched printed circuit board at $2.65 postpaid; IC test clip at $5.95 postpaid; complete kit of all parts including PC board, IC clip, and basic set of most-used circuit slides, chassis, etc. at $19.85 plus postage and insurance for 4 lb. Slides for special types of IC's are also available.



Connection to each lamp driver is made on the foil side of the board. The use of PC board terminals is optional as leads can be soldered directly to foil.

Looking down on the board, note that the transistor arrangement follows the pin arrangement of an in-line IC.

Mount the transformer on one wall of the chassis, and connect the three secondary leads to their appropriate pads on the board. Connect the primary to switch *S1* mounted on the top of the tester. Use a strain relief or rubber grommet where the line cord goes through the chassis. Mount the printed circuit board on four spacers.

Connect the 16-lead flat input cable to the input terminals on the circuit board, making sure that, when it comes to soldering the cable to the clip on the other end, you can identify and arrange the leads correctly. There must be a pin-for-pin correspondence between the lamps on the board and the clip. (If you are using only 14 pins, two leads may be removed from the cable.) Drill a hole and fit it with a grommet to hold the flat cable. Draw the cable through the hole in the chassis and connect it to the test clip. Identify pin 1 with a wear-proof mark. Use small lengths of heat-shrinkable tubing at the clip end to improve the looks, strengthen the cable termination, and remove the probability of short circuits.

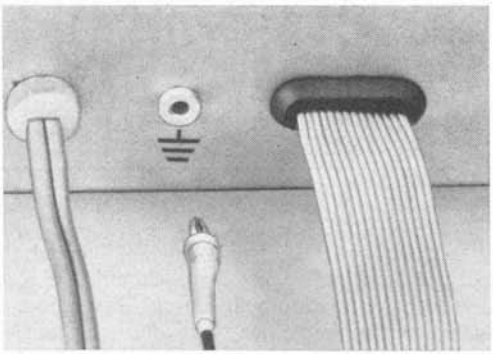
For high-speed logic systems, including TTL, the multi-lead cable should be less than 2' long. Longer lengths are acceptable for RTL, DTL, and MOS circuits.

For the ground connection, use a conventional banana plug and jack with a piece of flexible wire 2 or 3 feet long. Terminate the other end in a miniature alligator clip. The ground jack (*J1*) is connected to both the metal case and the PC board ground.

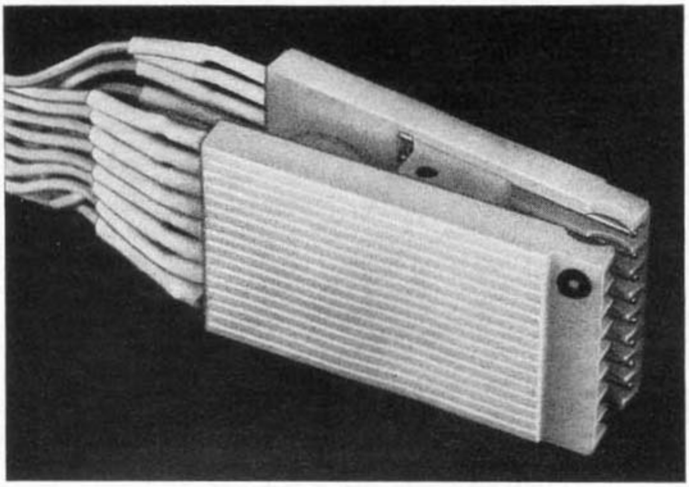
Make up some plastic slides with cutouts for the lamps so that they fit between the two rows of lamps. Mark the plastic (with permanent ink or temporary grease pencil) with the logic of the circuit to be tested.

Checkout and Use. With power supplied to the unit, connect the ground clip to the negative end of a 1.5-volt cell. As the positive end of the cell is connected to each pin of the test clip (via a test lead), the appropriate lamp should come on. The bulbs must correspond to the clip terminals.

To use, snap the correct slide into place and connect the ground clip to the ground terminal of the circuit under test. Connect the large test clip to the IC being tested, making sure that the locator dot at pin one is correctly positioned on pin 1 of the IC. Just open the test clip with a little pressure at the top end



Both the power line and 16-lead cable are passed through the metal chassis via rubber grommets. The ground jack (J1) is positioned at the center.

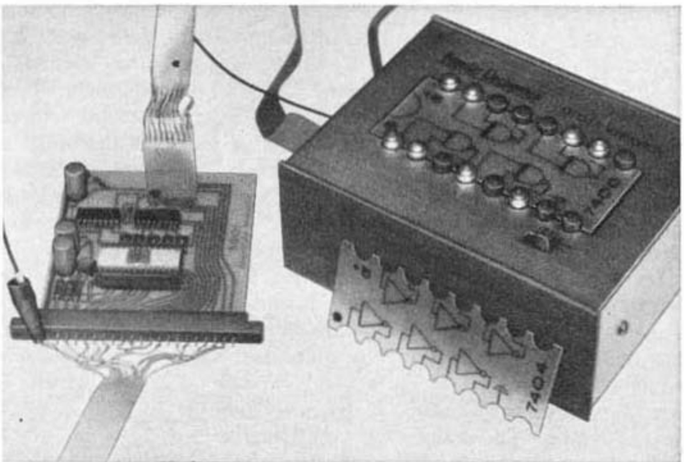


After wiring the 16-lead cable to the IC clamp, identify one end pin of the clamp with a dot to indicate pin 1. Make certain that each terminal of clamp corresponds with a similar terminal on PC board. Heat shrinkable tubing is used at cable-clamp interface for protection.

and fit it down over the IC. On a 14-pin in-line IC, the two right-hand clip connectors will be off the right side of the IC away from the locator notch or dot code.

The first thing to note is that operating voltage is applied to the IC. This is indicated by the lighting of the lamp at the power supply pin. The ground lamp should not be lit. Now check that the input pins that could hold the IC at reset, zero or other state have the correct voltages on them to permit proper operation. Generally, RTL direct set, reset, and direct clear inputs are disabled by grounding, while their counterparts in TTL and DTL are made positive to disable. There are enough exceptions to this rule however that the appropriate data sheets should always be on hand to check any IC to be tested.

After checking the various conditions that could cause difficulties, the logic rules for the IC should be verified. For example, on an inverter, when the input lamp is on (signifying a positive input), the output lamp should be off (signifying a grounded output), and vice versa. If both lamps are on, the IC is bad or there is an open ground. If both lamps are off, the IC is bad or the output is shorted. In the case of a flip-flop, the output lamps should turn on and off at half the rate of the input lamp. At high switching frequencies, the in-



To use, simply affix the IC clamp to the IC under test making sure that pin 1 the clamp is contacting pin 1 of the IC. Also make sure that the tester ground lead is connected to the IC ground terminal lead.

put and output lamps will all be on but with partial illumination due to the high switching speed. Proportional brightness can also be used as a relative indicator of the duty cycle of other "too fast to see" signals. The logic can be cycled at a slower rate by using an external oscillator so that the indications become clear. A bounceless pushbutton may be used to "step" the logic manually, for a more detailed analysis. While you will not be able to see such things as a one-microsecond reset pulse, the indicator lamps connected to the flip-flop outputs will show the effects of such a pulse.

A few digital IC's have open collector circuits (readout drivers for example). An unused open collector in a system may never get to a high state and thus may show an off condition on its lamp even when the IC is perfectly good. If there is no connection to these outputs, then a pullup resistor of about 2200 ohms to the circuit positive may be used. -30-

Leakage Current & Electrical Shock

BY PAUL B. JARRETT, MD

THE SENSITIVITY of man to electric shock and electric currents is well established. Until recently, physicians could discount the effects of minute currents and low voltages because of the insulating properties of the skin. When dry and callonsed, the skin has an average resistance of about 100,000 ohms. Skin wet with perspiration, however, may have a resistance of less than 1000 ohms. Skin resistance varies with body area and vasomotor (flushing or capillary constriction) response.

A current flow of from 9 to 14 mA produces discomfort. With a current of 15 to 25 mA, the victim loses his ability to release the conductors due to muscle contraction in tetany. At 25 to 50 mA, respiratory paralysis can occur (depending on the current path) and the victim is in pain. If the current reaches 75 to 100 mA, ventricular fibrillation (heart irregularity) ensues and at 200 mA, or over, there is total cardiac standstill.

No Skin Insulation. A source of current acting on the body from under the skin is another matter. At 20 μA this current, if applied directly to myocardium (heart muscle) for more than 3 milliseconds, will produce fatal ventricular fibrillation.[1] In medical circles particular emphasis is now being placed on external cardiac pacemakers with transverse bipolar electrodes inserted through the right jugular vein. An engineering analysis of the death of one such patient has recently been discussed in the literature.[2]

It was determined that the external pacemaker had not been grounded, but instead was being supplied ac power from a 2-prong, 10-foot extension cord. Measurement of the leakage current of the pacemaker including the 3-wire power cable of the instrument itself, plus the 10-foot extension cord, revealed a current of 54 μA. Unfortunately, the patient with the pacemaker had been placed on an electrically operated bed that had been grounded to the hospital power system. The leakage current passed from the electrode into the patients heart through his body and into the ground connection on the bed.

This accident has emphasized the growing interest in safety problems associated with medical electronic apparatus. Hospital personnel must be properly instructed about electrical safety.[3] Patients with internally placed electrodes must not be placed in beds with ground connections that are accessible to the patient. The pacemakers should only be used with a current limitation device of 5 μA under any condition. Untrained hospital personnel should also be taught the use of a new electrometer which permits safety monitoring of electronic equipment for leakage currents, static charges, and insulation resistance.[4]—Dr. Paul B. Jarrett

1. J.M.R. Bruner. *Anesthesiology*, 28/2. 1967.
2. Von Der Mosel. *Measurement & Data News*. Vol. 4 No. 4. July & August 1970.
3. Von Der Mosel. *Medical-Surgical Review*. Oct.-Nov. 1970.
4. Keveti Instruments (Mod EP-3), Annapolis, Md.