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BUILD THIS

Digital IC TESTER

Need to identify unmarked IC's? Check out "defective" ones? Learn how digital-logic circuits work? The Programma III, which you can build for about $100, will do all that and more.

GARY McCLELLAN

UNTIL RECENTLY, IC TESTERS HAVE BEEN a rarity in electronics labs, and that is unfortunate because they can be so helpful—in identifying unmarked IC's, in checking for defective ones, as training devices, etc. Sad to say, they are frequently expensive, and often require other test equipment to perform their functions. But meet the Programma III digital-IC tester! It allows you to check IC's at a breakthrough low cost, and replaces several pieces of test equipment—all in one neat package.

The device was originally designed for use in identifying unknown IC's, but it seems as if every day a new use pops up for it. For example, a cable was made up using a 16-pin IC test-clip and DIP header. The header is plugged into the test socket on the IC tester, and the clip snapped over a suspect IC in another piece of equipment. The result is a low cost "logic anayzer," or a device that will display many logic states at once. That can speed up troubleshooting immeasurably in many cases. Commercial logic analyzers cost thousands of dollars, while ours costs a tiny fraction of that. More on applications later!

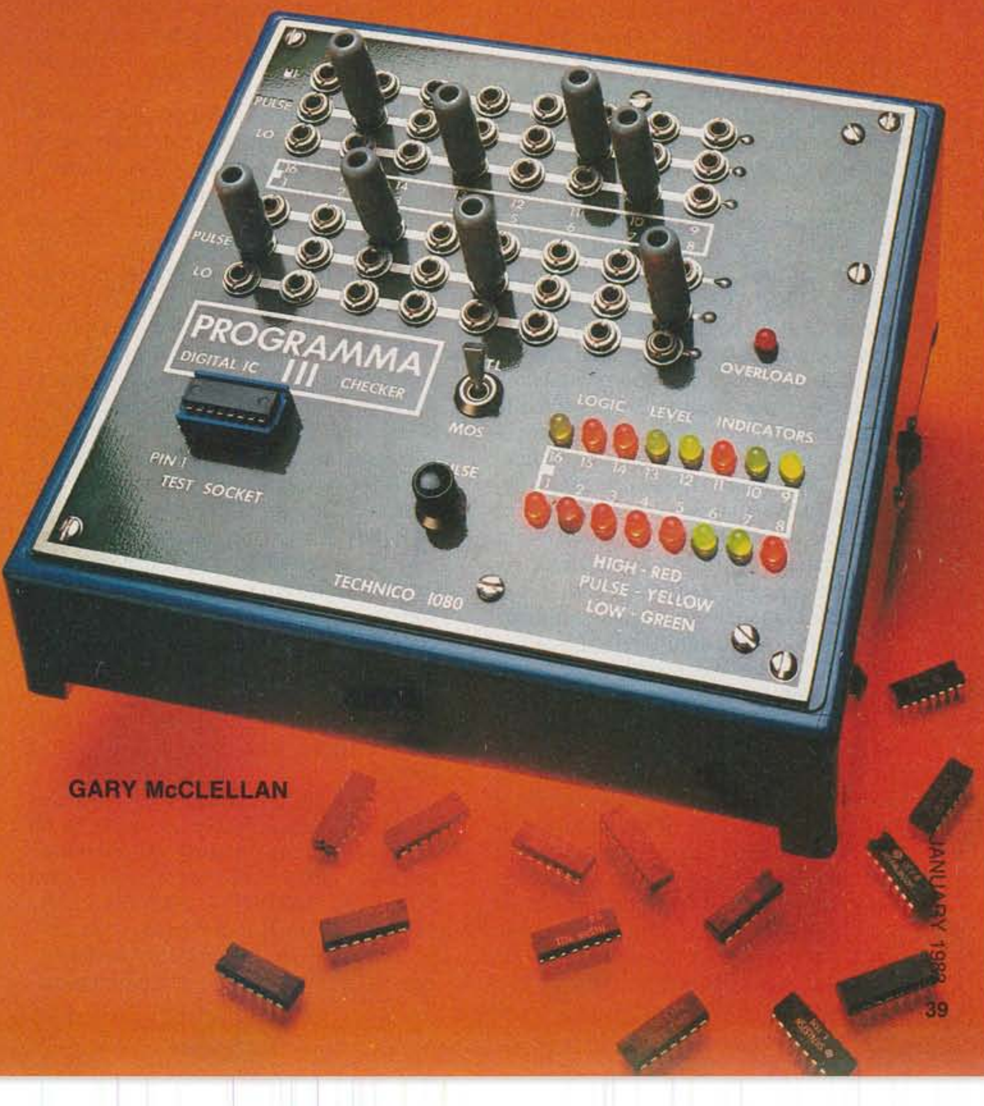
The Programma III has many novel features that help to make it versatile as well as low-cost. A "zero insertion force" (ZIF) test-socket is used so that components can be easily inserted and removed without bending or breaking leads. That's important—you know how easy it is to break a pin.

Connections to each pin of the test socket are made via an array of jacks. For each pin there is a jack that can be connected either to ground, a pulse signal, or +5 volts. Standard miniature phone-plugs, similar to those used on transistor radios, are plugged into the jacks, applying the desired signal or voltage, or shorting the IC-pin to ground. As a bonus, components may be wired to the plugs, allowing you to build up actual circuits for testing parts. (Good examples would be the NE555 timer, and any one-shot.) The pulse signal just mentioned can be used to increment counters or registers. It is produced by pressing the PULSE button.

Finally, the logic-level display is unique. It uses tri-color LED's to show the status of each IC pin, with red indicating a logic-high, yellow indicating a pulse condition, and green indicating a logic-low. Those features combine to make the Programma III a device that is invaluable in your work with digital IC's.

The construction of the Programma III is something special. The front panel is a PC board! That gives you a finished project that looks just like the one shown in the photographs, and there is no tedious lettering of the jacks required. In addition, the lettering on the board resists wear far better than any transfer-type lettering can. The "panel-board" concept makes project building easier, and the final result looks first rate. Inside, the panel-board greatly simplifies the wiring, as all wire connections are made directly to the jacks.

The display electronics are also something special. You'll be surprised to dis-



cover that there are only seven IC's in the whole unit! They are all standard, low-cost parts, which makes them easy to find. In addition, this is probably one of the first projects you've seen that uses a VMOS power FET. It does a superior job in the pulse-generator section, and allows pulses to swing the full five-volt range. The display electronics mount on a separate PC board, and simply plug into the panel-board, further simplifying construction.

How it works

The Programma III owes its unique features to some clever applications of standard IC's. Let's look at the circuit before starting construction.

The device is built on two PC boards, which we'll call the panel board and the display board. The larger board, which contains the IC test-socket and the jacks, is the panel board; the smaller board, which contains the LED's and IC's, is the display board. Be sure to keep those distinctions in mind as you read the circuit theory and assemble the project.

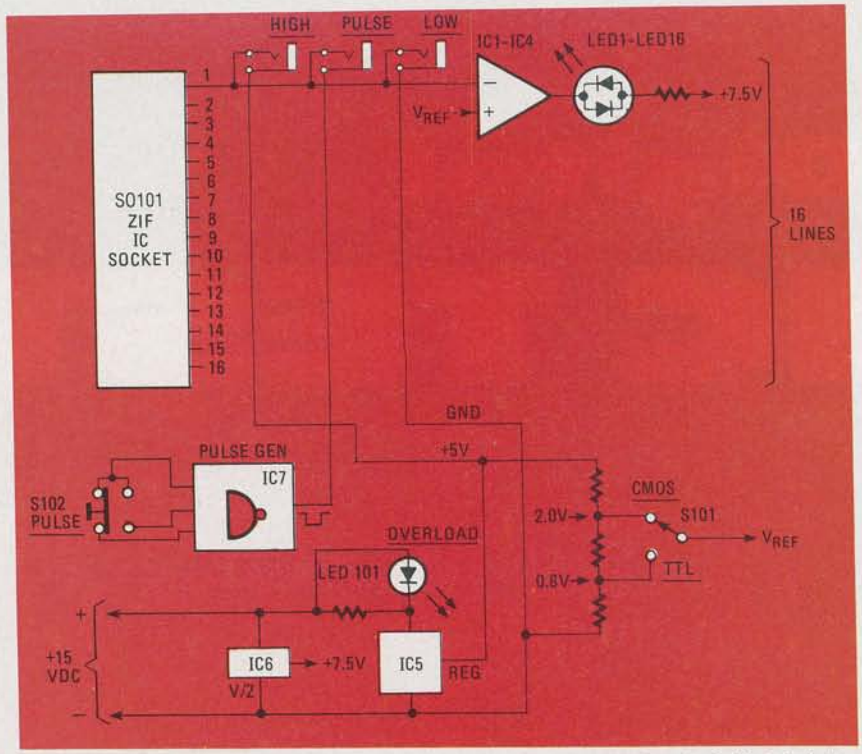


FIG. 1—SHORTING PLUGS inserted in jacks (shown at top) determine whether a logic-high, logic-low, or pulse is applied to each IC pin.

Display board

This is the smaller board, but since it contains the active circuitry, it will be discussed first. Refer to Fig. 1, and the schematic in Fig. 2, for details as you read about it. The display board contains a power supply, pulse generator, and a set of comparators. Figure 1 shows that circuitry in its basic form, but note that the IC socket, jacks, and switches are all on the panel board. You'll be surprised to discover that the display-board isn't much more complicated than its block diagram!

The power supply is simple, but has a clever twist. The IC tester may be powered by an unregulated 12–18-volts-DC source. That voltage runs the comparators and an IC audio amplifier, IC6. Now you may be wondering what a power amplifier is doing in a power supply—especially since nothing is connected to its input! But that IC has what the manufacturer calls a "self-centering output stage." That means it will effectively divide the power supply voltage by two, providing the LED's with the proper voltage. That neat little problem-solver replaces two power transistors and an op-amp, reducing the parts count...and cost.

Power for a standard five-volt regulator, IC5, is supplied through a resistor. The IC supplies regulated power for the pulse-generator circuit and for the IC being tested. Since it is possible to short the five-volt supply with a bad IC, or by misusing the tester, overload protection is built in; that's the job of the series resistor. You can draw up to 100 mA without affecting the five-volt power, but exceed that by much and the output voltage drops quickly. That voltage drop protects the unit from damage by overloads and the OVERLOAD LED lights up to indicate that there's a problem.

Finally, the five-volt output is tapped to provide two reference voltages; those drive the comparators, which will be discussed shortly. The voltages correspond to the thresholds for TTL (0.8 volt) and CMOS (2.0 volts) devices. We want to know when the outputs from the IC being tested go above or below those values; if they don't, the part is defective.

The pulse-generator circuit is simple, and also a bit unusual. Refer to the schematic for details. It consists of NAND gates IC7-a and IC7-b, and Q1. The gates are wired as a "bounceless pushbutton"—a circuit that generates a single pulse each time the PULSE button is pressed. That's necessary because switch bounce can cause many pulses when the switch is pressed, and that makes checking flip-flops, counters, and registers impossible! The output from one of the gates switches a new device-type called a VMOS power FET, which features high input-impedance and high output-current. It is used to advantage in the circuit because it can bring the pulse line to within a few millivolts of ground. That insures more reliable switching of the IC under test, as conventional transistors may come as only close as 0.6 volt of ground.

The comparator circuit is as simple as the block diagram makes it out to be. It contains sixteen op-amp comparators, and each is driven by an IC test-socket pin. Type LM324's—with four comparators in each IC—are used, so the circuitry is contained in just four packages. The V_{REF} input goes to all comparators.

PARTS LIST—DISPLAY BOARD

All resistors ¼ watt, 5%, unless otherwise noted
R1, R2—10,000 ohms
R3—470 ohms
R4–R19—100,000 ohms
R20–R35, R40—1000 ohms
R36—68 ohms, 1 watt
R37—8200 ohms
R38—3300 ohms
R39—2200 ohms

Capacitors
C1—1000 µF, 25 volts, axial-lead electrolyic
C2–C7—0.1 µF, 25 volts, ceramic disc

Semiconductors
IC1–IC4—LM324N quad op-amp
IC5—MC7805 5-volt regulator
IC6—LM380N audio amplifier (14-pin package)
IC7—CA4011 quad CMOS NAND gate
Q1—VN10KM (Siliconix) VMOS power FET (Radio Shack 276-2070)
LED1–LED16—tri-color LED (see text)
SO1—16-pin IC socket

Miscellaneous: PC boards, 14-pin IC socket, solder, etc.

The following is available from Technico Services, PO Box 20HC, Orangehurst, Fullerton, CA 92633: set of two etched & drilled PC boards (IC-1), $30.00. Available from ABC Electronics, 2033 W. La Habra Boulevard, La Habra, CA 90631 is a set of all parts, *excluding PC boards* (IC-1P), $85.00. CA residents please add sales tax; foreign orders please add $3.00 for postage & handling.

That voltage is equal to the IC threshold-voltage, and comes from resistors connected across the five-volt power supply.

In operation, the comparators compare the voltages on the IC pins to V_{REF}. If the IC-pin voltage is greater, the output of the comparator will snap high. That connects the LED (through a current-limiting resistor) to + 15 volts, causing the red diode in the package to glow. On the other hand, if the IC-pin voltage is less than V_{REF}, the comparator output snaps to ground, causing the green diode in the package to glow. Just think of the comparator output as an SPDT switch; all it does is to switch one side of the LED to ground, or to + 15 volts. The other side of the LED stays at 7.5 volts. If the IC pin is pulsed rapidly, the two diodes in the LED package will turn on and off in turn and the colors blend to form yellow. A simple, but neat and elegant way to indicate logic levels, don't you think?

Panel board

The panel-board circuitry is restricted to just a few components. They include a switching matrix made up out of jacks, and a few switches. The arrangement for pin 1 is shown in Fig. 1. The wiring for the other pins from the IC socket are arranged in the same manner, with jacks from the HIGH, PULSE, and LOW lines connecting to it. Although it looks like quite a bit of wiring, the PC board simplifies things considerably. Furthermore, the connections to the display board are made using just two connectors. That makes construction, testing, and troubleshooting simple.

Assembly

We'll assemble the display board first. It isn't difficult, but it is important to follow instructions. The LED's, for example, must be installed *last*. They mount a fixed distance off the display board, and if you install them incorrectly, you won't be able to install the panel board! If you follow the directions, there should be no problem with assembly.

The first step is to obtain the parts. Since the display board is double sided, and tough to make, you may want to buy it from the source in the Parts List. Of course you may make your own using the artwork provided in Figs. 3 and 4. (The same goes for the panel board, which will be shown in the next part of this article.)

The IC's should be no problem, but be sure to use first-quality parts. If you scrounge the IC's from the junkbox, be sure to test them in an active circuit to make sure they are good. It's embarassing to build an IC checker and discover it won't work due to a bad IC! Actually, since the IC's this project uses are so inexpensive, I can't imagine why you wouldn't use factory-fresh IC's anyway. The extra cost of new parts is a lot less

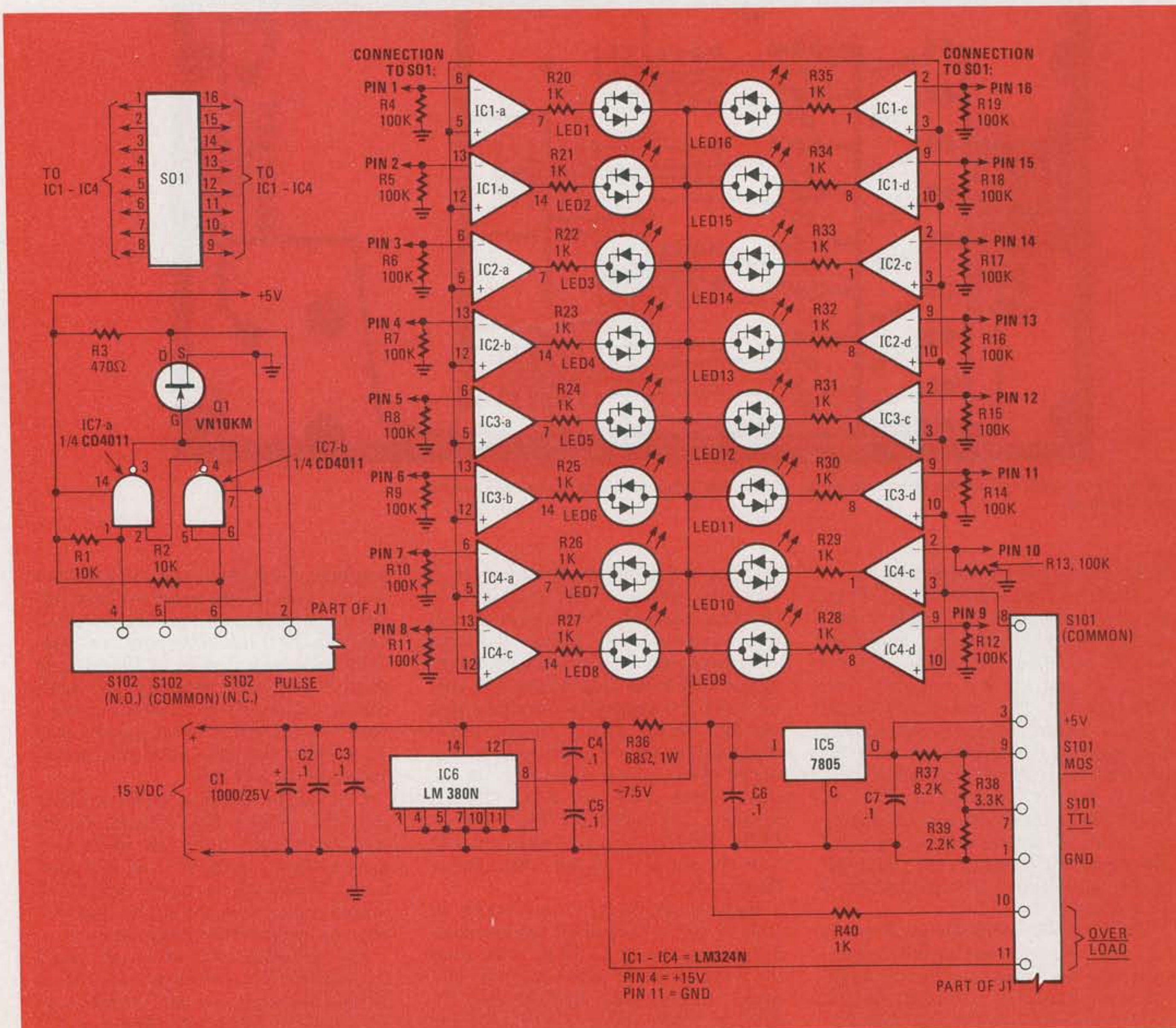


FIG. 2—VMOS POWER FET, Q1, permits test voltages to approach ideal TTL or CMOS logic levels.

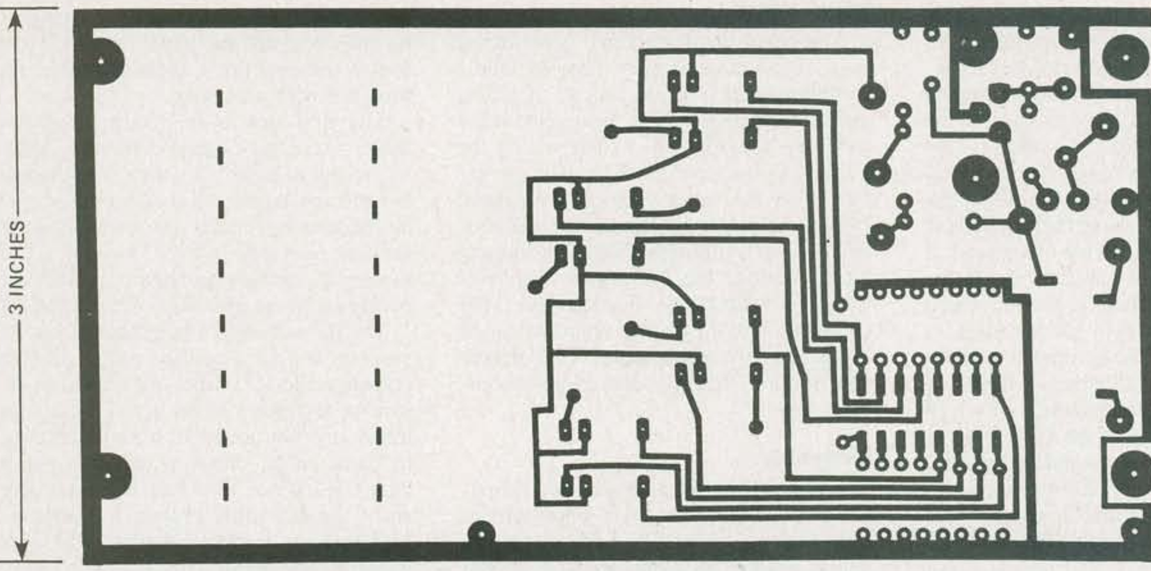


FIG. 3—THIS SIDE OF IC TESTER's display board is the one on which most components are mounted.

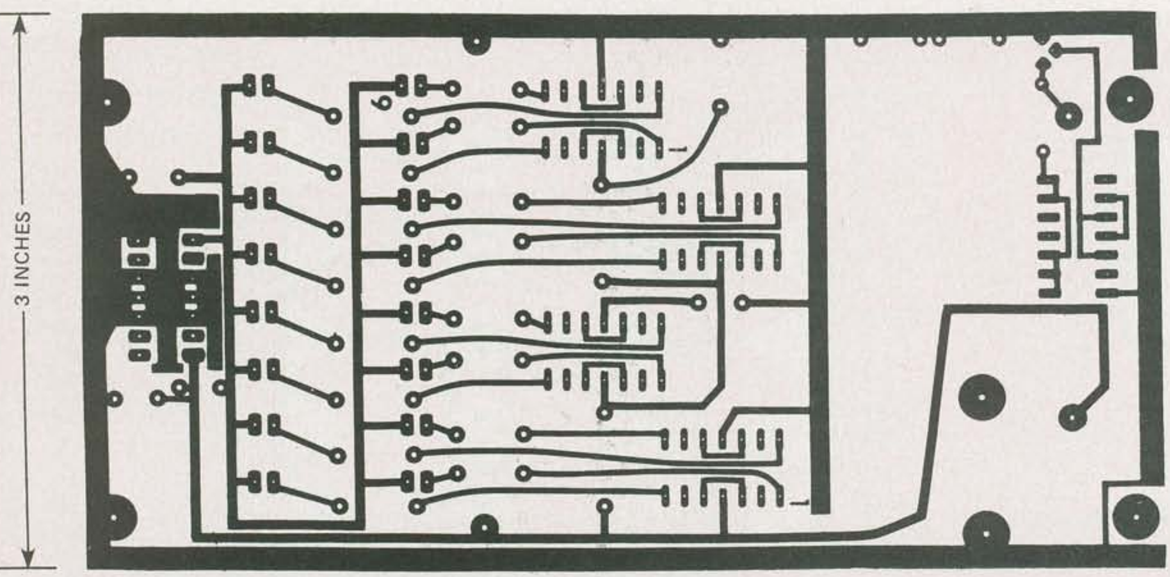


FIG. 4—"FOIL-SIDE" of display board. Note that, while board is double-sided, holes need not be plated-through.

bother than troubleshooting later on.

The LED's are important, too. There are several types of tri-color LED's on the market. The Programma III uses the kind with the two diodes in parallel, and as a result, the package has *two* leads. Another type of tri-color LED has the diodes in series, and the package has *three* leads. Stay away from that one; you want the two-leaded device. If you want to save money, you can substitute standard red LED's for the ones called for. The display won't look as elegant, because logic-low states won't be indicated, but you'll still get the information you need, and that's what counts.

Keep those tips in mind when shopping for parts. Since it is important to control costs today, keep them low by reading the ads in this magazine, comparing prices, and then buying from the best suppliers.

Once you have the boards and parts, it's time to get started. Refer to Figs. 5 and 6 for details for this phase of construction. Study Fig. 5 for a moment, and orient your board so it faces the same way. **Note that the parts-placement diagrams show the board from the side on which the components are mounted but that the foil pattern you see in the diagrams is on *the other side* of the board**. Now you are all set to install the parts, which consist of IC's, jumpers, resistors, and capacitors. The LED's—LED1–LED16—and the wires to SO1 won't be installed yet; *don't* rush and put them in first!

Begin with the IC's and insert an LM324 at IC1. Normally I would recommend using sockets for the IC's, but since the some of the IC pins have to be soldered on both sides of the board, it's better to solder the IC's directly to the board. Use gentle heat, and don't cook anything. Press the IC in place with your fingers, then flip the board over and solder all 14 leads to the foil. Then return to the *component side* of the board and carefully solder pins 2, 5, 6, 9, 19 and 13 to the foil. Use solder sparingly, and watch out for shorts. If you accidently create a solder bridge between two terminals, heat it , and push away the solder with a toothpick or X-ACTO knife.

Continue by installing another LM324 at the IC2 position. Solder it in as you did with the first IC. After that, install two more LM324's at the IC3 and IC4 positions. When you're done, check for missed connections and shorts, and correct any errors before going farther.

Moving to the left of the board, install an LM380 at IC6. (You may use a socket for this device, if you like.) Orient it as shown in Fig. 5 and solder the pins to the foil on the reverse side of the board. Move

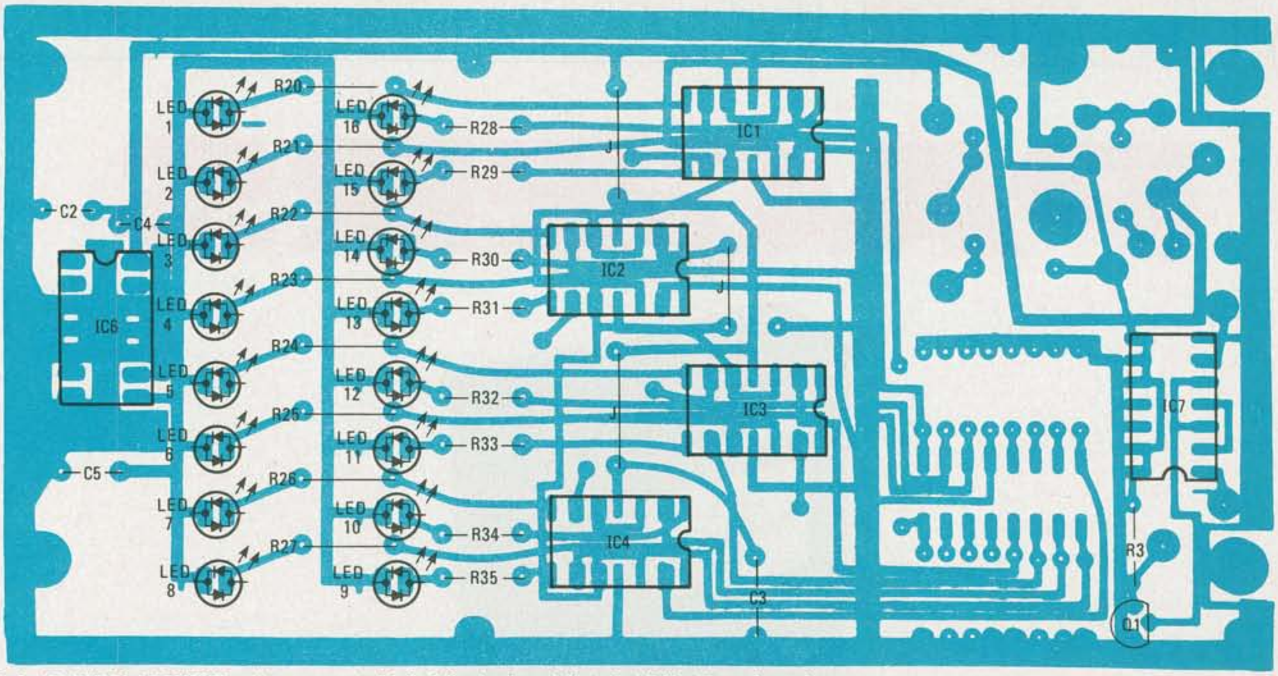


FIG. 5—PARTS PLACEMENT on "component-side" of display board. Note that foil pattern shown is on side of board *opposite* the one on which components are mounted.

to the right of the board and install a CD4011 at IC7. Press it in place with your finger, then turn the board over and solder the pins to the foil. Flip back to the component-side of the board and carefully solder pins 1, 6, and 8 to the foil on *that* side of the board. Be careful not to bridge pin 6 and pin 7; they are close together because of the foil trace nearby. That takes care of the IC's. Check your work again for shorts and errors, fix any problems, and you can continue.

There are three jumpers, and they come next. They are by IC1, IC2, and IC3, as indicated in Fig. 5. You can make the jumpers from short pieces of hookup wire, or short lengths of resistor lead. Install the first jumper to the left of IC1 and solder the leads to the foil on the other side of the board. Move across IC2, and install another jumper to the left of IC3. Position it so that it can't touch the foil that runs nearby—in fact, you should slip a piece of insulated tubing over the jumper if you used bare wire. Move to pin 1 of IC3, and install the third jumper. Note that it runs between the two IC's, and parallel to them.

The resistors come next. Note that these are all 1K units except for R3 (470 ohms), which is off in a corner by itself and which should be installed first. Solder its leads to the foil on the other side of the board. Move to the left of the LM324's and start installing the 1K resistors—note that there are 16 of them—as shown in Fig. 5. Then turn the board over and solder the leads to the foil. Be sure to clip off the excess lead lengths.

Now for the capacitors. Note that they are all of the same value—0.1 μF. Either ceramic disc or Mylar types may be used. Starting at the far left of the board, install 0.1 μF discs at C2, C5, and C4. Solder the leads on the other side of the board, and clip off the excess. Position the capacitor bodies so that they stand straight up. Then move along the bottom of the board, and install C3. Press its body flat against the board before soldering the leads; we don't want this part to stand up in the air. Clip off the excess leads, and you are finished with the capacitors.

For the time being, the last part to be installed on the component side of the board is Q1, the VMOS power FET. It goes in the bottom right corner, next to the 470-ohm resistor. Install the device as shown, with the flat in the case pointing toward the right edge of the board. Solder the leads on the other side of the board, and clip off the excess. That completes the component installation on this side of the board for now, though we still have to install the LED's and wire SO1.

Next time we'll complete the display board and wire it to the panel board. We'll also finish up construction and put the IC tester into operation. **R-E**

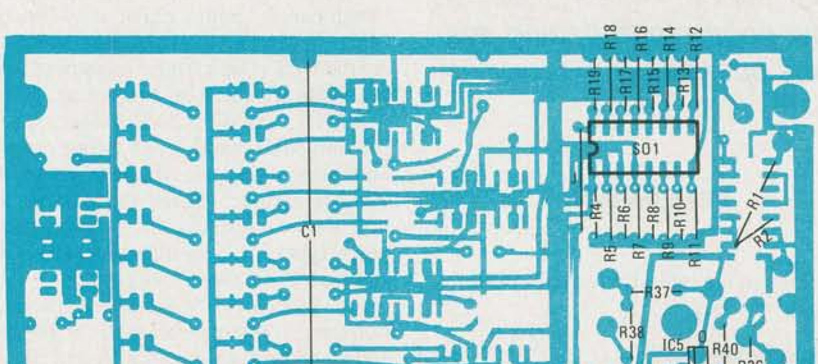


FIG. 6—PARTS PLACEMENT on "foil-side" of display board. Resistor R2 (at right) is soldered to pads on opposite sides of board.