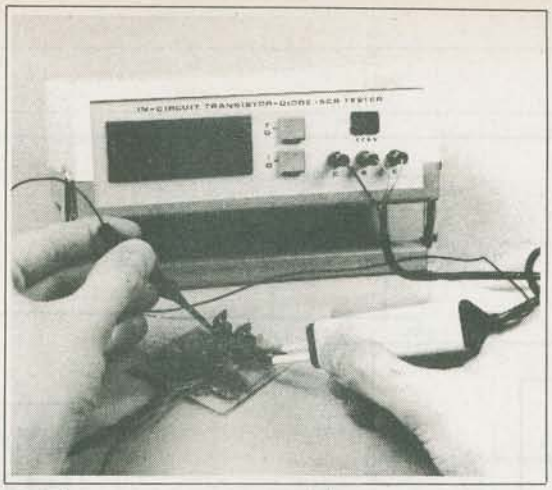


Transistor Tester

An in-circuit transistor tester that will test your components rather than your patience.

By Allan Wilcox

How many hours have you spent testing transistor after transistor in a ponderous search for the monstrous component that has blackened your golden PCB? How often do you wish for a device that could tell good from bad with a single prod from a probe?

Wish no longer. This tester will confirm a single measurement if a diode, transistor or thyristor is OK as well as showing its polarity (PNP/NPN for a transistor and PN/NP for a diode). It is tolerant of in-circuit resistance of the order of 40R across the junctions so you can flit from component to component without once reaching for your soldering iron. There is even a buzzer which sounds whenever a healthy piece of semiconductor is tested.

The Test

To test a transistor a 5Hz square wave is applied to the collector-emitter terminals of the device being examined (see Fig.1). Forward bias is supplied to the base, again with a 5Hz square wave.

The low saturation voltage of a good transistor is taken as the indication of a good device but is differentiated from a short circuit by checking that conduction occurs in one direction only.

If conduction occurs on the positive half-cycle (relative to the emitter) this is interpreted as being a good NPN transistor.

Conduction on the other half-cycle would be due to a good PNP device.

The design criterion here is that the collector-emitter voltage must fall below 500mV for a good indication to be given. This ensures the tester ignores any diodes that may be in circuit. This is particularly important in order to detect a collector- base short which would act as a diode, conducting on one half- cycle only and erroneously indicating a good device.

Diodes, thyristors and Darlington transistors have a forward voltage drop between 500mV and 1V so to test these a separate range is provided. On this range the threshold for a good indication is increased to approximately 1V.

The Display

A 4-digit LCD is used to show the status of the device under test. The first three 'digits' can show either an n or a p, and indicate the device type. The first digit is blanked when testing diodes.

The fourth digit shows either a t or a d to indicate transistor or diode range. It also serves as an 'on' indicator. Failed devices will give a display of nnn on the LCD if the test terminals are short circuited. If they are open circuit, the first three letters of the LCD are blank.

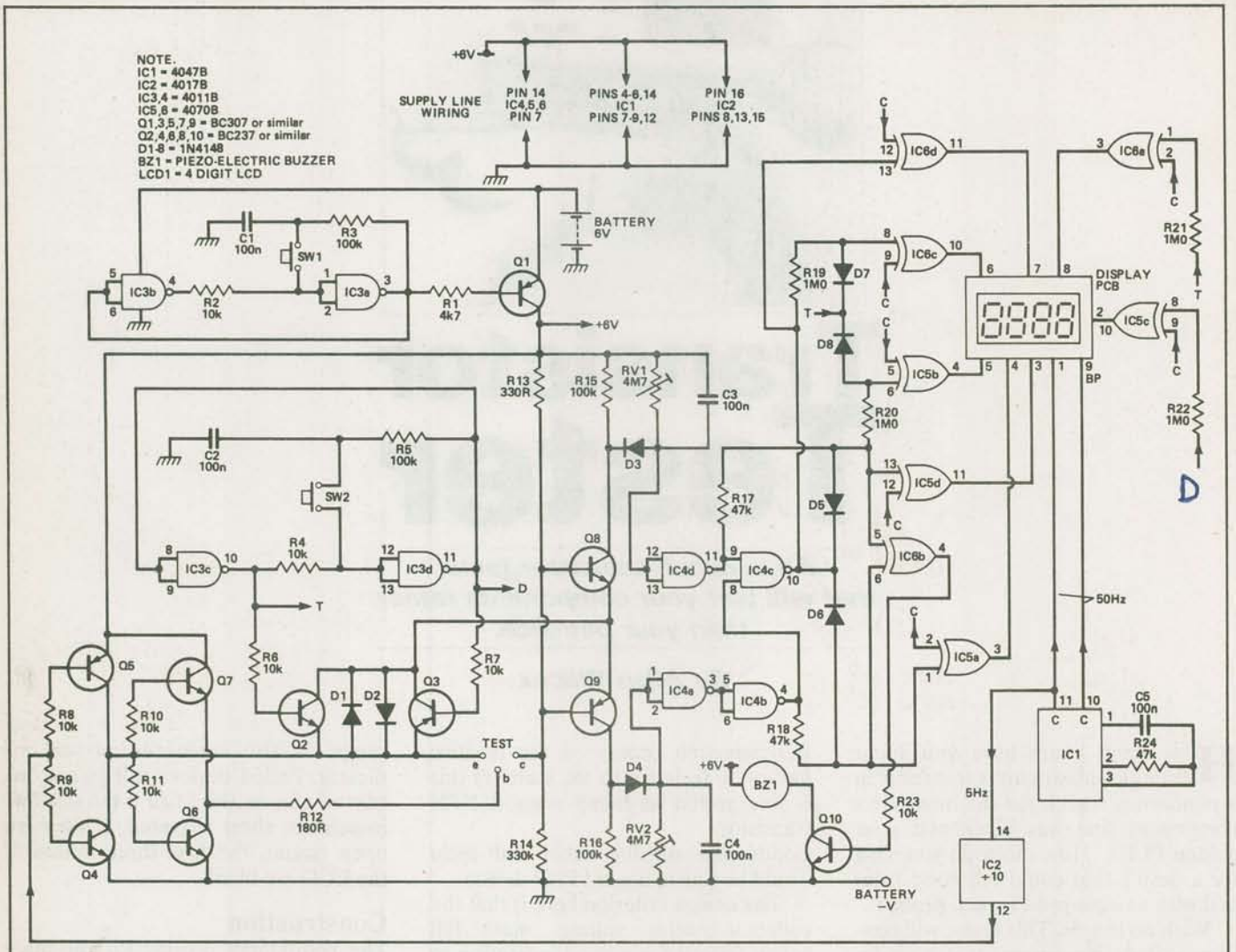
Construction

The component overlay for the main PCB is shown in Fig. 2. All ICs are CMOS and so the usual precautions against static should be taken. Note that they all face the same way on the board.

All odd numbered transistors are PNP and even numbered are NPN. The presets RV1, RV2 may be replaced by 4M7 fixed resistors with just a small increase in the response time resulting.

Avoid any stress on the LCD display, taking care not to overtighten any fixing nuts. The mounting bezel specified comes complete with two socket strips on a board. These were removed and used on the display PCB (fig.3). Take care to observe the polarity of the ribbon cable when connecting the main PCB to the display PCB.

Note that the two switches are momentary push to make, similar to a keyboard type. The ones used on the prototype were from the junk box.



The complete circuit diagram.

Shock, Horror, Probe

Testing a transistor involves connecting into the circuit at three separate points. Manipulating three individual probes with only two individual hands can be a practical problem. To overcome this, a special collector-emitter test probe was constructed using a small Eveready torch case into which were fitted two short lengths of curtain wire to form the probes. Dart points were filed down to fit tightly into these. The result can be seen in the photograph.

The probe used for the base connection is one commercially available. In addition to sockets for the circuit probes, a transistor socket was fitted to the from panel of the case to ease the testing of devices out of circuit.

Testing And Setting Up

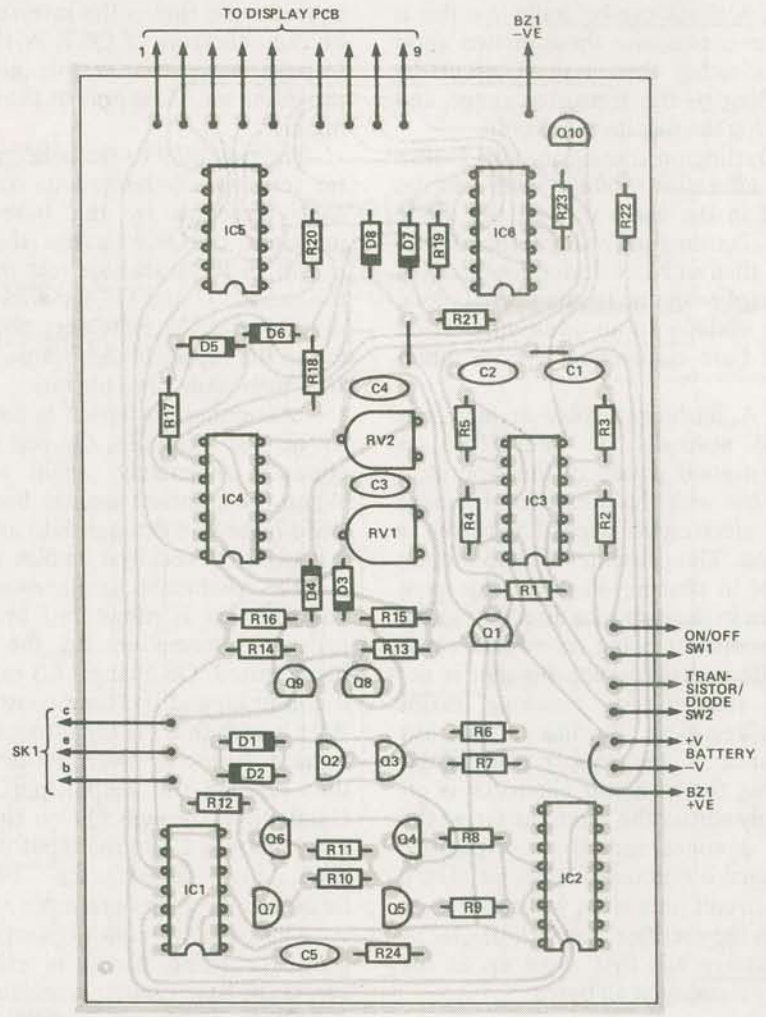
If the presets (RV1,2) are fitted, turn both counterclockwise and connect up the batteries. When on, the display should blank apart from the mode indication which should be a d or t. This should alternate each time SW2 is operated.

Now select the diode mode and advance a preset until the display starts to flash, then back off until the display just blanks. Repeat this procedure with the other preset.

To test the unit connect a diode across the collector-emitter terminals. The display should show **pn** when the diode anode is connected to the collector terminal and **np** when the diode is reversed. There should be no response from the connection of the diode when the unit is in the transistor test mode.

Check the transistor mode using a good transistor of each type. The display should remain blank until the base connection is made. Now short the collector-emitter probes together and check the display shows **nnn**.

Note that the buzzer will sound continuously while a good device of any type is connected. This is useful for rapid testing of components on a board when there is no regard for polarity. Thyristors should be tested on the diode range due to their higher saturation voltage. The collector, emitter and base terminals become anode, cathode and gate respectively. A good device will show pn (it does of course act as a diode) but only when the gate connection is made. Confirm that point otherwise it is faulty. If the



The component overlay the main PCB.

Parts List

Resistors (.25W, 5%)

R1 4k7
R2,4,6-11,23 ..... 10k
R3,5,15,16 ..... 100k
R12..... 180R
R13,14 ..... 330R
R17,18,24..... 47k
R19,20,21,22 ..... 1M0
RV1,2..... 4M7 trim

Capacitors

C1-5 ..... 100n

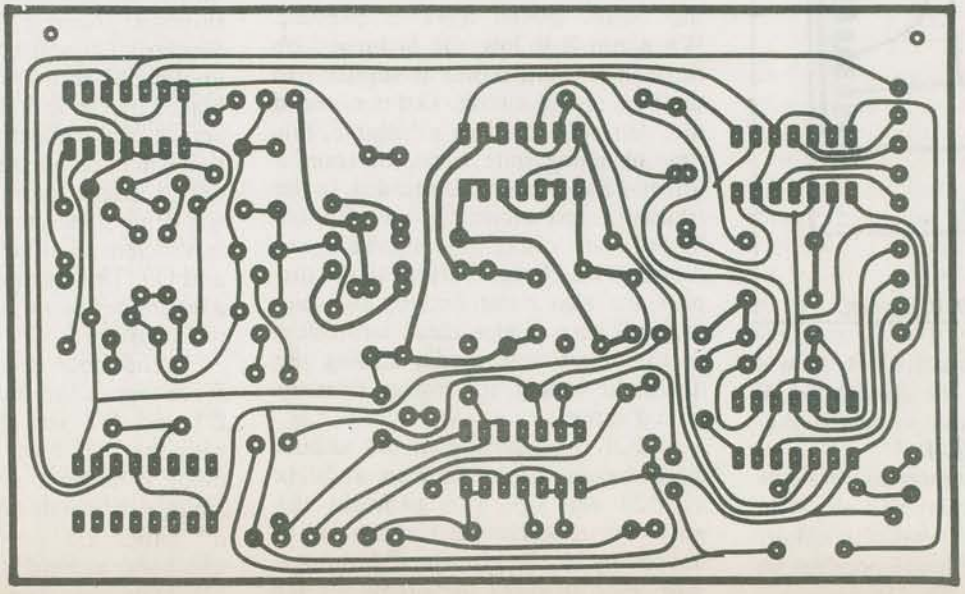
Semiconductors

IC1 ..... 4047B
IC2 ..... 4017B
IC3,4 ..... 4011B
IC5,6 ..... 4070B
Q1,3,5,7,9 ...2N3905 or equiv
Q2,4,6,8,10. 2N3094 or equiv

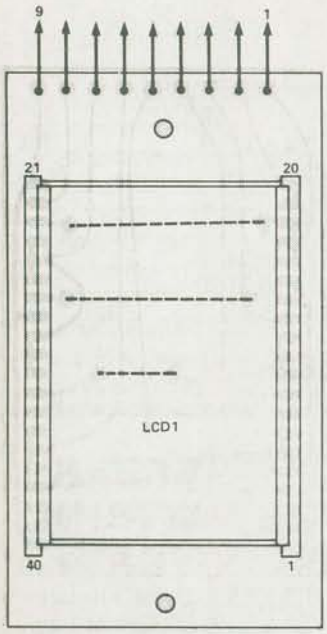
Miscellaneous

BZ1 ..... piezo buzzer
LCD1..... ICM7211AIPL 4-digit direct-drive LCD
SW1,2..... push-to-make

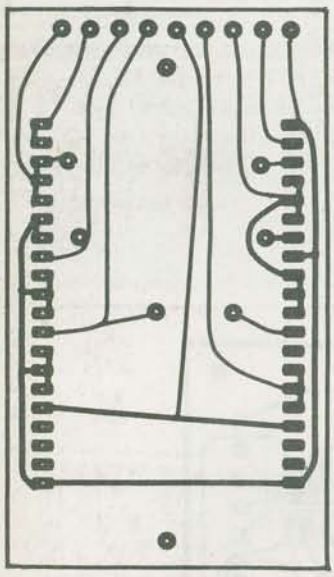
Battery holder, LCD bezel, case. The LCD is available from Electrosonic, 1100 Gordon Baker Rd., Willowdale, Ont. (416) 494- 1555.



The main PCB.



Component overlay for the LCD.



The LCD printed circuit board.

thyristor has an internal diode then it will show np before the application of the gate connection due to the conduction of the internal diode.

Once the gate connection is made in this case, the display will show nn (which would normally indicate a short circuit) due to a legitimate conduction in both directions. The display will similarly show nn when testing two diodes which are connected 'back to back'. A check can be made that this is due to conduction through two good diodes rather than a short circuit by switching to the transistor range and checking the display blanks off.

Darlington transistors also have a high saturation voltage and can be tested in the same way on the diode range. Darlingtons with internal diodes mean that an NPN device for example will display np due to an internal diode which updates to nn upon application of the base connection in both directions.

A flashing display at any time should normally be interpreted as being a good device of the type indicated but with the presence of a large value electrolytic capacitor across a junction. The presence of such a component in circuit will give some conduction in the opposite direction to the semiconductor being tested and cause this effect. As a result, this unit is not really suitable for checking mains supply rectifiers. Because of the low resistance of the supply transformer winding, the reservoir capacitor is effectively across the diode as far as the tester is concerned. If the capacitive reactance is below 40R or so at 5Hz, a short circuit indication will result even though the rectifier may well be OK. A low battery will first show up as the display flashing at all times.

How It Works

Gates a and b in IC3 are wired as a bistable that changes state each time the on/off switch SW1 is pressed. When pin 3 is low, Q1 is turned on through R1 and power is supplied to the rest of the circuit. Gates c and d are also connected as a bistable, this time changing state when the transistor/diode switch SW2 is pressed. In the transistor test mode Q2 and Q3 are biased on, effectively shorting out diodes D1,2. (Some features of the display are also controlled by this bistable). These diodes come into effect in the diode test mode, raising the threshold voltage for testing as mentioned above.

IC1 is connected in the astable mode having a frequency set at 50Hz by R24 and C5. This provides the waveform to drive the display and is divided by IC2 to give the 5Hz square wave used to drive the bridge circuit formed by Q4-7. The result of this is that the collectors of Q4,5 have a 5Hz square wave that is the inverse of that on the collectors of Q6,7. A 1V peak-to-peak waveform is this generated providing an AC supply ot the test terminals.

The potential to the collector-emitter terminals is limited to 600mV in each direction by the base-emitter junctions of Q8,9 across these terminals in the transistor text mode. In this mode Q2 and Q3 are always on as the Q4 and Q5 collectors switch between the supply lines because IC3 pin 10 is high while pin 11 is low.

Assuming no device is connected tot he test terminals, Q8 and Q9 will conduct alternately, again at 5Hz. When the common emitter line is low Q8 is biased on through R13 and when it is high, Q9 received its bias via R14. It is the conduction or otherwise of Q8 and Q9 that is monitored by IC4 to provide information on the device being tested. Q8 charges C3 each time it conducts, and the time constant C3-RV1 is such that the input to gate IC4d remains below its switching threshold, thus holding the output pin 1 high. Conduction through Q9 on the other hand charges C4 so the input to gate a stays just above the switching threshold, keeping output pin 3 low.

The collector-emitter junction of a transistor being tested is effectively across the base-emitter junctions of Q8 and Q9 so if, say, a good NPN transistor is in circuit the bias to Q8 is diverted and it will switch off. Forward bias to the test transistor at this time is through Q7 and R12.

Similarly Q9 will be turned off by the application of a PNP device, this time biased by Q6 and R12. A short circuit across the collector-emitter connection will of course turn off both Q8 and Q9. A diode across these connections will draw some current but this will be insufficient to effect conduction of Q8 and Q9. This ensures a transistor with a base-emitter or base-collector short will register.

In the diode test mode, the bistable IC changes state, reverse biasing Q2,3. D1 and D2 are effectively in series with the bias feed to Q8 and Q9. A diode connected across the collector-emitter terminals will be able to turn off either Q8 or Q9 depending on which way around is connected.

The time constant RV1-C3 and RV2-C4 is dictated by the choice of

5Hz as the rate at which the supply to the test terminals is reversed. This in turn is a trade off between the response time of the instrument and reasonable immunity to the effect of any large value electrolytic capacitor that may be in circuit across a junction.

Good immunity to in-circuit resistance is achieved because the resistance across the junction must fall below one tenth of the value of R13, 14in the case of the collector-emitter connection and one tenth of R 12 in the case of the base-emitter connection before the conduction of Q8,9 or the transistor being tested is affected.

In-circuit resistance below this will reduce the bias in each case to under the 600mV required for conduction.
A conventional 4-digit LCD us used to indicate the status of the deice being tested. The display is driven by a perfect square wave from the bistable output of IC1. The individual segments required to represent the desired letters are driven by the exclusive-OR gates of IC5 and IC6.

The clock output from pin 10 of IC1 is connected to one input of each EX-OR gate and also to the backplate of the LCD. If the second input to any gate goes high, a square wave will then turn on any segments connected to the output of that gate.

Open circuit across the test connections blanks the first three letters of the LCD since both inputs to IC4 from Q8 and Q9 are high, forcing a low on pin 10 and the five control inputs of the relevant gates. If a good NPN transistor is tested, Q8 turns off, sending the output of IC4d low and IC4c high, displaying nnn and releasing control of the lines through R17 and R18. Since Q9 is o, IC4b is high and the display npn is completed.

With a PNP transistor, the output of IC4b goes low as Q9 turns off, leaving n showing on the second digit. A p is completed each side from IC5b and IC5d, since the output IC4d is high.
In short circuit, both Q8 and Q9 are off, sending the lines through R17 and R18 low. This leaves a display of nnn from the high output of IC4c.

In the diode mode, the first digit of the LCD is blanked by sending the control inputs of IC5b and IC6c low through D7 and D8. The bistable ICs turns off Q2 and Q3 placing diodes D1 and D2 in series with the bias path to Q8 and Q9. The voltage across the collector-emitter test connections is now about 1.2v and the application of a diode will cause the cutoff either Q8 or Q9 depending on its direction. This displays either pn or np as described above.

The buzzer sounds if the inputs of gate IC6b are different, which only occurs when a good device is in circuit. ■

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