There is no need to unsolder suspect transistors!

Build an in-circuit transistor tester

by COLIN DAWSON

Have you ever desoldered a suspect transistor, only to find that it checks OK? Troubleshooting exercises are often hindered by this type of false alarm, but many of them could be avoided with an "in-circuit" checker such as the EA Handy Tester.

In the absence of a CRO, most hobbyists and servicemen rely on voltage measurements to locate faulty transistors. Even so, there are many situations where voltage measurements do not give a clear indication of faulty devices. Flip-flop circuits are just one example.

Another reason why voltage measurements may not be useful is that power applied to a faulty circuit may cause further damage. And while resistance measurements can be helpful in some instances, they do not always give clear cut results.

The EA Handy Tester overcomes these problems. It tests both NPN and PNP transistors in circuit at the press of a switch. There is no need to apply power to the circuit with the suspect components. As a bonus, the Handy Tester will test diodes and SCRs as well.

So instead of desoldering the component, all you have to do is clip three test leads to it (or two in the case of a diode). If the device checks OK, you simply unclip the test leads and move on to the next suspect. This method not only saves time but is also much kinder to printed circuit boards and components. Excessive heat can lift PCB tracks and damage components if you're not careful.

There are two LED indicators to indicate whether a component is "good" or "bad". When a good NPN transistor is tested, one LED flashes. When a good PNP device is tested, the other LED flashes. If the device is faulty, either both LEDs flash (device short circuit) or both are extinguished (device open circuit). What could be easier?

There is no NPN/PNP switch on the Tester – it automatically indicates the polarity of the transistor under test. The front panel artwork tells you which LED should be flashing for the given transistor type and, by comparing this with the indicator, you can identify the polarity at a glance. All you have to know about a transistor is which leads are its base, collector and emitter.

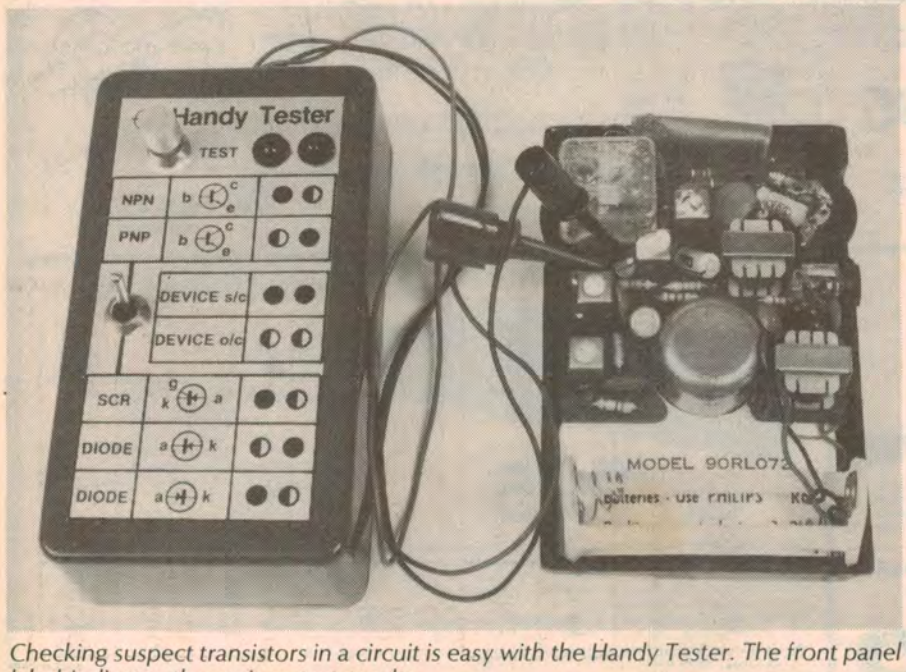
Note that the tester is only supposed to indicate that the transistor action is taking place – ie, base current causes the collector-emitter path to become a low resistance in one direction. It does not give any indication of beta or high leakage in a transistor. This is not a serious limitation as most faults are of the "go/no go" type.

Diodes and SCRs are tested in similar fashion – just compare test results with the front panel artwork. In the case of diodes, only two test leads are required. The Handy Tester will then indicate whether or not the diode is working and indicate its polarity.

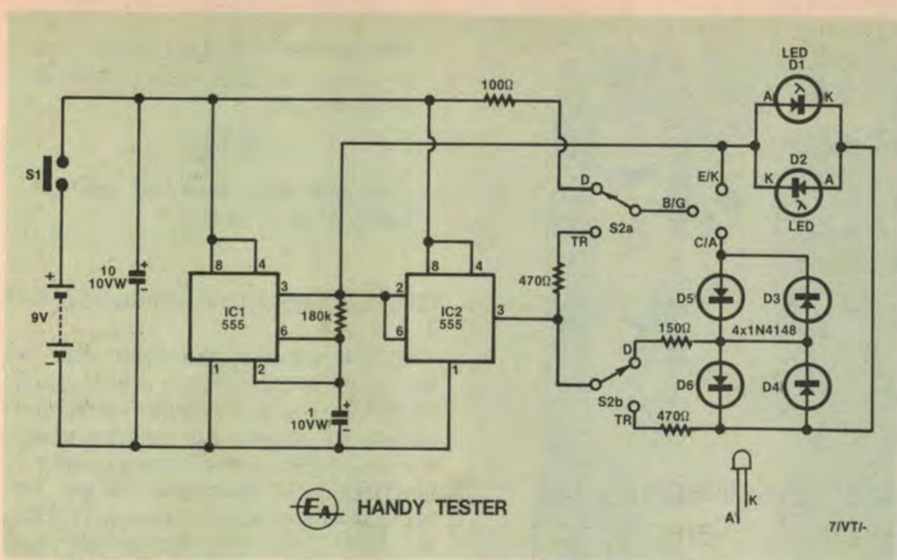
The principle of operation of the tester is fairly simple. The two LEDS are connected in parallel but with reverse polarity to each other. They are driven by a square wave oscillator with complementary outputs so that one LED will be on for each half cycle. The component under test is connected in parallel with the LEDs and, in the event of being forward biased or triggered, will shunt the LED current.

A good component will only conduct on positive or negative half cycles and will thus prevent one of the LEDS from illuminating.

A component which is short circuit will conduct on both positive and negative half cycles, diverting current from both LEDS. Conversely, a component which is



Checking suspect transistors in a circuit is easy with the Handy Tester. The front panel label indicates the various test results.



The circuit is basically a 2Hz oscillator with complementary outputs. It tests transistors, diodes and SCRs at the press of a button.

open circuit will not conduct at all and both LEDS will flash to indicate the fault condition.

How it works

The circuit is based on one originally published in the English magazine "Television" for June 1983. Their circuit used a 556 dual timer IC but we have adapted it to use two 555s since these are considerably cheaper and more readily available.

The way in which the two 555s are wired in this circuit is rather unusual. Instead of using the more familiar astable configuration, IC1 has been connected to operate as a Schmitt trigger oscillator with a 2Hz output frequency. Note that the discharge pin (pin 7) has not been used. Instead, the pin 3 output has been tied to pins 2 and 6 via a 180kΩ timing resistor.

Here's how it works. When power is first applied, the pin 2 trigger input of IC1 is held low by a 1μF capacitor and thus the pin 3 output is high. The 1μF capacitor now charges via the 180kΩ resistor and, after about 0.25s, the pin 6 threshold input reaches its critical value of two thirds supply (ie 2/3Vcc). IC1 now toggles and the pin 3 output goes low.

The 1μF capacitor now begins to discharge via the 180kΩ resistor until, after a further 0.25s, it falls to 1/3Vcc and IC1 is retriggered (pin 3 high). In this way, IC1 functions as a Schmitt trigger oscillator while ever power is applied to it.

The output of IC1 is used as one of the tester outputs (E/K) and is also used to control IC2. No timing network is used with IC2 – it operates simply as an inverter. When the input signal is high, the 2/3Vcc threshold is exceeded and IC2's pin 3 output goes low. Similarly, when the input signal is low, a trigger pulse is sensed and the output goes high.

In this manner, IC1 and IC2 produce complementary square wave outputs, each waveform having an amplitude of 9V RMS.

For the moment, assume that switch S2 is switched to the transistor (TR) test position. This will allow the output from IC2 to drive one side of the LEDs via a series 470Ω current limiting resistor. The other side of the LEDs is driven by the output of IC1, irrespective of the mode selected.

While one LED is forward biased the other will be reverse biased. Normally this is not an acceptable practice – LEDs can easily be destroyed by reverse biasing. The qualifier is that the reverse voltage becomes destructive only if it exceeds 5V. Because the typical forward voltage for a red LED is only about 1.7V, the voltage across the parallel pair can never exceed this value – regardless of the polarity.

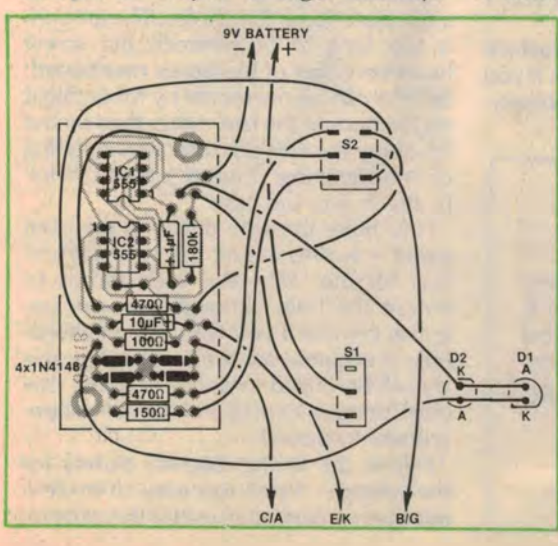
So as long as the test terminals are open circuit, the two LEDs will flash alternately on and off. When the output of IC1 is high, LED D1 is forward biased and therefore illuminated. When the output of IC2 is high, LED D2 is illuminated.

Suppose now that we short the emitter/cathode (E/K) terminal to the collector/anode (C/A) terminal. When the output of IC1 is high, current will be diverted through diodes D5 and D6 which together have a forward voltage drop of 1.2V. This voltage is insufficient to turn on LED D1 which will thus remain off. Similarly, diodes D3 and D4 conduct when the output of IC2 goes high, thus extinguishing LED D2.

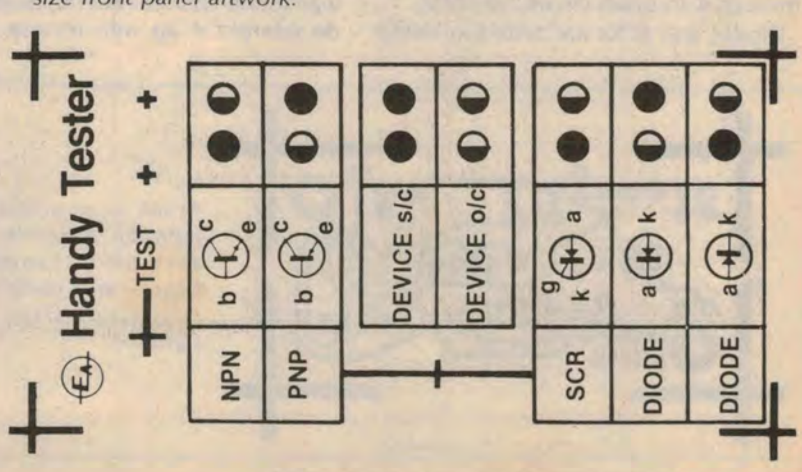
So both LEDs will remain off if there is a short circuit between the E/K and C/A terminals.

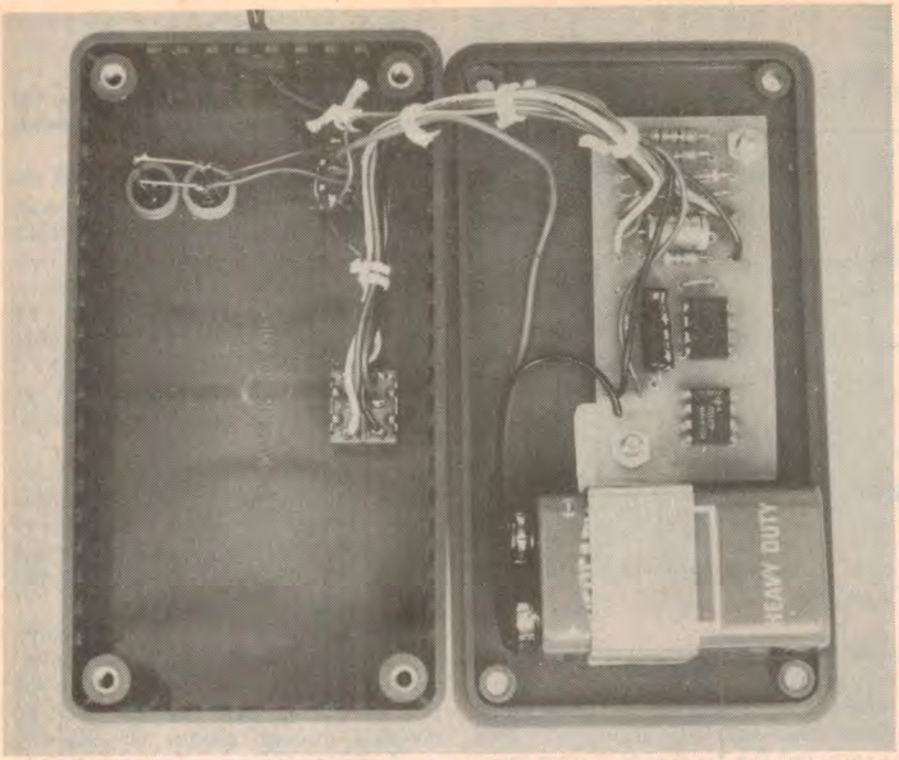
If we now connect a functioning transistor to the three test terminals, it will act as a short circuit between emitter and collector only during the half cycle for which it is forward biased. An NPN transistor is forward biased when its emitter is low and its collector and base high – ie, when the output of IC2 is high. In this condition, current will flow via diodes D3 and D4 and the collector-emitter junction of the transistor. Thus, for a good NPN transistor, only LED D1 will continue flashing.

Similarly, only LED D2 continues to



Construction is easy – just follow this wiring diagram. Below is an actual-size front panel artwork.





View inside the completed prototype. Make sure that you wire the two indicator LEDs up correctly, otherwise they could be damaged.

We estimate that the current cost of components for this project is approximately

$15

This includes sales tax, but not the cost of a battery.

flash for a good PNP transistor.

What happens if there is a base-emitter short or a base-collector short in the transistor? If this is the case, the transistor will be unable to turn on and so both LEDs will flash to indicate an open circuit between collector and emitter. What this means is that the tester is unable to identify the specific fault condition. It simply tells you whether or not the transistor is actually working.

Some readers may be wondering why two back-to-back diode pairs are used in the circuit. Why not simply use one pair? The reason is that, by using two diode pairs, the circuit is rendered less susceptible to parallel resistances in the circuit under test. A low value resistance between the E/K and C/A terminals, for example, will have less voltage across it and thus less current will be diverted through it to upset circuit operation.

Diodes and SCRs are tested in similar fashion to transistors. However, to test these components it is necessary to switch out one of the back-to-back diode pairs. The reason for this is that, if we were to simply add a test diode in series with the existing "detour" diodes, the forward voltage drop would be around 1.8V. This voltage would, in many cases, exceed the forward voltage of the LEDs and thus the LEDs could never extinguish.

This brings us to the function of S2 – the mode selector switch. When S2 is switched to the "D" position, diodes D4 and D6 are bypassed, leaving only D3 or D5 plus the test component in the detour circuit. Connecting a diode with its anode to the C/A terminal will cause it to "short out" LED 2, leaving only LED 1 to flash.

However, it doesn't really matter which way round you connect the diode. If you do connect it up with reverse polarity, LED 2 will flash on and off instead of LED 1.

An SCR will have the same effect on the circuit as a diode but it will require triggering. This is accomplished by connecting its gate to the positive supply line via a 100Ω current limiting resistor. A functional SCR connected as per the front panel diagram will cause only LED 1 to flash. Swapping the anode and cathode connections will cause LED 2 to flash instead.

A Triac is tested in the same way as an SCR with its A2 terminal connected in place of the anode and A1 in place of the cathode.

Power for the circuit is derived from a small 9V battery such as an Eveready 216. Supply line filtering is provided by a 10μF electrolytic capacitor, while switch S1 switches the supply line to provide the test function.

Construction

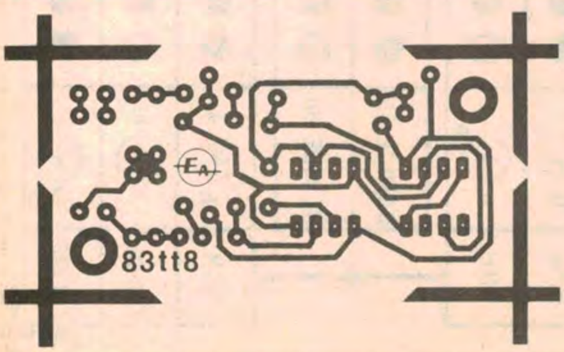
The printed circuit board (PCB) used for this project is coded 83tt8 and measures only 30 × 61mm. Only a few minutes work will be needed to solder the components in place, but watch the orientation – all the components except the resistors are polarised. Note that there is a link on the PCB next to IC2.

The Handy Tester is mounted in a small plastic utility box. Ours, measuring 112 × 62 × 31mm, was obtained from Jaycar. The UB4 plastic case (better known to us as the "second smallest zippy box") would be equally suitable.

The front panel artwork is made from "Scotchcal" material and can be used as a template for drilling holes. The artwork is too long to fit between the screw holes on either of the boxes mentioned, but this can be overcome by mounting it on the back of the box rather than on the lid. Spray the artwork with a hard-setting clear lacquer (eg, "Estapol"), then carefully attach it to the case.

Four holes must be drilled in the front panel – two to mount the switches and two for the LEDs. We used bezels to mount the LEDs although you can use epoxy cement if you wish. An additional hole is required for the test leads – this should be drilled in one end of the box (near the test switch) and a small rubber grommet inserted.

Follow the wiring diagram closely for the wiring – it's all too easy to make a mistake. In particular watch the orienta-



At left is an actual size reproduction of the PCB artwork. Finished boards and panels are available from kit suppliers.

PARTS LIST

1 printed circuit board, code 83tt8, 30 x 61mm
1 Scotchcal front panel, 49 x 96mm
1 plastic utility box, 31 x 62 x 112mm
3 small E-Z hooks; 1 red, 1 green, 1 black
1 DPDT miniature toggle switch
1 SPST momentary contact switch (click action type)
1 9V battery (Eveready 216 or equiv.)
1 battery clip to suit
1 rubber grommet (approx 8mm)

SEMICONDUCTORS
2 555 timer ICs
4 1N4148 diodes
2 red LEDS plus mounting bezels

CAPACITORS
1 10μF/10VW electrolytic (axial leads)
1 1μF/10VW electrolytic (axial leads)

RESISTORS
1 x 180kΩ, 2 x 470Ω, 1 x 150Ω, 1 x 100Ω

MISCELLANEOUS
Hook-up wire, machine screws and nuts, scrap aluminium (for battery clamp), solder, etc.

tion of the LEDs. As explained earlier in the text, unless they are wired with reverse polarity to each other, they could be damaged.

Once the wiring is completed, the PCB can be mounted on the lid of the case using machine screws and nuts. Two mounting holes are required and these should be countersunk so that the screw heads will not damage bench tops. The battery clamp is made from a small piece of scrap aluminium and is secured by one of the PCB mounting screws.

Use flexible multistrand wire for the test leads and make them at least 20cm long. We used small E-Z hooks (the ones with retracting hooks) to make the test connections – red for the collector, green for the base and black for the emitter connection. This works quite well and is easy to remember.

To check the Handy Tester, connect the battery and depress the test switch (S1). The two LEDs should flash alternately. Now short the E/K and C/A terminals. together and depress the test switch – the two LEDs should now be extinguished.

In use, the tester will give clear indications where the surrounding circuit resistances are 50Ω or more. It tends to give ambiguous readings when testing the output stages of audio amplifiers where the circuit resistances are lower than this.