

Scope Component Test Unit

David Botto

In view of the increasing complexity of present day TV sets and VCRs, anything that makes life easier for the service engineer is welcome. You'll find the component test unit described in this article one of the most useful and time saving instruments on your bench – it won't stand idly on a shelf. It can be used with almost any oscilloscope to test transistors, diodes, thyristors, zener diodes, capacitors and even resistors, the condition of the component being displayed on the scope's screen.

The component tester really proves its worth when checking semiconductor devices. The usual method of checking a transistor or diode is with an ohmmeter. This is quite good, up to a point: as engineers know from hard and sad experience however, it's not a method that's one hundred per cent reliable. With the scope component tester the slightest leakage or fault in a transistor or diode is revealed – the test method has proved to be completely reliable. With the exception of thyristors, there's a further advantage – only two test leads are required. This is a lot easier than juggling with three test prods to check a transistor.

Basic Principle

A knowledge of how the tester works will help in getting the best results from it. Fig. 1 shows a simplified circuit. An a.c. voltage is applied to resistors R-low and R-high via terminals A and B. Experiments have shown that the frequency of this a.c. input can be anything between about 25Hz and 20kHz. For convenience, the tester uses the 50Hz mains frequency. The scope's internal horizontal timebase is not used. Instead, the oscilloscope's external horizontal input (X input) is connected to point X. Point E goes to the scope's chassis and point Y to the vertical (Y) input. With the scope correctly set up, the screen display will consist of a horizontal line. This is because resistor R-high has an ohmic value several hundred times that of resistor R-low. If test points E and T are joined together, a vertical line will appear on the screen.

If a semiconductor junction, for example a diode, is connected across points E and T with the cathode to E,

the diode will conduct when the a.c. waveform is such that point T is positive with respect to point E. When the waveform swings negatively, the diode will cease to conduct. Fig. 2 shows the display on the screen. Reverse the diode and you get the waveform shown in Fig. 3.

Capacitors connected across test points E and T will produce ellipses of varying width depending on their capacitance value. A resistor produces a line set at an angle dependent upon its ohmic value.

Circuit

The complete circuit of the scope component test unit is shown in Fig. 4. Resistors R1 and R2 were not included in the original prototype but were added later. With no load connected to the transformer, the voltage across the primary winding is 240V a.c. When a load is connected to the secondary winding, the a.c. voltage across the primary winding is considerably reduced. The power applied to the component under test is thus limited, protecting small diodes and transistors.

Preset resistor VR1 controls the voltage applied to the scope's Y input while VR2 controls the voltage applied to the X input.

The battery and variable resistor VR3 (level control) are used for thyristor testing. A battery rather than a diode fed from the transformer is used to turn on the thyristor under test as this produces a good, clean waveform. The battery lasts a long time – almost its shelf life.

Construction

There's nothing critical about the construction – the photographs show the finished appearance and the internal layout. The small board used was designed to hold two i.c.s but proved to be ideal for use in the tester. If you decide to make your own board, the only point to watch is that the a.c. mains input circuitry is spaced well away from the rest of the circuit. An on/off switch was not included as we always unplug the tester when it's not in use – one could be incorporated as shown in Fig. 4. Fuses can also be added.

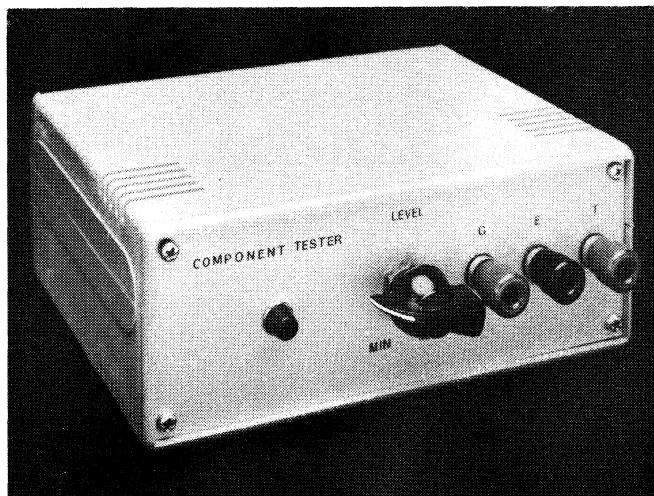
The screened leads that feed the scope's X and Y inputs were fitted with 75Ω BNC connectors, but this is not critical – fit connectors that suit the scope's input terminals.

The test leads have 4mm plugs at one end and mini or micro clips at the other end – these are very useful for making in-circuit tests.

It's a sound policy to apply a very thin coat of circuit varnish to the print side of the board when the basic construction has been completed. Then use a small brush to apply a thin coat of circuit varnish to all solder tags, joints, etc. This will help to ensure trouble-free operation in the long term.

Setting Up

Set the two controls VR1 and VR2 to the mid-position and the level control VR3 to its minimum position



External view of the unit.

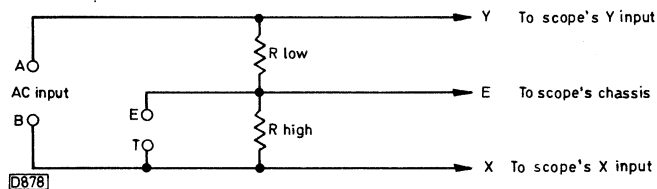


Fig. 1: Principle of the tester.

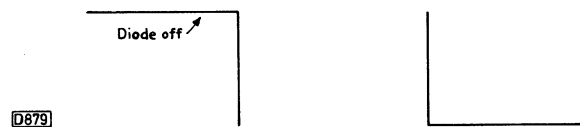


Fig. 2 (left): Diode off/on display.

Fig. 3 (right): Diode on/off display.

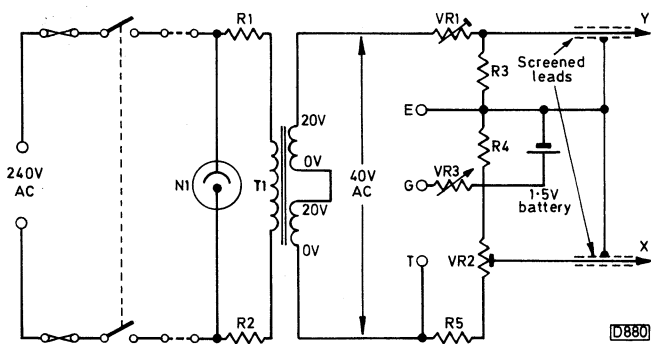


Fig. 4: Circuit of the test unit.

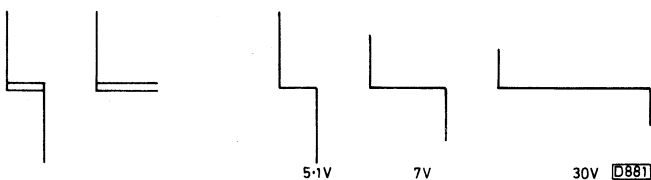


Fig. 5 (left): Double image obtained with a.c. coupling.

Fig. 6 (right): Displays obtained with zener diodes.

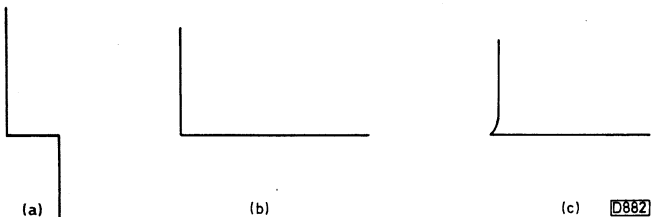


Fig. 7: Silicon npn transistor displays. (a) Base-emitter. (b) Base-collector. (c) Collector-emitter.

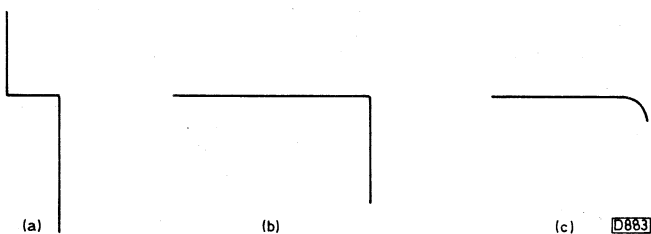


Fig. 8: Silicon pnp transistor waveforms. (a) Base-emitter. (b) Base-collector. (c) Collector-emitter.

(maximum resistance). Switch the scope to external X drive and set the Y input to the least sensitive d.c. range. The tester will work if an a.c. input is used, but with some scopes a double image may be obtained – see Fig. 5.

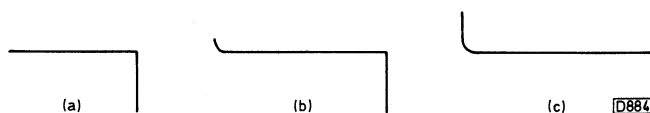


Fig. 9: Displays obtained with germanium transistors. (a) Base-collector. (b) Base-emitter. (c) Collector-emitter.

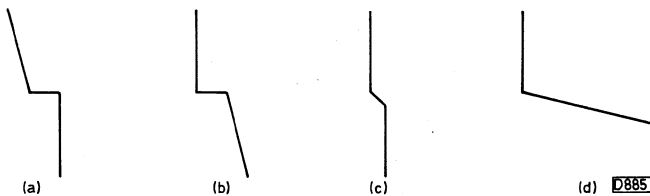


Fig. 10: Transistor fault conditions. (a)-(c) Leakage in or out of circuit check. (b)-(c) Out of a circuit check. (d) Transistor base-collector junction or diode leakage, out of circuit check.

Adjust the scope's controls for a centred horizontal line with slight over scanning. Short test leads E and T to produce a vertical line, then adjust the vertical gain control so that the line just scans the screen. VR1 is included for fine setting if needed.

Checking Zener Diodes

A very useful feature of the tester is the ability to check zener diodes and measure their voltage ratings against the scope's graticule. You'll need about four or five zener diodes for calibration, with voltage characteristics between 5V and 38V. With the cathode connected to E and the anode to T, a zener diode gives the waveform shown in Fig. 6: the higher its zener voltage, the wider the horizontal part of the trace. By using the scope's horizontal gain control to keep the width correct, at the same adjusting the preset VR2, the zener voltages can be calibrated against the graticule divisions. VR1 and VR2 should then be sealed with a tiny spot of sealant.

Transistor Tests

To check an npn transistor, connect lead E to its base and lead T to its emitter. The waveform displayed should be as in Fig. 7(a). Transferring lead T to the collector should produce the waveform shown in Fig. 7(b). With lead E connected to the emitter and lead T to the collector, the waveform should be as shown in Fig. 7(c). It's not usually necessary to make emitter-collector checks in day-to-day testing.

Use exactly the same procedure with a silicon pnp transistor to get the waveforms shown in Fig. 8(a-c).

The transistors used in power supplies and line output stages produce the same traces except that the horizontal section is wider. Germanium transistors give waveforms similar to those shown in Fig. 9.

Field effect transistors of either the junction or MOS type cannot be checked and could be damaged if you try.

A short-circuit device will produce a vertical line, an open-circuit device a horizontal line. Some other fault conditions are shown in Fig. 10.

Checking Thyristors

To check a thyristor, connect the E test lead to the cathode and the T test lead to the anode. The display

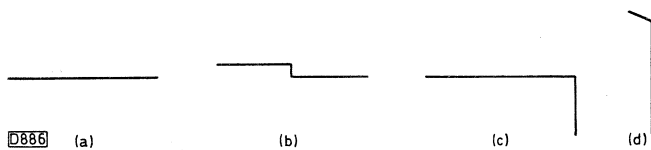


Fig. 11: Waveforms obtained with a BT106 thyristor. (a) With VR3 at minimum. (b) Thyristor just starting to conduct. (c) Thyristor on. (d) Saturation.

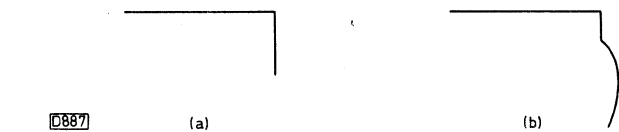


Fig. 12: Testing a diode-thyristor combination. (a) Diode test only. (b) Thyristor turned on.

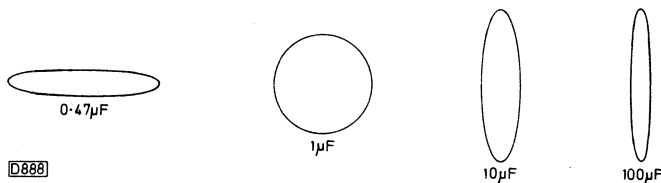


Fig. 13: Measurement of capacitance.



Fig. 14: Tests on LEDs. (a) Waveform for a small LED. (b) Waveform from a seven-segment LED.

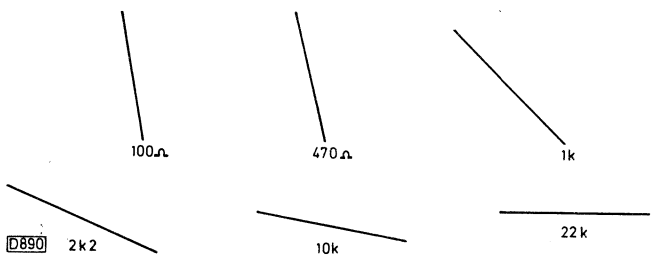


Fig. 15: Waveforms produced by various resistor values.

should then consist of a horizontal line. With the level control at minimum (maximum resistance), connect the

lead from socket G to the thyristor's gate. Some small thyristors, such as the TIC44, will then produce the waveform shown in Fig. 2. With larger thyristors such as the BT106, the level control must be turned slowly to obtain this waveform.

This test is also useful if you suspect that a thyristor is turning on too early or too late. Compare it with a known good thyristor of the same type.

On disconnecting the G lead, the horizontal line should reappear. Fig. 11 shows waveforms for the BT106.

The thyristors used in applications such as TV line output stages often have a diode incorporated in the same encapsulation, connected across the thyristor's anode and cathode. With the E lead to the cathode and the T lead to the anode, the waveform shown in Fig. 12(a) should be seen. This shows that the diode is o.k. Next connect the G test lead to the thyristor's gate and slowly turn up the level control. When the thyristor turns on, you'll see the waveform change as shown in Fig. 12(b).

Measuring Capacitance

Capacitors with values between about $0.22\mu\text{F}$ and some hundreds of microfarads can be measured. With the capacitor connected to test leads E and T, an ellipse will be seen, the size depending on the capacitor's value – see Fig. 13.

Large value capacitors will produce an almost vertical line. With these, use either the scope's X times five (or ten) control or increase the setting of the X gain control. If you calibrate settings with capacitors of known value, you'll find this test extremely useful and reliable.

LED Tests

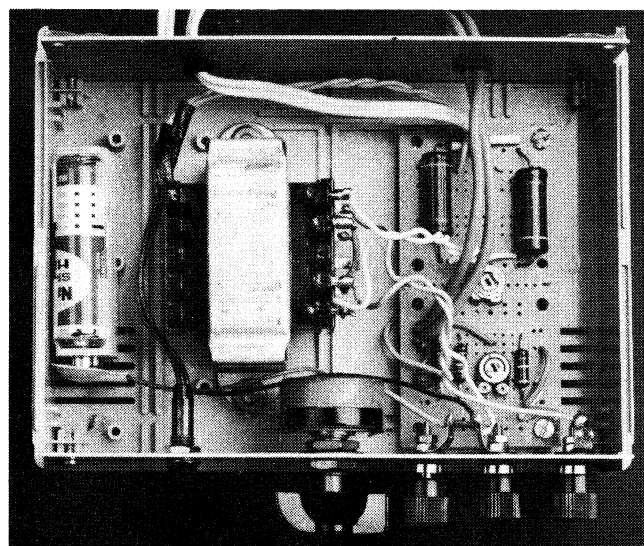
To test an LED, connect the E lead to the cathode (usually identified by a flat side or notch) and the T lead, with a 100Ω resistor in series, to the anode. The LED should light and the waveform shown in Fig. 14(a) should be seen. Reversing the leads will simply reverse the waveform – the LED will still produce light.

Seven-segment LEDs can also be tested. This test is particularly useful when one segment is not lighting. Is it due to the LED or the complex drive circuitry? Connect the E lead to the common cathode (or anode) connection and the T lead, via a 100Ω series resistor, to each segment

Components list

- | | |
|------------|--------------------------------------|
| R1 4.7k 2W | VR1 1k miniature horizontal preset |
| R2 4.7k 2W | VR2 100k miniature horizontal preset |
| R3 1.2k 1W | |
| R4 330k 1W | VR3 3k wirewound potentiometer |
| R5 820k 1W | |

- T1 RS 207-661 mains transformer.
 N1 Tandy 272-708 or similar miniature 240V a.c. neon.
 PCB Tandy 276-159 experimenters' board.
 Plastic case with feet – Tandy 270-9501 or similar.
 Two BNC 75Ω connectors, RS, or as required.
 Battery holder and 1.5V battery – UM3 or equivalent.
 Screened audio lead, mini-clip test leads, etc.
 Three terminals, two red one black, Tandy 274-661.
 Optional: Double-pole on/off switch; two 630mA 20mm anti-surge fuses with holders.



Internal view of the unit.

connection in turn. The segments should light and the waveform shown in Fig. 14(b) should be displayed – an FND500 was used to get this trace.

Resistor Waveforms

The displays obtained when resistors of various values are connected across T and E are shown in Fig. 15. This test won't replace your ohmmeter, but is useful when making in-circuit checks.

In-circuit Tests

A helpful feature of the tester is its use for in-circuit tests. Many transistors, diodes, capacitors, etc. can be tested whilst still in circuit – disconnect the equipment from the mains supply of course! Also make sure that reservoir/smoothing capacitors and the c.r.t.'s final anode are discharged.

In some cases the waveforms will be affected by other

components in the circuit, i.e. those shunting the component being checked. In practice you'll soon get used to this. If you service particular TV sets or VCRs regularly, it's helpful to note various key waveforms you should obtain. If there's room, these can be drawn on or around the circuit diagram.

If it's necessary to isolate a transistor, unsolder only two of its leads and keep them clear of the print. Check the transistor, then resolder the two leads if it tests good. This saves time and also avoids the problems of finding the board unmarked after removing a transistor completely – and perhaps putting it back the wrong way round . . .

The same principle applies with diodes, capacitors etc. – with only one lead being unsoldered of course.

Continuity Testing

Continuity checks on print and transformer windings etc. can also be made. Doubtless you'll find many additional uses for your component tester.