Octopus Component Tester for a Dual Trace Oscilloscope

(Republished from November 1971 LIL)
(Capt Karnazes, HQ Air Force Communications Command)

Troubleshooting of de-energized printed circuit boards, utilizing an ohmmeter, requires removal from the circuit of all but one lead of every component under test. This procedure is not only time consuming, but involves considerable de-soldering and re-soldering, a procedure which can lead to additional problems from too much heat application, and the risk of possible poor soldering techniques and lead bending. Physical size determines the amount of heat a component can safely dissipate. Electronic-part miniaturization and micro-miniaturization have made present day soldering techniques obsolete. Not only are the components very small, but they are quite close together, so that de-soldering, an old troubleshooting method and a byproduct of the use of the ohmmeter in testing, destroys the reliability of the Printed Circuit Boards.

An ohmmeter cannot detect a shorted inductor or an open capacitor, even after the reactive component is lifted from the circuit; and some ohmmeters generate enough current at low range to damage solid state components. As these parts decrease in size, their current handling capacity correspondingly decreases. The use of ohmmeters becomes even more undesirable.

It remains for the technician to locate the defective components without removing them from the circuit or subjecting them to destructive current. From the standpoint of damaged boards due to the excessive heat from soldering irons, costly manhours expended in the removal and replacement of components that tested good, and replacement of components damaged by testing with an ohmmeter, it all points to the need for something better.

A tester (Figure 1) designed for in-circuit use to locate defective components of Printed Circuit Boards quickly and safely, without the necessity of removing component's leads from the circuit, was fabricated, and tested at this terminal station.

FIGURE NO. 1

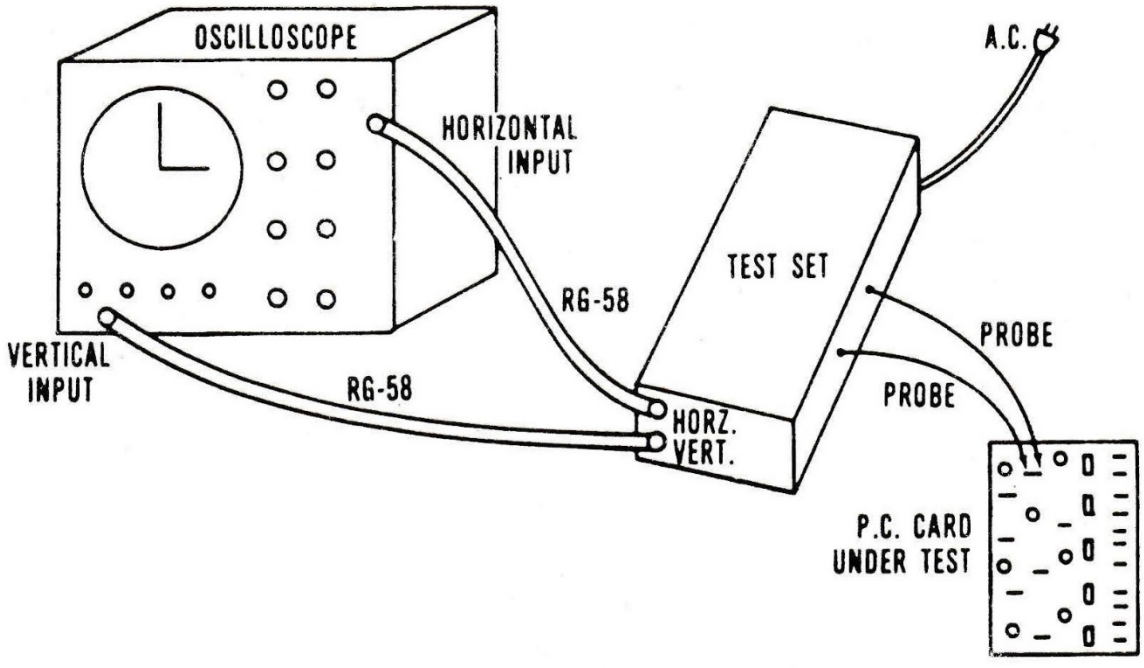
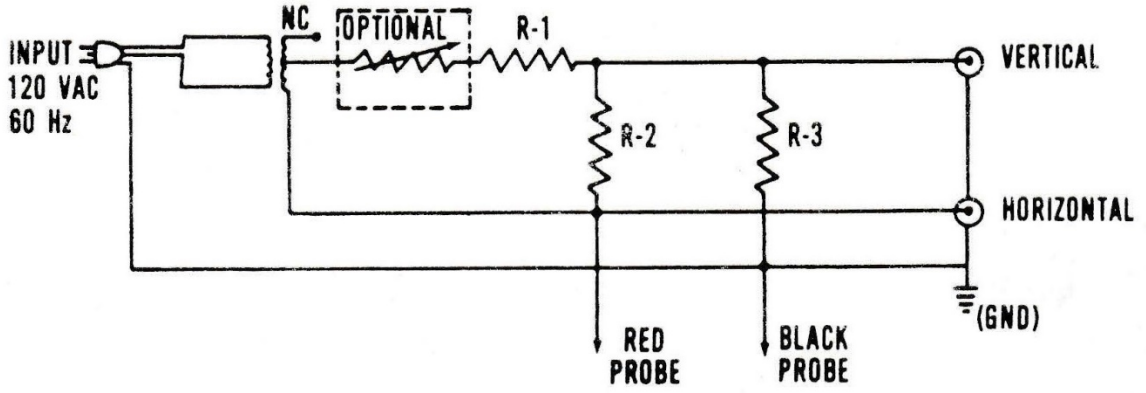


Figure 2 is the test set schematic diagram. This test set, specifically designed to quickly test delicate components, does not deliver more that 1.0 milliamperes of AC current. It energizes components during test, without removal of circuit interconnections, much the same as they are energized in-circuit during normal service. Low voltage and low current are necessary for the protection of delicate components; a center tapped 6.3-volt filament transformer is commonly used. It delivers about 3.0 volts AC from the center tap, which is dropped by resistors to 1.0 volt, the 1000-ohm resistor placed across the 1.0 volt assures current of 1.0 milliampere.

FIGURE NO. 2

R1 - 200 OHM ¼ WATT RESISTOR
(OPTIONAL 1 KOHM POTENTIOMETER)
R2 - 100 OHM ¼ WATT RESISTOR
R3 - 1000 OHM ¼ WATT RESISTER
1 - FILLAMENT TRANSFORMER (OR SIMILAR)
1 - AC PLUG AND CORD

1 - RED TIPPED PROBE
1 - BLACK TIPPED PROBE
1 - SMALL BOARD FOR MOUNTING COMPONENTS
2 - RG-58 CORDS WITH LEADS HAVING BNC CONNECTORS FOR O-SCOPE



POTENTIOMETER R-1 (OPTIONAL) IS ADDED TO VARY AC AT PROBE END TO CHECK ZENER DIODES. IF THE POTENTIOMETER IS USED, THE 200 OHM RESISTOR IS REMOVED FROM THE CIRCUIT.

1.0 VOLTS TO APPROX
2.0 VOLTS DEPENDING ON R-1

When the tester is to be used, its vertical output is connected to the oscilloscope vertical input and its horizontal output to the oscilloscope horizontal input. The oscilloscope vertical and horizontal gain controls should be adjusted to prevent trace ends from going off screen. Standard operational procedures for any board being tested for shorts require the power be removed. If the Printed Circuit Board of chassis under the test is grounded, the black lead should be attached to the ground end of the components.

Since each basic component being tested projects a different display, Figure 3 illustrates the most common oscilloscope displays. Because the test set is an AC device, the technician can observe reactive components, Lissajous and front-to-back ratios of Junction components.

When observing transistors, check first from the base to one side and then from the base to the other side. A collector-to-emitter test should have to pass through two junctions in series, and therefore usually does not produce a usable result. An ideal single Junction check will produce a 90-degree step

display, indicating an extremely high front-to back ratio. This means an open in the reverse direction and a short in the forward direction. A display that ls open more than 90 degrees is something less than Perfect; the wider the angle the less the merit of the Junction. (Refer to Figure 4)

For the technician to become proficient in testing components in-circuit, it is only necessary for him to recognize the combination patterns arising from grouped components. If the diode and capacitor pictured in Figure 5 were under test, the display shown in that figure could be the result. The oscilloscope presents both a Lissajous (Xc reactance) and a 90-degree junction step, informing us that the components are neither shorted nor open.

If the transistor circuit shown ln Figure 5 were under test (base-to-emitter) the trace shown would result. The scope pattern comprises both a Junction step and Lissajous (Xl reactance), again informing us that the components are neither shorted nor open. Because of the coil resistance, the Junction step appears to be greater than 90 degrees… in fact, approximately 120 degrees. This is common in any circuit that contains resistance in parallel with a junction component.

If the transistor pictured in Figure 7 contained an electrical short between the base and the collector, the display shown would result during testing from the base to the collector.

To check a potentiometer for noise, connect one probe to the pot arm and the other probe to either end, then manipulate the pot through its range while observing the oscilloscope pattern. (Refer to Figure 8.) It is also useful in checking circuit continuity in such devices as switches, fuses, lamps, printed wiring, and high resistance solder joints.

To distinguish NPN from PNP transistors, move the red probe to the transistor base and the black (grounded) lead to either the emitter or collector. If the step pattern turns downward, the transistor is NPN; if the pattern opens upward, the transistor is PNP. The same technique can also be used to determine diode direction.

Occasionally it may "appear" necessary to de-solder a part to determine its condition. It has been found that in such instances a "comparison" check with a known good board does away with the need to de-solder the suspected component. This comparison method, which gives conclusive results, is recommended whenever there is any question regarding a component's operating condition.

Very small value capacitors will appear open rather than reactive, and very small inductors will appear shorted rather than reactive. In most cases, however, this is immaterial since it is still possible to detect a shorted capacitor and any open inductor. Obviously, an ohmmeter could do no better than the "test set" on such components. There is, however, a method of regaining the reactive Lissajous for observation of these small components when that is desired; merely increase the gain adjustments on the oscilloscope to the desired amplification. Remember, of course, to trim the gain settings to normal before checking other components.

If other than a filament transformer is used, a 1K potentiometer can be inserted in place of the 200-ohm resistor. This allows for an increase in voltage when checking Zener diodes with more than a 3-volt breakdown point. The Figure 9 represents the display seen on the oscilloscope

FIGURE NO. 3
TYPICAL OSCILLOSCOPE DISPLAY PATTERNS

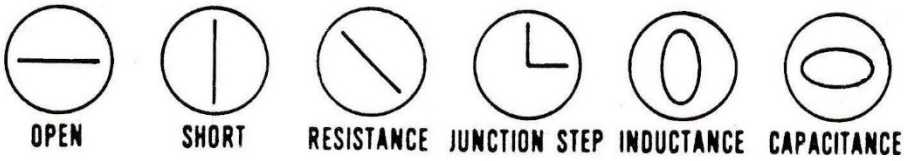


FIGURE NO. 4
TRANSISTOR CHECK - SINGLE JUNCTION

FIGURE NO. 5
IN CIRCUIT DIODE CHECK

FIGURE NO. 6
IN CIRCUIT TRANSISTOR CHECK

FIGURE NO. 7
TRANSISTOR CHECK - BASE TO COLLECTOR

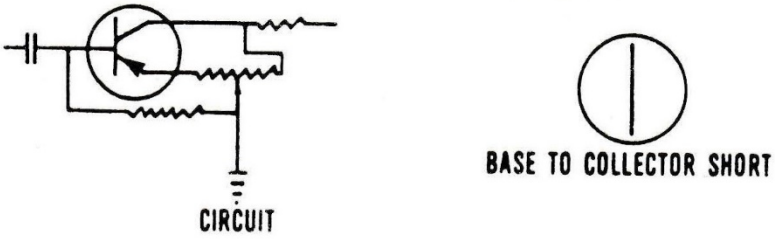


FIGURE NO. 8
POTENTIOMETER CHECK

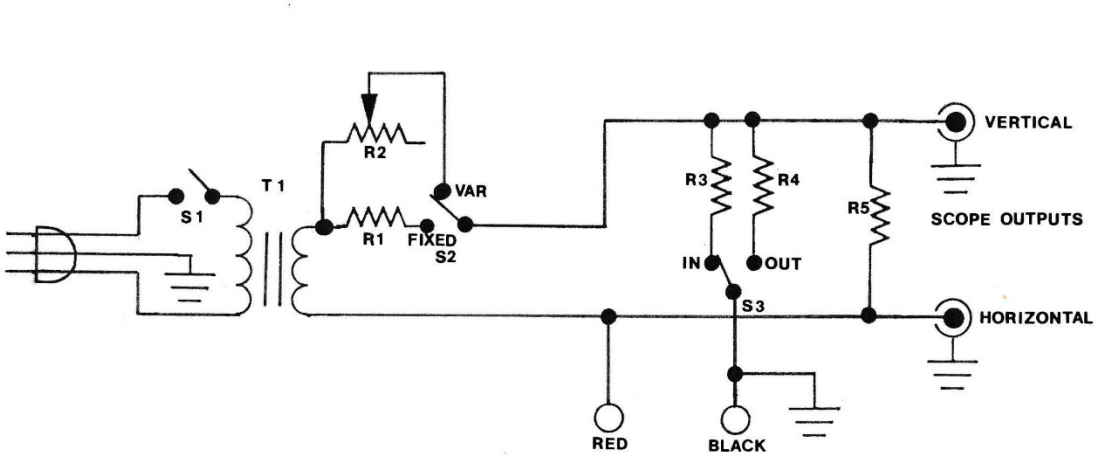
FIGURE NO. 9
ZENER DIODE BREAKDOWN DISPLAY

After some years of testing, technicians in the field have come up with a more useable variation. The parts are listed Below along with a schematic to show how they are assembled.

VARIATION 1 Parts List:

1 EA	R1	480 ohm Resistor ¼ W
1 EA	R2	1K ohm Potentiometer
1 EA	R3	1000 ohm Resistor ¼ W
1 EA	R4	2000 ohm Resistor ¼ W
1 EA	R5	100 ohm Resistor ¼ W
1 EA	S1	ON/OFF SPST 120V switch
2 EA	S2/S3	ON/ON SPDT LV switch
1 EA	T1	6.3VAC Filament Transformer Center tapped secondary (One winding not used)
2 EA	V/H	BNC Terminals (Jacks) panel mount
1 EA	Red	Test Lead Terminal (Banana type)
1 EA	Blk	Test Lead Terminal (Banana type)
1 EA	Chassis	(Bud Box or Equivalent) Size and type not important

Schematic:



Test Readings before using device:

* These figures are with (S2 in “FIXED” Position) (S3 in “IN” position) (S1 in “ON” position)

Rp	Resistance of Parallel Circuit	90.9 ohms
Rt	Total Resistance	570.0 ohms (can be higher)
It	Current Total	11.035 mA (max allowed)
IR5	Current through R5	10.032 mA
IR3	Current through R3	1.0032 mA (max allowed)

* These figures with (S3 in “OUT” Position)

Rt	Total Resistance	575.238 ohms
It	Current Total	10.95 mA
IR5	Current through R5	10.44 mA
IR4	Current through R3	0.51 mA

S2 Allows switching between a fixed resistance for normal operation and variable resistance for zener breakdown voltages.

S3 Allows switching between in circuit and out of circuit testing.

All grounds are chassis grounds.