Do you ever go through your junk box, dig out parts for a project, and then hesitate when you don't know if they're good or bad? Most of us toss the parts back into the box and either forget about the project or buy new parts. N2OZ has an easy way of checking some of those mystery parts while clearing out your junk box.

Build A Quick and Easy Curve Tracer To Test Components

BY LEW OZIMEK*, N2OZ

My ham shack is probably similar to most shacks which exist in this world. It consists of a predominance of commercial equipment, a smattering of homebrew units, some miscellaneous component parts of every description, and a very limited selection of test equipment.

In recent years commercial gear rapidly has replaced homemade equipment in many amateur stations. The reason for this trend is quite obvious: Available items keep getting better and better and the prices keep getting lower and lower. What other result can be expected? The dearth of homemade amateur items is frustrating It is the antithesis of my early days in the hobby when the average individual who wanted a piece of electronic gear had little choice but to build it. How much satisfaction, pleasure, and personal technical growth has been lost by the movement towards purchased items? I defy anyone to quantify it.

An important prerequisite to success with homemade gear, however, is the availability of useful test equipment. Before I retired, I was able to borrow electronic test equipment from my place of employment without any difficulty. Now that source is no longer available, and I am reduced to making do with the meager assortment of test equipment I own or borrowing from friends in the hobby.

These facts certainly were prominent in my mind when I read a short article entitled an "Inexpensive Curve Tracer" in my amateur radio club newsletter. The author, M. Chisena, KA2ZEV, presented a schematic with a summary of the performance capability of a simple, versatile tester. The device apparently is well known to skilled technicians in the electronics industry who have used it for many, many years, but its history is lost to antiquity Its potential capability fascinated me, and I felt that if it could come close to the performance parameters claimed, it would go a long way towards filling a big void in my home shop test capability.

The schematic for this tester is shown in fig. 1. The only components required are a 6.3 VAC transformer, three 150 ohm resistors (1/2 watt or larger), and some test leads It requires an oscilloscope to provide the display. The only restriction is that the scope must accept separate inputs to the horizontal and vertical circuits. Otherwise anything goes. The scope I used is an old 5 MHz unit that a friend of mine built many years ago as part of a Bell & Howell Schools training course. He left it with me when he moved away, and I was on the verge of throwing it away because it barely provided a meaningful presentation About all I could see on it were frequency waves present in a circuit under test without being able to analyze their content. Better scopes are surely available in every fleamarket at miniscule prices. However, my poor excuse for a scope worked superbly with the adapter in fig. 1.

Fig 2 shows how the unit is connected to the scope. Note that the junction of R1 and R2 is connected to the horizontal input of the scope as well as to the red test lead The junction of

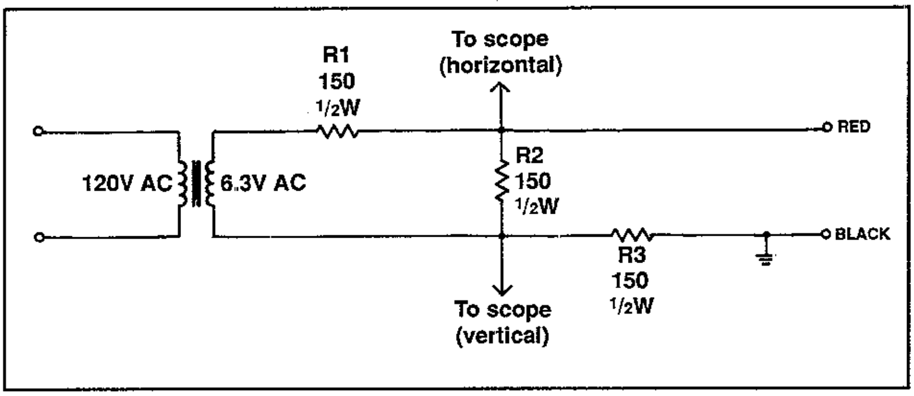

Fig. 1– Schematic of the "Curve Tracer" Component Tester. Input transformer is a small 6.3 volt filament unit. All resistors are 1/2 watt or larger.

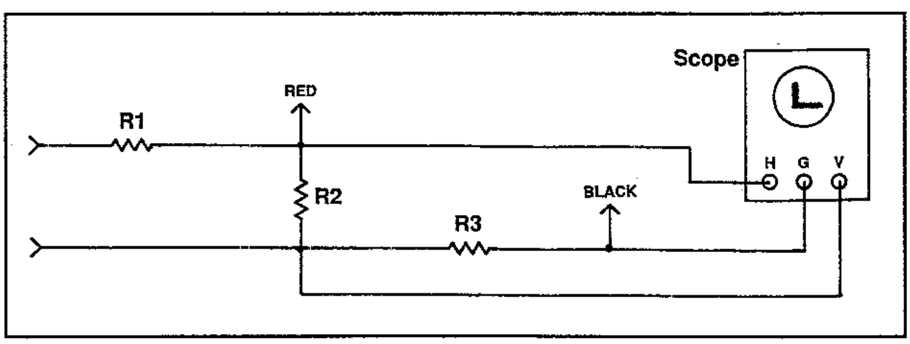

Fig. 2– Interconnection diagram showing the Curve Tracer connected to an oscilloscope. Only three connections are required on the scope: horizontal input, vertical input, and ground.

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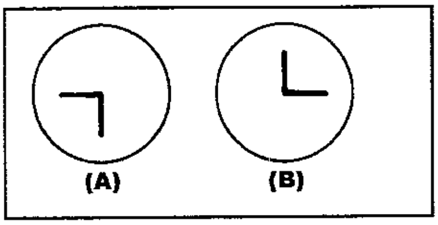

Fig. 3– Pattern displayed on the scope when a diode is tested. (A) Results when black probe is on the cathode and red is on the diode. (B) Results when test leads are reversed. Any reduction in the right angle shows a leaky junction (defective unit).

R2 and R3 goes to the vertical input. The output end of R3 is connected to the black probe and to ground on the oscilloscope. It is a very simple device to be sure.

Construction

Layout and assembly is a snap with so few components involved. Almost all of the parts came from my "junk" box, including a metal case measuring 4" × 2" × 2½". (The enclosure size is primarily controlled by the size of the 6.3 VAC transformer available.) Make all connections to terminal strips fastened appropriately in the case. Run all leads leaving the box through grommets in the sides of the metal enclosure to prevent chafing or wear of the wires. Remember that 110 VAC is being fed to the primary of the transformer. Secure the input power lead inside the case and take suitable precaution when working in this area.

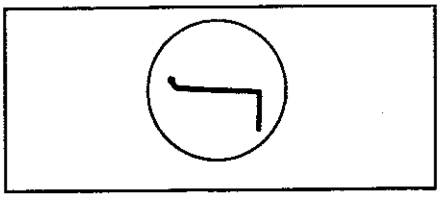

Fig. 4– Test pattern of a zener diode with the black lead on the cathode and the red lead on the anode.

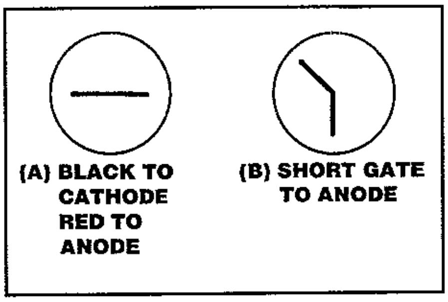

Fig. 5– Thyristor (SCR) test pattern. Again the black probe goes to the cathode and the red to the anode.

Adjustment

1. Turn off the internal horizontal sweep of the scope by turning the input selector switch to external or off.

2. Apply power to the tester to generate a horizontal scope sweep synched to the 60 Hz input frequency. Adjust the horizontal length on the scope to just fill the screen.

3. Short the red and black test leads to produce a vertical line. Adjust it to just fill the vertical screen.

That is the complete adjustment procedure. Nothing could be simpler!

Operation

The application of alternating voltages to both the horizontal and vertical deflection plates of an oscilloscope creates patterns called *Lissajous* figures. A common application of this technique is to compare two different frequencies (one frequency applied to the horizontal, the other to the vertical) to calibrate audio-frequency signal generators. In our tester the same frequency is applied to both plates so the *Lissajous* patterns are synchronized and stationary.

In order to use the tester, just touch the black and red probes to the leads of a component under test and observe the pattern on the scope. Since only 6 volts is being applied, there is no danger of damaging a component. In fact, the test leads can be interchanged during test without a problem. The only effect will be an inverse image on the screen for most of the components (not all). This will be shown in the examples below.

There is no limit to the types of discrete components you can test, including diodes, transistors, capacitors, resistors, ICs, and inductors. To effectively use the tester, you should create a catalog of test patterns for the types of components you expect to evaluate. Root through the supply of odds and ends of parts you may have accumulated over the years. Test them and record the results in the manner shown in this article. You will quickly develop the capability of easily evaluating results and recognizing failures. In fact, you may be amazed at how many defective components are stored in your spare-parts coffer. I certainly was. Be aware, though, that these tests provide a "go" "no-go" result. No real quantitative test results ensue.

Test Results

The following are the results of tests performed on miscellaneous components I found in my shack. The orientation of the test leads is shown for each of the tests with some examples of inverse patterns created when the leads are reversed. Since the black lead is connected to ground, it normally is connected to ground or equivalent of a component if appropriate. The results I obtained are analyzed and discussed as necessary. Any deviation from these normal patterns—such as leaky junctions (less than a 90 degree angle), shorts (vertical line), or opens (horizontal line)—are sure signs of a failure.

Diodes. Place the black probe on the cathode and the red on the anode. The resulting pattern is shown in fig. 3(A). Reversing the leads produces an inverse image as shown in fig. 3(B). The sharp 90 degree angle of the L pattern indicates that the diode is conducting in only one direction of the input AC sine wave.

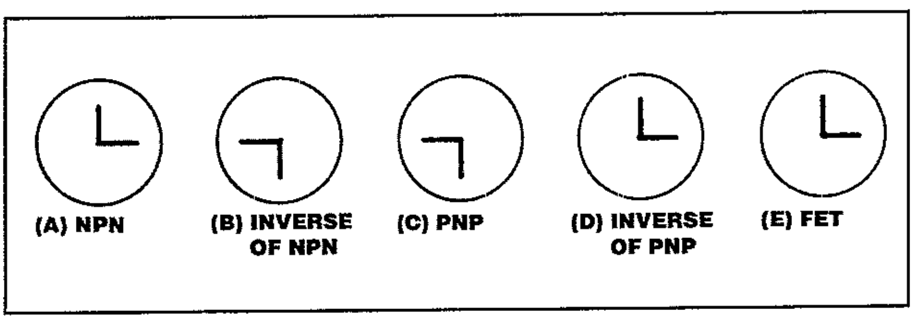

Fig. 6– Series of test patterns of transistors. (A) is an NPN and (C) is a PNP with the black test lead to the base and the red lead either to the collector or emitter. (B) and (D) are the reverse pattern, resulting when leads are reversed. In (E) a field effect transistor (FET) is shown with the black lead on the anode and red on the drain (D) or on the source (S).

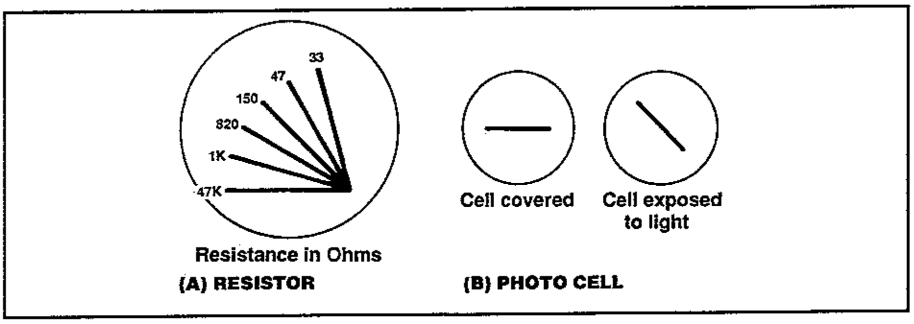

Fig. 7– (A) is the pattern for different values of resistors. In (B) the pattern of a photo cell is shown with the cell covered and cell exposed to light. Note the change in resistance following the pattern of (A).

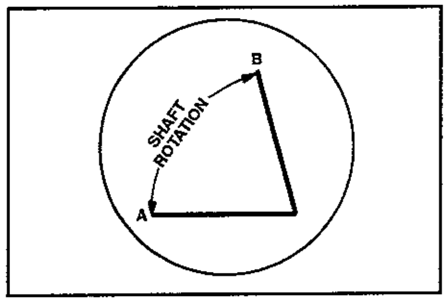

Fig. 8–Potentiometer pattern displayed on the scope. The slope depends on the resistance value. A jittery trace when the shaft is rotated indicates a noisy potentiometer.

Any reduction of that sharp angle shows a leaky diode; a good junction will always have a 90 degree (or close to it) angle.

Zener Diode. Again apply the black lead to the cathode and the red to the anode of a low-voltage zener (I used a 3 5 V). The resulting pattern of this diode duplicates fig. 3 with the addition of a turn up at the left edge of the pattern (fig. 4). The extra bend is caused by zener conduction. A zener above 6 volts will not show the turn up because only 6 volts is used in this circuit and no zener conduction occurs until its applied voltage exceeds the zener rating. The inverse is not shown here, but you can try it in your own tests.

SCR Thyristor. The test result of this device is shown in fig. 5. To get a meaningful reading place the black probe on the cathode (C) and the red probe on the anode (A) and short the gate to the anode. (A similar test can be done on TRIACS by using Main Terminals 1 and 2 (MT1, MT2) and bridging over the test probe.)

Transistors. Connect the black lead to the base of a transistor and the red lead to either the collector or emitter. The results are shown in fig. 6(A) for a NPN transistor and fig. 6(C) for a PNP. Reversing the leads results in the inverse pattern shown in figs. 6(B) and 6(D). Note how simple it is to identify NPN and PNP transistors by the patterns produced. A sharp 90 degree angle is important (I can't emphasize this too much) to ensure that no leakage exists in the junctions. In fig. 6(E) a FET (field effect transistor) is shown. With the black lead on the anode the L pattern will be seen when the red lead is placed on D (drain) or on S (source).

Resistors. No lead orientation is required. The patterns in fig. 7(A) show that a 47K ohm resistor (or higher) presents a horizontal line. This line rotates towards the vertical as the resistance value decreases. It actually is a rough limited quantitative measurement of resistance.

A cadmium sulfide photo cell is shown in fig. 7(B). With the cell covered, the pattern shown is horizontal (open or very high resistance). When it is exposed to light, the trace reverts to a slanted line (resistor).

Potentiometers. Fig. 8 shows the change in a pattern as the control shaft is rotated. This pattern can fall anywhere from horizontal to vertical, depending on the value of resistance. If the line jiggles as the shaft is rotated, the potentiometer is noisy.

Capacitors. Fig. 9 presents the change in pattern from a 2000 µF (vertical line) to a 0.1 µF (horizontal line) capacitor. No test lead orientation applies. The low limit of my tester ap-

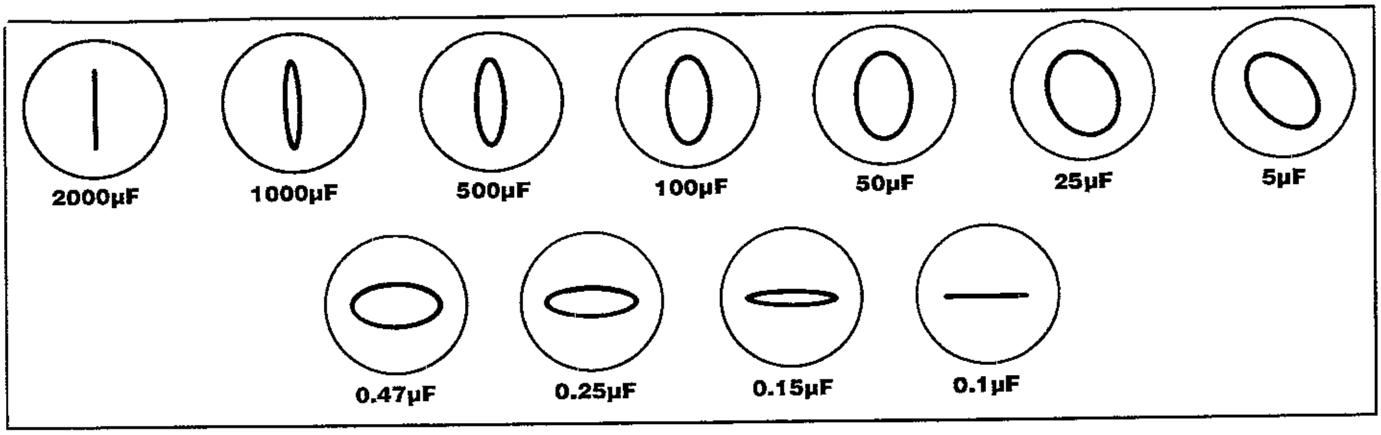

Fig. 9– Patterns of capacitors showing the variation displayed from a 2000 µF down to a 0 1 µF.

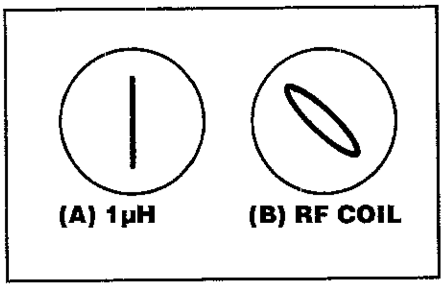

Fig. 10– Inductor's test results show a small inductance (1 µH) as a vertical line and a large inductor as a slanted loop

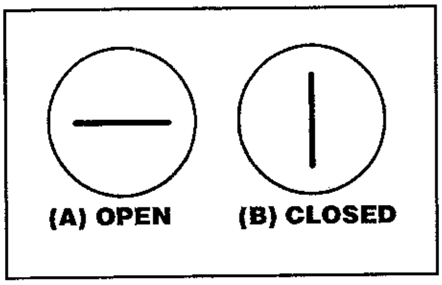

Fig. 11– Test results of a switch. When the switch is open (infinite resistance), a horizontal line is seen When it is closed (zero resistance), a vertical line is shown

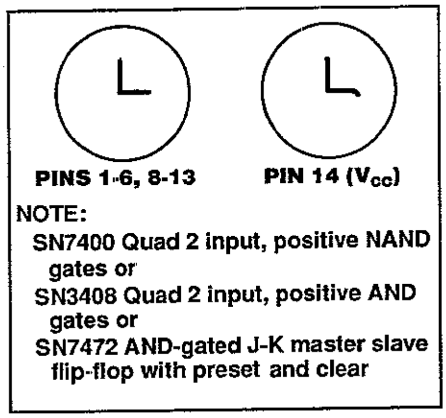

Fig. 12– Transistor test results with the black lead to IC ground connection (or Vss) and red lead to all other pins. All pins show the right-angle pattern (like a diode) except for Vcc, which includes an additional tail. Any decrease in the right-angle pattern shows a leaky junction.

pears to be 0 1 µF. In order to test smaller capacitors, the frequency of the input voltage must be increased, which may be a worthwhile experiment in the future.

Inductors. My availability of coils was very limited, but two different results are shown in fig. 10.

Switch. The tester shows a short as a vertical line and an open as a horizontal line Fig 11 shows the patterns for the two stages of a toggle switch. (Obviously, this test can be used on fuses, continuity checks, etc)

Integrated Circuits. My miscellaneous ICs are predominantly TTL, so that is what I tested. The black lead is normally connected to ground (or Vss), and the red lead to the other pins in sequence It helps to have available a diagram of the IC which shows the pin configuration, functions, and internal design Examples of the importance of correlating results to the design of the IC are presented later on in this article

Fig. 12 shows the results (all identical) of three different ICs. With black on ground (pin 7) a good 90 degree angle is seen on pins 1 to 6 and 8 to 13 (again, a leaky junction will reduce that angle). The Vcc input (pin 14) presents a unique pattern which is acceptable. Fig. 13 shows the design configuration of a SN7400 to allow you to correlate patterns to pin functions

Fig. 14 is the pattern of a SN7413 with its internal design shown in fig. 15. The importance of the internal design is emphasized because it identifies NC pins (no connection) which show up as opens

Fig. 16 displays the pattern of a SN7476. Here again we see the sharp Ls of a good IC and the unique pattern of Vcc.

I could keep going, but what I have shown is an excellent start of a signature pattern catalog. Whenever a pattern deviates from the standard, it probably means a failed component I certainly was surprised at the number of defective components I had stored away A little more time with this tester and all of my bad parts will be purged.

In Circuit Testing

Experiment with any chassis or unit that you can work on and not miss. But first be sure that **NO POWER IS APPLIED TO A CIRCUIT YOU ARE TESTING** with this device. Conduct the same types of tests described in the previous sections, but be aware that a wired circuit may place special loads and impedances on component junctions which are not present with a non-wired isolated device. The patterns in a wired circuit will not necessarily be identical to those shown in our catalog of signature patterns. My own experience has been that some patterns will be the same and other patterns will be unique, requiring further evaluation. On a questionable transistor, unsolder only the C and E leads and lift them to permit accurate testing of the transistor One end of a diode may be lifted in a similar manner to verify test results It is also conceivable that an IC may have to be lifted from the circuit to confirm test results.

To verify performance of my unit as an in-circuit tester, I decided to analyze my Heath Model 10-4550 10 MHz Dual Trace Oscilloscope. This scope has been inoperative for a number of years, and I gave up trying to repair it about five years ago, when after curing a series of problems, I could not find the source of a failure in the sweep circuits.

Heath "trouble locating guides" normally

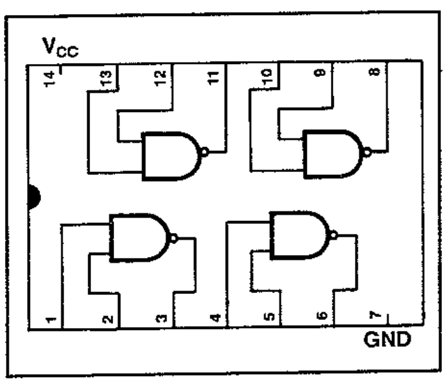

Fig. 13– Lead configuration/internal design of an SN7400 IC Correlate the design to the test patterns in fig 12.

used voltage measurements to try to pinpoint problems This was aided and abetted by a strong technical support group at Heath which is now no longer available. With this curve tester I decided to go through the horizontal sweep circuits, checking all of the key components. The entire process took less than an hour (one thing that expedited it is that Heath used sockets to hold ICs so no unsoldering of ICs was necessary). During the tests I found one defective transistor and three defective ICs. It was comforting to verify performance of some FETs and Zeners which had always been question marks to me in the past I hate to think how many times I replaced a suspect part with a defective part not knowing that the replacement was bad. Now, finally, the culprits have been identified and replacements ordered. By the time this gets to print, I fully expect to have a working scope once again.

Reprise

I was pleasantly surprised by many things related to this tester The low cost was expected, but the ease with which it was assembled and tested was a delight. The big point, however, is that the component test results far exceeded my expectations I was able to make positive evaluations of a wide range of devices with a high level of confidence. With this tester I do not have to guess about the performance of parts In a short time I know! Some individuals may not be comfortable with a "go" "no-go" device and would prefer quantitative tests. Personally, if I'm trying to make a repair, identification of a failed component is all I am interested in.

It is hoped that the reader will build this device and find it as effective as I have It may lead to your trying your hand at repairing amateur radio gear as well as TVs, VCRs, audio systems, and what have you.

One last note: Horizontal output transistors on TVs and video displays do not test well. Many have built-in damper diodes which look like shorts to this tester.

Good luck and good repairs! ■

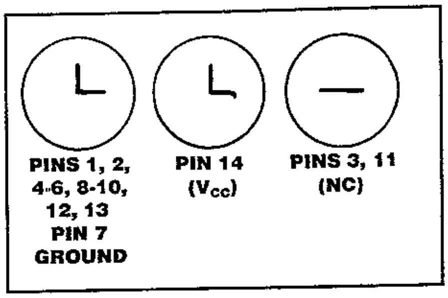

Fig. 14– Test pattern of an SN7413 with the black lead on ground and the red on other pins. The pattern is the same as that of an SN7400 except for pins 3 and 11, which have no internal connection (NC) show up as an open

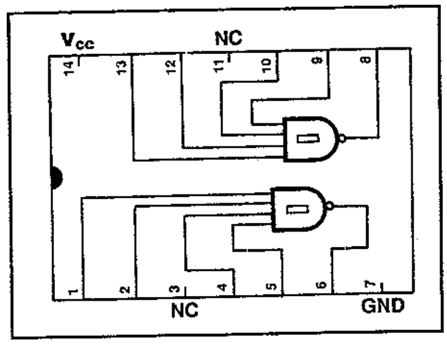

Fig. 15– Internal design of an SN7413 to show the correlation of the test pattern to the pin functions.

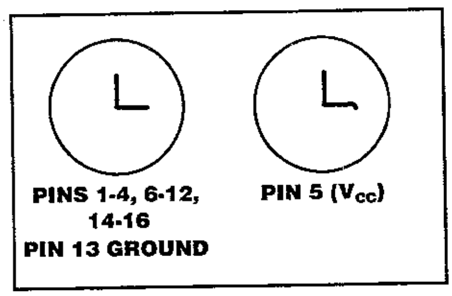

Fig 16– Test pattern of an SN7476 again with the black lead on ground and the red on the other pins Pattern is identical to fig. 12. As with all test patterns, the right angle is important because any decrease indicates a leaky junction and a defective IC