

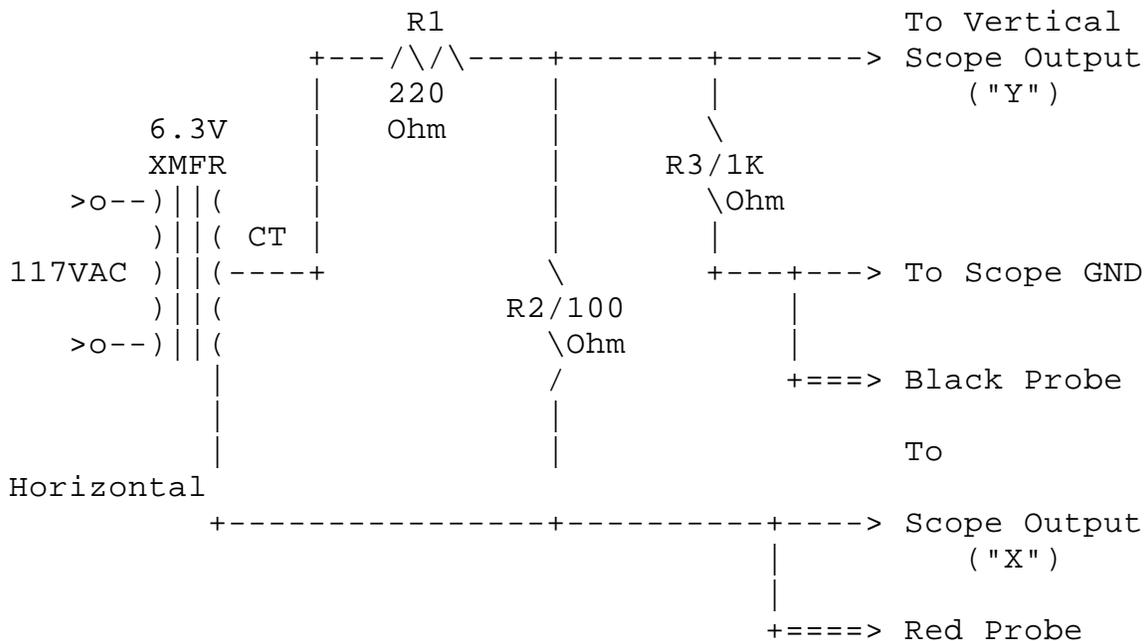
# Analog Signature Analysis Using a Curve Tracer

Analog Signature Analysis (“ASA”) is a “power off” troubleshooting technique that applies a sine wave (AC) stimulus to a component creating a voltage vs. current signature.

A curve tracer, or ‘Octopus’ is an inexpensive piece of testing equipment that utilizes ASA and uses an oscilloscope as a display but allows you to test components with the power turned off.

The curve tracer (Fig. 1) can be used with any type of oscilloscope and consists of a 6.3-VCT filament transformer, three ½watt resistors, and two test probes. Half the filament voltage is applied to a voltage divider consisting of R1 and R2 yielding 1-volt ac at the top of R3. This voltage can be applied to any component or combination of components across which the test leads are placed. The current is limited to 1 mA by R3. The voltage across the probes is applied to the horizontal input of a scope, while the voltage across R3 as a result of the current through it is applied to the vertical input. What we see on the scope is actually a display of the voltage *across* a component under test versus the *current through* that component.

Figure 1  
Schematic of the Curve Tracer Testing Device



You must have a dual channel oscilloscope capable of operating in the "XY mode" in order to use a curve tracer. In the XY mode, one channel is switched from a vertical input (Y) to a horizontal input (X) replacing the normal horizontal timebase generator.

To use the curve tracer, set your oscilloscope to the XY mode and adjust the X and Y position controls so the spot is in the dead center of the oscilloscope's CRT display. Connect the curve tracer to the oscilloscope and plug in the transformer. With the two leads open (not touching each other or anything else) adjust the X input for as large a trace as you can without going off the sides of the CRT. Under these open-circuit conditions the full 1-volt ac appears across the horizontal input. Since no current is being drawn through R3, no voltage appears across it or the vertical input. Short the two leads together and adjust the Y input the same way. With the test leads shorted together, the trace flips to a vertical line. The vertical amplifier gain is adjusted to give a 2" trace. The shorted test leads short out the horizontal input and cause the full 1-volt of ac to appear across R3 and so across the vertical input.

All ASA signatures are made up of four basic components: resistance (any value from an open to a short), capacitance, inductance, and semiconductance. Resistors have a constant voltage/current ratio causing a linear diagonal signature with the angle of slope being directly proportional to the resistance value. Capacitors and inductors cause a phase shift between voltage and current producing a circle or elliptical signature directly proportional to the amount of capacitance or inductance. Diodes, the simplest semiconductive device, allow current to flow in one direction and not the other. These signatures are displayed by a horizontal line that goes vertical just after the center axis of the display.

It is with semiconductors that the curve tracer really excels. Normally, you would use a meter set to the "diode test" to test diodes, transistors, voltage regulators and integrated circuits. The meter will unambiguously test the vast majority of semiconductors but every now and then a transistor will test "good" with a meter, but breakdown when it is operating at full voltage and current. The curve tracer is better at identifying this type of unusual problem.

The curve tracer can also be used to test all types of integrated circuits. Complex or composite signatures are combinations of the four basic ASA signatures. Integrated circuits are made up of transistors (which are a combination of diodes), resistors, and capacitors. The signatures displayed by ICs are composite signatures. These devices have built-in protection circuits, which allow current to flow in both directions displaying a signature that is vertical in the bottom half, then horizontal, then vertical in the top half. These signatures are typically called "chair patterns". Common zener diodes will display a chair pattern that has a vertical break-over point at 0.6 volts (the conducting voltage of a silicon device) and a second break-over point at the rated voltage for the zener diode. Variations of this signature found in ICs are due to resistive and capacitive elements. CMOS integrated circuits are built with capacitors causing their signatures to display a loop in the "back" of the chair pattern.

Leakage current is indicated by curvature of the linear portions and the rounding of corners in the diode or chair pattern. Gaps in the signature indicate that the current path is being interrupted. Resistive (diagonal) portions of a signature not found in a good device indicate damage to the component. Capacitive signatures that flutter, vary in size, and change shape indicate a possible problem in the dielectric.

Integrated circuits of the same type (e.g., 7404) but differing in manufacturer can display slight differences because of the various ways in which the components are constructed. This is a normal condition and should not be confused with a device failure.

The user should attempt to relate the degree of the failure to the type of signature being sought. For example, a catastrophic PCB failure can be expected to be caused by a failed device with a dramatic signature difference from that of the same device in a known good PCB. A marginally operating or intermittent board may have a failed component that indicates a small signature difference from a known good board.

Internally shorted bipolar (TTL) ICs will produce a resistive signature. This will be a near straight line pivoting to the one o'clock position. A catastrophic short will exhibit this effect in the LOW range and results from a resistive value of four to ten ohms.

It should be kept in mind that leakage current, the most common IC failure, will increase with an increase in temperature. Most boards run at a higher temperature than they are tested at, so a small leakage current can be a real problem. Leakage current shows up as a rounded transition (corner) or as a curvature in a normally straight line.

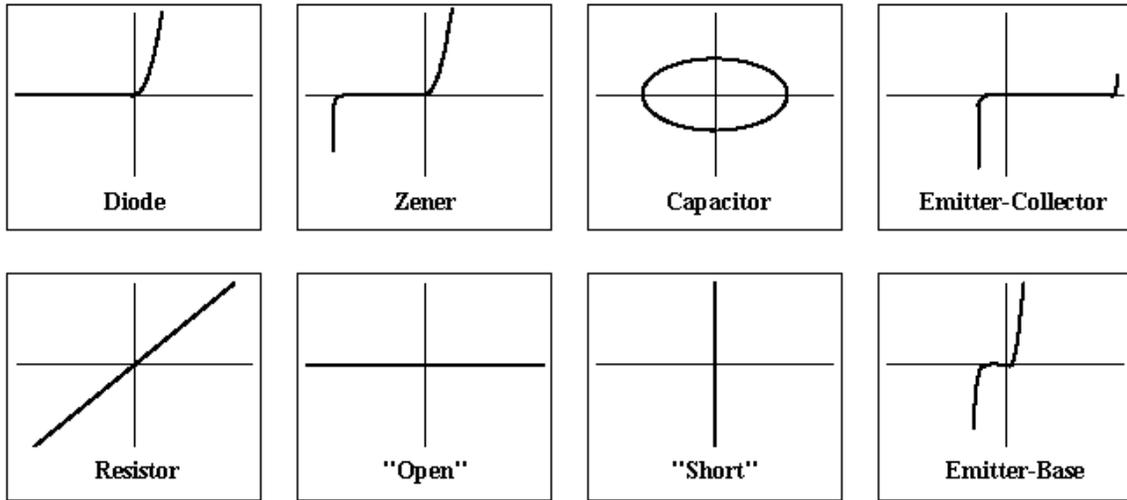
There are parallel and loading effects on signatures of components that are in-circuit. The lowest impedance device will tend to dominate that signature so analyze these signatures carefully looking for tell-tale indications of the four basic signatures previously discussed.

To test an IC, the curve tracer is connected to chassis ground on one side and each pin of the IC is probed in turn by the other input. A unique visual signature is produced for each pin that is a combination of all the components connected to that particular node.

As an added bonus, the curve tracer can be used to identify which lead is which in any transistor and tell you if it's NPN or PNP. PNP junctions will be inverted from the NPN trace shown on your scope. With a digital multimeter, it is easy to identify which lead is the base but it is impossible to identify the collector and emitter. Both the base-to-emitter junction and the base-to-collector junction give the same reading. The curve tracer, however, makes it obvious.

In circuit testing is done with \*no\* power applied to the equipment under test. With some experience, one is able to test components in and out of circuit and troubleshoot without danger of damage to components.

**Examples:**



**Resistors:**

Open	Horizontal line
10 K	10 degree
1 K	45 degree
0	Vertical line

**Capacitors:**

0.1 uF	Shallow ellipse
2.6 uF	Circle
50. uF	Narrow vertical

<b><u>Transformers:</u></b>	Ellipse depending on impedance.
<b><u>Diodes (Germanium):</u></b>	Right angle display.
<b><u>Diodes (Silicon):</u></b>	Right angle, one side longer (any leakage showing less sharp angle).
<b><u>Transistors:</u></b>	Test as two diodes (B to E and B to C).
<b><u>Integrated Circuits:</u></b>	Input for gates and counters show a certain signature display. Outputs display a different signature. A short will show a vertical line. An open will show a horizontal line

This curve tracer, or 'Octopus,' as it is commonly known, has the potential of being one of the fastest, most informative, most versatile, and most reliable troubleshooting instruments you ever used. Its uses are limited only by the imagination and technical savvy of the user. The one-volt at a maximum of one mA that it puts out is completely safe to use on all transistors and low-voltage diodes and capacitors. You use it without any power applied to the equipment being tested, so there is no danger of a test probe slipping, shorting something out and blowing a transistor. Since it is a dynamic test, exposing the unit being tested to a continuously varying voltage, each readout yields a wealth of information that would require dozens of separate static tests to duplicate.

Just consider what it will tell you: it indicates shorts, open circuits, approximate resistance and capacitance values, inductance, and the quality of diodes and transistor junctions. It separates germanium from silicon diodes, indicates the polarity of such diodes and separates germanium from silicon transistors and NPN from PNP types. It will pick out the base of an unmarked transistor. It will reveal the presence of resistance or capacitance across a diode or transistor junction. You can also use it to phase transformer windings. The more familiar you become with the device, the more uses you will find for it.

But make it a habit to understand thoroughly the why of every trace you see. Letter the peaks and zero-crossings of a sine wave and then letter each trace to correlate the spot positions with the instantaneous voltage and polarity of the applied 60 Hz 4 sine wave. If you see a puzzling trace, try to duplicate it with a diode, a resistance or capacitance box, and possibly an inductance. Doing this will make an excellent teaching instrument of the curve tracer.

**Sources:**

"A Simple On-Board X-Y Tester" By John T. Frye; Popular Electronics; August, 1975  
Huntron, Inc.  
Randy Fromm