What is a Curve Tracer vs an Analog Signature Analyzer vs a SMU?

As more background it might be good to answer the question; What is a Curve Tracer vs an Analog Signature Analyzer vs a Source Measure Unit anyway?

All three are basically very similar in that the hardware is set up to measure both voltage and current at the same time and at this most simple level could be considered to be more or less the same thing. The differences come in the details of the specific kinds of test measurements to be made and the kind of electrical components being tested.

To review, a Source Measure Unit (SMU) is an instrument that combines a sourcing function and a measurement function on the same pin or connector. It can source voltage or current and simultaneously measure voltage and/or current. An SMU instrument might have one or more channels that are generally considered to operate independently. The ADALM1000 for example has two channels and the block diagram is shown in figure 1.

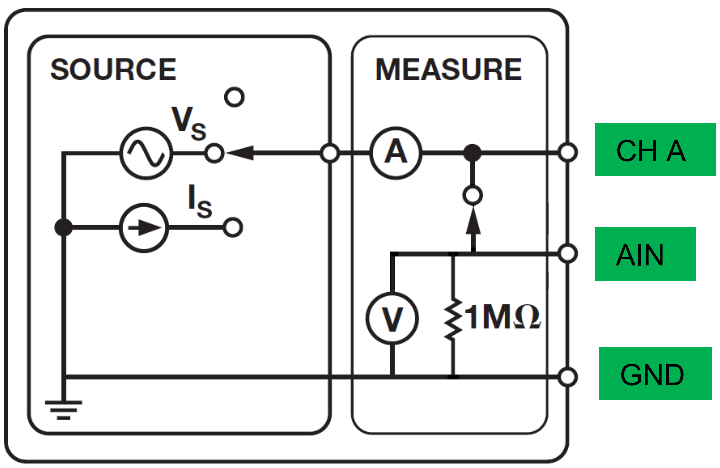

Figure 1, Block diagram of one ADALM1000 SMU channel

A Curve Tracer displays the voltage vs current characteristic curves of electronic devices such as transistors and diodes. The thing that makes a curve tracer a little different is that generally two synchronized stimulus signals are applied to the test device. For example measuring the characteristic curves of an NPN transistor by measuring the collector current while sweeping the collector voltage for a series of base current values. Curve tracers generally use linear or stepped voltage waveforms at low enough rates to be considered DC measurements. Figure 2 shows the two SMU channels of the ADALM1000 configured to display the I/V characteristic curves of an NPN transistor for example. As channel A sweeps the collector voltage and measures the collector current, channel B steps through a series of DC voltages that provide base current steps (through 10 KΩ resistor) to the device under test. The frequency of the collector voltage ramp is N times the frequency of the stair-step waveform applied to the base, where N is the number of steps.

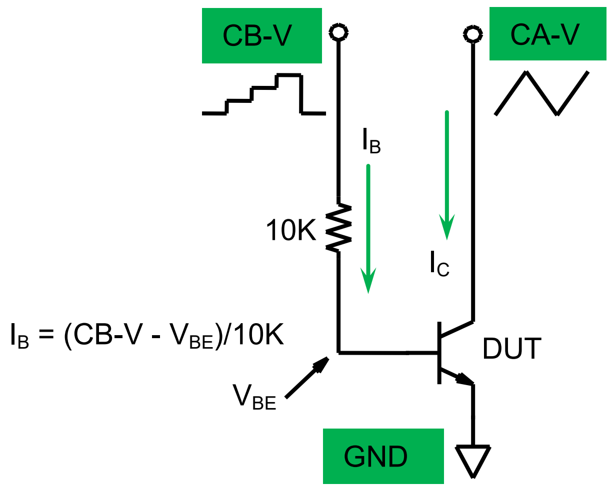

Figure 2, ADALM1000 as NPN transistor curve tracer.

When performed with the ALM1000 the collector current I_C is available as the Channel A current trace. The collector, emitter voltage V_{CE} is the Channel A voltage trace. The base current I_B is available as the Channel B current trace.

As shown in figure 3 the collector current for the various base current steps can be plotted vs the collector voltage using the X-Y plotting tool with the Channel B voltage on the X axis and the Channel A current on the Y axis.

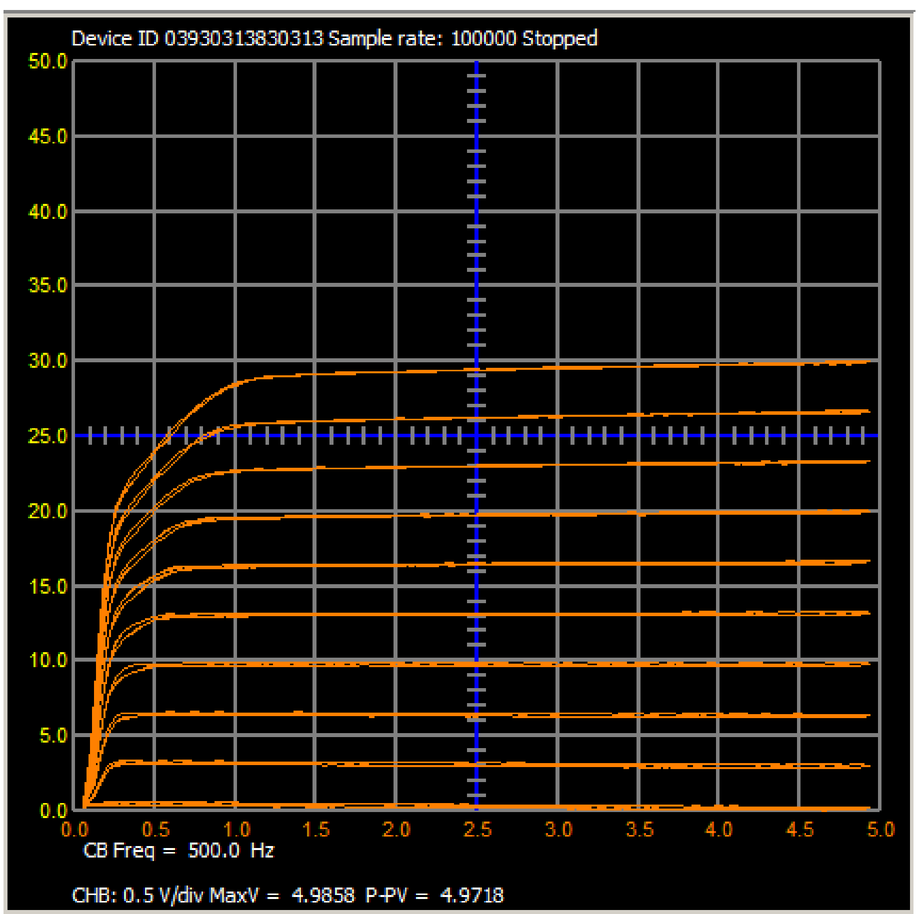

Figure 3, M1K typical NPN I_C vs. V_{CE} characteristic curves.

Analog signature analysis (ASA) applies a sinewave (generally the case but other wave shapes could be used as well) stimulus to a pair of component or PCB pins creating a voltage vs. current signature for that particular pair of pins. The signature is displayed on the computer screen as an X vs Y plot, with the current on the vertical axis and the voltage on the horizontal axis, for analysis. Unlike the curve tracer and perhaps the SMU, signature analysis uses AC signals over a range of various frequencies to display and analyze the current vs voltage characteristics of the component(s) being tested. For simple combinations of passive components like resistors, capacitors and inductors the relative amplitude and phase of the voltage and current provides a measure of the lumped impedance of the network. The measured results can then be reduced to a simple equivalent RLC (series or parallel) network. The test frequency can be adjusted to suit the component values to be tested. For example, a low enough frequency could be chosen such that the reactive part of the network can be neglected and just the resistive part measured. At low enough frequencies inductors can be considered as shorts and capacitors as opens. At high enough frequencies the opposite is true.

All analog signatures are made up of four basic components; resistance (can be any value from an open to a short), capacitance, inductance, and non-linear conductance from semiconductor devices (diode junctions). Understanding these basic signature shapes can simplify the analysis of more complex signatures. An open circuit, infinite resistance, draws no current so results in a horizontal line on the grid. A short circuit, zero resistance, draws maximum current so results in a vertical line. Resistors have a constant voltage/current ratio resulting in a linear diagonal line with the angle of the 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 and the test frequency.

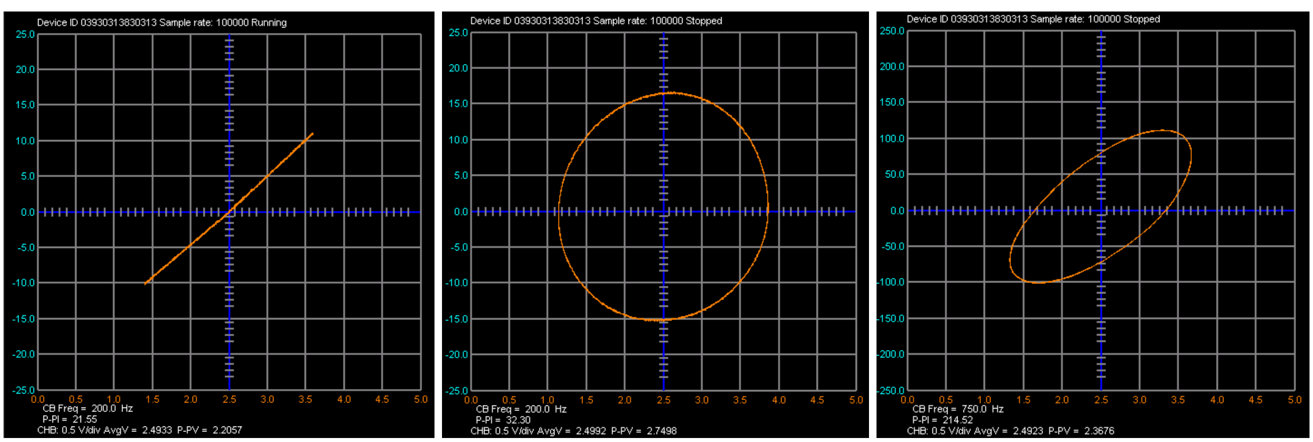

Figure 4, Resistor, capacitor and inductor signatures

In the signatures in figure 4 we see the diagonal line as we expect for a simple resistor. The capacitor signature is an elliptical shape as we expect from the 90 degree phase shift. The inductor signature ellipse is tilted at about 45 degrees because the internal series resistance of the inductor (about 7Ω in this case) is about the same as the reactive part of the impedance at the test frequency.

Diodes, the simplest semiconductor device, allow current to flow in one direction and not the other as we saw. Diode signatures, as shown in figure 5, result in a horizontal line (diode off) when reverse biased and the line goes vertical for forward bias voltages (diode on). For circuits containing non-linear components such as diodes combining a DC offset component and small AC component for the test signal can allow the user to obtain impedance characteristics of the network at different points along the non-linear parts of the response curves.

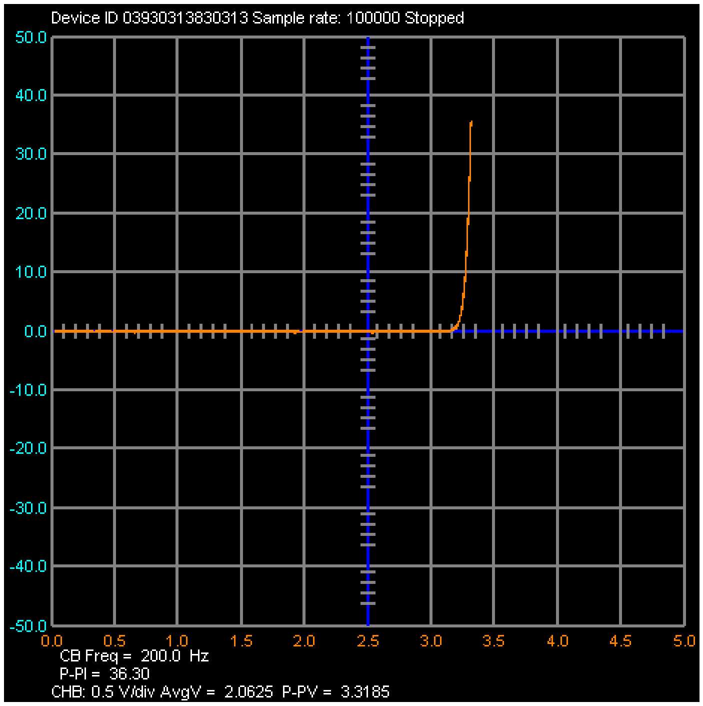

Figure 5, Diode signature

Figure 6 shows how the two channels of the ADALM1000 can be used as an Analog Signature Analyzer. The sinewave stimulus is applied by CH A, The "source" resistor Rs provides a current limiting function in case the component or part of the network being tested contains a short circuit and can be adjusted to best match the components being tested. The current measurement function of Channel A also provides the current through the test component. CH B (in Hi Z or SPLIT I/O mode) measures the voltage across the test component.

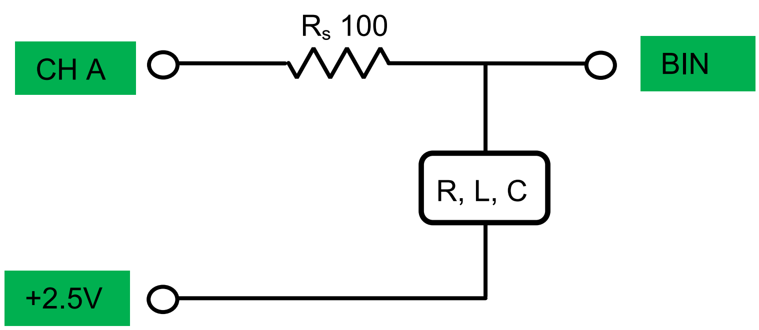

Figure 6, ADALM1000 as Analog Signature Analyzer

Just looking at the ellipse in the X-Y plot it is often difficult to tell an inductor from a capacitor. In addition to the I vs V plotting capability of the ALICE 1.3 Desktop software the Impedance Analyzer tool can be used to display a polar plot of the complex impedance and display the gain, phase and equivalent series R, L or C of the network under test.

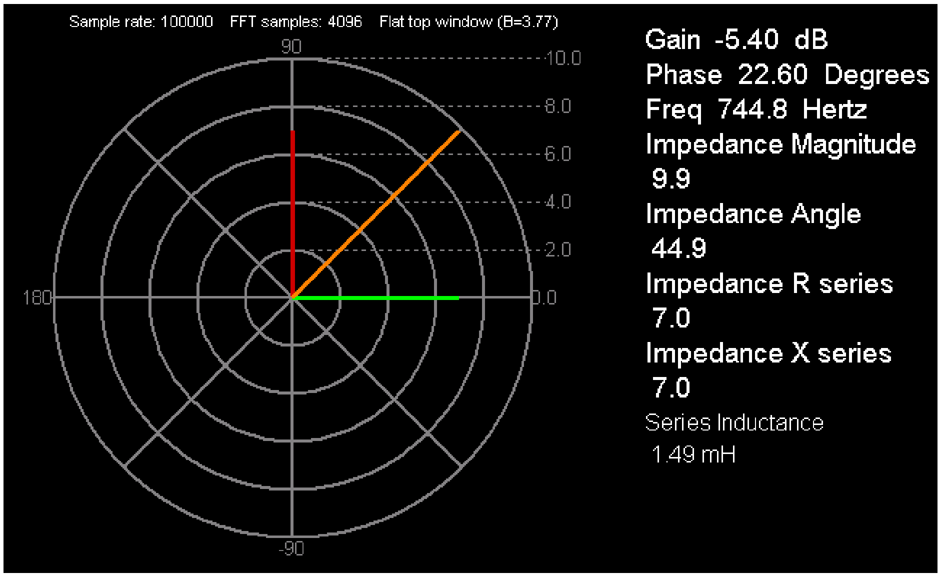

Figure 7, ALICE Impedance Plot example

Analog signature analysis (ASA) is an elegant, powerful fault-diagnosis technique for printed circuit boards as well as electrical components. ASA is often the technique of choice whenever schematics or other documentation is not available. In situations like these, comparing the analog signatures of a known-good component or PCB assembly with those of the suspect one can often indicate the source of the problem or failure. A major advantage when testing a component with ASA techniques is that the device or PCB under test does not necessarily need to be powered up. This makes the technique ideal for evaluating so-called "dead boards."

As an example of using this signature technique on a complex component, consider what I call the “turn on” test of the ADP3300 three terminal LDO voltage regulator shown in figure 8. In this example we sweep the input supply voltage with Channel A while measuring the input supply current. A 330Ω load resistor is used to include extra current in the input supply as the circuit turns on. The capacitor added to the output is the smallest value that stabilizes the LDO. Channel B can optionally be used to monitor the output voltage of the LDO as well.

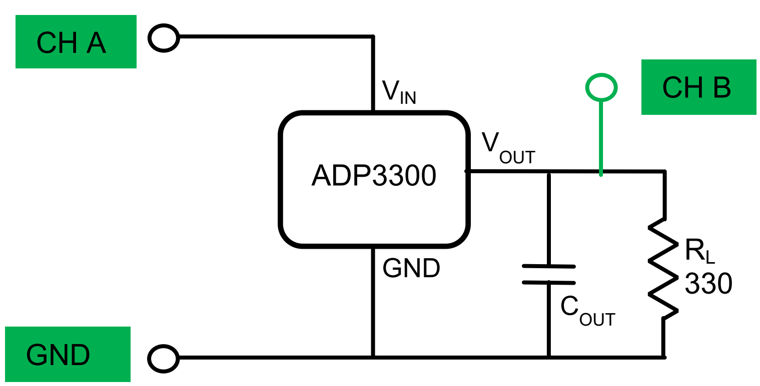

Figure 8, ADP3300 “turn on” test

In figure 9 we see the input current vs input voltage “turn on” signature for the ADP3300. No current flows into the circuit until V_{IN} is greater than about 1.5 V. The current then jumps up and tracks the slope of the 330Ω load resistor. When the output voltage reaches 3.3V and the circuit starts to regulate the current is more of less constant at 10 mA (3.3V/330Ω).

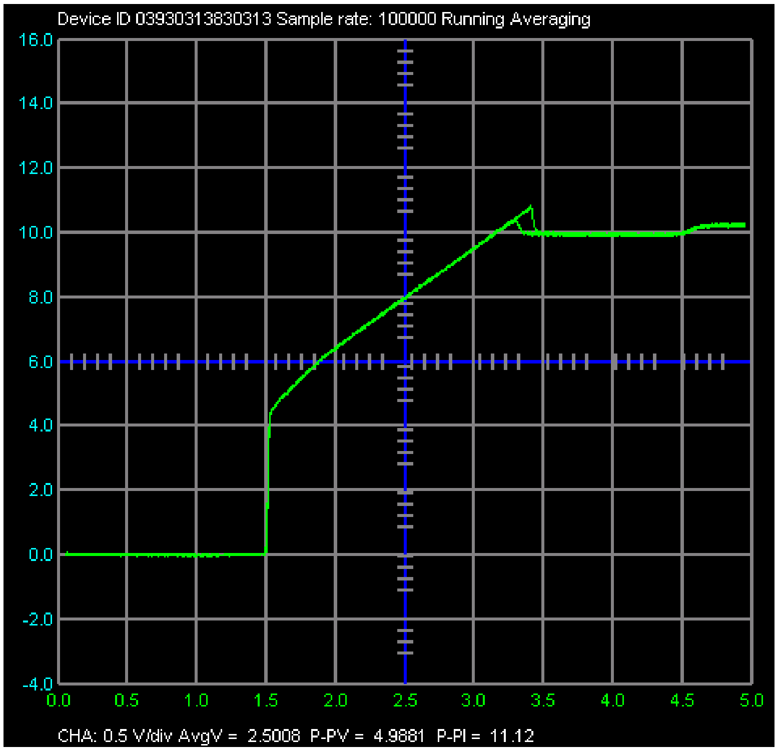

Figure 9, ADP3300 “turn on” signature

If there were to be a problem or failure with the component, a resistive (diagonal) portion of a signature not found in the good device, such as the flat sections below 1.5 V and above 3.5V in figure 8, can indicate leakage currents that result from damage to the component.

In conclusion we can see that the versatile hardware design of the ADALM1000 can be viewed as either an SMU, a semiconductor Curve Tracer or an Analog Signature Analyzer.