Testing Piezoelectric devices for R&D and Manufacturing.

The demand for reliable piezoelectric devices has prompted manufacturers to do more thorough testing in R&D and production. A piezoelectric material is an electro-mechanical device that when excited by a wide range of frequencies varying "modes' of operation or "resonances" exist. A frequency response analyzer, such as the SA Series Vector Network Analyzer by Core Technology Group, allows piezoelectric devices to be studied and characterized for multiple modes of operation and resonances.

Testing and characterization of piezoelectric devices is necessary for optimization of supporting electronic circuits and also for determining electrical model equivalent circuits of the device for computer simulation.

Application of piezoelectric devices range from automotive to semiconductor manufacturing and include ultrasonic cleaners, accelerometers, ultrasonic transducers, high resolution LASER focusing, precision positioning systems, semiconductor wire bonding, resonator, oscillators and crystals.

Piezoelectric materials are mainly capacitive devices. Because of this, many of the parameters and characteristics of the devices can be represented as an electrical model of a series/parallel resonant circuit. Some of the important parameters of the device are series resonant frequency (Fs), parallel or anti-resonance (Fp), quality factor (Q), equivalent capacitance (C1), equivalent inductance (L1), series resistance (R1) and parallel capacitance (Co) to name a few. The electrical model is shown in figure 1.

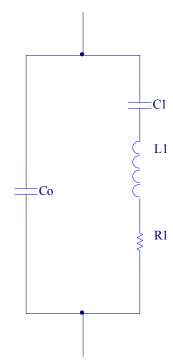

Figure 1. Electrical circuit equivalent model of a piezoelectric device.

All of the above parameters can be extracted from the frequency sweep analysis of impedance and admittance of the device. An example frequency sweep is shown in figure 2.

140 Independence Lane
Chalfont PA 18914
www.CoreTechGroup.com

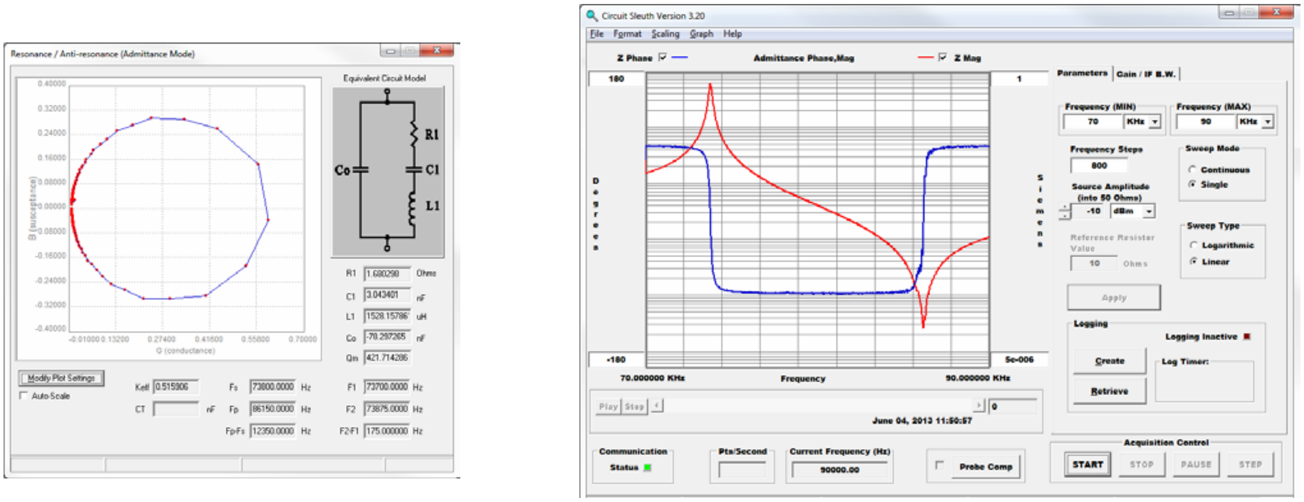

Figure 2. Example output of a frequency sweep of a piezoelectric device.

For testing purposes, it is important to have the proper test fixture for mounting the piezoelectric device quickly and for connecting to the analyzer. Figure 3 illustrates a fixture for mounting disc type piezoelectric elements. The bottom electrode of the device rests on top of a copper conducting plate and the device is held firmly in place with a conductive metal spring clip. The clip also serves as a connection to the top electrode of the device. The fixture insures a reliable electrical connection and also allows for quick changing of devices.

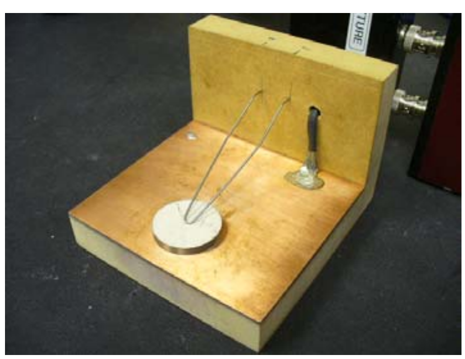

Figure 3. Fixture for mounting disc type piezoelectric elements.

The schematic for a typical piezoelectric test setup is shown in figure 4. Please note that the fixtue can be constructed such that it can be directly attached to the front of the analyzer for easy setup .

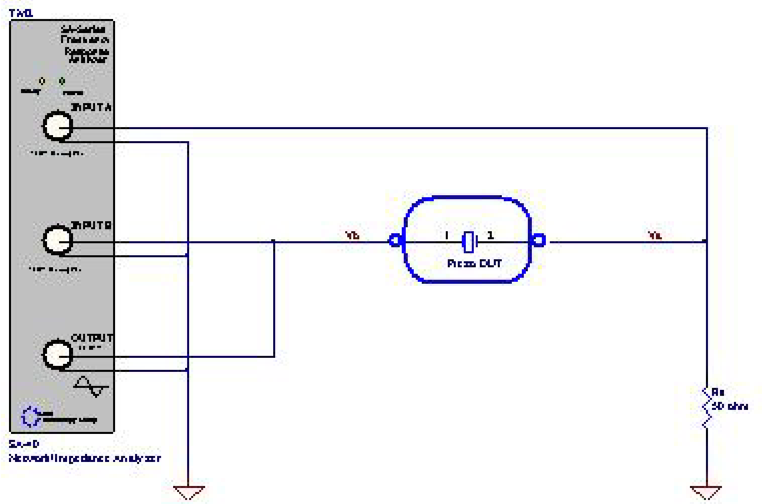

Figure 4. Impedance measurement setup for a piezoelectric element with the SA Series Vector Network Analyzer.

Figure 5 illustrates a test setup with a disc type piezoelectric element mounted.

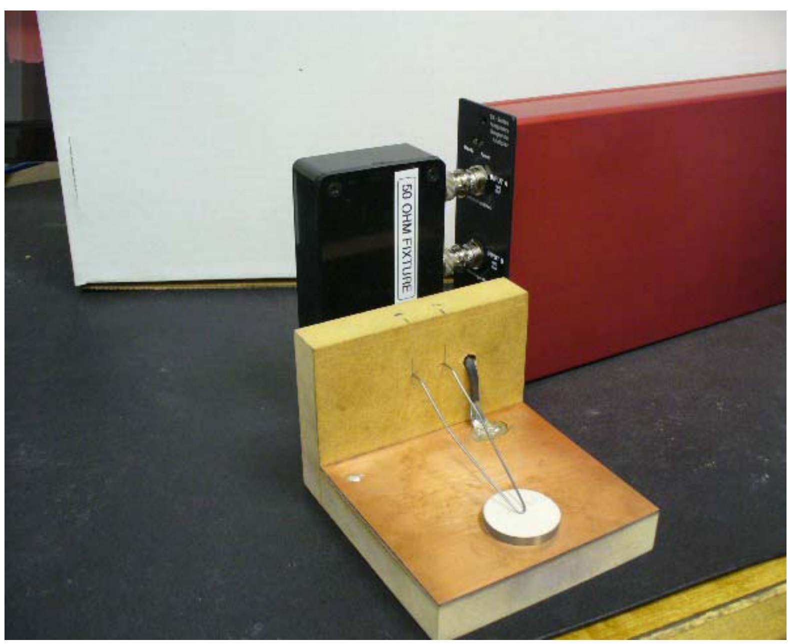

Figure 5. Test setup shown with fixture connected to the SA Series Vector Network Analyzer with a disc type element ready for testing.

Initial testing of the device is over a broad frequency sweep and exposes many modes of operation and resonant points of the device. The frequency range of the test shown in figure 6 is from 10 KHz to 300 KHz.

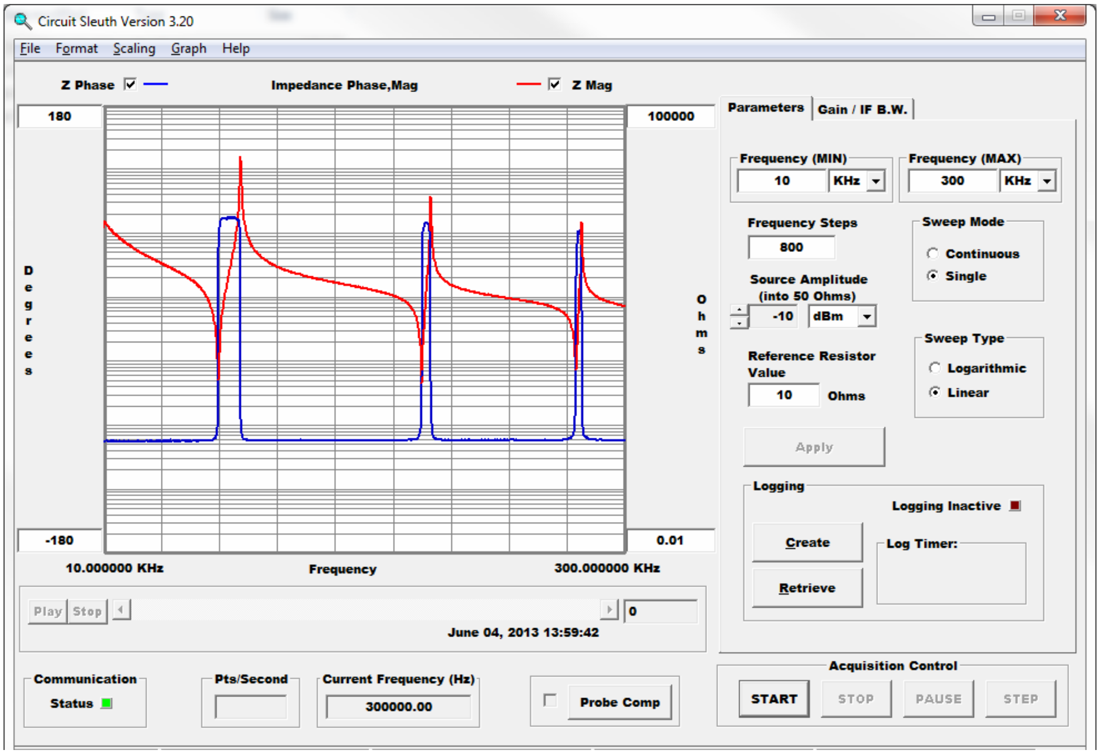

Figure 6. Broad frequency sweep of piezoelectric device showing many modes and resonance points.

For this example, we will study the impedance and admittance of the device in the frequency range of 70 KHz to 90 KHz. Figure 7 shows the impedance profile of the device over the specified frequency range.

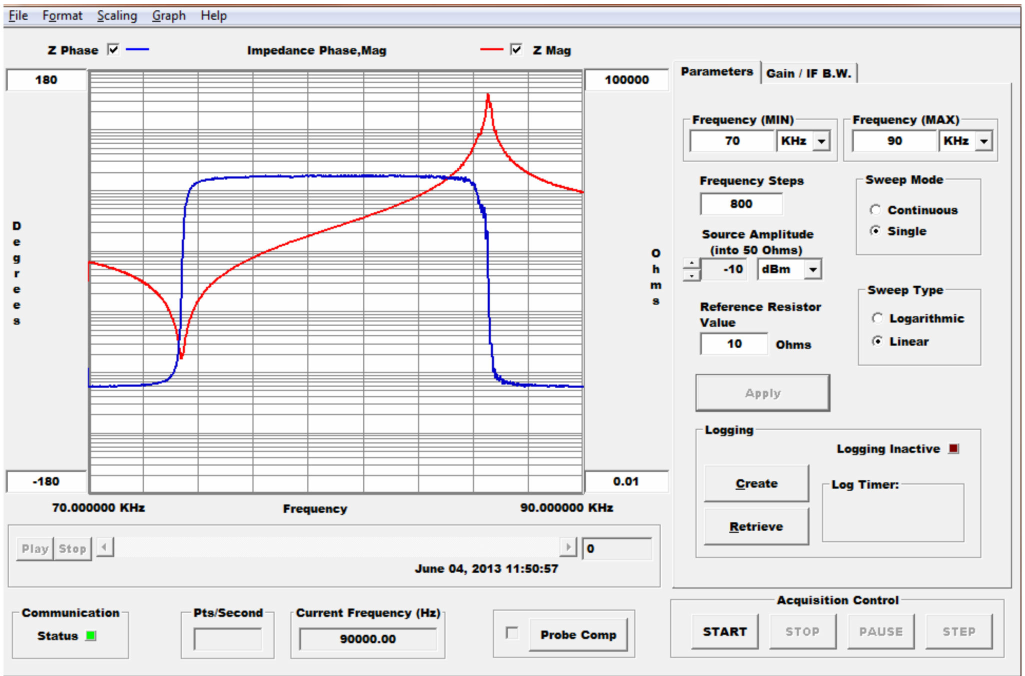

Figure 7. Impedance profile of piezoelectric device over 70 KHz to 90 KHz range.

It is useful to use the circle diagram along with the admittance frequency plot to help to determine the piezoelectric element parameters. Figure 8 illustrates the circle diagram and admittance profile of the device under test. Note that the important characteristics and parameters of the device are displayed on the circle diagram including Fs, Fp & Q. Additionally, the electrical circuit parameters have also been calculated for the model of the device. This is shown in figure 9.

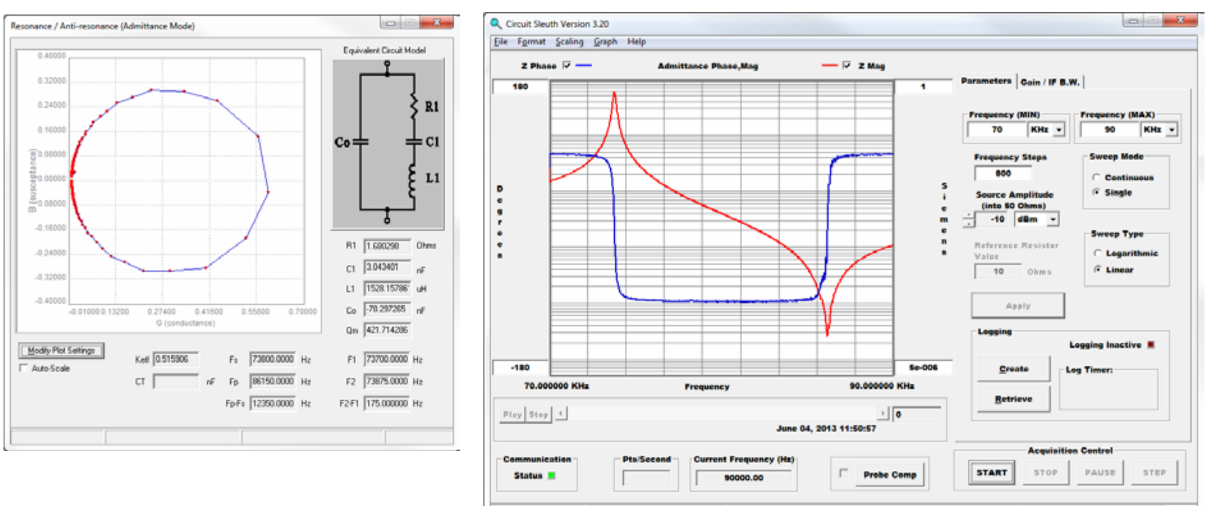

Figure 8. Circle diagram and admittance profile of the device under test showing all calculated parameters and electrical circuit model.

The Equivalent circuit model parameters can be used to construct an equivalent circuit suitable for use in an electrical simulation. This can be extremely useful when designing electronics around the circuit to simulate system performance before hardware is designed.

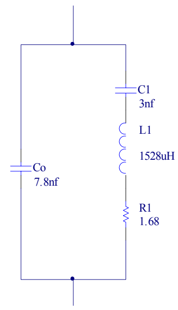

Figure 9. The electrical circuit model of the piezoelectric device with the corresponding component values.

The model of the device can now be used in a computer simulation. The admittance plot of the device model is shown in figure 10. The model is useful to designers who are developing support electronics and drive electronics for the piezoelectric device. The model enables them to work with an accurate representation of the actual device and help them optimize their designs before building hardware.

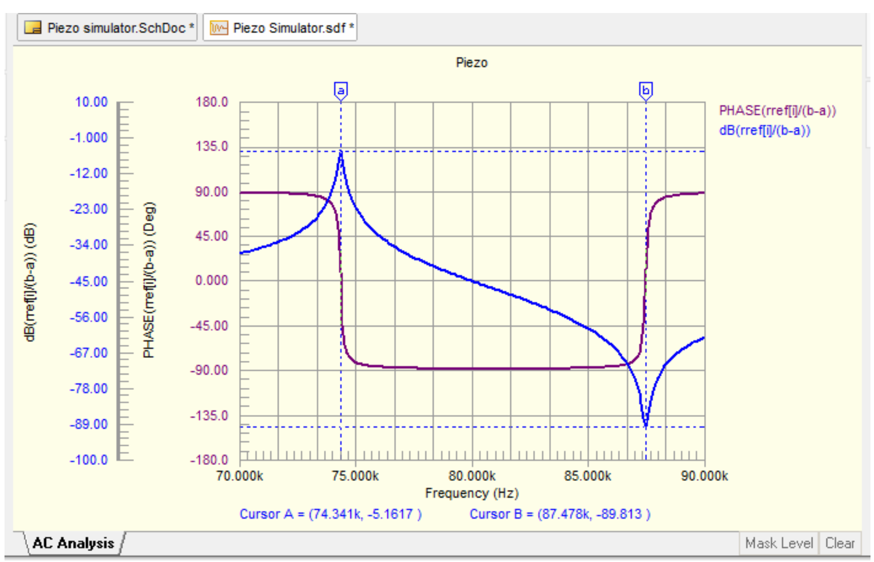

Figure 10. Computer simulation of piezoelectric device admittance using parameters calculated from frequency sweep measurements.

This application brief has illustrated how to measure piezoelectric devices with the SA Series Frequency Response Analyzer. It is important to make these measurements so that designers can know the limits of the device and construct electrical systems to optimize performance. The use of the impedance and admittance data to determine the device parameters was also described and a model of the piezoelectric device at the frequency band of interest was constructed.

We hope that this application note has been helpful. Further suggestions on additional application note topics or comments on this one are welcome.

Core Technology Group is committed to helping its customers by offering cost effective test equipment and services. Feel free to contact us at any time. We would be happy to answer any questions about your applications and testing needs. General contact information is listed below. Individuals can also be contacted through our website.

Core Technology Group
140 Independence Lane
Chalfont, Pennsylvania, 18914
USA
www.coretechgroup.com
Phone: 215-822-0120
Fax: 215-997-5544