TEST EQUIPMENT PLUS

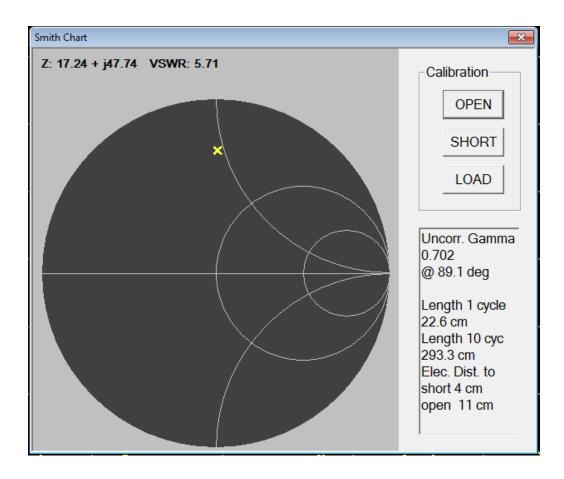Signal Hound USB-SA44B / USB-TG44A

Application Note 1:

The Smith Chart

1   Using the Smith Chart

Making Single-Frequency Vector Impedance Measurements

The The Signal Hound USB-SA44B can be used with a directional coupler (purchased separately) and an external reference 10 MHz input to make single-frequency vector impedance measurements. One common representation for this is the Smith Chart.

1.1 Activating the Smith Chart Utility

1. Connect the Signal Hound USB-SA44B to the PC using the included USB cable. Connect the USB-TG44A or power on your RF generator.

2. Launch the Signal Hound application software.

3. Connect an external reference 10 MHz from your USB-TG44A or RF generator to your USB-SA44B spectrum analyzer using a BNC cable.

4. From the Menu, select Settings→External Reference.

5. Enter a span of 10 KHz, and set your center frequency.

6. If you are using a USB-TG44A, select   Utilities→Tracking Generator CW, then use the default settings.

7. Install your directional coupler as follows:

    a. Connect the OUT port to your RF generator or TG44A

    b. Connect the COUPLED port to the SA44B

    c. Leave the IN port open, or use an "open" from your VNA cal kit. This will serve as your **S1-port**.

8. Adjust your reference level and attenuator so that the signal level peak is within 1 division of the top reference level.

9. Launch the Smith Chart utility from the Utilities menu.

10. Click OPEN to measure the S11 open.

11. If you have a VNA cal kit, connect the short, then click SHORT. Connect the load, then click LOAD.

You should see an X appear at the far right of the Smith Chart view. Attach a 50 ohm load or an antenna to your directional coupler to your S1 port. You should see the X jump to the center of the Smith Chart.

Please note: You must exit the smith chart utility to change frequency. The utility is for a single frequency only.

1.2   Taking Measurements

First of all, a few things you should know:

- ❑   A 50 ohm system is assumed.

- ❑   The VSWR of your RF generator will increase measurement inaccuracy. Adding a good 6-10 dB pad at the output will reduce this effect.

- ❑   There is a small amount of phase drift due to accumulated rounding errors, so you will need to re-calibrate every 15 minutes or so to reduce inaccuracies.

- ❑   While no "Standards" are required, a good 50 ohm load will improve measurement accuracy. Optionally, a network analyzer's standard open, short, and load may be used for best results.

You can measure the complex impedance of a load by first measuring your standards. Start with the Open. If you do not have any standards, simply measure the Open Port with nothing connected.

Apply the load or antenna to the Open Port. In the upper left of the Smith Chart window, the complex impedance will be shown. You may use this complex impedance for characterization of an antenna, load matching, etc.

1.2.1   Measuring Electrical Length

An added feature of our Smith chart utility is an electrical length measurement utility. To measure the electrical length of a cable, you do not need the directional coupler. Substitute a simple THRU instead. Ignore the complex impedance shown, and use only the magnitude and phase vector data.

1. Select a center frequency with a wavelength that is close to the expected electrical length of the cable.

2. Launch the Smith Chart utility as described above, except substitute an SMA barrel THRU for the directional coupler, then click OPEN.

3. Insert the cable to be measured. You should have an X on the right half of the Smith Chart.

4. Look in the lower right corner for "Length 1 cycle." This is the calculated electrical length based on roughly 1 wavelength.

5. For better accuracy, you may take this calculated electrical length and repeat steps 1-4 with a frequency 10 times higher than the calculated electrical length. Use the "Length 10 cyc" measurement.

1.2.2 Measuring Electrical Distance to an Open or Short

To measure the distance to an open or short in a cable, use the Smith chart with directional coupler, as before. Select a frequency such that the wavelength is less than 1/4 of the electrical length of the cable. This allows you to see whether the fault is a short or open, and the approximate electrical distance to it. For example, if you are checking a 40m cable with propagation velocity of 0.75, you would use a frequency less than 1.875 MHz (3e8 (m/s) / (30m / 0.75) / 4).

Do your open and short calibration, then connect the faulty cable. Look in the bottom right section of the Smith chart window. Identify the open and short distances. Choose the lesser number. This should represent the electrical distance to the fault and the nature of the fault (open or short).

To get a more accurate electrical distance, select a frequency with a wavelength approximately 3 times the distance to the fault (e.g. freq=0.33 * 3e10/fault distance). Run the test as above, but now select the open or short from the first test. For best accuracy, increase frequency until the cable length in front of the open or short causes a full 360 degree rotation. This frequency's wavelength represents exactly twice the distance to the fault.

To get the physical distance to the fault, multiply the electrical length by the cable's propagation velocity.

1.3 Impedance Matching

There are numerous online tools for matching a complex load impedance to a 50 ohm source. Agilent Technologies® has a great web page on using the Smith Chart for impedance matching. Visit **http://contact.tm.agilent.com/Agilent/tmo/an-95-1/classes/imatch.html** or search for their "Interactive Impedance Matching Model." Other calculators are available as well.

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