How to measure VSWR using a Rigol DSA-1000 series Spectrum Analyzer

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Solution: The purpose of this document is to provide step-by-step instruction on measuring the VSWR (Voltage Standing Wave Ratio) of a passive RF component.

The VSWR can be used to judge the quality of impedance matching for cables and other passive devices. It is also mainly used to determine the efficiency of antennas to radiate power.

A perfectly matched antenna/cable system will have a VSWR = 1. In reality, VSWR's are typically in the 1.1 to 1.2 range.

Higher VSWR's indicate a greater degree of impedance mismatch. For antenna user's this indicates less efficiency.

Equipment: To measure the VSWR, you will need the following:

1. Rigol DSA-1000 series of Spectrum Analyzer with a tracking generator (TG) option.
2. Coaxial Directional Coupler with impedance match for component being tested.
3. Antenna or other component to test.
4. Impedance matched coaxial cable to connect coupler to the tracking generator. Depending on the Directional Coupler design, you may need another cable or adapter to connect it to the DSA.

Steps:

1. Clean all connectors with a lint free swab and IPA. Make sure to remove any contamination, dirt, or metallic flakes in and around mating surfaces.

2. Connect the RF coupler coupled (CPL) connection to the RF Input of the DSA.

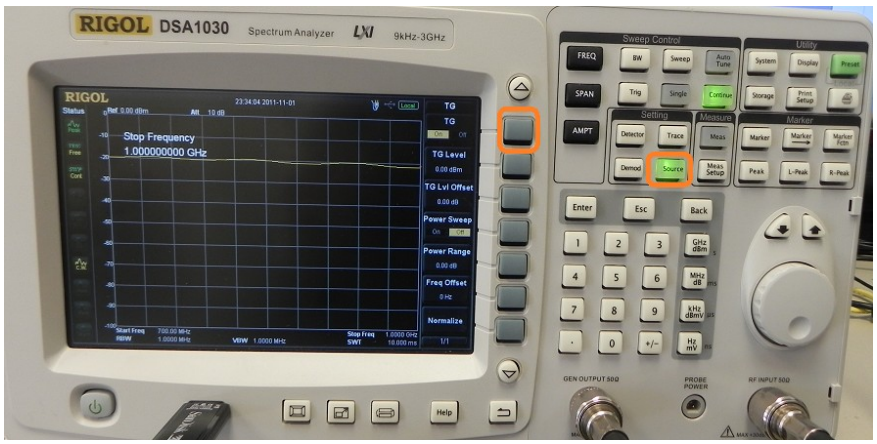3. Connect the cable from the TG output on the front panel of the DSA to the output (OUT) of the coupler.

    NOTE: Leave the input (IN) of the coupler open. This will provide 100% reflection and be used to minimize the effects of the the cabling, adapters, and coupler.

4. Configure the DSA frequency span for the DUT by pressing the FREQ key on the DSA display and setting the Start and Stop frequency.

    • Press FREQ > Start Freq > Use Keypad to enter start frequency and select units.

    • Press FREQ > Stop Freq > Use Keypad to enter start frequency and select units.

5. We can correct for the cabling, adapters, and coupler effects by storing the open circuit (no DUT = Max Reflection) conditions by normalizing the current setup.
   - Enable the tracking generator (Press Source > TG On)
   - Store the normalized reference
        (Press Source > Normalize > Stor Ref)
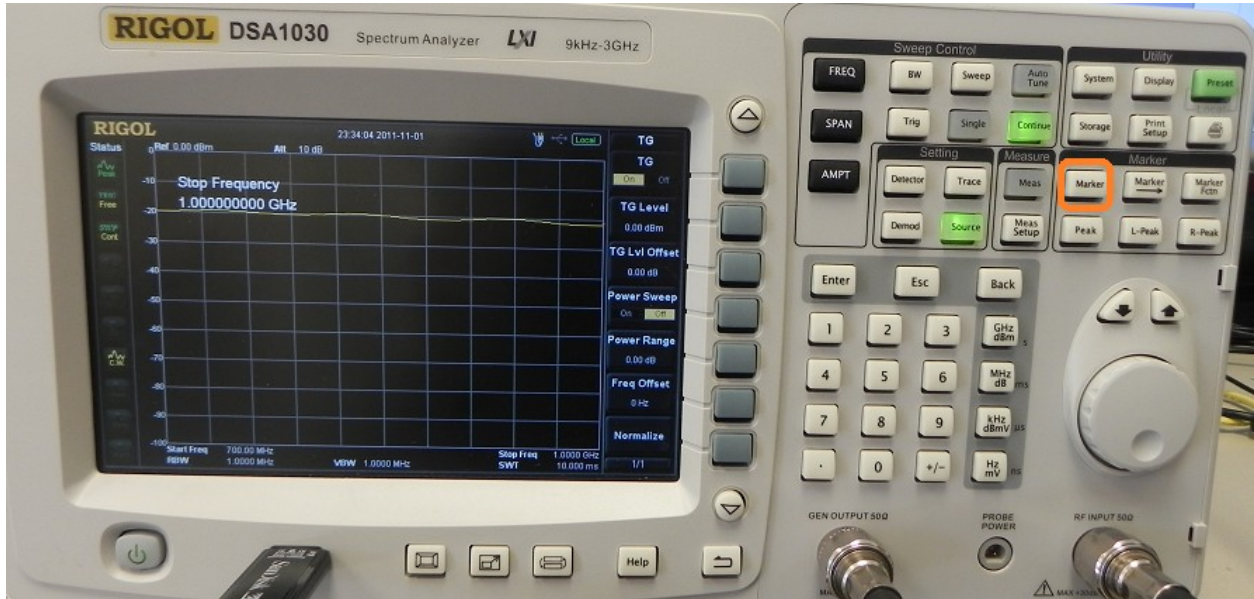   - Enable normalized reference (Normalize > On)

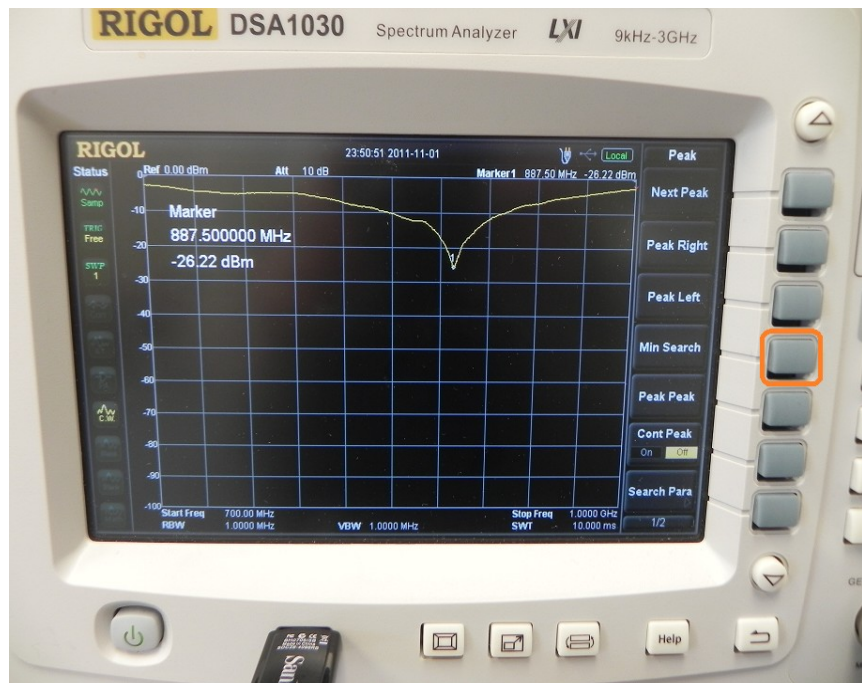NOTE: You can also view the normalized reference trace by enabling the Ref Trace.
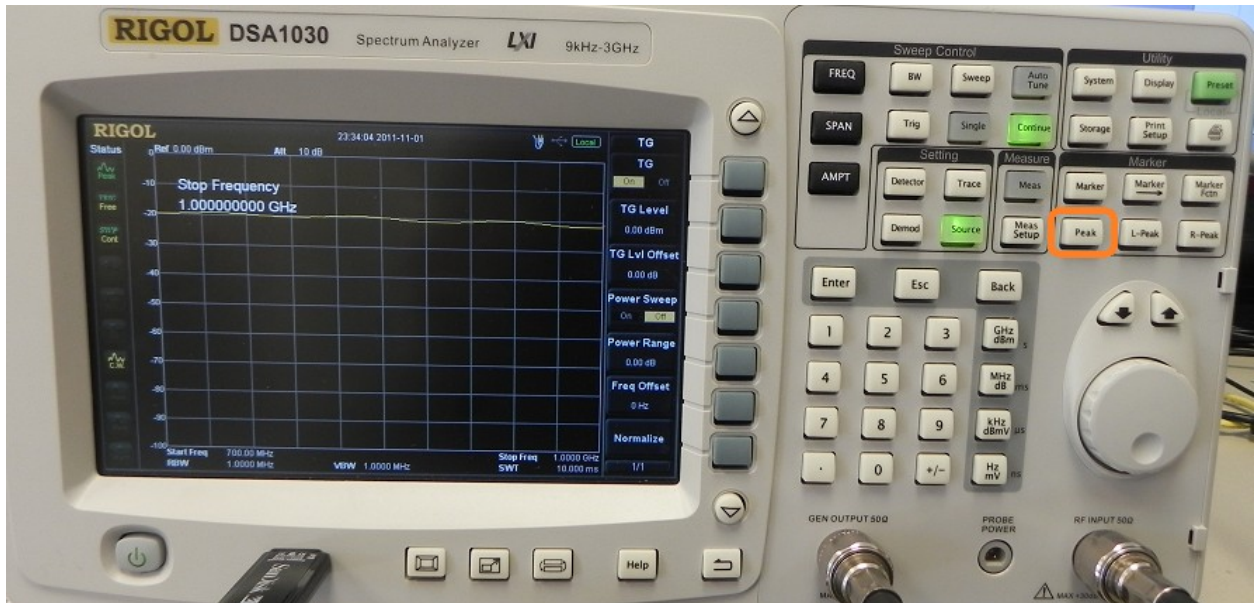

6. Connect the DUT of interest to the coupler input (IN).
7. Select a marker to identify your location on the trace.
   - Press Marker > Normal

8. You can use the scroll wheel to manually mark the minimum or you can use the Peak Minimum function to find the lowest spot on the trace automatically.
   - Press Peak > Min Search

9. The minimum value displayed on the DSA is the return loss of the DUT. Record this value in dB.

Calculations: The VSWR can be calculated by the following

a = Return Loss (dB)
r = Reflection coefficient of the DUT
s = VSWR

$r = 10^{(-0.05 * a)}$
$s = (1 + |r|) / (1- |r|)$

For our example of an 800MHz antenna, we have the following:

a = -26.22 dB
$r = 10^{(-0.05 * 26.22)} = 10^{(-1.31)} = 0.05$
$s = (1+0.05) / (1-0.05) = 1.11$