

## How to Measure VSWR using a Rigol DSA800 Series Spectrum Analyzer

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.

## Required Equipment

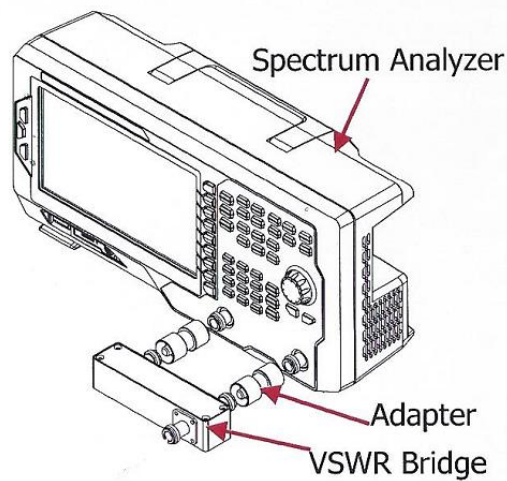
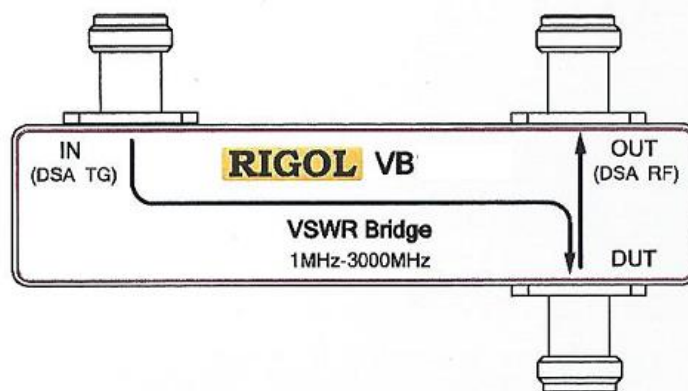
To measure the VSWR, you will need the following:

- Rigol DSA800 series of Spectrum Analyzer with a tracking generator (-TG part number)
- (Optional) Rigol VSWR-DSA800 (You can calculate the VSWR manually using the return loss measurement calculations at the end of this document)
- Coaxial Directional Coupler or Rigol model VB1000 VSWR bridge with impedance match for component being tested
- Antenna or other component to test
- 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.

## Test Steps for Analyzers that have the Rigol VSWR-DS800 option installed

1. Clean all connectors with a lint free swab and electronics contact cleaner. Make sure to remove any contamination, dirt, or metallic flakes in and around mating surfaces.
2. Connect the Rigol VB1000 series VSWR bridge or other directional coupler to the DSA.

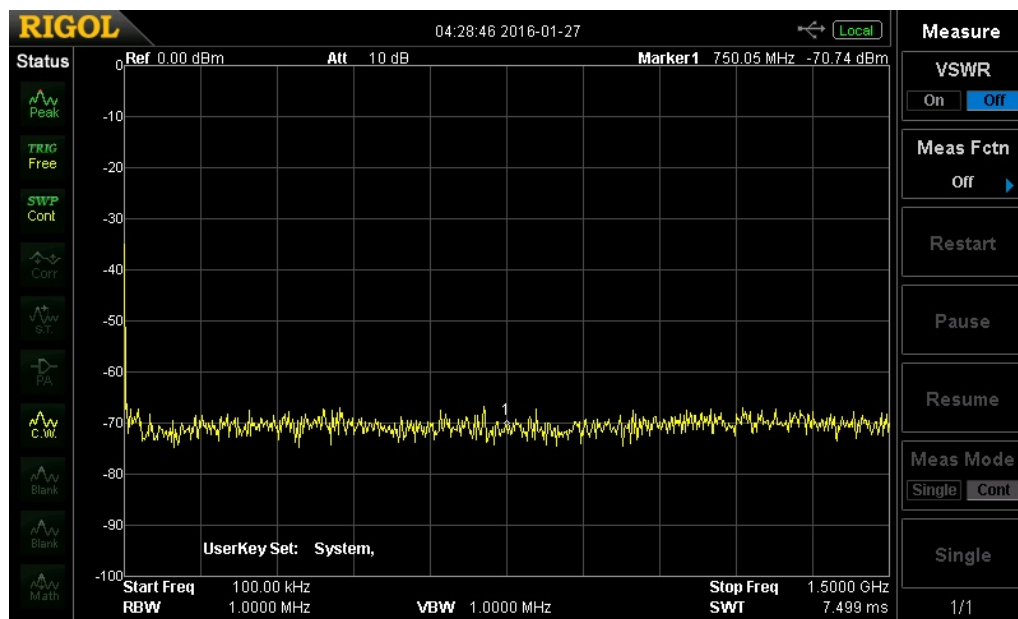
The Rigol VB1000 series can be attached to the analyzer as shown below:



If you are using another direction coupler or bridge, please see the connection instructions for the specific model you are using to ensure proper connections.

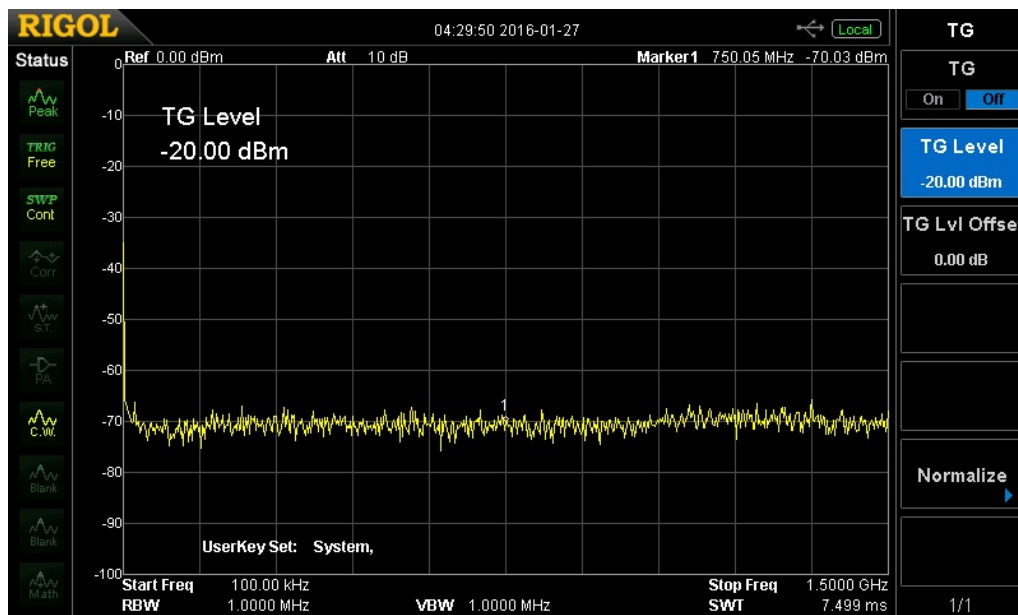
**NOTE:** Leave the DUT connection of the coupler open at this time. This will provide 100% reflection and be used to minimize the effects of the cabling, adapters, and coupler.

3. 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 or scroll wheel to enter start frequency and select units.
  - Press FREQ > Stop Freq > Use Keypad or scroll wheel to enter stop frequency and select units.



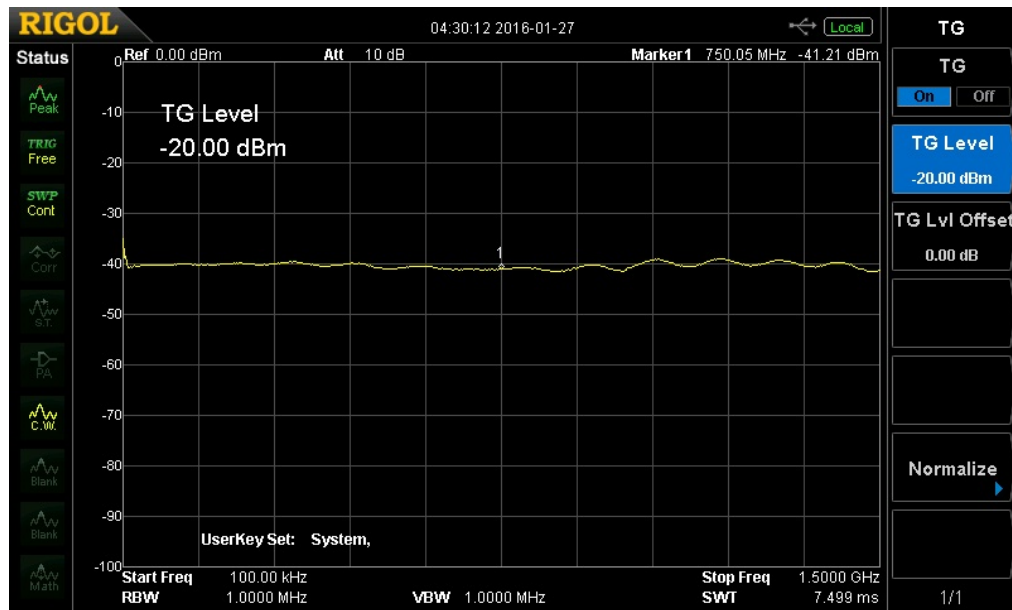
4. Set the tracking generator output amplitude level to a value that is appropriate for your DUT

- Press TG > set TG level



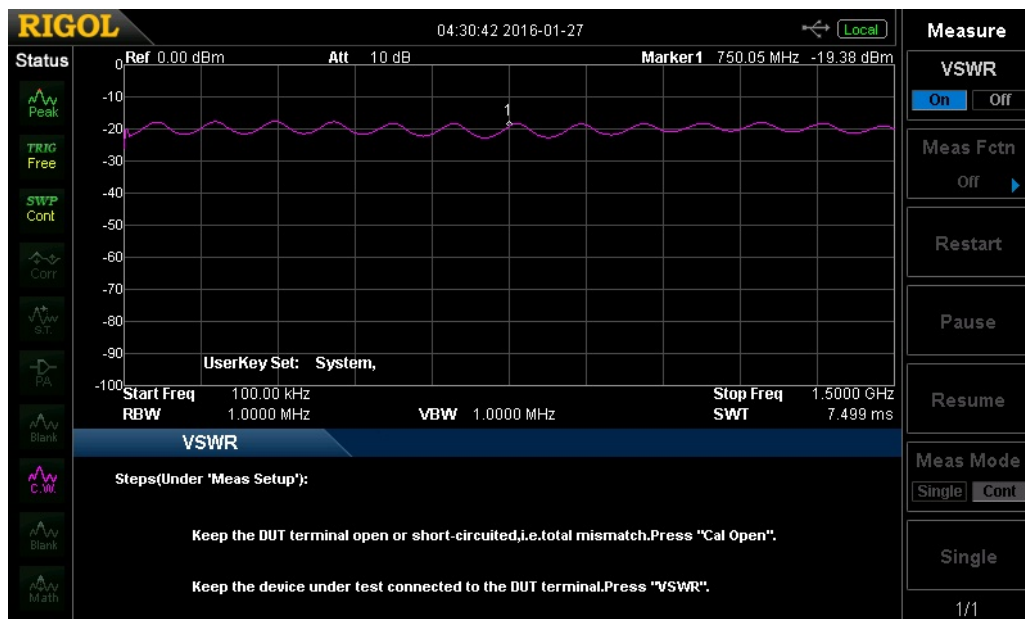
5. Enable the tracking generator. This will begin sourcing an RF source that will sweep from the start frequency to the stop frequency

- Press TG > TG = On



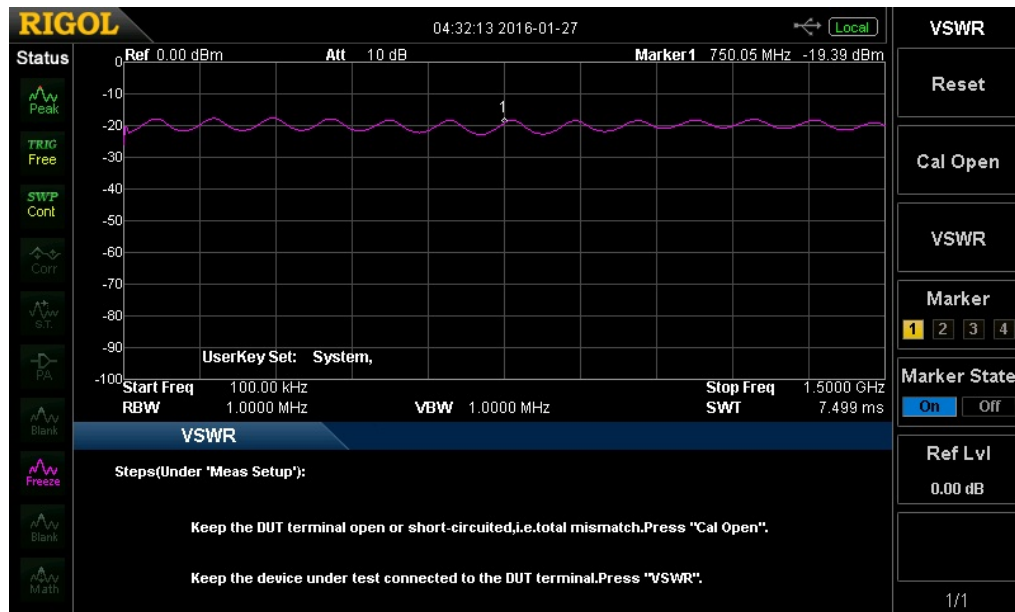
6. Enable the VSWR automatic measurements (valid for instruments that have the VSWR-DSA800 option installed)

- Press MEAS > VSWR = ON



7. Normalize the output with no DUT connected to the DUT port on the VB1000 series bridge or directional coupler.

- Press MEAS SETUP > CAL OPEN



8. Connect the DUT and associated cabling

9. Enable VSWR measurements

- Press VSWR

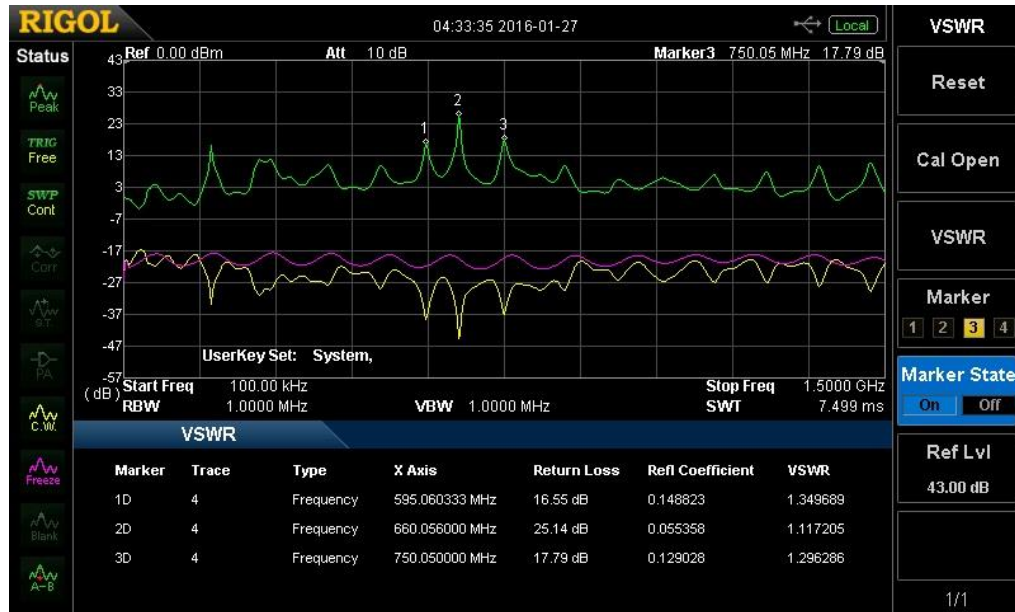
The Yellow trace represents the return loss vs. frequency

The Purple trace represents the full reflection from the VSWR bridge with no DUT connected (Cal Open)

The Green trace represents the calculated VSWR curve for the DUT

10. Adjust the Ref Level to show the full range of the green VSWR curve

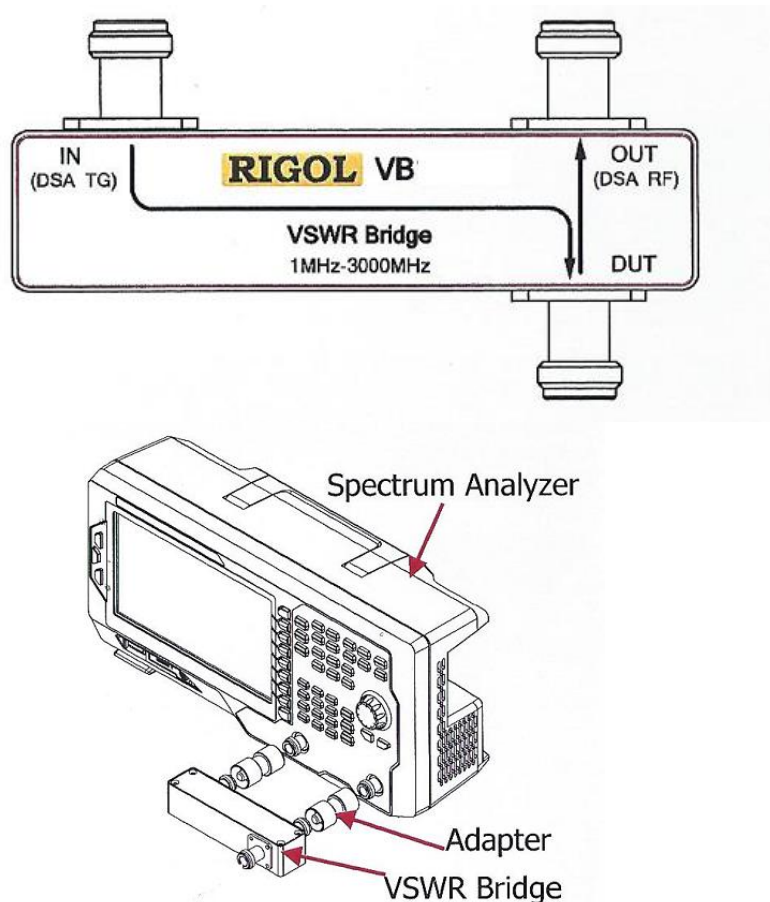
11. You can select markers (1,2,3, or 4) and move them to specific peaks to read out the specific VSWR value for each peak on the green curve as shown in the following picture:



## Test Steps for Analyzers without the Rigol VSWR-DS800 option installed

1. Clean all connectors with a lint free swab and electronics contact cleaner. Make sure to remove any contamination, dirt, or metallic flakes in and around mating surfaces.
2. Connect the Rigol VB1000 series VSWR bridge or other directional coupler to the DSA.

The Rigol VB1000 series can be attached to the analyzer as shown below:



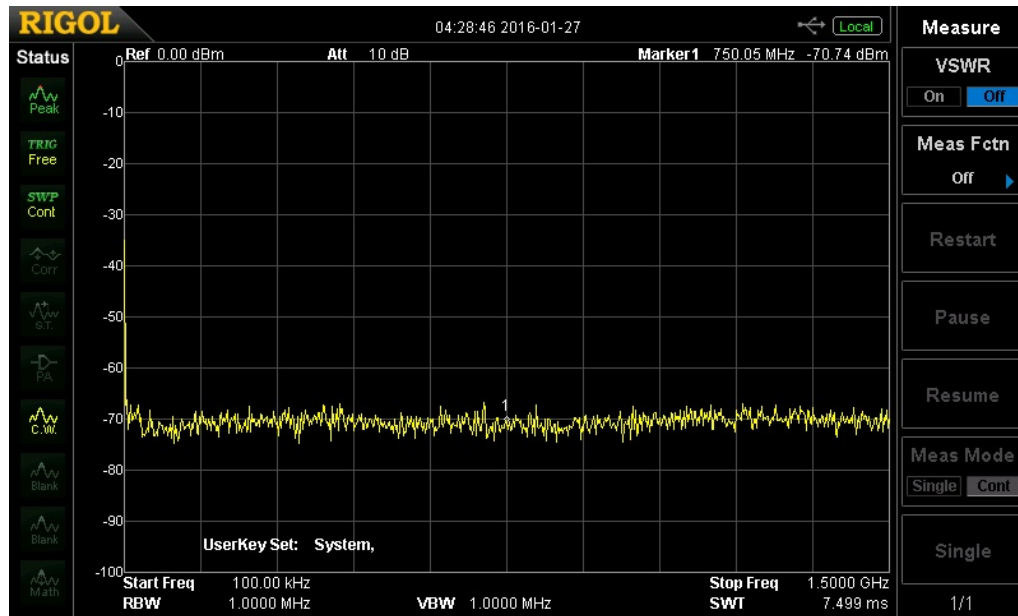
If you are using another direction coupler or bridge, please see the connection instructions for the specific model you are using to ensure proper connections.

**NOTE:** Leave the DUT connection of the coupler open at this time. This will provide 100% reflection and be used to minimize the effects of the cabling, adapters, and coupler.

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

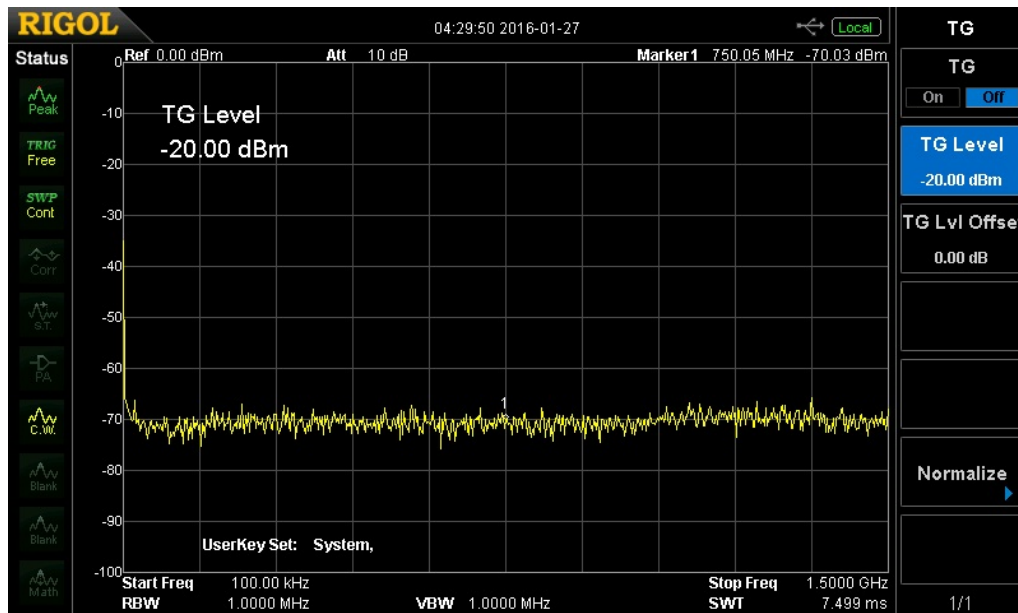


- Press FREQ > Start Freq > Use Keypad or scroll wheel to enter start frequency and select units.
- Press FREQ > Stop Freq > Use Keypad or scroll wheel to enter stop frequency and select units.



4. Set the tracking generator output amplitude level to a value that is appropriate for your DUT

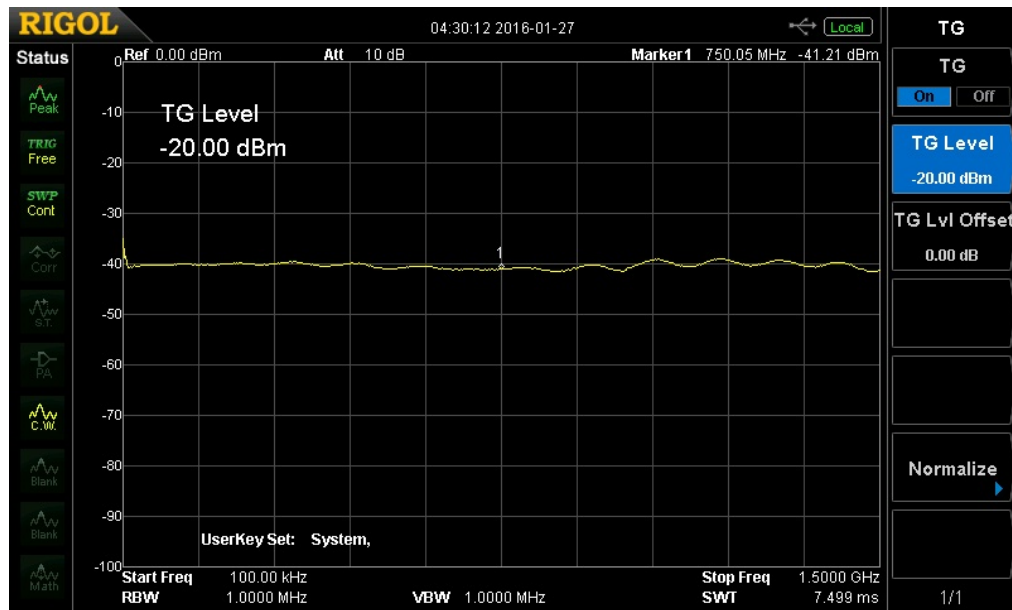
- Press TG > set TG level





5. Enable the tracking generator. This will begin sourcing an RF source that will sweep from the start frequency to the stop frequency

- Press TG > TG = On

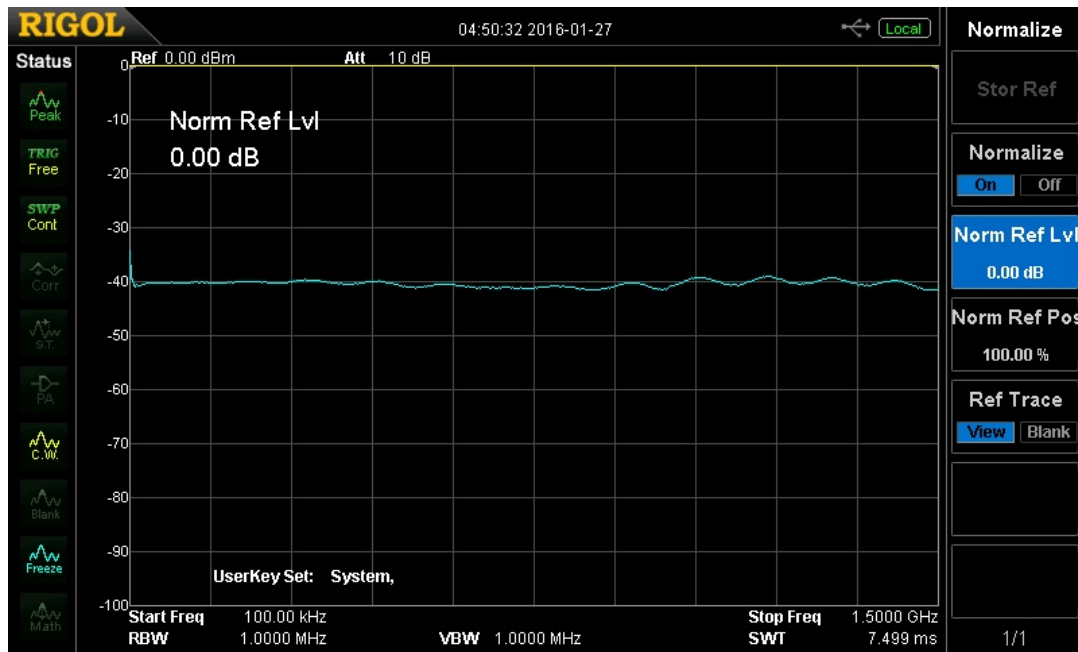


6. Open the Normalize menu

- Press TG > Normalize

## 7. Store the open calibration (no DUT connected = Full reflection) trace

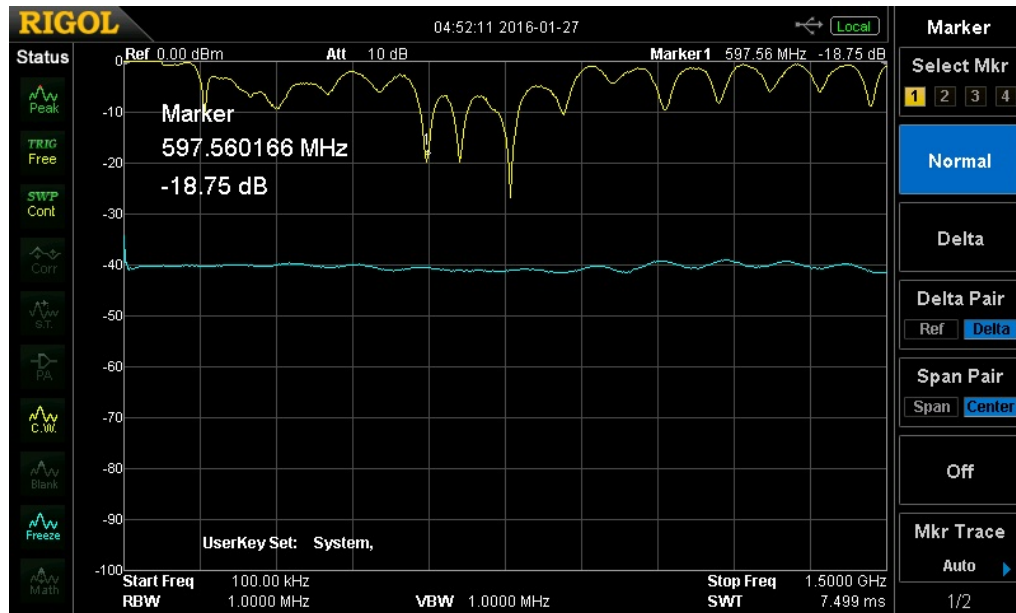
- Press Stor Ref
- Normalize = ON



The trace should now be a flat line at the top (0dBm) of the display. This indicates that any reflections and losses are “normalized” and removed from the trace.

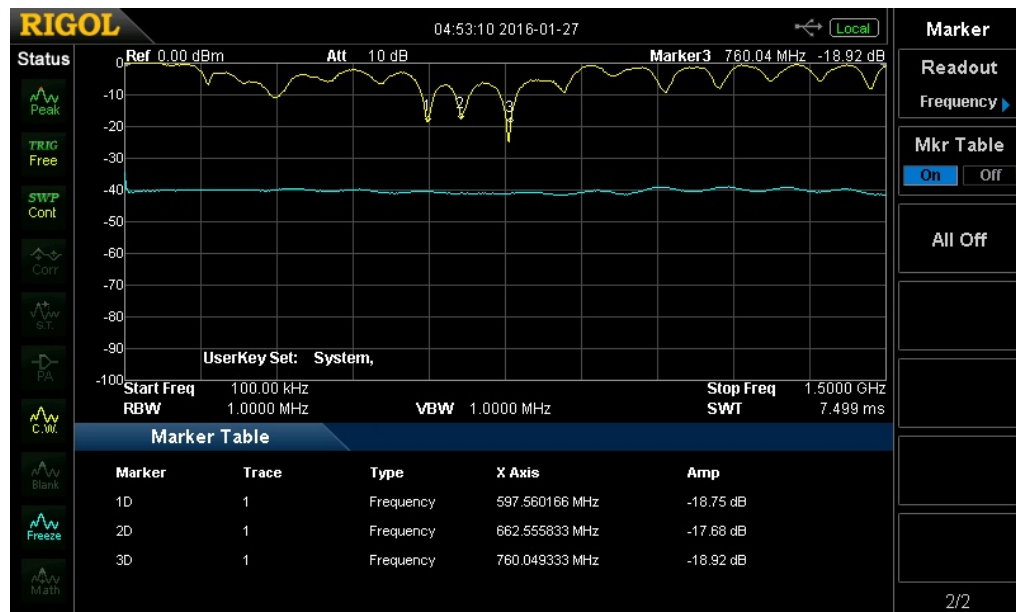
**NOTE:** You can also view the normalized reference trace (Light Blue trace) by setting Ref Trace = View.

- Connect the DUT of interest to the coupler input (IN). Now, parts of the trace should drop below 0dBm.



- Select a marker to identify your location on the trace.

- Press Marker > Normal



- You can use the scroll wheel to manually mark the minimum, activate the marker table, or you can use the Peak Minimum function to find the lowest spot on the trace automatically.

- Press Peak > Min Search

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

The VSWR can be calculated by the following:

a = Return Loss (dB)

r = Reflection coefficient of the DUT

s = VSWR

$r = 10^{(-0.05 * a)}$

$s = (1 + |r|) / (1 - |r|)$