FREEDOM
Communication Technologies

Application Note:
Swept Return Loss & VSWR Antenna Measurements using the Eagle Technologies RF Bridge

FCT-1008A

Introduction

Return loss and VSWR are a measure of the magnitude of a transmitted RF Signal in relation to the magnitude the reflected RF signal on RF components and networks, including an antenna. Maximum power transfer occurs when the impedance of the transmission load is perfectly matched to the impedance of the line load. In practice this is virtually impossible to achieve. An impedance mismatch at any point in an RF network will result in a reflection of the input signal and a reduction of the output power available for processing or radiation from the antenna.

Radio and RF engineers seek to minimize these mismatches to ensure the best power transfer efficiency in their systems. Excessive reflections could distort or even damage the transmitter. Reverse power protection circuits are normally employed to trip the power amplifier at a certain level of reverse power, but the cause of the reflection must be investigated and repaired. To do this we measure the Return Loss (RL) of the component, cable feeder and/or antenna.

The same technique may be used to tune variable frequency (tunable) antenna systems where the tuned response is adjusted for the best RL. A preventive maintenance schedule will call for the periodic check of the system parameters and compare it against commissioning data. Return Loss is measured in decibels and can be converted to VSWR by a simple mathematical equation. VSWR is a more common term used in radio engineering.

Test Equipment

1. Freedom Communication Technologies R8000 with Tracking Generator and Spectrum Analyzer (ESA) options.
2. Eagle Technologies R8000 3GHz RF Bridge, Accessories and Calibration Kit. Includes all connection cables and accessories.

Configuration Diagram.
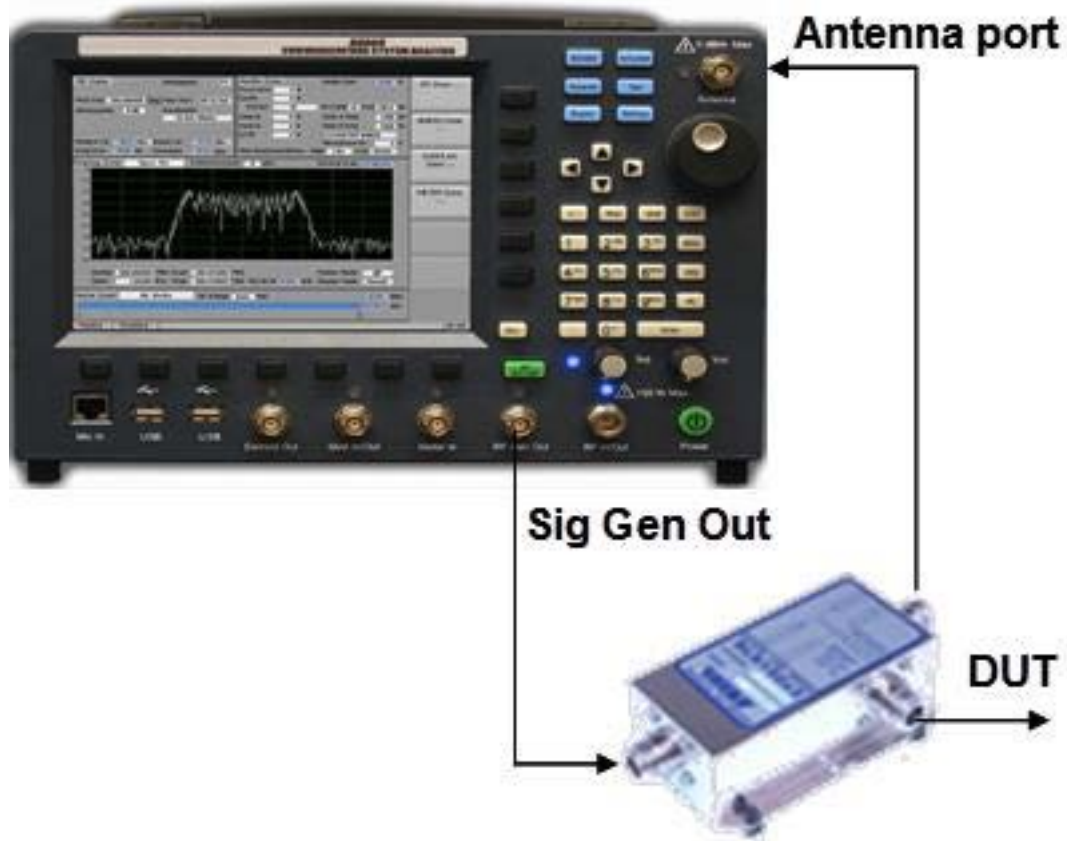
Test Procedure
Connect the RF Bridge to the R8000 as shown above

R8000.
1. Select the blue "Test" key
2. Select the "Standard" test key from the menu.
3. Select the blue "Instrument" key
4. Select "Tracking Generator"
5. Set "Start" and "Stop" frequencies to the band to be measured
6. Alternatively set a "Center Frequency" and "Span"
7. Select More 2 of 4
8. Set "Vertical Scale" to 10dB
9. Set "No of Points" to 400 Note for higher or lower resolution set 100-600 points. The lower the resolution the faster the display update rate when tuning a component..
10. Select "Select Marker" set to 1
11. Set Marker Mode "Normal"
12. Set Display Mode "Normal"
13. Select 4 o 4
14. Set "Output Level" to -10dBm
15. Set "Attenuation" to 0Bm
16. Set "Gen Port" to "Gen Out"
17. Set "Monitor Port" to "Antenna"
18. Select "More to 1 of 4"

19. Set "Reference Level" to -20dBm

Note:
The frequency Vs level characteristics the R8000, Connecting cables and the Eagle Bridge are now displayed as the "Reference" to be used to measure RL. At some future time the R800 will be enhanced with "Normalization" to calibrate a straight line zero reference for RL measurements. Note that the current error is less than 3dB, typically 1.5dB, worst case for the current reference trace across the range HF/VHF/UHF frequency band.
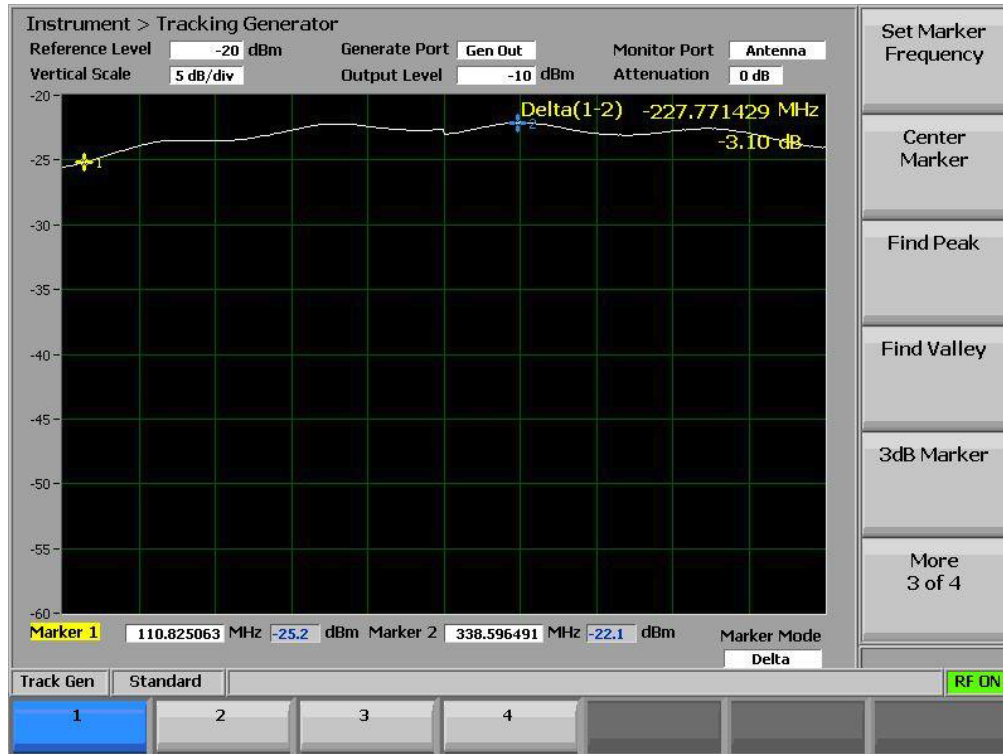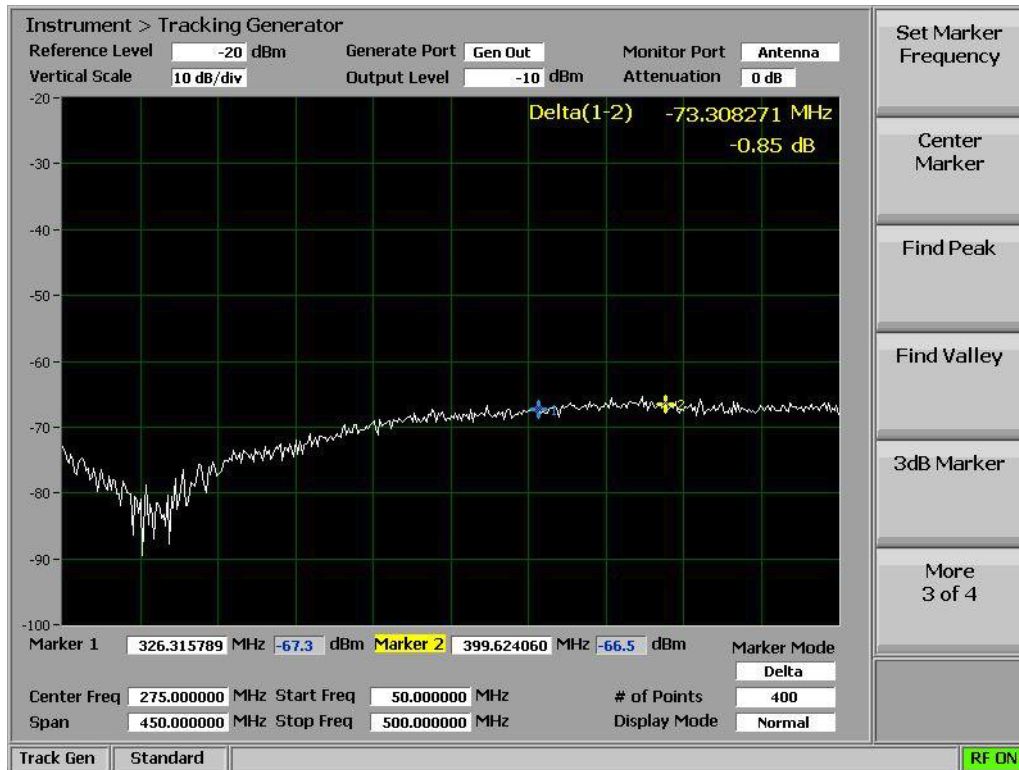

Check Calibration

Note:
This calibration checks the precision of the Eagle RF Bridge.

1. Connect the Eagle 50Ohm termination to the DUT port.
2. Check that the displayed reference line (Directivity) is greater than 40dB down from the original reference line.
EG:(-67)-(-23)=44dB

Measurement Procedure
Connect the component, system, cable feeders and/or Antenna to be measured to the DUT port of the Eagle Bridge
1.   Select "Vertical Scale" to 5dB
2.   Select "2 of 4" and "Select Marker" 1
3.   Select "Find Peak"
4.   "Select Marker" 2
5.   Select "Marker Mode" "Delta"
6.   .Select "Find Valley"

The displayed difference (Delta) between the Delta markers is the RL in dB.
Refer to Table 1 to convert the RL to VSWR if required.

Note:
 At some future date an additional key (RL/VSWR) will offer the option of the displayed delta level parameter as either RL or VSWR.
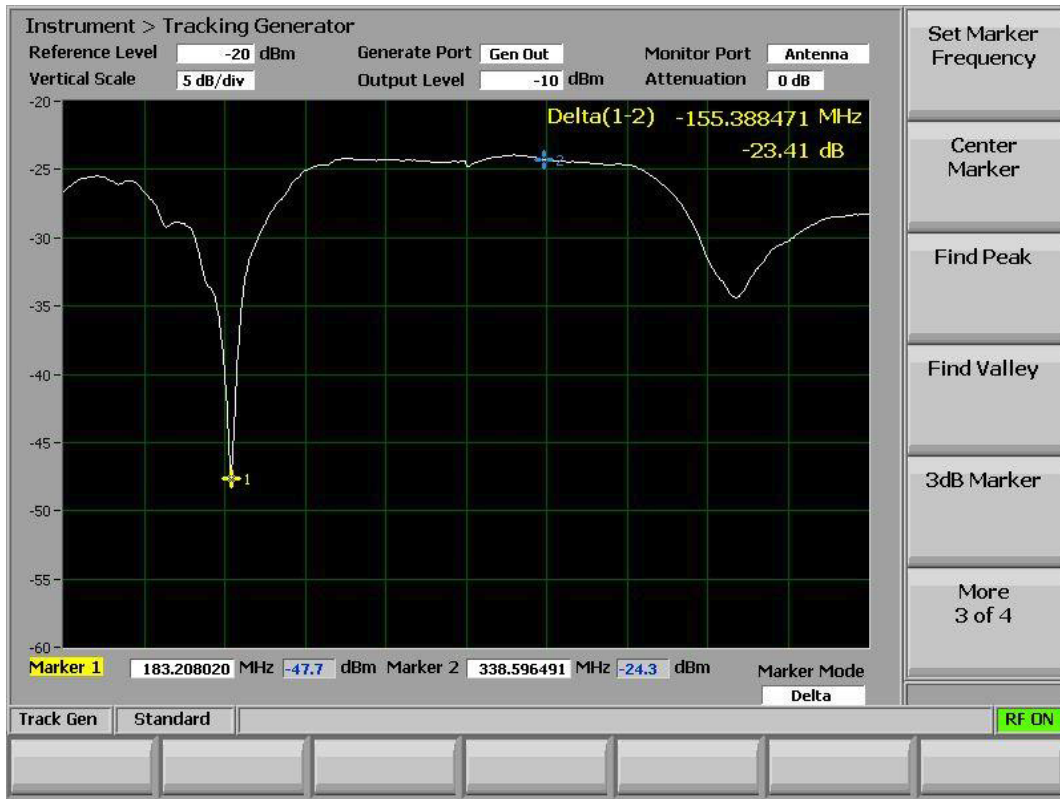
Example Displayed Results

Table1 Return Loss to VSWR

RL	VSWR		RL	VSWR		RL	VSWR		RL	VSWR		RL	VSWR
- 0.00	INF		- 0.01	1737.178		- 0.02	868.5893		- 0.03	579.0599		- 0.04	434.2952
- 0.05	347.4365		- 0.06	289.5308		- 0.07	248.1696		- 0.08	217.1488		- 0.09	193.0215
- 0.1	173.7197		- 0.2	86.86273		- 0.3	57.91169		- 0.4	43.43712		- 0.5	34.75315
- 0.6	28.96448		- 0.7	24.83026		- 0.8	21.73007		- 0.9	19.31924		- 1.0	17.39096
- 1.1	15.81363		- 1.2	14.49950		- 1.3	13.38784		- 1.4	12.43527		- 1.5	11.60995
- 1.6	10.88805		- 1.7	10.25129		- 1.8	9.685503		- 1.9	9.179470		- 2.0	8.724232
- 2.1	8.312532		- 2.2	7.938432		- 2.3	7.597029		- 2.4	7.284235		- 2.5	6.996616
- 2.6	6.731269		- 2.7	6.485717		- 2.8	6.257841		- 2.9	6.045811		- 3.0	5.848044
- 3.1	5.663157		- 3.2	5.489945		- 3.3	5.327345		- 3.4	5.174421		- 3.5	5.030343
- 3.6	4.894375		- 3.7	4.765858		- 3.8	4.644205		- 3.9	4.528886		- 4.0	4.419428
- 4.1	4.315400		- 4.2	4.216416		- 4.3	4.122123		- 4.4	4.032201		- 4.5	3.946359
- 4.6	3.864330		- 4.7	3.785871		- 4.8	3.710759		- 4.9	3.638788		- 5.0	3.569771
- 5.1	3.503533		- 5.2	3.439914		- 5.3	3.378766		- 5.4	3.319951		- 5.5	3.263342
- 5.6	3.208820		- 5.7	3.156276		- 5.8	3.105608		- 5.9	3.056719		- 6.0	3.009520
- 6.1	2.963930		- 6.2	2.919869		- 6.3	2.877264		- 6.4	2.836048		- 6.5	2.796156
- 6.6	2.757528		- 6.7	2.720107		- 6.8	2.683840		- 6.9	2.648676		- 7.0	2.614568
- 7.1	2.581472		- 7.2	2.549346		- 7.3	2.518148		- 7.4	2.487842		- 7.5	2.458392
- 7.6	2.429763		- 7.7	2.401925		- 7.8	2.374845		- 7.9	2.348497		- 8.0	2.322851
- 8.1	2.297882		- 8.2	2.273564		- 8.3	2.249875		- 8.4	2.226792		- 8.5	2.204293
- 8.6	2.182358		- 8.7	2.160967		- 8.8	2.140102		- 8.9	2.119745		- 9.0	2.099878
- 9.1	2.080486		- 9.2	2.061553		- 9.3	2.043064		- 9.4	2.025005		- 9.5	2.007363
- 9.6	1.990123		- 9.7	1.973273		- 9.8	1.956803		- 9.9	1.940699		- 10.0	1.924951
- 11	1.784888		- 12	1.670900		- 13	1.576895		- 14	1.498520		- 15	1.432581
- 16	1.376678		- 17	1.328977		- 18	1.288048		- 19	1.252764		- 20	1.222222
- 21	1.195691		- 22	1.172574		- 23	1.152377		- 24	1.134690		- 25	1.119170
- 26	1.105526		- 27	1.093514		- 28	1.082923		- 29	1.073573		- 30	1.065311
- 31	1.058002		- 32	1.051532		- 33	1.045800		- 34	1.040718		- 35	1.036209
- 36	1.032208		- 37	1.028656		- 38	1.025500		- 39	1.022695		- 40	1.020202
- 41	1.017985		- 42	1.016014		- 43	1.014260		- 44	1.012699		- 45	1.011310
- 46	1.010074		- 47	1.008974		- 48	1.007994		- 49	1.007122		- 50	1.006345
- 51	1.005653		- 52	1.005036		- 53	1.004487		- 54	1.003999		- 55	1.003563
- 56	1.003175		- 57	1.002829		- 58	1.002521		- 59	1.002247		- 60	1.002002
- 61	1.001784		- 62	1.001590		- 63	1.001417		- 64	1.001263		- 65	1.001125
- 66	1.001003		- 67	1.000894		- 68	1.000797		- 69	1.000710		- 70	1.000633
- 71	1.000564		- 72	1.000503		- 73	1.000448		- 74	1.000399		- 75	1.000356
- 76	1.000317		- 77	1.000283		- 78	1.000252		- 79	1.000224		- 80	1.000200
- 81	1.000178		- 82	1.000159		- 83	1.000142		- 84	1.000126		- 85	1.000112
- 86	1.000100		- 87	1.000089		- 88	1.000080		- 89	1.000071		- 90	1.000063
- 91	1.000056		- 92	1.000050		- 93	1.000045		- 94	1.000040		- 95	1.000036
- 96	1.000032		- 97	1.000028		- 98	1.000025		- 99	1.000022		- 100	1.000020