

Antenna VSWR Measurement with your StormLink IQ Receiver

White Paper

James Logan
OneRain, Inc.

Using your StormLink IQ Receiver as an VSWR Meter for testing an antenna

Background:

The StormLink IQ can be used to visualize the spectral energy. When configured with a noise source or frequency generator, it can be used to measure the energy being reflected by an antenna. Measuring the returned energy for an open connection (no antenna connected) vs. the returned energy with the noise source connected to the antenna. The difference between those two is the return loss (RL). The return loss can be used to calculate the VSWR for the antenna using the following formula:

Return Loss = RL = Antenna Connected – Not Connected

$$VSWR = \frac{10^{\frac{RL[dB]}{20}} + 1}{10^{\frac{RL[dB]}{20}} - 1}$$

A VSWR reading of 1.0 means that the antenna is perfectly tuned for that frequency and no energy is lost. A VSWR Reading of between 1.0 and 1.5 is acceptable. If the antenna is used for transmission, a high SWR reading can damage the radio. If the antenna is used only for receiving RF, then while a high SWR won't damage the radio, a high VSWR can degrade the receive signal. The following table gives you some ranges.

SWR Reading	
1.0	Perfect Signal, no energy lost
1.0 – 1.5	Pretty Good, most energy converted to RF
1.5 – 2.0	Could be better, tuning can improve
2.0 – 2.5	Could be better, should be tuned
2.5 – 2.9	Could damage radio. Not good for transmitter
> 3.0	Bad, radio will likely be damaged, there is an installation problem.

What you need:

1. StormLink IQ Receiver – USB Dongle
2. White noise generator
 - a. These can be purchased on ebay for about \$20
<http://www.ebay.com/bhp/noise-generator>

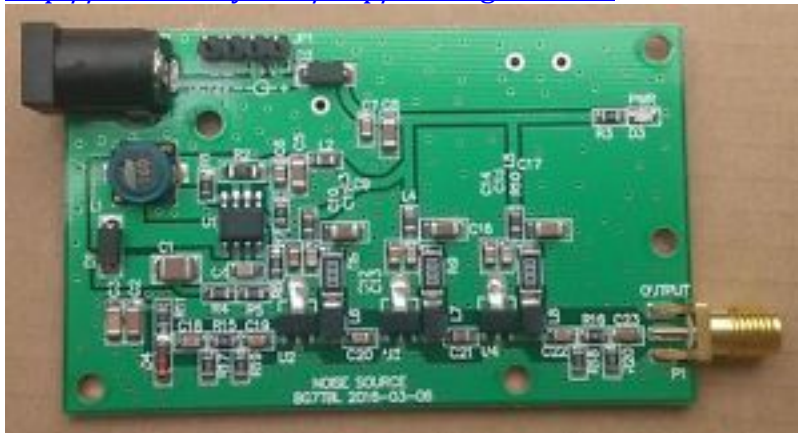


Figure 1 White Noise Source

3. Directional Coupler
 - a. Directional coupler , can also be purchase for about \$35



Figure 2 Directional Coupler

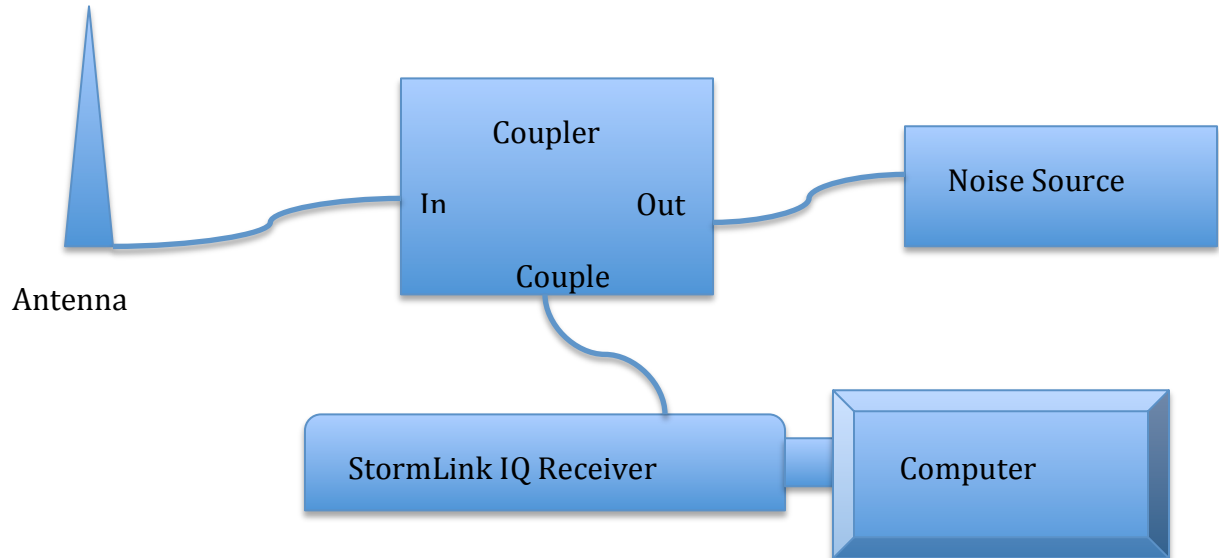
4. Download the following open source spectrum analyzer software
 - a. A list of many freely available spectrum analyzer software are at
<http://www.rtl-sdr.com/big-list-rtl-sdr-supported-software/>

The best choice for spectrum analysis is software that provides both a spectral energy graph and a waterfall display to show the energy over time.

- b. Spectrum Analysis Software – A few options below, you only need one
 - i. <http://www.rtl-sdr.com/rtl-sdr-quick-start-guide/>
 - ii. RTLSDR Scanner – Win/Mac/Linux - <http://eartoearoak.com/software/rtl-sdr-scanner>
 - iii. Spektrum – Win/Linux - <https://github.com/pavels/spektrum>
- c. The best choice for spectrum analysis software for this application is the RTLSDR scanner. It performs a scan across the frequency range, allows averaging of results, and has comparison and difference tools for simplifying the VSWR measurement process.

Steps to get it running:

- 5. Install the software and make sure it runs with your StormLink IQ receiver. I installed the RTLSDR Scanner following the instructions on the link <http://eartoearoak.com/software/rtlsdr-scanner/rtlsdr-scanner-installation>
- 6. Configure you're the noise source, antenna, coupler, StormLink IQ like the following diagram:



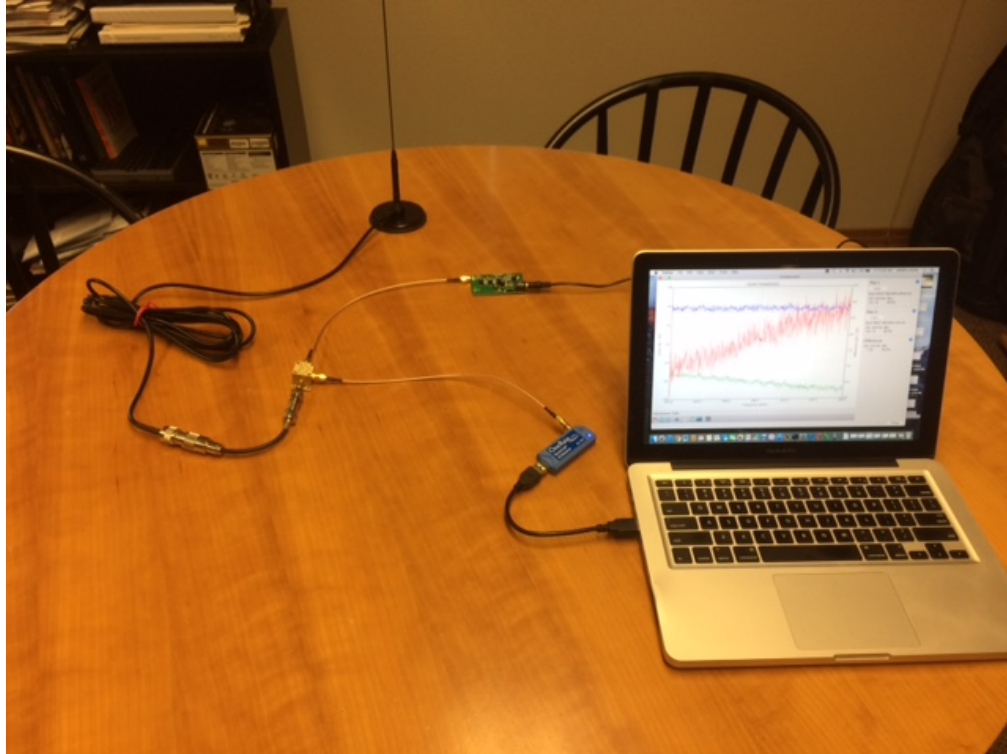


Figure 3 Configuration for testing an omni antenna

7. Testing the antennas VSWR
 - a. Configure the parts but leave the antenna disconnected.
 - b. Set the RTLSDR Scanner software to scan across the frequency range you want to test. For example, to test 169.500 MHz, you would have it scan across the range 160 through 180.
 - c. Record the first scan with the antenna disconnected. Save the data off as a file for use later. Label the filename so you can find it. I used "scan 195.0-198.0MHz open.rfs".
 - d. Connect the antenna and record again and save it off with an appropriate filename "scan 195.0-198.0MHz antenna.rfs"
 - e. The two files can be compared using the compare option in the tools menu. Load the open file, then load the antenna file and the compare tools will graph and calculate the difference across the frequency range.

The following link gives you another description of the VSWR testing procedures.
<http://www.rtl-sdr.com/rtl-sdr-tutorial-measuring-filter-characteristics-and-antenna-vswr-with-an-rtl-sdr-and-noise-source/>

We test the open energy and then the antenna connected energy. Save off the data for both (File -> Save) with an appropriate filename. The difference between the two is “RL” the energy lost due to the antenna.

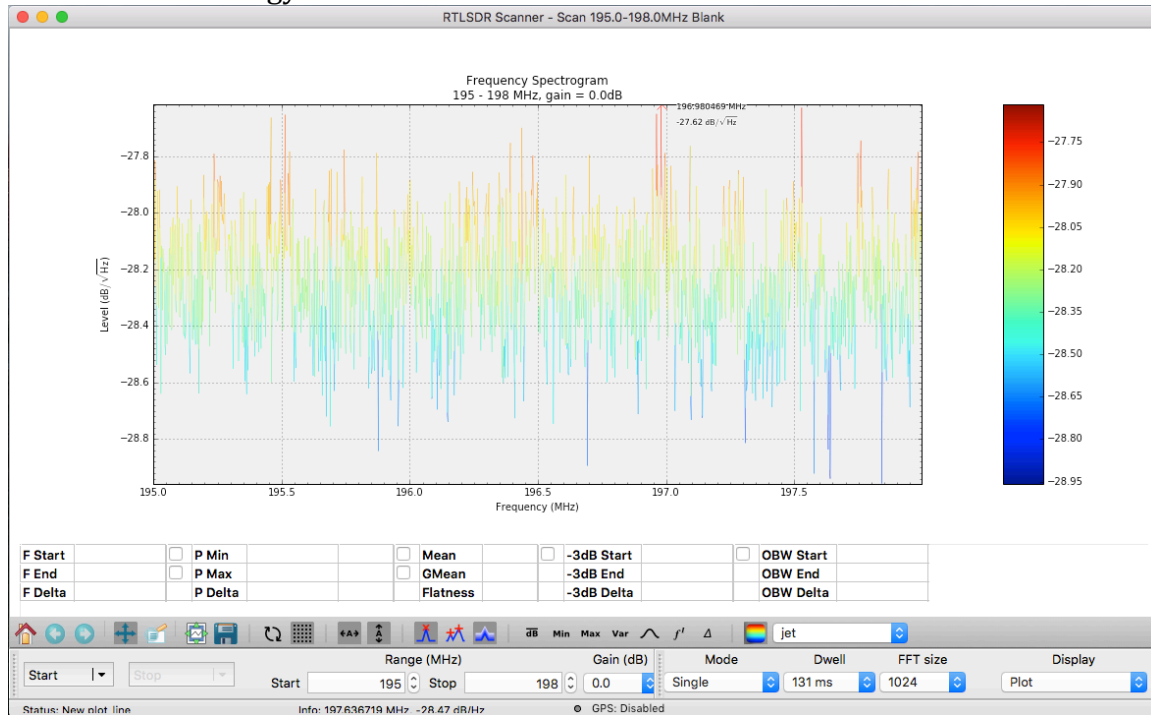


Figure 4 Spectrogram with no antenna connected

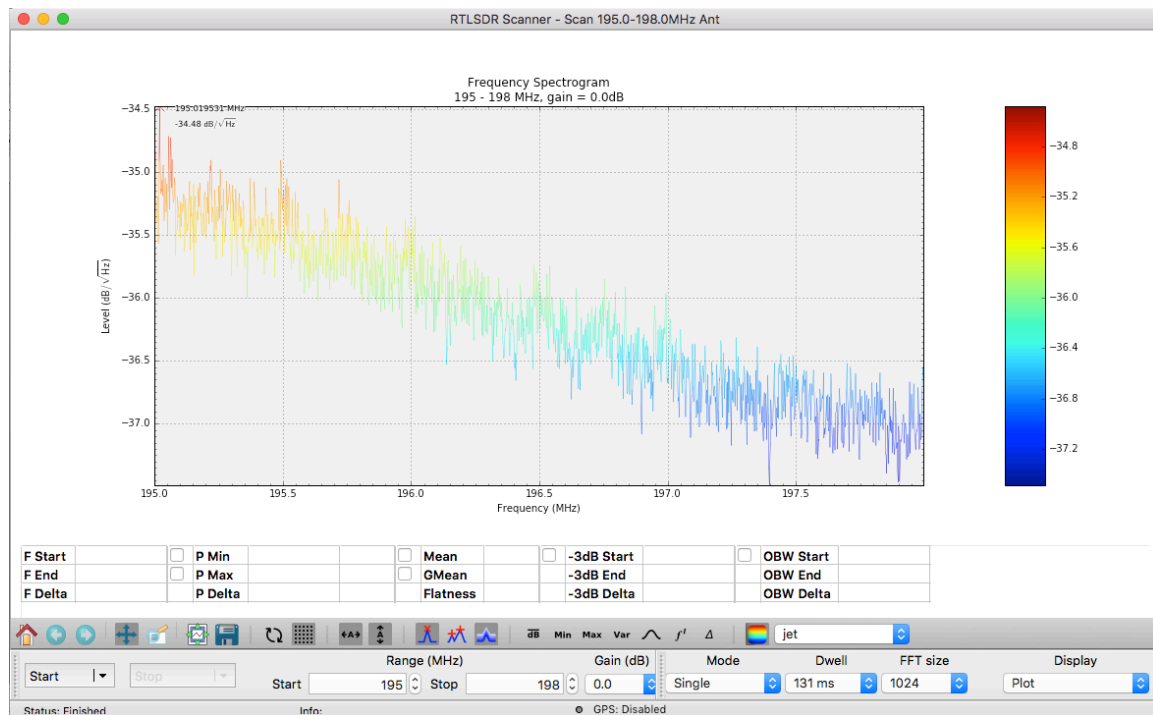


Figure 5 Spectrogram with Antenna Connected

Comparison of the open vs. antenna, which the difference is signal loss. The comparison option is in Tools on the application menu. Select the files for the two plots you want to compare and it will automatically create the difference plot.

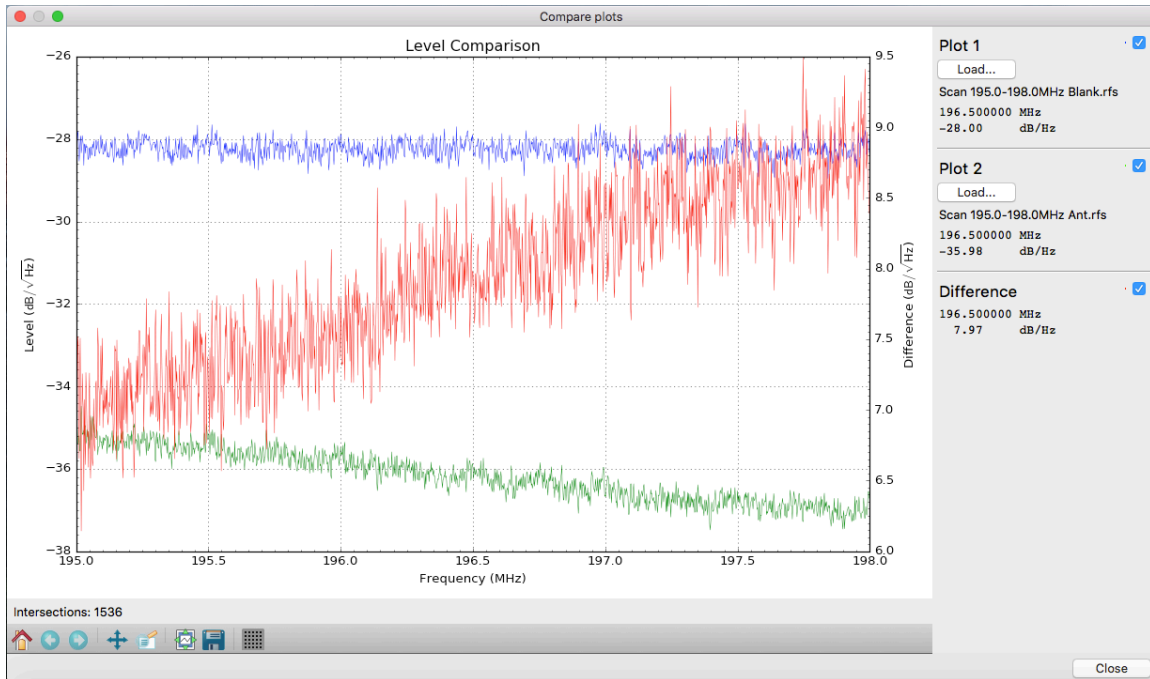


Figure 6 Comparison of Antenna vs Open

Looking at the signal at 169.5 MHz, the difference is 7.97, when put into the calculation:

$$VSWR = ((10 ^ {RL / 20}) + 1) / ((10 ^ {RL / 20}) - 1)$$

$$\text{For } RL = 7.97, \text{ the } VSWR = (2.503 + 1) / (2.503 - 1) = 1.08$$

Which is a very good. It means that this antenna, for 169.5 MHz should work pretty well for that frequency.