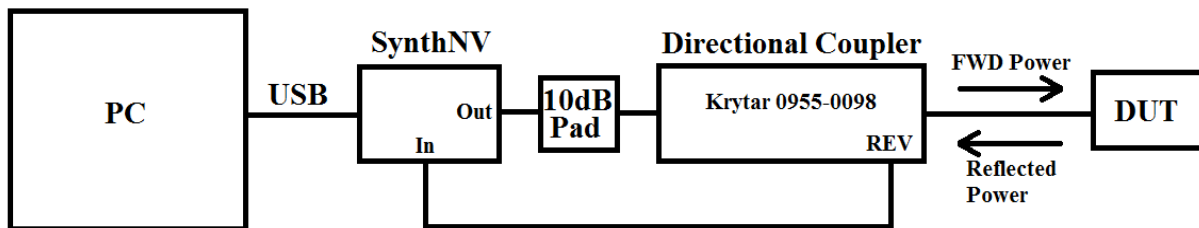


Measuring Return Loss with the Windfreak Technologies SynthNV RF Signal Generator / Detector (On a Budget)

The Windfreak Technologies SynthNV is a powerful RF signal generator that can also act as a basic Scalar Network Analyzer. The procedure to get throughput magnitude response of a device over frequency, such as a bandpass filter (DUT) is intuitive and straightforward. After a simple calibration procedure the DUT can be cabled between the input and output of the SynthNV and swept over frequency. This response is measured by the SynthNV and displayed on the computer screen as gain in dB vs frequency.

It would also be nice to measure the quality of the 50 ohm match of a DUT. This is done by measuring return loss. Return loss is a measure of the magnitude of reflected power as compared to the forward power. ie. If you are generating 0dBm of RF power from the SynthNV and your DUT has 10dB of return loss, then -10dBm of power is reflecting back towards the SynthNV and is lost. Ideally return loss would be > 20dB across the band of interest. There is a formula to convert between Voltage Standing Wave Ratio (VSWR) and return loss. They are different ways of expressing the same phenomenon.



Reflected Power Test Setup

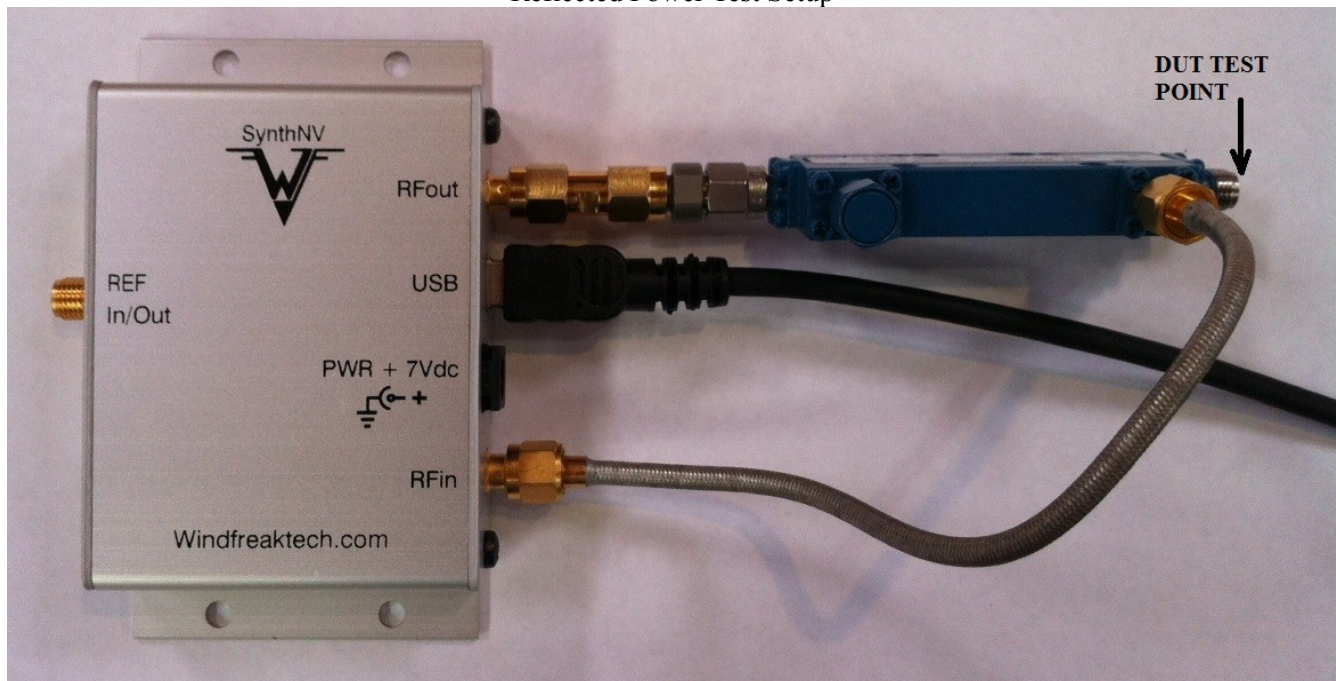


Figure 1

Bill of Materials:

- 1) Windfreak Technologies SynthNV (\$499US without case, \$574 as shown)
- 2) SMA male to male adapter
- 3) 10 dB SMA attenuator (pad)
- 4) Krytar 0955-0098 (HP) directional coupler
- 5) 50 ohm SMA attenuators for verification (3dB, 6dB, 10dB, 30dB) optional

The Krytar coupler is rated for 2GHz to 8GHz, 16dB of coupling and 20dB of directivity. There are some that are better but cost more. This one I bought used for \$75US on ebay. I found that it can be used reasonably down to 1GHz, but best performance of the setup is 1.5GHz to 3.5GHz. The attenuators and adapters shown above are generic ones that I had laying around the lab. The final goal here will be testing a 2.4GHz whip antenna purchased from Sparkfun (WRL-00558 for \$10US).

The only notable item about the design of the setup is the 10dB pad located between the SynthNV output and the coupler. The output of the SynthNV is driven by an amplifier that has a pullup inductor to Vcc and a dc decoupling series capacitor. This is designed to be 50 ohms across the band, but is still not as good as a connectorized pad. The 10dB pad is there to make the SynthNV have a “lab quality” 50 ohm output. Plus there is plenty of power since the SynthNV can put out +17dBm and the detector on the SynthNV input will saturate at anything above 0dBm. The noise floor of the detector is down at -70dBm.

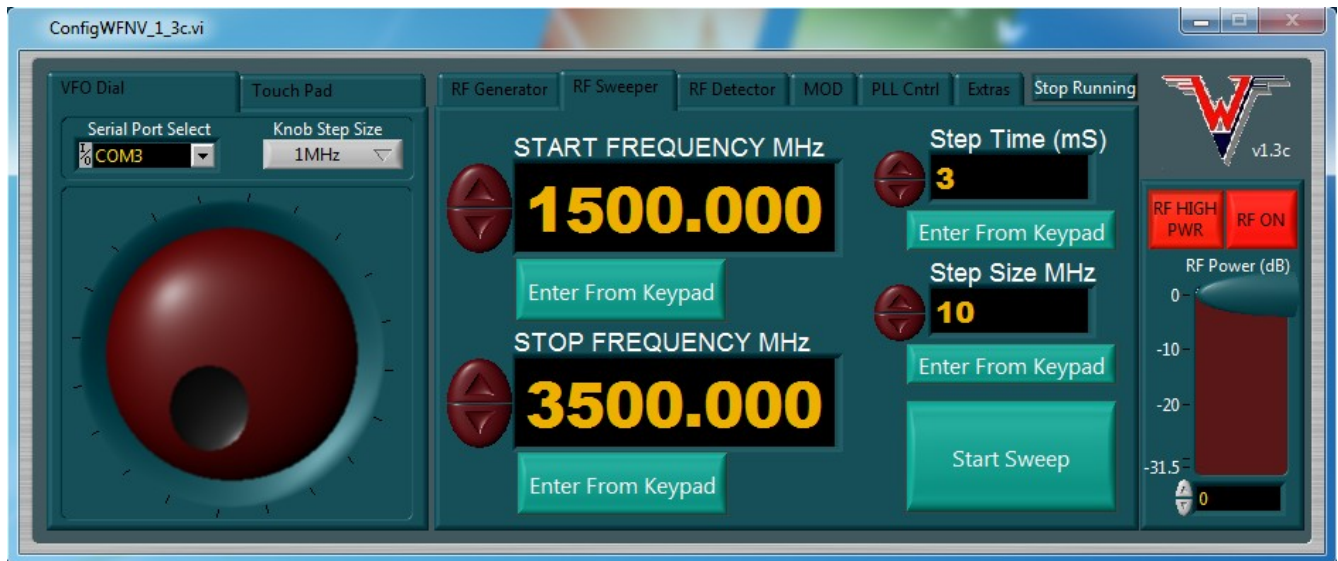


Figure 2 Setup

Start the ConfigWFNV software, go to the “RF Sweeper” tab, and set up the sweep as shown in Figure 2. Adjust the “RF Power” to maximum. Then click “Start Sweep” to bring up the Sweeper program. Note: You can ignore the Frequency and the RF Detector Pwr dBm displays at the top of the Sweeper program.

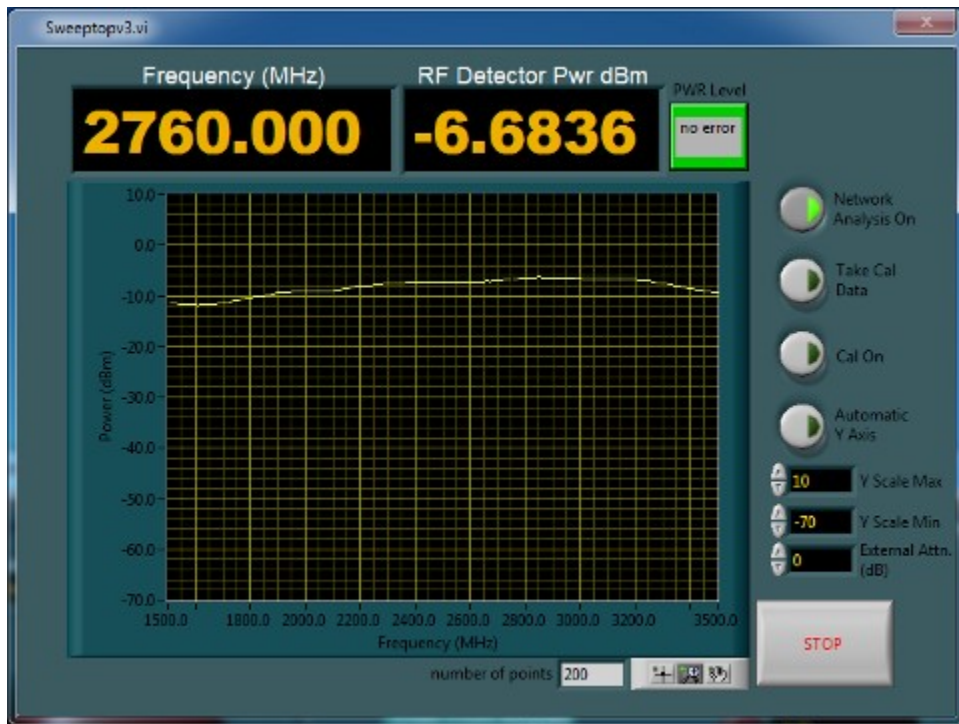


Figure 3

When the sweeper program starts the signal generator side of the SynthNV is sweeping the RF signal as dictated by Figure 2. In order to measure RF power via the detector at every point you will need to click the “Network Analysis On” button.

Leave the output of the Krytar directional coupler open. This sets up a 100% RF reflection at the coupler's output which is 0dB of return loss. In Figure 3 the trace is showing all the reflected power coming out of the reflected side of the coupler.

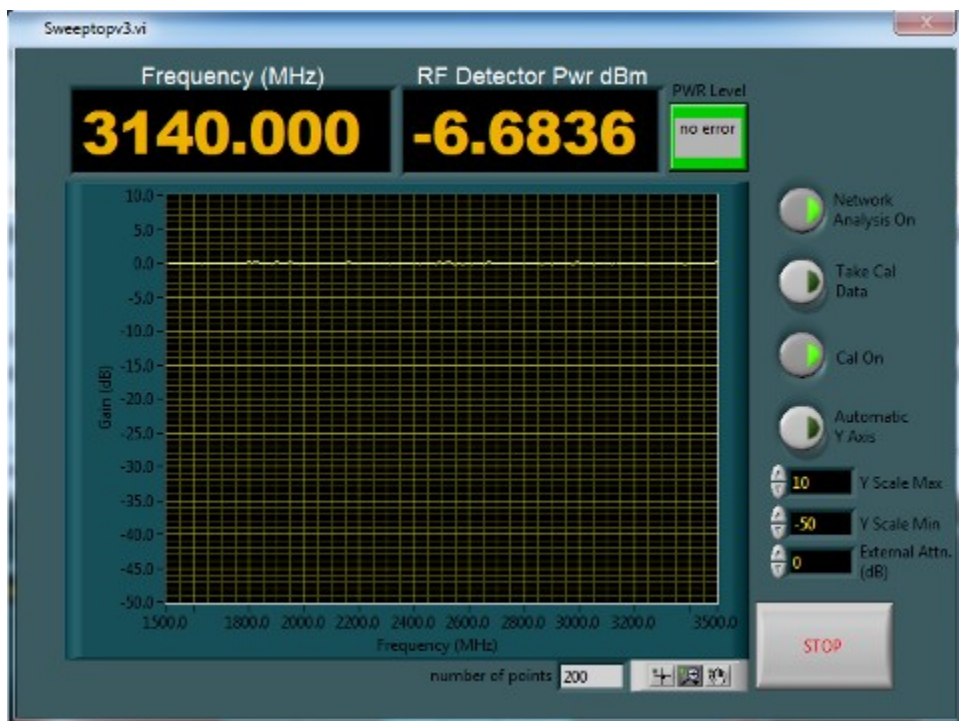


Figure 4

By clicking the “Take Cal Data” button, then clicking “Cal On” you can see in Figure 4 that the trace is calibrated to 0dB of return loss across the band. This is correct. Since the coupler is not loaded with 50 ohms, it should show 0dB of return loss since 100% of the power is reflected.

We will use the attenuators to test and see how accurately we can measure return loss. Lets start with the 3dB pad. Screw it on the output of the coupler. Do not terminate its output. It is our DUT for now.

A 3dB pad will always show at least 6dB of return loss. Think of the propagation of the RF wave along the path; As RF comes out of the coupler it passes into and through the 3dB pad. It loses 3dB of power in this process. As it hits the unterminated SMA connector it reflects back in the opposite direction. Now it travels back through the pad and loses another 3dB of power. The final total loss is 6dB.

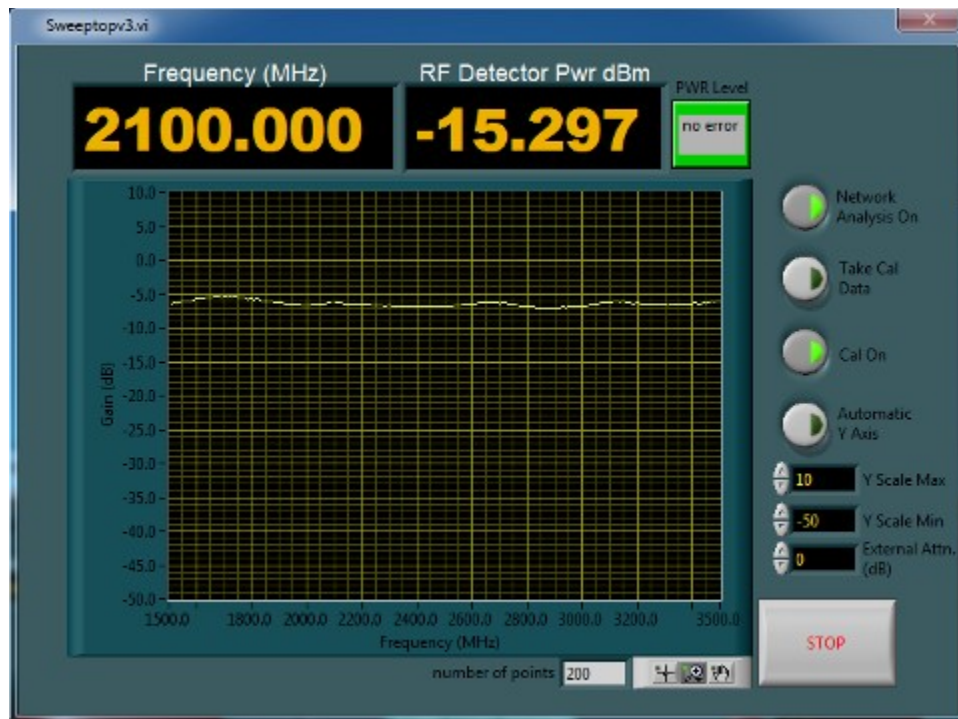


Figure 5

As shown in Figure 5 the unterminated 3dB pad shows 6dB of return loss +/-1dB.

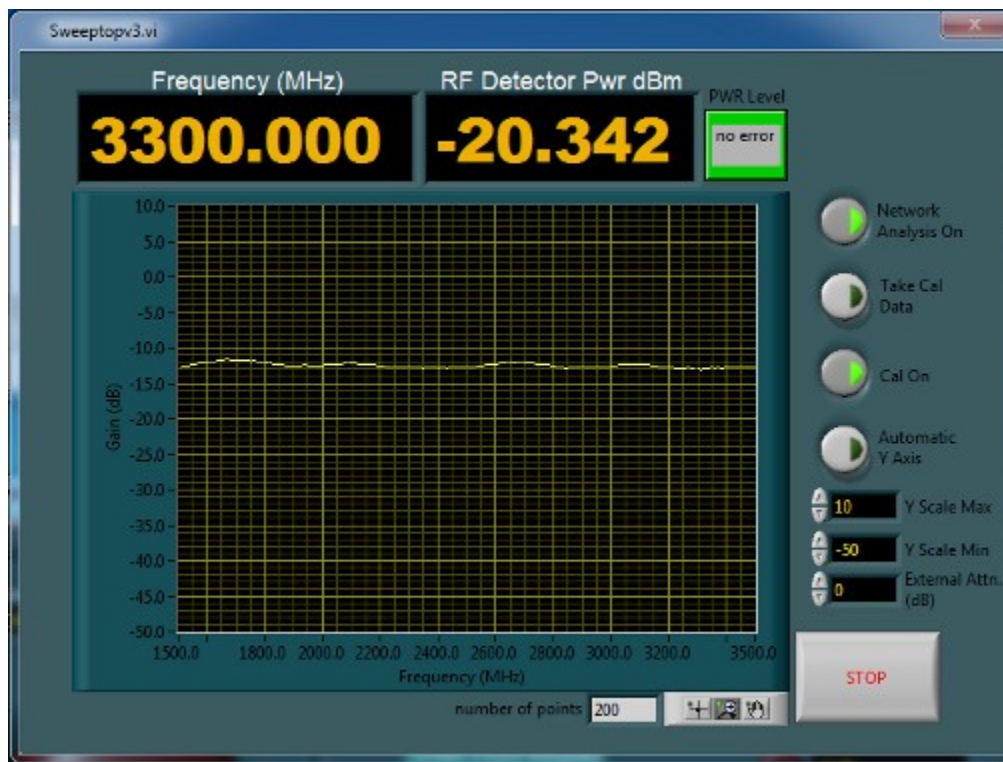


Figure 6

As shown in Figure 6, there is 12 dB of return loss given by an unterminated 6dB pad.

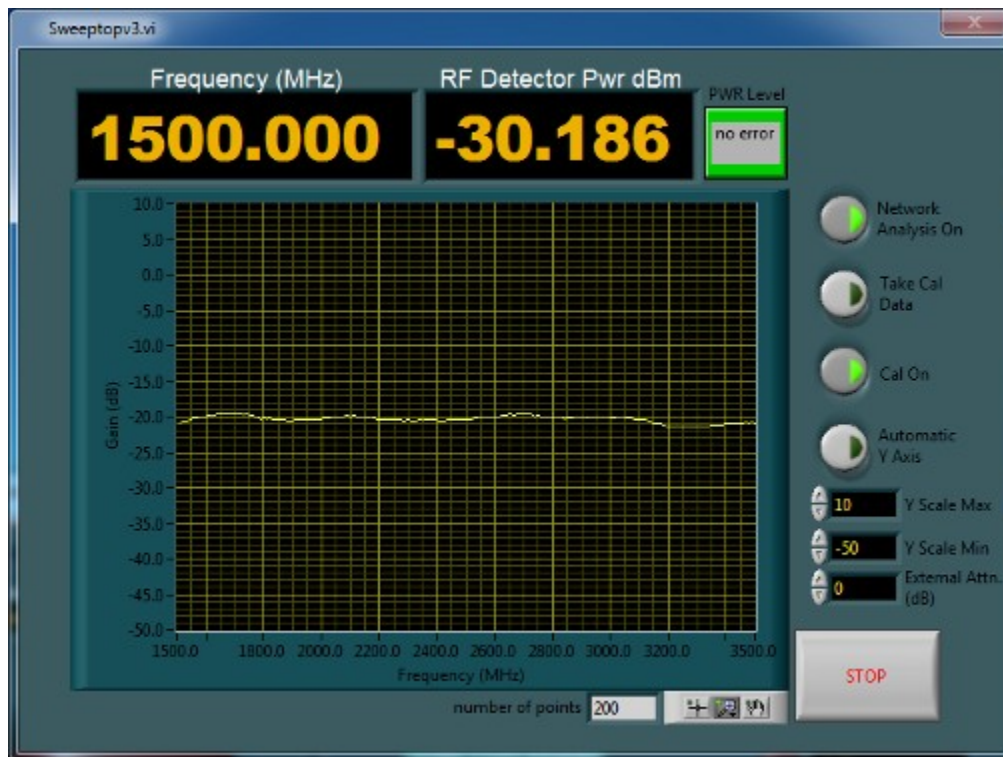


Figure 7

As shown in figure 7, there is 20 dB of return loss given by an unterminated 10dB pad.

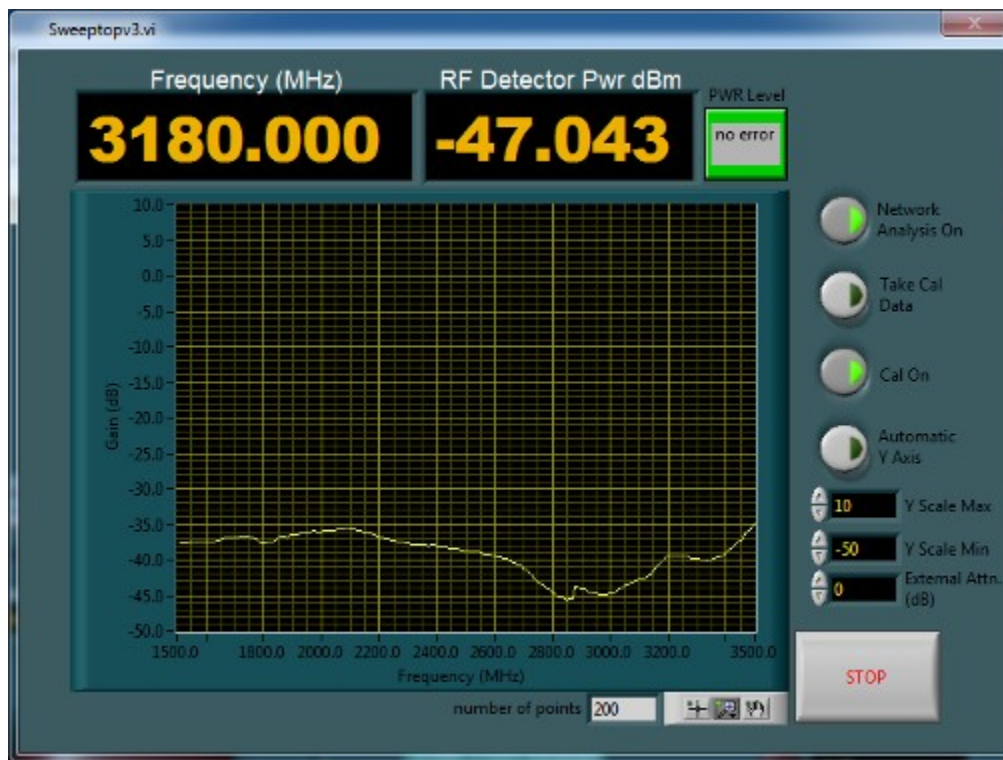


Figure 8

Figure 8 is the maximum return loss I could get with the terminators and pads I keep around the lab. Im not sure if the limitation is the test setup or if that is the best the pads can do. But better than 35dB is a fantastic result and very usable for your next RF circuit matching or antenna design project!

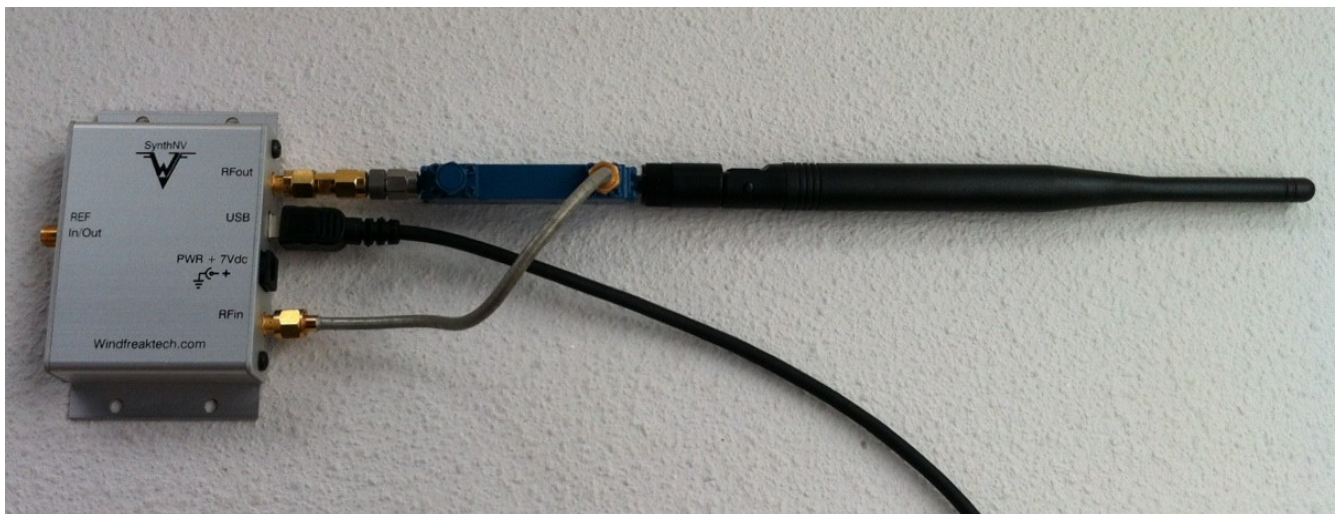


Figure 9

Figure 9 shows the Sparkfun antenna hooked up as the DUT.

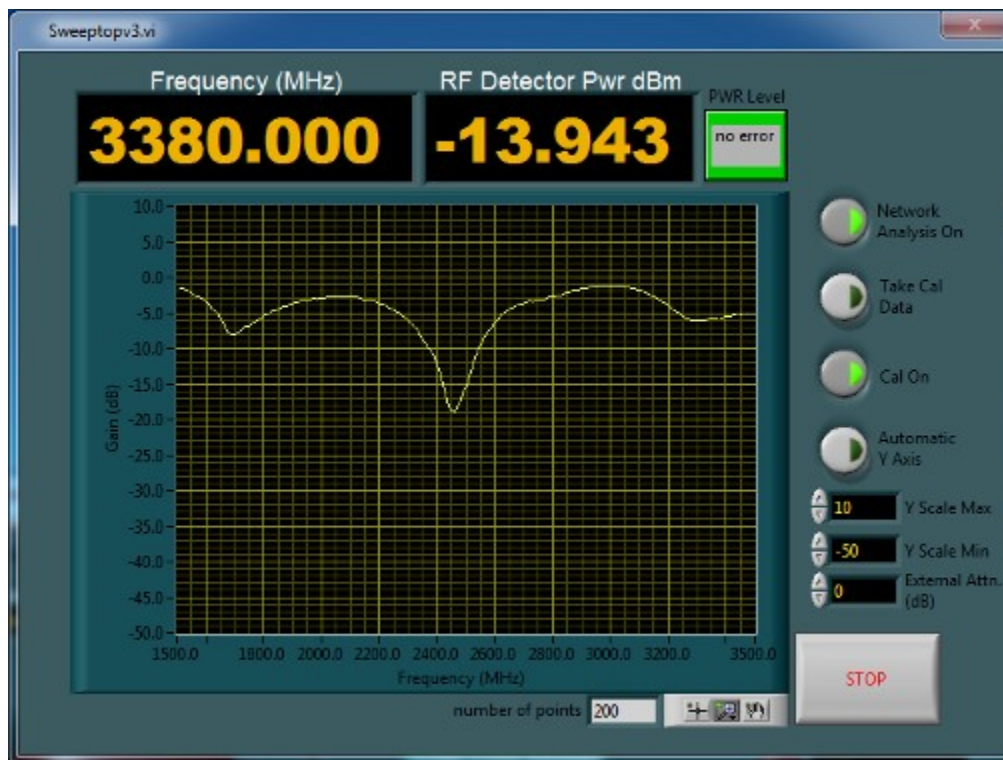


Figure 10

Figure 10 shows the results from sweeping the Sparkun 2.45GHz antenna. This antenna has a good match showing better than 10dB of return loss from 2.4 – 2.55 GHz.

So as you can see, this setup can give surprisingly accurate single port return loss measurements for a fraction of the cost of a lab quality Network Analyzer. This test setup is also extremely portable and can be taken into the field and run completely off of your laptop's USB power to test antennas in real world conditions.

With Kind Regards,
David Goins
CTO

dgoins@windfreaktech.com

Windfreak Technologies, LLC.
<http://www.windfreaktech.com/>