Measuring Received Signal Power

EE361 Lab 4

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Abstract

This document outlines a procedure to qualitatively measure radio frequency (RF) signals in the real world, and to increase intuition when working with antennas and radio receivers. In these experiments, we use an affordable software defined radio (SDR) to tune in to public radio stations as far away as Vancouver, BC, as well as pick up public service bands used by emergency workers. Finally, we used the receiver to locate a hidden transmitter on campus.

1 Equipment and Parts

- RTL-SDR USB Receiver
- Whip Antenna
- SDR Sharp Software
- Map

2 Introduction

3 Experimental Design

3.1 Tuning In To FM Radio

First, we used our SDR receiver to tune in to an FM radio station. We adjusted the RF gain of the device to 19.7dB, and set the sample rate to 2.4 megasamples per second. We selected the "WFM" option to enable wideband FM, then listened in at 88.1MHz. Terry O'Reilly, of CBC/2's Under the Influence joined us for the duration of our measurements.

3.2 Antenna Placement and Orientation

Next, we developed a strategy for measuring received power. We noticed that the relative power shown in the spectrum viewer varied widely over time, so we turned the decay of the spectrum up to about 50%. With a higher decay, we saw a more consistently shaped spectrum over a window of time.

We saw two main shapes: a rounded triangular shape, and a rectangular shape. In the case of the rectangular shape, we measure both the width and height, and compute the area to measure received power. In the case of the rounded triangular shape, we reflected that a triangular shape in logarithmic scale is very close to an impulse in linear scale. So, we recorded the peak value, which was at the center frequency for each transmitter.

We also recorded estimates of the signal-to-noise ratio, and noticed that antenna orientation had a large effect on the relative received power of the signal.

3.3 Effect of RF Gain

Again, we tuned to 88.1MHz CBC/2 (Under the Influence, with Terry O'Reilly), and measured the following as we adjusted the RF gain of the SDR:

- Noise Floor
- SNR
- Relative Received Power

3.4 Received Power Measurements of FM Radio Stations

3.5 Received Power Measurements of Digital FM Radio Stations

3.6 Public Service Frequencies

3.7 Foxhunting and Path-Loss Modeling

4 Results

4.1 FM Radio

After adjusting our SDR as specified in Section 3.1, we picked up a station at 150.7MHz (Table 1). Then, we tuned in to Western Washington University KUGS, as shown in Figure 1.

Table 1: Tuning In To an FM Radio Station

Property	Value
Band (MHz)	150.7
Gain (dB)	19.7
Sample Rate (Msps)	2.4
Tuner AGC	OFF

After a few songs, we measured the noise floor (Table 1).

Table 2: Tuning in to KUGS

Property	Value
Noise Floor (dB)	-57

4.2 Antenna Placement and Orientation

Next, we observed the effect of antenna orientation on the relative received power and the noise floor (Figures 2, 3, 4). As a part of these measurements,

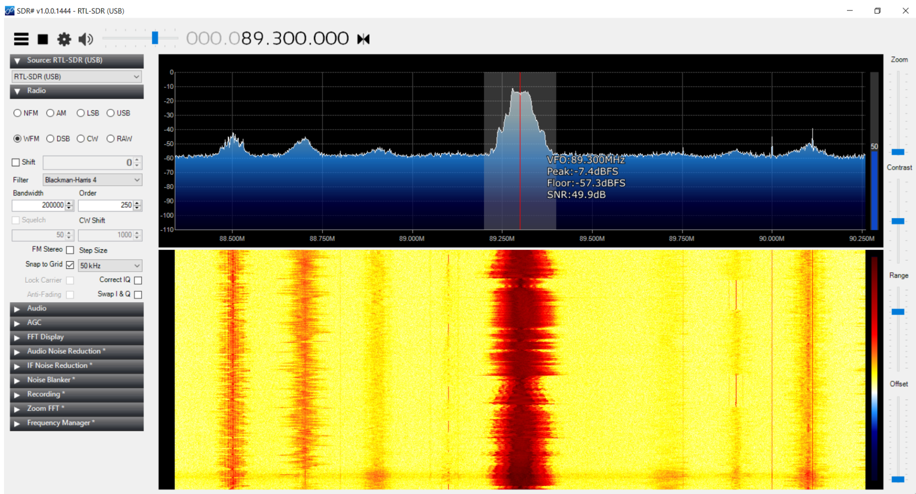

Figure 1: KUGS Radio Station

we noticed several sources of noise. There were several bands containing sharp spikes of interference. One of these spikes can be seen clearly in Figure 2. The noise floor was dependent on our location and direction as well. By moving the antenna, we were able to increase our SNR drastically, or even decrease it to almost zero (Figure 4).

4.3 Effect of RF Gain

Still tuned in to KUGS, we adjusted the RF gain and measured the corresponding noise floor and peak relative received power. Using this data, we could calculate the SNR (Equation (1)). The most useable range of SNR without clipping was around 20dB to 30dB (Table 3).

(1)

$$SNR_dB = Peak_dB - NoiseFloor_dB$$

Table 3: Effect of RF Gain, Measured at 88.1MHz

Gain (dB)	Noise Floor (dB)	Peak (dB)	SNR (dB)
19.7	-56	-25	31
0	-56	-42	14
49.6	-35	5 (clipping)	40
29.7	-50	-12	38

4.4 Received Power Measurements of FM Radio Stations

Testing some stuff

Table 4: Relative Received Power of Three Analog FM Radio Stations

Frequency (MHz)	Call Sign	Strength	Distance (mi)	Measured Relative Received Power (dB)	Effective Radiated Power

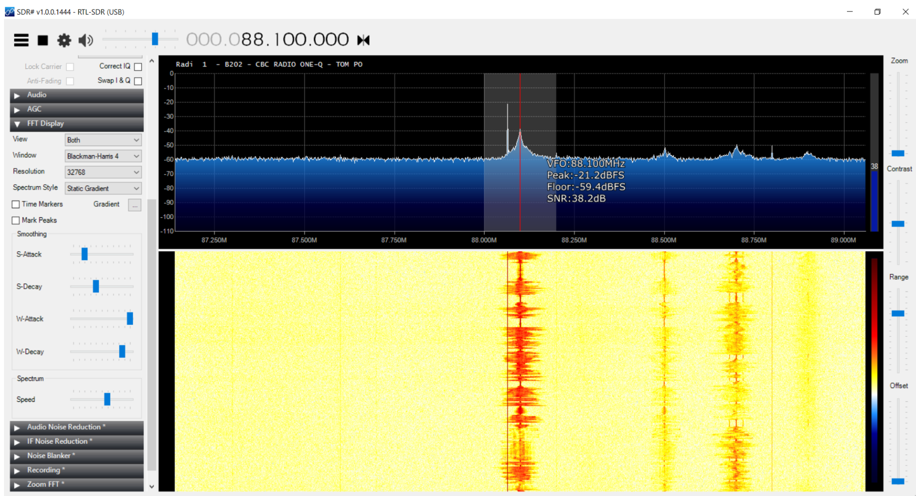

Figure 2: Antenna Angle 1

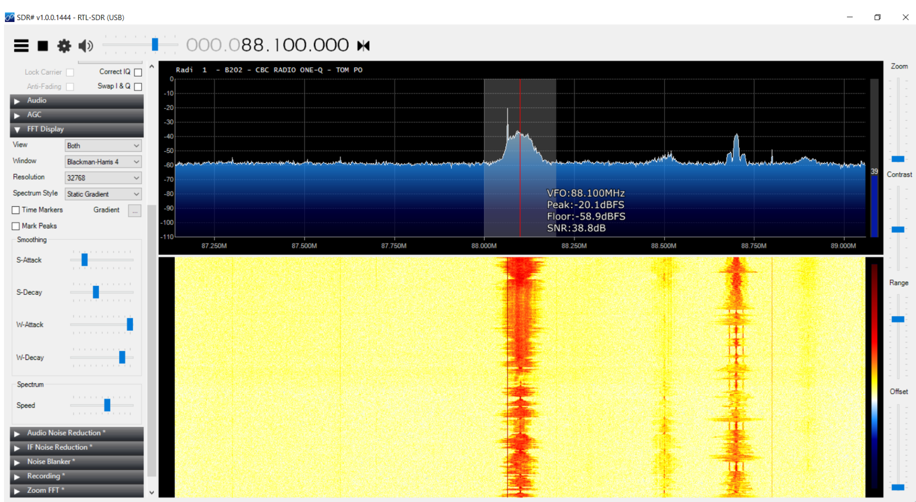

Figure 3: Antenna Angle 2

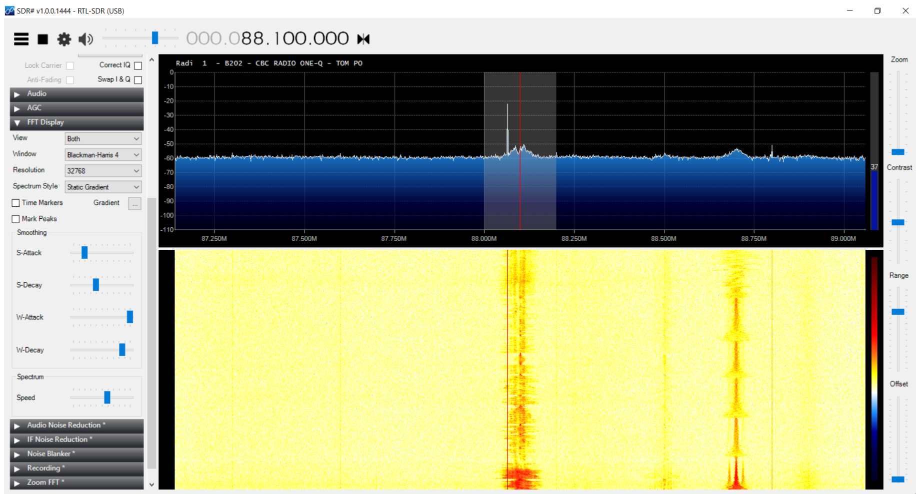

Figure 4: Antenna Angle 3

Table 5: Relative Received Power of Three Digital FM Radio Stations

Frequency (MHz)	Call Sign	Distance (mi)	Height x Width (dB x MHz)	Measured Relative Received Power (dB)	Effective Radiated Power
92.9	KISM	16.7	-35 x 0.075		
103.5	CHQM	46.9	-38.5 x 0.125		
104.1	KAFE	16.7	-54 x 0.070		

4.6 Public Service Frequencies

Table 6: Public Service Frequencies

Frequency (MHz)	Public Service	Relative Received Power (dB)	RF Gain (dB)
453.225	Police	-5	12.7
453.55	Unknown	Not Recorded	12.5

4.7 Foxhunting and Path-Loss Modeling

5 Discussion

6 Conclusion

7 References

Appendices