A Survey of RFI below 270 MHz

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1 Summary

This document reports on a survey of radio frequency interference (RFI) below 270 MHz. The survey was conducted during business hours from the roof of the Ohio State University ElectroScience Laboratory (ESL) using a commercially available wideband discone antenna. The resolution of the survey is 30 kHz. Because the RFI at the observing site in this band is very strong, the sensitivity of this survey was sacrificed to ensure that the measurements were reasonably linear and free of self-generated harmonics intermodulation products. Thus, this survey is useful only for identifying strong RFI.

2 Instrumentation

The instrumentation consisted of a discone antenna, a long cable from the antenna to a room within ESL, a spectrum analyzer, and a PC for experiment control and data collection. These components are explained in more detail below.

The discone antenna used for this study was an AOR Model DA3000, which is intended for use primarily as a scanner radio antenna, and claimed by the manufacturer to be useable from 25 MHz to 2000 MHz. The discone has a pattern which is uniform in azimuth, with maximum gain slightly below the horizon and nulls toward the zenith and nadir. The discone was mounted on a temporary mast about 2.5 m

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above the main roof of ESL such that the antenna was about 12 m above the ground. A utility structure exists on the roof to the north of the antenna, which may have attenuated signals arriving from that direction.

The output of the antenna was connected via a long cable to a spectrum analyzer. The length of the cable was not measured but was on the order of 30 m. The spectrum analyzer was an Agilent Model E4407B. The spectrum analyzer was interfaced to a PC via RS-232 at 115.2 kb/s. A C-language program controls the spectrum analyzer and collects data using the techniques described in [1]. For this work, the following spectrum analyzer settings are held constant throughout the experiment: Input attenuation: 30 dB; Internal preamp: ON; Resolution bandwidth (RBW): 30 kHz; Detection method: SAMPLE (as opposed to PEAK (the default for this spectrum analyzer)). The PC directs the spectrum analyzer to take measurements in the following sequence:

1. *Max Hold.* 100 sweeps from 0-90 MHz are taken. Each sweep samples the spectrum at 3001 points (that is, every 30 kHz). The output is a "max hold" over the 100 sweeps; that is, the result is a power spectrum where each bin indicates the maximum value observed in that bin. This requires about 25 s.

2. *Power Average.* Same as max hold, except the 100 sweeps are linearly averaged. This requires about 25 s.

3. Steps 1 and 2 are repeated for 90-180 MHz.

4. Steps 1 and 2 are repeated for 180-270 MHz.

5. Go to Step 1.

The max hold and power average measurements are different, but complementary measurements. Power averaging is most effective for characterizing weak, stationary signals. Max hold, on the other hand, is essential for detecting low-duty cycle signals, such as radar pulses or irregularly-timed (possibly one-time) bursts.

As a separate measurement, the antenna was replaced by an ambient temperature matched load, and the experiment was repeated. This facilitates a rudimentary temperature calibration and also serves as a useful diagnostic.

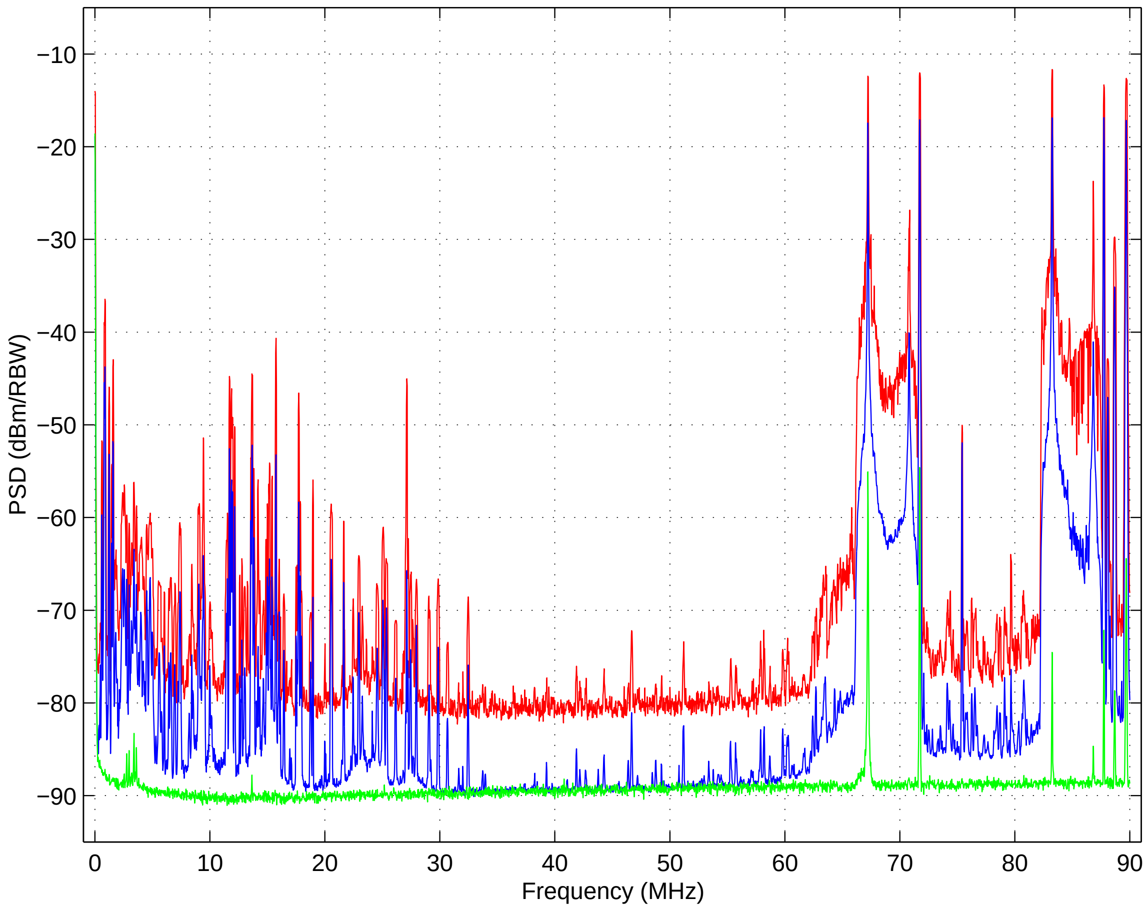
Using this procedure, data were collected for about 5 min during the afternoon hours of Oct 17, 2002. In each band and for each mode, a total of about 200 sweeps were performed. All data presented in the following section were calibrated to remove the seperately-measured transfer function of the long cable connecting the antenna to the spectrum analyzer. Thus, the indicated power spectral density (PSD) is that measured at the terminals of the antenna.

3 Results

Figure 1 shows the results for the 0-90 MHz band. This figure shows the max hold and power average results computed for the entire observation time. In other words, the max hold result is the max hold over all ∼200 sweeps; similarly the power average result is the average over all sweeps. A summary of known RFI is also given in Figure 1.

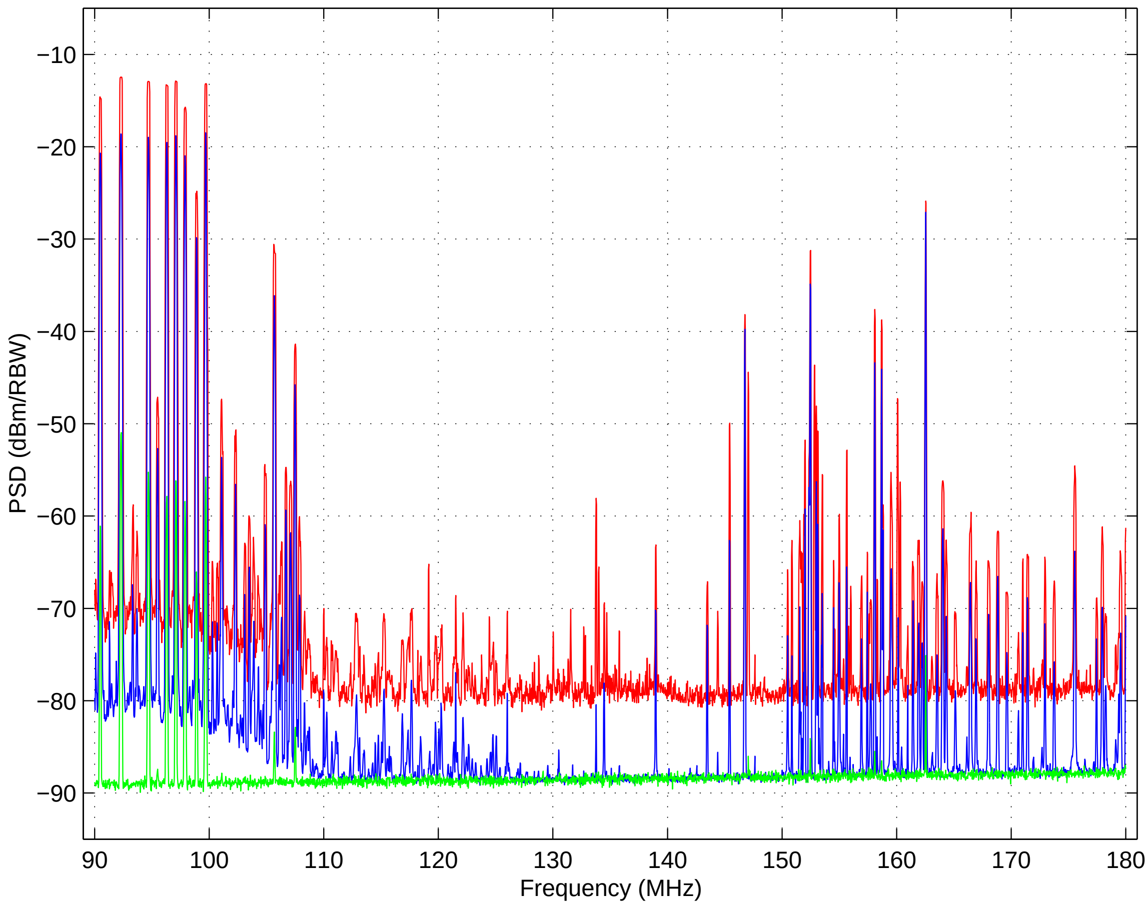
The ambient temperature matched load was measured at about -90 dBm/(30 kHz). This infers a receiver temperature $T_R \sim 2.4 \times 10^6$ °K, equivalent to a noise figure of about 39 dB. A more reasonable noise figure could be obtained by using a low-noise amplifier at the antenna; however, such an amplifier would have to have an extraordinarily high compression point in order to remain linear in the presence of the strong signals observed in Figure 1. For example, an amplifier with an input third-order intercept point (IIP3) of +20 dBm (very high for an LNA!) would generate third-order intermodulation products on the order of -70 dBm/(30 kHz) – well above the present noise floor – in response to the TV signals shown in Figure 1. Thus, the introduction of an LNA would almost certainly result in the introduction of spurious signals, or worse.

Another "interesting" observation to be made from Figure 1 is how much of much of the RFI couples directly onto the cable, as noted in the matched load measurement.



- 67.25 MHz (Video)/70.83 MHz (Color)/71.75 MHz (Audio): TV Channel 4
- 83.25 MHz (Video)/86.83 MHz (Color)/87.75 MHz (Audio): TV Channel 6
- 88-108 MHz: Broadcast FM stations

Figure 1: 0-90 MHz, 30 kHz resolution. *Top/Red:* Antenna/Max hold, *Middle/Blue:* Antenna/Average, *Bottom/Green:* Terminator/Average.



- 88-108 MHz: Broadcast FM stations

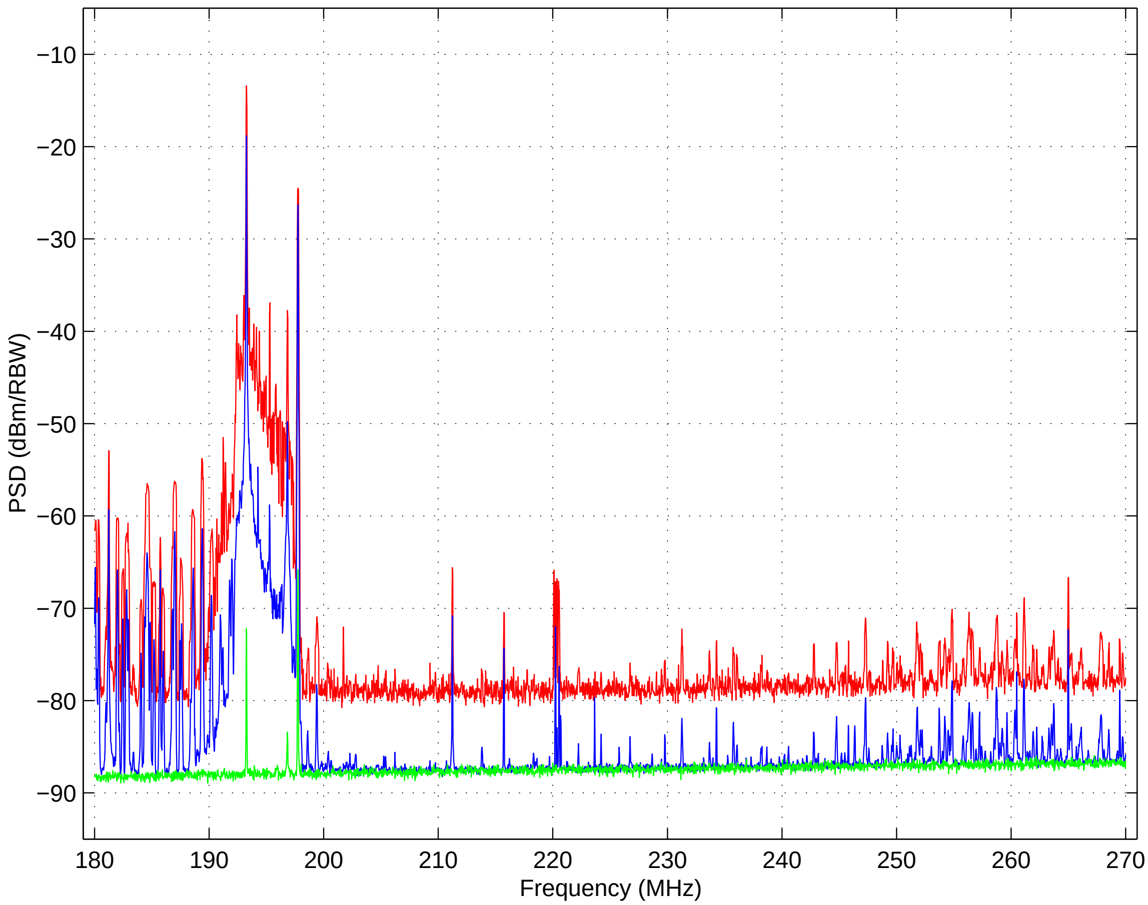
Figure 2: 90-180 MHz, 30 kHz resolution. See Figure 1 for key.

Figure 2 shows the results for the 90-180 MHz band, and Figure 3 shows the results for the 180-270 MHz band. Figures 4 through 7 show details of various segments of these spectra for closer examination.

References

[1] S.W. Ellingson, "Agilent Spectrum Analyzer Computer Control Demo", IIP Memo 20, June 6, 2002. (see [2])

[2] ESL's NASA IIP Project Document Server, http://esl.eng.ohio-state.edu/∼swe/iip/docserv.html.



- 193.25 MHz (Video)/196.83 MHz (Color)/197.75 MHz (Audio): TV Channel 10

Figure 3: 180-270 MHz, 30 kHz resolution. See Figure 1 for key.

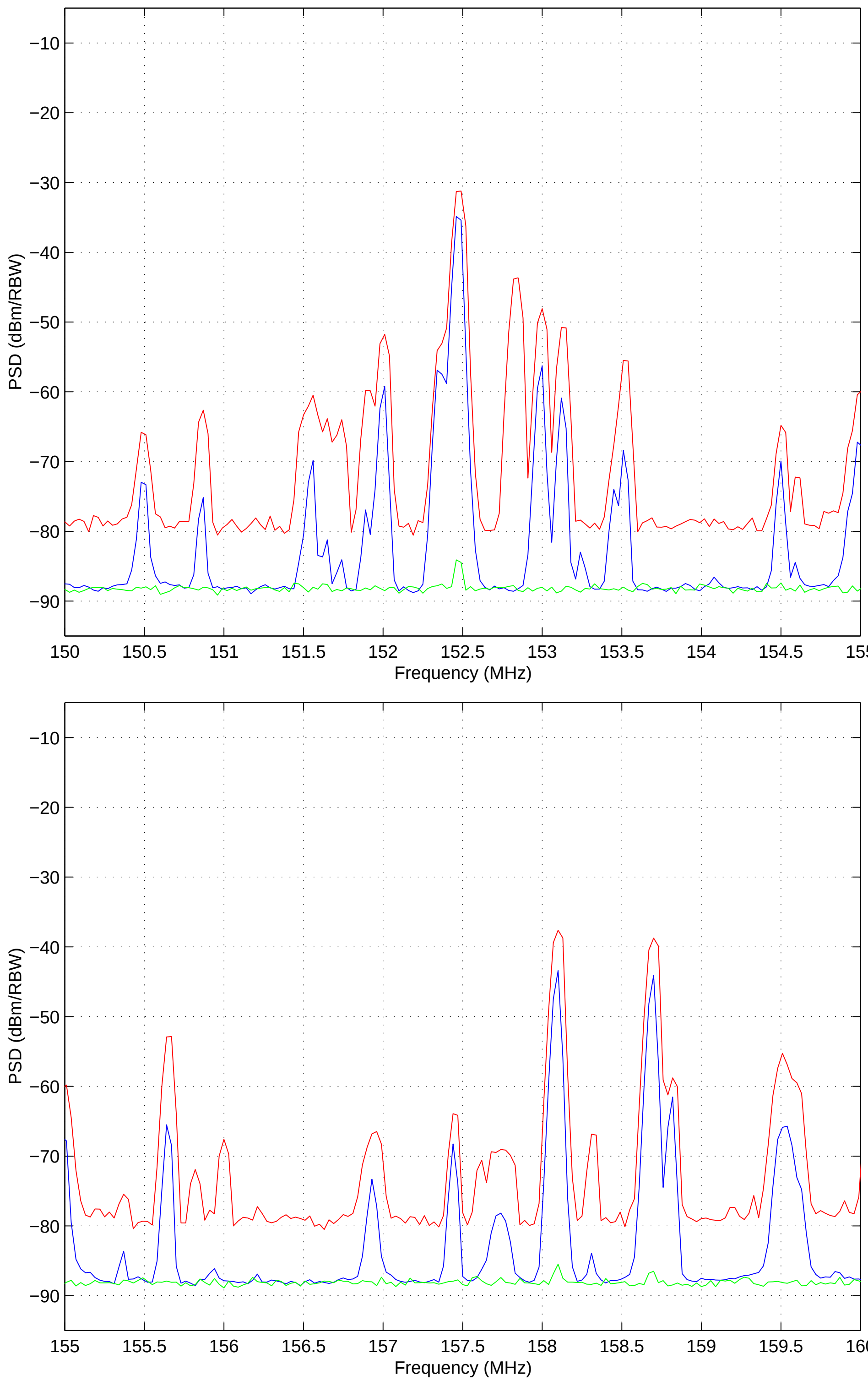


Figure 4: Detail of 150-160 MHz, 30 kHz resolution. See Figure 1 for key.

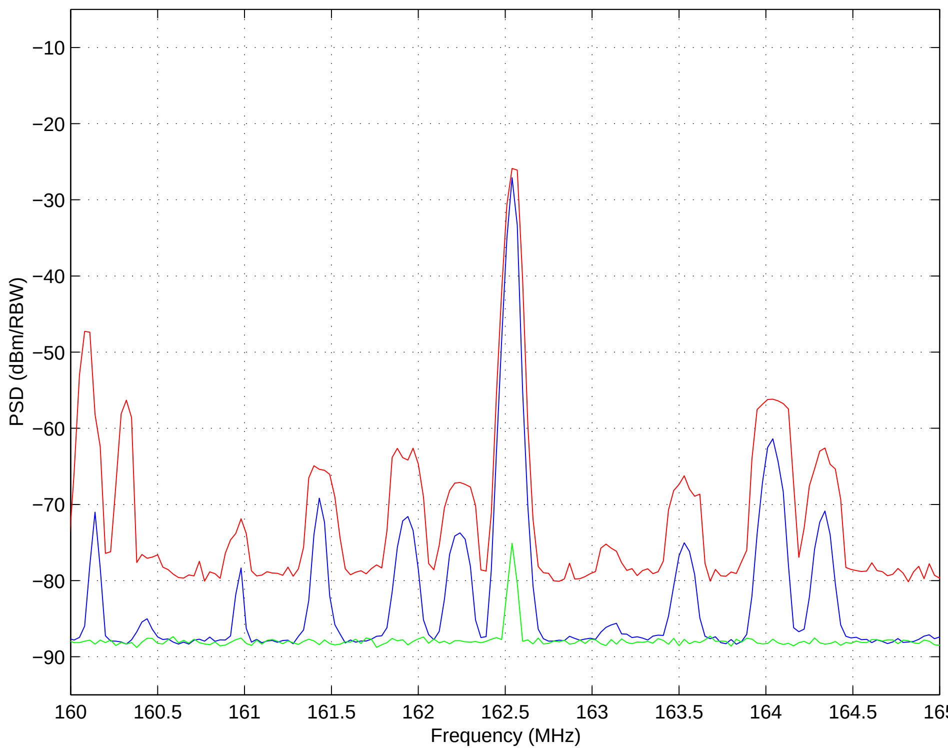
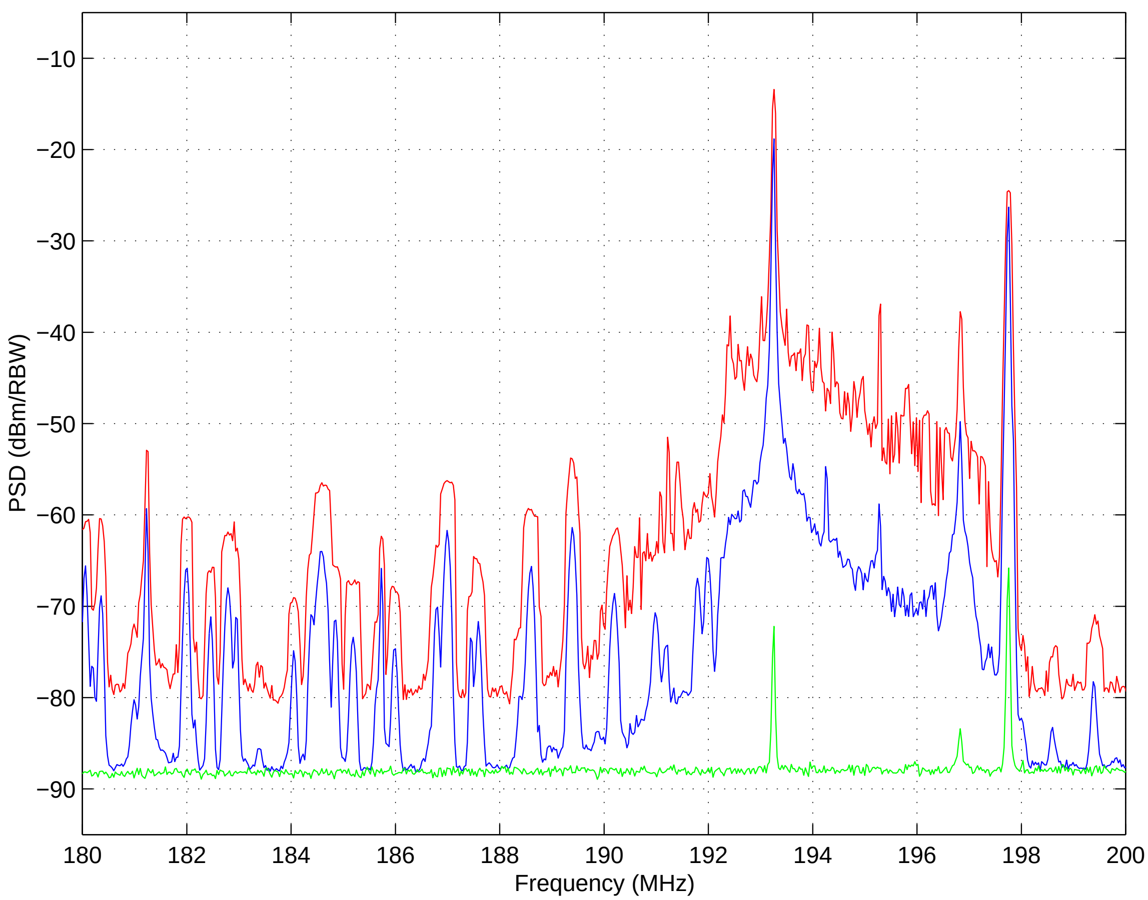


Figure 5: Detail of 160-165 MHz, 30 kHz resolution. See Figure 1 for key.



- 193.25 MHz (Video)/196.83 MHz (Color)/197.75 MHz (Audio): TV Channel 10

Figure 6: Detail of 180-200 MHz, 30 kHz resolution. See Figure 1 for key.

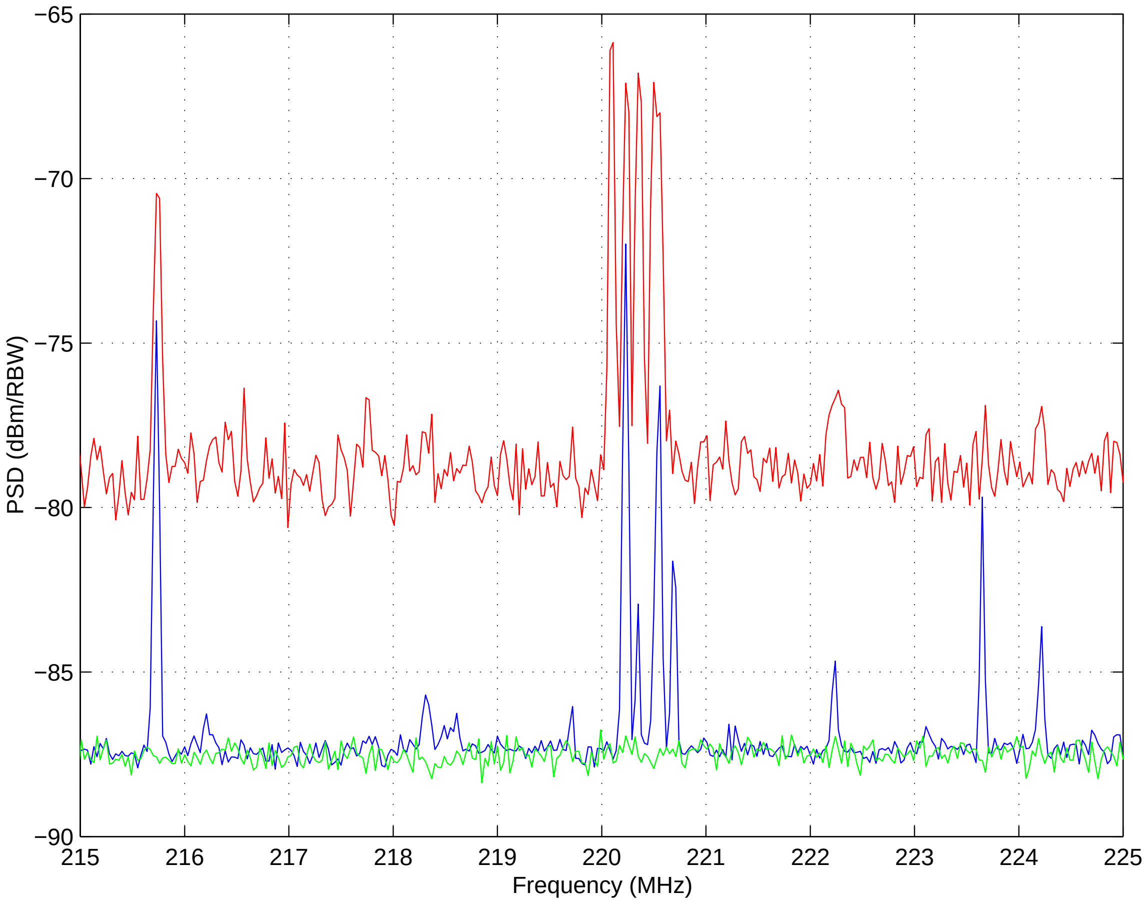


Figure 7: Detail of 215-225 MHz, 30 kHz resolution. See Figure 1 for key