Initial LISA Measurements from the ESL Roof

S.W. Ellingson*

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1 Introduction

This report documents some initial observations made with the Ohio State University (OSU) ElectroScience Laboratory's (ESL) recently-completed L-band Interference Surveyor/Analyzer (LISA) instrument from the roof of ESL on August 29, 2002.

In these observations, the antenna/front end unit (AFEU) was placed on a large ground plane, facing the zenith, as shown in Figure 1. Three foot sections of RG-58 were used at both the AFEU and equipment rack ends to connect to 100-ft. sections of Belden 9913 cable, resulting in an overall length of 106-ft. of cable for each of the three connections between the AFEU and the equipment rack.

The measurements were made in the late evening, long after sunset. The ambient temperature was about 68° F under clear skies.

2 1200–1800 MHz Observations

In this section, we describe scans of the 1200–1800 MHz region using LISA's spectrum analyzer. The procedure was as follows: First, we performed a max-hold measurement over 100 sweeps. "Max hold" means that the result shows the maximum value obtained in any given frequency bin over all sweeps performed, as opposed to (for example) the average. Max holding is very useful for detecting strong but short-lived signals, such as radar pulses, that are often hard to see in averaged spectra. Second,

*ElectroScience Laboratory, The Ohio State University, 1320 Kinnear Rd., Columbus, OH 43212; ellingson.1@osu.edu.

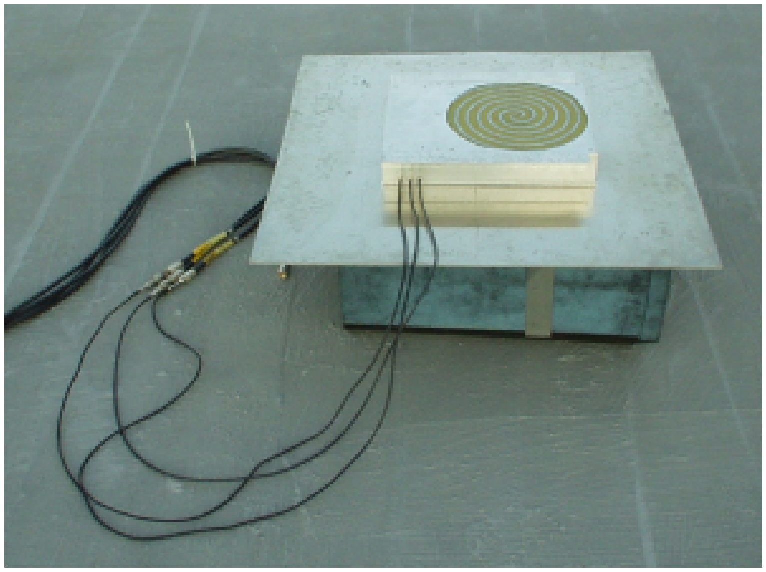

Figure 1: AFEU on roof.

we performed 100 more sweeps, this time computing the linear average as opposed to max-holding. Third, we repeated the 100-sweep average looking at the AFEU's reference load in lieu of the antenna. The reference load is an ambient-temperature matched terminator with a 6-dB pad, resulting in an estimated noise temperature of about 513° K. These three measurements were repeated 17 times.

The data were calibrated as follows: The system frequency response from the AFEU input of the equipment rack to the spectrum analyzer was known from a previous laboratory measurement. However, since the AFEU was connected to the rack by a new, long cable, the absolute value of the receiver gain was unknown. This value was determined by requiring that the noise power density in an RF-quiet portion of the spectrum (1420 MHz, in this case) agree with the temperature of the reference load, estimated to be 513° K (approximately −112 dBm/MHz) above. Note that this method requires that the receiver temperature be small compared to reference load temperature, which is believed to be true given that the AFEU noise figure is estimated to be less than 1.5 dB. This correction was used to scale the frequency response measurement obtained in the laboratory, which was then applied to the data from this measurement.

Figure 2 summarizes the results. Looking first at the measurement of the reference

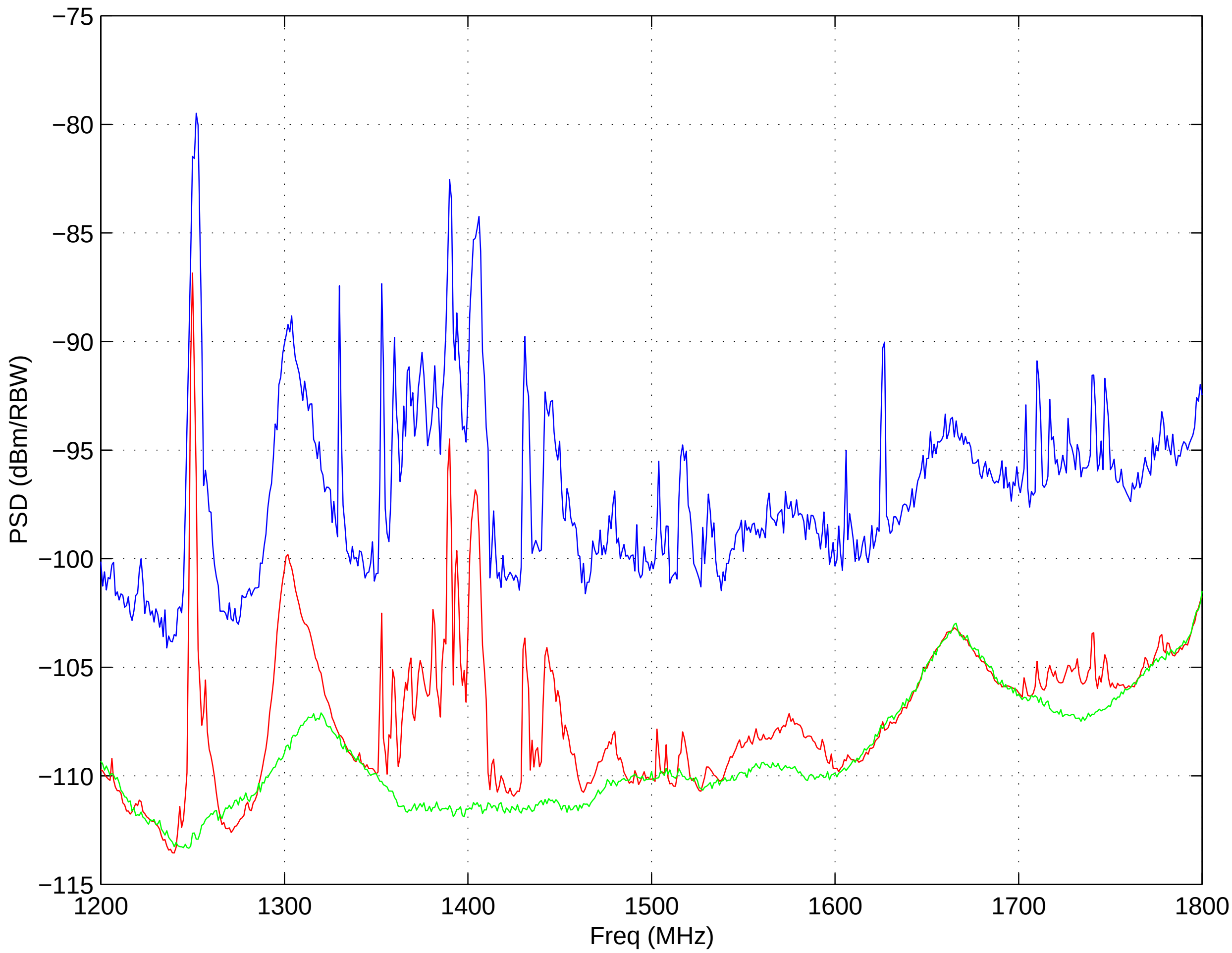

Figure 2: *Top:* Max-hold. *Middle:* Linear average looking through the antenna. *Bottom:* Linear average looking at the reference load. In all cases, cumulative results over 1700 sweeps with resolution bandwidth (RBW) = 1 MHz. Passband calibration applied as described in the text.

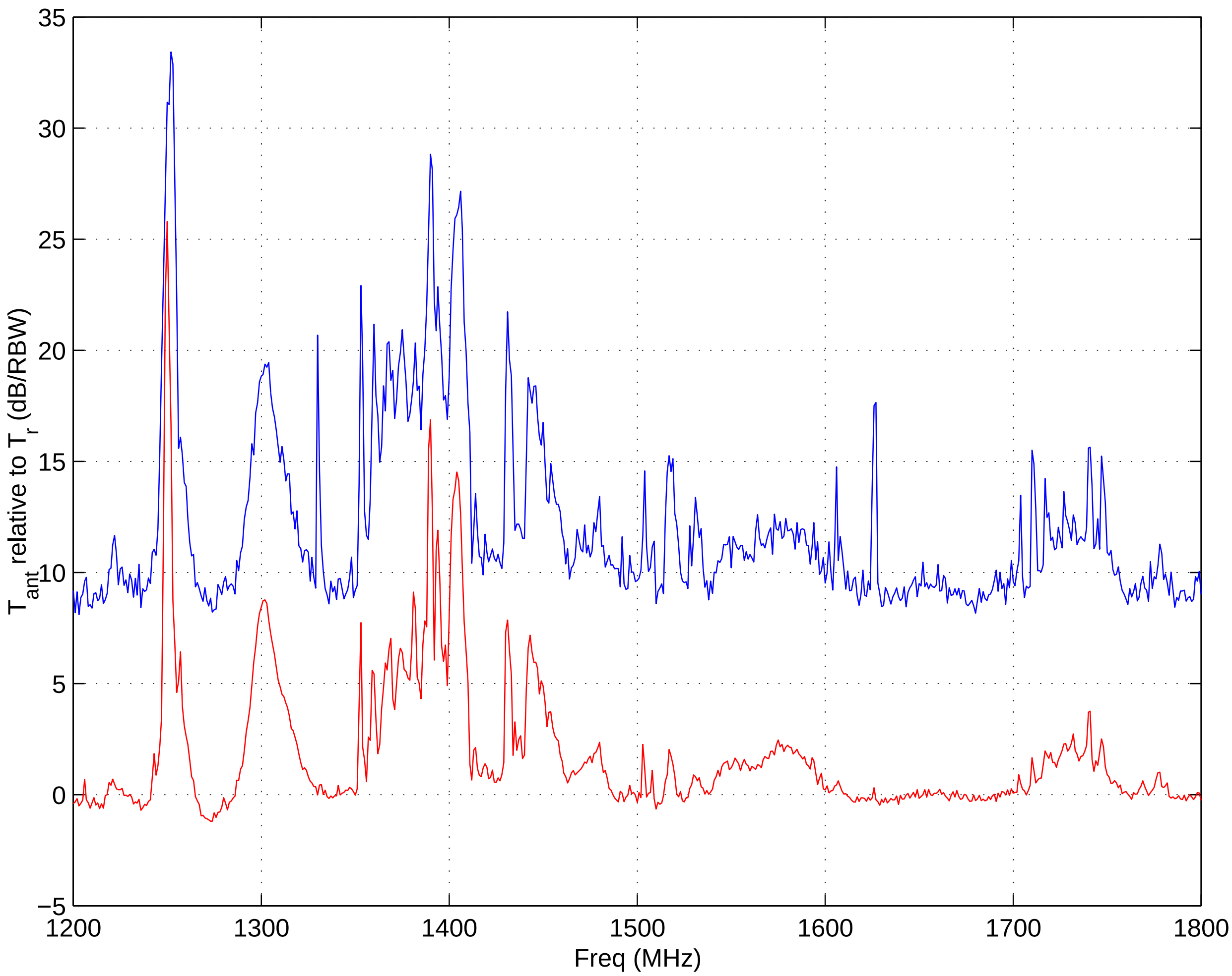

Figure 3: Same as Figure 2, except results are normalized with respect to the reference load measurement.

load, note that there is much (on the order of 5 dB) variation in the observed power spectral density. This is cause for concern, since the PSD of the reference load should be relatively flat, even over the 600 MHz shown here. Therefore, this result seems to indicate a variation in the system temperature which is independent of the gain response, and should probably be investigated further. To aid in the process of identifying signals, we can plot the data shown in Figure 2 so that the results are normalized with respect to the reference load power spectral density (PSD), which is nominally flat. The result is shown in Figure 3. In this Figure, we can see a number of signals – both known and unknown – that appear significantly above the system noise, as well as a few regions that are supposed to be and in fact appear to be signal-free. These include the following:

- 1250 MHz: This is a very strong amateur radio broadcast, identified in a previous report [1], about 3 MHz wide.

- 1331 MHz: This is a previously identified air traffic control radar [2], about 2 MHz wide. Note that the radar is not visible in the linear average PSD, consistent with the burst nature of the transmission and the low-duty-cycle sweep method of measurement.

- 1411–1428 MHz: This much of the ITU-protected 1400-1427 MHz radio astronomy band appears to be relatively clear in this measurement.

- 1610–1614 MHz: This ITU-protected radio astronomy band appears to be relatively clear in this measurement.

- 1626 MHz: A strong signal from an Iridium satellite is visible in the max-hold PSD, but not in the linear average PSD. Again, this is consistent with the burst nature of the transmission and the low-duty-cycle sweep method of observation.

3 Iridium Observations

Signals from Iridium satellites provide a useful "sanity check" of LISA system performance, since they are weak with respect to many terrestrial signals, yet strong, narrowband (roughly 30 kHz), and easy to identify. Figure 4 shows a measurement of the 1610–1630 MHz band, which includes the region aroung 1624 MHz where Iridium seems to be most active, as well as the 1610–1614 MHz radio astronomy band. The measurement method was similar to that described in the previous section, except (1) RBW = 10 kHz and (2) these results are not calibrated to level the system passband, since the variation is hardly noticible over this relative small swath of spectrum. Note that Iridium signals are clearly present, and in contrast the radio astronomy band seems to be very quiet, as expected.

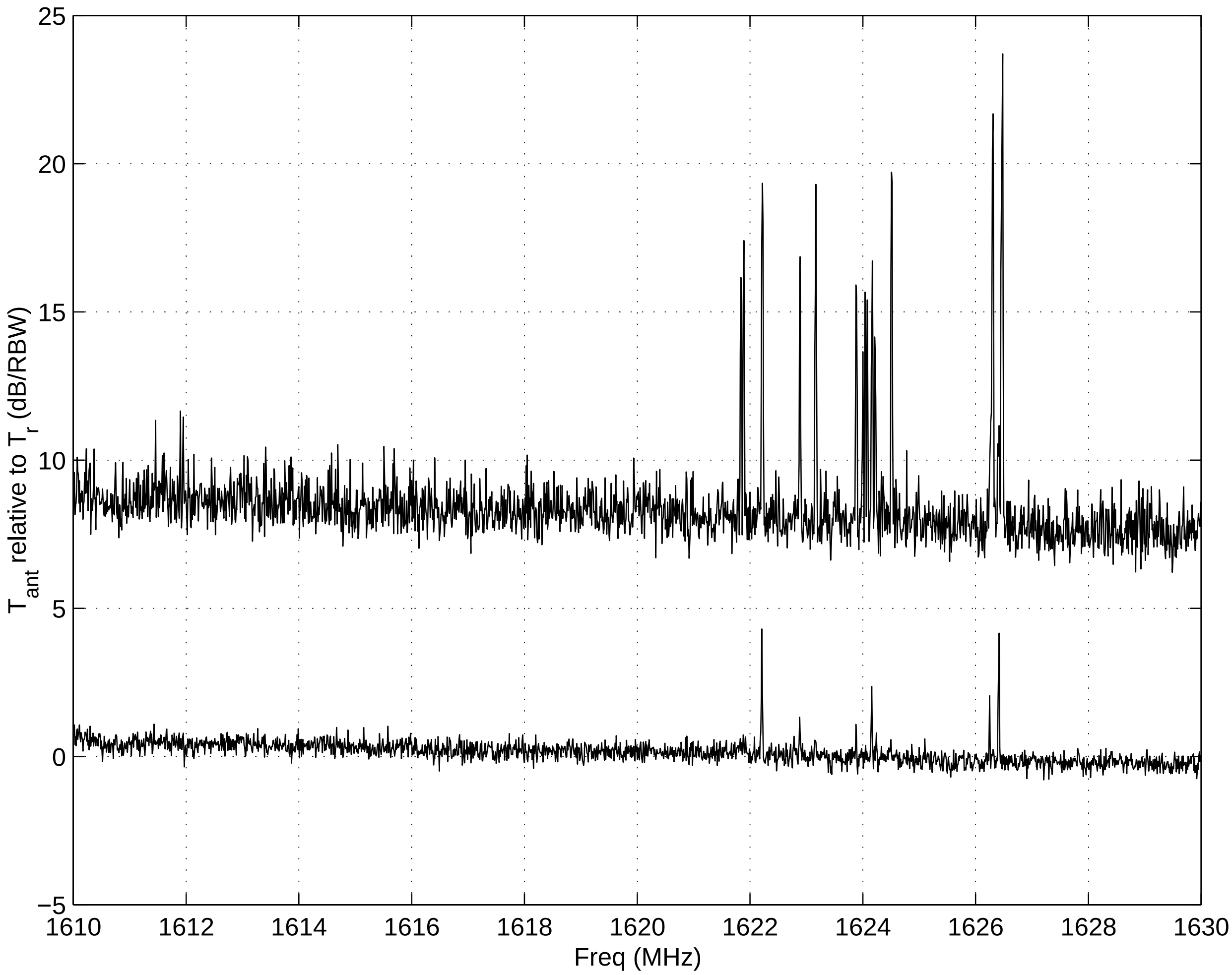

Figure 4: Spectrum analyzer observations of Iridium signals. Power in RBW = 10 kHz relative to the reference load. *Top:* Max hold, *Bottom:* Linear average. 400 sweeps.

Figure 5 shows results of observations of the same region of spectrum using LISA's coherent sampling system. This experiment consisted of 242 acquisitions of 16384 (16K) complex samples each, taken every 1.7 s (approximately). The sample rate is 20 MSPS, so each acquisition represents 819.2 μs of data, the observing duty cycle is about 0.05%, and the entire data set represents about 0.2 s of observation. The RBW is that of the FFT; in this case, about 1.2 kHz. Note that the 16 MHz passband defined by the 8 MHz lowpass filters of the direct-conversion receiver are clearly visible. The null in the center of the spectrum occurs because the I and Q A/Ds are AC-coupled, which helps to reduce I-Q imbalance and improves A/D dynamic range. From the bottom panel in Figure 5, we see internally-generated unmodulated spurious signals at 1620, 1625, and 1630 MHz exactly. These are believed (but not yet confirmed) to be generated by the spectrum analyzer. The top two panels in Figure 5 reveal many Iridium signals.

In Figure 6, we zoom in to view the spectra of individual signals.

References

[1] S.W. Ellingson, "IIP RFI Survey: Version 2," Informal Report, July 16, 2002.

[2] S.W. Ellingson and G.A. Hampson, "On Air Test of the IIP Receiver Using Observations of an ATC Radar," Informal Report, June 29, 2002.

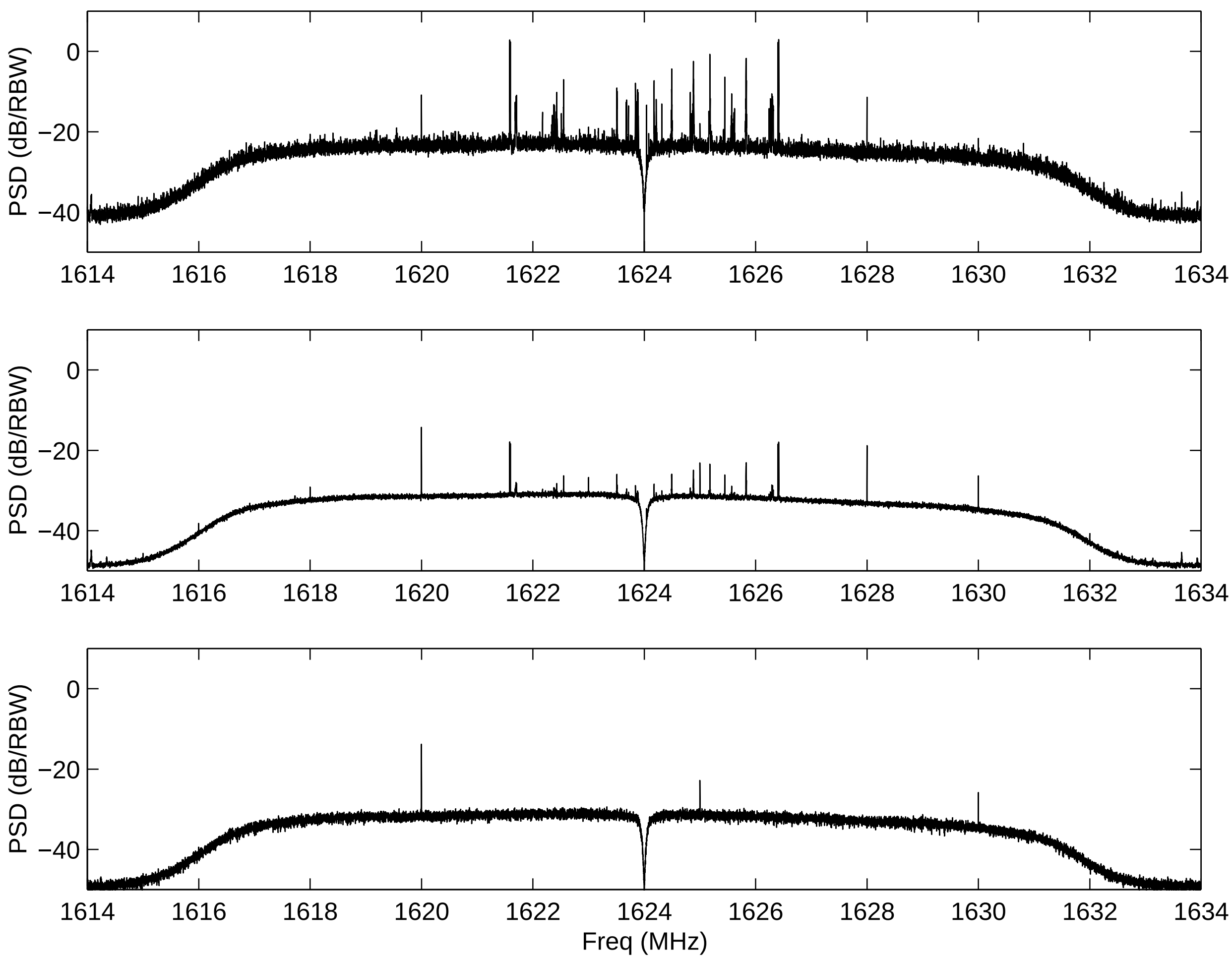

Figure 5: Observations of Iridium signals using the coherent sampling system. *Top:* Max hold, sky; *Middle:* Average, sky; *Bottom:* Average, reference load. 0.2 seconds of observing (except for the bottom panel, which is less) with RBW $\sim$ 1.2 kHz. Uncalibrated passband.

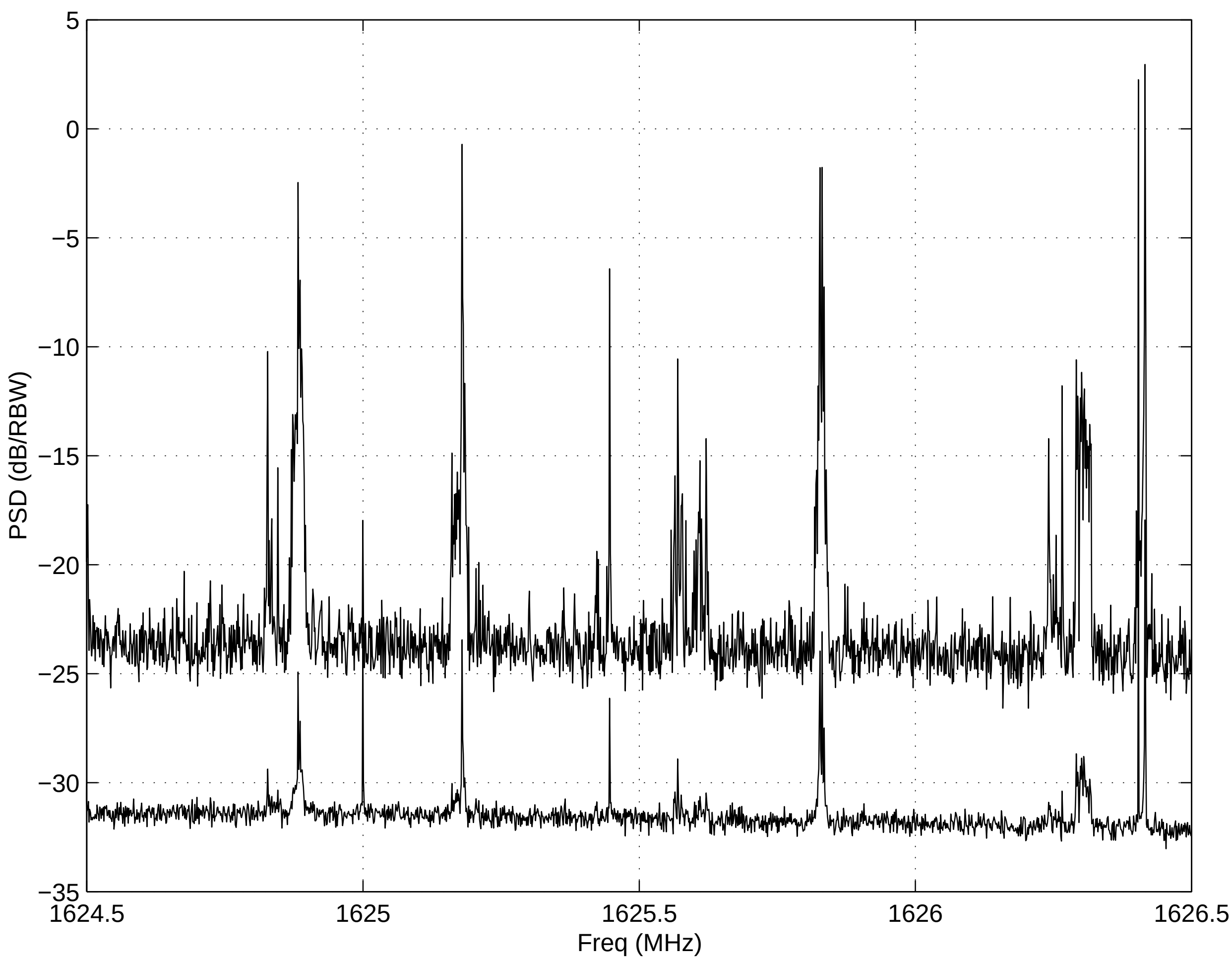

Figure 6: Zooming in on Figure 5 in order to resolve the spectra of individual signals. *Top:* max hold, *Bottom:* linear average.