Testing the Susceptibility of GNSS Receivers to Radio Frequency Interference

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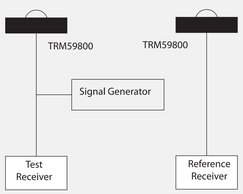
Introduction

Global Navigational Satellite Systems (GNSS) data acquisition frequently occurs in a variety of challenging environments, which include locations with elevated Radio Frequency (RF) noise characteristics. Tracking the relatively low powered GNSS carrier signals broadcast from space becomes even more challenging in the presence of adjacent band RF noise. The demand for terrestrial RF spectrum use for a variety of non-GNSS applications is ever increasing, which poses potential challenges for GNSS site operators who would like to acquire the highest quality data possible.

In recent years, UNAVCO has observed an increase in the number of GNSS sites in our network which are negatively impacted by RF interference. In previous work, we have shown that telemetry systems utilizing the Iridium satellite constellation can degrade GNSS data quality, as the adjacent-band (1610-1616 Mhz) signals transmitted by Iridium data transmitters are close in proximity to the L1 frequency of GNSS.

To better characterize GNSS receiver susceptibility to more general RF interference, we use a signal generator to provide a Continuous Wave (CW) noise source. We combine the CW noise with the incoming signal from the GNSS antenna before it enters the receiver. We vary the power and frequency of the generated CW noise. Changes in the recorded signal-to-noise measurements are then used to characterize each receivers susceptibility to a CW noise source.

Test Configuration



GPS Frequencies :
L1 = 1575.42 MHz
L2 = 1227.60 MHz
L5 = 1176.45 MHz

Receivers Tested

(1) Septentrio PolaRx5, (2) Javad Sigma, (3) Leica GR10,
(4) Trimble NetR9, (5) Trimble NetRS, (6) Topcon NetG5.

Noise Power and Frequency Range

- 8 discrete noise power levels were tested ranging from -80 to -10 dB.
- 64 discrete frequencies were tested ranging from 1100 to 1730 MHz.
- Each frequency and power level setting was held for 1 min.
- The test duration for each receiver tested took approximately 8.5 hrs.

Data Processing

1) Each test receiver's 1Hz signal-to-noise values for each satellite were divided by the 1Hz signal-to-noise values recorded by a reference receiver (collocated and not subject to interference).

2) The normalized SNR values for each satellite were then averaged for each epoch.

3) The figures display the computed normalized SNR values over a grid of tested frequencies (x-axis) and tested power levels (y-axis).

4) Cool colors show when the test receiver's SNR values were lower than what was recorded by the reference receiver, indicating a susceptibility to interference at the given frequency and power level.

5) Solid dark blue indicates the receiver stopped tracking all satellites.

6) The normalized SNR values for each GPS frequency (L1, L2, and L5) were each plotted separately.

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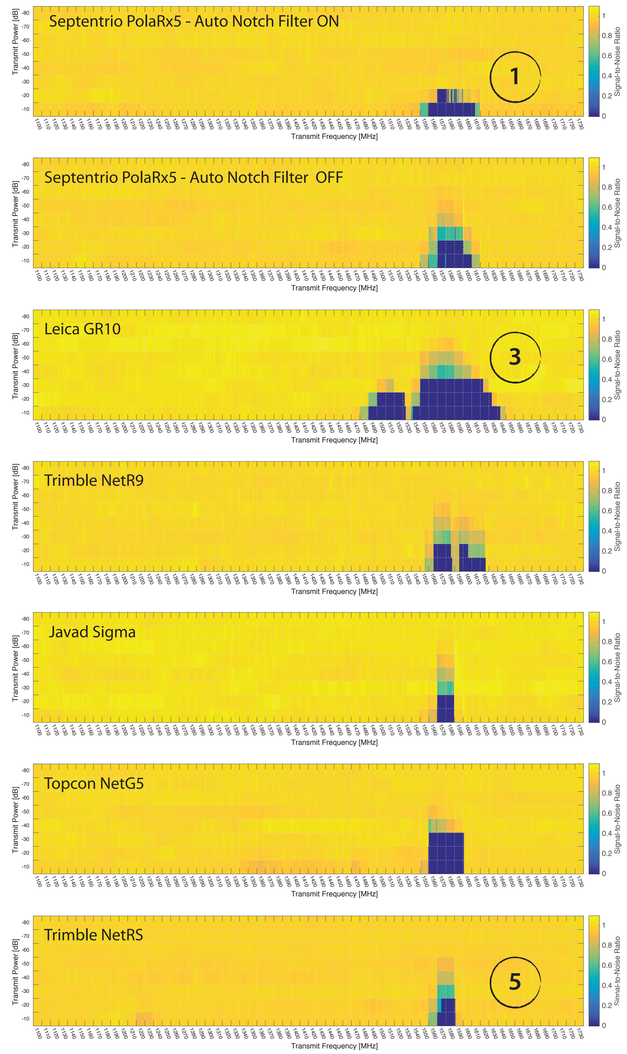
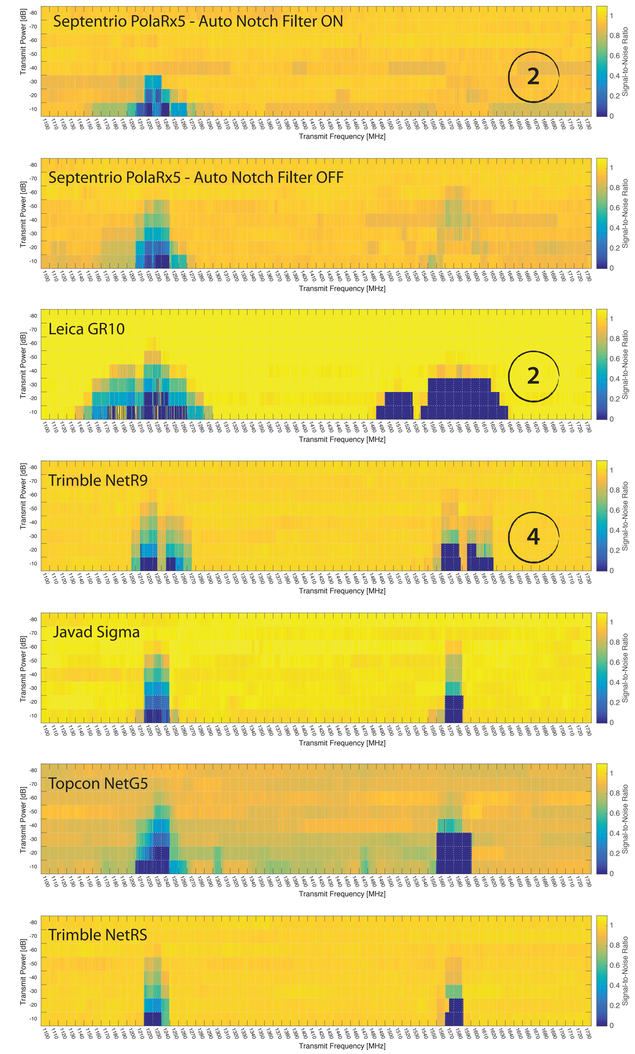
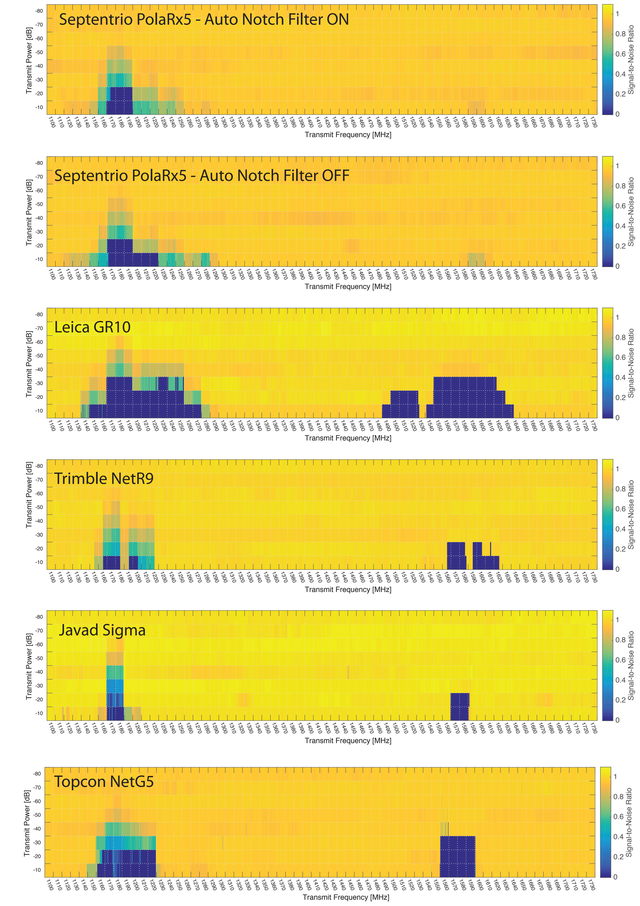
Normalized L1 SNR



Normalized L2 SNR

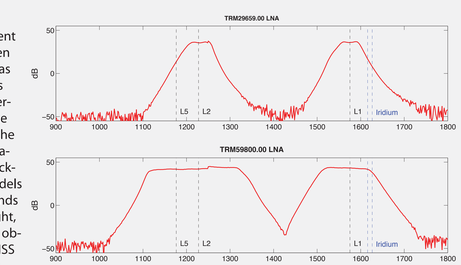


Normalized L5 SNR



Discussion

1. Septentrio's PolaRx5 receiver includes an RF mitigation tool allowing users to apply an automatic digital notch filter in the receiver front end for CW noise sources. The test results improved when the filter was enabled.
2. Some receivers showed interference susceptibility at frequencies near L1 when tracking L2 and L5.
3. The frequency range over which each receiver was susceptible varied significantly between each make and model.
4. Some receivers appear to employ notch filtering at frequencies that carry L-band correction services.
5. Older GPS-only hardware seems to employ narrower filters in the RF front-end.

Antennas

Antennas were not tested in this experiment because the noise was introduced between the antenna and the test receiver. Antennas also play an important role in a given site's susceptibility to RF interference. If the interference is within the amplified range of the antenna's LNA and of sufficient strength, the amplifier can saturate. Antenna LNA saturation can cause degradation of receiver tracking performance. Some new antenna models include LNA's with wider amplification bands to better support newer GNSS signals (Right, Bottom). UNAVCO has seen an increase in observation noise at a subset sites where GNSS compatible antennas have replaced older GPS-only designs.