Preliminary Testing:
Out-of-Channel Interference (Out-of-Band Emissions)

1. Introduction

To inform the US DOT understanding of the revised 5.9 GHz band allocations in the FCC's draft NPRM, the US DOT went into the lab to investigate the ramifications of the new proposed rules. Specifically, we looked at the performance of three media in operation—DSRC, LTE-CV2X, and unlicensed Wi-Fi (UNII) when positioned in adjacent channels. The proposal includes allowing UNII to expand up to channel 177 (incorporating 5850-5895 MHz), DSRC in channel 180 (5895-5905 MHz), and LTE-CV2X in channel 183 (5905-5925 MHz) with power levels and parameters as per Appendix B in the NPRM. The purpose of this paper is to document potential for adjacent band interference in this proposed allocation scenario.

2. Process

The laboratory test process described here is to illustrate the potential for adjacent channel interference. Establishing the level of interference will require additional testing. All three technologies were set up individually in a laboratory environment and configured to transmit such that they would pass significant data from the transmitter to the receiver. Figure 1 illustrates the test configuration.

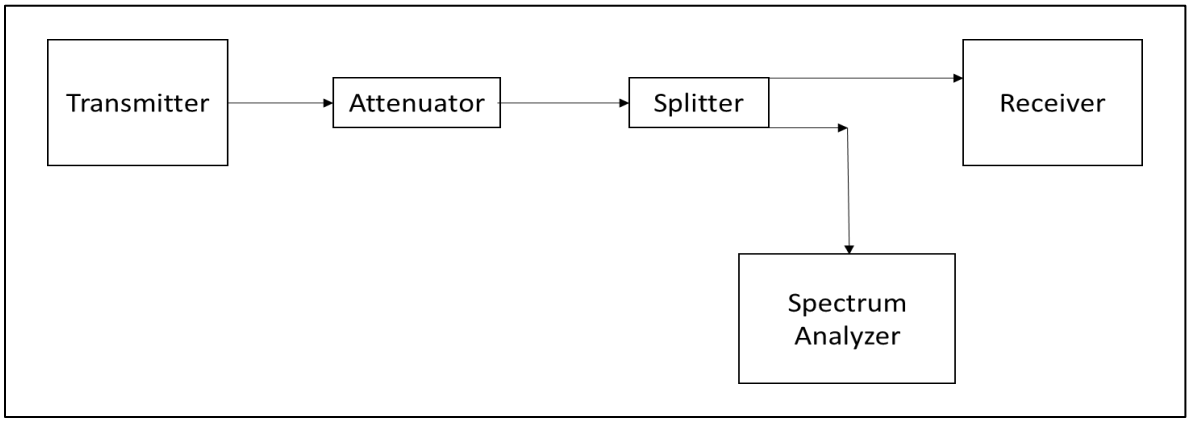

Figure 1. Equipment Configuration

This preliminary investigation focused solely on emissions in the adjacent channels, due to the requested quick turnaround for this preliminary analysis. The spectrum analyzer was set to compare all three technologies in a similar plot.

3. Spectrum Plots

Starting at the top of the 5.9 GHz Safety Band, a plot of the LTE C-V2X is shown in Figure 2. This is a max hold plot and illustrates the out-of-band emissions (OOBE). This plot is centered at 5915 MHz and has a span of 50 MHz. While the main channel is in the 20 MHz designated for this technology, we can observe that OOBE extends another 20 MHz to either side with considerable energy. Figures 3 and 4 are similar plots for DSRC and UNII devices. (Again, this data is to indicate potential interference to adjacent channels; more testing is needed to quantify the level of interference.)

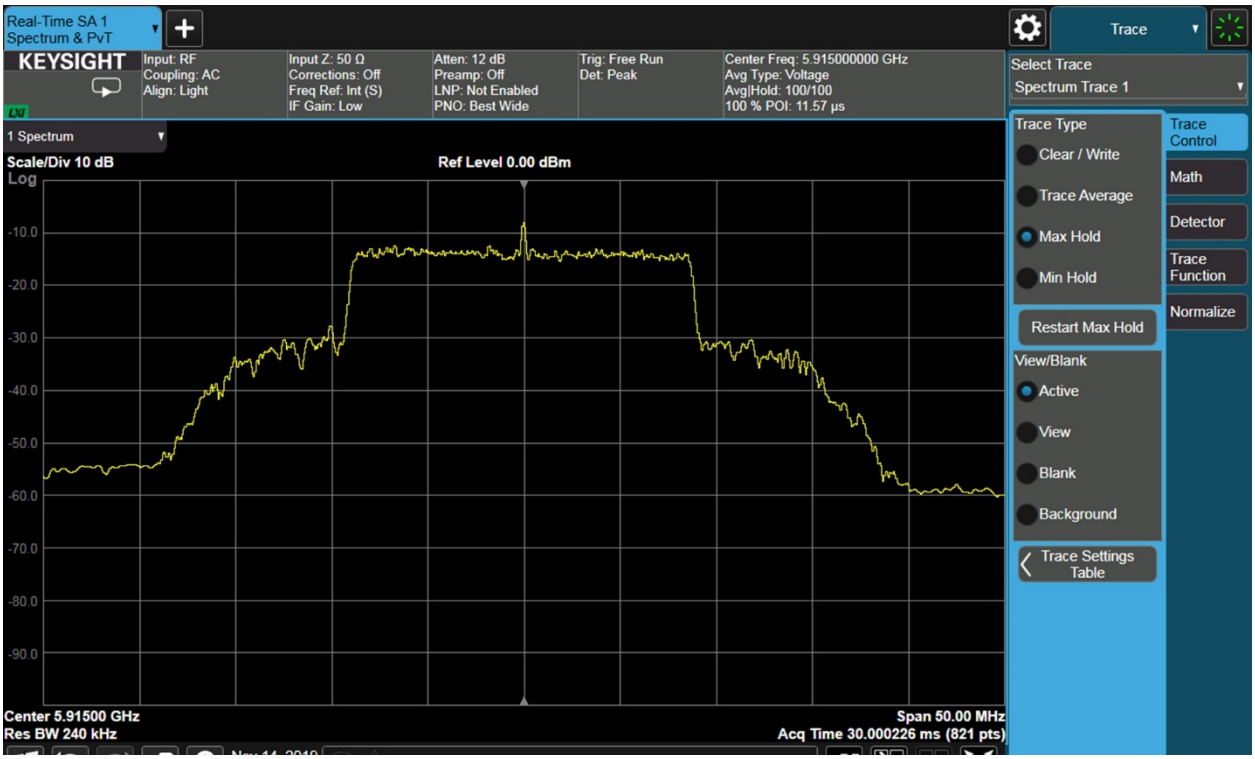

Figure 2. LTE C-V2X spectrum plot

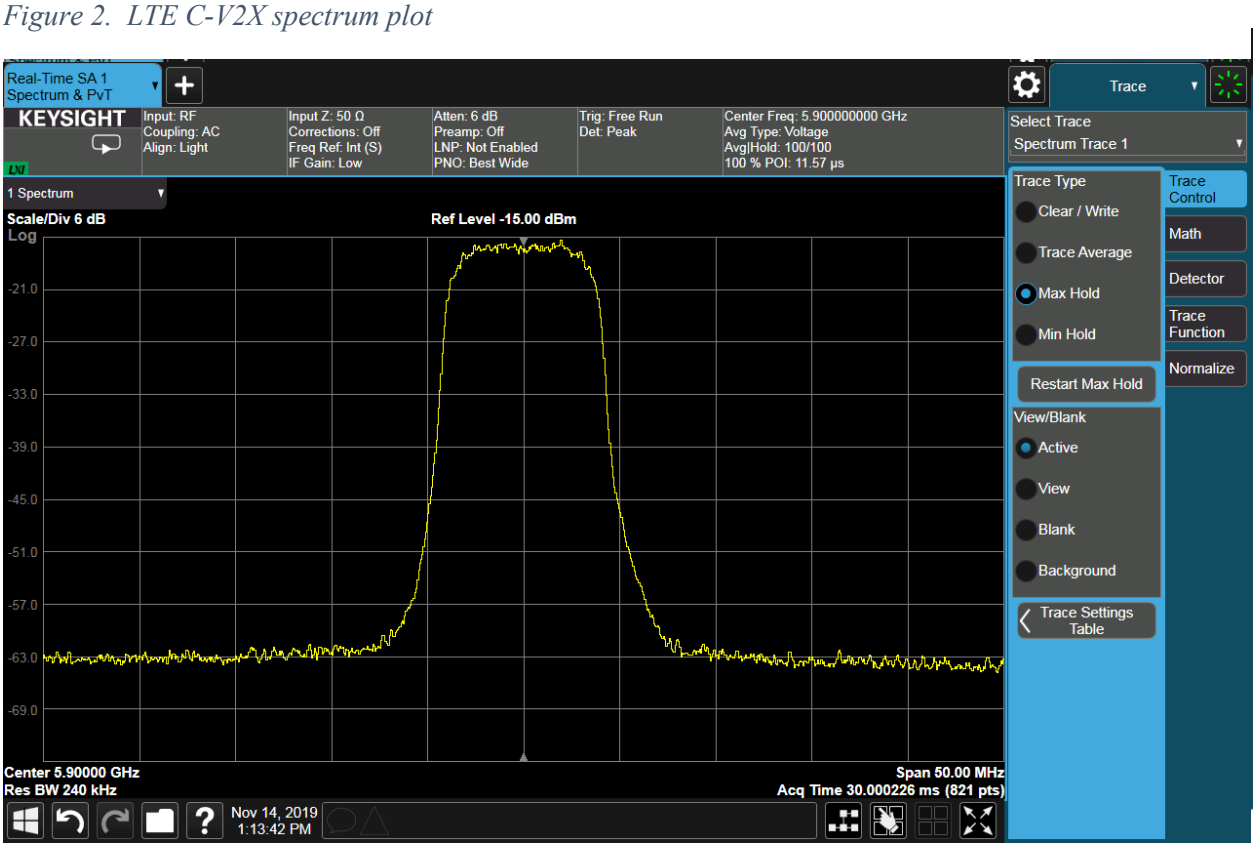

Figure 3. DSRC spectrum plot

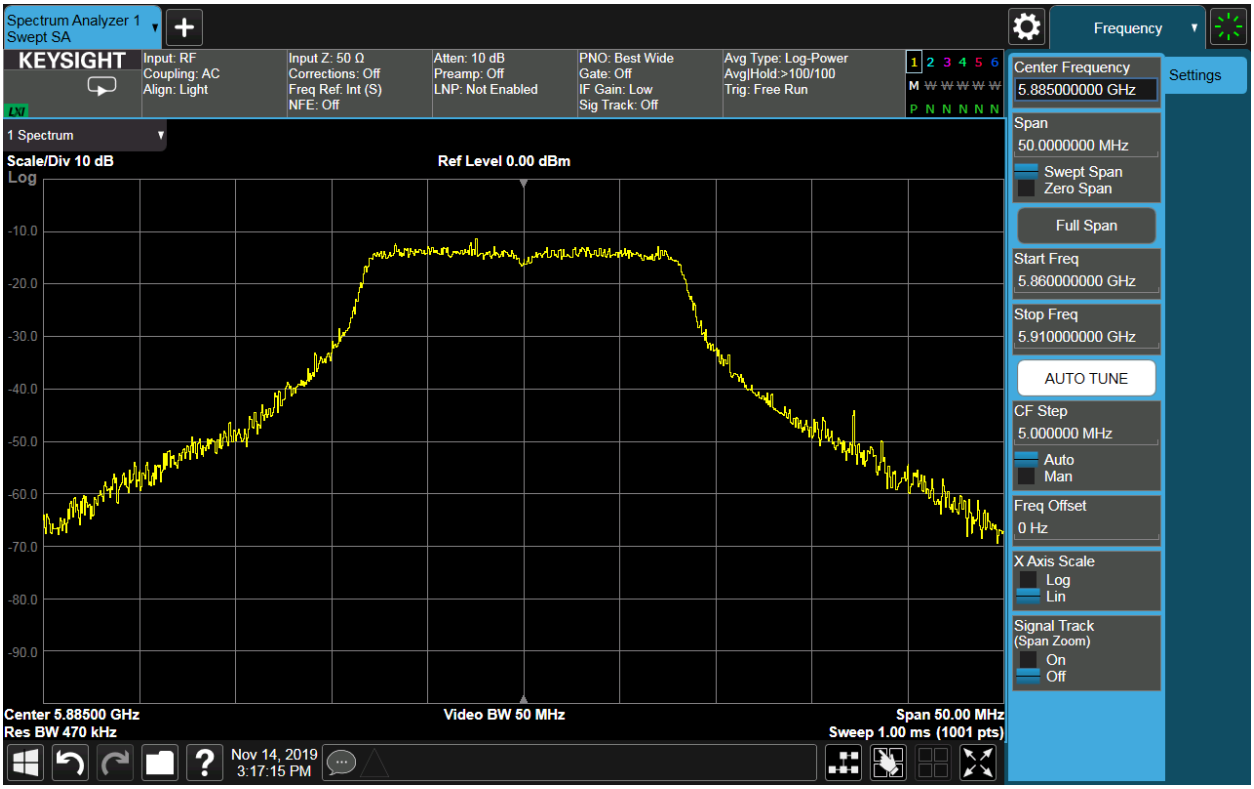

Figure 4. UNII spectrum plot

In addition to these figures, we captured "waterfall" plots across the 5875 to 5925 MHz spectrum. Again, starting at the top with LTE C-V2X in figure 5, the top half of the chart is an instantaneous capture of the spectrum. The lower half is spectrum occupancy over time. The color-coding reflects the energy in dBm in a narrowly quantized portion of the band. Red represents the highest power at roughly -20 dBm. The dark blue represents the noise floor of the spectrum analyzer at roughly -72 dBm. Figures 6 and 7 are similar plots for DSRC and UNII.

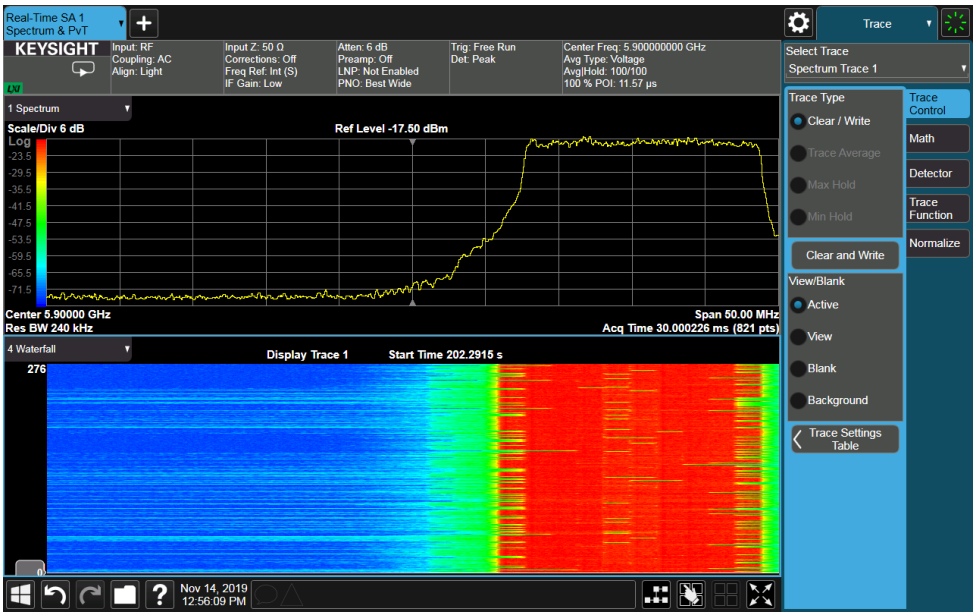

Figure 5. LTE C-V2X in the 5875 to 5925 MHz spectrum with Waterfall plot

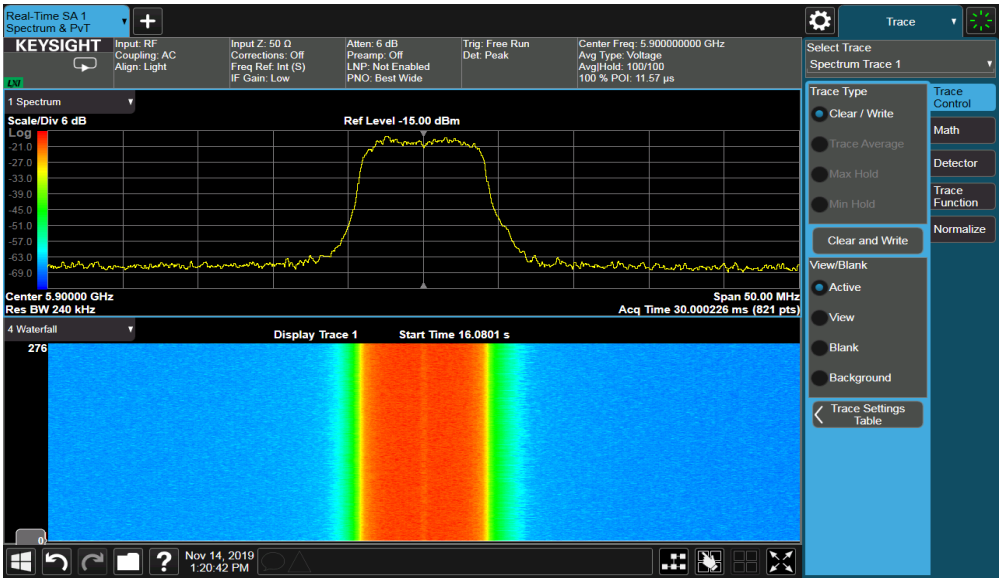

Figure 6. DSRC in the 5875 to 5925 MHz spectrum with Waterfall plot

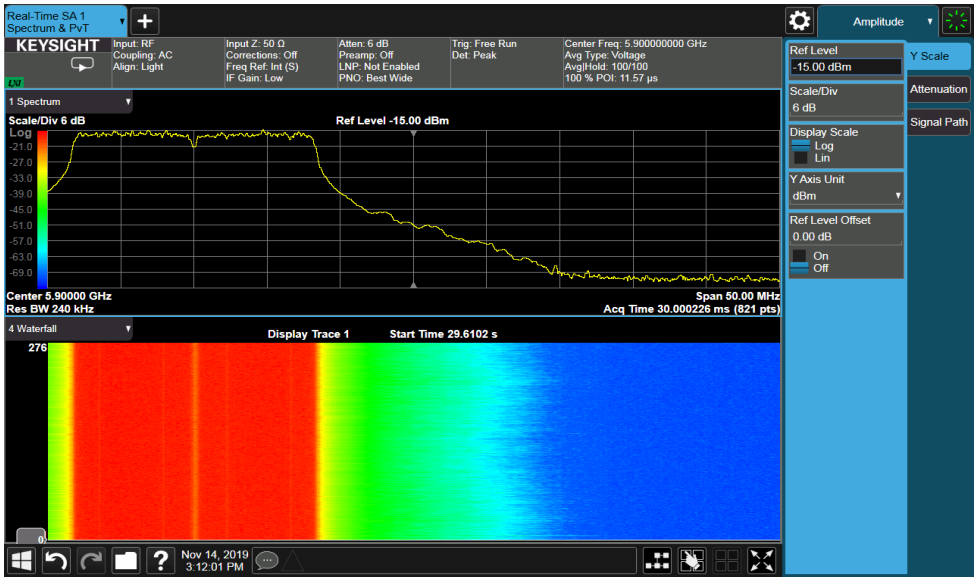

Figure 7. UNII in the 5875 to 5925 MHz spectrum with Waterfall plot

In all three, energy extends outside of the designated channel:

- Energy from the LTE-CV2X, only 17dB down, leaks into the adjacent channel.
- Energy from the UNII, only 20 dB down, leaks into the adjacent channel.
- Energy from the DSRC, at 40 dB down, leaks into the adjacent channel.

4. Conclusion.

While additional testing is needed to determine the level of interference from one device to another, **it is clear that interference will occur**, raising the question of the reliability of V2X communications in this configuration. Without a high level of reliability, transportation safety will be impacted. These draft results also suggest that the rules and the division of spectrum, as described in the draft NPRM, may result in significant adjacent channel interference between the different radio services and thus may need reconsideration.