Exploring Radar Waveforms

In this activity we will use the Pluto to experiment with two different types of radar system. Both the radars we will implement will continuously transmit signals (i.e. they are not pulsed). These include a CW radar and FMCW radar. These are two common types of radar systems although Geospace radars most often use phase coding and much better forms of synchronization. The pluto does not support synchronization and the monopole antennas also have poor isolation from each other.

The radar scripts were derived from Luigi Freitas who created them for the Lime SDR:

https://luigifreitas.me/2018-11-23/software-defined-radar-cw-doppler-radar-with-limesdr

Related scripts and processing can be found in an number of places. Another good set of tools is the gnuradio-radar toolbox at:

https://grradar.wordpress.com/

https://github.com/kit-cel/gr-radar

Exploring radar waveforms with gnu radio companion

There are two GRC scripts available that implement the waveform generation, reception, and signal processing for the radar systems. The first implements the CW radar which provides fine doppler resolution but no range information. This radar works pretty well with the pluto and you should be able to see yourself moving around pretty easily if you move fast. The second implements the FMCW radar system which uses the beat frequency between the transmitter and receiver to provide an indication of range to a target. In practice this signal can alias in range so in can be ambiguous as to how far away something you detect is. The FMCW radar also has more synchronization issues than the CW radar implementation. You will see a strong signal which is effectively "zero range" for the radar and this will jump around depending on how fast your computer is running.

The scripts are located in the Activities/day2/pluto_radar directory.

<u>What to do</u>

1. Load up and run the single frequency CW radar script (sfcw_pluto.grc)

The display shows the TX and RX waveforms a doppler time intensity plot in a waterfall style.

a. Can you detect yourself or other targets moving?

b. Can you improve your SNR? (e.g. carrying something metal, etc).

c. What range of velocities can you detect?

d. How does it work at 2.45 GHz instead of 5.75 GHz?

2. Load up and run the swept frequency FMCW radar script (fmcw_pluto.gr)

This display shows the TX and RX waveforms, the beat frequency, and a range time intensity plot in waterfall style (i.e. the FFT of the beat frequency is essentially the range).

a. Can you detect any targets?

b. What range extent is covered by the radar?

c. Why does that make it hard to detect anything indoors?

Questions to consider:

1. What could make these radar systems work better?

2. How does the radar performance change with different FFT lengths?

3. What happens if you raise your transmit power or receiver gain?

4. How could you enable higher sensitivity in a given direction?

Extra credit:

1. Using the above examples create a pulsed radar at 5.75 GHz using the Vector Source block as shown in: http://wvurail.org/dspira/labs/01/ to create the pulse. Compute the magnitude of a vector of the return signal for a fixed range extent and display it as a range time intensity plot. It may be hard to properly synchronize the returns.