Software Defined Radio Communication for V2X

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Introduction

The UNLV REU Smart Cities site allows for undergraduate researches to tackle projects regarding different areas that can aid in the development of smarter, more technologically advanced living societies.

Through research areas including: Intelligent Transportation Systems (ITS), Automated Vehicles (AV), and Vehicle to EVerything communication (V2X), we can better understand the technology that can contribute to creating more efficient ways to navigate our communities. Specifically regarding V2X, we can ensure that this technology is frequently used to improve important aspects to urban life such as safety.

Purpose/Aim

The purpose of our project is to develop a Software Defined Radio (SDR) system to allow for various types of communications between a vehicle and its surroundings. The completion of such a goal will allow us to have a suitable base for many different types of radio communication we wish to implement. An accurate summation of the potential of this research is that it is a stepping stone towards a type of 'Everything to Everything (X2X) communication.

Methods/Tools

- MATLAB R2021a & MATLAB R2022a
- nooelec RTL-SDR Bundle:
  - nesdr smart
  - nooelec antenna base
  - 3 antenna masts
- MathWorks Digital Signal Processing System Toolbox
- MathWorks Communications Systems Toolbox
- MathWorks Signal Processing Toolbox
- Software-Defined Radio Using MATLAB, Simulink, and the RTL-SDR eBook
- RTL-SDR Support from Communications Toolbox

Results

- Completed worksheet covering common signal processing methods and concepts.
- Found and read documentation on the nooelec RTL-SDR, FM and AM signals, and the modulation and demodulation process.
- Interfaced nooelec RTL-SDR antenna in MATLAB to receive FM signals.
- Created Simulink and MATLAB models and scripts to model the nooelec RTL-SDR.
- Constraints included searching for compatible toolboxes, and working with different versions of MATLAB.

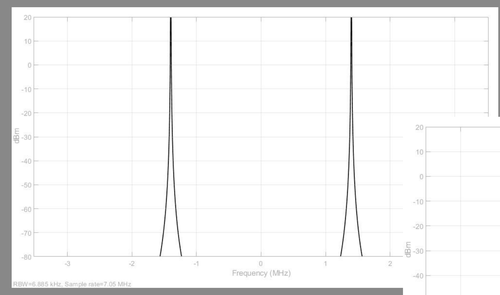

Figure 1: Original Signal defined in script as Signal1.

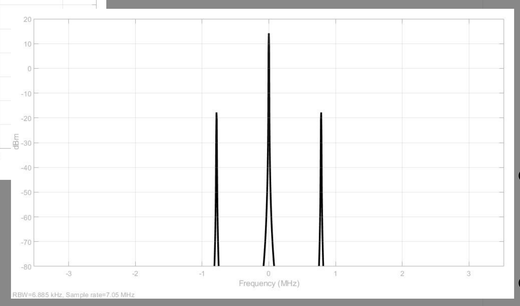

Figure 2: Final, demodulated and filtered signal centered at

MATLAB Model of RTL-SDR Hardware

```
Signal1 = InputI + InputQ; %InputI + 1.5*x

Fn = Fs/2;
[B,A] = cheby2(4,30,[(Fc-3e6)/Fn (Fc+3e6)/Fn]); %Cutoff freqs originally divided by Fs, and originally 390e6 and 410e6
freqz(B,A);
Signal2 = filter(B,A,Signal1);

NCO = cos((2*pi*403.6e6)*t);


Signal3 = Signal2.*NCO;

[B2,A2] = cheby2(6,30,(3.6e6+3e6)/Fn);
freqz(B2,A2);
Signal4 = filter(B2,A2,Signal3); %running signal multipled by NCO through same IIR%

Signal5 = downsample(Signal4,Fs/28.8e6);

dt2 = 1/28.8e6;
t2 = (0:dt2:StopTime-dt2)';
% NCONew = cos((2*pi*403.6e6)*t2);
NCO2 = cos((2*pi*3.6e6)*t2); %previously 3.6e6 (0.0872) %use envelope detector instead

Signal6 = Signal5.*NCO2; %pass Signal5 through envelope detector

Fs = 28800000;  % Sampling Frequency

N              = 70;       % Order
Fc             = 3000000;  % Cutoff Frequency
flag           = 'scale';  % Sampling Flag
SidelobeAtten = 60;        % Window Parameter

% Create the window vector for the design algorithm.
```

Figure 3: MATLAB script showing the modulation and filtering of signal in Figure 1

Conclusions

- The RTL-Software Defined Radio (SDR) was found to be very useful in studying the fundamentals of signal processing.
- The interfacing of the nooelec RTL-SDR with MATLAB was successful, as well as the recreation of the modulation and demodulation process within Simulink.

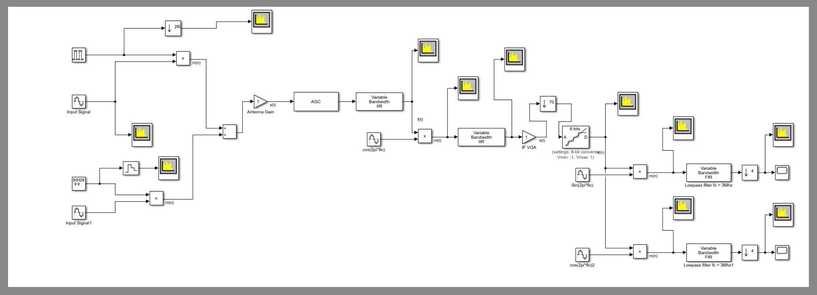

Figure 4: Simulink representation of the nooelec RTL-SDR

Future Research

- Through learning about the RTL-SDR we can continue with a strong basis in V2X research regarding the modulation and demodulation of different types of signals.
- We can also expand upon the general use for a Software Defined Radio by applying it with other types of Vehicle communication:
  - Vehicle to Infrastructure
  - Vehicle to Vehicle
  - Vehicle to Pedestrian

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