Digital and Wireless Communication

Project Report

3G mobile communication

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Description

We are simulating a **3G mobile communication** system. We are going to send an audio signal using a transmitter. Pass the signal across different channels, and finally receive the signal using the receiver.

Here's the specification of the system:

Pulse shape of base-band pulse : The transmit pulse-shaping filter is a root-raised cosine (RRC) with roll-off α =0.22
Modulation type: QPSK
Bit rate: up to 2 M bit/s
Channel BW: 5 MHz
Frequency band: 1920- 1980 MHz (uplink) 2110-2170 MHz (downlink)

Implementation

We are going to explain our steps (in details) in the two parts: **Matlab and USRP**

MATLAB

Reading the audio signal

We used a **Wav** audio file for the whole simulation. We applied all the following steps on this file.

Digital Upconversion

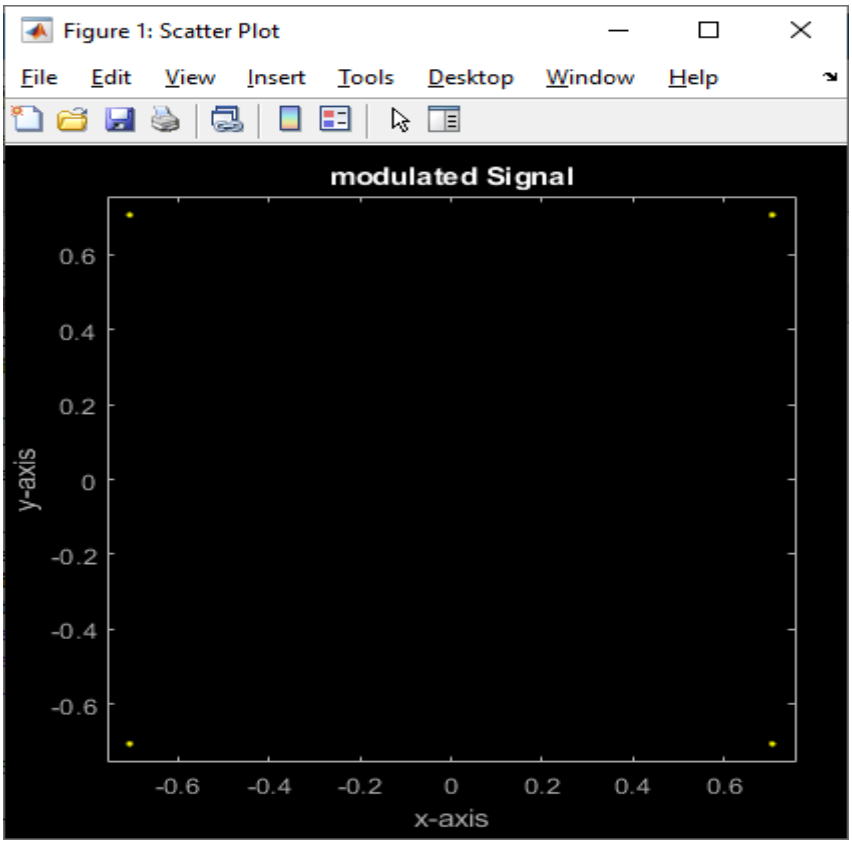
According to the 3G Specification, The signal is transmitted in range 1920- 1980 MHz. So, we multiplied our audio signal by a carrier sinusoidal signal with fc **1950 MHZ.** And we then Downconverted the Signal in the same way at the receiver.

Quantization and Encoding

We implemented two functions: **Quantizer** that quantizes the signal into a number of levels. Then we used the function **Encode** to convert the audio signal from its original form into binary sequence.

QPSK Modulation

3G uses **QPSK.** So, We used the built-in matlab function QPSK modulator on the encoded audio signal to generate the modulated signal.
Here's a plot of the modulated signal

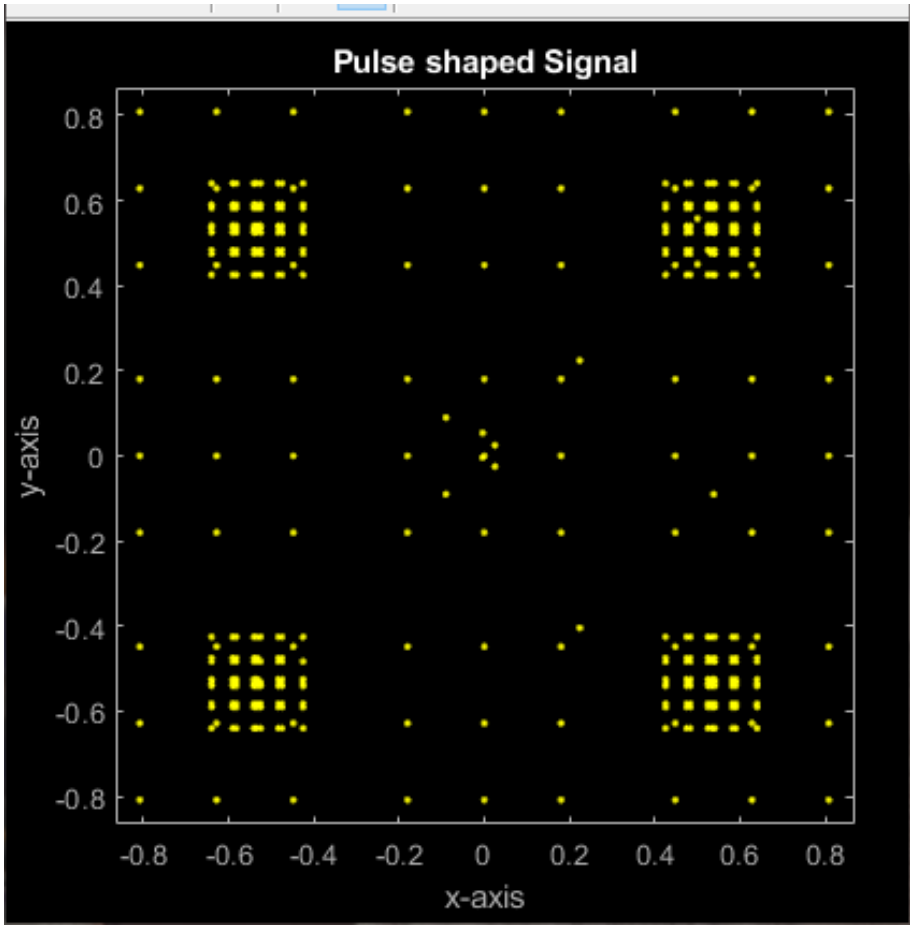


As we can see, there are four points representing the constellation of the **QPSK.**
This before adding any kind of noise/multipath fading.

Pulse shaping filter

We passed the signal through a pulse shaping filter, a root raised cosine(RRC) with a roll of = 0.22, Number of symbols 4 with 2 samples per symbol.

The following plot is the transmitted signal after the pulse shaping filter.



Adding Additive White Gaussian Noise:

(**AWGN**) is a basic noise model used in communication to mimic the effect of many random processes that occur in nature. The modifiers denote specific characteristics:

- ***Additive*** because it is added to any noise that might be intrinsic to the information system.
- ***White*** refers to the idea that it has uniform power across the frequency band for the information system. It is an analogy to the color white which has uniform emissions at all frequencies in the visible spectrum.
- ***Gaussian*** because it has a normal distribution in the time domain with an average time domain value of zero

Channel problems

We can alternate between different conditions that face any signal in the wireless communication like the noise ratio that we can control it by many way but the simplest way is the increasing of the signal power hence we define the concept of signal to noise ratio SNR that describe the relation between the power of the signal and the power of the noise and we tend to increase that ration by increasing the power of the transmitted signal to make the receiver task easier.
Another condition that may face any signal with transmitting is the attenuation of the transmitted signal power due to various variables during wireless propagation and that condition is called “**Fading**” and we tend to decrease its effect on the signal. Fading differs from one environment to another due to many reasons like the condition of the atmosphere such as rainfall and lightning, geographical position, time, radio frequency etc. The channel between transmitter and receiver can also be time varying or fixed depending upon whether the transmitter/receiver are fixed or moving with respect to each other.

We use **TWO** models to see the effect of Fading

- Rayleigh Model
- Rician Model

  And try different parameters with the same model

  For Rayleigh :

Rayleigh Model1 parameters:

maxDopplerShift = 30*2e6/(3e8)
delayVector = 5*1e-6;
gainVector = -3

Rayleigh Model2 parameters:

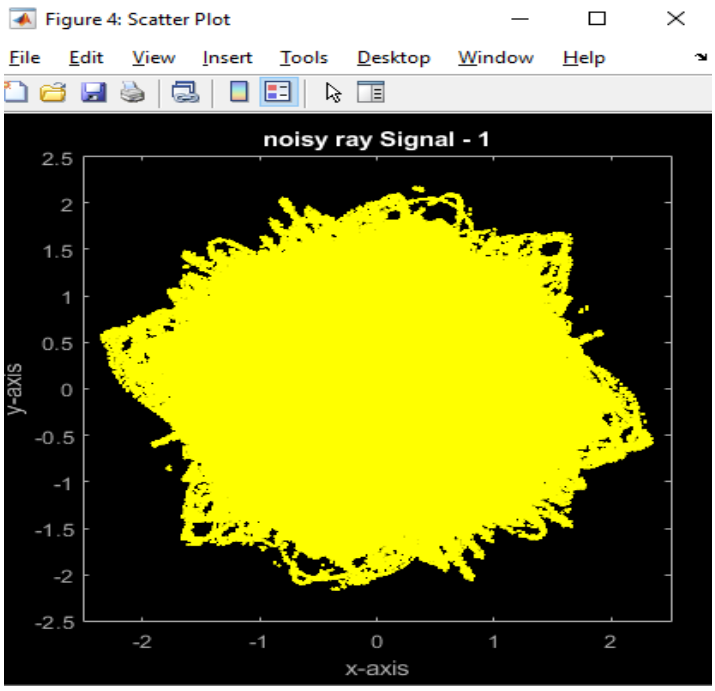
maxDopplerShift = 50*2e6/(3e8)
delayVector = 25*1e-6
gainVector = 10

Rayleigh Model3 parameters:

maxDopplerShift = 40*2e6/(3e8)
delayVector = 10*1e-6
gainVector = -10

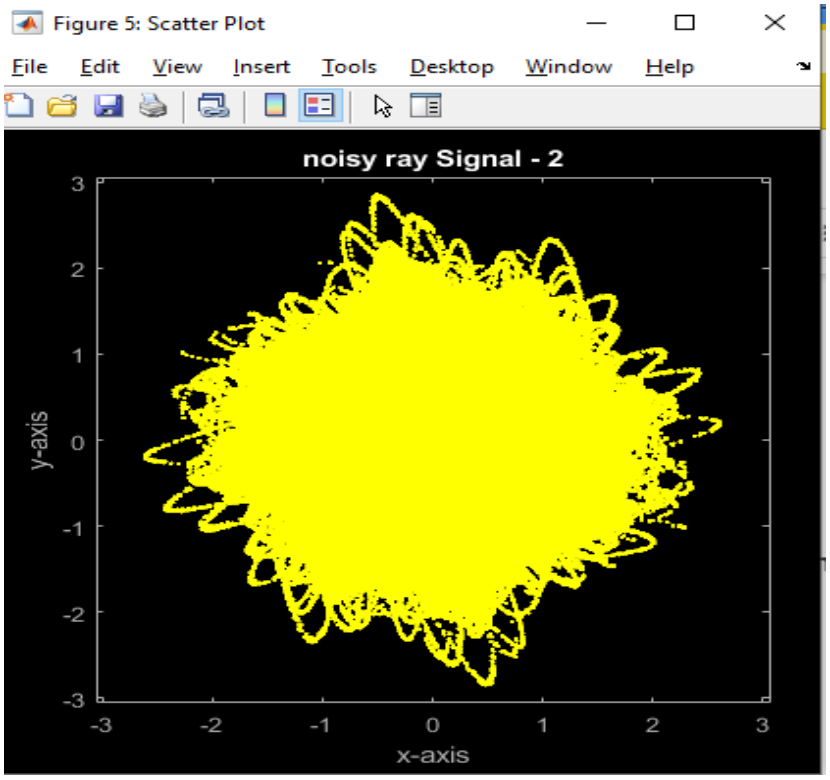
model1:

That was small parameters so we notice that its effect will be less than the next two models

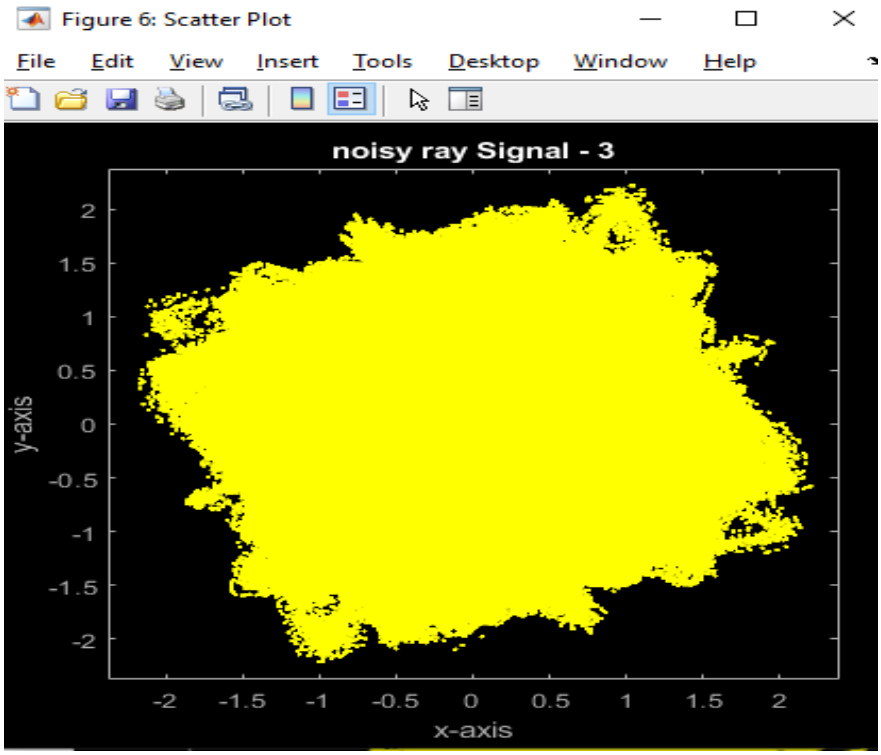


Model 2:

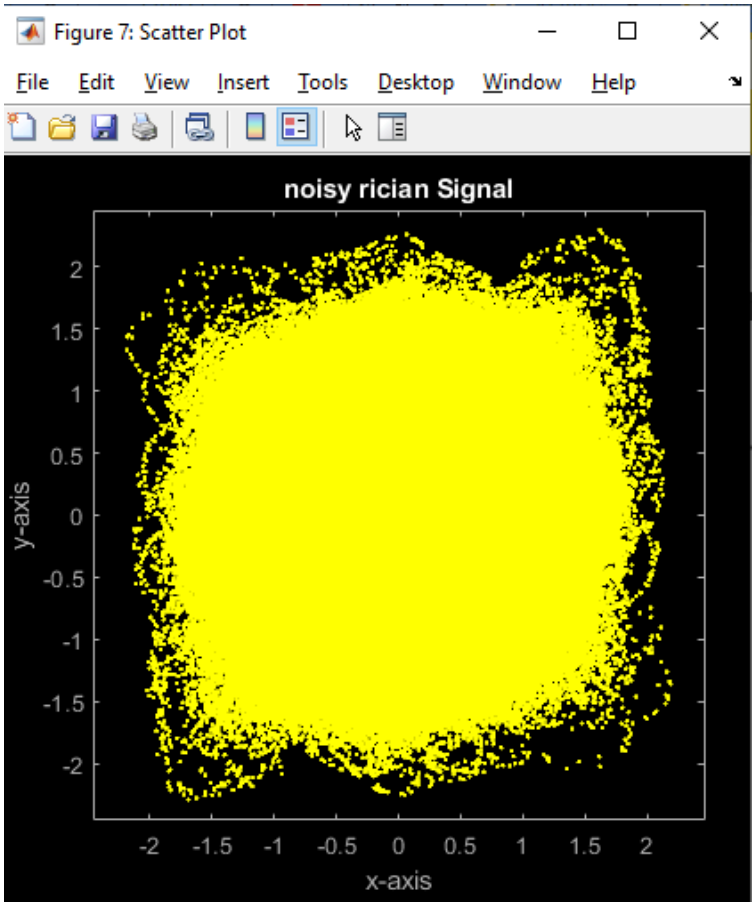
We notice increasing in the noise with the increasing of the doppler effect



Model 3:



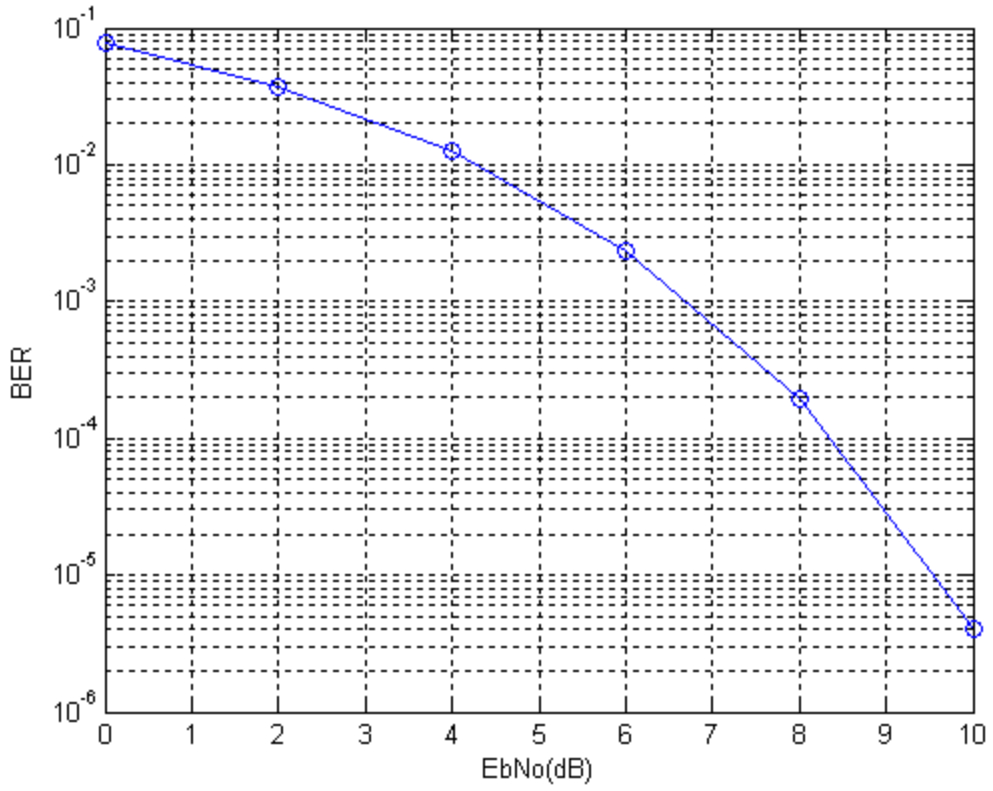
The 2nd type of Fading is Rician Channel:



Bit Error Rate(BER):

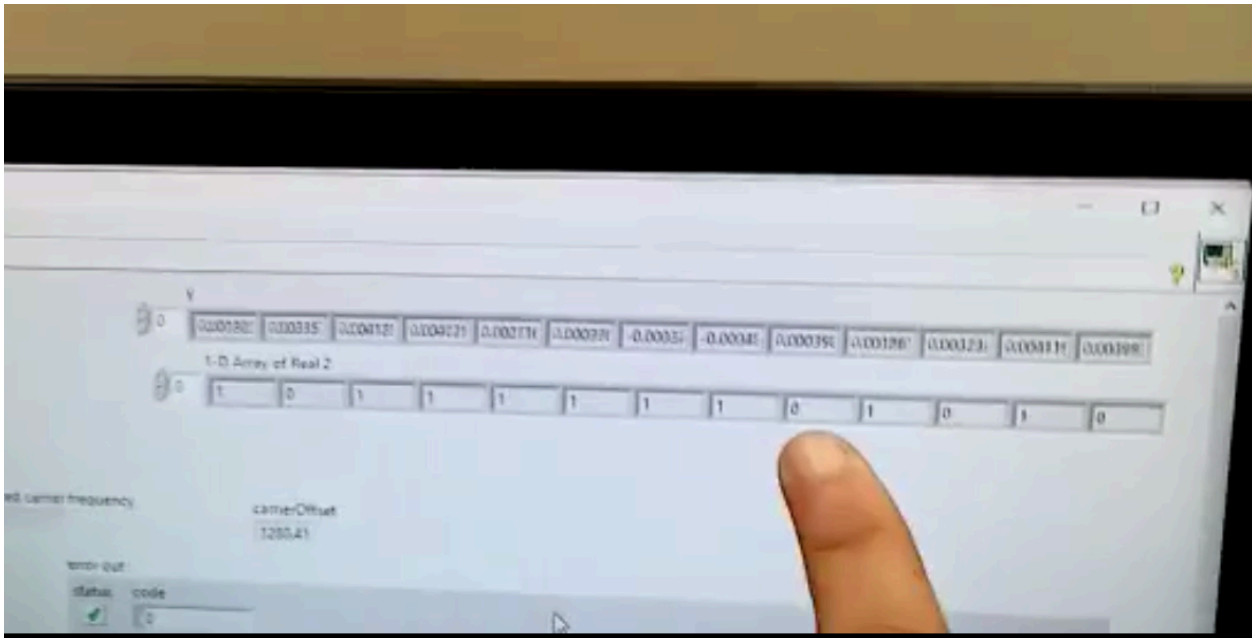
Simulating a QPSK system is equivalent to simulating two BPSK systems in parallel. So there is no difference in bit error rate(BER). Since the simulation is at baseband we multiply the in-phase and quadrature streams by 1 and j respectively (instead of cos and sin carriers).

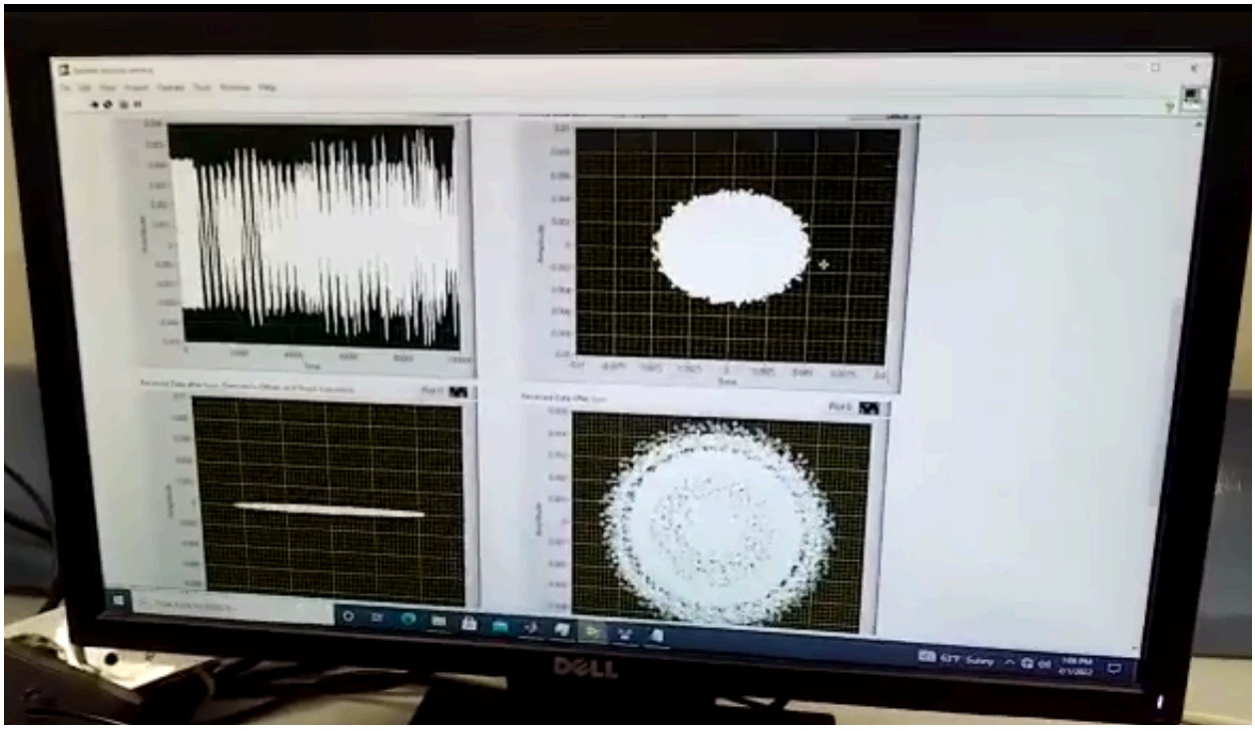
The graph of it should be like that :



USRPs:

Please note that we implemented all requirements in USRPs but during adding the block that plays the sound we did not manage to hear it although there was no error appeared to us while running. TA asked us to print the message bits as in the first Pic to let you know that we received it correctly and to let the USRP devices available to our colleagues. The TA asked us to end with that and she wrote that in the paper she had.


1-D Array of Real 2
carrierOffset
1280.41
status
code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