Department of Electrical & Electronic Engineering

Brac University

Semester- Fall 2021

Course Number: EEE 342

Course Title: Introduction to Communication Engineering Laboratory

Lab Report

Section: 1

Final Project

Group Number: 06

Other Group members:

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3.	18121068	Nowshin Sadia

Task No-1

Objective:

The primary objective of this analysis in the initial part (task-1) of the project was to design a communication link for AM audio transmission. Firstly, we will trigger a message signal, then modulate it with a carrier, and then add noise to the modulated signal using an AWGN (Additive White Gaussian Noise) channel. Then we will need to demodulate this modulated signal in order to recover our original message signal.

Required Blocks & Components:

- Sine Wave
- Analog Filter Design
- Band Limited White Noise
- Zero Order Hold
- Spectrum Analyzer
- Scope
- Adder
- Product
- Gain
- Constant

Methodology:

- We used a Sine wave as message signal, sampled at 1.8^-6 with an amplitude of 1and a frequency of 1000 Hz. Then, with the modulation index set to 0.5, we inserted a gain block. Afterwards, there's a carrier signal, which is a Sine wave with an amplitude of 17.88 and a frequency of 1350000 Hz sampled at 1.8^-6. This particular amplitude was chosen to reduce SNR in this case.
- We demodulated our modulated signal by multiplying a sync carrier with our modulated signal and then reconstructing our basic message signal with a Lowpass bandpass filter. We've also added a spectrum analyzer scope to see how the message signal, carrier signal, and zero order hold affect each other. The ability to visualize the message signal, analog filter, carrier signal, and reconstructed signal has been visualized through scope.

Nureen (18321047)

01

$SNR = 40 dB$

$\mu = 0.5$

$f_m = 1 \text{ KHz}$

$f_c = 1.35 \text{ MHz}$

RF Band width $= 9 \text{ KHz}$

channel noise power spectral density, $N_o =$

-150 dBm/Hz

$= 1 \times 10^{-18}$

watt/Hz

Lets assume,

channel Noise $= 120$

$f_m = 1 \text{ KH}$

$= 1000 \text{ Hz}$

We know,

$$SNR = 10 \log_{10} \left(\frac{P_s}{P_N} \right)$$

$$40 = 10 \log \left(\frac{P_s}{P_n} \right)$$

$$P_s = \frac{\mu^2 A_c^2}{4}$$

$$P_N = N_o B_m$$

$$= N_o \times 2 \times f_m$$

$$10^4 = \frac{(\mu^2 A_{c_o}^2)/4}{2 N_o f_m}$$

$$A_{c_o} = \sqrt{\frac{2 \times N_o \times f_m \times 10^4 \times 4}{\mu^2}}$$

$$= 1.789 \times 10^{-5}$$

Nureen (1832104)

02

Powerloss, $P_{so} = \frac{\mu^2 A_{co}^2}{}$

$= \frac{(0.5)^2 \times (1.789\times10^{-5})^2}{4}$

$= 2\times10^{-11}$ W

from channel Loss

$120 = 10 \log_{10} \frac{P_{in}}{P_{out}}$

$10^{12} = \frac{P_{in}}{P_{out}}$

$\therefore P_{in} = P_{out} \times 10^{12}$

$= 2\times10^{11} \times 10^{12}$

$= 20$

$\therefore A_{ci} = \sqrt{\frac{P_{in}\times 4}{\mu^2}}$

$= \sqrt{\frac{20\times4}{(0.5)^2}}$

$=$ ~~4447~~ 17.88 v.

channel Bandwidth = $2 * f_m$

$\therefore 9 = 2 * f_m$

$\therefore f_m = \frac{9}{2}$

$= 4.5$ KHz

if $f_m = 200$ Hz

$\therefore SNR = 10 \log_{10} \left(\frac{P_S}{P_N}\right)$

$= 10 \log_{10} \left\{ \frac{(0.5)^2 \times (1.789 \times 10^{-5})^2 / 4}{2 \times 10^{-18} \times 200} \right.$

$= 10 \log_{10} 56 \times 10^3$

$= 46.99$

if $\mu_0 = 1$, $f_m = 1\,KHz$

$$SNR = 10 \log_{10} \left(\frac{\frac{\mu^2 A_{c}^2}{4}}{2 N_o f_m} \right)$$

$$= 10 \log_{10} \left(\frac{\frac{(1)^2 \times (1.789 \times 10^{-5})^2}{4}}{2 \times 10^{-18} \times 1000} \right)$$

$$= 10 \log_{10} 40 \times 10^3$$

$$= 46.02$$

$\mu = 1.5$, $f_m = 1\,KHz$

$$SNR = 10 \log_{10} \left(\frac{\mu^2 A_c^2/4}{2 \times N_o\ f_m} \right)$$

$$= 10 \log_{10} \frac{\frac{(1.5)^2 \times (1.78 \times 10^{-5})^2}{4}}{2 \times 10^{-18} \times 1000}$$

$$= 49.49$$

Nureen (1832104?)

05

if $f_m = 4.5$ KHz
$= 4500$ Hz

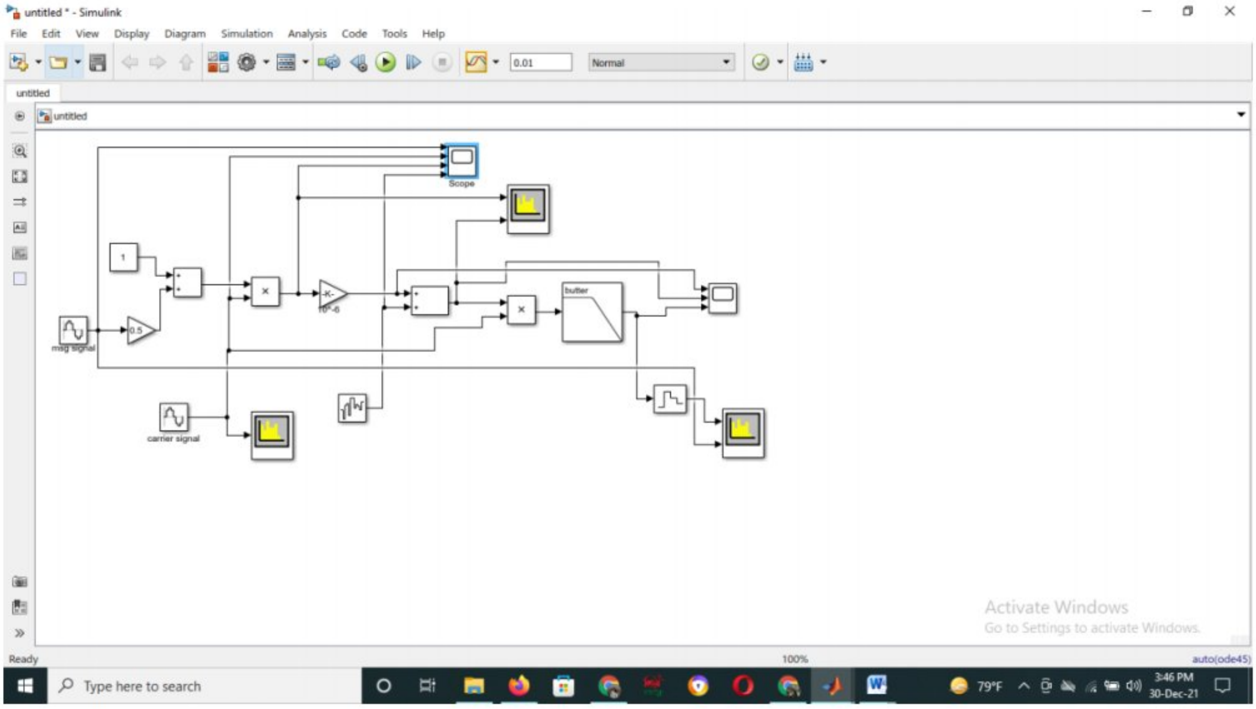
$$SNR = 10 \log_{10} \left(\frac{P_S}{P_N} \right)$$

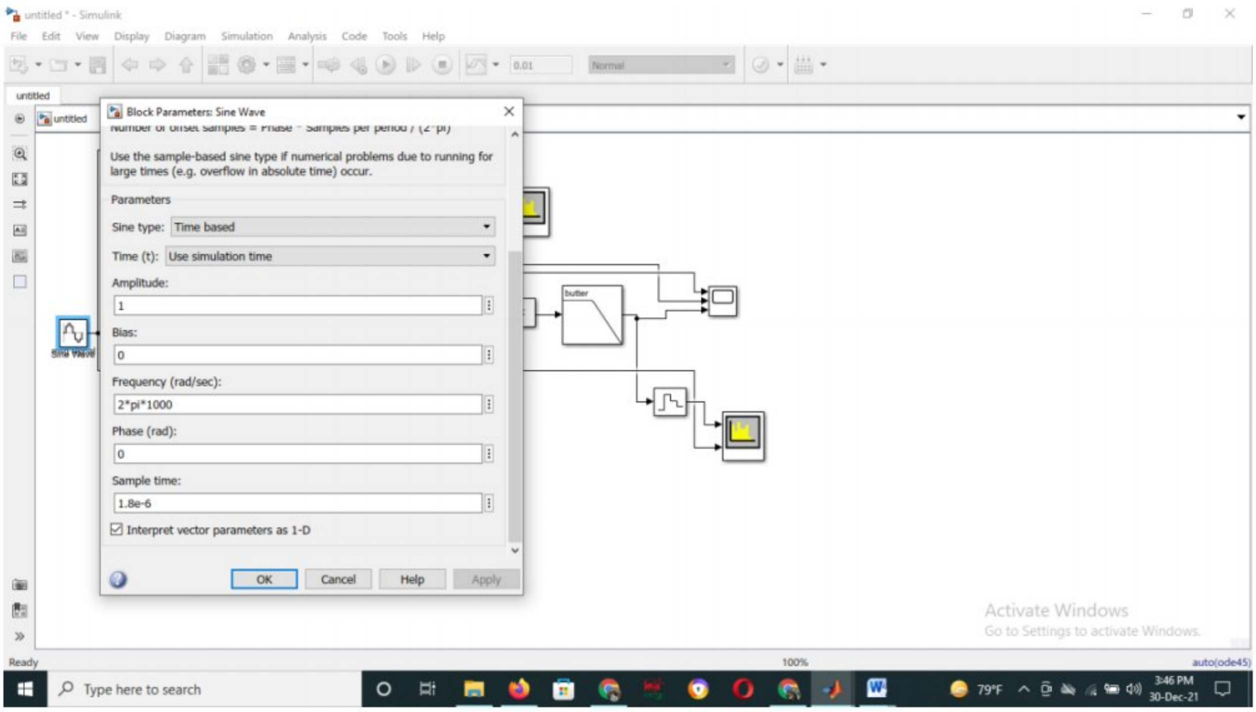
$$= 10 \log_{10} \left\{ \frac{\frac{(0.5)^2 \times (1.789 \times 10^{-5})^2}{4}}{2 \times 10^{-18} \times 4500} \right\}$$

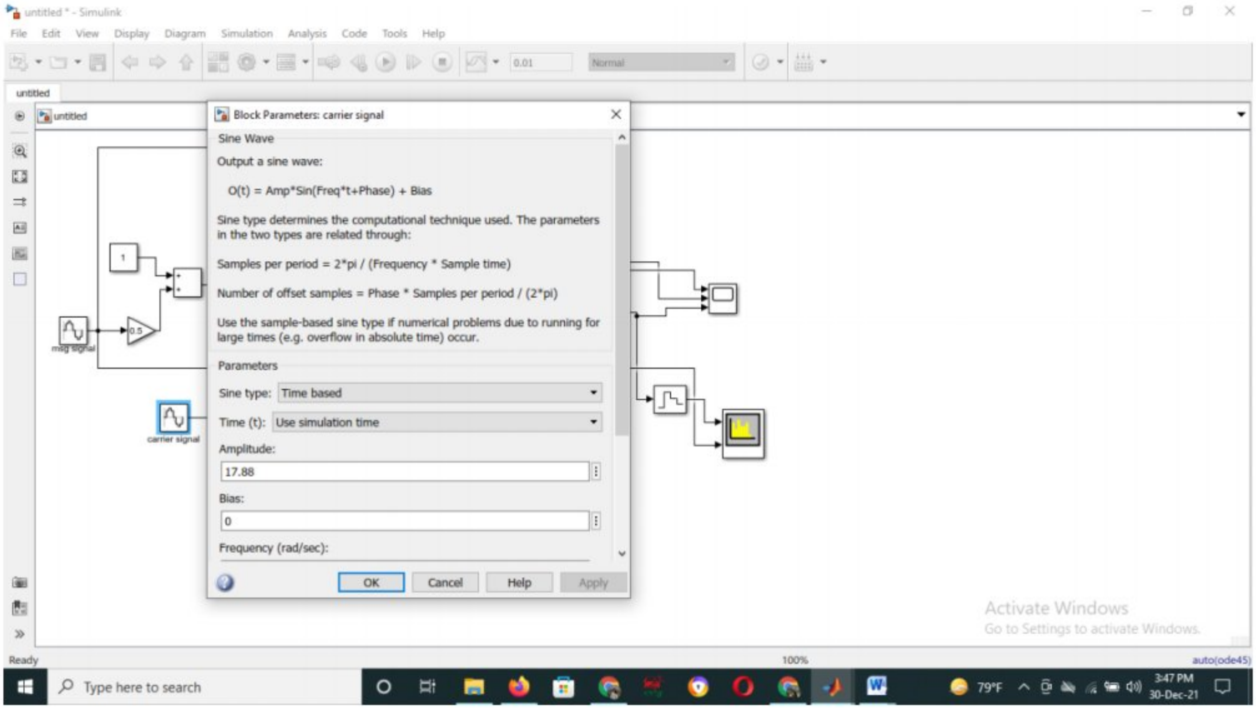
$$= 10 \log_{10} 2222.58$$

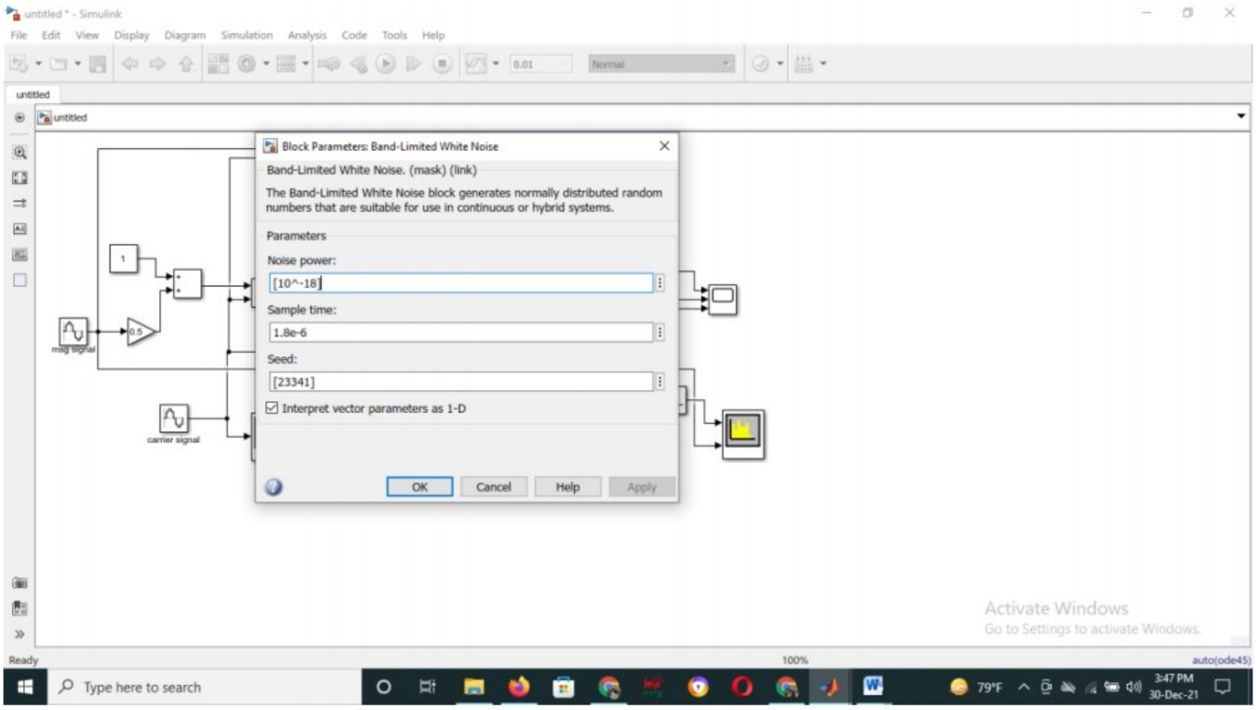
$$= 33.47$$

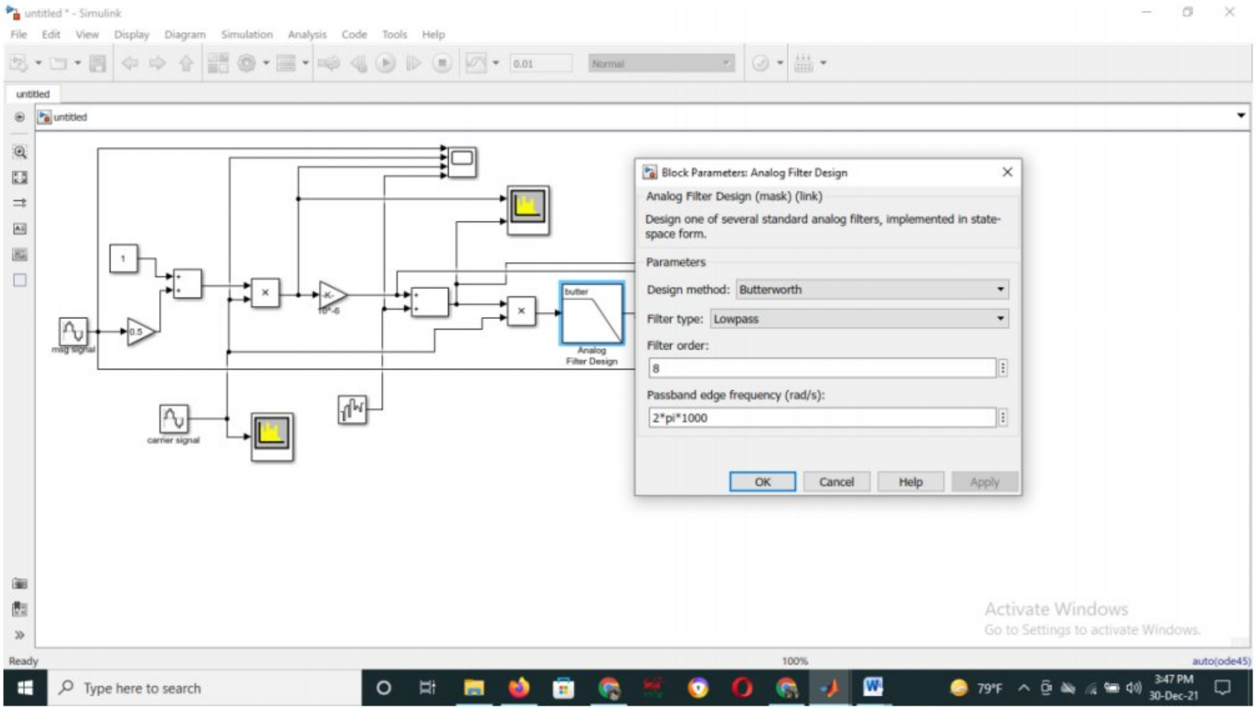
Block Diagram :





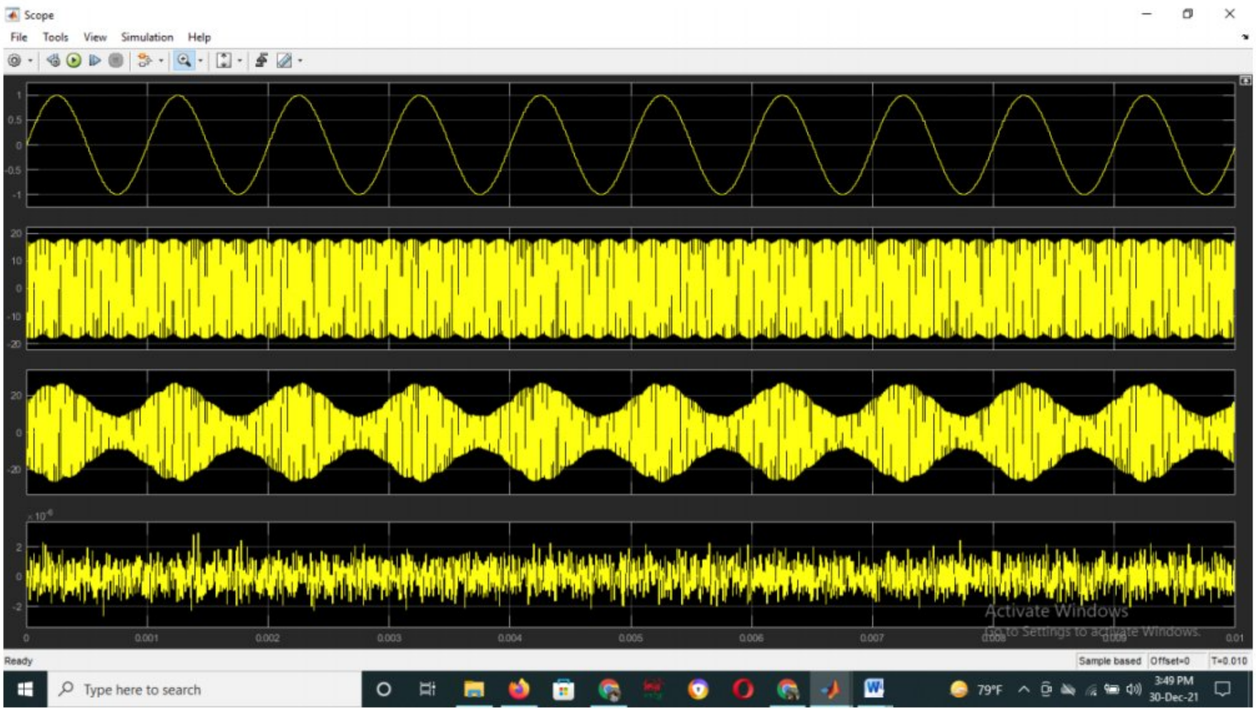

untitled * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
Block Parameters: carrier signal
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(Freq*t+Phase) + Bias
Sine type determines the computational technique used. The parameters in the two types are related through:
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per period / (2*pi)
Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.
Parameters
Sine type: Time based
Time (t): Use simulation time
Amplitude:
17.88
Bias:
0
Frequency (rad/sec):
OK Cancel Help Apply
msg signal
carrier signal
Activate Windows
Go to Settings to activate Windows.
Ready
100%
auto(ode45)
Type here to search
79°F
3:47 PM
30-Dec-21


untitled * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
Block Parameters: Band-Limited White Noise
Band-Limited White Noise. (mask) (link)
The Band-Limited White Noise block generates normally distributed random numbers that are suitable for use in continuous or hybrid systems.
Parameters
Noise power:
[10^-18]
Sample time:
1.8e-6
Seed:
[23341]
Interpret vector parameters as 1-D
OK Cancel Help Apply
msg signal
carrier signal
Activate Windows
Go to Settings to activate Windows.
Ready
100%
auto(ode45)
Type here to search
79°F
3:47 PM
30-Dec-21

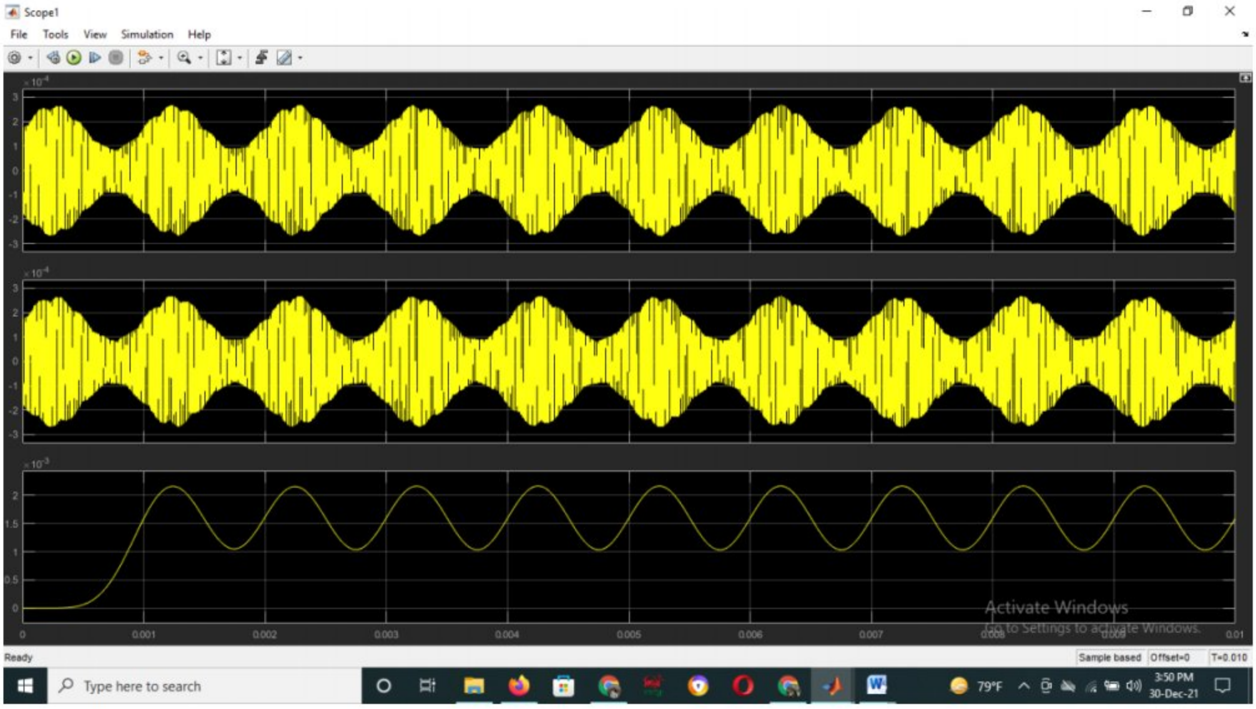


Results:

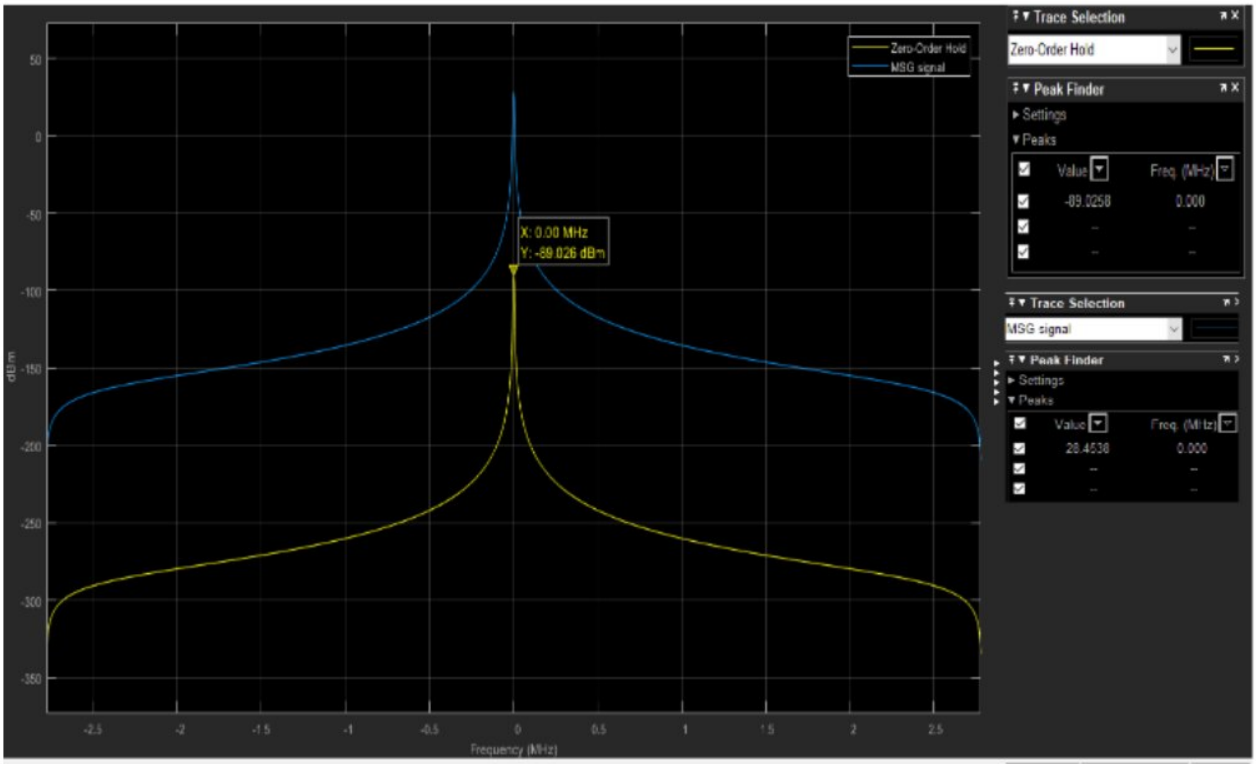
waveform of message, carrier, Modulated signal and noise:



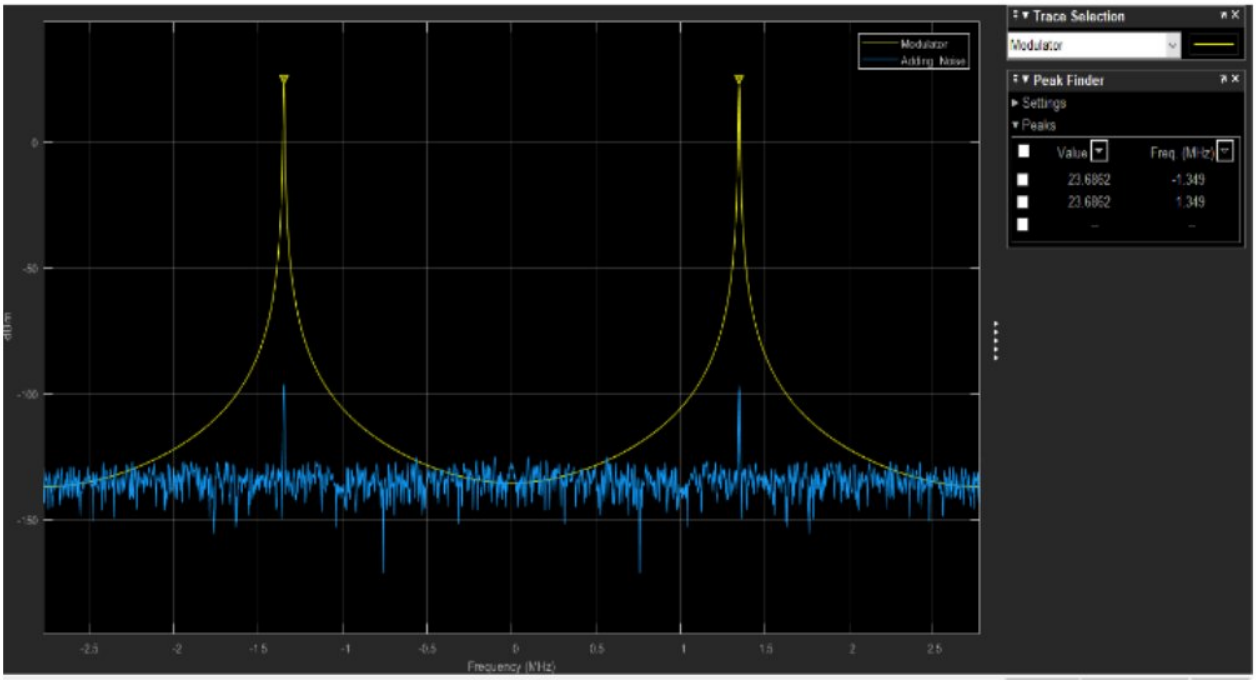
waveform of channel loss, added noise and demodulated filtered signal



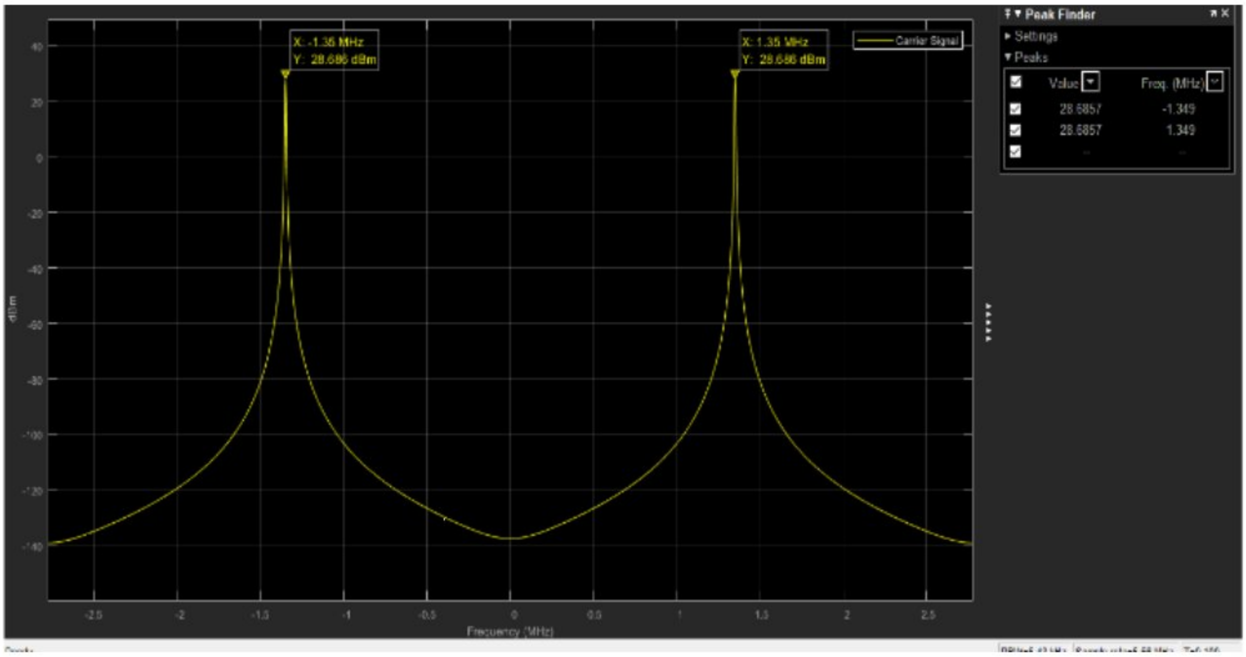
Spectrum of massage signal and output signa



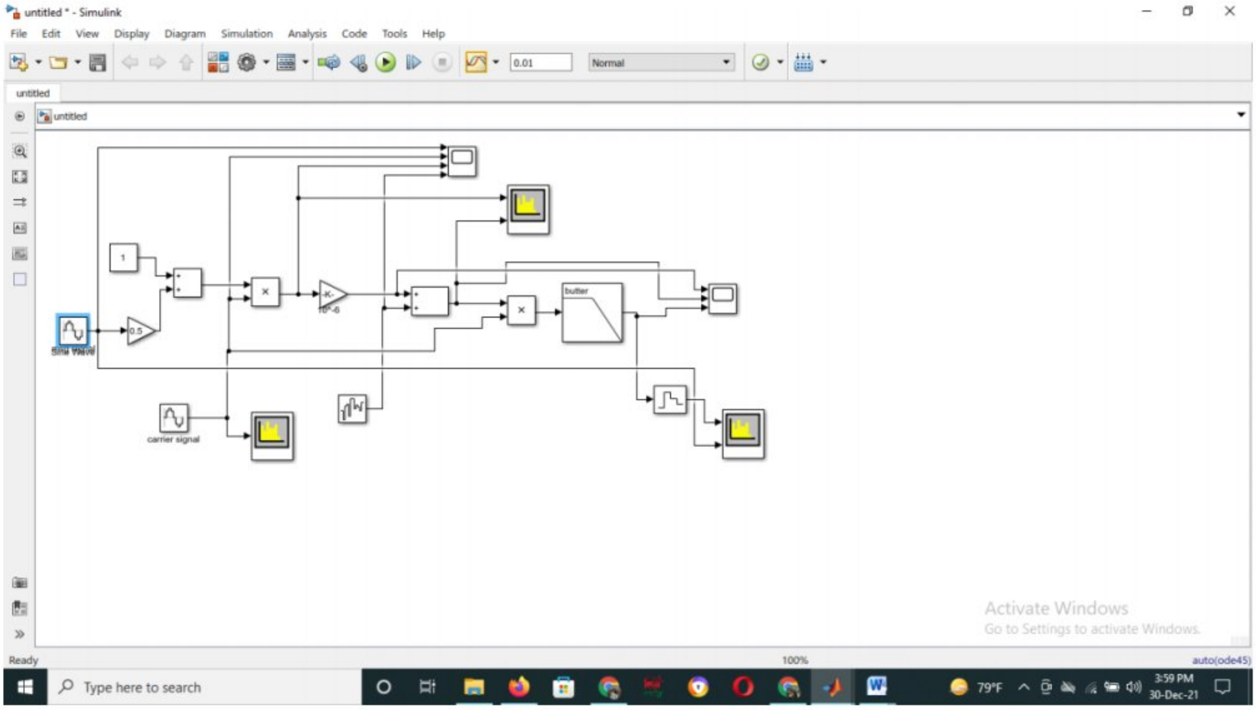
Spectrum of modulated signal and received signal

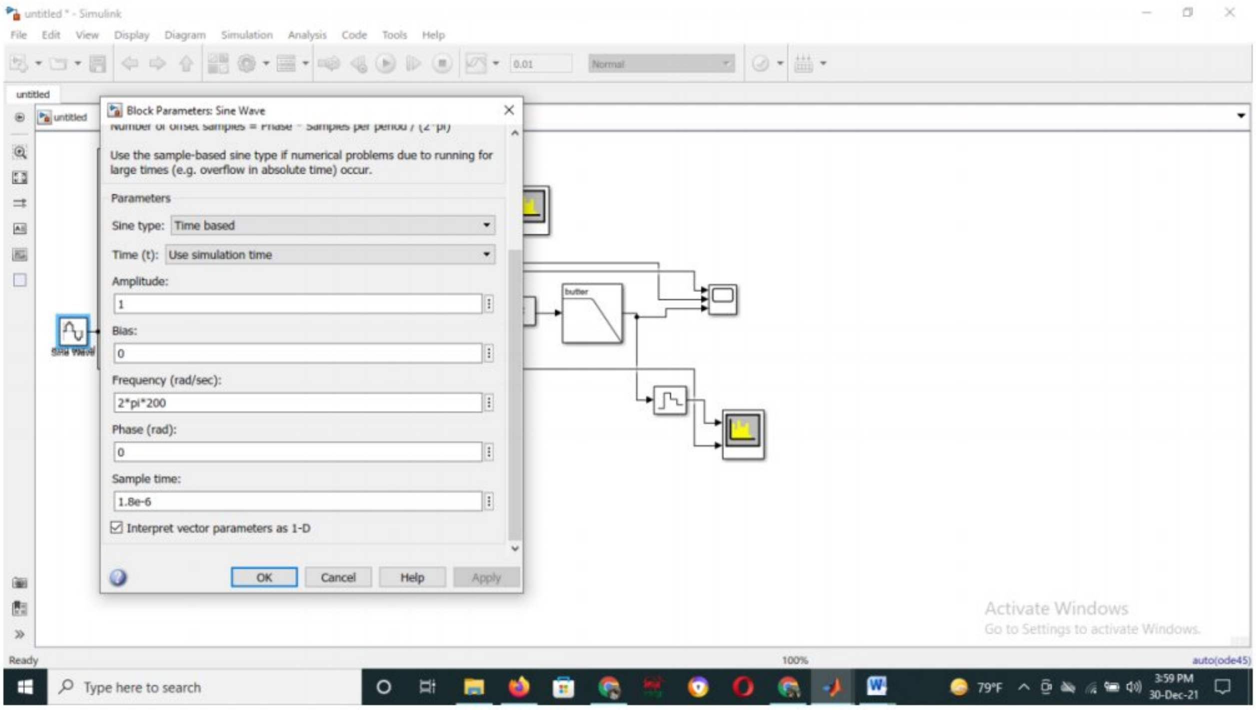


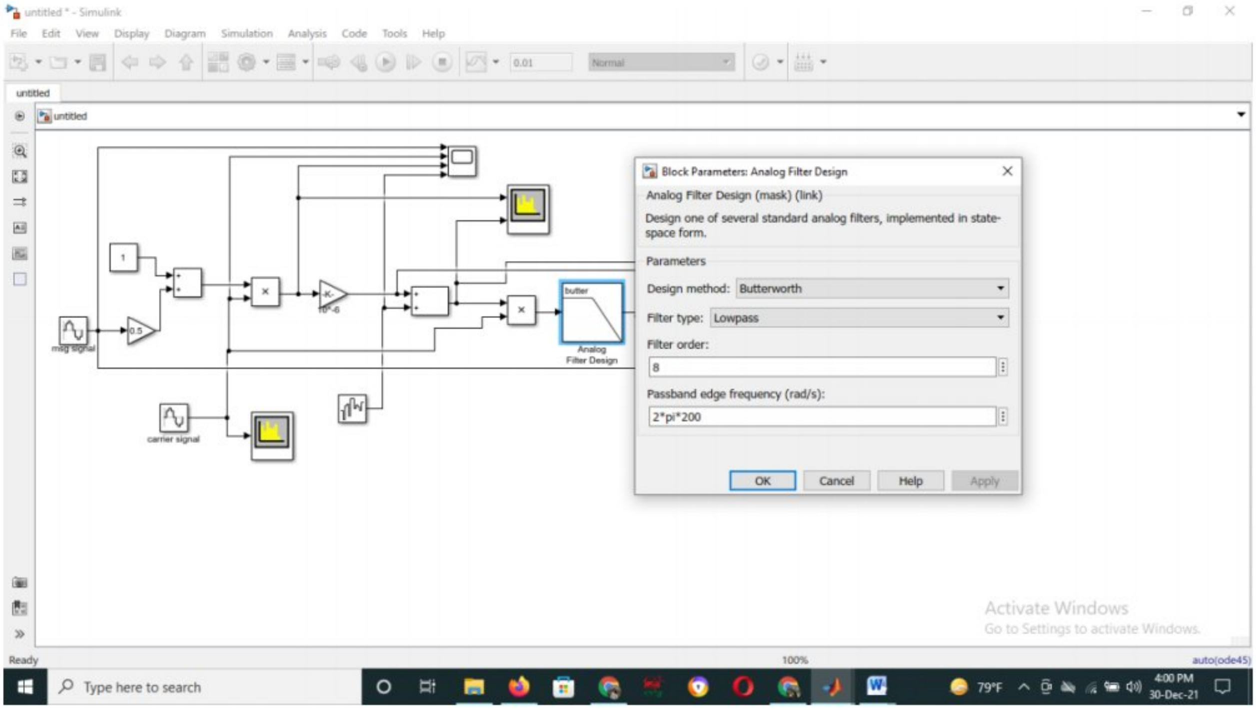
Carrier power from the graph



Changed, massage frequency=200Hz & filter cut off frequency=200Hz

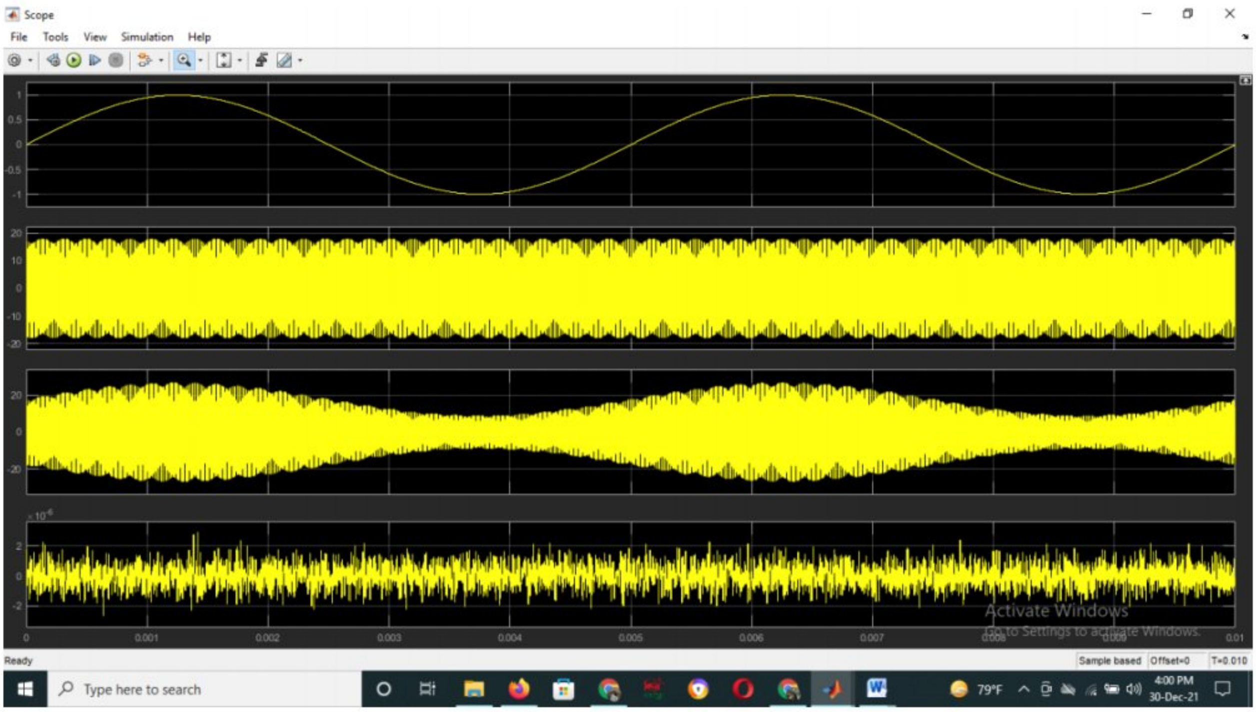




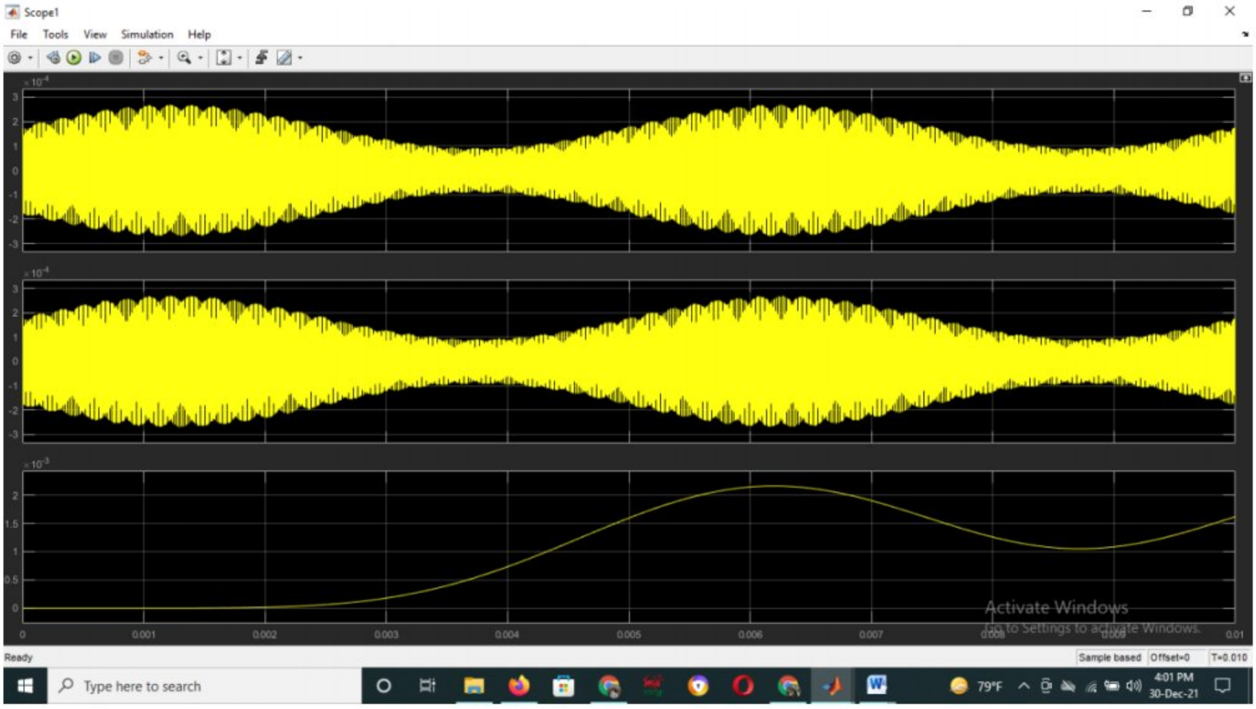


Results:

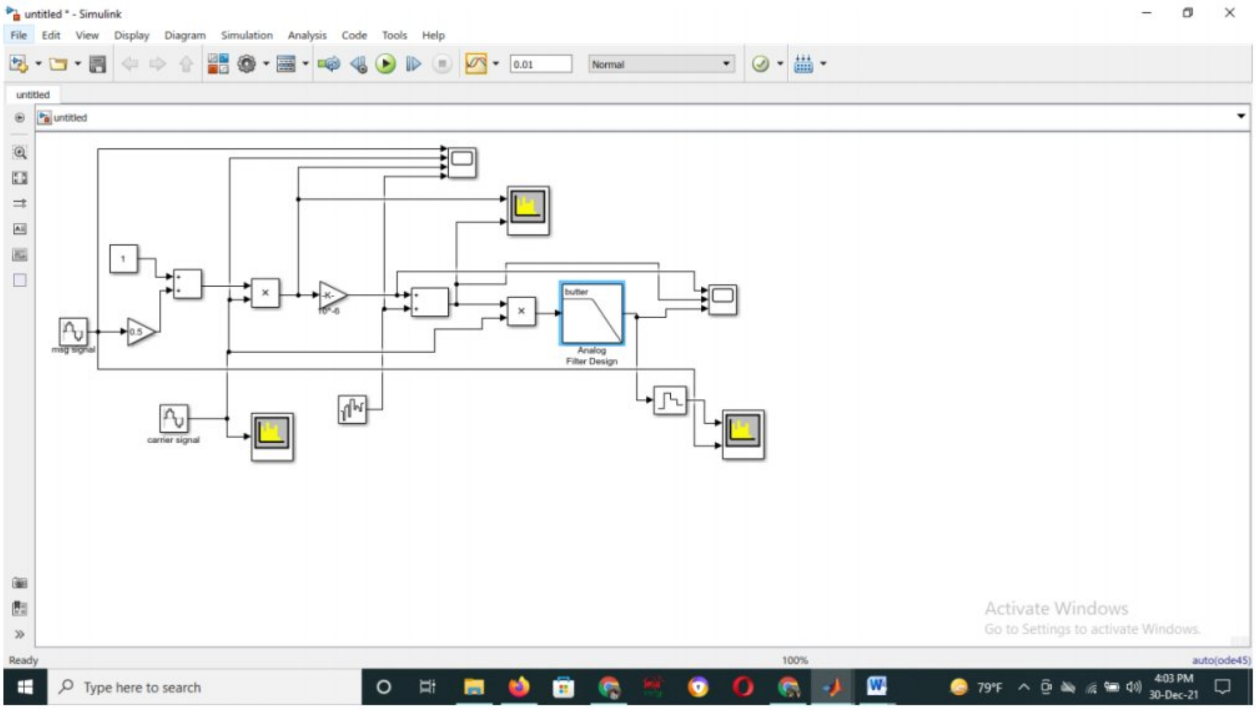
waveform of message, carrier, Modulated signal and noise

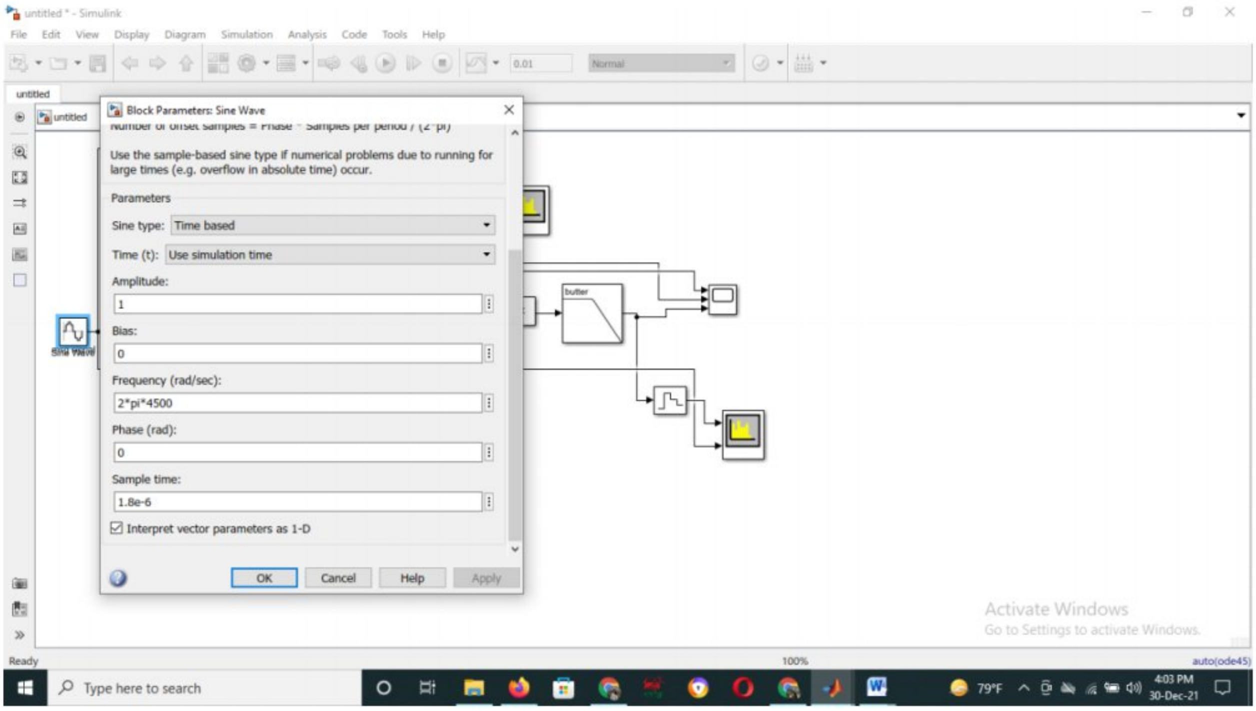


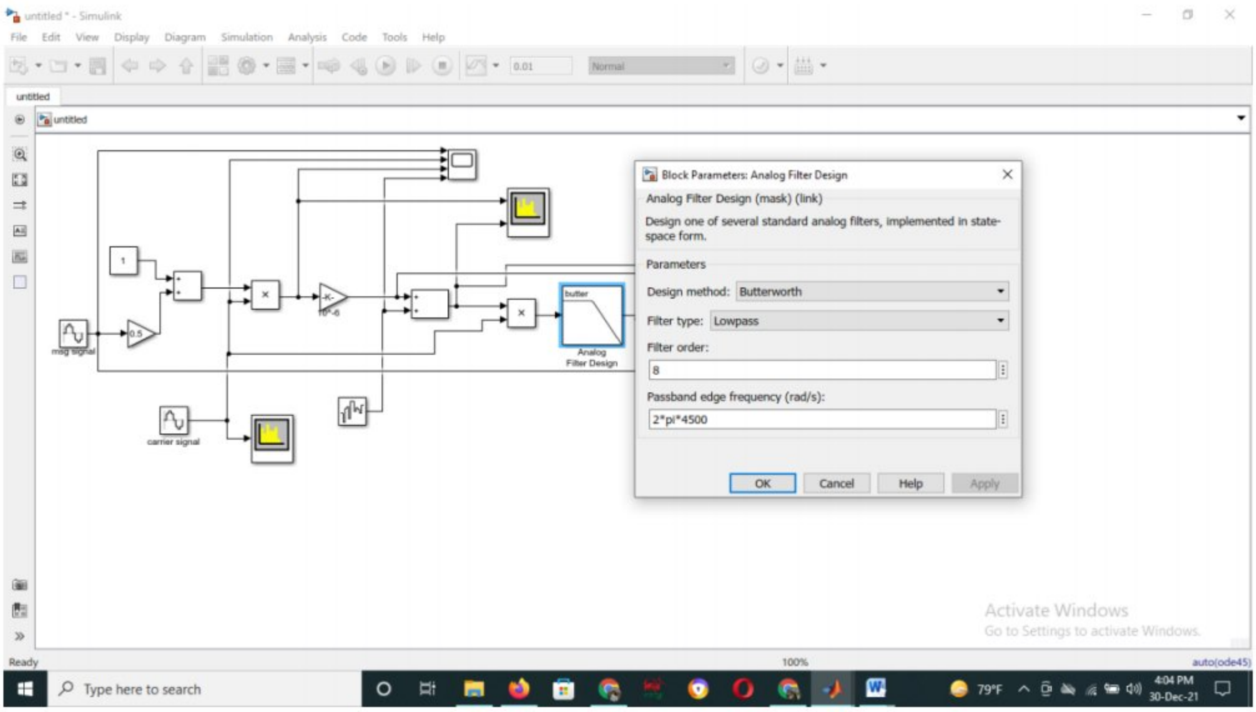
waveform of channel loss, added noise and demodulated filtered signal



Changed, massage frequency=4500Hz & filter cut off frequency=4500Hz

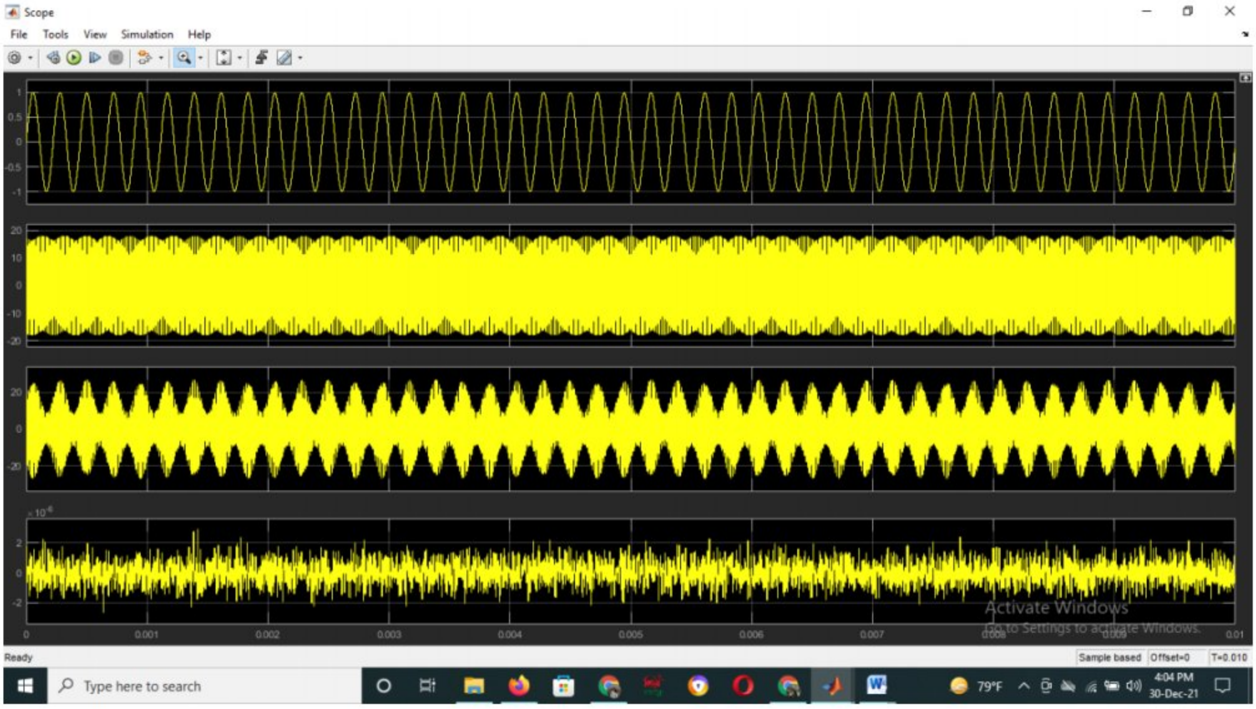



untitled * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
Block Parameters: Sine Wave
Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.
Parameters
Sine type: Time based
Time (t): Use simulation time
Amplitude:
1
Bias:
0
Frequency (rad/sec):
2*pi*4500
Phase (rad):
0
Sample time:
1.8e-6
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply
butter
Sine Wave
Activate Windows
Go to Settings to activate Windows.
Ready
100%
auto(ode45)
Type here to search
79°F
4:03 PM
30-Dec-21

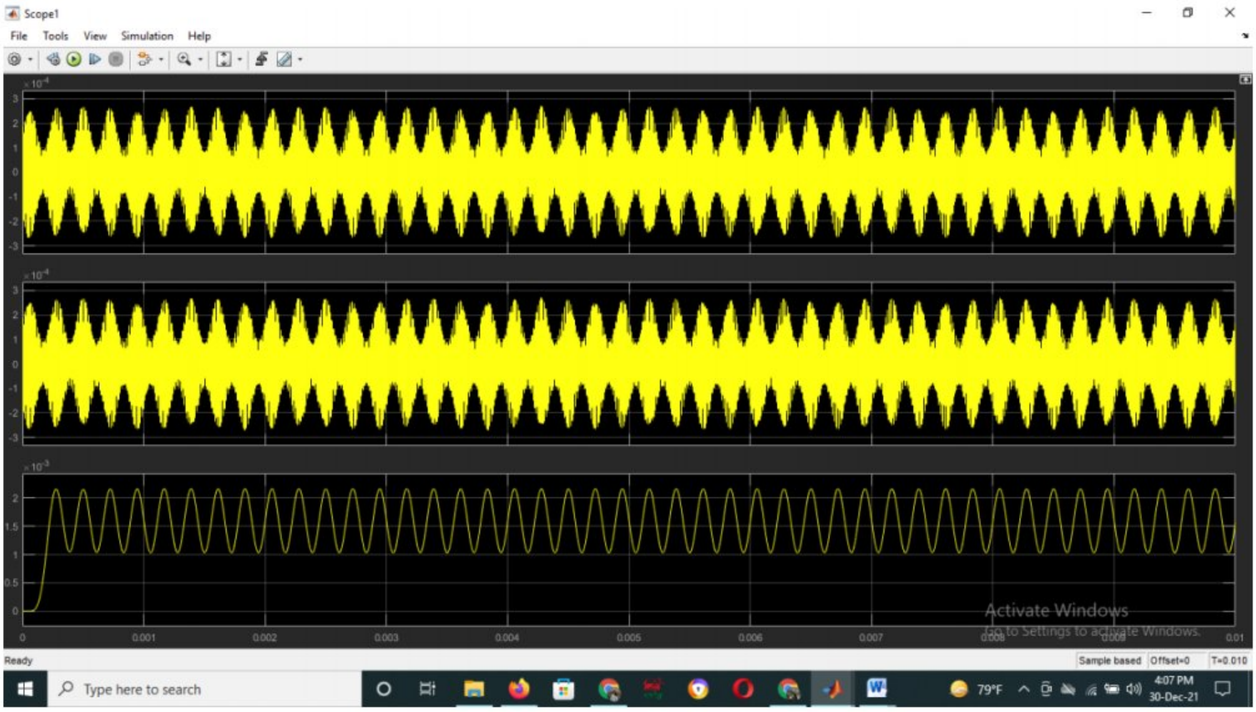

untitled * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
Block Parameters: Analog Filter Design
Analog Filter Design (mask) (link)
Design one of several standard analog filters, implemented in state-space form.
Parameters
Design method: Butterworth
Filter type: Lowpass
Filter order:
8
Passband edge frequency (rad/s):
2*pi*4500
OK
Cancel
Help
Apply
msg signal
carrier signal
Analog Filter Design
butter
0.5
1
Activate Windows
Go to Settings to activate Windows.
Ready
100%
auto(ode45)
Type here to search
79°F
4:04 PM
30-Dec-21

Results:

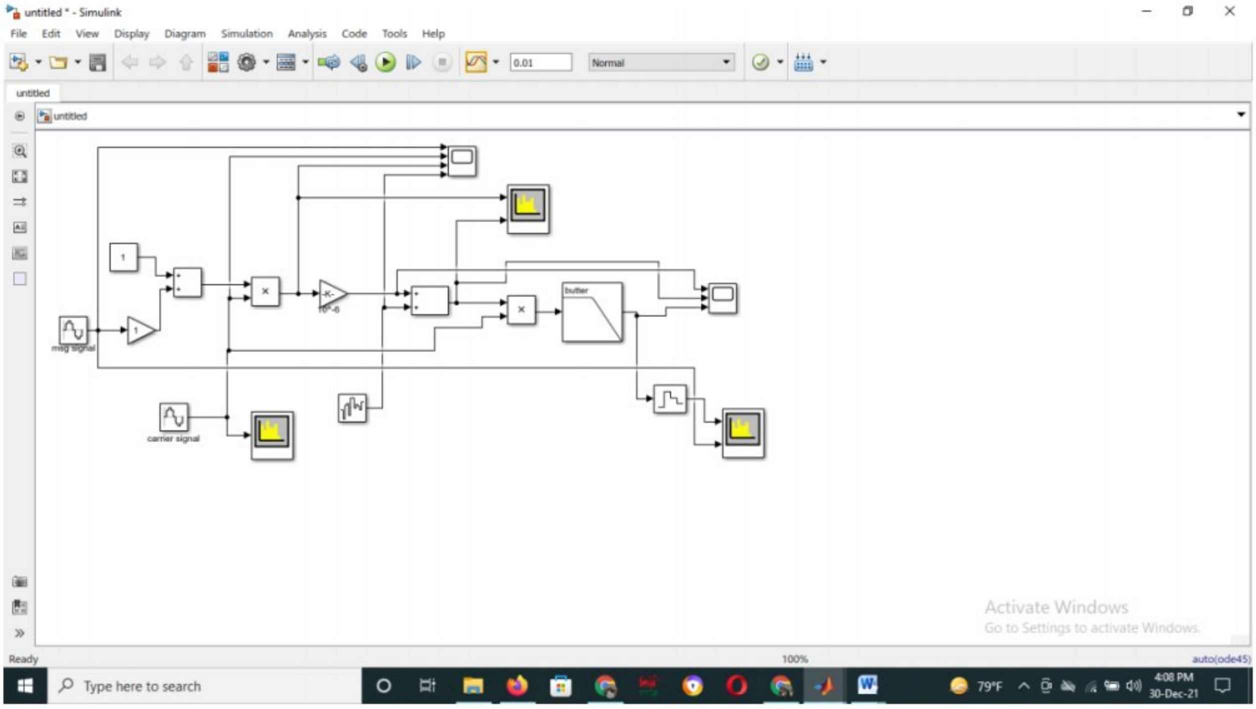
waveform of message, carrier, Modulated signal and noise



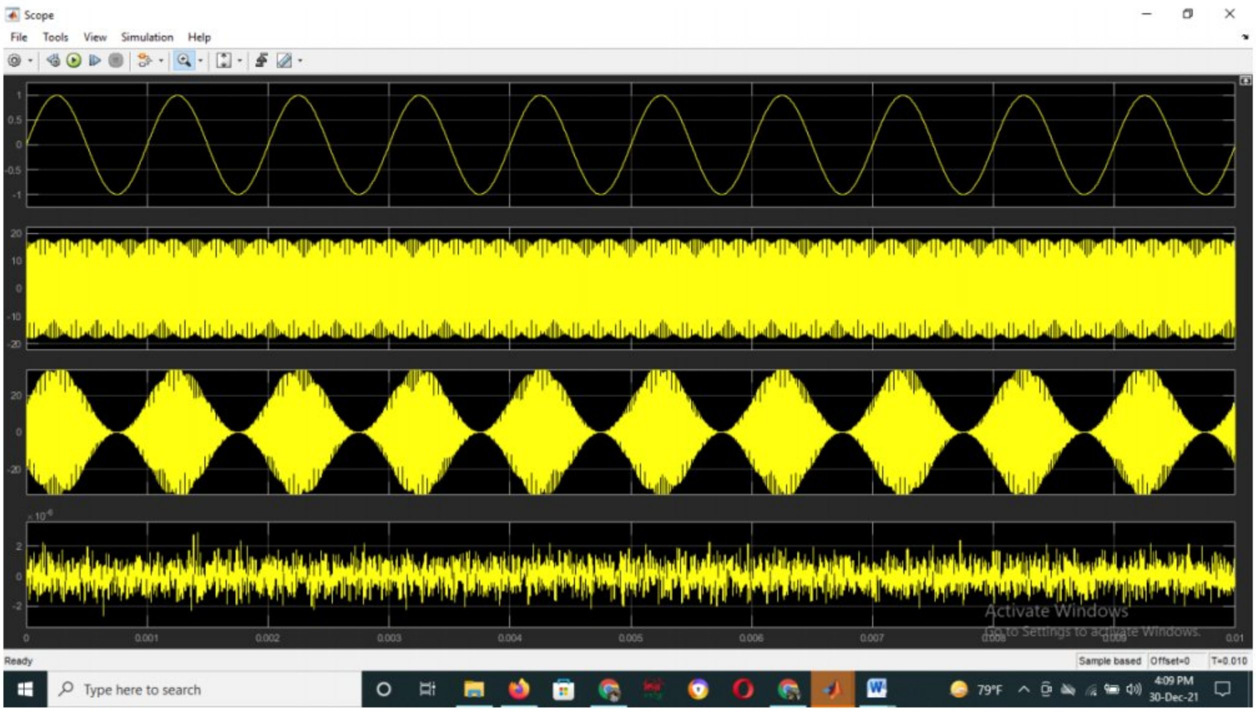
waveform of channel loss, added noise and demodulated filtered signal



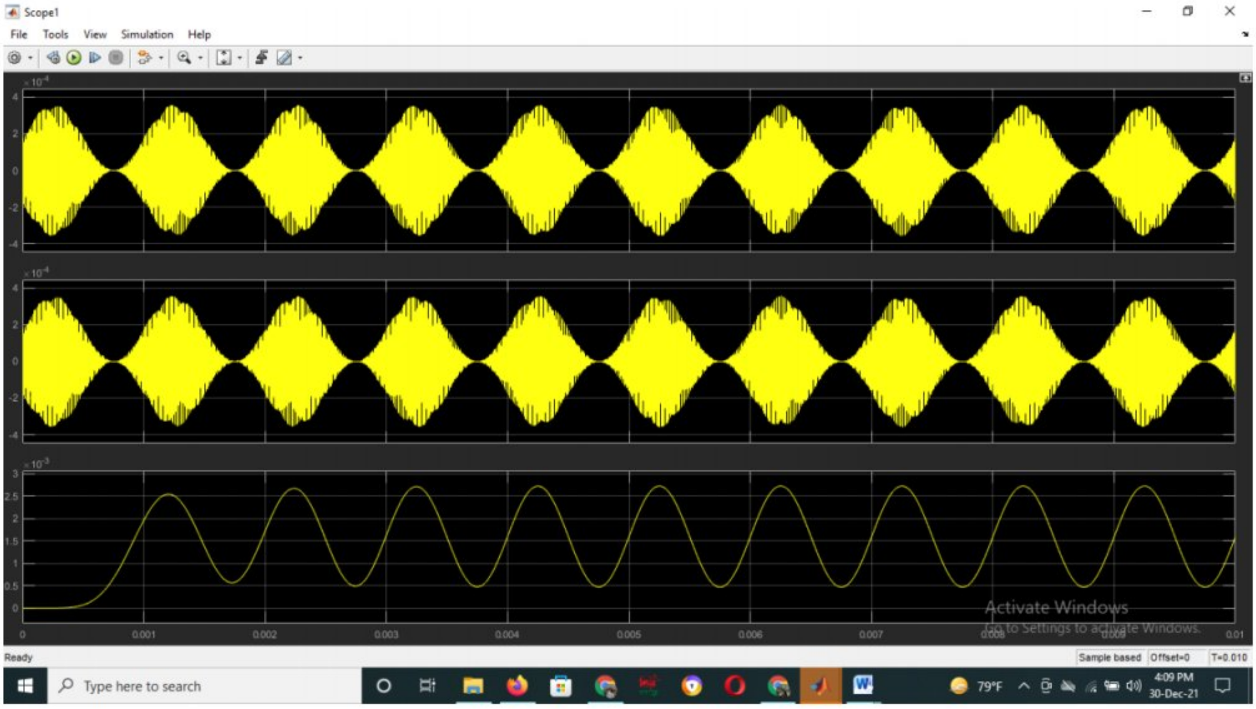
For modulation index = 1

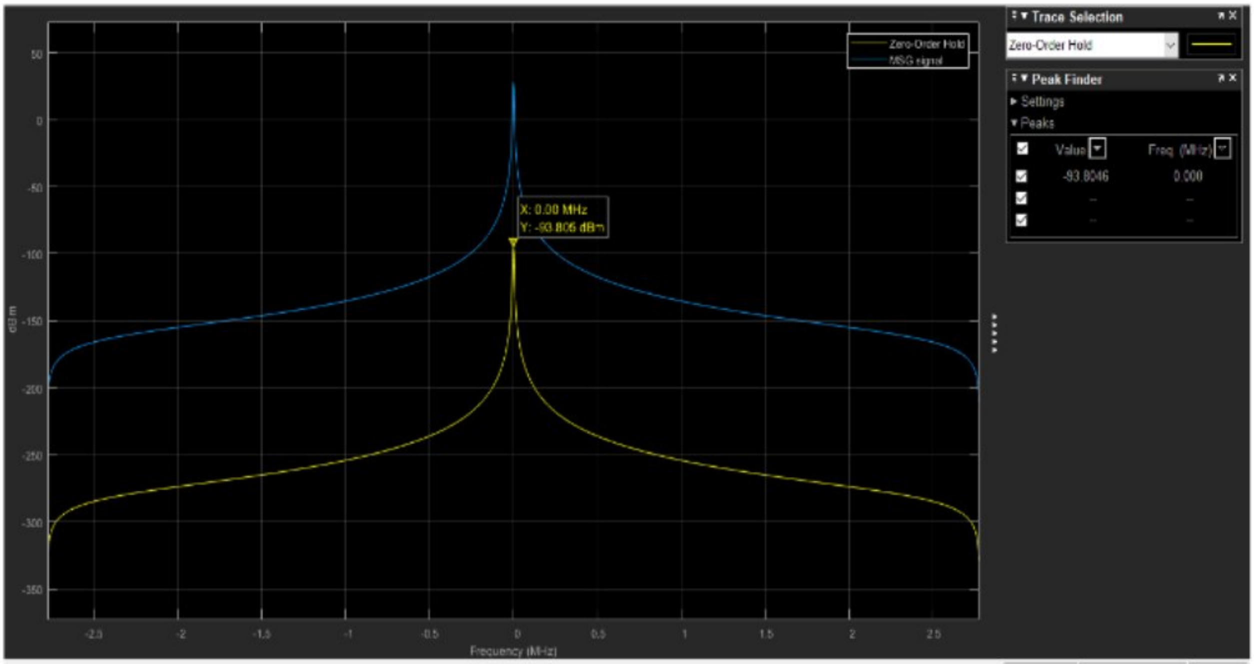


waveform of message, carrier, Modulated signal and noise

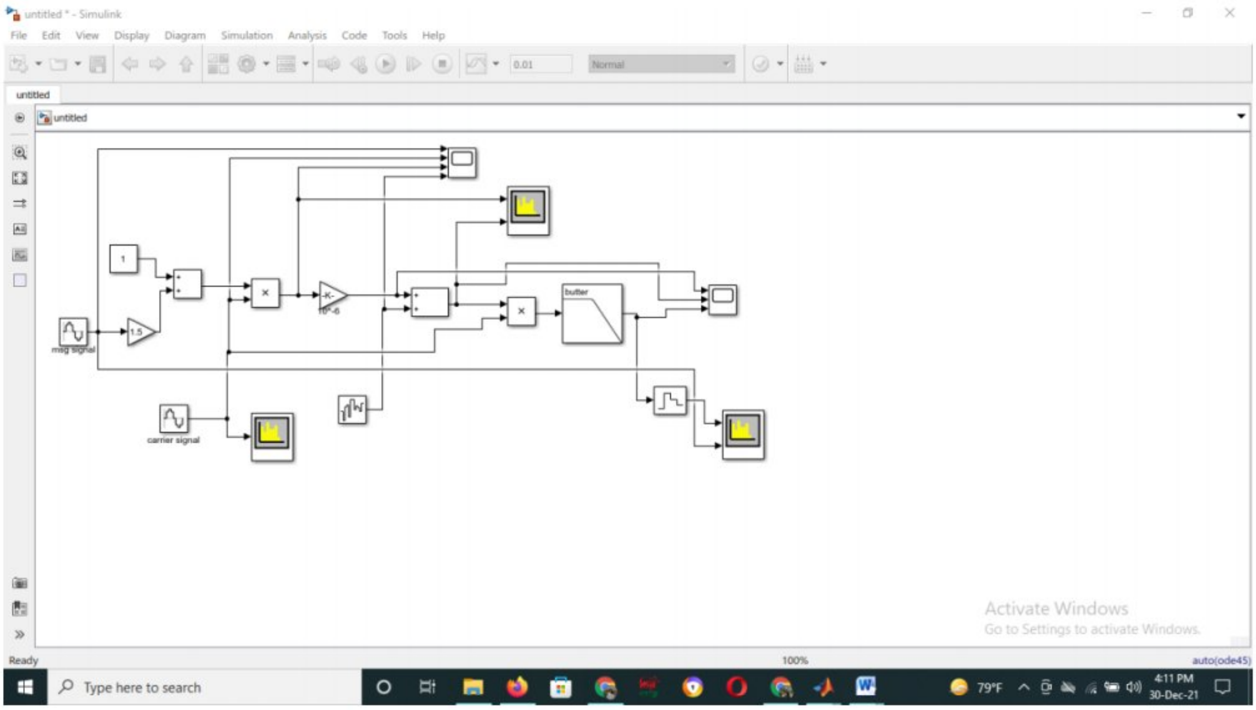


waveform of channel loss, added noise and demodulated filtered signal

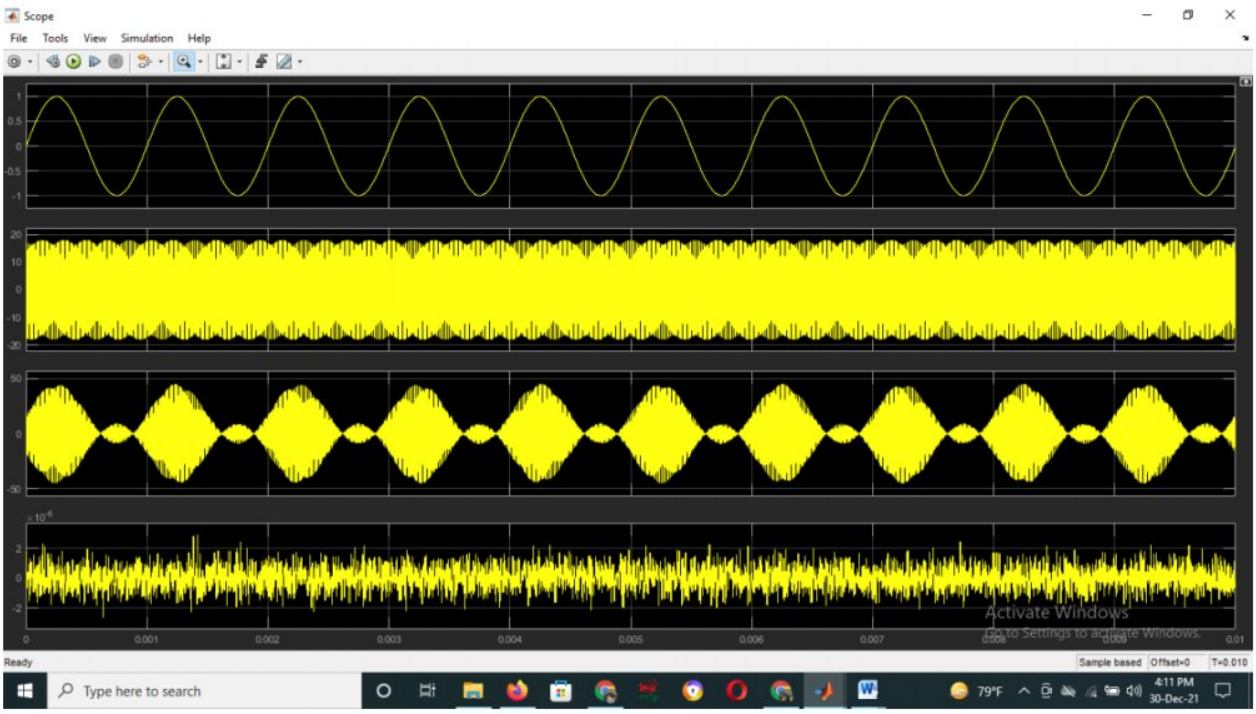




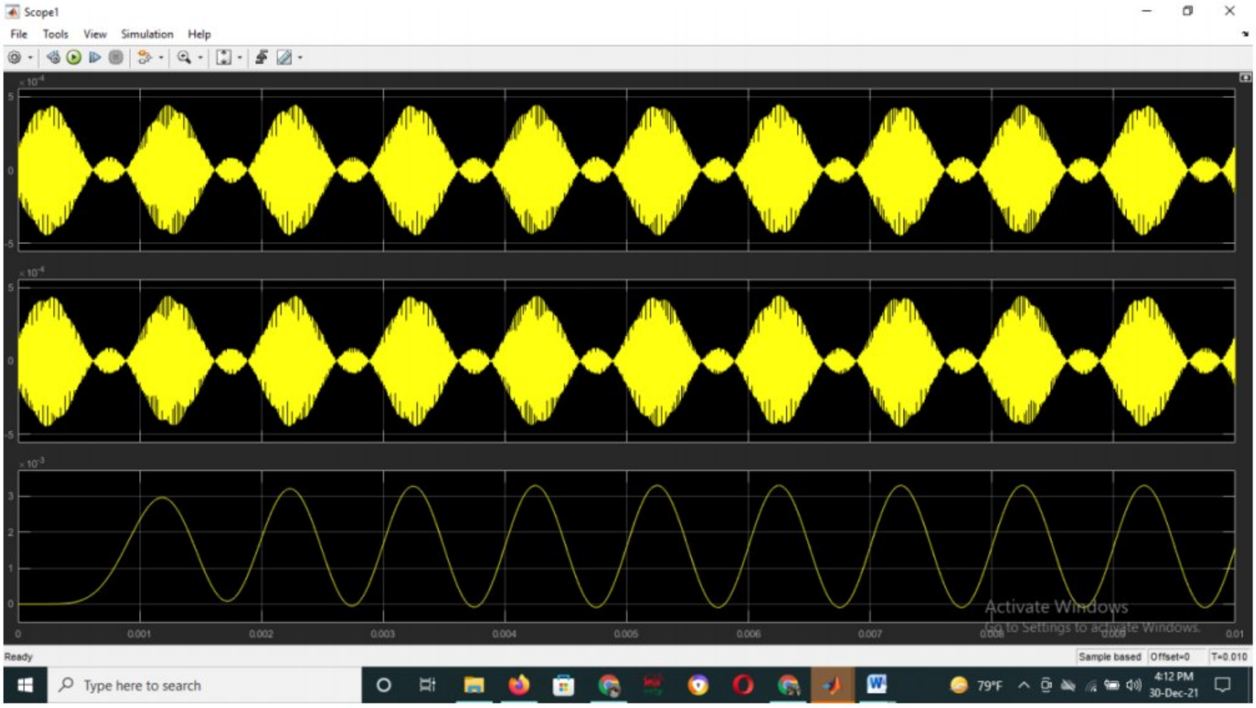
For modulation index = 1.5

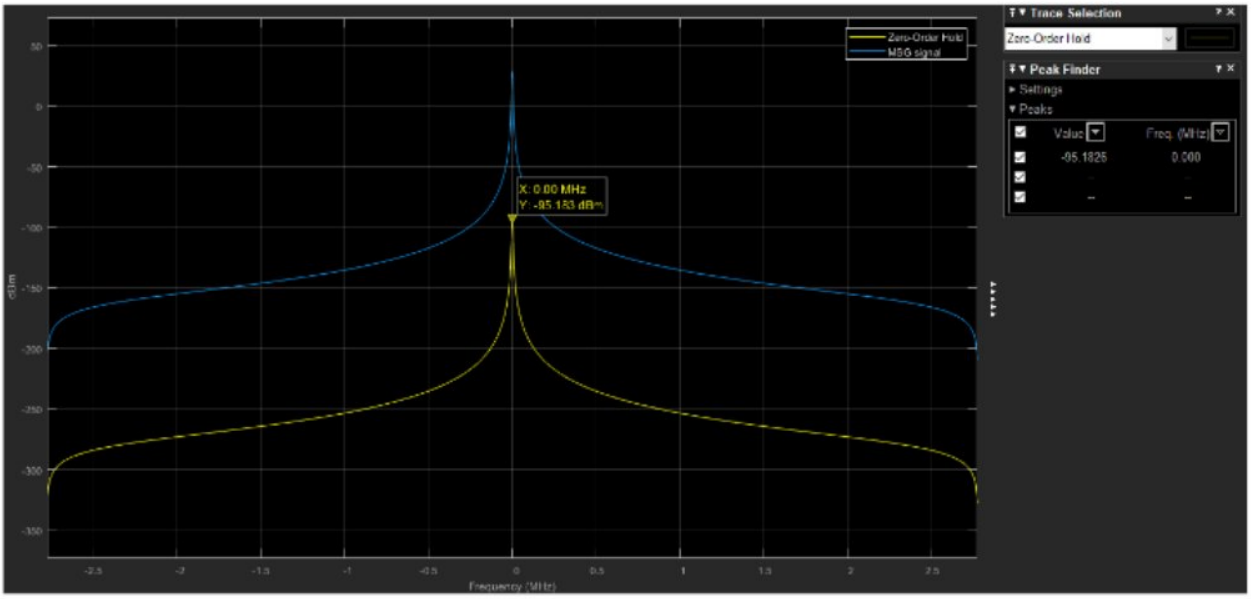


waveform of message, carrier, Modulated signal and noise



waveform of channel loss, added noise and demodulated filtered signal





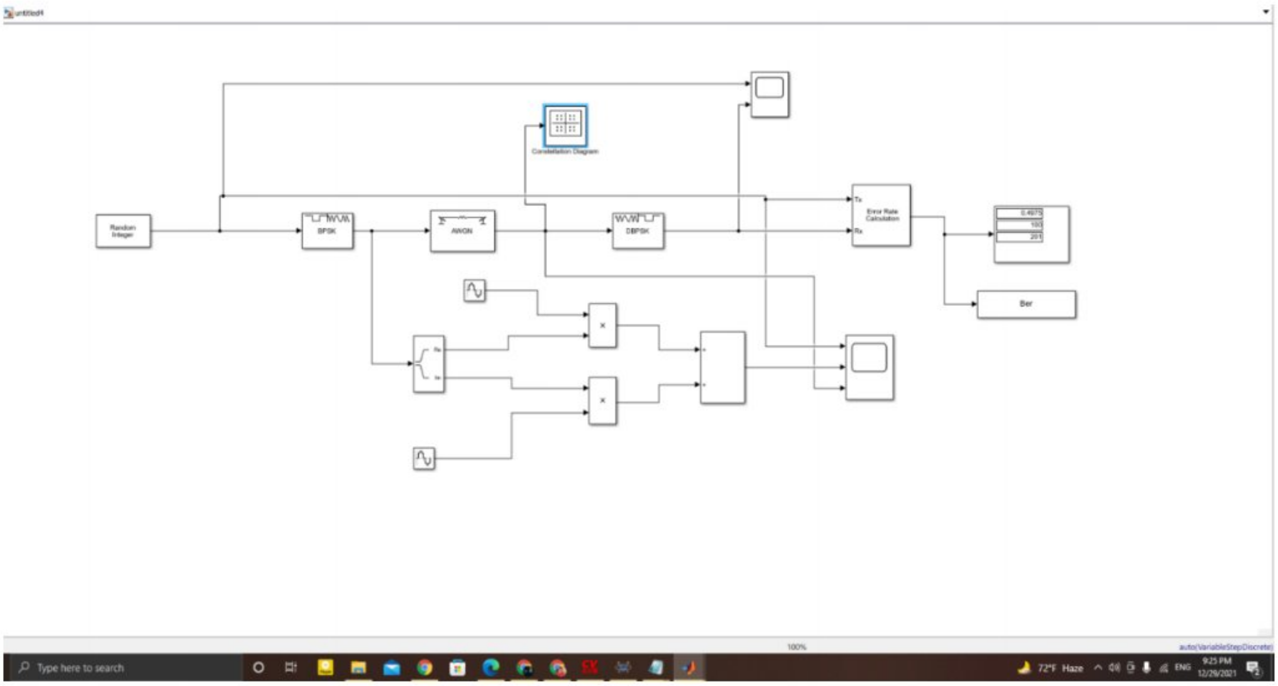
<u>Discussion & Conclusion:</u>

Modulation Index =1 gives perfect modulation (100%). Whenever MI<1 we get under modulation. The demodulated component became more distorted when the gain was increased, suggesting an increase in the modulation index to 1 and then 1.5. We could see there was already an over modulation as soon as we examined at the time domain graph of the modulation index 1.5. Modulation exceeding 1 (MI>1) results in over modulation and distortion, which is why it is strongly discouraged. When, MI value is more than 1, the carrier experiences a 180 degree phase reversal, which causes additional sidebands, hence the wave shape gets distorted. Over modulated wave causes interference which cannot be eliminated. SNR also changed while changing MI. For MI= 0.5 SNR is 40 ; when MI= 1 our SNR is 46.02 and for MI=1.5, SNR=49.49 and fm=4500hz then SNR =33.47

When we altered the message signal to 200 Hz, we can visualize from the figures given above that our output wave forms changed radically.We had trouble creating the entire process and computing the necessary queries. We had to conduct extensive research in this topic and watch our theory lesson videos to gain a general comprehension of the fundamentals.

Task 2-3

Circuit Diagram for Binary Phase Shift keying



Simulink Blocks

1.Random Integer Generator

2.BPSK modulator and demodulator

3.AWGN channel

4.Complex to Real Image block

5.Constellation block

6.Sine Wave

7.Scope

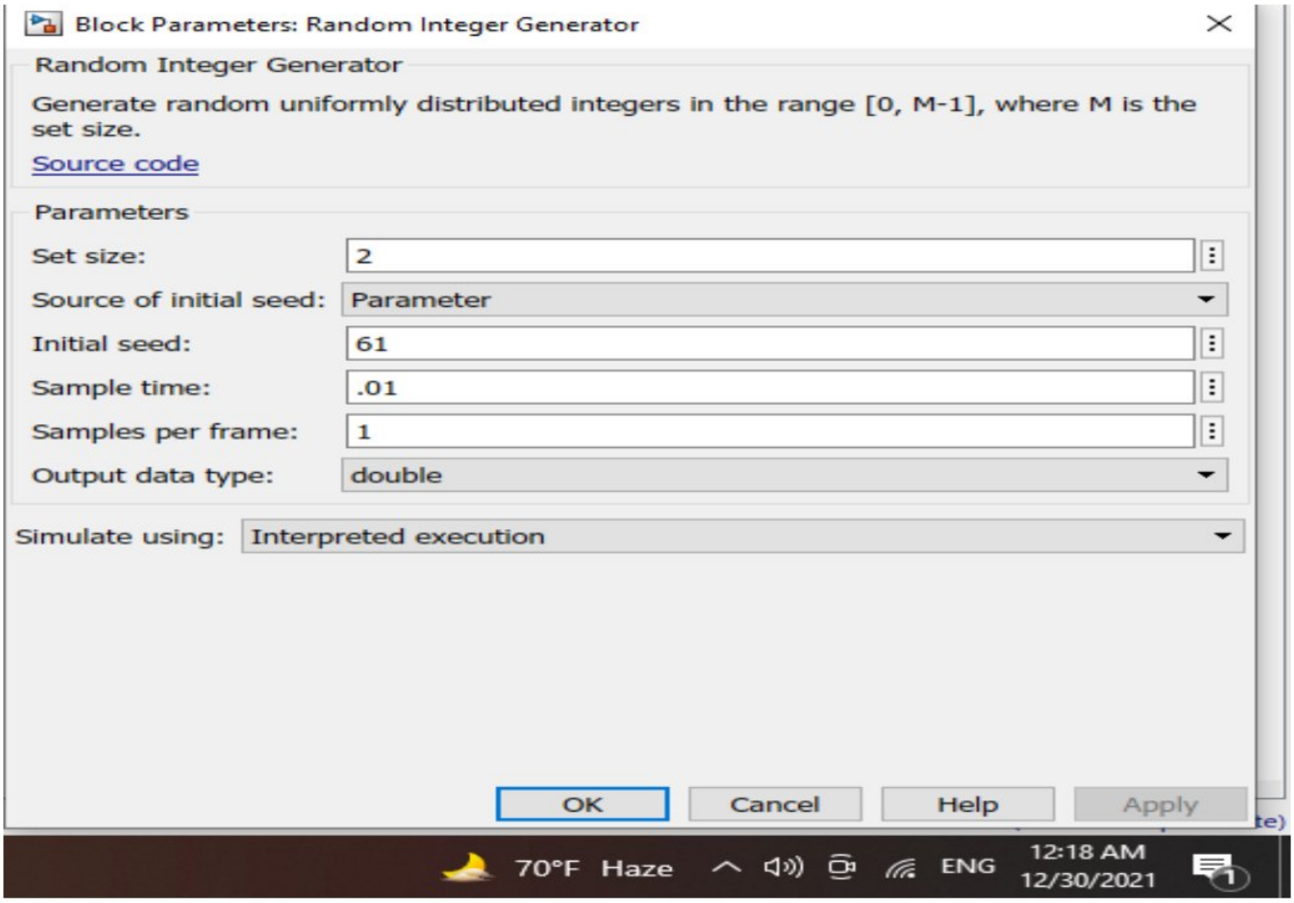
8.Error rate calculation

9.Display and To Workspace block

10.Product and adder block.

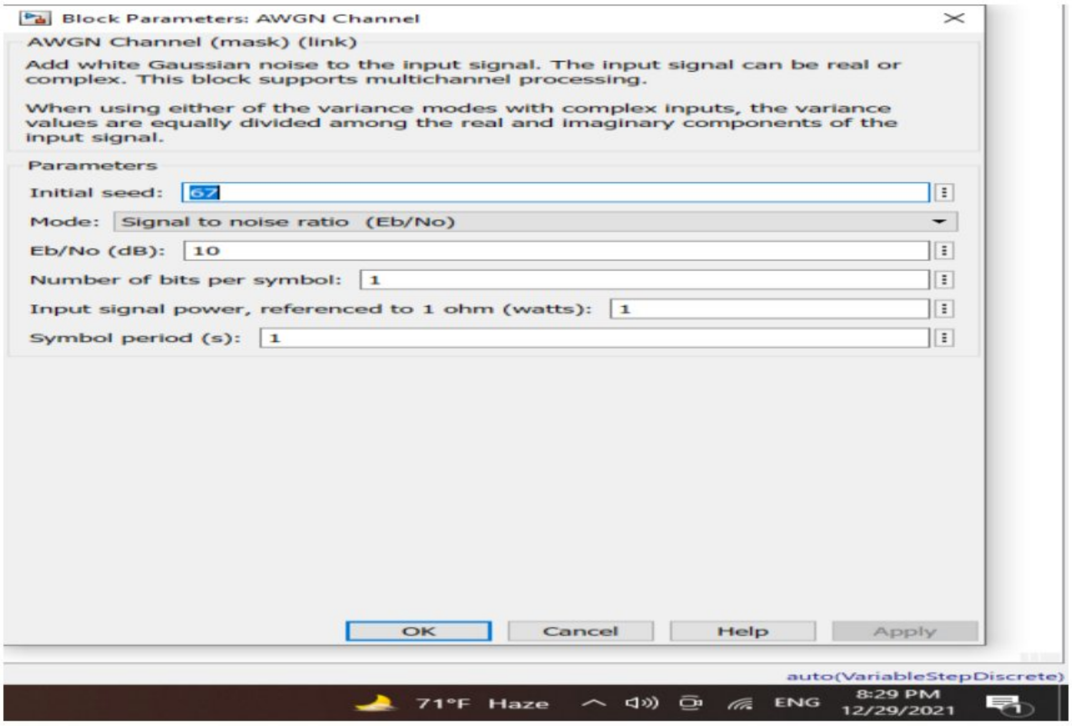
Parameters for the BPSK

1.Random Generator: Set size 2 defines that it generate one bit at a time which is either 0 or 1.

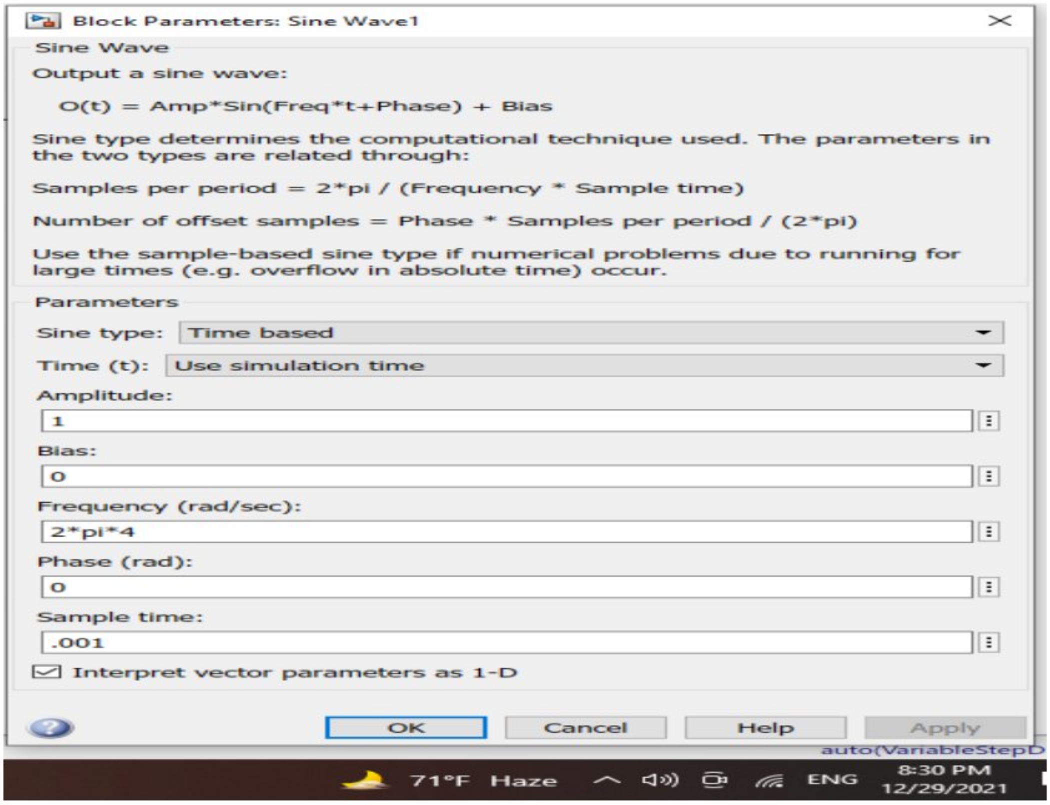


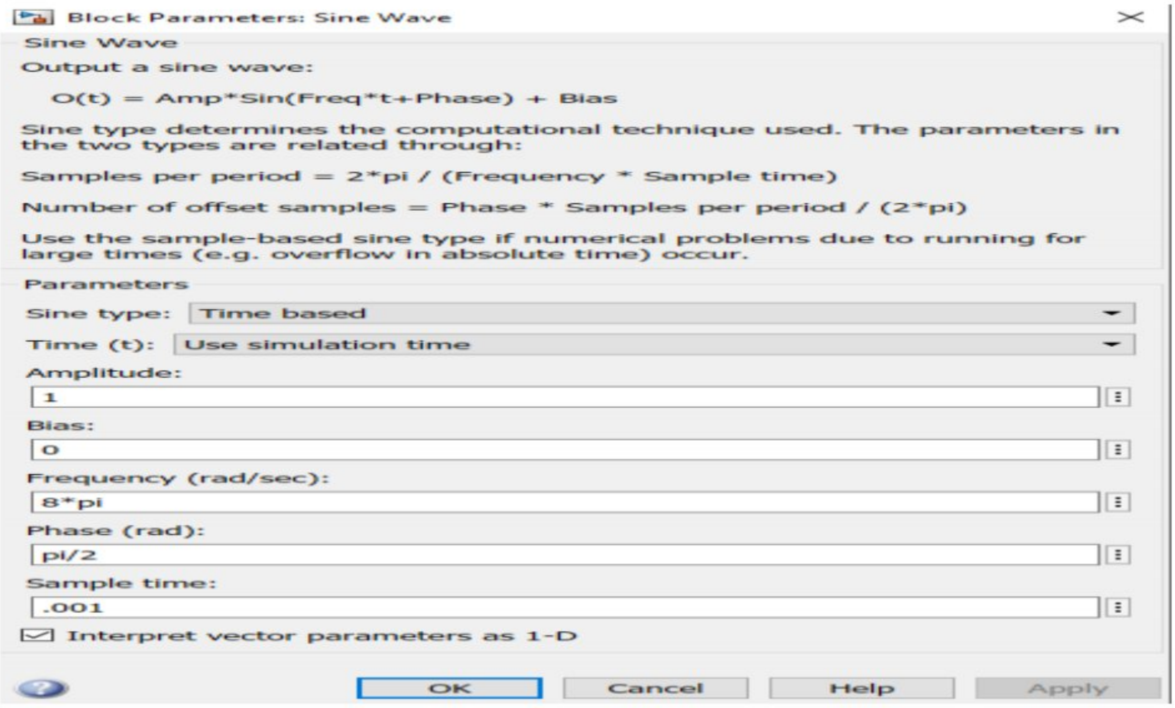
2.Additive White Gaussian Noise Channel

We vary Eb/No from 0 to: 20 with an increment of 5 to observe the bit error rate for both BPSK and QPSK communication channel.

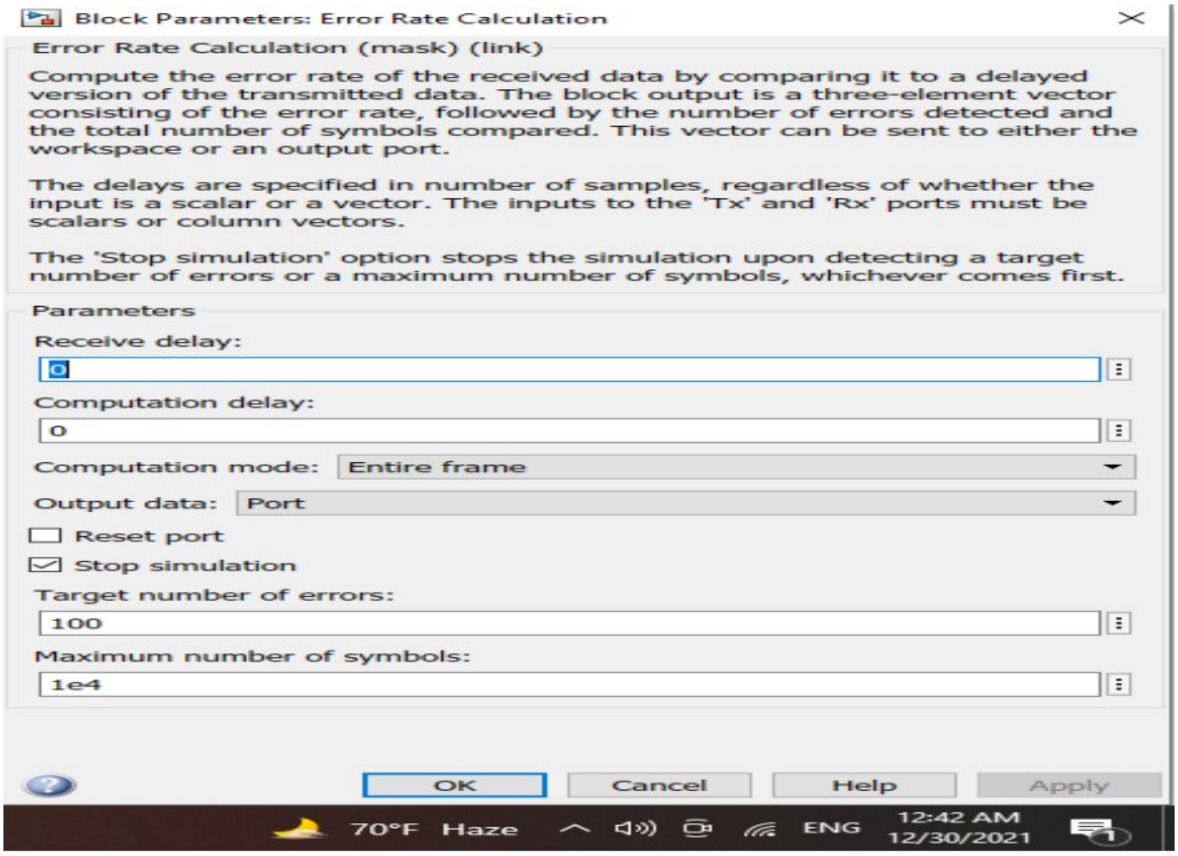


3. Sine wave: These signals are required to expand the complex modulated signal into real and imaginary parts.



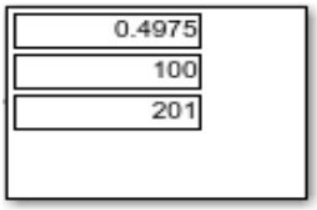


4.Error rate calculation is accommodated of maximum le4 symbol and count up to 100 number of errors as target.

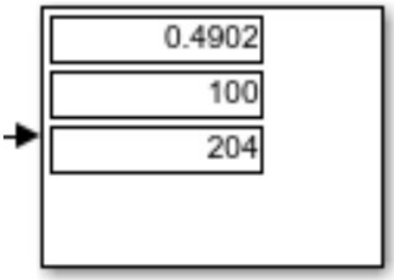


EB/No results

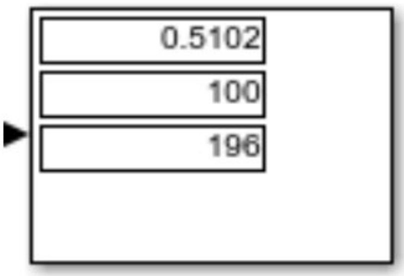
Eb/No=5db



Eb/No = 15db

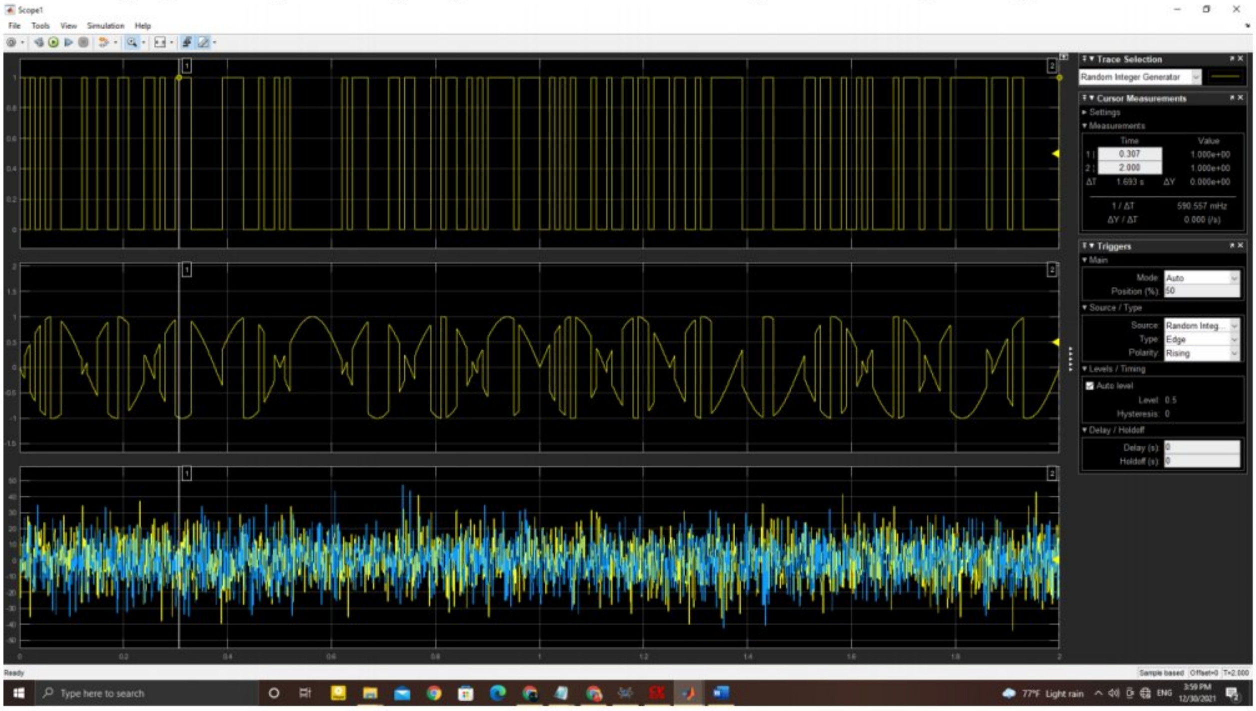


Eb/No =20

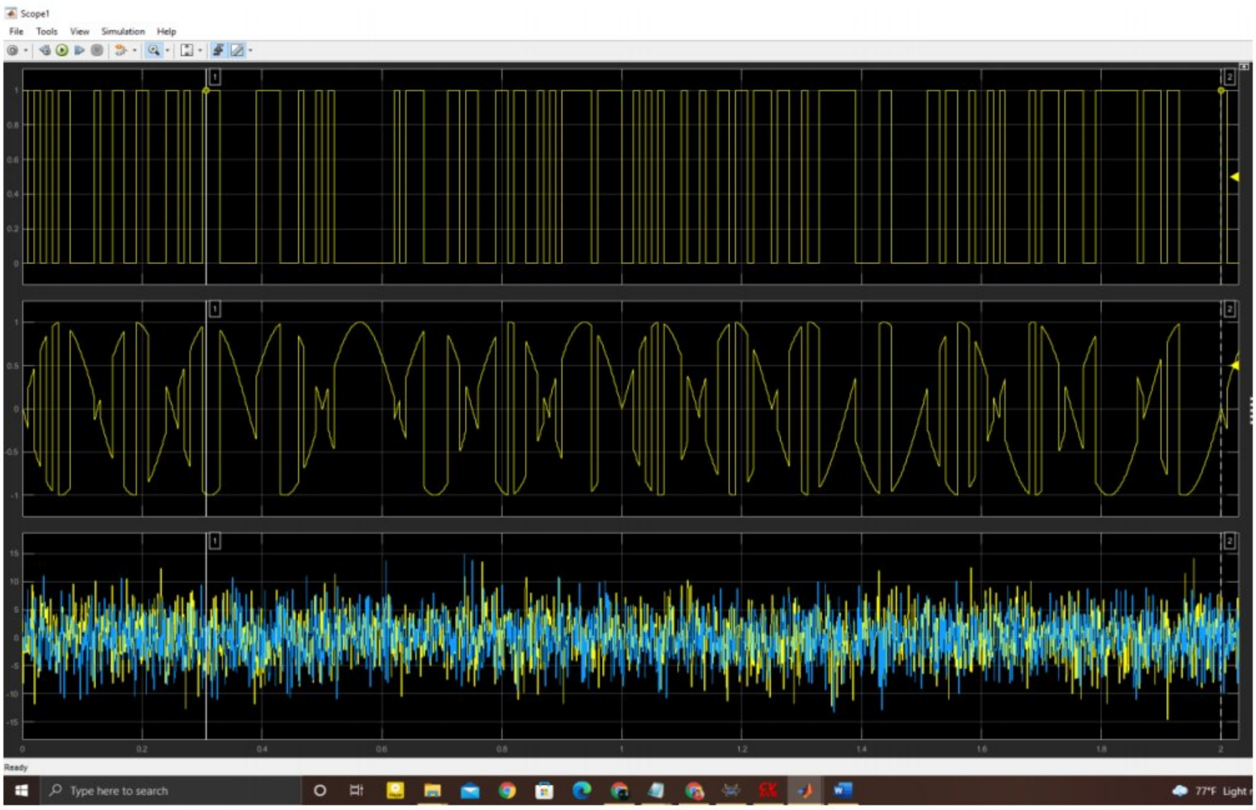


From the result we can observe that the error rate decrease with an escalation of signal energy and Noise power ratio.

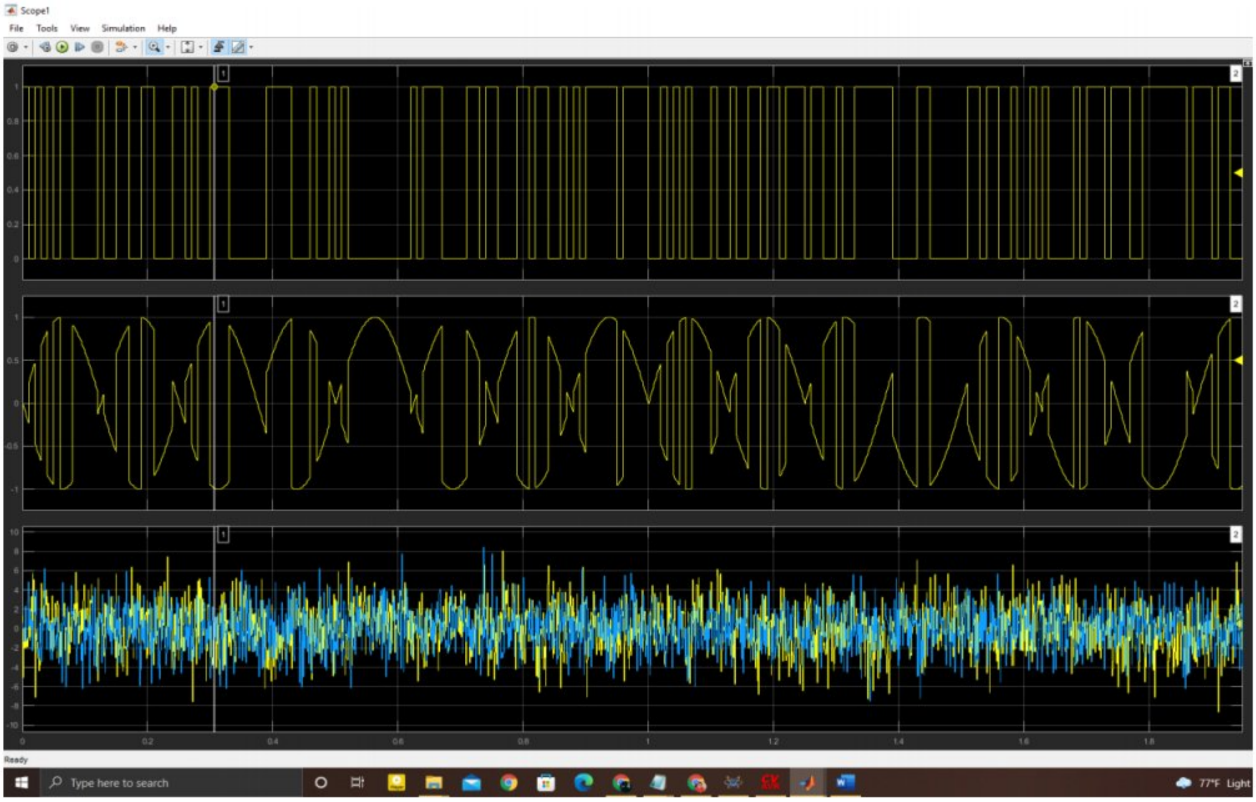
Here the graph for Input Binary sequence vs Modulated Signal vs Corrupted Signal at Eb/No=5db



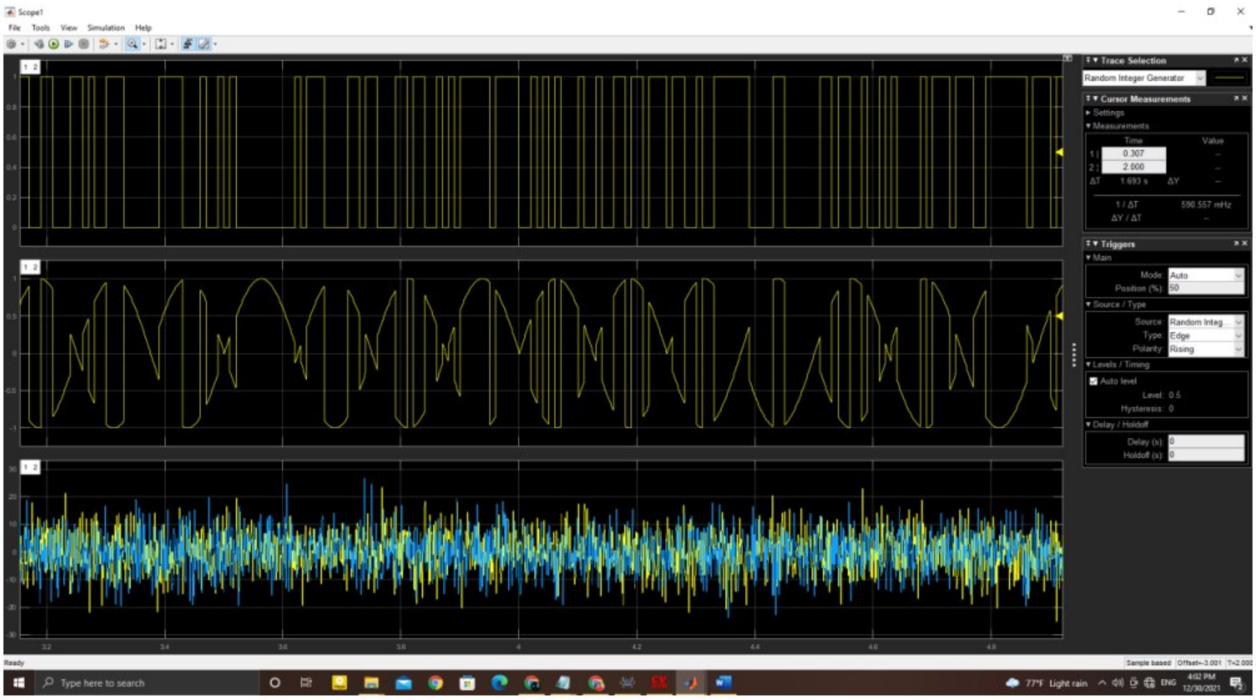
Input Binary sequence vs Modulated Signal vs Corrupted Signal at Eb/No=15db



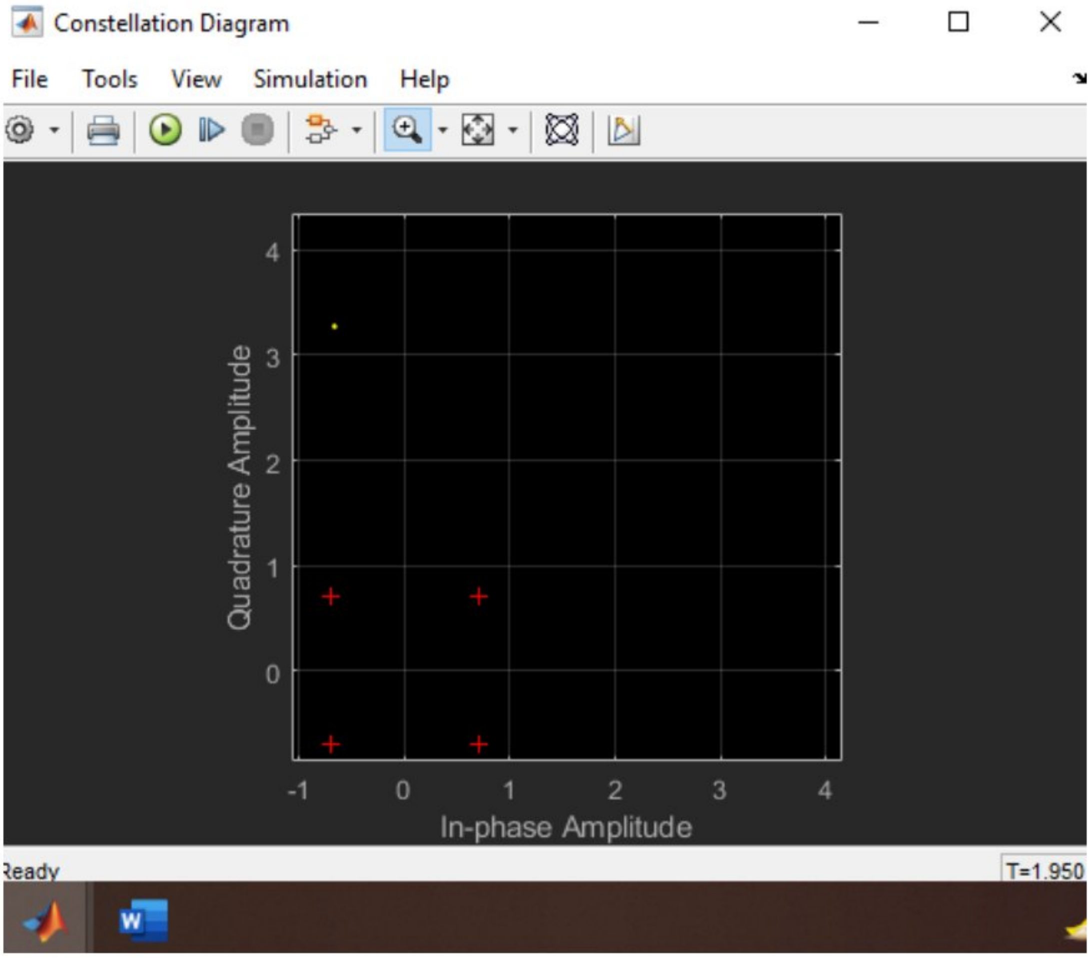
Input Binary sequence vs Modulated Signal vs Corrupted Signal at Eb/No=20db



Input Binary sequence vs Modulated Signal vs Corrupted Signal at Eb/No=10db



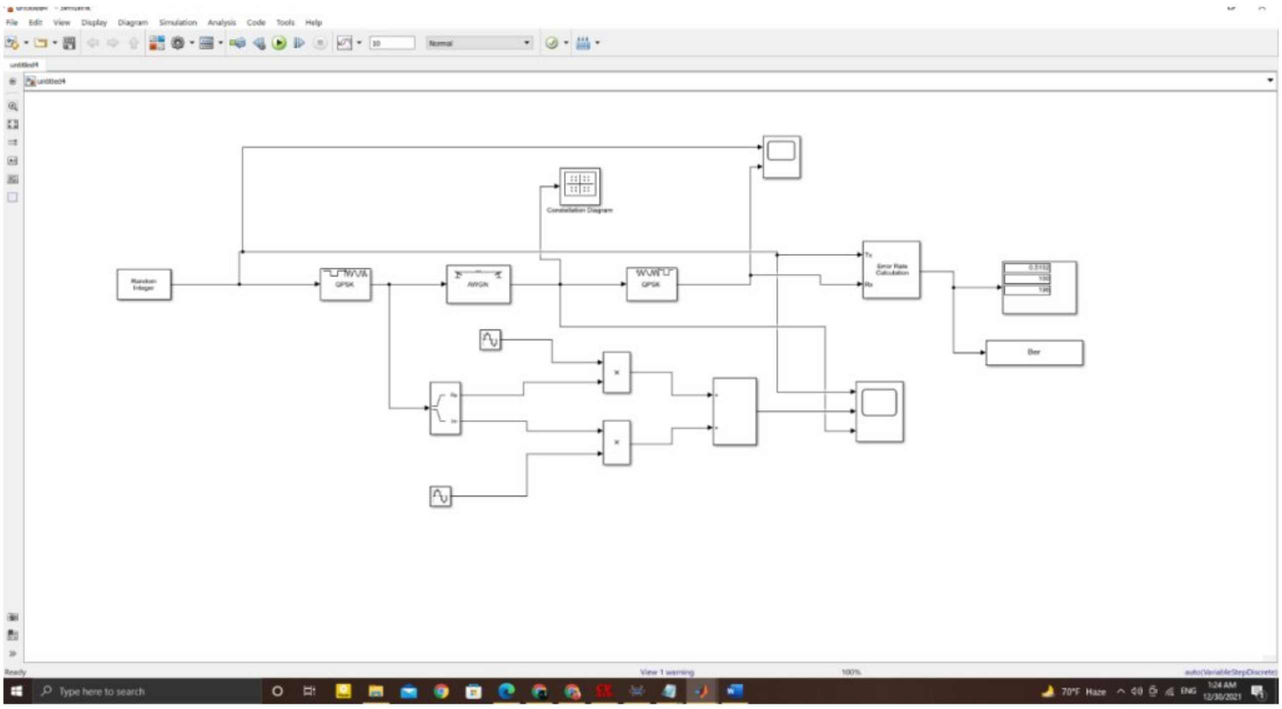
Constellation Diagram of BPSK Modulator



Task2:

Here we asked to show Signals generate link and modulator diagrams, simulation results including waveforms, evaluation of results, contrasting between BPSK and QPSK.

Circuit Diagram for Quadrature phase shift keying



Simulink Blocks

1.Random Integer Generator

2.QBPSK modulator and demodulator

3.AWGN channel

4.Complex to Real Image block

5.Constellation block

6.Sine Wave

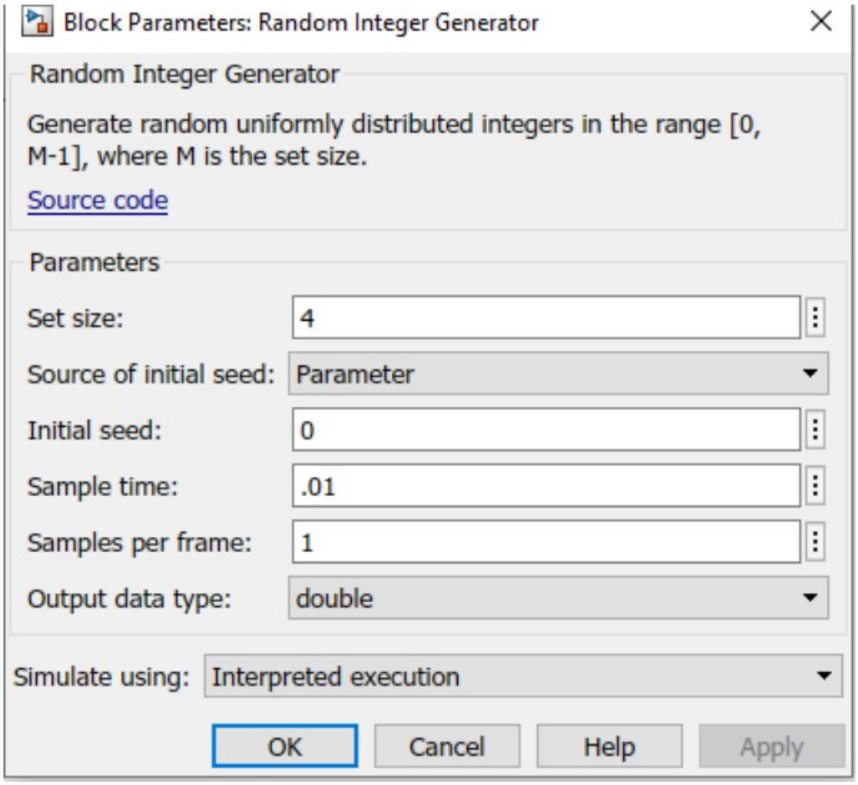
7.Scope

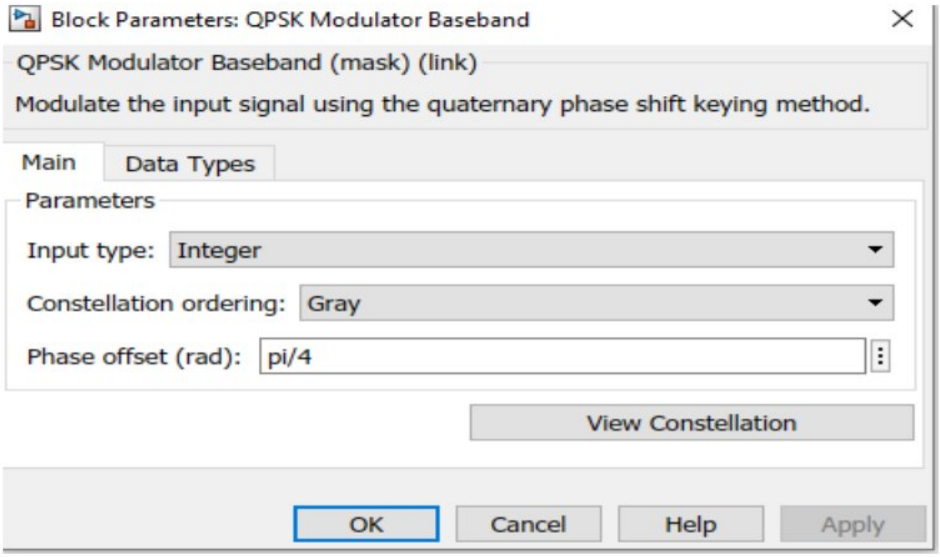
8.Error rate calculation

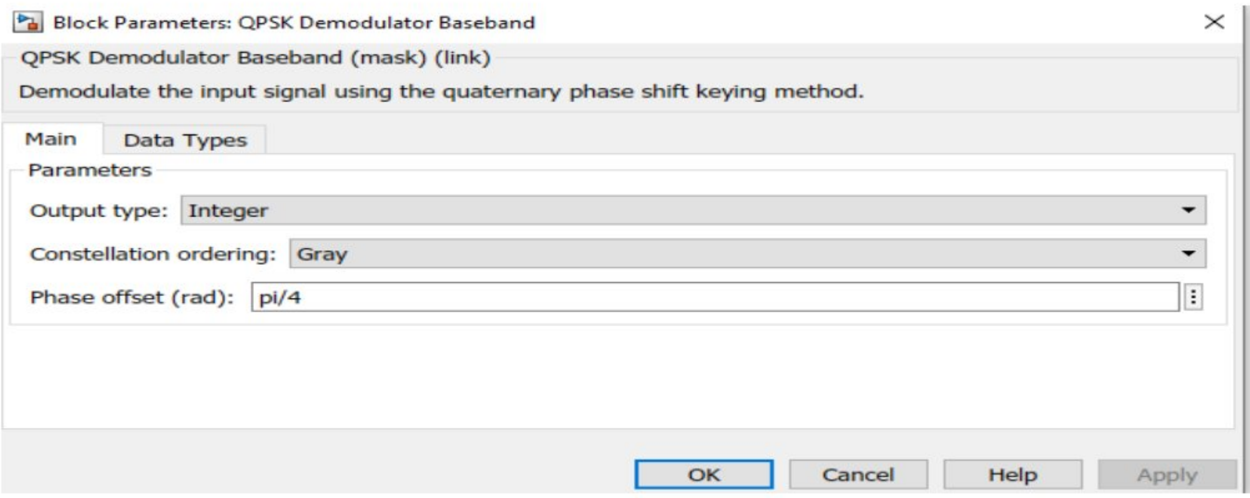
9.Display and To Workspace block

10.Product and adder block.

Parameters:

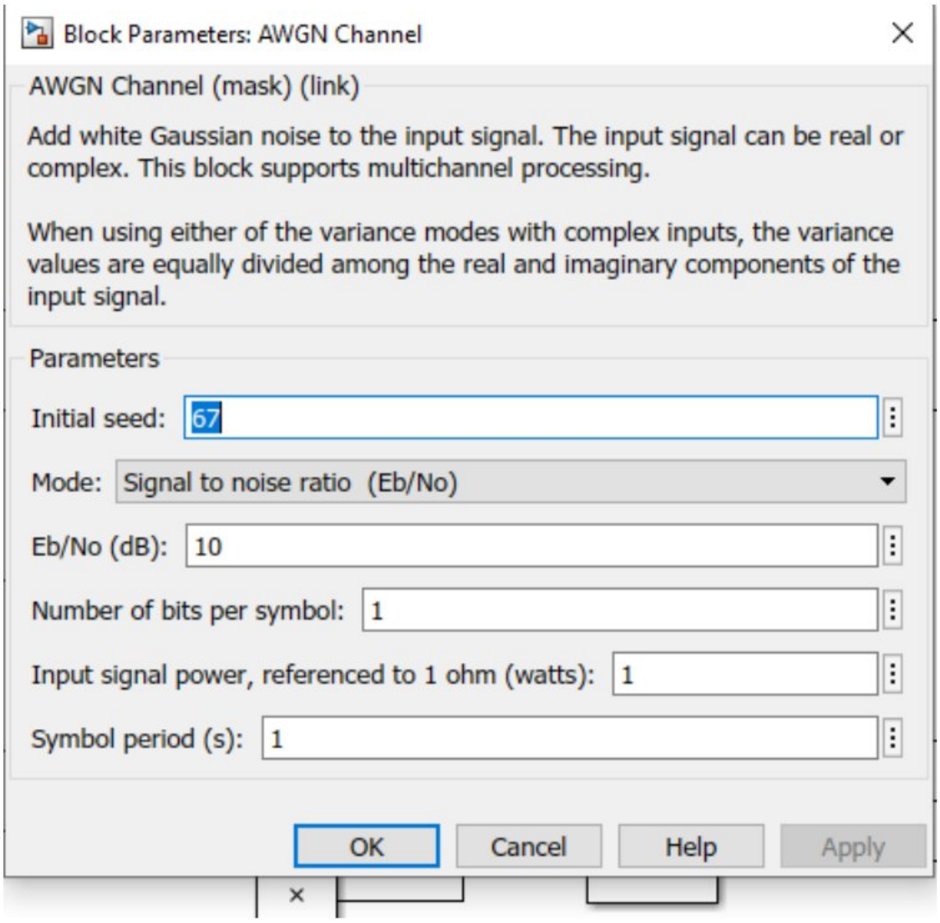

Block Parameters: Random Integer Generator
Random Integer Generator
Generate random uniformly distributed integers in the range [0, M-1], where M is the set size.
Source code
Parameters
Set size:
4
Source of initial seed:
Parameter
Initial seed:
0
Sample time:
.01
Samples per frame:
1
Output data type:
double
Simulate using:
Interpreted execution
OK
Cancel
Help
Apply

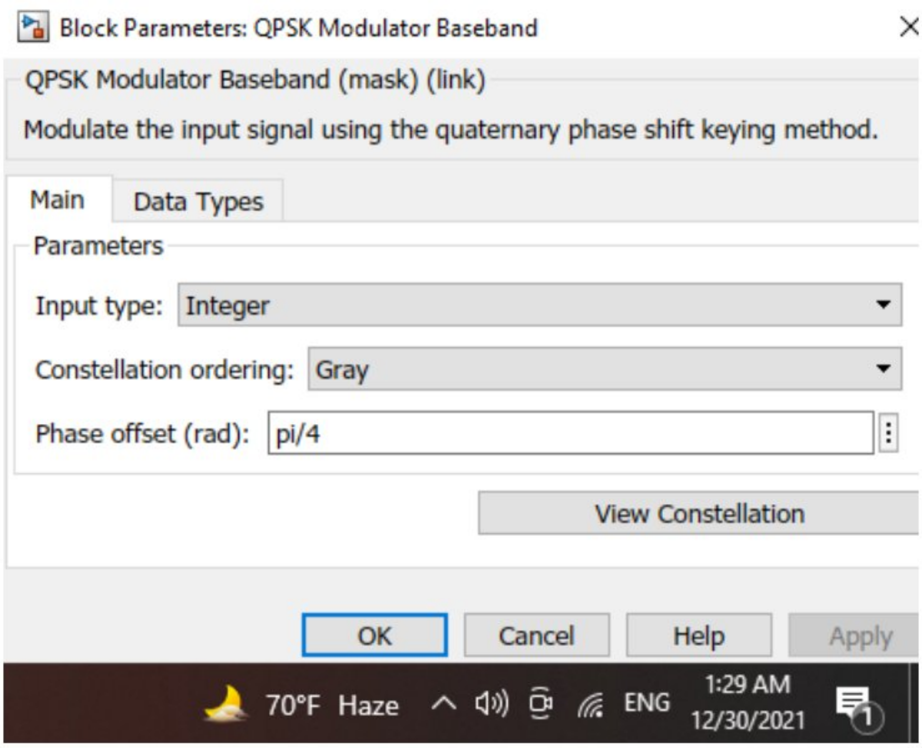

Block Parameters: QPSK Modulator Baseband
QPSK Modulator Baseband (mask) (link)
Modulate the input signal using the quaternary phase shift keying method.
Main
Data Types
Parameters
Input type:
Integer
Constellation ordering:
Gray
Phase offset (rad):
pi/4
View Constellation
OK
Cancel
Help
Apply


Block Parameters: QPSK Demodulator Baseband
QPSK Demodulator Baseband (mask) (link)
Demodulate the input signal using the quaternary phase shift keying method.
Main
Data Types
Parameters
Output type:
Integer
Constellation ordering:
Gray
Phase offset (rad):
pi/4
OK
Cancel
Help
Apply

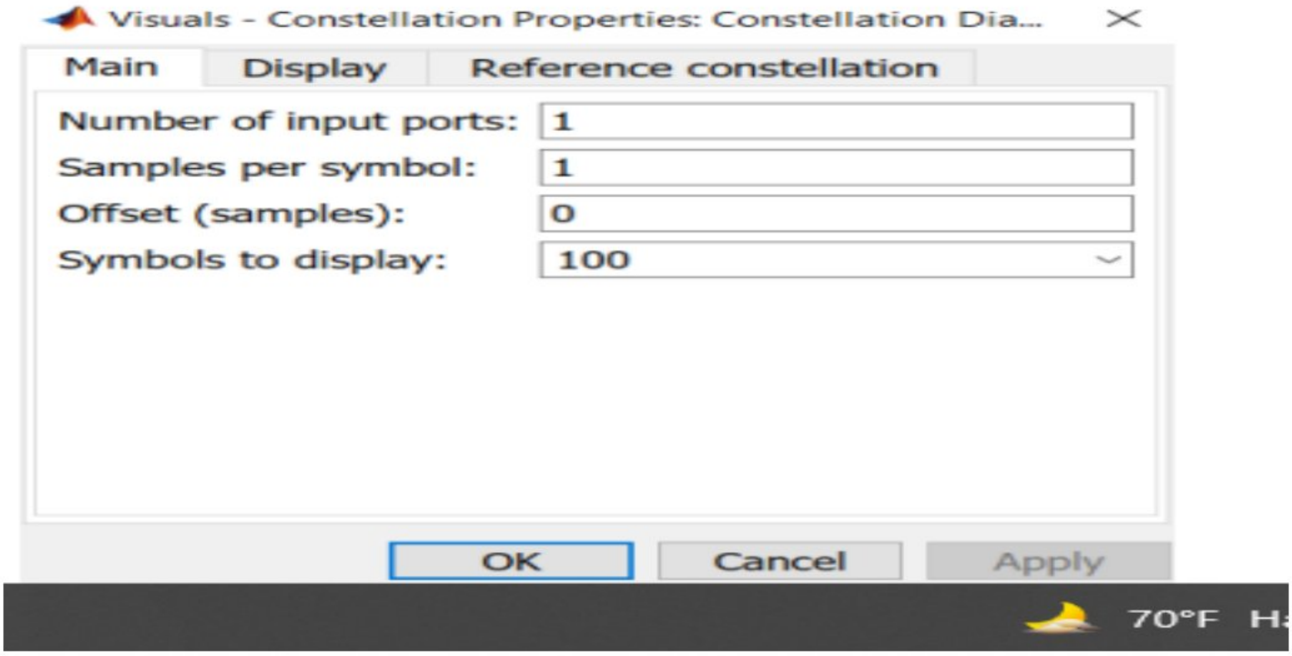
Additive White Gaussian Noise Channel

We vary Eb/No from 1 to: 20 with an increment of .5 to observe the bit error rate for both BPSK and QPSK communication channel.

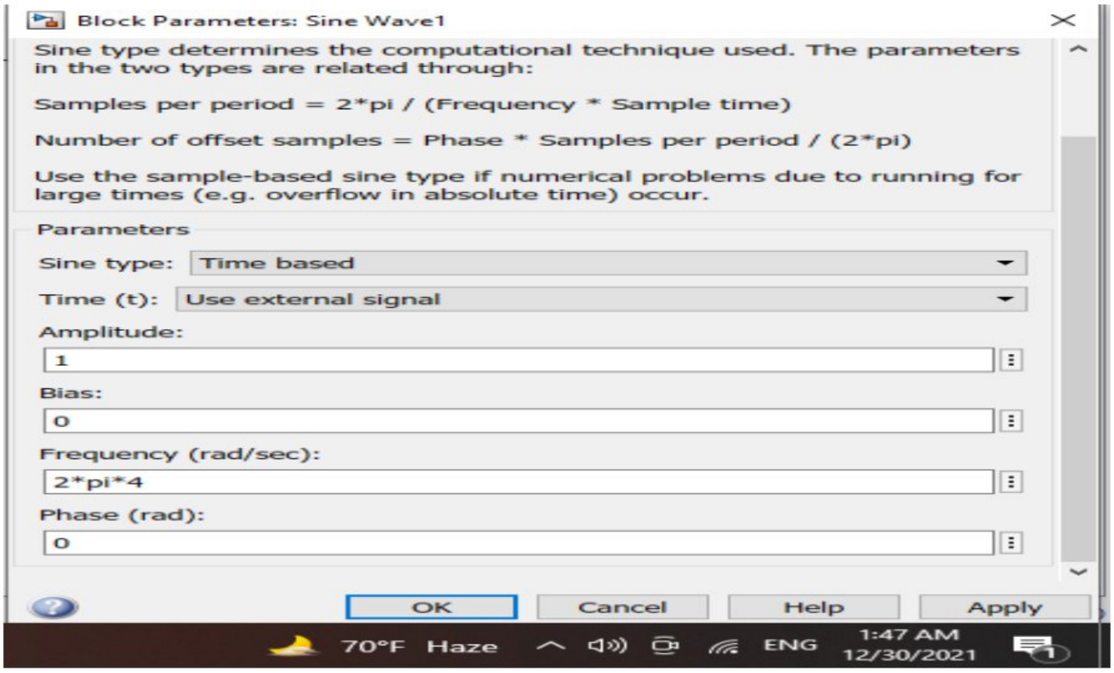




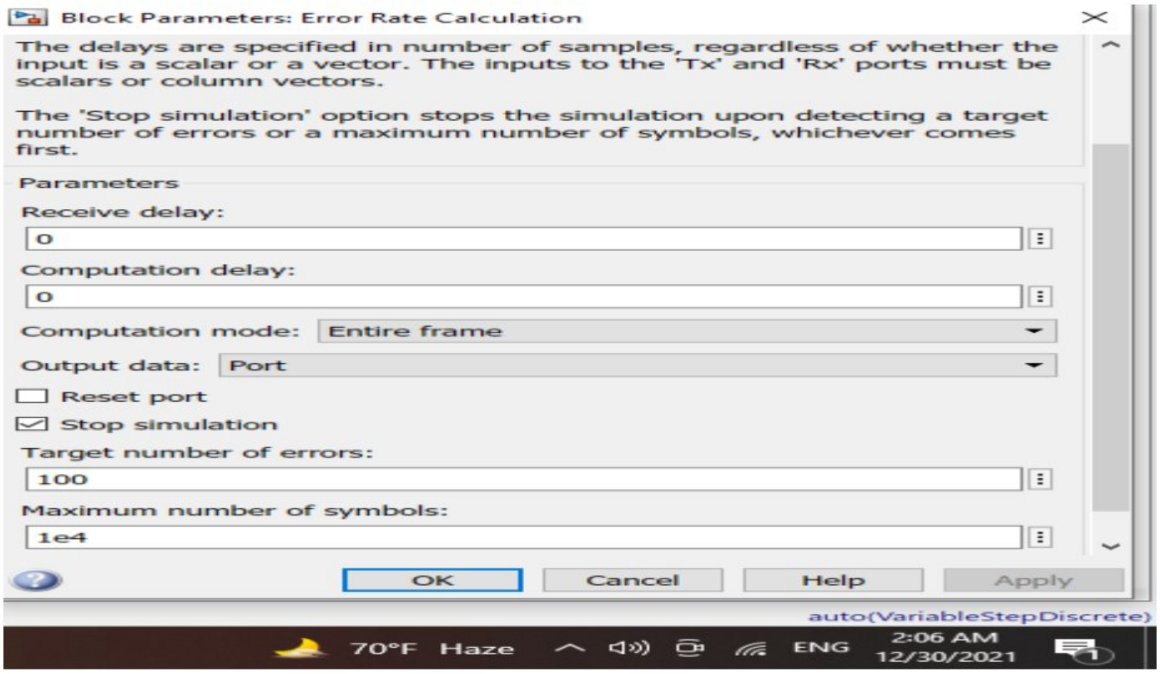
Constellation Diagram of modulator it defines the possible symbol that can be transmitted by the system as a collection of points.



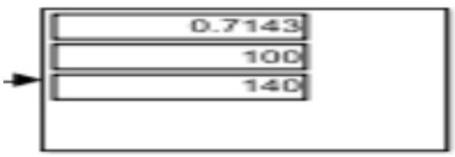
<u>Sine wave :</u> Sine wave: These signals are required to expand the complex modulated signal into real and imaginary parts.

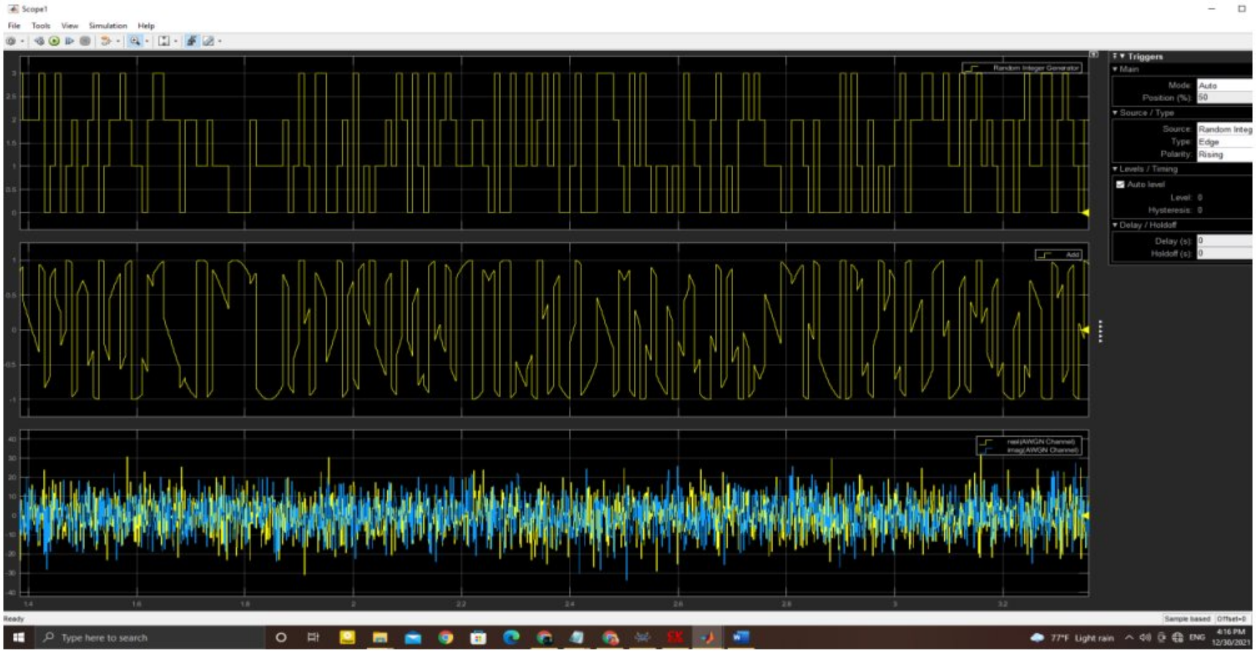


Error rate calculation is accommodated of maximum le4 symbol and count up to 100 number of errors as target.

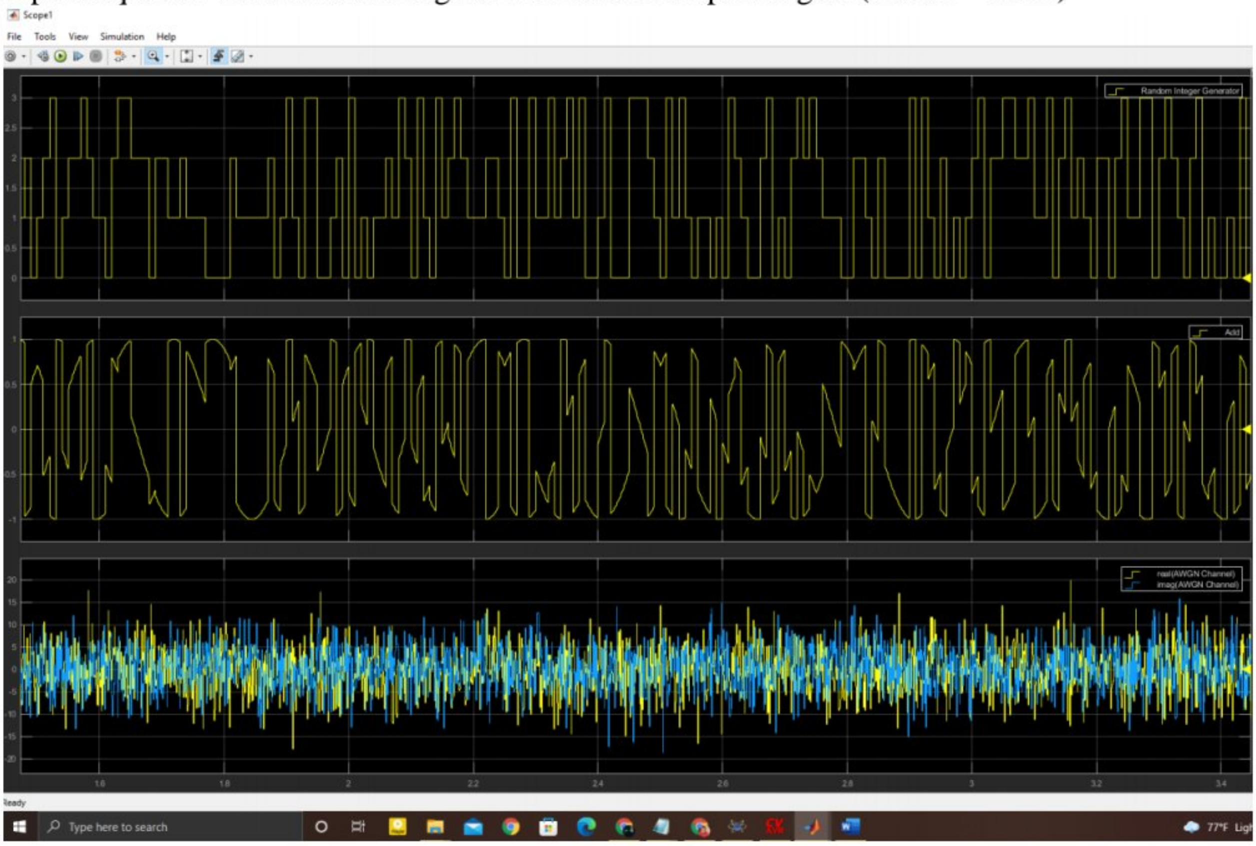


<u>Results:</u> i. Error Rate for Eb/No = 5dB

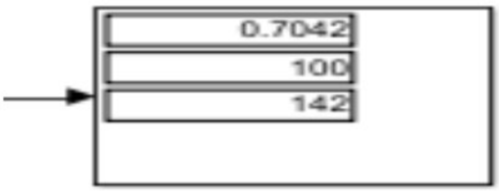




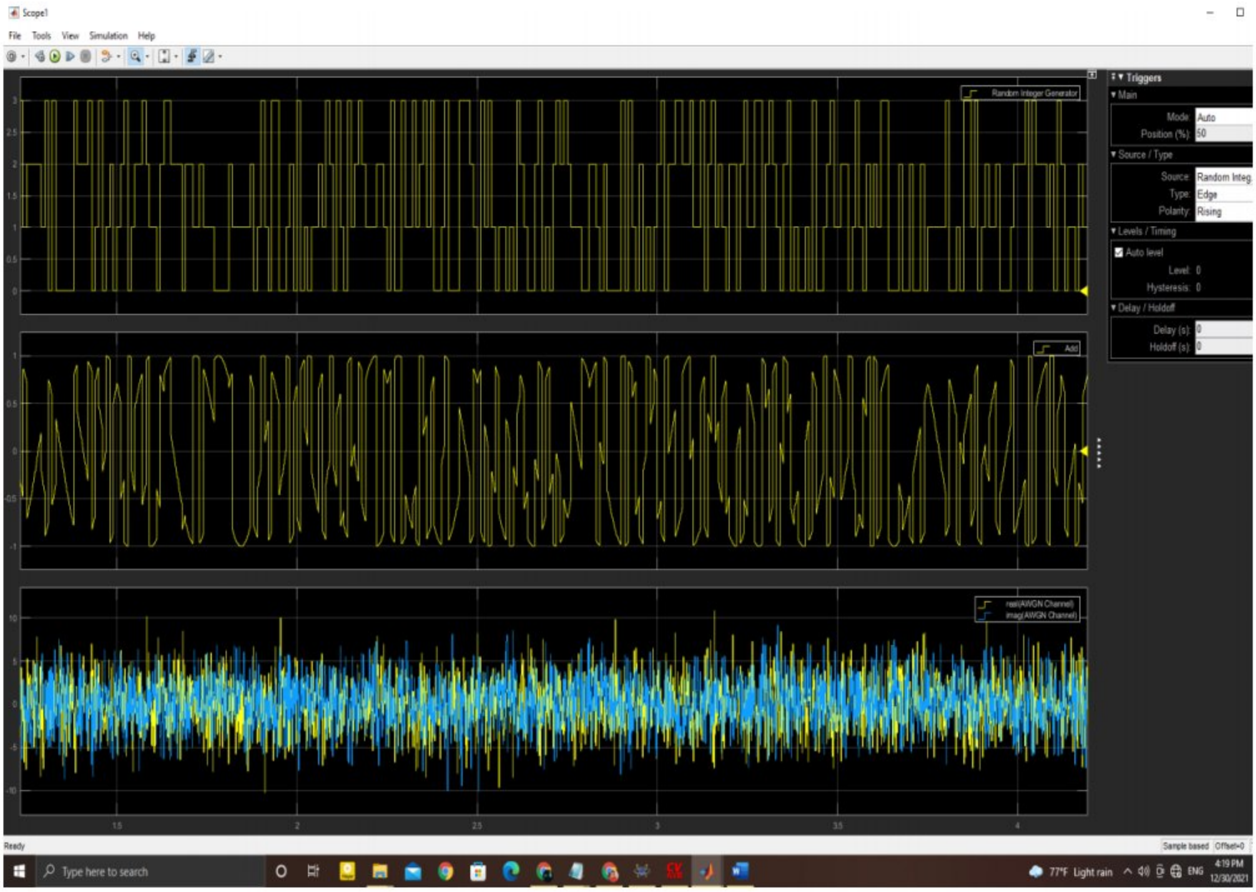
Input Sequence Vs. Modulated Signal Vs. Noise Corrupted Signal (Eb/No = 10dB)



Error Rate For Eb/No =10dB

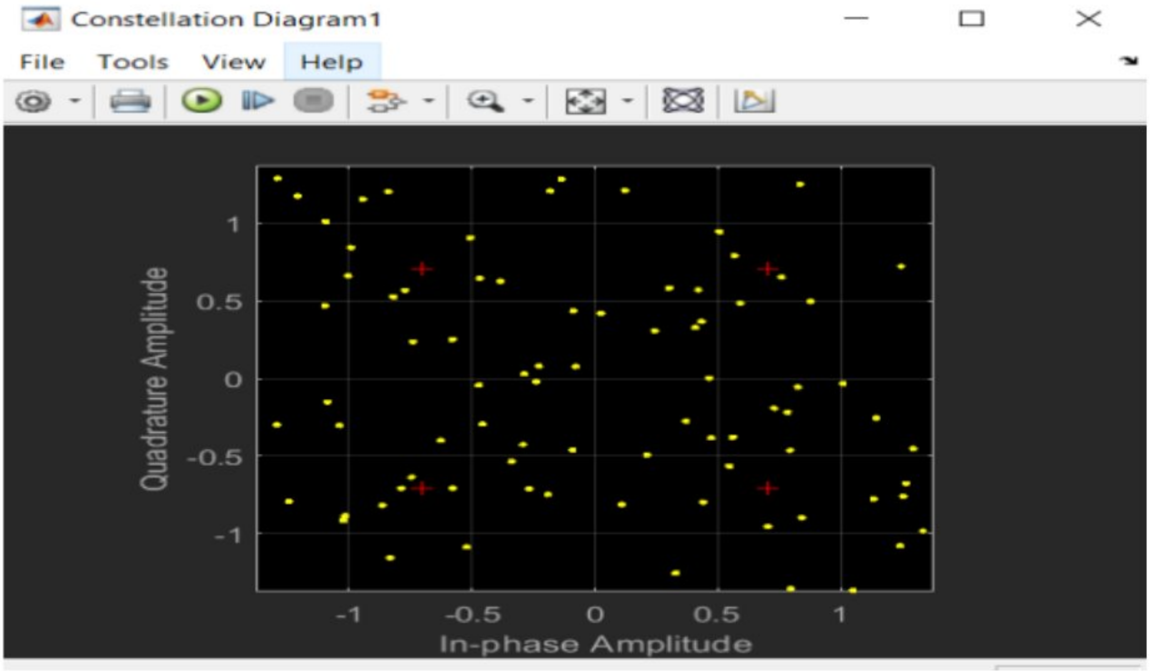


Input Sequence Vs. Modulated Signal Vs. Noise Corrupted Signal (Eb/No = 15dB)

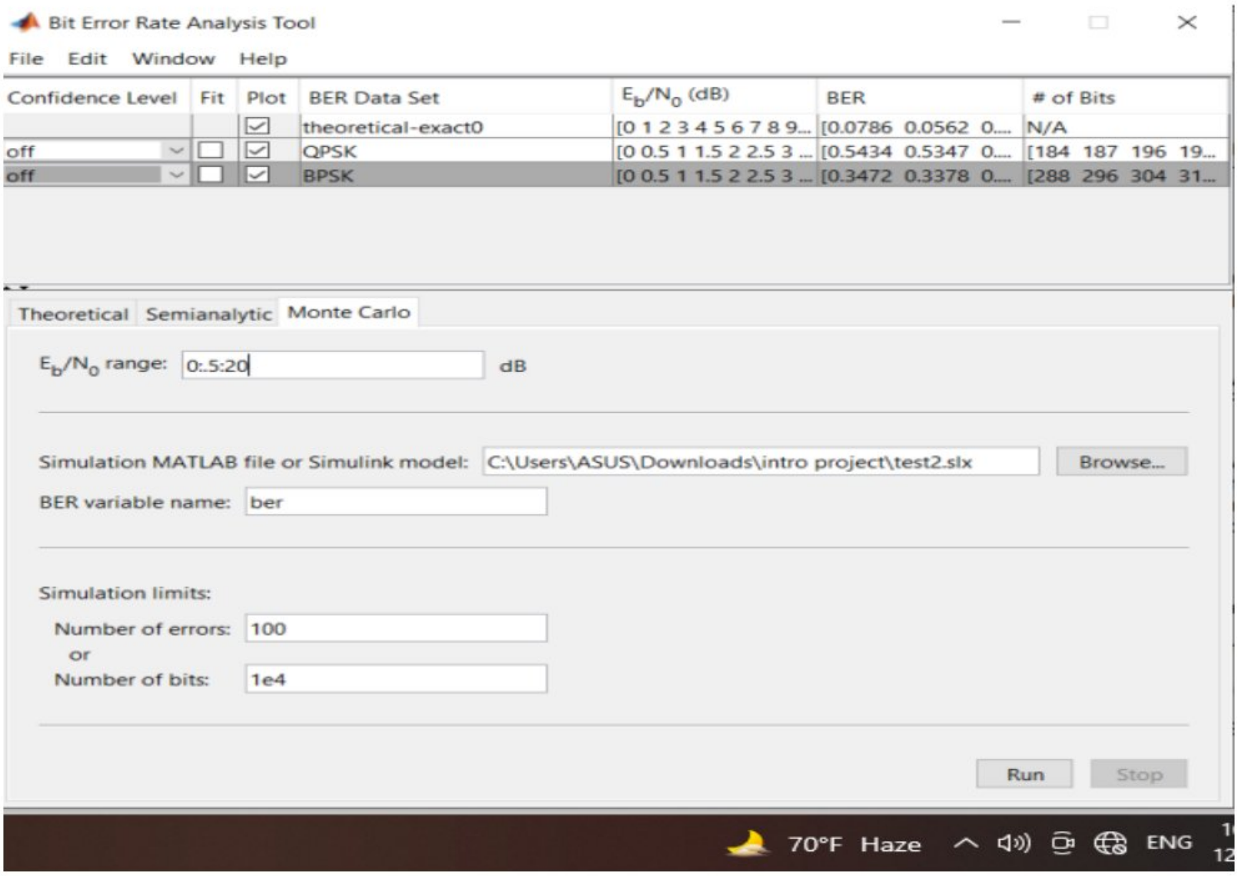


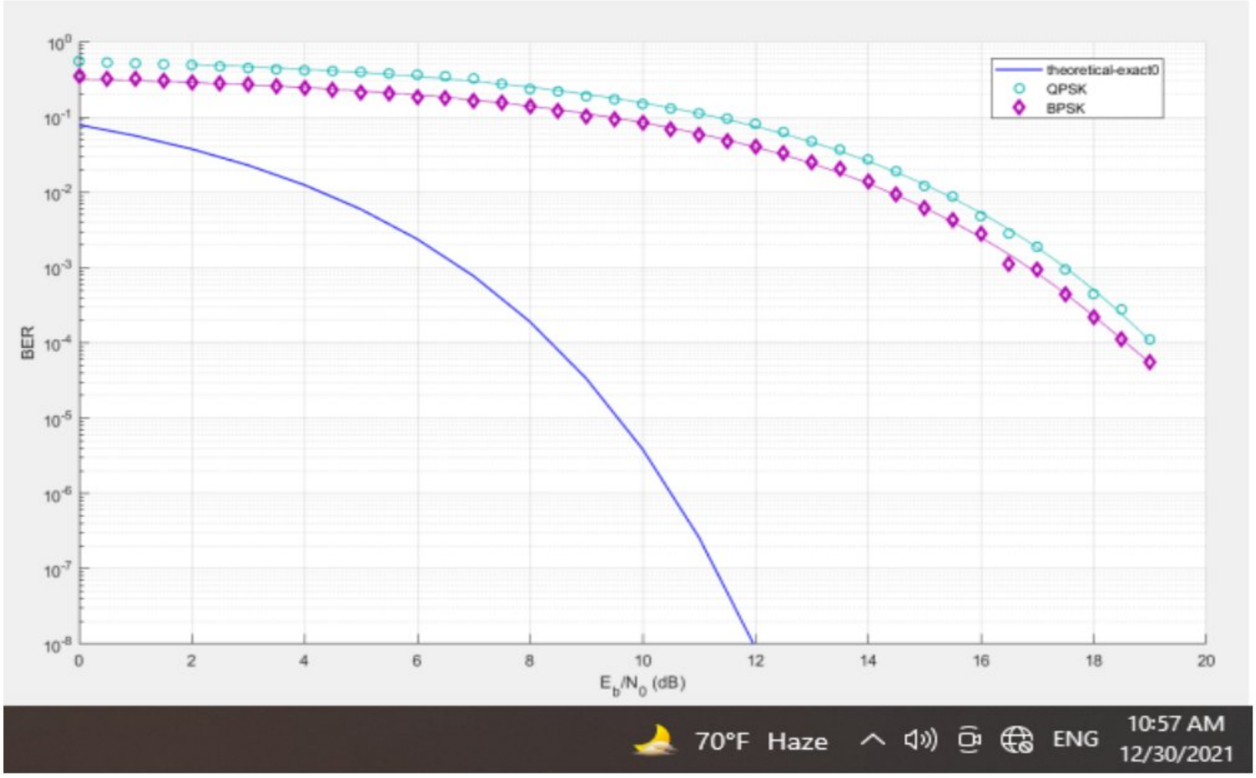
we observe a decreasing bit error rate with an increasing Eb/No in QPSK; But in case of BPSK, the error rate is even lower for the same level of Eb/No ratio. From our results, it is evident that BPSK modulation is preferred in cases where we need to consider small amounts of transmitting energy. The main reason is that the BPSK offers acceptable BER while transmitting signals of relatively low energy.

Constellation Diagram of QPSK Modulator



BerTools and performance curve





We know QPSk uses for higher power to transmit two bits simultaneously like BPSK . So the EB/No ratio would be higher in case of QPSK compare to BPSK to achieve the same bit error probability . to achieve ber 10^-5

Eb/No for BPSK =18.5 from curve

Eb/No=19 these are approx. value

So (Eb/No)BPSK/(Eb/No)QPSK=18.5/19=.97368=so its can be said that QPSK need higher signal power than BPSK to achieve same BER.

Comment on BPSK

One bit per symbol is sent in BPSK. It is capable of transmitting 1 bit per second. QPSK has a bit rate of 2T and transmits two bits per symbol. QPSK can transmit at a rate of 2 bits per Hz in baseband. According to the performance curve, Bpsk requires a signal energy to noise level ratio of 18.5 to produce a BER of 10-5, but QPSK requires almost 19. Because each carrier step has a spectrum efficiency of 2 bits/Hz, BPSK is exceptionally spectrally efficient. At the same bandwidth as BPSK, it is feasible to produce double the data rate. Qpsk is therefore more efficient, although it consumes twice as much power as BPSK.

Task3:

Here we asked to construct a BPSK modulator with operational function blocks on the time domains BPSK and evaluate the modulation.

Simulink Blocks

1. pulse Generator

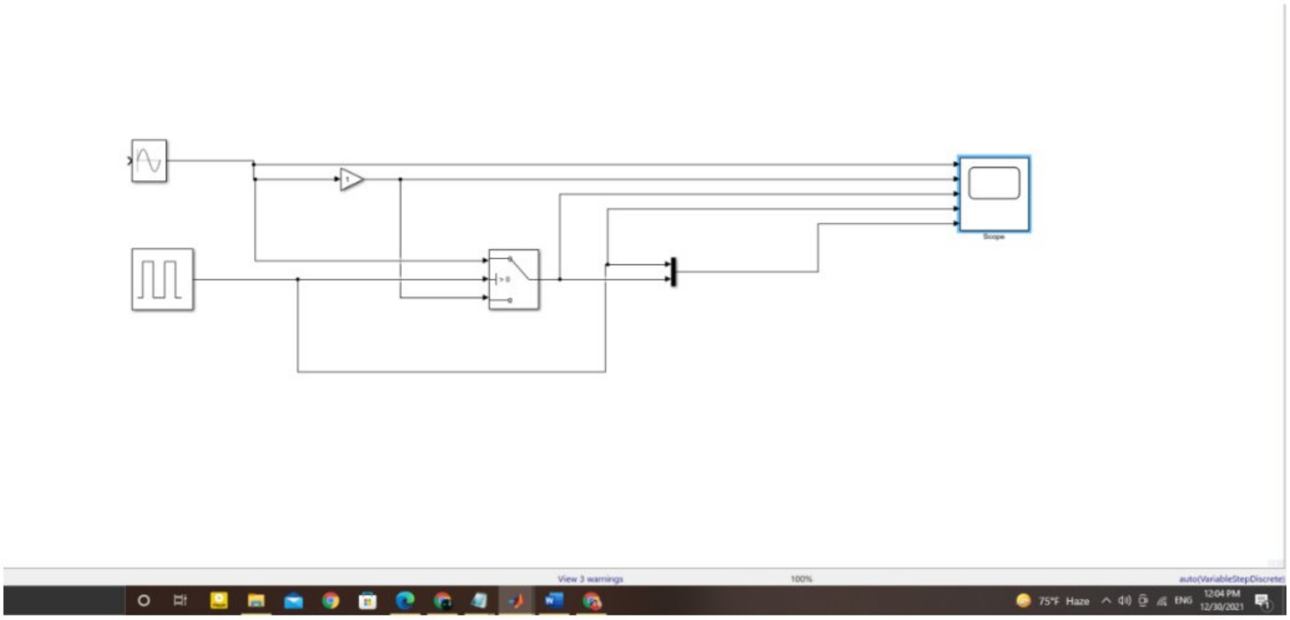
2.sine wave

3.Switch

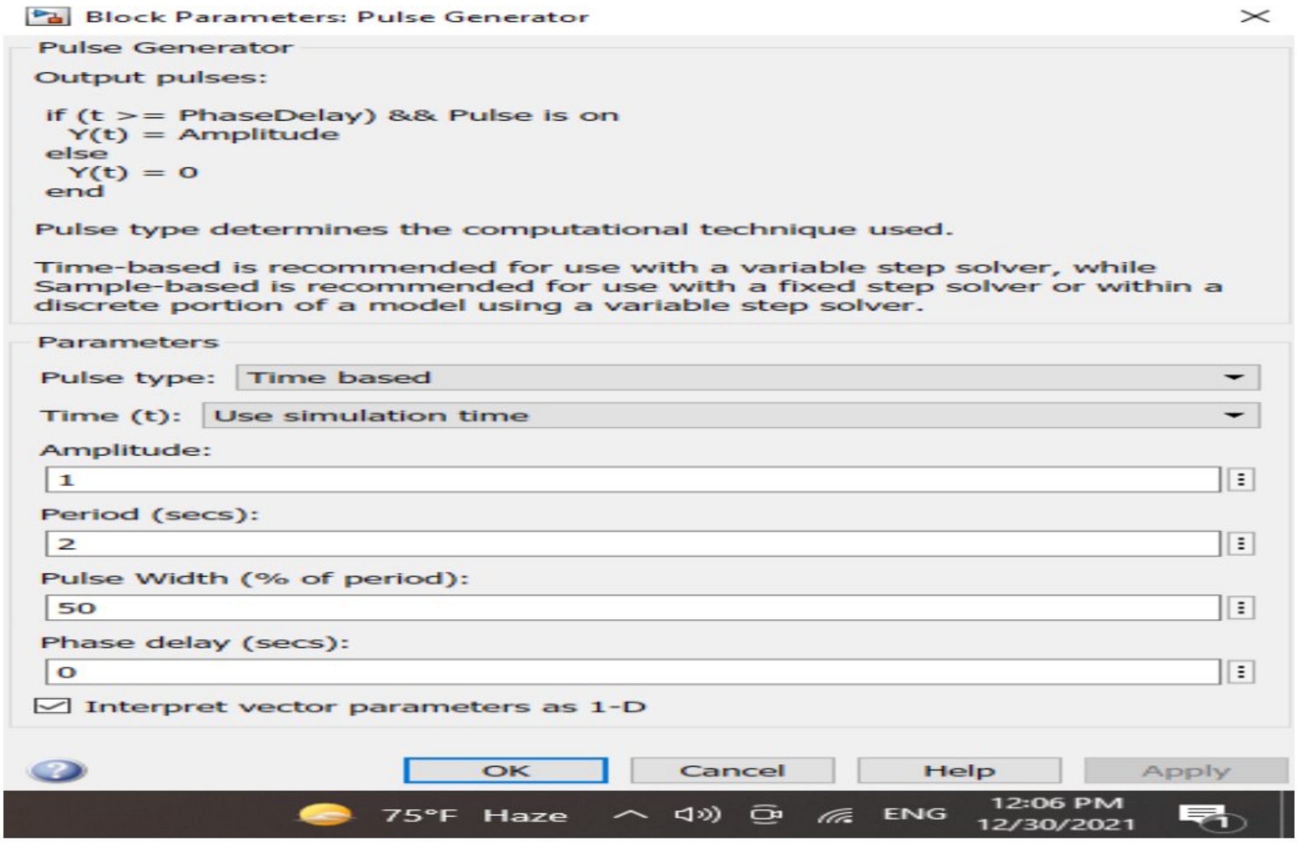
4. Mux

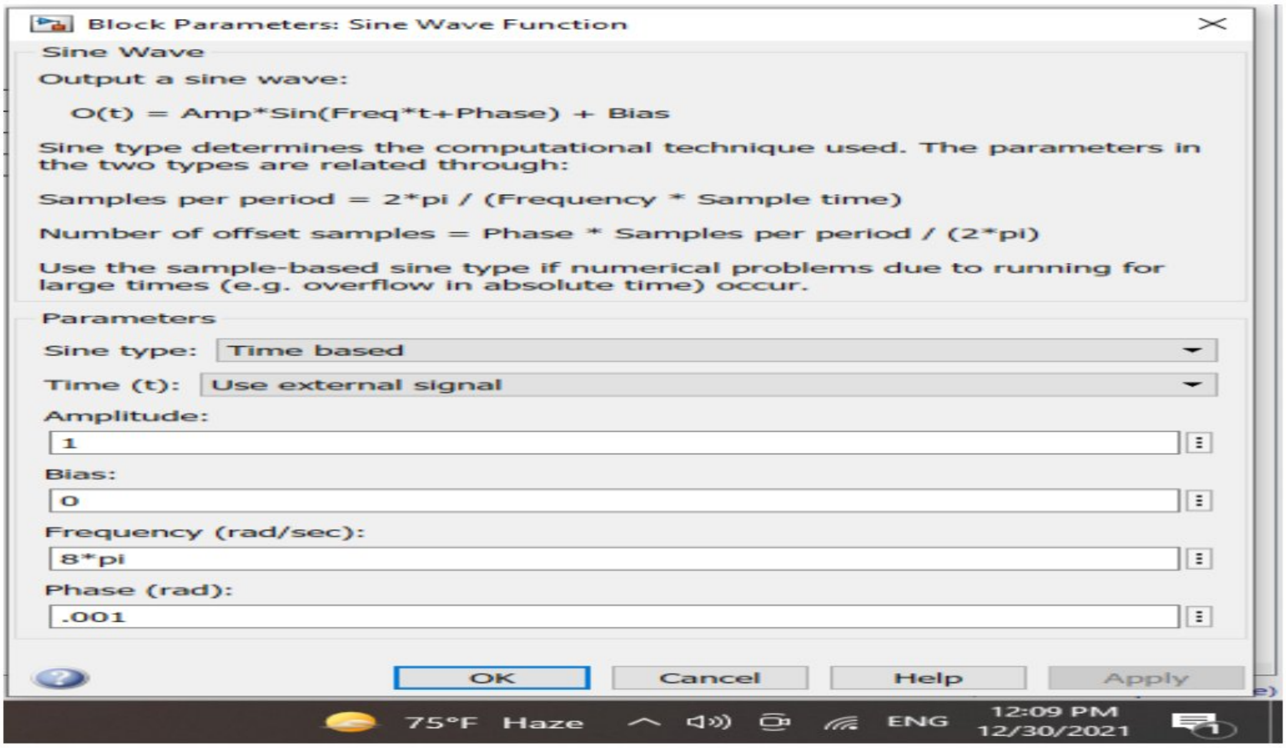
5.Scope

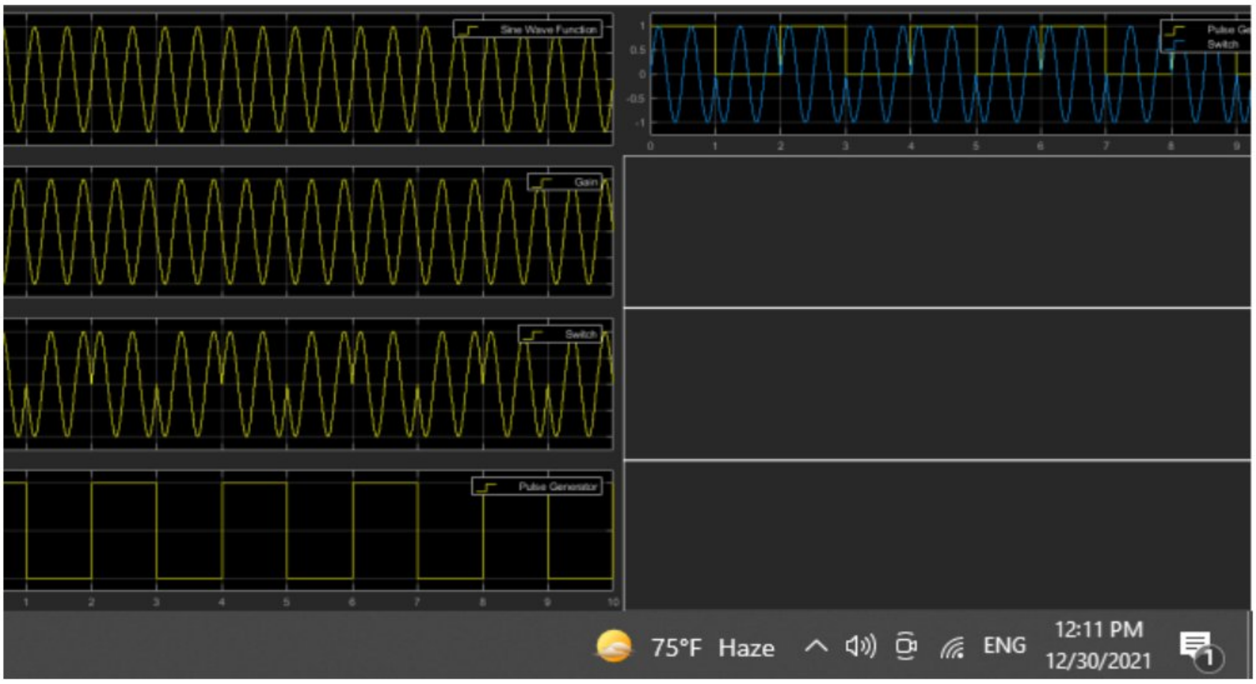
The BPSK modulation is accomplished in Matlab simulink using a bit sequence generator as the input signal of a bit stream supplied to a switch that compares the threshold level of a signal with two sine wave carriers in opposing phase and frequency. The scope receives the switch's output, which displays the time-based modulated signal.



Parameters:


Block Parameters: Pulse Generator
Pulse Generator
Output pulses:
if (t >= PhaseDelay) && Pulse is on
Y(t) = Amplitude
else
Y(t) = 0
end
Pulse type determines the computational technique used.
Time-based is recommended for use with a variable step solver, while Sample-based is recommended for use with a fixed step solver or within a discrete portion of a model using a variable step solver.
Parameters
Pulse type: Time based
Time (t): Use simulation time
Amplitude:
1
Period (secs):
2
Pulse Width (% of period):
50
Phase delay (secs):
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply
75°F Haze
ENG
12:06 PM
12/30/2021


Block Parameters: Sine Wave Function
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(Freq*t+Phase) + Bias
Sine type determines the computational technique used. The parameters in the two types are related through:
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per period / (2*pi)
Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.
Parameters
Sine type: Time based
Time (t): Use external signal
Amplitude:
1
Bias:
0
Frequency (rad/sec):
8*pi
Phase (rad):
.001
OK
Cancel
Help
Apply
75°F Haze
ENG
12:09 PM
12/30/2021



Discussion:

We have to use the built-in mode in order to modulate the input signal in terms of BPSK and QPSK. However, the modulated signal has a complicated phrase that is difficult to comprehend with scope. As a result, we employed complicated to create a Real-image. Only show the true part of the block. Furthermore, using the bertool function from MATLAB was the only way to observe BER versus Eb/No in Simulink. To attain the BER level 10-5, we had to produce roughly 2000 sequences of input samples, which took a long time. For a better perspective, we have to increase the amount of symbols displayed in the constellation block. For BPSK and the Eb/No versus Ber curve, the number of bits per symbol in the AWGN channel was 1. In the main AWGN block, we have to write variable term Eb/No as Eb/No value and real value in Bertool.

Conclusion:

In this project we tried to plot circuit in Simulink and generate and observe results. As Eb/No grows, the bit error rate in QPSK and BPSK decreases. Although, given the same Eb/No ratio, the error rate in BPSK is far lower. Our findings suggest that BPSK modulation is favored when just a little amount of transmitting energy is needed. We established a communication link utilizing BPSK and QPSK and observed the waveforms in this section of our study. We experimented with several Eb/No values (5,10,15) to observe how they interact with the BER error rate.