Project Report

Brac University

Department of Electrical and Electronics Engineering

Introduction to Communication Engineering Laboratory

EEE342

Group No: 12

Prepared By:

Name	ID	Email Address
Sumaiya Tarique Labiba	19121032	sumaiya.tarique.labiba@g.bracu.ac.bd
Pronoyan Saha	19121131	pronoyan.saha@g.bracu.ac.bd
Asef Jamil Ajwad	19121040	asef.jamil.ajwad@g.bracu.ac.bd

Date of submission: 31/09/2021

Design and simulation of a communication link using AM

Noise power calculation:

Channel noise power spectral density = -150 dBm/Hz
Converting into dB,

$$\text{dBm} = \text{dBm/Hz} + 10 \log (\text{BW})$$

$$\Rightarrow \text{dBm} = -150 + 10 \log (9000)$$

$$\Rightarrow \text{dBm} = -110.45757$$

Converting into Watts/Hz,

$$\text{dBm} = 10\log_{10} (\text{Power in mW/Hz}) \text{ ... [referencing to 1mW]}$$

$$\Rightarrow P = 10^{(\text{dBm}/10)} \text{ mW/Hz}$$

$$\Rightarrow P = (10^{(-110.45757/10)})\times 10^{-3} \text{ Watts/Hz}$$

$$\Rightarrow P = 9.000011\times 10^{-15} \text{ Watts/Hz}$$

Noise power = 9.000011×10^{-15} Watts/Hz

Simulink Model:

Obtained SNR = 40dB
Modulation index = 0.5 (50% modulation)

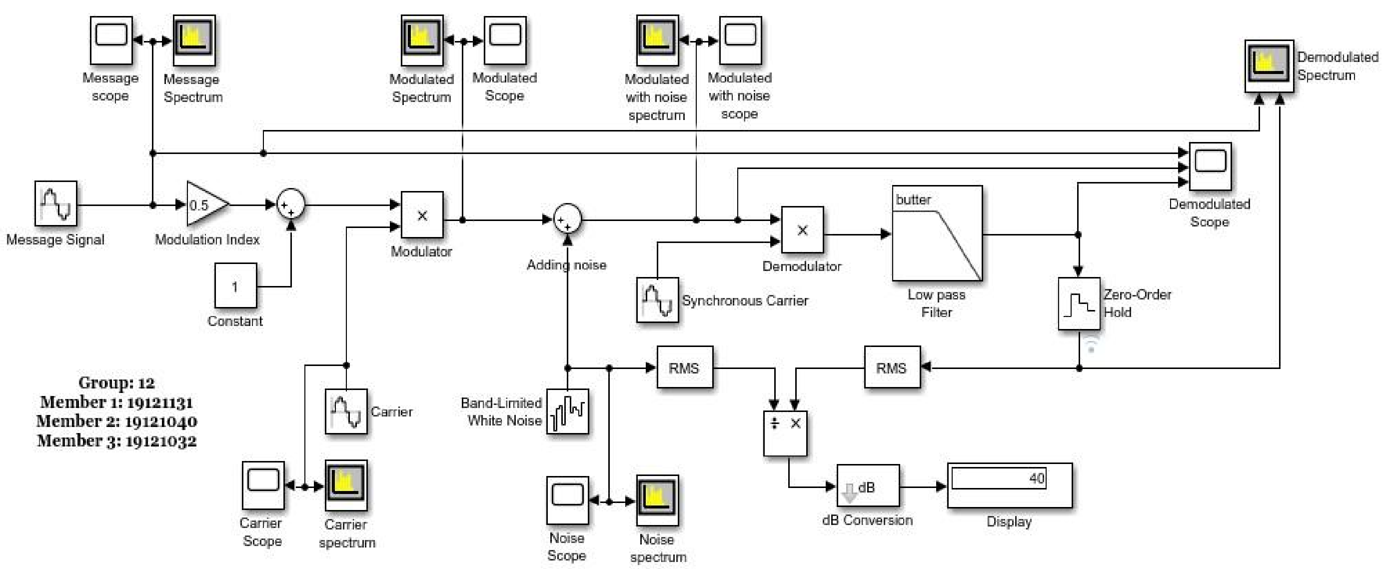


Figure: Simulink model of AM

Block Parameters:

Sample frequency = 25MHz (25000000) [Sample frequency is greater than 2×Carrier frequency]

Simple time = 1/Sample frequency = 1/25000000

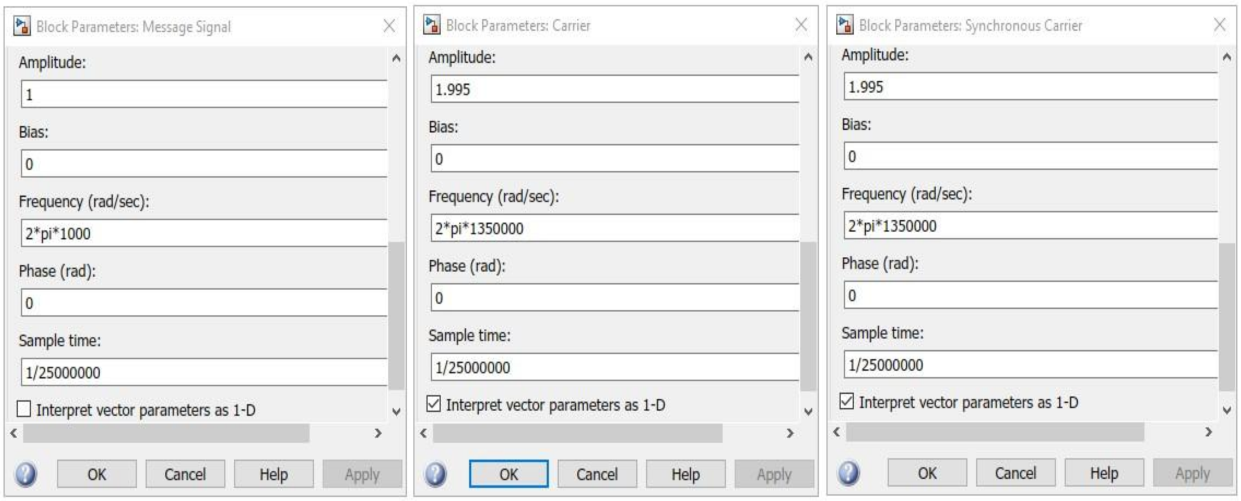


Figure: parameters for message, carrier & synchronous carrier

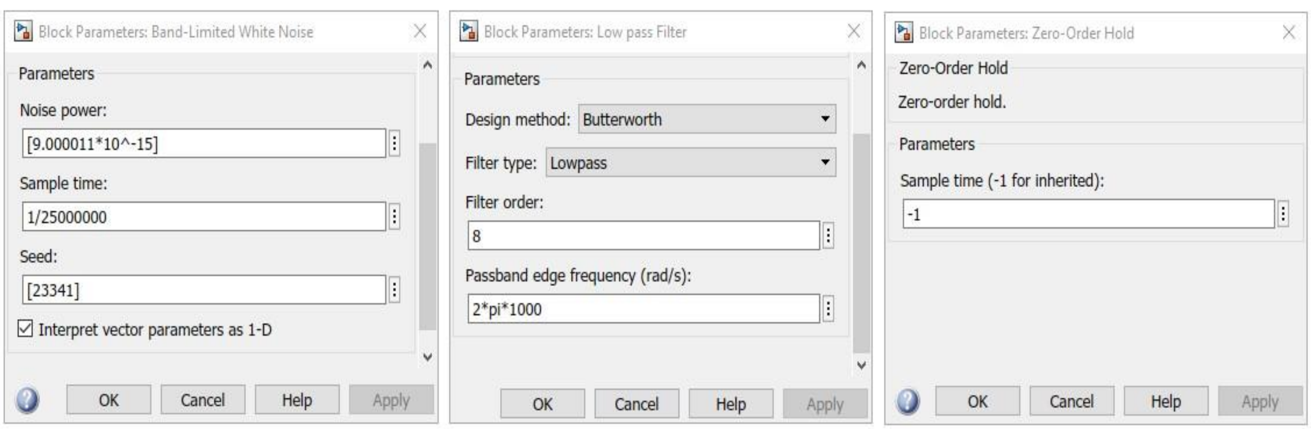


Figure: parameters for added noise, LFP & Zero Order Hold block

Here, sample time in all the block parameters has been set the same for smoother simulation. The passband edge frequency at the LPF has been set as same as the message frequency to extract the exact message signal.

Simulated waveforms and spectrums:

Message signal:

Message bands shown at 0.001M Hz or 1k Hz

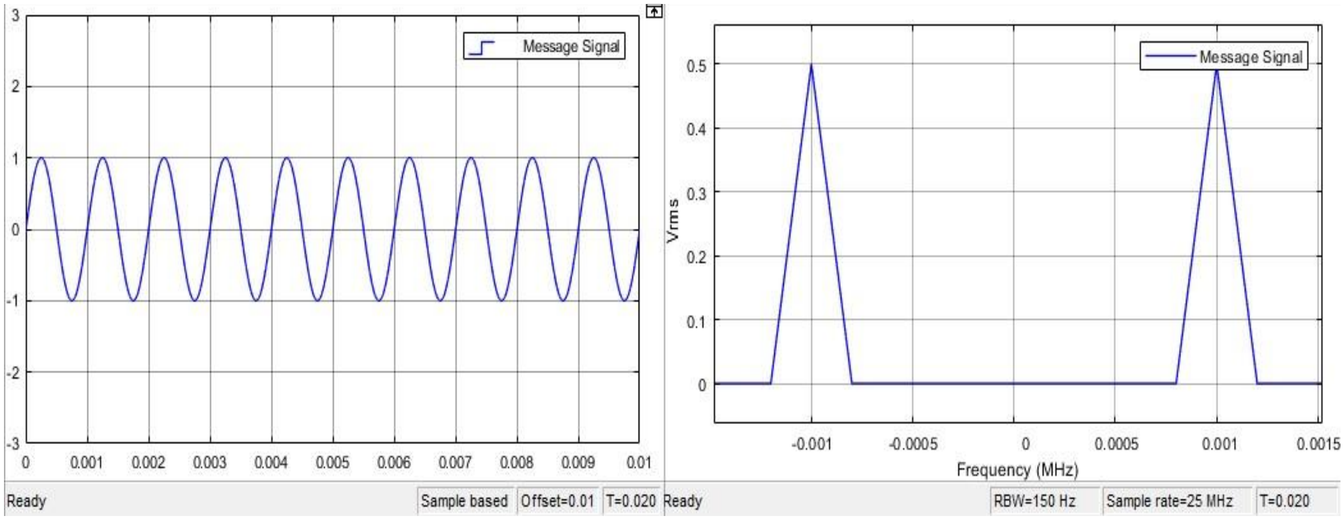


Figure: Message signal in time and frequency domain

Carrier:

Carrier bands shown at 1.35M Hz

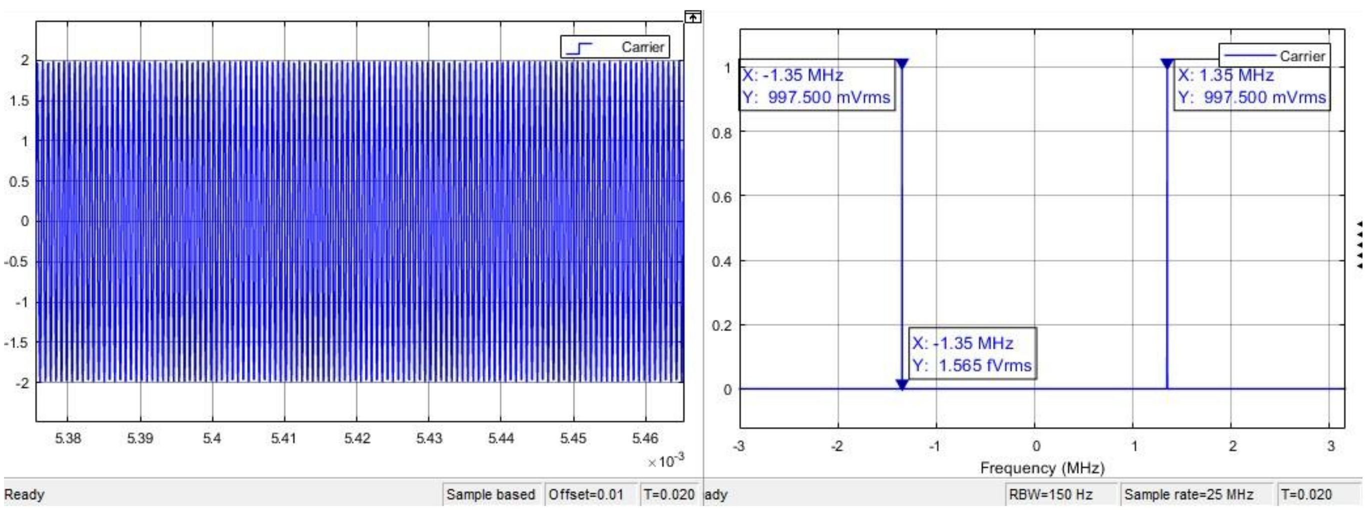


Figure: Message signal in time and frequency domain

Added AWGN:

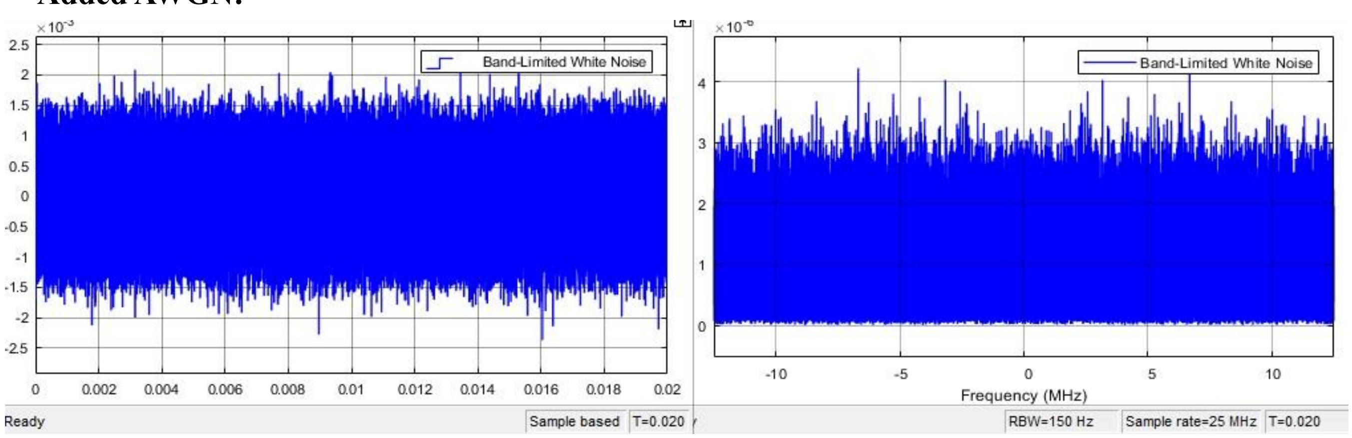


Figure: Added AWGN in time and frequency domain

Modulated signal before adding AWGN:

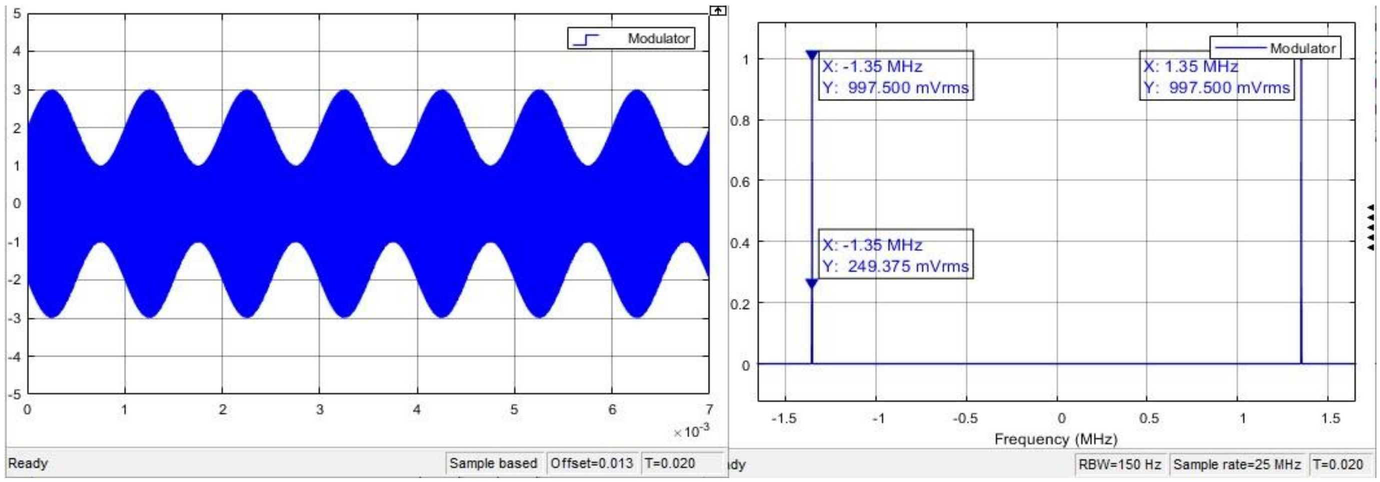


Figure: modulated signal before adding AWGN in time and frequency domain

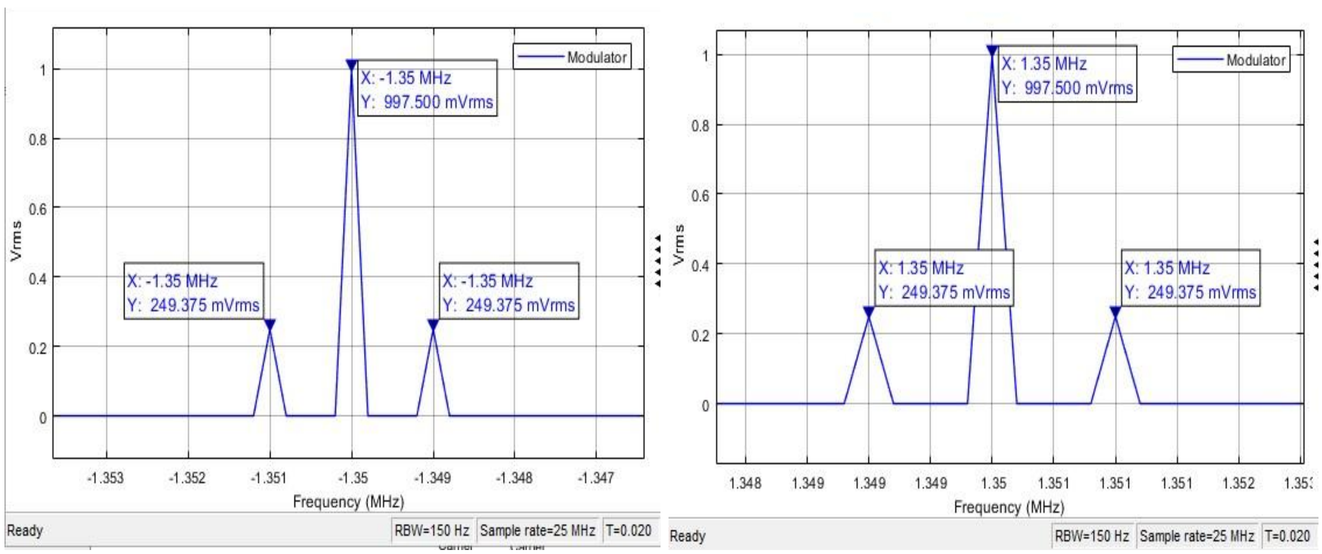


Figure: modulated signal bands in both negative and positive frequency domain [zoomed in]

Modulated signal is under modulated. For the DSB-WC modulated output, we can notice the carrier band at 1.35MHz for each side. The message bands are located at (Fc-fm) and (Fc+fm) frequencies on each side.

Modulated signal after adding AWGN:

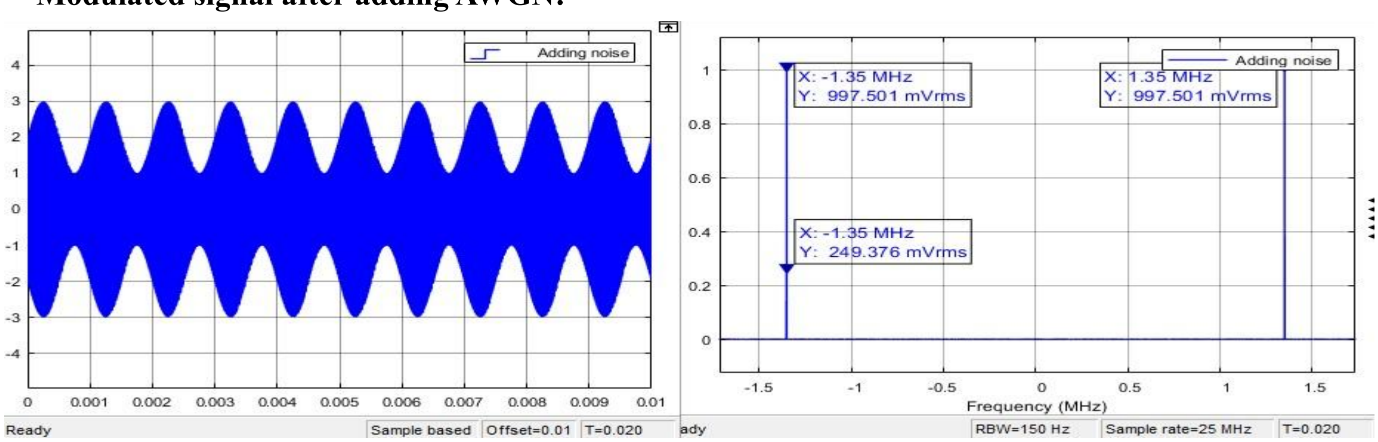


Figure: modulated signal after adding AWGN in time and frequency domain

As the noise power is very low, we can not notice any major effects on the signal after adding AWGN.

Demodulated signals in time and frequency domain:

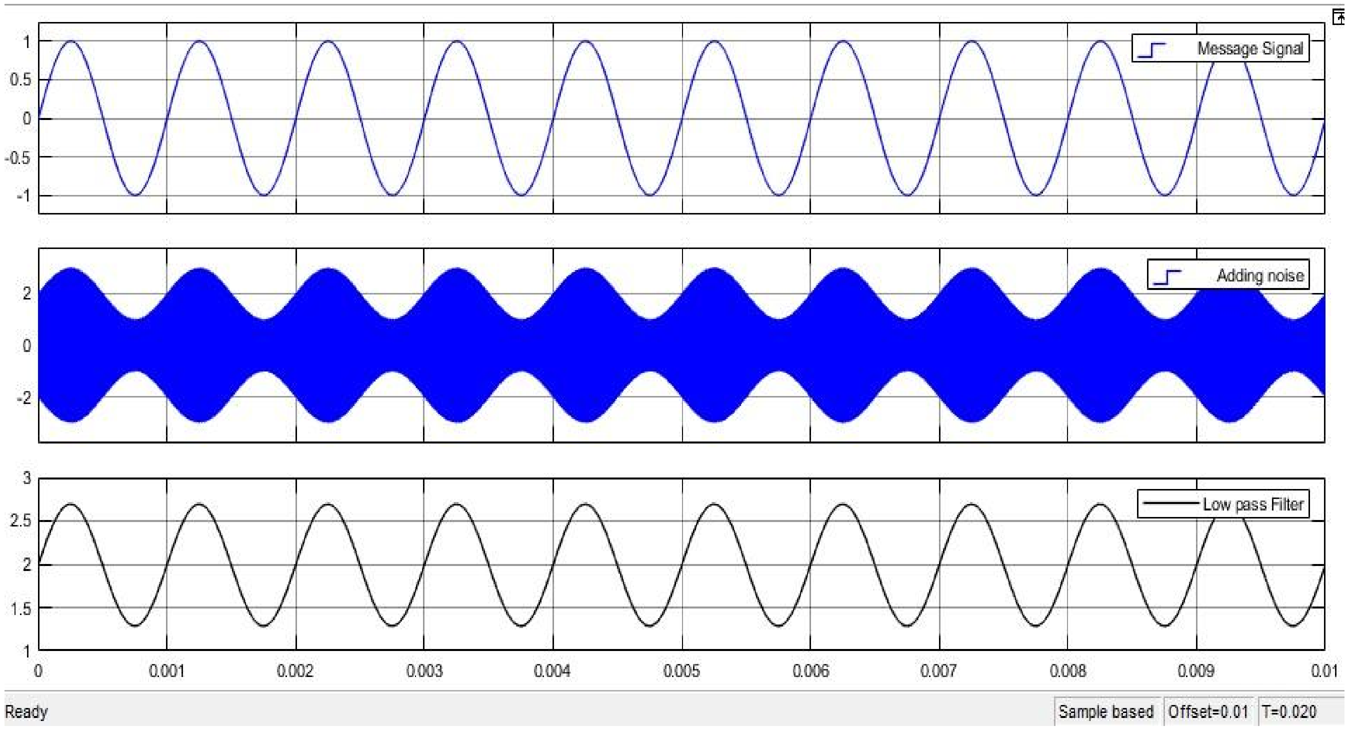


Figure: Message signal, modulated signal & demodulated signal in time domain

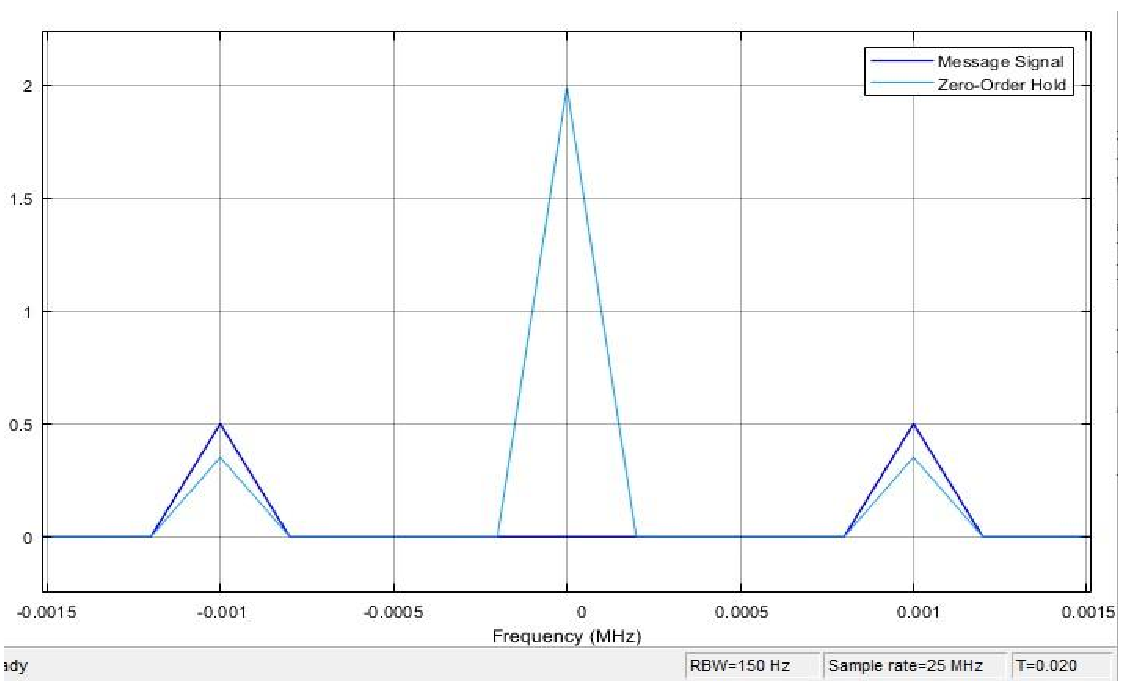


Figure: Message signal & demodulated signal in frequency domain

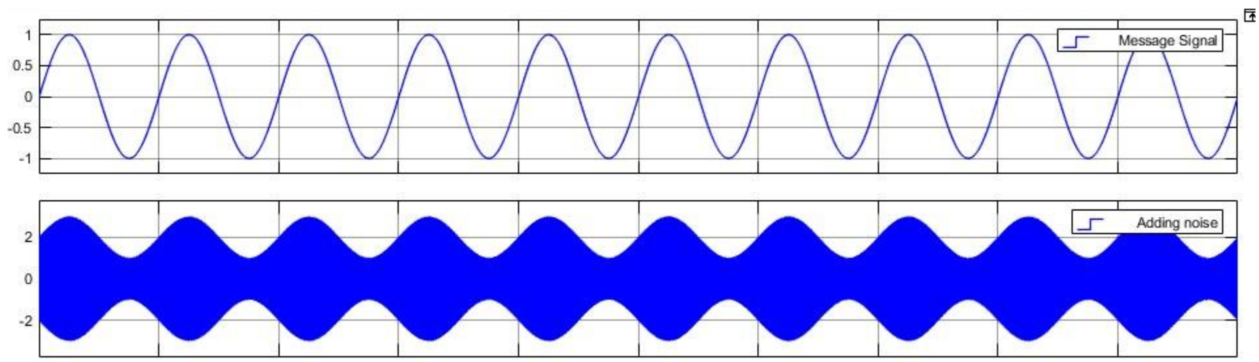
As this is DSB-WC modulation, we notice that the carrier is still present at the demodulated signal output. And the message bands are located at 0.001MHz or 1kHz frequency.

<u>Answer to the question no: 1</u>

The maximum RF bandwidth available in the communication link is 9kHz. This indicates that the maximum frequency of message signal that can be transmitted without exceeding the specified BW limit is 4.5kHz.

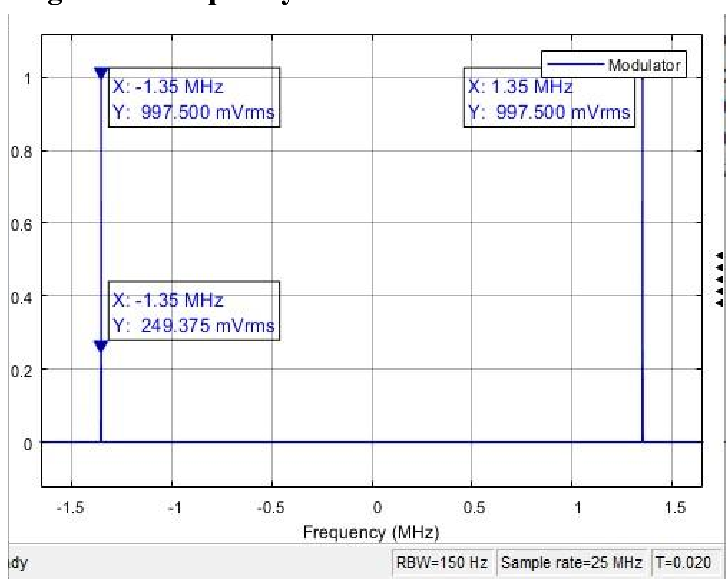
<u>Answer to the question no: 2</u>

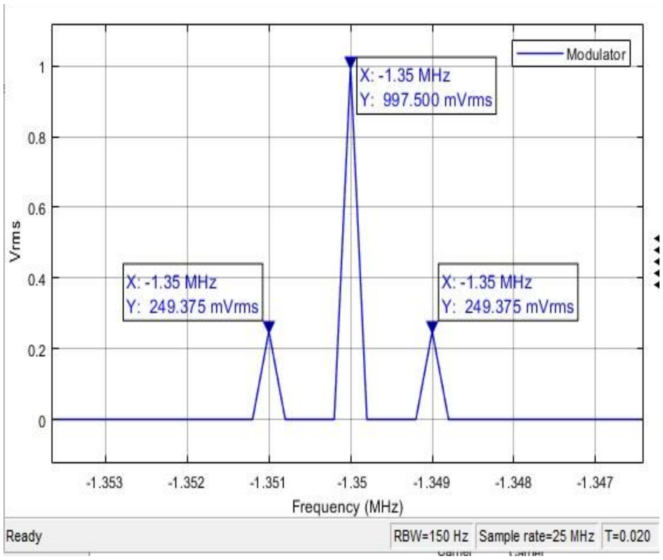
Message and modulated signals in time domain:

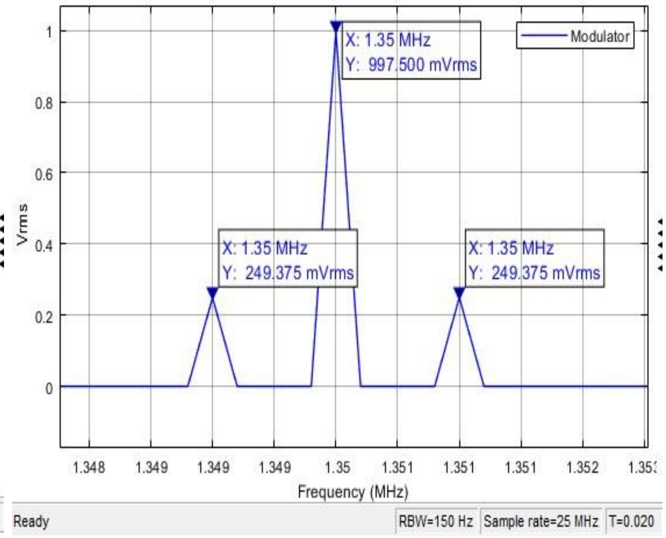


Here, the moduled output is Undermodulated as the modulation index is 0.5

Message and modulated signals in frequency domain:







For the DSB-WC modulated output, we can notice the carrier band at 1.35MHz for each side. The message bands are located at (Fc-fm) and (Fc+fm) frequencies on each side.

Answer to the question no: 3

Obtained SNR = 40.00dB. For this SNR,

Carrier power = $Ac^2/2$ [Ac = Carrier Amplitude]

$= 1.995^2/2$ Watts

$= 1.99$ Watts

Again,

Power on each sideband, $P_s = (\mu^2 \times Ac^2)/4$ [μ = Modulation index]

$= (0.5^2 \times 1.995^2)/4$ Watts

$= 0.249$ Watts

Answer to the question no: 4

Relation between SNR and Frequency,

SNR = 10 $\log_{10}(P_S / P_N)$ ... [P_S = signal power, P_N = noise power]

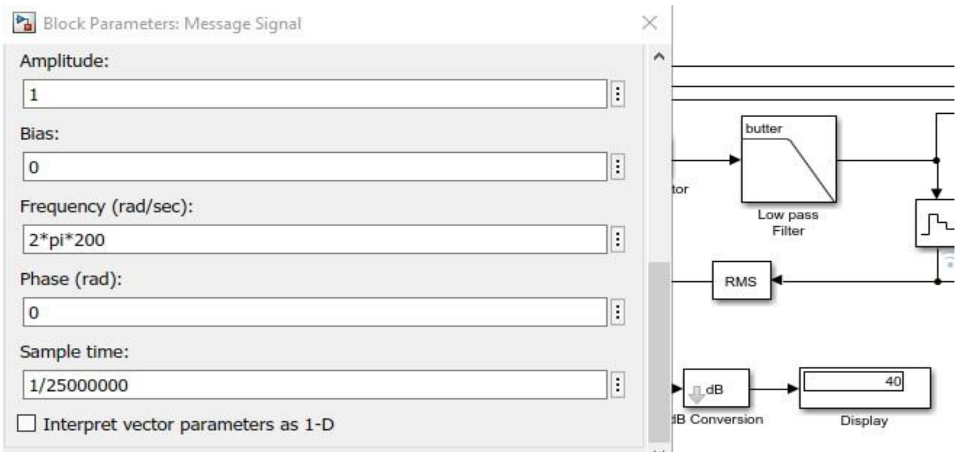
=> 40 = 10 $\log_{10}(P_S / P_N)$

=> $10^4 = \{ (\mu^2 A_{CO}^2) / 4 \} / \{2 N_O f_m \}$

...[f_m = message frequency, N_O= peak of the noise power spectrum density]

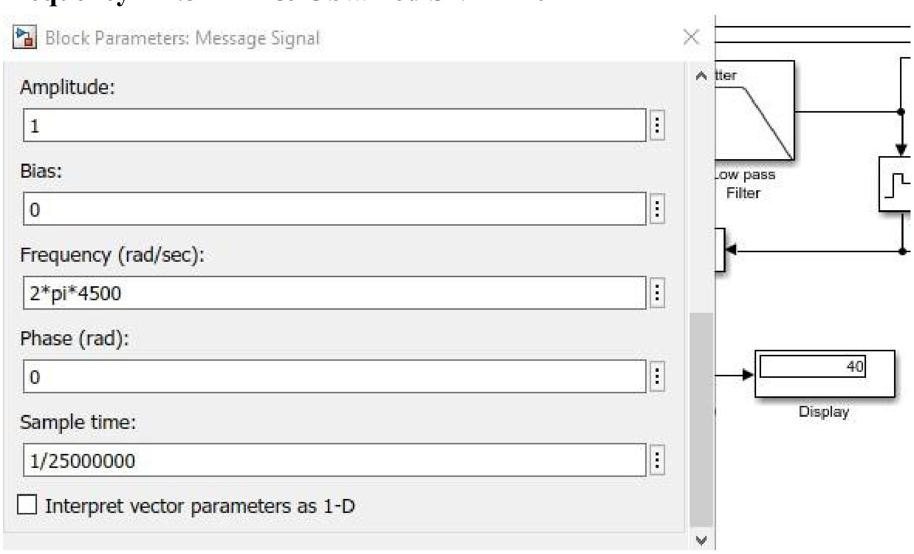
Here, the message frequency is inversely proportional to SNR.

- **Message frequency = 200 Hz & Obtained SNR = 40**



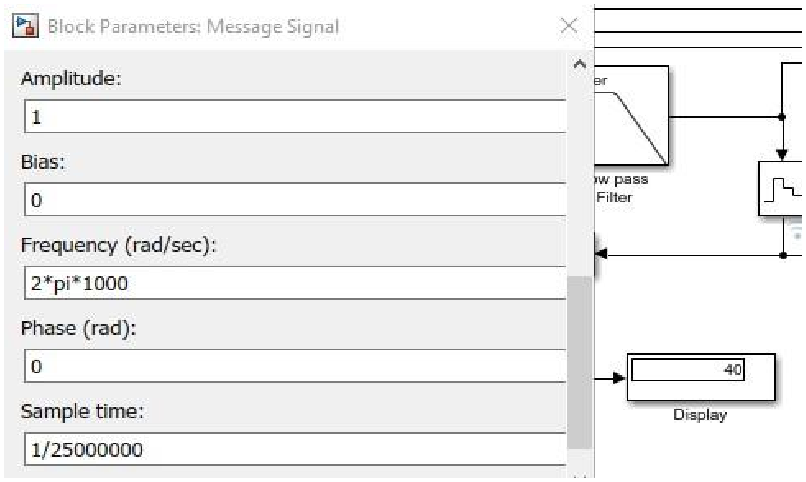
If we decrease the message frequency to 200Hz, the SNR stays the same.

- **Message frequency = 4.5k Hz & Obtained SNR = 40**



If we increase the message frequency to 4.5k Hz, the SNR stays the same as well.

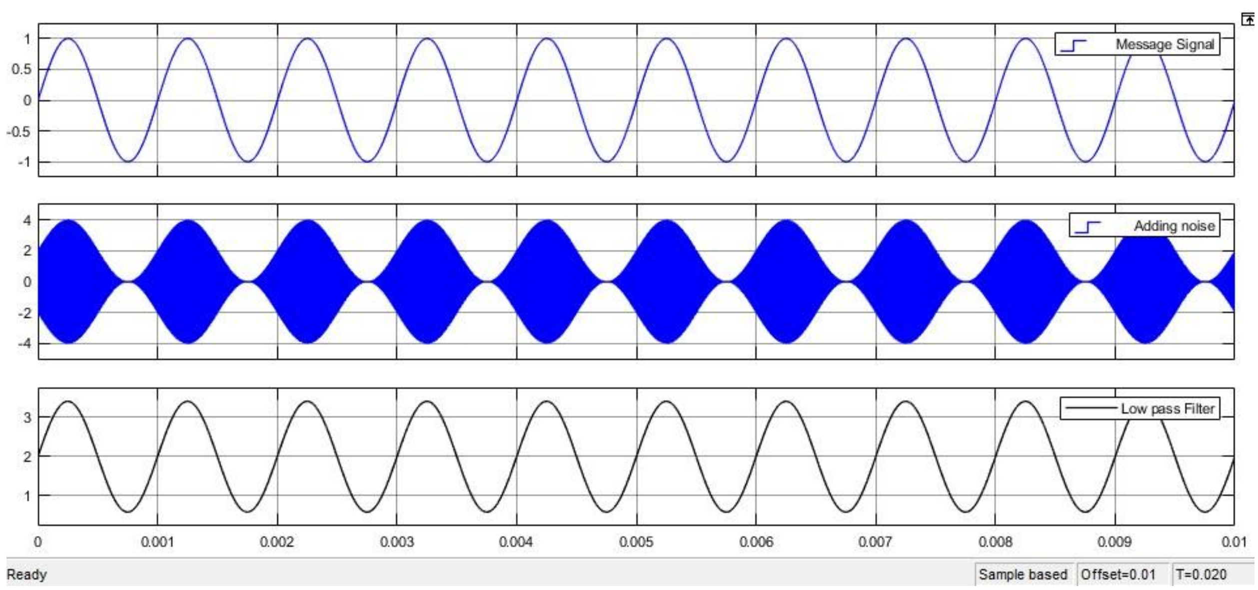
- **Message frequency = 1000 Hz , Modulation index (m) = 1 & Obtained SNR = 40**



If we keep the message frequency to 1k Hz and change the modulation index to 1 from 0.5, the SNR stays the same as well.

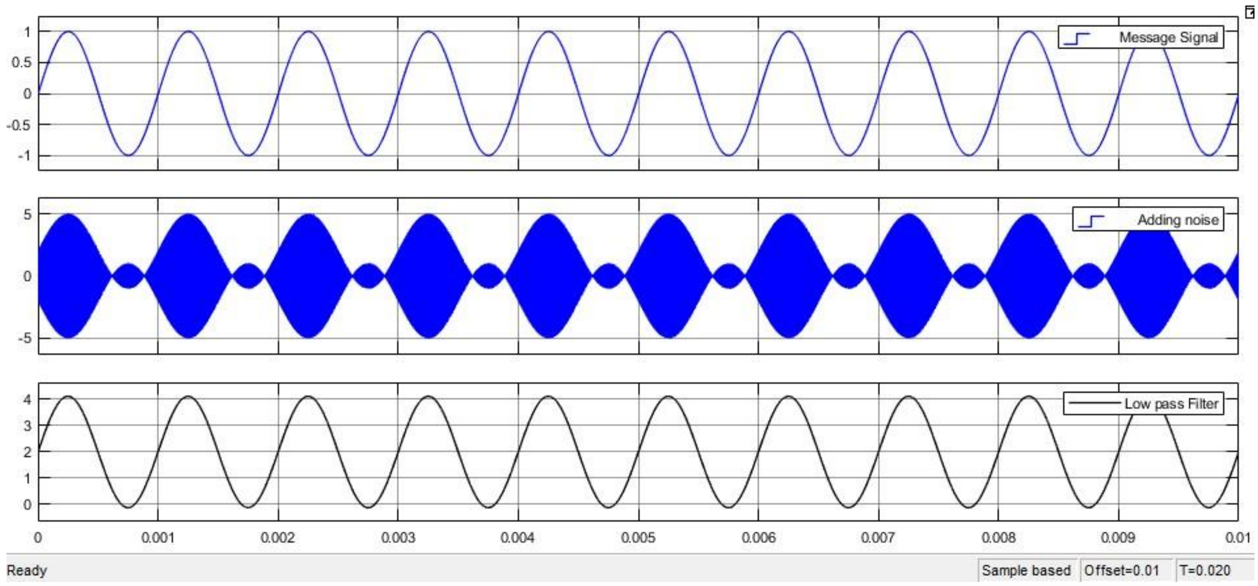
<u>Answer to the question no: 5</u>

Time domain waveforms:
Modulation index (m) = 1,



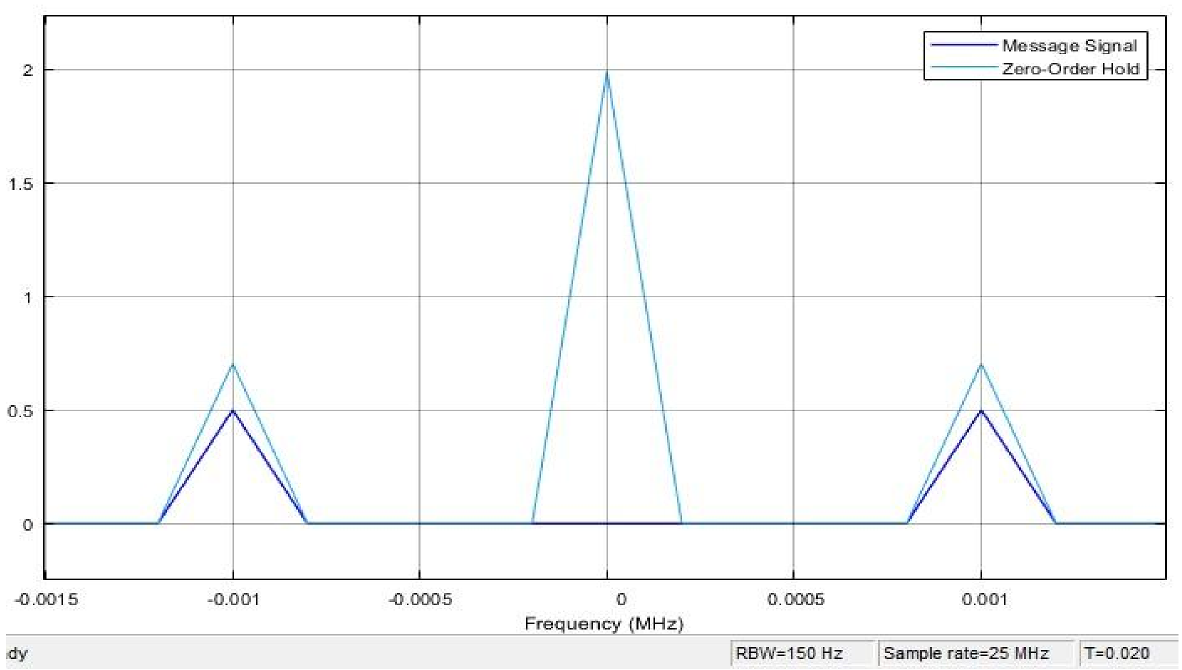
For modulation index 1, the modulated signal is shown to be perfectly modulated.

Modulation index (m) = 1.5,

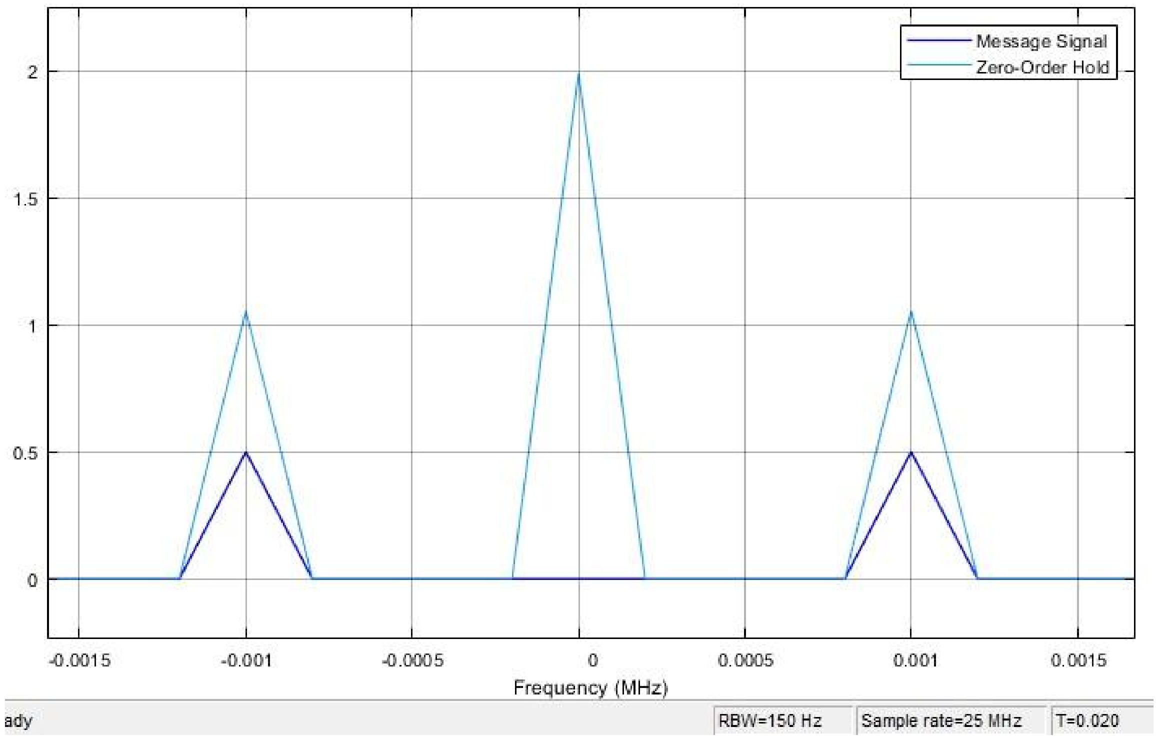


For modulation index 1.5, the modulated signal is shown to be overmodulated. In this case the signal gets distorted and the envelope detection is not possible. Additionally the carrier faces 180º phase shift. Therefore it is not ideal for the modulation index to be greater than 1.

Signals in Frequency Spectrum:
For modulation index (m) = 1



For modulation index (m) = 1.5



Discussion:

In the AM communication link, Double Sideband Modulation With Carrier (DSB-WC) method has been used. Here, AWGN has been added to the modulated signal, maintaining the given criteria. The signal has been passed through a Low Pass Filter (LPF) to extract the message signal keeping the passband frequency same as the message frequency. To obtain the Signal to Noise Ratio (SNR), the demodulated signal power was divided by Noise Power after passing through the RMS block to obtain powers of these signals. Simultaneously, the SNR has been converted in dB scale and the obtained value was 40dB. It is noteworthy that the demodulated signal is passed through a Zero Order Hold Simulink block as well before presenting it in the frequency spectrum. This particular block converts the signal from continuous time domain to discrete time domain. After changing certain parameters such as sample time and simulating the connection link, we get the SNR 40dB maintaining the desired criteria.

Here, when the modulation index is kept equal or less than 1, the signal is extracted without any distortion. Ideally, when the modulation index is 1, we can extract the envelope perfectly. For modulation index greater than 1, the signal gets distorted and the envelope detection gets impossible.