Roll No: AM.EN.U4ECE22135 Date: 16/05/2025

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19ECE384 / 19EAC386 Open lab-LabVIEW Programming (1-0-2-3)
S_6 B.Tech. ECE and EAC

Lab sheet 2 Basic waveform operations

Course Outcome mapping

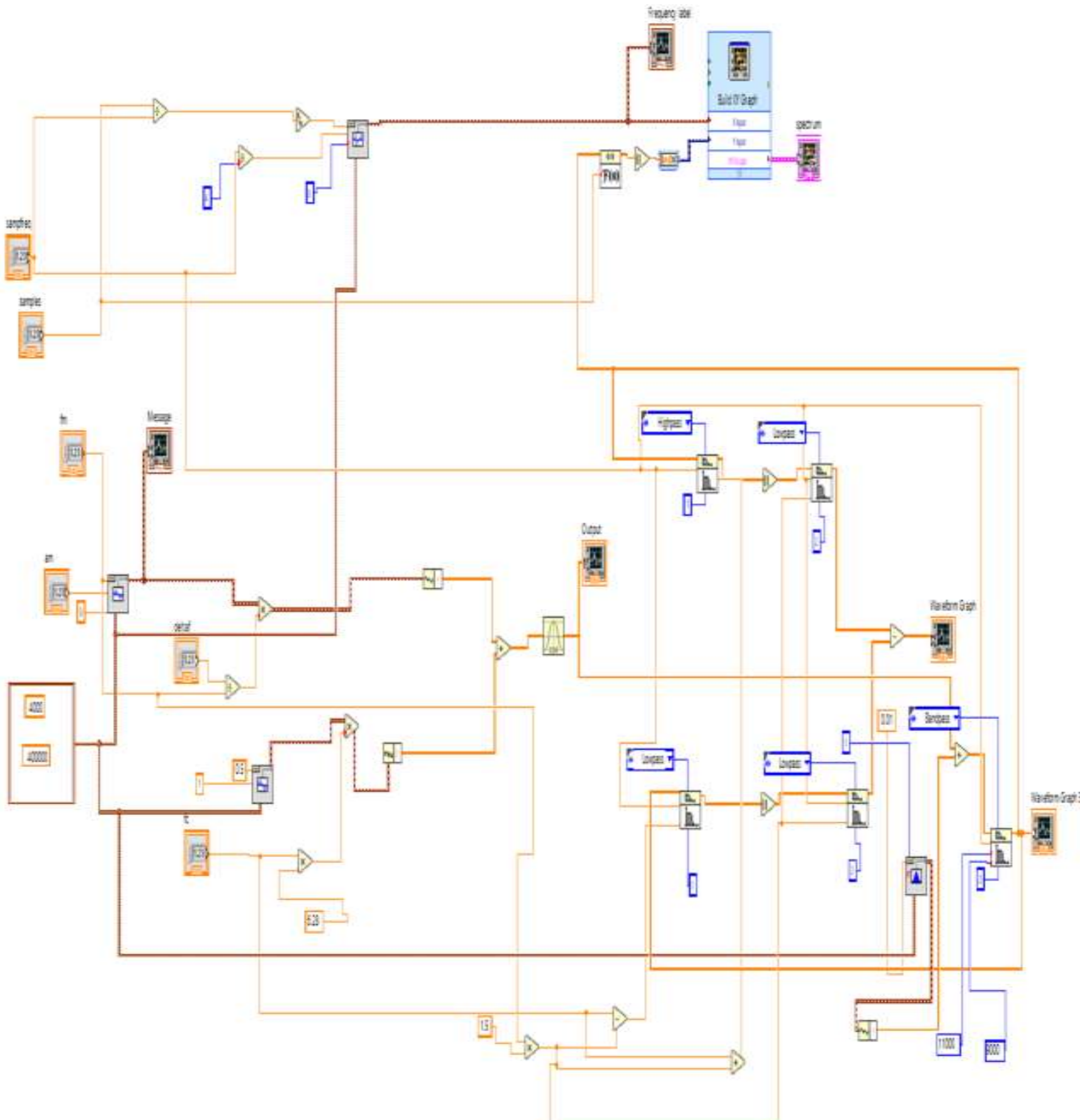
CO1	Ability to analyze practical problems and investigate scope for applying technology to develop feasible solutions	✓
CO2	Ability to review the state-of-the-art literature in the selected technology domain and arrive at functional solutions	
CO3	Design the required system using appropriate EDA tools and implement the hardware	
CO4	Ability to analyze the implementation impact and suggest improvements or modifications	
CO5	Present the concept with adequate validation on technical aspects and cost analysis using a report and seminar	

1. Implement FM demodulator.

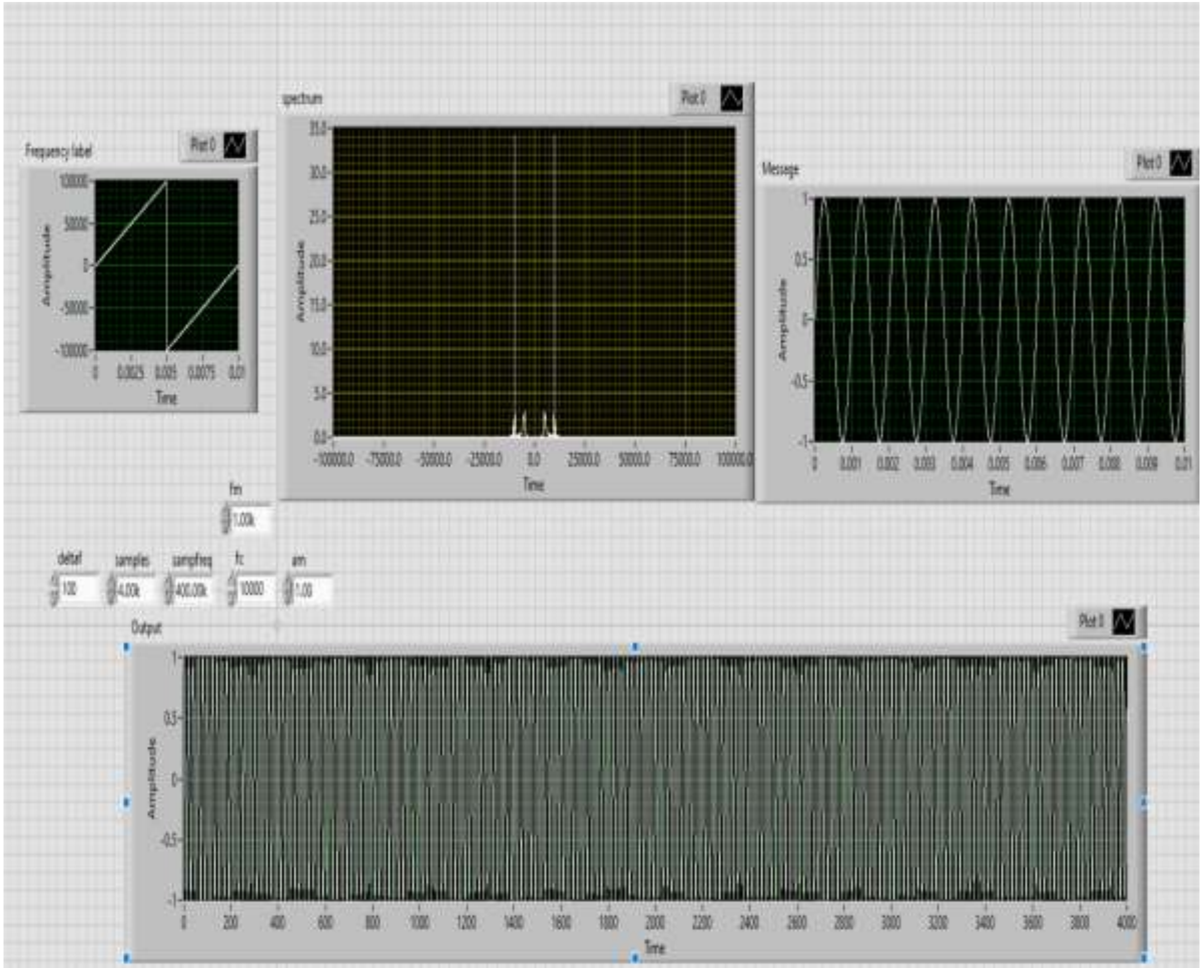
a. Plot the demodulated FM signal for modulation index/phase deviation β of (i)

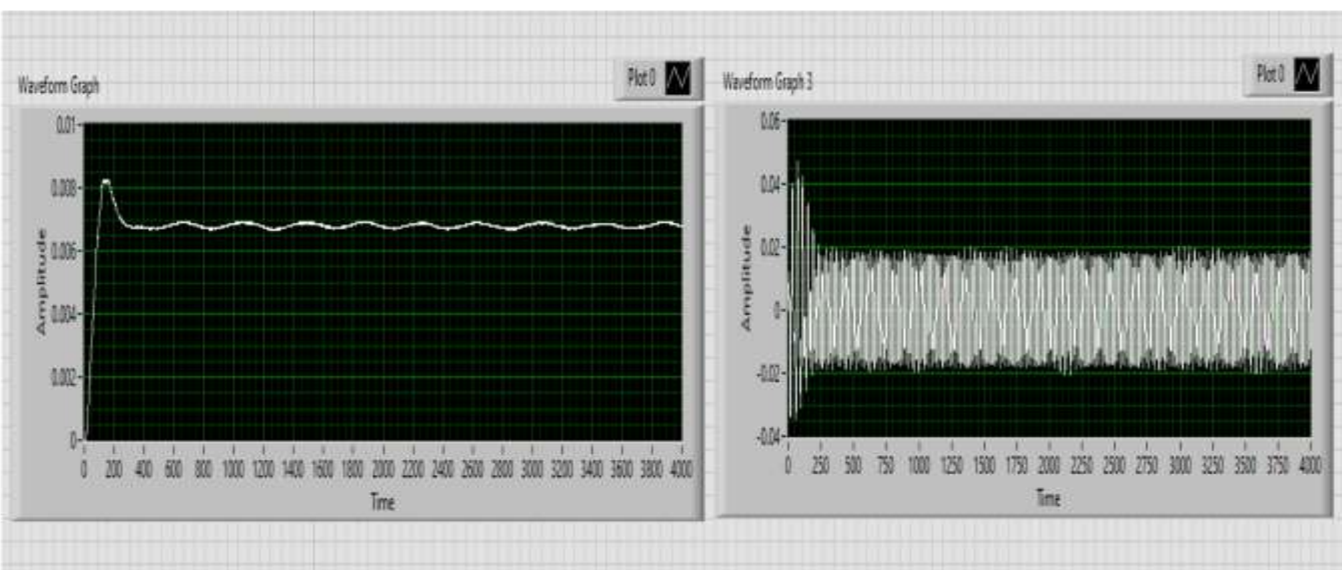
0.1, (ii) 1 and (iii) 5, and message signal frequency fm=1000Hz. Use appropriate carrier and sampling rate.

Block Diagram:

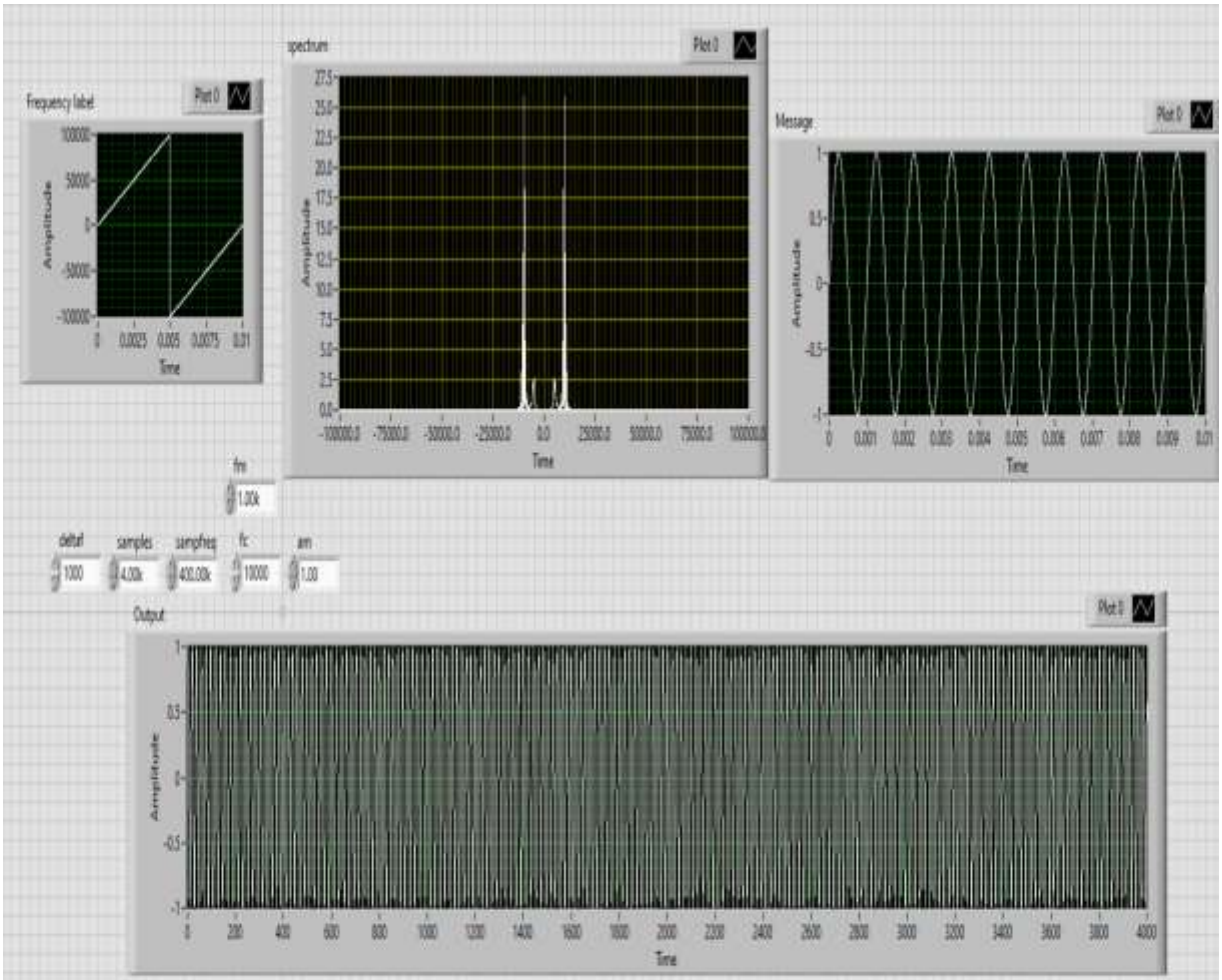

Frequency label
Build XY Graph
spectrum
sampfreq
samples
fm
Message
am
Output
Highpass
Lowpass
Lowpass
Lowpass
Bandpass
Waveform Graph
Waveform Graph 3
4000
400000
11000
8000

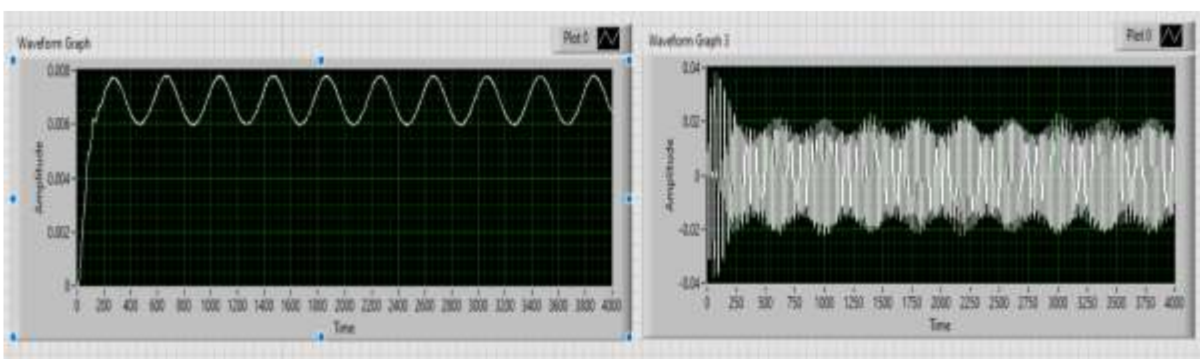
(i) Beta=0.1


Frequency label
Plot 0
Amplitude
Time
spectrum
Message
fm
deltaf
samples
sampfreq
fc
am
Output

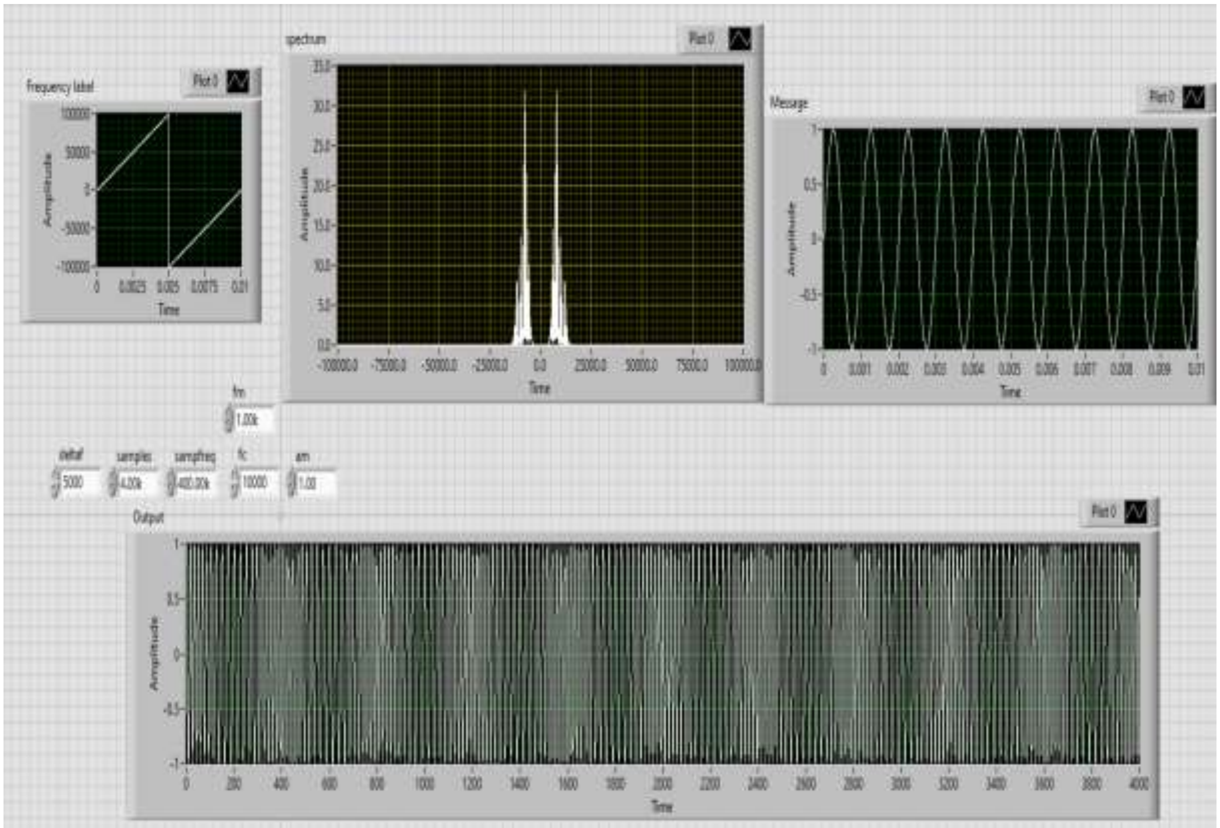

Waveform Graph
Plot 0
Amplitude
Time
Waveform Graph 3

(ii) Beta=1

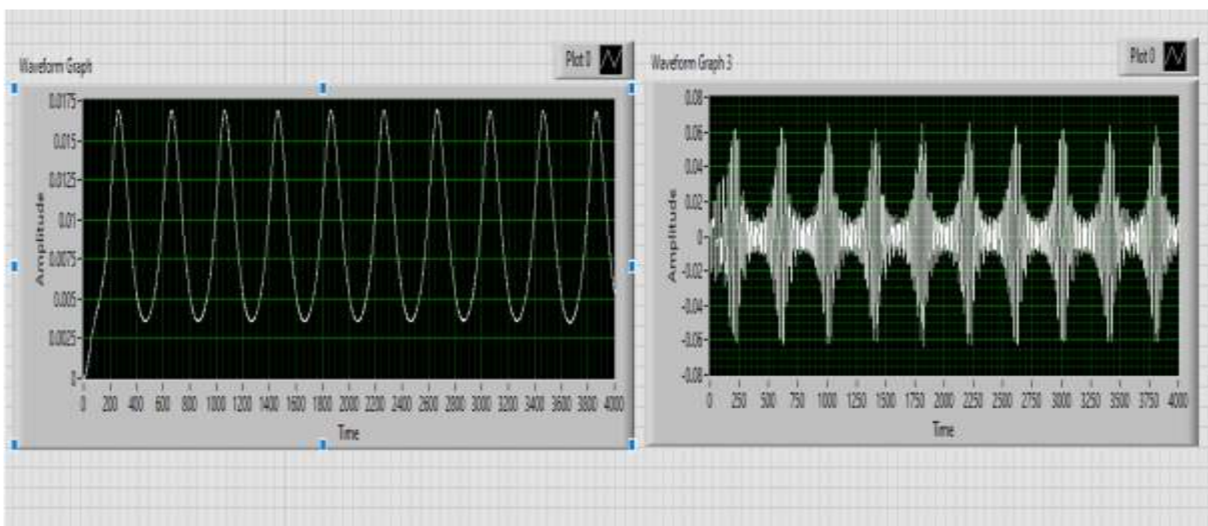

Frequency label
spectrum
Message
Output
Amplitude
Time
deltaf
samples
sampfreq
fc
am
fm


Waveform Graph
Amplitude
Time

(iii) Beta=5



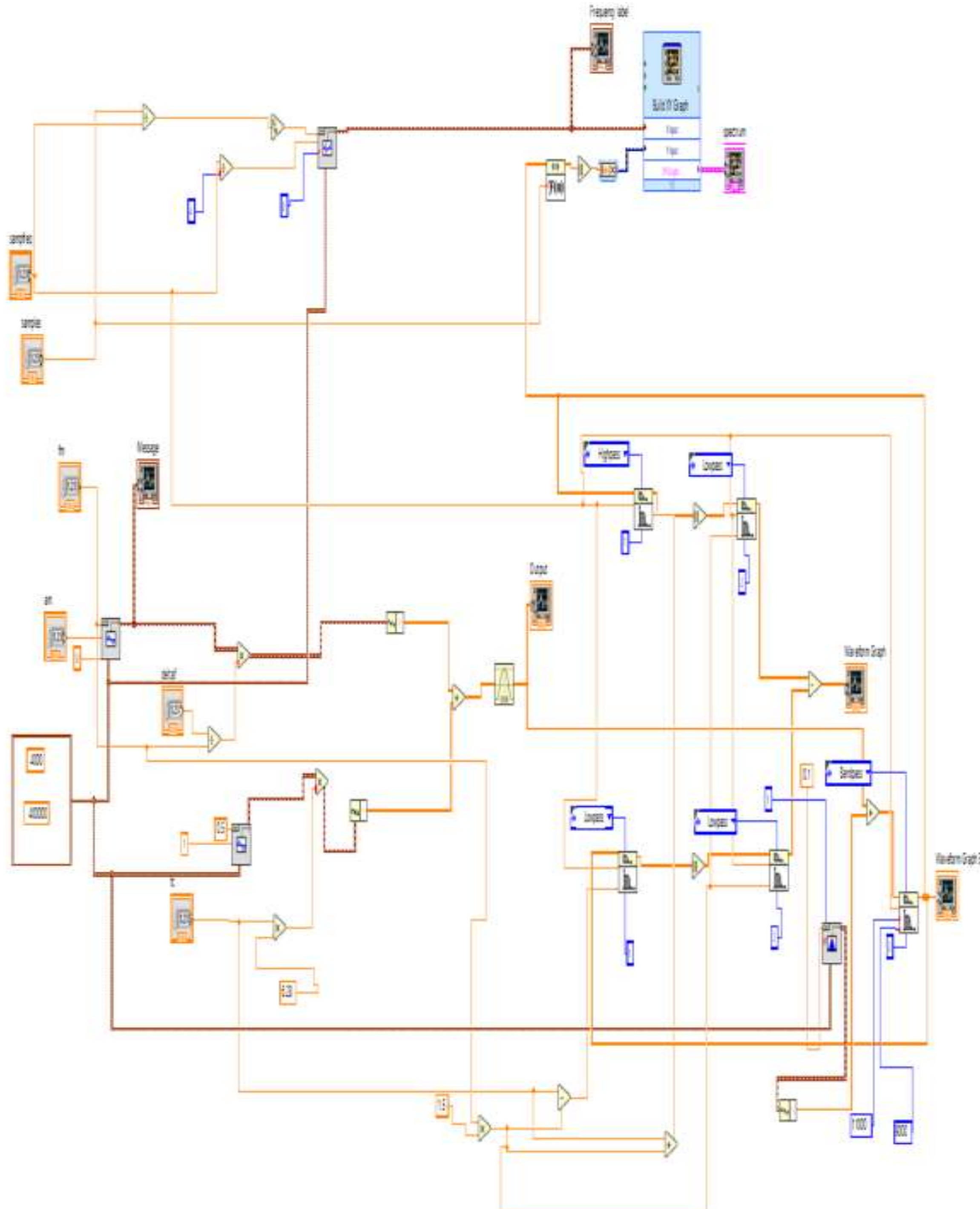
Frequency label
Plot 0
Amplitude
Time
spectrum
Plot 0
Amplitude
Time
Message
Plot 0
Amplitude
Time
fm
deltaf
samples
sampfreq
fc
am
Output
Plot 0
Amplitude
Time



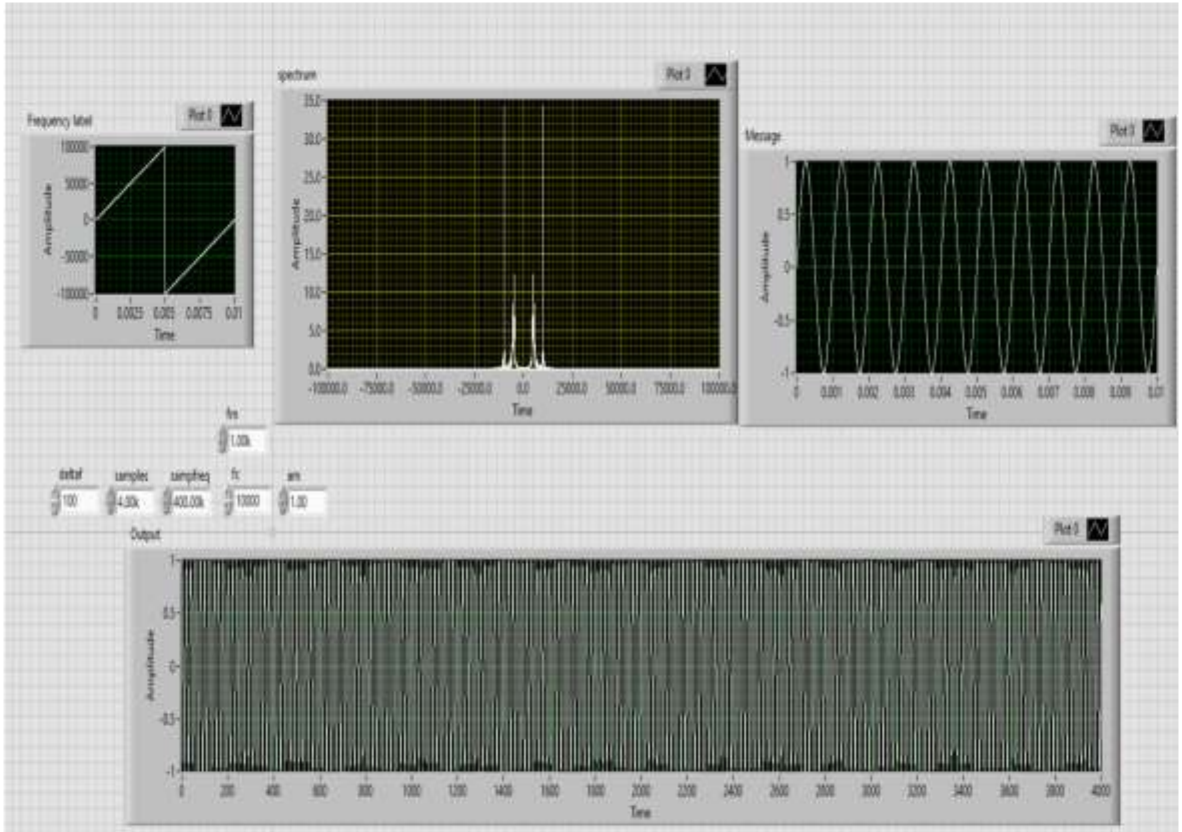
Waveform Graph
Plot 0
Amplitude
Time
Waveform Graph 3
Plot 0
Amplitude
Time

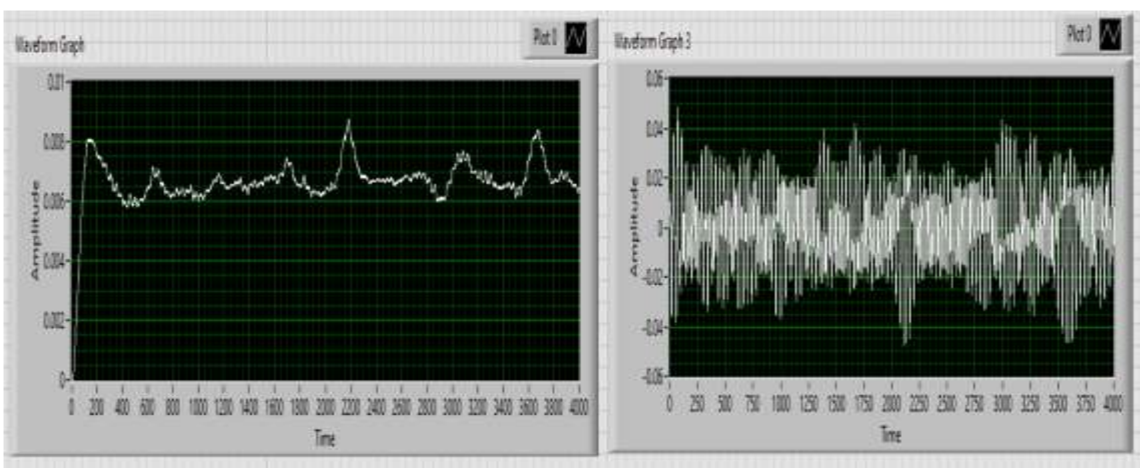
b. Add AWGN to the channel and see the performance.

Block diagram:

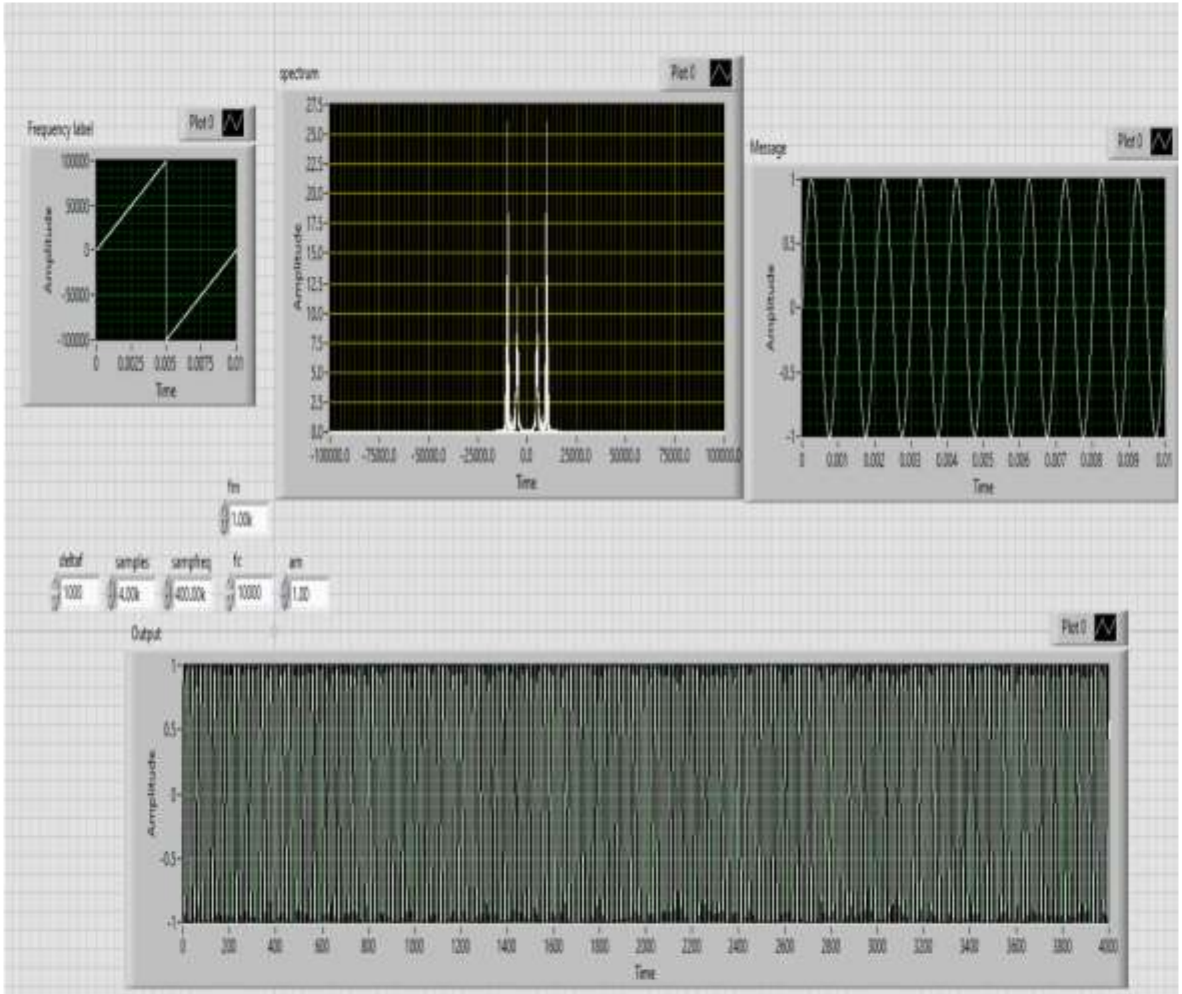


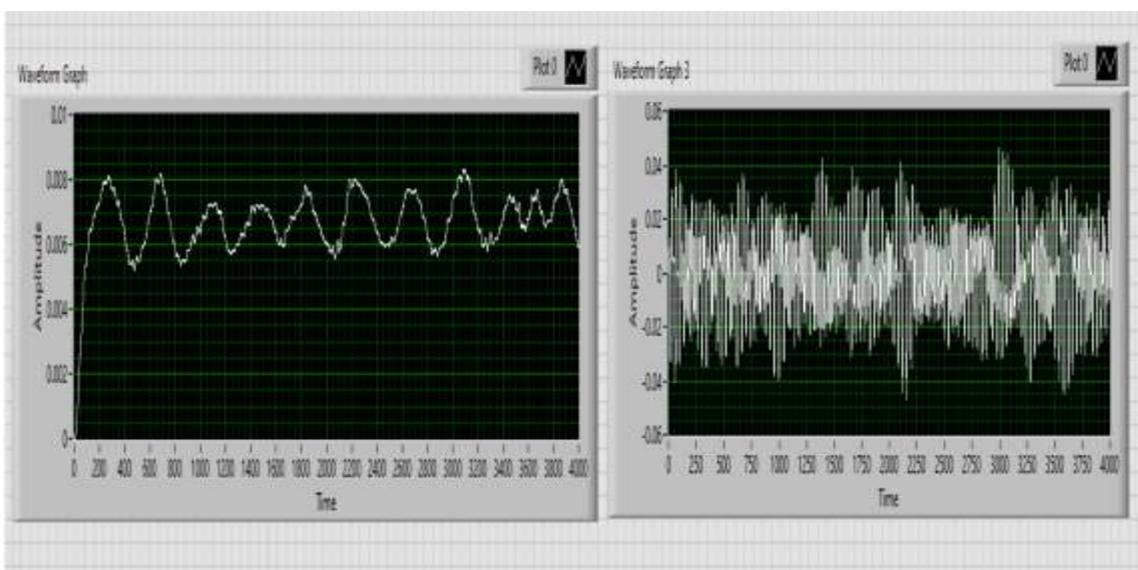
For beta =0.1



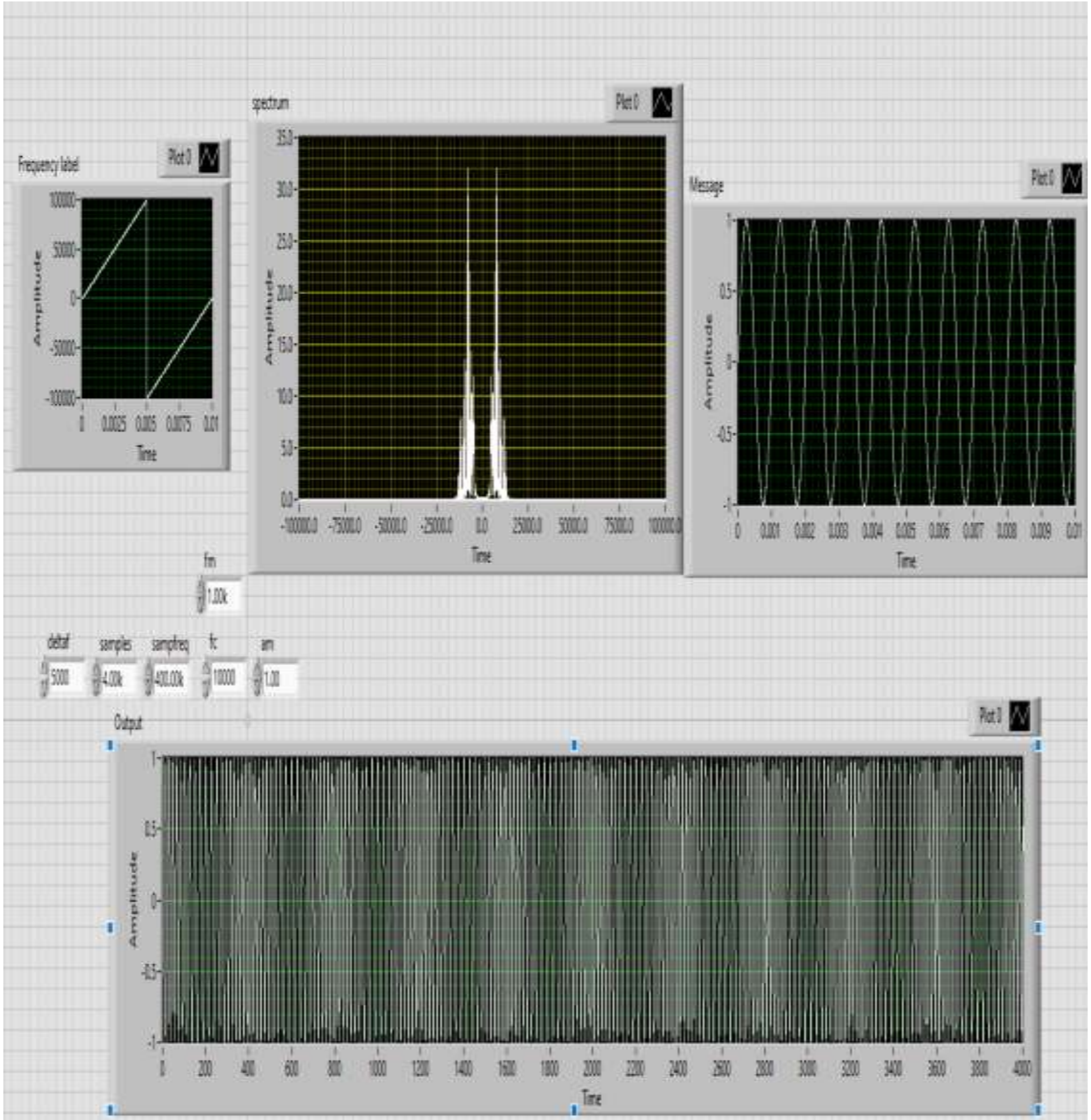


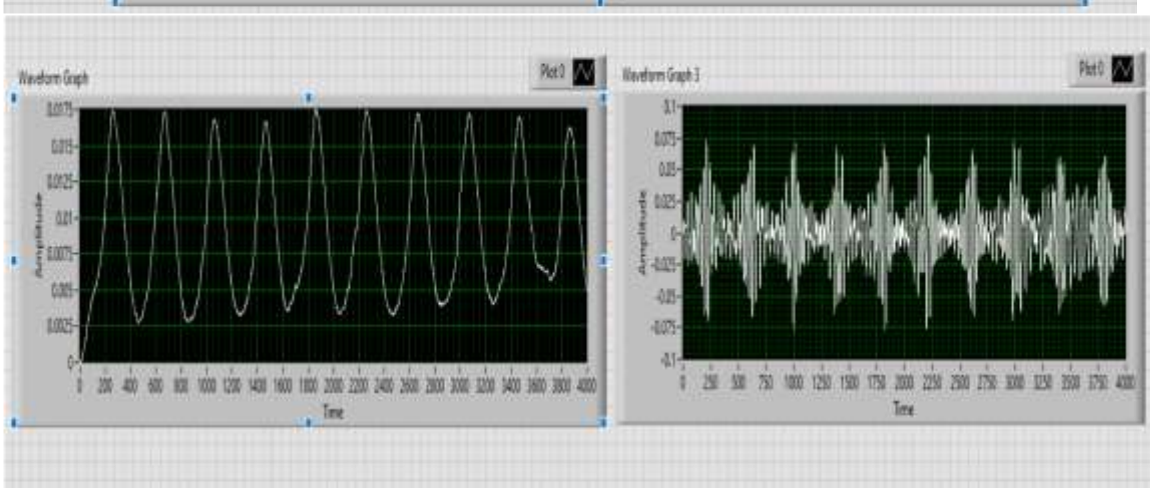
When beta is 1





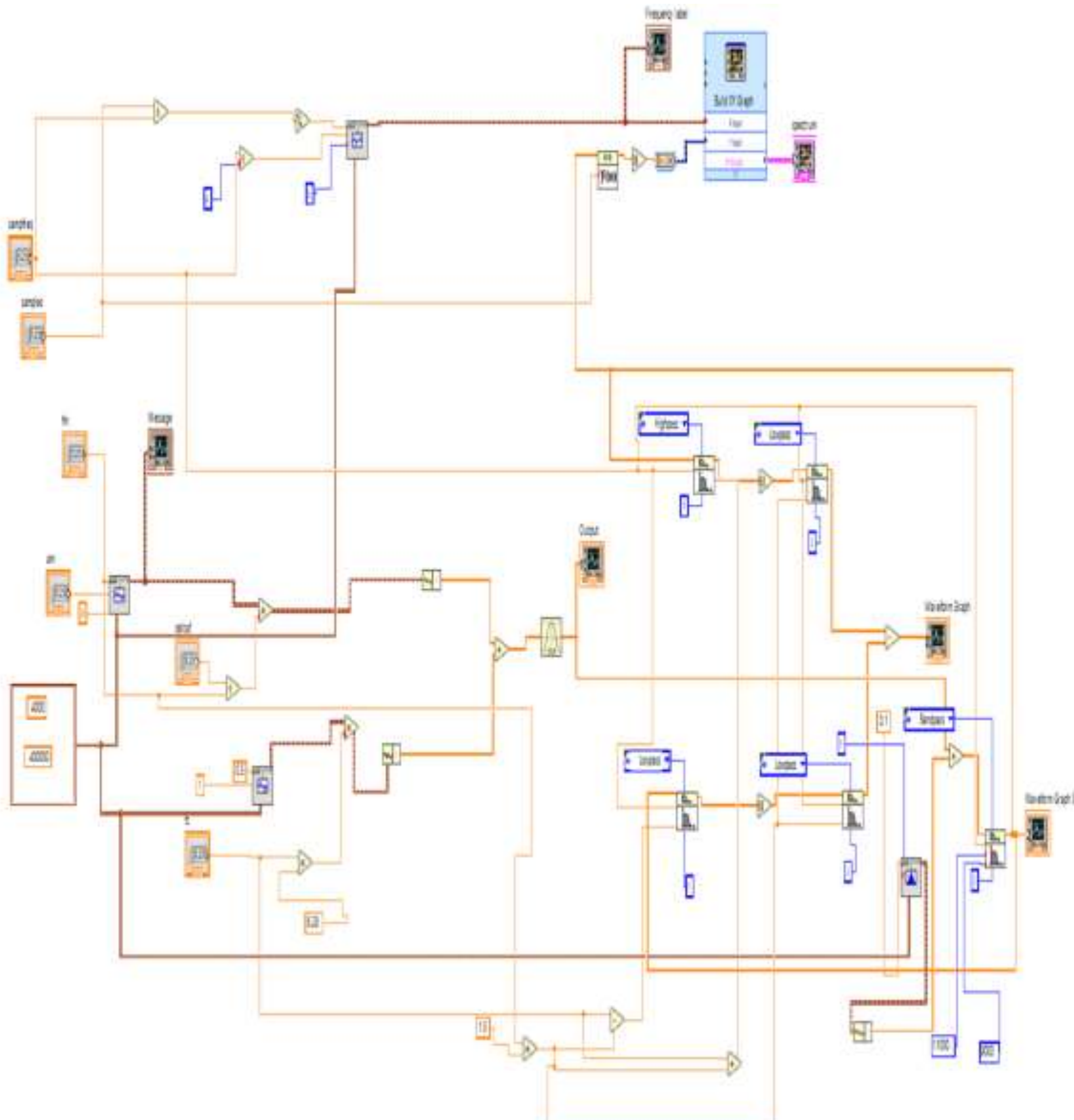
Beta is 5


Frequency label
Plot 0
spectrum
Plot 0
Message
Plot 0
Amplitude
Time
fm
1.00k
deltaf
5000
samples
4.00k
sampfreq
400.00k
fc
10000
am
1.00
Output
Plot 0
Amplitude
Time

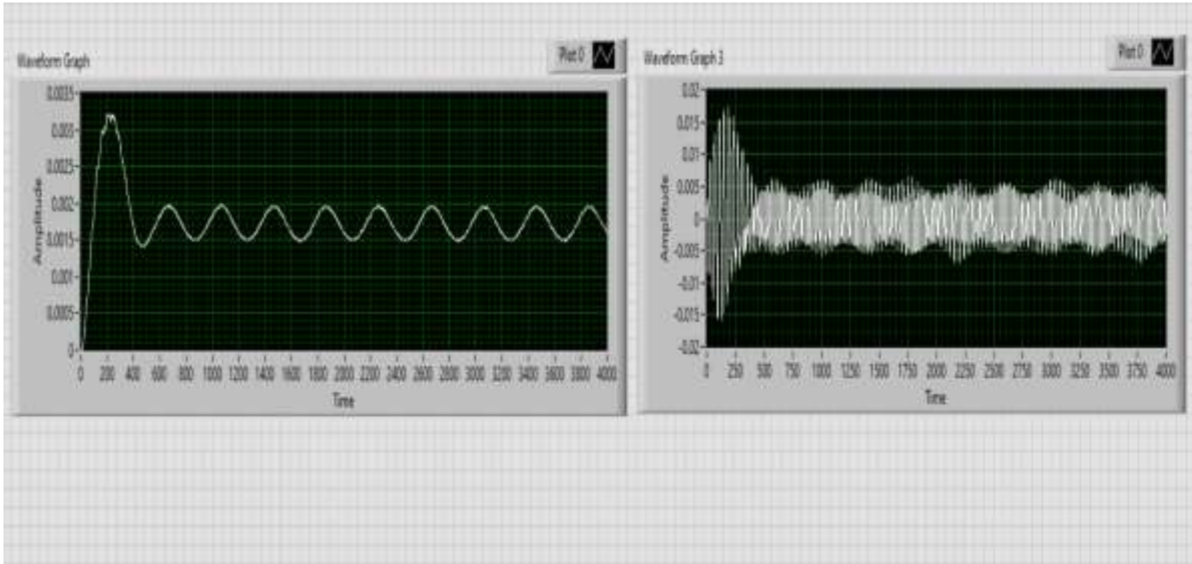

Waveform Graph
Plot 0
Waveform Graph 3
Plot 0
Amplitude
Time

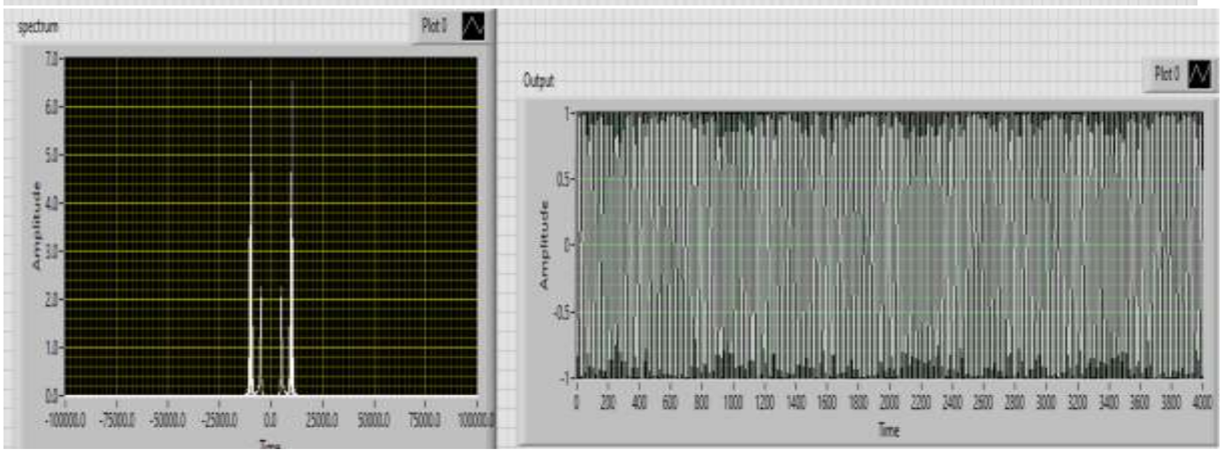
2. Introduce a Butterworth band pass filter with center frequency fc and bandwidth (i) Δf
(ii) 2 Δf and (iii) 4 Δf in the channel and see its effect on noise.

BLOCK DIAGRAM:

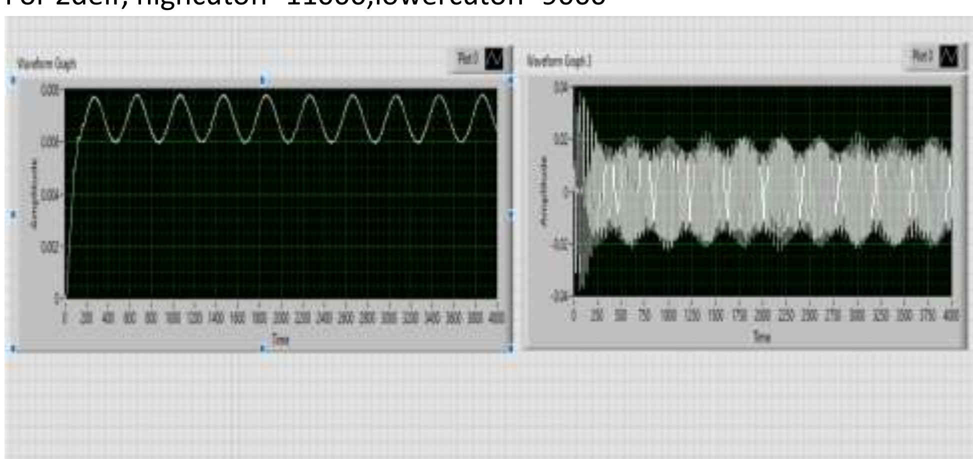


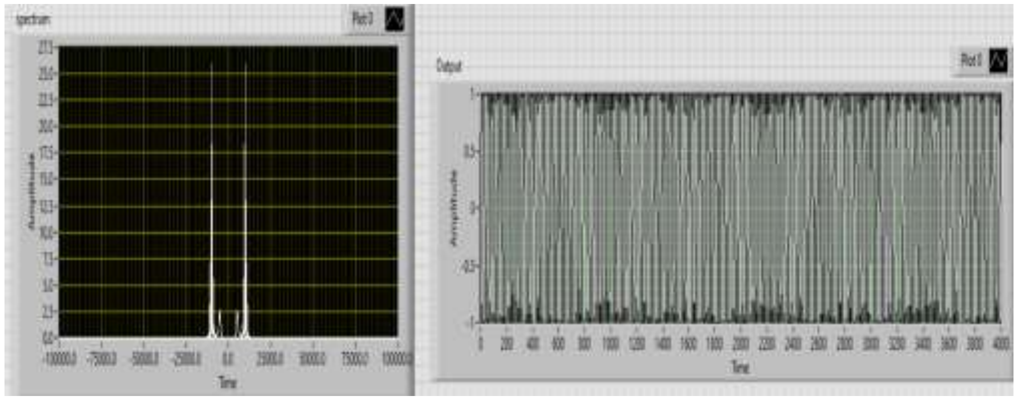
(i) For delf, highcutoff=10500, lowercutoff=9500



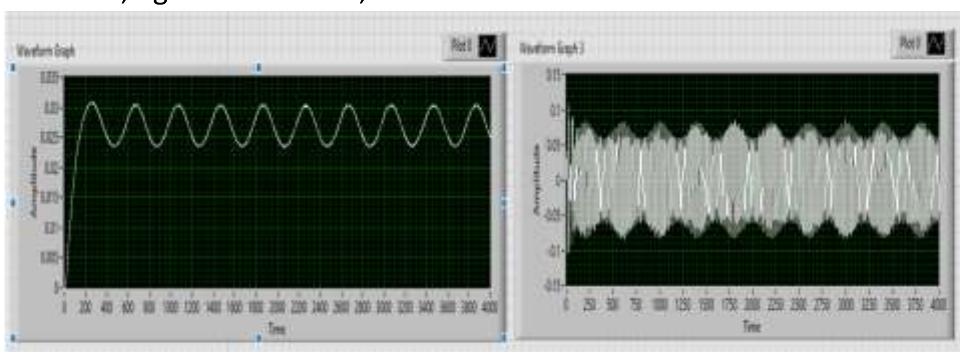


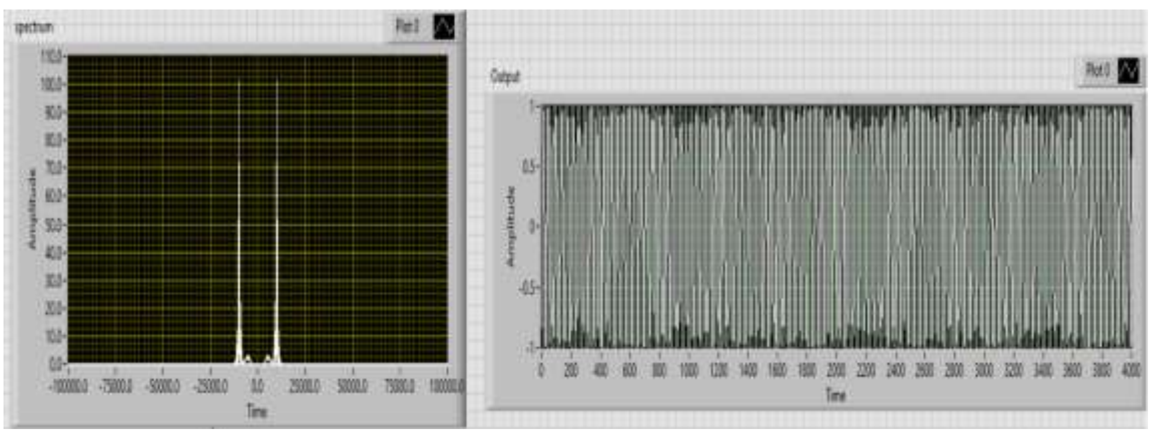
(ii) For 2delf, highcutoff=11000,lowercutoff=9000





(iii) For 4delf,highcutoff=12000,lowcutoff=8000





3. Based on the above results, what is the trade-off when one limits the bandwidth of FM channel?

When the bandwidth of an FM channel is increased, it helps reduce the amount of noise in the demodulated signal, leading to a higher signal-to-noise ratio and improved output quality. However, this comes at the cost of limiting the frequency deviation range of the FM signal. Such a limitation can cause distortion or loss of information, particularly when dealing with higher modulation indices. Thus, there's a trade-off between minimizing noise and maintaining the accuracy of the original signal.

4. How can you convert an FM system to PM system, and PM system to FM system?

FM to PM Conversion: To convert frequency modulation into phase modulation, first integrate the message signal before feeding it into a phase modulator. This method works because frequency is the time derivative of phase, so integration effectively transforms the FM signal into an equivalent PM signal.

PM to FM Conversion: To achieve phase modulation using a frequency modulator, differentiate the message signal before applying it. Since phase is the integral of frequency, differentiating the message signal causes the frequency modulator to produce a signal that behaves like phase modulation.

RESULT

FM demodulation was carried out for three modulation indices: $\beta = 0.1$, 1, and 5, using a message signal with a frequency of 1000 Hz. For $\beta = 0.1$, the frequency deviation was minimal, and the demodulated signal closely resembled the original message but was more prone to noise interference. At $\beta = 1$, the output quality improved with better clarity and moderate resistance to noise. For $\beta = 5$, the system showed strong noise immunity and effectively preserved the message signal, though it demanded a much wider bandwidth. When additive white Gaussian noise (AWGN) was introduced into the channel, the signal quality deteriorated more significantly at lower β values, while higher modulation indices maintained clearer demodulation. A Butterworth band-pass filter was applied to the channel using bandwidths of Δf, $2\Delta f$, and $4\Delta f$. A narrow bandwidth (Δf) caused distortion due to insufficient coverage of the FM signal spectrum. A medium bandwidth ($2\Delta f$) provided a good compromise between noise filtering and signal accuracy. A wide bandwidth ($4\Delta f$) preserved the signal more effectively but allowed more noise to pass through.

INFERENCE:

The experiment highlights the significant impact of the modulation index on FM system performance. Increasing the modulation index enhances the system's ability to resist noise, resulting in a clearer demodulated output even under noisy conditions; however, this comes with the trade-off of requiring more bandwidth. The use of filters with different bandwidths showed that there's a balance to strike between noise reduction and maintaining signal quality. While narrow filters effectively limit noise, they can also cause signal distortion or loss. On the other hand, wider filters preserve the signal’s shape but allow more noise to pass through. Therefore, choosing the right bandwidth is crucial for efficient FM transmission. Furthermore, the ability to switch between FM and PM by integrating or differentiating the message signal demonstrates the fundamental connection between frequency and phase modulation.