U20CS110

Date

Expt. No. 04

Experiment NO.-4

Frequency modulation and Demodulation

Aim: To demonstrate frequency modulation and demodulation process by observing the waveforms in time domain and their spectra in frequency domain by varying the parameters of massage signal. Draw waveforms and spectra. Use virtual mode with appropriate software.

Apparatus required Matlab software, Labalive software

Theory:

1) Angle modulation is the process in which the frequency or phase of the carrier varies according to the message signal.

2) The standard equation of the angle modulation wave is

$$S(t) = A_c \cos(\theta_i(t))$$

where A_c = Amplitude of modulated / Carrier wave
θ_i = Angle of modulated waving

3) Angle modulation is further divided into frequency modulation and phase modulation

1) **Frequency Modulation:** is the process of varying the frequency of the carrier signal linearly with the message signal

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2) Phase Modulation is the process of varying the phase of carrier signal linearly with message signal.

4) As frequency of modulated wave increases, the amplitude of the modulating or message signal increases. Similarly, the frequency of modulated wave decreases, when the amplitude of modulated signal decreases.

Note: The frequency of modulated (carrier) wave remains constant and is equal to the frequency of carrier signal, when amplitude of modulating signal is zero.

5) Mathematically, the equation for instantaneous frequency f_i in FM modulation.

$$f_i = f_c + (K_f)\, m(t) \quad \text{---} (1)$$

carrier frequency — frequency sensitivity — message signal

6) We know relationship between ω_i and $\theta_i(t)$

$$\omega_i = \frac{d(\theta_i)}{dt} \quad \text{---} (2)$$

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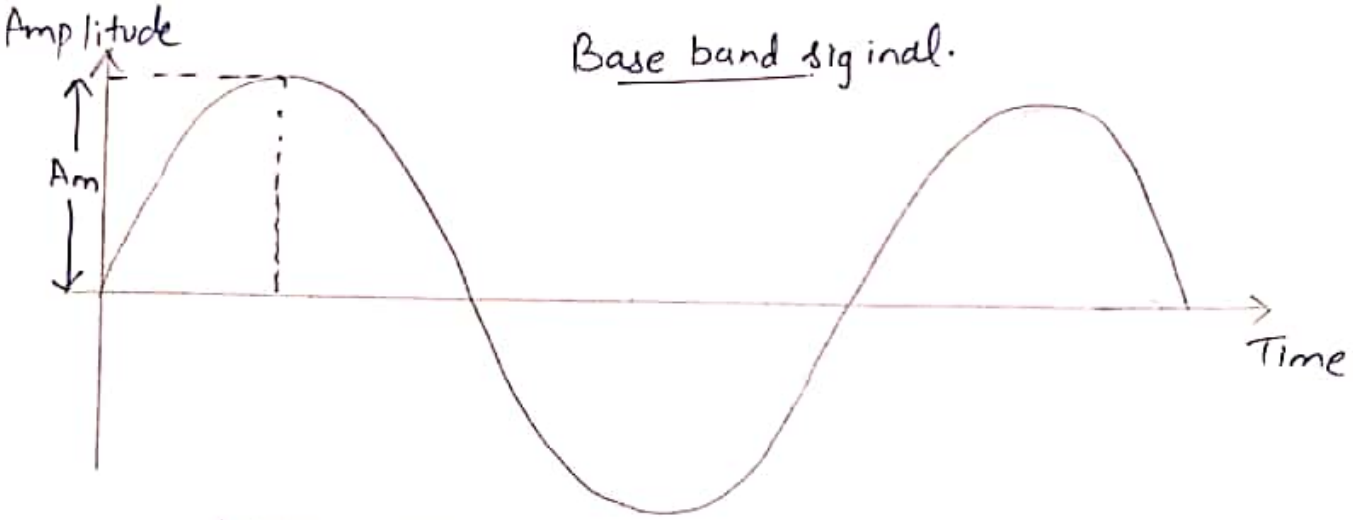
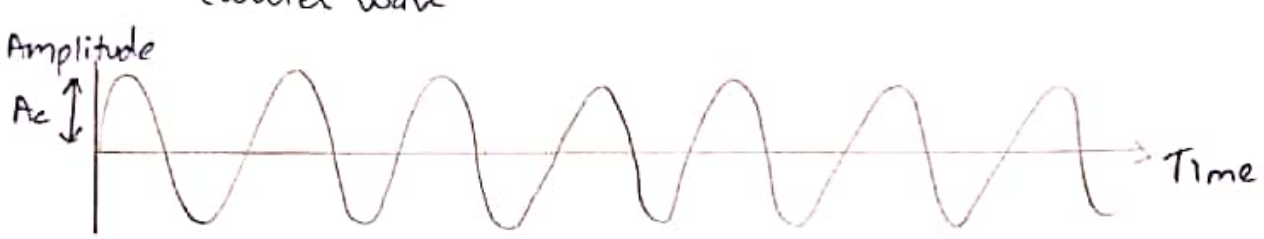
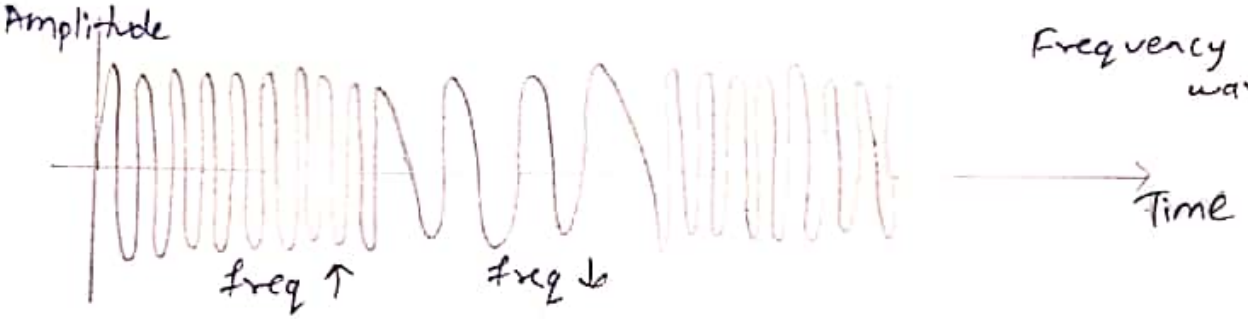
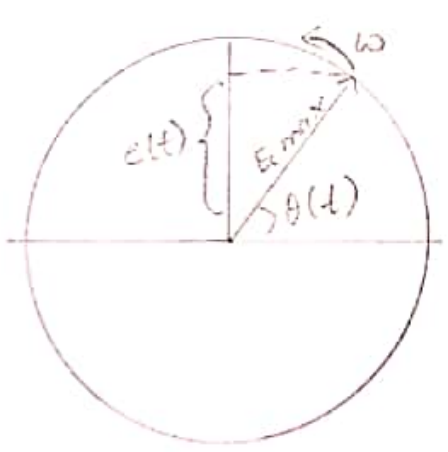


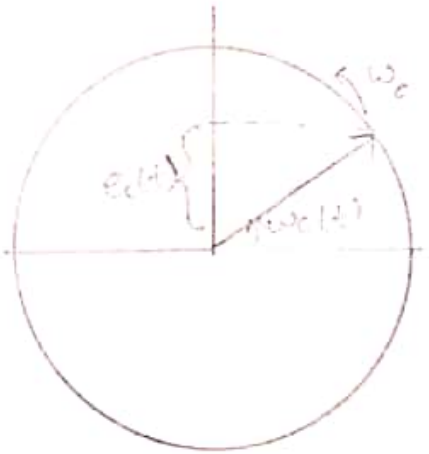




Rotating phasor representation of carrier of amplitude E_c max.



a) Instantaneous angular velocity $\omega_i(t)$



b) at constant angular velocity (ω_c)

$$2\pi f_i = \frac{d\theta_i}{dt}$$

$$d\theta_i(t) = 2\pi f_i\, dt$$

substitute f_i from eqn (1)

$$\theta_i(t) = 2\pi f_c + 2\pi k_f + \int m(t)dt \quad -(3)$$

substitute $\theta_i(t)$ value in standard eqn of angle modulation

$$s(t) = A_c \cos(2\pi f_c t + 2\pi k_f \int m(t)dt) \quad -(4)$$

eqn of FM wave

7) Finally, eqn of FM wave

$$s(t) = A_c \cos[2\pi f_c t + 2\pi k_p \int m(t)dt] \quad -(4)$$

If modulating signal $m(t) = A_m \cos(2\pi f_m t)$ then eqn of FM

$$s(t) = A_c \cos[2\pi f_c t + \beta \sin(2\pi f_m t)] \quad -(5)$$

$$\beta = \frac{k_f A_m}{f_m} = \frac{\Delta F}{f_m} = \text{modulating index}$$

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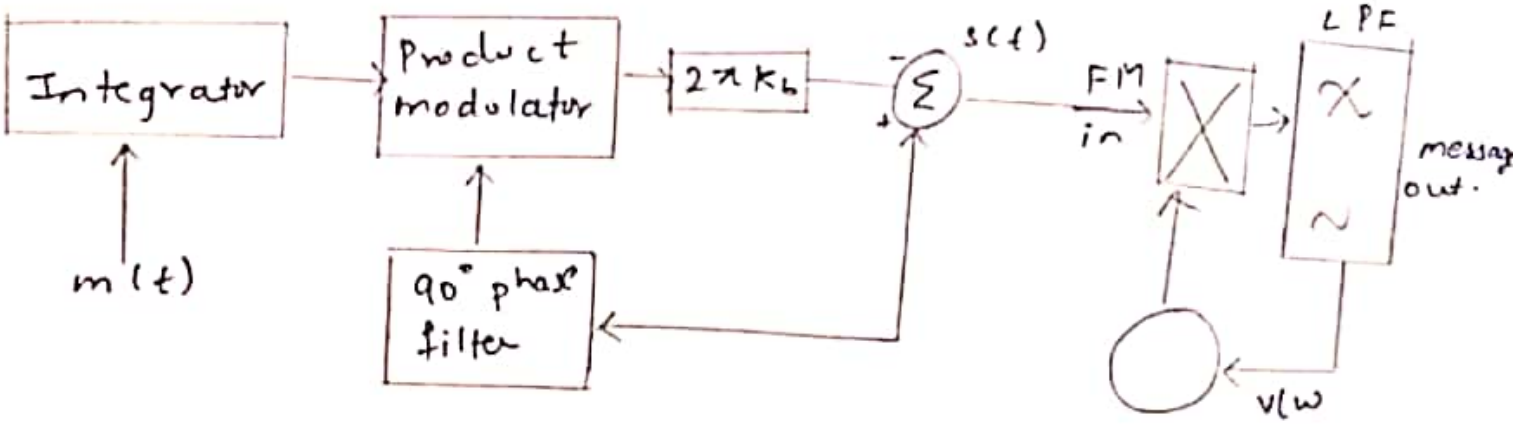
Block diagram of FM modulator & demodulator.



8) The difference between FM modulated frequency (instantaneous) and normal frequency is termed as frequency deviation.
It is denoted by $[\Delta F = (f_i - f_c) = k_f \Delta m]$

9) The amount of change in carrier frequency produced, by the amplitude of input modulating signal, is called frequency deviation.

$$f_d = f_{max} - f_c = f_c - f_{min}$$

10) Bandwidth $= 2 \times [f_m + \Delta f]$

11) In Fm, Carrier amplitude is constant.
∴ Transmitted power is constant and transmitted power does not depend on modulation index.

12) Applications and Advantages of FM

→ FM is resilient to noise and interface.
∴ It is used for high quality broadcast transmissio

→ FM is ideal for mobile radio communication application including more general two way radio communication or portable application where signals levels are likely to very considerably.

→ Radar, Telemetry, observing infants through ECG.

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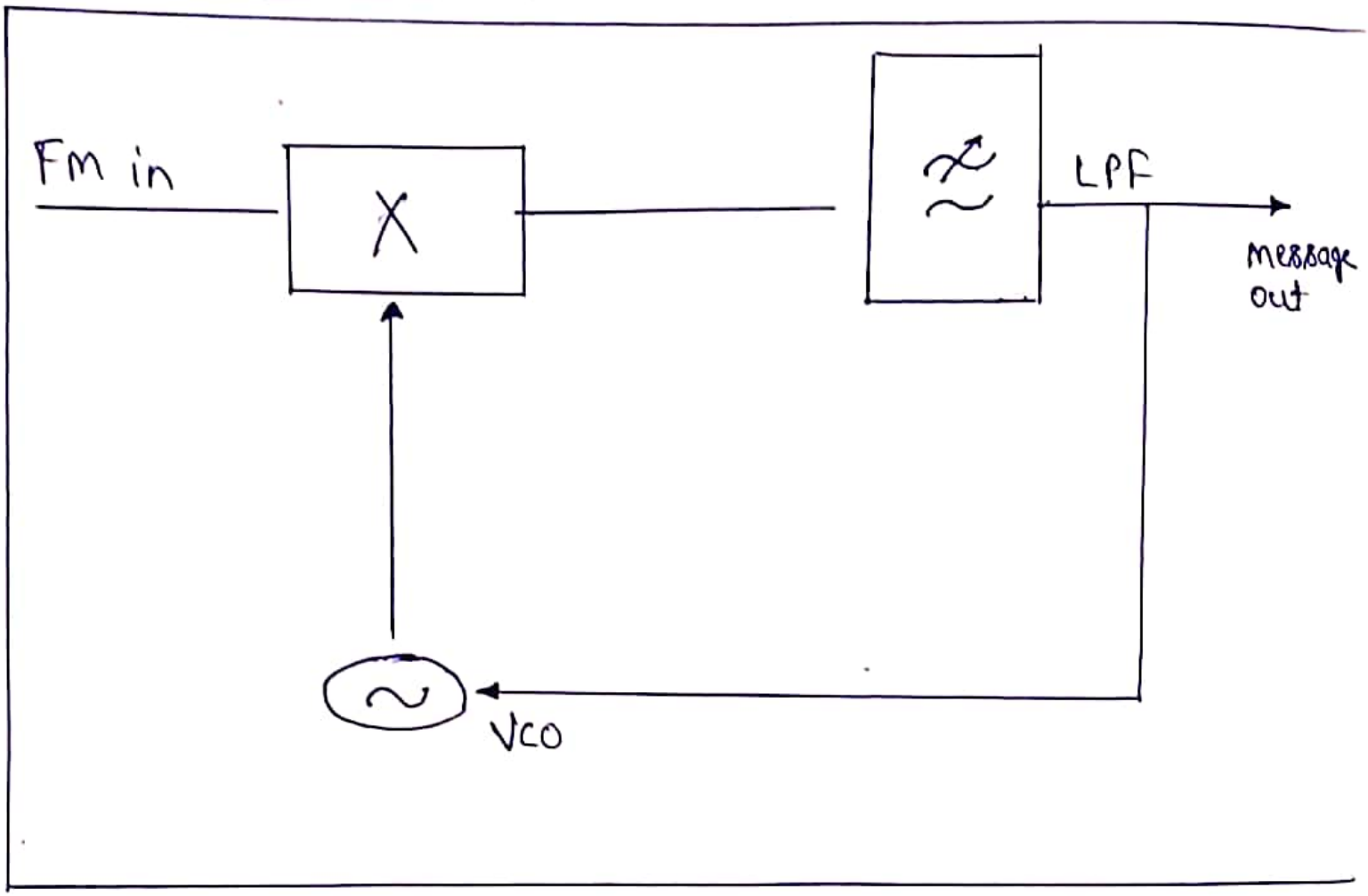
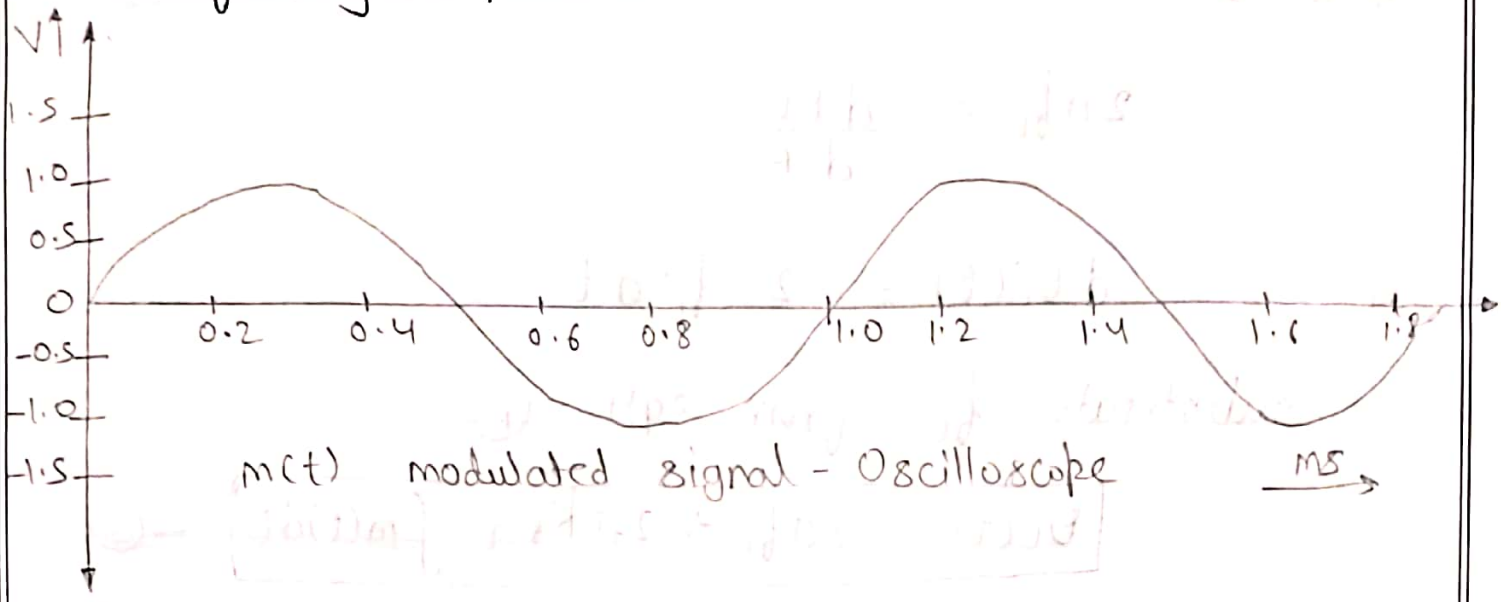
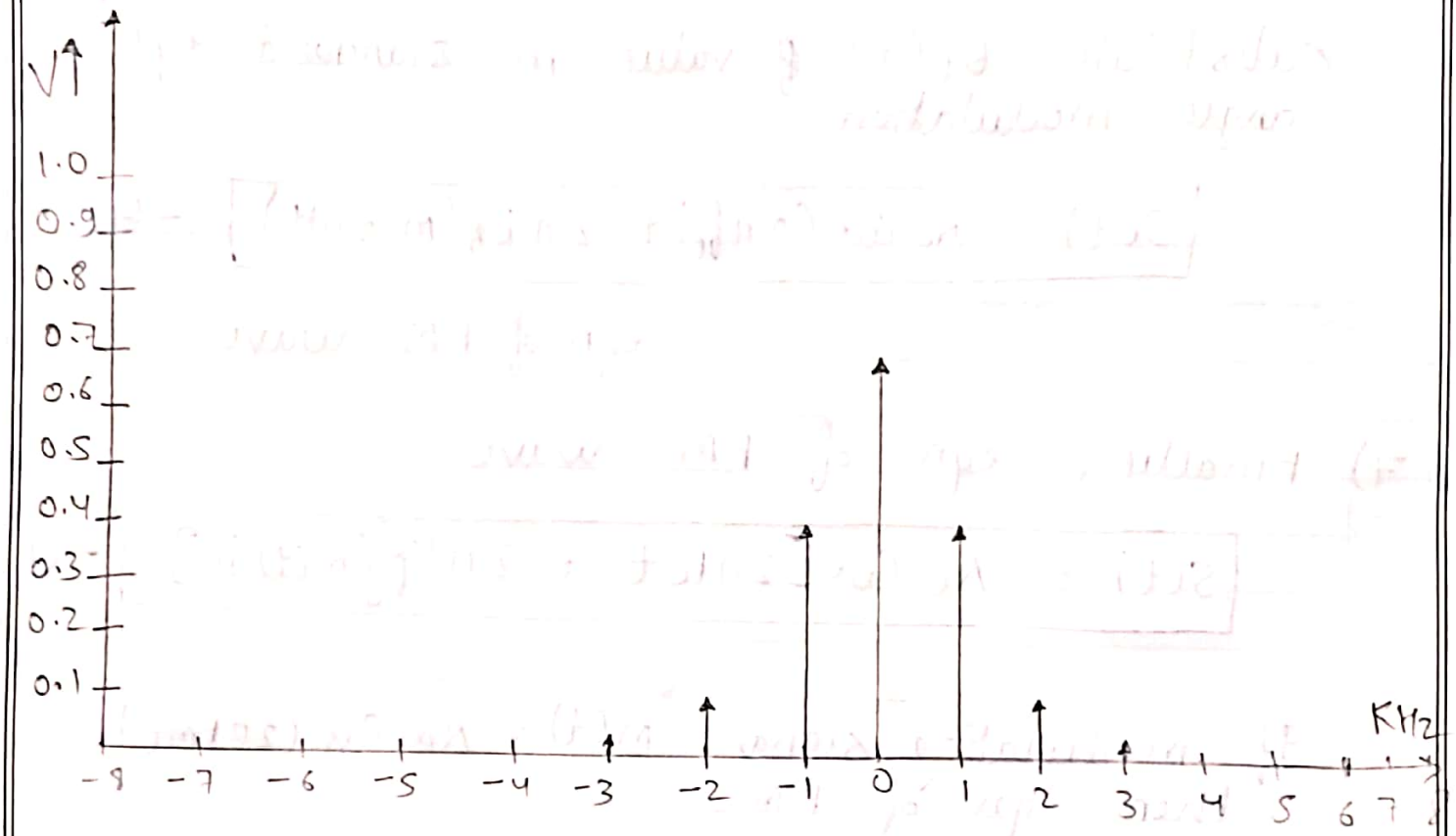
FM Demodulator



Frequency Spectrum



m(t) modulated signal - Oscilloscope



|s(t)| Transmitted signal - Spectrum Analyzer

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MAT-LAB CODE

```
clc; clear all; close all;
fs = 5000;
fc = 200;
t = (0:1/fs:0.4);
m = sin(2*pi*10*t);
% + sin(2*pi*30*t);
fdev = 100; % Frequency deviation value.
%% FM Modulation
y = fmmat(m, fc, fs, fdev)
%% plotting the base band signal
Subplot(311);
Plot(t, m);
title('Modulation/Baseband signal');
x label('time -->');
y label('Amplitude -->');
%% plotting the fm signal
Subplot(312);
plot(t, y);
title('FM Modulated signal');
x label('Time -->');
y label('Amplitude -->');

%% Frequency deviation
z = fmdemode(y, fc, fs, fdev);
subplot(313);
plot(t, z, 'r');
```

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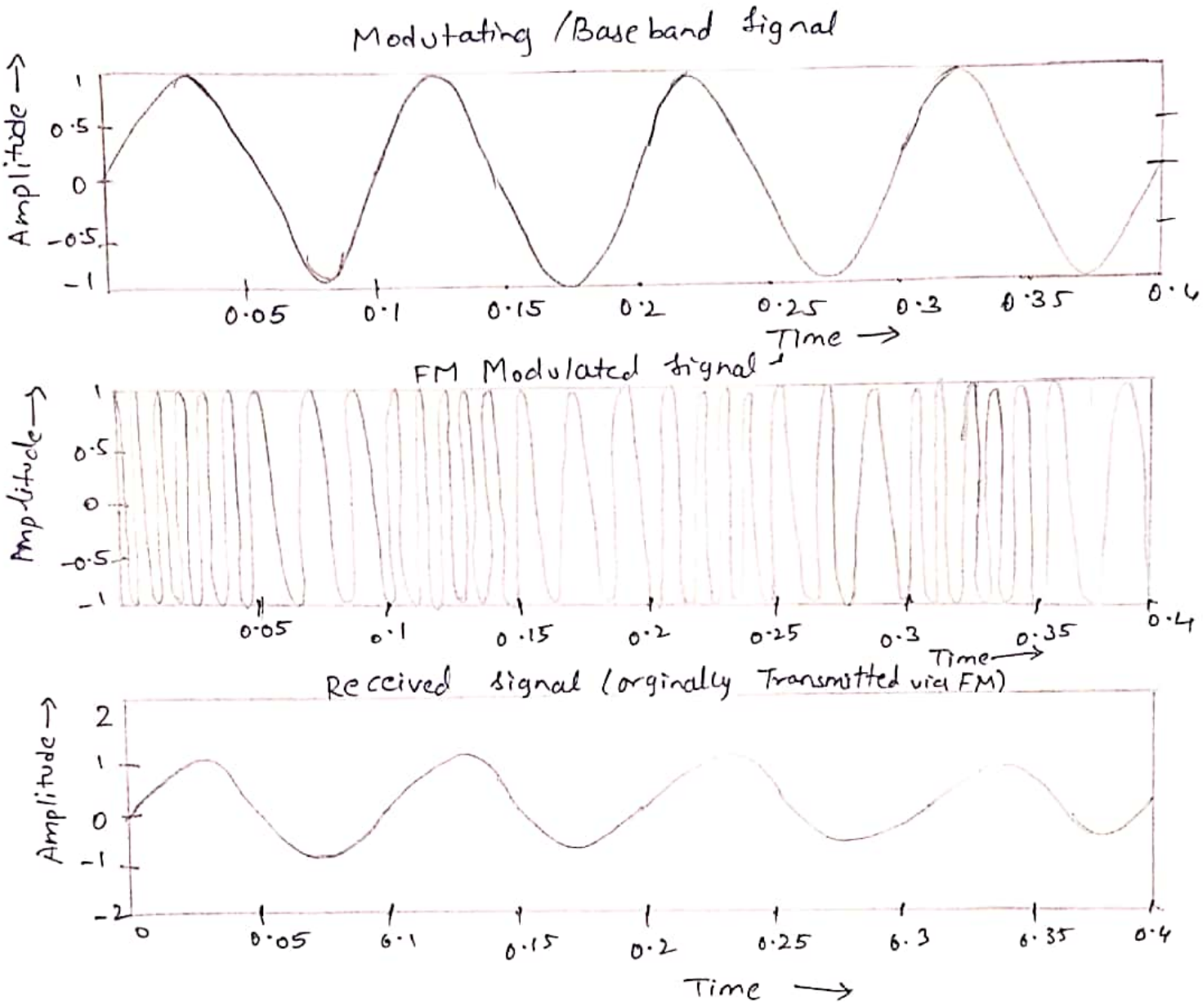
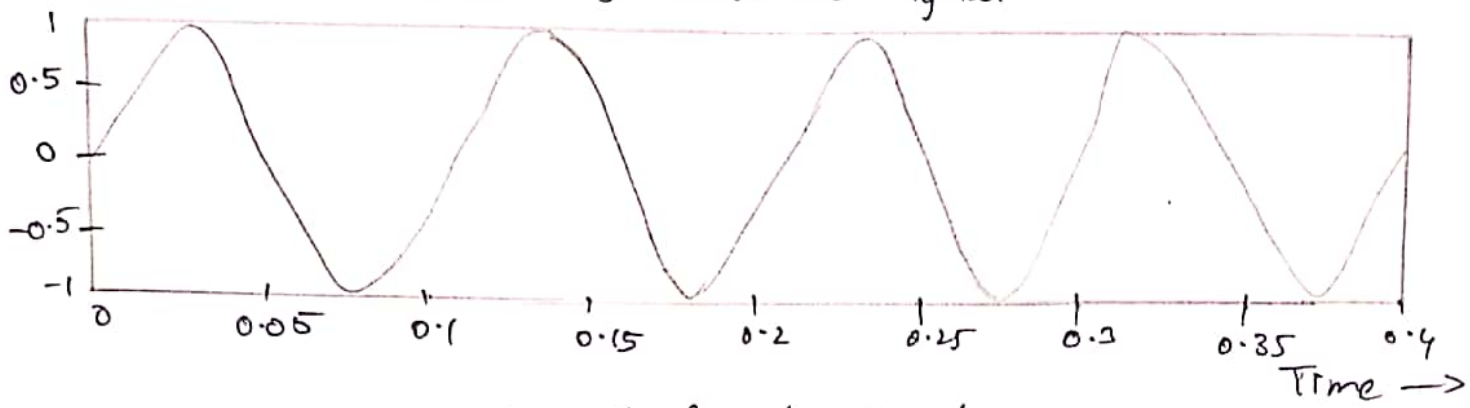
Frequency deviation 100 Hz.

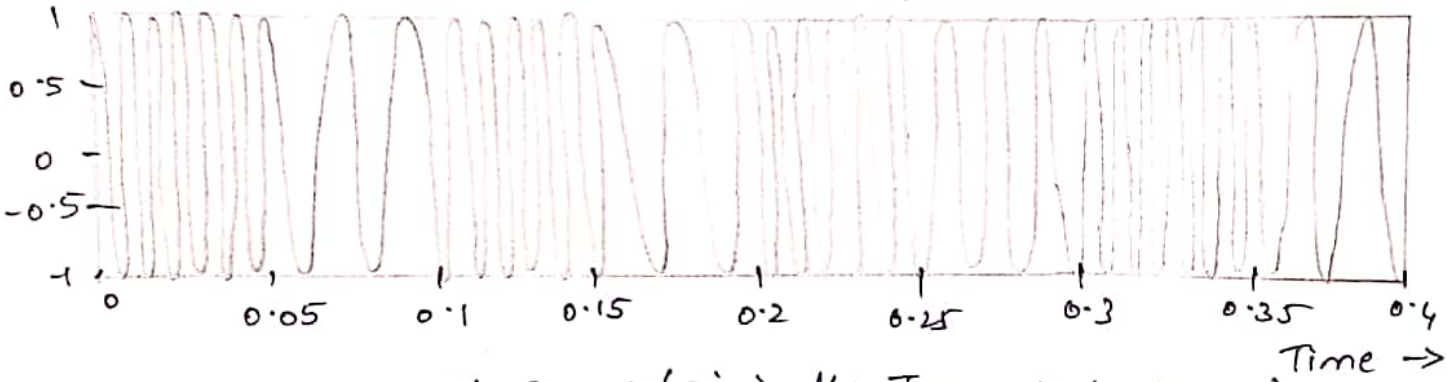


Frequency deviation 150 Hz

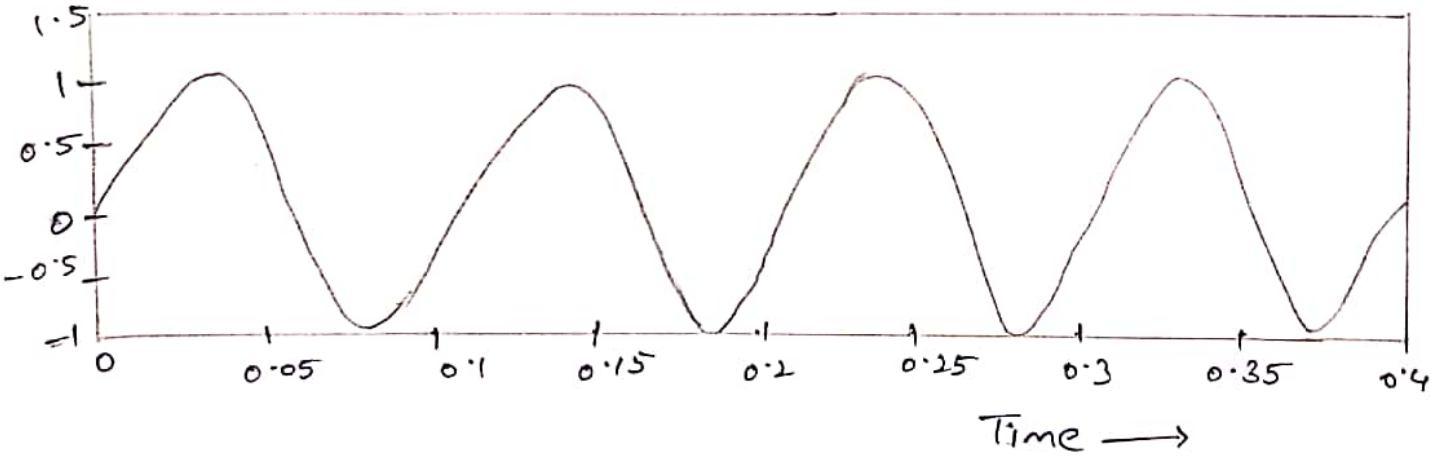
Modulating / Baseband signal



FM Modulated signal signal



Received signal (originally Transmitted via FM)



```
title ('Recieved signal (originally transmitted)
                    via FM)');
x label ("time -->");
y label ('Amplitude -->');
```

Conclusion

We have successfully verified and understood the concept of frequency modulation and demodulation using MATLAB and also learnt applications of FM.

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