Netaji Subash University of Technology

East Campus

Communication Systems Lab

Practical File

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CSE 4th Sem.

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Experiment-1

Aim: To study and analyse the generation of AM signal and observe the effect of modulation index or variation in baseband signal amplitude using MATLAB or similar simulation tool

THEORY:

A continuous-wave goes on continuously without any intervals and it is the baseband message signal, which contains the information. This wave has to be modulated.

According to the standard definition, “The amplitude of the carrier signal varies in accordance with the instantaneous amplitude of the modulating signal.” Which means, the amplitude of the carrier signal containing no information varies as per the amplitude of the signal containing information, at each instant.

Time-domain Representation of the Waves

Let the modulating signal be,

$$m(t)=A_m\cos(2\pi f_m t)$$

and the carrier signal be,

$$c(t)=A_c\cos(2\pi f_c t)$$

Then, the equation of Amplitude Modulated wave will be $s(t)=[A_c+A_m\cos(2\pi f_m t)]\cos(2\pi f_c t)$

Modulation Index

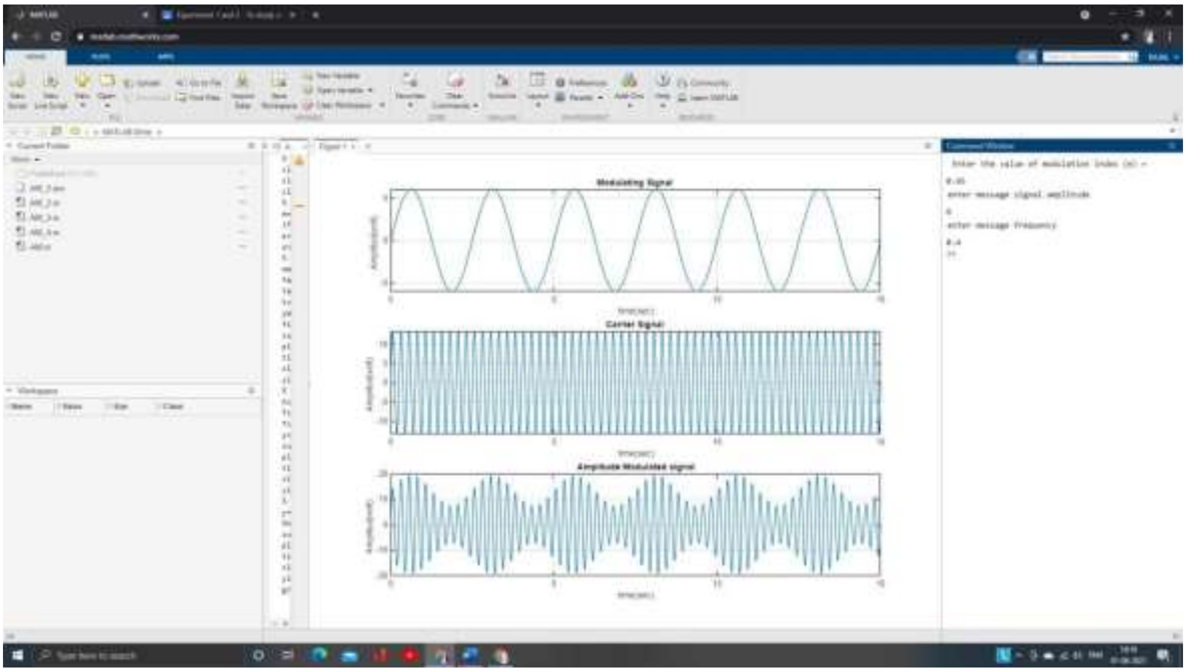
A carrier wave, after being modulated, if the modulated level is calculated, then such an attempt is called as **Modulation Index** or **Modulation Depth**. It states the level of modulation that a carrier wave undergoes. $\mu=Am/Ac$

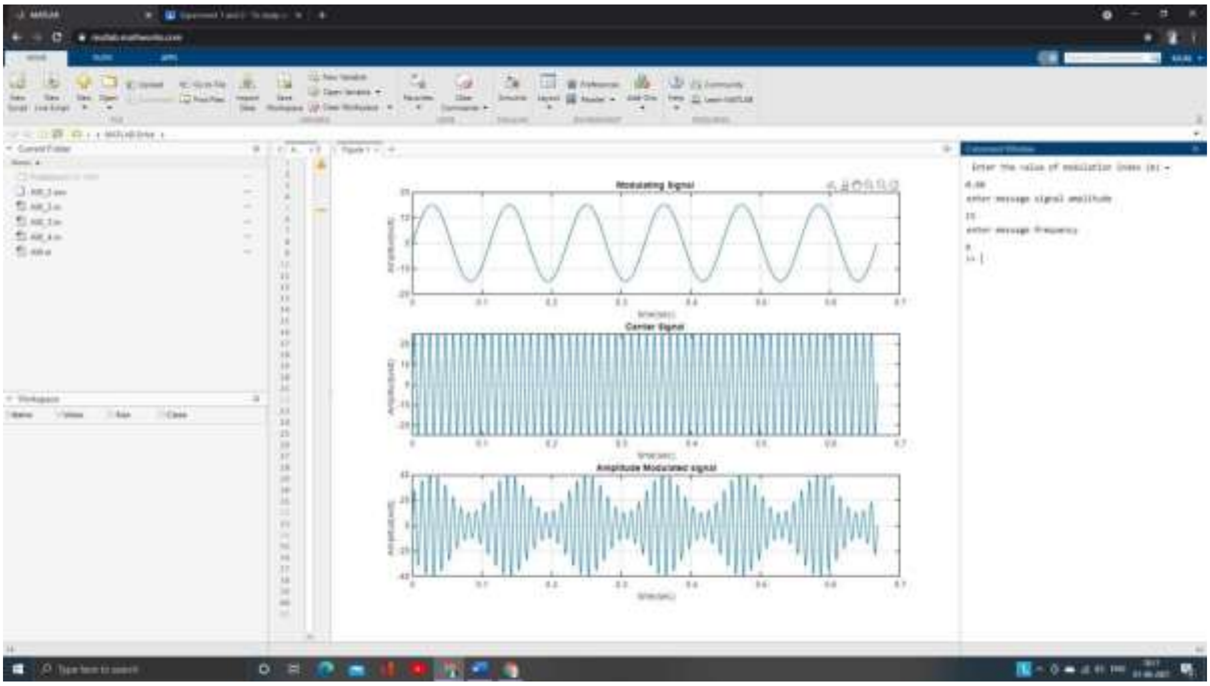
MATLAB CODE

```
% AM Modulation
clc; close
all; clear
all;
% Define AM modulation Index
m=input(' Enter the value of modulation index (m) = ');
if (0>m||m>1)
error('m may be less than or equal to one and greater than to zero');
end
% modulating/Message signal generation
Am=input('enter message signal amplitude'); % Amplitude of modulating signal
fa=input('enter message frequency');        % Frequency of modulating signal
Ta=1/fa; % Time period of modulating signal
t=0:Ta/999:6*Ta; % Total time for simulation
ym=Am*sin(2*pi*fa*t); % Eqation of modulating signal
```

```
figure(1)
subplot(3,1,1);
plot(t,ym), grid on;% Graphical representation of Modulating signal
title ( '  Modulating Signal   ');
xlabel ( ' time(sec) '); ylabel ('
Amplitud(volt)    '); % carrier
signal generation
Ac=Am/m;% Amplitude of carrier signal [ where, modulation Index (m)=Am/Ac ]
fc=fa*10;% Frequency of carrier signal Tc=1/fc;%
Time period of carrier signal
yc=Ac*sin(2*pi*fc*t);% Eqation of carrier signal
subplot(3,1,2);
plot(t,yc), grid on;% Graphical representation of carrier signal
title ( '  Carrier Signal   ');
xlabel ( ' time(sec) '); ylabel
(' Amplitud(volt)    ');
%  AM Modulation
y=Ac*(1+m*sin(2*pi*fa*t)).*sin(2*pi*fc*t); % Equation of Amplitude
%modulated signal
subplot(3,1,3);
plot(t,y);% Graphical representation of AM signal
title ( '  Amplitude Modulated signal  ');
xlabel ( ' time(sec) ');
ylabel (' Amplitud(volt)    ');
grid on;
```

GRAPH





RESULT

The AM signal was generated and analyzed by observing the effect of Modulation Index and variation in Baseband signal.

Experiment -2

AIM : Study Amplitude Demodulation by using any free alternative software of MATLAB.

Software Used : MATLAB Software

Theory :

Demodulation is a key process in the reception of any amplitude modulated signals whether used for broadcast or two way radio communication systems.

Demodulation is the process by which the original information bearing signal, i.e. the modulation is extracted from the incoming overall received signal.

Amplitude Modulation Signal with larger carrier frequency are detected by using envelope detector.

The Envelope detector employs circuit that introduce the envelope detector of AM waves is baseband signal.

The detectors are characterized as:-

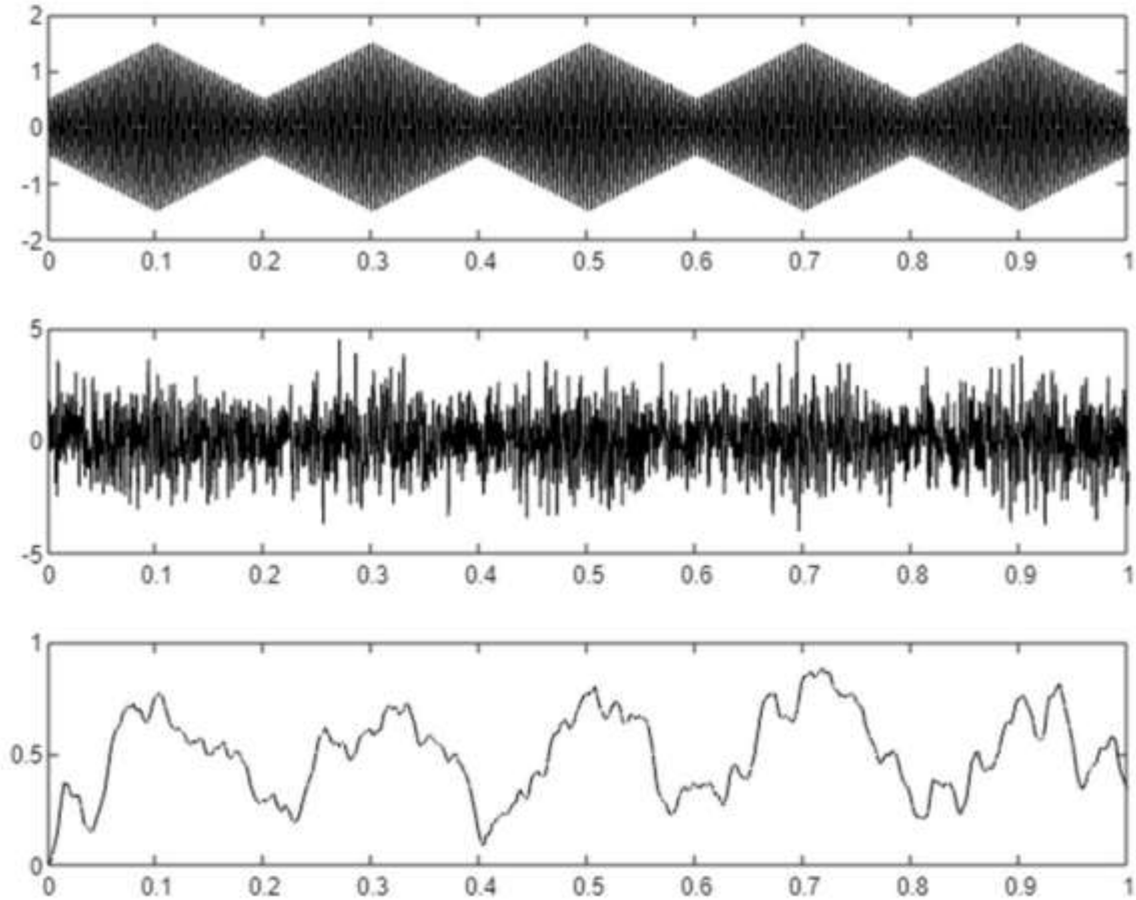
a) Square Law Detector

b) Envelope Detector

Code:

```
close all;  clear all;
fs = 2000;                          % Sampling frequency f = 5;                              %
Signal frequency fc = 250;                          % Carrier frequency N = 2000;
% Use 1 sec of data t = (1:N)/fs;% Time axis for plotting
wn = .02;                           % PSD lowpass filter cut - off frequency
[b,a] = butter(2,wn);                    % Design lowpass filter
% Generate AM signal
w = (1:N)* 2*pi*fc/fs;                   % Carrier frequency = 250 Hz w1 = (1:N)*2*pi*f/fs;
% Signal frequency = 5 Hz vc = sin(w);                          % Define carrier vsig =
sawtooth(w1,.5);                % Define signal
vm = (1 + .5 * vsig) .* vc;             % Create modulated signal with a Modulation constant = 0.5 subplot(3,1,1); plot(t,vm,'k');
% Plot AM Signal....axis, label,title.......
% Add noise with 3.16 times power (10 db) of signal for SNR of -10 db noise = randn(1,N);
scale = (var(vsig)/var(noise)) * 3.16;
vm = vm + noise * scale;                 % Add noise to modulated signal subplot(3,1,2); plot(t,vm,'k');
% Plot AM signal..axis, label,title.......
% Phase sensitive detection
ishift = fix(.125 * fs/fc);              % Shift carrier by 1/4
vc = [vc(ishift:N) vc(1:ishift-1)];      % period (45 deg) using periodic shift v1 = vc .* vm;
% Multiplier vout = filter(b,a,v1);                  % Apply lowpass filter
subplot(3,1,3);
plot(t,vout,'k');                        % Plot AM Signal
```

Observation:



2
1
0
-1
-2
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
5
0
-5
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
1
0.5
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Experiment No. -3

AIM : Study Frequency Modulation by using any free alternative software of MATLAB.

Software Used : MATLAB Software

Theory :

Frequency modulation uses the information signal, $V_m(t)$ to vary the carrier frequency within some small range about its original value. Here are the three signals in mathematical form:

- Information: $V_m(t)$
- Carrier: $V_c(t) = V_{co}$ sin (2 □ f_c t + □□□
- FM: V_{FM} (t) = V_{co} sin (2 □□□ f_c + (□ f/V_{mo}) V_m (t)□□□ t + □□

Modulation index for FM, analogous to AM:

□ = □ f/f_m , where f_m is the maximum modulating frequency used.

Peak deviation frequency as a multiple of the maximum modulating frequency, f_m , i.e. □ f = □ f_m.

Bandwidth of a FM signal may be predicted using:

$$BW = 2 (\square + 1) f_m$$

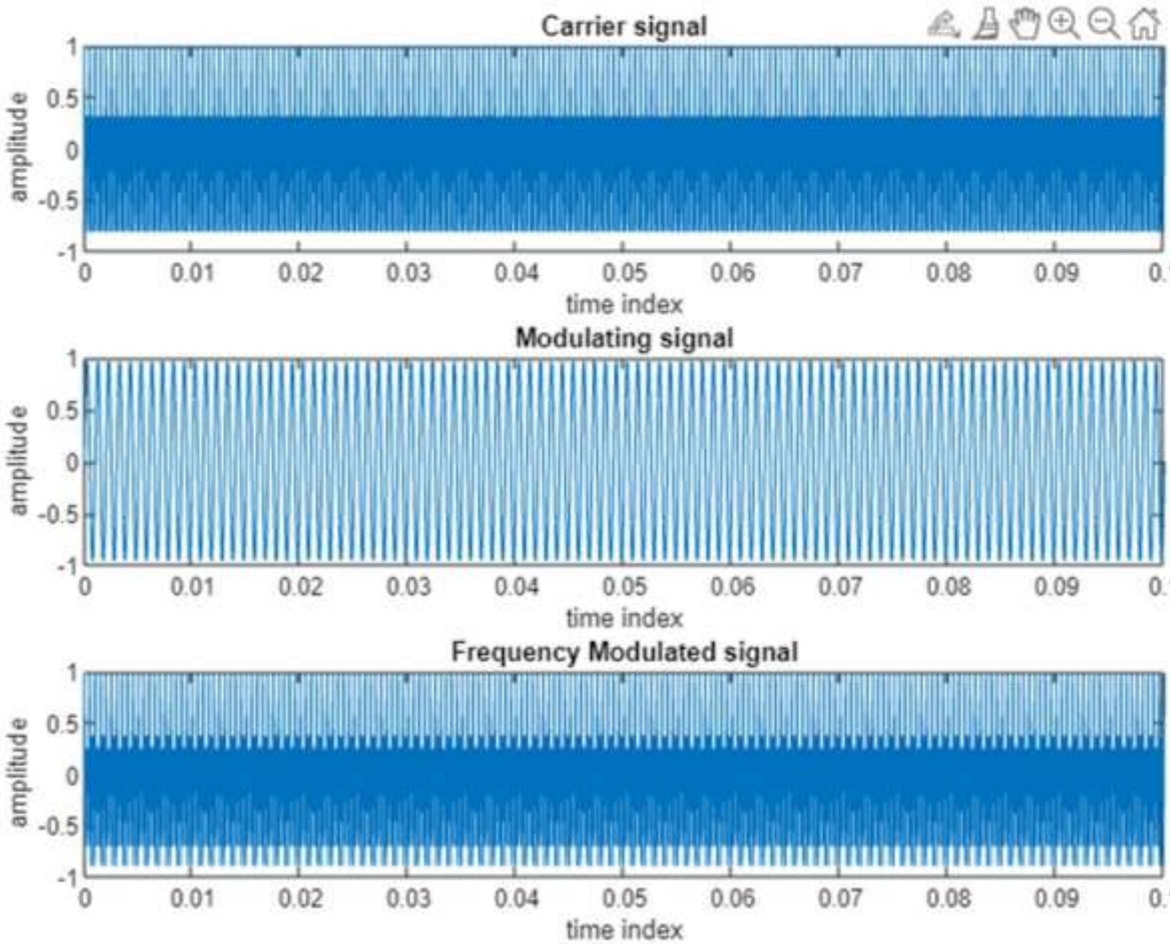
where □ is the modulation index and f_m is the maximum modulating frequency used.

FM radio has a significantly larger bandwidth than AM radio, but the FM radio band is also larger.

Code:

```
%FM generation
clc; clear all; close
all;
fc=4000;%input('Enter the carrier signal freq in hz,fc='); fm=1000;%input('Enter the
modulating signal freq in hz,fm ='); m=.2;%%input('Modulation index,m= ');
t=0:0.0001:0.1; c=cos(2*pi*fc*t);%carrier signal M=sin(2*pi*fm*t);% modulating
signal subplot(3,1,1);plot(t,c);
ylabel('amplitude');xlabel('time index');title('Carrier signal'); subplot(3,1,2);plot(t,M);
ylabel('amplitude');xlabel('time index');title('Modulating signal'); y=cos(2*pi*fc*t-
(m.*cos(2*pi*fm*t))); subplot(3,1,3);plot(t,y);
ylabel('amplitude');xlabel('time index');title('Frequency Modulated signal'); fs=8000;
p=fmmod(y,fc,fs,(fc-fm)); figure;
subplot(1,1,1);plot(p);
```

Observation:



Carrier signal
amplitude
time index
Modulating signal
amplitude
time index
Frequency Modulated signal
amplitude
time index

Experiment No. -4

AIM : Study Frequency Modulation by using any free alternative software of MATLAB.

Software Used : MATLAB Software

Theory :

Frequency modulation uses the information signal, $V_m(t)$ to vary the carrier frequency within some small range about its original value. Here are the three signals in mathematical form:

- Information: $V_m(t)$
- Carrier: $V_c(t) = V_{co}$ sin (2 □ □ f_c t + □ □ □
- FM: V_{FM} (t) = V_{co} sin (2 □ □ □ □ f_c + (□ □f/V_{mo}) V_m (t)□ □ □ t + □ □

Modulation index for FM, analogous to AM:

□ − □ □f/f_m , where f_m is the maximum modulating frequency used.

Peak deviation frequency as a multiple of the maximum modulating frequency, f_m , i.e. □ □f − □ □ f_m.

Bandwidth of a FM signal may be predicted using:

$$BW - 2 (\square + 1)\, f_m$$

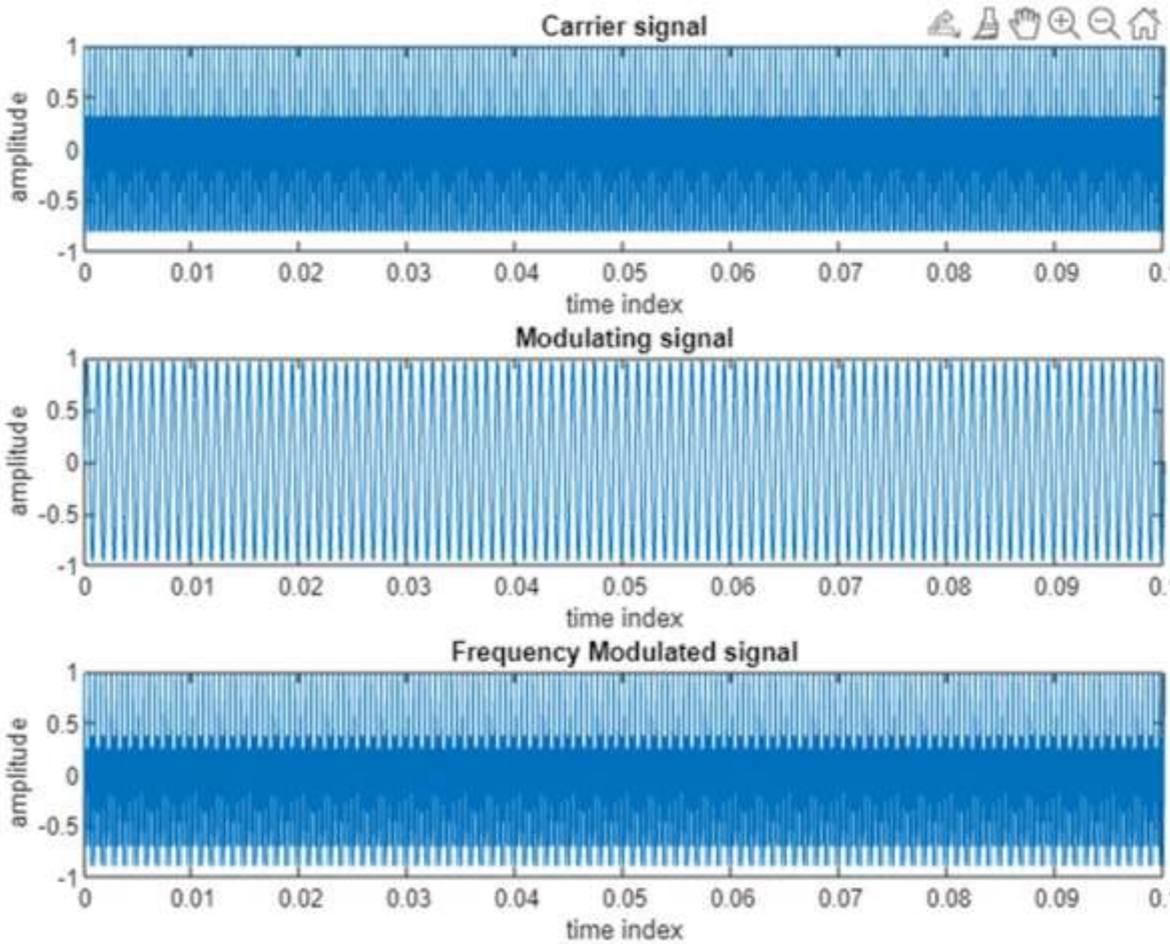
where □ is the modulation index and f_m is the maximum modulating frequency used.

FM radio has a significantly larger bandwidth than AM radio, but the FM radio band is also larger.

Code:

```
%FM generation
clc; clear all; close
all;
fc=4000;%input('Enter the carrier signal freq in hz,fc='); fm=1000;%input('Enter the
modulating signal freq in hz,fm ='); m=.2;%%input('Modulation index,m= ');
t=0:0.0001:0.1; c=cos(2*pi*fc*t);%carrier signal M=sin(2*pi*fm*t);% modulating
signal subplot(3,1,1);plot(t,c);
ylabel('amplitude');xlabel('time index');title('Carrier signal'); subplot(3,1,2);plot(t,M);
ylabel('amplitude');xlabel('time index');title('Modulating signal'); y=cos(2*pi*fc*t-
(m.*cos(2*pi*fm*t))); subplot(3,1,3);plot(t,y);
ylabel('amplitude');xlabel('time index');title('Frequency Modulated signal'); fs=8000;
p=fmdemod(y,fc,fs,(fc-fm)); figure;
subplot(1,1,1);plot(p);
```

Observation:



Carrier signal
amplitude
time index
Modulating signal
amplitude
time index
Frequency Modulated signal
amplitude
time index

Experiment No. -5

AIM : Study Phase Modulation by using any free alternative software of MATLAB.

Software Used : MATLAB Software

Theory :

In Phase Modulation (PM) systems, the phase of the carrier is changed according to the variations in the message signal.

If m(t) is the message signal to be transmitted and the carrier onto which the signal is modulated is

$c(t) = Ac \sin(\omega_c(t) + \Phi_c)$, then the modulated signal is $y(t) = A_c \sin(\omega_c(t) + m(t) + \Phi_c)$, The modulation signal could here be $m(t) = \cos(\omega_c(t) + h*\omega_m(t))$, where h is the modulation index Modulation Index :

$h = \Delta\theta$, where $\Delta\theta$ is peak phase deviation.

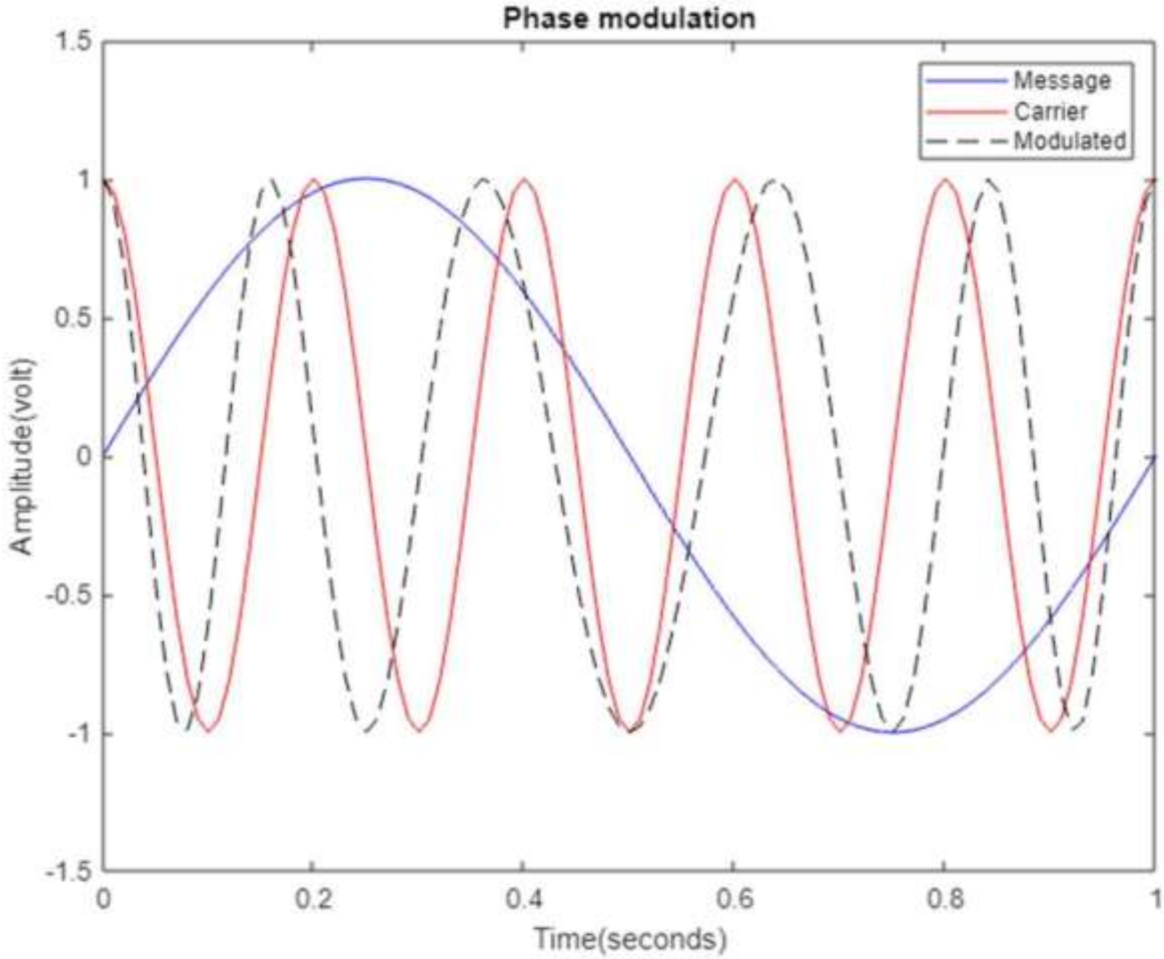
Bandwidth :

- For small amplitude signal : $BW = 2 f_m$.
- For large amplitude signal : $BW = 2(h+1) f_m$.

where, $f_m = \omega_m/2\pi$ and h is the modulation index. Code:

```
clear all
t = 0:0.01:1;                % time variable
fc = 5;                      % carrier frequency
%------------------------------------------
% create message signal m(t)
m=sin(2*pi*t);
%------------------------------------------
kp  = pi/2;                  % phase deviation constant
%------------------------------------------------ % modulating the carrier
with the message signal
carrier = cos(2*pi*fc*t);
modulated = cos(2*pi*fc*t + kp*m);
%------------------------------------------------
%------------------------------------------------
% Plotting the signals
plot(t,m,'b',t,carrier,'r',t,modulated,'k--') axis([0 1 -1.5 1.5]);
xlabel('Time(seconds)'); ylabel('Amplitude(volt)');
title('Phase modulation');
legend('Message','Carrier','Modulated');
```

Observation:


Phase modulation
Message
Carrier
Modulated
Amplitude(volt)
Time(seconds)
1.5
1
0.5
0
-0.5
-1
-1.5
0
0.2
0.4
0.6
0.8
1

Experiment-6

Aim- To study and analyze the detection of PM signal.

Theory- Demodulation of phase modulated signal by extracting instantaneous phase can be done using Hilbert transform.

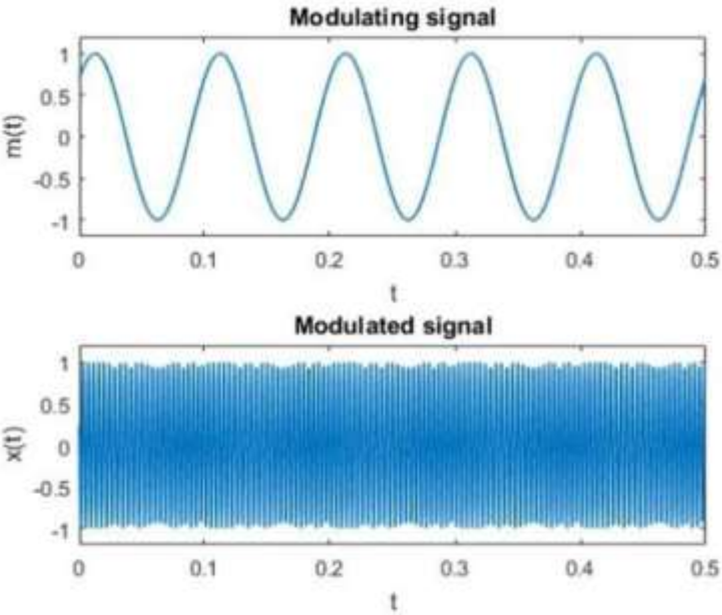
We note that the instantaneous phase is \phi(t) = 2 \pi f_c t + \beta + \alpha sin \left(2 \pi f_m t + \theta \right) is linear in time, that is proportional to 2 \pi f_c t. This linear offset needs to be subtracted from the instantaneous phase to obtained the information bearing modulated signal. If the carrier frequency is known at the receiver, this can be done easily. If not, the carrier frequency term 2 \pi f_c t needs to be estimated using a linear fit of the unwrapped instantaneous phase.

MATLAB CODE-

```
%Demonstrate simple Phase Demodulation using Hilbert transform

clearvars; clc;

fc = 240; %carrier frequency

fm = 10; %frequency of modulating signal

alpha = 1; %amplitude of modulating signal

theta = pi/4; %phase offset of modulating signal

beta = pi/5; %constant carrier phase offset

receiverKnowsCarrier= 'False'; %If receiver knows the carrier frequency & phase offset


fs = 8*fc; %sampling frequency

duration = 0.5; %duration of the signal

t = 0:1/fs:1-1/fs; %time base


%Phase Modulation

m_t = alpha*sin(2*pi*fm*t + theta); %modulating signal

x = cos(2*pi*fc*t + beta + m_t ); %modulated signal


figure(); subplot(2,1,1)

plot(t,m_t) %plot modulating signal

title('Modulating signal'); xlabel('t'); ylabel('m(t)')


subplot(2,1,2)
```

```
plot(t,x) %plot modulated signal
title('Modulated signal'); xlabel('t');ylabel('x(t)')

%Add AWGN noise to the transmitted signal
nMean = 0; %noise mean
nSigma = 0.1; %noise sigma
n = nMean + nSigma*randn(size(t)); %awgn noise
r = x + n;  %noisy received signal

%Demodulation of the noisy Phase Modulated signal
z= hilbert(r); %form the analytical signal from the received vector
inst_phase = unwrap(angle(z)); %instaneous phase

%If receiver don't know the carrier, estimate the subtraction term
if strcmpi(receiverKnowsCarrier,'True')
   offsetTerm = 2*pi*fc*t+beta; %if carrier frequency & phase offset is known
else
   p = polyfit(t,inst_phase,1); %linearly fit the instaneous phase
   estimated = polyval(p,t); %re-evaluate the offset term using the fitted values
   offsetTerm = estimated;
end

demodulated = inst_phase - offsetTerm;

figure()
plot(t,demodulated); %demodulated signal
title('Demodulated signal'); xlabel('n'); ylabel('\hat{m(t)}');
```

WAVEFORMS-



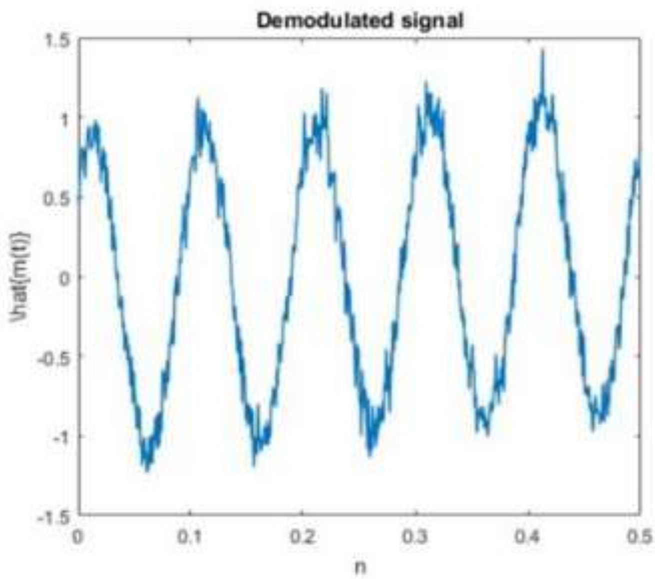


Figure 2: Demodulated signal from the noisy received signal

EXPERIMENT – 7

AIM:

To generate DSB-SC(Double Side Band- Suppressed Carrier) using MATLAB

THEORY:

Double-sideband suppressed-carrier transmission (**DSB-SC**) is transmission in which frequencies produced by amplitude modulation (AM) are symmetrically spaced above and below the carrier frequency and the carrier level is reduced to the lowest practical level, ideally being completely suppressed

In the DSB-SC modulation, unlike in AM, the wave carrier is not transmitted; thus, much of the power is distributed between the side bands, which implies an increase of the cover in DSB-SC, compared to AM, for the same power use

DSB-SC transmission is a special case of double-sideband reduced carrier transmission. It is used for radio data systems. This mode is frequently used in Amateur radio voice communications, especially on High-Frequency bands.

PROGRAM:

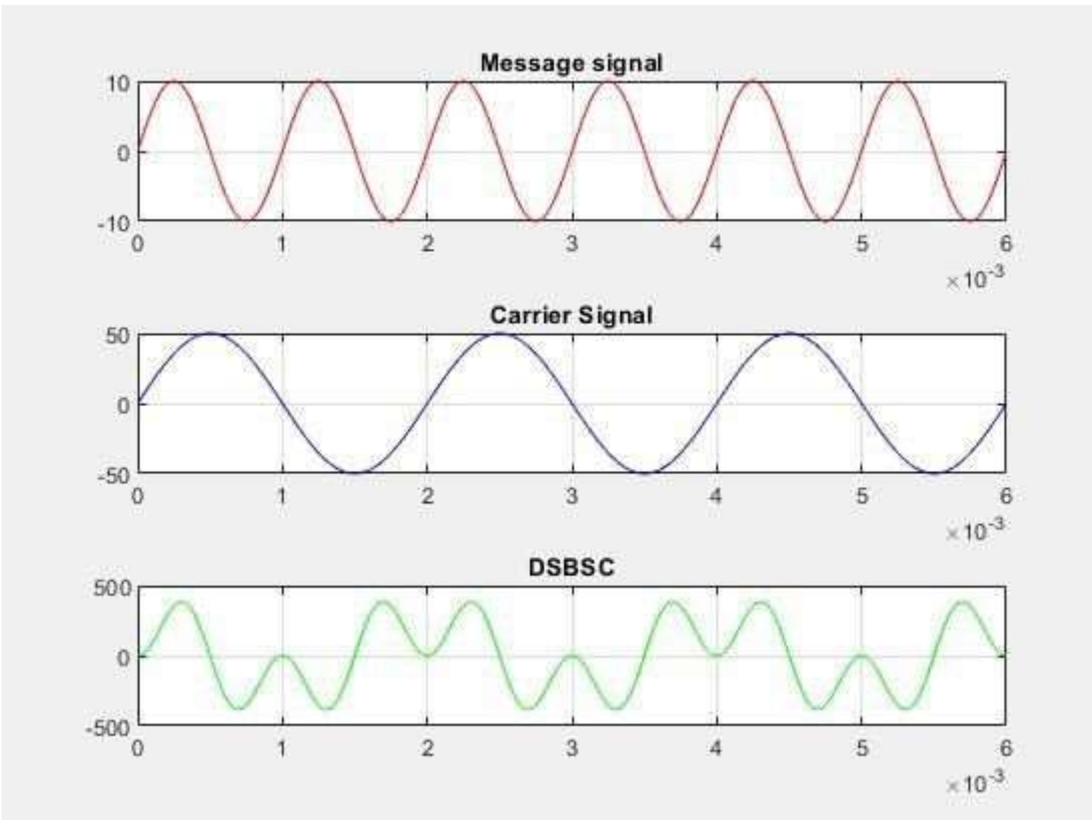
```
function amplitude = dsbsc


fm = input('Enter the value of message signal frequency: ');

fc = input('Enter the value of carrier signal frequency: ');

Am = input('Enter the value be of message signal amplitude: ');

Ac = input('Enter the value of carrier signal amplitude: ');
```

```
Tm = 1/fm;

Tc = 1/fc;


t1 = 0:Tm/999:6*Tm;


message_signal = Am*sin(2*pi*fm*t1);

subplot(3,1,1)

plot(t1, message_signal, 'r');

grid();

title('Message signal');


carrier_signal = Ac*sin(2*pi*fc*t1);

subplot(3,1,2)

plot(t1, carrier_signal, 'b');

grid();

title('Carrier Signal');


amplitude = message_signal.*carrier_signal;

subplot(3,1,3)

plot(t1,amplitude, 'g');

grid();
```

title('DSBSC');

end
‘

GRAPH:



RESULT:

DSB-SC (Double Side Band – Suppressed Carrier) was generated using MATLAB.

EXPERIMENT-8

AIM: To generate SSB-SC (single side band suppressed carrier) by using MATLAB.

THEORY

An SSB signal is produced by passing the DSB signal through a highly selective band pass filter. This filter selects either the upper or the lower sideband. Hence transmission bandwidth can be cut by half if one sideband is entirely suppressed. This leads to single-sideband modulation (SSB). In SSB modulation bandwidth saving is accompanied by a considerable increase in equipment complexity.

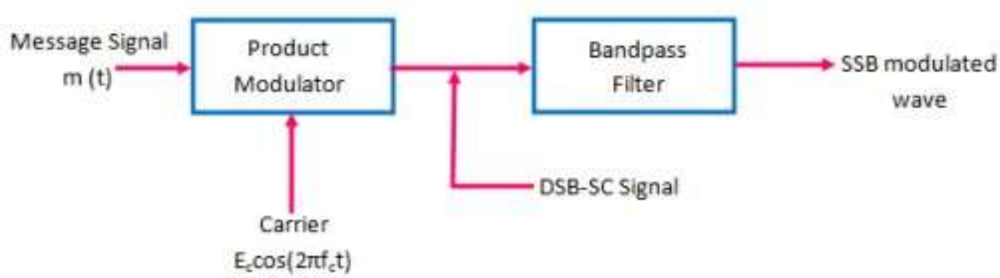


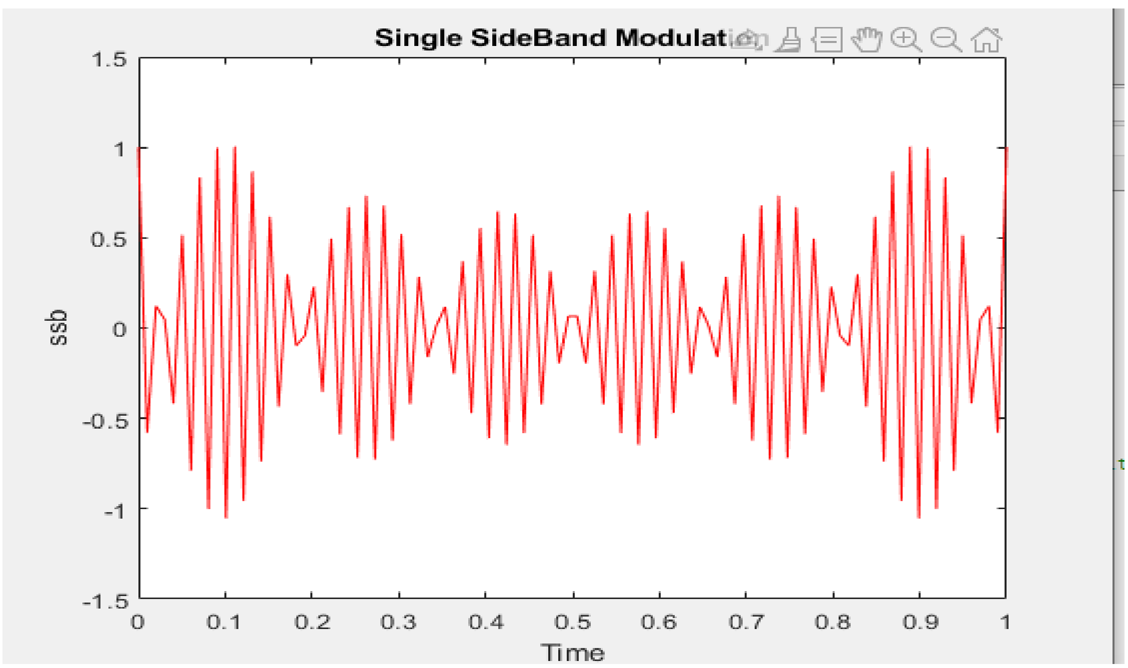
Fig:Block diagram of SSB-SC Modulation

PROGRAM

```
%SingleSideBand Supressed Carrier (SSB-SC)

fc = 400; %Carrier Frequency

fm = 50;  %Baseband Frequency

t = linspace(0,1,10);  %Timebase

m = cos(2*pi*fm*t);      %Baseband signal/message signal
```

```
mh = imag(hilbert(m));    %Hilbert Transform of baseband

sb = m.*cos(2*pi*fc*t) - mh.*sin(2*pi*fc*t);   %Expression for SSB
with USB, use + for LSB

plot(t,sb);

title('Single SideBand Modulation');

xlabel('Time');

ylabel('ssb');
```

GRAPH



RESULT :

The SSB-SC amplitude modulation and demodulation were performed successfully and waveforms were obtained.