University School of Automation and Robotics
GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY
East Delhi Campus, Surajmal Vihar
Delhi - 110092

Principles of Communication Systems Lab

COURSE CODE: ARI 353

2023-2024

SUBMITTED TO:

Dr. Ghanendra Kumar

(ASSISTANT PROFESSOR)

SUBMITTED BY:

Vipul Goyal

IIOT-B1

ENROLL. NO: 02419011721

INDEX

S.NO	EXPERIMENT	REMARK
1.	To study the function of Amplitude Modulation	
2.	To study the function of Amplitude Modulation & Demodulation	
3.	To study the working of the Balanced Modulator and demodulator.	
4.	To study the working of the Balanced Modulator and demodulator.	
5.	To study the process of frequency modulation and demodulation.	
6.	To verify the spectrum of AM and FM signals using spectrum analyzer	

EXPERIMENT NO-1

AMPLITUDE MODULATION USING MATLAB

AIM: To study the function of Amplitude Modulation

APPARATUS/SOFTWARE REQUIRED:

1. PC with windows(95/98/XP/NT/2000)
2. MATLAB Software with communication toolbox

THEORY:

Amplitude modulation (AM) is a modulation technique utilized in electronic communication, most ordinarily for transmitting data by means of a carrier wave. In amplitude modulation, the amplitude that is the signal quality of the carrier wave differs with respect to that of the message signal being transmitted.

CODE:

```
Fc = 200;
% sampling frequency
Fs= 4000;
t = (0 : 1 / Fs : 1);
% sine Wave with time duration of 't'
x = sin(2*pi*t);
% Amplitude Modulation
y = modulate(x, Fc, Fs, 'am');
plot(t,y);
title(“Vipul Goyal-02419011721”,'Amplitude Modulation');
xlabel('Time(sec)');
ylabel('Amplitude');
```

RESULT:

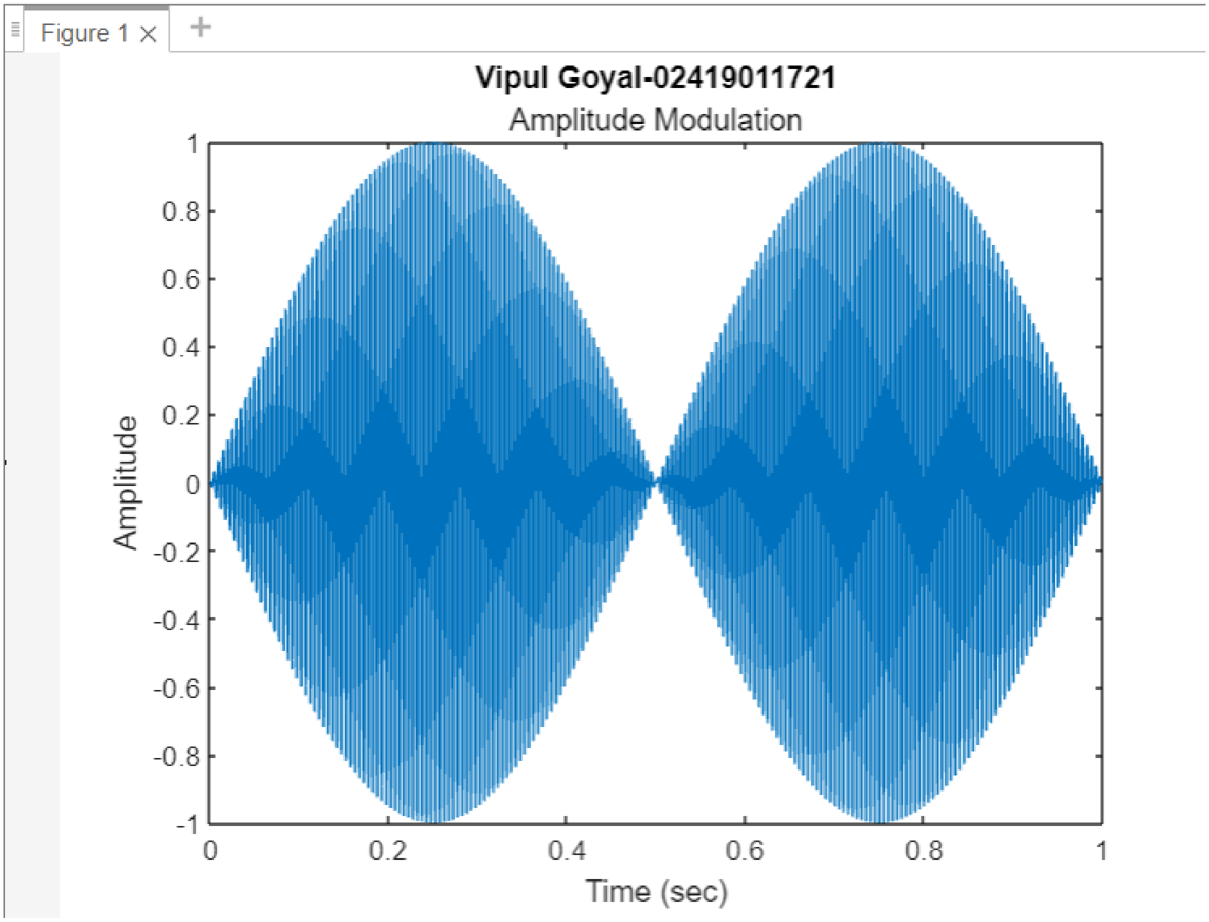


Figure 1
Vipul Goyal-02419011721
Amplitude Modulation
Amplitude
Time (sec)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.2
0.4
0.6
0.8
1

EXPERIMENT NO-2

AMPLITUDE MODULATION & DEMODULATION

AIM: To study the function of Amplitude Modulation & Demodulation (under modulation, perfect modulation & over modulation) and also to calculate the modulation index.

APPARATUS/SOFTWARE REQUIRED:

1. PC with windows(95/98/XP/NT/2000)

2. MATLAB Software with communication toolbox

THEORY:

Modulation is defined as the process of changing the characteristics (Amplitude, Frequency or Phase) of the carrier signal (high frequency signal) in accordance with the intensity of the message signal (modulating signal).

Amplitude modulation is defined as a system of modulation in which the amplitude of the carrier is varied in accordance with amplitude of the message signal (modulating signal).

The message signal is given by the expression.

$E_m(t) = E_m \cos Wmt$

Where, Wm is -----> Angular frequency

E_m --------◊ Amplitude

Carrier voltage $E_c(t) = E_c \cos Wct$

$E(t)=E_c + K_aE_m \cos W_mt$ KaEm

cosWmt -----◊ change in carrier amplitude

Ka-----◊ constant

The amplitude modulated voltage is given by $E=E(t)\cos W_c t$ From above two equations

$$E=(E_c+KaE_m \cos W_m t)\cos W_c t.$$

$$E=(1+KaE_m/E_c \cos W_m t)\, E_c \cos W_c t$$

$$E=E_c(1+M_a \cos W_m t)\cos W_c t$$

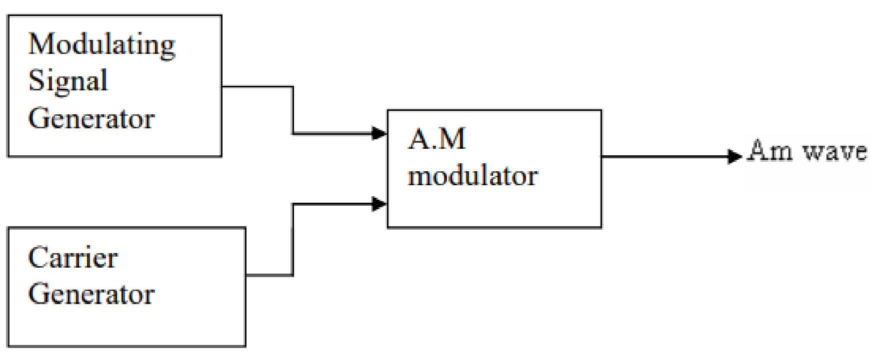
Where M_a-----◊ depth of modulation/ modulation index/modulation factor

$$M_a=KaE_m/E_c$$

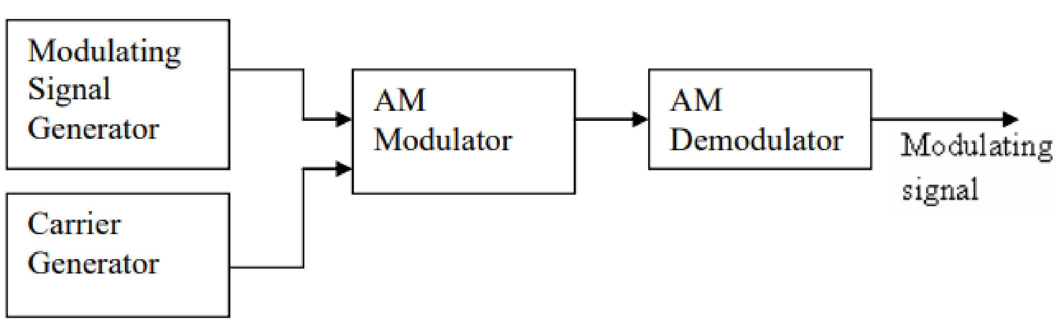
100* Ma gives the percentage of modulation.

BLOCK DIAGRAM:

1.Modulation:



2.Demodulation:

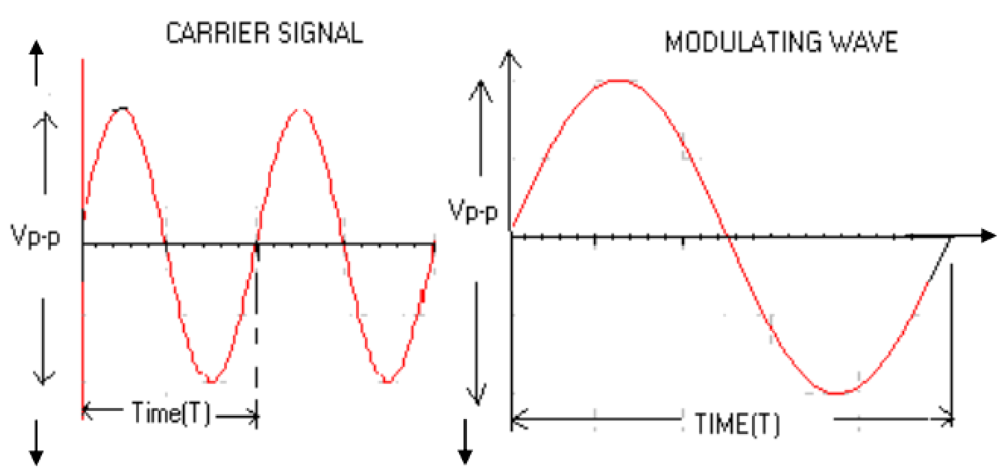


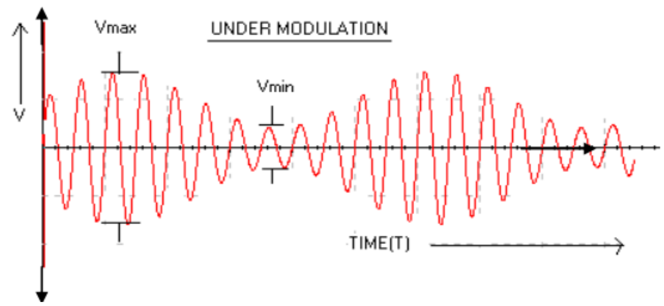
CODE:

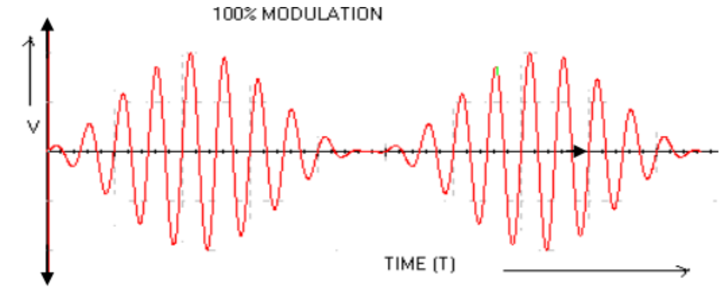
```
% program for AM modulation and demodulation
close all
clear all
clc fs=8000;
fm=20;
fc=500;
Am=1;
Ac=1;
t=[0:0.1*fs]/fs;
m=Am*cos(2*pi*fm*t);
c=Ac*cos(2*pi*fc*t);
ka=0.5; u=ka*Am;
s1=Ac*(1+u*cos(2*pi*fm*t)).*cos(2*pi*fc*t);
subplot(4,3,1:3);
plot(t,m);
title("Vipul Goyal-02419011721",'Modulating or Message signal(fm=20Hz)');
subplot(4,3,4:6); plot(t,c);
title('Carrier signal(fc=500Hz)');
 subplot(4,3,7); plot(t,s1);
title('Under Modulated signal(ka.Am=0.5)');
Am=2;
 ka=0.5;
u=ka*Am;
s2=Ac*(1+u*cos(2*pi*fm*t)).*cos(2*pi*fc*t);
 subplot(4,3,8); plot(t,s2);
title('Exact Modulated signal(ka.Am=1)');
 Am=5;
 ka=0.5;
 u=ka*Am;
```

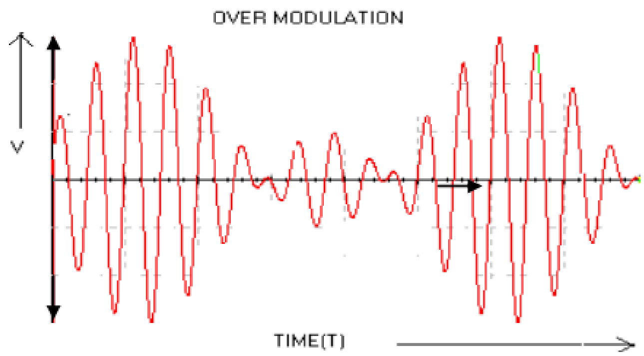
```
s3=Ac*(1+u*cos(2*pi*fm*t)).*cos(2*pi*fc*t);
subplot(4,3,9);
plot(t,s3);
title('Over Modulated signal(ka.Am=2.5)');
r1= s1.*c; [b a] = butter(1,0.01);
mr1= filter(b,a,r1);
subplot(4,3,10);
plot(t,mr1);
title(' deModulated signal for(ka.Am=0.5)');
r2= s2.*c; [b a] = butter(1,0.01);
mr2= filter(b,a,r2);
subplot(4,3,11);
plot(t,mr2);
title(' deModulated signal for(ka.Am=1)');
r3= s3.*c;
[b a] = butter(1,0.01);
mr3= filter(b,a,r3);
subplot(4,3,12);
plot(t,mr3);
title(' deModulated signal for(ka.Am=2.5)');
```

EXPECTED WAVEFORMS:

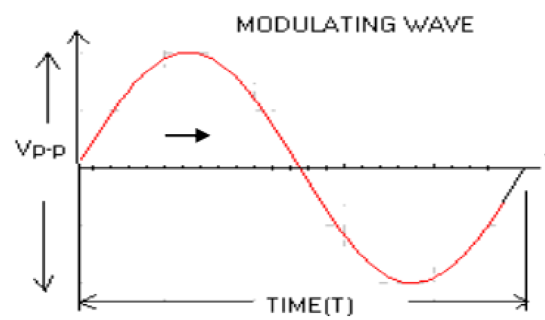




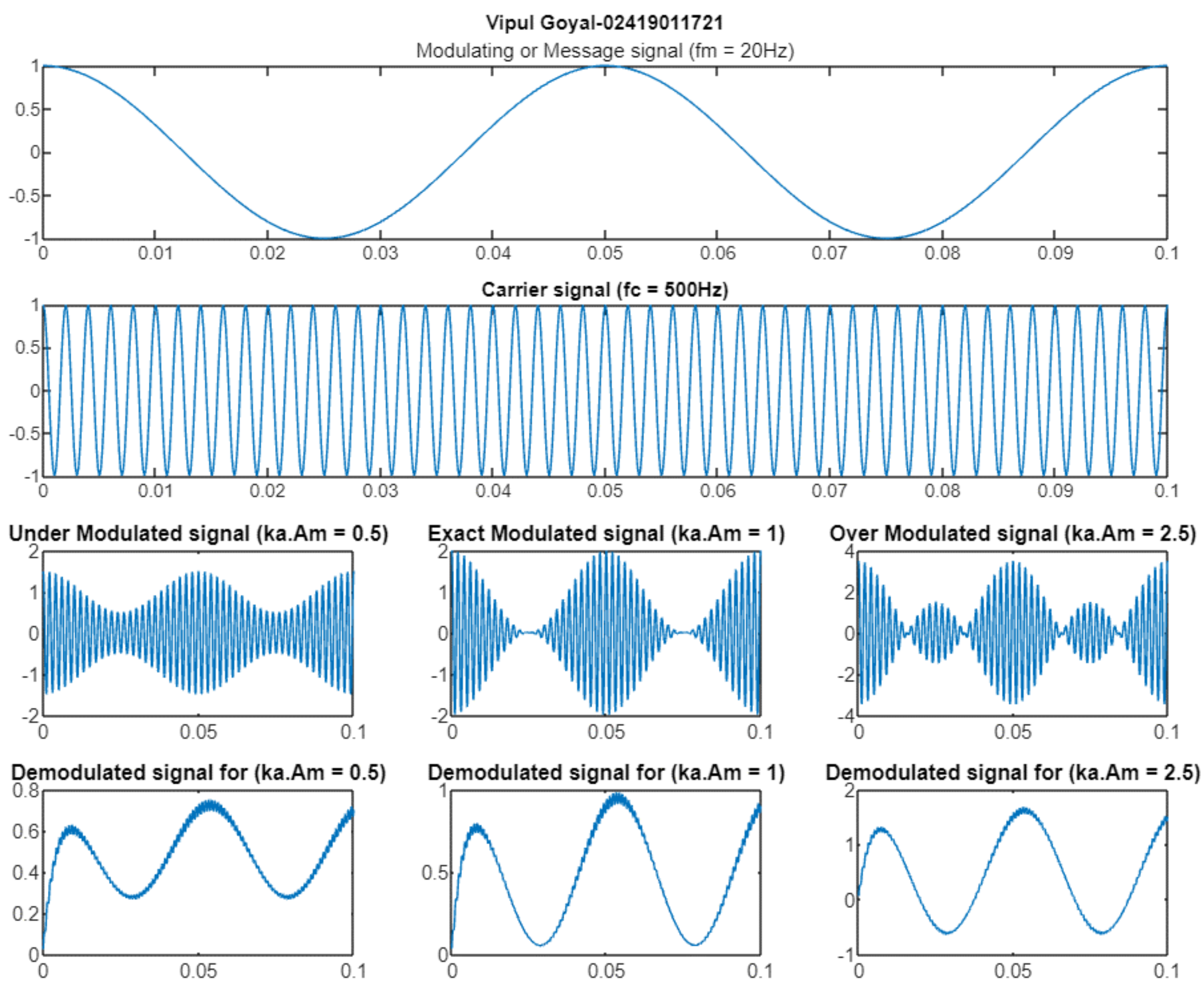




Demodulated signal



RESULT:



EXPERIMENT NO-3

DSB-SC MODULATOR & DETECTOR

AIM: To study the working of the Balanced Modulator and demodulator.

APPARATUS/SOFTWARE REQUIRED:

1. PC with windows (95/98/XP/NT/2000)

2. MATLAB Software with communication toolbox

THEORY:

Balanced modulator circuit is used to generate only the two side bands DSB-SC. The balanced modulation system is a system is a system of adding message to carrier wave frequency there by only the side bands are produced. It consists of two AM modulators arranged in a balanced configuration. The AM modulator is assumed to be identical. The carrier input to the two modulators is same.

If we eliminate or suppress the carrier then the system becomes suppressed carrier DSB-SC. In this we need reinsert the carrier is complicated and costly. Hence the suppressed carrier DSB system may be used in point-to-point communication system.

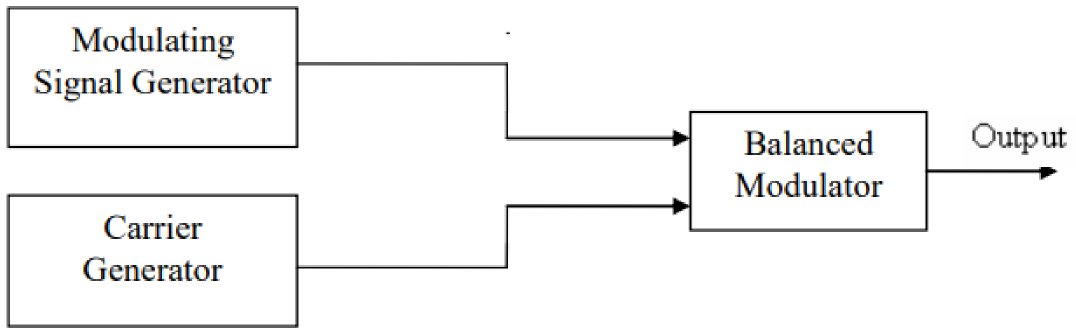
Generation of suppressed carrier amplitude modulated volt balanced modulator may be of the following types.

1. Using transistors or FET.

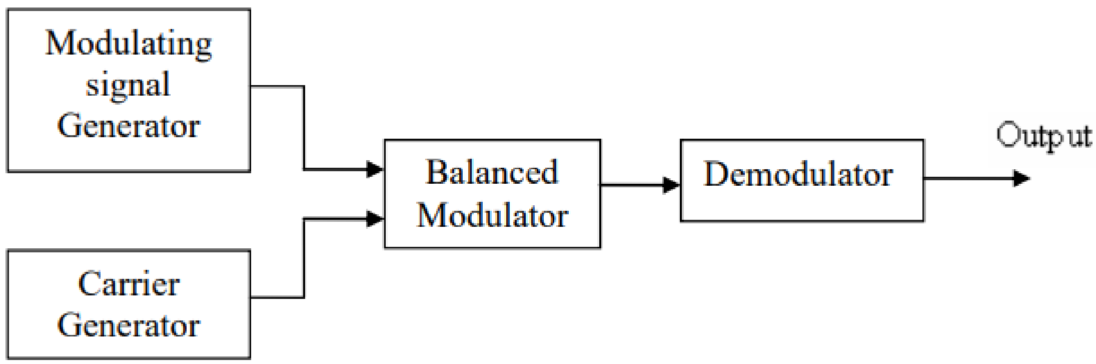
2. Using Diodes

BLOCK DIAGRAM:

1.Modulation:



2.Demodulation:

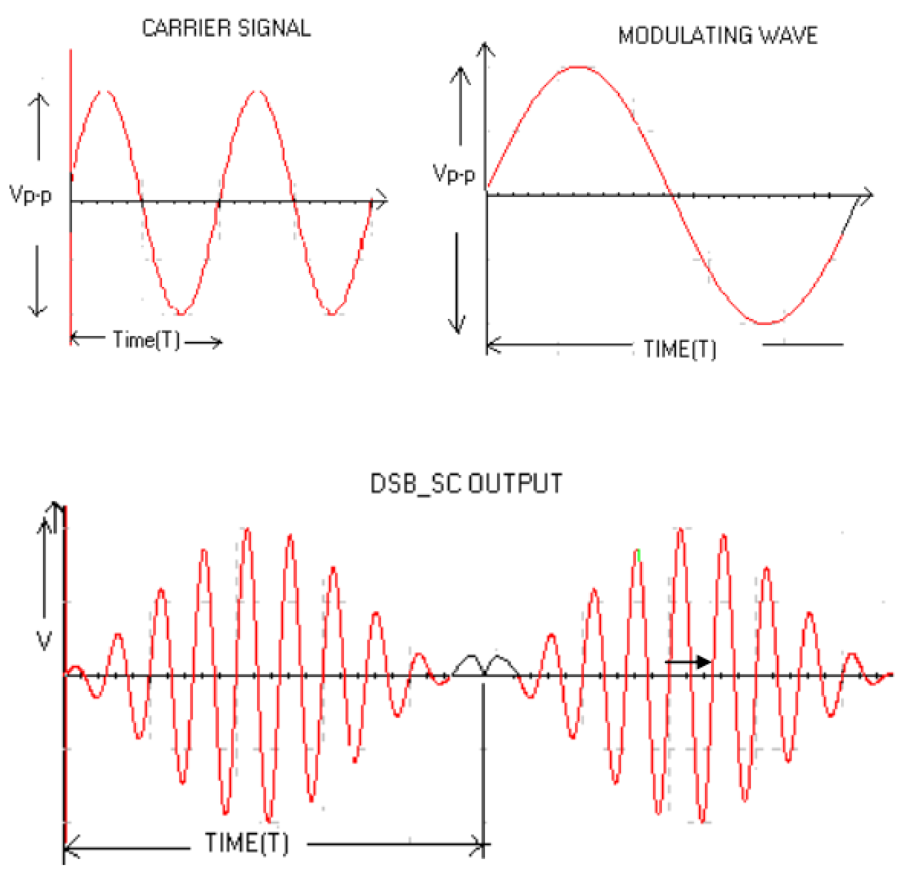


CODE:

```
% program for dsbsc modulation and demodulation
clear all
clc t =0:0.000001:.001;
Vm= 1;
Vc= 1;
fm = 2000;
fc= 50000;
m_t = Vm*sin(2*pi*fm*t);
subplot(4,1,1)
title({"\fontsize{12}Vipul Goyal-02419011721",'\bfMessage Signal'});
subplot(4,1,2);
plot(t, c_t);
```

```
title('Carrier Signal');
subplot(4,1,3);
s_t = m_t .* c_t;
hold on;
plot(t, s_t);
plot(t, m_t, 'r:');
plot(t, -m_t, 'r:');
hold off;
title('DSB-SC Modulated Signal');
r = s_t .* c_t;
[b, a] = butter(1, 0.01);
mr = filter(b, a, r);
subplot(4,1,4);
plot(t, mr);
title('Demodulated Signal');
```

EXPECTED WAVEFORM:



RESULT:

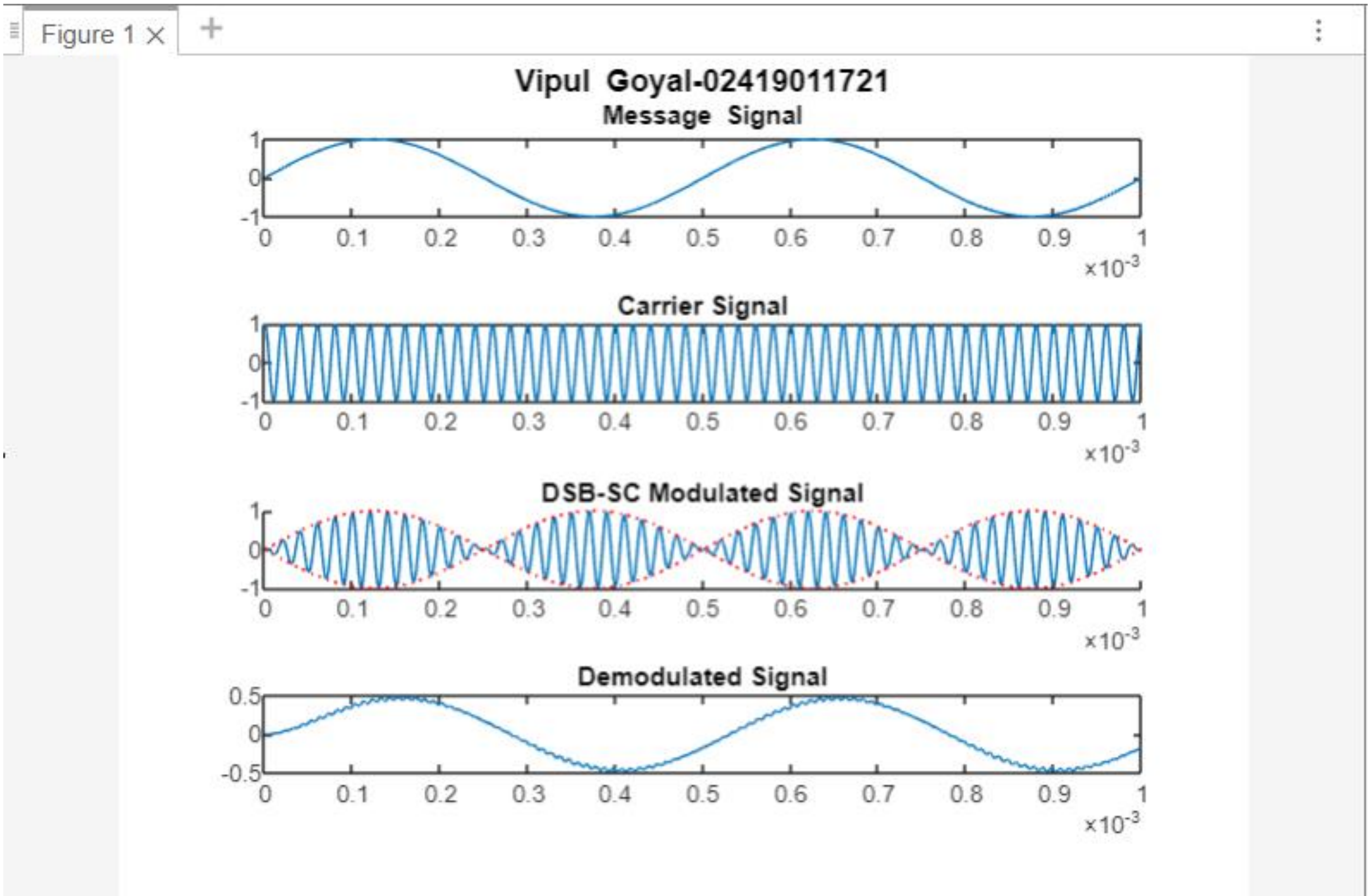


Figure 1
Vipul Goyal-02419011721
Message Signal
Carrier Signal
DSB-SC Modulated Signal
Demodulated Signal

EXPERIMENT.NO-4

SSB-SC MODULATOR & DETECTOR

(PHASE SHIFT METHOD)

AIM: To generate SSB using phase method and detection of SSB signal using Synchronous detector.

APPARATUS/SOFTWARE REQUIRED:

1. PC with windows (95/98/XP/NT/2000)

2. MATLAB Software with communication toolbox

THEORY:

AM and DSBSC modulation are wasteful of band width because they both require a transmission bandwidth which is equal to twice the message bandwidth In SSB only one side band and the carrier is used. The other side band is suppressed at the transmitter, but no information is lost. Thus the communication channel needs to provide the same band width, when only one side band is transmitted. So the modulation system is referred to as SSB system.

The base band signal may not be recovered from a SSB signal by the Use of a diode modulator. The bae band signal can be recovered if the spectral component of the output i.e either the LSB or USB is multiplied by the carrier signal.

Consider the modulating signal

M(t)=Am cos Wmt

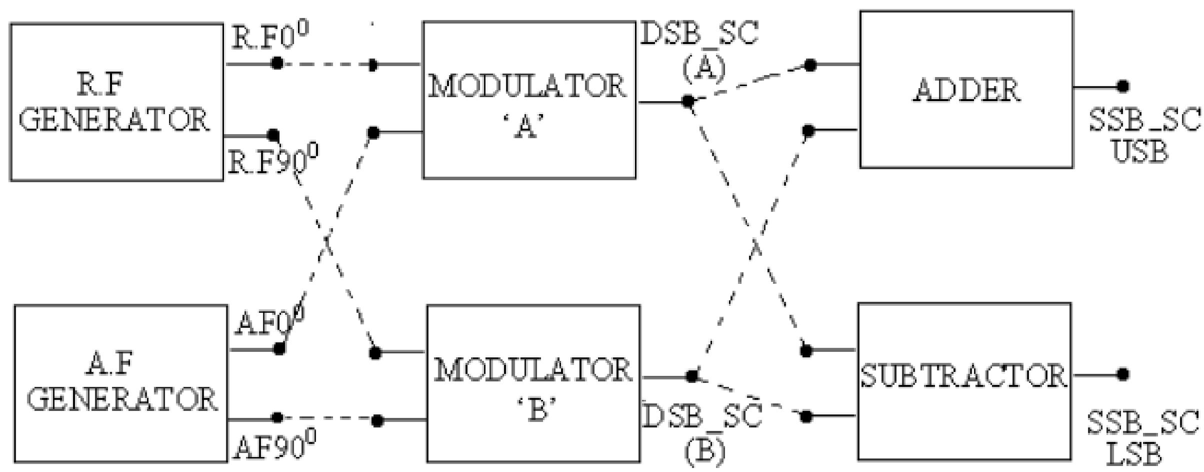
C(t)=Ac cosWct

M(t)c(t)= AcAm cosWmt cosWct

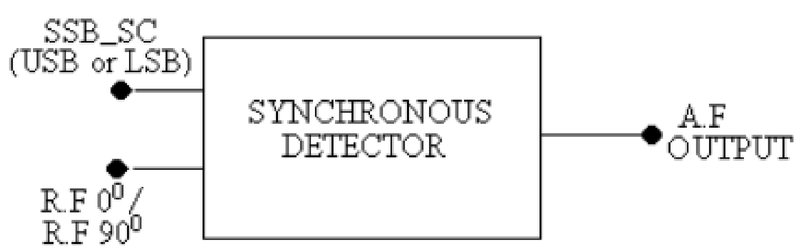
The above signal when passed through a filter, only one of the above component is obtained which lays the SSB signal.

BLOCK DIAGRAM: -

SSB MODULATION



SSB DEMODULATION/SYNCHRONOUS DETECTOR

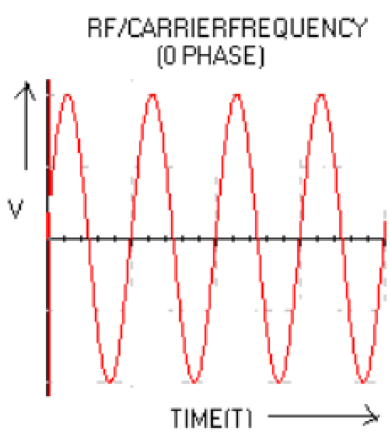


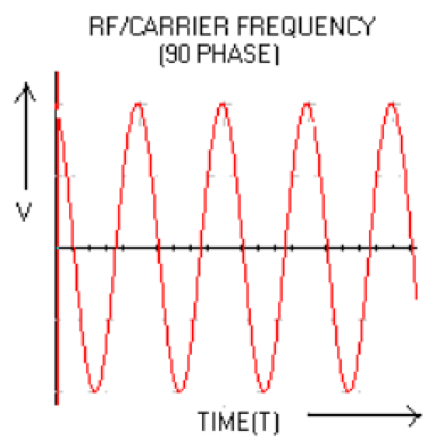
CODE:

```
% program for ssb modulation and demodulation
close all
clear all
clc fs=8000;
fm=20;
fc=50; Am=1; Ac=1;
t=[0:0.1*fs]/fs;
subplot(5,1,1);
m1=Am*cos(2*pi*fm*t);
```

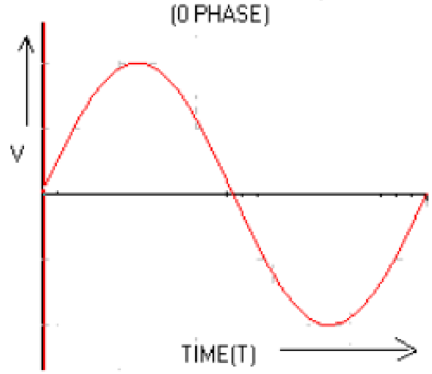
```
plot(t,m1);
title("Vipul Goyal-02419011721",'Message Signal');
m2=Am*sin(2*pi*fm*t);
subplot(5,1,2)
c1=Ac*cos(2*pi*fc*t);
 plot(t,c1) title('Carrier Signal');
c2=Ac*sin(2*pi*fc*t);
subplot(5,1,3)
 % Susb=0.5* Am*cos(2*pi*fm*t).* Ac*cos(2*pi*fc*t) -- 0.5* Am*sin(2*pi*fm*t).*
Ac*sin(2*pi*fc*t);
Susb=0.5*m1.*c1-0.5*m2.*c2;
plot(t,Susb);
 title('SSB-SC Signal with USB');
 subplot(5,1,4);
Slsb=0.5*m1.*c1+0.5*m2.*c2; plot(t,Slsb);
title('SSB-SC Signal with LSB');
 r = Susb.*c1;
 subplot(5,1,5);
 [b a] = butter(1,0.0001);
mr= filter(b,a,r);
```

EXPECTED WAVE FORMS:

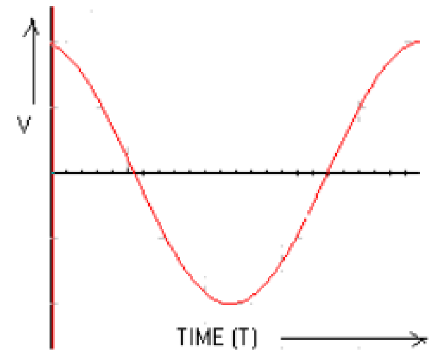


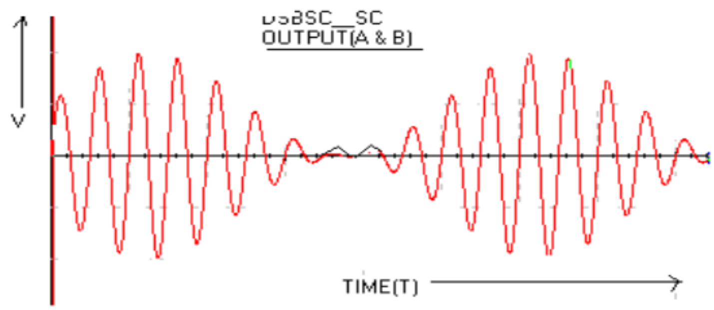


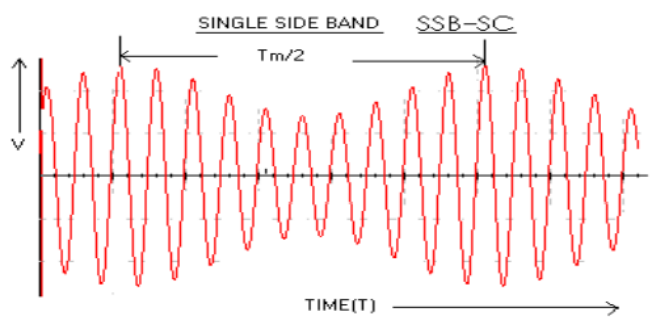
AF/MODULATINGFREQUENCY
(0 PHASE)



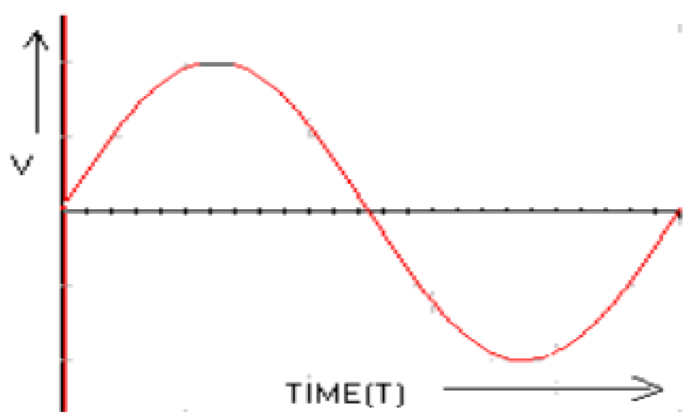
AF/MODULATING FREQUENCY
(90 PHASE)







SSB DEMODULATED OUTPUT



RESULT:

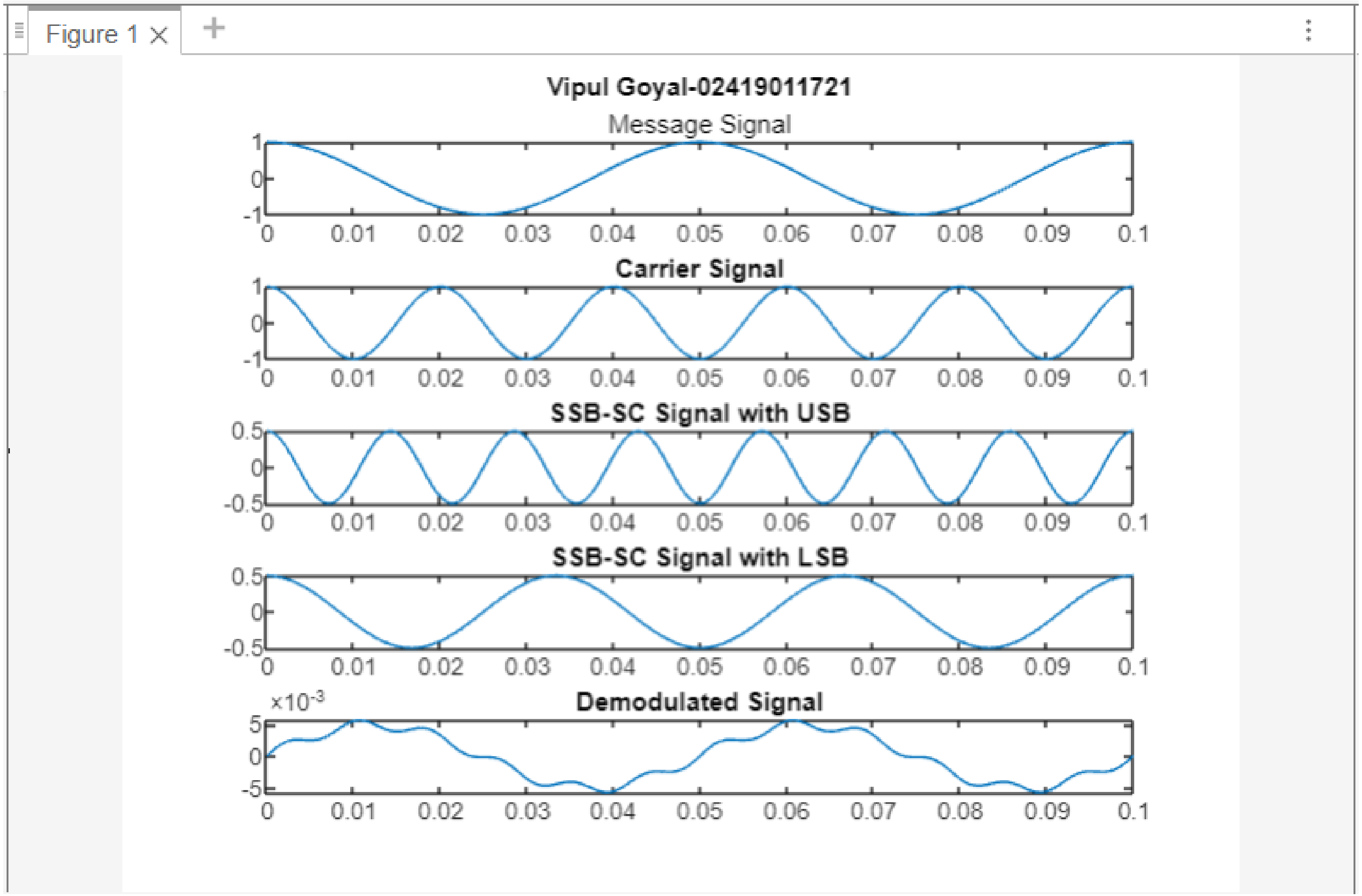


Figure 1
Vipul Goyal-02419011721
Message Signal
Carrier Signal
SSB-SC Signal with USB
SSB-SC Signal with LSB
Demodulated Signal
×10-3
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1

EXPERIMENT NO-5

FREQUENCY MODULATION AND DEMODULATION

AIM: To study the process of frequency modulation and demodulation.

APPARATUS/SOFTWARE REQUIRED:

1. PC with windows(95/98/XP/NT/2000)
2. MATLAB Software with communication toolbox

THEORY:

The modulation system in which the modulator output is of constant amplitude, in which the signal information is super imposed on the carrier through variations of the carrier frequency.

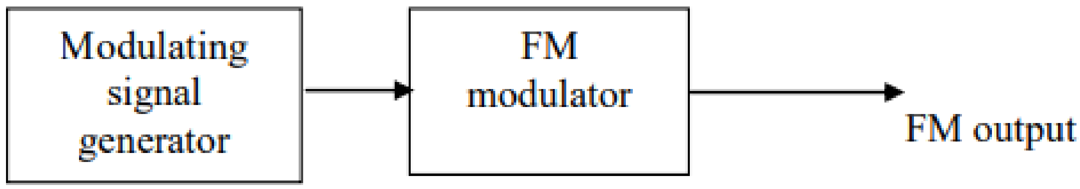
The frequency modulation is a non-linear modulation process. Each spectral component of the base band signal gives rise to one or two spectral components in the modulated signal. These components are separated from the carrier by a frequency difference equal to the frequency of base band component. Most importantly the nature of the modulators is such that the spectral components which produce decently on the carrier frquency and the base band frequencies.The spetral components in the modulated wave form depend on the amplitude.

The modulation index for FM is defined as

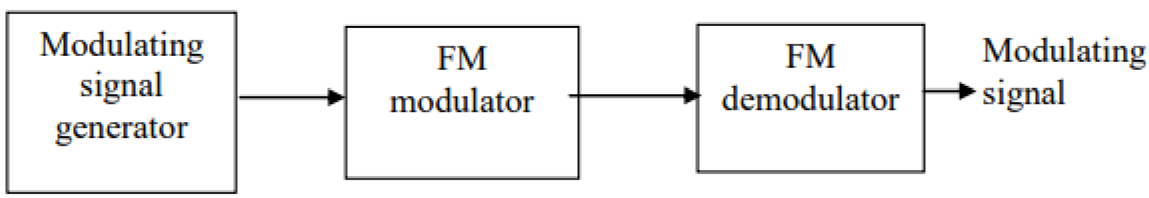
Mf= max frequency deviation/ modulating frequency

BLOCK DIAGRAM:

1.Modulation



2.Demodulation

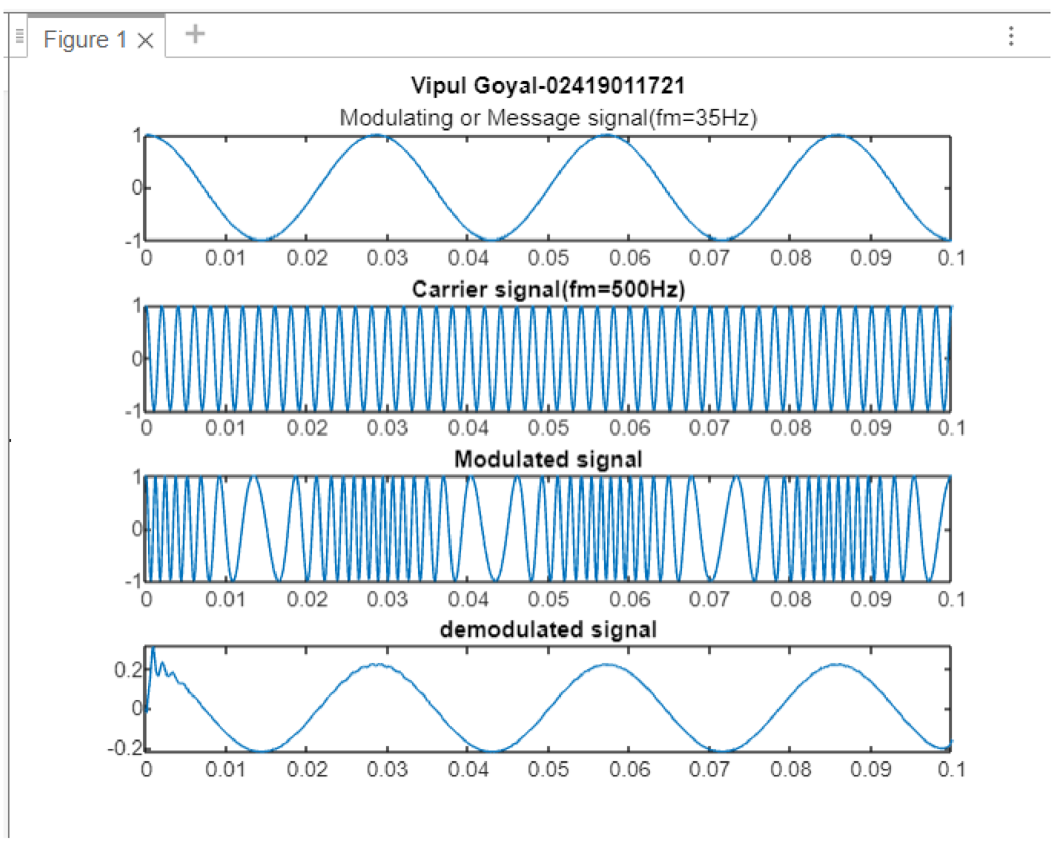


CODE:

```
% program for fm modulation and demodulation
%fm=35HZ,fc=500HZ,Am=1V,Ac=1V,B=10
fs=10000;
Ac=1;
Am=1;
fm=35;
fc=500;
B=10;
t=(0:.1*fs)/fs;
wc=2*pi*fc;
wm=2*pi*fm;
m_t=Am*cos(wm*t);
subplot(4,1,1);
plot(t,m_t);
```

```
title("Vipul Goyal-02419011721",'Modulating or Message signal(fm=35Hz)');

c_t=Ac*cos(wc*t);

subplot(4,1,2);

plot(t,c_t);

title('Carrier signal(fm=500Hz)');

s_t=Ac*cos((wc*t)+B*sin(wm*t));

subplot(4,1,3);

plot(t,s_t);

title('Modulated signal');

d=demod(s_t,fc,fs,'fm');

subplot(4,1,4);

plot(t,d);

title('demodulated signal');
```

RESULT:



EXPERIMENT NO-6

STUDY OF SPECTRUM ANALYZER AND ANALYSIS OF AM AND FM SIGNALS

AIM: To verify the spectrum of AM and FM signals using spectrum analyzer

APPARATUS/SOFTWARE REQUIRED:

1. PC with windows(95/98/XP/NT/2000)

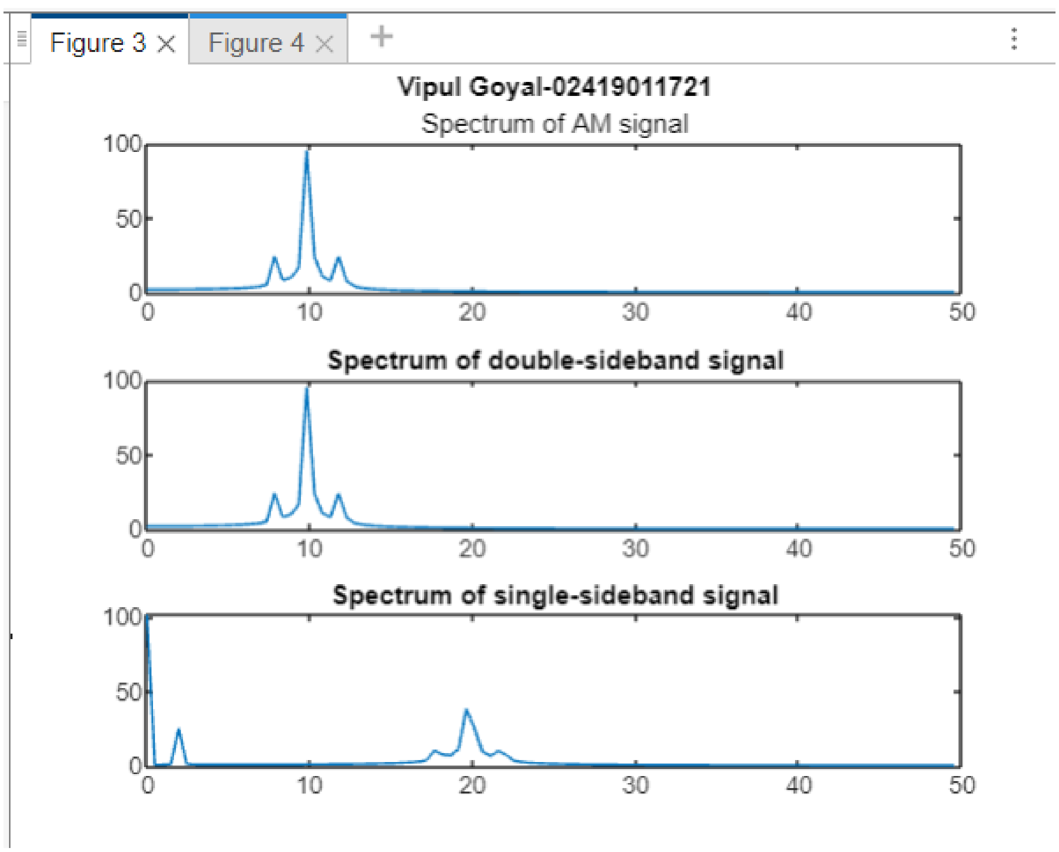
2. MATLAB Software with communication toolbox

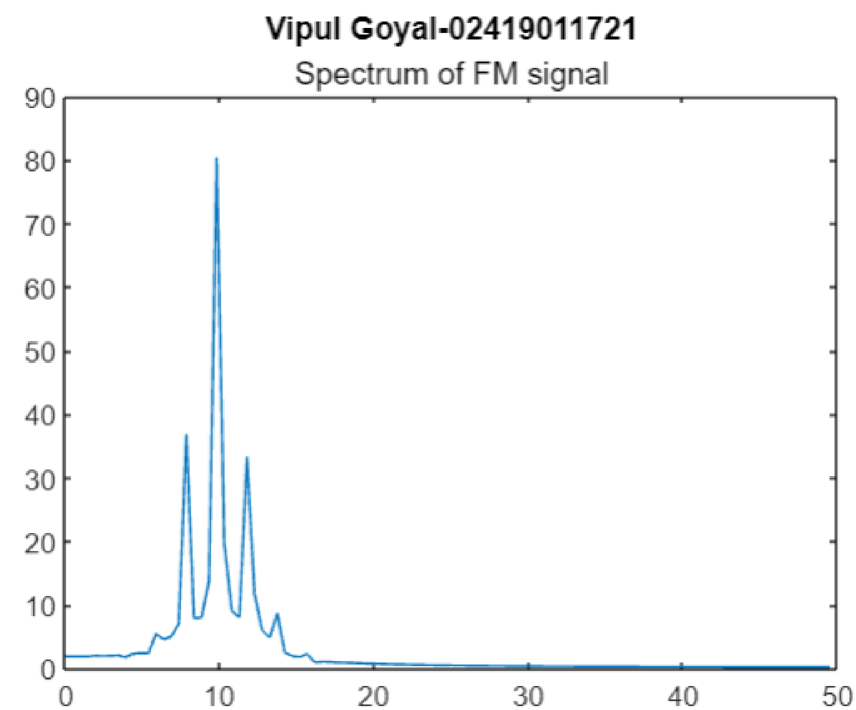
CODE:

```
% program of spectrum analyzer and analysis of am and fm signals
Fs = 100; % Sampling frequency
t = [0:2*Fs+1]'/Fs;
Fc = 10; % Carrier frequency
x = sin(2*pi*2*t); % Message signal
Ac = 1; % Amplitude of carrier
mu = 0.5; % Modulation index
xam = (1 + mu * x) .* cos(2 * pi * Fc * t);
zam = fft(xam);
zam = abs(zam(1:length(zam)/2+1));
frqam = [0:length(zam)-1]*Fs/length(zam)/2;
ydouble = xam;
zdouble = fft(ydouble);
zdouble = abs(zdouble(1:length(zdouble)/2+1));
frqdouble = [0:length(zdouble)-1]*Fs/length(zdouble)/2;
ysingle = xam .* cos(2 * pi * Fc * t);
zsingle = fft(ysingle);
```

```
zsingle = abs(zsingle(1:length(zsingle)/2+1));
frqsingle = [0:length(zsingle)-1]*Fs/length(zsingle)/2;
figure;
subplot(3,1,1);
plot(frqam, zam);
title("Vipul Goyal-02419011721",'Spectrum of AM signal');
subplot(3,1,2);
plot(frqdouble, zdouble);
title('Spectrum of double-sideband signal');
subplot(3,1,3); plot(frqsingle, zsingle);
title('Spectrum of single-sideband signal');
kf = 10; % Frequency deviation factor
xfm = cos(2 * pi * Fc * t + kf * cumsum(x) * 1/Fs);
zfm = fft(xfm);
zfm = abs(zfm(1:length(zfm)/2+1));
frqfm = [0:length(zfm)-1]*Fs/length(zfm)/2;
```

RESULT:





Vipul Goyal-02419011721
Spectrum of FM signal
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50