5. FRERQUENCY DIVISION MULTIPLEXING

Aim:

To construct the frequency division multiplexing and demultiplexing circuit and to verify its operation

Theory:

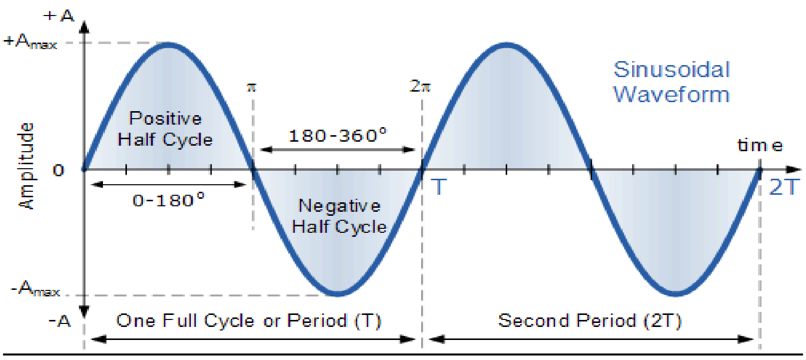
When several communications channels are using a single channel, efficiency may be realized by sending all the messages on one transmission facility through a process called multiplexing. Applications of multiplexing range from telephone networks to the glamour of FM stereo and space probe telemetry system and cellular mobile. There are two basic multiplexing techniques

1. Frequency Division Multiplexing (FDM)
2. Time Division Multiplexing (TDM)

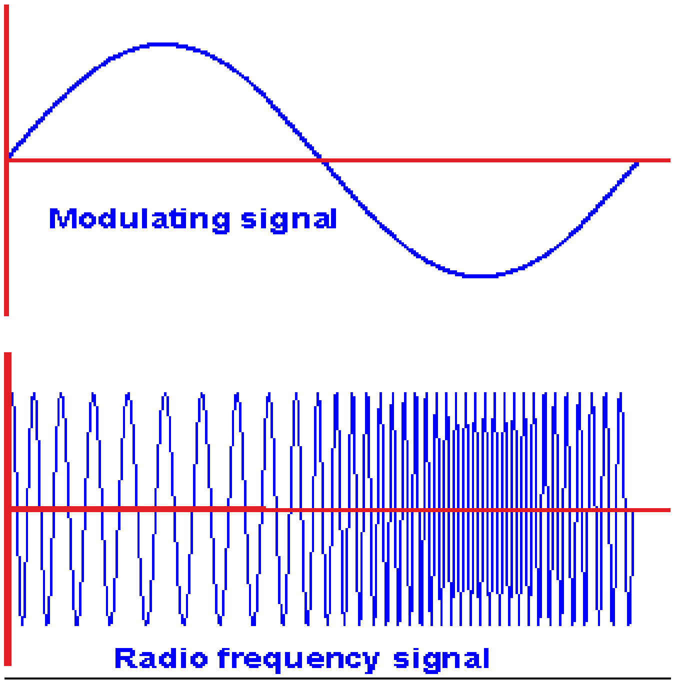
The principle of the frequency division multiplexing is that several input messages individually modulate the sub carrier's fc1, fc2, etc. After passing through LPFs to limit the message bandwidth. We show the sub carrier modulation as SSB, and it often is; but any of the CW modulation techniques or a mixture of them could be employed. The modulated signals are then summoned to produce the base band signal with the spectrum, the designation "base band" is used here to indicate that the final carrier modulation has not yet taken place. The major practical problem of FDM is cross talks, the unwanted coupling of one message into another. Intelligible cross talk arises

Primarily because of non-linearity in the system, which cause 1 message signal to appear as modulation on sub carrier. Consequently, standard practice calls for negative feedback to minimize amplifier non linearity in FDM systems

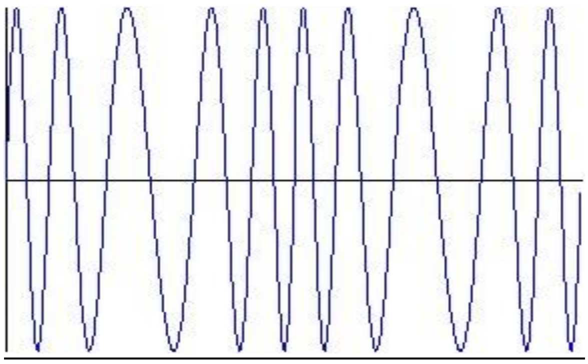
Message signal 1



Message signal 2 and FM wave 1

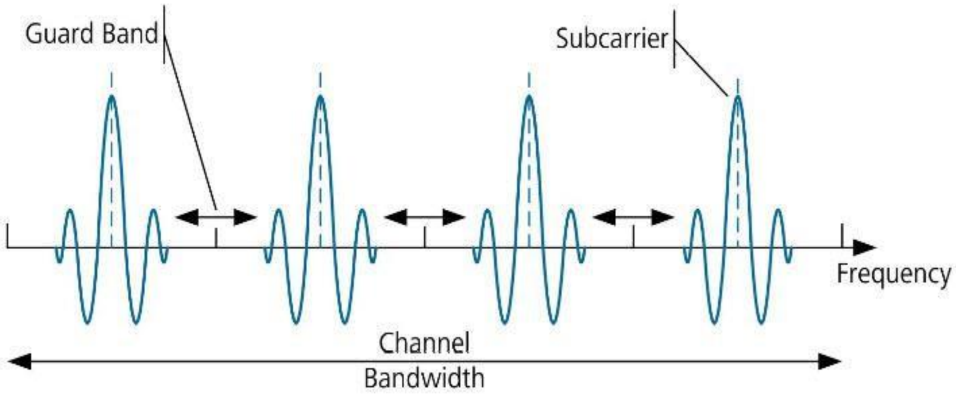


FM Wave 2

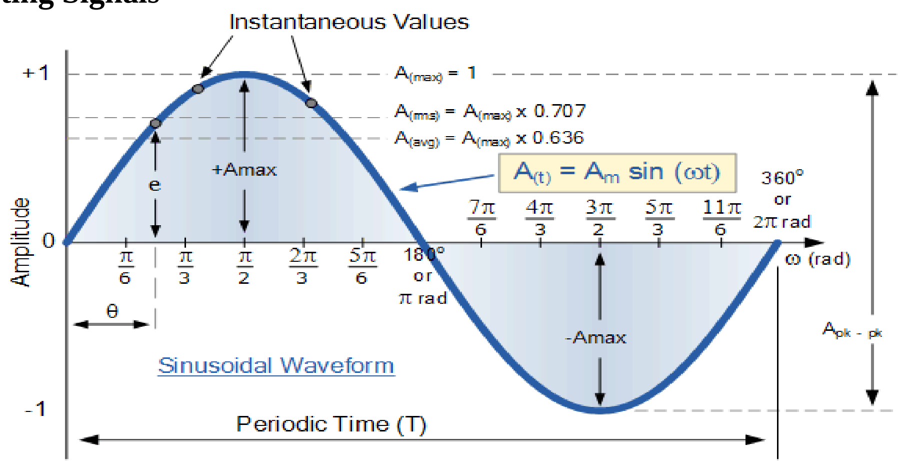


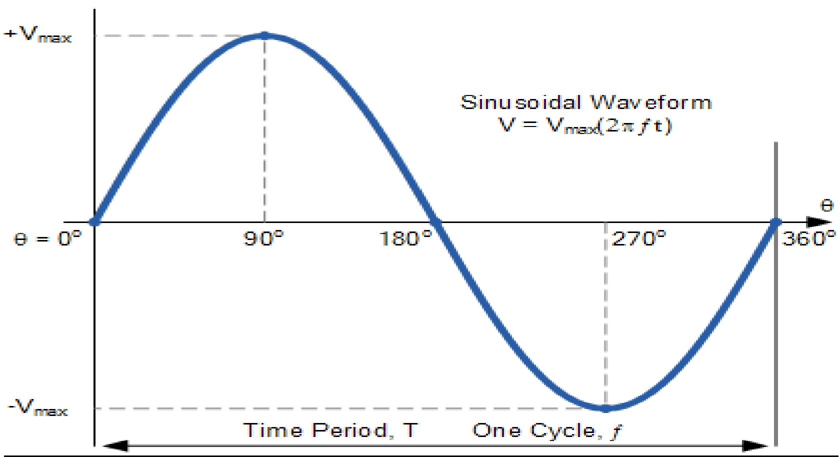
FDM Output

Frequency Division Multiplexing



Demodulating Signals



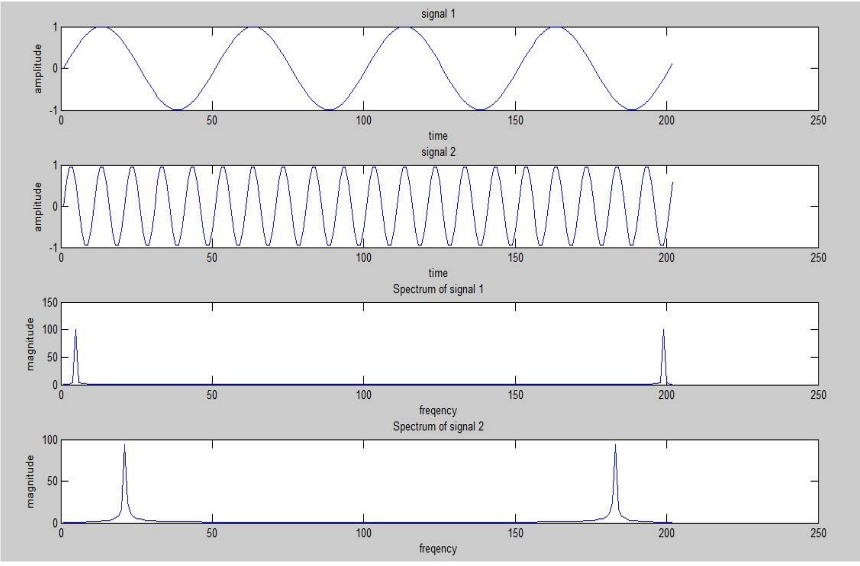


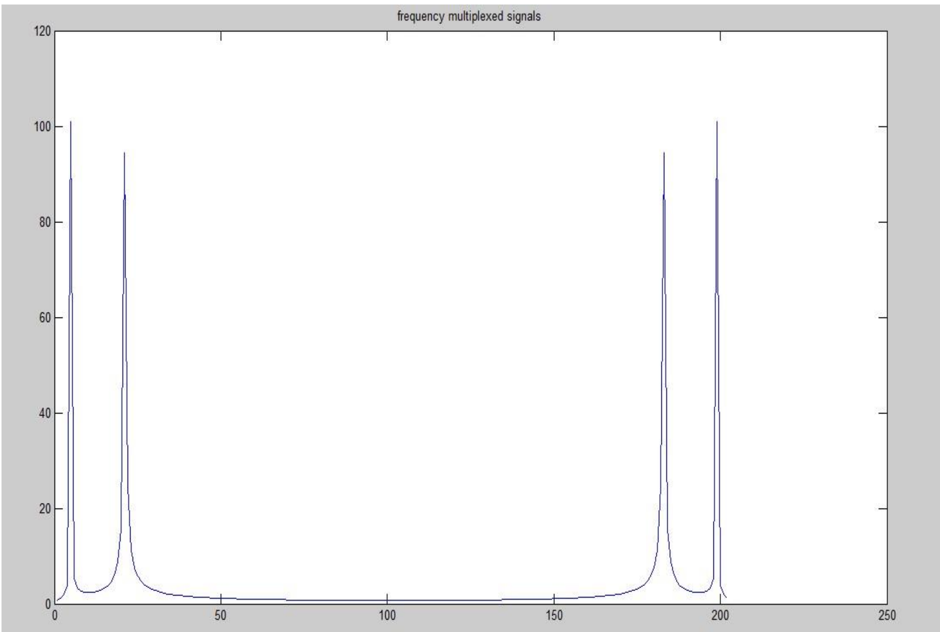
Matlab Program

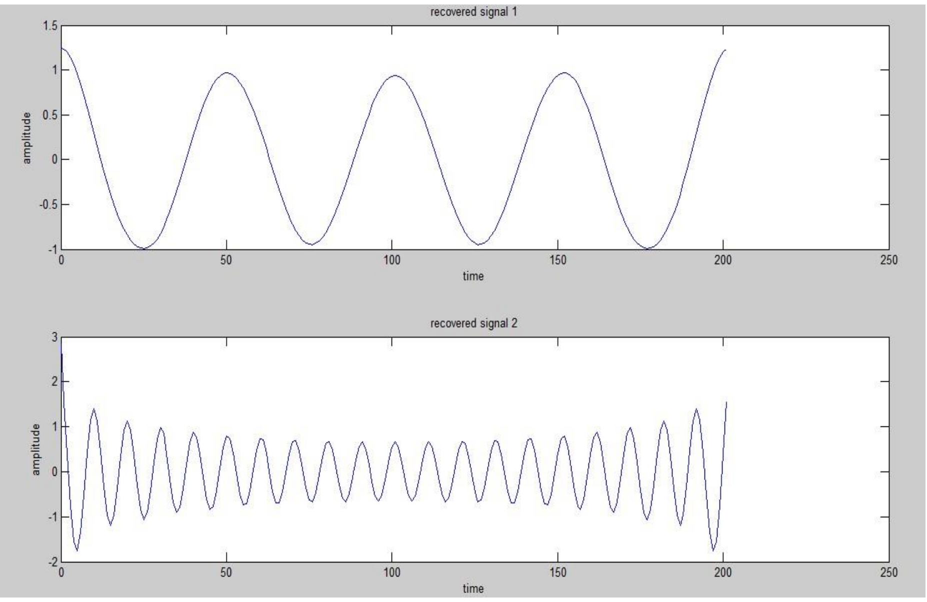
```
close all;
clear all;
clc;
Fs = 100; % sampling freq
t = [0:2*Fs+1]'/Fs;
x1 = sin(2*pi*2*t); % signal 1
signal z1 = fft(x1);
z1=abs(z1);
x2 = sin(2*pi*10*t); % signal 2
signal z2 = fft(x2);
z2=abs(z2);
figure;
subplot(4,1,1);
plot(x1); title('signal 1');
xlabel('time');
ylabel('amplitude');
subplot(4,1,2);
plot(x2);
title('signal 2');
xlabel('time');
ylabel('amplitude');
subplot(4,1,3);\
plot(z1);
title('Spectrum of signal 1');
xlabel('frequency');
ylabel('magnitude'); subplot(4,1,4);
plot(z2); title('Spectrum of signal 2');
xlabel('frequency')
ylabel('magnitude');
% frequency multiplexing
z=z1+z2; figure; plot(z);
title('frequency multiplexed
signals'); figure;
```

```
% frequency demultiplexing
f1=[ones(10,1);  zeros(182,1);
ones(10,1)];%applying filter for signal 1
dz1=z.*f1; d1 = ifft(dz1); subplot(2,1,1)
plot(t*100,d1); f2=[zeros(10,1);
ones(182,1); zeros(10,1)];% applying
filter for signal 2 dz2=z.*f2; d2 =
ifft(dz2); title('recovered signal 1');
xlabel('time'); ylabel('amplitude');
subplot(2,1,2) plot(t*100,d2);
title('recovered signal 2');xlabel('time');ylabel('amplitude');
```

Waveforms







Pre Lab Question

1. Explain multiplexing?
2. Explain different types of multiplexing?
3. What are the advantages of multiplexing?

Lab Assignment

1. Observe FDM output at different channels?
2. Observe FDM output for 3 inputs using matlab code

Post Lab Questions

1. Explain Frequency-division multiplexing
2. Differentiate FDM & TDM
3. What is the BW of FDM
4. Explain FDM Generation

Result:

The frequency division multiplexing and multiplexing is constructed and its operation is verified

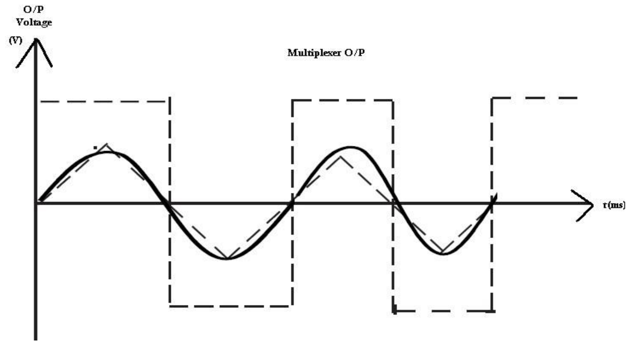
TIME DIVISION MULTIPLEXING

Aim

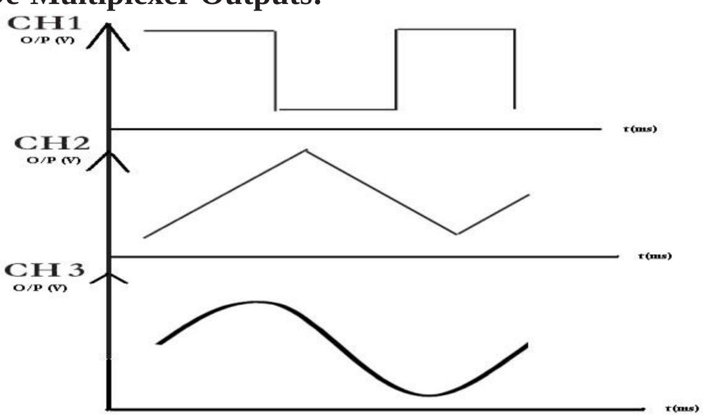
To study the operation of Time-Division multiplexing.

Theory: The TDM system is highly sensitive to dispersion in the common channel, that is, to variations of amplitude with frequency or lack of proportionality of phase with frequency. Accordingly, accurate equalization of both magnitude and phase response of the channel is necessary to ensure a satisfactory operation of the system. The primary advantage of TDM is that several channels of information can be transmitted simultaneously over a single cable. In hardware implementation, a 555 timer is used as a clock generator. This timer is a highly stable device for generating accurate time delays, which is of 100 KHz frequency (approximately). This clock signal is connected to the 74163 IC, a synchronous pre-set-able binary counter. It divides the clock signal frequency into three parts and those are used as selection lines for multiplexer and Demultiplexer. In built signal generator is provided with sine, square and triangle outputs with variable frequency. These three signals can be used as inputs to the multiplexer, IC 4051 is an 8 to 1 analog multiplexer. It selects one-of eight signal sources as a result of a unique three-bit binary code at the select inputs. Again IC 4051 is wired as 1 to 8 Demultiplexer. Demux input receives the data source and transmits the data signals on different channels.

Expected Waveforms (Hardware): Multiplexer



De-Multiplexer Outputs:

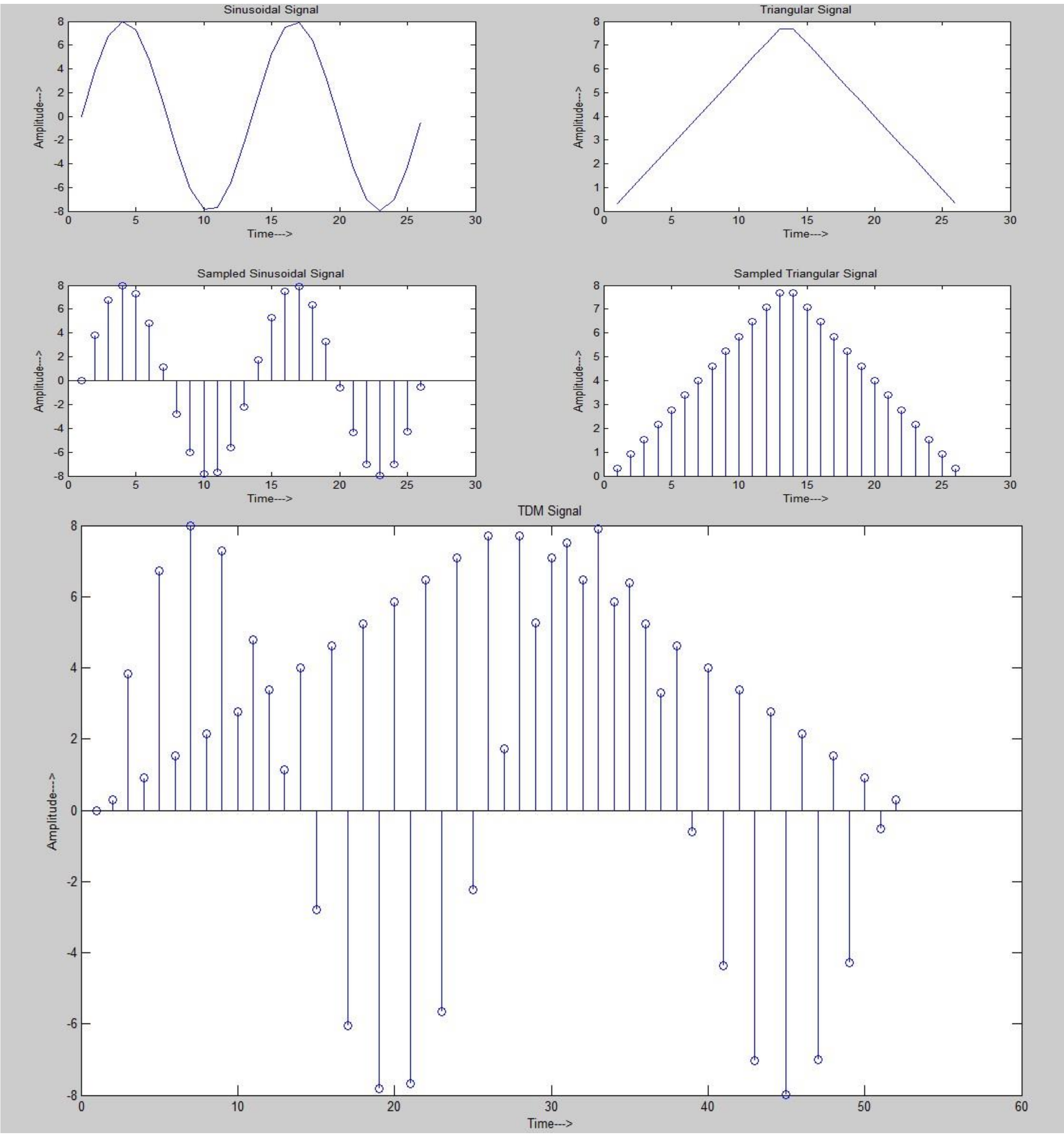


Matlab Program

```
clc;
close all;
clear all;
% Signal generation x=0:.5:4*pi; % signal taken upto 4pi
sig1=8*sin(x); % generate 1st sinusoidal signal
l=length(sig1);
sig2=8*triang(l); % Generate 2nd triangular Signal
% Display of Both Signal
subplot(2,2,1);
plot(sig1);
title('Sinusoidal Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
subplot(2,2,2); plot(sig2); title('Triangular Signal');
ylabel('Amplitude--->'); xlabel('Time--->'); % Display of Both
Sampled Signal
subplot(2,2,3);
stem(sig1);
title('Sampled Sinusoidal Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
subplot(2,2,4); stem(sig2);
title('Sampled Triangular
Signal'); ylabel('Amplitude--->');
xlabel('Time--->');
l1=length(sig1); l2=length(sig2);
for i=1:l1 sig(1,i)=sig1(i); % Making Both row vector
to a matrix sig(2,i)=sig2(i); end
% TDM of both quantize
signal
tdmsig=reshape(sig,1,2*l1); %
Display of TDM Signal
```

```
figure stem(tdmsig);
title('TDM Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
% Demultiplexing of TDM Signal
demux=reshape(tdmsig,2,l1); for i=1:l1 sig3(i)=demux(1,i); %
Converting The matrix into row vectors sig4(i)=demux(2,i);
end
% display of demultiplexed signal
figure subplot(2,1,1) plot(sig3);
title('Recovered Sinusoidal Signal'); ylabel('Amplitude--->');
xlabel('Time--->'); subplot(2,1,2) plot(sig4);
title('Recovered Triangular Signal'); ylabel('Amplitude--->');
xlabel('Time--->');
```

Expected Waveforms (Simulation)



6. a) AMPLITUDE MODULATION AND DEMODUALTION
b) FREQUENCY MODULATION AND DEMODULATION

Aim:

1. To generate amplitude modulated wave and determine the percentage modulation.
2. To demodulate the modulated wave using envelope detector.

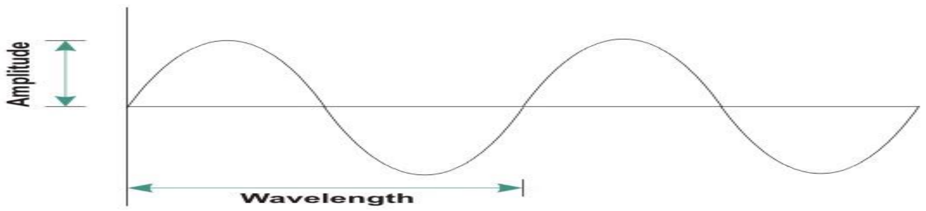
Amplitude Modulation is defined as a process in which the amplitude of the carrier wave c(t) is varied linearly with the instantaneous amplitude of the message signal m(t).The standard form of an amplitude modulated (AM) wave is defined by

$$s(t) = A_c\left[1 + K_a m(t)\cos(2\pi f_c t)\right]$$

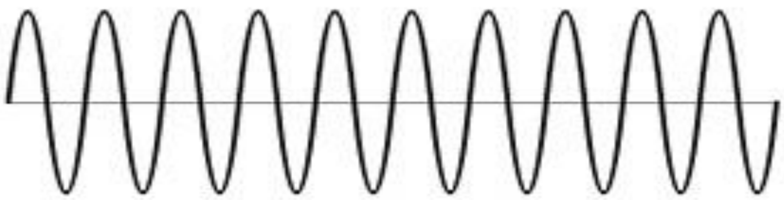
where *Ka* is a constant called the amplitude sensitivity of the modulator. The demodulation circuit is used to recover the message signal from the incoming AM wave at the receiver. An envelope detector is a simple and yet highly effective device that is well suited for the demodulation of AM wave, for which the percentage modulation is less than 100%.Ideally, an envelope detector produces an output signal that follows the envelop of the input signal wave form exactly; hence, the name. Some version of this circuit is used in almost all commercial AM radio receivers. The Modulation Index is defined as,

$$m = \frac{(E_{max} - E_{min})}{(E_{max} + E_{min})}$$

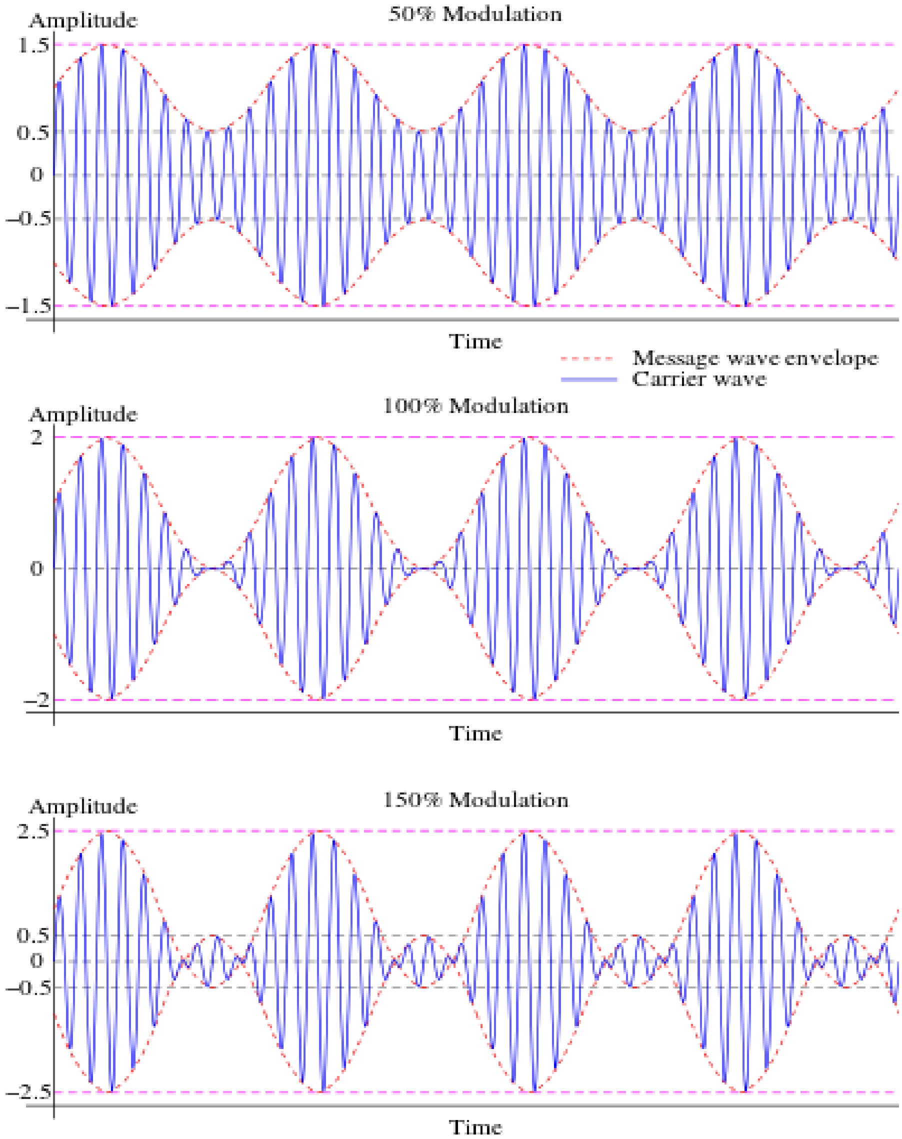
where Emax and Emin are the maximum and minimum amplitudes of the modulated wave.



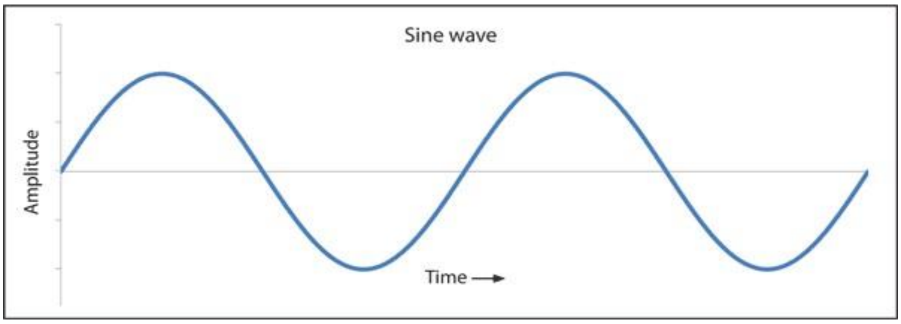
Message signal



Carrier signal



Types of Amplitude modulated waveforms



Demodulated signal

Tables:

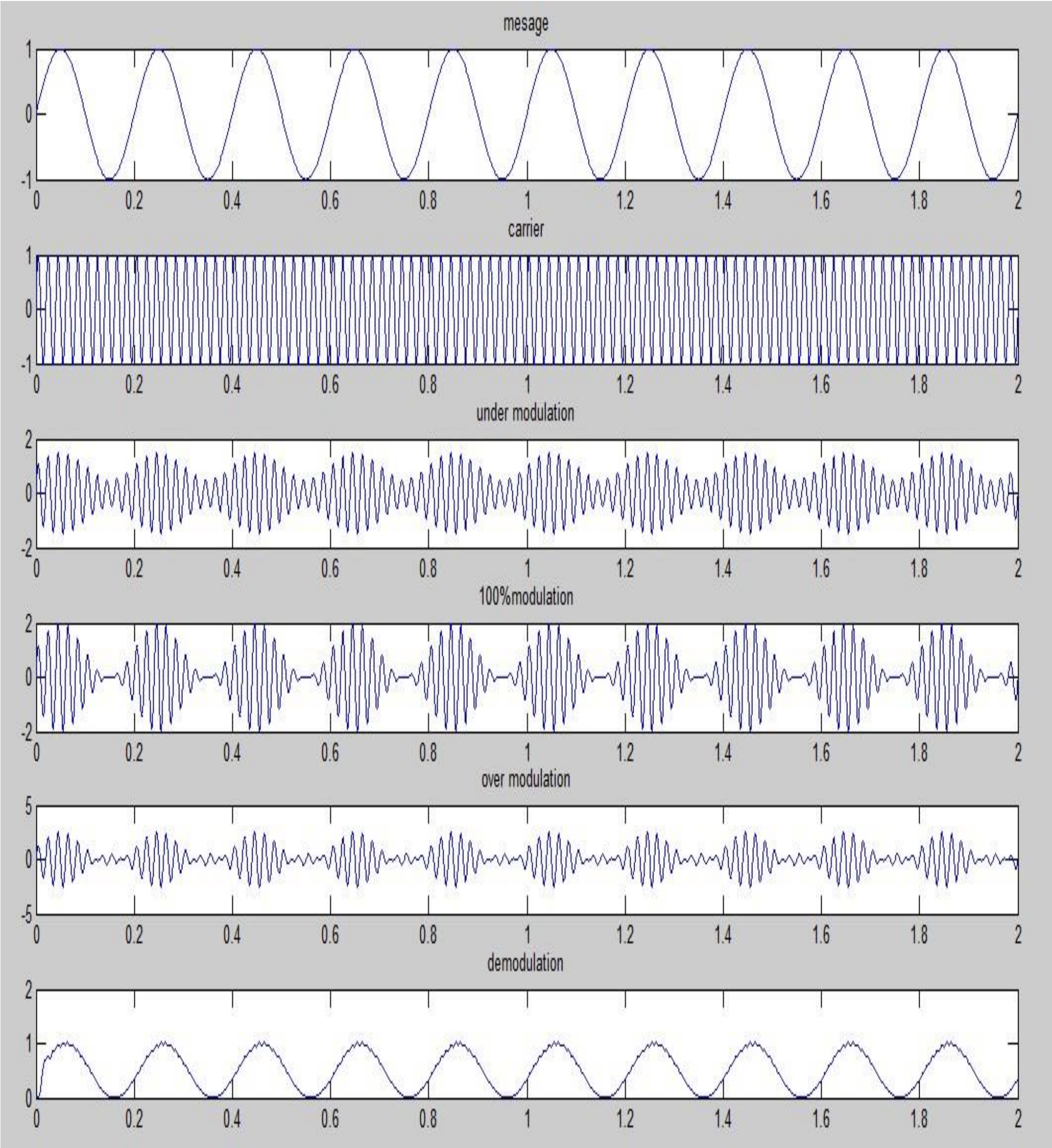
S. No	Vmax (Volts)	Vmin (Volts)	Theoretical μ= Vm/Vc	μ = $\frac{Vmax-Vmin}{Vmax+Vmin}$

Matlab Program:

```
clc; clear all;
close all;
t=[0:0.001:2];
f1=5;
m=sin(2*pi*f1*t)
subplot(6,2,[1,2]);
plot(t,m);
title('message');
f2=50;
c=sin(2*pi*f2*t);
subplot(6,2,[3,4]);
plot(t,c);
title('carrier');
m1=0.5;
s1=(1+(m1*m)).*c;
subplot(6,2,[5,6]);
plot(t,s1); title('under
modulation'); m2=1;
s2=(1+(m2*m)).*c;
subplot(6,2,[7,8]);
plot(t,s2);
title('100%modulation');
m3=1.5;
s3=(1+(m3*m)).*c;
subplot(6,2,[9,10]);
plot(t,s3); title('over
modulation'); s5=s2.*c;
```

```
[b,a]=butter(5,0.1);
s4=filter(b,a,s5);
subplot(6,2,[11,12]);
plot(t,s4);
title('demodulation' );
```

Expected Waveforms:



Prelab questions

1. Why modulation is an essential process of communication system?
2. Explain Block diagram of Communication system?
3. Explain need for modulation?
4. Define Amplitude modulation?
5. How carrier is differing from message?

Post lab questions

1. What are the distortions that are likely to be present in the demodulated output when diode detector is used?
2. Explain how negative peak clipping occurs in the demodulated signal when diode detector is used?
3. Explain under modulation, 100% modulation, over modulation?
4. Explain High level modulation?
5. Write the formulae to calculate practical modulation index?

Result:

Thus the AM wave is generated and its depth of modulation is calculated matlab simulation program.

DSB-SC MODULATION USING BALANCED and RING MODULATORS

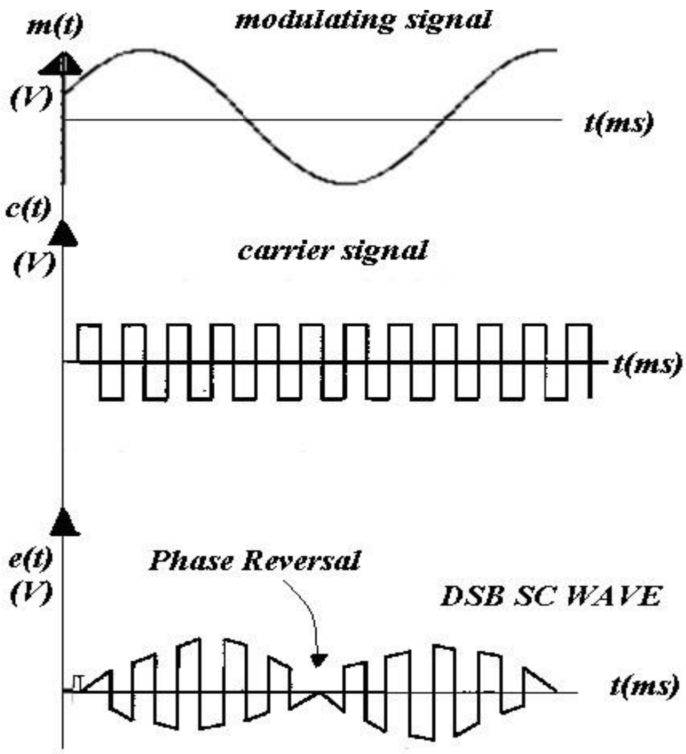
Aim

To generate AM-Double Side Band Suppressed Carrier (DSB-SC) signal using Balanced Modulator and Ring modulator.

Balanced Modulator Theory

Balanced modulator is used for generating DSB-SC signal. A balanced modulator consists of two standard amplitude modulators arranged in a balanced configuration so as to suppress the carrier wave. The two modulators are identical except the reversal of sign of the modulating signal applied to them.

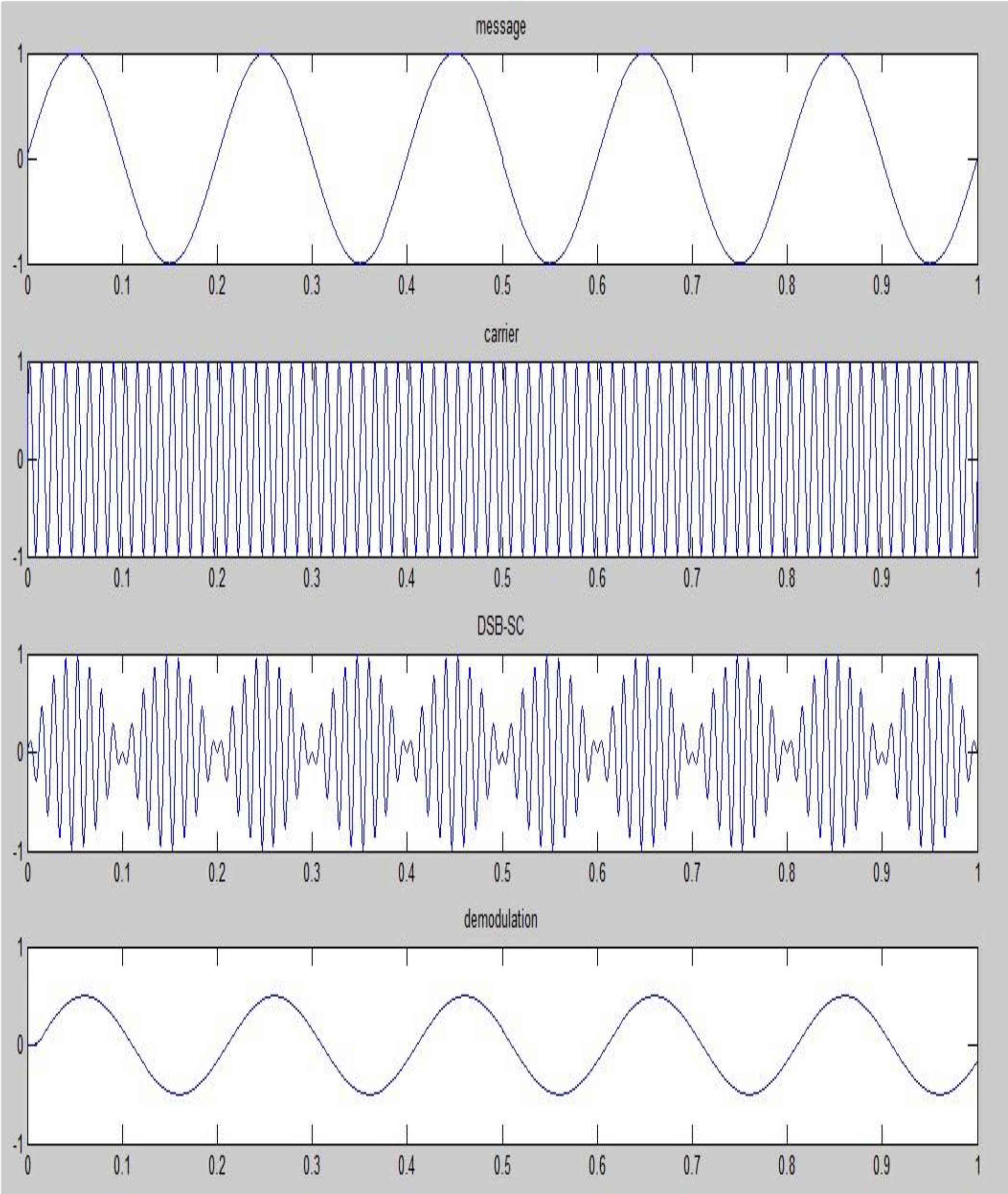
Expected Wave Forms



Matlab Program:

```
clc; clear all; close
all;  t=[0:0.001:1];
f1=5;
m=sin(2*pi*f1*t)
subplot(4,2,[1,2]);
plot(t,m);
title('message');
f2=80;
c=sin(2*pi*f2*t);
subplot(4,2,[3,4]);
plot(t,c);
title('carrier');
s=m.*c;
subplot(4,2,[5,6]);
plot(t,s); title('DSB-
SC'); s1=s.*c;
[b,a]=butter(5,0.1);
s2=filter(b,a,s1);
subplot(4,2,[7,8]);
plot(t,s2);
title('demodulation');
```

Expected Waveforms:



Ring Modulator Theory

The operation of the ring modulator is explained with the assumptions that the diodes act as perfect switches and that they are switched ON and OFF by the RF carrier signal. This is because the amplitude and frequency of the carrier is higher than that of the modulating signal. The operation can be divided into different modes without the modulating signal and with the modulating signal as follows:

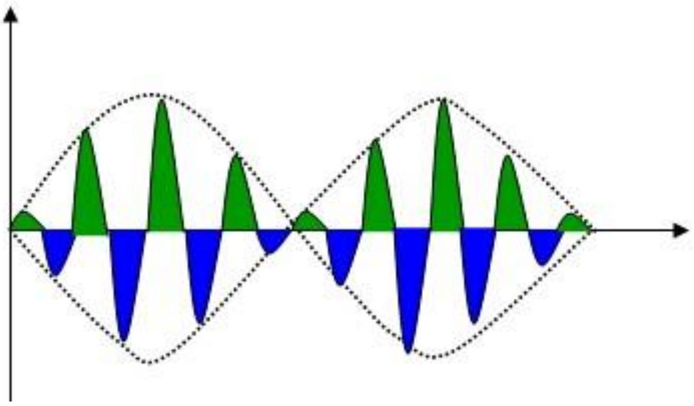
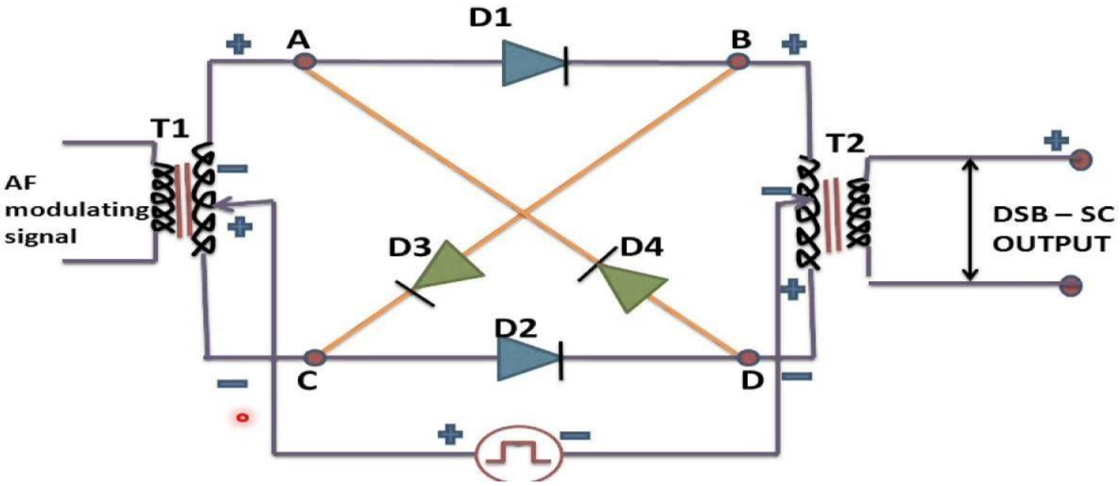
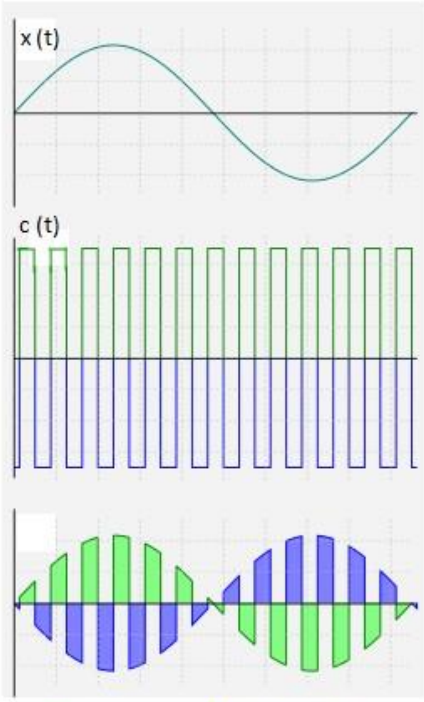


Fig: DSB –SC Output across secondary transformer

Ring Modulator circuit diagram:



Expected Wave Forms



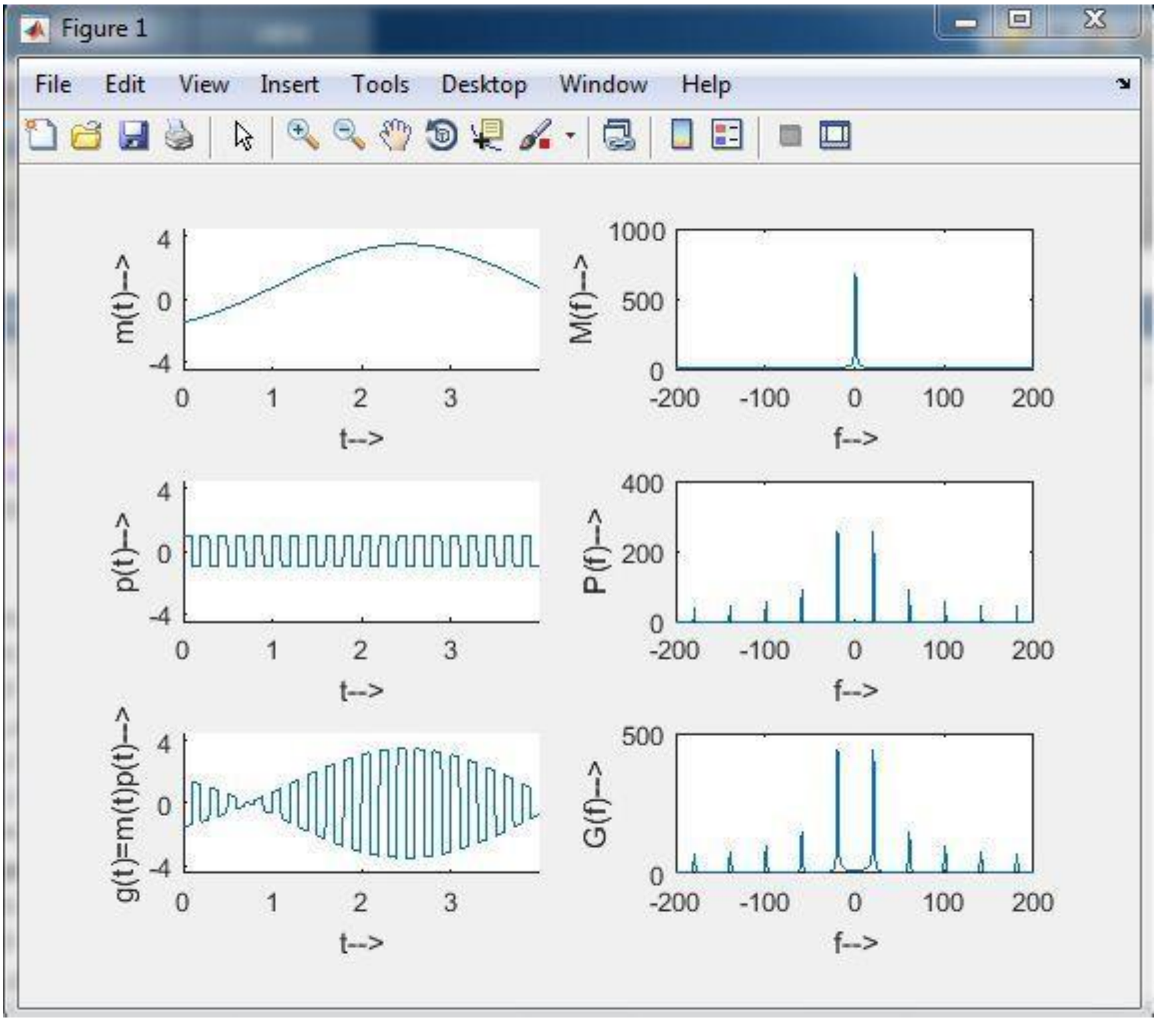
D1 ,D2 ON   D3 ,D4 ON

DSB-SC Signal at primary of T_2

Matlab Program

```
clc clear all;
close all;
t=0:0.01:(4-0.01);
T=10;  f=1/T;
a=2*sin(2*pi*f*t)-1.5*cos(4*pi*f*t);
subplot(321);
axis([0 (4-0.01) -4.5 4.5]); hold on;
plot(t,a); xlabel('t-->');
ylabel('m(t)-->');
pulses=[ones(1,10) -ones(1,10)];
pul=repmat(pulses,1,20);
subplot(323)
axis([0 (4-0.01) -4.5 4.5]); hold on;
plot(t,pul); xlabel('t-->');
ylabel('p(t)-->'); subplot(325)
a1=pul.*a;
axis([0 (4-0.01) -4.5 4.5]); hold on;
plot(t,a1); xlabel('t-->');
ylabel('g(t)=m(t)p(t)-->');
%%%%%%%%%%%%%%%FFT%%%%%%%%%  s1 =
abs(fftshift((fft(a))));
subplot(322) pt=20;
f=-199:200; %f=-99:100;
%axis([0 (4-0.01) -4.5 4.5]); hold on;
%s1=s1(-99:100);
plot(f,s1); xlabel('f--
>'); ylabel('M(f)-->');
s2=fftshift(abs(fft(pul)));
subplot(324) f=-199:200;
plot(f,s2); xlabel('f--
>'); ylabel('P(f)-->');
s3=fftshift(abs(fft(a1)));
subplot(326) f=-199:200;
```

```
plot(f,s3); xlabel('f--
>');
ylabel('G(f)-->');
```



Result:

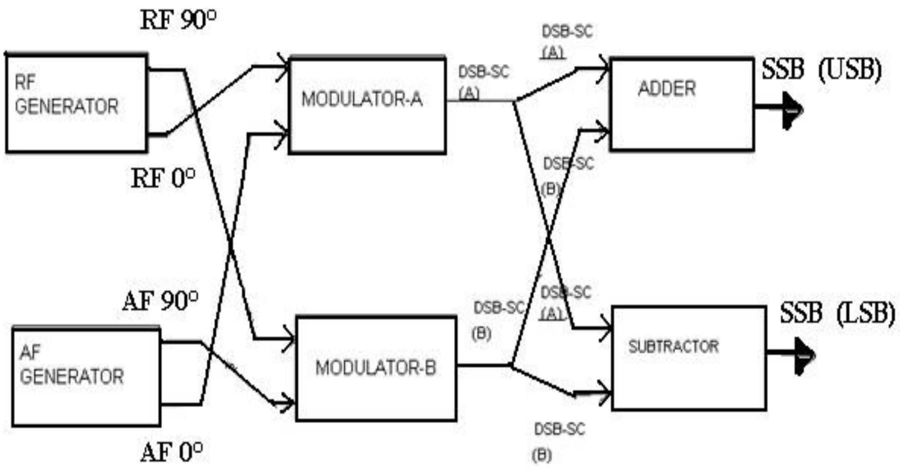
The DSBSC wave is generated using the balanced and the ring modulator methods and carrier suppression is calculated.

SINGLE SIDEBAND MODULATION AND DEMODULATION

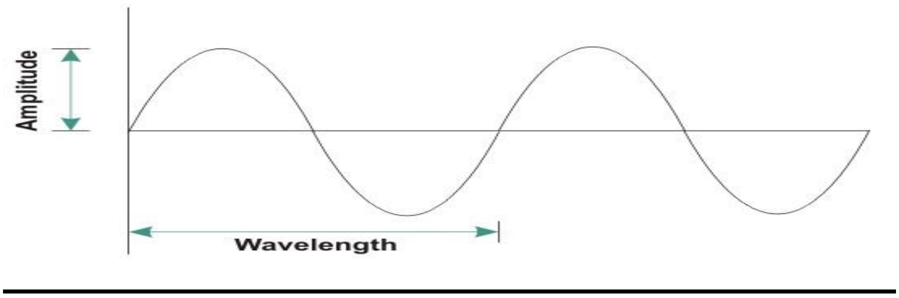
Aim

To generate the SSB modulated wave using Phase shift method and demodulate the SSB modulated wave.

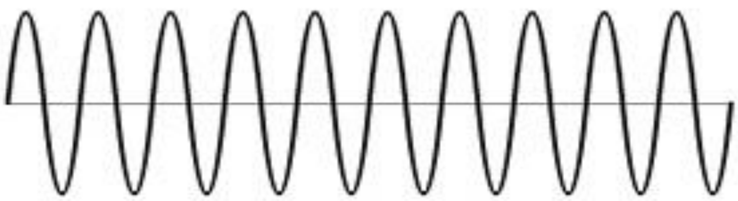
Block Diagram and Theory



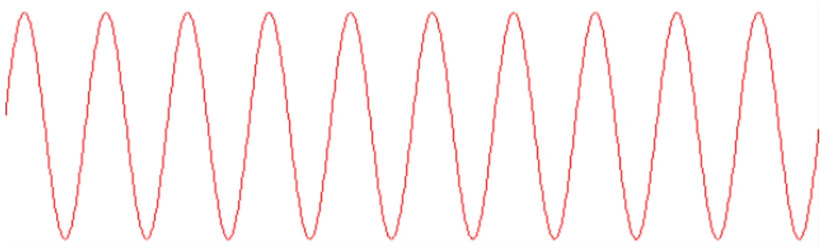
Expected waveforms



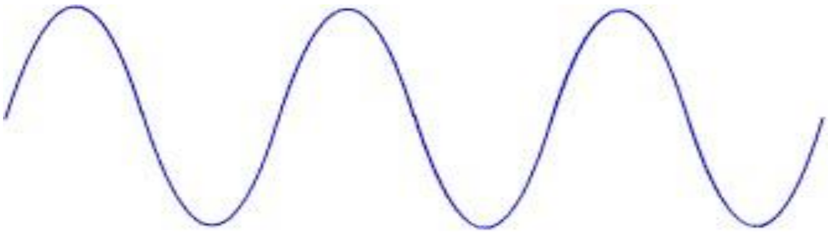
Message signal



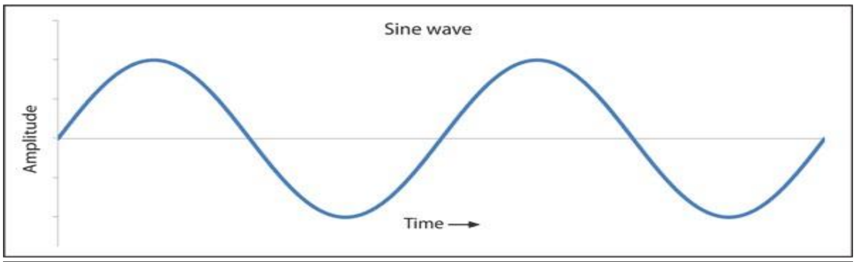
Carrier signal



SSB USB Signal



SSB LSB Signal



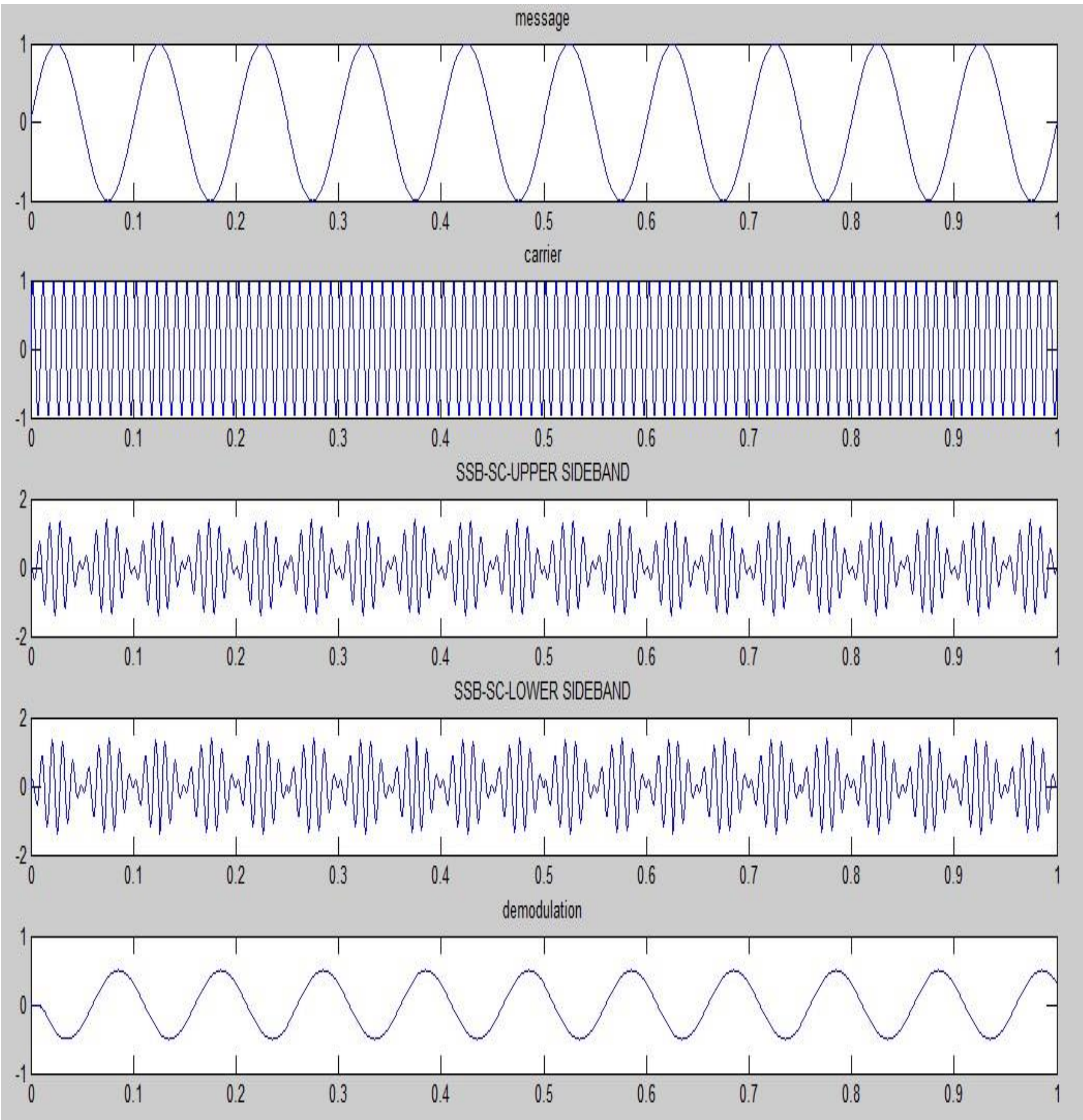
Demodulated signal

Matlab Program:

```
clc; clear all;
close all;
t=[0:0.001:1]
; f1=5;
m1=sin(2*pi*f1*t);

m2=hilbert(m1);
subplot(4,2,[1,2]);
plot(t,m1);
title('message');
f2=100;
c1=sin(2*pi*f2*t);
c2=cos(2*pi*f2*t);
subplot(4,2,[3,4]);
plot(t,c1);
title('carrier');
subplot(4,2,[5,6]);
plot(t,s); title('SSB-
SC'); s1=s.*c1;
[b,a]=butter(5,0.1);
s2=filter(b,a,s1);
subplot(4,2,[7,8]);
plot(t,s2);title('demodulation');
```

Expected Waveforms:



Lab Assignment:

1. Generate SSBSC using filter method?
2. Observe the spectrum and calculate transmission bandwidth.

Post Lab Questions:

1. Explain Phase shift method for generation of SSBSC
2. Write Power equation of SSBSC

3. Mention applications of SSBSC.
4. Explain advantages of phase shift method.
5. Explain COSTAS loop.

Result:

The SSB modulated wave using Phase shift method is generated and SSB Modulated wave is demodulated.

6. b) FREQUENCY MODULATION AND DEMODULATION

Aim

1. To generate frequency modulated signal and determine the modulation index and bandwidth for various values of amplitude and frequency of modulating signal through simulation.
2. To demodulate a FM wave using FM detector through simulation.

FM Theory

Frequency modulation is a system in which the frequency of the carrier is varied in accordance with the signal amplitude. Let's assume for the moment that the carrier of the transmitter is at its resting frequency (no modulation) of 100MHz and we apply a modulating signal. The amplitude of the modulating signal will cause the carrier to deviate from this resting frequency by a certain amount. If we increase the amplitude of this signal, we will increase the deviation to a maximum of 75 kHz as specified by the Federal Communication Commission (FCC). If we remove the modulating voltage, the carrier shifts back to resting frequency (100MHz). From this we can say that the deviation of the carrier is proportional to the amplitude of the modulating voltage. The shift in the carrier frequency from its resting point compared to the amplitude of the modulating voltage is called the deviation ratio (a deviation ratio of 5 is the maximum allowed in commercially broadcast FM). The rate at which the carrier shifts from its resting point to a no resting point is determined by the frequency of the modulating signal. The interaction between the amplitude and frequency of the modulating signal on the carrier is complex and requires the use of Bessel‟s function to analyse the results. If the modulating signal is 15 kHz at a certain amplitude and the carrier shift is 75 kHz, the transmitter will produce eight significant sidebands. This is known as the maximum deviation ratio. If the frequency deviation of the carrier is known and the frequency of the modulating signal is known then

Modulation index (β) = freq dev (Δf) / freq AF (fm)

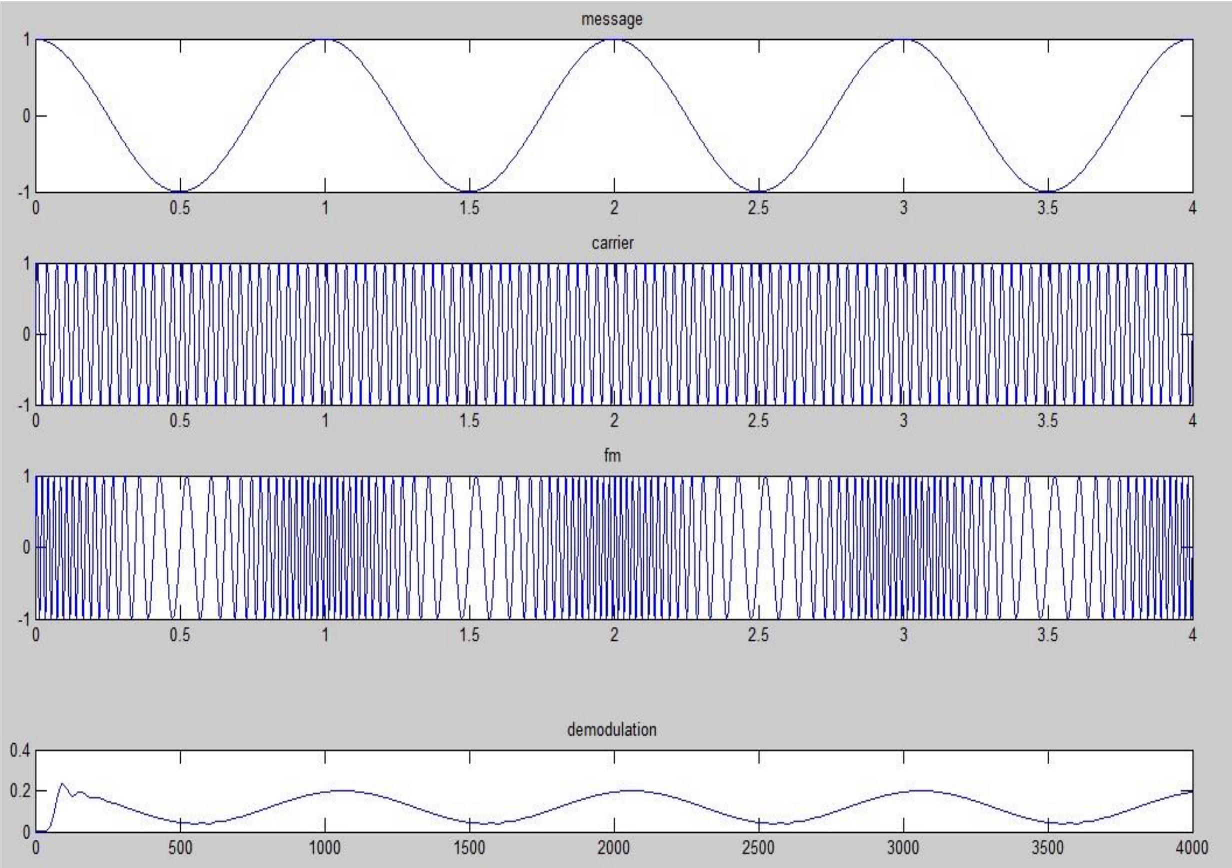
Types of FM:

Narrow band and wide band FM are the two types, defined with respect to the β value.

Matlab Program:

```
clc; clear all; close
all;
t=[0:0.001:4];f1=1
m=cos(2*pi*f1*t);
subplot(4,2,[1,2]);
plot(t,m);
title('message');
f2=30;
c=sin(2*pi*f2*t);
subplot(4,2,[3,4]);
plot(t,c);
title('carrier');
mf=20;
s=sin((2*pi*f2*t)+(mf*sin(2*pi*f1*t)))
subplot(4,2,[5,6]); plot(t,s); title('fm');
syms t1;
x=diff(s); y=abs(x);
[b,a]=butter(10,0.033)
s1=filter(b,a,y);
subplot(6,2,[11,12]);
plot(s1);
title('demodulation');
```

Expected Waveforms:



FM Modulation

S. No.	Modulating Signal Voltage (V)	Carrier Freq (KHz)	Change In Freq (KHz)	Freq Dev (KHz)	Mf =Freq dev/fm

FM Demodulation

S.No.	Mod-voltage (E_m) in mv	Modulating Frequency in (kHz)	Demodulated Signal voltage	Demodulated Signal frequency

Pre Lab Questions

1. Define Frequency modulation?
2. What are the advantages of FM over AM
3. What are applications of FM?

Lab Assignment

1. Generate PM output using Frequency modulation?
2. Observe the spectrum and calculate BW?

Post Lab Questions

1. Define Modulation Index?
2. Define Frequency Deviation?
3. When the amplitude of modulating signal increases then the effect on freq deviation?
4. Compare AM & FM
5. Compare NBFM & WBFM.

Result

The process of frequency modulation and demodulation is simulated and the frequency deviation and modulation index is calculated