ANALOG COMMUNICATION LABORATORY

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EXPERIMENT - 1

AIM:

Generation & detection of Amplitude modulation using MATLAB

THEORY:

Modulation is defined as process in which changing the characteristics usually amplitude, frequency and phase of high frequency wave (Carrier wave) by using instantaneous values of the low frequency signal (modulating signal).

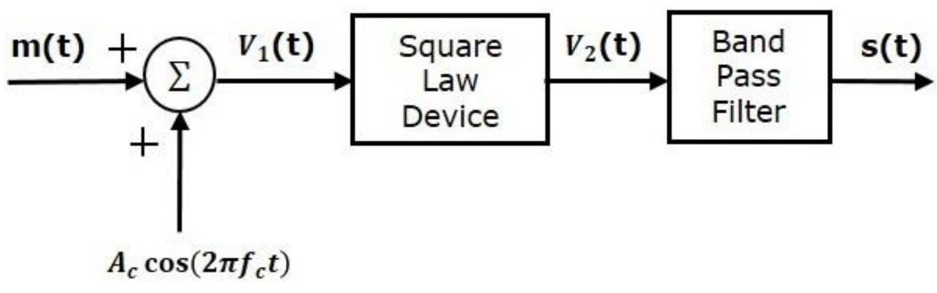
Amplitude modulation (AM) is defined as a process in which the amplitude of the carrier wave c(t) is varied about a mean value, linearly with the base band signal m(t). An AM wave may thus be described, in its most general form, as a function of time as follows. S(t)=A [1+Kam(t)] Cos (2πfct) The amplitude of Kam(t) is always less than unity, that is |Kam(t)| 1 for any t, the carrier wave becomes over modulated, resulting in carrier phase reversals. whenever the factor 1+Kam(t) crosses zero. The absolute maximum value of Kam(t) multiplied by 100 is referred to as the percentage modulation.

The following two modulators generate AM wave.

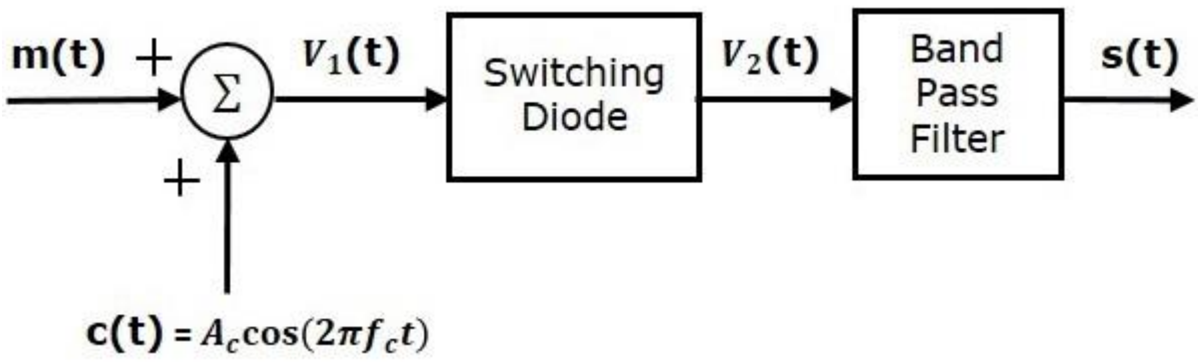
- Square law modulator
- Switching modulator

BLOCK DIAGRAM:

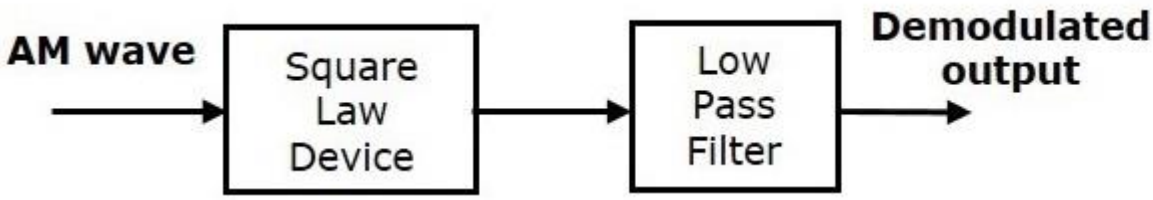
SQUARE LAW MODULATOR



SWITCHING MODULATOR



DEMODULATOR

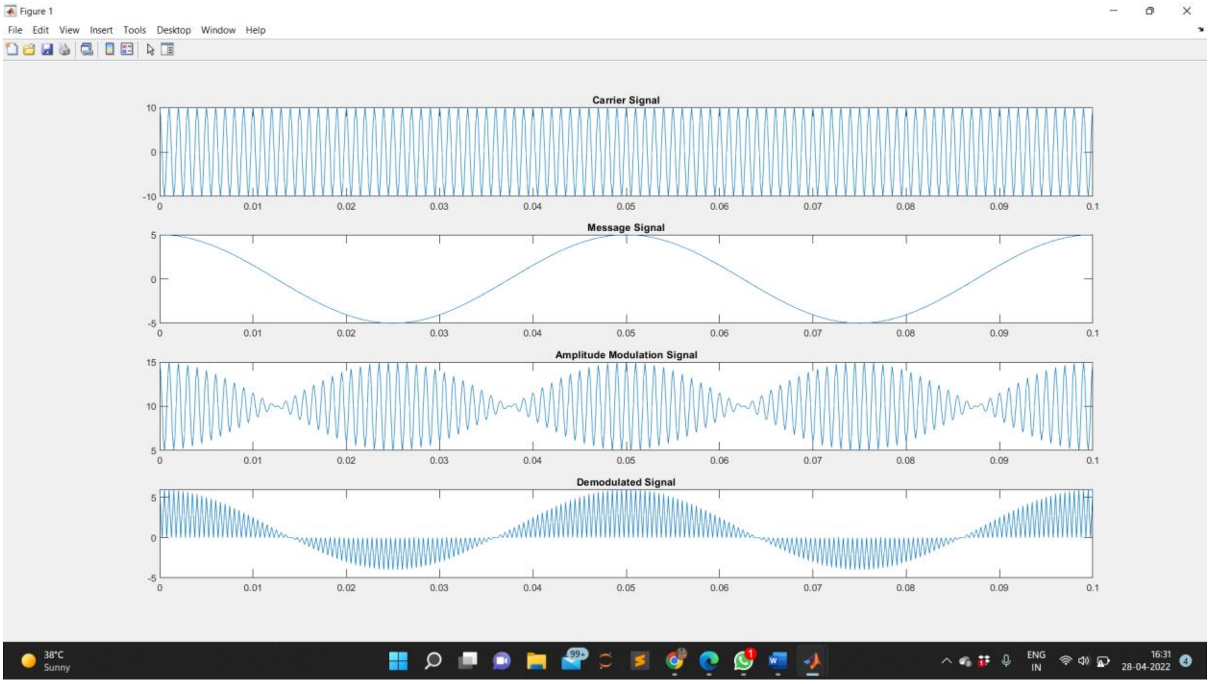


MATLAB CODE:

```
fc = 1000; %carrier frequency
fm = 20; %message signal frequency
fs = 8000; %sampling frequency
Am = 5; %Amplitude of message signal
Ac = 10; %Amplitude of carrier signal
T = 1/fs; %Time period
t = [0:T:0.1]; %Time range used in plotting signals
m = Am/Ac; %modulation index given as the ratio of
message signal amplitude with carrier signal amplitude
```

```
%Carrier Signal
Sc = Ac*cos(2*pi*fc*t);
subplot(4,1,1); %Representation of plot at 1st row , 1st
column out of 4 rows
plot(t,Sc); %Representing Carrier signal (Sc) wrt time at
1st row , 1st column
title('Carrier Signal')

%Message Signal
Sm = Am*cos(2*pi*fm*t);
subplot(4,1,2); %Representation of plot at 2nd row , 1st
column out of 4 rows
plot(t,Sm); %Representing message signal (Sm) wrt time at
2nd row , 1st column
title('Message Signal')

%amplitude modulation
%AM = ammod(Sm,fc,fs);
AM = Ac*(1+(m*cos(2*pi*fm*t).*cos(2*pi*fc*t)));
%AM = Ac*cos(2*pi*fc*t)+(Ac*m*Sm.*cos(2*pi*fc*t));
subplot(4,1,3); %Representation of plot at 3rd row , 1st
column out of 4 rows
plot(t,AM); %Representing Amplitude Modulation signal
(AM) wrt time at 3rd row , 1st column
title('Amplitude Modulation Signal')

%amplitude demodulation
DAM = (1+Sm).*cos(2*pi*fc*t).*cos(2*pi*fc*t);
subplot(4,1,4); %Representation of plot at 4th row , 1st
column out of 4 rows
plot(t,DAM); %Representing Amplitude Demodulation signal
(DAM) wrt time at 4th row , 1st column
title('Demodulated Signal')
```

WAVEFORM OBTAINED:



RESULT:

The output waveforms of Amplitude modulation and de-modulation are observed and plotted.

APPLICATIONS:

AM was the earliest modulation method used to transmit voice by radio. It remains in use today in many forms of communication; for example it is used in portable two way radios, VHF aircraft radio, Citizen's Band Radio and in computer modems. "AM" is often used to refer to medium wave AM radio broadcasting.

EXPERIMENT - 2

AIM:

Generation & detection of Frequency modulation using MATLAB

THEORY:

Modulation is defined as process in which changing the characteristics usually amplitude, frequency and phase of high frequency wave (Carrier wave) by using instantaneous values of the low frequency signal (modulating signal).

FM Modulation is a non-linear modulation technique. In FM the frequency of carrier is varied in accordance with amplitude of modulating signal (AF signal). But amplitude is maintained constant. Since the variation in phase angular term it is comes under angle modulation scheme, the most important feature of FM modulation is that it can be provide better discrimination against noise and interference than AM. The disadvantage of FM is it requires more transmission bandwidth than AM and we transmit the FM signals to longer distances.

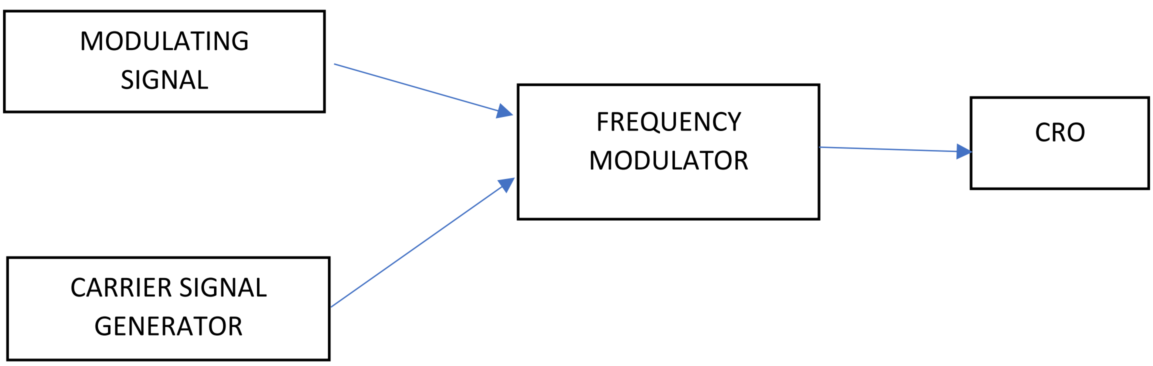
The quantity Kf represents frequency sensitivity of modulator. Hence Kf * Am represents the total deviation f. The ratio of max frequency deviation to modulating frequency defines as modulation index, which is given by

Modulation index = (Max frequency deviation / Modulating frequency)

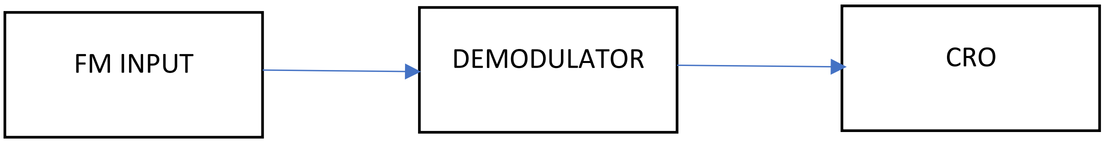
If Modulation index is less than one then the modulated wave is called Narrow Band FM signal. If Modulation index is greater than one then the modulated wave is called Wide Band FM signal.

BLOCK DIAGRAM:

MODULATOR



DEMODULATOR

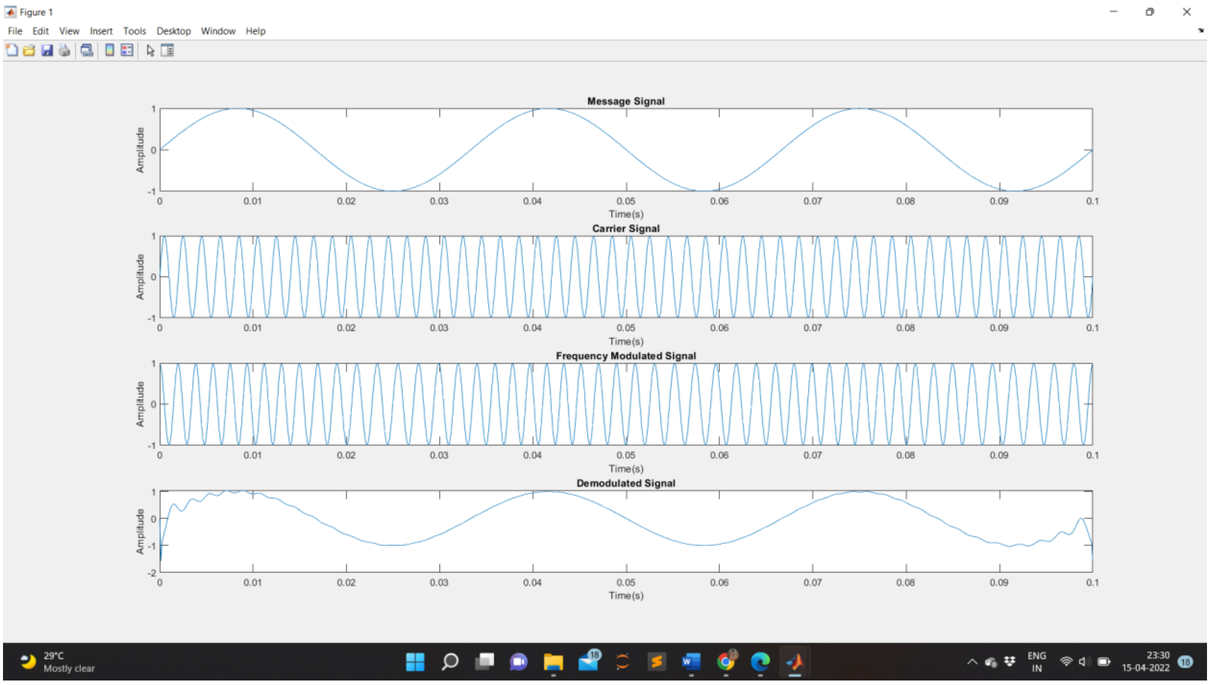


MATLAB CODE:

```
fc = 500; %carrier frequency
fm = 30; %message signal frequency
fs = 8000; %sampling frequency
Am = 1;
Ac = 1;
t = [0:1/fs:0.1]'; %time range for plotting signals
x = sin(2*pi*fm*t); %Modulating signal assuming frequency
as 10 since message frequency is not given
fDev = 50; %frequency deviation
y = fmmod(x,fc,fs,fDev); %frequency modulation function
z = fmdemod(y,fc,fs,fDev); %frequency demodulation
function
subplot(4,1,1); %Representation of plot at 1st row , 1st
column out of 4 rows
plot(t,x); %Representing Modulating signal (x) wrt time
at 1st row , 1st column
xlabel('Time(s)');
ylabel('Amplitude');
title('Message Signal')
subplot(4,1,2); %Representation of plot at 2nd row , 1st
column out of 4 rows
plot(t,sin(2*pi*fc*t)); %Representing Carrier signal wrt
time at 2nd row , 1st column
xlabel('Time(s)');
ylabel('Amplitude');
title('Carrier Signal');
subplot(4,1,3); %Representation of plot at 3rd row , 1st
column out of 4 rows
plot(t,y); %Representing Frequency Modulation (y) wrt
time at 3rd row , 1st column
xlabel('Time(s)');
ylabel('Amplitude');
title('Frequency Modulated Signal');
subplot(4,1,4); %Representation of plot at 4th row , 1st
column out of 4 rows
```

```
plot(t,z); %Representing Frequency Demodulation (z) wrt
time at 4th row , 1st column
xlabel('Time(s)');
ylabel('Amplitude');
title('Demodulated Signal')
```

WAVEFORM OBTAINED:



RESULT:

The output waveforms of Frequency modulation and de-modulation are observed and plotted.

APPLICATIONS:

Frequency modulation is widely used for FM radio broadcasting. It is also used in telemetry, radar, seismic prospecting, and monitoring newborns for seizures 31 via EEG, two-way radio systems, music synthesis, magnetic tape-recording systems and some video-transmission systems.

EXPERIMENT - 3

AIM:

Generation of SSBSC signal using MATLAB

THEORY:

AM & DSB-SC both modulation techniques require bandwidth twice of the modulating signal bandwidth. Since two side bands having the same information. It is possible to recover the base band signal from any one of the side band, so only one side band is enough to give information without any loss of course the carrier is suppressed. Such transmission system is called single side band transmission system. SSB requires transmission bandwidth is equal to modulating signal bandwidth.

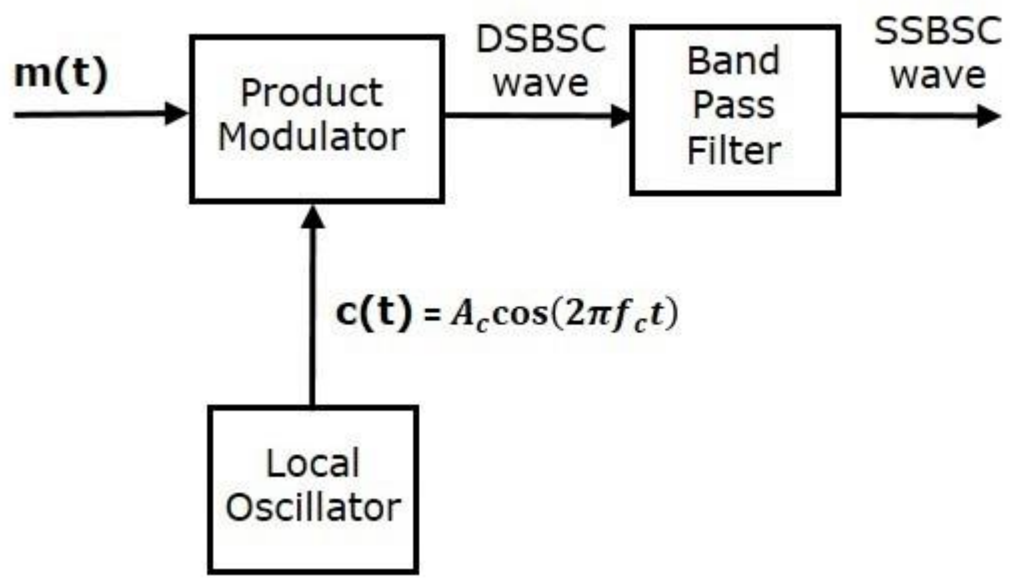
We can generate SSBSC wave using the following two methods.

- Frequency discrimination method
- Phase discrimination method

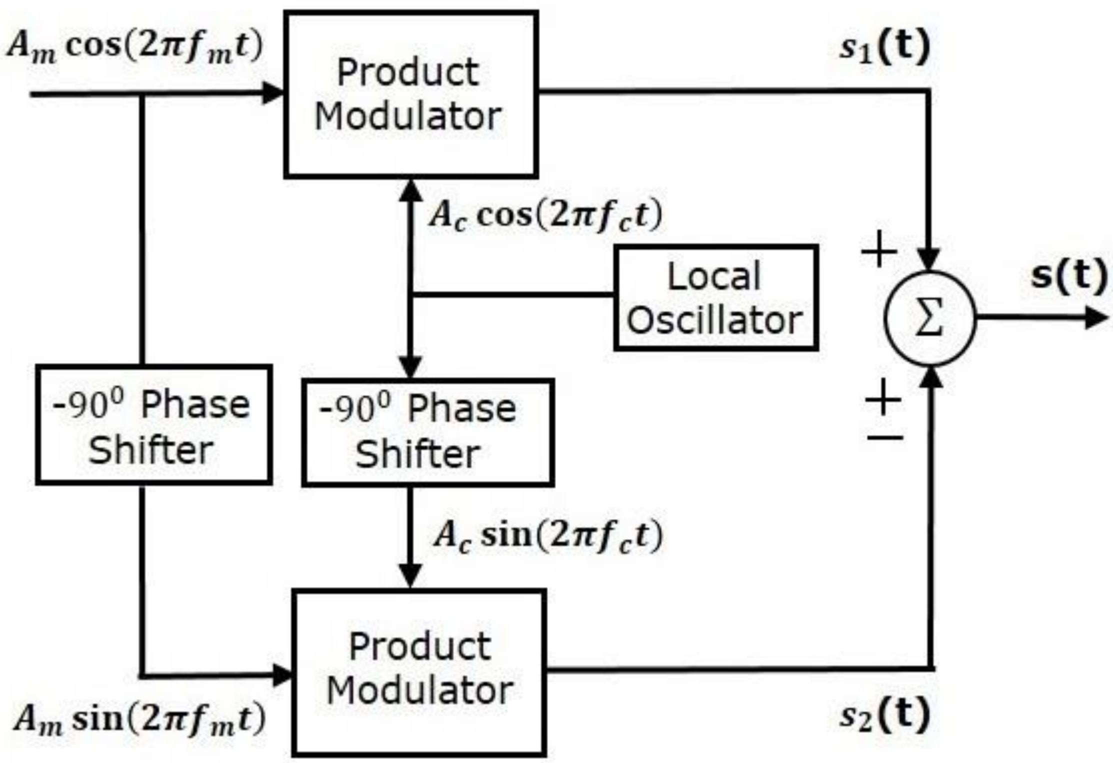
The reduced bandwidth also improves the SNR ratio and allows more no of channels in a given frequency. These advantage of SSB results in wide spread of SSB for aircrafts, transonic radio telephones, and mature radio communication systems.

BLOCK DIAGRAM:

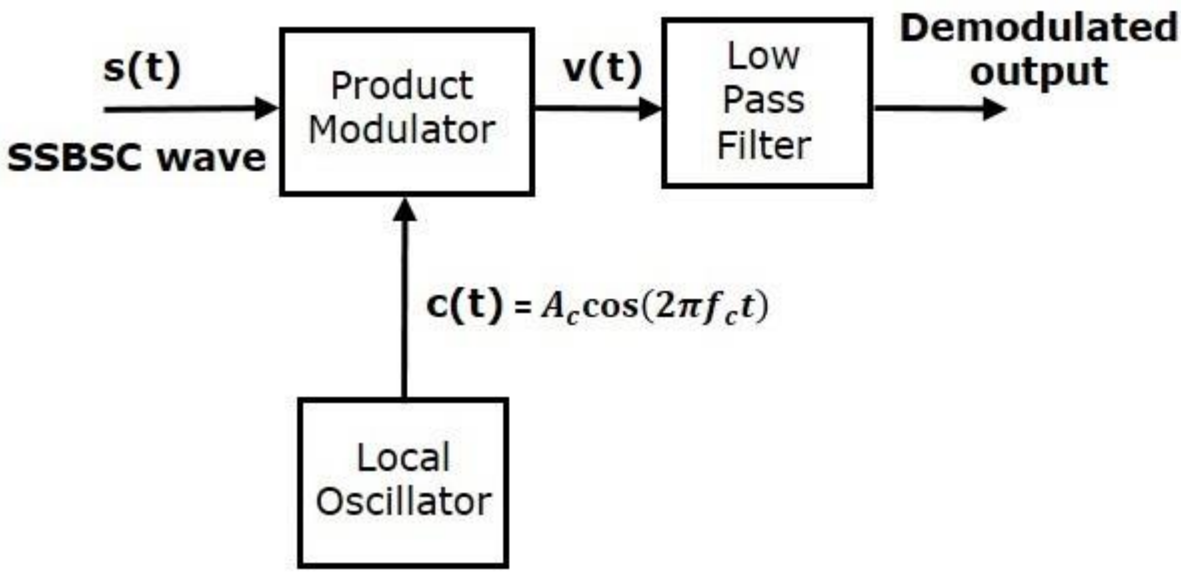
FREQUENCY DISCRIMINATION METHOD



PHASE DISCRIMINATION METHOD



DEMODULATION

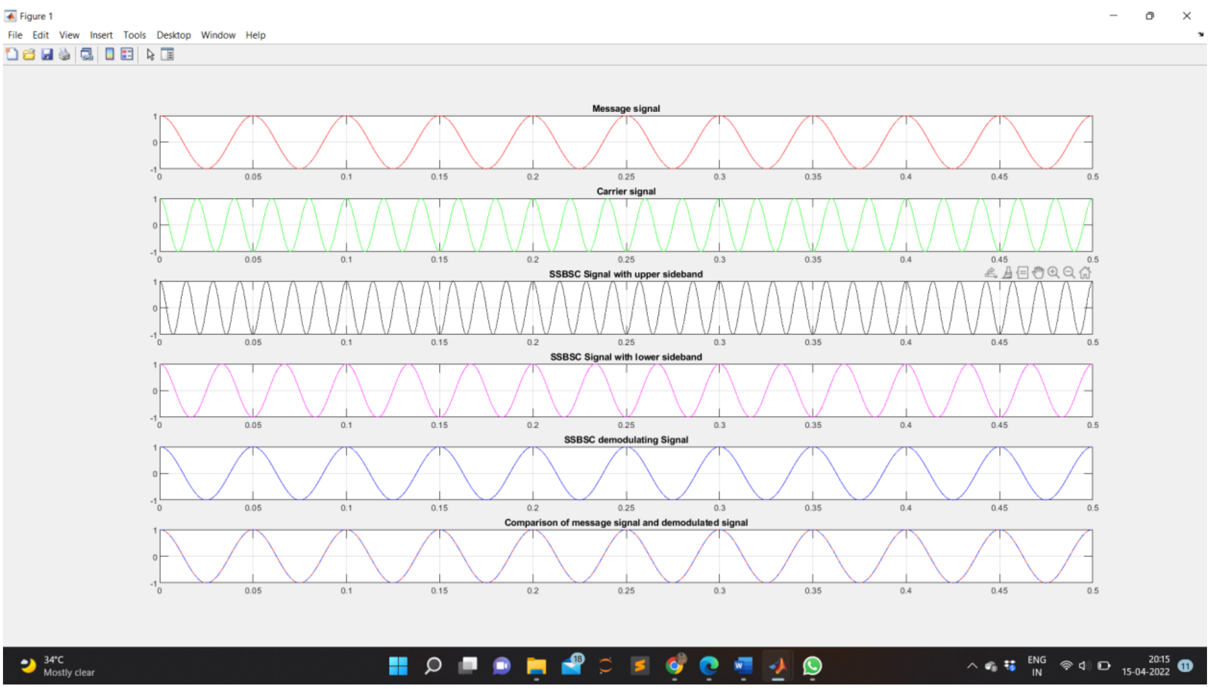


MATLAB CODE:

```
fc = 50; %carrier frequency
fm = 20; %message signal frequency
fs = 8000; %sampling frequency
Am = 1; %Amplitude of message signal
Ac = 1; %Amplitude of carrier signal
T = 1/fs; %Time period
t = [0:T/999:0.5]; %Time range used in plotting signals
m = Am/Ac; %modulation index given as the ratio of
message signal amplitude with carrier signal amplitude

%Message Signal
Sm = Am*cos(2*pi*fm*t);
subplot(6,1,1)
plot(t, Sm, 'r');
grid();
title('Message signal');

%Carrier Signal
Sc = Ac*cos(2*pi*fc*t);
subplot(6,1,2)
plot(t, Sc, 'g');
grid();
title('Carrier signal');

%SSBSC Signal with upper sideband
```

```
ssb_us = ((Am*Ac).*cos(2*pi*(fc+fm).*t));
subplot(6,1,3)
plot(t, ssb_us, 'k');
grid();
title('SSBSC Signal with upper sideband');

%SSBSC Signal with lower sideband
ssb_ls = ((Am*Ac).*cos(2*pi*(fc-fm).*t));
subplot(6,1,4)
plot(t, ssb_ls, 'm');
grid();
title('SSBSC Signal with lower sideband');

%SSBSC demodulating Signal
ssb_dm = (Am*Ac*Ac).*(cos(2*pi*fm*t)); %Demodulating
signal for both (upper sideband as well as lower
sideband) is same
subplot(6,1,5)
plot(t, ssb_dm, 'b');
grid();
title('SSBSC demodulating Signal');

%Comparison of original and demodulated signal
subplot(6,1,6)
plot(t,Sm,'r',t,ssb_dm,'b--');
grid();
title('Comparison of message signal and demodulated
signal');
```

WAVEFORM OBTAINED:



RESULT:

The output waveforms of SSB modulation and de-modulation are observed and plotted.

APPLICATIONS:

In radio communications, single-sideband modulation (SSB) or singlesideband suppressed-carrier modulation (SSB-SC) is a refinement of amplitude modulation which uses transmitter power and bandwidth more efficiently.

EXPERIMENT - 4

AIM:

Generation of DSBSC signal using MATLAB

THEORY:

The transmission of a signal, which contains a carrier along with two sidebands can be termed as Double Sideband Full Carrier system or simply DSBFC. If this carrier is suppressed and the saved power is distributed to the two sidebands, then such a process is called as Double Sideband Suppressed Carrier system or simply DSBSC.

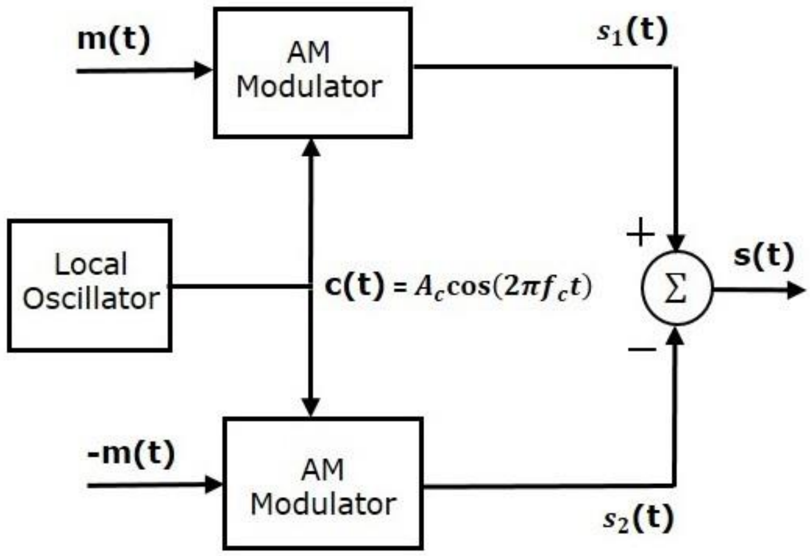
Balance modulator is used for generation of double side band suppress carrier signal. The output of balanced modulator is equal to the product of applied input signals. In order to generate this it uses the nonlinear characteristics of semi conductor device. Since the carrier does not convey any information, transmitting the carrier along with side band is only wasting of transmission power; therefore carrier is suppressed before transmission. By doing suppression 67% of transmission power can be saved. The method of transmission of modulated wave without carrier is DSBSC signal. Balance modulator is also used in generation of SSB signals. The modulated signal undergoes a phase reversal whenever the base band signal crosses zero. Unlike AM, The envelope of DSBSC id different from base band signal. The ring modulator is another circuit for generating the DSBSC signal.

The following two modulators generate DSBSC wave.

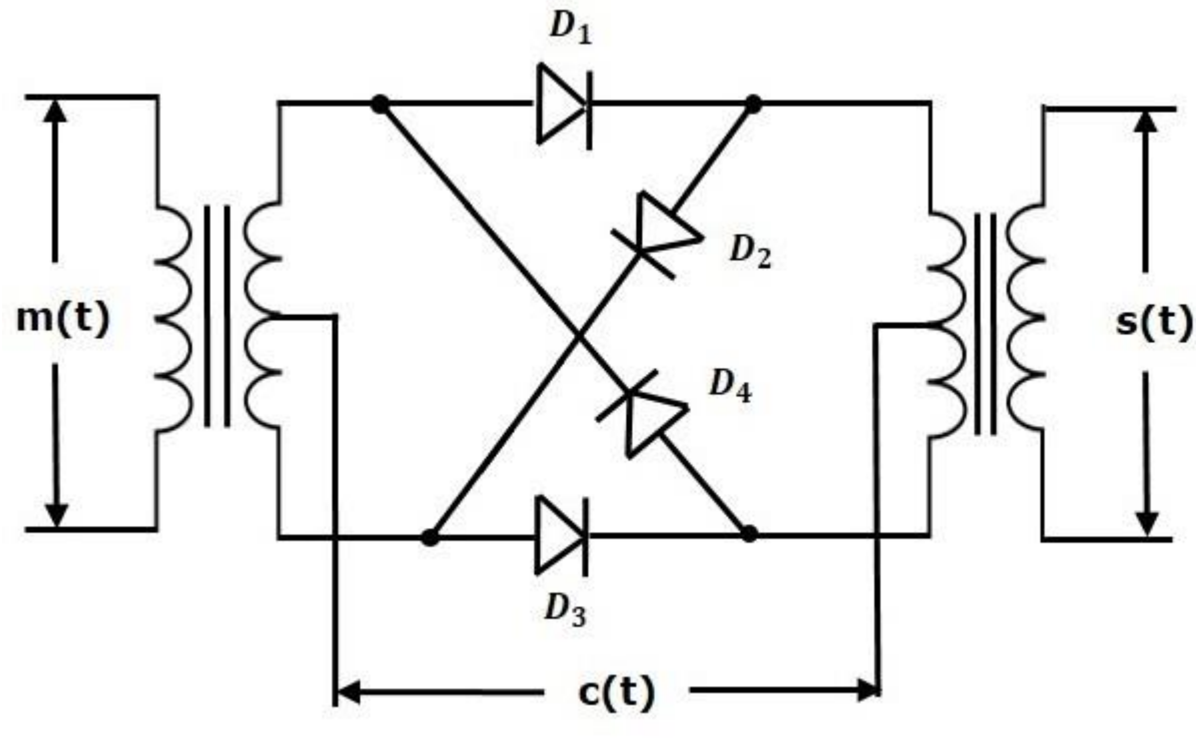
- Balanced modulator
- Ring modulator

BLOCK DIAGRAM:

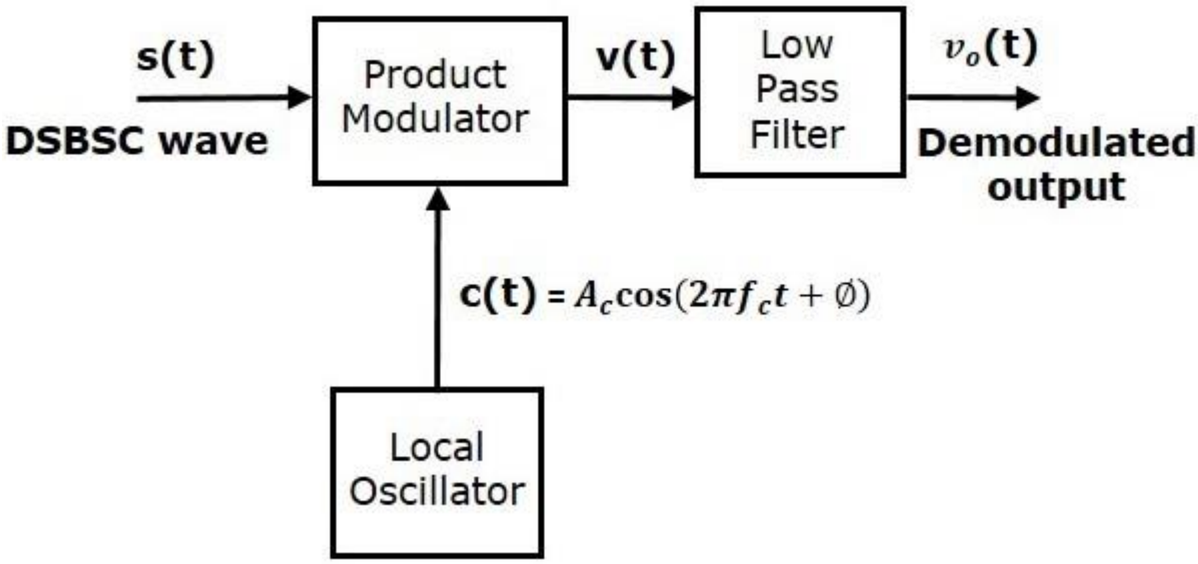
BALANCED MODULATOR



RING MODULATOR



DEMODULATION

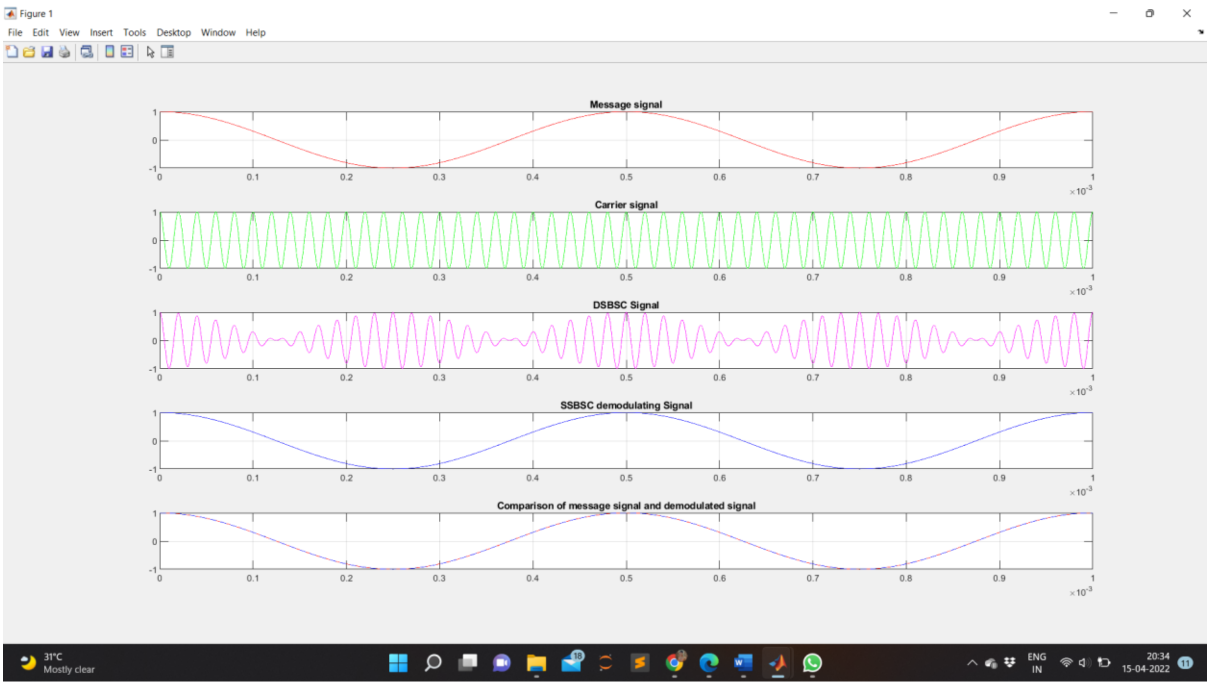


MATLAB CODE:

```
fc =50000; %carrier frequency
fm = 2000; %message signal frequency
fs = 800000; %sampling frequency
Am = 1; %Amplitude of message signal
Ac = 1; %Amplitude of carrier signal
T = 1/fs; %Time period
t = [0:T/999:0.001]; %Time range used in plotting signals
m = Am/Ac; %modulation index given as the ratio of
message signal amplitude with carrier signal amplitude

%Message Signal
Sm = Am*cos(2*pi*fm*t);
subplot(5,1,1)
plot(t, Sm, 'r');
grid();
title('Message signal');

%Carrier Signal
Sc = Ac*cos(2*pi*fc*t);
subplot(5,1,2)
plot(t, Sc, 'g');
grid();
title('Carrier signal');

%DSBSC Signal
dssb = ((Am*Ac).*(cos(2*pi*fc.*t)).*(cos(2*pi*fm*t)));
```

```
subplot(5,1,3)
plot(t, dssb, 'm');
grid();
title('DSBSC Signal');

%DSBSC demodulating Signal
dssb_dm = ((Am*Ac*Ac)).*(cos(2*pi*fm*t));
subplot(5,1,4)
plot(t, dssb_dm, 'b');
grid();
title('SSBSC demodulating Signal');

%Comparison of original and demodulated signal
subplot(5,1,5)
plot(t,Sm,'r',t,dssb_dm,'b--');
grid();
title('Comparison of message signal and demodulated
signal');
```

<u>WAVEFORM OBTAINED:</u>



RESULT:

The output waveforms of DSBSC modulation and de-modulation are observed and plotted.

APPLICATIONS:

DSB-SC transmission is a special case of double-sideband reduced carrier transmission. It is used for radio data systems.

EXPERIMENT - 5

AIM:

Generation and detection of Pulse Amplitude Modulation using MATLAB

THEORY:

Pulse modulation is used to transmit analog information. In this system continuous wave forms are sampled at regular intervals. Information regarding the signal is transmitted only at the sampling times together with syncing signals.

At the receiving end, the original waveforms may be reconstituted from the information regarding the samples.

The pulse amplitude modulation is the simplest form of the pulse modulation. PAM is a pulse modulation system is which the signal is sampled at regular intervals, and each sample is made proportional to the amplitude of the signal at the instant of sampling. The pulses are then sent by either wire or cables are used to modulated carrier.

The two types of PAM are i) Double polarity PAM, and ii) the single polarity PAM, in which a fixed dc level is added to the signal to ensure that the pulses are always positive. Instantaneous PAM sampling occurs if the pulses used in the modulator are infinitely short.

Natural PAM sampling occurs when finite-width pulses are used in the modulator, but the tops of the pulses are forced to follow the modulating waveform.

Flat-topped sampling is a system quite often used because of the ease of generating the modulated wave.

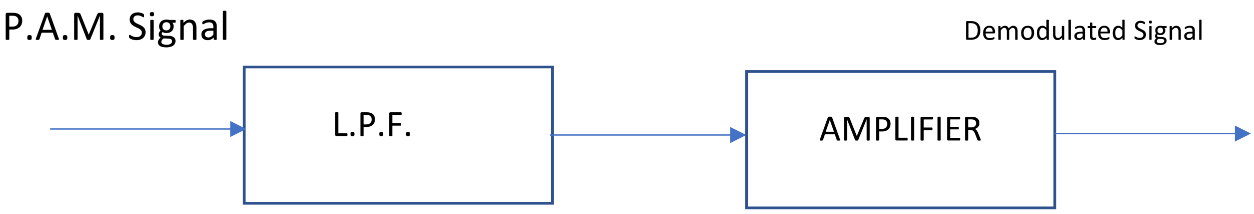
PAM signals are very rarely used for transmission purposes directly. The reason for this lies in the fact that the modulating information is contained in the amplitude factor of the pulses, which can be easily distorted during transmission by noise, crosstalk, other forms of distortion. They are used frequently as an intermediate step in other pulsemodulating methods, especially where timedivision multiplexing is used.

The demodulation of the PAM is quite a simple process. PAM is fed to the integrating Rx circuit (LPF), from which the demodulating signal emerges whose amplitude at any instant is proportional to the PAM at that instant. This signal is given to an inverting amplifier to amplify Its level so that demodulated output is having almost equal amplitude with the modulating signal, but it is having same phase difference.

BLOCK DIAGRAM:

MODULATOR

DEMODULATOR

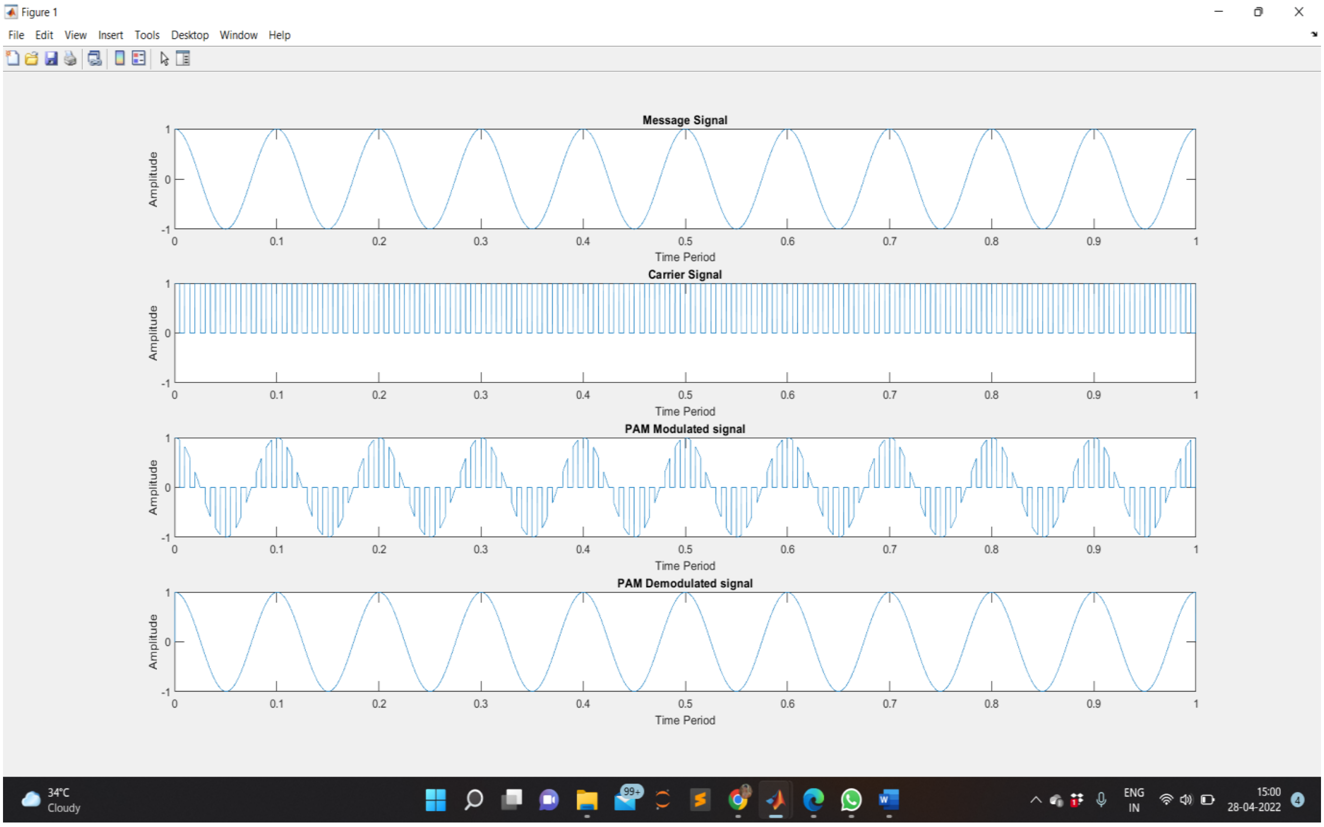


MATLAB CODE:

```
fc= 100; %carrier frequency
fm= fc/10; %message signal frequency
fs= 100*fc; %sampling frequency
```

```
t=0:1/fs:1; %Time range used in plotting signals

%Message Signal
Sm = cos(2*pi*fm*t);
subplot(4,1,1);
plot(t,Sm);
title('Message Signal');
xlabel('Time Period');
ylabel('Amplitude');

%Carrier Signal
Sc= 0.5*square(2*pi*fc*t)+0.5;
subplot(4,1,2);
plot(t,Sc);
title('Carrier Signal')
xlabel('Time Period');
ylabel('Amplitude');
ylim([-1 1]);

%Pulse Amplitude Modulation Signal
PAM = Sm.*Sc;
subplot(4,1,3);
plot(t,PAM);
title('PAM Modulated signal')
xlabel('Time Period');
ylabel('Amplitude');

%Demodulation
filter = fir1(100,fm/fs,'high');
DPAM = conv(filter,Sm);
t1 = 0:1/(length(DPAM)-1):1;
subplot(4,1,4);
plot(t1,DPAM);
title('PAM Demodulated signal')
xlabel('Time Period');
ylabel('Amplitude');
```

WAVEFORM OBTAINED:



RESULT:

The pulse amplitude modulation and demodulation is studied, verified and the output waveforms are plotted.

APPLICATIONS:

Some versions of the Ethernet communication standard are an example of PAM usage. The concept is also used for the study of photosynthesis using a specialized instrument that involves a spectrofluorometric measurement of the kinetics of fluorescence rise and decay in the light-harvesting antenna of thylakoid membranes, thus querying various aspects of the state of the photosystems under different environmental conditions.

EXPERIMENT - 6

AIM:

Study the Pulse Width Modulation (PWM) and Demodulation Techniques

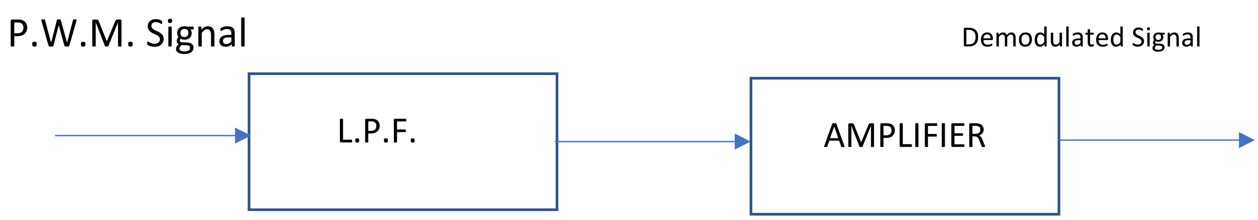
THEORY:

PWM is also called as pulse duration modulation or pulse length modulation. In PWM, the width of the pulse is varied in proportional to the amplitude of the analog input signal. Three types of PWM signals are available. Leading edge, trail edge and central edge. In leading edge PWM, the leading edge is fixed and trail edge is modulated where as in trailing edge PWM, the trailing edge is fixed and leading edge is modulated. In PWM with centered, the middle of the pulse is fixed and both edges are modulated according to the amplitude of modulating signal. PWM has disadvantage that it is varying the pulse with width and therefore varying power is not constant. So the transmitter and receiver must be able to handle maximum pulse width, but PWM works even though synchronization is not exist between the Tx and Rx pulse trails, where PPM does not. Applying trigger pulses at sampling rate to control the starting time of the pulse can generate PWM and end of the pulse depends on the amplitude of the modulating signals. The pulse width will be maximum at positive peak and minimum width at negative peak.

BLOCK DIAGRAM:

MODULATOR

DEMODULATOR

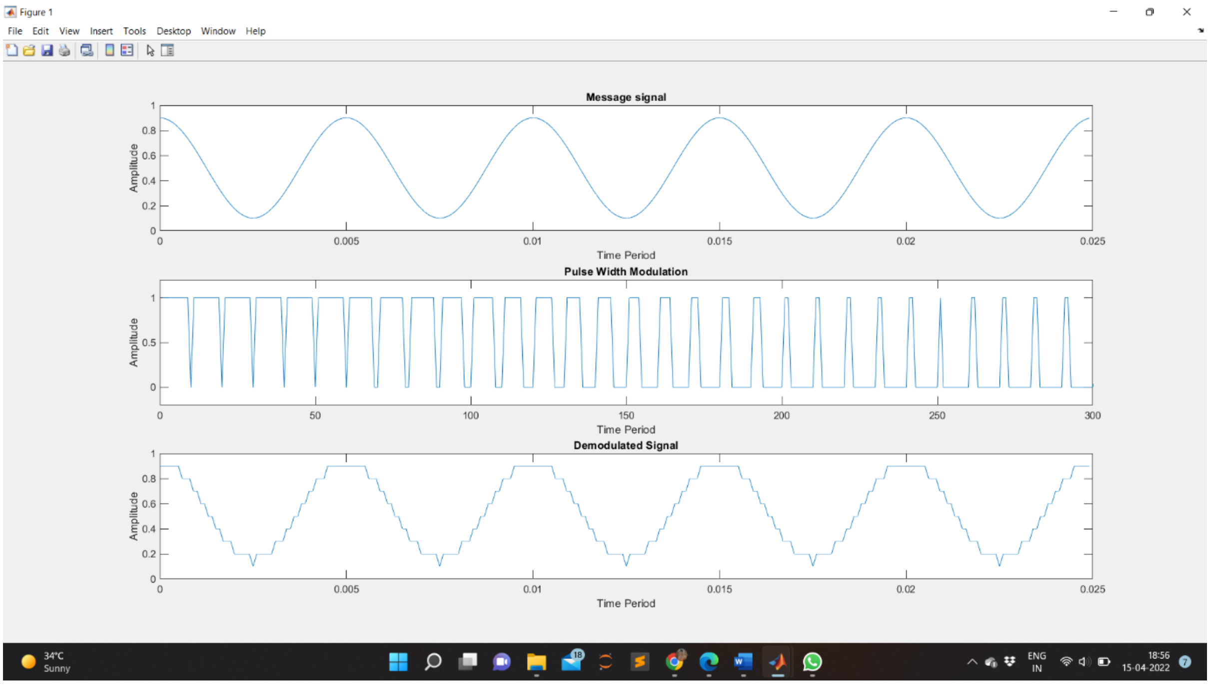


MATLAB CODE:

```
fc=1000; %carrier frequency
fs=10000; %sampling frequency
f1=200;
t=0:1/fs:((5/f1)-(1/fs)); %Time range used in plotting
signals

%Message Signal
Sm =0.4*cos(2*pi*f1*t)+0.5;
subplot(3,1,1);
plot(t,Sm);
title('Message signal');
xlabel('Time Period');
ylabel('Amplitude');

%modulation
PWM = modulate(Sm,fc,fs,'pwm');
subplot(3,1,2);
plot(PWM);
axis([0 300 -0.2 1.2]);
title('Pulse Width Modulation');
xlabel('Time Period');
ylabel('Amplitude');

%demodulation
DPWM = demod(PWM,fc,fs,'pwm');
subplot(3,1,3);
plot(t,DPWM);
title('Demodulated Signal');
xlabel('Time Period');
```

```
ylabel('Amplitude');
```

WAVEFORM OBTAINED:



RESULT:

The pulse width modulation and demodulation is studied, verified and the out put waveforms are plotted.

APPLICATIONS:

This modulation technique used to encode a message into a pulsing signal. Although this modulation technique can be used to encode information for transmission, its main use is to allow the control of the power supplied to electrical devices, especially to inertial loads such as motors. In addition, PWM is one of the two principal algorithms used in photovoltaic solar battery chargers,the other being maximum power point tracking.

EXPERIMENT - 7

AIM:

To study the frequency response of Pre-Emphasis and De-Emphasis Circuit

THEORY:

In FM the interference (The noise) increases linearly with frequency, and the noise power in the receiver output is concentrated at higher frequency.

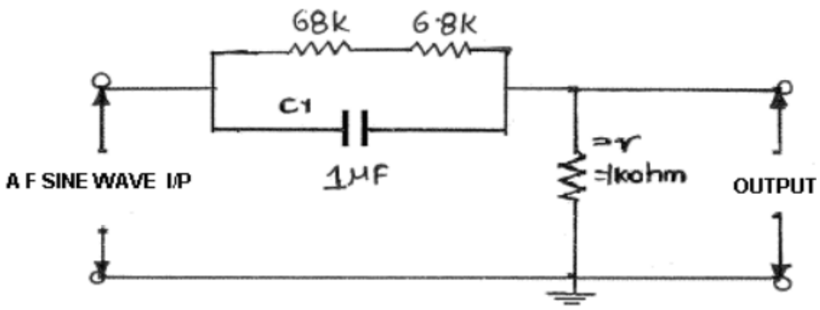
At the transmitter, weaker high frequency components of audio signal are boosted before modulation by pre-emphasis filter. At the receiver, the demodulator output passed through the De-emphasis filter, which undoes the pre-emphasis by attenuating the higher frequency components, where most of the noise is concentrated. The transfer functions of pre-emphasis and de-emphasis (PDE) are having exact opposite. Thus the process of pre-emphasis and d-emphasis leaves the desired signal untouched, but reduces the noise power considerably.

The PDE method of reduction is not limited just to FM broadcast; it is also used in audiotape recording and phonograph (analog) recording. We could also use PDE in AM broadcasting to improve the SNR, but in practice, this is not done for some reasons. That is output noise amplitude is constant with frequency, and does not vary as in FM. Hence de emphasis does yield such a dramatic improvement in AM as it does in FM.

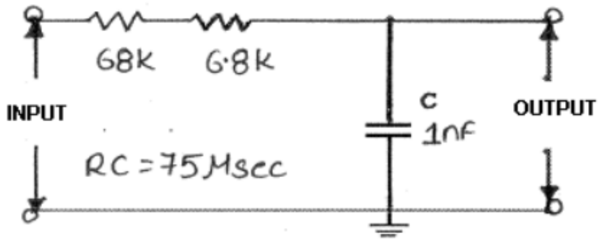
The noise triangle shows, noise has a greater effect on the higher modulating frequencies than on the lower ones. Thus, if the higher frequencies were artificially boosted at the transmitter and correspondingly cut at the receiver, an improvement in noise immunity could be expected, there by increasing the signal-to-noise ratio. This boosting of the higher modulating frequencies, in accordance with a prearranged curve, is termed pre-emphasis, and the compensation at the receiver is called de-emphasis.

CIRCUIT DIAGRAM:

PRE EMPHASIS CKT



DE EMPHASIS CIRCUIT



MATLAB CODE:

```
num_samples = 2^13; % no. of samples
fs=5000; % sampling frequency
Ts=1/fs; %Time range in terms of sampling frequency
fm1=20; %Message signal frequency 1
fm2=30; %Message signal frequency 2
fc=200; %carrier frequency
t=(0:num_samples-1)*Ts;
f=(-num_samples/2:num_samples/2-1)*fs/num_samples;

f_cutoff_pe=10;
Wn_pe=f_cutoff_pe/(fs/2);
[b_pe,a_pe]=butter(1,Wn_pe); %returns the transfer
function coefficients of an 1st order lowpass digital
Butterworth filter with normalized cutoff frequency Wn_pe

mt=sin(2*pi*fm1*t); %Modulating signal
figure(1);
subplot(211);
plot(t,mt);
axis([0 .6 min(mt)-1 max(mt)+1]);
grid on;title('Modulating Signal (Time Domain)');
```

```
Mf=fftshift(abs(fft(mt))); %rearranges a Fourier
transform by shifting the zero-frequency component to the
center of the array
subplot(212);
plot(f,Mf);
grid on;axis([-50 50 0 max(Mf)+100]);
title('Modulating Signal (Frequency Domain)');

[H_pe,W]=freqz(a_pe,b_pe); %Returns a_pe complex
frequency response for digital filter b_pe
figure(2);
subplot(211);
semilogx(W*pi*(fs/2),abs(H_pe),'m','linewidth',2) %Plots
x and y coordinates using log scale on the values
mentioned
xlabel('frequency');
ylabel('H_pe');
axis([0 fs/2 0 50]);
grid on;
xlabel('frequency');
ylabel('Amplitude');
title('Pre-emphasisFilter Magnitude Response');

[H_de,W]=freqz(b_pe,a_pe); %Returns a_pe complex
frequency response for digital filter b_pe
subplot(212);
semilogx(W*pi*(fs/2),abs(H_de),'m','linewidth',2); %Plots
x and y coordinates using log scale on the values
mentioned
axis([0 fs/2 0 1]);
grid on;
xlabel('frequency');
ylabel('Amplitude');
title('De-emphasis Filter Magnitude Response');
```

WAVEFORM OBTAINED:

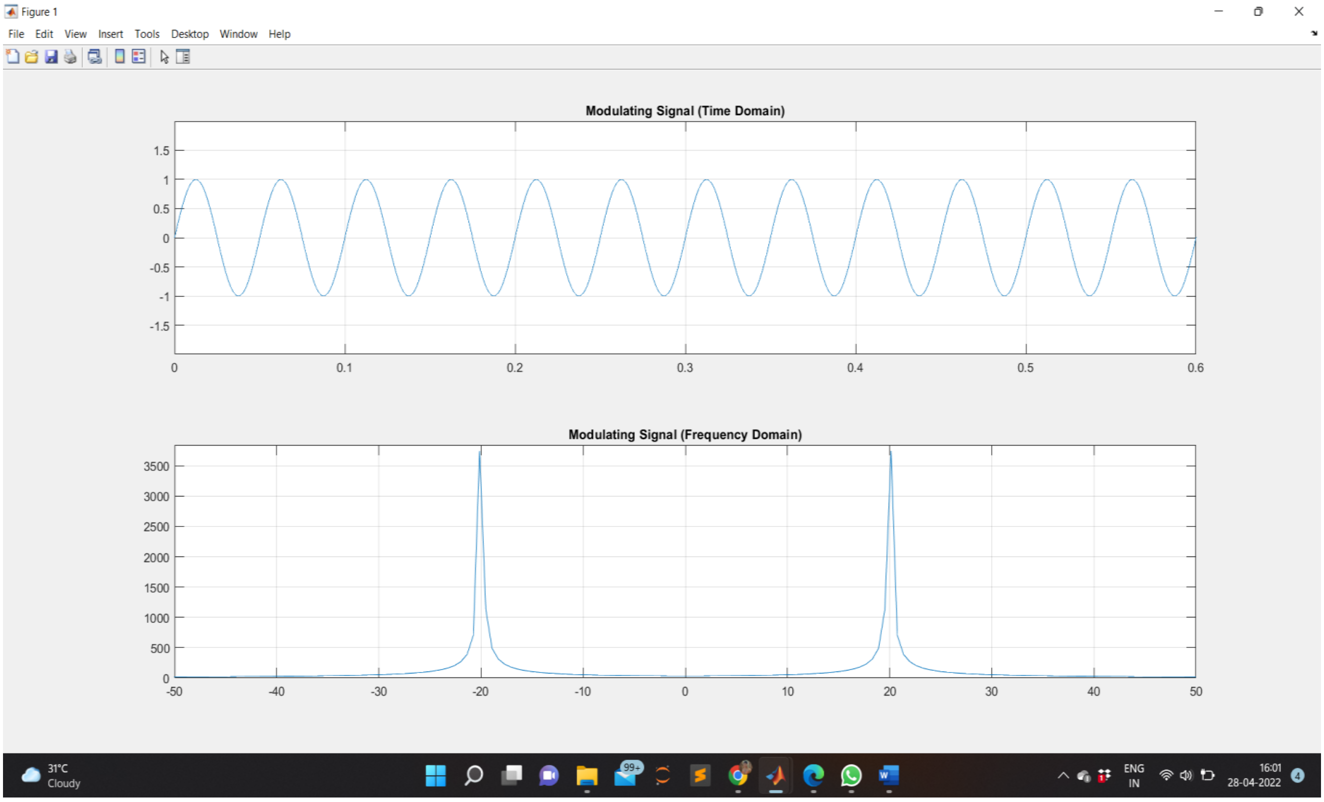
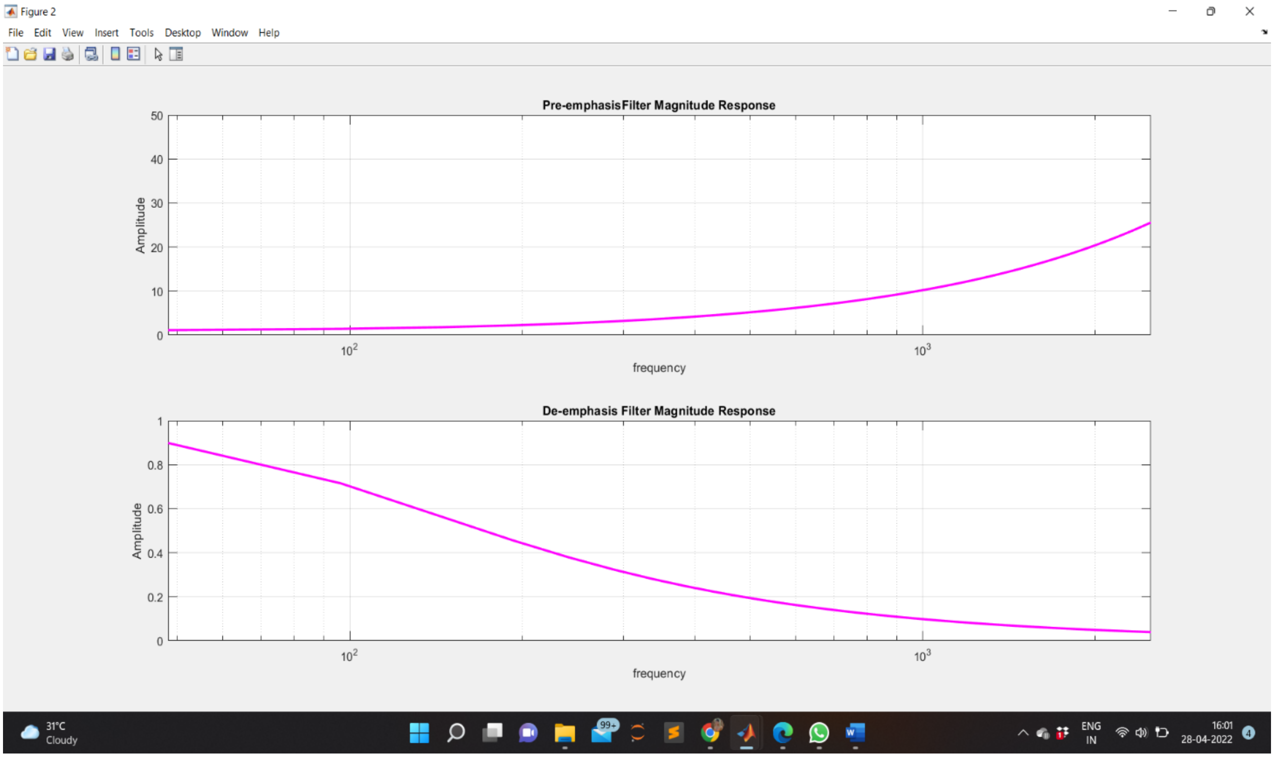


Figure 1
File Edit View Insert Tools Desktop Window Help
Modulating Signal (Time Domain)
Modulating Signal (Frequency Domain)
31°C
Cloudy
ENG
IN
16:01
28-04-2022



RESULT:

The frequency response of pre-emphasis and de-emphasis is studied, verified and the output waveforms are plotted.

APPLICATIONS:

Emphasis is commonly used in LP records and FM broadcasting. Pre-emphasis is employed in frequency modulation or phase modulation transmitters to equalize the modulating signal drive power in terms of deviation ratio. The receiver demodulation process includes a reciprocal network, called a de-emphasis network to restore the original signal power distribution.

EXPERIMENT - 8

AIM:

To study Analog Multiplexing and Demultiplexing Techniques- Frequency Division Multiplexing and Demultiplexing

THEORY:

When several communications channels are between the two same point‟s significant economics may be realized by sending all the messages on one transmission facility a process called multiplexing.

Applications of multiplexing range from the vital, if prosaic, telephone networks to the glamour of FM stereo and space probe telemetry system. There are two basic multiplexing techniques

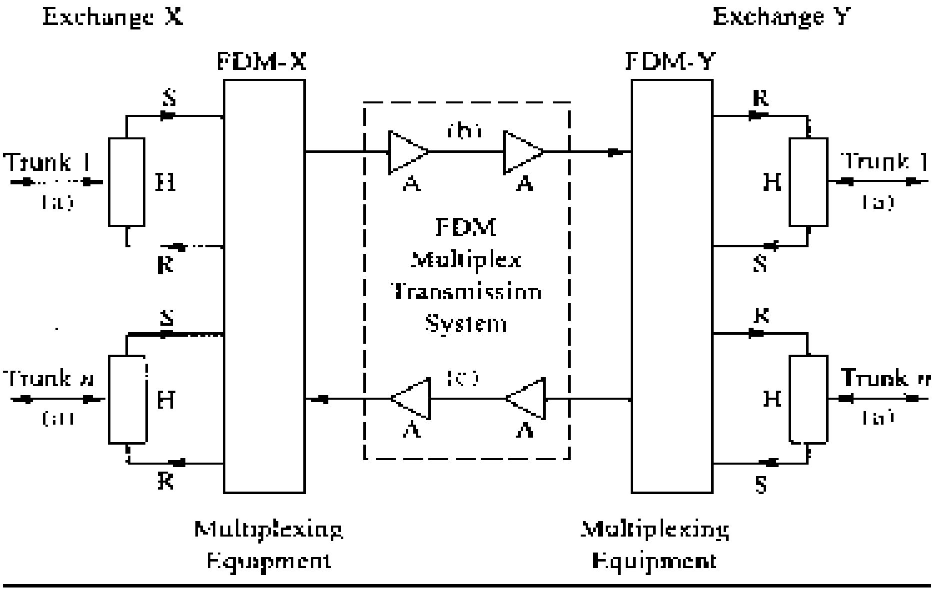
1. Frequency Division Multiplexing (FDM)

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 could be employed or a Mixture of them. The modulated signals are then summoned to produce the base band signal with the spectrumXb9f), 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‟s 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.

CIRCUIT DIAGRAM:



MATLAB CODE:

```
Fs = 100; % sampling freq
t = [0:2*Fs+1]'/Fs;

x1 = sin(2*pi*2*t); % signal 1 signal
figure;
subplot(4,1,1);
plot(x1);
title('signal 1');
xlabel('time');
ylabel('amplitude');

x2 = sin(2*pi*10*t); % signal 2 signal
subplot(4,1,2);
plot(x2);
title('signal 2');
xlabel('time');
ylabel('amplitude');

z1 = fft(x1); %Fourier transform of signal 1
z1=abs(z1); %Returns absolute value of fourier transform
of signal 1
subplot(4,1,3);
plot(z1);
title('Spectrum of signal 1');
xlabel('freqency');
ylabel('magnitude');
```

```
z2 = fft(x2); %Fourier transform of signal 2
z2=abs(z2); %Returns absolute value of fourier transform
of signal 2
subplot(4,1,4);
plot(z2);
title('Spectrum of signal 2');
xlabel('freqency')
ylabel('magnitude');

% freqency multiplexing
z=z1+z2;
figure;
plot(z);
title('frequency multiplexed signals');
figure;

% freqency demultiplexing
f1=[ones(10,1); %Returns a 10 by 1 array of ones
zeros(182,1);
ones(10,1)]; %applying filter for signal 1
dz1=z.*f1;
d1 = ifft(dz1); %Inverse transform of each column of ones
matrix
subplot(2,1,1)
plot(t*100,d1);
title('Demultiplexed signal 1');
xlabel('time');
ylabel('amplitude');

f2=[zeros(10,1); %Returns a 10 by 1 array of ones
ones(182,1);
zeros(10,1)];% applying filter for signal 2
dz2=z.*f2;
d2 = ifft(dz2); %Inverse transform of each column of ones
matrix
subplot(2,1,2)
plot(t*100,d2);
title('Demultiplexed signal 2');
xlabel('time');
ylabel('amplitude');
```

WAVEFORM OBTAINED:

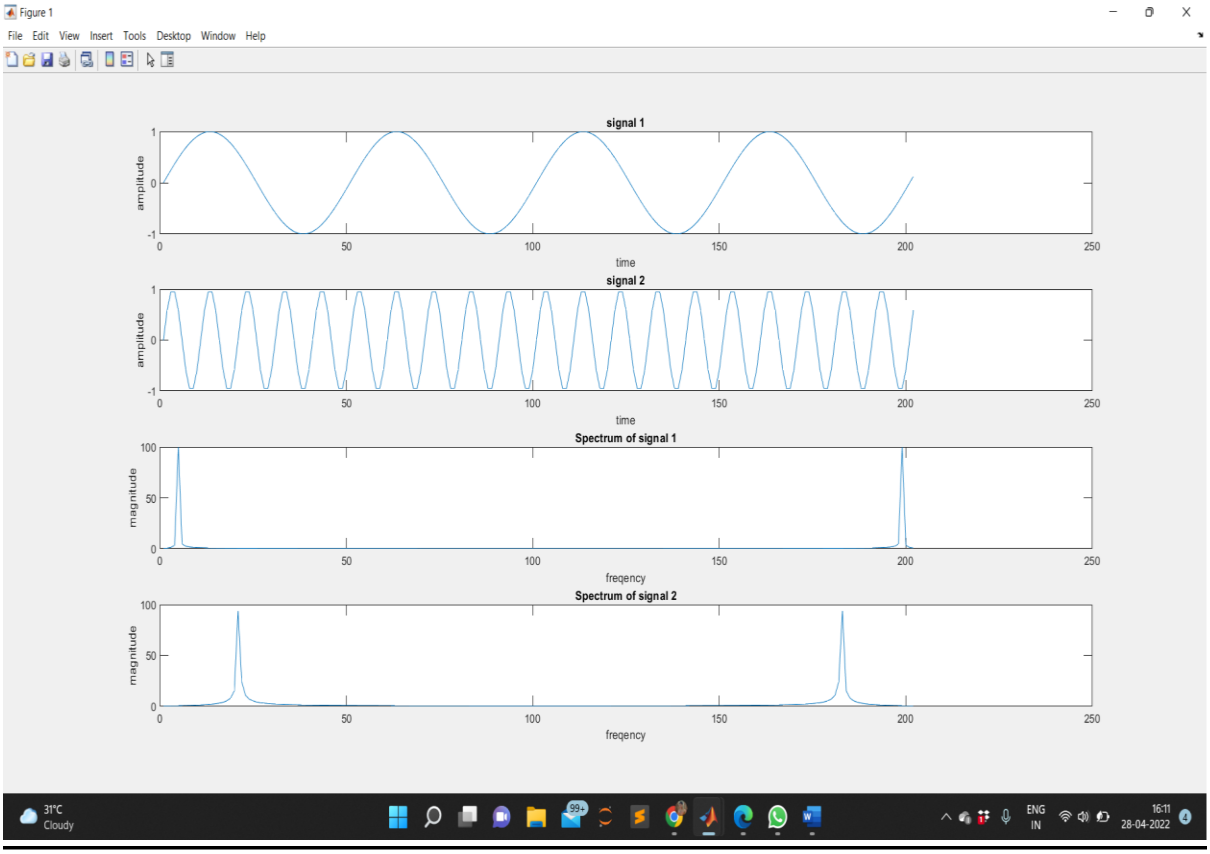


Figure 1
File Edit View Insert Tools Desktop Window Help
signal 1
amplitude
time
signal 2
amplitude
time
Spectrum of signal 1
magnitude
freqency
Spectrum of signal 2
magnitude
freqency
31°C
Cloudy
ENG
IN
16:11
28-04-2022

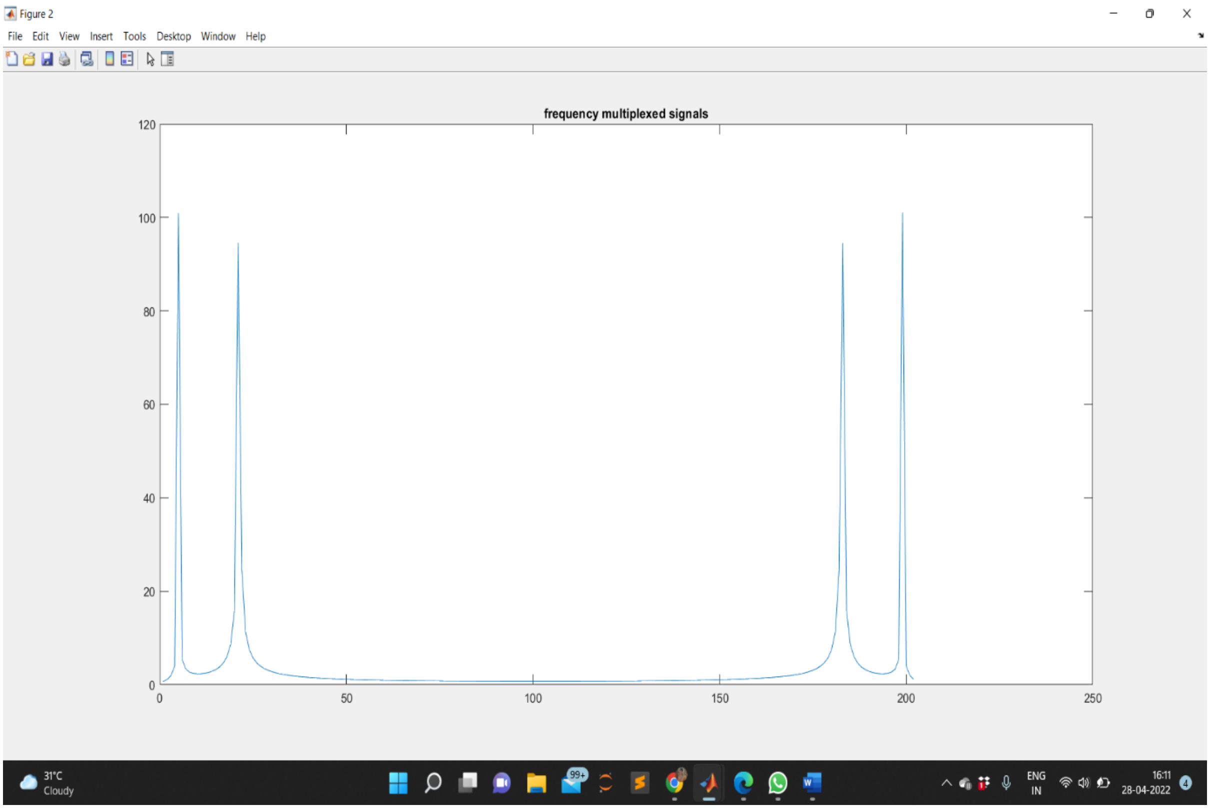
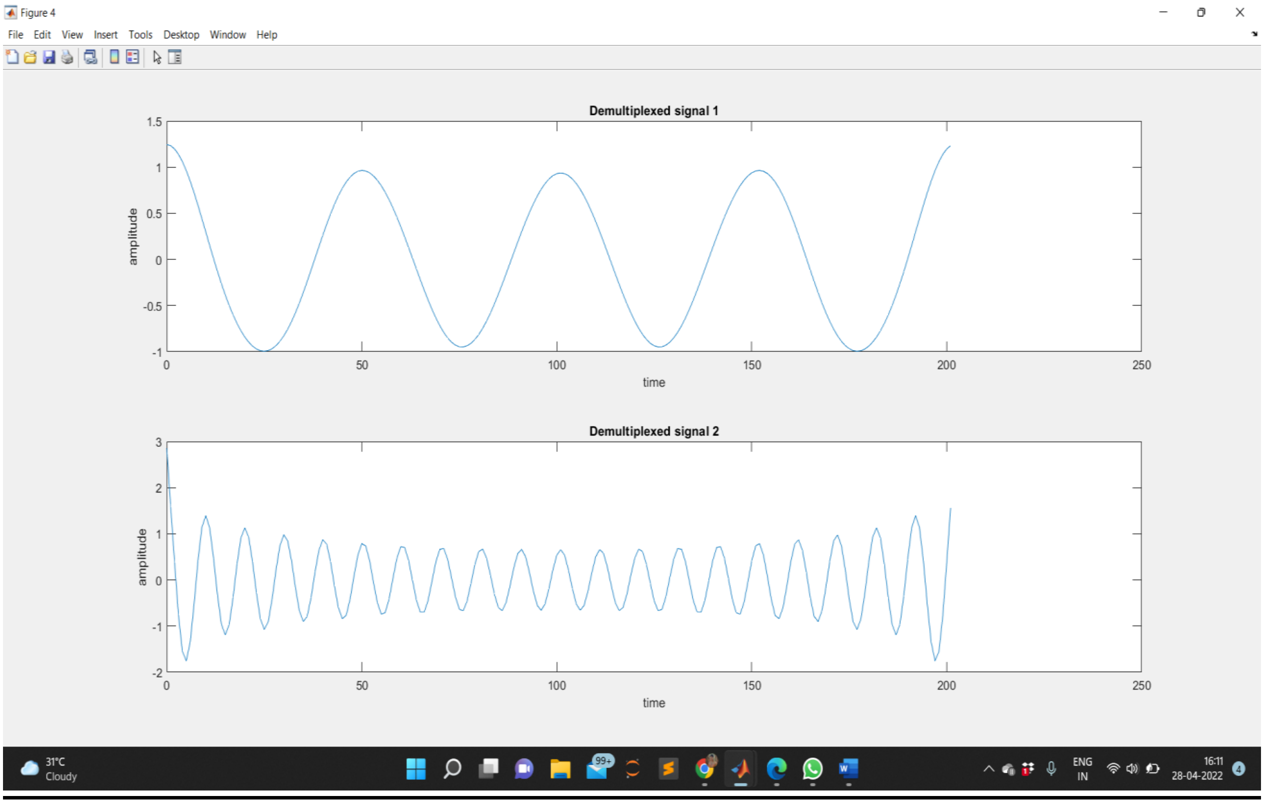


Figure 2
File Edit View Insert Tools Desktop Window Help
frequency multiplexed signals
31°C
Cloudy
ENG
IN
16:11
28-04-2022



RESULT:

The frequency division multiplexing and demultiplexing of analog multiplexing is studied, verified and the output waveforms are plotted.

APPLICATIONS:

1. FDM is used for FM & AM radio broadcasting. AM broadcasting uses a bandwidth of 550-1650 KHz, where as FM broadcasting used a bandwidth of 88-108 MHz

2. FDM is used in Television broadcasting.

3. First generation Cellular telephone also uses FDM.

4. Used in Stereo FM transmissions.

5. Twentieth century telephone companies used FDM for long-distance connections to multiplex thousands of voice signals through co-axial cable systems.

6. Telemetry a. Used to send feedback from multiple sensors over a single channel

7. Telephone Systems a. Had been used for decades to send multiple telephone conversations over a minimum number of cables b. The multiplexing process is used at multiple levels to send 10,800 phone calls over a single channel

8. Cable TV a. Multiple TV signals are multiplexed on a common coaxial cable