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COMMUNICATION THEORY LABORATORY MANUAL

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Experiment No: 1

Experiment Name: Generation of some message signals in MATLAB and finding their frequency spectra.

Theory : Frequency spectrum of any signal could be found by doing Fourier Transform of that signal. The Fourier transform decomposes a function of time (a signal) into the frequencies that make it up, in a way similar to how a musical chord can be expressed as the frequencies (or pitches) of its constituent notes. The Fourier transform of a function of time itself is a complex-valued function of frequency, whose absolute value represents the amount of that frequency present in the original function, and whose complex argument is the phase offset of the basic sinusoid in that frequency. The Fourier transform is called the frequency domain representation of the original signal. The term Fourier transform refers to both the frequency domain representation and the mathematical operation that associates the frequency domain representation to a function of time.

Part (i)

What we will do here: We will create a rectangular function rect($\frac{t}{0.04}$) and see its spectrum.

Matlab Files: A function file and Main file need to create and they must be created in **same folder**

Function file:

F
```
1   function y=rect(t,start,stop)
2 - y=(1).*(t>=start).*(t<stop);
3 - end
```

Code Explanation :

Main file is written below. When main file runs, it will call the function file if required.

F1 Create a function which name is "rect" where t, start, stop are the inputs arguments. (Here, t is the total time, start is the starting time of the rectangle and stop is the ending time of the rectangle) When we call this functions, we have to give this three things as input. Y is the output. It will be received by the main file.[inputs and output are arbitrary, made by the code writer. Here the input argument can be a single one, or many as the code writer needs]

F2 Function body defines how the output y is related with the inputs

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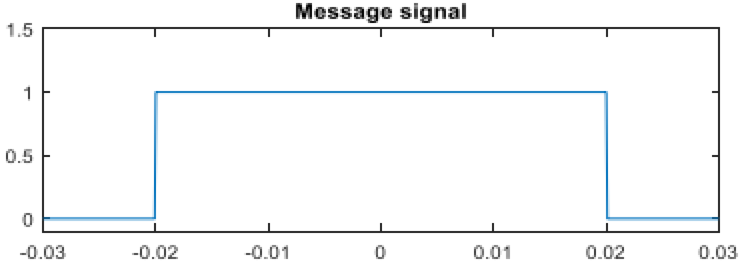
Main file :

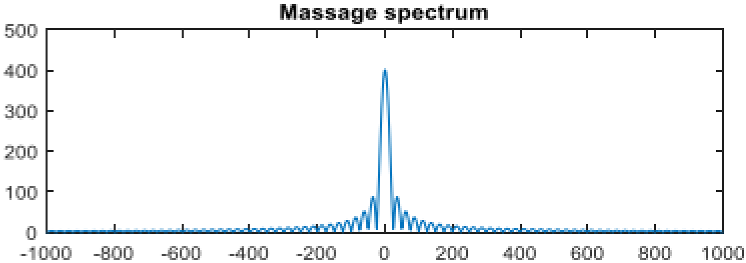
M

```
clc


ts=1.e-4;
t=-0.16:ts:0.16;

m_sig=rect(t,start,stop);
Lfft=length(t);
Lfft=2^ceil(log2(Lfft));
freqm=(-Lfft/2:Lfft/2-1)/(Lfft*ts);
M_fre=fftshift(fft(m_sig,Lfft));

figure(1)
Trange=[-.03 .03 -.1 1.5];
subplot(211);
td1=plot(t,m_sig);
axis(Trange)
title('Massage Signal');

Frange=[-1000 1000 0 500];
subplot(212);
td2=plot(freqm,abs(M_fre));
axis(Frange)
title('Massage Specrum');
```

Command Window Input:
start=-.02;stop=.02;

Output:





Code Explanation :

M1 "clc" clear all input and output from the Command Window display, gives us a "clean screen."

M2 "clear all" clears all objects in the MATLAB workspace and closes the MuPAD engine associated with the MATLAB workspace resetting all its assumptions.

M3 "closes all" open figures and removes the data that's held within them

M4 Indicates sampling time ts=0.0001

M5 A computer can't work with continuous data. It uses discreat data. So here we take some discreate point starts from -0.16 and with the increament of ts we take each data point upto 0.16

M7 this create a matrics having single row and its value depends on t matrics .F2 line denote a function where t is the independent variable and this function select the value of "m_sig" for every value of "t"

M8 length command means Length of vector. length(X) returns the length of vector X. So it determine the length of t and store the data to Lfft.

M9 " ceil" Round towards plus infinity. ceil(X) rounds the elements of X to the nearest integers
towards infinity. log2 Base 2 logarithm and dissect floating point number. By this line value of "Lfft" change to 2^n where n is positive integer. Which make the code more efficient and reduce the compiling time. Because It is fastest for powers of two.

M10 It gives us the frequency range or frequency limit(Any frequency can not be here). Depeendent on the sampling time(Ts) and sampling instance a particular frequency range is calculated here.

M11 " fftshift"Shift zero-frequency component to center of spectrum & "fft" means Fast Fourier transform. fft(m_sig,Lfft) returns the Lfft-point Discrete Fourier Transform. If the length of m_sig is less than Lfft, m_sig is padded with trailing zeros to length Lfft. If the length of m_sig is greater than Lfft, the sequence m_sig is truncated. When m_sig is a matrix, the length of the columns are adjusted in the same manner.

M13 For create figure window (In many cases, we will need more than one figure. Then, we can use figure(2); figure(3) such dommands.)

M14 Range the figure according to the given quantity in the third bracket

M15 subplot(m,n,p) divides the current figure into an m-by-n grid and creates axes in the position specified by p.

M16 Create a plot where t is in x axis and m_sig at y axis

M17 Range the plot axis according to Trange

M18 Print the name of the figure at the top

M20 Range the figure according to the given quantity in the third bracket

M21 subplot(m,n,p) divides the current figure into an m-by-n grid and creates axes in the position specified by p.

M22 Create a plot where freqm is in x axis and M_fre at y axis

M23 Range the plot axis according to Frange

M24 Print the name of the figure at the top

Part(ii)

What we will do here: We will create a triangular function and see its spectrum.

Matlab Files: A function file and Main file need to create and they must be created in **same folder**

Function file:

```
function y =triangl(t)
y=(1-abs(t)).*(t>=-1).*(t<1);
end
```

Main file :

```
1   clc
2   clear all
3   close all
4   ts=1.e-4;
5   t=-0.16:ts:0.16;
6
7   m_sig=triangl((t+0.01)/.01)-triangl((t-0.01)/.01);
8   Lfft=length(t);
9   Lfft=2^ceil(log2(Lfft));
10  freqm=(-Lfft/2:Lfft/2-1)/(Lfft*ts);
11  M_fre=fftshift(fft(m_sig,Lfft));
12
13  figure(1)
14  Trange=[-.03 .03 -1.5 1.5];
15  subplot(211);
16  td1=plot(t,m_sig);
17  axis(Trange)
18  title('Message signal');
19
20  Frange=[-200 200 0 200];
21  subplot(212);
22  td2=plot(freqm,abs(M_fre));
23  axis(Frange)
24  title ('Massage spectrum');
```

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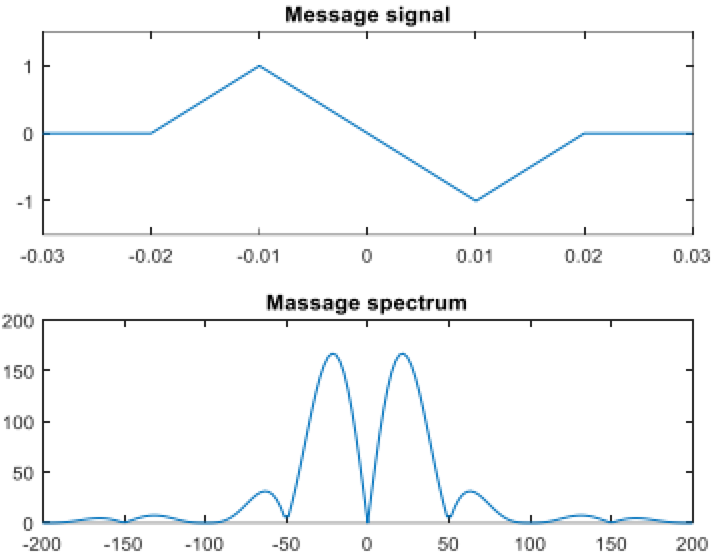
Output :



Part(iii)

What we will do here: We will create a sinc function sinc($\frac{2t}{0.005}$) and see its spectrum.

(It is not necessary to create a function file because MATLAB has already build in function named 'sinc')

Main File:

```
clc
clear all
close all
ts=1.e-4;
t=-0.04:ts:0.04;
Ta=.005;
signal=sinc(2*t/Ta); %Sinc Function

figure(1)
subplot(121)
td=plot(t,signal);
axis([-0.025 0.025 -1.5 1.5])
set(td,'linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('sinc(t)')
```

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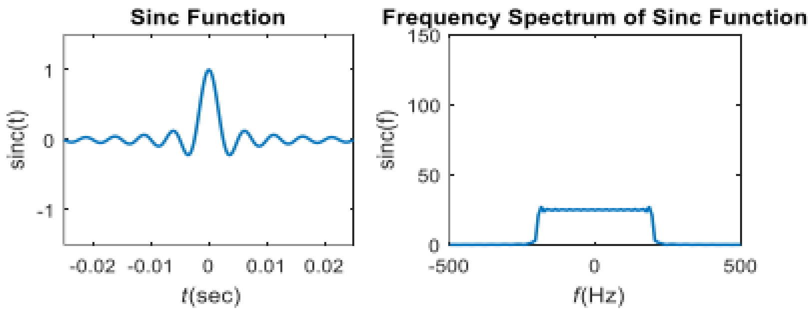
```
title('Sinc Function')

L_sig=length(signal);
Lfft=length(t);
Lfft=2^ceil(log2(Lfft));
Signal_fre=fftshift(fft(signal,Lfft));
freqm=(-Lfft/2:Lfft/2-1)/(Lfft*ts);

subplot(122);
fd=plot(freqm,abs(Signal_fre));
axis([-500 500 0 150]);
set(fd,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('sinc(f)');
title('Frequency Spectrum of Sinc Function');
```

Output:



Part(iv)

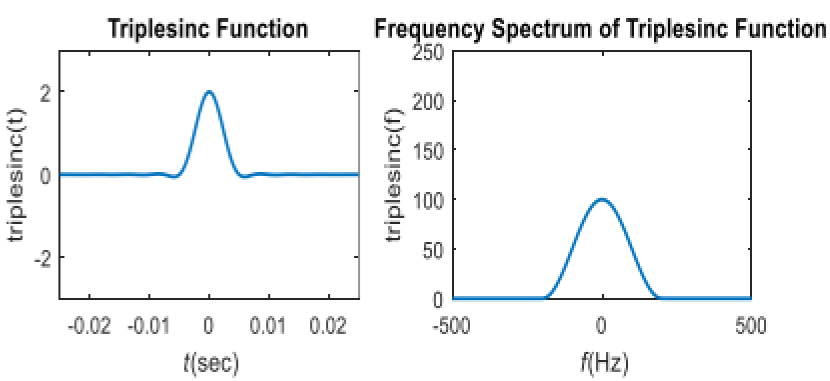
What we will do here: We will add three sinc function sinc($\frac{2t}{.005}$), sinc($\frac{2t-0.005}{0.005}$) & sinc($\frac{2t+0.005}{0.005}$) to see the signal and its spectrum.

(It is not necessary to create a function file because MATLAB has already build in function named 'sinc'. So only addition three sinc function will create triplesinc function)

Main File:

```
clc
clear all
close all
ts=1.e-4;
t=-0.04:ts:0.04;
Ta=.005;

sig_1=sinc(2*t/Ta);
sig_2=sinc(2*t/Ta-1);
sig_3=sinc(2*t/Ta+1);
signal=2*sig_1+sig_2+sig_3; %triplesinc Function

figure(1)
subplot(121)
td=plot(t,signal);
axis([-0.025 0.025 -3 3])
set(td,'linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('triplesinc(t)')
title('Triplesinc Function')

L_sig=length(signal);
Lfft=length(t);
Lfft=2^ceil(log2(Lfft));
Signal_fre=fftshift(fft(signal,Lfft));
freqm=(-Lfft/2:Lfft/2-1)/(Lfft*ts);

subplot(122);
fd=plot(freqm,abs(Signal_fre));
axis([-500 500 0 250]);
set(fd,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('triplesinc(f)');
title('Frequency Spectrum of Triplesinc Function');
```

Output:



Experiment No:2
Name of the experiment: DSB-SC modulation and Demodulation.

Objective: Familiarization with DSB-SC signal, simulation of the modulation and demodulation of DSB-SC signal.

Theory: DSB-SC modulation is that where modulating signal is multiplying by carrier and produce modulated signal.The process of recovering the signal from the modulated signal is referred to as demodulation of DSB-SC.For modulator input is message signal and output of multiplier is passed through a band pass filter.On the other hand for demodulator input is DSB-SC signal and output of multiplier is passed through a low pass filter.In the DSB there are two sideband such that upper side band(USB) and lower side band(LSB).

Function file :

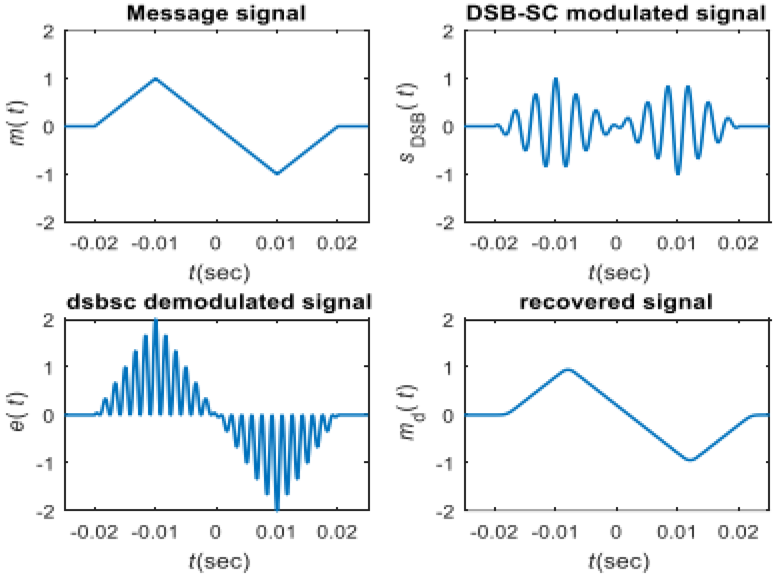
```
function y =triangl(t);
y=(1-abs(t)).*(t>=-1).*(t<1);
end
```

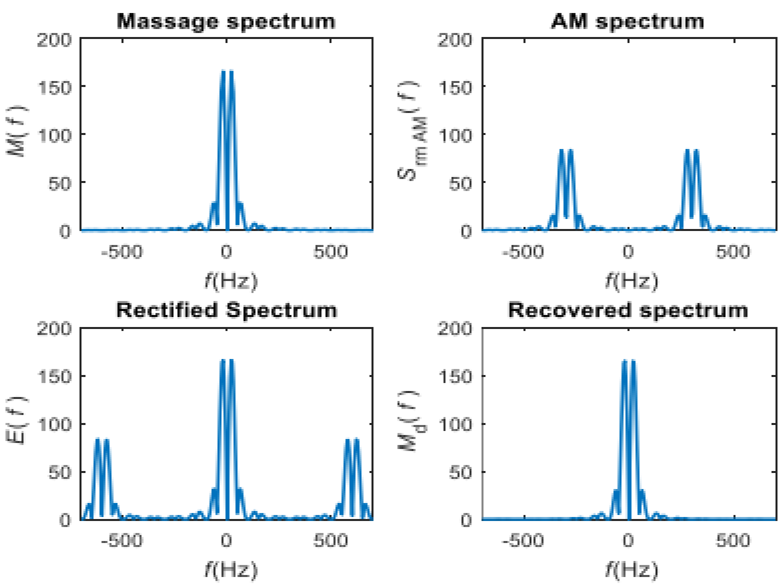
Main file:

```
ts=1.e-4;
t=-0.04:ts:0.04;
Ta=0.01;
m_sig=triangl((t+0.01)/0.01)-triangl((t-0.01)/0.01);
Lm_sig=length(m_sig);
Lfft=length(t); Lfft=2^ceil(log2(Lfft));
M_fre=fftshift(fft(m_sig,Lfft));
freqm=(-Lfft/2:Lfft/2-1)/(Lfft*ts);

B_m=150;
h=fir1(40,B_m*ts);
fc=300;

s_dsb=m_sig.*cos(2*pi*fc*t);                %DSB modulation
Lfft=length(t);Lfft=2^ceil(log2(Lfft)+1);
S_dsb=fftshift(fft(s_dsb,Lfft));
freqs=(-Lfft/2:Lfft/2-1)/(Lfft*ts);

s_dem=2*s_dsb.*cos(2*pi*fc*t);              %DSB demodulation
S_dem=fftshift(fft(s_dem,Lfft));

s_rec=filter(h,1,s_dem);                    % filtering process
S_rec=fftshift(fft(s_rec,Lfft));

Trange=[-0.025 0.025 -2  2];
figure(1)

subplot(221);
td1=plot(t,m_sig);
axis(Trange);
set(td1,'linewidth',1.5);
xlabel('{\it t}(sec)');          %used to label x-axis
ylabel('{\it m}({\it t})');      %used to label y-axis
title('Message signal');
```

```
subplot(222);
td2=plot(t,s_dsb);
axis(Trange);
set(td2,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it s}_{\rm DSB}({\it t})');
title('DSB-SC modulated signal');

subplot(223);
td3=plot(t,s_dem);
axis(Trange);
set(td3,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it e}({\it t})')
title(' dsbsc demodulated signal');
subplot(224);
td4=plot(t,s_rec);
axis(Trange);
set(td4,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it m}_d({\it t})');
title('recovered signal');
Frange=[-700 700 0 200];

figure(2)
subplot(221);
fd1= plot(freqm,abs(M_fre));
axis(Frange);
set(fd1,'linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it M}({\it f })');
title ('Massage spectrum');
subplot(222);
fd2= plot(freqs,abs(S_dsb));
axis(Frange);
set(fd2,'linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it S}_{rm AM}({\it f })');
title ('AM spectrum');
subplot(223);
fd3= plot(freqs,abs(S_dem));
axis(Frange);
set(fd3,'linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it E}({\it f })');
title ('Rectified Spectrum');
subplot(224);
fd4= plot(freqs,abs(S_rec));
axis(Frange);
set(fd4,'linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it M}_d({\it f })');
title ('Recovered spectrum');
```

Output:


Message signal
m(t)
t(sec)
DSB-SC modulated signal
$s_{DSB}(t)$
t(sec)
dsbsc demodulated signal
e(t)
t(sec)
recovered signal
$m_d(t)$
t(sec)


Massage spectrum
M(f)
f(Hz)
AM spectrum
$S_{rm AM}(f)$
f(Hz)
Rectified Spectrum
E(f)
f(Hz)
Recovered spectrum
$M_d(f)$
f(Hz)

Experiment No:3

Name of the experiment:AM modulation and demodulation.

Objective: Familiarization with DSB+C(AM) signal, simulation of the modulation and demodulation of DSB+C(AM) signal.

Theory: Amplitude modulation is that where double sideband are added with carrier and it is alternativeOf DSB-SC.There are two way of demodulation such as Rectifier detection and Envelop detection.Amplitude modulation has two sideband such as upper sideband(USB) and lower sideband(LSB).For a broadcast system with a multitude of receiver for each transmitter ,it is more economicalTo have one expensive high power transmitter and simpler,less expensive receiver.

Function file:

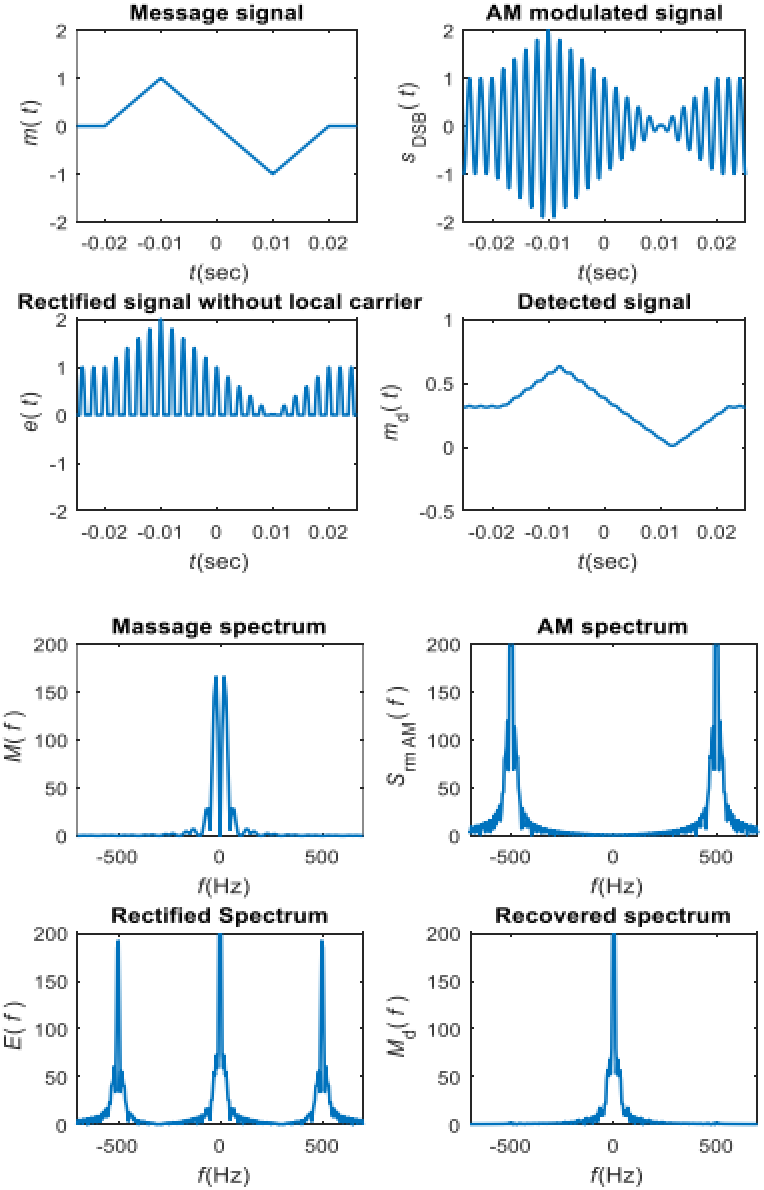
```
function y =triangl(t);
y=(1-abs(t)).*(t>=-1).*(t<1);
end
```

Main file:

```
ts=1.e-4;
t=-0.04:ts:0.04;
Ta=0.01;fc=500;
m_sig=triangl((t+0.01)/0.01)-triangl((t-0.01)/0.01);
Lm_sig=length(m_sig);
Lfft=length(t);Lfft=2^ceil(log2(Lfft));
M_fre=fftshift(fft(m_sig,Lfft));
freqm=(-Lfft/2:Lfft/2-1)/(Lfft*ts);
B_m=150;
h=fir1(40,B_m*ts);
s_am=(1+m_sig).*cos(2*pi*fc*t);
Lfft=length(t);Lfft=2^ceil(log2(Lfft)+1);
S_am=fftshift(fft(s_am,Lfft));
freqs=(-Lfft/2:Lfft/2-1)/(Lfft*ts);
s_dem=s_am.*(s_am>0);
S_dem=fftshift(fft(s_dem,Lfft));
s_rec=filter(h,1,s_dem);
S_rec=fftshift(fft(s_rec,Lfft));
Trange=[-0.025 0.025 -2 2];
figure(1)
subplot(221);
td1=plot(t,m_sig);
axis(Trange);
set(td1,'linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it m}({\it t})');
title('Message signal');
subplot(222);
td2=plot(t,s_am);
axis(Trange);
set(td2,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it s}_{\rm DSB}({\it t})');
title('AM modulated signal');
```

```
subplot(223);
td3=plot(t,s_dem);
axis(Trange);
set(td3,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it e}({\it t})')
title(' Rectified signal without local carrier');
subplot(224);
td4=plot(t,s_rec);
Trangelow=[-0.025 0.025 -0.5   1];
axis(Trangelow);
set(td4,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it m}_d({\it t})');
title('Detected signal');
Frange=[-700 700 0 200];
figure(2)
subplot(221);
fd1= plot(freqm,abs(M_fre));
axis(Frange);
set(fd1,'linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it M}({\it f })');
title ('Massage spectrum');
subplot(222);
fd2= plot(freqs,abs(S_am));
axis(Frange);
set(fd2,'linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it S}_{rm AM}({\it f })');
title ('AM spectrum');
subplot(223);
fd3= plot(freqs,abs(S_dem));
axis(Frange);
set(fd3,'linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it E}({\it f })');
title ('Rectified Spectrum');
subplot(224);
fd4= plot(freqs,abs(S_rec));
axis(Frange);
set(fd4,'linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it M}_d({\it f })');
title ('Recovered spectrum')
```

Output:


Message signal
m(t)
t(sec)
AM modulated signal
s_DSB(t)
t(sec)
Rectified signal without local carrier
e(t)
t(sec)
Detected signal
m_d(t)
t(sec)
Massage spectrum
M(f)
f(Hz)
AM spectrum
S_rm AM(f)
f(Hz)
Rectified Spectrum
E(f)
f(Hz)
Recovered spectrum
M_d(f)
f(Hz)

Experiment No:4

Name of the experiment: Finding out the SSB-SC modulation & demodulation signal.

Objective: To simulate SSB-SC modulation & demodulation signal using Matlab.

Theory: The DSB spectrum has two sidebands-the upper side band(USB) & the lower sideband(LSB).Both containing the complete information of the baseband signal. A scheme in which only one sideband is transmitted is known as single sideband(SSB) transmission which requires only one-half the bandwidth of the DSB signal.

Function file:

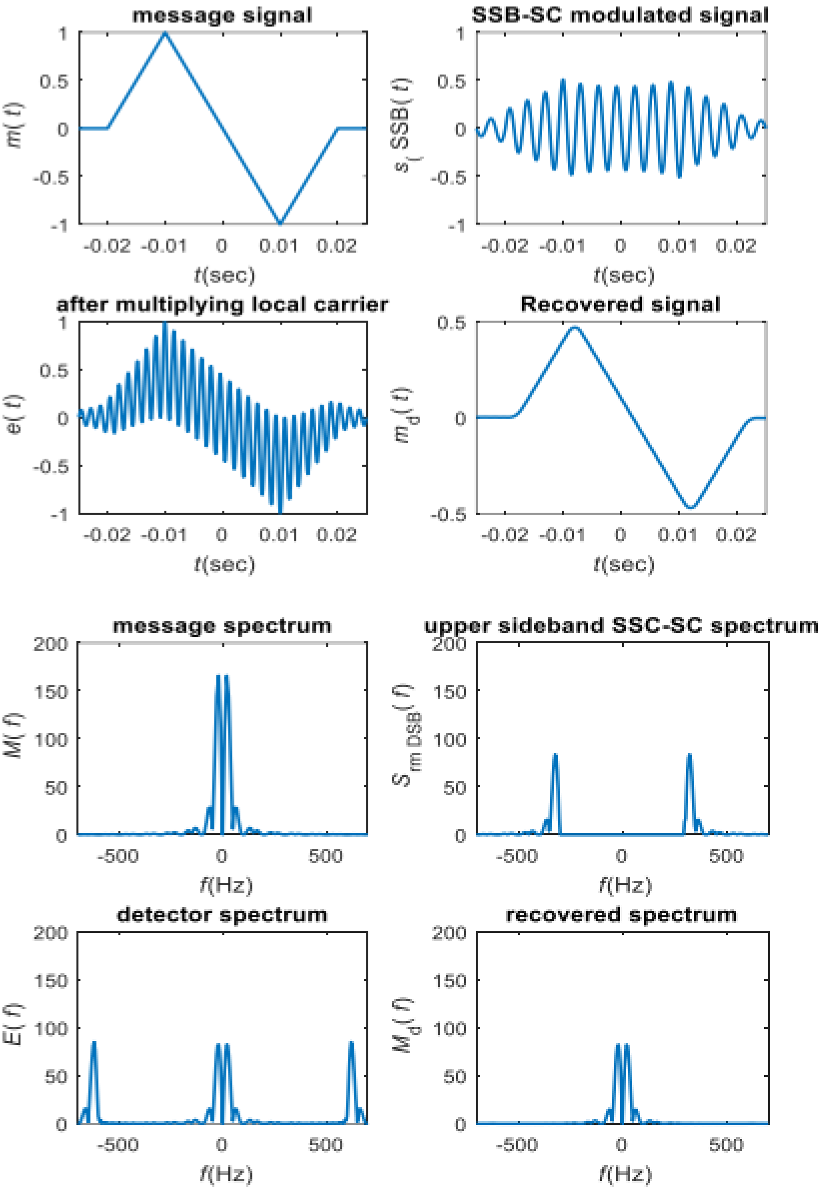
```
function y =triangl(t);
y=(1-abs(t)).*(t>=-1).*(t<1);
end
```

Main File:

```
ts=1.e-4;
t=-0.04:ts:0.04;
Ta=0.01;
fc=300;
m_sig=triangl((t+0.01)/0.01)-triangl((t-0.01)/0.01);
Lm_sig=length(m_sig);
Lfft=length(t);Lfft=2^ceil(log2(Lfft));
M_fre=fftshift(fft(m_sig,Lfft));
freqm=(-Lfft/2:Lfft/2-1)/(Lfft*ts);
 B_m=150;
h=fir1(40,[B_m*ts]);
 s_dsb=m_sig.*cos(2*pi*fc*t);
Lfft=length(t);
Lfft=2^ceil(log2(Lfft)+1);
S_dsb=fftshift(fft(s_dsb,Lfft));
 L_lsb=floor(fc*ts*Lfft);
SSBfilt=ones(1,Lfft);
SSBfilt(Lfft/2-L_lsb+1:Lfft/2+L_lsb)=zeros(1,2*L_lsb);
S_ssb=S_dsb.*SSBfilt;
freqs=(-Lfft/2:Lfft/2-1)/(Lfft*ts);
s_ssb=real(ifft(fftshift(S_ssb)));
s_ssb=s_ssb(1:Lm_sig);
 s_dem=s_ssb.*cos(2*pi*fc*t)*2;
S_dem=fftshift(fft(s_dem,Lfft));
 s_rec=filter(h,1,s_dem);
S_rec=fftshift(fft(s_rec,Lfft));
   Trange=[-0.025 0.025 -1 1];
figure(1)
subplot(221);
td1=plot(t,m_sig);
axis(Trange);
set(td1,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it m}({\it t})');
title('message signal');
subplot(222);
td2=plot(t,s_ssb);
```

```
axis(Trange);
set(td2,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it s}_({\rm SSB}({\it t})')
title('SSB-SC modulated signal');
subplot(223);
td3=plot(t,s_dem);
axis(Trange);
set(td3,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it e}({\it t})')
title('after multiplying local carrier');
subplot(224);
td4=plot(t,s_rec);
   Trangelow=[-0.025 0.025 -0.5 1];
axis(Trangelow);
set(td4,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it m}_d({\it t})')
title('Recovered signal');
   Frange=[-700 700 0 200];
figure(2)
subplot(221);
fd1=plot(freqm,abs(M_fre));
axis(Frange);
set(fd1,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it M}({\it f})');
title('message spectrum');
subplot(222);
fd2=plot(freqs,abs(S_ssb));
axis(Frange);
set(fd2,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it S}_{rm DSB}({\it f})');
title('upper sideband SSC-SC spectrum');
 subplot(223);
fd3=plot(freqs,abs(S_dem));
axis(Frange);
set(fd3,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it E}({\it f})');
title('detector spectrum');
 subplot(224);
fd4=plot(freqs,abs(S_rec));
axis(Frange);
set(fd4,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it M}_d({\it f})');
title('recovered spectrum');
```

Output Signal:



Experiment No:5

Name of the experiment: Finding out the QAM modulation & demodulation signal.

Objective: To simulate the QAM modulation & demodulation signal with Matlab.

Theory: The DSB signal occupy twice the bandwidth required for the baseband. This problem can be solved by QAM.In a QAM signal, there are two carriers, each having the same frequency but differing in phase by 90 degrees (one quarter of a cycle, from which the term quadrature arises). One signal is called the I signal, and the other is called the Q signal. Mathematically, one of the signals can be represented by a sine wave, and the other by a cosine wave. The two modulated carriers are combined at the source for transmission. At the destination, the carriers are separated, the data is extracted from each, and then the data is combined into the original modulating information.

Function file:

```
function y =triangl(t);
y=(1-abs(t)).*(t>=-1).*(t<1);
end

function [ m ] = triplesinc( t ,Ta )
sig_1=sinc(2*t/Ta);
sig_2=sinc(2*t/Ta-1);
sig_3=sinc(2*t/Ta+1);
m=2*sig_1+sig_2+sig_3;
end
```

Main File:

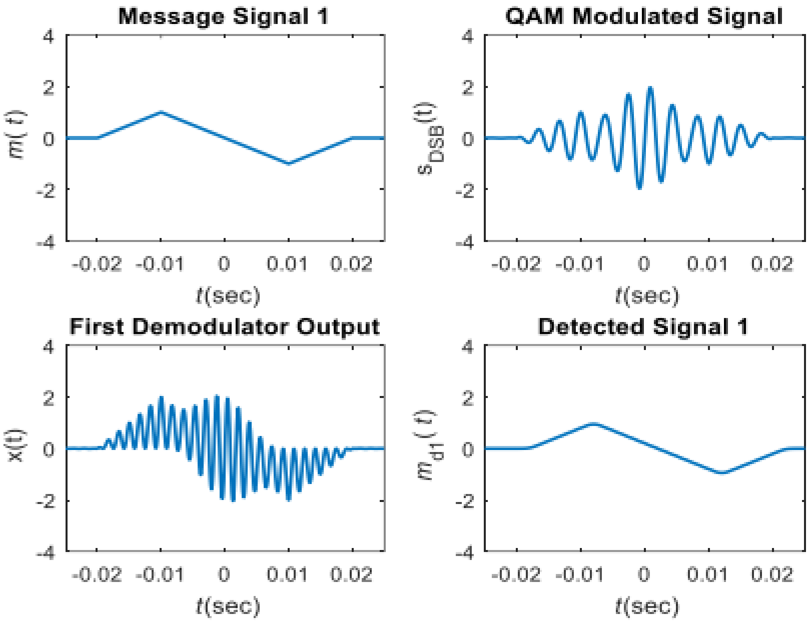
```
clc
clear all
close all
ts=1.e-4;
t=-0.04:ts:0.04;
Ta=0.01;
fc=300;
m_sig1=triangl((t+0.01)/0.01)-triangl((t-0.01)/0.01);
m_sig2=triplesinc(t,Ta);
Lm_sig=length(m_sig1);
Lfft=length(m_sig1);
Lfft=length(t);
Lfft=2^ceil(log2(Lfft));
M1_fre=fftshift(fft(m_sig1,Lfft));
M2_fre=fftshift(fft(m_sig2,Lfft));
freqm=(-Lfft/2:Lfft/2-1)/(Lfft*ts);
B_m=150;
h=fir1(40,[B_m*ts]);
s_qam=m_sig1.*cos(2*pi*fc*t)+m_sig2.*sin(2*pi*fc*t);
Lfft=length(t);
Lfft=2^ceil(log2(Lfft)+1);
S_qam=fftshift(fft(s_qam,Lfft));

freqs=(-Lfft/2:Lfft/2-1)/(Lfft*ts);
```

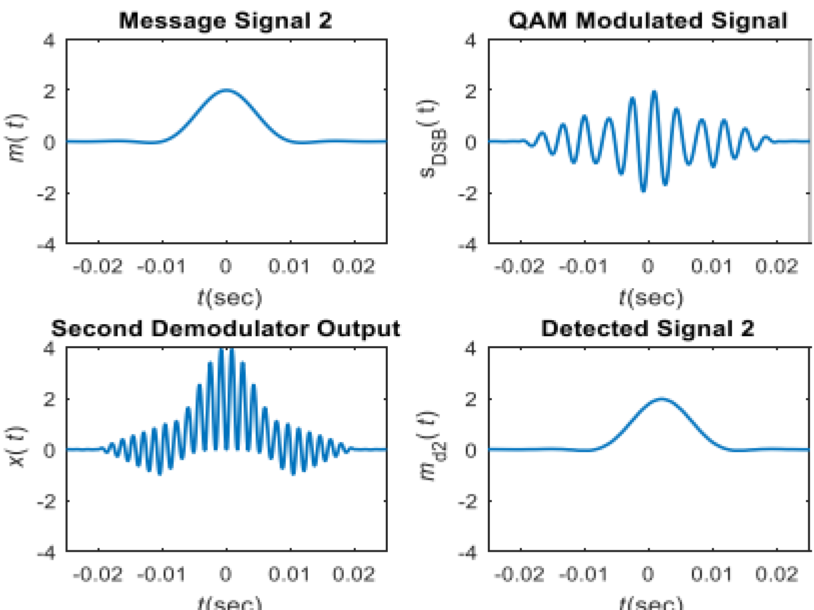
```
s_dem1=s_qam.*cos(2*pi*fc*t)*2;
s_dem2=s_qam.*sin(2*pi*fc*t)*2;
S_dem1=fftshift(fft(s_dem1,Lfft));
S_dem2=fftshift(fft(s_dem2,Lfft));

s_rec1=filter(h,1,s_dem1);
s_rec2=filter(h,1,s_dem2);
S_rec1=fftshift(fft(s_rec1,Lfft));
S_rec2=fftshift(fft(s_rec2,Lfft));

Trange=[-0.025 0.025 -4 4];
 figure(1)
 subplot(221);
td1=plot(t,m_sig1);
axis(Trange);
set(td1,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it m}({\it t})');
title('Message Signal 1');

subplot(222);
td2=plot(t,s_qam);
axis(Trange);
set(td2,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('s_{DSB}(t)')
title('QAM Modulated Signal');

subplot(223);
td3=plot(t,s_dem1);
axis(Trange);
set(td3,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel(' x(t)')
title('First Demodulator Output');

subplot(224);
td4=plot(t,s_rec1);
axis(Trange);
set(td4,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it m}_{d1}({\it t})')
title('Detected Signal 1');


figure(2)
 subplot(221);
td5=plot(t,m_sig2);
axis(Trange);
set(td5,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it m}({\it t})');
title('Message Signal 2');
```

```
subplot(222);
td6=plot(t,s_qam);
axis(Trange);
set(td6,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel(' s_{DSB}( t)')
title('QAM Modulated Signal');

subplot(223);
td7=plot(t,s_dem2);
axis(Trange);
set(td7,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it x}({\it t})')
title('Second Demodulator Output');

subplot(224);
td8=plot(t,s_rec1);
axis(Trange);
set(td8,'Linewidth',1.5);
xlabel('{\it t}(sec)');
ylabel('{\it m}_{d2}({\it t})')
title('Detected Signal 2');

Frange=[-700 700 0 250];

figure(3)
 subplot(221);
fd1=plot(freqm,abs(M1_fre));
axis(Frange);
set(fd1,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it M}({\it f})');
title('Message 1 Spectrum');

subplot(222);
fd2=plot(freqs,abs(S_qam));
axis(Frange);
set(fd2,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it S}_{ AM}({\it f})');
title('QAM Spectrum Magnitude');

subplot(223);
fd3=plot(freqs,abs(S_dem1));
axis(Frange);
set(fd3,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it E1}({\it f})');
title('First Femodulator Spectrum');

subplot(224);
fd4=plot(freqs,abs(S_rec1));
axis(Frange);
set(fd4,'Linewidth',1.5);
```

```
xlabel('{\it f}(Hz)');
ylabel('{\it M}_{d1}({\it f})');
title('Recovered Spectrum 1');

figure(4)
 subplot(221);
fd1=plot(freqm,abs(M2_fre));
axis(Frange);
set(fd1,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it M}({\it f})');
title('Message 2 Spectrum');

subplot(222);
fd2=plot(freqs,abs(S_qam));
axis(Frange);
set(fd2,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it S}_{ AM}({\it f})');
title('QAM Spectrum Magnitude 2');
 subplot(223);
fd3=plot(freqs,abs(S_dem2));
axis(Frange);
set(fd3,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it E2}({\it f})');
title('Second Demodulator Spectrum');
 subplot(224);
fd4=plot(freqs,abs(S_rec2));
axis(Frange);
set(fd4,'Linewidth',1.5);
xlabel('{\it f}(Hz)');
ylabel('{\it M}_{d2}({\it f})');
title('Recovered Spectrum 1');
```

Output Signals:





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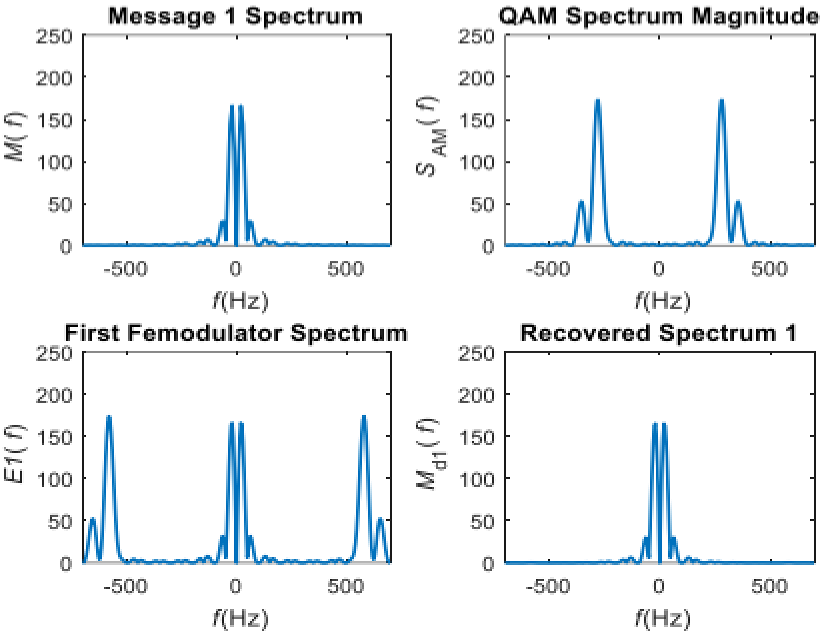
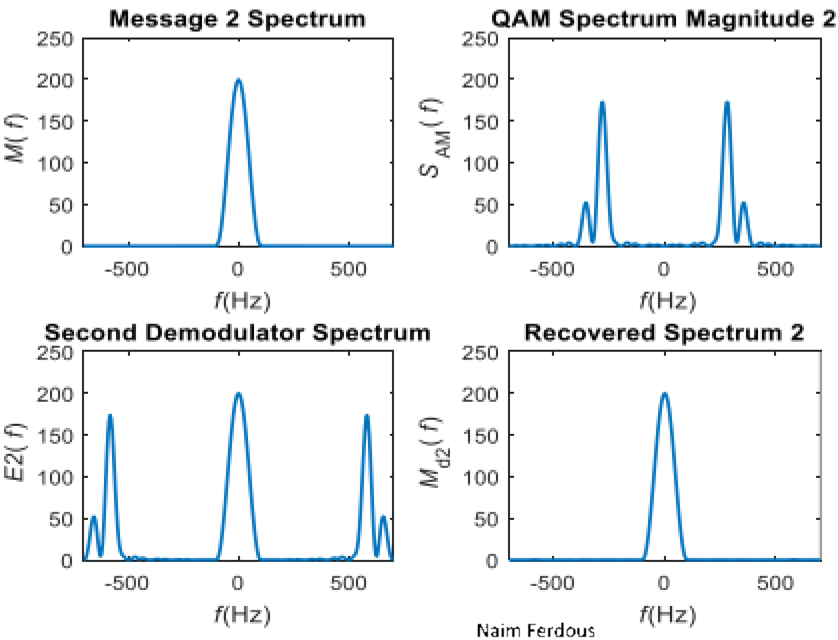

Message 1 Spectrum
M(f)
f(Hz)
QAM Spectrum Magnitude
$S_{AM}(f)$
f(Hz)
First Femodulator Spectrum
E1(f)
f(Hz)
Recovered Spectrum 1
$M_{d1}(f)$
f(Hz)


Message 2 Spectrum
M(f)
f(Hz)
QAM Spectrum Magnitude 2
$S_{AM}(f)$
f(Hz)
Second Demodulator Spectrum
E2(f)
f(Hz)
Recovered Spectrum 2
$M_{d2}(f)$
f(Hz)

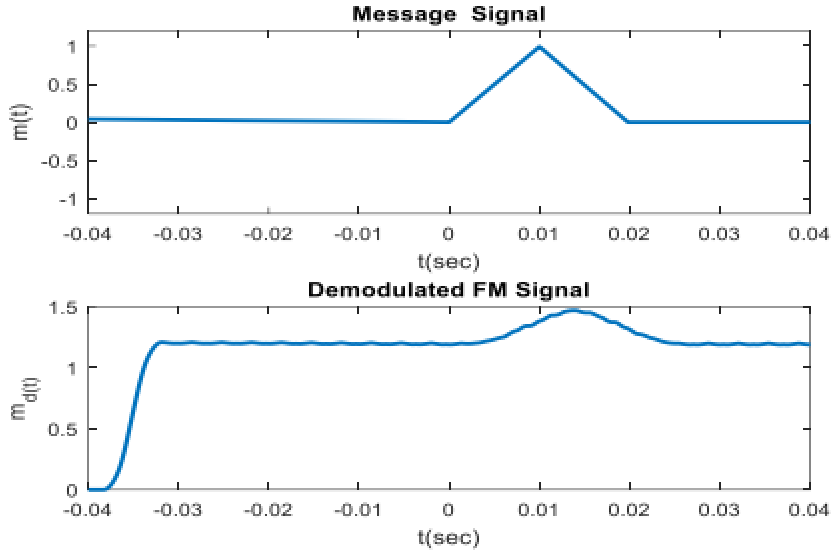
Experiment No. 06
Name of the experiment: FM modulation and demodulation.
Objective: Familiarization with FM signal, simulation of the modulation and demodulation of FM signal.
Theory: In FM, carrier frequency would be varied in proportion to the message m(t). The carrier angular frequency $\omega(t)=\omega_c+k.m(t)$. Where k is some constant. For demodulation one can use an operational amplifier differentiator at the FM receiver.

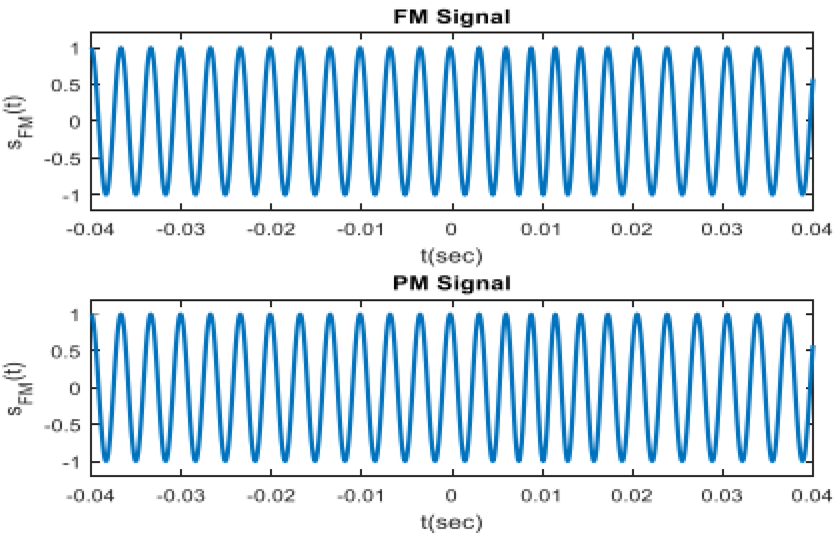
Here FM coefficient is $k_f = 80$ and PM coefficient is $k_p = \pi$ and the carrier frequency is 300 hz.

Function File:
```
function [y]=triangl(t);
y=(1-abs(t)).*(t>=-1).*(t<1);
end
```
Main File:
```
clc
clear all
ts=1.e-4;t= -0.04:ts:0.04;
Ta=0.01;
m_sig= triangl((t+0.01/Ta)-triangl((t-0.01)/Ta));
Lfft=length(t);
Lfft=2^ceil(log2(Lfft));
freqm=(-Lfft/2:Lfft/2-1)/(Lfft*ts);
B_m=100;
h=fir1(80,[B_m*ts]);
kf=160*pi;
kp=pi;
m_intg=kf*ts*cumsum(m_sig);
s_fm=cos(2*pi*300*t+m_intg);
s_pm=cos(2*pi*300*t+m_sig*kp);
Lfft=length(t);
Lfft=2^ceil(log2(Lfft)+1);
S_fm=fftshift(fft(s_fm,Lfft));
S_pm=fftshift(fft(s_pm,Lfft));
freqs=(-Lfft/2:Lfft/2-1)/(Lfft*ts);
s_fmdem=diff([s_fm(1) s_fm])/ts/kf;
s_fmrec=s_fmdem.*(s_fmdem>0)
s_dec=filter(h,1,s_fmrec);
trange=[-0.04 0.04 -1.2 1.2];
figure(1)
subplot(211);
m1=plot(t,m_sig);
axis(trange);
set(m1,'linewidth',2);
xlabel('t(sec)');
ylabel('m(t)')
title('Message  Signal');
subplot(212);
```

```
m2=plot(t,s_dec);
set(m2,'linewidth',2);
xlabel('t(sec)');
ylabel('m_{d(t)}')
title(' Demodulated FM Signal ');
figure(2)
subplot(211);
td1=plot(t,s_fm);
axis(trange);
set(td1,'Linewidth',2);
xlabel('t(sec)');
ylabel('s_{FM}(t)')
title('FM Signal');
subplot(212);
td2=plot(t,s_pm);
axis(trange);
set(td2,'Linewidth',2);
xlabel('t(sec)');
ylabel('s_{FM}(t)')
title('PM Signal');
figure(3)
subplot(211);
fp1=plot(t,s_fmdem);
set(fp1,'Linewidth',2);
xlabel('t(sec)');
ylabel('d s_{FM}(t)/dt')
title('FM Derivative');
subplot(212);
fp2=plot(t,s_fmrec);
set(fp2,'Linewidth',1);
xlabel('t(sec)');
title('Rectified FM Derivative');
Frange=[-600 600 0 300];
figure(4)
subplot(211);
fd1=plot(freqs,abs(S_fm));
axis(Frange);
set(fd1,'Linewidth',1.5);
xlabel('t(sec)');
ylabel('s_{FM}(t)/dt')
title('FM Amplitude Spectrum');
subplot(212);
fd2=plot(freqs,abs(S_pm));
axis(Frange);
set(fd2,'Linewidth',1.5);
xlabel('f(Hz)');
ylabel('s_{PM}(t)/dt')
title('PM amplitude Spectrum')
```

OUTPUT:





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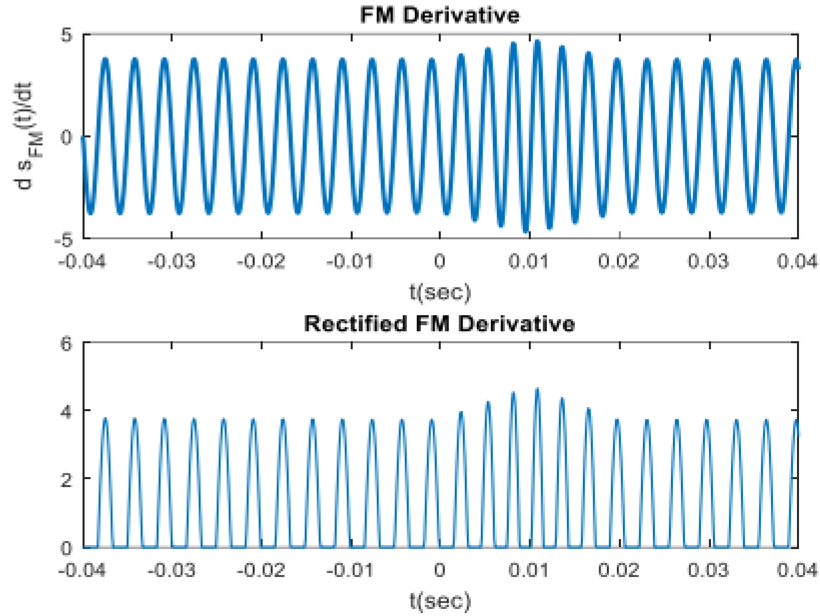

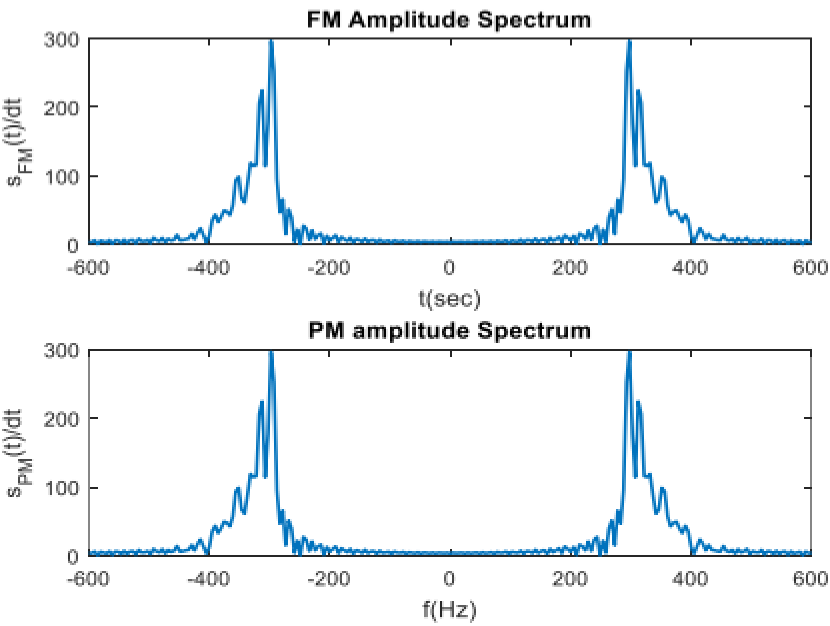

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Experiment No. 07

Name of the experiment: **Delta modulation and demodulation.**

Objective: Familiarization with Delta Modulation, simulation of the modulation and reconstruction of DM signal.

Theory: Delta modulation is done by oversampling the baseband signal. This increase the correlation between adjacent samples which results in a small prediction error. In delta modulation we use a first order predictor which is just a time delay of T_s

MATLAB CODE:

```
clc;
clear all;
close all;
a=2;
t=0:2*pi/50:2*pi;
x=a*sin(t);
l=length(x);
plot(x,'r');
delta=0.2;
hold on
xn=0;
for i=1:l;
   if x(i)>xn(i)
   d(i)=1;
   xn(i+1)=xn(i)+delta;
   else
       d(i)=0;
       xn(i+1)=xn(i)-delta;
end
end
stairs(xn)
hold on
for i=l:d
   if d(i)>xn(i)
       d(i)=0;
       xn(i+1)=xn(i)-delta;
   else
       d(i)=1;
       xn(i+1)=xn(i)-delta;
   end
 end
plot(xn,'c');
legend('Analog signal','Delta modulation','demodulation')
title('DELTA MODULATION/DEMODULATION')
```

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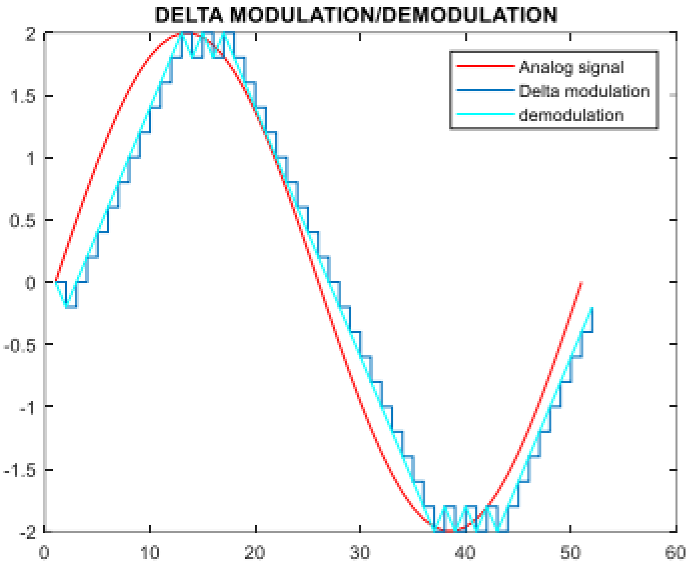
Output Figure:



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