K. N. Toosi University of Technology

Simulation of AM Modulation and Demodulation Methods

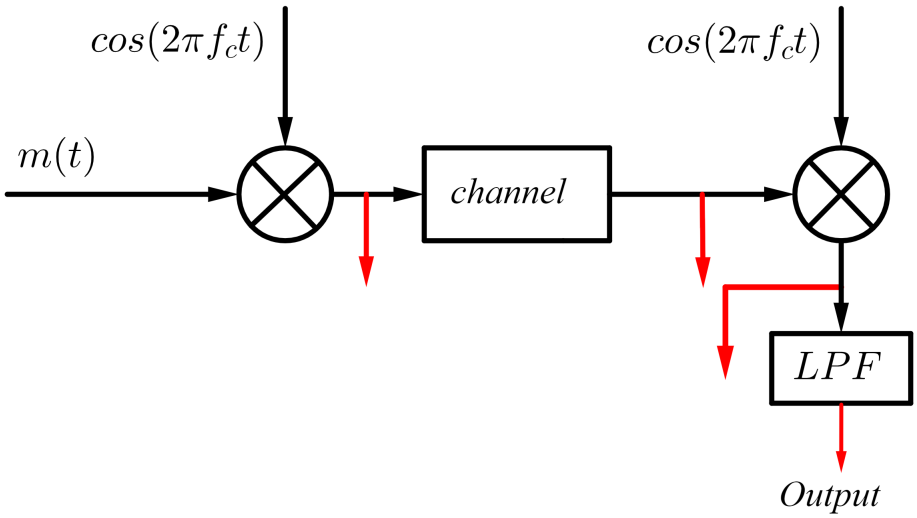
Morteza Karimi

July 10,2024

FT Function

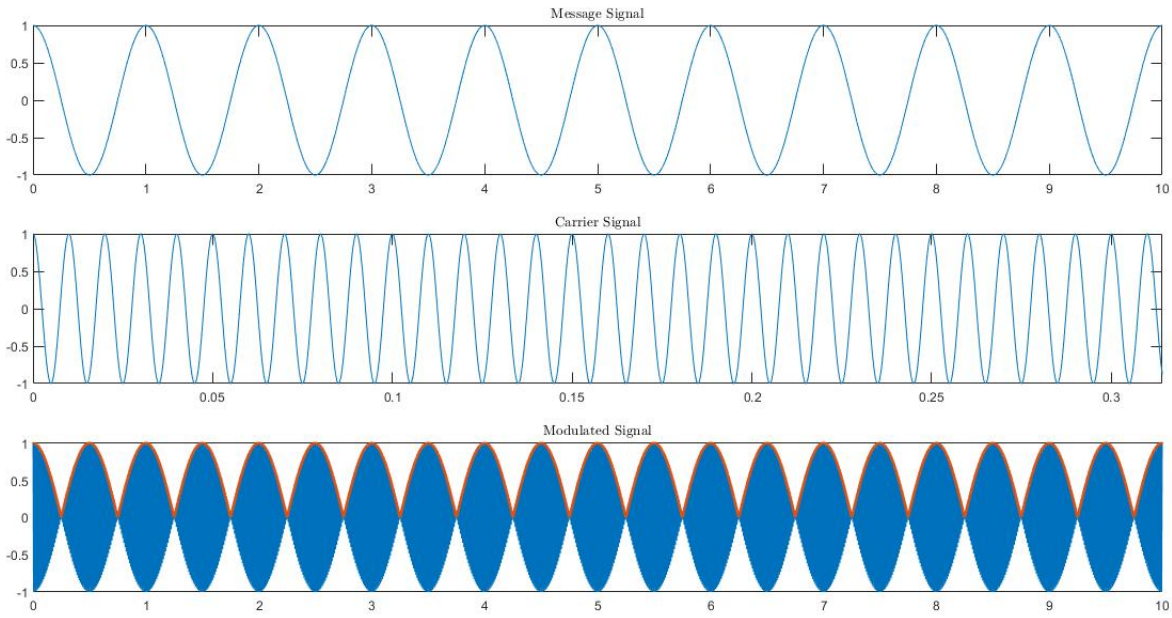
```
function [f,X]=FT(x,ts)
n=32*2^(nextpow2(length(x)));
X=fft(x,n);
dw=(2*pi)/n;
w=-pi:dw:pi-dw;
w=w*(1/ts);
f=w/(2*pi);
X=fftshift(X);
end
```

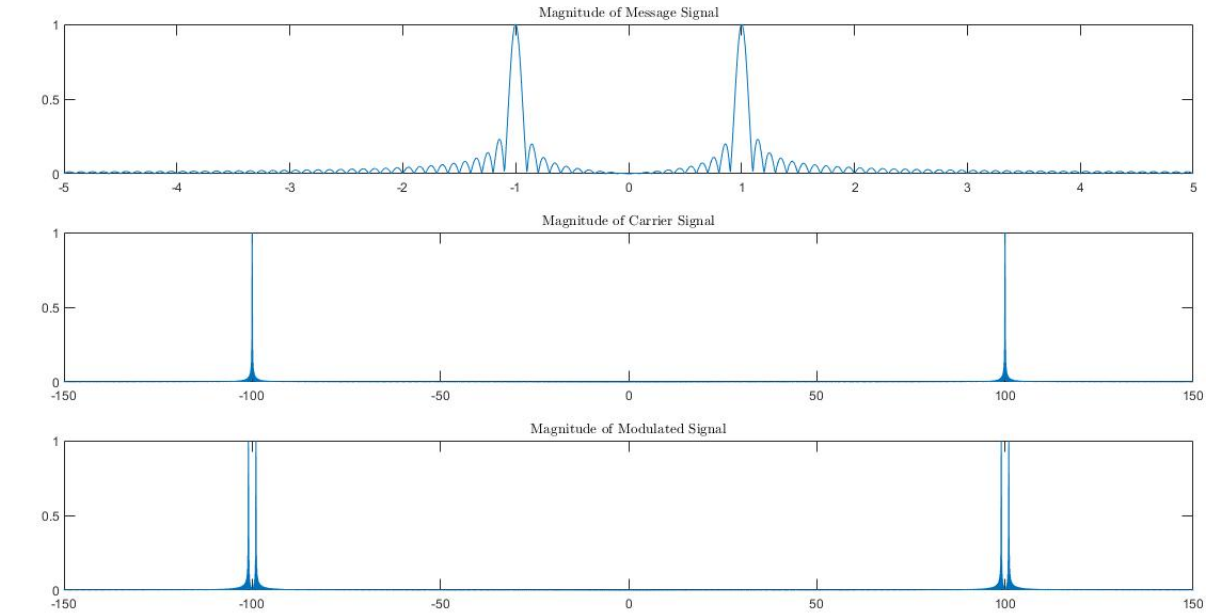
DSB SC

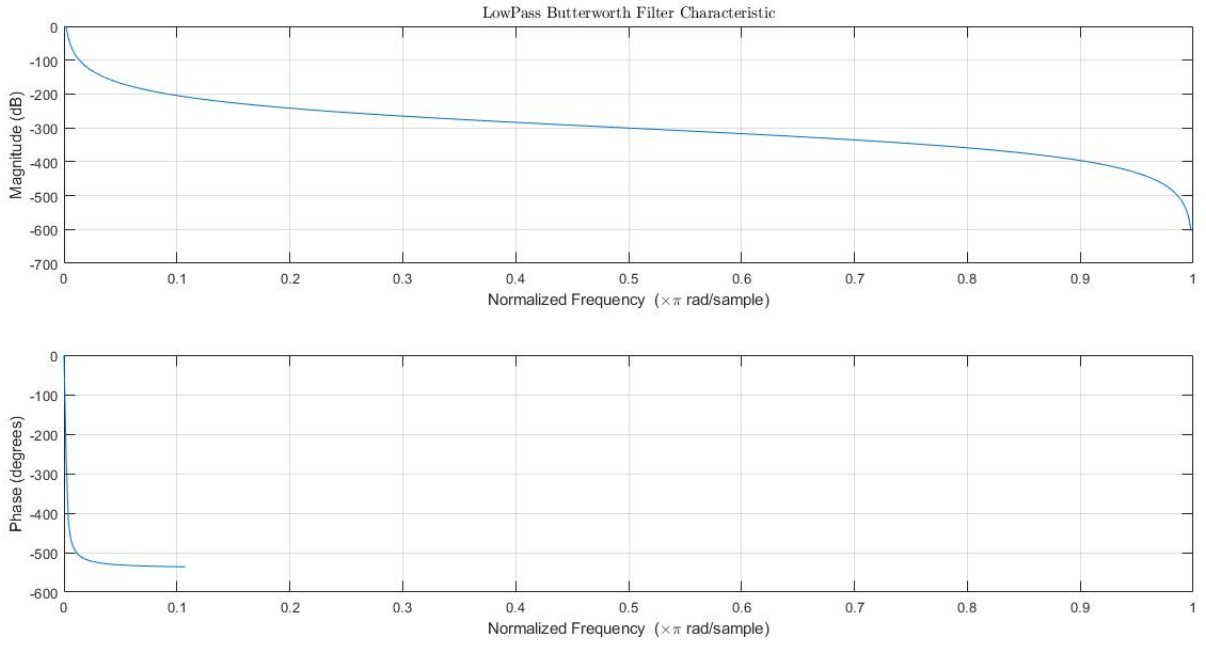


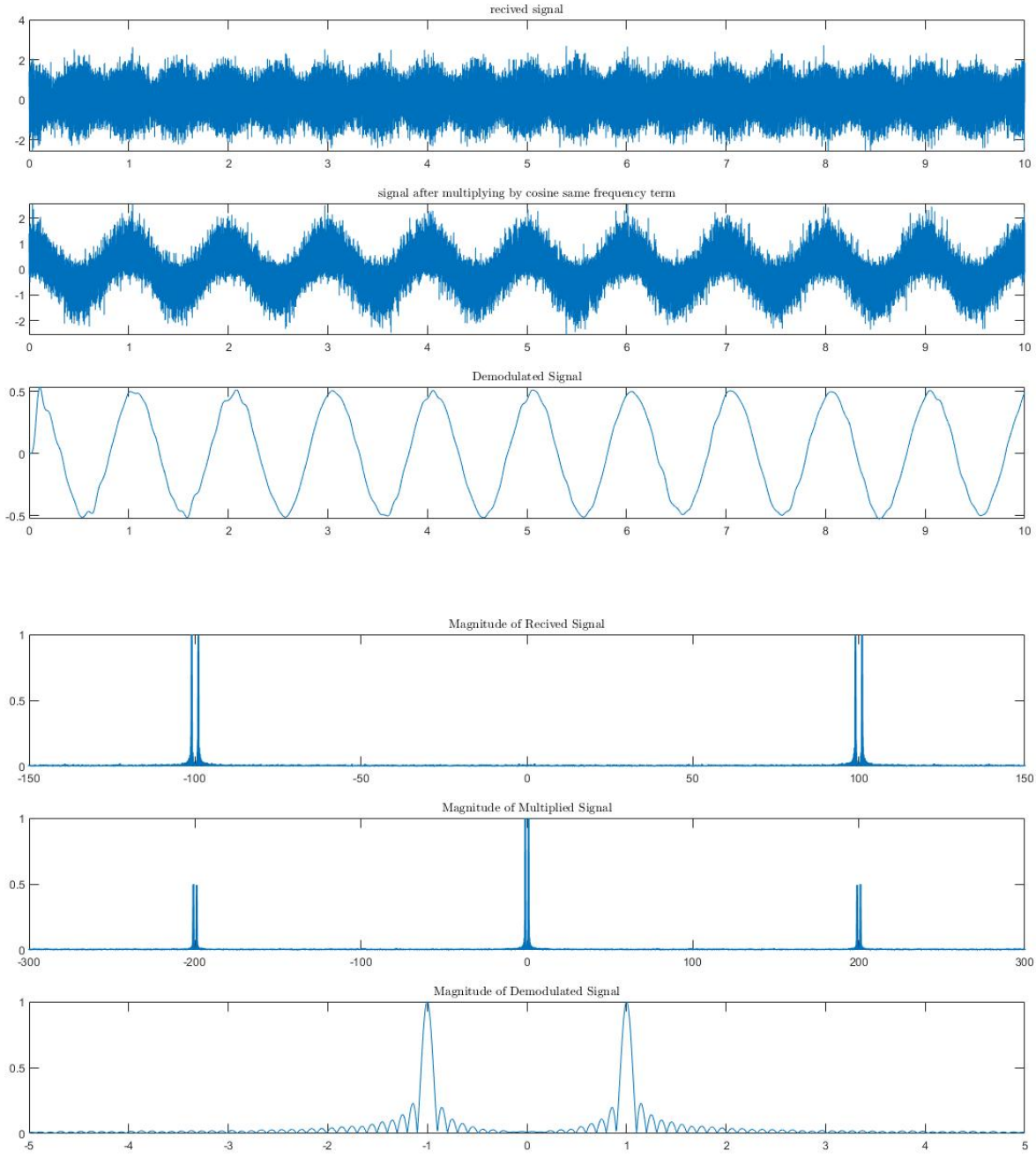
```
clear
clc
%%
%Moduation in Reciver
ts=1e-4;              %time resolution
fc=100;               %carrier frequency
t=0:ts:10;            %time descryption
x=cos(2*pi*t);        %message signal
c=cos(2*pi*fc*t);  %carrier signal
u=c.*x;               %modualted signal
figure(1)
subplot(3,1,1)
plot(t,x)
title('Message Signal','interpreter','latex')
subplot(3,1,2)
plot(t,c)
xlim([0,2*pi*0.05])
title('Carrier Signal','interpreter','latex')
subplot(3,1,3)
plot(t,u)
hold on
plot(t,envelope(u),'linewidth',2)
title('Modulated Signal','interpreter','latex')
%%
%frequency analysis
figure(2)
subplot(3,1,1)
[f1,X]=FT(x,ts);
plot(f1,abs(X)/max(abs(X)))
xlim([-5 5])
title('Magnitude of Message Signal','interpreter','latex')
subplot(3,1,2)
[f2,C]=FT(c,ts);
plot(f2,abs(C)/max(abs(C)))
xlim([-150 150])
title('Magnitude of Carrier Signal','interpreter','latex')
subplot(3,1,3)
[f3,U]=FT(u,ts);
plot(f3,abs(U)/max(abs(U)))
xlim([-150 150])
title('Magnitude of Modulated Signal','interpreter','latex')
%%
%filter
fcut=10;                                  %3dB cut frequency
fs=10000;
[b,a] = butter(6,fcut/(fs/2),'low');    %lowpass butterworth filter definition
figure(3)
freqz(b,a)
title('LowPass Butterworth Filter Characteristic','interpreter','latex')
%%
%Deomudolation
u=u+0.5*normrnd(0,1,1,length(t));  %noise addition
r=u.*cos(2*pi*fc*t);              %multiplying by cosine term
signal=filter(b,a,r);             %passing the signal through the filter
figure(4)
subplot(3,1,1)
```

```
plot(t,u)
title('recived signal','interpreter','latex')
subplot(3,1,2)
plot(t,r)
title('signal after multiplying by cosine same frequency term','interpreter','latex')
subplot(3,1,3)
plot(t,signal)
title('Demodulated Signal','interpreter','latex')
%%
%frequency analysis
figure(5)
subplot(3,1,1)
[f1,U]=FT(u,ts);
plot(f1,abs(U)/max(abs(U)),'linewidth',1.5)
xlim([-150 150])
title('Magnitude of Recived Signal','interpreter','latex')
subplot(3,1,2)
[f2,R]=FT(r,ts);
plot(f2,abs(R)/max(abs(R)),'linewidth',1.5)
xlim([-300 300])
title('Magnitude of Multiplied Signal','interpreter','latex')
subplot(3,1,3)
[f3,S]=FT(signal,ts);
plot(f3,abs(S)/max(abs(S)))
xlim([-5 5])
title('Magnitude of Demodulated Signal','interpreter','latex')
```

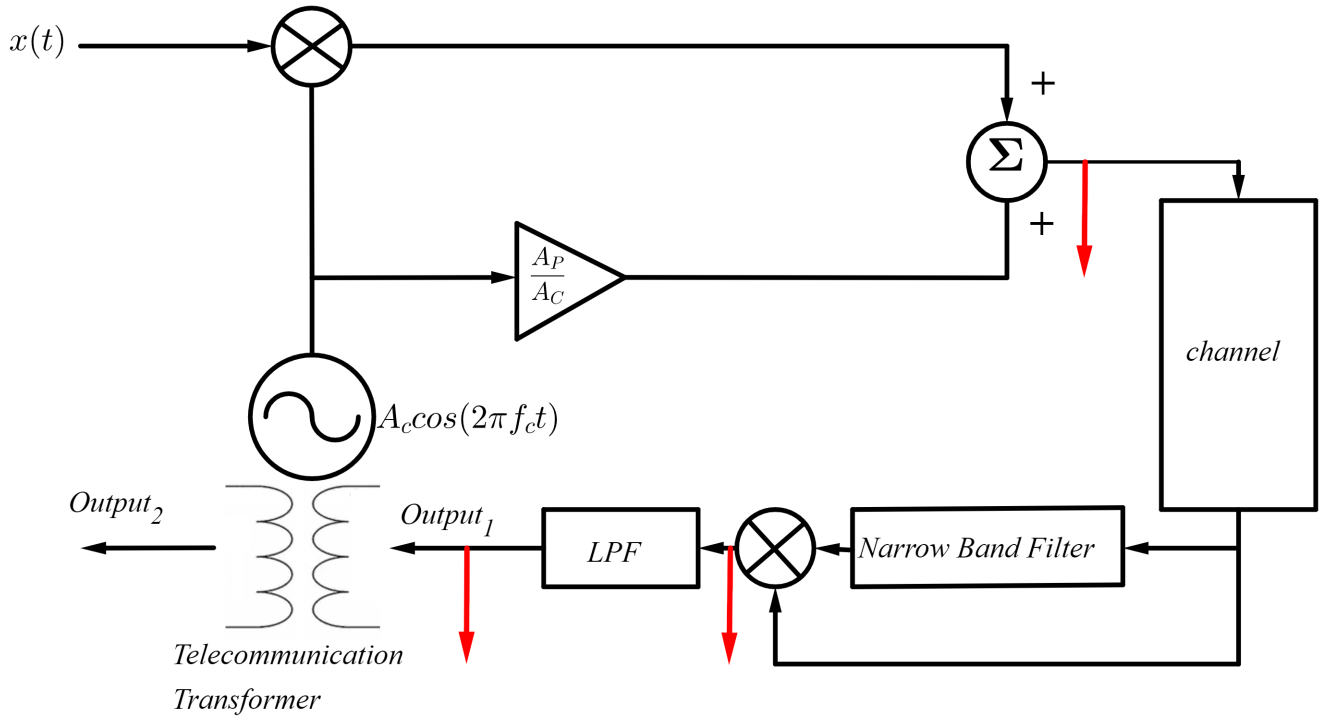



Magnitude of Message Signal
Magnitude of Carrier Signal
Magnitude of Modulated Signal


LowPass Butterworth Filter Characteristic
Magnitude (dB)
Phase (degrees)
Normalized Frequency (×π rad/sample)
Normalized Frequency (×π rad/sample)


recived signal
signal after multiplying by cosine same frequency term
Demodulated Signal
Magnitude of Recived Signal
Magnitude of Multiplied Signal
Magnitude of Demodulated Signal

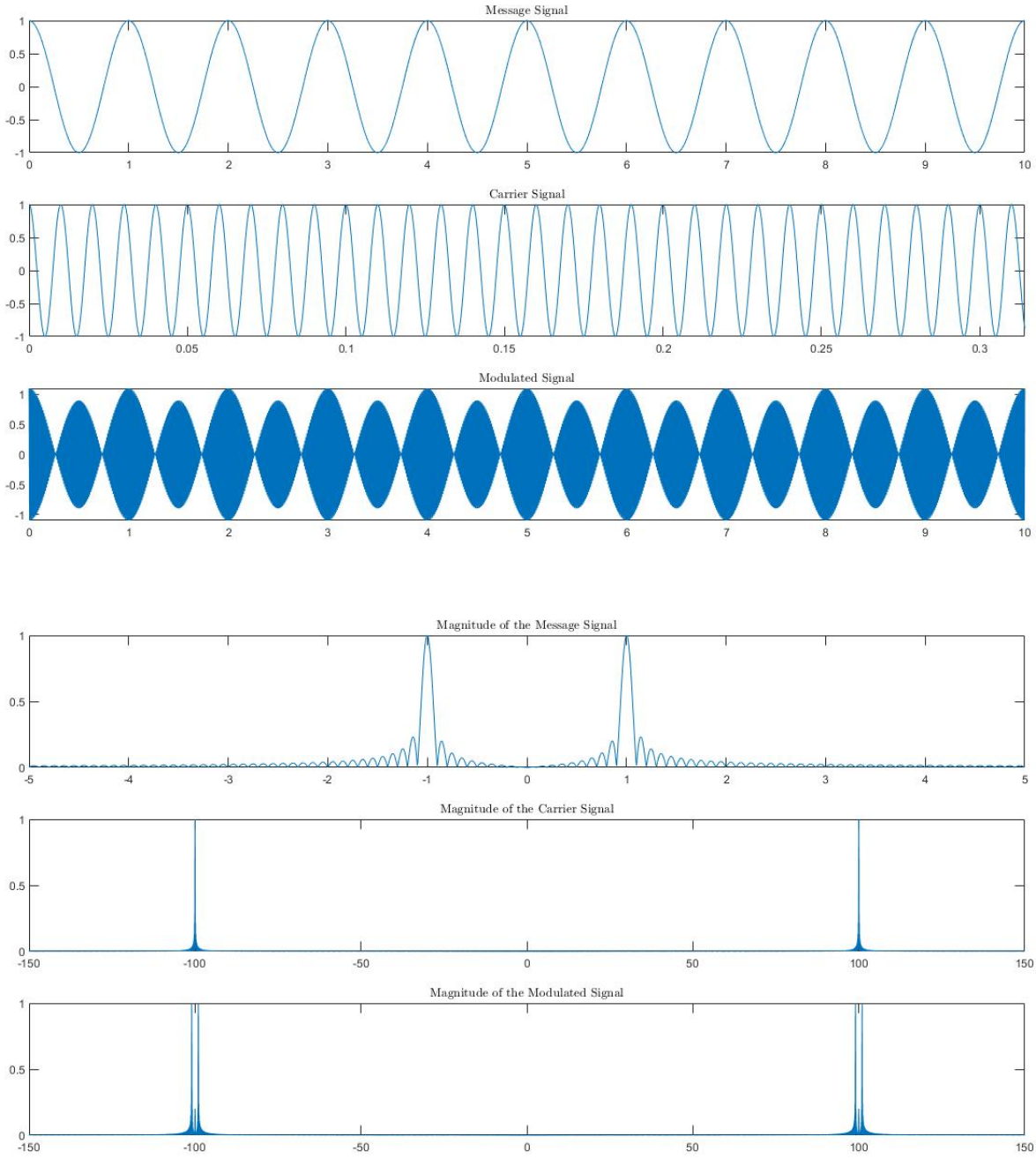
Conventioanl AM

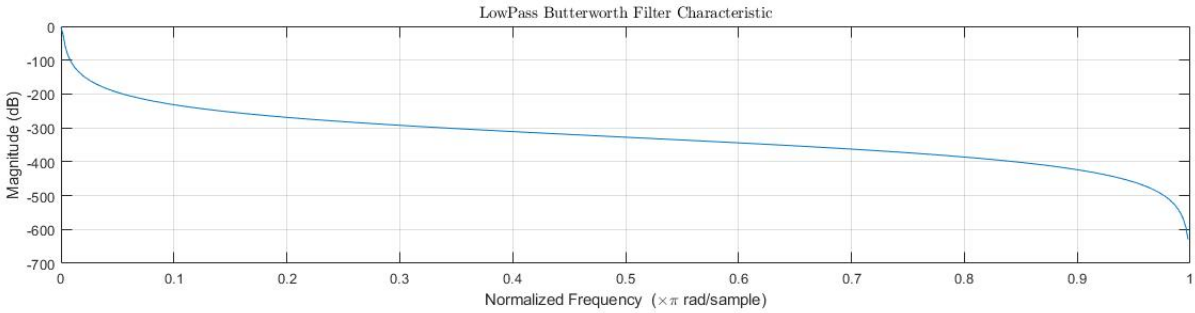


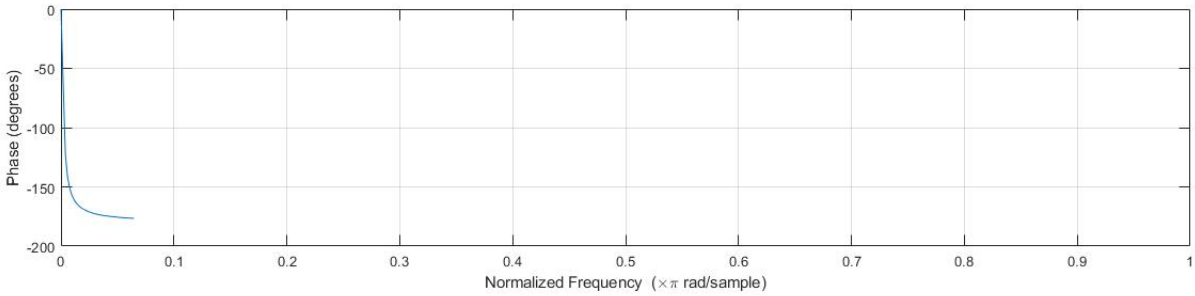

```
clear
clc
%%
%Moduation
%moduation index is equal to 0.1
ts=1e-4;
t=0:ts:10;
Ap=0.1;
Ac=1;
fc=100;
x=cos(2*pi*t);
c=Ac*cos(2*pi*fc*t);
u=c.*x+c*(Ap/Ac);
figure(1)
subplot(3,1,1)
plot(t,x)
title('Message Signal','interpreter','latex')
subplot(3,1,2)
plot(t,c)
xlim([0,2*pi*0.05])
title('Carrier Signal','interpreter','latex')
subplot(3,1,3)
plot(t,u)
title('Modulated Signal','interpreter','latex')
%%
%frequency domain analysis
figure(2)
```

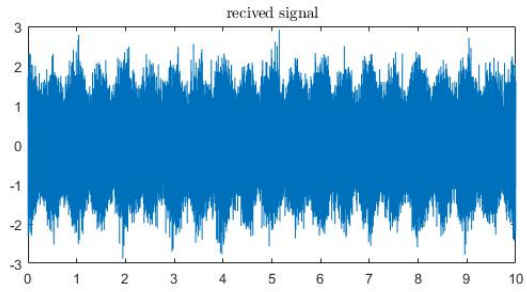
```
subplot(3,1,1)
[f1,X]=FT(x,ts);
plot(f1,abs(X)/max(abs(X)))
xlim([-5 5])
title('Magnitude of the Message Signal','interpreter','latex')
subplot(3,1,2)
[f2,C]=FT(c,ts);
plot(f2,abs(C)/max(abs(C)))
xlim([-150 150])
title('Magnitude of the Carrier Signal','interpreter','latex')
subplot(3,1,3)
[f3,U]=FT(u,ts);
plot(f3,abs(U)/max(abs(U)))
xlim([-150 150])
title('Magnitude of the Modulated Signal','interpreter','latex')
%%
%filter
fcut=5;                                    %3dB cut frequency
fs=10000;
[b,a] = butter(6,fcut/(fs/2),'low');     %lowpass butterworth filter definition
figure(3)
freqz(b,a)
title('LowPass Butterworth Filter Characteristic','interpreter','latex')
%%
%Demodulation
u=u+0.5*normrnd(0,1,1,length(t));
r=bandpass(u,[98,102],fs);
v=u.*r;
signal=filter(b,a,v);
figure(4)
subplot(2,2,1)
plot(t,u)
title('recived signal','interpreter','latex')
subplot(2,2,2)
plot(t,r)
title('The signal passed through the Narrowband Filter','interpreter','latex')
subplot(2,2,3)
plot(t,v)
title('Multiplication Signal','interpreter','latex')
subplot(2,2,4)
plot(t,signal)
title('Domodulated Signal','interpreter','latex')
%%
%frequency domain
[f1,U]=FT(u,ts);
[f2,R]=FT(r,ts);
[f3,V]=FT(v,ts);
[f4,S]=FT(signal,ts);
figure(5)
subplot(2,2,1)
plot(f1,abs(U)/max(abs(U)))
xlim([-150 150])
title('Magnitude of the Recived Signal','interpreter','latex')
subplot(2,2,2)
plot(f2,abs(R)/max(abs(R)))
xlim([-200 200])
```

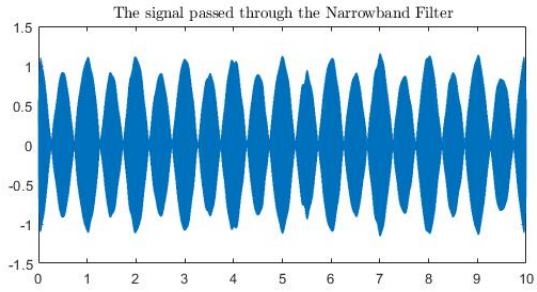
```
84 title('Magnitude of the signal passed through the narrowband filter','interpreter',
       'latex')
85 subplot(2,2,3)
86 plot(f3,abs(V)/max(abs(V)))
87 title('Magnitude of the Moltiplication Signal','interpreter','latex')
88 xlim([-250 250])
89 subplot(2,2,4)
90 plot(f4,abs(S)/max(abs(S)))
91 title('Magnitude of the Demodulated Signal','interpreter','latex')
92 xlim([-10 10])
```

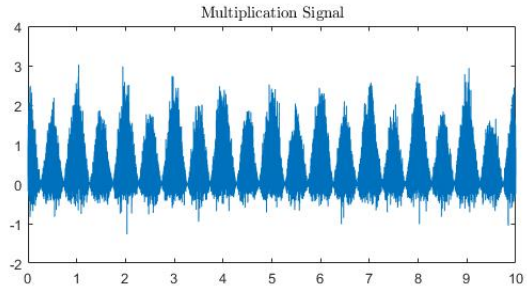


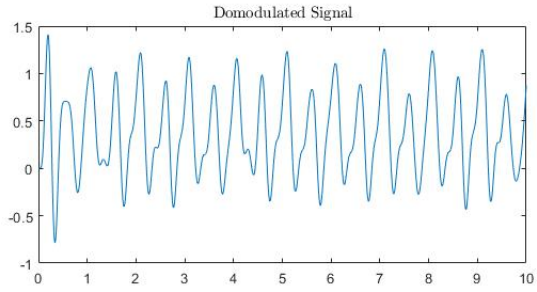

LowPass Butterworth Filter Characteristic
Magnitude (dB)
Normalized Frequency (×π rad/sample)

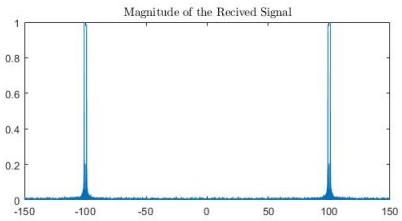

Phase (degrees)
Normalized Frequency (×π rad/sample)

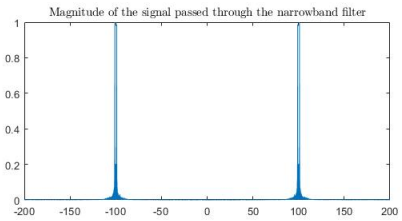

recived signal

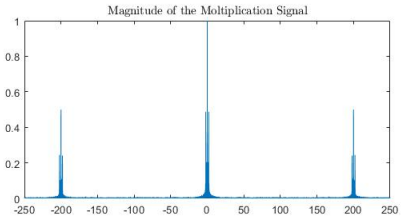

The signal passed through the Narrowband Filter

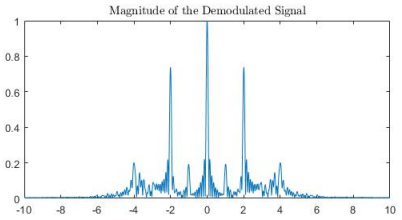

Multiplication Signal


Domodulated Signal

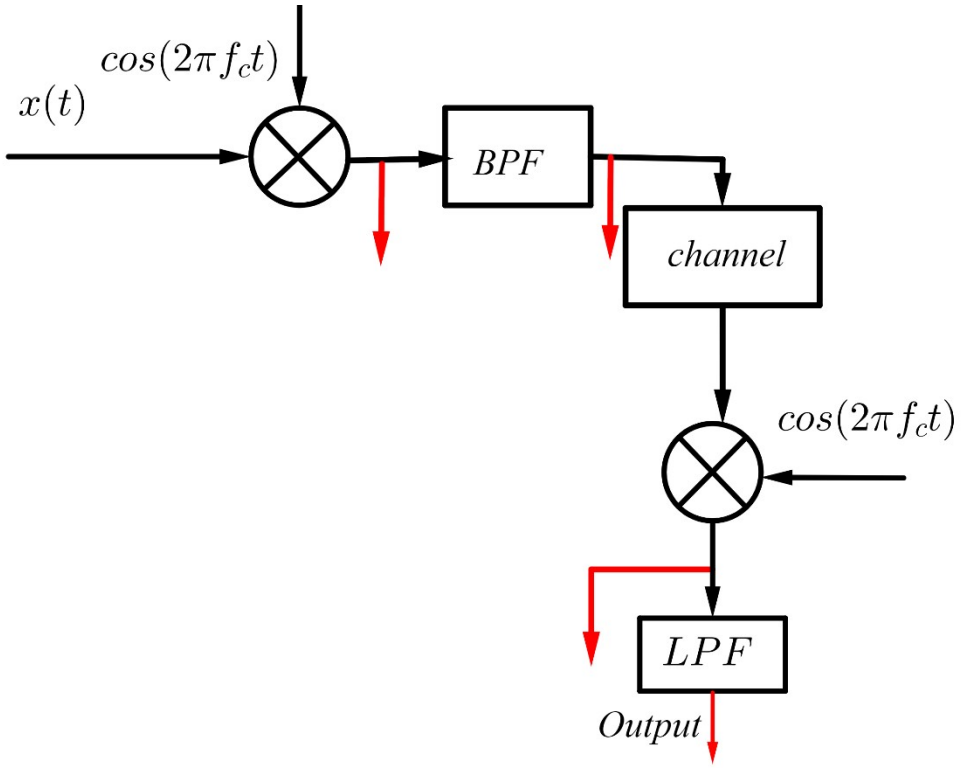

Magnitude of the Recived Signal


Magnitude of the signal passed through the narrowband filter


Magnitude of the Moltiplication Signal

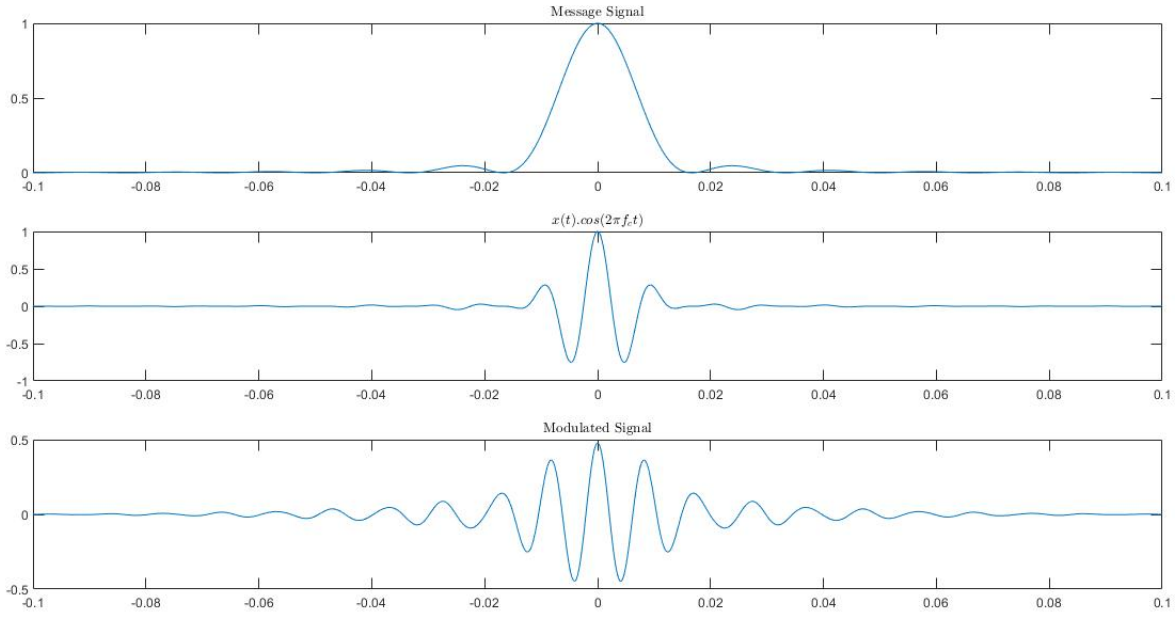

Magnitude of the Demodulated Signal

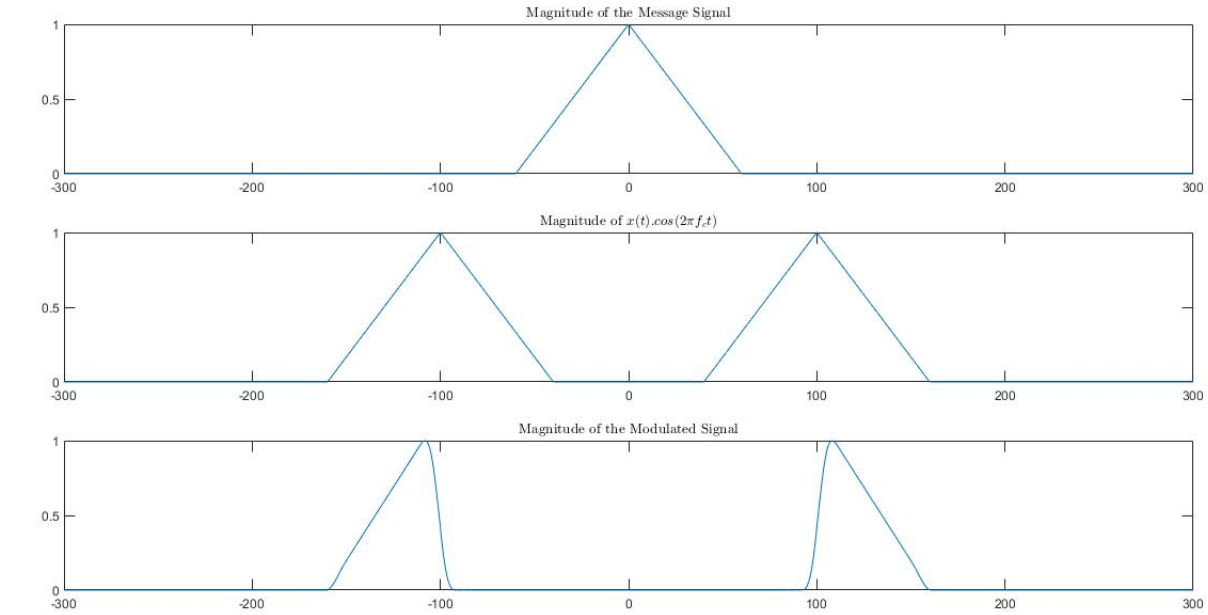
SSB

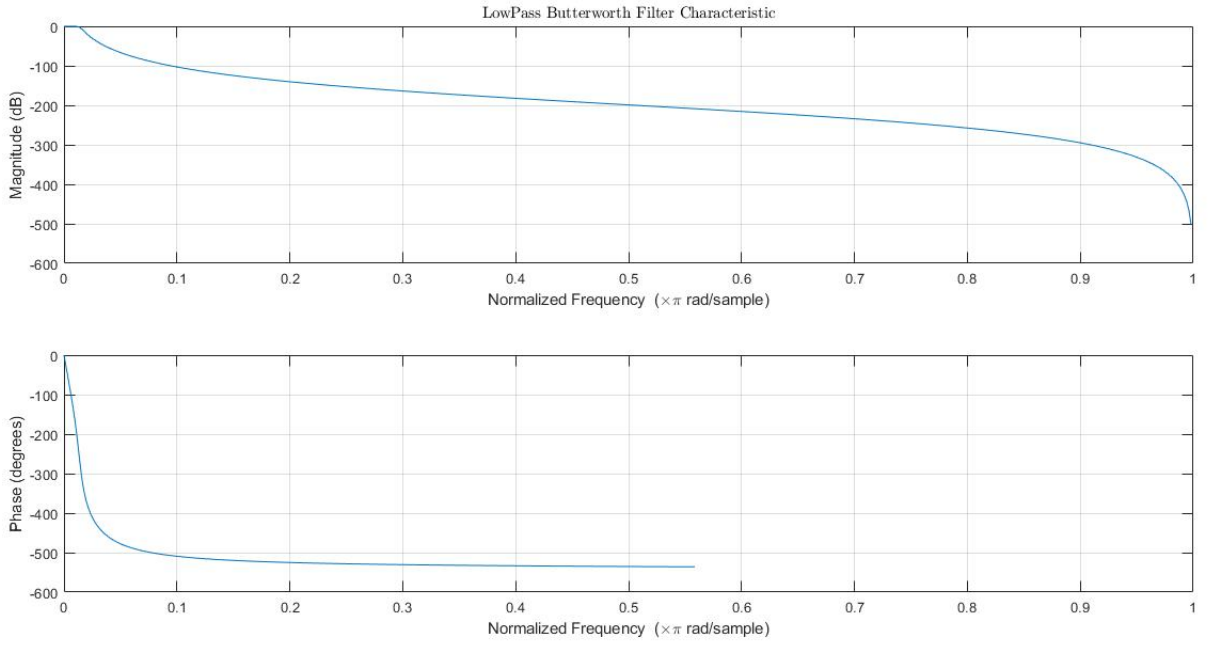

$cos(2\pi f_c t)$
$x(t)$
BPF
channel
$cos(2\pi f_c t)$
LPF
Output

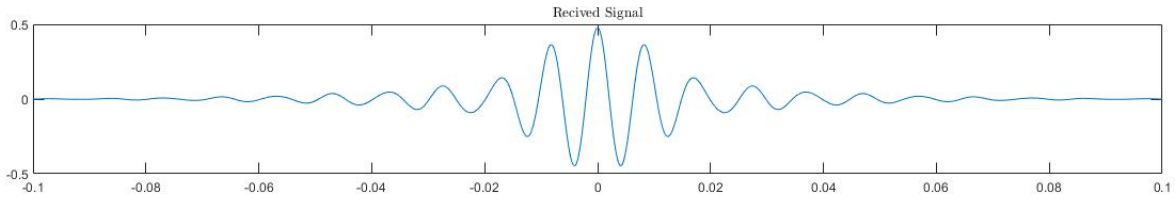
```
clear
clc
ts=1e-4;
fc=100;
t=-5:ts:5;
x=(sinc(60*t)).^2;
u=x.*cos(2*pi*fc*t);
r=bandpass(u,[110,150],1/ts);
figure(1)
subplot(3,1,1)
plot(t,x)
xlim([-0.1 0.1])
title('Message Signal','interpreter','latex')
subplot(3,1,2)
plot(t,u)
xlim([-0.1 0.1])
title('$x(t).cos(2\pi f_c t)$','interpreter','latex')
subplot(3,1,3)
plot(t,r)
xlim([-0.1 0.1])
title('Modulated Signal','interpreter','latex')
%%
%frequency analysis
[f1,X]=FT(x,1e-4);
[f2,U]=FT(u,1e-4);
[f3,R]=FT(r,1e-4);
figure(2)
subplot(3,1,1)
plot(f1,abs(X)/max(abs(X)))
title('Magnitude of the Message Signal','interpreter','latex')
xlim([-300 300])
subplot(3,1,2)
plot(f2,abs(U)/max(abs(U)))
title('Magnitude of $x(t).cos(2\pi f_c t)$','interpreter','latex')
xlim([-300 300])
subplot(3,1,3)
plot(f3,abs(R)/max(abs(R)))
title('Magnitude of the Modulated Signal','interpreter','latex')
xlim([-300 300])
%%
%filter
fcut=70;                                %3dB cut frequency
fs=10000;
[b,a] = butter(6,fcut/(fs/2),'low');    %lowpass butterworth filter definition
figure(3)
freqz(b,a)
title('LowPass Butterworth Filter Characteristic','interpreter','latex')
%%
%Demodulation
r=r+0*normrnd(0,1,1,length(t));
v=r.*cos(2*pi*fc*t);
signal=filter(b,a,v);
figure(4)
subplot(3,1,1)
plot(t,r)
xlim([-0.1 0.1])
```

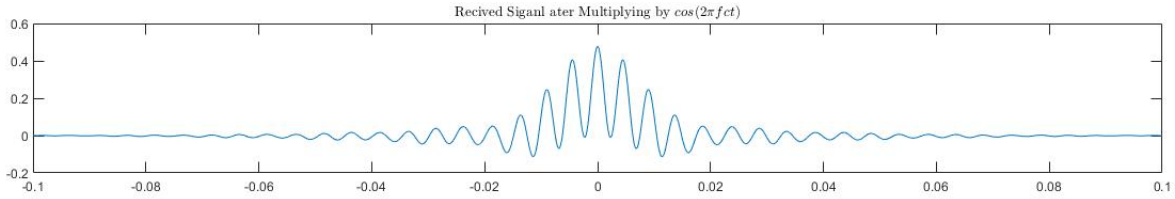
```
57 title('Recived Signal','interpreter','latex')
58 subplot(3,1,2)
59 plot(t,v)
60 xlim([-0.1 0.1])
61 title('Recived Siganl ater Multiplying by $cos(2\pi fct)$','interpreter','latex')
62 subplot(3,1,3)
63 plot(t,signal)
64 xlim([-0.1 0.1])
65 title('Demodulated Siganl','interpreter','latex')
66 %%
67 %frequency domain analysis
68 [f1,R]=FT(r,ts);
69 [f2,V]=FT(v,ts);
70 [f3,S]=FT(signal,ts);
71 figure(5)
72 subplot(3,1,1)
73 plot(f1,abs(R)/max(abs(R)))
74 xlim([-300 300])
75 title('Magnitude of the Recived Signal','interpreter','latex')
76 subplot(3,1,2)
77 plot(f2,abs(V)/max(abs(V)))
78 xlim([-400 400])
79 title('Magnitude of the Recived Siganl ater Multiplying by $cos(2\pi fct)$','
      interpreter','latex')
80 subplot(3,1,3)
81 plot(f3,abs(S)/max(abs(S)))
82 title('Magnitude of the Demodulated Signal','interpreter','latex')
83 xlim([-80 80])
```

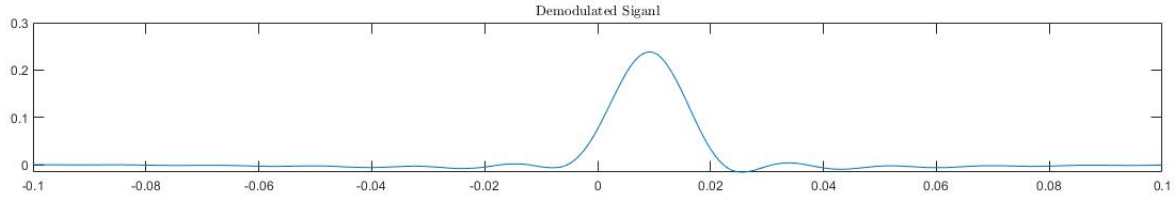


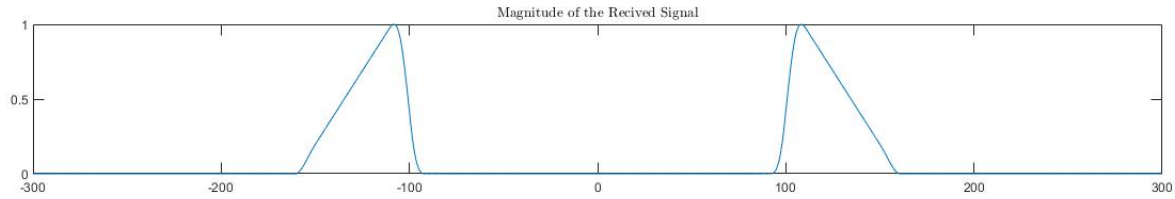

Magnitude of the Message Signal
Magnitude of $x(t).cos(2\pi f_c t)$
Magnitude of the Modulated Signal

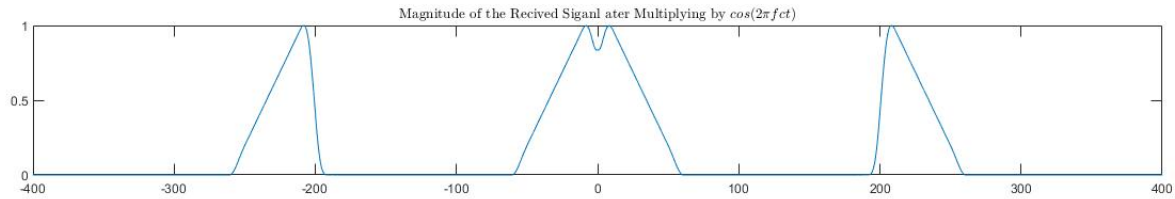

LowPass Butterworth Filter Characteristic
Magnitude (dB)
Normalized Frequency ($\times\pi$ rad/sample)
Phase (degrees)
Normalized Frequency ($\times\pi$ rad/sample)

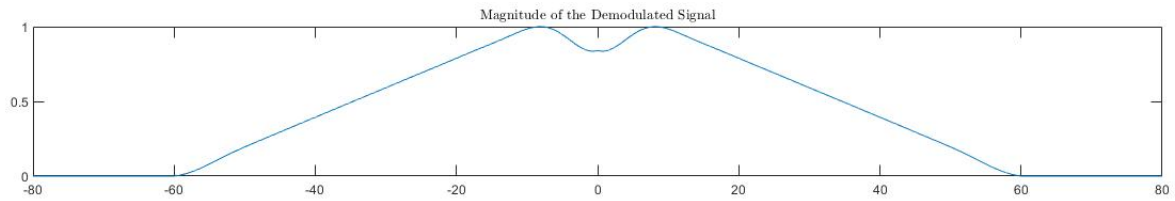

Recived Signal
0.5
0
-0.5
-0.1
-0.08
-0.06
-0.04
-0.02
0
0.02
0.04
0.06
0.08
0.1


Recived Siganl ater Multiplying by $cos(2\pi fct)$
0.6
0.4
0.2
0
-0.2
-0.1
-0.08
-0.06
-0.04
-0.02
0
0.02
0.04
0.06
0.08
0.1


Demodulated Siganl
0.3
0.2
0.1
0
-0.1
-0.08
-0.06
-0.04
-0.02
0
0.02
0.04
0.06
0.08
0.1


Magnitude of the Recived Signal
1
0.5
0
-300
-200
-100
0
100
200
300


Magnitude of the Recived Siganl ater Multiplying by $cos(2\pi fct)$
1
0.5
0
-400
-300
-200
-100
0
100
200
300
400


Magnitude of the Demodulated Signal
1
0.5
0
-80
-60
-40
-20
0
20
40
60
80