Analog final lab assignment

ID	NAME
6338	Ahmed Mohamed ahmed ali
6071	Ahmed Wael Mohamed
6297	Adel Ashraf Mohamed
6160	Mazen Medhat Farid
6646	Ahmed Tarek Ahmed
4629	Mahmoud Osama

Experiment 1:

Code:

```
clc
clear
close all
```

Read the audio file and get its sampling frequency

```
[y, F] = audioread('eric.wav');
ty = length(y)/F;
t = linspace(0, ty, length(y));
```

Input signal conversion to frequency domain (to apply ideal LPF)

```
z = fftshift(fft(y));
f = linspace(-F/2, F/2, length(y));
figure
plot(f, abs(z),'g');
title('Original Signal in Frequency Domain');
```

generate ideal filter

```
% Searching for indices where f = -4000 and f = 4000
for i = 1:length(f)
    if (abs((f(i)+4.0000e+3)) < 0.01)
        index1 = i;
    end
    if (abs((f(i)-4.0000e+3)) < 0.01)
        index2 = i;
        break;
    end
end


% Generating a rect from index1 to index2
range = index2-index1;
step = [zeros(1, index1) ones(1, range) zeros(1, length(f)-index2)];
step = step.';
```

Multiplying input signal by rect to eliminate frequencies other than 4k

```
yfilteredFreq = step.*z;
yfilteredFreqAbs = abs(step.*z);


figure
plot(f, yfilteredFreqAbs,'g');
xlim([-15000 15000]);
title('Filtered Signal in Frequency Domain');


% Converting the filtered signal to time domain to be modulated
yfiltered = ifft(fftshift(yfilteredFreq));
figure
plot(t, yfiltered,'r');
title('Filtered Signal in Time Domain');


% Signal after low pass filter
sound(yfiltered, F);
pause(9);
```

Filtered signal resampling

```
maxAmplitude = max(yfiltered);
yfiltered = resample(yfiltered, 500000, F);
yfiltered = yfiltered.';
interval = length(yfiltered);
```

DSB-SC Modulation and Demodulation

Modulation

```
t = linspace(0, ty, interval);
dsbsc = 5*cos(2*pi*100000*t).*yfiltered;
figure
plot(t, dsbsc,'r');
title('Modulted DSB-SC Signal in Time Domain');
zmsc = abs(fftshift(fft(dsbsc)));
fmsc = linspace(-500000/2, 500000/2, length(dsbsc));
figure
plot(fmsc, zmsc,'g');
xlim([-150000 150000]);
ylim([0 300]);
title('Modulated DSB-SC Signal in Frequency Domain');
```

Demodulation

```
dsbscEnvelope = abs(hilbert(dsbsc));
dsbscEnvelope = resample(dsbscEnvelope, F, 500000);
t = 0:1/F:length(dsbscEnvelope)/(F);
t = t(1:end-1);
figure
plot(t, dsbscEnvelope,'r');
title('Demodulted DSB-SC Signal in Time Domain');
zdsc = abs(fftshift(fft(dsbscEnvelope)));
fdsc = linspace(-F/2, F/2, length(dsbscEnvelope));
figure
plot(fdsc, zdsc,'g');
xlim([-8000 8000]);
ylim([0 1500]);
title('Demodulated DSB-SC Signal in Frequency Domain');
sound(dsbscEnvelope, F);
pause(9);
```

Coherent detection

```
dsbsc0 = awgn(dsbsc,0);
dsbsc10 = awgn(dsbsc,10);
dsbsc30 = awgn(dsbsc,30);
t = linspace(0, ty, length(dsbsc));
vpe = dsbsc.*cos((2*pi*100000*t) + deg2rad(20));
vfe = dsbsc.*cos(2*pi*100100*t);
v0 = dsbsc0.*cos(2*pi*100000*t);
v10 = dsbsc10.*cos(2*pi*100000*t);
v30 = dsbsc30.*cos(2*pi*100000*t);
v0 = resample(v0, F, 500000);
v10 = resample(v10, F, 500000);
v30 = resample(v30, F, 500000);
vpe = resample(vpe, F, 500000);
vfe = resample(vfe, F, 500000);
zsc0 = fftshift(fft(v0));
zsc10 = fftshift(fft(v10));
zsc30 = fftshift(fft(v30));
zscpe = fftshift(fft(vpe));
zscfe = fftshift(fft(vfe));
fsc = linspace(-F/2, F/2, length(v0));
for i = 1:length(fsc)
    if (abs((fsc(i)+4.0000e+3)) < 0.01)
        index1 = i;
    end
    if (abs((fsc(i)-4.0000e+3)) < 0.01)
        index2 = i;
        break;
    end
end
```

```
range = index2-index1;
step = [zeros(1, index1) ones(1, range) zeros(1, length(fsc)-(index2))];
dsbscCoherent0 = step.*zsc0;
dsbscCoherent10 = step.*zsc10;
dsbscCoherent30 = step.*zsc30;
dsbscCoherentpe = step.*zscpe;
dsbscCoherentfe = step.*zscfe;
figure
plot(fsc, abs(dsbscCoherent0),'g');
title('Demodulated DSB-SC Signal using Coherent Detection with SNR = 0 in
Frequency Domain');
xlim([-8000 8000]);
figure
plot(fsc, abs(dsbscCoherent10),'g');
title('Demodulated DSB-SC Signal using Coherent Detection with SNR = 10 in
Frequency Domain');
xlim([-8000 8000]);
figure
plot(fsc, abs(dsbscCoherent30),'g');
title('Demodulated DSB-SC Signal using Coherent Detection with SNR = 30 in
Frequency Domain');
xlim([-8000 8000]);
figure
plot(fsc, abs(dsbscCoherentpe),'g');
title('Demodulated DSB-SC Signal using Coherent Detection with Phase Error = 20
in Frequency Domain');
xlim([-8000 8000]);
figure
plot(fsc, abs(dsbscCoherentfe),'g');
title('Demodulated DSB-SC Signal using Coherent Detection with Frequency Error =
100 HZ in Frequency Domain');
xlim([-8000 8000]);
dsbscCoherentTime0 = ifft(fftshift(dsbscCoherent0));
dsbscCoherentTime10 = ifft(fftshift(dsbscCoherent10));
dsbscCoherentTime30 = ifft(fftshift(dsbscCoherent30));
dsbscCoherentTimepe = ifft(fftshift(dsbscCoherentpe));
dsbscCoherentTimefe = ifft(fftshift(dsbscCoherentfe));
t = linspace(0, ty, length(dsbscCoherentTime0));
figure
plot(t, abs(dsbscCoherentTime0),'r');
title('Demodulated DSB-SC Signal using Coherent Detection with SNR = 0 in Time
Domain');
sound(abs(dsbscCoherentTime0), F);
pause(9);
figure
plot(t, abs(dsbscCoherentTime10),'r');
title('Demodulated DSB-SC Signal using Coherent Detection with SNR = 10 in Time
Domain');
sound(abs(dsbscCoherentTime10), F);
```

```
pause(9);
figure
plot(t, abs(dsbscCoherentTime30),'r');
title('Demodulated DSB-SC Signal using Coherent Detection with SNR = 30 in Time
Domain');
sound(abs(dsbscCoherentTime30), F);
pause(9);
figure
plot(t, abs(dsbscCoherentTimepe),'r');
title('Demodulated DSB-SC Signal using Coherent Detection with Phase Error = 20
in Time Domain');
sound(abs(dsbscCoherentTimepe), F);
pause(9);
figure
plot(t, abs(dsbscCoherentTimefe),'g');
title('Demodulated DSB-SC Signal using Coherent Detection with Frequency Error =
100 HZ in Time Domain');
sound(abs(dsbscCoherentTimefe), F);
pause(9);
```

DSB-TC Modulation and Demodulation

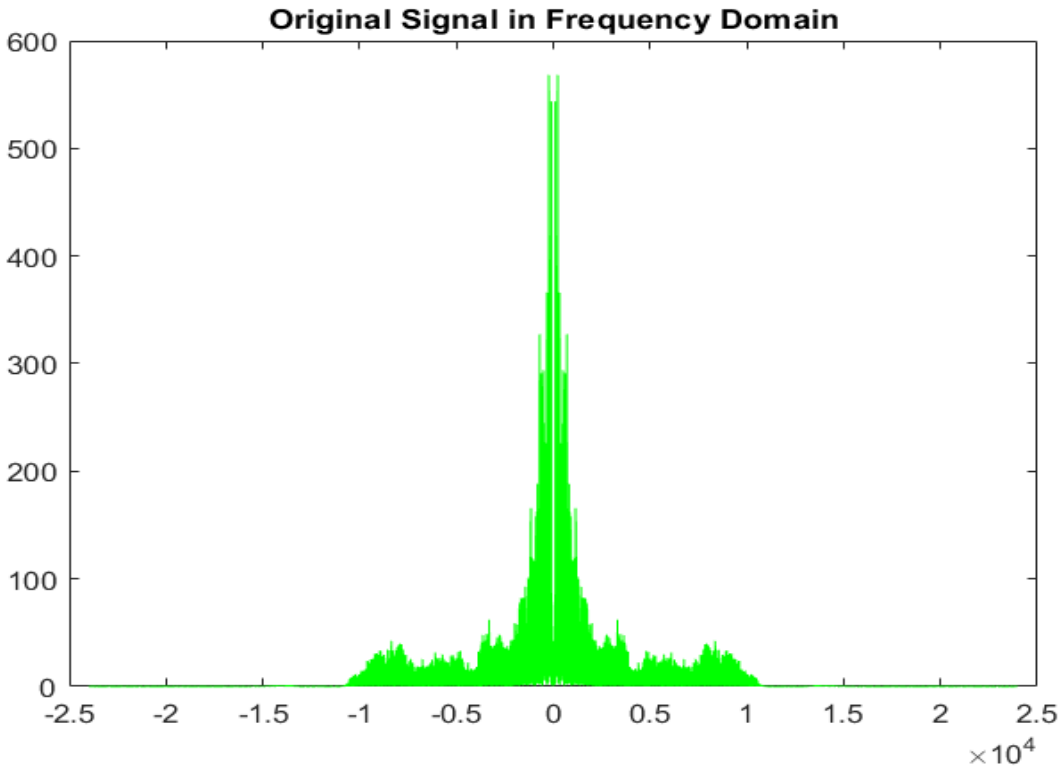
Modulation

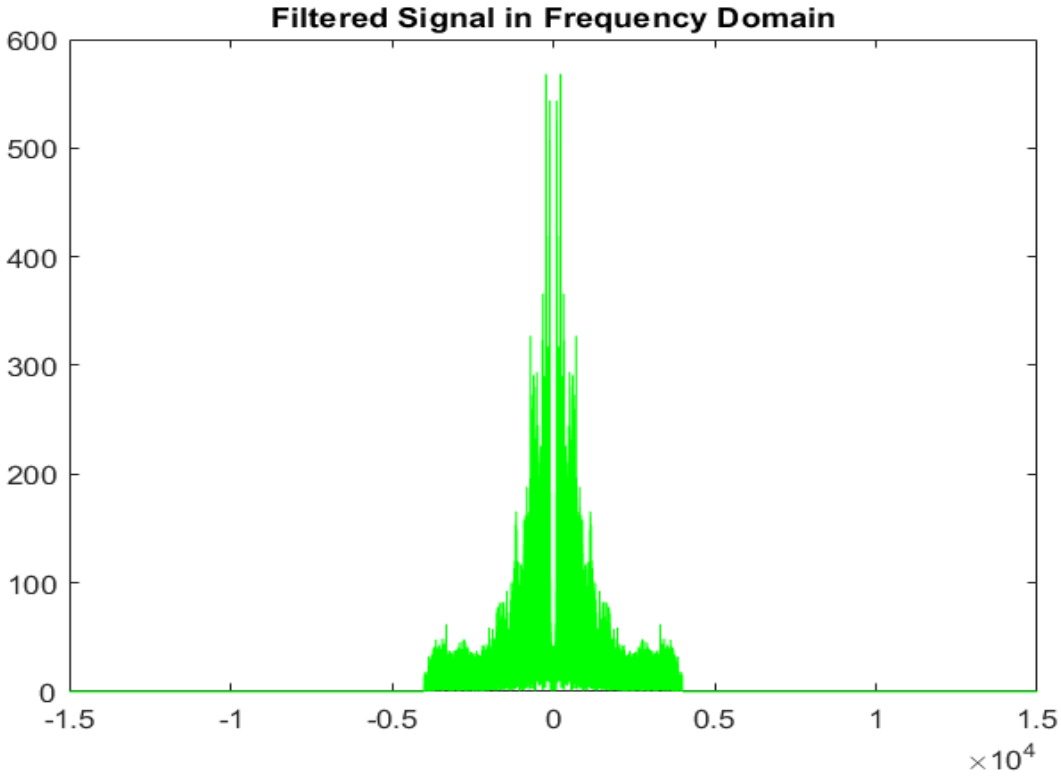
```
t = linspace(0, ty, interval);
dsbtc =
2.*maxAmplitude.*(1+(0.5/maxAmplitude).*yfiltered).*cos(2.*pi.*100000.*t);
figure
plot(t, dsbtc,'r');
title('Modulted DSB-TC Signal in Time Domain');
zmtc = abs(fftshift(fft(dsbtc)));
fmtc = linspace(-500000/2, 500000/2, length(dsbtc));
figure
plot(fmtc, zmtc,'g');
xlim([-150000 150000]);
ylim([0 1000]);
title('Modulated DSB-TC Signal in Frequency Domain');
```

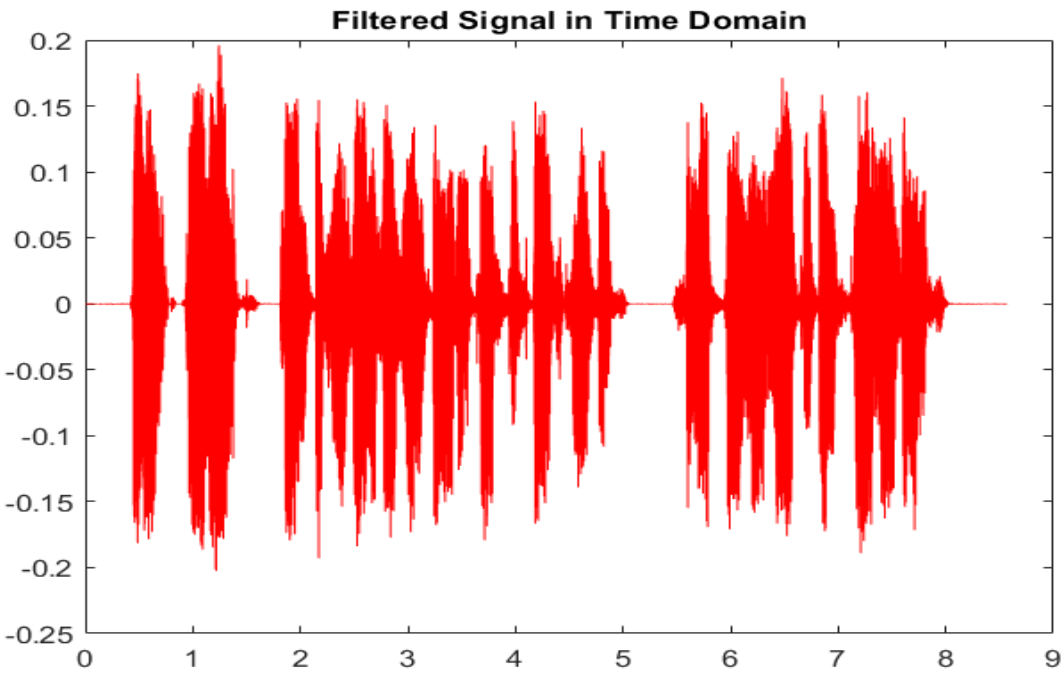
Demodulation

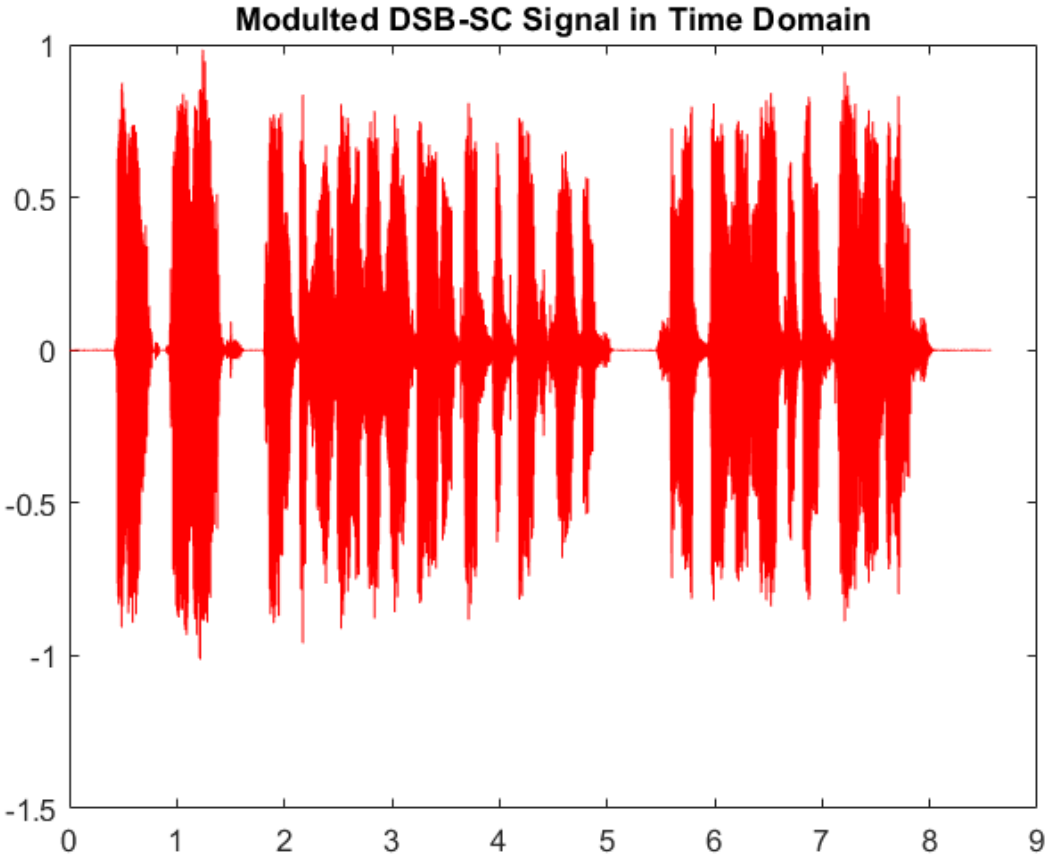
```
dsbtcEnvelope = abs(hilbert(dsbtc));
dsbtcEnvelope = resample(dsbtcEnvelope, F, 500000);
dsbtcEnvelope=dsbtcEnvelope-mean(dsbtcEnvelope);
t = 0:1/F:length(dsbtcEnvelope)/(F);
t = t(1:end-1);
figure
plot(t, dsbtcEnvelope,'r');
title('Demodulted DSB-TC Signal in Time Domain');
zdtc = abs(fftshift(fft(dsbtcEnvelope)));
fdtc = linspace(-F/2, F/2, length(dsbtcEnvelope));
figure
plot(fdtc, zdtc,'g');
xlim([-8000 8000]);
ylim([0 1000]);
title('Demodulated DSB-TC Signal in Frequency Domain');
sound(dsbtcEnvelope, F);
```

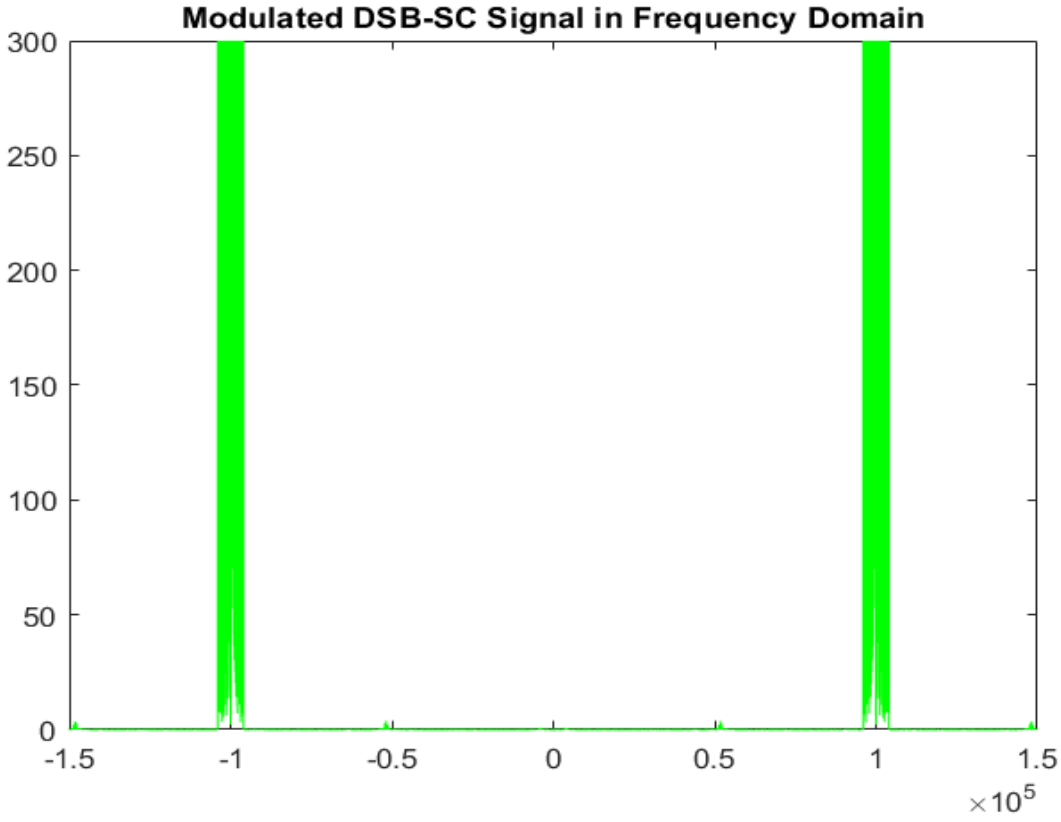
output:

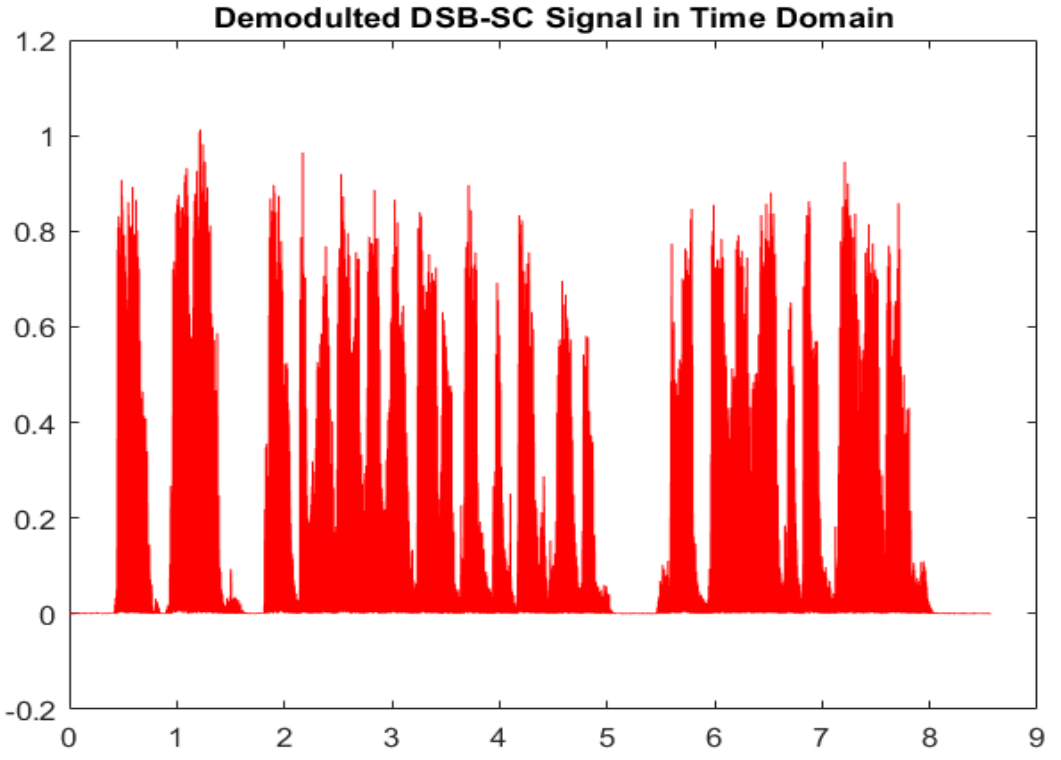

Original Signal in Frequency Domain
600
500
400
300
200
100
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
×10^4

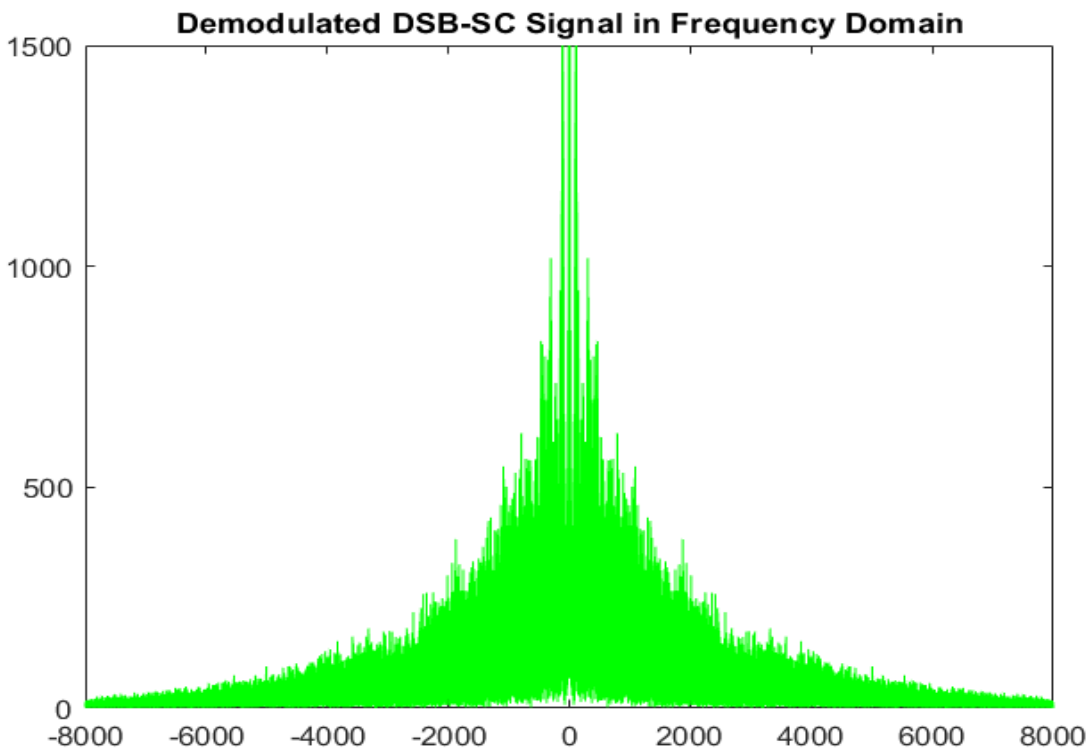

Filtered Signal in Frequency Domain
600
500
400
300
200
100
0
-1.5
-1
-0.5
0
0.5
1
1.5
×10^4

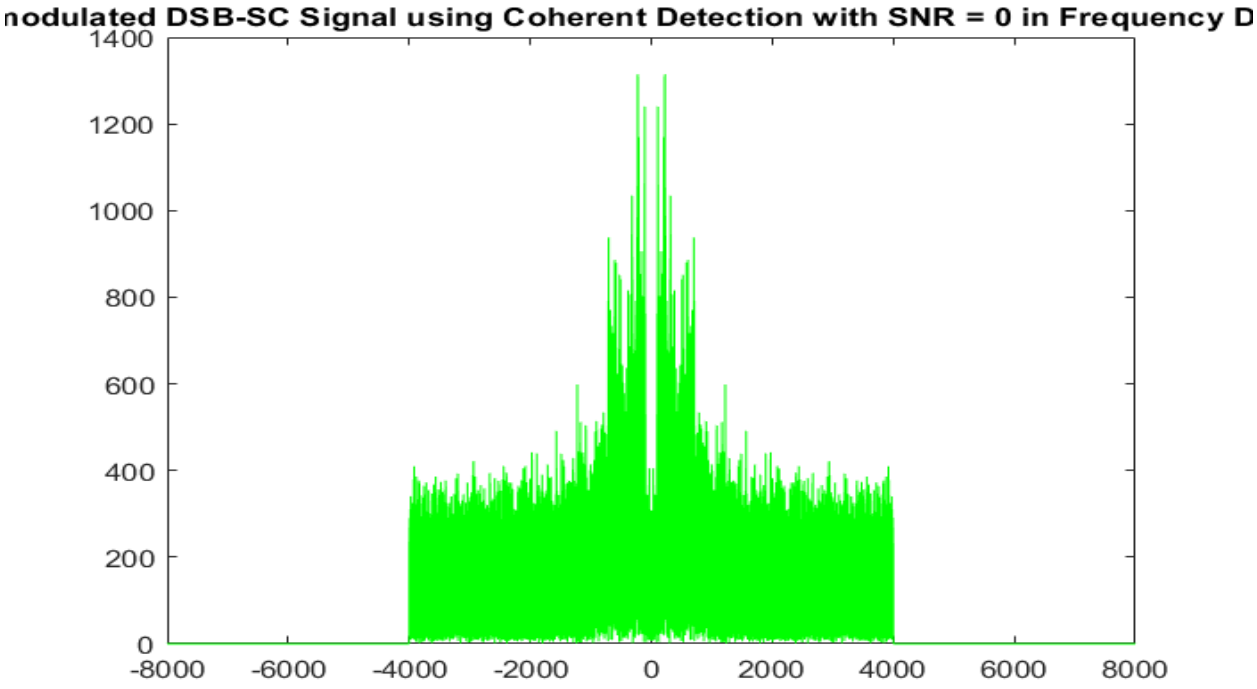

Filtered Signal in Time Domain
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
1
2
3
4
5
6
7
8
9

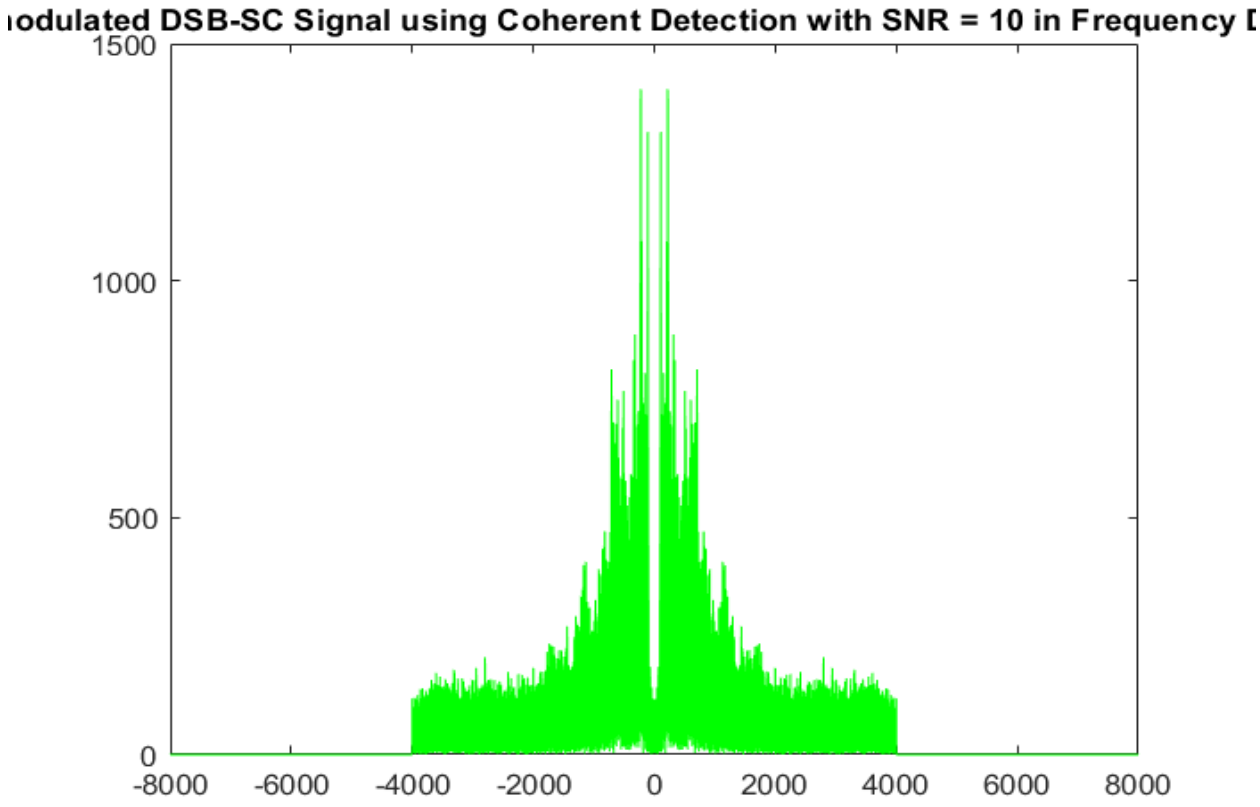

Modulted DSB-SC Signal in Time Domain
1
0.5
0
-0.5
-1
-1.5
0
1
2
3
4
5
6
7
8
9

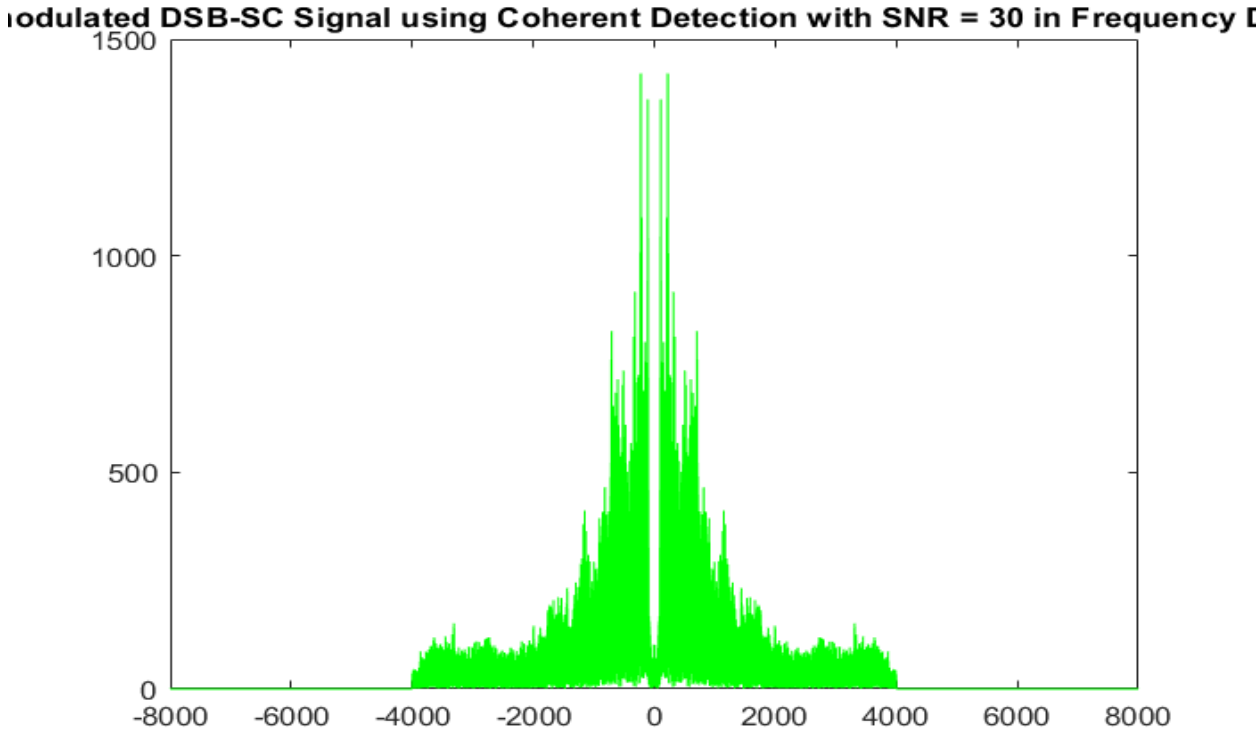

Modulated DSB-SC Signal in Frequency Domain
300
250
200
150
100
50
0
-1.5
-1
-0.5
0
0.5
1
1.5
×10^5

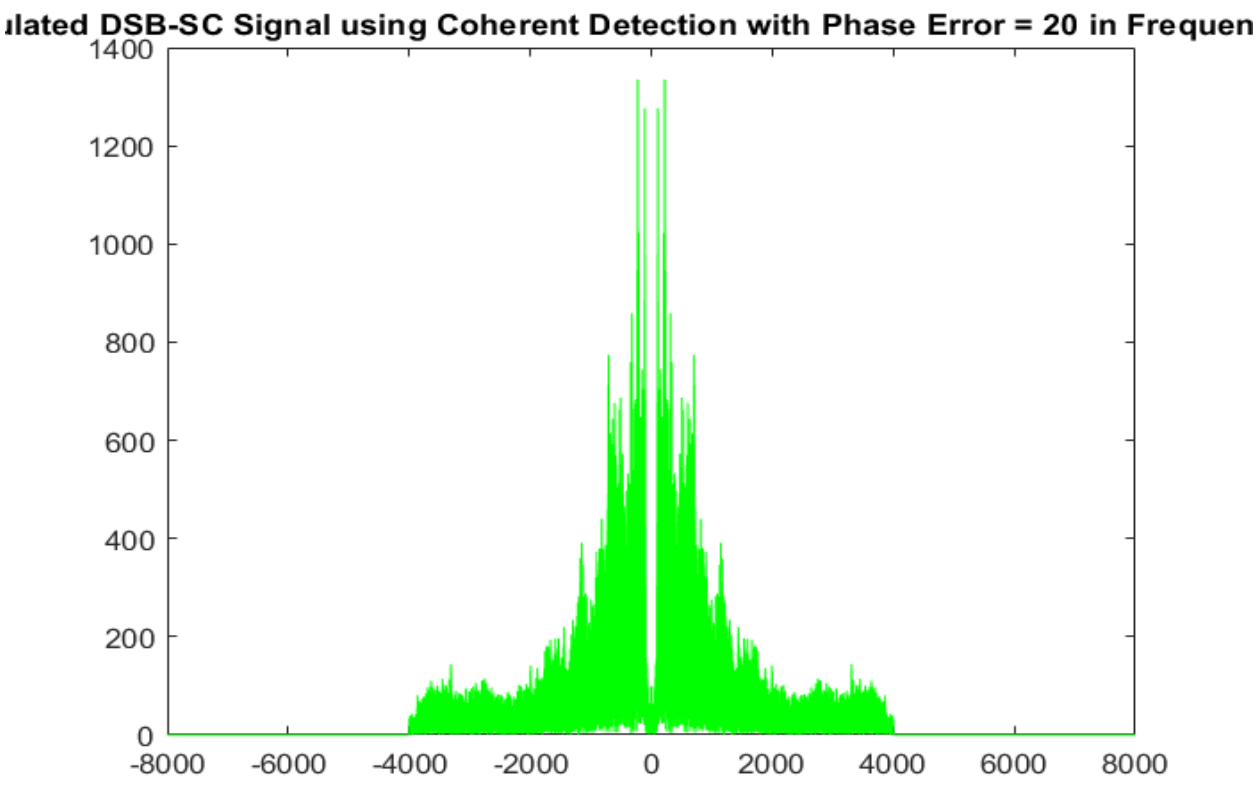

Demodulted DSB-SC Signal in Time Domain
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
1
2
3
4
5
6
7
8
9

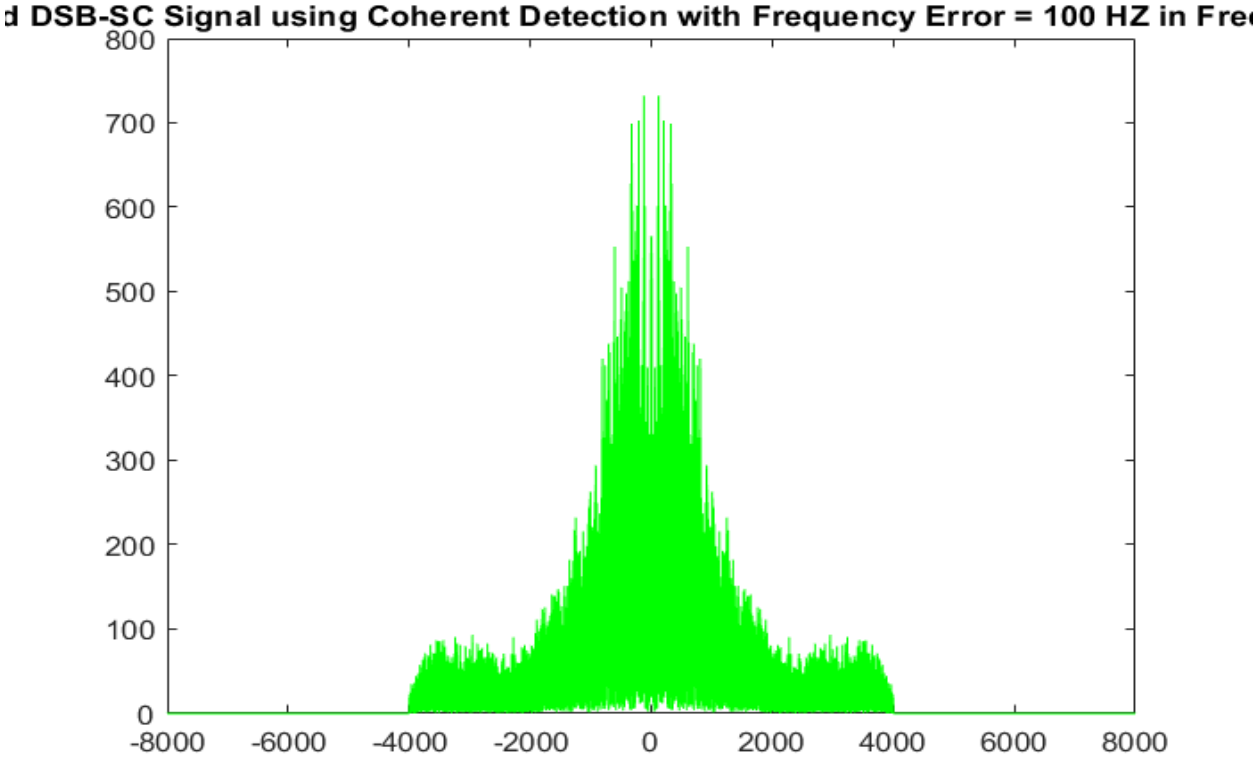

Demodulated DSB-SC Signal in Frequency Domain
1500
1000
500
0
-8000
-6000
-4000
-2000
0
2000
4000
6000
8000

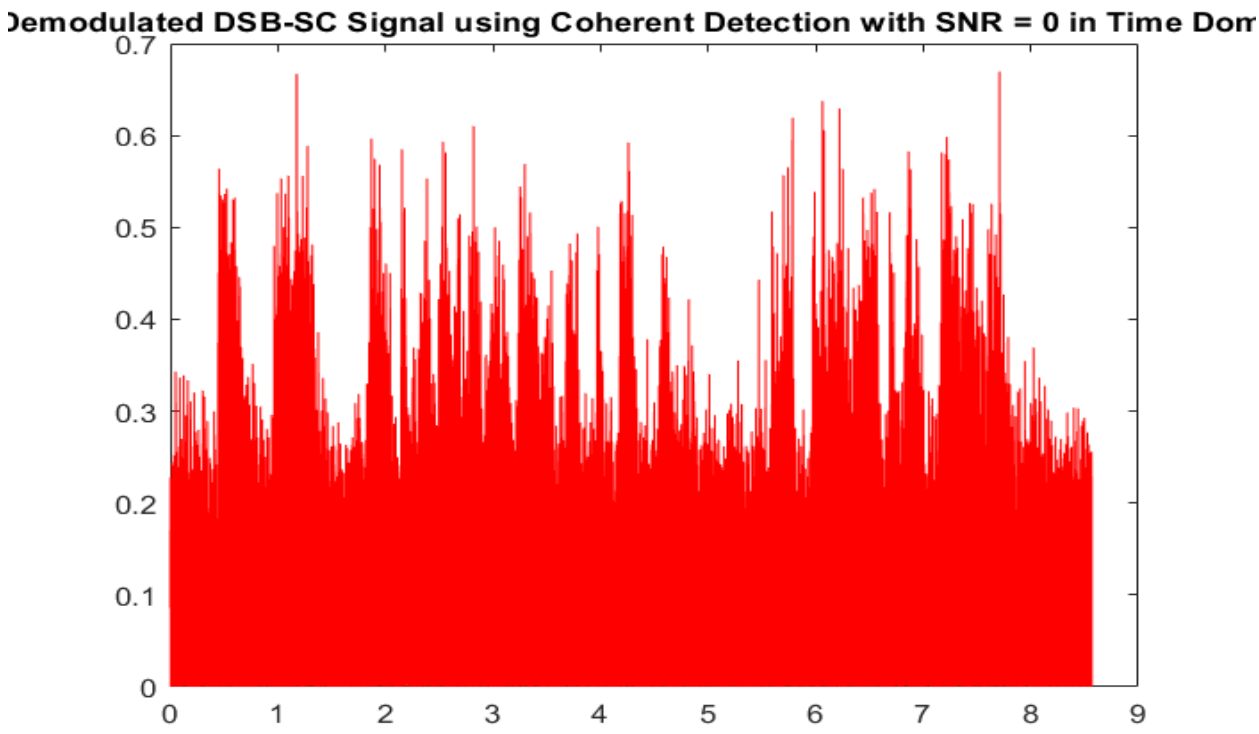

nodulated DSB-SC Signal using Coherent Detection with SNR = 0 in Frequency D
1400
1200
1000
800
600
400
200
0
-8000
-6000
-4000
-2000
0
2000
4000
6000
8000

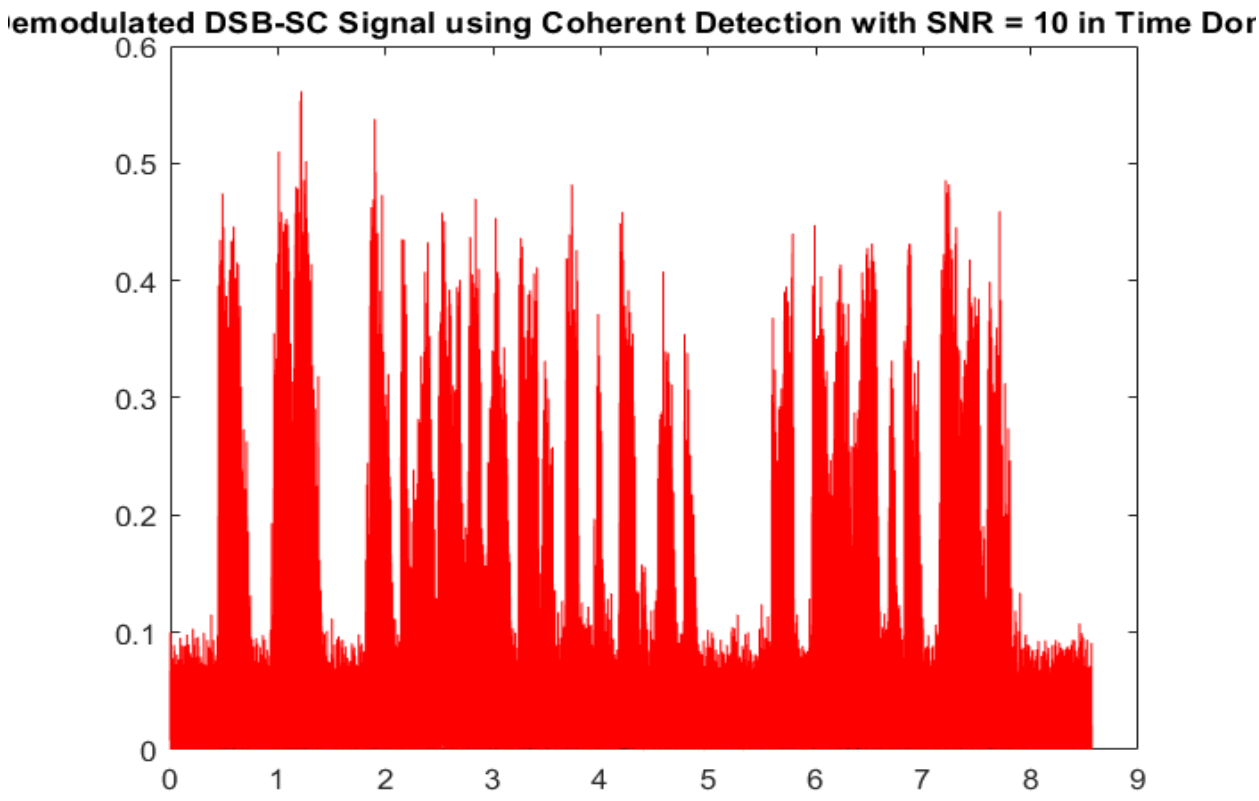

odulated DSB-SC Signal using Coherent Detection with SNR = 10 in Frequency D
1500
1000
500
0
-8000
-6000
-4000
-2000
0
2000
4000
6000
8000

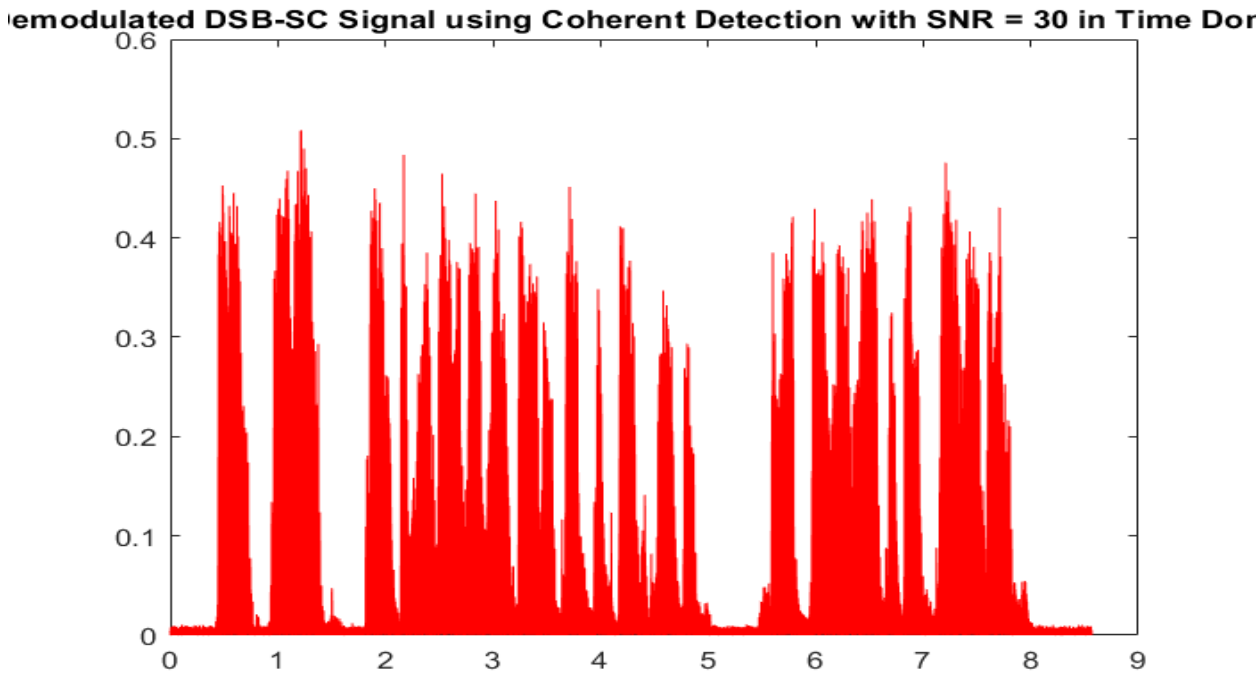

odulated DSB-SC Signal using Coherent Detection with SNR = 30 in Frequency D
1500
1000
500
0
-8000
-6000
-4000
-2000
0
2000
4000
6000
8000

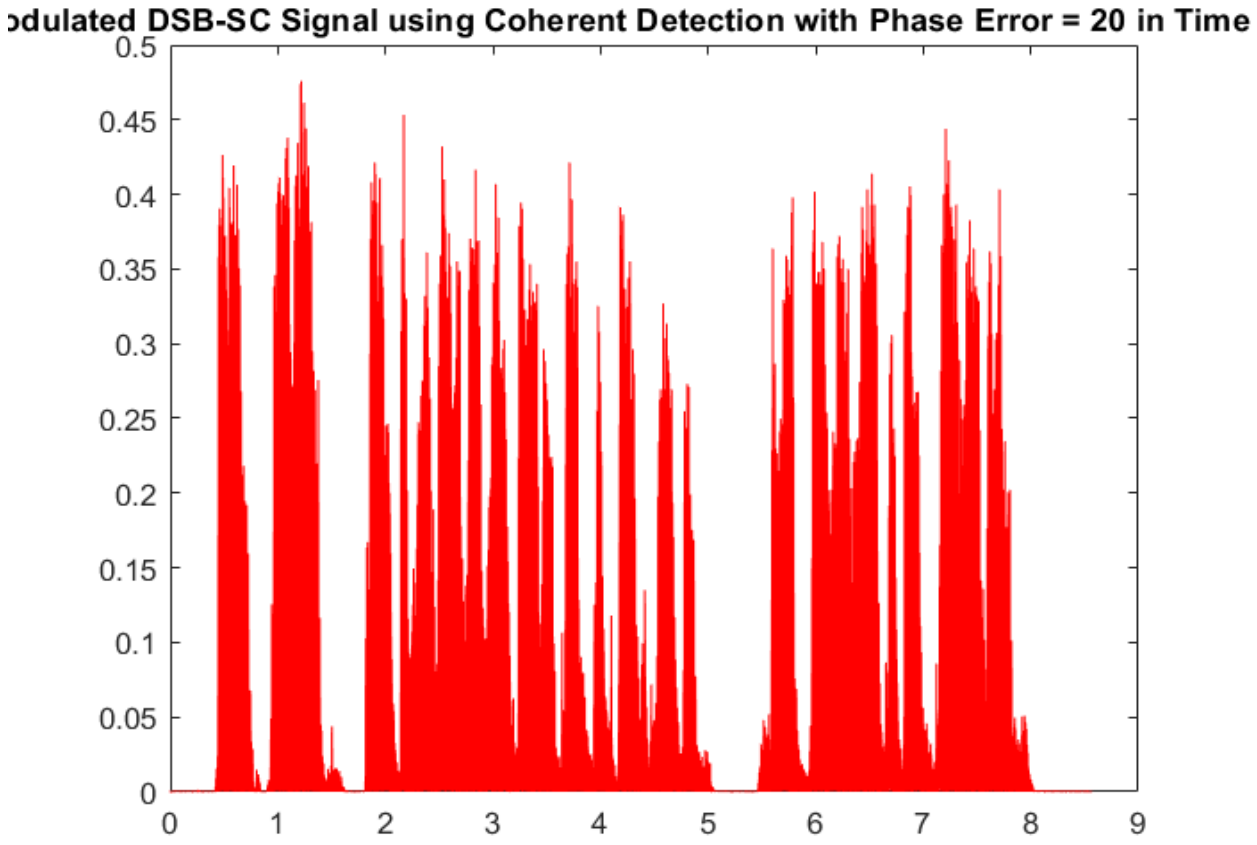

ılated DSB-SC Signal using Coherent Detection with Phase Error = 20 in Frequen
1400
1200
1000
800
600
400
200
0
-8000
-6000
-4000
-2000
0
2000
4000
6000
8000

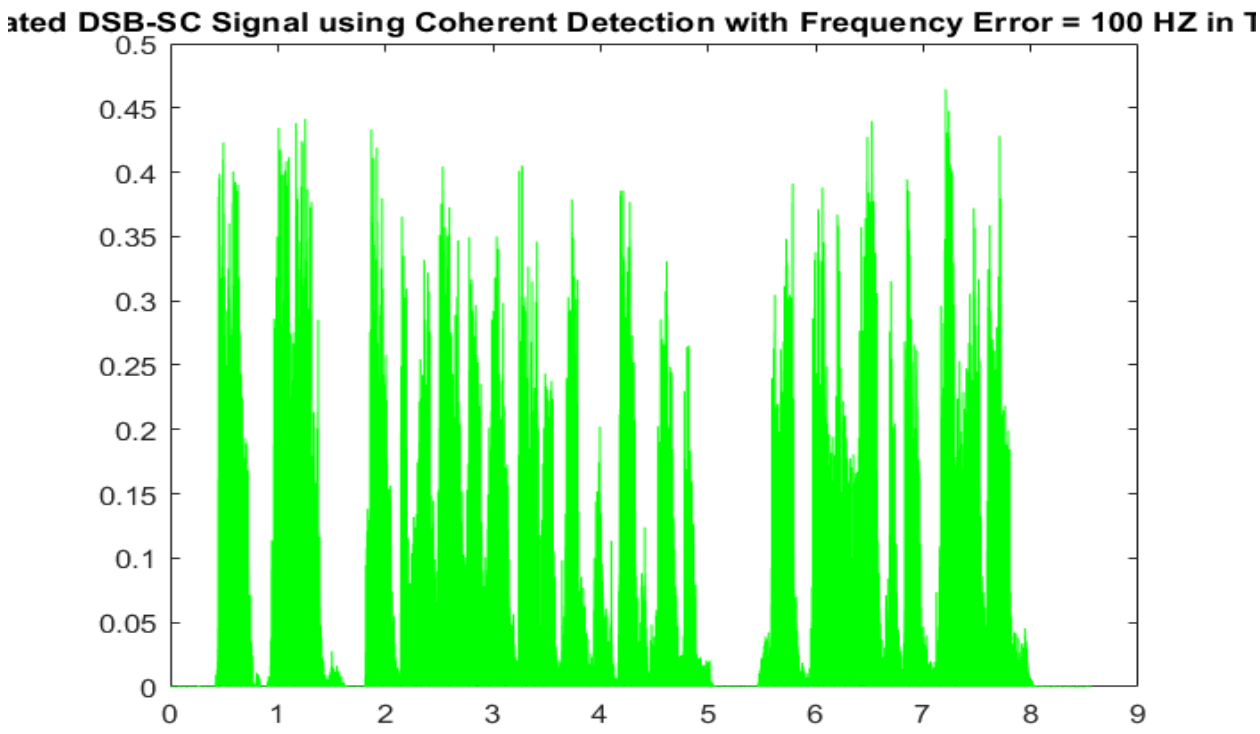

d DSB-SC Signal using Coherent Detection with Frequency Error = 100 HZ in Fre
800
700
600
500
400
300
200
100
0
-8000
-6000
-4000
-2000
0
2000
4000
6000
8000

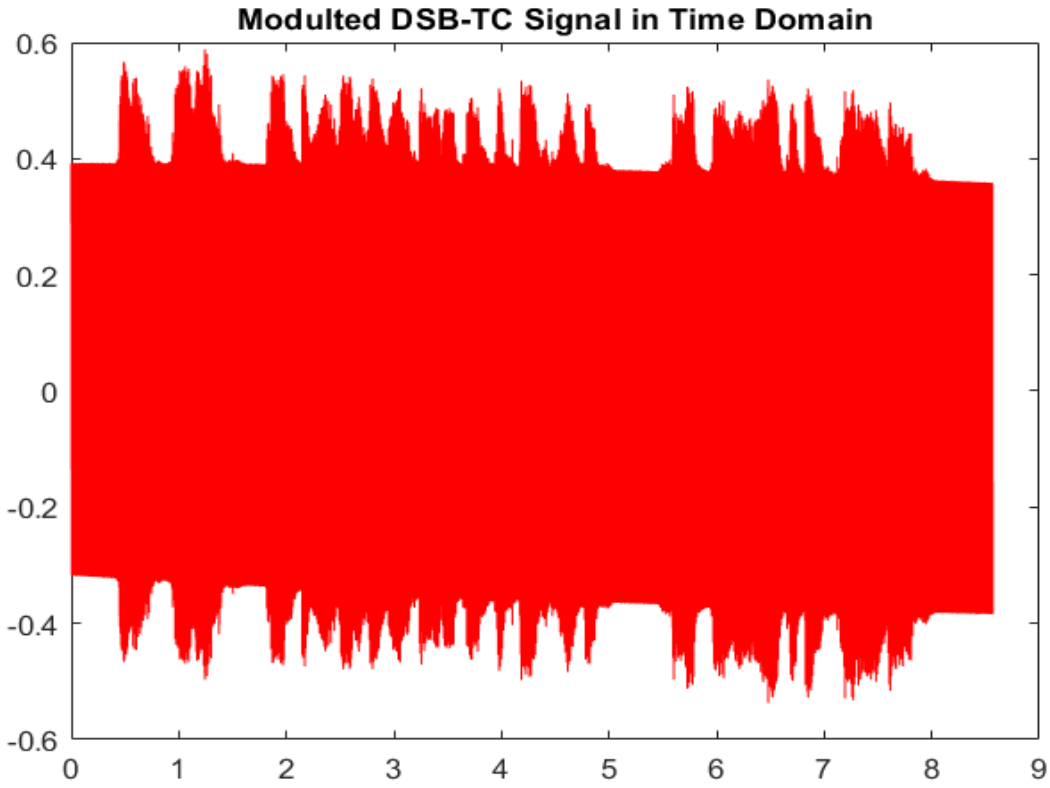

Demodulated DSB-SC Signal using Coherent Detection with SNR = 0 in Time Dom
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9

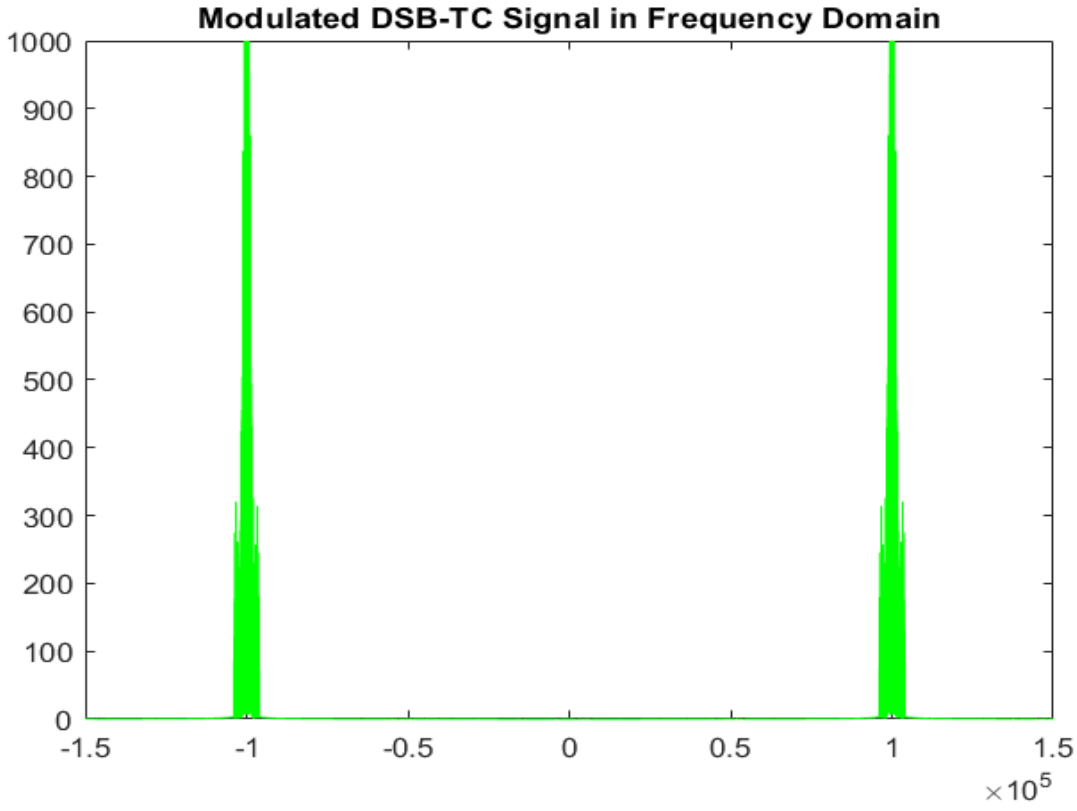

emodulated DSB-SC Signal using Coherent Detection with SNR = 10 in Time Dor
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9

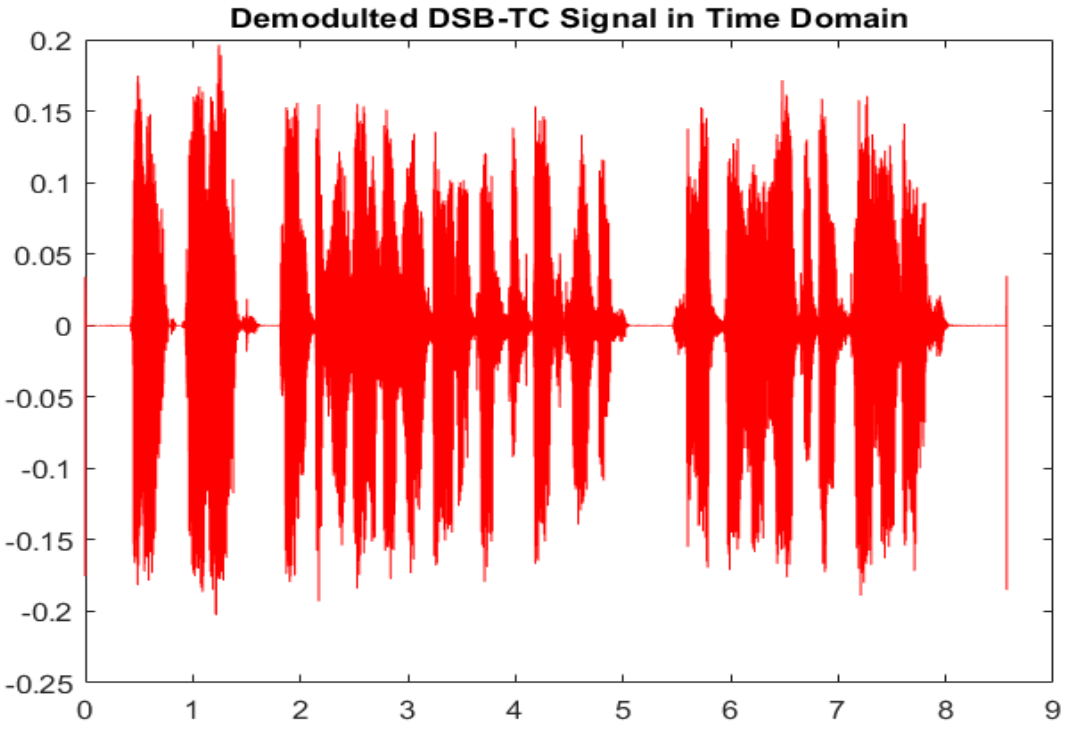

emodulated DSB-SC Signal using Coherent Detection with SNR = 30 in Time Dor
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9

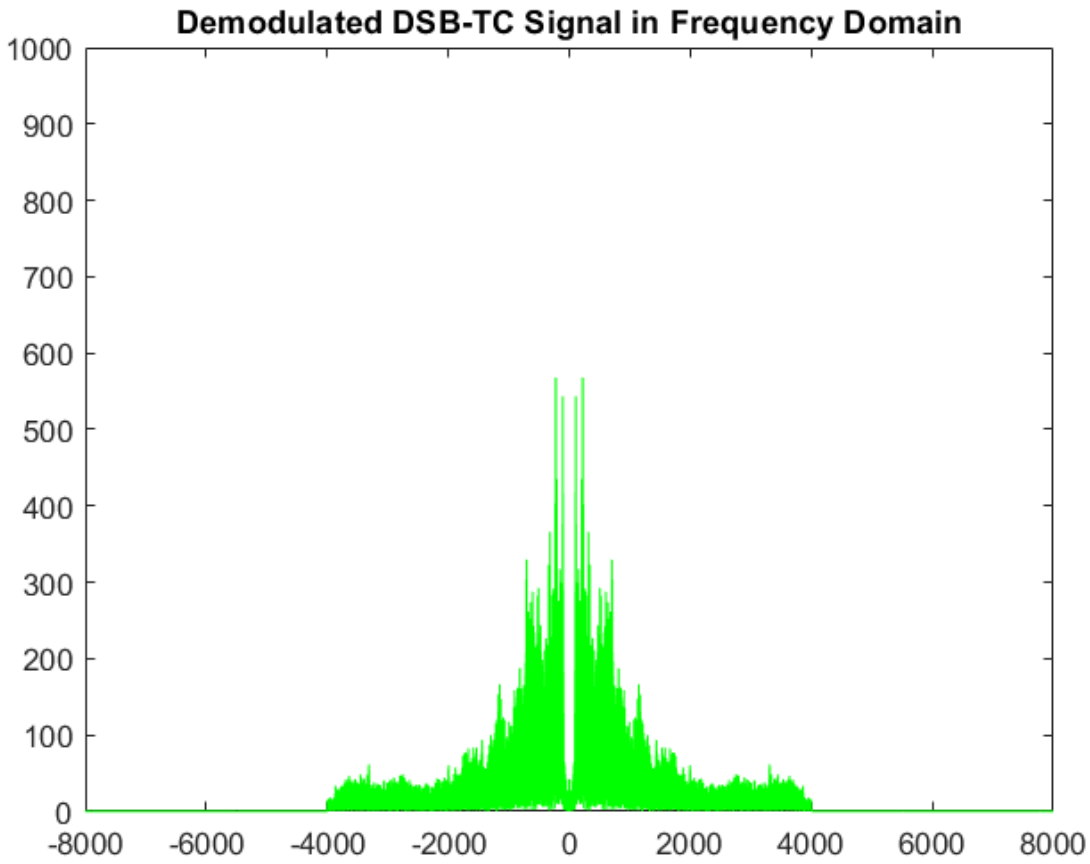

odulated DSB-SC Signal using Coherent Detection with Phase Error = 20 in Time
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
1
2
3
4
5
6
7
8
9


ated DSB-SC Signal using Coherent Detection with Frequency Error = 100 HZ in T
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
1
2
3
4
5
6
7
8
9


Modulted DSB-TC Signal in Time Domain
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
1
2
3
4
5
6
7
8
9


Modulated DSB-TC Signal in Frequency Domain
1000
900
800
700
600
500
400
300
200
100
0
-1.5
-1
-0.5
0
0.5
1
1.5
×10^5


Demodulted DSB-TC Signal in Time Domain
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
1
2
3
4
5
6
7
8
9



Experiment Conclusions

→ By using Envelope Detector, we observe that there is more distortion in case of DSB-SC. DSB-SC should be demodulated by coherent detection. Envelope Detector can be used to demodulate DSB-TC.

→It is called beat effect

Experiment 2:

Code:

```
clc
clear
close all
```

Read the audio file and get its sampling frequency

```
[y, F] = audioread('eric.wav');
ty = length(y)/F;
t = linspace(0, ty, length(y));
T=linspace(0, ty, length(y));
plot(t,y,'r');
title('Original Signal in Time Domain');
```

Input signal conversion to frequency domain

```
z = fftshift(fft(y));
zf=abs(z);
f = linspace(-F/2, F/2, length(y));
plot(f,zf,'g');
title('Original Signal in Frequency Domain');
```

apply ideal LPF ,Searching for indices where f = -4000 and f = 4000

```
for i = 1:length(f)
    if (abs((f(i)+4.0000e+3)) < 0.01)
        index1 = i;
    end
    if (abs((f(i)-4.0000e+3)) < 0.01)
        index2 = i;
        break;
    end
end


%Generating a rect from index1 to index2
range = index2-index1;
step = [zeros(1, index1) ones(1, range) zeros(1, length(f)-index2)];
step = step.';
```

Multiplying input signal by rect to eliminate frequencies other than 4k

```
yfilteredFreq = step.*z;
yfilteredFreqAbs = abs(step.*z);


figure
plot(f, yfilteredFreqAbs,'g');
xlim([-4.5 4.5].*10^3)
title('Filtered Signal in Frequency Domain at 4KHZ  (ideal filter)');
```

Converting the filtered signal to time domain to be modulated DSB-SC

```
yfiltered= ifft(ifftshift(yfilteredFreq));
yfiltered=yfiltered.';
figure
plot(T,yfiltered,'r');
title('Filtered Signal in Time Domain at 4KHZ  (ideal filter)');
sound(yfiltered, F);
pause(9);


%Filtered signal resampling
maxAmplitude = max(yfiltered);
yfiltered = resample(yfiltered, 500000, F);
interval = length(yfiltered);
```

DSB-SC Modulation

```
t = linspace(0, ty, interval);
carrier=cos(2*pi*100000*t);
dsbsc =carrier.*yfiltered;
figure
plot(t, dsbsc,'r');
title('Modulted DSB-SC Signal in Time Domain');
zm_sc=fftshift(fft(dsbsc));
zmsc = abs(fftshift(fft(dsbsc)));
fmsc = linspace(-500000/2, 500000/2, length(dsbsc));
figure
plot(fmsc, zmsc,'g');
xlim([-150000 150000]);
ylim([0 1000]);
title('Modulated DSB-SC Signal in Frequency Domain');
xlim([-12 12].*10^4)
```

remove USB to get SSB using ideal filter

```
for i1 = 1:length(dsbsc)
    if (abs((fmsc(i1)+1.0000e+5)) < 0.1)
        idx1 = i1;
    end
    if (abs((fmsc(i1)-1.0000e+5)) < 0.1)
        idx2 = i1;
        break;
    end
end


%Generating a rect from idx1 to idx2
range1 = idx2-idx1;
step1 = [zeros(1, idx1) ones(1, range1) zeros(1, length(fmsc)-idx2)];
LSB_Frequency = step1.*zm_sc;
LSB_FAbs = abs(step1.*zm_sc);
figure
plot(fmsc, LSB_FAbs,'g');
xlim([-150000 150000]);
ylim([0 1000]);
title('Obtain LSB in Frequency Domain using  from DSB-SC (ideal filter)');
xlim([-12 12].*10^4)
LSB_time = ifft(ifftshift(LSB_Frequency));
```

demodulation of SSB using coherent detector ideal filter

```
SSB_SC = LSB_time.*carrier;
SSB_SC = resample(SSB_SC,F,500000);
SSB_SC_ff= fftshift(fft(SSB_SC)) ;


%ideal lpf to get signal in frequency domain
SSB_SC_ff=SSB_SC_ff(1:end-1);
SSB_SC_ff =SSB_SC_ff.*step';
SSB_SC_time =ifft(ifftshift(SSB_SC_ff)) ;
signal_frequency_domain= fftshift(fft(SSB_SC_time));
figure
plot(T,SSB_SC_time,'r');
title('recieved LSB in Time Domain (ideal filter)');
figure;
plot(f,abs(signal_frequency_domain),'g');
title('recieved LSB in Freqency Domain (ideal filter)');
xlim([-4.5 4.5].*10^3)
sound(SSB_SC_time,F);
pause(9);
```

remove USB to get SSB using butter filter

Butterworth filter BPF to get LSB

```
fnorm = 500000/2;
BW_fitler=(500000*4000)/48000;
[numerator, denomenator] = butter(4,[100000 100000+BW_fitler]/fnorm,'bandpass');
Filter_DSB = filter(numerator, denomenator, dsbsc);
LSB_Butter = Filter_DSB.*carrier;
plot(fmsc,abs(fftshift(fft(Filter_DSB))),'g');
title('Obtain LSB in Freqency Domain (Butter filter)');


%down sample butter filter
LSB_down =resample(LSB_Butter,F,500000);
LSB_down =LSB_down(1:end-1);
lsb_freq=abs(fftshift(fft(LSB_down)));
```

Butterworth filter LPF to get LSB after demodulation

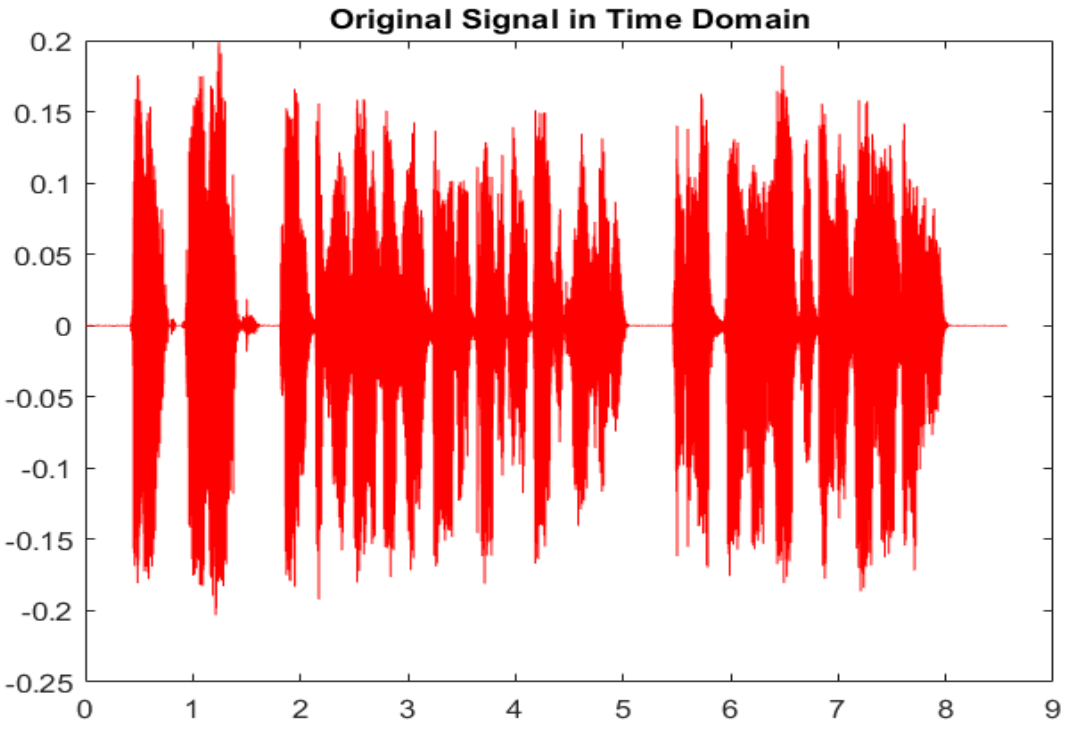
```
[numerator, denomenator] = butter(4,4000/(F/2));
LSB_LPF_Time = filter(numerator, denomenator, LSB_down);
LSB_LPF_Freq = fftshift(fft(LSB_LPF_Time));
figure
plot(LSB_LPF_Time,'r');
title('recieved LSB in Time Domain  (butter filter)');


figure
plot(f,abs(LSB_LPF_Freq),'g');
title('recieved LSB in Freqency Domain (butter filter)');
xlim([-4.5 4.5].*10^3)


%NOISE is added to signal
noised_signal_0  = awgn(LSB_time,0, 'measured');
noised_signal_10 = awgn(LSB_time,10,'measured');
noised_signal_30 = awgn(LSB_time,30,'measured');
noised_signal_0=noised_signal_0';
noised_signal_10=noised_signal_10';
noised_signal_30=noised_signal_30';
carrier=carrier.';
LSB0 = noised_signal_0.*carrier;
coherent0 = resample(LSB0,F,500000);
coherent0 = coherent0(1:end-1);
coherentFreq0 = fftshift(fft(coherent0));
coherentFilter0 = step.*coherentFreq0;
coherentTime0 = ifft(ifftshift(coherentFilter0)) ;
```

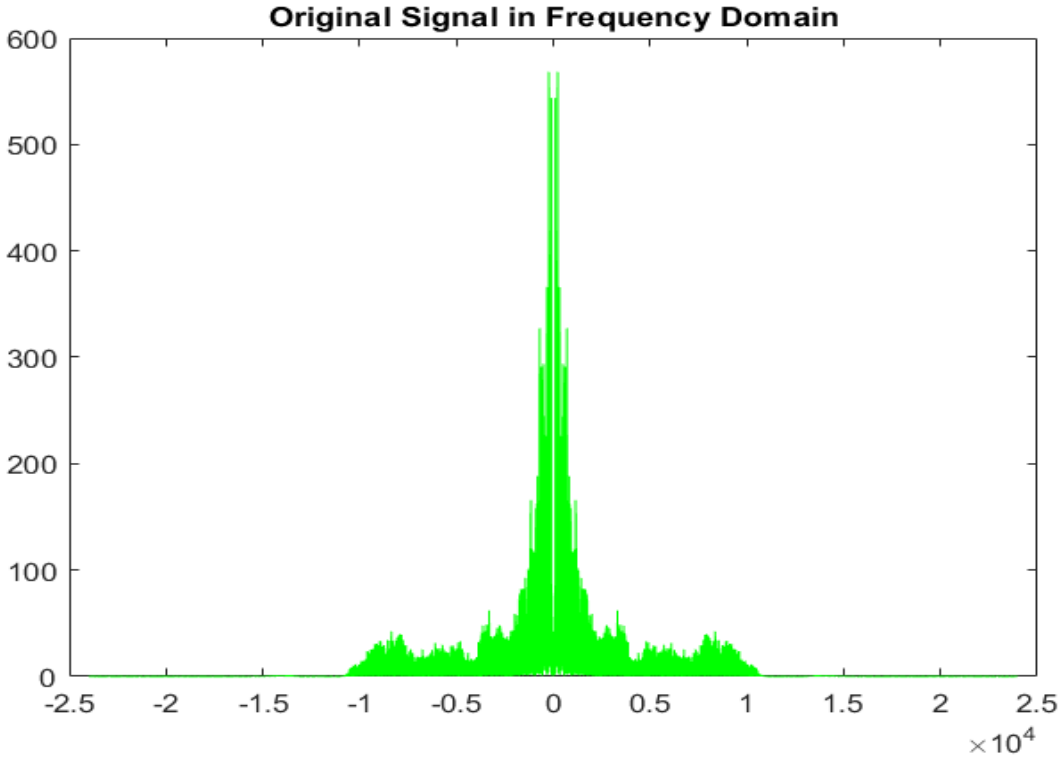
```
figure;
plot(T,coherentTime0,'r');
title('recieved LSB in Time Domain (ideal filter) with noise SNR=0');
figure;
plot(f,abs(coherentFilter0),'g');
title('recieved LSB in Freq Domain (ideal filter) with noise SNR=0');
xlim([-4.5 4.5].*10^3)
sound(real(coherentTime0),F);
pause(9);
LSB10 = noised_signal_10.*carrier;
coherent10 = resample(LSB10,F,500000);
coherent10 = coherent10(1:end-1);
coherentFreq10 = fftshift(fft(coherent10));
coherentFilter10 = step.*coherentFreq10;
coherentTime10 = ifft(ifftshift(coherentFilter10)) ;
figure;
plot(T,coherentTime10,'r');
title('recieved LSB in Time Domain (ideal filter) with noise SNR=10');
figure;
plot(f,abs(coherentFilter10),'g');
title('recieved LSB in Freq Domain (ideal filter) with noise SNR=10');
xlim([-4.5 4.5].*10^3)
sound(real(coherentTime10),F);
pause(9);
LSB30 = noised_signal_30.*carrier;
coherent30 = resample(LSB30,F,500000);
coherent30 = coherent30(1:end-1);
coherentFreq30 = fftshift(fft(coherent30));
coherentFilter30 = step.*coherentFreq30;
coherentTime30 = ifft(ifftshift(coherentFilter30)) ;
figure;
plot(T,coherentTime30,'r');
title('recieved LSB in Time Domain (ideal filter) with noise SNR=30');
figure;
plot(f,abs(coherentFilter30),'g');
title('recieved LSB in Freq Domain (ideal filter) with noise SNR=30');
xlim([-4.5 4.5].*10^3)
sound(real(coherentTime30),F);
pause(9);
```

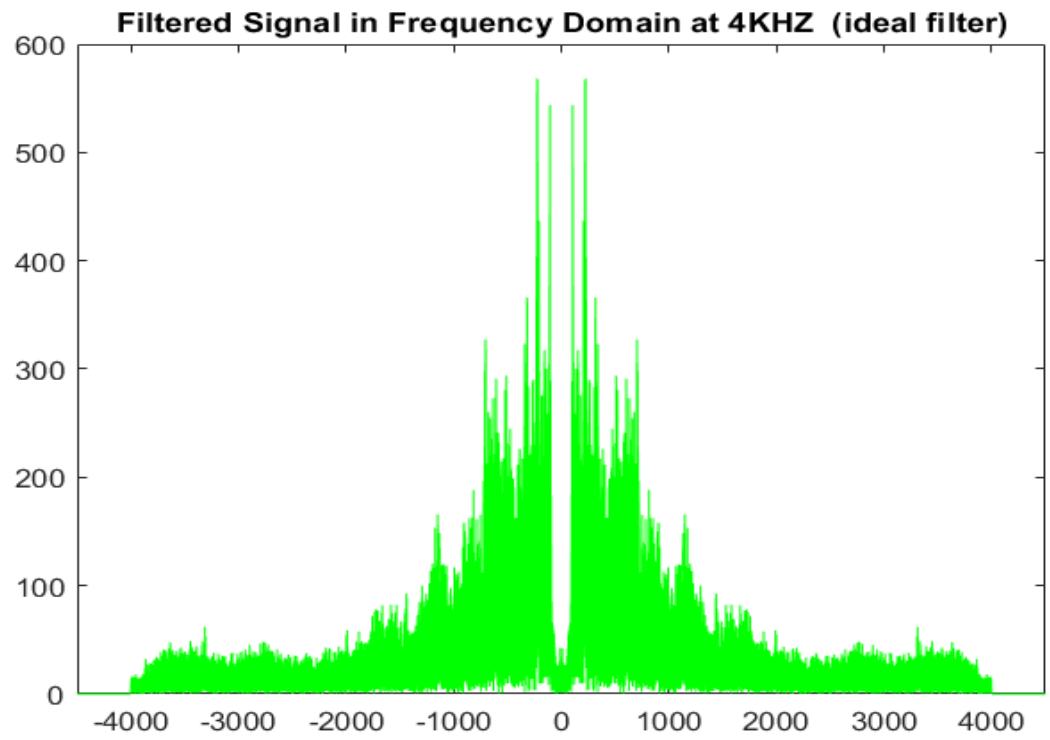
OBTAIN SSB-TC using ideal filter

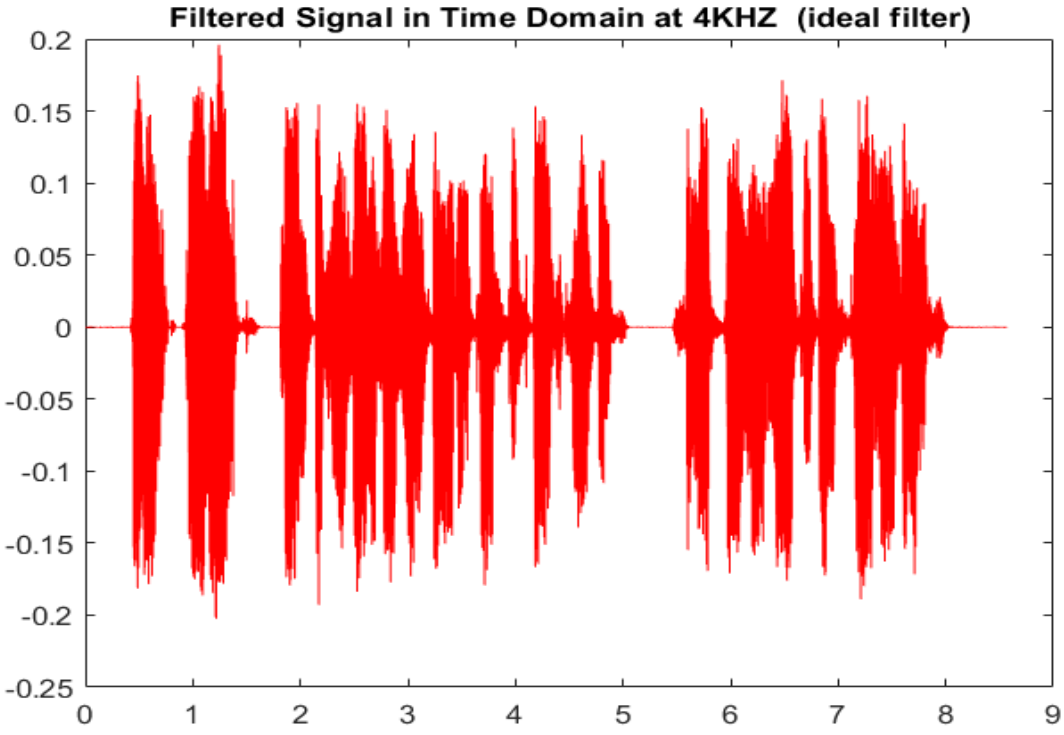
```
A=2*max(LSB_time);
carrier=carrier.';
SSB_TC=(A+LSB_time).*carrier;
SSB_TC_freq =  fftshift(fft(SSB_TC));
step=step.';
step=resample(step,500000,F);
SSB_SCinFreqIdeal =  SSB_TC_freq.*step;
SSB_TC_time = ifft(ifftshift(SSB_SCinFreqIdeal));
envelopeSSBTC=abs(hilbert(real(SSB_TC_time)));


%down sample envelop detector
envelopeSSBTC=resample(envelopeSSBTC,F,500000);
envelopeSSBTC=envelopeSSBTC-mean(envelopeSSBTC);
figure;
plot(T,envelopeSSBTC(1:end-1),'r');
title('Demodulated SSB-TC Signal in Time Domain');
zdtc = abs(fftshift(fft(envelopeSSBTC)));
fdtc = linspace(-F/2, F/2, length(envelopeSSBTC));
figure
plot(fdtc, zdtc,’g’);
xlim([-5000 5000]);
ylim([0 300]);
title('Demodulated SSB-TC Signal in Frequency Domain');
sound(real(envelopeSSBTC),F);
```

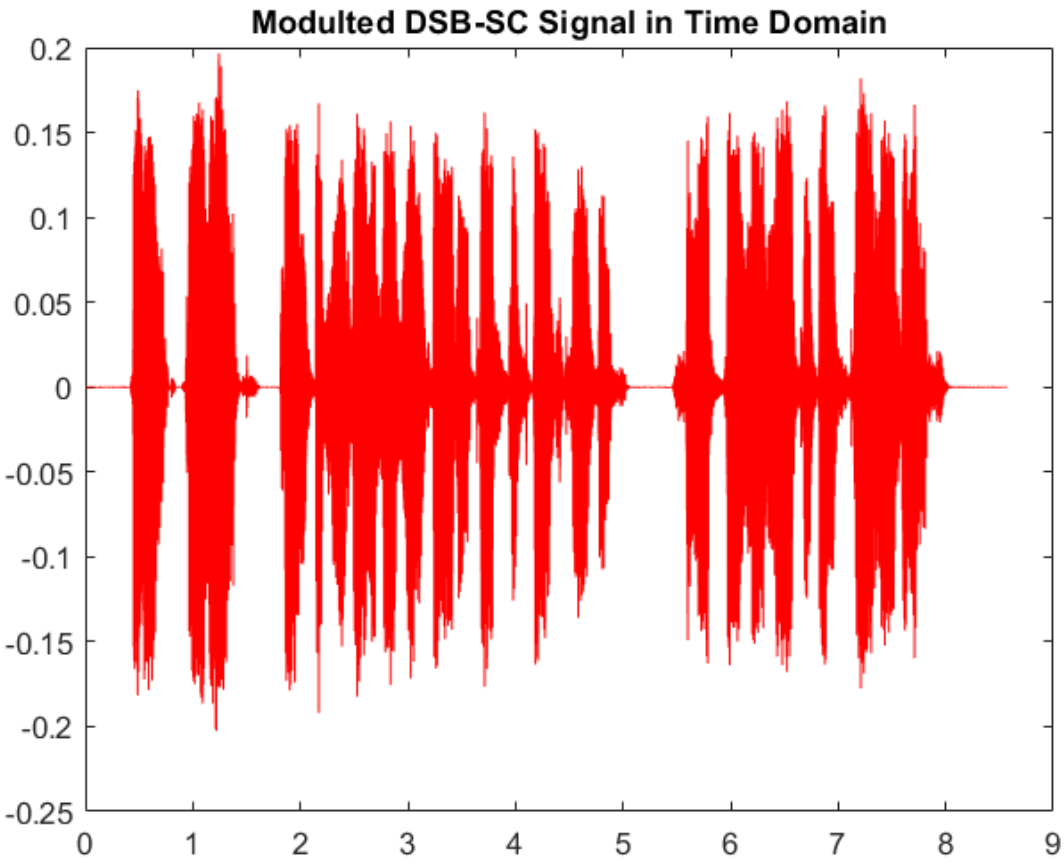
output:

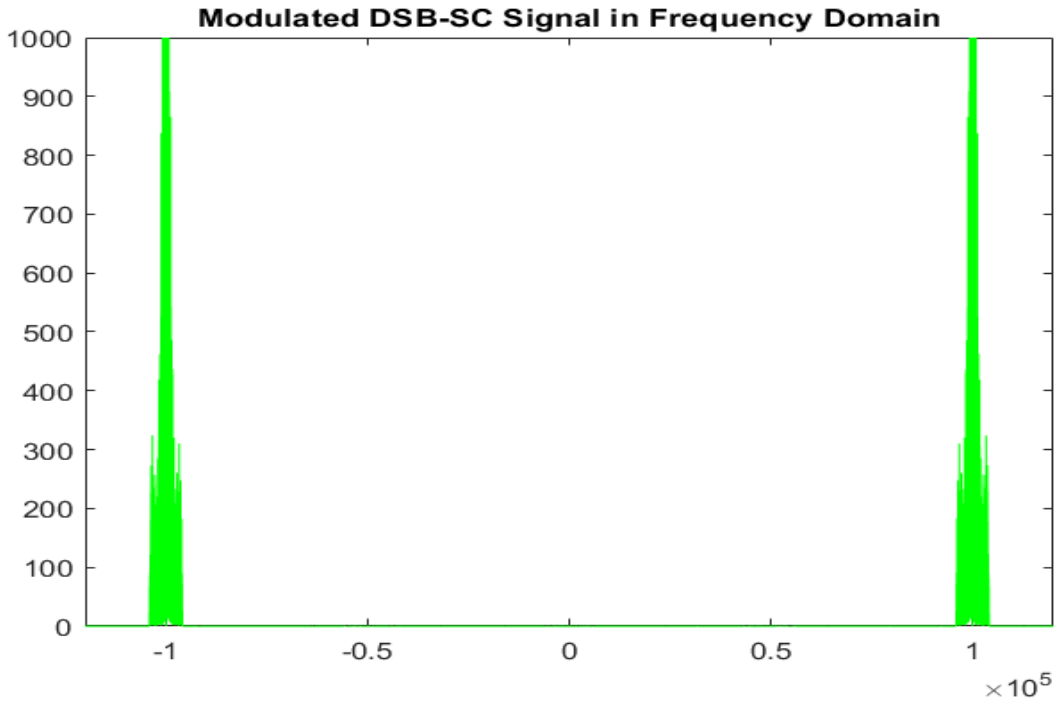

Original Signal in Time Domain
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
1
2
3
4
5
6
7
8
9

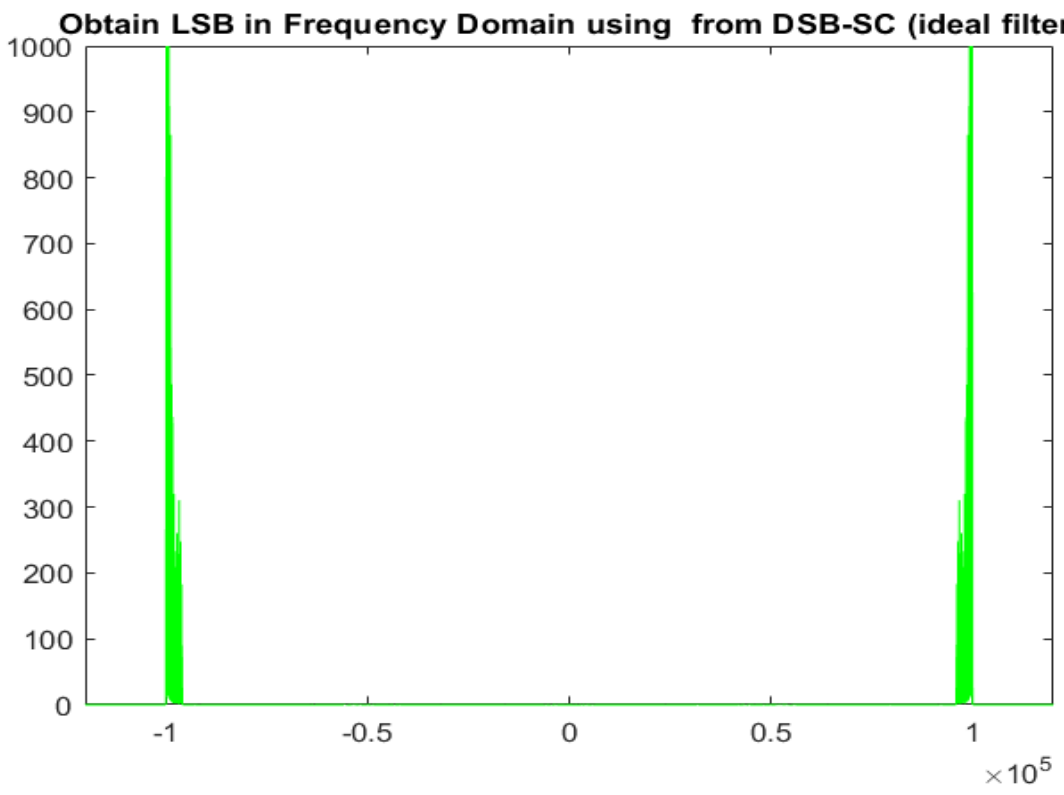

Original Signal in Frequency Domain
600
500
400
300
200
100
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
×10^4

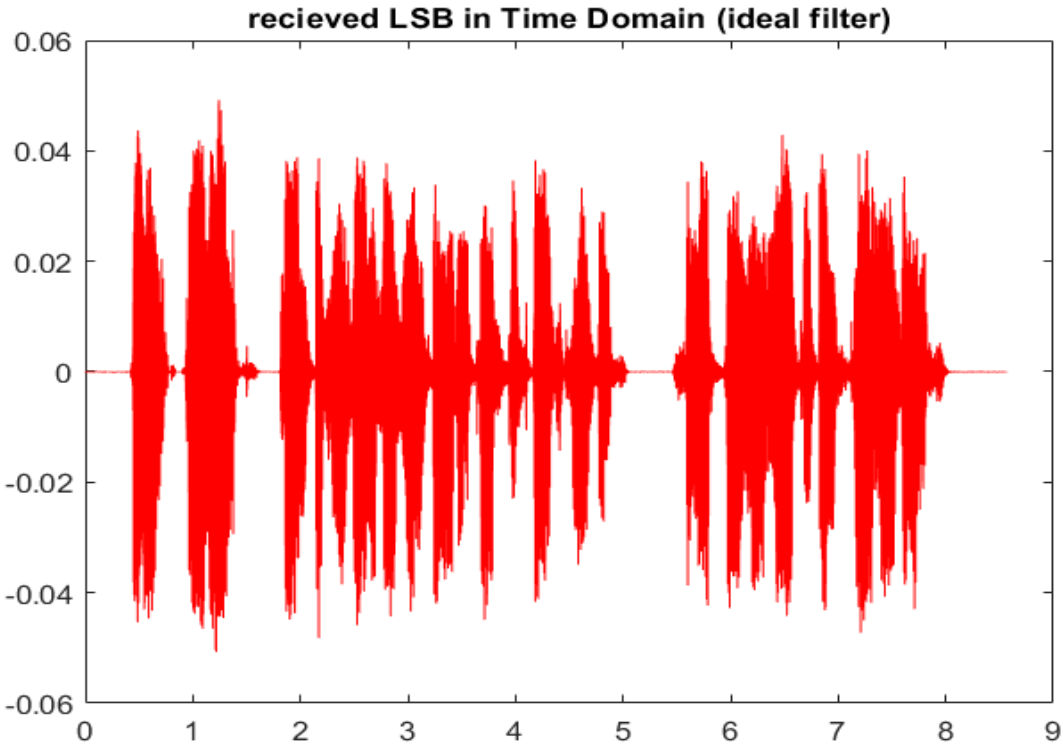

Filtered Signal in Frequency Domain at 4KHZ (ideal filter)
600
500
400
300
200
100
0
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000

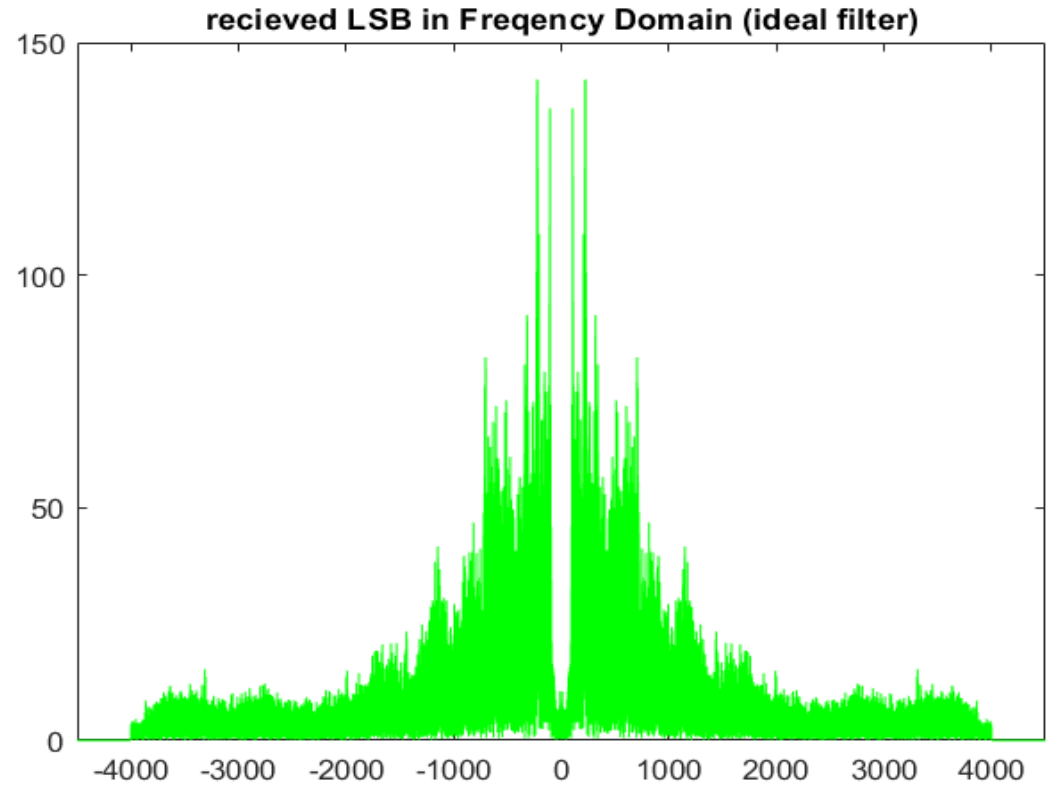

Filtered Signal in Time Domain at 4KHZ (ideal filter)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
1
2
3
4
5
6
7
8
9

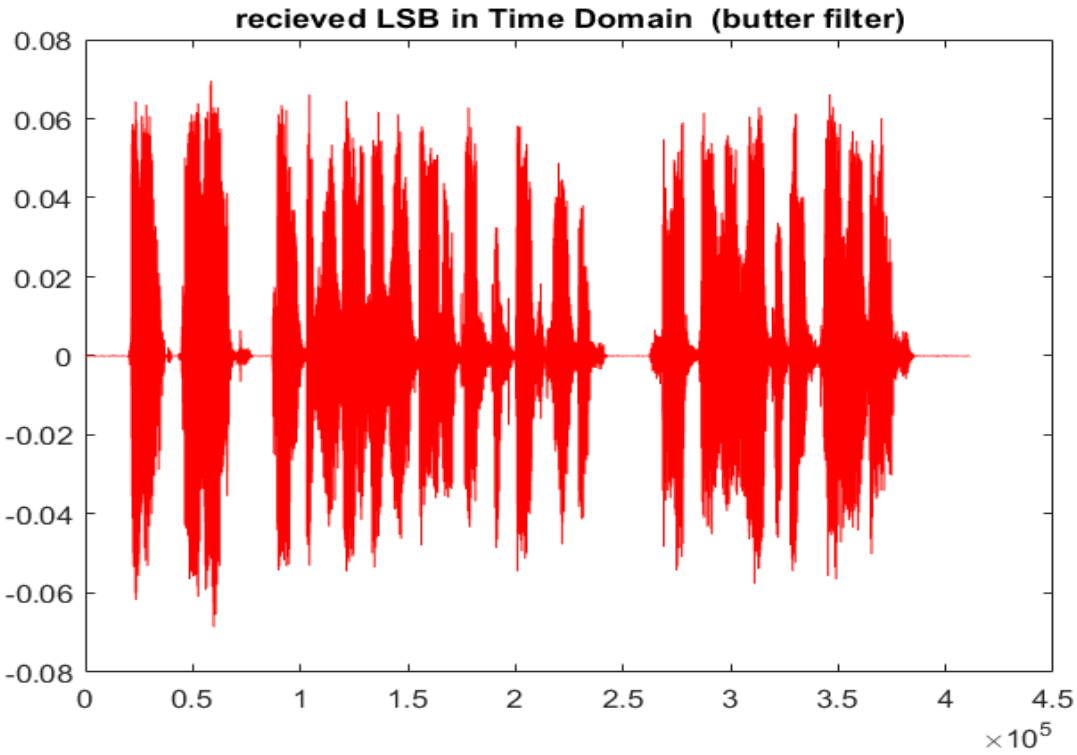

Modulted DSB-SC Signal in Time Domain
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
1
2
3
4
5
6
7
8
9

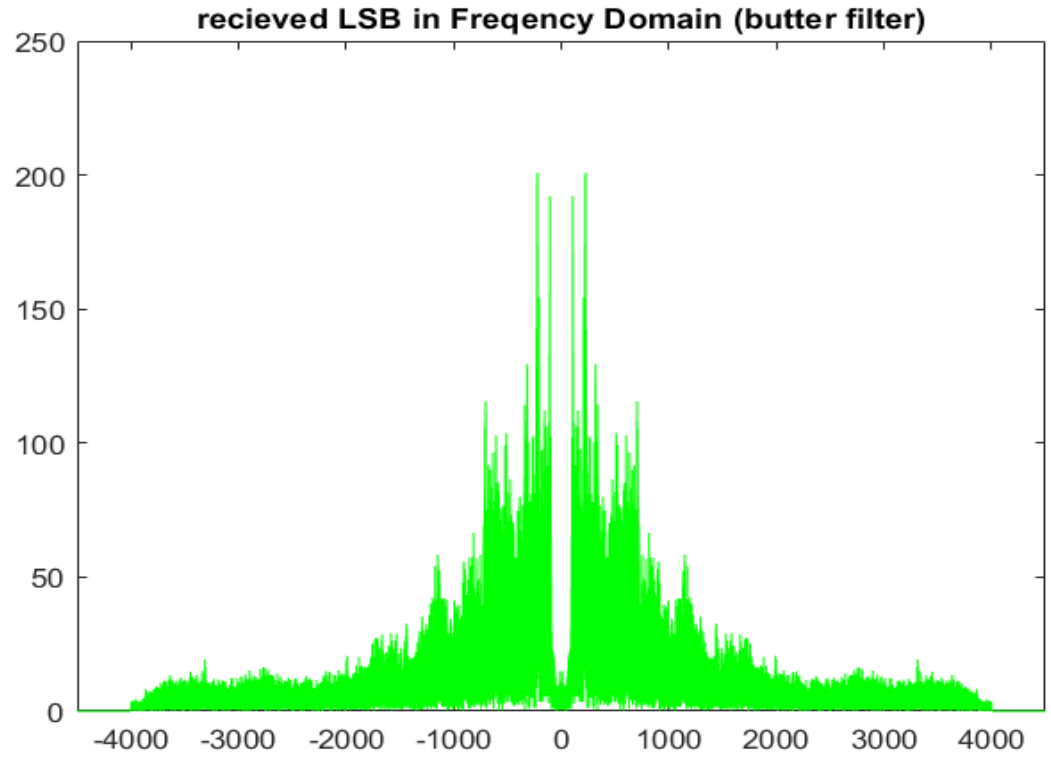

Modulated DSB-SC Signal in Frequency Domain
1000
900
800
700
600
500
400
300
200
100
0
-1
-0.5
0
0.5
1
×10^5

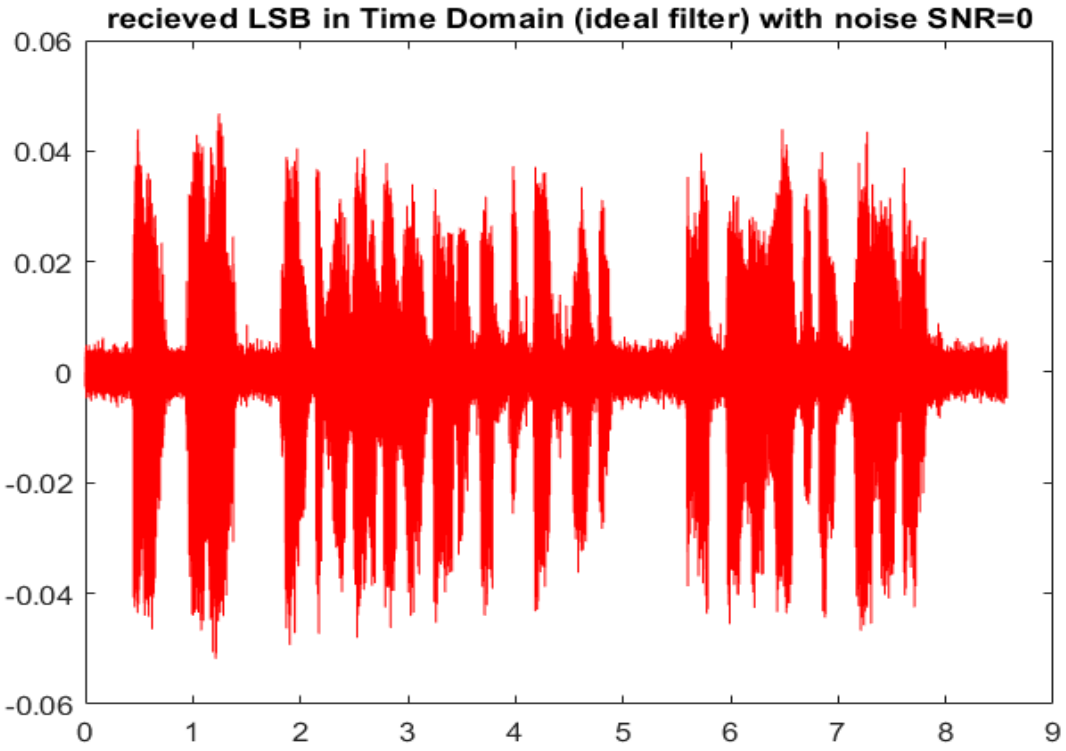

Obtain LSB in Frequency Domain using from DSB-SC (ideal filter)
1000
900
800
700
600
500
400
300
200
100
0
-1
-0.5
0
0.5
1
×10^5

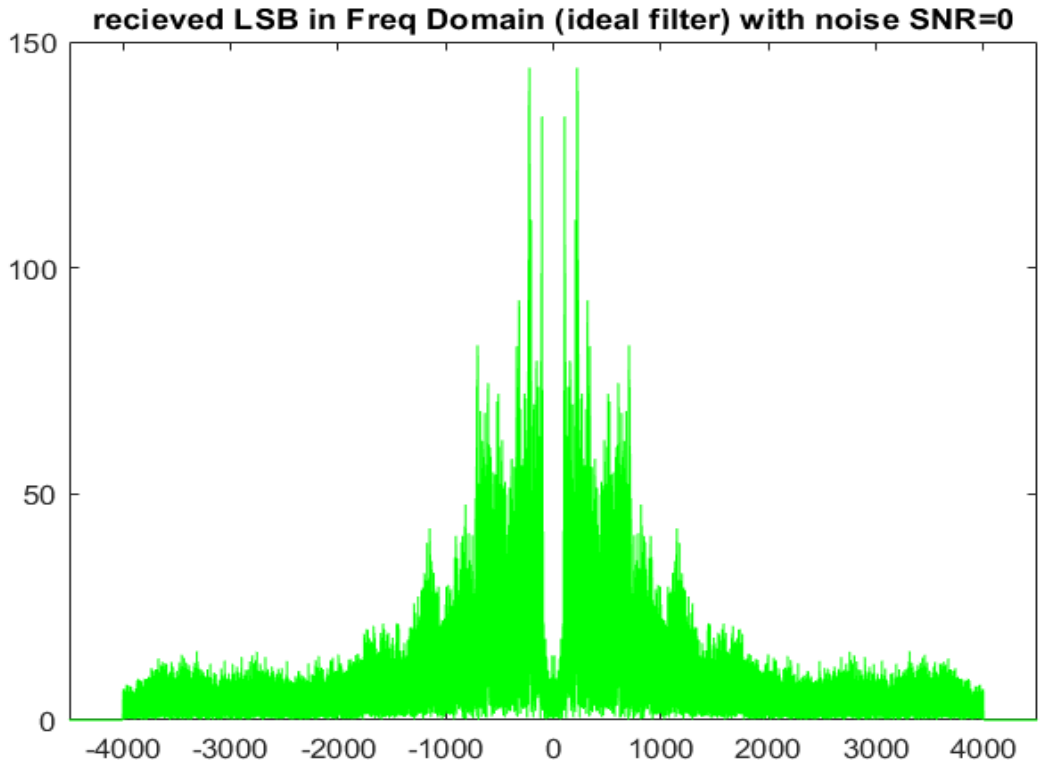

recieved LSB in Time Domain (ideal filter)
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
0
1
2
3
4
5
6
7
8
9

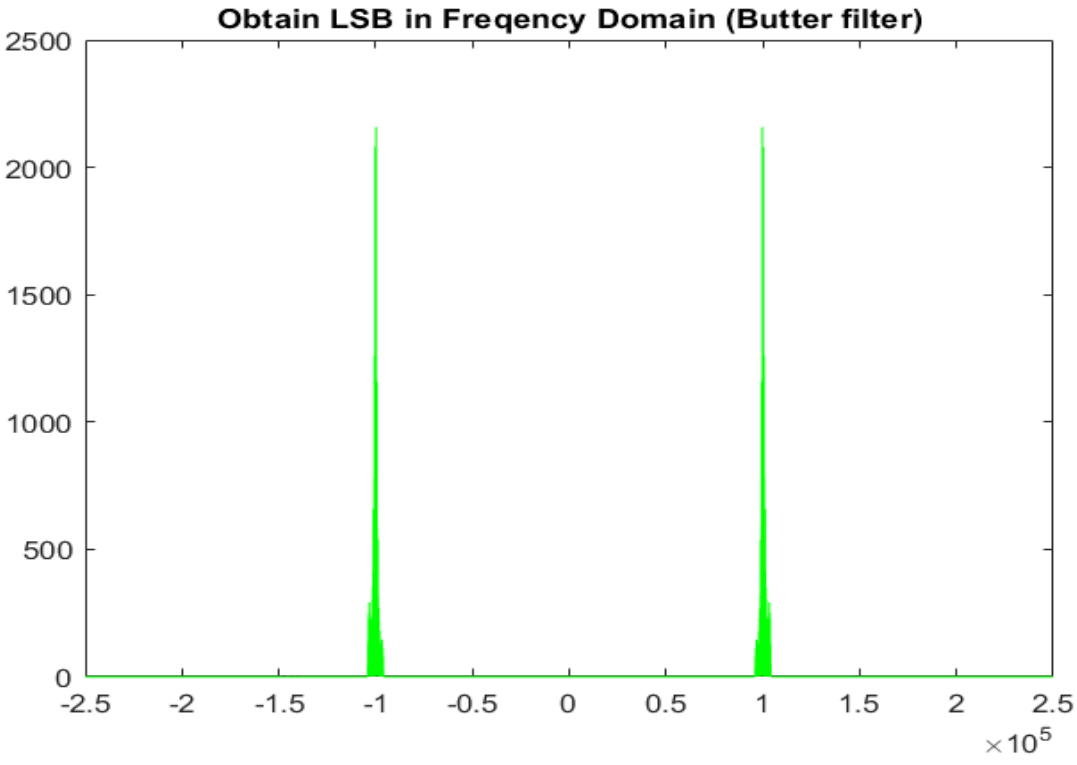

recieved LSB in Freqency Domain (ideal filter)
150
100
50
0
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000

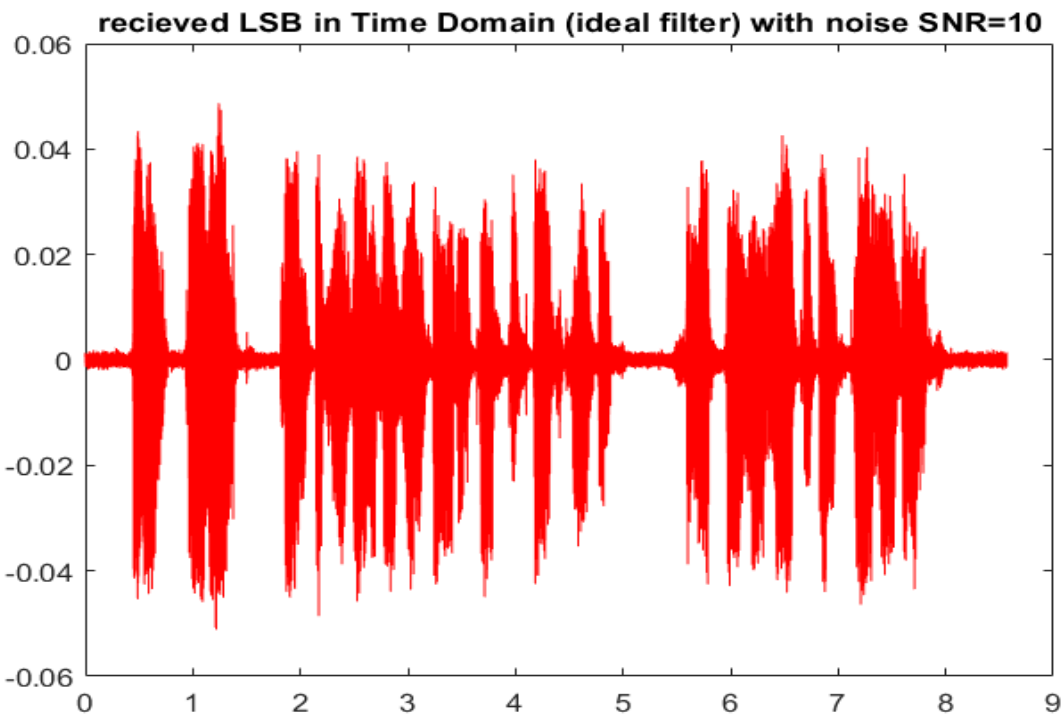

recieved LSB in Time Domain (butter filter)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
×10^5

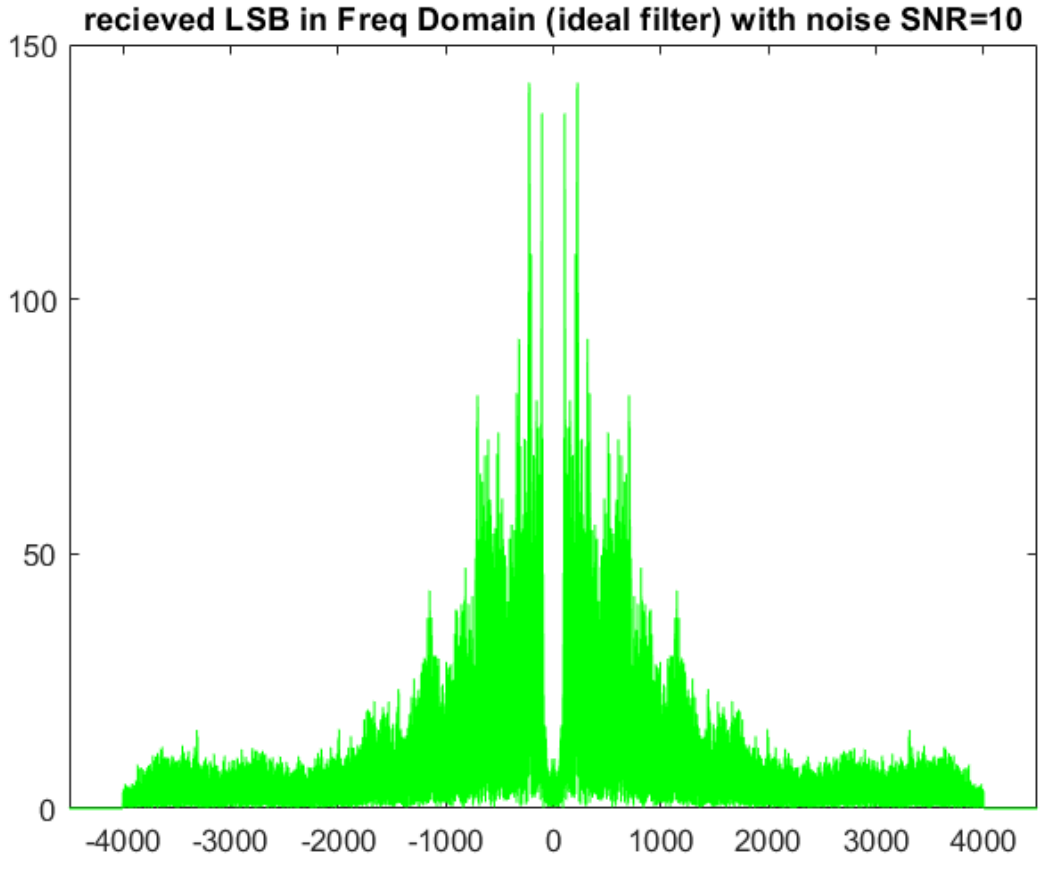

recieved LSB in Freqency Domain (butter filter)
250
200
150
100
50
0
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000

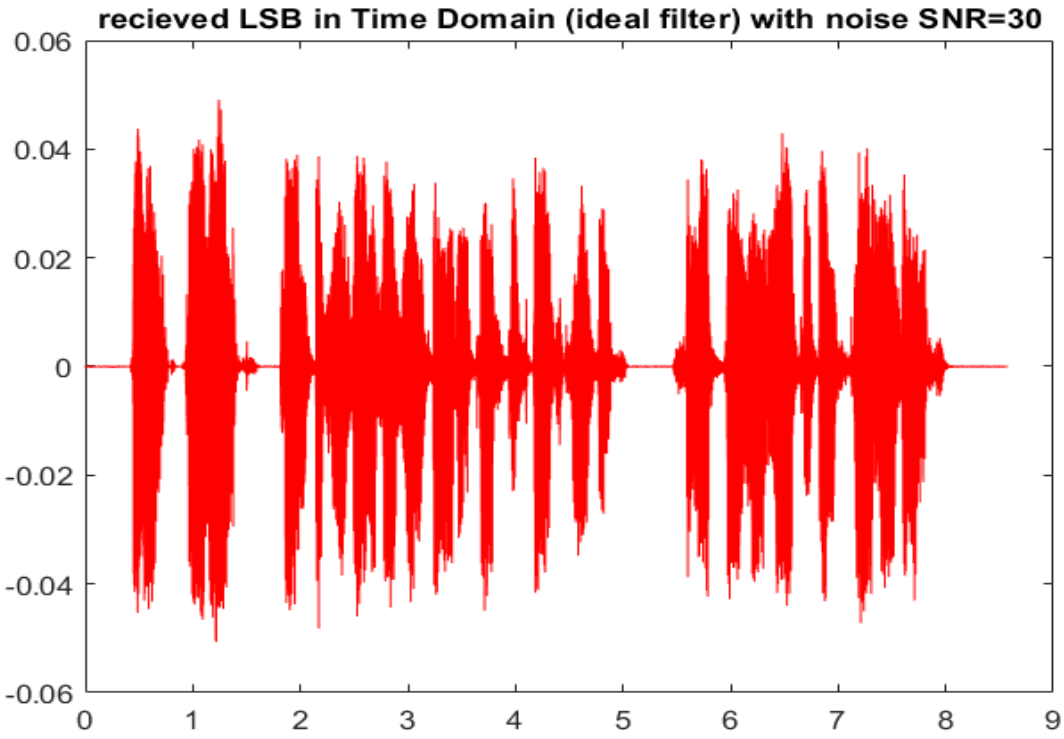

recieved LSB in Time Domain (ideal filter) with noise SNR=0
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
0
1
2
3
4
5
6
7
8
9

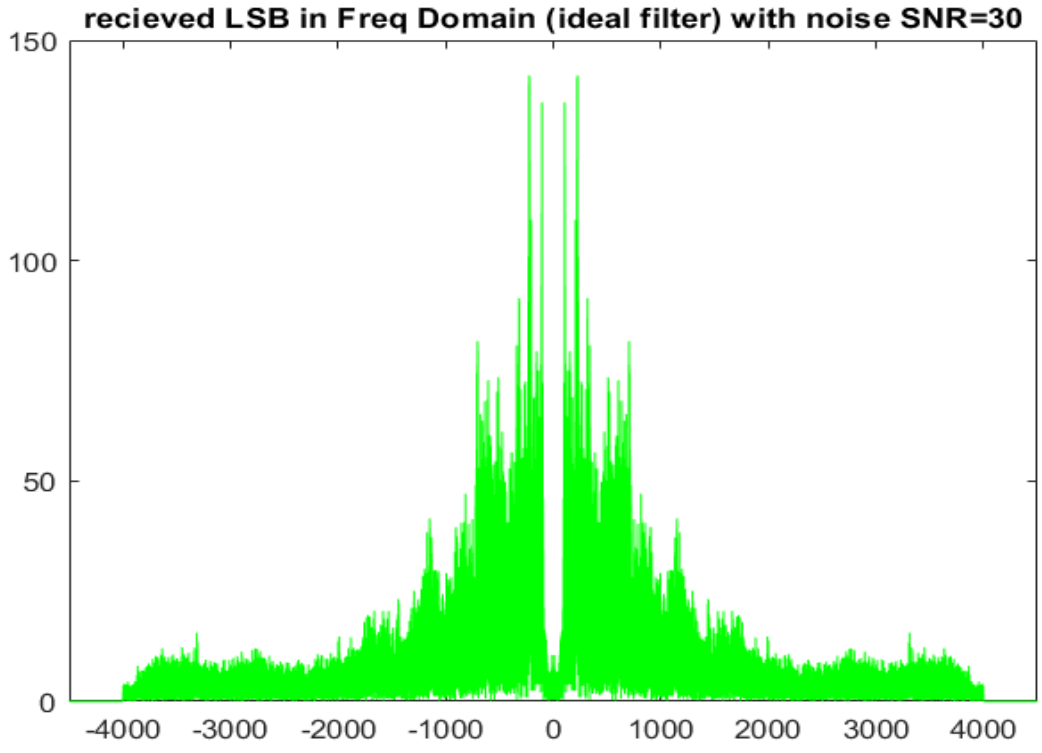

recieved LSB in Freq Domain (ideal filter) with noise SNR=0
150
100
50
0
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000

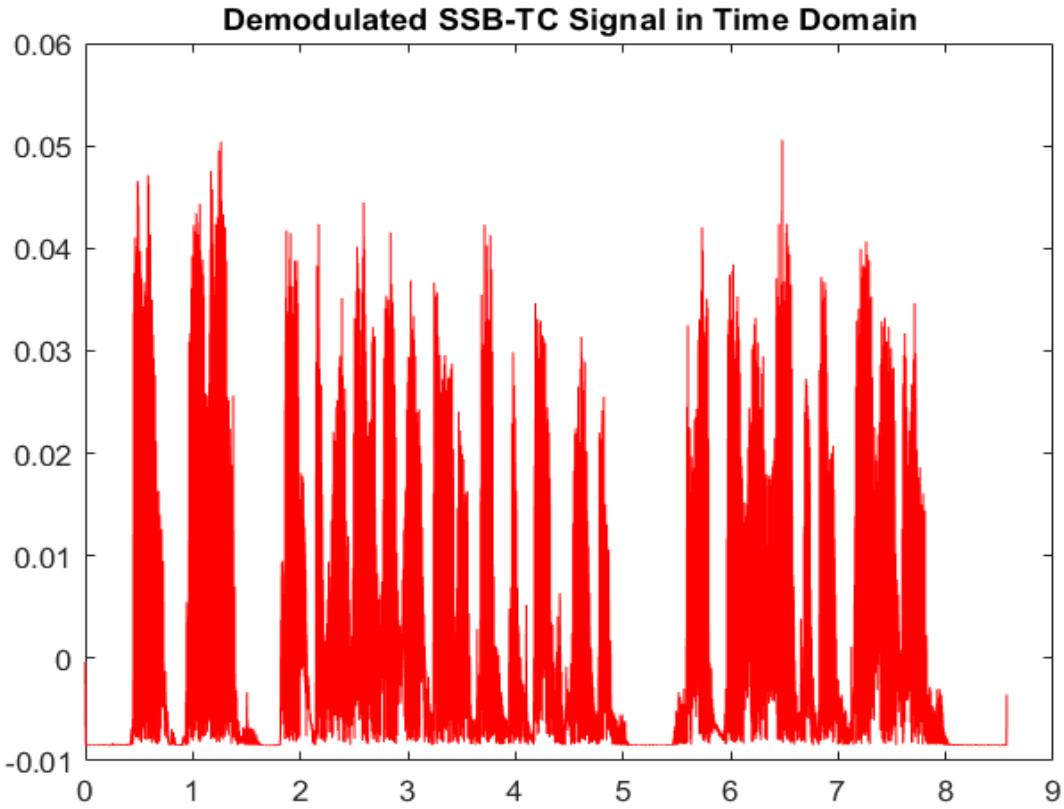

Obtain LSB in Freqency Domain (Butter filter)
2500
2000
1500
1000
500
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
×10^5

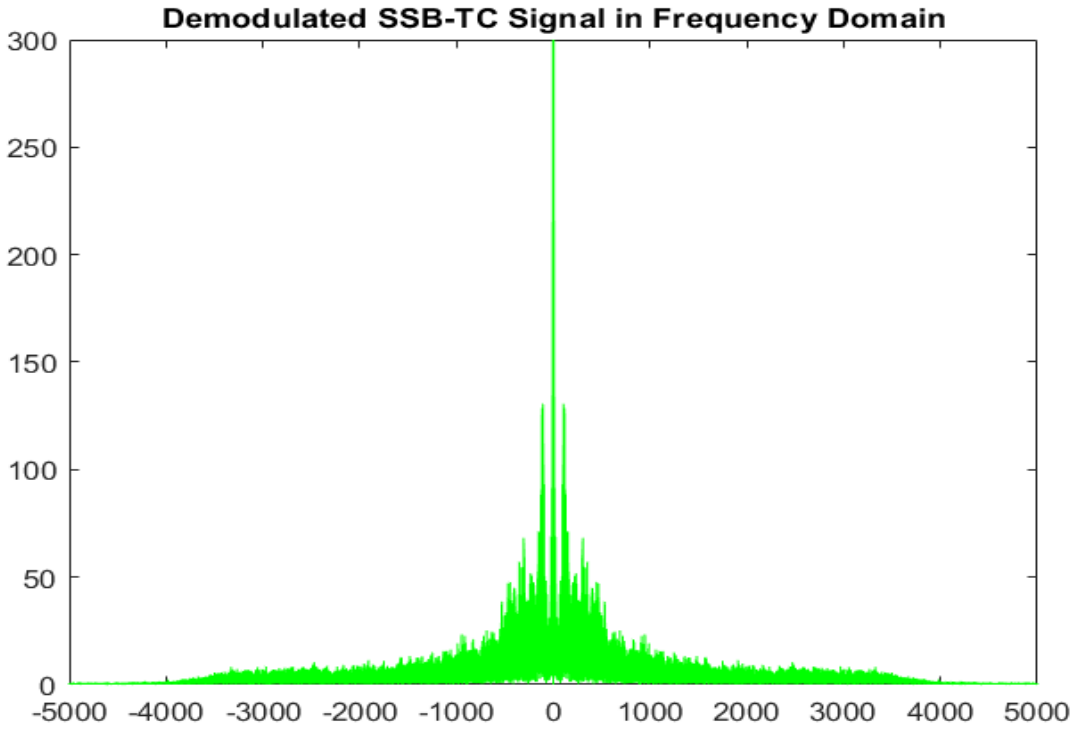

recieved LSB in Time Domain (ideal filter) with noise SNR=10
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
0
1
2
3
4
5
6
7
8
9


recieved LSB in Freq Domain (ideal filter) with noise SNR=10
150
100
50
0
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000


recieved LSB in Time Domain (ideal filter) with noise SNR=30
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
0
1
2
3
4
5
6
7
8
9


recieved LSB in Freq Domain (ideal filter) with noise SNR=30
150
100
50
0
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000


Demodulated SSB-TC Signal in Time Domain
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
0
1
2
3
4
5
6
7
8
9


Demodulated SSB-TC Signal in Frequency Domain
300
250
200
150
100
50
0
-5000
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000
5000

Experiment 3:

Code:

```
clc
clear
close all
```

Read the audio file and get its sampling frequency

```
[y, F] = audioread('eric.wav');


ty = length(y)/F;
t = linspace(0, ty, length(y));
```

Input signal conversion to frequency domain (to apply ideal LPF)

```
z = fftshift(fft(y));
f = linspace(-F/2, F/2, length(y));


figure
plot(f, abs(z),'g');
title('Original Signal in Frequency Domain');
```

Searching for indices where f = -4000 and f = 4000

```
for i = 1:length(f)
    if (abs((f(i)+4.0000e+3)) < 0.01)
        index1 = i;
    end
    if (abs((f(i)-4.0000e+3)) < 0.01)
        index2 = i;
        break;
    end
end


% Generating a rect from index1 to index2
range = index2-index1;
step = [zeros(1, index1) ones(1, range) zeros(1, length(f)-index2)];
step = step.';
```

Multiplying input signal by rect to eliminate frequencies other than 4k

```
yfilteredFreq = step.*z;
yfilteredFreqAbs = abs(step.*z);


figure
plot(f, yfilteredFreqAbs,'g');
xlim([-15000 15000]);
title('Filtered Signal in Frequency Domain');
```

Converting the filtered signal to time domain to be modulated

```
yfiltered = ifft(fftshift(yfilteredFreq));
figure
plot(t, yfiltered,'r');
title('Filtered Signal in Time Domain');
```

Signal after low pass filter

```
sound(yfiltered, F);
pause(9);
```

Filtered signal resampling

```
maxAmplitude = max(yfiltered);
yfiltered = resample(yfiltered, 500000, F);
yfiltered = yfiltered.';
interval = length(yfiltered);
```

Frequency Modulation

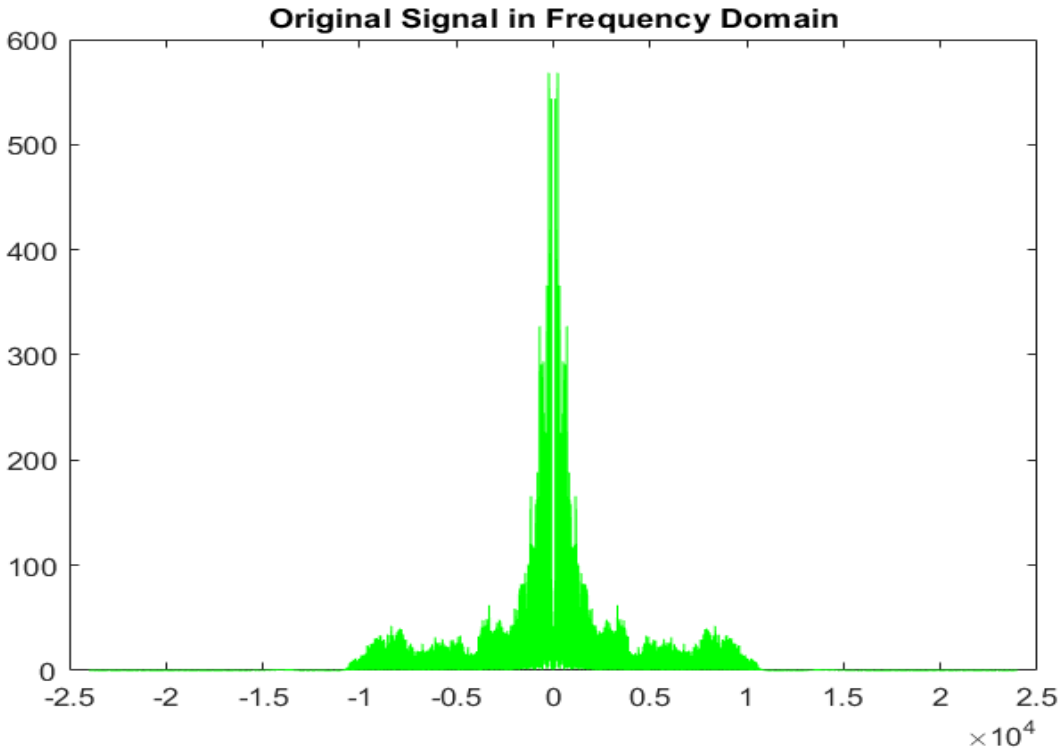
NBFM Signal

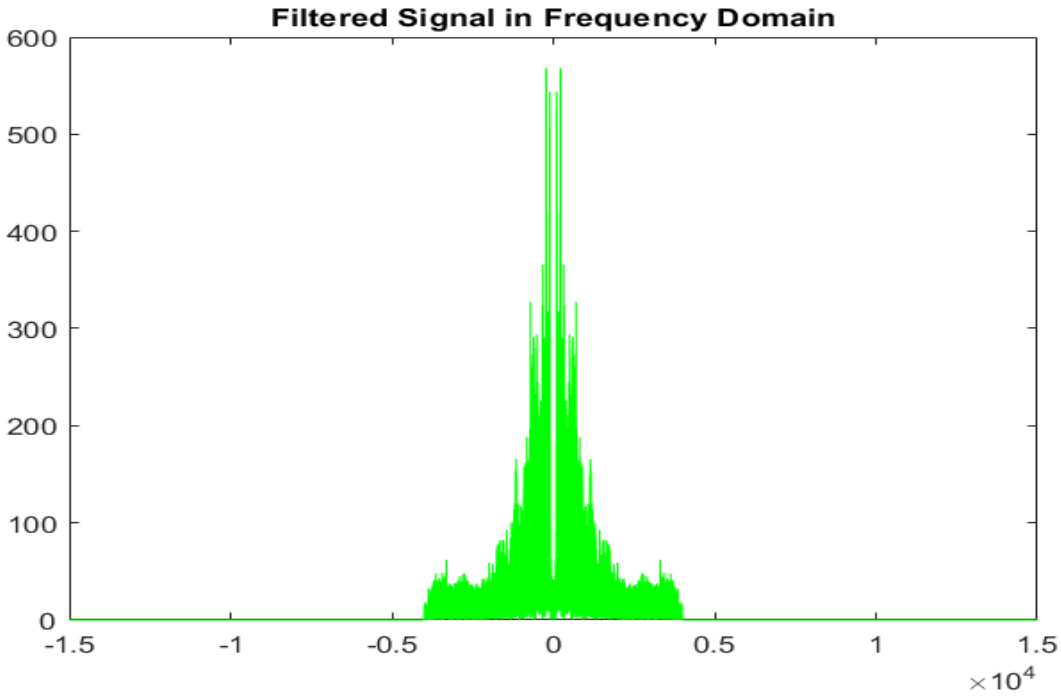
```
kf = 1e+1*pi;
t = linspace(0, ty, interval);
deltaF = abs(kf*max(yfiltered));
m_int = kf.*cumsum(yfiltered);
nbfm = 2*maxAmplitude.*cos(2.*pi.*100000.*t + m_int);
figure
plot(t, nbfm,'r');
title('Modulted NBFM Signal in Time Domain');
zmnbfm = abs(fftshift(fft(nbfm)));
fmnbfm = linspace(-500000/2, 500000/2, length(nbfm));
figure
plot(fmnbfm, zmnbfm,'g');
title('Modulated NBFM Signal in Frequency Domain');
```

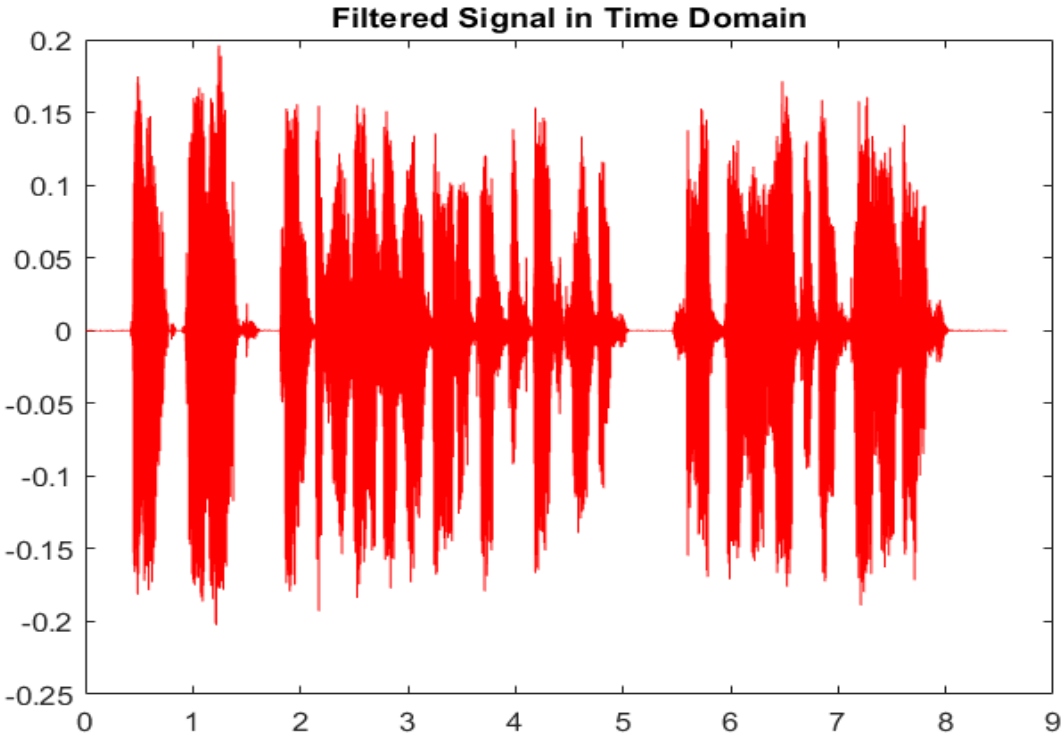
Frequency Demodulation

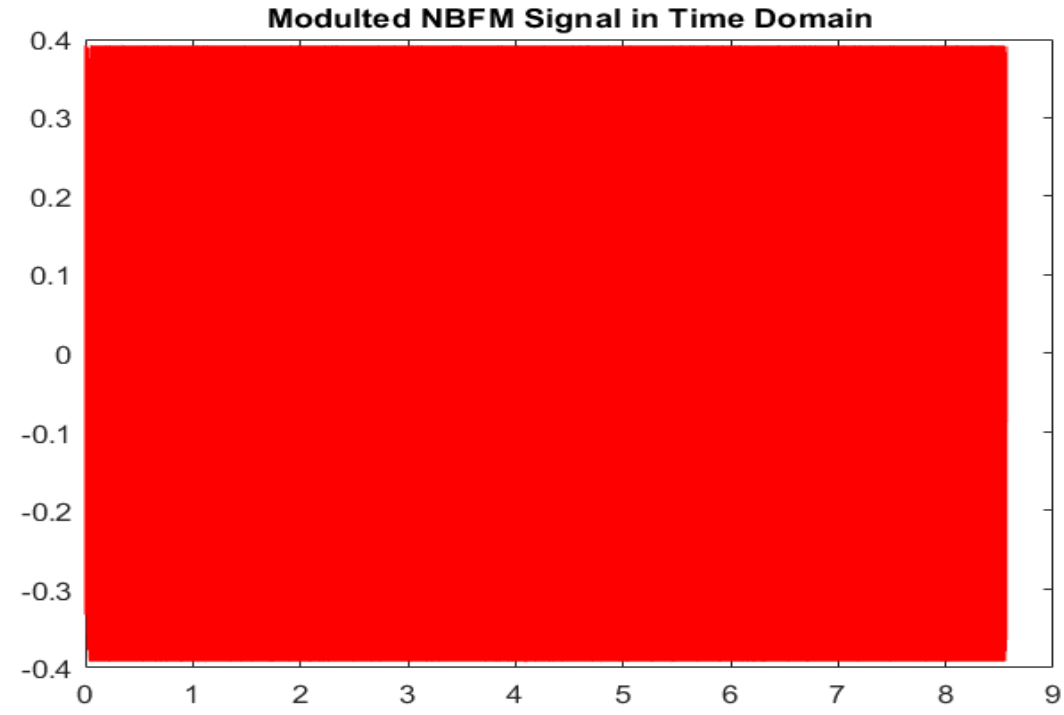
```
nbfm = diff(nbfm);
nbfmEnvelope = abs(hilbert(nbfm));
nbfmEnvelope = resample(nbfmEnvelope, F, 500000);
sound(nbfmEnvelope , F);
```

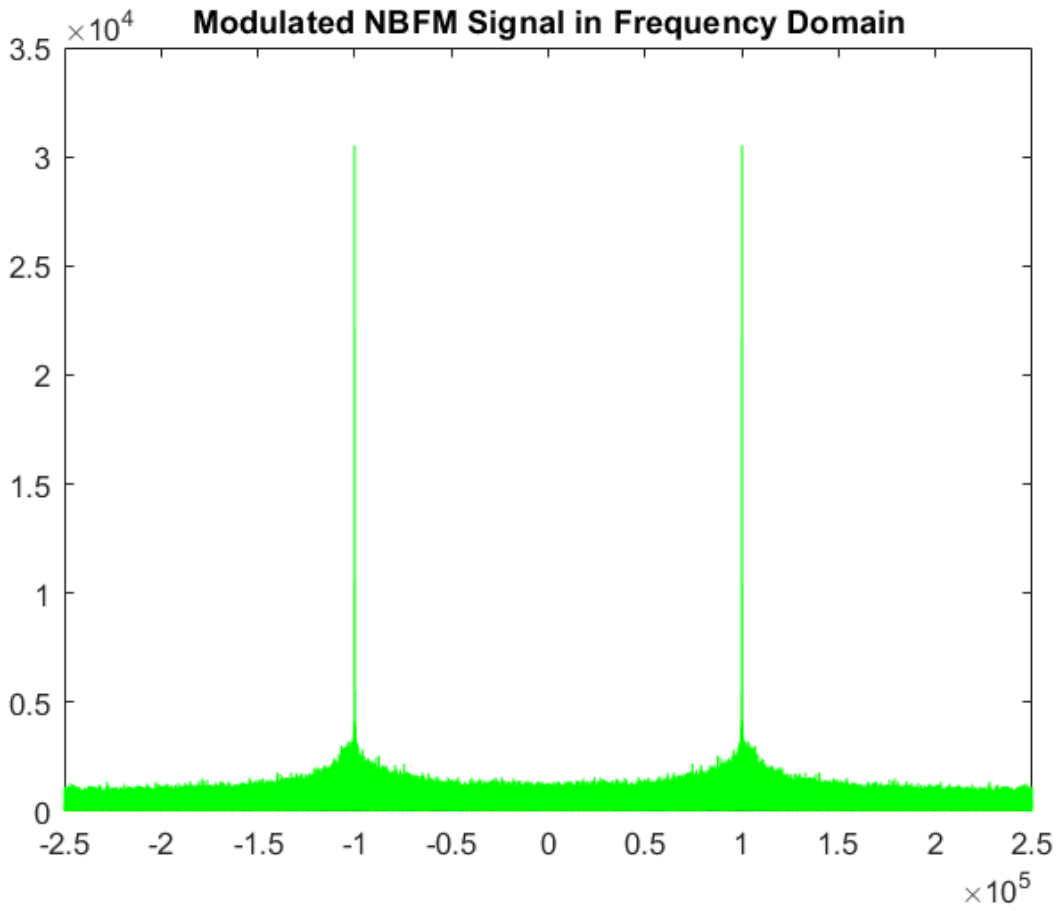
output:


Original Signal in Frequency Domain
600
500
400
300
200
100
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
×10^4


Filtered Signal in Frequency Domain
600
500
400
300
200
100
0
-1.5
-1
-0.5
0
0.5
1
1.5
×10^4


Filtered Signal in Time Domain
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
1
2
3
4
5
6
7
8
9


Modulted NBFM Signal in Time Domain
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
1
2
3
4
5
6
7
8
9



Experiment 3 Conclusions

→When the instantaneous frequency increases the value of the phase deviation increases.

→To achieve NBFM modulation index, frequency deviation, phase deviation and frequency deviation constant are very small.