Name	**Sec**	**BN**
Donia Gameel Mahmoud Mohammed	1	25
Heba Ashraf Raslan Abd-Elmaaboud	2	33

Results, answers and comments:

2-In synchronous demodulation: each signal is restored with half the magnitude of the original signals.

3- **Phase shift = 10:**

- Signal1 =>very little attenuation (making it lower than the original ones.)
- Signals 2 & 3=> interfere slightly with each other's

Phase shift = 30:

- Signal1 =>more attenuation (making it lower than the original ones.)
- Signals 2 & 3=> interfere more with each other's

Phase shift = 90:

- Signal1 =>completely attenuation (no audio) (making it lower than the original ones.)
- Signals 2 & 3=> interchanged where signal 2 is restored when demodulating to restore signal 3 & vice versa.

4-frequency shift makes attenuation and distortion of the output signal

In case of 10 ➔ attenuation and distortion of the signal are more than in case of 2

In order to demodulate the received signal at the receiver we use a synchronous carrier same as modulating carrier.

Using a synchronous carrier may cause attenuation or noise to the received signal if the local carrier in the receiver is not synchronized with the received signal carrier.

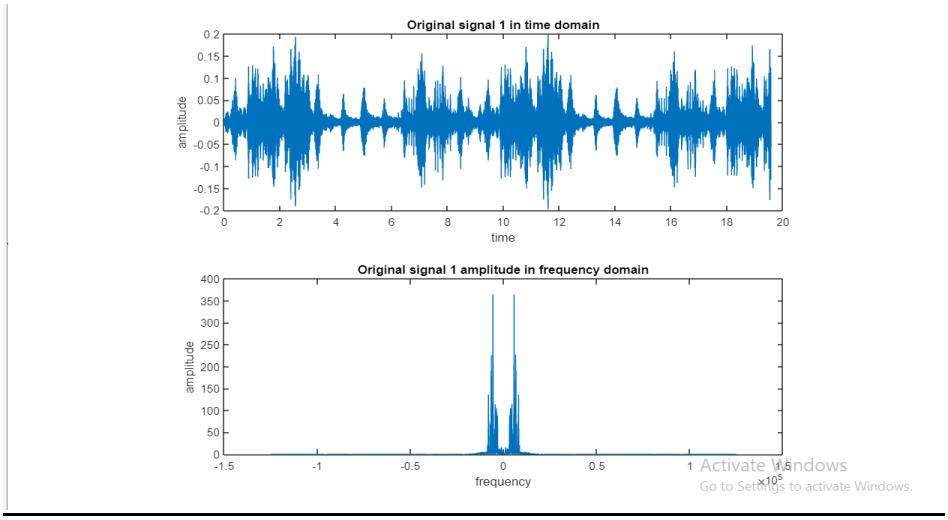
Phase error may cause attenuation of the output signal without causing distortion as long as it is constant. Attenuation increases as phase error increases.

Sin and cos signals with the same fc interfere together in the case of phase shift. The interference between them increase when phase shift increase. When phase shift reaches 90, they are completely interchanged.

Frequency shift causes attenuation and distortion of the output signal.

Figures:

(1) Original Signals:



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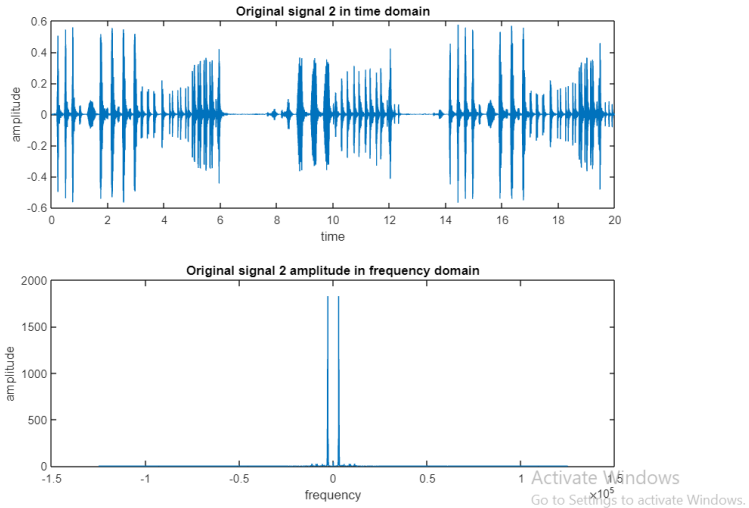

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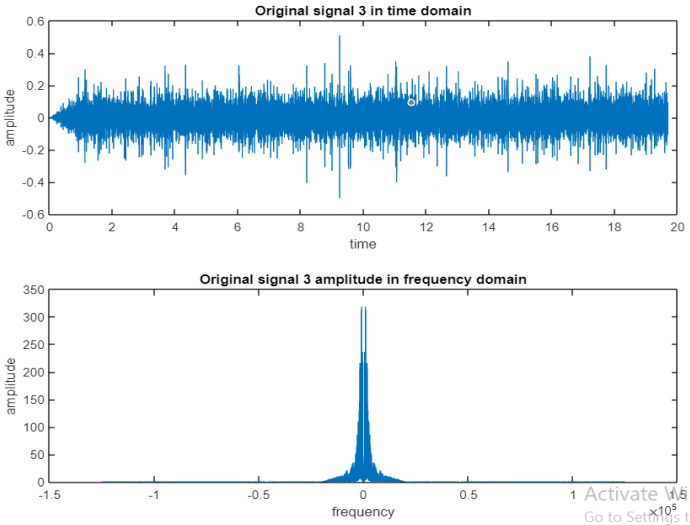

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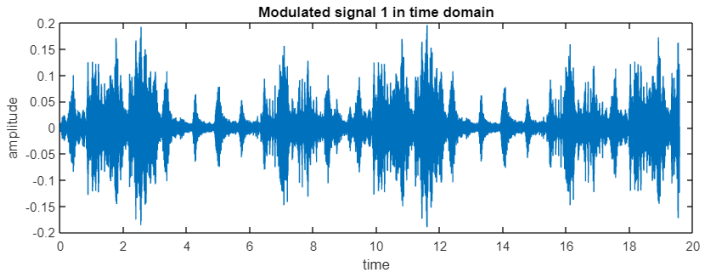
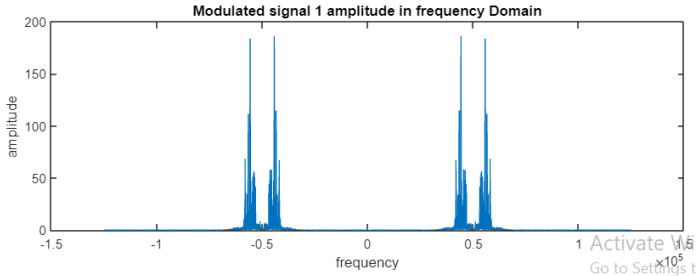
(2) Modulated signals:





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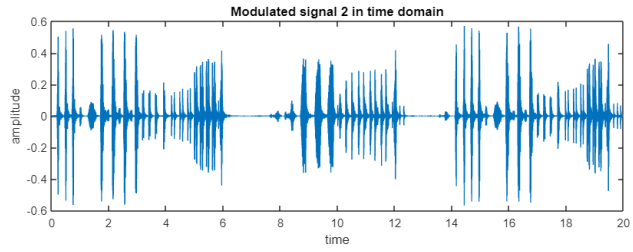

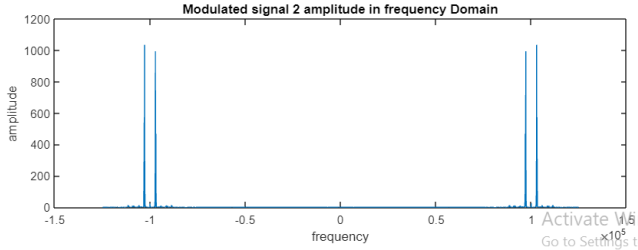

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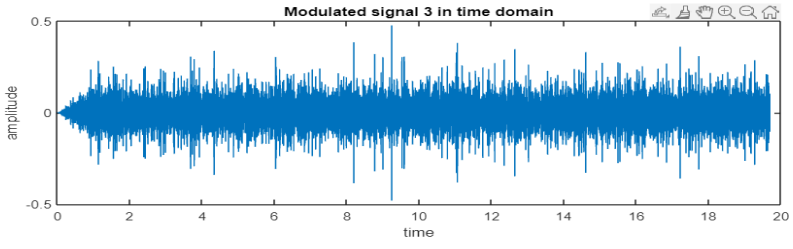

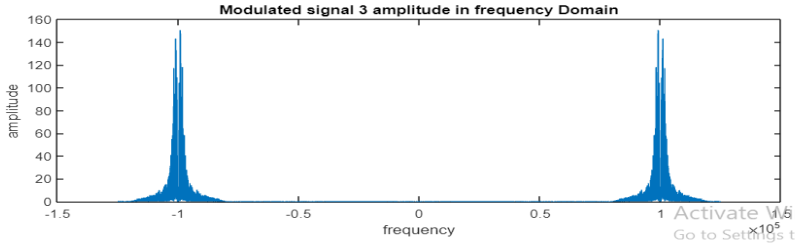

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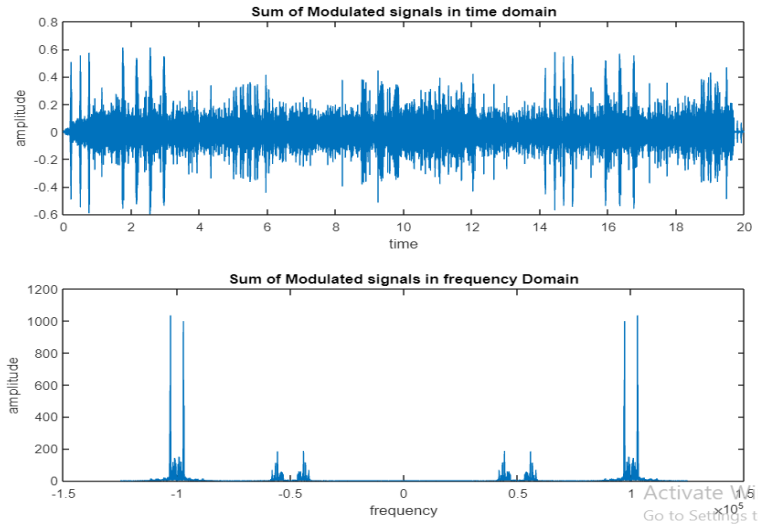
(3) Sum of 3 modulated signals:



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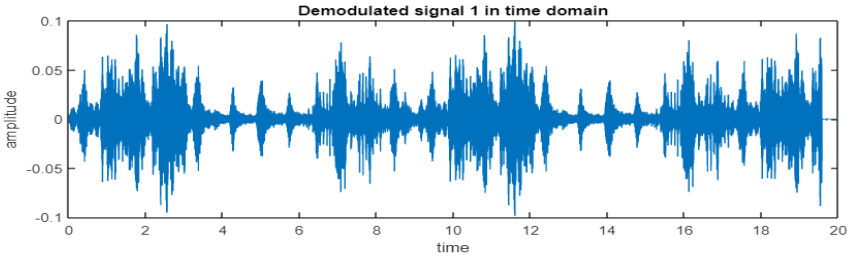
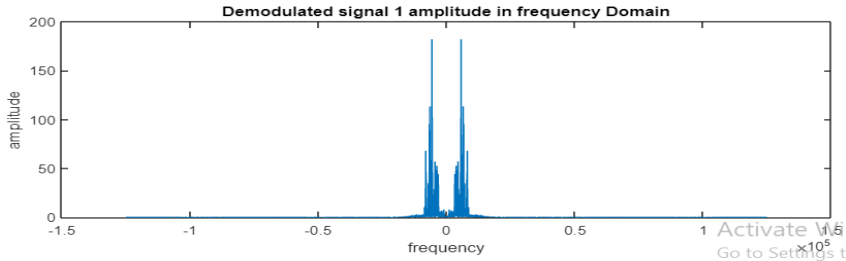
(4) Demodulated signals:





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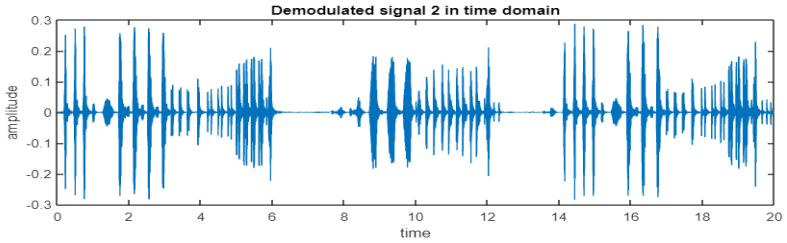

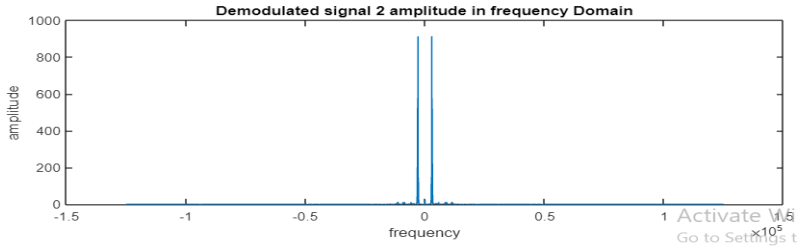

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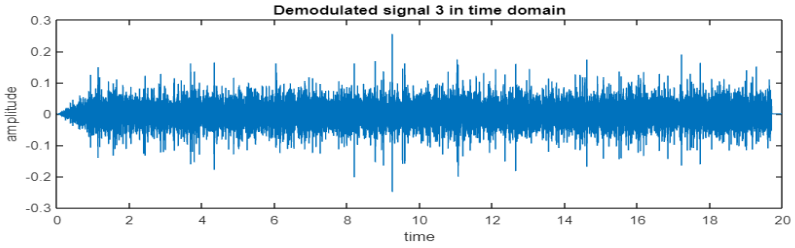

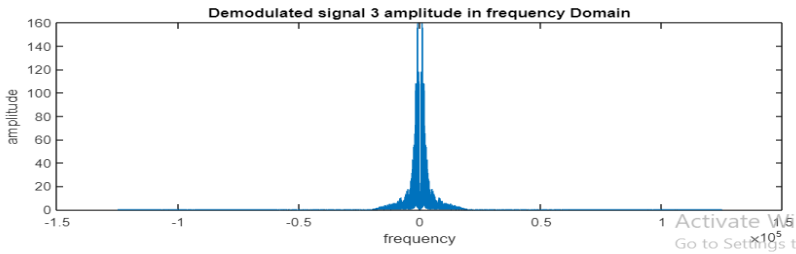

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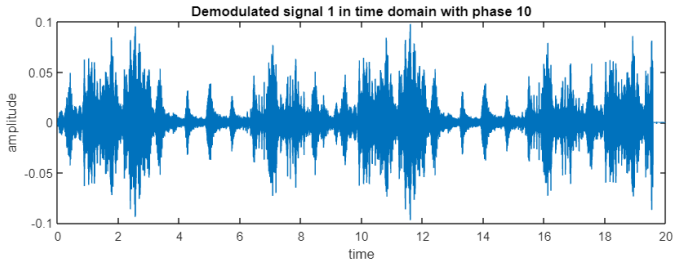
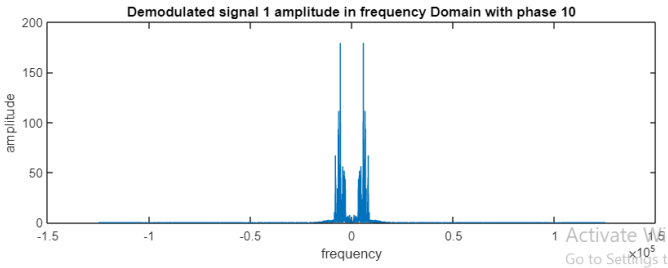
(5) Demodulated signals with phase 10





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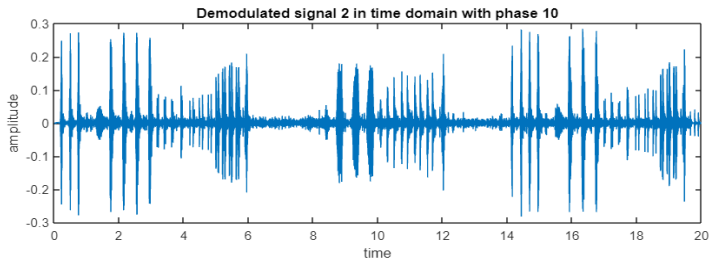

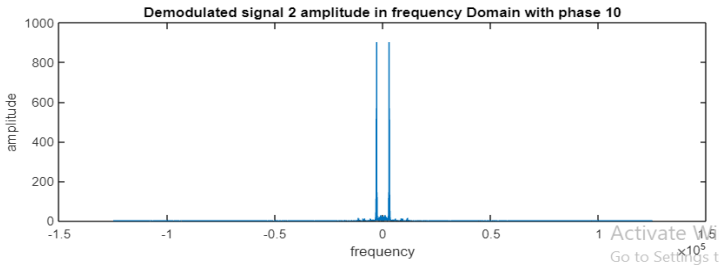

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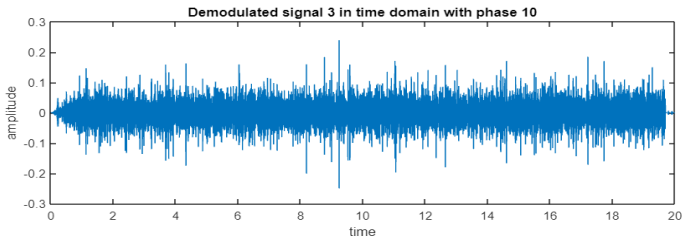

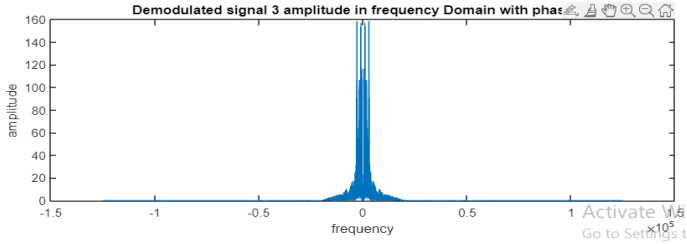

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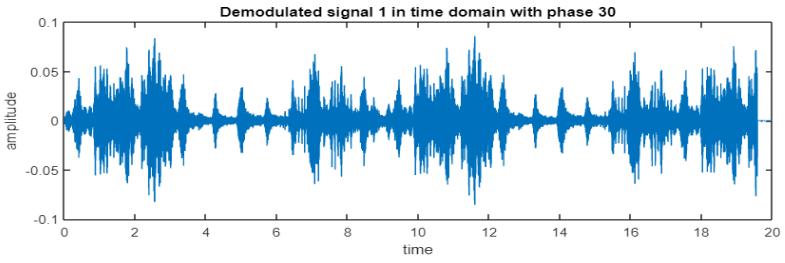
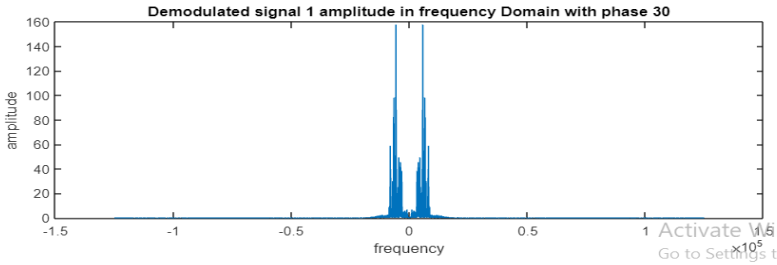
(6) Demodulated with phase 30:





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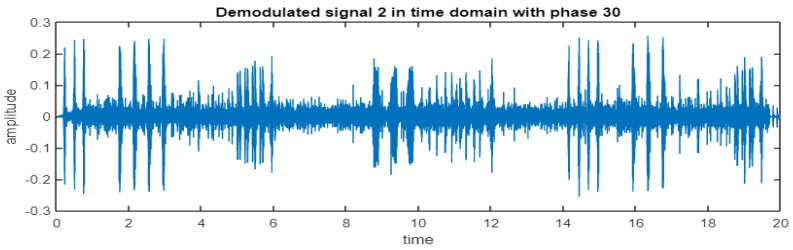

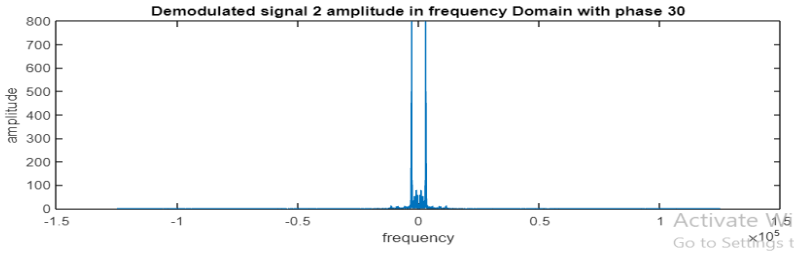

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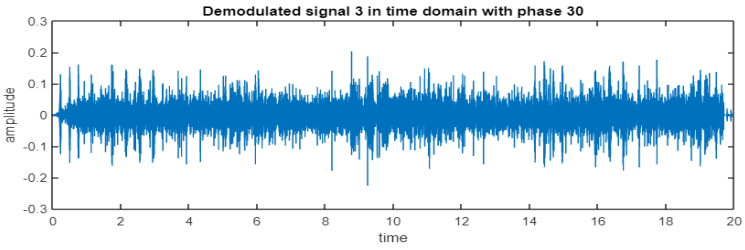

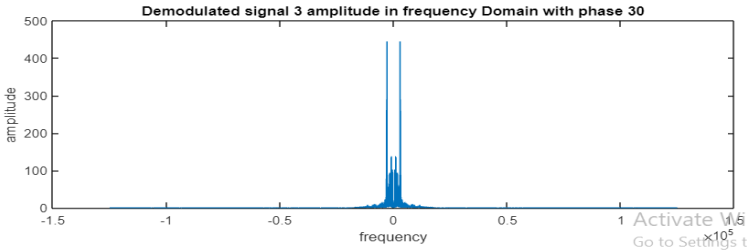

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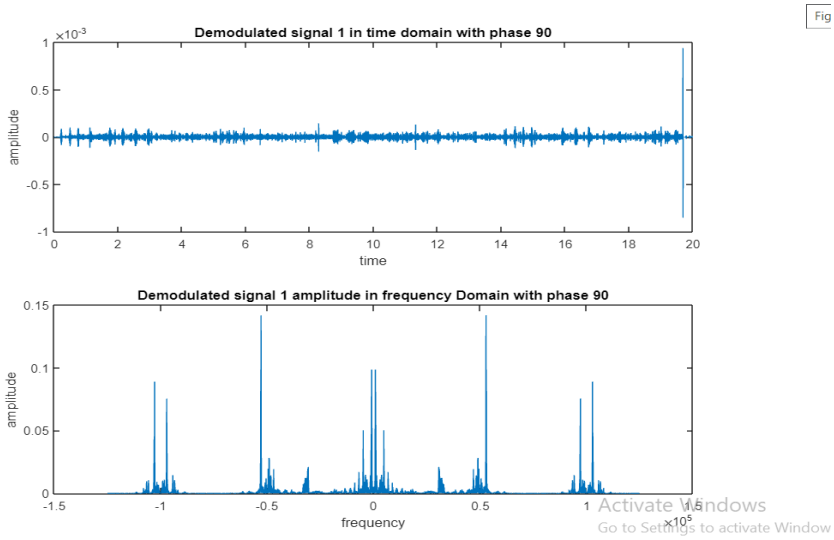
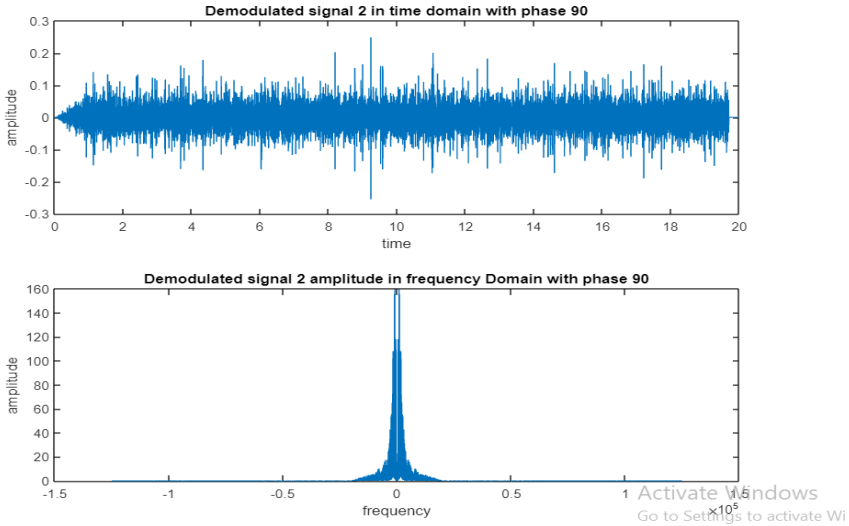
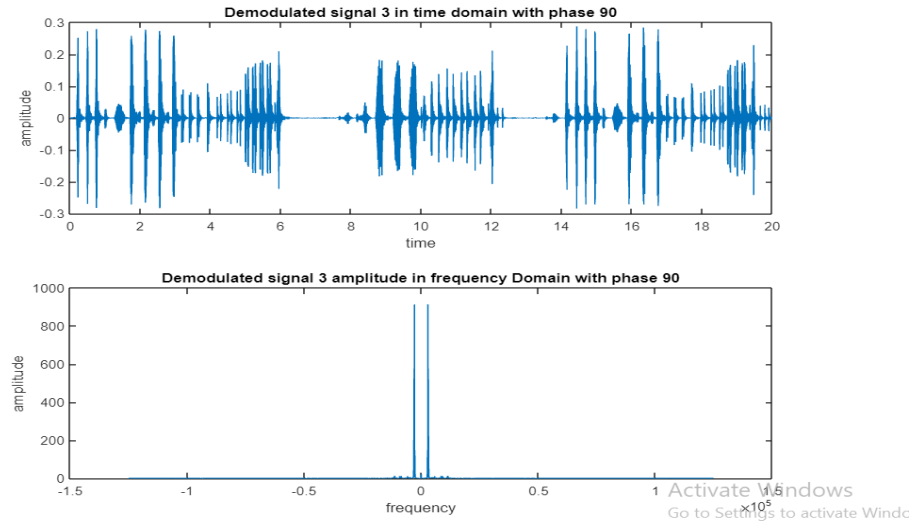
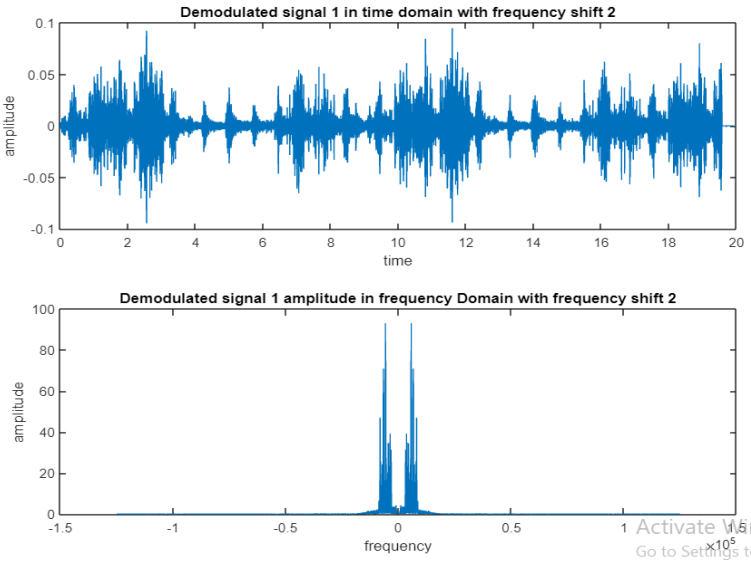
(7) Demodulated signals with phase 90







(8) Demodulated with frequency shift 2



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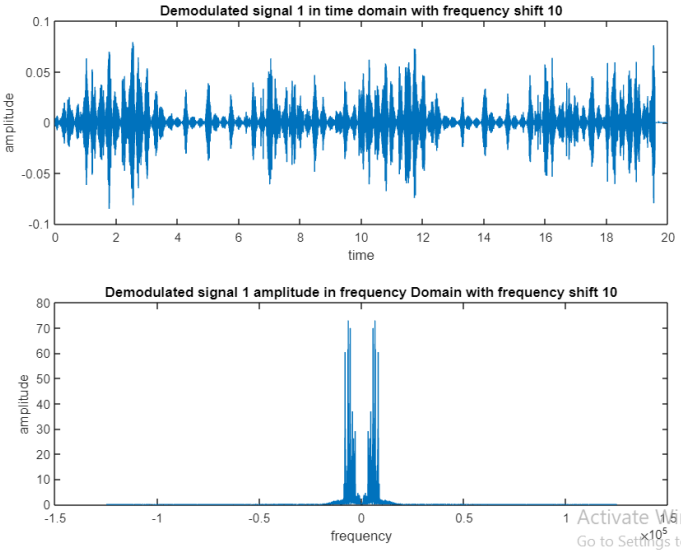
(9) Demodulated with frequency shift 10



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Code:

```
%------------------- read audio signals---------------------------%
[y1,fs1]=audioread('signal1.wav');
[y2,fs2]=audioread('signal2.wav');
[y3,fs3]=audioread('signal3.wav');
%sound(y1,fs1);

%-------------------------variables-----------------------------%
```

```
 y1 = y1(:,1);
 y2 = y2(:,1);
 y3 = y3(:,1);
%-------------------------------------------------------------------%
 ts1 = 1/fs1;
 ts2 = 1/fs2;
 ts3 = 1/fs3;
 t1 = 0:ts1:(length(y1)-1)/fs1;
 t2 = 0:ts2:(length(y2)-1)/fs2;
 t3 = 0:ts3:(length(y3)-1)/fs3;
%-------------------------------------------------------------------%
 f1 = -fs1/2:fs1/2;
 f2 = -fs2/2:fs2/2;
 f3 = -fs3/2:fs3/2;
%--------------------------resampling-----------------------------%
Fs=250000;
[p,q] = rat(Fs/fs1);
resamplSignal1 = resample(y1,p,q);

[p,q] = rat(Fs/fs2);
resamplSignal2 = resample(y2,p,q);

[p,q] = rat(Fs/fs3);
resamplSignal3 = resample(y3,p,q);
%-------------------------------------------------------------------%
ts=1/Fs;
f = -Fs/2:Fs/2;
timeAfterReSampling1=0:ts:(length(resamplSignal1)-1)*ts;
timeAfterReSampling2=0:ts:(length(resamplSignal2)-1)*ts;
timeAfterReSampling3=0:ts:(length(resamplSignal3)-1)*ts;



%-------------------------------------------------------------------%
y1_amplitude=abs(fftshift(fft(resamplSignal1,Fs+1)));
y2_amplitude=abs(fftshift(fft(resamplSignal2,Fs+1)));
y3_amplitude=abs(fftshift(fft(resamplSignal3,Fs+1)));
%------------plotting originsl signal1 in in time and frequency domain-----
--------%
figure;

subplot(2,1,1);
plot(timeAfterReSampling1,resamplSignal1);
title('Original signal 1 in time domain');
xlabel('time');
ylabel('amplitude');

subplot(2,1,2);
plot(f,y1_amplitude);
title('Original signal 1 amplitude in frequency domain');
xlabel('frequency');
ylabel('amplitude');

%------------plotting originsl signal2 in in time and frequency domain-----
--------%

figure;
subplot(2,1,1);
plot(timeAfterReSampling2,resamplSignal2);
title('Original signal 2 in time domain');
xlabel('time');
```

```
ylabel('amplitude');

subplot(2,1,2);
plot(f,y2_amplitude);
title('Original signal 2 amplitude in frequency domain');
xlabel('frequency');
ylabel('amplitude');

%------------plotting originsl signal3 in in time and frequency domain-----
--------%

figure;
subplot(2,1,1);
plot(timeAfterReSampling3,resamplSignal3);
title('Original signal 3 in time domain');
xlabel('time');
ylabel('amplitude');

subplot(2,1,2);
plot(f,y3_amplitude);
title('Original signal 3 amplitude in frequency domain');
xlabel('frequency');
ylabel('amplitude');
%-----------------------------------------------------------------%
fc1=50000;
fc2=100000;


%------------plotting modulated signal1 in in time and frequency domain----
---------%
% signal 1
c1=cos(2*pi*fc1*timeAfterReSampling1).';
modulated_signal1=(resamplSignal1).*c1;
modulated_amplitude1 = abs(fftshift(fft(modulated_signal1,Fs+1)));
figure;
subplot(2,1,1);
plot(timeAfterReSampling1,modulated_signal1);
title('Modulated signal 1 in time domain');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,modulated_amplitude1);
title('Modulated signal 1 amplitude in frequency Domain');
xlabel('frequency');
ylabel('amplitude');

%------------plotting modulated signal2 in in time and frequency domain----
---------%
% signal 2
figure;
c2=cos(2*pi*fc2*timeAfterReSampling2).';
modulated_signal2=(resamplSignal2).*c2;
modulated_amplitude2 = abs(fftshift(fft(modulated_signal2,Fs+1)));

subplot(2,1,1);
plot(timeAfterReSampling2,modulated_signal2);
title('Modulated signal 2 in time domain');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
```

```
plot(f,modulated_amplitude2);
title('Modulated signal 2 amplitude in frequency Domain');
xlabel('frequency');
ylabel('amplitude');

%------------plotting modulated signal3 in in time and frequency domain----
---------%
% signal 3
figure;
c3=sin(2*pi*fc2*timeAfterReSampling3).';
modulated_signal3=(resamplSignal3).*c3;
modulated_amplitude3 = abs(fftshift(fft(modulated_signal3,Fs+1)));

subplot(2,1,1);
plot(timeAfterReSampling3,modulated_signal3);
title('Modulated signal 3 in time domain');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,modulated_amplitude3);
title('Modulated signal 3 amplitude in frequency Domain');
xlabel('frequency');
ylabel('amplitude');
%-----------------------------Sum-----------------------------%
len = max(length(modulated_signal1),
max(length(modulated_signal2),length(modulated_signal3)));
t = 0:ts:(len-1)*ts;

SignalwithLengthLen1=[modulated_signal1;zeros(len-
length(modulated_signal1), 1)];
SignalwithLengthLen2=[modulated_signal2;zeros(len-
length(modulated_signal2), 1)];
SignalwithLengthLen3=[modulated_signal3;zeros(len-
length(modulated_signal3), 1)];

sumModulated=SignalwithLengthLen1+SignalwithLengthLen2+SignalwithLengthLen3
;

sumModulated_frequencyDomain = abs(fftshift(fft(sumModulated,Fs+1)));
%---------------------plotting modulated signal-------------------%
figure;

subplot(2,1,1);
plot(t,sumModulated);
title('Sum of Modulated signals in time domain');
xlabel('time');
ylabel('amplitude');

subplot(2,1,2);
plot(f,sumModulated_frequencyDomain);
title('Sum of Modulated signals in frequency Domain');
xlabel('frequency');
ylabel('amplitude');

%---------------------restore first signal-------------------%
sync_carr1 = cos(2*pi*fc1*t).';
demodulated11=(sumModulated).*sync_carr1;
demodulated11=lowpass(demodulated11,fc1,Fs*3);
demodulated_amplitude1= abs(fftshift(fft(demodulated11,Fs+1)));
```

```
figure;
subplot(2,1,1);
plot(t,demodulated11);
title('Demodulated signal 1 in time domain');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude1);
title('Demodulated signal 1 amplitude in frequency Domain');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal1.wav',demodulated11,Fs);
%----------------------restore second signal-------------------%
sync_carr2 = cos(2*pi*fc2*t).';
demodulated12=(sumModulated).*sync_carr2;
demodulated12=lowpass(demodulated12,fc1,Fs*3);
demodulated_amplitude2= abs(fftshift(fft(demodulated12,Fs+1)));

figure;
subplot(2,1,1);
plot(t,demodulated12);
title('Demodulated signal 2 in time domain');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude2);
title('Demodulated signal 2 amplitude in frequency Domain');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal2.wav',demodulated12,Fs);
%----------------------restore third signal-------------------%
sync_carr3 = sin(2*pi*fc2*t).';
demodulated13=(sumModulated).*sync_carr3;
demodulated13=lowpass(demodulated13,fc1,Fs*3);
demodulated_amplitude3= abs(fftshift(fft(demodulated13,Fs+1)));

figure;
subplot(2,1,1);
plot(t,demodulated13);
title('Demodulated signal 3 in time domain');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude3);
title('Demodulated signal 3 amplitude in frequency Domain');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal3.wav',demodulated13,Fs);
%----------------------pjase shift 10-------------------%
%----------------------restore first signal-------------------%
sync_carr1 = cos(2*pi*fc1*t+10*pi/180).';
demodulated11=(sumModulated).*sync_carr1;
demodulated11=lowpass(demodulated11,fc1,Fs*3);
demodulated_amplitude1= abs(fftshift(fft(demodulated11,Fs+1)));

figure;
```

```
subplot(2,1,1);
plot(t,demodulated11);
title('Demodulated signal 1 in time domain with phase 10');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude1);
title('Demodulated signal 1 amplitude in frequency Domain with phase 10');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal1_phase_10.wav',demodulated11,Fs);
%---------------------restore second signal-------------------%
sync_carr2 = cos(2*pi*fc2*t+10*pi/180).';
demodulated12=(sumModulated).*sync_carr2;
demodulated12=lowpass(demodulated12,fc1,Fs*3);
demodulated_amplitude2= abs(fftshift(fft(demodulated12,Fs+1)));

figure;
subplot(2,1,1);
plot(t,demodulated12);
title('Demodulated signal 2 in time domain with phase 10');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude2);
title('Demodulated signal 2 amplitude in frequency Domain with phase 10');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal2_phase_10.wav',demodulated12,Fs);
%---------------------restore third signal-------------------%
sync_carr3 = sin(2*pi*fc2*t+10*pi/180).';
demodulated13=(sumModulated).*sync_carr3;
demodulated13=lowpass(demodulated13,fc1,Fs*3);
demodulated_amplitude3= abs(fftshift(fft(demodulated13,Fs+1)));

figure;
subplot(2,1,1);
plot(t,demodulated13);
title('Demodulated signal 3 in time domain with phase 10');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude3);
title('Demodulated signal 3 amplitude in frequency Domain with phase 10');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal3_phase_10.wav',demodulated13,Fs);

%---------------------pjase shift 30-------------------%
%---------------------restore first signal-------------------%
sync_carr1 = cos(2*pi*fc1*t+30*pi/180).';
demodulated11=(sumModulated).*sync_carr1;
demodulated11=lowpass(demodulated11,fc1,Fs*3);
demodulated_amplitude1= abs(fftshift(fft(demodulated11,Fs+1)));

figure;
subplot(2,1,1);
```

```
plot(t,demodulated11);
title('Demodulated signal 1 in time domain with phase 30');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude1);
title('Demodulated signal 1 amplitude in frequency Domain with phase 30');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal1_phase_30.wav',demodulated11,Fs);
%---------------------restore second signal-------------------%
sync_carr2 = cos(2*pi*fc2*t+30*pi/180).';
demodulated12=(sumModulated).*sync_carr2;
demodulated12=lowpass(demodulated12,fc1,Fs*3);
demodulated_amplitude2= abs(fftshift(fft(demodulated12,Fs+1)));

figure;
subplot(2,1,1);
plot(t,demodulated12);
title('Demodulated signal 2 in time domain with phase 30');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude2);
title('Demodulated signal 2 amplitude in frequency Domain with phase 30');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal2_phase_30.wav',demodulated12,Fs);
%---------------------restore third signal-------------------%
sync_carr3 = sin(2*pi*fc2*t+30*pi/180).';
demodulated13=(sumModulated).*sync_carr3;
demodulated13=lowpass(demodulated13,fc1,Fs*3);
demodulated_amplitude3= abs(fftshift(fft(demodulated13,Fs+1)));

figure;
subplot(2,1,1);
plot(t,demodulated13);
title('Demodulated signal 3 in time domain with phase 30');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude3);
title('Demodulated signal 3 amplitude in frequency Domain with phase 30');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal3_phase_30.wav',demodulated13,Fs);

%---------------------pjase shift 90-------------------%
%---------------------restore first signal-------------------%
sync_carr1 = cos(2*pi*fc1*t+90*pi/180).';
demodulated11=(sumModulated).*sync_carr1;
demodulated11=lowpass(demodulated11,fc1,Fs*3);
demodulated_amplitude1= abs(fftshift(fft(demodulated11,Fs+1)));

figure;
subplot(2,1,1);
plot(t,demodulated11);
```

```
title('Demodulated signal 1 in time domain with phase 90');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude1);
title('Demodulated signal 1 amplitude in frequency Domain with phase 90');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal1_phase_90.wav',demodulated11,Fs);
%---------------------restore second signal-------------------%
sync_carr2 = cos(2*pi*fc2*t+90*pi/180).';
demodulated12=(sumModulated).*sync_carr2;
demodulated12=lowpass(demodulated12,fc1,Fs*3);
demodulated_amplitude2= abs(fftshift(fft(demodulated12,Fs+1)));

figure;
subplot(2,1,1);
plot(t,demodulated12);
title('Demodulated signal 2 in time domain with phase 90');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude2);
title('Demodulated signal 2 amplitude in frequency Domain with phase 90');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal2_phase_90.wav',demodulated12,Fs);
%---------------------restore third signal-------------------%
sync_carr3 = sin(2*pi*fc2*t+90*pi/180).';
demodulated13=(sumModulated).*sync_carr3;
demodulated13=lowpass(demodulated13,fc1,Fs*3);
demodulated_amplitude3= abs(fftshift(fft(demodulated13,Fs+1)));

figure;
subplot(2,1,1);
plot(t,demodulated13);
title('Demodulated signal 3 in time domain with phase 90');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude3);
title('Demodulated signal 3 amplitude in frequency Domain with phase 90');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal3_phase_90.wav',demodulated13,Fs);

%---------------------Frequrncy shift 2-------------------%
sync_carr1 = cos(2*pi*(fc1+10)*t).';
demodulated11=(sumModulated).*sync_carr1;
demodulated11=lowpass(demodulated11,fc1,Fs*3);
demodulated_amplitude1= abs(fftshift(fft(demodulated11,Fs+1)));

figure;
subplot(2,1,1);
plot(t,demodulated11);
title('Demodulated signal 1 in time domain with frequency shift 2');
xlabel('time');
```

```
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude1);
title('Demodulated signal 1 amplitude in frequency Domain with frequency
shift 2');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal1_freq_2.wav',demodulated11,Fs);

%---------------------Frequrncy shift 10-------------------%
sync_carr1 = cos(2*pi*(fc1+2)*t).';
demodulated11=(sumModulated).*sync_carr1;
demodulated11=lowpass(demodulated11,fc1,Fs*3);
demodulated_amplitude1= abs(fftshift(fft(demodulated11,Fs+1)));

figure;
subplot(2,1,1);
plot(t,demodulated11);
title('Demodulated signal 1 in time domain with frequency shift 10');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(f,demodulated_amplitude1);
title('Demodulated signal 1 amplitude in frequency Domain with frequency
shift 10');
xlabel('frequency');
ylabel('amplitude');

audiowrite('demodulatedSignal1_freq_10.wav',demodulated11,Fs);
```