Implemention/Analysis of Frequency Modulated and Demodulated Signal using Matlab

Lab # 07

Fall 2023

CSE-402L Digital Signal Processing Lab

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Class Section: **C**

"On my honor, as student of University of Engineering and Technology, I have neither given nor received unauthorized assistance on this academic work."

Submitted to:

Dr. Yasir Saleem Afridi

Date:

11^{th} December 2023

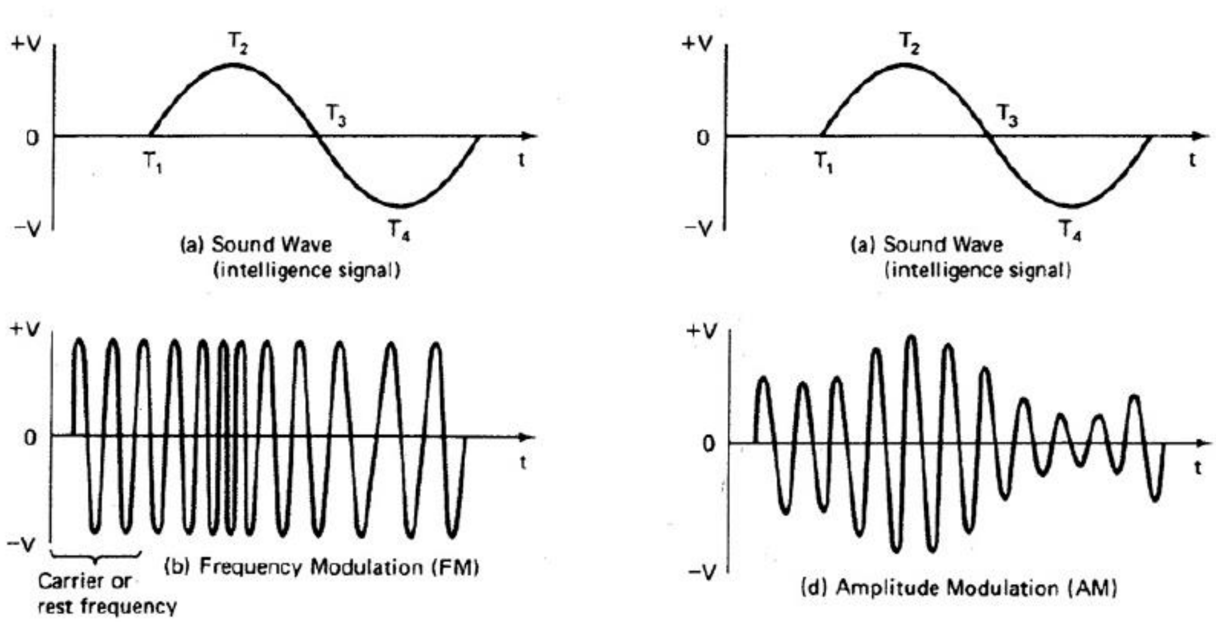
Department of Computer Systems Engineering

University of Engineering and Technology, Peshawar

Demonstration of Concepts	**Poor (Does not meet expectation (1))** The student failed to demonstrate a clear understanding of the assignment concepts	**Fair (Meet Expectation (2-3))** The student demonstrated a clear understanding of some of the assignment concepts	**Good (Exceeds Expectation (4-5)** The student demonstrated a clear understanding of the assignment concepts	**Score** **30%**
Accuracy	The student completed (<50%) tasks and provided MATLAB code and/or Simulink models with errors. Outputs shown are not correct in form of graphs (no labels) and/or tables along with incorrect analysis or remarks.	The student completed partial tasks (50% - <90%) with accurate MATLAB code and/or Simulink models. Correct outputs are shown in form of graphs (without labels) and/or tables along with correct analysis or remarks.	The student completed all required tasks (90%-100%) with accurate MATLAB code and/or Simulink models. Correct outputs are shown in form of labeled graphs and/or tables along with correct analysis or remarks.	**30%**
Following Directions	The student clearly failed to follow the verbal and written instructions to successfully complete the lab	The student failed to follow the some of the verbal and written instructions to successfully complete all requirements of the lab	The student followed the verbal and written instructions to successfully complete requirements of the lab	**20%**
Time Utilization	The student failed to complete even part of the lab in the allotted amount of time	The student failed to complete the entire lab in the allotted amount of time	The student completed the lab in its entirety in the allotted amount of time	**20%**

Implemention/Analysis of Frequency Modulated and Demodulated Signal using Matlab

A sine wave carrier can be modified for the purpose of transmitting information from one place to another by varying its frequency. This is known as **frequency modulation (FM).**
Frequency modulation (FM) is the standard technique for high-fidelity communications as is evident in the received signals of the FM band (88-108 MHz) vs. the AM band (450-1650 KHz). The main reason for the improved fidelity is that FM detectors, when properly designed, are not sensitive to random amplitude variations which are the dominant part of electrical noise (heard as static on the AM radio). Frequency modulation is not only used in commercial radio broadcasts, but also in police and hospital communications, emergency channels, TV sound, wireless (cellular) telephone systems.



$V_{AM} = V_c \sin 2\pi f_c t + (V_m \sin 2\pi f_m t)(\sin 2\pi f_c t)$

Tasks:

1. Set the sampling frequency to 1kHz and carrier frequency to 200 Hz. Generate a time vector having a duration of 0.2 s.

```
fs = 1000; % Sampling Frequency
fc = 200;  % Carrier Frequency
t = (0:1/fs:0.2)';
```

2. Create two tone sinusoidal signal with frequencies 30 and 60 Hz

3. Generate a Carrier Signal with the freq of 200Hz

4. Plot the modulating Signal and Carrier Signal

5. **Observe figure and comment on the frequencies of both signals and why.**

6. Set the frequency deviation to 50 Hz.

fDev = 50;

7. Frequency modulate x (Modulating Signal) using fmmod.

   y = fmmod(x,fc,fs,fDev);

8. Plot the original and modulated signals.

   plot(t,x,'c',t,y,'b--')
   xlabel('Time (s)')
   ylabel('Amplitude')
   legend('Original Signal','Modulated Signal')

9. Compare and Contrast Figure 1 and Figure 2
10. Change FDev to 100 Hz. Obtain the output and plot it (let say Figure 3). **Compare and Contrast the output shown in Figure 2 and Figure 3**
11. Perform Frequency Demodulation using Matlab function fmdemod

12. Plot the original and demodulated signals

Task 1:

Code:

```
fs = 1000; % Sampling frequency
fc = 200;  % Carrier frequency
t = (0:1/fs:0.2)'; % Time vector
```

Task 2 & 3:

Code:

```
x = sin(2*pi*30*t) + 2*sin(2*pi*60*t); % Original signal (sum of two sine waves)
x_c = sin(2*pi*fc*t); % Carrier signal
```

Task 4:

Code:

```
%%
% Plotting the original and carrier signals
figure(1);
plot(t, x, t, x_c);
xlabel('Time (s)');
ylabel('Amplitude');
legend('Original Signal', 'Carrier Signal');
grid on;
```

Output:

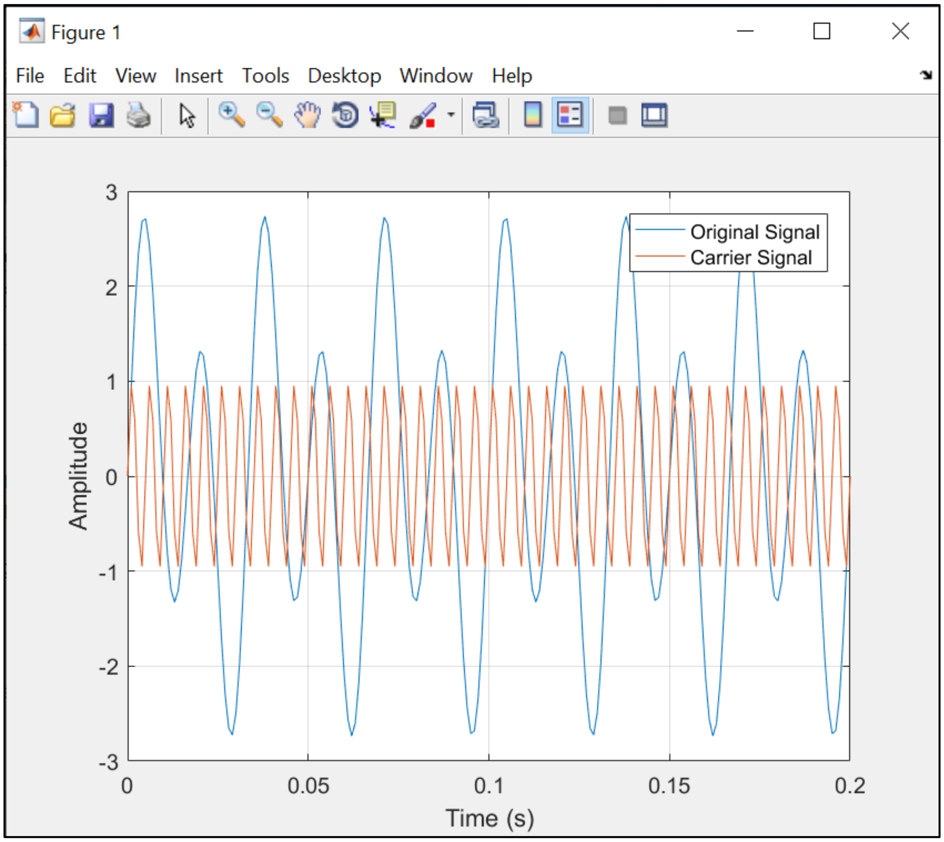


Figure 1

Task 5:

Observation:

It can be seen clearly from Figure 1, that Carrier Signal has high frequency (200 Hz) than the original message signal. Carrier signals complete more cycles in less time as compared to original signal.

Task 6,7,8,9 & 10:

Code:

```
% Frequency deviation for FM modulation
fDev1 = 50;
fDev2 = 100;

% FM modulation with different frequency deviations
y1 = fmmod(x, fc, fs, fDev1);
y2 = fmmod(x, fc, fs, fDev2);

% Plotting the original signal and modulated signal with fDev1
figure(2);
plot(t, x, 'c', t, y1, 'b--');
xlabel('Time (s)');
ylabel('Amplitude');
legend('Original Signal', 'Modulated Signal (fDev = 50 Hz)');
grid on;

% Plotting the original signal and modulated signal with fDev2
figure(3);
plot(t, x, 'c', t, y2, 'b--');
xlabel('Time (s)');
ylabel('Amplitude');
legend('Original Signal', 'Modulated Signal (fDev = 100 Hz)');
grid on;
%%
```

Output:

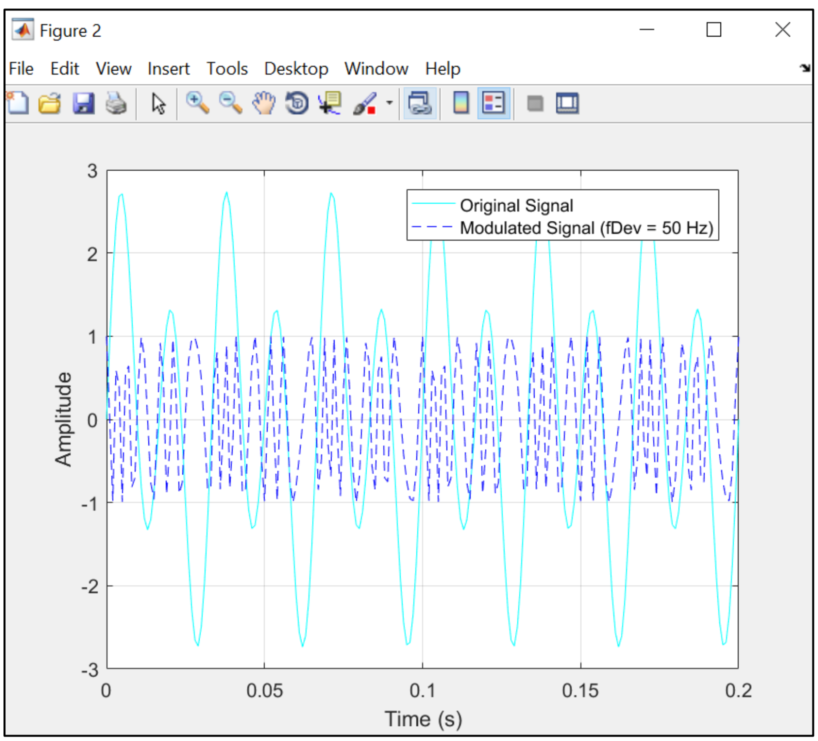


Figure 2

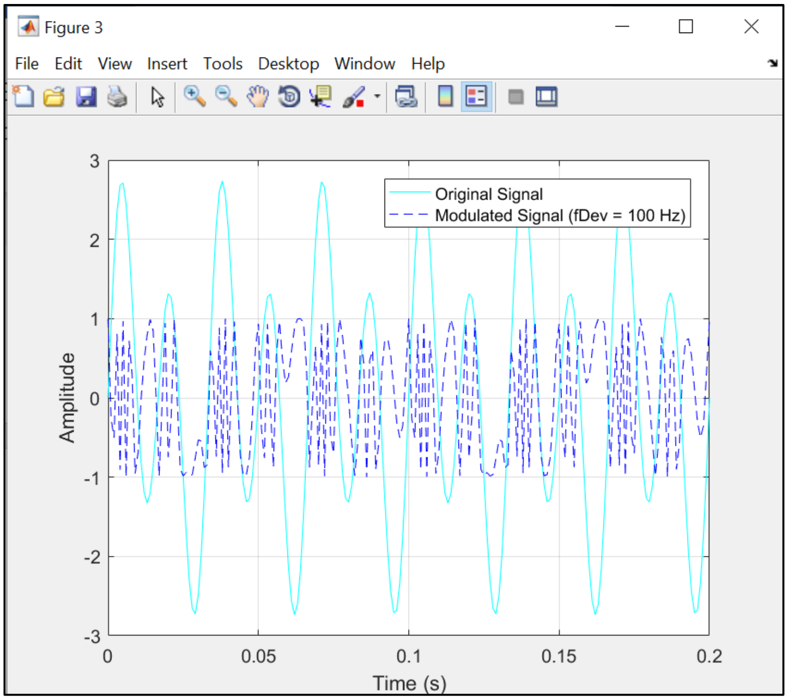


Figure 3

Observations:

By clearly analyzing Figure 2 and Figure 3, we can conclude that by doubling the fDev, the signal is distorted in the time domain and hence it deviates from the original signal when it is demodulated.

Task 11 & 12:

Code:

```
%%
% FM demodulation
z1 = fmdemod(y1, fc, fs, fDev1);
z2 = fmdemod(y2, fc, fs, fDev2);

% Plotting the original signal and demodulated signal with fDev1
figure(4);
plot(t, x, 'c', t, z1, 'b--');
xlabel('Time (s)');
ylabel('Amplitude');
legend('Original Signal', 'Demodulated Signal (fDev = 50 Hz)');
grid on;

% Plotting the original signal and demodulated signal with fDev2
figure(5);
plot(t, x, 'c', t, z2, 'b--');
xlabel('Time (s)');
ylabel('Amplitude');
legend('Original Signal', 'Demodulated Signal (fDev = 100 Hz)');
grid on;
```

Output:

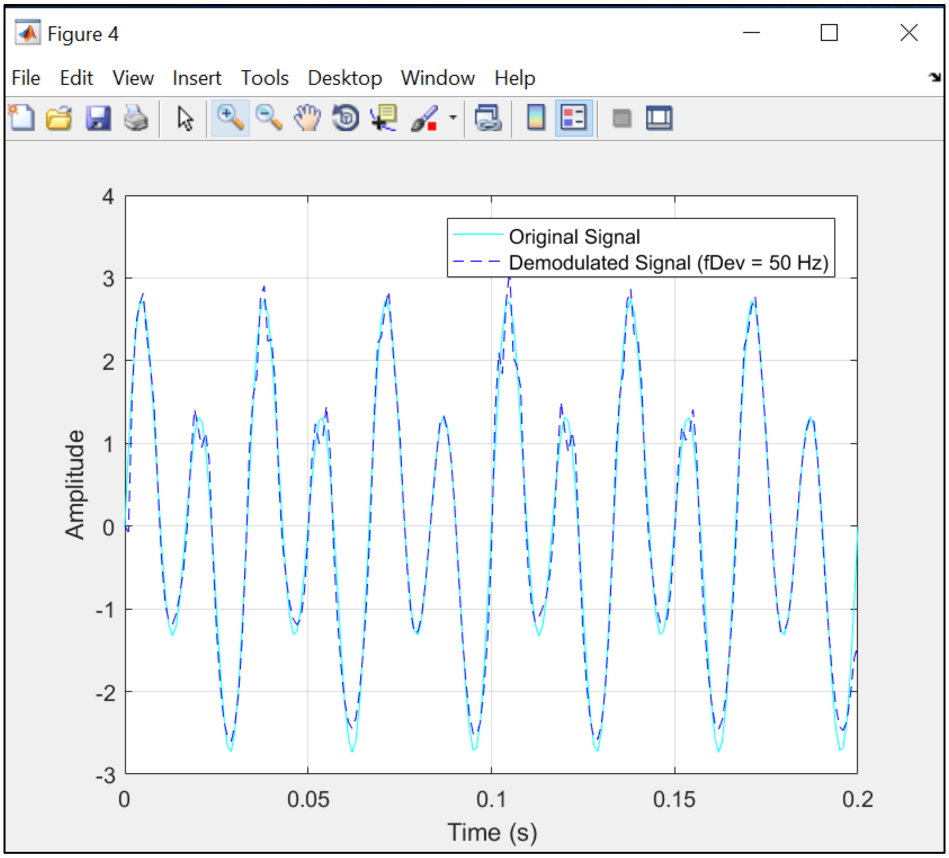


Figure 4

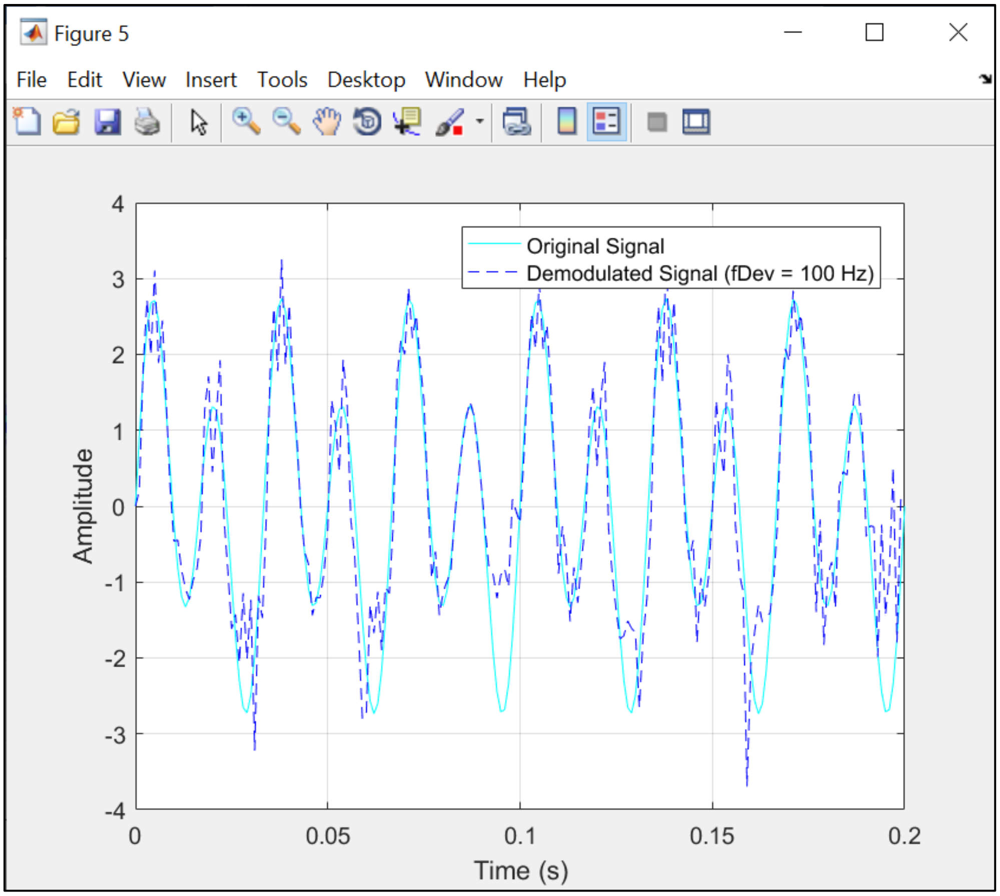


Figure 5
File Edit View Insert Tools Desktop Window Help
Original Signal
Demodulated Signal (fDev = 100 Hz)
Amplitude
Time (s)
4
3
2
1
0
-1
-2
-3
-4
0
0.05
0.1
0.15
0.2

Figure 5

Full Code:

Task1.m | AM_MOD.m | task2.m

```
clc;
clear all;

fs = 1000; % Sampling frequency
fc = 200;  % Carrier frequency
t = (0:1/fs:0.2)'; % Time vector

x = sin(2*pi*30*t) + 2*sin(2*pi*60*t); % Original signal (sum of two sine waves)
x_c = sin(2*pi*fc*t); % Carrier signal


% Plotting the original and carrier signals
figure(1);
plot(t, x, t, x_c);
xlabel('Time (s)');
ylabel('Amplitude');
legend('Original Signal', 'Carrier Signal');
grid on;

%%
% Frequency deviation for FM modulation
fDev1 = 50;
fDev2 = 100;

% FM modulation with different frequency deviations
```

Task1.m | AM_MOD.m | task2.m

```
% FM modulation with different frequency deviations
y1 = fmmod(x, fc, fs, fDev1);
y2 = fmmod(x, fc, fs, fDev2);

% Plotting the original signal and modulated signal with fDev1
figure(2);
plot(t, x, 'c', t, y1, 'b--');
xlabel('Time (s)');
ylabel('Amplitude');
legend('Original Signal', 'Modulated Signal (fDev = 50 Hz)');
grid on;

% Plotting the original signal and modulated signal with fDev2
figure(3);
plot(t, x, 'c', t, y2, 'b--');
xlabel('Time (s)');
```

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Task1.m AM_MOD.m task2.m

```matlab
xlabel('Time (s)');
ylabel('Amplitude');
legend('Original Signal', 'Modulated Signal (fDev = 100 Hz)');
grid on;
%%
% FM demodulation
z1 = fmdemod(y1, fc, fs, fDev1);
z2 = fmdemod(y2, fc, fs, fDev2);

% Plotting the original signal and demodulated signal with fDev1
figure(4);
plot(t, x, 'c', t, z1, 'b--');
xlabel('Time (s)');
ylabel('Amplitude');
legend('Original Signal', 'Demodulated Signal (fDev = 50 Hz)');
grid on;

% Plotting the original signal and demodulated signal with fDev2
figure(5);
plot(t, x, 'c', t, z2, 'b--');
xlabel('Time (s)');
ylabel('Amplitude');
legend('Original Signal', 'Demodulated Signal (fDev = 100 Hz)');
grid on;
```

Remarks/Conclusion:

In this lab, I learned how to simulate the process of **Frequency Modulation (FM)** and **demodulation**. At first, I generated an original signal composed of two sine waves and a carrier signal. I then modulated this signal with two different frequency deviations, creating modulated signals. These signals are plotted to visualize the modulation effect. Then I also demodulated the signals back to their original form and plot them for comparison. Additionally, I analyzed a graph of a modulated signal, noting its properties and the significance of modulation in telecommunications.