

# **Implementation/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<sup>th</sup> December 2023**

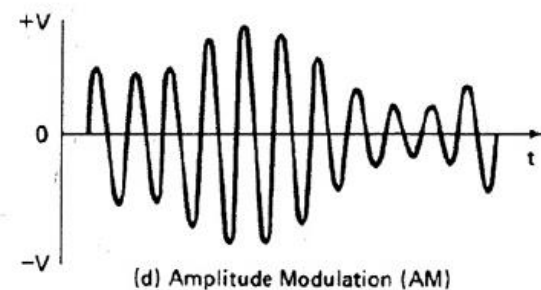
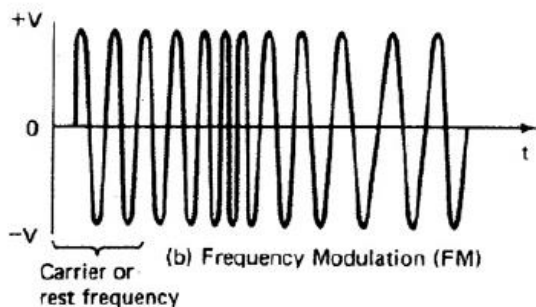
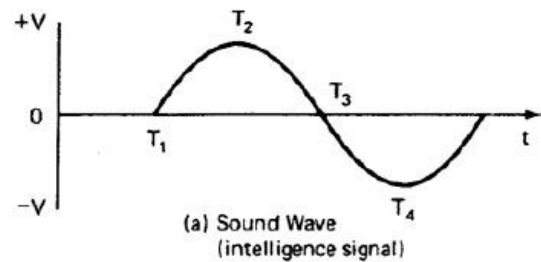
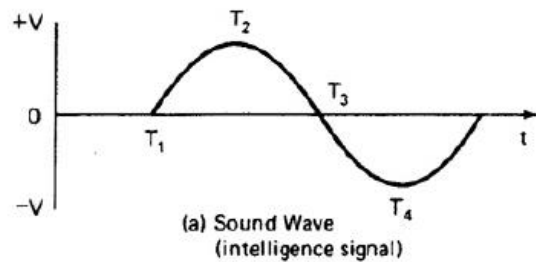
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Demonstration of Concepts	Poor (Does not meet expectation (1))	Fair (Meet Expectation (2-3))	Good (Exceeds Expectation (4-5))	Score
	The student failed to demonstrate a clear understanding of the assignment concepts	The student demonstrated a clear understanding of some of the assignment concepts	The student demonstrated a clear understanding of the assignment concepts	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%

## Implementation/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 fmod.  
`y = fmod(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:

```
4 - fs = 1000; % Sampling frequency
5 - fc = 200; % Carrier frequency
6 - t = (0:1/fs:0.2)'; % Time vector
7
```

### Task 2 & 3:

#### Code:

```
7
8 - x = sin(2*pi*30*t) + 2*sin(2*pi*60*t); % Original signal (sum of two sine waves)
9 - x_c = sin(2*pi*fc*t); % Carrier signal
10
```

### Task 4:

#### Code:

```
11 %%
12 % Plotting the original and carrier signals
13 - figure(1);
14 - plot(t, x, t, x_c);
15 - xlabel('Time (s)');
16 - ylabel('Amplitude');
17 - legend('Original Signal', 'Carrier Signal');
18 - grid on;
19
```

## Output:

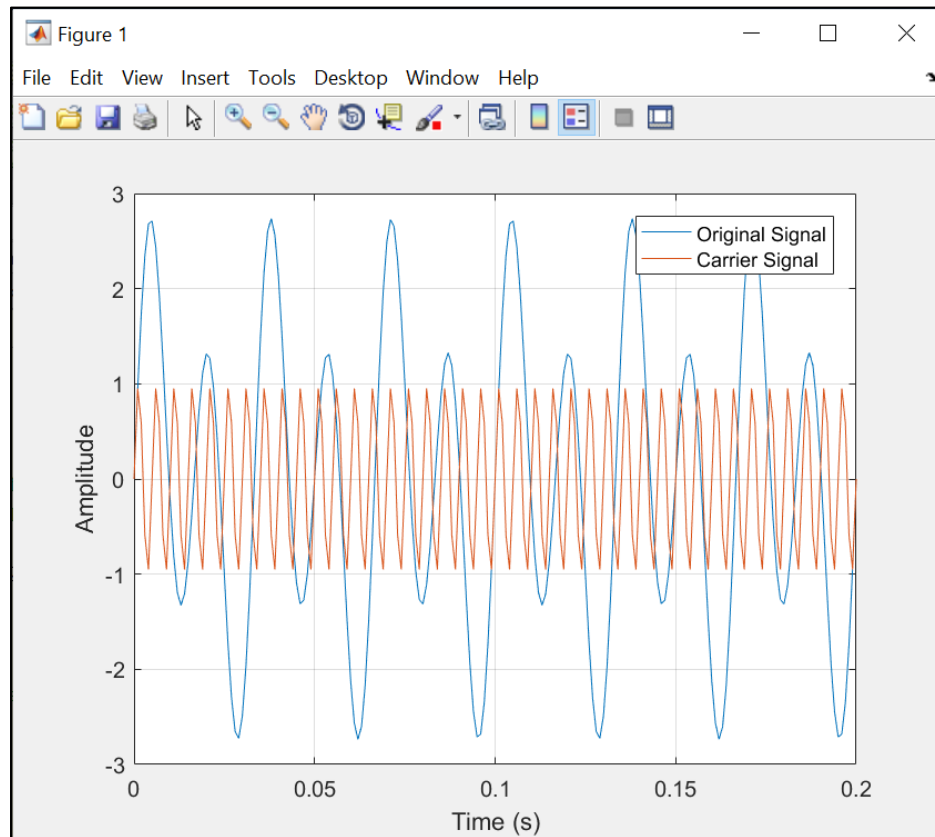


Figure 1

## 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:

```
21 % Frequency deviation for FM modulation
22 fDev1 = 50;
23 fDev2 = 100;
24
25 % FM modulation with different frequency deviations
26 y1 = fmod(x, fc, fs, fDev1);
27 y2 = fmod(x, fc, fs, fDev2);
28
29 % Plotting the original signal and modulated signal with fDev1
30 figure(2);
31 plot(t, x, 'c', t, y1, 'b--');
32 xlabel('Time (s)');
33 ylabel('Amplitude');
34 legend('Original Signal', 'Modulated Signal (fDev = 50 Hz)');
35 grid on;
36
37 % Plotting the original signal and modulated signal with fDev2
38 figure(3);
39 plot(t, x, 'c', t, y2, 'b--');
40 xlabel('Time (s)');
41 ylabel('Amplitude');
42 legend('Original Signal', 'Modulated Signal (fDev = 100 Hz)');
43 grid on;
44 %%
```

### Output:

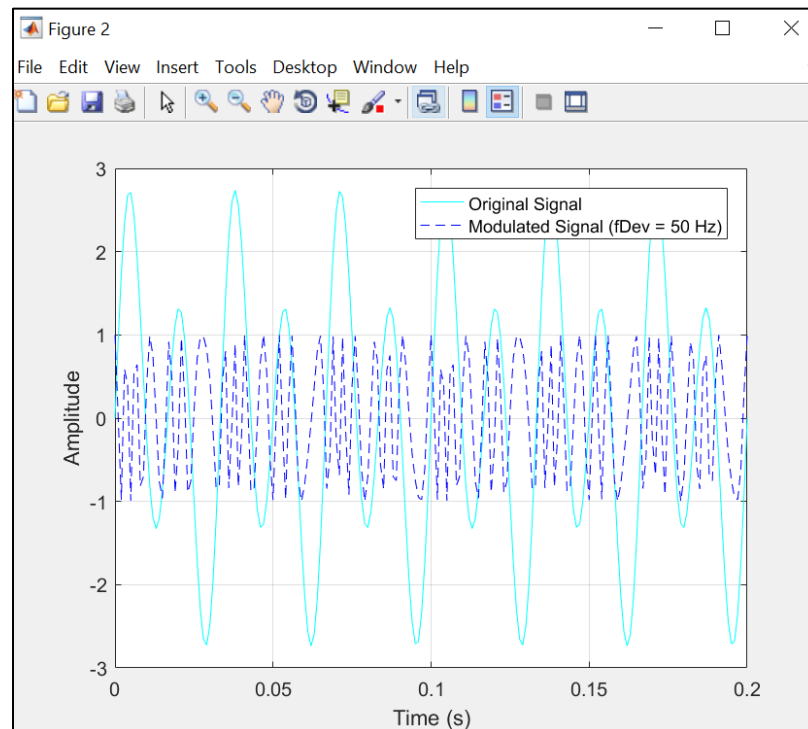


Figure 2

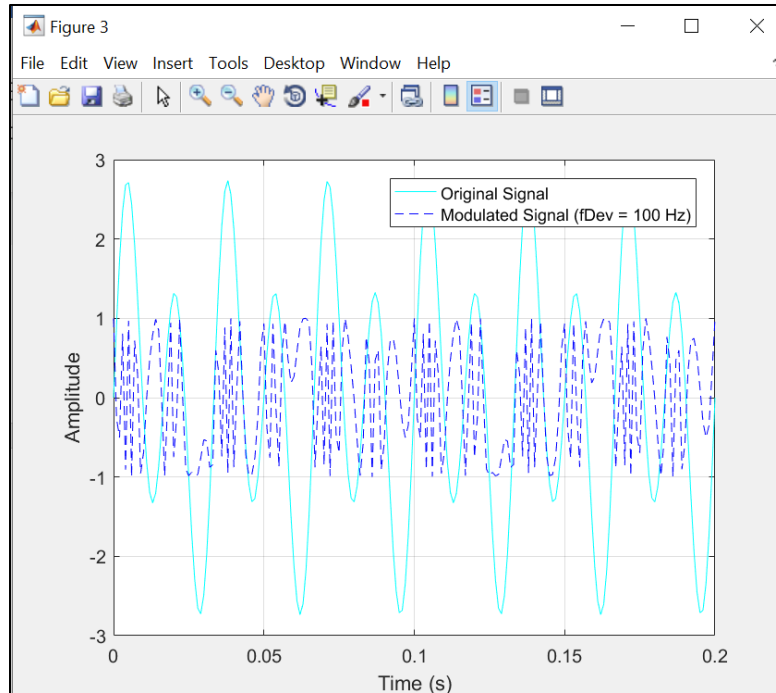


Figure 3

## Observations:

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

## Task 11 & 12:

## Code:

```

44 %%
45 % FM demodulation
46 z1 = fmdemod(y1, fc, fs, fDev1);
47 z2 = fmdemod(y2, fc, fs, fDev2);
48
49 % Plotting the original signal and demodulated signal with fDev1
50 figure(4);
51 plot(t, x, 'c', t, z1, 'b--');
52 xlabel('Time (s)');
53 ylabel('Amplitude');
54 legend('Original Signal', 'Demodulated Signal (fDev = 50 Hz)');
55 grid on;
56
57 % Plotting the original signal and demodulated signal with fDev2
58 figure(5);
59 plot(t, x, 'c', t, z2, 'b--');
60 xlabel('Time (s)');
61 ylabel('Amplitude');
62 legend('Original Signal', 'Demodulated Signal (fDev = 100 Hz)');
63 grid on;
64

```

## Output:

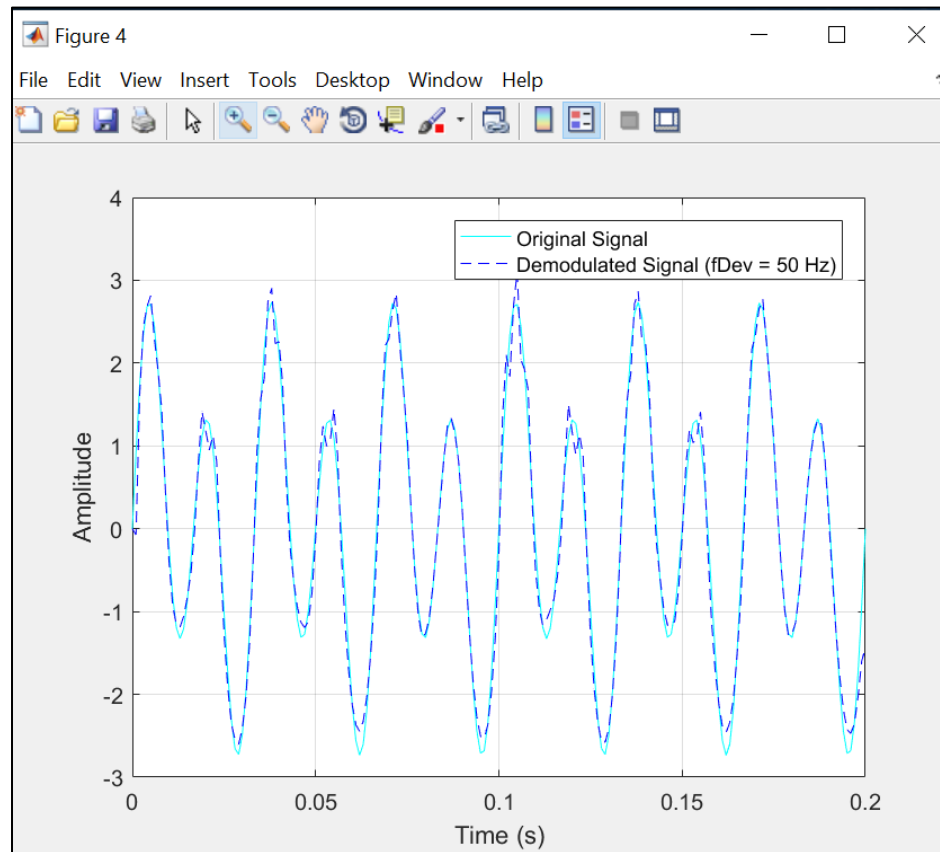


Figure 4



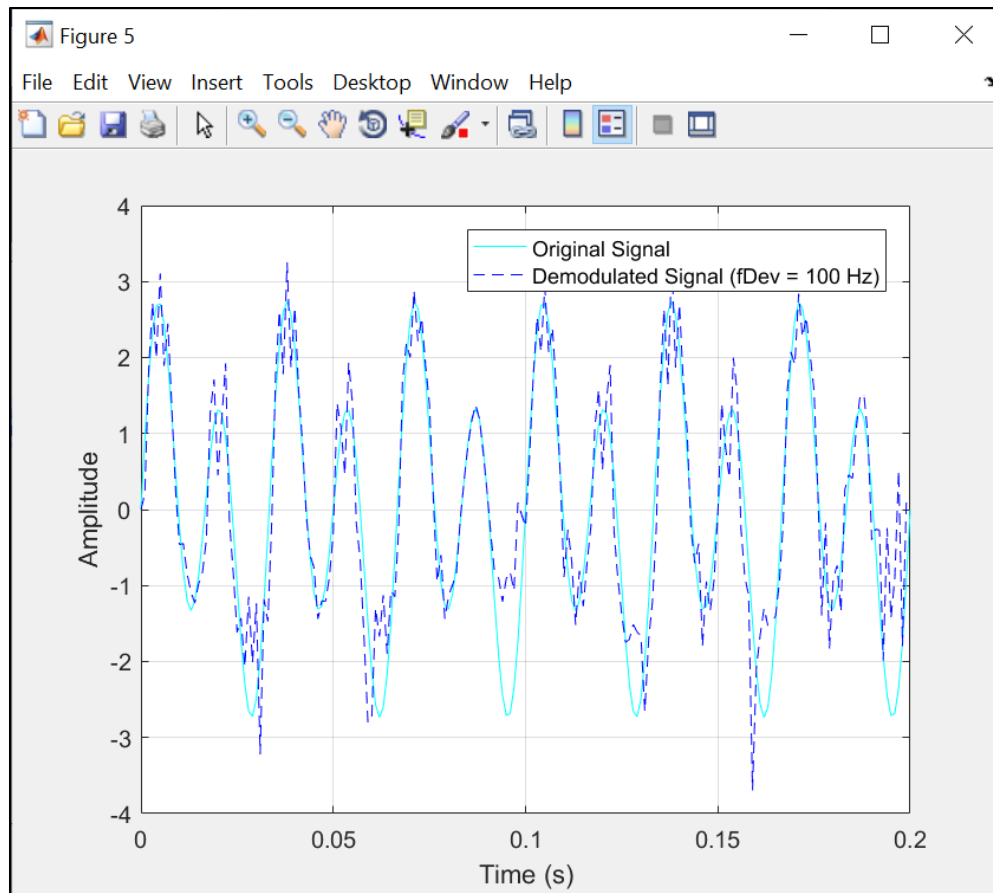


Figure 5

## Full Code:

```
Task1.m x AM_MOD.m x task2.m x +
1 -   clc;
2 -   clear all;
3
4 -   fs = 1000; % Sampling frequency
5 -   fc = 200; % Carrier frequency
6 -   t = (0:1/fs:0.2)'; % Time vector
7
8 -   x = sin(2*pi*30*t) + 2*sin(2*pi*60*t); % Original signal (sum of two sine waves)
9 -   x_c = sin(2*pi*fc*t); % Carrier signal
10
11
12   % Plotting the original and carrier signals
13   figure(1);
14   plot(t, x, t, x_c);
15   xlabel('Time (s)');
16   ylabel('Amplitude');
17   legend('Original Signal', 'Carrier Signal');
18   grid on;
19
20   %%
21   % Frequency deviation for FM modulation
22   fDev1 = 50;
23   fDev2 = 100;
24
25   % FM modulation with different frequency deviations
26
27   % FM modulation with different frequency deviations
28   y1 = fmmod(x, fc, fs, fDev1);
29   y2 = fmmod(x, fc, fs, fDev2);
30
31   % Plotting the original signal and modulated signal with fDev1
32   figure(2);
33   plot(t, x, 'c', t, y1, 'b--');
34   xlabel('Time (s)');
35   ylabel('Amplitude');
36   legend('Original Signal', 'Modulated Signal (fDev = 50 Hz)');
37   grid on;
38
39   % Plotting the original signal and modulated signal with fDev2
40   figure(3);
41   plot(t, x, 'c', t, y2, 'b--');
42   xlabel('Time (s)');
```

```
Editor - D:\Un\DSP Lab\Lab 07\Task1.m
Task1.m x AM_MOD.m x task2.m x +
40 - xlabel('Time (s)');
41 - ylabel('Amplitude');
42 - legend('Original Signal', 'Modulated Signal (fDev = 100 Hz)');
43 - grid on;
44 - %%
45 - % FM demodulation
46 - z1 = fmdemod(y1, fc, fs, fDev1);
47 - z2 = fmdemod(y2, fc, fs, fDev2);
48 -
49 - % Plotting the original signal and demodulated signal with fDev1
50 - figure(4);
51 - plot(t, x, 'c', t, z1, 'b--');
52 - xlabel('Time (s)');
53 - ylabel('Amplitude');
54 - legend('Original Signal', 'Demodulated Signal (fDev = 50 Hz)');
55 - grid on;
56 -
57 - % Plotting the original signal and demodulated signal with fDev2
58 - figure(5);
59 - plot(t, x, 'c', t, z2, 'b--');
60 - xlabel('Time (s)');
61 - ylabel('Amplitude');
62 - legend('Original Signal', 'Demodulated Signal (fDev = 100 Hz)');
63 - grid on;
64 -
```