Signals Systems and Communication Lab

Laboratory report submitted for the partial fulfillment
of the requirements for the degree of

Bachelor of Technology
in
Electronics and Communication Engineering

by

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February 2021

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Chapter *8*

Experiment - 8

8.1 Aim of the experiment

1. To generate frequency modulated signal and demodulate it (without MATLAB inbuilt function)

8.2 Software Used

MATLAB

8.3 Theory

8.3.1 About Frequency modulation (FM) :

Frequency modulation (FM) is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave. The technology is used in telecommunications, radio broadcasting, signal processing, and computing. In this process, the frequency of the carrier signal varies linearly with the message signal.

Frequency modulation is widely used for FM radio broadcasting. It is also used in telemetry, radar, seismic prospecting, and monitoring newborns for seizures via EEG, two-way radio systems, sound synthesis, magnetic tape-recording systems and some video-transmission systems. In radio transmission, an advantage of frequency modulation is that it has a larger signal-to-noise ratio and therefore rejects radio frequency interference better than an equal power amplitude modulation (AM) signal. For this reason, most music is broadcast over FM radio. Frequency modulation and phase modulation are the two complementary principal methods of angle modulation.

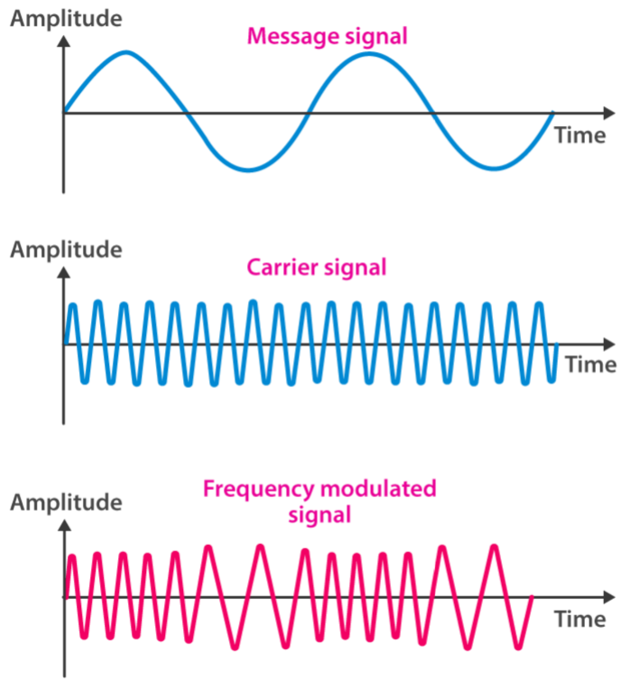

Figure 8.1 FM Modulation

Consider a message signal defined by S(t) = $A_m cos(2\pi f_m t)$. The instantaneous frequency of the FM signal is expressed as :

$$f(t) = f_c + \Delta f cos(2\pi f_m t) \tag{8.1}$$

where Δf = $k_f A_m$ is the maximum frequency deviation that occurs in the carrier frequency.

8.3.2 About Modulation index (β):

The FM modulation index is equal to the ratio of the frequency deviation to the modulating frequency. From the formula and definition of the modulation index, it can be seen that there is no term that includes the carrier frequency and this means that it is totally independent of the carrier frequency. Modulation index (β) is :

$$\beta = \frac{\Delta f}{f_m} = \frac{k_f A_m}{f_m} \tag{8.2}$$

The equation β is a dimensionless quantity since k_f has the units of $volt^{-1}$ $second^{-1}$. The FM signal is given by :

$$S_{FM}(t) = A_c cos[(2\pi f_c t + \beta sin(2\pi f_m t)] \tag{8.3}$$

8.3.3 About Frequency DeModulation (FM) :

Demodulation is of three types :

- Frequency discrimination
- Phase Shift Discrimination
- Phase-Locked-Loop detector (PLL)

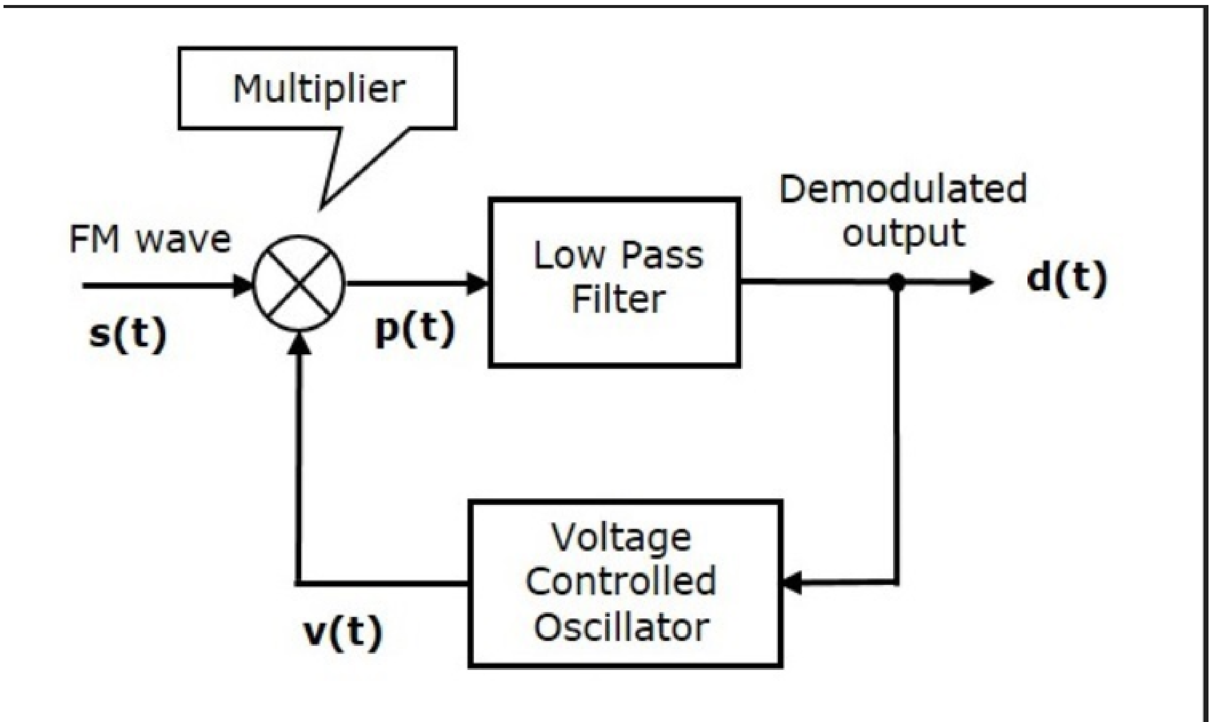

Figure 8.2 FM Demodulation

8.4 Code and Results

8.4.1 FM wave generation in time domain and frequency domain

```
% Name = Mohit Akhouri
% Roll no = 19UCC023
% SSC LAB Batch D1 - Monday ( 2-5 pm )

% This code will generate FM ( frequency modulated ) wave in time
 domain
% and frequency domain

t = linspace(0,1,500); % defining range for time axis
fc = 12000; % defining carrier frequency
fm = 4500; % defining message frequency
am = 1; % definining message amplitude
ac = 1; % defining carrier amplitude
Beta1 = 1; % defining modulation index 1
Beta2 = 5; % defining modulation index 2
Beta3 = 7; % defining modulation index 3
Beta4 = 10; % defining modulation index 4
Kf1 = (Beta1*fm)/am; % calculating max. frequency deviation for beta 1
Kf2 = (Beta2*fm)/am; % calculating max. frequency deviation for beta 2
Kf3 = (Beta3*fm)/am; % calculating max. frequency deviation for beta 3
Kf4 = (Beta4*fm)/am; % calculating max. frequency deviation for beta 4

mt = am*cos(2*pi*fm*t); % defining message signal
ct = ac*cos(2*pi*fc*t); % defining carrier signal

% plotting the message signal and carrier signal
figure;
subplot(2,1,1);
plot(t,mt);
xlabel('time(t)->');
ylabel('m(t)->');
title('Message Signal m(t)');
grid on;
subplot(2,1,2);
plot(t,ct);
xlabel('time(t)->');
ylabel('c(t)->');
title('Carrier Signal c(t)');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');

FM1t = ac*cos(2*pi*fc*t + Beta1*sin(2*pi*fm*t)); % definig FM wave for
 beta 1
FM2t = ac*cos(2*pi*fc*t + Beta2*sin(2*pi*fm*t)); % definig FM wave for
 beta 2
FM3t = ac*cos(2*pi*fc*t + Beta3*sin(2*pi*fm*t)); % definig FM wave for
 beta 3
FM4t = ac*cos(2*pi*fc*t + Beta4*sin(2*pi*fm*t)); % definig FM wave for
 beta 4

fs = 2*fc; % defining sampling frequency
N = length(t); % defining N ( total samples )
```

Figure 8.3 Part 1 of Code for FM wave generation

```
ts = 1/fs; % defining sampling time
f=linspace(-fs/2,fs/2,N); % defining frequency interval

% plotting FM wave in time domain and frequency domain for beta 1
figure;
subplot(2,1,1);
plot(t,FM1t);
xlabel('time(t)->');
ylabel('X_{FM1}(t)->');
title('X_{FM1}(t)  (Frequency modulated) signal for \beta = 1');
grid on;
subplot(2,1,2);
plot(f,abs(fftshift(fft(FM1t))));
xlabel('Frequency(Hz)->');
ylabel('X_{FM1}(\omega)->');
title('Magnitude plot of X_{FM1}(\omega) in frequency domain for \beta
 = 1');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');

% plotting FM wave in time domain and frequency domain for beta 2
figure;
subplot(2,1,1);
plot(t,FM2t);
xlabel('time(t)->');
ylabel('X_{FM2}(t)->');
title('X_{FM2}(t)  (Frequency modulated) signal for \beta = 5');
grid on;
subplot(2,1,2);
plot(f,abs(fftshift(fft(FM2t))));
xlabel('Frequency(Hz)->');
ylabel('X_{FM2}(\omega)->');
title('Magnitude plot of X_{FM2}(\omega) in frequency domain for \beta
 = 5');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');

% plotting FM wave in time domain and frequency domain for beta 3
figure;
subplot(2,1,1);
plot(t,FM3t);
xlabel('time(t)->');
ylabel('X_{FM3}(t)->');
title('X_{FM3}(t)  (Frequency modulated) signal for \beta = 7');
grid on;
subplot(2,1,2);
plot(f,abs(fftshift(fft(FM3t))));
xlabel('Frequency(Hz)->');
ylabel('X_{FM3}(\omega)->');
title('Magnitude plot of X_{FM3}(\omega) in frequency domain for \beta
 = 7');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');
```

Figure 8.4 Part 2 of Code for FM wave generation

```
% plotting FM wave in time domain and frequency domain for beta 4
figure;
subplot(2,1,1);
plot(t,FM4t);
xlabel('time(t)->');
ylabel('X_{FM4}(t)->');
title('X_{FM4}(t) (Frequency modulated) signal for \beta = 10');
grid on;
subplot(2,1,2);
plot(f,abs(fftshift(fft(FM4t))));
xlabel('Frequency(Hz)->');
ylabel('X_{FM2}(\omega)->');
title('Magnitude plot of X_{FM4}(\omega) in frequency domain for \beta
 = 10');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');
```

Figure 8.5 Part 3 of Code for FM wave generation

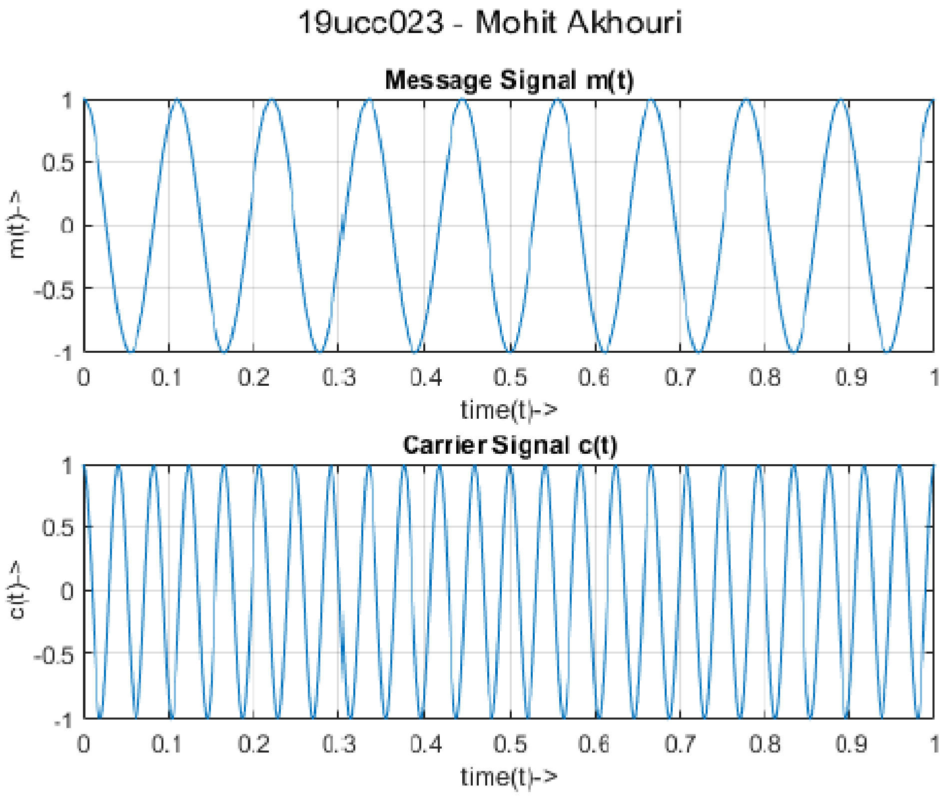

Figure 8.6 Message signal and carrier signal in time domain

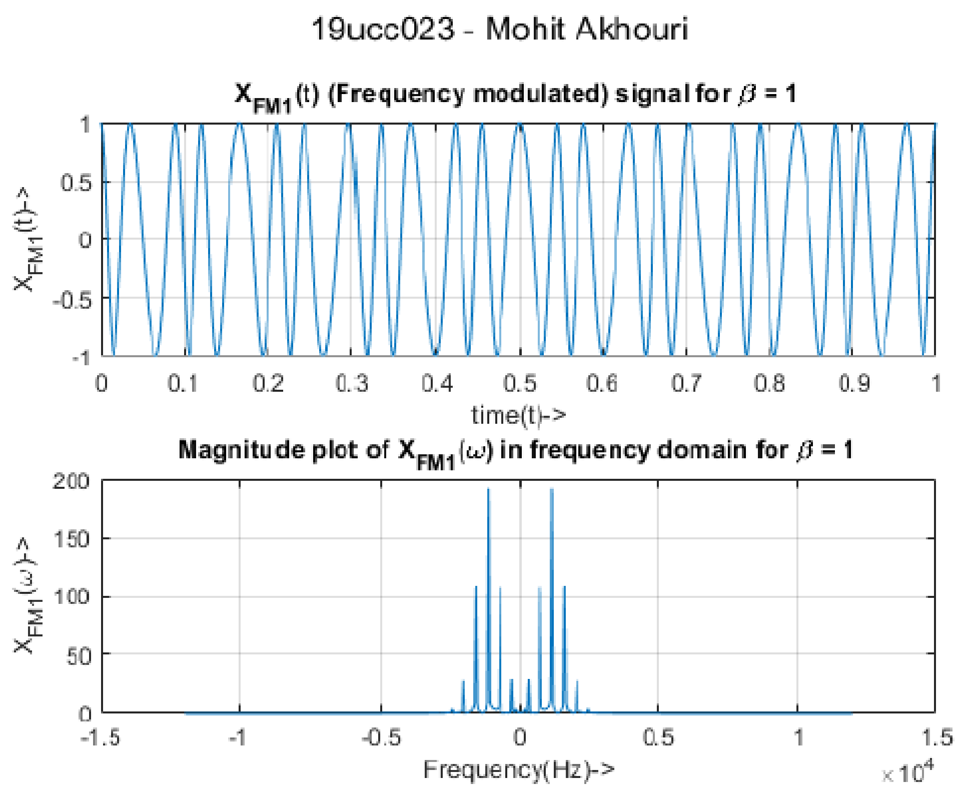

Figure 8.7 FM wave for $\beta = 1$

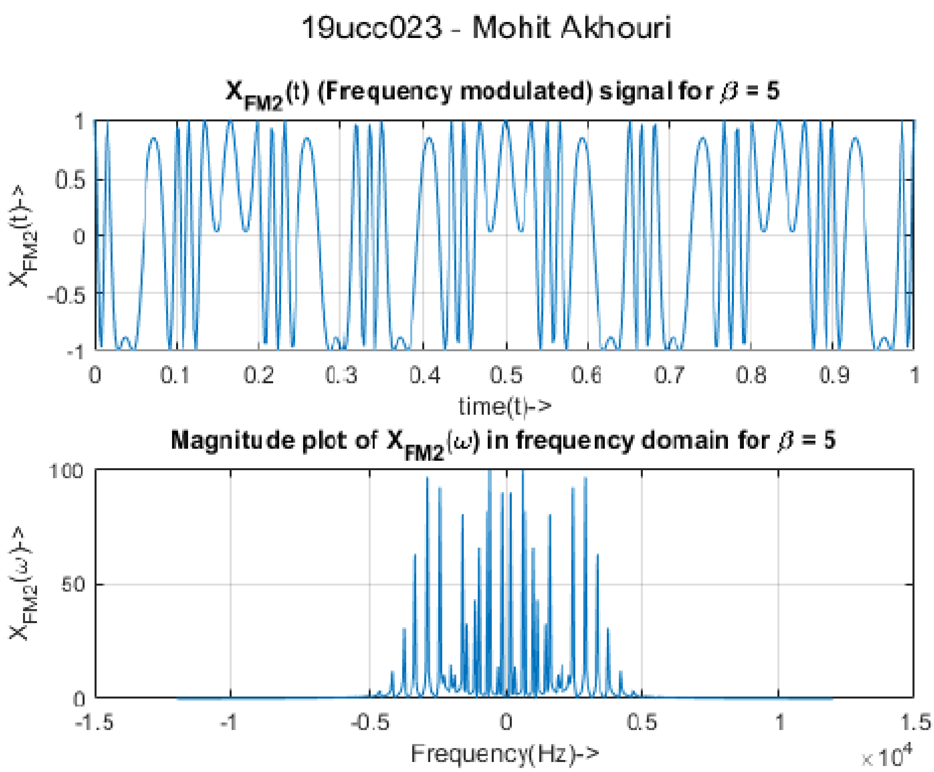

Figure 8.8 FM wave for $\beta = 5$

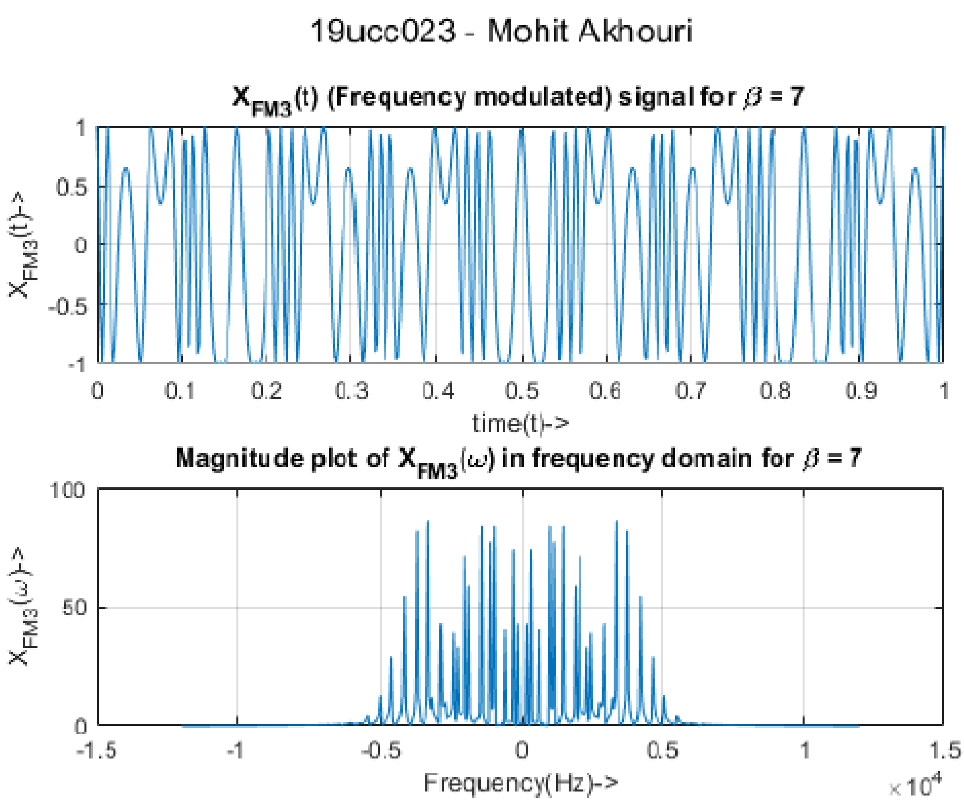

Figure 8.9 FM wave for $\beta = 7$

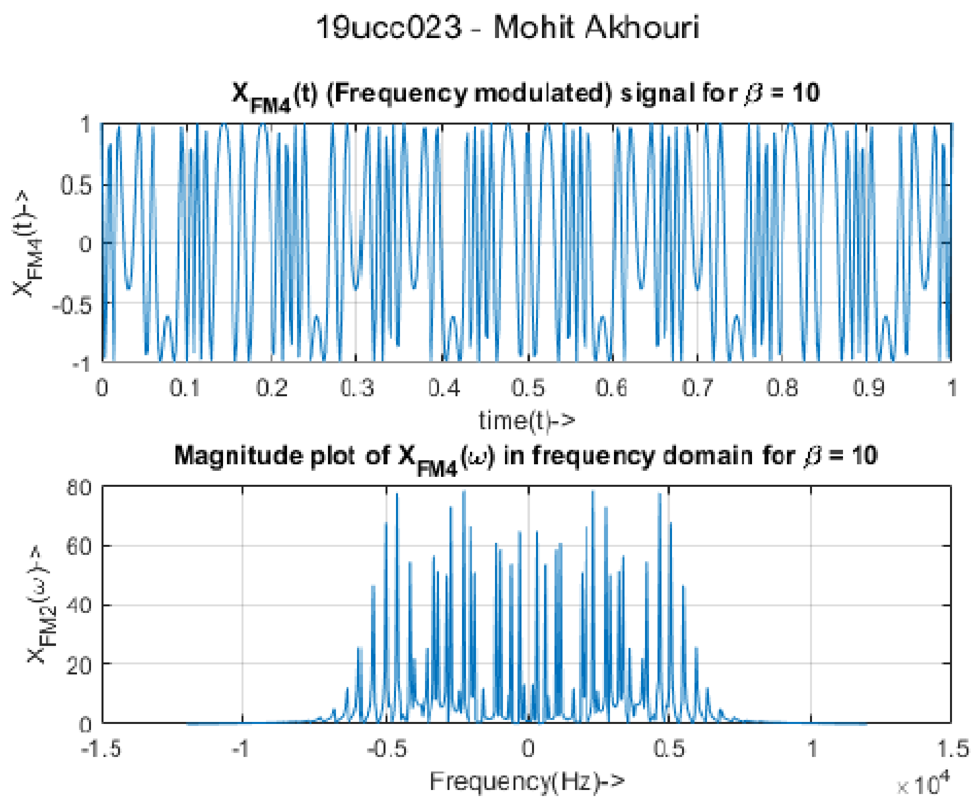

Figure 8.10 FM wave for $\beta = 10$

8.5 Conclusion

In this experiment, I studied about the FM wave modulation and demodulation for different value of modulation index (β) and how to demodulate them using inbuilt MATLAB function **fmdemod**.