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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Chapter 7

Experiment - 7

7.1 Aim of the experiment

1. To generate amplitude modulated signals (=0.3,0.5 and 1) and Demodulate the modulated wave.
2. To implement a Double Side Band - Suppressed Carrier (DSB-SC) modulator using a sampler (switch) and a band-pass filter and recover the modulating signal.

7.2 Software Used

MATLAB

7.3 Theory

7.3.1 About AM Modulation :

Amplitude modulation (AM) is a modulation technique used in electronic communication, most commonly for transmitting messages with a radio carrier wave. In amplitude modulation, the amplitude (signal strength) of the carrier wave is varied in proportion to that of the message signal, such as an audio signal. This technique contrasts with angle modulation, in which either the frequency of the carrier wave is varied as in frequency modulation, or its phase, as in phase modulation.
In Amplitude Modulation the amplitude of high frequency sine wave (carrier) is varied in accordance with the instantaneous value of the modulating signal.

$$m(t) = A_m cos(2 f_m t) \tag{7.1}$$

$$c(t) = A cos(2\pi f_c(t)) \tag{7.2}$$

$$S_{AM}(t) = [A_c + A_m cos(2\pi f_m t)] cos(2\pi f_c(t)) \tag{7.3}$$

Where equation 7.1 is **modulating signal**, equation 7.2 is **carrier signal** and equation 7.3 is equation of **Amplitude modulated wave** . A_m is amplitude of modulating signal, A_c is amplitude of carrier signal, f_m is frequency of modulating signal and f_c is frequency of carrier signal.

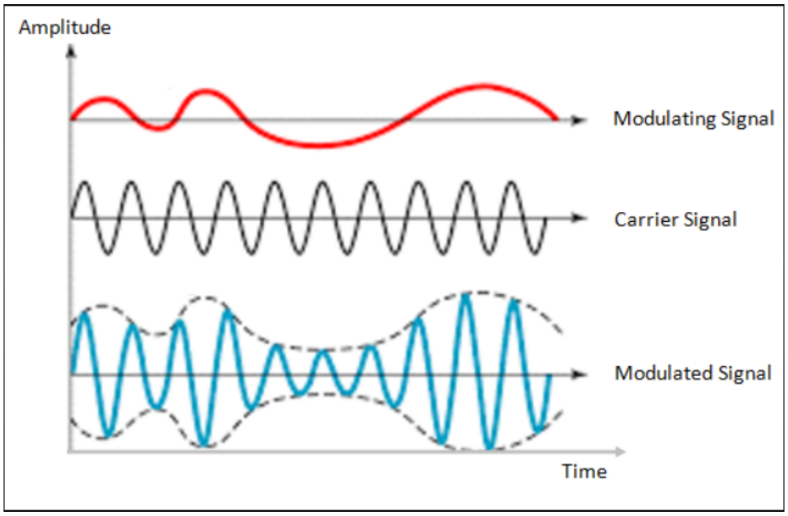

Figure 7.1 AM modulation of message signal

7.3.2 About Modulation Index :

Modulation index is also known as modulation depth is defined for the carrier wave to describe the modu- lated variable of carrier signal varying with respect to its unmodulated level. It is represented as follows:

$$\mu = \frac{m_p}{A} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} \tag{7.4}$$

where, m_p is the peak value of modulating signal and A is carrier amplitude, V_{max} and V_{min} are maximum and minimum values of the envelope.

7.3.3 About DSB-SC Modulation :

Double-sideband suppressed-carrier transmission (DSB-SC) is transmission in which frequencies produced by amplitude modulation (AM) are symmetrically spaced above and below the carrier frequency and the carrier level is reduced to the lowest practical level, ideally being completely suppressed. In the DSB-SC modulation, unlike in AM, the wave carrier is not transmitted; thus, much of the power is distributed between the side bands, which implies an increase of the cover in DSB-SC, compared to AM, for the same power use. DSB-SC transmission is a special case of double-sideband reduced carrier transmission. It is used for radio data systems. This mode is frequently used in Amateur radio voice communications, especially on High-Frequency bands. The basic transmit signal for DSB-SC is :

$$S_{DSB-SC}(t) = m(t)cos(2\pi f_c t) \tag{7.5}$$

where f_c is the carrier frequency. The fourier transform S(f) the modulator output is related to the Fourier transform M(f) of the message signal by :

$$S(f) = \frac{1}{2}M(f - f_c) + \frac{1}{2}M(f + f_c) \tag{7.6}$$

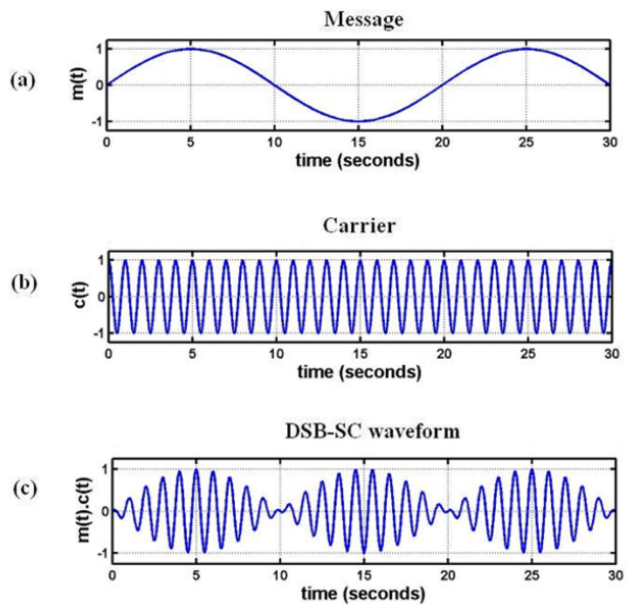

Figure 7.2 DSB-SC Modulation of message signal

7.3.4 About DSB-SC Demodulation :

Demodulation is recovering the message signal back from the modulated signal. Demodulation has two basic types.

- Non Coherent or Envelop Detection
- Coherent or Product Detection

Envelop detection is mainly reserved for Double side band (DSB) and Vestigial side band (VSB) type modulation. The **Product or Coherent detection** can be used in every AM type.

7.3.5 About Coherent detection:

The same carrier signal (which is used for generating SSB-SC wave) is used to detect the message signal. In this process, the message signal can be extracted from SSB-SC wave by multiplying it with a carrier, having the same frequency and the phase of the carrier used in SSB-SC modulation. The resulting signal is then passed through a Low Pass Filter. The output of this filter is the desired message signal.

7.4 Code and Results

7.4.1 AM Wave generation in time and frequency domain

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

% This code will generate AM wave forms in time and frequency domains

Am = 10; % defining Am modulating amplitude
fm = 200; % defining fm modulating frequency
fc = 2000; % defining fc carrier frequency

t = linspace(0,0.02,300); % defining range for time axis

% generating AM wave form for 30% modulation
mu1 = 0.3; % 30% modulation index
Ac1 = Am/mu1; % defining carrier amplitude
m1t = Am*cos(2*pi*fm*t); % defining message signal
c1t = Ac1*cos(2*pi*fc*t); % defining carrier signal
am1 = (Ac1 + Am*cos(2*pi*fm*t)).*cos(2*pi*fc*t); % AM signal for 30%
 modulation

% plotting figures
figure;
subplot(3,1,1);
plot(t,m1t);
xlabel('time(t)->');
ylabel('m(t) ->');
title('Message signal');
grid on;
subplot(3,1,2);
plot(t,c1t);
xlabel('time(t)->');
ylabel('c(t) ->');
title('Carrier signal');
grid on;
subplot(3,1,3);
plot(t,am1);
xlabel('time(t)->');
ylabel('X_{AM}(t) ->');
title('X_{AM}(t) for 30% modulation');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');

% generating AM wave form for 50% modulation
mu2 = 0.5; % 50% modulation index
Ac2 = Am/mu2; % defining carrier amplitude
m2t = Am*cos(2*pi*fm*t); % defining message signal
c2t = Ac2*cos(2*pi*fc*t); % defining carrier signal
am2 = (Ac2 + Am*cos(2*pi*fm*t)).*cos(2*pi*fc*t); % AM signal for 50%
 modulation

% plotting figures
figure;
```

Figure 7.3 Part 1 of Code for AM wave generation

```
subplot(3,1,1);
plot(t,m2t);
xlabel('time(t)->');
ylabel('m(t) ->');
title('Message signal');
grid on;
subplot(3,1,2);
plot(t,c2t);
xlabel('time(t)->');
ylabel('c(t) ->');
title('Carrier signal');
grid on;
subplot(3,1,3);
plot(t,am2);
xlabel('time(t)->');
ylabel('X_{AM}(t) ->');
title('X_{AM}(t) for 50% modulation');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');

% generating AM wave form for 100% modulation
mu3 = 1; % 100% modulation index
Ac3 = Am/mu3; % defining carrier amplitude
m3t = Am*cos(2*pi*fm*t);  % defining message signal
c3t = Ac3*cos(2*pi*fc*t); % defining carrier signal
am3 = (Ac3+ Am*cos(2*pi*fm*t)).*cos(2*pi*fc*t); % AM signal for 100%
 modulation

% plotting figures
figure;
subplot(3,1,1);
plot(t,m3t);
xlabel('time(t)->');
ylabel('m(t) ->');
title('Message signal');
grid on;
subplot(3,1,2);
plot(t,c3t);
xlabel('time(t)->');
ylabel('c(t) ->');
title('Carrier signal');
grid on;
subplot(3,1,3);
plot(t,am3);
xlabel('time(t)->');
ylabel('X_{AM}(t) ->');
title('X_{AM}(t) for 100% modulation');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');

% frequency respose for 30% modulation
fft1=fftshift(fft(am1));
fft1_modified=(abs(fft1));
```

Figure 7.4 Part 2 of Code for AM wave generation

```
% frequency response for 50% modulation
fft2=fftshift(fft(am2));
fft2_modified=(abs(fft2));

% frequency response for 100% modulation
fft3=fftshift(fft(am3));
fft3_modified=(abs(fft3));

% plotting figures
figure;
subplot(3,1,1);
plot(fft1_modified);
xlabel('frequency(Hz)->');
ylabel('X_{AM}(\omega)->');
title('X_{AM}(\omega) for 30% modulation');
grid on;
subplot(3,1,2);
plot(fft2_modified);
xlabel('frequency(Hz)->');
ylabel('X_{AM}(\omega)->');
title('X_{AM}(\omega) for 50% modulation');
grid on;
subplot(3,1,3);
plot(fft3_modified);
xlabel('frequency(Hz)->');
ylabel('X_{AM}(\omega)->');
title('X_{AM}(\omega) for 100% modulation');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');
```

Figure 7.5 Part 3 of Code for AM wave generation

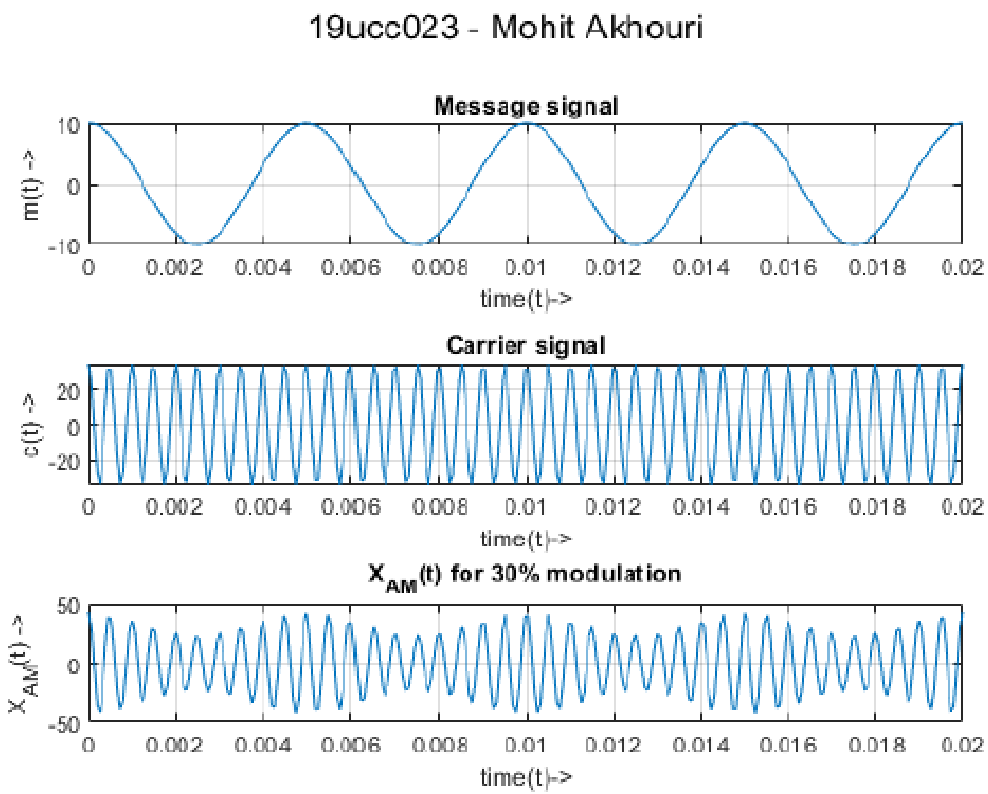

Figure 7.6 AM wave generation for 30% modulation

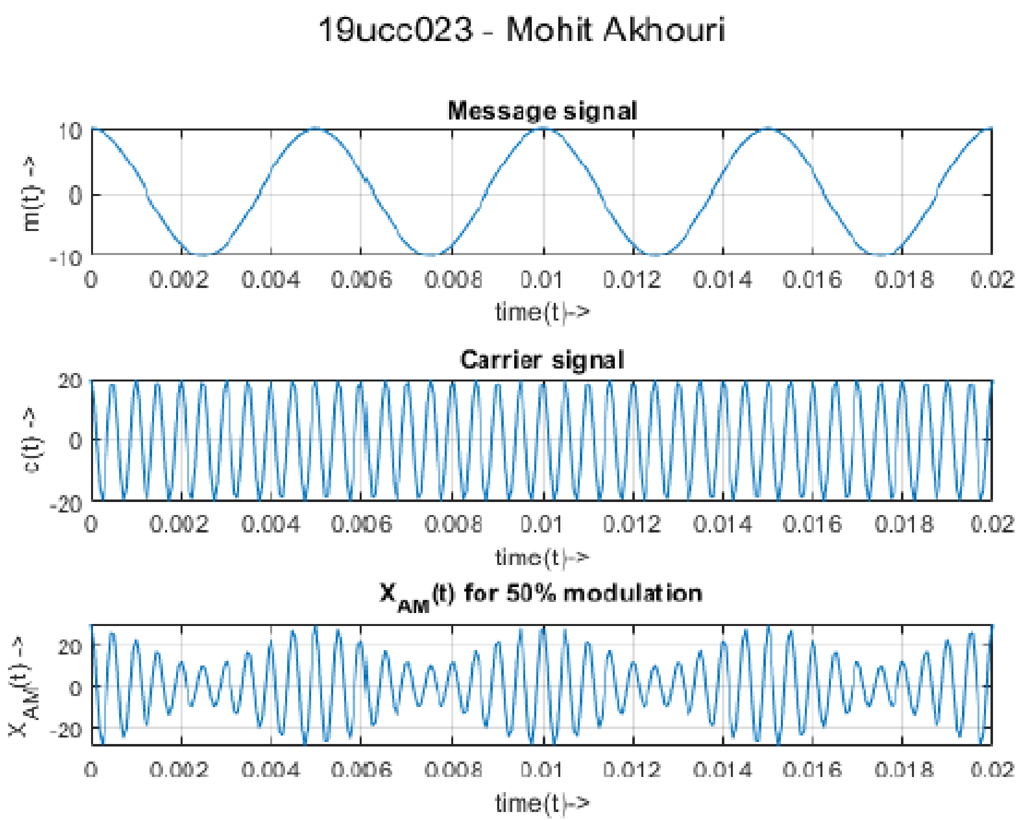

Figure 7.7 AM wave generation for 50% modulation

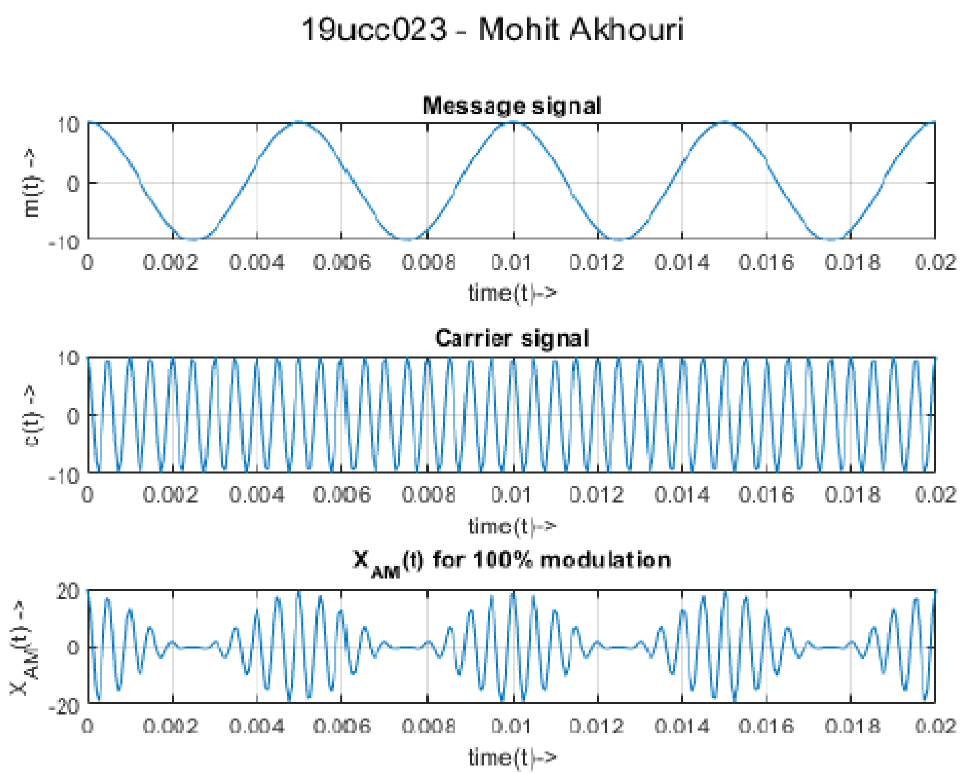

Figure 7.8 AM wave generation for 100% modulation

7.4.2 Illustration of Over-Modulation for modulation index 1.2 in AM waves

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

% this code will illustrate the over modulation in case of AM
 modulated
% signal for mu = 1.2
Am = 10; % defining modulating amplitude
fm = 200; % defining modulating frequency
fc = 2000; % defining carrier frequency
t = linspace(0,0.01,300); % defining time axis
mu = 1.2; % modulation index = 1.2
Ac = Am/mu; % defining carrier amplitude
mt = Am*cos(2*pi*fm*t); % defining message signal
ct = Ac*cos(2*pi*fc*t); % defining carrier signal

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

am = (Ac + Am*cos(2*pi*fm*t)).*cos(2*pi*fc*t); % AM modulation for mu
 = 1.2
% plotting figures
figure;
subplot(2,1,1);
plot(t,am);
xlabel('time(t)->');
ylabel('X_{AM}(t)->');
title('X_{AM}(t) for modulation index 1.2');
grid on;

demod1=abs(hilbert(am)); % obtaining demodulation for AM signal
% plotting figures
subplot(2,1,2);
plot(t,demod1);
xlabel('time(t)->');
ylabel('demodulated m(t)->');
title('Demodulated Distorted message signal (m(t))');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');
```

Figure 7.9 Code for illustration of Over Modulation for modulation index = 1.2

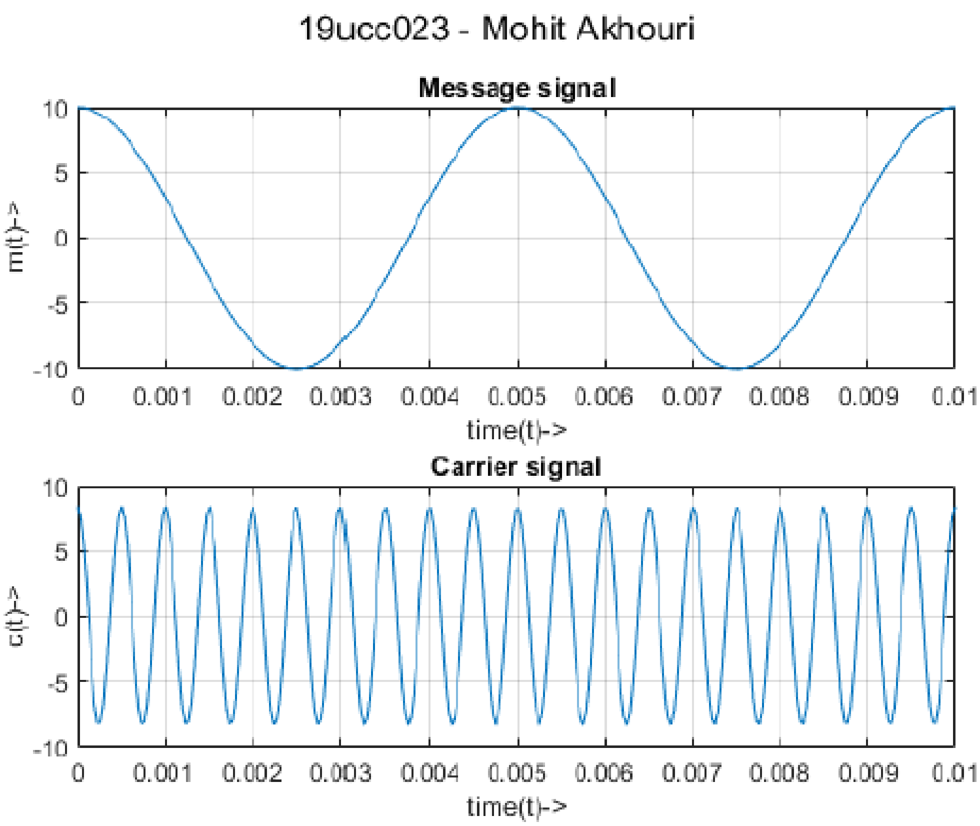

Figure 7.10 Graph of message signal and carrier signal

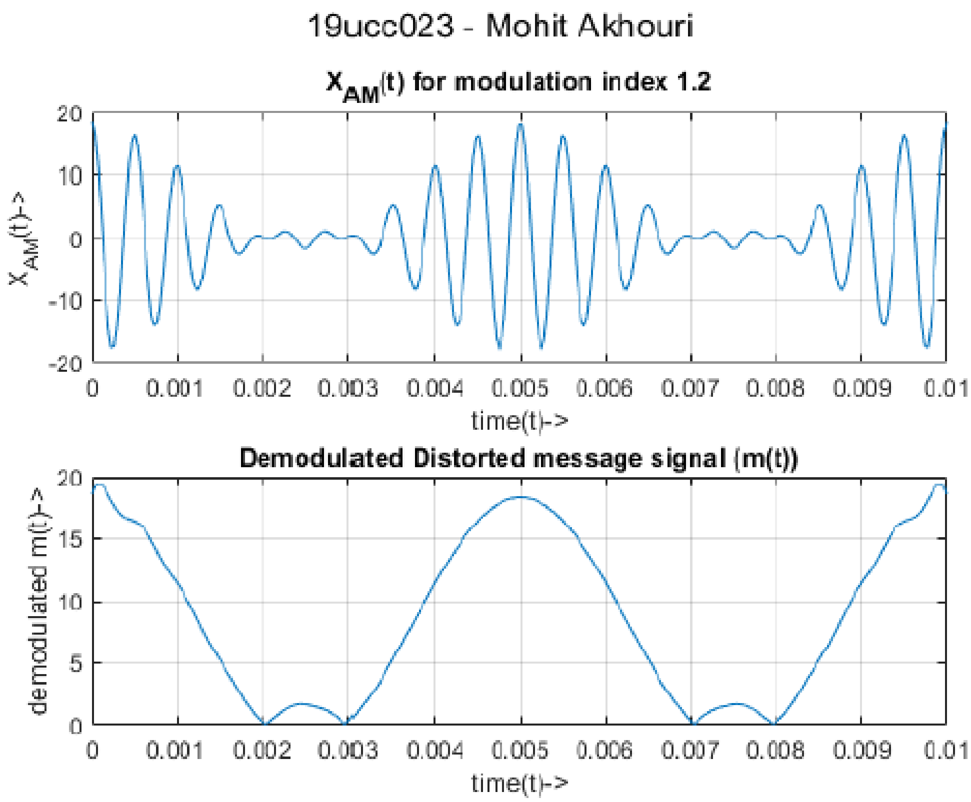

Figure 7.11 Graph of AM wave and Demodulated signal for modulation index = 1.2

7.4.3 Generation of DSB-SC wave in time and frequency domain

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

% this code will generate DSB-SC signals for 30%,50% and 100%
 modulation

Am = 5; % defining modulating amplitude
Ac = 5; % defining carrier amplitude
fm = 1; % defining modulating frequency
fc = 20; % defining carrier frequency
mu = Am/Ac; % defining modulation index

t = linspace(0,5,500); % defining time axis (t)
mt = Am*cos(2*pi*fm*t); % defining message signal
ct = Ac*cos(2*pi*fc*t); % defining carrier signal

% plotting figures
subplot(3,1,1);
plot(t,mt);
xlabel('time(t)->');
ylabel('m(t)->');
title('Message signal');
grid on;
subplot(3,1,2);
plot(t,ct);
xlabel('time(t)->');
ylabel('c(t)->');
title('Carrier signal');
grid on;

dsbsct = mt.*(Ac*cos(2*pi*fc*t)); % defining DSB-SC signal for mu=1
% plotting figures
subplot(3,1,3);
plot(t,dsbsct);
xlabel('time(t)->');
ylabel('X_{DSB-SC}(t)->');
title('X_{DSB-SC}(t) for 100% modulation');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');

fft1=fftshift(fft(dsbsct));
fft1_modified=(abs(fft1));

% plotting figure
figure;
plot(fft1_modified);
xlabel('frequency(Hz)->');
ylabel('X_{DSB-SC}(\omega)->');
title('19ucc023 - Mohit Akhouri','X_{DSB-SC}(\omega) for 100%
 modulation');
grid on;
```

Figure 7.12 Code for generation of DSB-SC signal in time and frequency domain

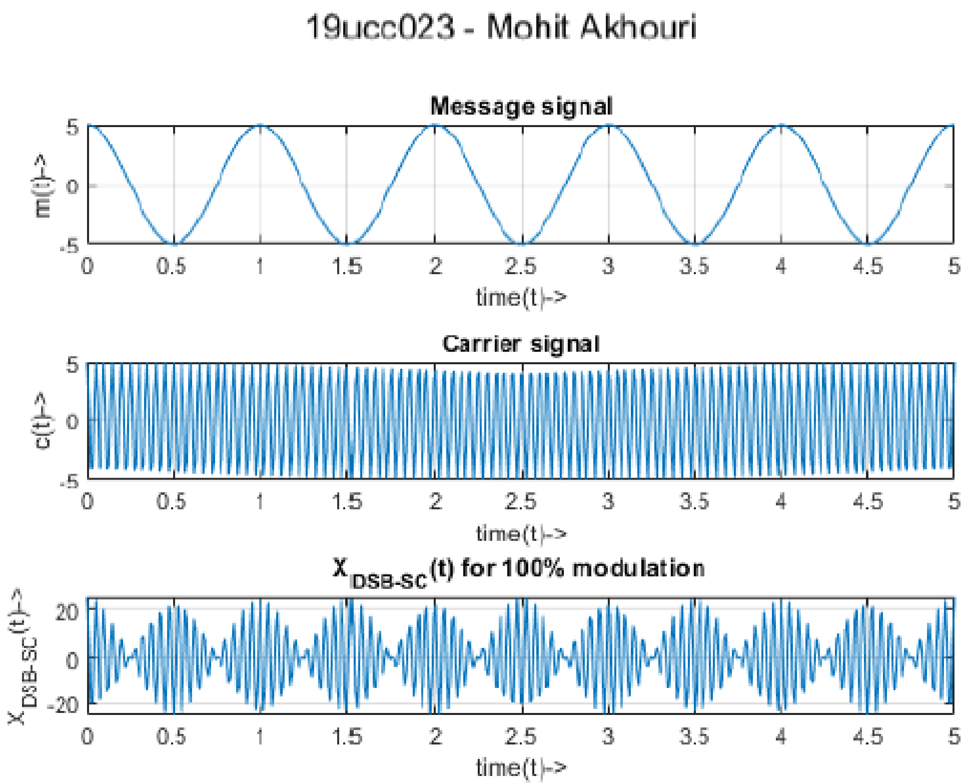

Figure 7.13 Graph of message signal, carrier signal and DSB-SC signal in time domain

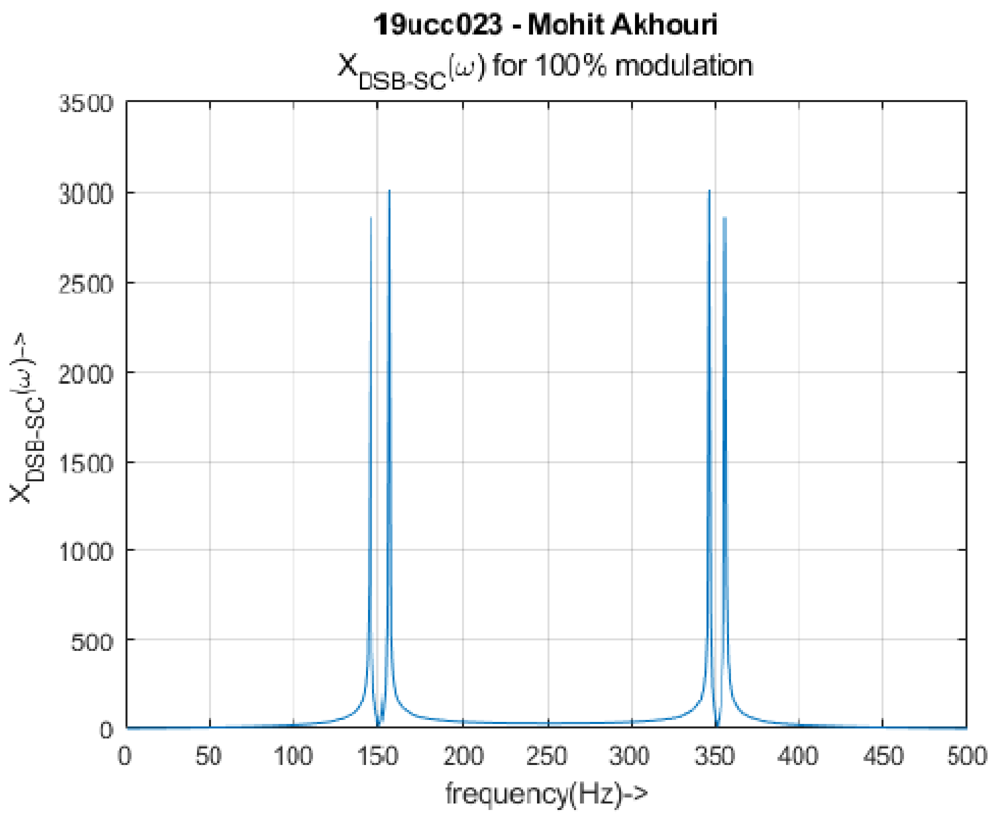

Figure 7.14 Graph of DSB-SC signal in frequency domain

7.5 Conclusion

In this experiment, we touched upon the concepts of Communication and studied two types of modulation techniques **DSB-SC** and **DSB-C or AM**. We learnt their equations and how to generate them using message signal and carrier signal in **time domain** and **frequency domain** using MATLAB. We also learnt about the detection techniques - namely , **Coherent detection** and **Non-coherent detection** for getting back the message signal. We learnt about the MATLAB function hilbert() and how it can be used for demodulation.