Experiment NO: 01

Experiment Name: To generate an amplitude modulated signal by developing a MATLAB program.

Objectives: To understand the principle of amplitude modulation and observe the waveforms of modulated signals.

Theory: Modulation is defined as the process by which some characteristics usually amplitude, frequency or phase of a voltage is varied in accordance with the instantaneous value of some other voltage called the modulating voltage. Accordingly modulation process may be classified as amplitude modulation, frequency modulation and phase modulation depending upon wheather the amplitude V_c, frequency w_c or the phase angle θ of the carrier voltage in varied.

Amplitude Modulated signal: In amplitude modulation, the amplitude of the carrier voltage varies in accordance with the instantaneous value of the modulating voltage.

Let, modulating voltage be given by,

$$v_m = V_m \sin W_m t$$

Let, the carrier voltage is given by,

$$v_c = V_c \sin(w_c t + \theta)$$

So, the amplitude modulated wave is given by,

$v = V_c\,[1 + m_a \sin \omega_m t]\,\sin \omega_c t$

Here, Modulation index $m_a = \dfrac{K_a V_m}{V_c}$

~~Matlab~~

Source code in MATLAB:

```
clc;
clear all;
close all;
t=0:0.001:2;
f1 =5
m = sin(2*pi*f1*t);
subplot (5,1,1);
plot (t,m);
title('Message signal');
xlabel('time');
ylabel('Amplitude');
grid on;

f2 = 50;
c = sin (2*pi*f2*t);
subplot(5,1,2);
plot (t,c);
title ('carrier signal');
xlabel('time');
ylabel('Amplitude');
grid on;

m1 = 0.5;
s1 = (1+(m1.*m)).*c;
subplot(5,1,3);
```

```
Plot (t, s1);
title('Under Modulation signal');
xlabel('time');
ylabel('Amplitude');
grid on;

m2=1;
s2=(1+(m2.*m)).*c;
subplot(5,1,4);
plot(t,s2);
title('Critical Modulation signal');
xlabel('time');
ylabel('Amplitude');
grid on;

m3=1.5;
s3=(1+(m3.*m)).*c;
subplot(5,1,5);
plot(t,s3);
title('Over Modulation signal');
xlabel('time');
ylabel('Amplitude');
grid on;
axis([0, 2, -2.5, 2.5]);
```

Results and Discussion:

In this lab experiment we demonstrates the effects of different levels of modulation on an amplitude modulated signal. It shows the undermodulation results in loss of information, over modulation causes distortion, and critical modulation provides the best fidelity of the original message signal.

Here are the main parameters used in this experiment:

- t: the time vector ranging from 0 to 2 seconds with a step of 0.001 seconds. This defines the duration and resolution of the signals.
- f1: the frequency of the message signal in Hz. This is set to 5 Hz.
- f2: the frequency of the carrier signal in Hz. This is set to 50 Hz.
- m1, m2, m3: the modulation indices used to creat three different levels of modulation. m1 is set to 0.5, which produces an under modulated signal. m2 is set to 1, which produces a critical modulated signal. m3 is set to 1.5, which produces an over-modulated signal.

Amplitude modulation is used in radio broadcasting, television broadcasting, wireless communication, remote control systems, medical devices etc.

Experiment NO:02

Experiment Name: To generate a frequency modulated signal by developing a MATLAB program.

Objectives: To observe the waveforms of the frequency modulated signals.

Theory: Modulation is defined as the process by which some characteristics usually amplitude, frequency or phase of a voltage is varied in accordance with the instantaneous value of some other voltage called the modulating voltage. Accordingly modulation process may be classified as amplitude modulation, frequency modulation and phase modulation depending upon wheather the amplitude V_c, frequency W_c or the phase angle θ of the carrier voltage is varied.

Frequency Modulated Signal: In a frequency modulation, it consists in varying the frequency of the carrier voltage in accordance with the instantaneous value of the modulating voltage.

Let, modulating voltage be given by,

$$v_m = V_m \cos W_m t$$

Let, the carrier voltage is given by,

$$v_c = V_c \sin(W_c t + \theta)$$

So, the frequency modulated wave is given by,

$$s(t) = A_c \sin[2\pi f_c t + m_f A_m \sin(2\pi f_m t)]$$

Here, Modulation index $m_f = \frac{K_f}{f_m}$

Source code in MATLAB:

```
clc;
clear all;
close all;
fm =15;
B =5
t = 0:0.0001:0.25;
m= cos(2*pi*fm*t);
subplot(3,1,1);
plot(t,m,'red');
xlabel('Time');
ylabel('Amplitude');
title('Message signal');
axis([0,0.25,-1.5,1.5]);
grid on;

fc = 150;
c =sin(2*pi*fc*t);
subplot(3,1,2);
plot(t, c, 'black');
xlabel('Time');
ylabel('Amplitude');
title('carrier signal');
axis([0,0.25,-1.5,1.5]);
grid on;
```

```
y = sin(2*pi*fc*t + (B*sin(2*pi*fm*t)));
subplot(3,1,3);
plot(t,y,'blue');
xlabel('Time');
ylabel('Amplitude');
title('Frequency Modulated signal');
axis([0, 0.25, -1.5, 1.5]);
grid on;
```

Results and Discussion:

In this experiment, we have demonstrate how to generate an FM signal using MATLAB. The experiment can be extended by varying the parameters, such as the message signal frequency and the frequency deviation, to observe their effect on the resulting FM signal. The parameters used in this experiment are:

- fm: The frequency of the message signal in Hz. This is set to 15 Hz.
- B: The frequency deviation in Hz. This parameters controls the amount by which the frequency of the carrier signal deviates from its nominal frequency. In this case, the frequency deviation is set to 5 Hz.
- t: The time vector in seconds. The simulation runs for 0.25 seconds with a time step of 0.0001 seconds.
- fc = The frequency of the carrier signal in Hz. This is set to 150 Hz

The third plot shows the FM signal. The plot shows that the frequency of the FM signal varies smoothly over time.

Frequency modulation used in radio broadcasting, television broadcasting, wireless communication, Radal system, navigation system etc.

Experiment NO: 03

Experiment Name: To generate a phase modulated signal by developing a MATLAB program.

Objectives: To understand the concepts of phase modulation and observe the waveforms of the phase modulated signals.

Theory: Modulation is defined as the process by which some characteristics usually amplitude frequency or phase of a voltage is varied in accordance with the instantaneous value of some other voltage called the modulating voltage. Accordingly modulation process may be classified as amplitude modulation, frequency modulation and phase modulation depending upon wheather the amplitude V_c, frequency W_c or phase angle θ of the carrier voltage is varied.

Phase Modulated Signal: In a phase modulation it consists in varying the phase angle of a carrier voltage in accordance with the instantaneous value of the modulating voltage.

Let, modulating voltage be given by,

$$V_m = V_m \sin W_m t$$

Let, the carrier voltage is given by,

$$V_c = V_c \sin(\omega_c + \theta)$$

So, the phase modulated wave is given by,

$$v = V_c \sin[\omega_c t + m_p \sin \omega_m t]$$

Here, Modulation index $m_p = K_p V_m$

Source code in MATLAB:

```
clc;
clear all;
close all;
fm = 10;
fc = 100;
mp = 5;
time = 0:0.0001:0.50;
message_signal = sin(2*pi*fm*time);
subplot(3,1,1);
plot(time, message_signal, 'black');
xlabel('Time');
ylabel('Amplitude');
title('Message signal');
grid on;
carrier_signal = sin(2*pi*fc*time);
subplot(3,1,2);
plot(time, carrier_signal, 'black');
xlabel('Time');
ylabel('Amplitude');
title('Carrier signal');
grid on;
modulated_signal = sin(2*pi*fc*time + mp*
                   (sin(2*pi*fm*time)));

subplot(3,1,3);
```

```
Plot(time, modulated_signal, 'black');
xlabel('Time');
ylabel('Amplitude');
title('Phase Modulated Signal');
grid on;
```

Results and Discussion:

The experiment demonstrates the basic principle of phase modulation and its ability to transmit information by varying the phase of the carrier signal in response to the message signal.

The parameters used in the experiment are:

- f_m = the frequency of the message signal, set to 10 Hz.
- f_c = The frequency of the carrier signal, set to 100 Hz.
- m_p = the modulation index set to 5.

The experiment involves generating a message signal and a carrier signal, which are then used to generate a phase modulated signal. The modulated signal is obtained by adding the phase modulation to the carrier signal. Phase modulation is used in various communication systems, including satelite communication, digital audio broadcasting and high frequency radio communication, Wireless LAN etc.

Experiment NO:04

Experiment Name: To convert an amplitude modulated signal into an amplitude demodulated signal using MATLAB application.

Objectives: To undestand the priciple of amplitude demodulation and observe the waveforms of demodulated signal.

Theory: Demodulation is the act of extracting the original information bearing signal from a modulated carrier wave. A demodulator is an electronic circuit that is used to recover the information content from the modulated carrier wave. In other words, we can say that the demodulation is just the opposition of a modulation process.

There are several ways of demodulation depending on how parameters of the base-band signal are transmitted such as amplitude, frequency or phase. An amplitude modulated signal encodes the information onto the carrier wave by varying its amplitude indirect sympathy with analog signal to be sent. There are two different methods used to demodulation of AM signals.

- Envelope detector: the envelope detector is a very simple method of demodulation. It consists of a rectifier and low pass filter. The rectifier may be in the form of a single diode and the filter is usually an R-C lowpass type. This is the general used circuit.

- Product detector: The product detector multiplies the signal by the signal of a Local oscillator with the same frequency and phase as the carrier of the incoming signal. After filtering the incoming signal the original audio signal will result.

Source code in MATLAB:

```
clc;
clear all;
close all;
vm =1;
vc = 1;
fc = 100;
fm =5;
fs = 13000; % sampling frequency
t =0:1/fs:0.5;
c =vc* sin(2* pi *fc* t);
m= vm * sin (2 * pi *fm *t);
y =ammod (m,fc, fs);
subplot (4,1,1);
plot (t,m);
title('Modulating signal');
xlabel('Time');
ylabel('Amplitude');
```

```
subplot(4,1,2);
plot(t,c);
title('carrier signal');
xlabel('Time');
ylabel('Amplitude');

subplot(4,1,3);
plot(t,y);
title('Modulated signal');
xlabel('Time');
ylabel('Amplitude');

%% Demodulation
d = demod(y,fc,fs,'am');
subplot(4,1,4);
plot(t,d);
title('Demodulated signal');
grid on;
```

Results and Discussion:

In this experiment, we demonstrates the process of amplitude demodulation of a message singnal using MATLAB. The demodulation of the modulated signal is done using the demod() function in MATLAB, with the demodulation type set to 'am'. The parameters used in the code are as follows:

- vc: amplitude of the carrier signal.
- fc: frequency of the carrier signal.
- vm: amplitude of the message signal.
- fm: amplitude of the message signal.
- fs: sampling frequency.
- t: time vector.

The fourth subplot shows the demodulated signal, which is the original message signal.

Applications are - radio broadcasting, television broadcasting, wireless communication, medical imaging, navigation systems, industrial automation etc.

Experiment NO: 05

Experiment Name: To convert a frequency modulated signal into a frequency demodulated signal using MATLAB application.

Objectives: To understand the principle of frequency demodulation and observe the waveforms of demodulated signal.

Theory: Demodulation is the act of extracting the original information-bearing signal from a modulated carrier wave or the process of separating the original information from the modulated carrier wave.

For a signal modulated with a linear modulation, like amplitude modulation we can use a synchronous detector, for a signal modulated with an angular modulation, use a frequency demodulator.

There are several common types of FM demodulation, some of them are:

- The Quadrature detector, which phase shifts the signal by 90° and multiplies it with an un-shifted version. One of the terms that drop out from this operation is the original information signal, which is selected and amplified.
- The signal is fed into a PLL and the error signal is used as the demodulated signal.

• Another method uses two AM demodulators, one tuned to high end of the band and other to the low end and fed the output into a difference amplifier.

Source code in MATLAB:

```
clc;
clear all;
close all;
Ac=1;
Am=1;
fm = 15;
B =5;
fs = 10000;
t =0:1/fs:0.5;
m= Am*cos(2*pi*fm*t);
subplot(4,1,1);
plot(t,m,'black');
xlabel('Time');
ylabel('Amplitude');
title('Message signal');
grid on;

fc=150;
c=Ac*sin(2*pi*fc*t);
subplot(4,1,2);
plot(t,c,'black');
xlabel('Time');
ylabel('Amplitude');
title('Carrier signal');
%axis([0,0.25,-1.5,1.5]);
grid on;
```

```
y = Ac*sin(2*pi*fc*t+(B*sin(2*pi*fm*t)));
subplot(4,1,3);
plot (t,y,'black');
xlabel('Time');
ylabel('Amplitude');
title('FM signal');
grid on;

x=demod(y,fc,fs,'fm');
subplot(4,1,4);
plot(t,x,'black');
xlabel('Time');
ylabel('Amplitude');
title('Demodulated signal');
grid on;
```

Results and Discussion:

In this lab experiment, we demonstrates the process FM demodulation of a message signal using MATLAB. The demodulation of the FM modulated signal is done using the demod() function in MATLAB with the demodulation type set to 'fm'. The parameters used in the code are as follows:

- AC: amplitude of the carrier signal.
- Am: amplitude of the message signal.
- fm: frequency of the message signal.
- B: frequency deviation constant.
- t: time vector

The fourth subplot shows the demodulated signal, which is the original message signal.

It is used in radio broadcasting, television broadcasting, radio frequency identification (RFID), wireless communication etc.

Experiment NO: 06

Experiment Name: To develop a MATLAB program to analyze the frequency response of the Pre-Emphasis and De-Emphasis circuits.

Objectives: To observe the waveforms of Pre-Emphasis and De-Emphasis by using a MATLAB software.

Theory:

Pre-Emphasis: Pre-Emphasis refers to boosting the relative amplitudes of the modulating voltage for higher audio frequencies from 2 to approximately 15KHZ.

At the transmitter, the modulating signal is passed through a simple network which amplifies the high frequency, components more than the low-frequency components. The simplest form of such a circuit is a simple high pass fillter.

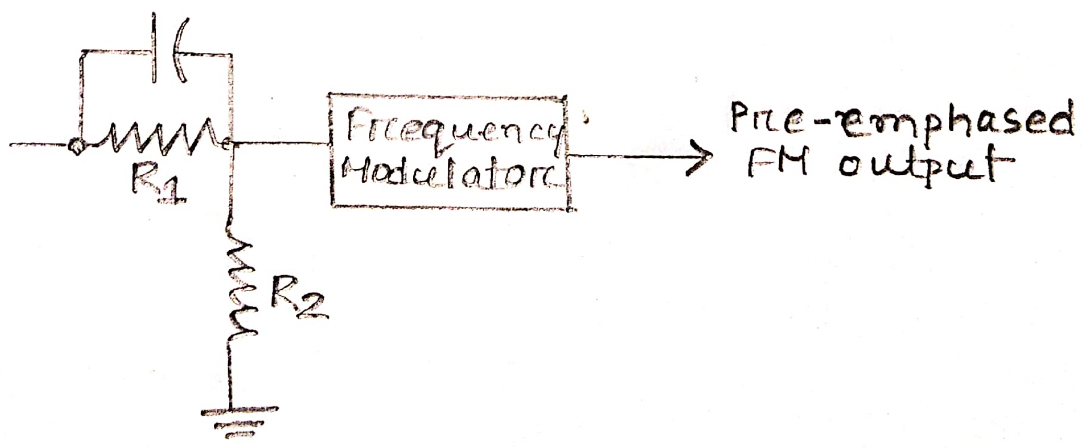

Figure-01: Pre-Emphasis Circuit

De-Emphasis: De-Emphasis means the attenuating those frequencies by the anount by which they are boosted.
To return the frequency response to its normal level, a de-emphasis circuit is used at the receiver. This is a simple low pass filter with a constant of 75 ms.

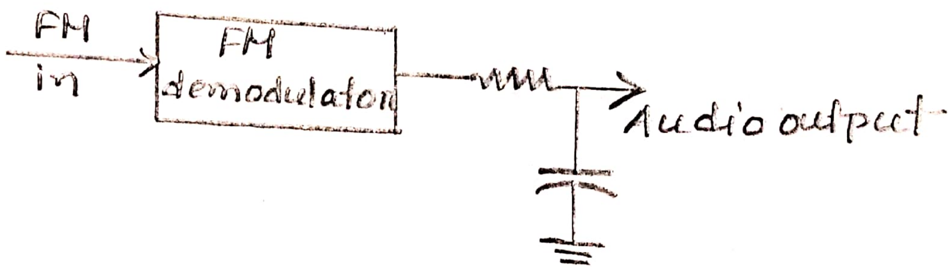

Figure-02: De-Emphasis circuit

Source code in MATLAB:

```
clc;
close all;
clear all;
f1 = 10;
for f=1:50
    x(f) = (1/sqrt(1+(f1/f)^2));
    f2(f) = f;
end
subplot(2,1,1);
plot(f2,x);
title('Pre emphasis waveform');
for f=1:50
    y(f) = (1/sqrt(1+(f/f1)^2));
    f3(f) = f;
end
subplot(2,1,2);
plot(f3,y);
title('de emphasis waveform');
```

Results and Discussion:

In this experiment, we are ploting the pre-emplasis waveform for a range of frequencies from 1 to 50 HZ, with a fixed pre-emphasis co-efficient of 10HZ. The plot shows that the amplitude of the pre-emphasis waveform decreases as the frequency increases. This is because the pre-emplasis filter attenuates high-frequency components to a greater extant that low-frequency components.

Also, we are ploting the de-amphasis waveform for a range of frequencies from 1 to 50 HZ, with a fixed de-emphasis coefficient of 10 HZ. The plot shoues that the amplitude of the de-amphasis waveform increases as the frequency increases. This is because the de-emphasis filter amplifies low-frequency components to a greater extent than high-frequency components.

Some applications are audio signal processing Speech communication systems, radio broadcasting, digital audio processing etc.