Exprement NO:4

Experiment Name: To design and observe the amplitude modulation in matlab.

objective: ① Observe the wave from of amplitude modulation modulated signal.

Theory: Modulation is defined as the process by which some characteristics usually by which some amplitude, frequency or phase of voltage (usually sinosoidal voltage) is varied in accrodance with the intanteneous value of some other voltage, called the modulation. voltage.

The term carrier is applied to the voltage whose charicterctistic is varied and the term modulating voltage is used for the voltage in accrodance with which the variation in made.

Accrodingly modulation process may be classified as

① Amplitude modulation.

(ii) Frequency modulation

(iii) phase modulation.

Expression for Amplitude modulated voltage:

In amplitude modulation, the amplitude of the carrier voltage varies in accordance with the instaneous value of the modulating voltage. let, the modulating voltage or the signal be given by the expression.

$$v_m = V_m \cos \omega_m t$$

where,

ω_m = angular frequency

V_m = Amplitude.

Let,

the carrier voltage be given by

$$v_c = V_c \cos \omega_c t$$

For convenience in calculation the phase anlgle θ has been taken as zero. Since it does not play any part in the modulation process. This however, dues not in any way reduce the ge generality of the expression.

On amplitude modulation, amplitude of the carrier no longer remains constant but varies with time as given by the following expression.

$$V(t) = V_c + k_a V_m \cos \omega_m t$$

where, $k_a, V_m \cos \omega_m t$ is the change in the carrier amplitude.

The instanceous value of modulated carrier voltage is then given by.

$$v = V(t) \cos \omega_c t$$

$$= [V_c + k_a V_m \cos \omega_m t] \cos \omega_c t$$

$$= V_c \left[1 + \frac{k_a V_m}{V_c} \cos \omega_m t \right] \cos \omega_c t$$

let, ma is modulation index or modulation factor or depth of modulation and ~~it~~ is given by

$$ma = \frac{K_a V_m}{V_c}$$

$$\therefore V = V_c\left[1 + ma \cos \omega_m t\right] \cos \omega_c t$$

<u>Code:</u> MATLAB code for Amplitude Modulation is.

```
clc
clear all
close all
Ac = input ('Enter carrier signal amplitude :');
Am = input('Enter message signal amplitude :');
fc = input ('Enter carrier frequency :');
fm = input(' Enter message frequency :');
m =input ('Enter modulation index :');
t =input (' Enter time period :');
t1 = linspace (0,t,1000);
y1 = sin (2*pi*fm*t1);
y2 = sin(2*pi*fc*t1);
eq = (1+m.*y1).*(Ac.*y2);
subplot(3,1,1);
plot(t1,y1);
xlabel ('Time');
ylabel (' Amplitude');
title ('message signal')
subplot (3,1,2)
plot (t1,y2);
```

```
Xlablel ('Time');
ylabel ('Amplitude');
title ('carrier signal');
subplot (+1, e4);
plot (+1, eq, 'r');
Xlabel('Time');
ylabel ('Amplitude');
title('Amplitude modulated signal');
```

Input and output:

Enter carrier signal amplitude: 5

Enter message signal amplitude: 1

Enter carrier frequency: 20000

Enter message frequency: 1000

Enter modulation index: 5

Enter time period: 5

Procedure: At first we open matlab. Take a new empty file. Then we genrate the message signal and carrier signal. Then we process those signal and produce modulated signal. Then we label the figure of message, carrier, modulated signal. Then we print the figure.

Result: From the figure, we can see the carrier signal, message signal, amplitude modulated signal. The output amplitude modulated signal is as expected. So, the expriment is correct.

Discussion: The output of our experiment and the theoretical expected value exactly same so the experiment is correct.

precaution: ① Write code in matlab carefully.

② Input perfect value to get perfect output.

Experiment NO : 2

Experiment Name: To design and observe the frequecy modulation in matlab.

objective: ① observe the wave from of the frequency modulated signal.

Theory: Modulation is defined as the process by which some characteristics, usually amplitude, frequency or phase of voltage (usually sinusodial voltage) is varied in accrodance with the instantenous value of some other votage, called the modulating voltage. Then the term carrier is applied to the voltage whose characteristics is varied and the term modulating voltage is used for the voltage in accordance with which the variation is made.

let, the carrier voltage be given by

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

where, ω_c is angular frequency of the carrier

v_c is the amplitude of carrier (volt).

θ_c is the phase angle in radians

let, $\phi = \omega_c t + \theta$

so, $v_c = v_c \sin\theta$

Obivously the angular frequency ω_c is related to the phase angle θ by the relation

$$\omega_c = \frac{d\theta}{dt}$$

on frequency modulation, the frequency of the carrier on large remains constant but varies with time in accordance with the instantenous value the modulating voltage. thas the frequency of the carrier voltage. after frequency modulation. It given by.

$$\omega = \omega_c + k_f \cdot v_m$$
$$= \omega_c + k_f V_m \cos \omega_m t$$

where, k_f is the constant of proportionality.

Now,

$$\phi = \int \omega \cdot dt$$
$$= \int [\omega_c + k_f V_m \cos \omega_m t] \cdot dt$$
$$= \omega_c t + k_f V_m \frac{1}{\omega_m} \sin \omega_m t + \theta_i$$

Where, θ_i is constant of integration and represents a constant phase angle. θ_i may be negletect in the following analysis. since it is ~~o~~ ~~ios~~ in significant in the modulation process. Hence the frequency modulate carriere voltage is given by

$$v = V_c \sin [\omega_c t + k_f \frac{V_m}{\omega_m} \sin W_m t]$$

Instantenous frequency of frequency modulated ~~ct~~ carrier voltage in Hz is given by

$$f = \frac{\omega}{2\pi} = f_c + k_f \frac{V_m}{2\pi} \cos W_m t$$

The maximum value of frequency is given by -

$$f_{max} = f_c + k_f \frac{V_m}{2\pi}$$

The minimum value of frequency is given by.

$$f_{min} = f_c - k_f \frac{V_m}{2\pi}$$

Thus frequency deviation.

$$f_d = f_{max} - f_c = f_c - f_{min} = k_f \frac{V_m}{2\pi}$$

modulation index m_f is the ratio of frequency devation to modulation frequency and is also included by δ.

$$\delta = m_f = \frac{f_d}{f_m} = \frac{\omega_d}{\omega_m} = \frac{k_f \cdot V_m}{\omega_m}$$

Thus the expression for the frequency modulated voltage is given by

$$v = V_c \sin(\omega_c t + m_f \sin \omega_m t)$$

Code: MATLAB code for frequency Modulation is-

```
clc
clear all
close all
Vm =1;
Vc =1;
fm =2;
fc = 50;
mf =15;
t =0:1/1000:1;
vm = Vm* cos(2*pi*fm*t);
subplot(3,1,1);
plot(t, vm);
xlabel('Time');
ylabel('Amplitude');
title('Message signal');
vc = Vc* sin(2*pi*fc*t);
subpot(3,1,2)
plot(t,vc);
xlabel('Time');
ylabel('Amplitude');
title('Carrier signal');
v=Vc* sin(2*pi*fc*t+(mf.*sin(2*pi*fm*t)));
subplot(3,1,3);
plot(t,v);
xlabel('Time');
ylabel('Amplitude');
title('Frequency modulated signal');
```

Procedure: At first we open matlab. Take a new empty file. then we generate the message signal and carrier signal. then we process those signal and produce modulated signal. Then we plot the figure and label the message, carrier, modulated signal.

Result: From the figure, we can see the carrier signal, message signal, frequency modulated signal. The output amplitude frequency modulated signal is as expected. So, the expriment is correct.

Discussion: The output of our experiment and the theoritical expected value exactly same. So, the experiment is correct.

Precaution: (i) Write code in Matlab correctfully.

(ii) Input perfect value to get perfect output

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Experiment NO:3

Experiment Name: To desgin and observe the phase modulation in matlab.

objective: (i) observe the wave from of phase modulation modulated signal.

Theory: Modulation is defined as the process by which some characteristics usually amplitude, frequency or phase of voltage (usualy sinusoidal voltage) is varied in accorodance with the instantenous value of same other voltage called the modulating voltage. The term carrier is applied to the voltage whose characteristic is varied and the term modulating voltage is for the voltage in accordance with which the varitation is made.

According modulation process may be classified as

(i) Amplituded modulation.

(ii) Frequency modulation.

(iii) phase modulation.

In phase modulation, the phase of the carrier voltage varies in accordance with the instantaneous value of the modulating voltage.

Expression: for phase modulation voltage:

let, the carrier voltage be,

$$v_c = V_c \sin(\omega_c t + \theta_0)$$

and the modulating voltage be

$$v_m = V_m \sin \omega_m t$$

Instantenous phase of the carrier before modulation is given by

$$\phi_c = \omega_c t + \theta_0$$

After phase modulation, the instantenous phase of the carrier is given by

$$\theta(t) = \omega_c t + \theta_0 + k_p v_m$$
$$= \omega_c t + \theta_0 + k_p V_m \sin \omega_m t$$

The phase ~~m~~ modulated carrier voltage is then given by,

$$v = V_c \sin[\omega_c t + \theta_0 + k_p V_m \sin \omega_m t]$$

In phase modulation process, the constant phase angle θ_0 plays no part and ~~hene~~ hence for the sake of simplification θ_0 may be omitted. Then the modulated carrier voltage given by

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

The maximum phase devation obviously is $k_p V_m$ and may be indicated by ϕ_m. Then the modulation voltage maybe,

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

code: MATLAB code for phase modulation is

```
clc
clear all
close all
vm=1;
vc=1;
fm=2;
fc=50;
mf=15;
t=0:1/1000:1;
Vm=Vm*cos(2*pi*fm*t);
subplot(3,1,1);
plot(t,Vm);
xlabel('Time');
ylabel('Amplitude');
title('message signal');
Vc=Vc*sin(2*pi*fc*t);
subplot(3,1,2);
plot(t,vc);
xlabel('Time');
ylabel('Amplitude');
title('carrier signal');
V=Vc*sin(2*pi*fc*t+(mf*sin(2*pi*fm*t)));
subplot(3,1,3);
plot(t,v);
xlabel('Time');
ylabel('Amplitude');
title('phase modulated signal');
```

Procedure: At first we open matlab. Take a new empty file. Then we generate the message signal, and carrier signal. Then we process those signal and produce modulated signal. Then we plot figure and label the message, carrier, modulated signal.

Result: From the figure we can see the carrier signal message signal phase modulated signal. The output is an same as the expected phase modulated signal.

Discussion: The output of our experiment and the theoritical expected value ~~exactly~~ exactly same. So, the experiment is correct.

Precaution: (i) Write code in matlab correctly.

(ii) Input perfect value to get perfect output.

Experiment NO: 4

Experiment Name: To generate amplitude demodulation signal using MATLAB.

Theory:

Amplitude Demodulation: The process of ~~demo~~ detection provides a mans of recovering the modulating signal from ~~d~~ modulating signal. Demodulation is the reverse process of modulation. The detector circuit is employed to separate the carrier wave and eliminate the side bands. Since the envelop of an AM wave has the same shape as the message. Independept of the carrier frequency and phase. Demodulation can be accomplished by extracting envelope.

An ~~e~~ increased time constant Rc result in a marginal output follows the modulation envelope. A further increase in time constant the discharging curve become horizontal then the rate of modulation envelope during negative half cycle of the modulation voltage. The modulation is faster than the ~~w~~ rate of voltage Rc combination. The output ~~fa~~ to ~~f~~llow the modulation is ~~a~~ called a digonal clipping. This will occur even high modulation indey.

The depth of modulation at the detector output geneter than unity and circuit impedence is less then circuit load ($R_1 > Z_n$) results in clipping of negative

```
vd(1)=0;
for i=2:Length(y)
    if y(i)> vd(i-1);
      vd(i)=y(i);
  else
     vd(i)= vd(i-1)-0.023*vd(i-1);
      end
    end
h= firl(100,0.0125,'low');
foutputc = filter(h,1,vd);
subplot(5,1,4);
plot(t,vd);
title('Envelope detector output modulating signal');
xlabel('Time (s)');
ylabel('amplitude');
subplot(5,1,5);
plot(t,foutputc);
title('Demodulated signal');
xlabel('time (s)');
ylabel('amplitude');
```

Discussion: The output of our experiment and the theoritical expected value exactly same. So the experiment is may be correct.

Precaution: (i) write code in Matlab correctly

(ii) Input perfect value to get perfect output.

Experiment name: To write down a program using matlab for all generator of frequency ~~demodulation~~ demodulated signal.

objectives: ① To understand the theoritical foundations for frequency Demodulation.

② To understand the waveframs of demodulatied signal.

③ To build simple F.m demodulator by using frequency discriminator.

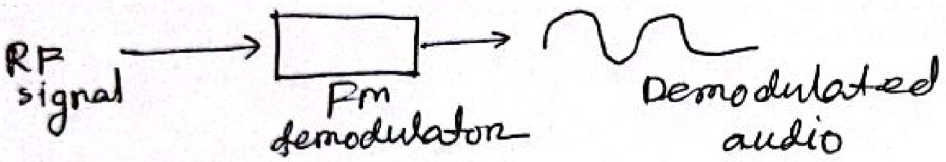
④ Using matlab m-file implement F.m demodulation.

Theory: Fm demodulation is also called F.m delection and sometimes the phase Fm ~~dis~~ discrimination. although this terms tend to be used with older circuit and techonlogy.

F.m demodulation is a key process in the reception of a frequency modulated signal. Once the signal has been received, filtered and amplified, it is necessary to recover the original modulation from the carrier. It is this process that is called demodulation or delection.

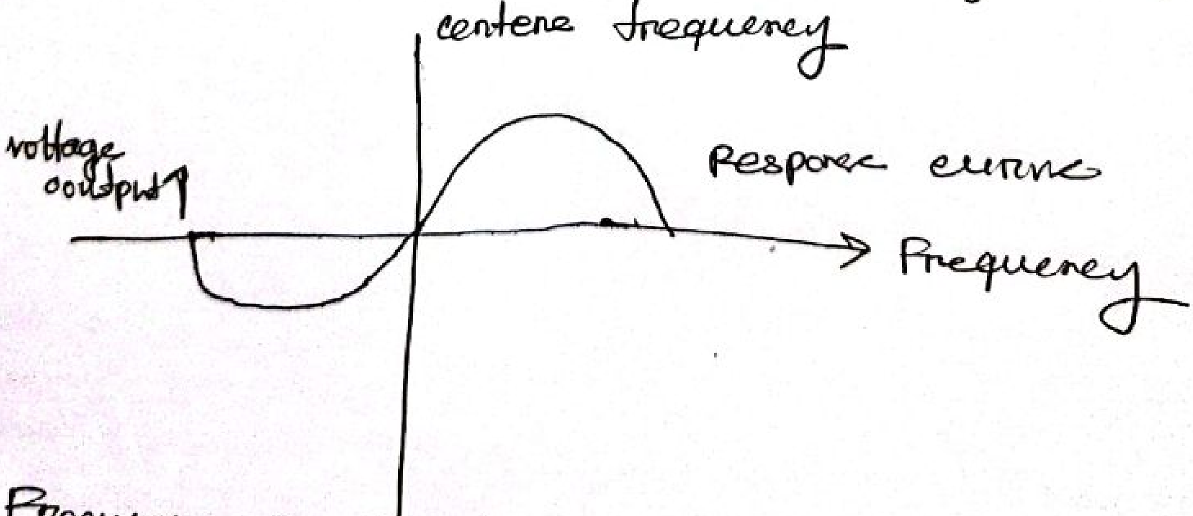
Fm demodulator circuits are found in any receiver that uses F.m broadcas receivers, two way radios. like walkie talkies.

FM demodulation basics: In any radio that is designed to receive frequency modulated signal there is some from frequency modulated R.F signals and take the modulation from the signal to output only the modulation that had been applied a the transmitter



Principle of Fm demodulation

A further requirement for the F.m demodulator is that it should not be sensitive to amplitude variations As the modulation is carried by only the frequency deviation. fno amplitude ~~no~~ sensitivily is wanted. If an Fm demodulator is sensitive to amplitude various as well as frequency variations, then the demodulator can be proceded a limiting stage.



Frequency demodulator response curve.

Mathmatical Expression:

Demodulation using differentiation – we know that the equation of F.M wave is

$$s(t) = A_c \cos\left(2\pi f_c t + 2\pi k_f \int m(t)\cdot dt\right)$$

Differentiate the above equation with respect to (t)

$$\frac{ds(t)}{dt} = -A_c\left(2\pi f_c + 2\pi k_f\, m(t)\right) \sin\left(2\pi f_c t + 2\pi k_f \int m(t)\cdot dt\right)$$

we can write, $-\sin\theta$ as $\sin(\theta - 180^\circ)$

$$\Rightarrow \frac{ds(t)}{dt} = A_c\left(2\pi f_c + 2\pi k_f\, m(t)\right) \sin\left(2\pi f_c t + 2\pi k_f \int m(t)\cdot dt - 180^\circ\right)$$

$$\Rightarrow \frac{ds(t)}{dt} = A_c(2\pi f_c)\left[1 + \frac{k_f}{k_c} m(t)\right] \sin\left[2\pi f_c t + 2\pi k_f \int m(t)\, dt - 180^\circ\right]$$

In the above equation, the amplitude term resembles the envelope of AM wave and the angle term ~~rem~~ resembles to angle of FM wave. Here, our requirement is the modulating signal m(t).

The following fig shows the diagram of FM demodulator

FM wave → [Differentiator] → [Envelope Detector] → Demodulated output

The block diagram consists of the differentiator and the envelope detector. Differentiator is used to convert the FM wave into a combinations of AM wave and FM wave. We know the operation of the envelop detector. It produces the demodulated output of AM ~~wave~~ wave which is nothing but the modulating signal.

Experiment name: To study the frequency response of Pre-Emphasis and De-Emphasis circuits.

Objective:

1. Pre-emphasis and De-emphasis trainer kits.
2. C.R.O (20 MHz)
3. Function generator (1 MHz)
4. patch chords and Probes
5. pc with windows
6. MATLAB software with communication toolbox.

Theory: Frequency modulation is much immune to noise than amplitude modulation and significantly more immune than phase modulation. A signal noise frequency will affect the output of the receiver only if it falls with in its pass band.

The noise has greater effect on the higher modulating frequencies more than on lower ones. Thus, if the higher frequencies were aritically boosted at the transmitter and corresponding cut at the receiver, improvement iat the in noise co immunity could be expected. This booting of the higher frequenices, in accordance with a pre-arrengend curve, is termed pre-amphasis and the compensation at the receiver is alled de-amphasis.

Procedure:

Pre-emphasis:

① connect the circuit ~~per~~ as per circuit diagram

② Apply a sine wave to the input terminal of 2 V_{p-p} (V_1)

③ By varying the input frequency with fixed amplitude, note down the output amplitude (V_0) with respect to the input frequency

④ Calculate the gain using the formula

$$\text{Gain} = 20\log(V_0/V_1)\ \text{db}$$

where, V_0 = output voltage in volts

V_1 = Input voltage in volts.

And plot the frequency response.

De-emphasis:

① Connect the circuit as pre circuit diagram.

② Repeat steps. 2, 3 and 4 of Pre-emphasis to de-emphasis also.