Modulation

Amplitude modulation

- Exp_name.
- objectives.
- Required components.
- Theory.
- Mathematical expression.
- Algorithm.
- Result and discussion.

Theory

Modulation is the process of combining an audio frequency signal with a radio frequency carrier wave. The resultand wave is called modulated ~~wave~~ carrier wave. There are different kind of modulation.

- Modulation
  - Continuous
    - Amplitude
    - Angle
      - fre.mod
      - Phase modu
  - Pulse modu
    - PAM
    - PWM
    - PPM

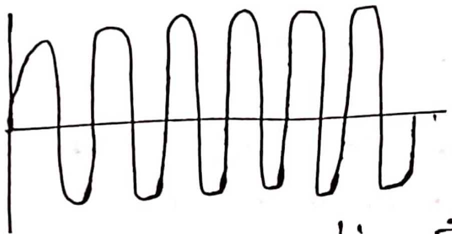
So we can see, in continuous wave modulation there are three modulation:

1) Amplitude modulation.
2) frequency modulation.
3) Phase modulation.

So fore doing any modulating we first need two signal
1) Message signal.
2) carrier signal.

Message signal/ Modulating signal:

A signal which contains a message and which has to undergo the process of modulation is known as message signal. It is also known as modulating signal. A message signal is shown in below figure:



it is a low frequency audio frequency signal.

Carrier signal:

carrier is a high frequency signal which has a certain amplitude, frequency and phase. But it doesn't contains any information. It is an empty signal and is used to carry signal to the receiver after modulation. An carrier signal shows in below figure:

it is a high frequency undamed radio wave produced by radio frequency oscillators.

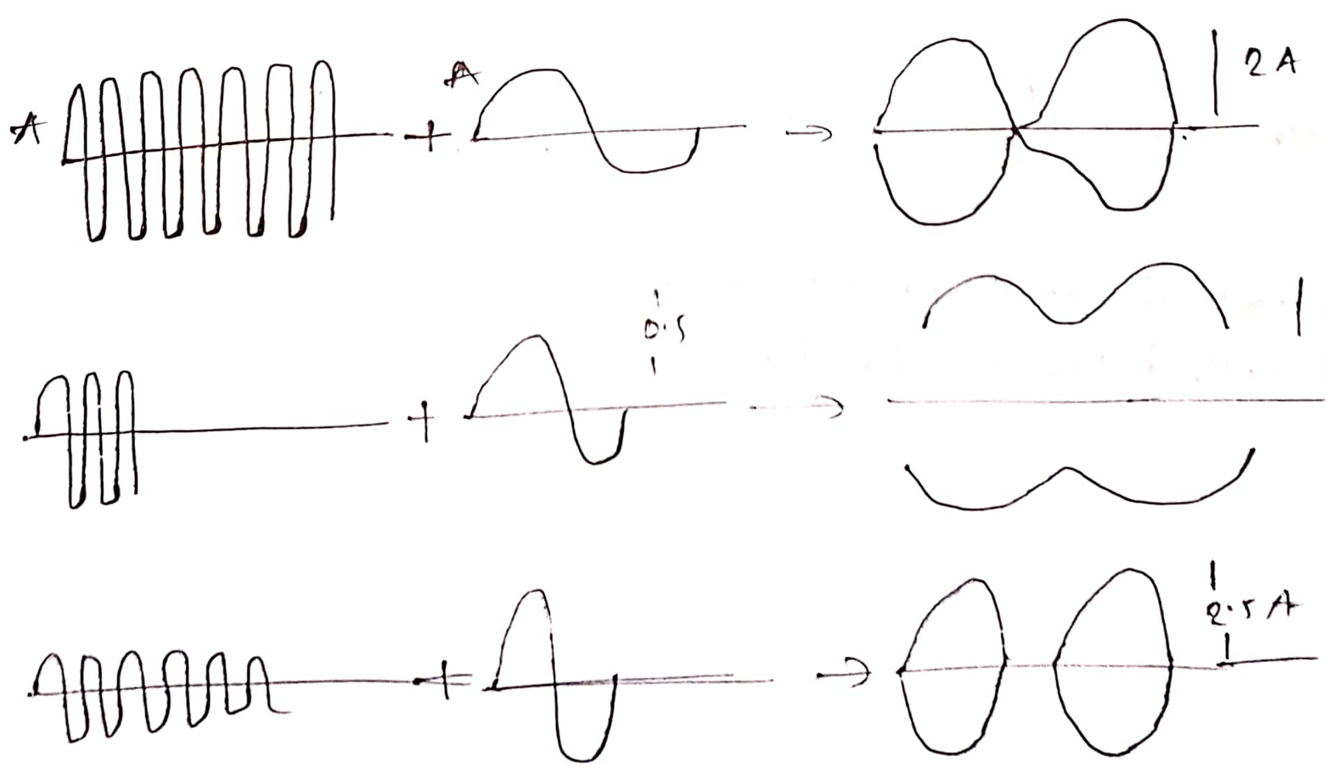
Amplitude Frequency

Amplitude modulation is the process in which the amplitude of the high frequency carrier wave is changed accordance with the amplitude of the intensity of the message signal. It is often called AM and is commonly used to transmitting a piece of information through a radio carrier wave. Amplitude modulation is mostly used in the form of electronic communication.

In amplitude modulation the amplitude of the carrier wave is changed but not the frequency. So the frequency remain constant.

$$\text{modulation factor } m = \frac{\text{Amplitude change in carrier}}{\text{amplitude of the normal carrier}}$$

$m = 1 \rightarrow 100\%$ modulation:



Mathematical equation

$m(t) = V_m \cos \omega_m t$

$c(t) = V_c \cos \omega_m t$

$m_{am}(t) = V_c + m(t)$

$= V_c + mV_c \cancel{m(t)} \cos \omega_m t$

$= V_c(1 + m\cos\omega_m t)$ $\quad | m = V_m/V_c$

. ~~m~~

modulated wave:

$V_{am} = m_{am} \cos \omega_c t$

$= V_c(1 + m\cos\omega_m t)\cos\omega_c t$

$= V_c(\cos\omega_c t + m\cos\omega_m t)$

$= V_c\cos\omega_c t + V_c m \cos\omega_c t \, \omega_m t$

$= V_c\cos\omega_c t + \frac{V_c m}{2}\cos(\omega_c t + \omega_m t) + \frac{mV_c}{2}\cos(\omega_c t - \omega_m t)$

For $\sin\theta$

$V_{am} = V_c\sin\omega_c t + \left(\frac{mV_c}{2}\right)\cos(\omega_c - \omega_m) - \left(\frac{mV_c}{2}\right)\cos(\omega_c + \omega_m)$.

Here

$f_c + f_m$ is called upper side band and

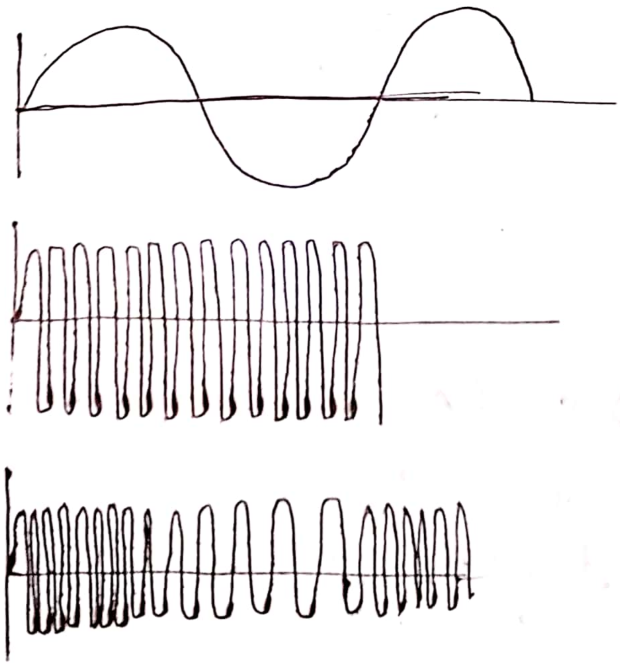
$f_c - f_m$ is called lower side band.

Frequency modulation:

In frequency modulation, the frequency of the carrier wave is changed according to the amplitude of the message signal. Here the amount of change is determine by the amplitude of the modulating signal. whereas the rate of change is determine by the frequency of the modulating signal. Modulating signal is nothing but the information that has to be transmitted after coverted into a electronic signal.

like amplitude modulation frequency modulation also have the similar aprosh; ~~it~~ In frequency modulation the amplitude of the modulated wave is remain constant. only the frequency is changed, according to the message signal.

The process of of frequency modulation is:



when the modulating amplitude is zero, the ~~the~~ frequency remain in his normal frequency. It is called resting frequency.

Frequency deviation:

The change of frequency either above or below the resting frequency is called frequency deviation. It represented as: Δf.

~~Total ve~~

Carrier Swing:

Total variation in frequency from lowest to highest is called carrier swing. Its mean:

$$\text{carrier swing} = (2 \times \Delta f)$$

Mathematical Expression:

Lets take two signal:

Message Signal $\rightarrow m(t) = A_m \cos 2\pi f_m t$

carrier " $\rightarrow c(t) = A_c \cos 2\pi f_c t$.

As it is frequency modulation signal:

$$s(t) = A_c \cos \theta$$

$f_i = f_c + K m(t)$

K = frequency sen

$$\theta = 2\pi f_i t.$$

$$\frac{d\theta}{dt} = 2\pi f_i$$

$$d\theta = 2\pi f_i \, dt$$

$$\int_0^\theta d\theta = 2\pi \int_0^t f_i \, dt \Rightarrow \theta = 2\pi \int_0^t f_c + K m(t).$$

$$= 2\pi f_c t + 2\pi K \int_0^t A_m \cos 2\pi f_m t \, dt$$

Here:

$$K = \Delta F / A_m$$

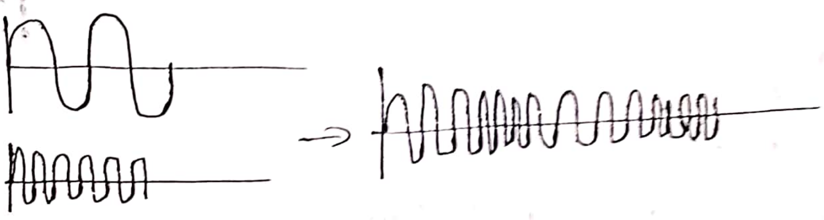
$$s(t) = A_c \cos \left[2\pi f_c t + \frac{2\pi \Delta f \, A_m \sin 2\pi f_m t}{A_m \, 2\pi f_m} \right]$$

$$= A_c \cos \left[2\pi f_c t + m \sin 2\pi f_m t \right]$$

Phase modulation:

It is a anothere kind of angle modulation in which the phase ~~of the~~ carrier is changed according to the amplitude of the message signal. The process of phase modulation is somewhat the same as that of frequency modulation. As, whenever there is any variation in the phase ~~of the~~ of the carrier wave, the frequency of the signal also shows variation.

When the amplitude is increase then the phase is lag in the modulated signal. The frequency will decrease. It will lead opposite. frequency will increase then.

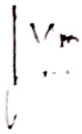


Mathematical equation:

Let:

message signal $\rightarrow V_m \sin 2\pi f_m t$

carrier " $\rightarrow V_c \sin 2\pi f_c t$



The PM can be written as:

$$V = A \sin(\omega_c t + \phi_m \sin \omega_m t)$$

ϕ_m is the maximum value of the phase change introduced by this perticular modulating signal.

we can write as.

$$V = A \sin(\omega_c t + m_p \sin \omega_m t)$$

$\phi_m = m_p =$ modulation index for phase modulation,

Pulse modulation:

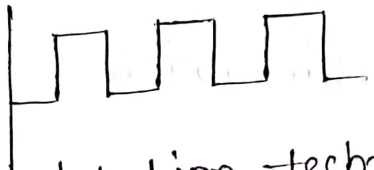
Analoge pulse modulation

Pulse is a kind of modulation where signal is transmitted in the form of pulse. Pulse can be classified into two type.

1) Analoge pulse modulation.
2) Digital pulse modulation.

what is pulse?

The signal which is occure in a short period of time and have a certain width are called pulse signal.



In analoge modulation technique:

1) Pulse amplitude modulation.
2) Pulse position modulation.
3) Pulse width modulation.

PAM

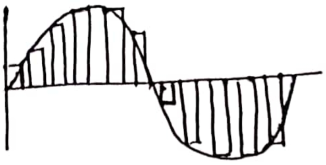
It is a modulation technique in which the amplitude of the pulse carrier is changed according to the amplitude to the message signal.

As we can see, the amplitude of the pulse is varying with respect to the amplitude of the analoge modulating signal. like amplitude modulation. But major difference is that here we use pulse as our carrier signal rather than continuous wave signal.

There is two kind of PAM.

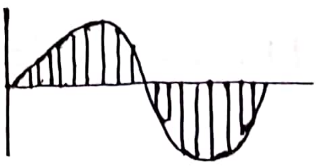
Flat-top PAM

flat-top is a method where the amplitude of the pulse remain constant during the sampling time. In otherwoord the pulse is Flatend at the top. This method is commonly used in digital audio and video signal.



Natural PAM

In natural PAM, the amplitude of the pluse varies accord to the amplitude of the original analog signal being sampled. This method is commonly used in telecommunication system.



Mathematical equations

The message signal is given by:

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

If $x(t)$ is a periodic signal with time period T_0 then it should satisfy the standed as $x(t) = x(t+T_0)$. The pulse train is a periodic signal with some fundamental time-period say T_0. Then the information present in each period of the pulse train is given by:

$$P = V_p \quad (0 < t < \Delta)$$
$$= 0 \quad (\Delta < t < T_0)$$

where Δ is the width of the pulse.

The pulse amplitude modulation is obtained by multipling the message with the pulse train and given by:

$$P_a = P \times V_m$$

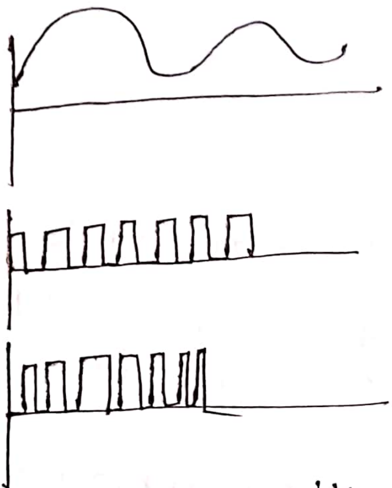
so we can write the equation as:

$$P_a = (r_p V_m \sin \omega_m t) \quad 0 \leq t \leq \Delta$$

$$= 0 \quad \Delta \leq t \leq T_0$$

Pulse width modulation:

In pwm the width of the pulse is varied according to the amplitude of the message signal. The amplitude of the signal kept constant only the variation of the pulse is noticed. As due to constant amplitude property it gets less affected by noise. The figure below shows the pulse width modulation:



As we can see that unlike PAM the amplitude of the signal is constant, only the width is varing. The pwm is similar to the pwm is frequency modulation. for the variation of the width of the pulse, the frequency of the pulse is also shows variation.

Mathematical equation:

Let Δ be the width of the pulse in the unmodulated Pulse train. In PWM

$$\nabla \propto Vm$$

where Vm is the amplitude of the message signal.

Mathematicaly the width of pulse in PWM signal is given by:

$$Am = \nabla(1+Vm)$$

where, there is no message, i.e $Vm=0$, then the width of the pulse will be the original width ∇.

for positive value of message, the width will propotionaly increases by $(1+Vm)$

for the negative value of the message, the width decreases by $(1-Vm)$ factor.

Pulse position modulation

In PPM the position of the pulse is changed in accordance with the amplitude of the modulating signal. where the amplitude and width are kept constant only the position of the pulse is varied. The below figure shows the pulse position modulation.

Here the pulse amplitude and pulse width are two constant that does not show any variation, only the position of the pulse shows variation. Here the position is showing variation according to the reference pulse. Here reference pulse is nothing but the PWM pulses. Basically, the falling edge of PWM pulse acts as the starting of the PPM pulses.

Mathematical equation:

Let t_p indicates the timing instant of the leading or trailing edge of the pulse in each period of the pulse train. In PPM

$$t_p \propto v_m$$

Mathematically, the position of the leading or trailing edge of the pulse is given by:

$$t_p = f(v_m)$$

when there is no message then the positive of the leading on trailing will be equal to the original position, and hence $t_p = 0$.

for positive value of the message the signal is propositionaly shifted right by $t_p = f(v_m)$

for negative value of the message the signal is propositionaly shifted left by $-t_p = -f(v_m)$,

CamScanner

Digital modulating techniques:

Modulation can be classified mainly two catagori:

1) Analoge modulation.
2) Digital modulation.

Digital modulation:

The modulation which use discrete signal for modulating a carrier wave is called digital modulation. Digital modulation removes communication noise as well as provide enhanced strength for the signal intrusion.

Binary signal:

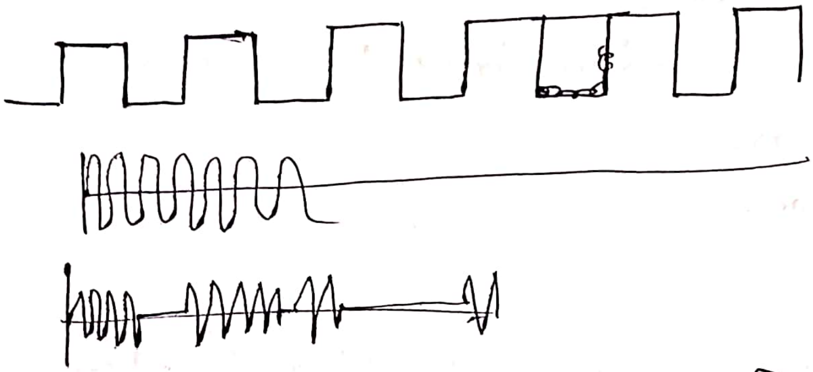
The signal which consists of only two possible values, like 0 and 1 are called binary signal.

There are different kind of modulation:

1) Amplitude shift keying.
2) frequency shift keying.
3) phase shift keying.

Amplitude shift keying:

ASK is a type of modulation where the digital signal is represent as a change in amplitude. In order to carry out amplitude shift keying, we requres a carrier signal and a binary sequence signal. it is also know on off keying. This is because the carrier waves switch between 0 and 1 according to the high and low level of input signal.



In ask the phase and frequency of the carrier wave are maintained at a constant level and only its amplitude is varied according with the amplitude of the digitalized modulating signal. It associated only in two level.

Mathematical Expression:

Let the message be binary sequence of 1's and 0's. It can be represented as a follows:

$$V_m = V_m \quad \text{when symbol is } 1$$
$$= 0 \quad \text{" " " } 0$$

Let the carrier signal be defined as:

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

The corresponding ASK signal is given by the product of V_m and V_c as:

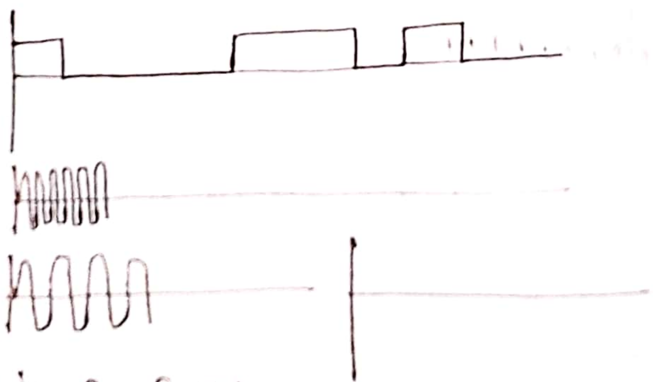
$$V_{ASK} = V_m V_c \cos \omega_c t, \text{ when symbol is } 1$$
$$= 0, \text{ when symbol is } 0$$

Frequency shift keying:

A digital modulating techniques that allows data transmission by changing the frequency of the carrier wave according to the digital modulating signal is known as frequency shift keying. (FSK).

The simplest from of FSK is binary frequency shift keying. Here the frequency of the carrier wave changed between discrete binary values of the modulating signal. Thus the frequency ~~of the~~ carrier shows variations according to the binary message signal.

In frequency shift keying, the carrier is modulated in such a way that high frequency signal is achieved for high level that is 1 of the binary data input. Similarly the low-frequency signal is obtained in case of low level that is 0 of the message signal.



Mathematical Exp:

Let two carrier be defined:

$$v_{c_1} = V_c \cos \omega_{c_1} t = V_c \cos 2\pi f_{c_1} t$$

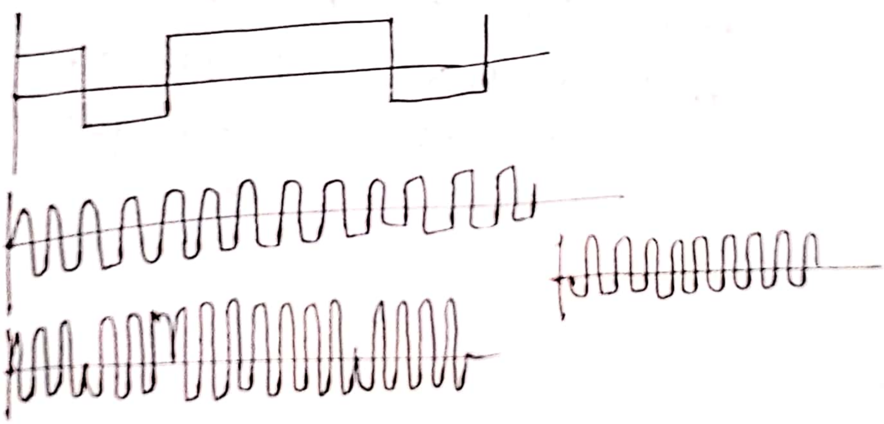
$$v_{c_2} = V_c \cos \omega_{c_2} t = V_c \cos 2\pi f_{c_2} t$$

FSK signal can be written as:

$$V_{FSK} = V_m V_c \cos \omega_{c_1} t \quad \text{— for } 1$$
$$= V_m V_c \cos 2\pi f_{c_1} t$$
$$= V_m V_c \cos \omega_{c_2} t \quad \text{— for } 0$$

Phase Shift Keying:

Phase shift keying is a type of digital modulating technique where we transmit the data by modulating the phase of the carrier signal. The modulation is carried out by changing the input at regular intervals of time. Here we use finite phase and each of these phases can be represented by a unique patterns of bits. The number of bits used is the same in each case. A demodulator is used to determine the phase of the signal and recover the original data from it.



Mathematical equation

Let two carrier signal defined as:

$$v_{c_1} = V_c \cos \omega_c t$$

$$v_{c_2} = -V_c \cos \omega_c t$$

The corresponding PSK signal is defined by:

$$v_{PSK} = V_m V_c \cos \omega_c t \; ; \text{ when symbol is } 1$$

$$= -V_m V_c \cos \omega_c t \; ; \text{ when symbol is } 0.$$