Ministry of high Education and Scientific Research
Southern Technical University
Technological institute of Basra
Department of Electronic Techniques

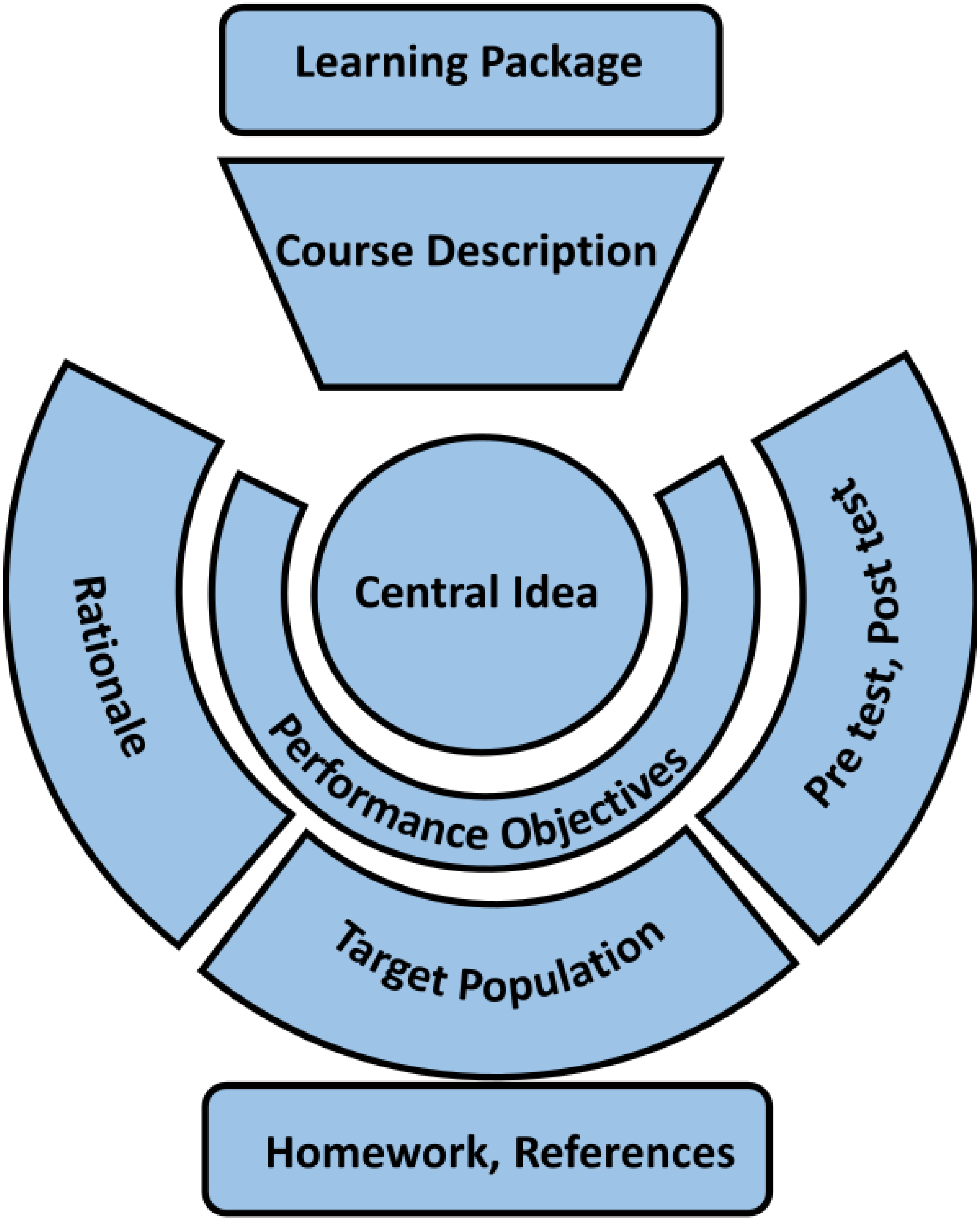
Learning package

Communication2 E222

For
Second year students

By

Mr. Ali Mohammed Hussein Ali
Assistant Lecture
Dep. Of Electronic Techniques
2025


Learning Package
Course Description
Central Idea
Rationale
Performance Objectives
Pre test, Post test
Target Population
Homework, References

Course Name:

Communication 2

Course Code:

E222

Semester / Year:

Second Year

Description Preparation Date:

27/ 06/ 2025

Available Attendance Forms:

Attendance only

Number of Credit Hours (Total) / Number of Units (Total)

60 hours/4 hour weekly/4 unit

Course administrator's name (mention all, if more than one name)

Name: Mr. Ali Mohammed Hussein Ali

Email: ali.m.husaen@stu.edu.iq

Course Objectives

1. **Understand Fundamental Modulation Techniques – Learn the principles of analog modulation (AM, FM, PM) and digital modulation (ASK, FSK, PSK).**

   Analyze Modulation Performance – Compare different modulation schemes in terms of bandwidth efficiency, power efficiency, and noise immunity.

2. **Explore Applications of Modulation – Study real-world uses of modulation in wireless communication, broadcasting, and data transmission systems.**

Teaching and Learning Strategies

1. **Cooperative Concept Planning Strategy.**
2. **Brainstorming Teaching Strategy.**
3. **Note-taking Sequence Strategy.**

Course Structure

Weeks	Hours	Required Learning Outcomes	Unit or subject name	Learning method	Evaluation method
1 2 3 4 5 6 7 8 9 10 11 12 13 14	4hours 4hours 4hours 4hours 4hours 4hours 4hours 4hours 4hours 4hours 4hours 4hours 4hours 4hours	**1.** Understand the principles of wireless transmission 2. Analyze multiple access techniques. 3.to Use Electronic Laboratory Tools, such as Multimeters, Signal Generators, and oscilloscopes. 4. Demonstrate knowledge of digital modulation schemes	Angle Modulation (FM a PM) Amplitude Modulation (Pulse Position Modulati (PPM) Pulse Width Modulation (PWM) Pulse Amplitude Modulation (PAM)	1.Conducting laboratory experiments to build a test digital circuits. This enhances theoretical understanding and develops practical skills. 2.Seeking feedback from instructors and peers to identify strengths and weakness 3.Reviewing concepts periodicall and applying them to new problems to reinforce memory and understanding. 4.Using educational software and interactive applications to better understand concepts, such as circuit simulations. 5.Encouraging self-research on n topics in electronics and explorin recent 7e4t4developments.	Weekly, Monthly, Daily, and Written Exams, And Final Term Exam.

Course Evaluation

Distribution as follows: 20 points for Midterm Theoretical Exams for the first semester, 20 points for Midterm Practical Exams for the first semester, 10 points for Daily Exam Exam.	
Learning and Teaching Resources	
Required textbooks (curricular books, if any)	Wireless Communications" by Andrea Goldsmith ,Principles of Wireless Networks" by
Main references (sources)	Communication Systems" – Simon Haykin
Recommended books and references (scientific journals, reports…)	Wireless Communications" by Andrea Goldsmith,"Principles of Mobile Communication"
Electronic References, Websites	IEEE Xplore – https://www.ieee.org

Course Description

Ministry of high Education and Scientific Research
Southern Technical University
Technological institute of Basra
Department of Electronic Techniques

Learning package

In

Modulation

For

Students of Second Year

BY

Mr. Ali Mohammed Hussein Ali
Assistant Lecture
Dep. Of Electronic Techniques
2025

1-*Overview*

1 / A –Target population :-

For students of Second year /Technological institute of Basra
Dep. Of Electronic Techniques

1 / B –Rationale :-

Modulation in wireless communication enables efficient transmission by converting baseband signals to higher frequencies suitable for propagation, while allowing multiple users to share the same bandwidth through techniques like frequency division. It also improves signal quality and resistance to noise/interference

1 / C –Central Idea :-

1– Efficient Transmission

Modulation converts low-frequency baseband signals (like voice or data) into high-frequency carrier signals. This allows the signal to travel longer distances with minimal loss and enables multiple signals to be transmitted simultaneously over different frequency bands (multiplexing).

2-Reduced Antenna Size

For effective radiation, the antenna size must be comparable to the signal wavelength. High-frequency modulated signals have shorter wavelengths, allowing the use of smaller, practical antennas in wireless devices.

1 / D – Performance Objectives

1. Spectral Efficiency

- Modulation techniques aim to maximize the data rate transmitted within a given bandwidth.
- Higher-order modulation (e.g., 64-QAM) packs more bits per symbol, improving efficiency but requiring better signal quality.
- Ensures optimal use of limited frequency spectrum.

2. Power Efficiency

- Modulation should minimize transmit power while maintaining reliable communication.
- Techniques like BPSK or QPSK are robust in low-power scenarios (e.g., deep-space communication).
- Balances energy consumption with error performance (BER)

2-Pretest

1. **Purpose of Pretesting**:
   Pretesting ensures that the modulation scheme (e.g., QPSK, 16-QAM, OFDM) performs well under real-world channel conditions (like noise, interference, and fading). It helps identify potential issues before full deployment.
2. **Key Parameters Checked**:
   During pretesting, parameters like **Bit Error Rate (BER)**, **Signal-to-Noise Ratio (SNR)**, and **spectral efficiency** are measured to verify if the modulation meets performance requirements.

3-Modulation

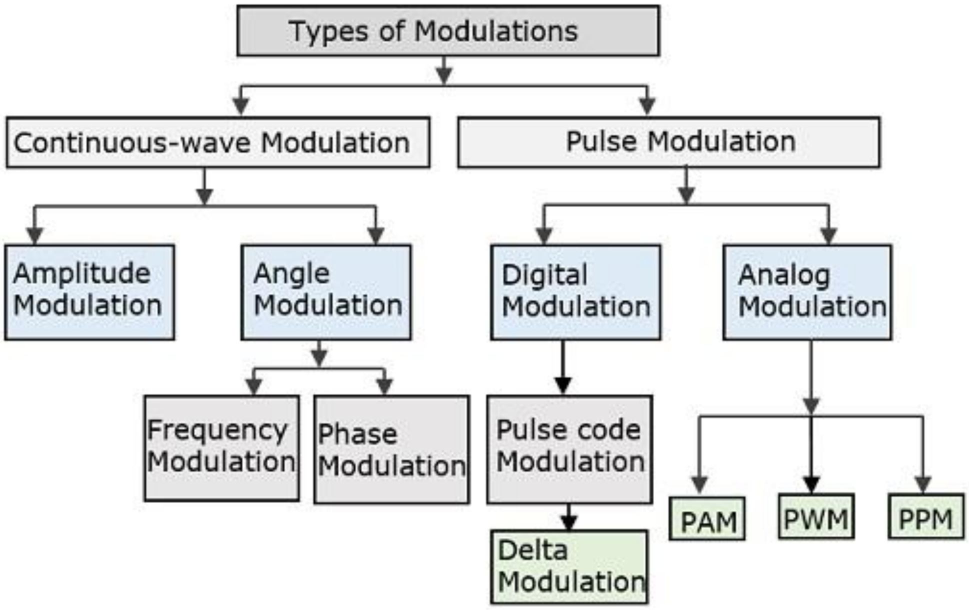
Definition of Modulation:

Modulation is formally defined as the process by which some characteristic of a
carrier signal is varied by an information signal. The baseband signal (information signal) is referred to as the modulating wave, and the result of the modulation process is referred to as the modulated wave. This process is being achieved by passing the information signal and the carrier wave through an anonliner device together with BPF.

Modulation is necessary because of the following reasons :
1- Reduction in the height of the antenna.
2- Avoids the interference of signals.
3- Increases the range of communication.
4- Multiplexing of the signal is possible.
5- Improves the quality of reception.

Type of modulation:

Modulation can take deferent forms depends on the :-
1- Types of (Carrier) Modulation.
2- The method by which the characteristic of the carrier wave is changed by the modulation.



Amplitude Modulation

1- Amplitude Modulation:

It is defined as the process of varying the amplitude of a sinusoidal carrier wave in synchronism with, and in direct proportion, to the amplitude of a modulating signal.

The unmodulated carrier signal is given as :

$s(t) = A_c \cos \omega_c t \ , \ \omega_c = 2\pi f_c$

A sinusoidal modulated (band-pass) carrier signal is represented by :

$S_{AM}(t) = A(t) \cos \theta(t)$

where $A(t)$ is the envelope and

$\theta(t) = \omega_c t + \phi(t) = 2\pi f_c t + \phi(t)$

$\phi(t)$ is called the instantaneous phase deviation of $S_{AM}(t)$ and f_c is the carrier frequency.

For amplitude modulation, we can write:

$$SAM(t) = A(t) \cos \omega c\, t$$

where $A(t)$ is linearly related to the modulating signal $x(t)$. $A(t)$ is called the instantaneous amplitude of $SAM(t)$ and amplitude modulation is also referred to as linear modulation.

A normal amplitude-modulated signal is given by :

$$SAM(t) = [Ac + x(t)]\cos\omega ct$$
$$= Ac \cos \omega c\, t + x(t)\cos\omega ct$$

2-Modulation Index and Modulation depth :

Modulation Index : The ratio between the amplitudes of the modulating signal and carrier signal, expressed by the equation.

$$m = Am/Ac$$

m = modulation index (unit less)

Am = peak amplitude of the modulating signal voltage (volts).

Ac = peak amplitude of the carrier signal voltage (volts).

Percent Modulation, M is m stated as a percentage i.e :-

$$M = m \times 100\%$$

When $Am = Ac$, i.e $m = 1$, there is no distortion at the output signal

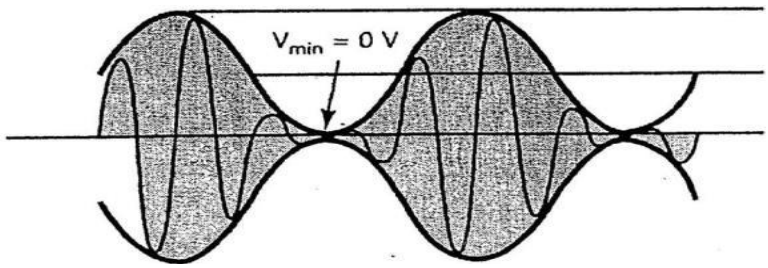


Fig. 1: (m = 1.0) 100% modulated wave.

<u>**Ex 1**</u>**: If the modulated signal of Amplitude Modulation (AM):-**
$\boldsymbol{V(t) = 20(4 + 4sin2\pi104t).\ cos2\pi106t}$. $\boldsymbol{Determine\ Ac}$, $\boldsymbol{m}$, $\boldsymbol{fc}$, $\boldsymbol{fm}$?

<u>*Sol.:*</u>

$\boldsymbol{S_{AM}}(t) = \boldsymbol{A_c}\,[\mathbf{1} + \boldsymbol{m\ x(t)}]\ \boldsymbol{cos\omega_c t}$ (General equation of AM).

$\boldsymbol{V(t) = 20(4 + 4sin2\pi10^{4}t).\ cos2\pi10^{6}t}$.

$\boldsymbol{V(t) = 80(1 + sin2\pi10^{4}t).\ cos2\pi10^{6}t}$.

$\therefore \boldsymbol{Ac = 80\ volt\ ,\ m = 1,\ fc = 10^{6}\ Hz,\ f_m = 10^{4}\ Hz}$.

<u>3-Bandwidth in Amplitude Modulation :</u>

The bandwidth of an amplitude modulated signal is of importance for many reasons. The amplitude modulation, AM bandwidth is important when designing filters to receive the signals, determining the channel spacing, and for several other reasons.

The spectrum and bandwidth of an amplitude modulated signal are determined by the sidebands that are generated when amplitude modulation is applied to the carrier.

$$\boldsymbol{Bandwidth\ (B.W) = f_{USB} - f_{LSB}}$$

<u>Ex:</u> A standard AM broadcast station is allowed to transmit modulating frequencies up to 7 kHz. If the AM station is transmitting on a frequency of 1053 kHz, what are the sideband frequencies and total bandwidth?

<u>Sol.:</u>

$fUSB = fc + fm = 1053 + 7 = 1060\ kHz.$

$fLSB = fc - fm = 1053 - 7 = 1046\ kHz.$

$B.W = fUSB - fLSB = 1060\ kHz - 1046\ kHz = 14\ kHz.$

$\therefore B.W = 2fm$

Post Test

A standard AM broadcast station is allowed to transmit modulating frequencies up to 8 kHz. If the AM station is transmitting on a frequency of 1060 kHz, what are the sideband frequencies and total bandwidth?

Key Answer

1. Sideband Frequencies:

In AM (Amplitude Modulation), the sidebands are generated above and below the carrier frequency.

- Upper Sideband (USB):

$f_0 + f_m = 1060\ kHz + 8\ kHz = 1068\ kHz$

- Lower Sideband (LSB):

$f_0 - f_m = 1060\text{ kHz} - 8\text{ kHz} = 1052\text{ kHz}$

Total Bandwidth:

The bandwidth of an AM signal is the difference between the highest and lowest frequencies in the modulated signal.

$$\text{Bandwidth} = (f_0 + f_m) - (f_0 - f_m) = 2f_m$$

$$\text{Bandwidth} = 2 \times 8\text{ kHz} = 16\text{ kHz}$$

Home work

An audio signal $\boldsymbol{x(t) = 40\, sin(26389)t}$, is amplitude modulated with a sinusoidal carrier signal $\boldsymbol{s(t) = 60\, sin\,(6.157 \times 10_6)t}$

Determine :-

a- modulation index.

b- percentage modulation**.**

c- frequencies of the audio signal and the carrier signal.

Reference

"Communication Systems" – Simon Haykin

Ministry of high Education and Scientific Research
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Learning package

In

Angle Modulation

For

Second year students

BY

Mr. Ali Mohammed Hussein Ali
Assistant Lecture
Dep. Of Electronic Techniques
2025

1 / A –Target population :-

For students of Second year /Technological institute of Basra
Dep. Of Electronic Techniques

1 / B –Rationale :-

1. **Improved Noise Immunity**:
   Angle modulation (FM/PM) offers better resistance to noise and interference compared to amplitude modulation (AM). Since information is encoded in the frequency or phase variations, amplitude distortions (e.g., noise) have less impact on signal quality.
2. **Constant Power Transmission**:
   Unlike AM, angle-modulated signals have a constant envelope, allowing efficient use of power amplifiers (operating in saturation mode) without signal distortion, leading to higher power efficiency in communication systems.

1 / C –Central Idea :-

Angle modulation varies the angle (phase or frequency) of the carrier signal to transmit information. It includes:

1. Frequency Modulation (FM) – The frequency of the carrier changes based on the message signal, while the amplitude remains constant.
2. Phase Modulation (PM) – The phase of the carrier shifts in proportion to the message signal, keeping amplitude unchanged.

1 / D – Performance Objectives

1. Understand Modulation Principles:
    - Explain the key differences between FM and PM, including how frequency and phase of the carrier wave vary with the modulating signal.
    - Derive mathematical expressions for instantaneous frequency and phase deviation.
2. Analyze Performance Characteristics:
    - Compare bandwidth efficiency and noise immunity of angle modulation with amplitude modulation (AM).
    - Calculate modulation index, frequency deviation, and Carson's rule for FM signals.

Angle Modulation

Definition:
The modulation in which, the angle of the carrier wave is varied according to the baseband signal (information signal).

• An important feature of this modulation is that it can provide better discrimination against noise and interference than amplitude modulation.

• An important feature of Angle mod. is that it can provide better discrimination against noise and distortion

• Complexity Vs. Noise and interference Trade-off.

There are two types of the angle modulation:
• Phase modulation.
• Frequency Modulation.
The angle modulated signal can be expressed as:
$\boldsymbol{S(t) = A_c \cos[\theta_i(t)]}$

Where $\boldsymbol{\theta_i(t)}$ denotes the angle of a modulated sinusoidal carrier and $\boldsymbol{A_c}$ is the carrier amplitude. A complete oscillation occurs whenever $\boldsymbol{\theta_i(t)}$ changes by 2π radians.

In the simple case of an unmodulated carrier, $\boldsymbol{A_c \cos(2\pi f_c t)}$, the angle $\boldsymbol{\theta_i(t)}$ is: $\boldsymbol{\theta_i(t) = 2\pi f_c t + \emptyset_c}$

The constant $\emptyset_c$ is the value of $\boldsymbol{\theta_i(t)}$ at $t = 0$.

There are an infinite number of ways in which the angle is varied in some manner with the information (baseband) signal. However, we shall consider two commonly used methods.

a) Phase Modulation (PM).

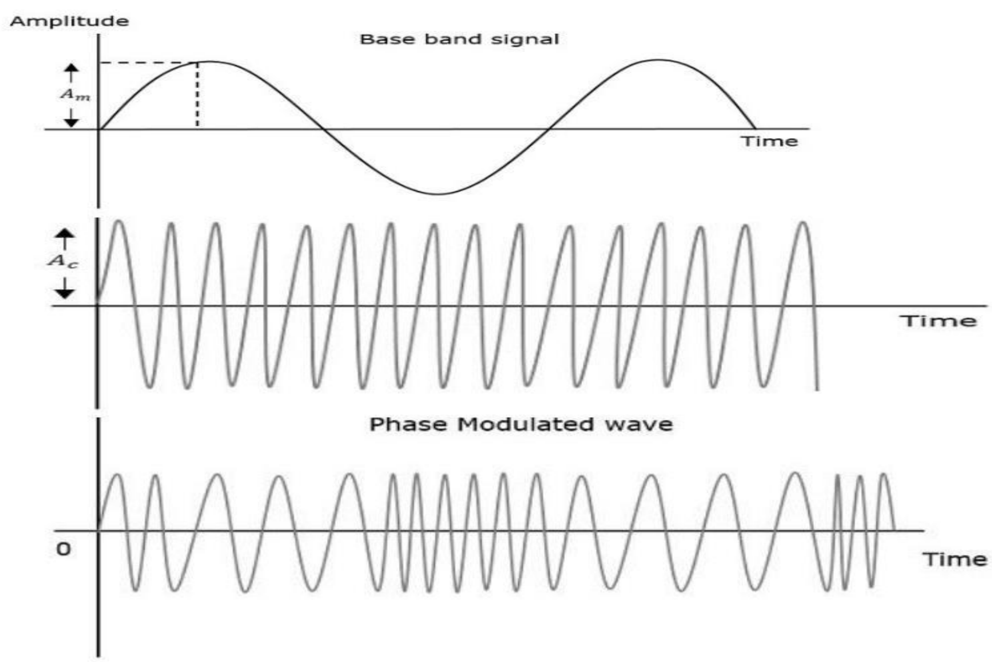
Phase Modulation **(PM)** is that form of angle modulation in which the angle is varied linearly with the information signal $\boldsymbol{x(t)}$, as shown below:

$$\boldsymbol{\theta_i(t) = 2\pi f_c t + k_p x(t)}.$$

The term $\boldsymbol{2\pi f_c t}$ represents the angle of the unmodulated carrier and the constant $\boldsymbol{k_p}$ represents the phase sensitivity of the modulator, $\boldsymbol{rad\ V}$

The phase-modulated signal $\boldsymbol{S_{PM}(t)}$ is thus described in the time domain by:

$$\boldsymbol{S_{PM}(t) = A_c\cos(2\pi f_c t + k_p x(t))}.$$



Phase Modulation signal.

As shown in Fig. the phase of the carrier is varied instead of its frequency. In effect, PM is a modified version of FM, because any phase change is related to a change in frequency.

If the information signal sinusoidal wave $x(t) = A_m \sin(\omega_m t)$ in PM Then:-

$$S_{PM}(t) = A_c \cos(\omega_c t + k_p A_m \sin(\omega_m t))$$
$$\beta = k_p A_m$$

A_m: Maximum amplitude of the modulation signal.
β : Modulation Index of PM [rad].

$$S_{PM}(t) = A_c \cos(\omega_c t + \beta \sin(\omega_m t))$$

b) Frequency Modulation (FM).

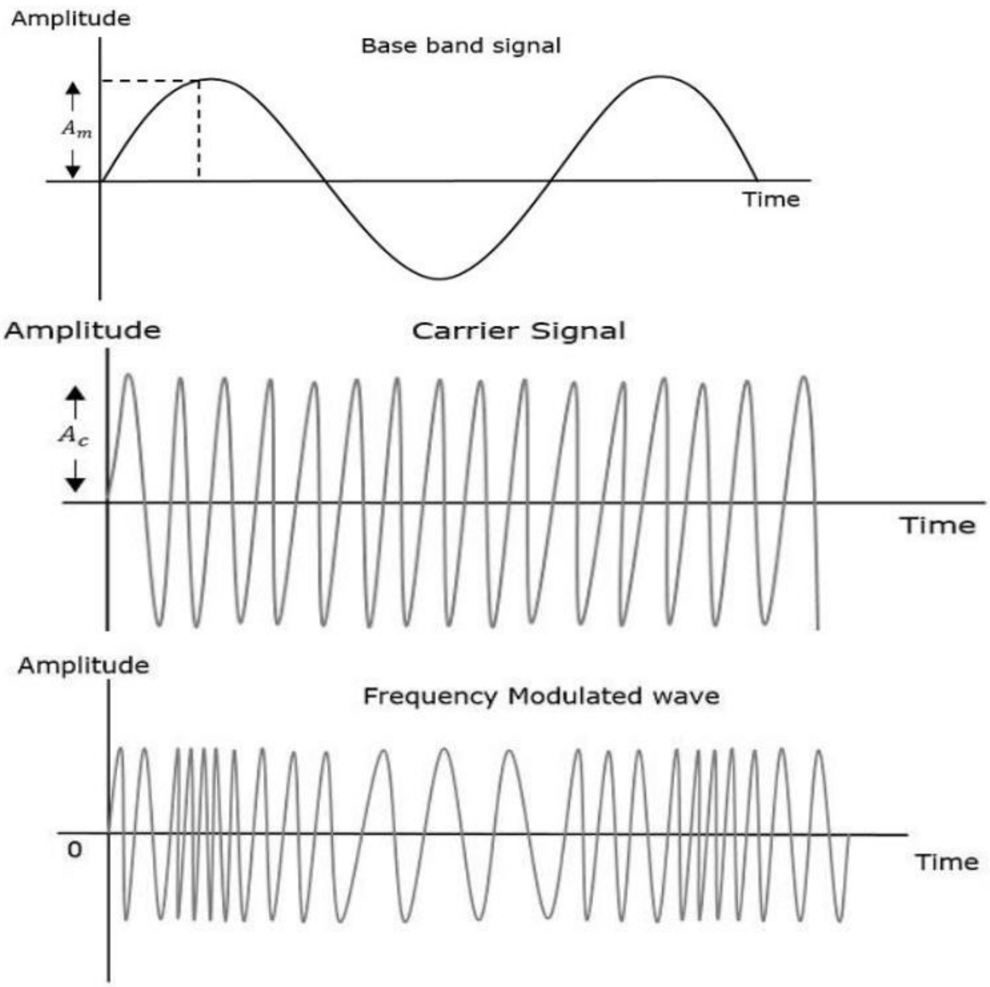
Frequency Modulation FM is that form of angle modulation in which the instantaneous frequency is varied linearly with the information signal $x(t)$, as shown by:

$$f_i(t) = f_c + k_f x(t).$$

The term $f_i(t)$ represents the frequency of the unmodulated carrier and the constant k_f represents the frequency sensitivity of the modulator, Hz/V.

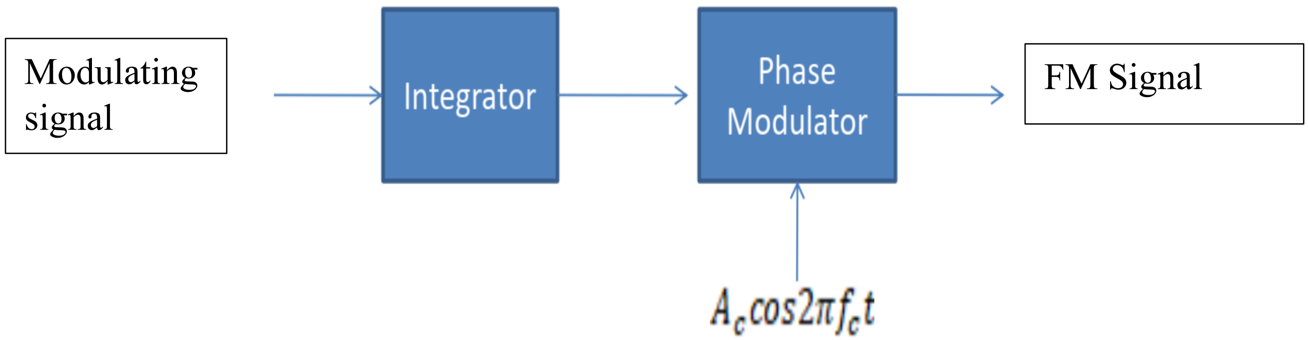
• The frequency modulated signal $S_{FM}(t)$ is thus described in the time domain by:

$$\theta_i(t) = 2\pi \int f_i(\lambda) d\lambda \; t0 .$$
$$S_{FM}(t) = A_c \cos\left[2\pi f_c t + 2\pi k_f \int x(\lambda) d\lambda \; t0\right]$$

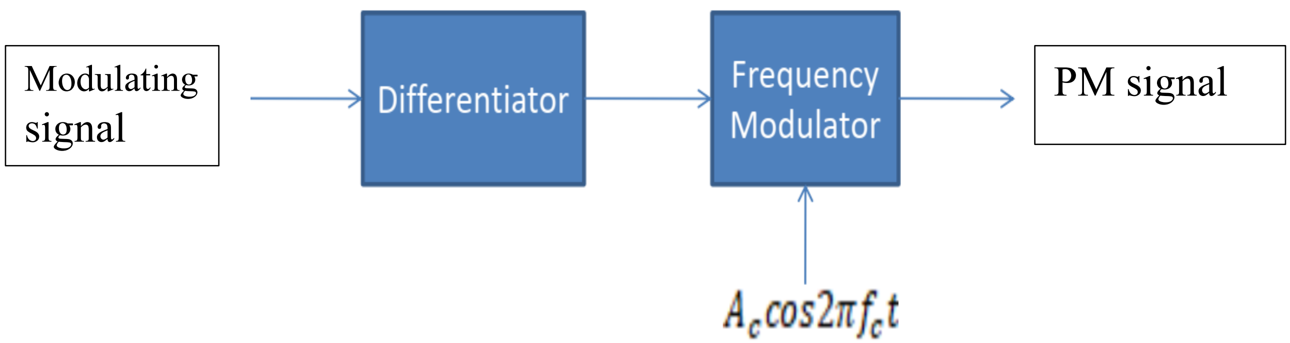


Frequency Modulation signal.

Relationship between Phase Modulation (PM) and Frequency Modulation (FM):



FM signal generation using Phase Modulator.



PM signal generation using Frequency Modulator.

Post Test

Compare and contrast Frequency Modulation (FM) and Phase Modulation (PM) by discussing:

1. How the **modulating signal** affects the carrier wave in each case.
2. The relationship between **frequency deviation** and **modulating signal amplitude** in FM vs. PM.
3. Which type of modulation is more resistant to **noise** and why.

Key Answer

FM varies frequency with the modulating signal, while PM varies phase. In FM, frequency deviation depends on the amplitude of the modulating signal, whereas in PM, it depends on both amplitude and frequency. FM is generally more noise-resistant because noise affects amplitude more than frequency.)

HomeWorks

An information signal $x(t)=3\cos(2\pi\times103t)$ is used to frequency modulate a carrier signal $s(t)=10\cos(2\pi\times106t)$.

The frequency sensitivity of the modulator is kf=2×103

1. Calculate the frequency deviation Δf.
2. Determine the modulation index β.
3. Write the mathematical expression for the FM signal SFM(t)
4. Sketch the frequency spectrum of the FM signal, labeling the carrier and significant sidebands.

Reference

Communication Systems" – Simon Haykin

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Technological institute of Basra
Department of Electronic Techniques

Learning package

In

PULSE CODE MODULATION (PCM)

For

Second year students

BY

Mr. Ali Mohammed Hussein Ali
Assistant Lecture
Dep. Of Electronic Techniques
2025

1 / A –Target population :-

For students of Second year /Technological institute of Basra
Dep. Of Electronic Techniques

1 / B –Rationale :-

1. Efficient Signal Representation: Pulse Code Modulation (PCM) converts analog signals into digital form by sampling, quantizing, and encoding, enabling efficient transmission and storage with minimal loss of quality.
2. Noise Immunity: PCM enhances communication reliability by transmitting discrete digital pulses, which are less susceptible to noise and distortion compared to analog signals, ensuring clearer signal recovery at the receiver.

2 / C –Central Idea :-

1. Digital Conversion of Analog Signals: PCM converts continuous analog signals into discrete digital form by sampling, quantizing, and encoding, ensuring accurate and noise-resistant transmission.
2. Efficient and Reliable Communication: By representing signals in binary code, PCM improves signal quality, reduces distortion, and enables easy storage and processing in digital systems

1 / D – Performance Objectives

1. High Signal-to-Noise Ratio (SNR): PCM aims to maintain a high SNR by minimizing quantization noise, ensuring accurate digital representation of the analog signal.
2. Efficient Bandwidth Utilization: PCM optimizes bandwidth usage by converting analog signals into digital bit streams, enabling effective transmission and multiplexing in communication systems.

PULSE CODE MODULATION

Definition

Pulse-code modulation is known as a digital pulse modulation technique. In fact, the pulse-code modulation (PCM) is quite complex compared to the analog pulse modulation techniques (i.e., PAM, PWM and PPM) in the sense that the message signal is subjected to a great number of operations.

2. Elements of a PCM system

Figure1(A) shows the basic elements of a PCM system. It consists of three mains parts i.e., transmitter, transmission path and receiver. The essential operations in the transmitter of a PCM system is sampling, quantizing and encoding as shown in figure 1(A). As discussed earlier, sampling is the operation in which an analog (i.e.,continuous-time) signal is sampled according to the sampling theorem resulting in a discrete-time signal. The quantizing and encoding operations are usually performed in the same circuit which is known as an analog-to-digital converter (ADC).

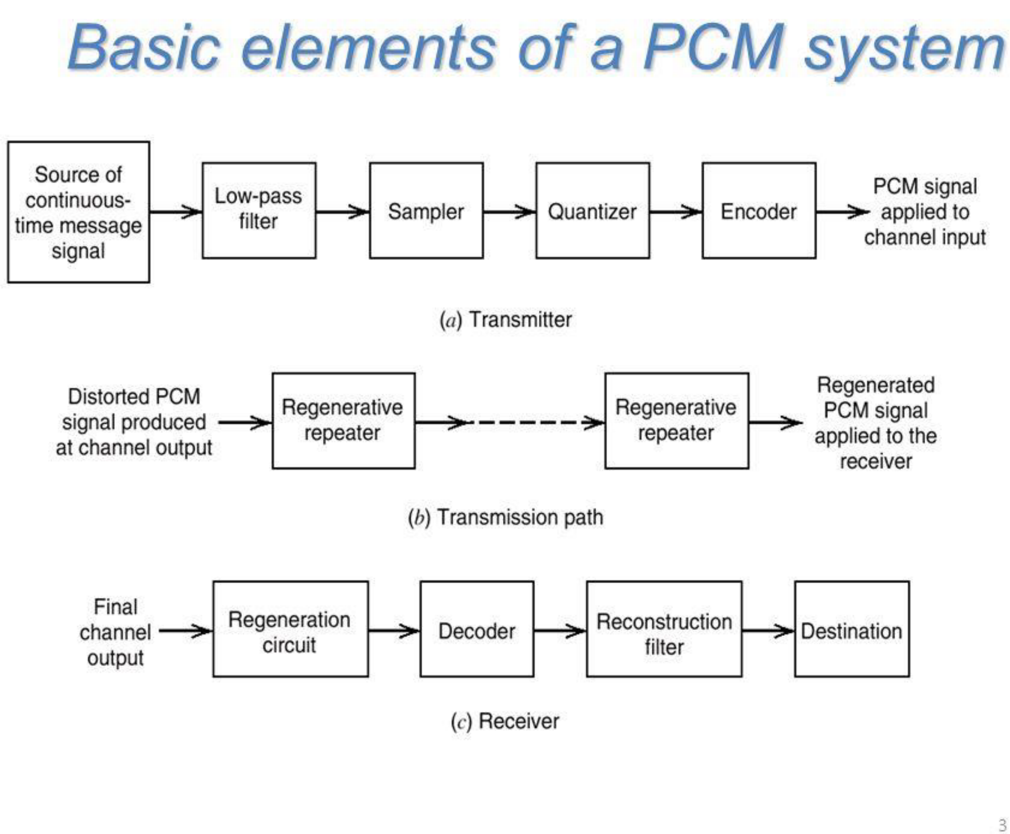

Fig 1 Basic Element Of A PCM System

Block diagram of a Repeater

Fig. 4 shows the block diagram of a regenerative repeater. The amplitude equalizer shapes the distorted PCM wave so as to compensate for the effects of amplitude and phase distortions. The timing circuit periodic pulse train which is derived from the input PCM pulses. This pulse train is then applied to the decision-making device. The decision-making device uses this pulse train for sampling the equalized PCM pulses.

The sampling is carried out at the instants where the signal to noise ratio is maximum. The decision device makes a decision about whether the equalized PCM wave at its input has a 0 value or 1 value at the instant of sampling. Such a decision is made by comparing equalized PCM with a reference level called decision threshold as illustrated in fig. 4 At the output of the decision device, we get a clean PCM signal without any trace of noise.

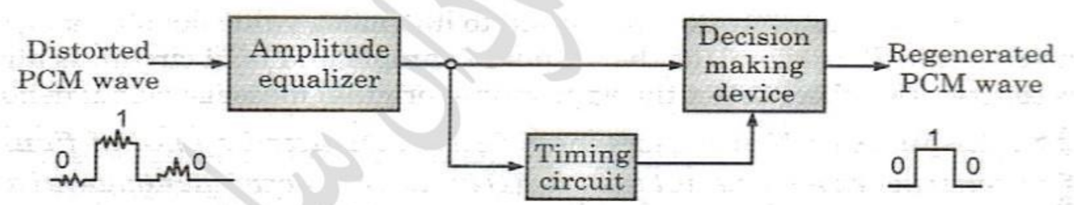

Fig. 4 *Block diagram of a regenerative repeater.*

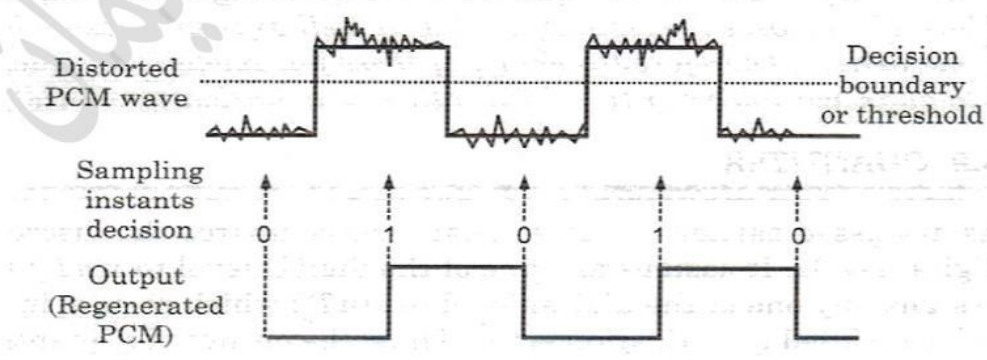

Fig. 5 *Waveforms of a regenerative repeater.*

Post Test

Why is quantization necessary in PCM, and what is the main drawback of this process?

Key Answer

Quantization converts continuous amplitude samples into discrete levels for digital representation. The main drawback is quantization error (or noise), which occurs due to the approximation of signal amplitudes.

HomeWorks

Explain the three main steps involved in PCM and describe each step briefly.

Reference

Communication Systems" – Simon Haykin

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Learning package

In

PAM, PWM & PPM

For

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1 / A –Target population :-

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1 / B –Rationale:-

1. Efficient Signal Encoding & Noise Resistance
2. Bandwidth & Power Optimization

3 / C –Central Idea :-

1- Pulse Position Modulation (PPM):

- The information is encoded in the time position of the pulses while keeping amplitude and width constant.
- Used in optical communication and radar systems for noise resistance.

2-Pulse Width Modulation (PWM):

- The signal information is represented by varying the width (duration) of the pulses while amplitude remains fixed.
- Commonly used in power control, motor speed regulation, and digital audio amplifiers.

3-Pulse Amplitude Modulation (PAM):

- The signal is transmitted by varying the amplitude of the pulses while keeping width and position constant.
- Found in early digital communication systems and Ethernet communications.

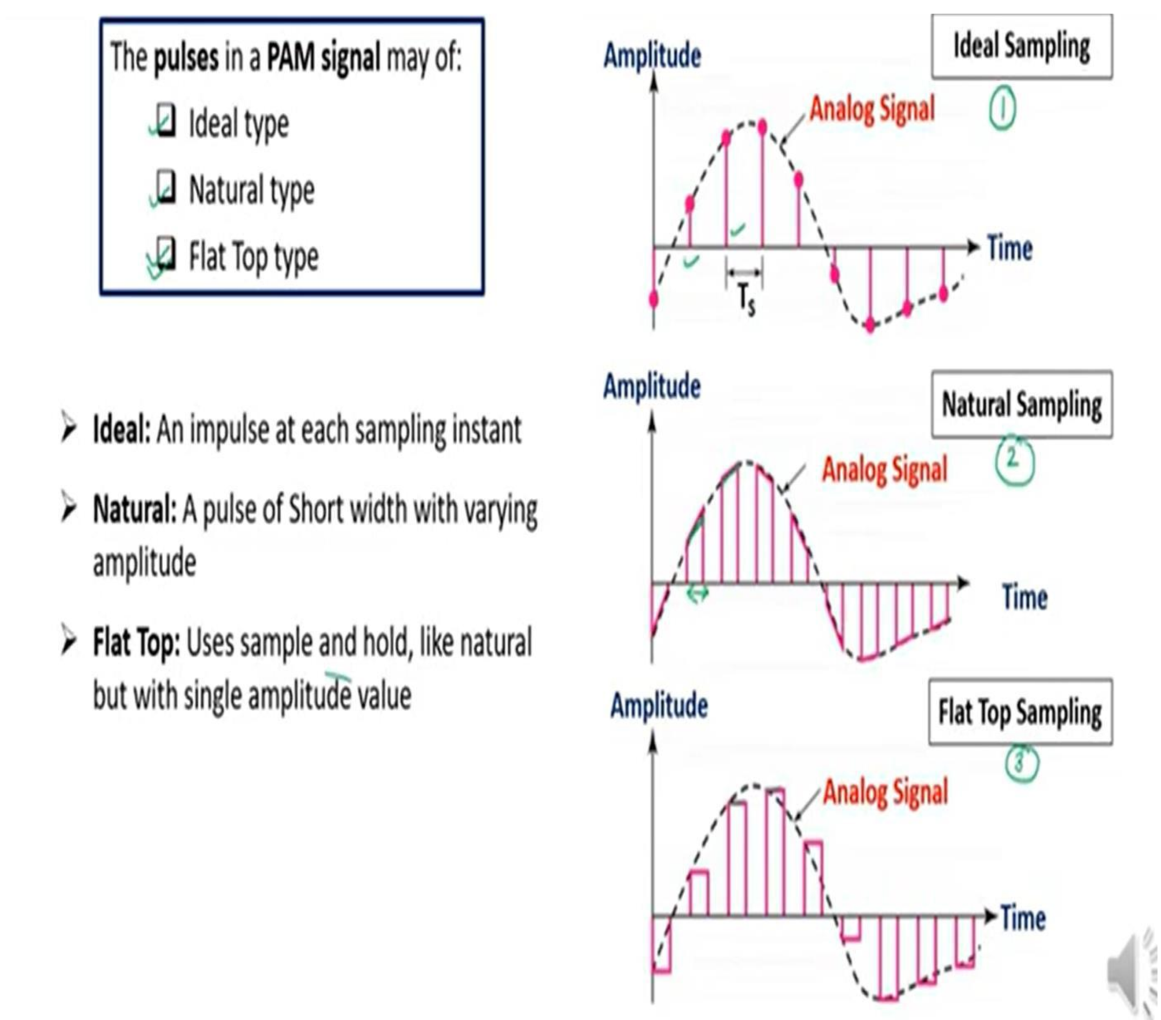
1 / D – Performance Objectives

1. Pulse Position Modulation (PPM): The position of the pulse varies in time according to the amplitude of the modulating signal, while pulse width and amplitude remain constant.
2. Pulse Width Modulation (PWM): The width (duration) of the pulse changes based on the modulating signal's amplitude, while pulse amplitude and position stay fixed.
3. Pulse Amplitude Modulation (PAM): The amplitude of the pulses varies with the modulating signal, while pulse width and position remain unchanged.

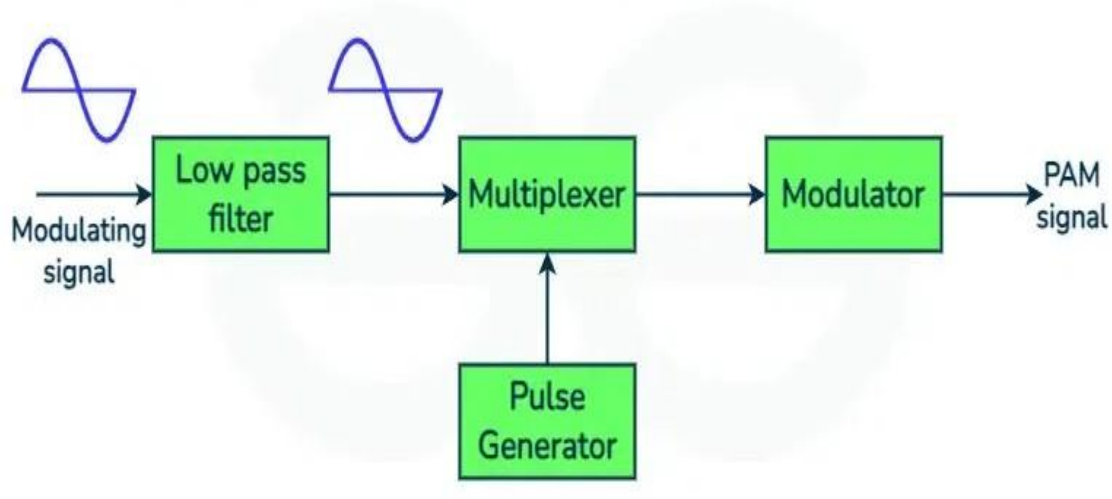
Pulse Amplitude Modulation (PAM)

Pulse amplitude modulation is a technique in which the amplitude of each pulse is controlled by the instantaneous amplitude of the modulation signal.

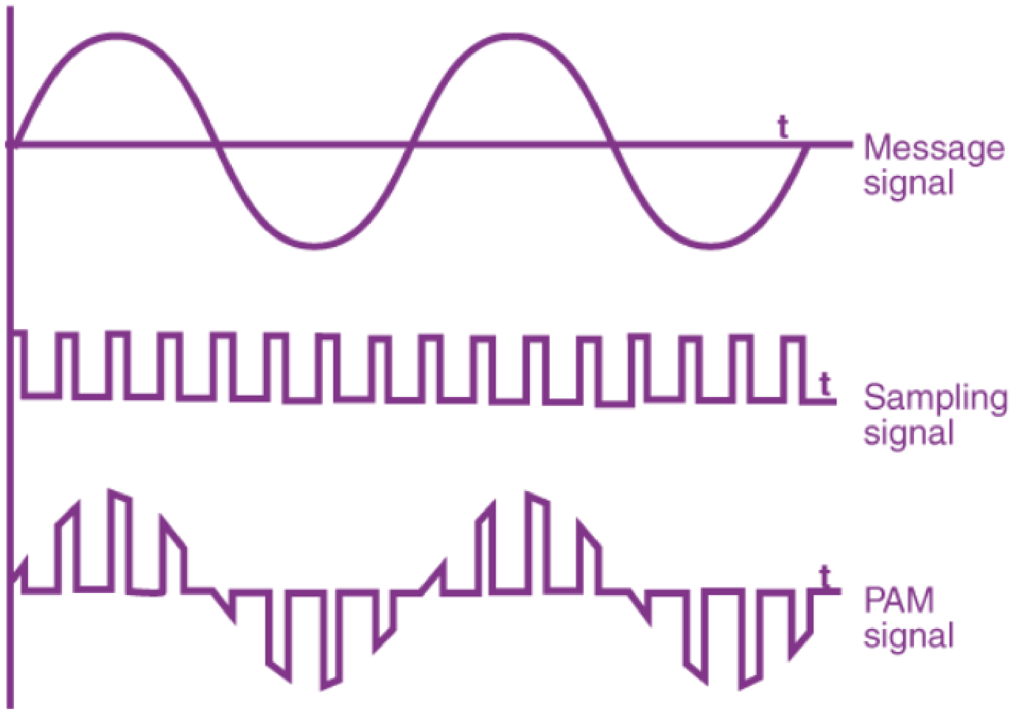
It is a modulation system in which the signal is sampled at regular intervals and each sample is made proportional to the amplitude of the signal at the instant of sampling. This technique transmits the data by encoding in the amplitude of a series of signal pulses.



PAM Generation



1. Signal Processing: The modulating signal is first passed through a low-pass filter to remove high-frequency components, ensuring the signal is within the desired bandwidth.
2. Modulation**:** The filtered signal is then fed into a modulator along with pulses generated by a pulse generator. The modulator combines these inputs to produce the PAM signal, where the amplitude of the pulses varies according to the modulating signal.



Pulse Amplitude Modulation Signal

Advantages of PAM

• Both modulation and demodulation are simple.
• Easy construction of transmitter and receiver circuits.

Disadvantages of PAM

• A large bandwidth is required for transmission.
• More noise.
• Here, the amplitude varies. Therefore, the power required will be more.

Applications of PAM

• Mainly used in ethernet communication.
• Many microcontrollers use this technique in order to generate control
signals.
• It is used in photo-biology.
• It acts as an electronic driver for LED circuits

2-Pulse Width Modulation (PWM)

PWM (Pulse Width Modulation) is a pulse modulation technique in which the width of the pulse is varied proportionally with the amplitude of the modulating signal.

The data is encoded in the variation of the width of the pulses for transmission. The width of the pulse is varied but the amplitude and frequency of the same pulse remain constant throughout the operation.

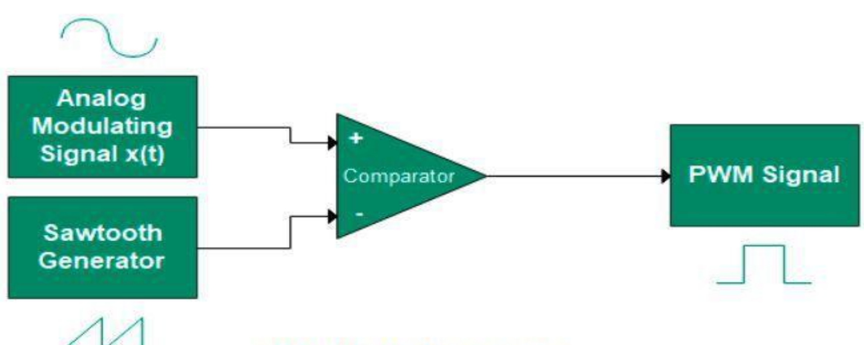
Why is Pulse Width Modulation used?

Pulse width modulation is an effective method that is used to control the amount of power delivered to a load without dissipating any wasted power

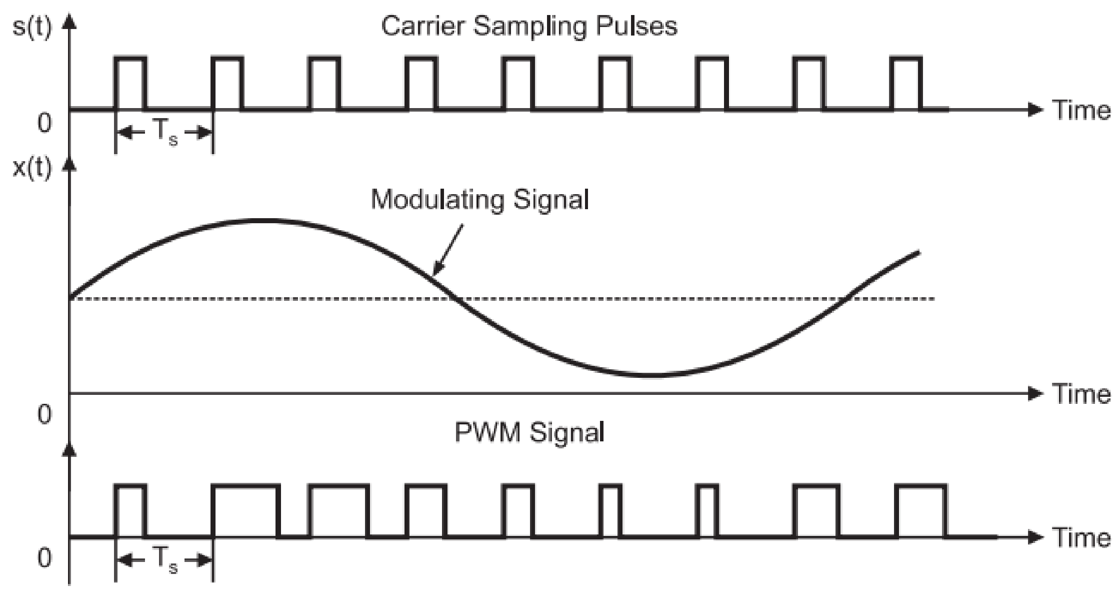
PWM Generation

In a PWM generation system, there are three main components: The comparator, modulating signal, and sawtooth wave generating circuit. A PWM modulating signal is generated using a comparator.

The modulating signal forms one part of the input to the comparator, while the non-sinusoidal wave or sawtooth wave forms the other part of the input. The comparator compares two signals and generates a PWM signal as its output waveform.



Pulse Width Modulation



If the sawtooth signal is more than the modulating signal, then the output signal is in a "High" state. The value of the magnitude determines the comparator output which defines the width of the pulse generated at the output.

Types of Pulse Width Modulation Technique

There are three conventional types of pulse width modulation technique and they are named as follows:

• **Trail Edge Modulation –** In this technique, the signal's lead edge is
modulated, and the trailing edge is kept fixed.
• **Lead Edge Modulation –** In this technique, the signal's lead edge is fixed,
and the trailing edge is modulated.
• **Pulse Center Two Edge Modulation –** In this technique, the pulse centre is
fixed and both edges of the pulse are modulated

Advantages PWM

• PWM technique is accurate and has a fast response time.
• PWM technique provides a high input power factor.

Disadvantages PWM

• As the PWM frequency is high, switching losses are considerably high.
• It induces Radio Frequency Interference (RFI)

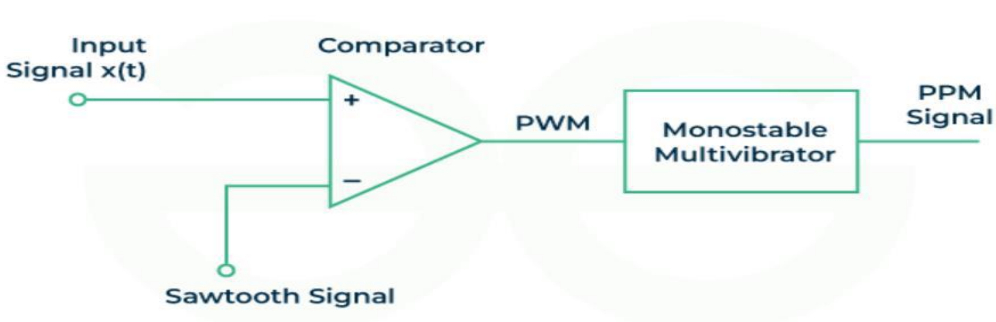
Pulse Position Modulation (PPM)

Pulse position modulation is a modulation technique in which the position of pulse varies according to instantaneous value of amplitude of sampled
modulating signal.

If we try to summarize it, *Displacement of pulse is directly proportional to amplitude value of sampled message signal.*

Pulse Position Modulation Block Diagram

Let us see the basic block diagram used for generation of Pulse Position



in this block diagram, firstly a PAM (pulse amplitude modulated) signal is produced which is processed at comparator to generate a PWM (pulse width modulated signal).

After processing, the output of comparator is fed as an input to monostable vibrator.

Being negative edge-triggered, the output of vibrator goes high with trailing edge of PWM signal. The trailing edge of PWM shifts with modulating signal creating PPM pulses.

Post Test

1. In Pulse Position Modulation (PPM), how is the information signal encoded in the transmitted pulses?
2. What characteristic of the pulse is modified in Pulse Width Modulation (PWM) to represent the analog signal?
3. In Pulse Amplitude Modulation (PAM), what is information signal represented?

Key Answer

1. By shifting the position of the pulses relative to a reference time
2. The time duration (width) of the pulses
3. Varying the height (amplitude) of the pulses

HomeWorks

Explain how Pulse Position Modulation (PPM) encodes information. How does it differ from PWM and PAM?.

Reference

Communication Systems" – Simon Haykin