Principles of Communication (BEC-28)

Unit-4

Pulse Modulation and Digital Transmission of Analog Signal

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Content of Unit-IV

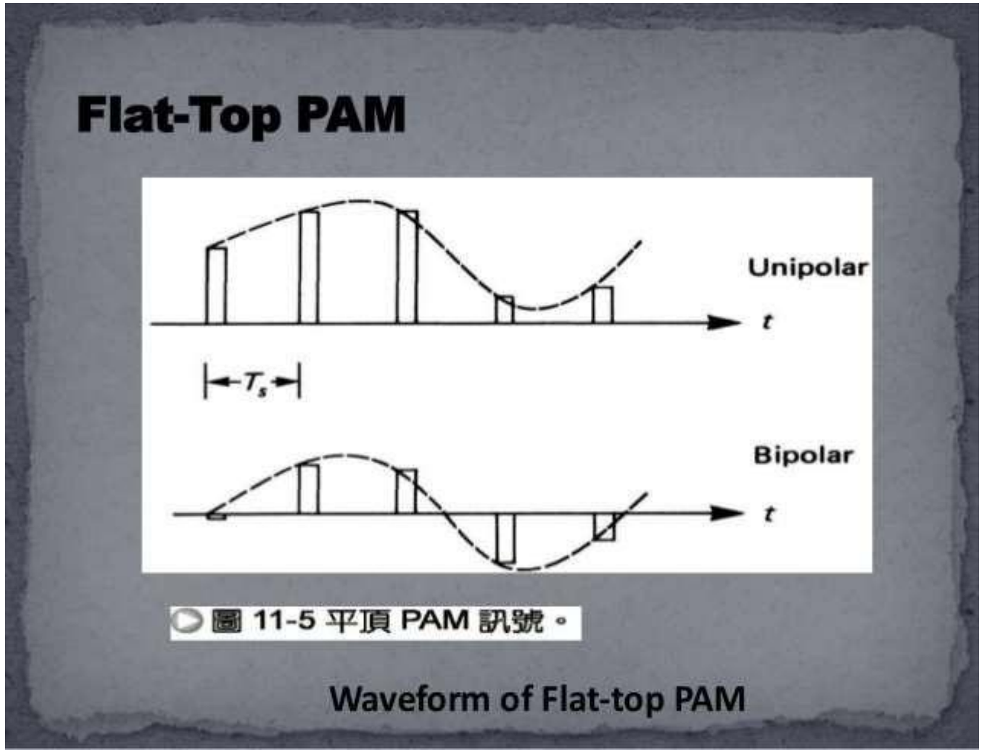
Pulse Modulation and Digital Transmission of Analog Signal: Sampling Theorem and its applications, Concept of Pulse Amplitude Modulation, Pulse width modulation and pulse position modulation, PCM, Pulse Time Modulation, TDM and FDM. Line Coding, Quantizer, Quantization Noise, Compounding multiplexer.

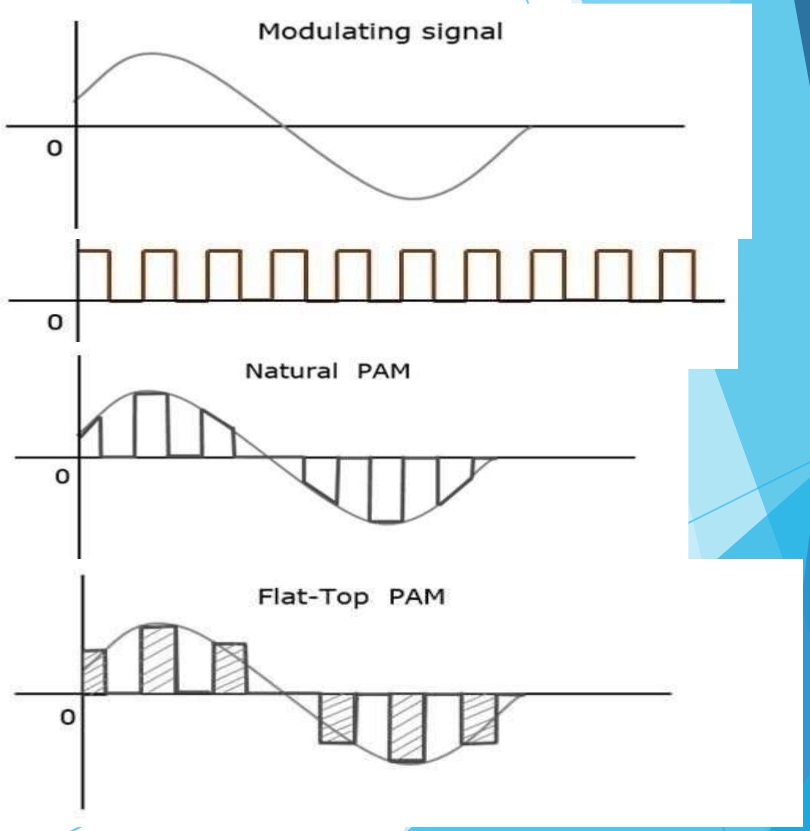
Pulse Amplitude Modulation (PAM)

- Amplitude of **the pulse carrier** varies proportional to the **instantaneous amplitude of the message signal.**
- The **width and positions** of the pulses are **constant** in this modulation.
- **PAM could be:**

(i) **Single polarity PAM**: A suitable **fixed DC bias is added to the signal** to ensure that all the pulses are positive.

(ii) **Double polarity PAM**: In this the pulses are both positive and negative.





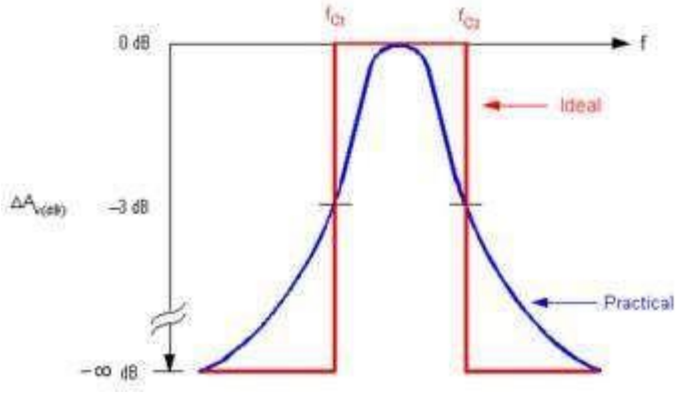
- Depending on type of sampling **PAM can be**:

    (i) Ideal Sampling PAM, (ii) Natural sampling PAM and (iii) Flat top PAM.

- The **advantage** of this modulation is the **generation and detection** is **easy** in this modulation and also **allows multiplexing.**

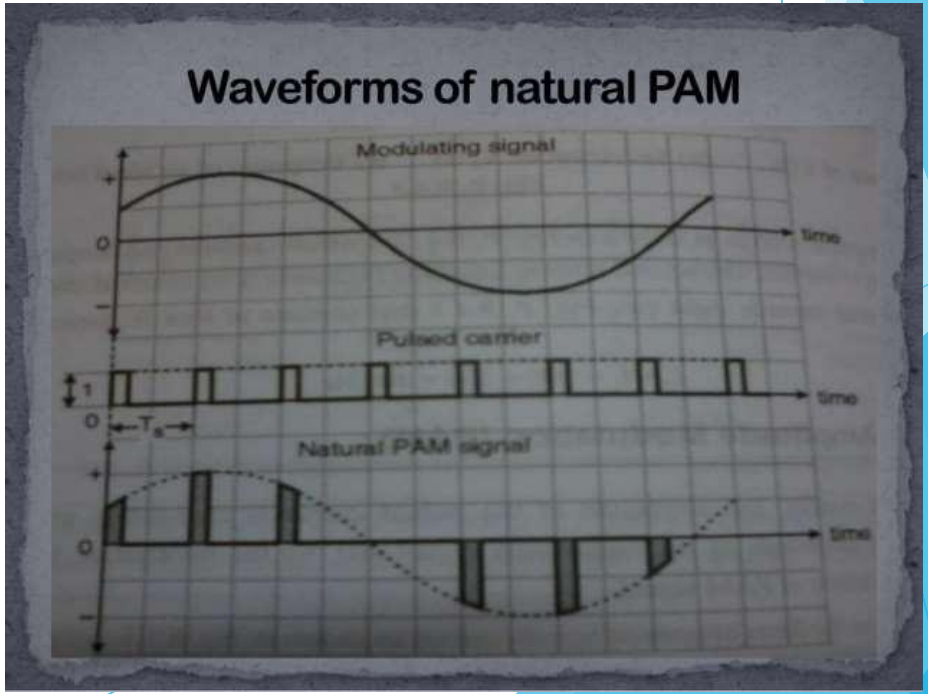
- The **disadvantage** is **large band width** of transmitted signal.

BPF characteristics



- For a **PAM signal** produced with **natural sampling**, the **sampled signal follows the waveform of the input signal** during the time that each sample is taken.
- A PAM signal is generated by using **a pulse train**, called the **sampling signal** (or clock signal) to operate an **electronic switch or "chopper"**. This produces **samples of the analog message signal**.
- The **switch is closed** for the duration of **each pulse**, allowing the **message signal** at that **sampling time to become part of the output.**
- The **switch is open for the remainder of each sampling period making the output zero**. This is known as **Natural PAM**.

In simplest form **PAM** can be visualized as **o/p of an AND gate** whose **two inputs** are **message signal x(t)** and **pulses at sampling rate**



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- For **flat-top sampling**, a sample-and-hold circuit is used in conjunction with the chopper to hold the amplitude of each pulse at a constant level during the sampling time,
- **Flat-top sampling**, produces **pulses whose amplitude remains fixed** during the sampling time. The **amplitude value** of the pulse depends on **the amplitude of the input signal at the time of sampling.**
- **Aperture Effect** seen in this type of **PAM. Equalizers** used at **receiver end**

Transmission Bandwidth in PAM

$\boldsymbol{\tau} \ll \mathbf{T_s}$

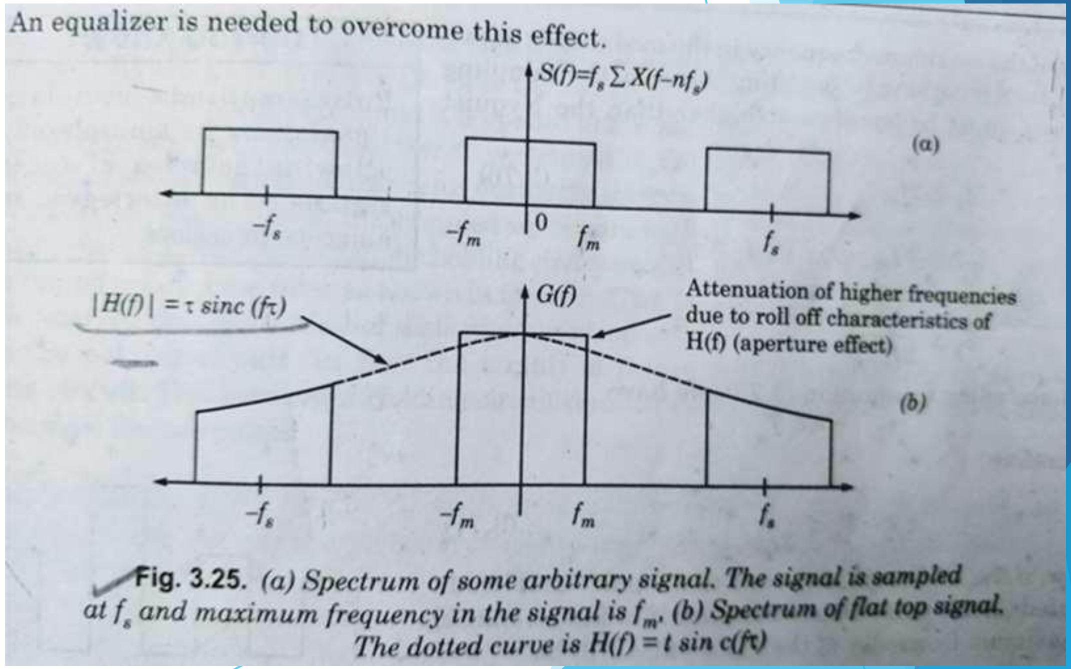
$\mathbf{f_s} \geq 2fm\ ;\ Ts \leq \frac{1}{2fm}$

$\boldsymbol{\tau} \ll \mathbf{Ts} \leq \frac{1}{2fm}$

If on and off time of PAM pulse is same **then** $\mathbf{f_{max}} = \frac{1}{2\tau}$

$\mathbf{BW} \geq fmax;\ \ BW \geq \frac{1}{2\tau}$

$BW \geq \frac{1}{2\tau} \gg \mathbf{fm}$



Transmission of PAM signals

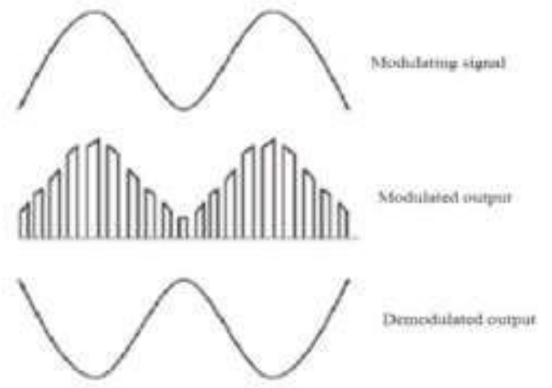
- For PAM signals to be transmitted through space using antennas, they must be **amplitude/ frequency/ phase** modulated by a **high frequency carrier** and only then they can be transmitted. Thus the **overall system is PAM-AM. PAM-FM or PAM-PM** and at receiving end, AM/ FM/PM detection is first employed to get the PAM signal and then message signal is recovered.

Drawbacks of PAM

- Bandwidth required for transmission of PAM signal is very large in comparison to maximum frequency present in modulating signal.
- Since amplitude of PAM pulses varies in accordance with modulating signal so interference of noise is maximum in PAM
- Variation of the peak power required by transmitter

Demodulation of PAM

- PAM signal sampled at Nyquist rate can be **reconstructed at the receiver end** , by passing it through an efficient **Low Pass Filter (LPF)** with exact cut off frequency of **fs/2**. This is known as **Reconstruction or Interpolation Filter**.
- The low pass filter eliminates the high-frequency ripples and generates the demodulated signal. This signal is then applied to the inverting amplifier to amplify its signal level to have the demodulated output with almost equal amplitude with the modulating signal



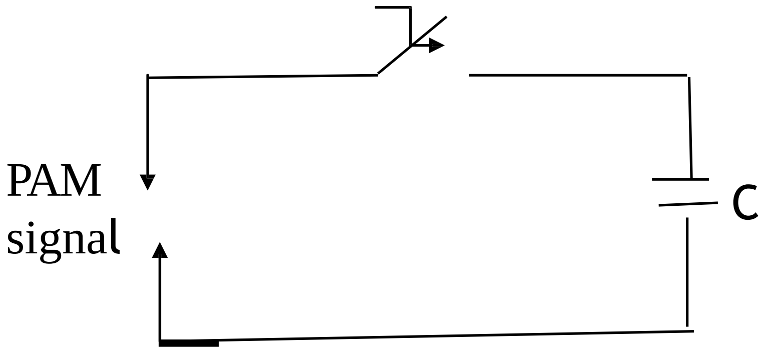
- For a **flat topped PAM**, a **holding circuit** followed by a **LPF** gives demodulated signal

Received PAM signal

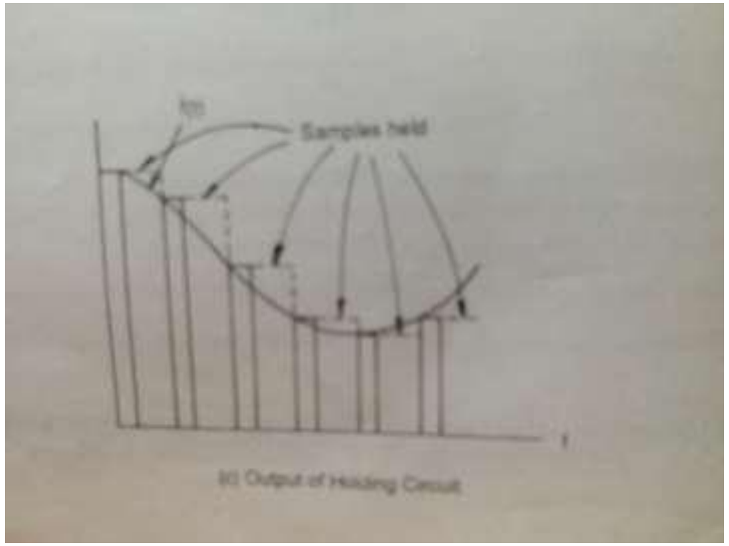
Holding circuit

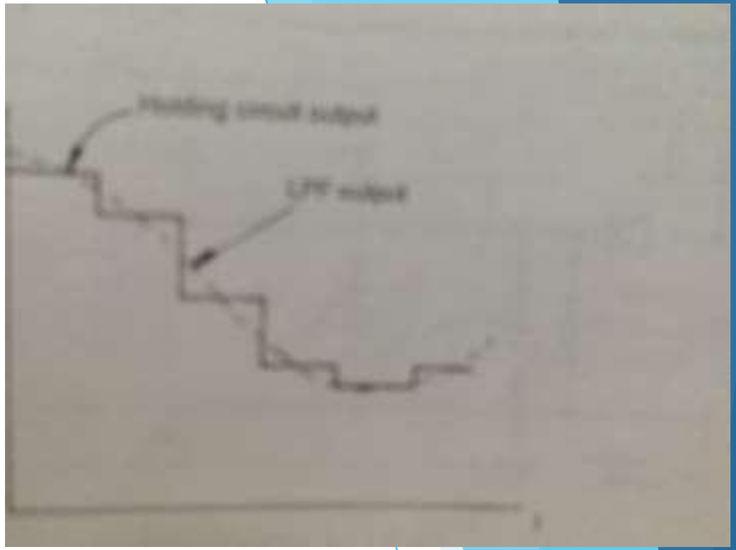
LPF

Demodulated signal



Zero order Holding Circuit





- Switch S closes after the arrival of pulse and opens at the end of pulse.
- Capacitor C charges to pulse amplitude value and holds this value during interval between two pulses.
- The sampled values are shown in fig.
- Holding circuit o/p smoothened in LPF.
- Known as zero order holding circuit, which considers only the previous sample to decide value between two pulses
- First order holding circuit considers previous two samples, second order holding circuit considers previous three samples.


Thank You