# Principles of Communication (BEC-28)

## Unit-4

## Pulse Modulation and Digital Transmission of Analog Signal

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## Content of Unit-IV

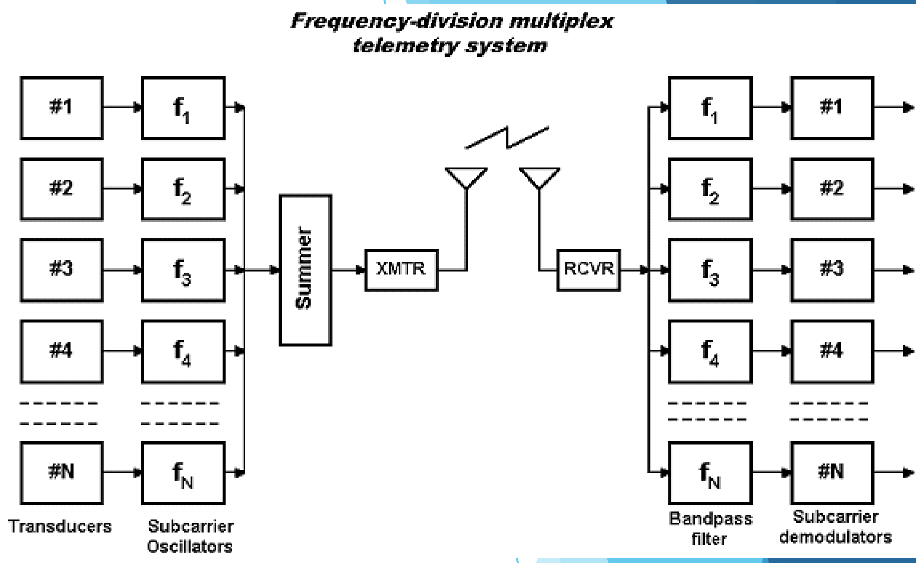
**Pulse Modulation and Digital Transmission of Analog Signal:** Sampling Theorem and its applications, Concept of Pulse Amplitude Modulation, Pulse width modulation and pulse position modulation, PCM, Pulse Time Modulation, TDM and FDM. Line Coding, Quantizer, Quantization Noise, Compounding multiplexer.

**Frequency Division Multiplex (FDM)**: **Separation of spectrum into smaller frequency**.

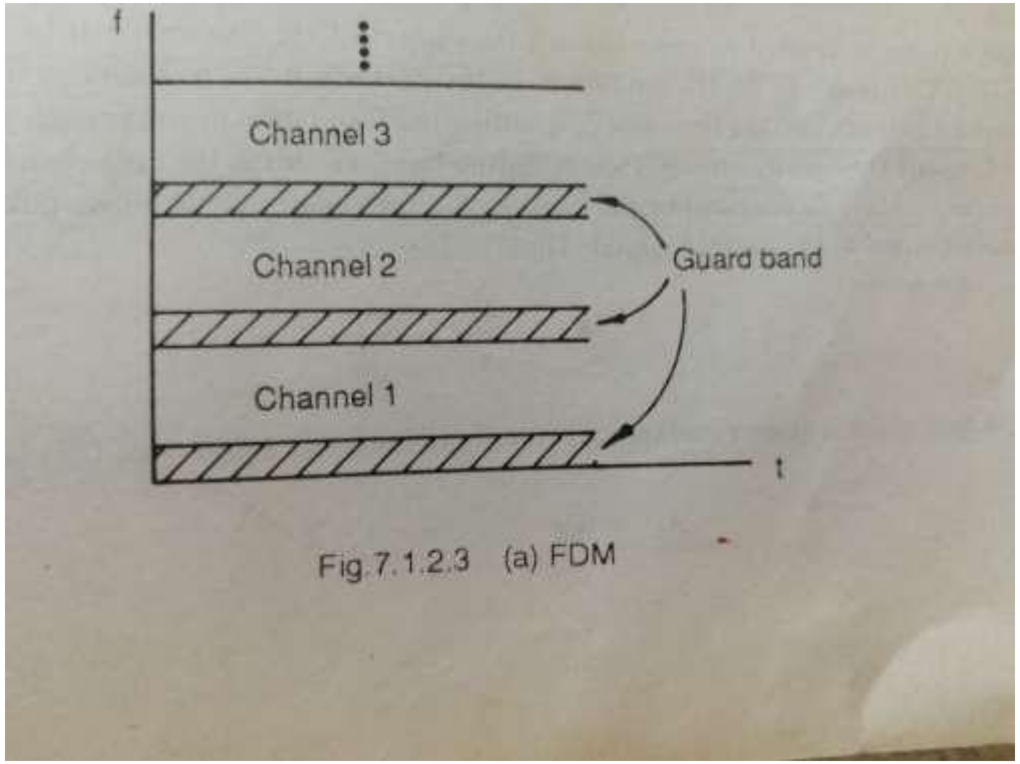
- Channel gets band of the spectrum for the whole time. Each signal allocated different frequency band i.e, Multiple carriers used
- Each message signal is limited to $f_m$ Hz.

**Example**: Multiplexing of telephonic signals from n subscribers

- Telephonic message (BW=3kHz) and broadcast signal limited to 5kHz. Without multiplexing if n channels transmitted, Interference and no useful information.




- In FDM, each baseband signal translated by Analog Modulation (AM/Angle) to different carrier frequencies.
- Each carrier separated from neighbouring by at least 2fm
- Multiplexed signals can be transmitted over a common channel without interference.
- At receiver, various carrier frequencies selected using BPF tuned to appropriate carrier frequencies and demodulated by separate detector.




**FDM System**

**Advantages**: No dynamic coordination needed and works also for analog signals

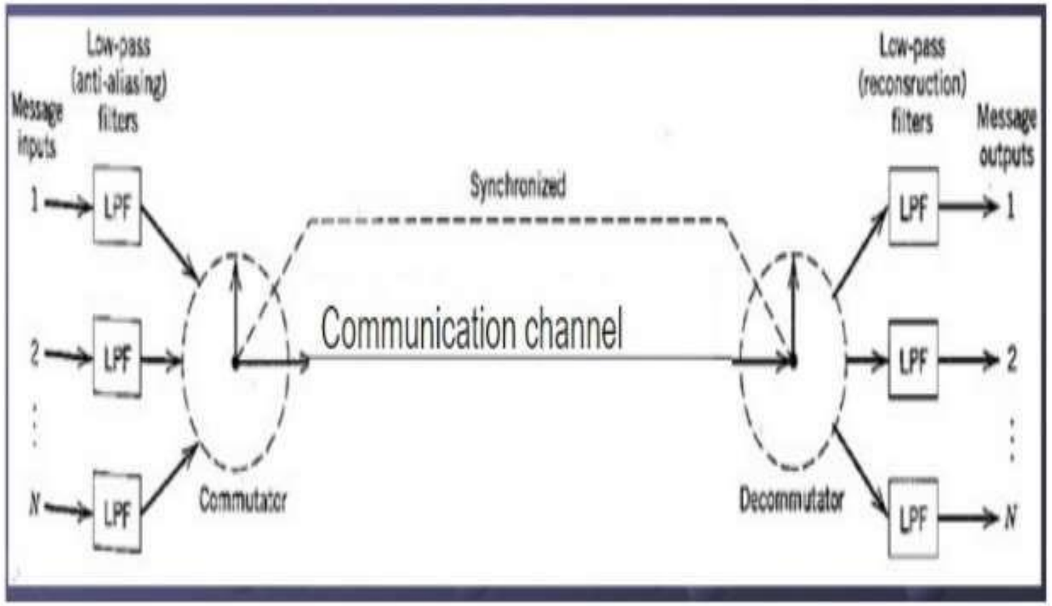
**Disadvantages**: Waste of bandwidth if traffic distributed uneven; inflexible;

# Time Division Multiplexing

- Time Division Multiplexing (TDM) is the time interleaving of samples from several sources so that the information from these sources can be transmitted serially over a single communication channel.
- **At the Transmitter** :Simultaneous transmission of several signals on a time-sharing basis.

  Each signal occupies its own distinct time slot, using all frequencies, for the duration of the transmission. Slots may be permanently assigned on demand
- **At the Receiver** : Decommutator (sampler) has to be synchronized with the incoming waveform
- In Pulse modulation techniques, there is a **free space between any two consecutive pulses** of a signal. This **free space between pulses** can be occupied by **pulses from other channel.** This is **Time Division Multiplexing (TDM)** and makes **maximum utilization of transmission channel.**
- **Applications of TDM:** Digital Telephony, Data communications, Satellite Access, Cellular radio

# Block diagram of TDM and PAM-TDM

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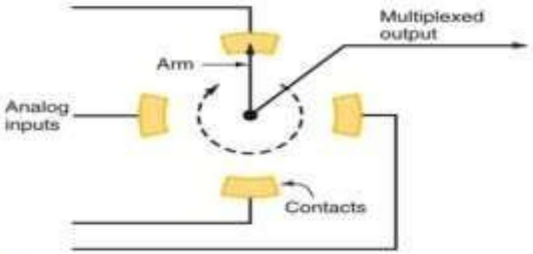
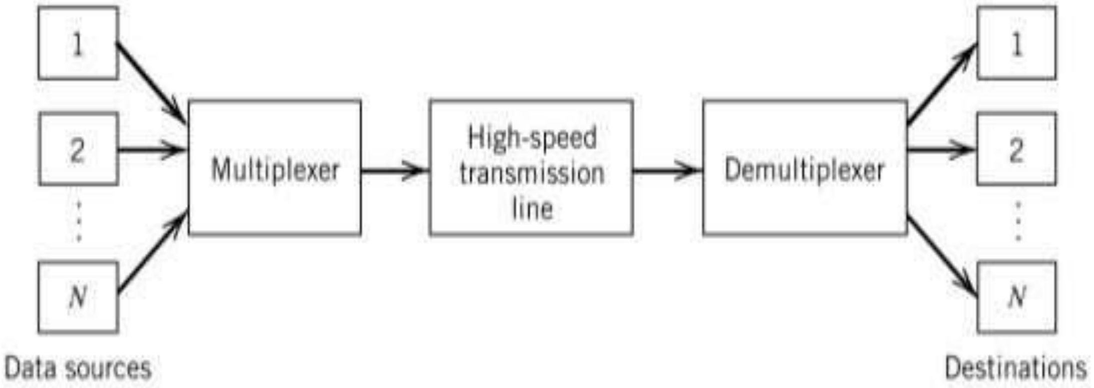
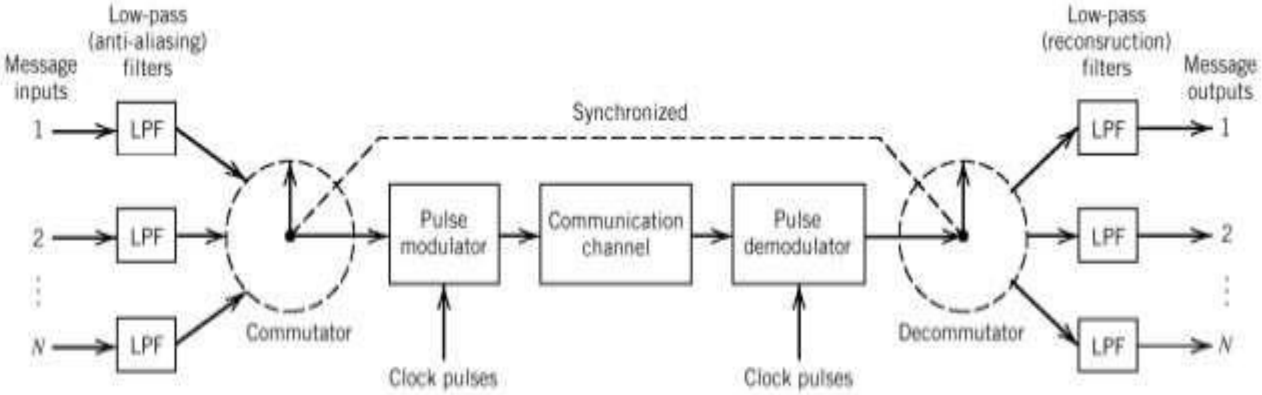
Simple rotary-switch multiplexer




Time Division Multiplexing




Conceptual diagram of multiplexing-demultiplexing.




PAM TDM System

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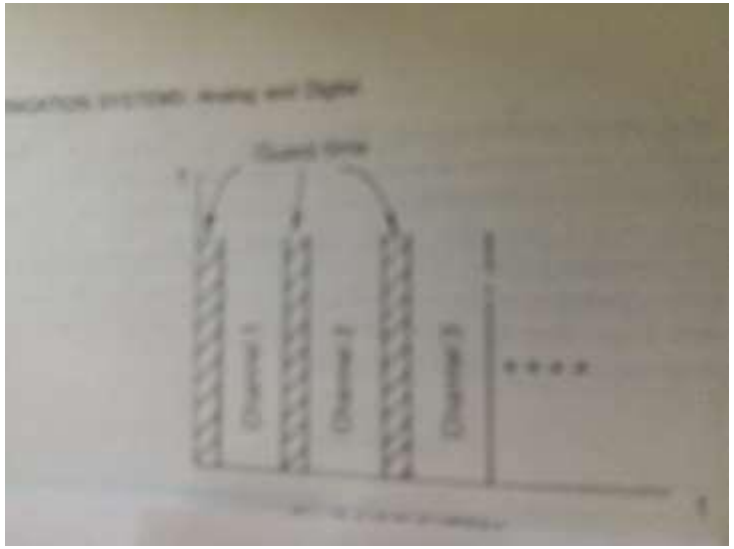


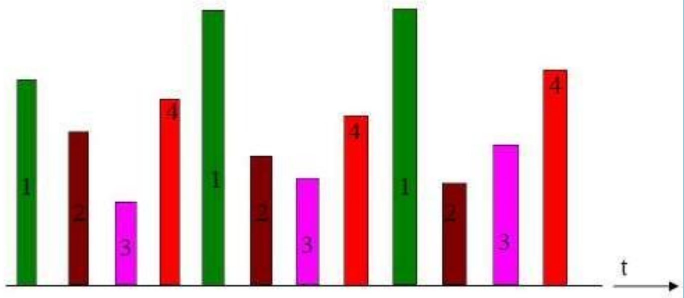
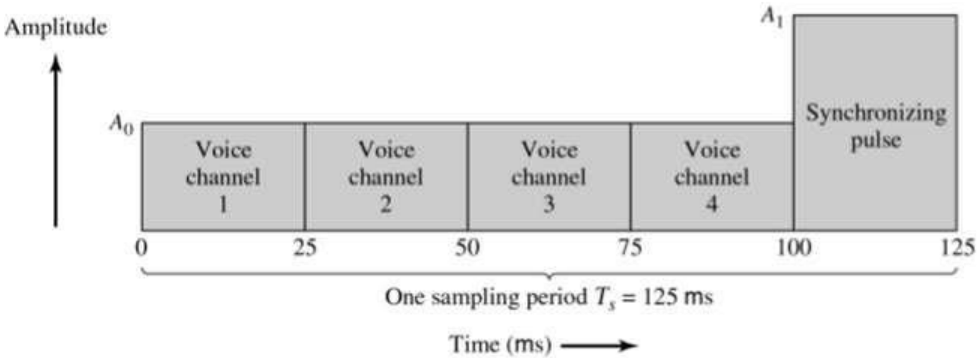


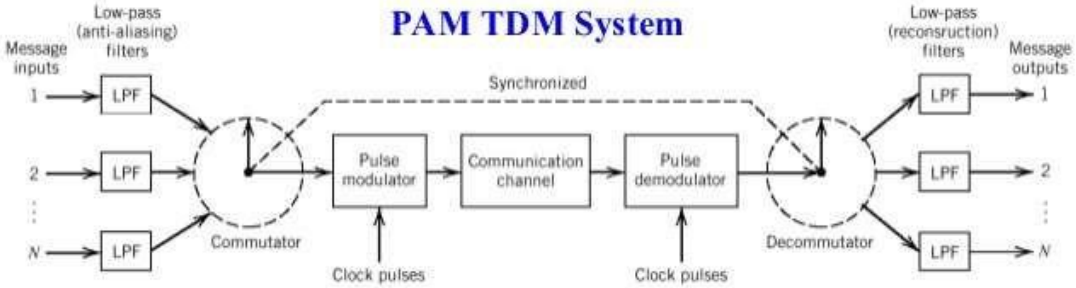

Fig: 2.23 Multiplexing of FOUR signals.

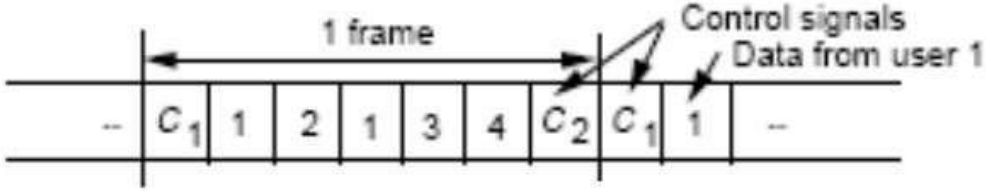
## TDM

- Composition of one frame of a multiplexed PAM signal incorporating four voice-signals and a synchronizing pulse.




## Block diagram of TDM system



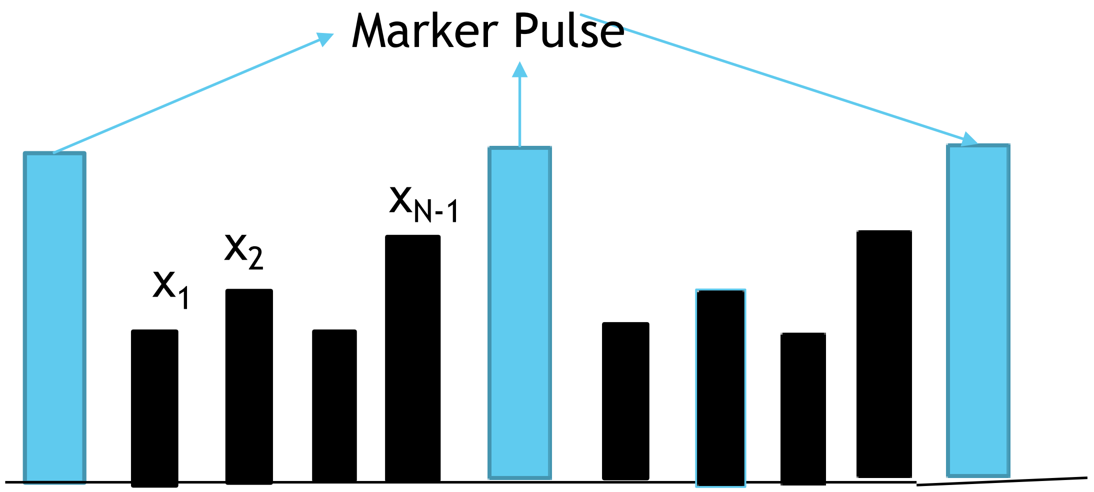




**A Typical Framing Structure for TDM**

- The system shows **TDM of ‘N’ PAM channels**.
- **Each channel** to be transmitted is passed through **LPF** to band limit its frequency to **$f_m$ Hz ( W Hz)**
- Outputs of LPF are connected to **the rotating sampling switch or commutator**.
- It takes **sample from each channel per revolution** and rotates at **the rate of fs.**
- Function of commutator is two fold**: (i) Taking narrow samples of each of N input messages at rate $1/T_s$ (ii) To sequentially interleave N samples Inside a sampling interval $T_s$**
- The **single signal composed due to multiplexing** of input channels given to **Transmission channel**
- If **W or $f_m$** is highest signal frequency in the message signal: **$fs \geq 2f_m$ or 2W**; **Ts or $1/fs \leq 1/2fm$**
- Thus time interval Ts contains one sample from each input**. It is called frame. If N input channels multiplexed**, each frame will have one sample from each of N channel's input
- Spacing between two samples: **Ts/N**
- No. of pulses/sec=1/ spacing between two pulses=$1/(Ts/N) = N/Ts$
- Ts=1/fs; No. of pulses per second=Nfs
- The no. of pulses transmitted per second is called **signalling rate of TDM ‘r’**
- **r=Nfs**; fs ≥2fm**;** **$r \geq 2Nf_m$ or $r \geq 2NW$**
- Pulsed TDM passed through LPF to convert it to baseband signal whose BW given **by half signalling rate**
- **B.W=$r/2$ = $Nf_m$=NW; Minimum Transmission Bandwidth**
- **At the receiver, decommutator separates the time multiplexed input channels which then passed through reconstruction filter**

# Synchronization in TDM system

- The time division multiplexing (TDM) needs synchronization between multiplexer and demultiplexer. If synchronization is not there between multiplexer and demultiplexer, a bit going to one channel may be received by the wrong channel.
- Because of this reason, one or more synchronization bits are usually added to the beginning of each frame called **Markers** (**highest amplitude**)
- These bits are called framing bits (Marker pulse), allows the demultiplexer to synchronize with the incoming stream so that that it can separate time slot accurately.
- Because of the marker pulse, no of channels to be multiplexed reduced by 1



# Application of PWM

- Although PWM is also used in communications, its main purpose is **actually to control the power that is supplied to various types of electrical devices,** most especially to inertial loads such as AC/DC motors.
- Pulse-width modulation (PWM) is used for controlling the amplitude of digital signals in order to control devices and **applications requiring power or electricity**. It essentially controls the amount of power, in the perspective of the voltage component, that is given to a device by cycling the **on-and-off phases of a digital signal quickly and varying the width of the "on" phase or duty cycle**. To the device, this would appear as a steady power input with an average voltage value, which is the result of the percentage of the on time. The duty cycle is expressed as the percentage of being fully (100%) on.
- A very powerful benefit of **PWM is that power loss is very minimal**. Compared to regulating power levels using an analog potentiometer to limit the power output by essentially choking the electrical pathway, thereby resulting in power loss as heat, PWM actually turns off the power output rather than limits it. Applications range from **controlling DC motors and light dimming to heating elements.**


Thank You