Al-Mustaqbal University
College of Engineering & Technology
Computer Techniques Engineering Department

Digital Communication

Lecture 4

Pulse Duration and Position Modulation (PDM & PPM)

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Aims of this Lecture

By the end of this lecture, students will **be able** to:

- **Understand** the principles of Pulse Duration Modulation (PDM) and Pulse Position Modulation (PPM).
- **Describe** how PDM and PPM are generated.
- **Identify** the differences between PDM, PPM, and PAM.
- **Recognize** the applications and transmission requirements for PDM and PPM.

Pulse Duration Modulation (PDM) - Overview

- Pulse **Duration** Modulation (PDM), also called **Pulse Width** Modulation (PWM), is a technique that modulates the duration (width) of each pulse.
- The pulse **width** changes based on the amplitude of the input signal x (t), while the leading edge is fixed.
- PWM is commonly used in applications where the amount of time the signal is high needs to represent the **input signal**.

Generation of PWM

How PWM is Generated:

- The input signal x(t) is applied to the **non-inverting input of a comparator**.
- A **sawtooth waveform** is applied to the inverting input of the comparator.
- The output is high when x(t) exceeds the sawtooth waveform.
- This creates a pulse with a **variable trailing edge**, representing the amplitude of x(t) by the pulse width.

Transmission Requirements for PWM

- **Rise Time Condition**:
  - For precise transmission, **rise time** t_r should be much smaller than the sampling period T_s: $t_r \ll T_s$.
- **Bandwidth Requirement**:
  - The minimum bandwidth required for PWM is determined by:

$$B_T \geq \frac{1}{2t_r}$$

where t_r is the rise time of the pulse.

Applications of PWM

- **Digital Data Transmission:** Used to represent digital data by adjusting the width of pulses, ensuring reliable communication.
- **Audio Signal Transmission:** Utilized in VoIP systems to transmit audio signals by modulating the pulse width based on sound levels.

Pulse Position Modulation (PPM) - Overview

- **Pulse Position Modulation (PPM):** A modulation technique where the position of each pulse is varied according to the amplitude of the input signal $x(t)$.
- Unlike PWM, PPM has a **fixed pulse width** but changes the position of each pulse based on the input signal.

Generation of PPM

- **How PPM is Generated**:
  - The trailing edge of each PWM pulse triggers a **monostable circuit** with a fixed duration.
  - This produces a pulse at a specific position that shifts in time, depending on the amplitude of $x(t)$ at the sampling instance KTs.

Characteristics of PPM Signals

- **Fixed Pulse Width:** The width of each pulse remains constant.
- **Variable Position:** The pulse position shifts based on the input signal’s amplitude at each sampling instance KTs.

Transmission Requirements for PPM

- **Rise Time Condition**:
  - For accurate transmission, the rise time t_r should be much smaller than the sampling period T_s: $t_r \ll T_s$.
- **Bandwidth Requirement**:
  - The required bandwidth for PPM transmission is:

$$B_T \geq \frac{1}{2t_r}$$

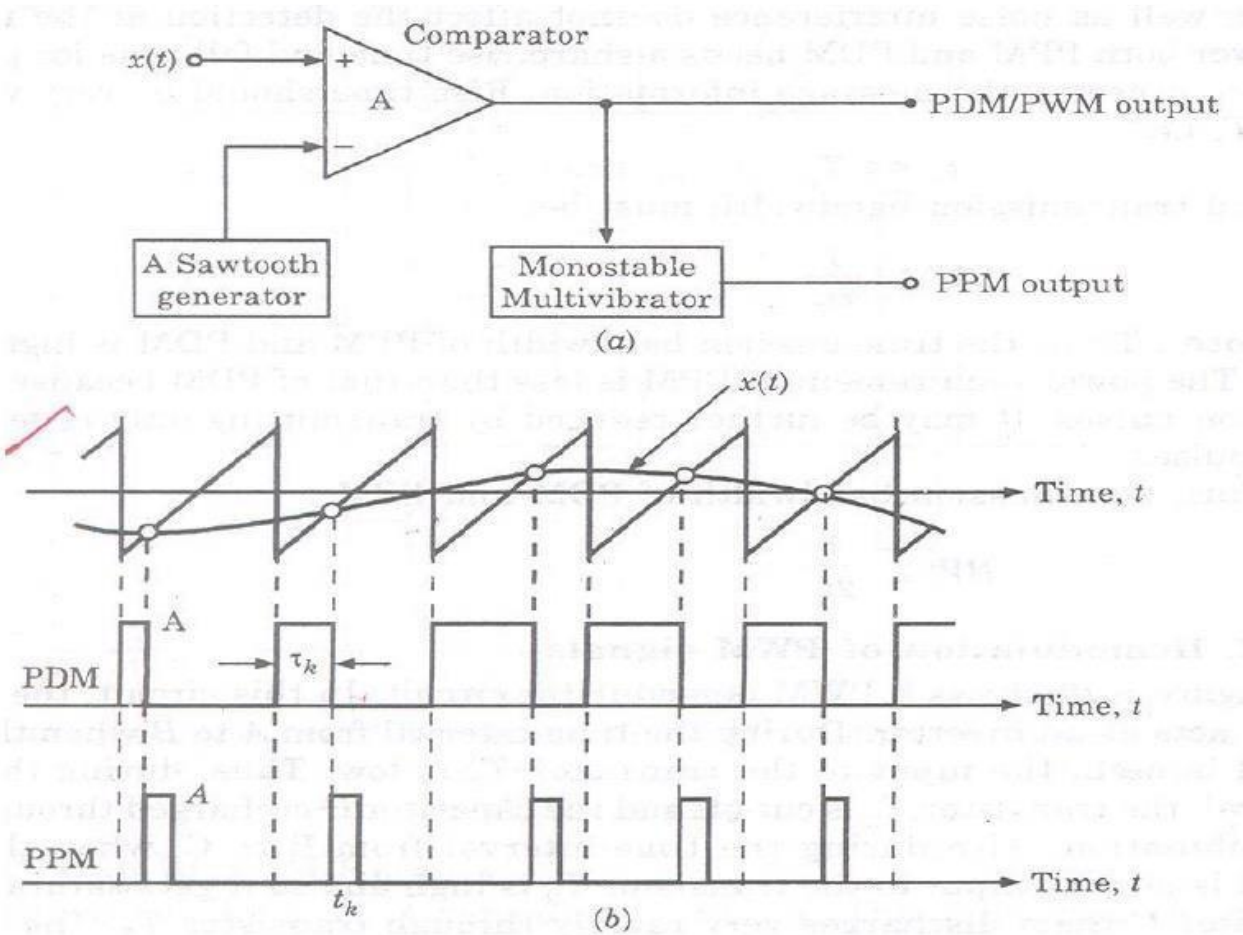
where t_r is the rise time.

Applications of PPM

- **Optical Communication:** Used in fiber optic and free-space communications where noise resistance is critical.
- **Remote Control Systems:** Employed in remote controls for drones and RC vehicles where precise timing is essential.
- **Digital Transmission:** Used in environments requiring noise resistance due to high timing

Comparison of PAM, PWM, and PPM

Basis for Comparison	PAM	PWM	PPM
Varying parameter	Amplitude	Width	Position
Immunity towards noise	Low	High	High
Signal to noise ratio	Low	Moderate	Comparitively high
Need of synchronization pulse	Not exist	Not exist	Exist
Bandwidth dependency	On pulse width	On rise time of pulse	On rise time of pulse
Transmission power	Variable	Variable	Constant
Bandwidth requirement	Low	High	High
Similarity of implementation	Similar to AM	Similar to FM	Similar to PM
Synchronization between Transmitter and Receiver	Not needed	Not needed	Needed



(a) Block diagram of PWM and PPM generator.
(b) Waveforms

Thank you