Al-Mustaqbal University
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Computer Techniques Engineering Department

Digital Communication

Lecture 3
Analog Pulse Modulation Methods

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Aims of this Lecture

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

- **Define** key concepts of pulse modulation methods like PAM, PWM, and PPM.

➢ **Explain** the principles of pulse modulation and its parameters.

Introduction to Analog Pulse Modulation Methods

- Analog pulse modulation methods involve sampling a continuous-time signal, $x(t)$, and modifying pulse parameters.

- Pulse parameters like **amplitude**, **duration**, and **position** can be modulated based on the sampled signal values.

Pulse Amplitude Modulation (PAM)

- In PAM, the amplitude of rectangular pulses varies with instantaneous sample values of the continuous signal.

- **Flat Top PAM**: Preferred for reducing noise interference during transmission.
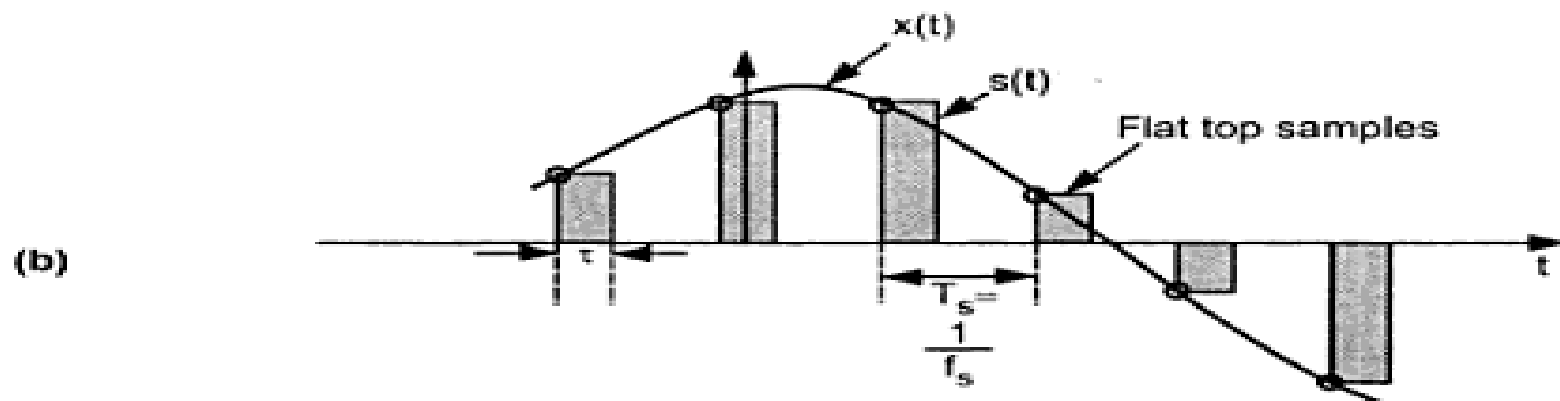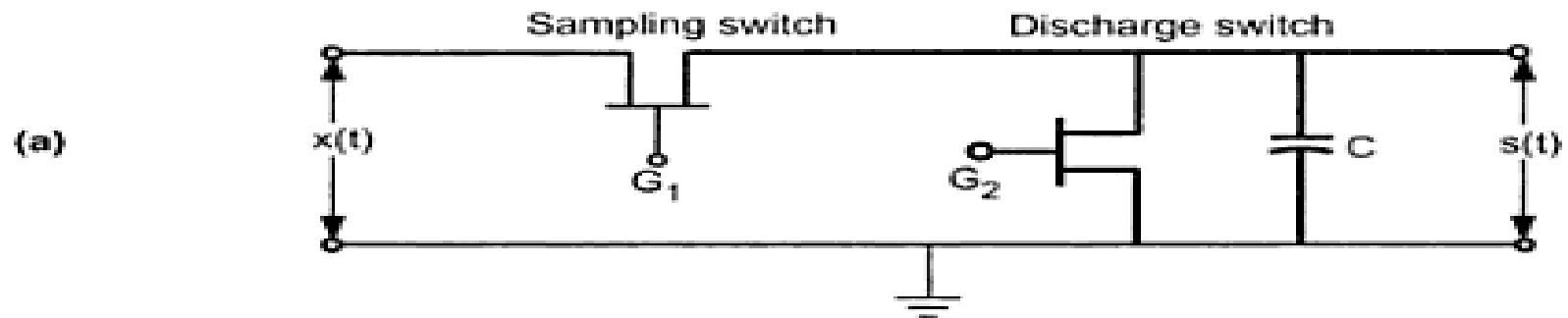
Flat Top PAM - Process

- At each sampling instance, a sampling switch closes for a brief period.
- During this time, a capacitor C holds a charge equal to the sample value of x(t).
- The switch opens, and C holds the charge to produce a flat top.
- Flat top PAM signal representation:

$$s(t) = \sum_{n=-\infty}^{\infty} x(nT_s)h(t - nT_s)$$

‣ Equation for PAM Spectrum:

$$S(f) = f_s \sum_{n=-\infty}^{\infty} X(f - nf_s)H(f)$$

(a) Sampling and hold circuit. (b) Flat top PAM

Nyquist Rate and PAM Bandwidth

- For PAM, sampling rate f_s should exceed the Nyquist rate:

$$f_s \geq 2W$$

- PAM bandwidth B_T must be at least as large as the highest frequency in the signal:

$$B_T \geq f_{max} \quad \text{or} \quad B \geq \frac{1}{2c}$$

- Transmission bandwidth $B_T \gg W$, indicating a higher requirement than original signal bandwidth.

Thank you