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

Digital Communication

Lecture 6

Source Coding Techniques

Introduction to Pulse Code Modulation (PCM)

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Aims of this Lecture

- **Understand** the concept and importance of source coding.
- **Explain** the steps involved in Pulse Code Modulation (PCM).
- **Identify** the key components and processes of the PCM transmitter and receiver.
- **Analyze** how PCM improves signal quality and reduces noise.

What is PCM?

Definition:

Pulse Code Modulation (PCM) is a widely used source coding technique where analog signals are sampled and digitized for transmission.

Steps in PCM:

1. **Sampling:** Input signal is sampled at $f_s \geq 2W$.
2. **Quantization:** Sampled values are rounded to the nearest discrete level.
3. **Encoding:** Quantized values are converted into binary words.
4. **Transmission:** The binary stream is transmitted over the channel.

PCM Transmitter Components

Low Pass Filter:

- Removes high-frequency noise from the input signal x(t).
- Ensures clean input for sampling.

Sample-and-Hold (S/H):

- Samples the continuous-time signal at regular intervals (fs ≥ 2W).
- Converts the signal into discrete time-domain values.

Quantizer:

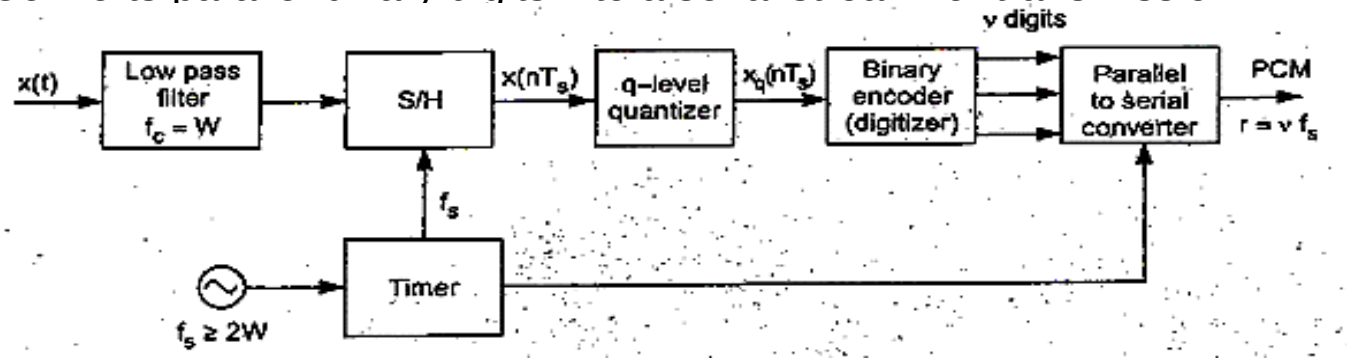
- Converts sampled signal into discrete amplitude levels (q-level).
- Reduces infinite possible amplitudes to fixed steps.

Binary Encoder:

- Encodes quantized amplitudes into binary digits (PCM codes).

Parallel-to-Serial Converter:

- Converts parallel binary digits into a serial stream for transmission.



The block diagram of PCM transmitter

PCM Formulas

1. **Number of Levels (q):**

   $$q = 2^v$$

   (v: Number of bits per sample)

2. **Signaling Rate (r):**

   $$r = v \cdot f_s$$

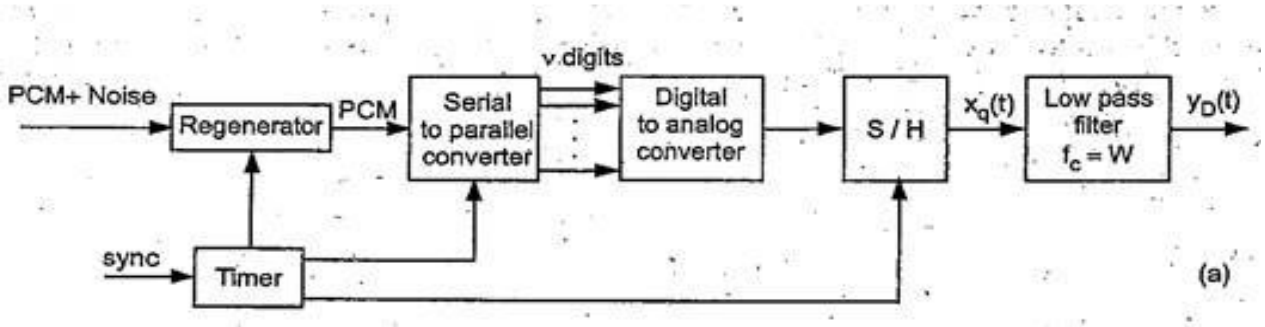
3. **Bandwidth Requirement (B_r):**

   $$B_r \geq vW$$

   (W: Maximum frequency of the original signal)

PCM Receiver Components

1. **Regenerator:**
    1. Restores noisy pulses to their original shape.
    2. Ensures integrity of the PCM signal during long-distance communication.
2. **Serial-to-Parallel Converter:**
    1. Converts the serial data stream back into parallel binary words.
3. **Digital-to-Analog Converter (DAC):**
    1. Converts binary data back into analog signals.
4. **Sample-and-Hold (S/H):**
    1. Holds reconstructed samples steady for filtering and playback.
5. **Low Pass Filter:**
    1. Removes high-frequency components, recovering y(t)y(t)y(t).



The block diagram of PCM receiver

Quantization Noise in PCM

1. **Quantization Error (ε):**
   $\varepsilon = x_q(nT_s) - x(nT_s)$
   - x_q: Quantized value
   - x: Actual sample value
2. **Signal-to-Noise Ratio (SNR):**
   $S/N = 4.8 + 6v$ (in dB)

- **Key Observation:**
  - Higher v (bits per sample) reduces quantization noise, improving signal quality.

Conclusion

- PCM is a key source coding technique for converting analog signals into digital form.
- Transmitter and receiver components ensure accurate signal digitization and recovery.

Thank you