

Introduction to Communication Systems

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Compact, easy-to-read notes for quick reference

1. What Is a Communication System?

- **Definition:** A set of interconnected elements that enable the transfer of information (messages) from a source to a destination.
- **Goal:** Deliver the intended message **accurately**, **reliably**, and **efficiently** despite the presence of noise, interference, and physical limitations.

2. Core Components

Component	Function	Typical Examples
Information Source	Generates the message (voice, video, data).	Human speech, sensor readings, computer files
Transmitter	Converts the message into a signal suitable for the channel.	Modulator, encoder, antenna
Channel (Medium)	Physical path the signal travels through.	Twisted-pair cable, optical fiber, free-space radio, satellite link
Receiver	Extracts the original information from the received signal.	Demodulator, decoder, filter
Destination	Final user or system that consumes the recovered information.	Mobile phone, computer, control system

3. Basic Signal Concepts

Concept	Description	Units
Amplitude	Height of the signal waveform.	Volts (V)
Frequency	Number of cycles per second.	Hertz (Hz)
Phase	Relative position of the waveform in time.	Radians (rad) or degrees (°)

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Concept	Description	Units
Bandwidth	Range of frequencies a signal occupies.	Hertz (Hz)
Power	Energy per unit time carried by the signal.	Watts (W)

4. Analog vs. Digital Communication

Feature	Analog	Digital
Signal Representation	Continuous amplitude variations.	Discrete symbols (bits).
Typical Modulation	AM, FM, PM.	ASK, FSK, PSK, QAM.
Noise Sensitivity	Directly degrades signal quality.	Errors can be detected/corrected.
Bandwidth Efficiency	Generally lower.	Higher (especially with advanced coding).
Common Applications	Traditional radio, analog TV, telephony (legacy).	Cellular networks, Wi-Fi, satellite data, IoT.

5. Modulation Techniques (Key to Transmitters)

Category	Principle	Example Uses
Amplitude Shift Keying (ASK)	Varies signal amplitude to represent bits.	RFID, low-rate optical links.
Frequency Shift Keying (FSK)	Changes carrier frequency for different symbols.	Bluetooth, low-power telemetry.
Phase Shift Keying (PSK)	Alters carrier phase.	Satellite links, Wi-Fi (BPSK, QPSK).
Quadrature Amplitude Modulation (QAM)	Combines amplitude and phase variations (2D constellation).	Cable modems, LTE, 5G (16-QAM, 64-QAM, 256-QAM).
Pulse-Code Modulation (PCM)	Samples analog signal, quantizes,	