
Module I: Basics of Analog Communication (5 Hours)

1. Basic Block Diagram of Analog Communication

Transmitter: Converts input signal into a modulated signal for efficient transmission.

Channel: The medium through which the signal is transmitted (air, wire, fiber, etc.).

Receiver: Extracts the original signal from the received modulated wave.

Noise Source: Random disturbances affecting signal quality during transmission.

2. Need for Modulation

To transmit signals over long distances.

To reduce the size of antennas.

To enable multiplexing (sending multiple signals simultaneously).

To shift frequency spectrum to avoid signal interference.

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3. Fourier Transform & Properties

Fourier Transform (FT) converts time-domain signals to frequency-domain, helping in signal analysis.

Key Properties:

Duality Property: Interchange of time and frequency domain expressions.

Frequency Shifting Property: Shifting in frequency domain equals multiplication by an exponential in time.

Modulation Property: Multiplying a signal by a sinusoid in time domain shifts its spectrum in the frequency domain.

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4. Introduction to Amplitude Modulation (AM)

Time-Domain Description:
AM wave = [Carrier] × [1 + modulation index × Message Signal]

Frequency-Domain Description:
Produces a spectrum consisting of the carrier frequency plus upper and lower sidebands.

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5. Generation of AM Waves

Square Law Modulator: Uses a non-linear device to generate AM by squaring the sum of carrier and message signal.

Switching Modulator: Uses switches to multiply the carrier with the message, producing AM.

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6. Detection of AM Waves

Square Law Detector: Uses a non-linear element to detect the envelope.

Envelope Detector: Simple circuit with diode and capacitor that tracks the envelope of AM signal.

Module II: DSB-SC, SSB, and VSB Modulation (6 Hours)

1. Double Sideband Suppressed Carrier (DSB-SC)

Time-Domain: Product of the carrier and the message.

Frequency-Domain: Two sidebands but carrier is suppressed.

Generation:

Balanced Modulator: Cancels carrier, outputs sidebands.

Ring Modulator: Uses diode ring for suppression.

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2. Single Side-Band (SSB) Modulation

More bandwidth-efficient than AM and DSB-SC.

Quadrature Carrier Multiplexing: Combines two signals into one using orthogonal carriers.

Generation:

Phase Discrimination Method: Uses phase shifts and filtering.

Demodulation: Coherent demodulation needed for signal recovery.

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3. Vestigial Sideband (VSB) Modulation

A compromise between AM and SSB.

Used in TV broadcasting.

Frequency-Domain: Partial suppression of one sideband.

Generation: Filtering one sideband partially.

Applications: Frequency Division Multiplexing (FDM) and Superheterodyne receivers.

Module III: Angle Modulation (5 Hours)

1. Frequency Modulation (FM)

FM: Frequency of carrier varies with amplitude of the message.

Narrowband FM: Small modulation index.

Wideband FM: Large modulation index, used for high-fidelity.

Bandwidth: Calculated using Carson's Rule.

Generation:

Indirect FM: Using phase modulation followed by integration.

Direct FM: Direct frequency variation of an oscillator.

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Module IV: Demodulation of FM (4 Hours)

1. FM Demodulation Techniques

Converts frequency variations back to amplitude.

Phase-Locked Loop (PLL): Tracks the frequency and phase of input FM signal.

Non-linear & Linear Models: Mathematical models to predict PLL behavior.

Nonlinear Effects: Distortion caused by non-ideal behavior in FM systems.

Module V: Random Process (4 Hours)

1. Random Variables and Processes

Statistical Averages: Mean, moments.

Autocorrelation & Cross-correlation: Measures signal similarity at different times.

Central Limit Theorem: Sum of many independent random variables approaches a Gaussian distribution.

Gaussian Process: A random process with Gaussian-distributed variables.

Module VI: Noise (5 Hours)

1. Types of Noise

Shot Noise: Due to discrete charge.

Thermal Noise: Due to random motion of electrons.

White Noise: Constant power spectral density.

Noise Equivalent Bandwidth: Bandwidth of an ideal filter passing same noise power.

Noise Figure: Measure of degradation caused by components.

2. Frequency Domain Representation

Power Spectral Density (PSD): Energy distribution of noise over frequency.

Response of Filters: How filters shape noise characteristics.

Superposition of Noise: Noise components add linearly.

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Module VII: Noise in CW Modulation Systems (3 Hours)

1. Receiver Model for Noise

How noise affects signal reception.

DSB-SC, SSB, AM Receivers: Different sensitivity to noise.

Threshold Effect: Abrupt deterioration below certain SNR in FM.

FM Pre-emphasis & De-emphasis:

Pre-emphasis: Boost high frequencies before transmission.

De-emphasis: Attenuate high frequencies at receiver to balance noise.