

# Principles of Electronic Communication (4331104) - Summer 2024 Solution

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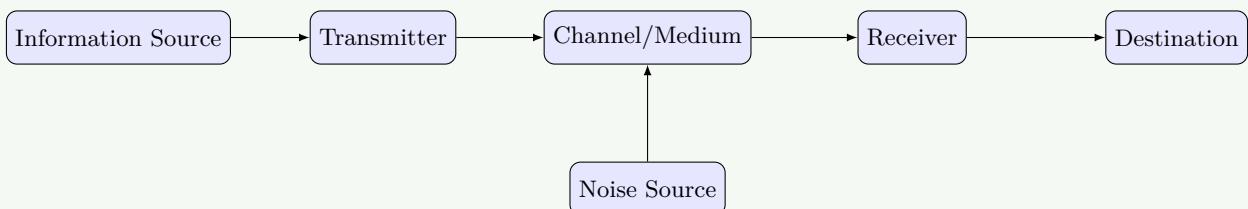
June 14, 2024

## Question 1 [a marks]

3 Draw and explain block diagram of communication system.

### Solution

Answer:



- **Information Source:** Generates message signal (voice, video, data).
- **Transmitter:** Converts message to suitable form for transmission.
- **Channel:** Medium through which signal travels (wires, fiber, air).
- **Receiver:** Extracts original message from received signal.
- **Destination:** End-user who receives the information.

### Mnemonic

"Information Travels Carefully Reaching Destination"

## Question 1 [b marks]

4 Explain applications of EM wave spectrum.

### Solution

Answer:

Frequency Band	Frequency Range	Applications
Radio waves	3 kHz - 300 MHz	AM/FM broadcasting, maritime communication
Microwaves	300 MHz - 300 GHz	Radar, satellite communication, microwave ovens
Infrared	300 GHz - 400 THz	Remote controls, thermal imaging, optical fibers
Visible light	400 THz - 800 THz	Fiber optic communication, photography
Ultraviolet	800 THz - 30 PHz	Sterilization, authentication, water purification
X-rays	30 PHz - 30 EHHz	Medical imaging, security scanning, material analysis
Gamma rays	>30 EHHz	Cancer treatment, food sterilization, industrial inspection

**Mnemonic**

"Radio Makes Invisible Very eXtreme Gamma signals"

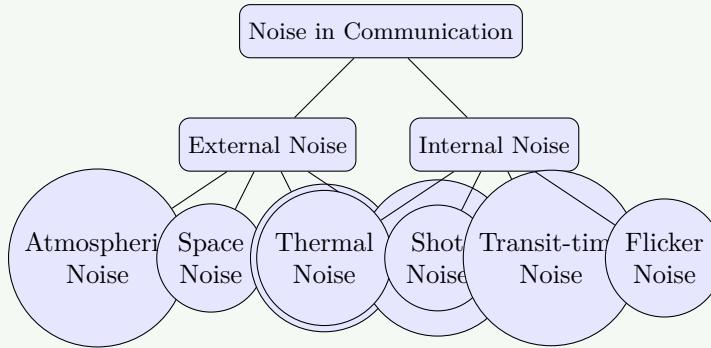
**Question 1 [c marks]**

7 State and explain external and internal noise.

**Solution****Answer:**

Type	External Noise	Internal Noise
<b>Source</b>	Outside the communication system	Inside electronic components
<b>Types</b>	Atmospheric, Space, Industrial, Man-made	Thermal, Shot, Transit-time, Flicker
<b>Control</b>	Can be reduced by shielding, filtering	Reduced by better components, cooling
<b>Examples</b>	Lightning, Solar radiation, Motor sparking	Electron movement in resistors, semiconductors
<b>Nature</b>	Usually unpredictable, varying	More consistent and quantifiable

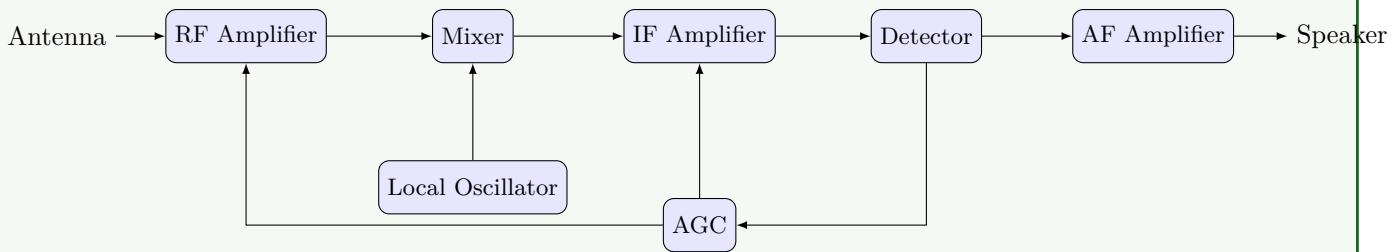
Diagram:

**Mnemonic**

"External Environmental Sources Invade; Internal Components Generate Noise"

**Question 1 [c marks]**

7 Draw and explain the block diagram of a Superheterodyne AM receiver.

**Solution****Answer:**

Block	Function
<b>RF Amplifier</b>	Amplifies weak radio signals and provides selectivity
<b>Local Oscillator</b>	Generates frequency for mixing with incoming signal
<b>Mixer</b>	Combines RF and local oscillator signals to produce IF
<b>IF Amplifier</b>	Amplifies signal at fixed intermediate frequency (455 kHz)
<b>Detector</b>	Extracts audio from modulated carrier (demodulation)
<b>AF Amplifier</b>	Amplifies audio signal to drive speaker
<b>AGC</b>	Automatic Gain Control - maintains constant output level

**Mnemonic**

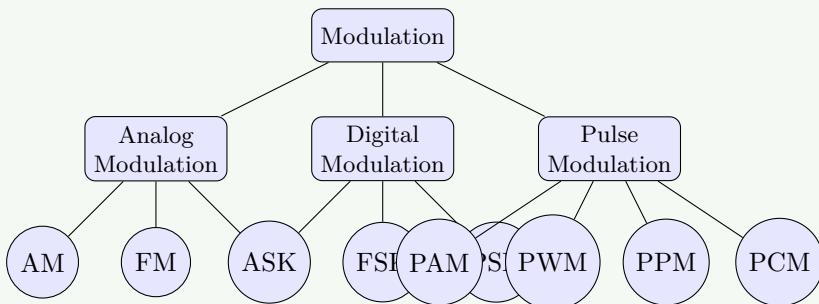
"Radio Loves Making Interesting Detected Audio Sounds"

**Question 2 [a marks]**

3 Define modulation. State types of modulation.

**Solution****Answer:**

**Modulation:** Process of varying one or more properties of a high-frequency carrier signal with a modulating signal containing information.

**Types of Modulation:****Mnemonic**

"All Modulations Alter Properties: Frequency, Amplitude, Phase"

**Question 2 [b marks]**

4 Define: Signal to noise ratio and Noise figure.

**Solution****Answer:**

Parameter	Definition	Formula	Unit	Significance
<b>Signal to Noise Ratio (SNR)</b>	Ratio of signal power to noise power	$SNR = \frac{P_{signal}}{P_{noise}}$	Expressed in dB	Higher value indicates better signal quality
<b>Noise Figure (NF)</b>	Measure of degradation of SNR as signal passes through system	$NF = \frac{SNR_{input}}{SNR_{output}}$	Expressed in dB	Lower value indicates better performance

**Mnemonic**

"SNR Shows Necessary Reception; Noise Figure Finds Fault"

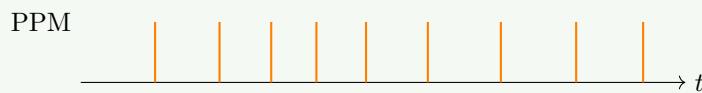
**Question 2 [c marks]**

7 Compare PAM, PWM and PPM techniques.

**Solution****Answer:**

Parameter	PAM	PWM	PPM
<b>Full Form</b>	Pulse Amplitude Modulation	Pulse Width Modulation	Pulse Position Modulation
<b>Modulated Parameter</b>	Amplitude of pulses	Width/duration of pulses	Position/timing of pulses
<b>Noise Immunity</b>	Poor	Good	Excellent
<b>Bandwidth</b>	Low	Medium	High
<b>Circuit Complexity</b>	Simple	Moderate	Complex
<b>Power Efficiency</b>	Poor	Good	Excellent
<b>Applications</b>	Simple data sampling	Motor control, power regulation	Precision timing, optical communication

Diagram:

**Mnemonic**

"Amplitude varies height, Width varies length, Position varies timing"

## Question 2 [a marks]

3 Differentiate between bit, symbol and Baud rate.

### Solution

#### Answer:

Parameter	Bit	Symbol	Baud Rate
<b>Definition</b>	Binary digit (0 or 1)	Group of bits	Number of symbols transmitted per second
<b>Unit</b>	No unit	No unit	Symbols per second (Baud)
<b>Relationship</b>	Basic unit of digital information	Multiple bits form one symbol	Baud rate × bits per symbol = bit rate
<b>Example</b>	0, 1	In 4-QAM, each symbol represents 2 bits	1200 baud means 1200 symbols per second

#### Mnemonic

"Bits Build Symbols, Bauds Show Speed"

## Question 2 [b marks]

4 State advantages and disadvantage of SSB over DSB.

### Solution

#### Answer:

Advantages of SSB over DSB	Disadvantages of SSB over DSB
<b>Bandwidth:</b> Requires only half the bandwidth	<b>Circuit Complexity:</b> More complex modulation and demodulation
<b>Power Efficiency:</b> Transmits only one sideband, saving power	<b>Receiver Design:</b> Requires precise frequency synchronization
<b>Less Fading:</b> Reduced selective fading effects	<b>Low Frequency Loss:</b> May lose low frequency components
<b>Less Interference:</b> Reduced adjacent channel interference	<b>Cost:</b> More expensive implementation

#### Mnemonic

"SSB Saves Bandwidth Power but Costs Complex Hardware"

## Question 2 [c marks]

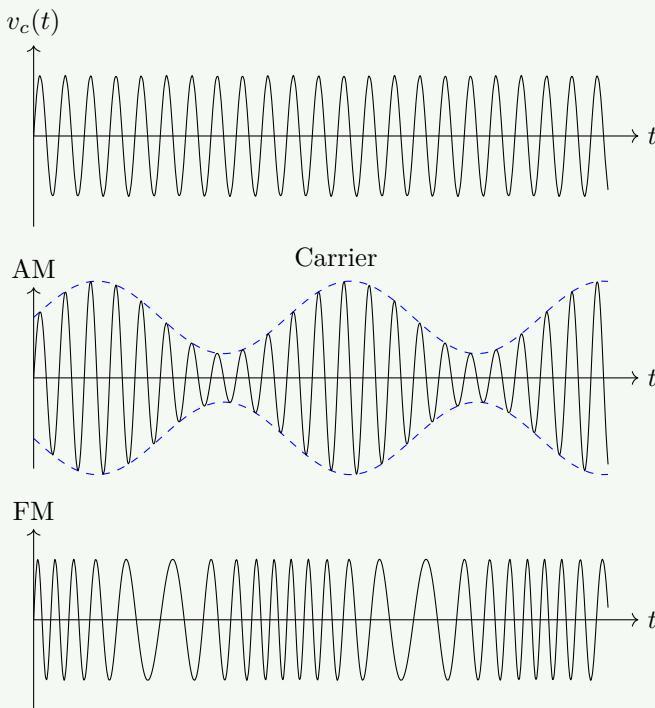
7 Compare Amplitude Modulation (AM) and Frequency Modulation (FM).

### Solution

#### Answer:

Parameter	AM	FM
Modulated Parameter	Amplitude of carrier	Frequency of carrier
Bandwidth	Narrow ( $2 \times f_m$ )	Wide ( $2 \times (f_m + \Delta f)$ )
Noise Immunity	Poor	Excellent
Power Efficiency	Poor (carrier contains most power)	Good
Circuit Complexity	Simple	Complex
Quality	Lower	Higher
Applications	Broadcasting (MW), Aircraft communication	FM radio, TV sound, Mobile communications

Diagram:



#### Mnemonic

"AM Alters strength, FM Fluctuates timing"

## Question 3 [a marks]

3 Compare AM receiver with FM receiver.

#### Solution

##### Answer:

Parameter	AM Receiver	FM Receiver
IF Frequency	455 kHz	10.7 MHz
Detector	Envelope detector	Discriminator/Ratio detector/PLL
Bandwidth	Narrow ( $\pm 5$ kHz)	Wide ( $\pm 75$ kHz)
Special Circuits	Simple	Limiter, De-emphasis
Complexity	Simple	Complex

**Mnemonic**

"AM Accepts Minimal bandwidth; FM Features More circuits"

**Question 3 [b marks]**

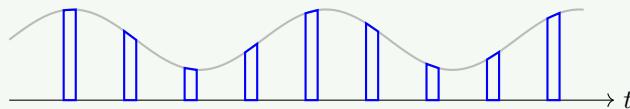
4 Define sampling? Explain types of sampling in brief.

**Solution****Answer:**

**Sampling:** Process of converting continuous-time signal into discrete-time signal by taking samples at regular intervals.

Type of Sampling	Description	Characteristics
<b>Ideal Sampling</b>	Instantaneous samples of the signal	Perfect but theoretical, uses impulse function
<b>Natural Sampling</b>	Signal is sampled for short durations	Top of pulses follow original signal
<b>Flat-top Sampling</b>	Samples held constant until next sample	Creates staircase approximation, easier to implement

Diagram:



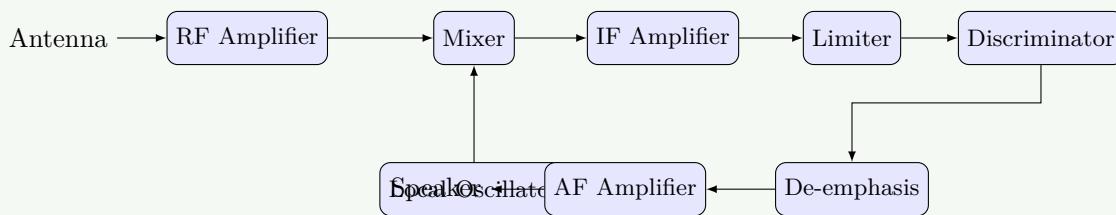
Natural Sampling (Blue Blocks)

**Mnemonic**

"Ideal takes Instants, Natural follows Nicely, Flat stays Fixed"

**Question 3 [c marks]**

7 Draw and explain the block diagram of FM receiver. What is the use of Limiter in FM receiver?

**Solution****Answer:**

Block	Function
<b>RF Amplifier</b>	Amplifies weak RF signal and provides selectivity
<b>Mixer/Local Oscillator</b>	Converts RF to IF (10.7 MHz)
<b>IF Amplifier</b>	Provides gain and selectivity at fixed frequency
<b>Limiter</b>	Removes amplitude variations, preserves frequency variations
<b>Discriminator</b>	Converts frequency variations to amplitude variations
<b>De-emphasis</b>	Reduces high-frequency noise
<b>AF Amplifier</b>	Amplifies recovered audio for speaker

**Limiter Function:** Removes amplitude variations from the FM signal before demodulation to ensure noise immunity, as information in FM is contained in frequency variations, not amplitude.

#### Mnemonic

"Radio Mixers Increase Frequency; Limiters Discriminate Audio Sound"

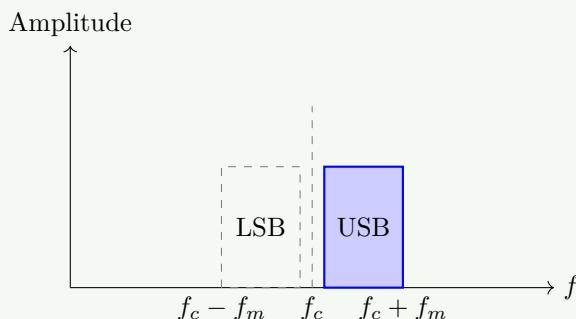
## Question 3 [a marks]

3 Describe the concept of single side band (SSB) transmission.

#### Solution

##### Answer:

**Single Sideband (SSB) Transmission:** Technique where only one sideband (upper or lower) is transmitted while suppressing the carrier and other sideband.



SSB Spectrum (USB Transmitted)

- **Bandwidth:** Requires only half the bandwidth ( $f_c \pm f_m$ ).
- **Power Efficiency:** More efficient as power concentrated in one sideband.
- **Types:** USB (Upper Sideband) and LSB (Lower Sideband).

#### Mnemonic

"SSB Saves Spectrum Bandwidth"

## Question 3 [b marks]

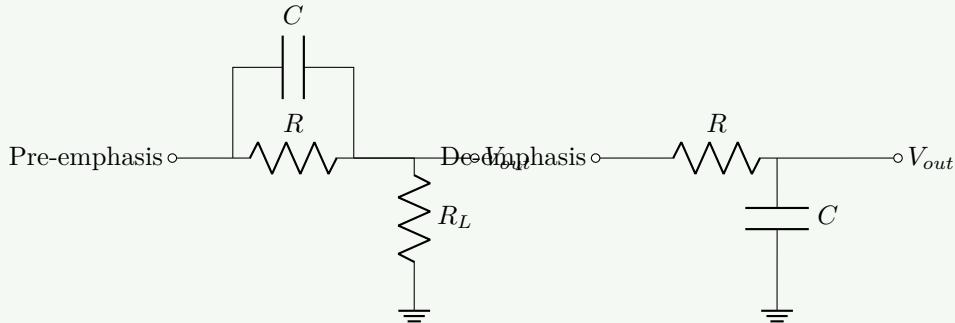
4 Explain pre-emphasis & de-emphasis circuit.

## Solution

**Answer:**

Parameter	Pre-emphasis	De-emphasis
<b>Location</b>	Transmitter	Receiver
<b>Circuit Type</b>	High-pass RC network	Low-pass RC network
<b>Function</b>	Boosts high frequencies before transmission	Attenuates high frequencies after reception
<b>Purpose</b>	Improves SNR for high frequencies	Restores original frequency response

**Circuit Diagram:**



### Mnemonic

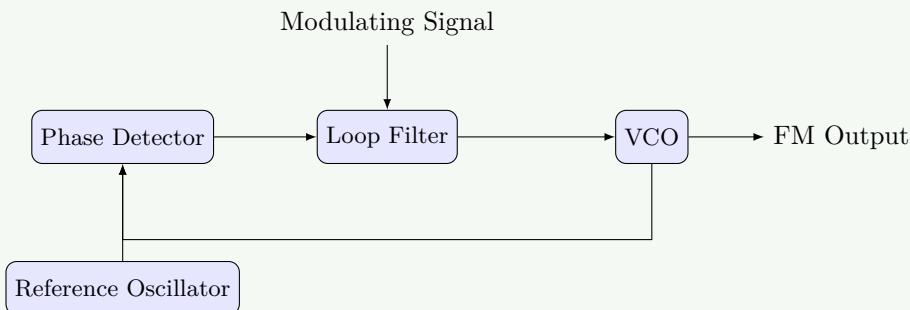
"Pre Pushes highs, De Drops them"

## Question 3 [c marks]

7 Illustrate generation of FM signal using Phase lock loop technique.

## Solution

**Answer:**



Component	Function
<b>Phase Detector</b>	Compares reference and VCO signals, generates error voltage
<b>Loop Filter</b>	Filters error voltage and combines with modulating signal
<b>VCO</b>	Generates frequency based on control voltage
<b>Reference Oscillator</b>	Provides stable reference frequency

### Working Process:

1. Modulating signal is applied to loop filter.
2. VCO frequency shifts proportional to modulating signal.
3. Phase detector generates error signal.
4. Loop maintains lock while allowing frequency modulation.
5. Output of VCO is the FM signal.

**Mnemonic**

"Phase Locks, Voltage Controls, Frequency Modulates"

**Question 4 [a marks]**

**3 Explain quantization process and its importance.**

**Solution****Answer:**

**Quantization:** Process of mapping continuous amplitude values to a finite set of discrete levels in analog-to-digital conversion.

Aspect	Description
<b>Process</b>	Dividing amplitude range into fixed levels and assigning digital values
<b>Types</b>	Uniform (equal steps) and Non-uniform (variable steps)
<b>Error</b>	Difference between actual and quantized value (quantization noise)

**Importance:**

- Enables digital representation of analog signals.
- Determines resolution and accuracy of digital signal.
- Affects signal-to-noise ratio in digital systems.

**Mnemonic**

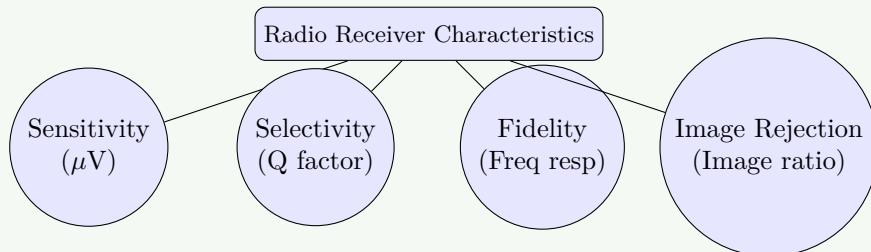
"Quantization Creates Digital from Analog"

**Question 4 [b marks]**

**4 Explain different characteristics of Radio receiver.**

**Solution****Answer:**

Characteristic	Definition	Significance
<b>Sensitivity</b>	Ability to receive weak signals	Determines reception range
<b>Selectivity</b>	Ability to separate adjacent channels	Prevents interference
<b>Fidelity</b>	Accuracy of reproduction	Determines sound quality
<b>Image Rejection</b>	Ability to reject image frequency	Prevents unwanted reception

**Diagram:****Mnemonic**

"Sensitive Selection Faithfully Images"

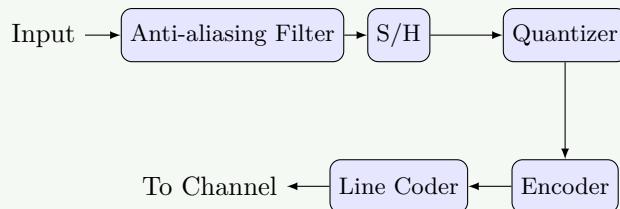
## Question 4 [c marks]

7 Draw and explain the block diagram of PCM transmitter and receiver.

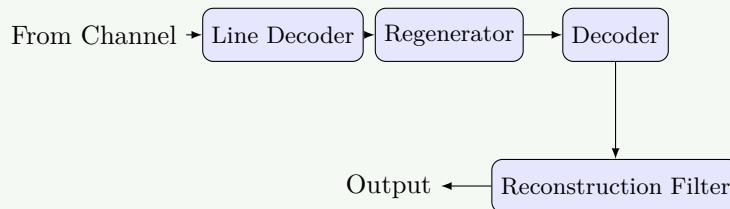
### Solution

**Answer:**

**PCM Transmitter:**



**PCM Receiver:**



Block	Function
<b>Anti-aliasing Filter</b>	Limits input bandwidth to prevent aliasing
<b>Sample &amp; Hold</b>	Converts continuous signal to discrete-time samples
<b>Quantizer</b>	Converts sample amplitudes to discrete levels
<b>Encoder</b>	Converts quantized values to binary code
<b>Line Coder</b>	Formats binary data for transmission
<b>Decoder</b>	Converts binary code back to quantized values
<b>Reconstruction Filter</b>	Smooths the stepped output to recover original signal

### Mnemonic

"Sample, Quantize, Encode, Transmit; Decode, Reconstruct, Output"

## Question 4 [a marks]

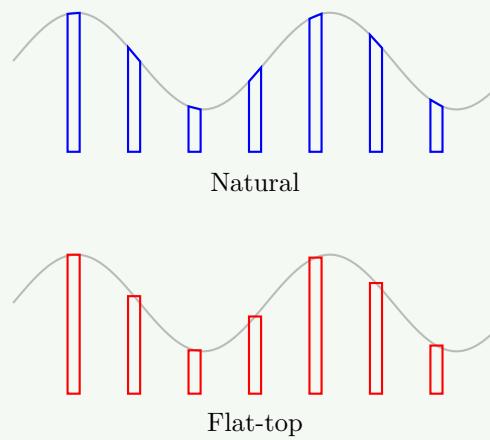
3 Compare Natural and Flat top sampling.

### Solution

**Answer:**

Parameter	Natural Sampling	Flat-top Sampling
<b>Shape</b>	Top of pulses follow input signal	Constant amplitude during sampling interval
<b>Implementation</b>	More difficult (analog switch)	Easier (sample and hold circuit)
<b>Spectrum</b>	Less harmonics	More harmonics
<b>Reconstruction</b>	Easier, more accurate	Requires compensation for distortion

**Diagram:**

**Mnemonic**

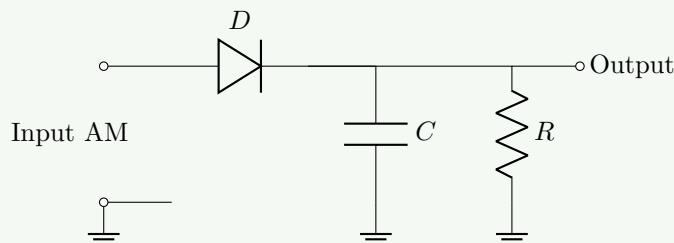
"Natural Follows, Flat Freezes"

**Question 4 [b marks]**

4 Explain Diode Detector circuit.

**Solution****Answer:**

**Diode Detector Circuit:** Used for demodulation of AM signals by extracting the envelope of the modulated wave.



Component	Function
Diode (D)	Rectifies the AM signal, passes only positive half
Capacitor (C)	Charges to peak value, smooths out carrier
Resistor (R)	Controls discharge time of capacitor

**Working:**

1. Diode rectifies AM signal.
2. Capacitor charges to peak value.
3. RC time constant allows capacitor to follow envelope.
4. Output follows the original modulating signal.

**Mnemonic**

"Diode Detects, Capacitor Captures"

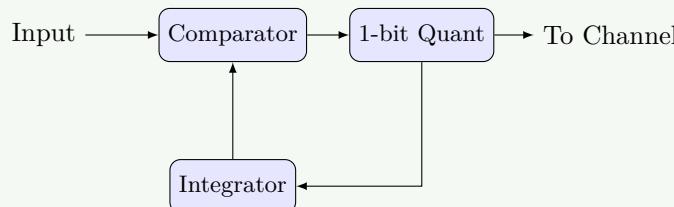
## Question 4 [c marks]

7 Draw and explain the block diagram of Delta Modulation.

### Solution

**Answer:**

**Delta Modulation Transmitter:**



**Delta Modulation Receiver:**



Component	Function
<b>Comparator</b>	Compares input with predicted value
<b>1-bit Quantizer</b>	Outputs binary 1 if input > predicted, 0 if input < predicted
<b>Integrator</b>	Generates predicted value by integrating previous output
<b>Low-pass Filter</b>	Smooths stepped output to recover original signal

**Limitations:**

- **Slope Overload:** Occurs when signal changes faster than step size can track.
- **Granular Noise:** Occurs during idle or constant parts of signal.

### Mnemonic

"Delta Detects Differences, Integrator Increments"

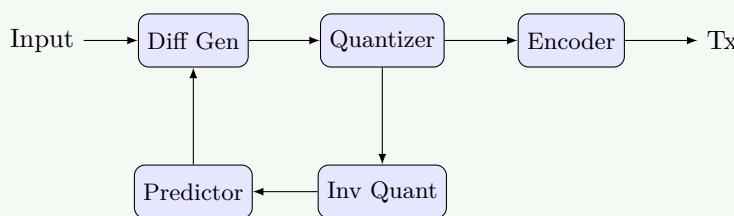
## Question 5 [a marks]

3 Illustrate working of DPCM.

### Solution

**Answer:**

**DPCM (Differential Pulse Code Modulation):** Encodes the difference between current sample and predicted value.



- **Predictor:** Estimates current sample based on previous samples.
- **Difference:** Only difference between actual and predicted is encoded.
- **Advantage:** Reduces bit rate compared to PCM by exploiting signal correlation.

**Mnemonic**

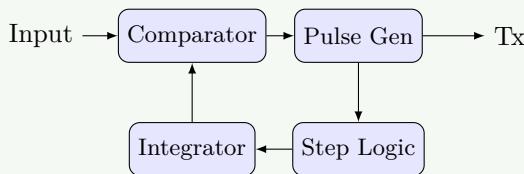
"Differences Predicted Create Minimized bits"

**Question 5 [b marks]**

4 Illustrate Adaptive Delta Modulation.

**Solution****Answer:**

**Adaptive Delta Modulation (ADM):** Improved version of DM that varies step size based on signal characteristics.

**Operation:**

1. If multiple 1's detected: increase step size to avoid slope overload.
2. If multiple 0's detected: increase step size to track falling signal.
3. If alternating 1's and 0's: decrease step size to reduce granular noise.

**Mnemonic**

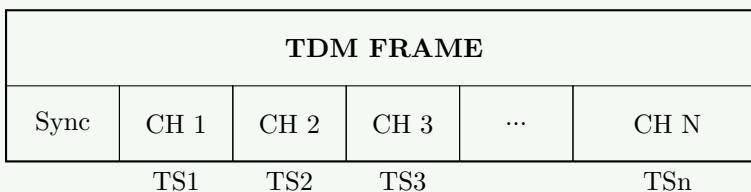
"Adapting Delta Makes Slopes Trackable"

**Question 5 [c marks]**

7 Illustrate TDM frame.

**Solution****Answer:**

**TDM (Time Division Multiplexing) Frame:** Structure used to combine multiple signals by assigning time slots.

**Frame Structure:**

Component	Description
Frame Sync	Pattern to identify frame boundaries
Channel Sample	Data from individual channel
Time Slot (TS)	Dedicated period for each channel
Frame Duration	Inversely proportional to sampling rate

**TDM Hierarchy:**

- Primary: 2.048 Mbps
- Secondary: 8.448 Mbps
- Tertiary: 34.368 Mbps
- Quaternary: 139.264 Mbps

**Mnemonic**

"Frames Synchronize Time Slots During Multiplexing"

**Question 5 [a marks]**

**3** State difference between DM and ADM.

**Solution****Answer:**

Parameter	Delta Modulation (DM)	Adaptive Delta Modulation (ADM)
<b>Step Size</b>	Fixed step size	Variable step size
<b>Slope Overload</b>	Common problem	Reduced by adaptive step size
<b>Granular Noise</b>	High during slow variations	Reduced by adaptive step size
<b>Circuit Complexity</b>	Simpler	More complex
<b>Signal Quality</b>	Lower	Higher

**Mnemonic**

"DM's Fixed Steps; ADM Adapts"

**Question 5 [b marks]**

**4** Explain the need of line coding. Explain AMI technique.

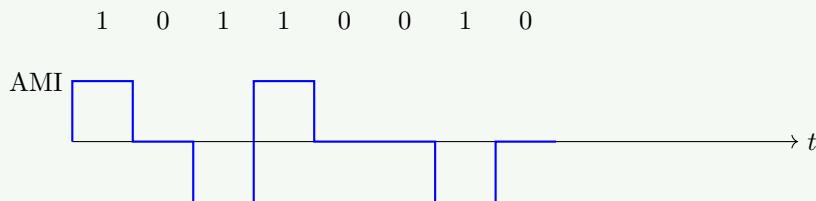
**Solution****Answer:****Need for Line Coding:**

- **DC Component:** To eliminate DC component for AC-coupled systems.
- **Synchronization:** To provide timing information for clock recovery.
- **Error Detection:** To enable detection of transmission errors.
- **Spectral Efficiency:** To shape signal spectrum for efficient bandwidth use.
- **Noise Immunity:** To provide resistance against channel noise.

**AMI (Alternate Mark Inversion) Technique:**

Parameter	Description
<b>Encoding Rule</b>	Binary 0 → 0V, Binary 1 → Alternating +V/-V
<b>DC Component</b>	No DC component (balanced code)
<b>Error Detection</b>	Can detect violations in alternating pattern
<b>Bandwidth</b>	Requires less bandwidth than NRZ codes

**Diagram:**

**Mnemonic**

"Alternating Marks Invert Polarity"

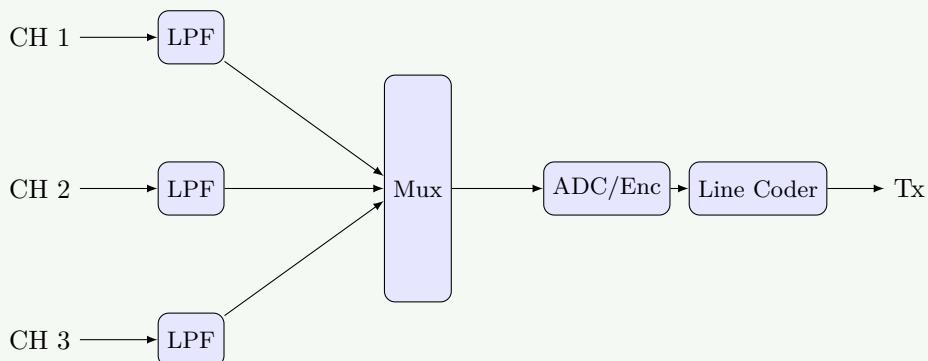
**Question 5 [c marks]**

7 Draw and explain block diagram of basic PCM-TDM system.

**Solution**

**Answer:**

**PCM-TDM Transmitter:**



Block	Function
<b>Low-pass Filter</b>	Limits bandwidth to satisfy sampling theorem
<b>Multiplexer</b>	Sample & Holds inputs and combines them sequentially
<b>ADC/Encoder</b>	Quantizes and encodes the multiplexed stream
<b>Line Coder</b>	Formats binary data for transmission
<b>Receiver</b>	Performs reverse operation (Decoder → Demux → LPFs)

**Mnemonic**

"Multiple Channels Sample, Quantize, Encode; Decode, Demultiplex, Filter"