Principles of Electronic Communication (4331104) - Summer 2024 Solution

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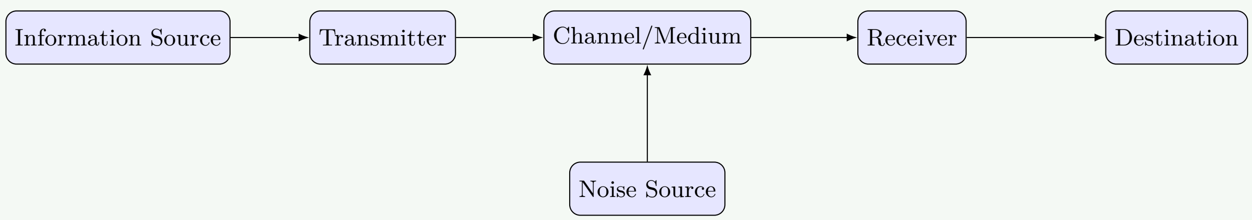
Question 1 [a marks]

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 EHz	Medical imaging, security scanning, material analysis
Gamma rays	>30 EHz	Cancer treatment, food sterilization, industrial inspection

Mnemonic

"Radio Makes Invisible Very eXtreme Gamma signals"

Question 1 [c marks]

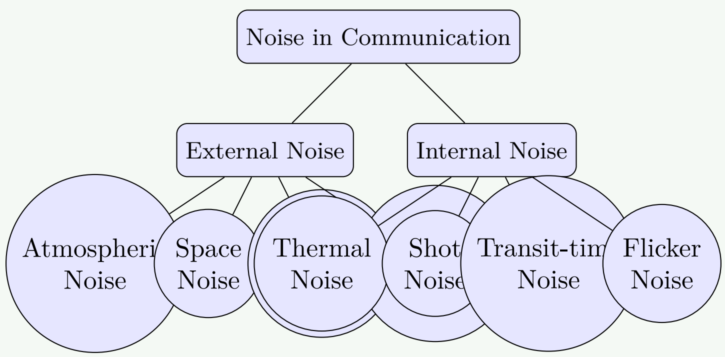
7 State and explain external and internal noise.

Solution

Answer:

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

Diagram:



Mnemonic

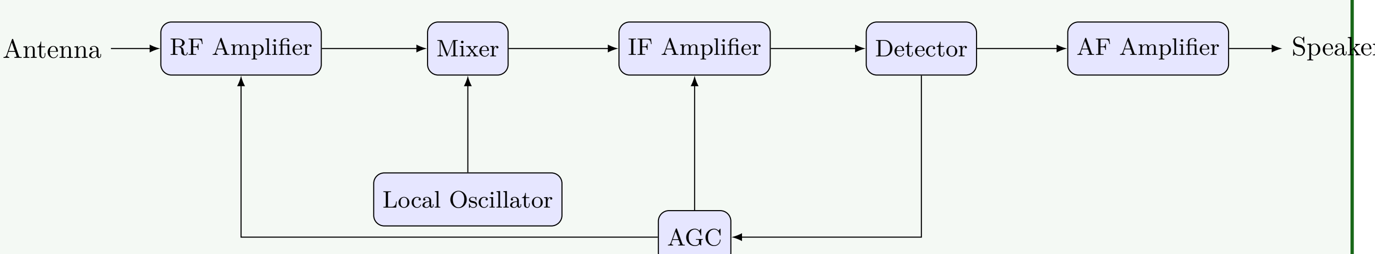
"External Environmental Sources Invade; Internal Components Generate Noise"

Question 1 [c marks]

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

Solution

Answer:



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

Mnemonic

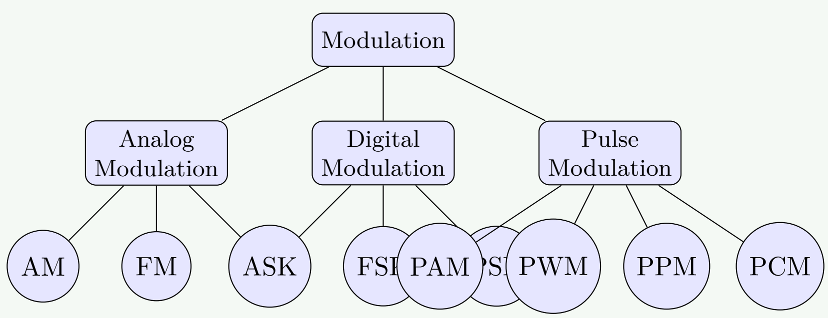
"Radio Loves Making Interesting Detected Audio Sounds"

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
Signal to Noise Ratio (SNR)	Ratio of signal power to noise power	$SNR = \frac{P_{signal}}{P_{noise}}$	Expressed in dB	Higher value indicates better signal quality
Noise Figure (NF)	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]

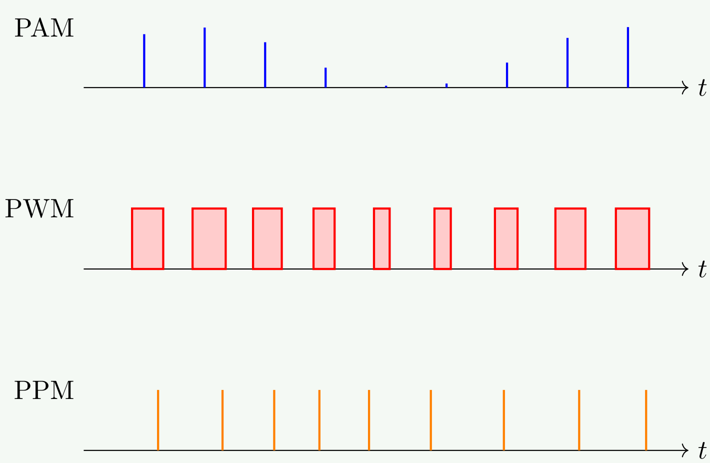
7 Compare PAM, PWM and PPM techniques.

Solution

Answer:

Parameter	PAM	PWM	PPM
Full Form	Pulse Amplitude Modulation	Pulse Width Modulation	Pulse Position Modulation
Modulated Parameter	Amplitude of pulses	Width/duration of pulses	Position/timing of pulses
Noise Immunity	Poor	Good	Excellent
Bandwidth	Low	Medium	High
Circuit Complexity	Simple	Moderate	Complex
Power Efficiency	Poor	Good	Excellent
Applications	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
Definition	Binary digit (0 or 1)	Group of bits	Number of symbols transmitted per second
Unit	No unit	No unit	Symbols per second (Baud)
Relationship	Basic unit of digital information	Multiple bits form one symbol	Baud rate $\times$ bits per symbol = bit rate
Example	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
Bandwidth: Requires only half the bandwidth	**Circuit Complexity**: More complex modulation and demodulation
Power Efficiency: Transmits only one sideband, saving power	**Receiver Design**: Requires precise frequency synchronization
Less Fading: Reduced selective fading effects	**Low Frequency Loss**: May lose low frequency components
Less Interference: Reduced adjacent channel interference	**Cost**: More expensive implementation

Mnemonic

"SSB Saves Bandwidth Power but Costs Complex Hardware"

Question 2 [c marks]

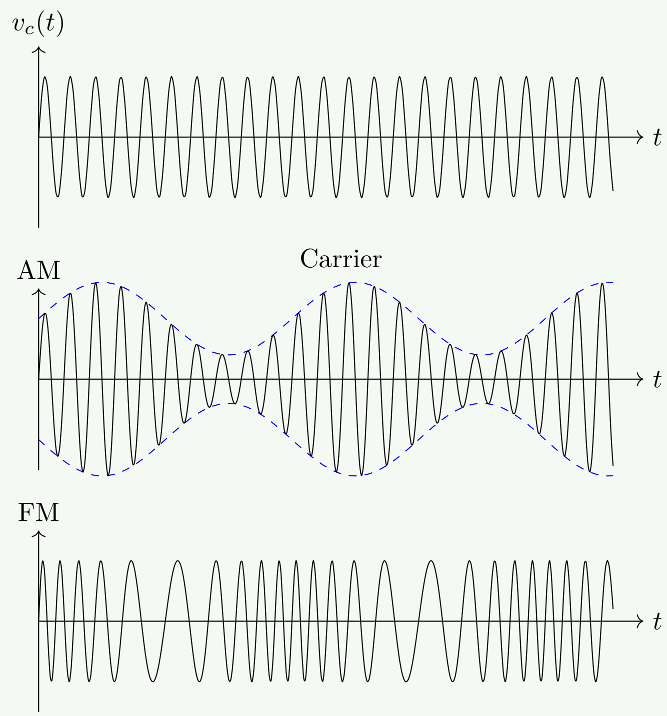
7 Compare Amplitude Modulation (AM) and Frequency Modulation (FM).

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 (±5 kHz)	Wide (±75 kHz)
Special Circuits	Simple	Limiter, De-emphasis
Complexity	Simple	Complex

> **Mnemonic**
>
> "AM Accepts Minimal bandwidth; FM Features More circuits"

Question 3 [b marks]

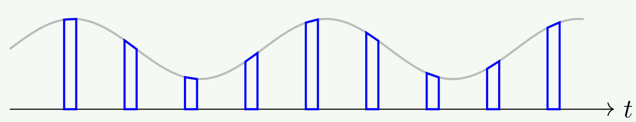
4 Define sampling? Explain types of sampling in brief.

Solution

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

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

Diagram:



Natural Sampling (Blue Blocks)

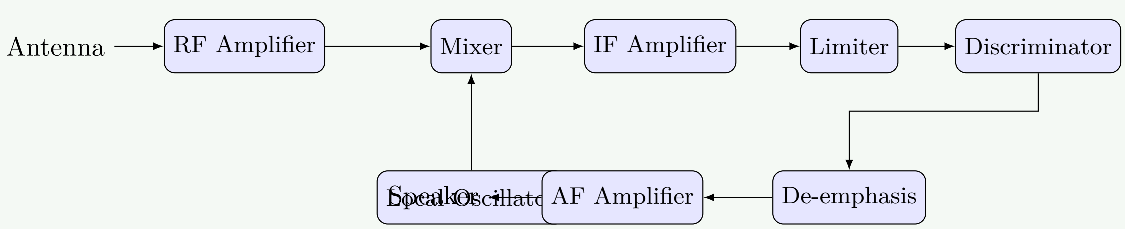
> **Mnemonic**
>
> "Ideal takes Instants, Natural follows Nicely, Flat stays Fixed"

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

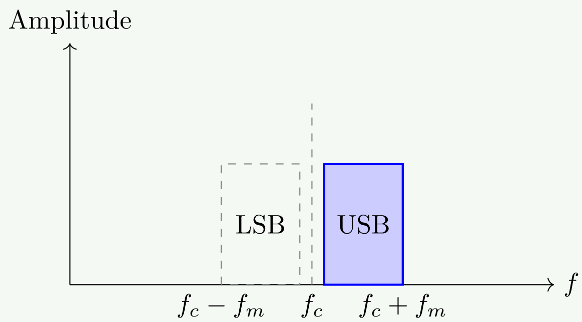
"Radio Mixers Increase Frequency; Limiters Discriminate Audio Sound"

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]

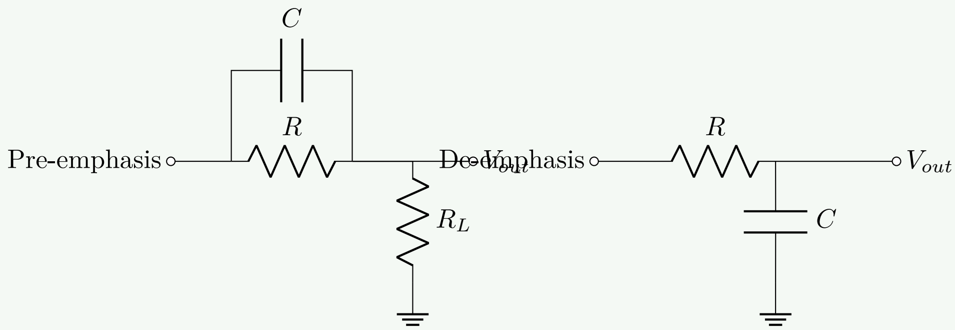
4 Explain pre-emphasis & de-emphasis circuit.

Solution

Answer:

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

Circuit Diagram:



Mnemonic

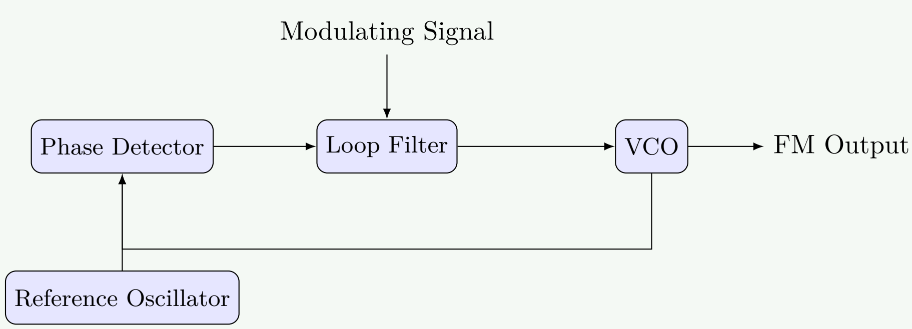
"Pre Pushes highs, De Drops them"

Question 3 [c marks]

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

Solution

Answer:



Component	Function
Phase Detector	Compares reference and VCO signals, generates error voltage
Loop Filter	Filters error voltage and combines with modulating signal
VCO	Generates frequency based on control voltage
Reference Oscillator	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
Process	Dividing amplitude range into fixed levels and assigning digital values
Types	Uniform (equal steps) and Non-uniform (variable steps)
Error	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]

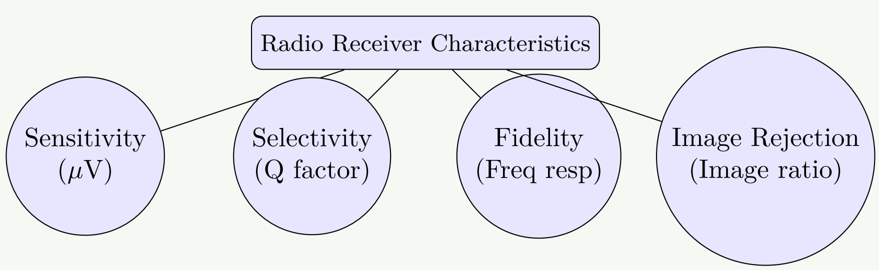
4 Explain different characteristics of Radio receiver.

Solution

Answer:

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

Diagram:



Mnemonic

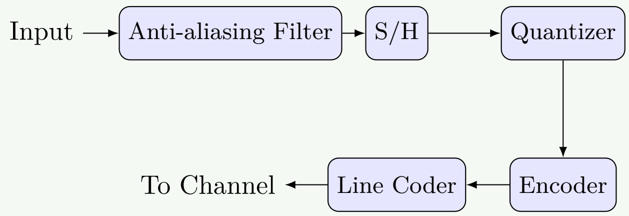
"Sensitive Selection Faithfully Images"

Question 4 [c marks]

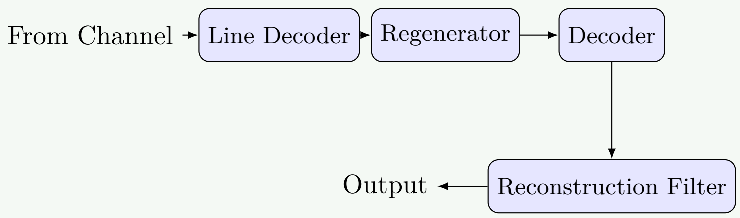
7 Draw and explain the block diagram of PCM transmitter and receiver.

Solution

Answer:
PCM Transmitter:



PCM Receiver:



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

Mnemonic

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

Question 4 [a marks]

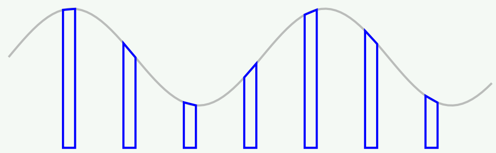
3 Compare Natural and Flat top sampling.

Solution

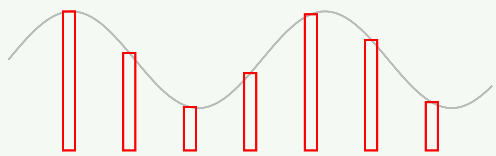
Answer:

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

Diagram:



Natural



Flat-top

Mnemonic

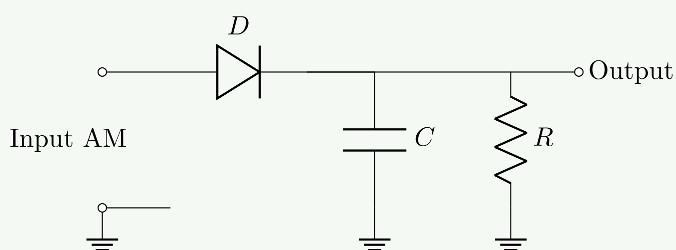
"Natural Follows, Flat Freezes"

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

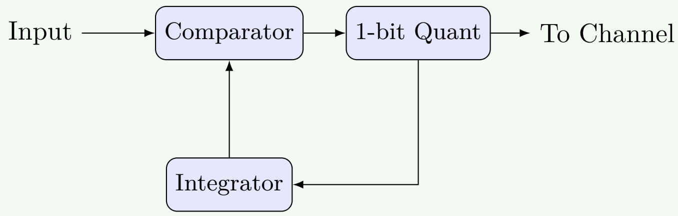
"Diode Detects, Capacitor Captures"

Question 4 [c marks]

7 Draw and explain the block diagram of Delta Modulation.

Solution

Answer:
Delta Modulation Transmitter:



Delta Modulation Receiver:

Component	Function
Comparator	Compares input with predicted value
1-bit Quantizer	Outputs binary 1 if input > predicted, 0 if input < predicted
Integrator	Generates predicted value by integrating previous output
Low-pass Filter	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

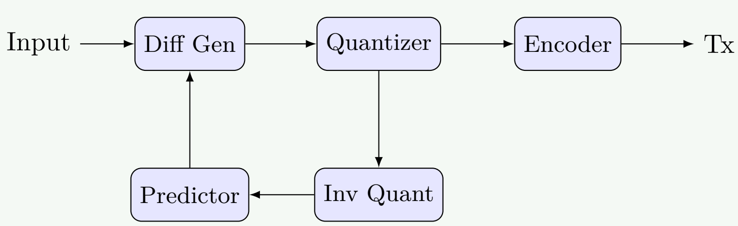
"Delta Detects Differences, Integrator Increments"

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.

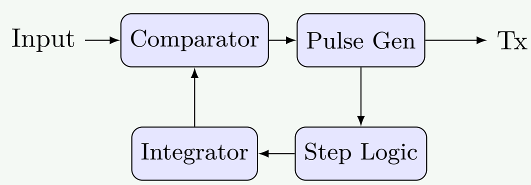
> **Mnemonic**
>
> "Differences Predicted Create Minimized bits"

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:

TDM FRAME					
Sync	CH 1	CH 2	CH 3	···	CH N
	TS1	TS2	TS3		TSn

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)
Step Size	Fixed step size	Variable step size
Slope Overload	Common problem	Reduced by adaptive step size
Granular Noise	High during slow variations	Reduced by adaptive step size
Circuit Complexity	Simpler	More complex
Signal Quality	Lower	Higher

Mnemonic

"DM's Fixed Steps; ADM Adapts"

Question 5 [b marks]

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

Solution

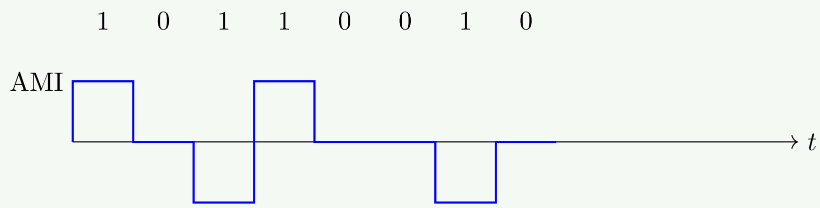
Answer:
Need for Line Coding:

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

Diagram:



Mnemonic

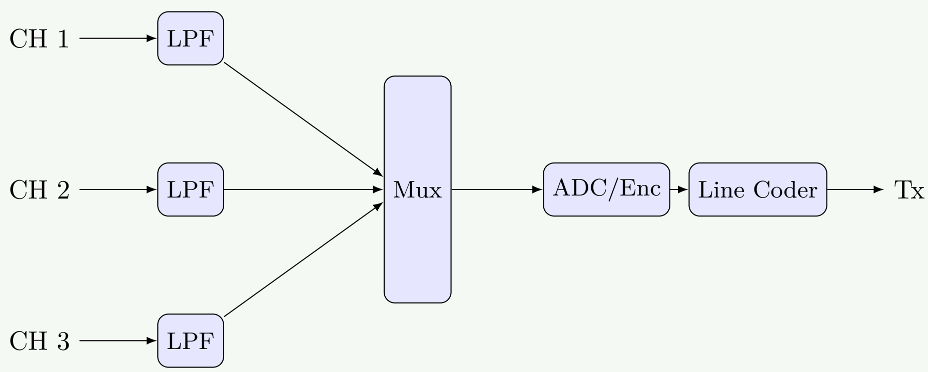
"Alternating Marks Invert Polarity"

Question 5 [c marks]

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

Solution

Answer:
PCM-TDM Transmitter:



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

Mnemonic

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