Principles of Electronic Communication (4331104) - Summer 2025 Solution

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Question 1 [a marks]

3 Compare Analog Signal and Digital Signal.

Solution

Answer:

Parameter	Analog Signal	Digital Signal
Nature	Continuous waveform	Discrete values (0 and 1)
Amplitude	Infinite variations	Fixed discrete levels
Noise Effect	More susceptible	Less susceptible
Bandwidth	Requires less bandwidth	Requires more bandwidth
Security	Less secure	More secure

- **Signal Type**: Analog signals are continuous, Digital signals are discrete.
- **Noise Resistance**: Digital signals have better noise immunity.

Mnemonic

"ABCD - Analog Bad for noise, Continuous; Digital Discrete, Clean signals"

Question 1 [b marks]

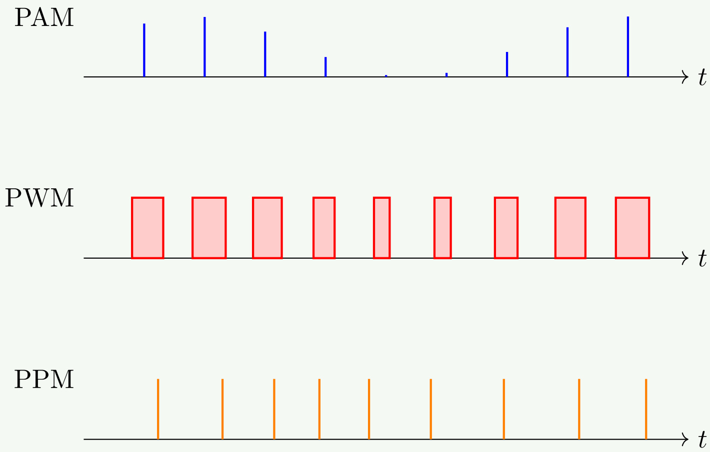
4 Compare PAM, PWM and PPM.

Solution

Answer:

Parameter	PAM	PWM	PPM
Full Form	Pulse Amplitude Modulation	Pulse Width Modulation	Pulse Position Modulation
Modulated Parameter	Amplitude	Width/Duration	Position/Time
Noise Immunity	Poor	Good	Excellent
Bandwidth	Minimum	Medium	Maximum
Power Consumption	High	Medium	Low

Diagram:



- **Modulation Parameter**: Each type modulates different pulse characteristics.
- **Applications**: PWM used in motor control, PPM in radio control systems.

Mnemonic

"PAM-Amplitude, PWM-Width, PPM-Position - AWP"

Question 1 [c marks]

7 Indicate the need of Modulation in detail. Calculate the height of antenna if the frequency of Carrier signal is 1 MHz.

Solution

Answer:
Need for Modulation:

Reason	Explanation
Antenna Size Reduction	Makes practical antenna sizes possible
Frequency Translation	Shifts signal to suitable frequency range
Multiplexing	Allows multiple signals on same medium
Noise Reduction	Improves signal-to-noise ratio
Power Efficiency	Better power utilization

Antenna Height Calculation:
For efficient radiation, antenna height = $\lambda/4$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{1 \times 10^6} = 300 \text{ meters}$$

$$\textbf{Antenna height} = \frac{\lambda}{4} = \frac{300}{4} = \textbf{75 meters}$$

- **Practical Antenna**: Without modulation, antenna would be impractically large.
- **Frequency Shifting**: Allows better propagation characteristics.

Mnemonic

"AFMNP - Antenna, Frequency, Multiplexing, Noise, Power"

Question 1 [c marks]

7 Write frequency bands with applications domains of EM Wave spectrum. Calculate Wavelength range of ELF band.

Solution

Answer:

Band	Frequency Range	Wavelength	Applications
ELF	30-300 Hz	$10^6 - 10^7$ m	Submarine communication
VLF	3-30 kHz	$10^4 - 10^5$ m	Navigation, time signals
LF	30-300 kHz	$10^3 - 10^4$ m	AM broadcasting
MF	300 kHz-3 MHz	100-1000 m	AM radio
HF	3-30 MHz	10-100 m	Short wave radio

ELF Wavelength Calculation:

- Lower frequency: $f_1 = 30$ Hz, $\lambda_1 = c/f_1 = (3 \times 10^8)/30 = \mathbf{10^7}$ **meters**
- Upper frequency: $f_2 = 300$ Hz, $\lambda_2 = c/f_2 = (3 \times 10^8)/300 = \mathbf{10^6}$ **meters**

ELF Wavelength range: 10^6 **to** 10^7 **meters**

- **Application Domain**: Each band suited for specific applications.
- **Propagation**: Lower frequencies have better ground wave propagation.

Mnemonic

"Every Valuable Learning Makes Happiness - ELF to HF bands"

Question 2 [a marks]

3 Compare AM and FM.

Solution

Answer:

Parameter	AM	FM
Modulated Parameter	Amplitude	Frequency
Bandwidth	$2f_m$	$2(\Delta f + f_m)$
Noise Immunity	Poor	Good
Power Efficiency	Low (33.33%)	High
Circuit Complexity	Simple	Complex

- **Bandwidth**: FM requires much wider bandwidth than AM.
- **Quality**: FM provides better audio quality.

Mnemonic

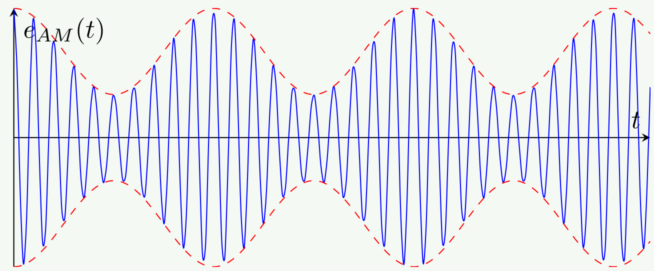
"AM-Amplitude simple, FM-Frequency complex but better quality"

Question 2 [b marks]

4 Draw waveform of Amplitude Modulated wave.

Solution

Answer:
Diagram:



Characteristics:

- **Envelope**: The envelope follows the modulating signal.
- **Carrier Frequency**: Remains constant throughout.
- **Amplitude Variation**: Amplitude varies with modulating signal.

Mnemonic

"Envelope Follows Message - EFM"

Question 2 [c marks]

7 Define Amplitude Modulation and Derive mathematical expression for Double Sideband Full Carrier (DSBFC) Amplitude Modulation (AM) signal.

Solution

Answer:
Definition: Amplitude Modulation is the process where amplitude of carrier signal varies according to instantaneous amplitude of modulating signal.
Mathematical Derivation:
Let carrier signal: $e_c(t) = E_c \cos(\omega_c t)$
Let modulating signal: $e_m(t) = E_m \cos(\omega_m t)$
AM Signal Expression:

$$e_{AM}(t) = [E_c + E_m \cos(\omega_m t)] \cos(\omega_c t)$$

$$e_{AM}(t) = E_c \cos(\omega_c t) + E_m \cos(\omega_m t) \cos(\omega_c t)$$

Using trigonometric identity:

$$\cos A \cos B = \frac{1}{2}[\cos(A + B) + \cos(A - B)]$$

Final AM Expression:

$$e_{AM}(t) = E_c \cos(\omega_c t) + \frac{E_m}{2} \cos(\omega_c + \omega_m)t + \frac{E_m}{2} \cos(\omega_c - \omega_m)t$$

Components:

- **Carrier Component**: $E_c \cos(\omega_c t)$
- **Upper Sideband**: $\frac{E_m}{2} \cos(\omega_c + \omega_m)t$
- **Lower Sideband**: $\frac{E_m}{2} \cos(\omega_c - \omega_m)t$

Mnemonic

"Carrier Plus Upper Lower Sidebands - CPULS"

Question 2 [a marks]

3 Compare Pre-emphasis and De-emphasis.

Solution

Answer:

Parameter	Pre-emphasis	De-emphasis
Location	At transmitter	At receiver
Function	Boosts high frequencies	Attenuates high frequencies
Frequency Response	High pass characteristic	Low pass characteristic
Purpose	Improve S/N ratio	Restore original signal
Time Constant	75 μs (FM broadcasting)	75 μs (FM broadcasting)

- **Noise Reduction**: Combined effect reduces noise in received signal.
- **Frequency Response**: Complementary characteristics.

Mnemonic

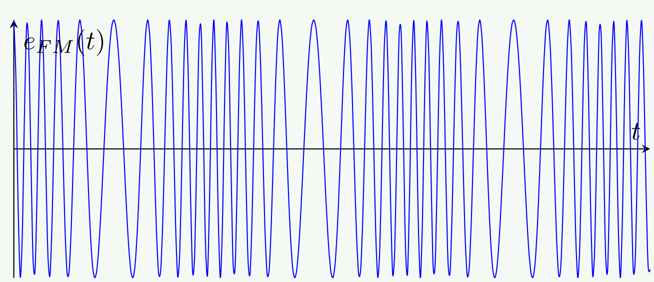
"Pre-Boost, De-Cut - Noise Reduction Circuit"

Question 2 [b marks]

4 Draw waveform of Frequency Modulated wave.

Solution

Answer:
Diagram:



Characteristics:
- **Constant Amplitude**: Amplitude remains constant.
- **Frequency Variation**: Frequency varies with modulating signal.
- **Phase Continuity**: Phase remains continuous.

Mnemonic

"Constant Amplitude, Variable Frequency - CAVF"

Question 2 [c marks]

7 Define Frequency Modulation and Derive mathematical expression for FM wave.

Solution

Answer:
Definition: Frequency Modulation is the process where frequency of carrier signal varies according to instantaneous amplitude of modulating signal.
Mathematical Derivation:
Let modulating signal: $e_m(t) = E_m \cos(\omega_m t)$
Instantaneous frequency: $f_i = f_c + k_f E_m \cos(\omega_m t)$
Where k_f = frequency sensitivity
Instantaneous angular frequency:

$$\omega_i = 2\pi[f_c + k_f E_m \cos(\omega_m t)]$$

$$\omega_i = \omega_c + 2\pi k_f E_m \cos(\omega_m t)$$

Phase calculation:

$$\theta(t) = \int \omega_i dt = \omega_c t + \frac{2\pi k_f E_m}{\omega_m} \sin(\omega_m t)$$

Let modulation index: $m_f = \frac{2\pi k_f E_m}{\omega_m} = \frac{\Delta f}{f_m}$
Final FM Expression:

$$e_{FM}(t) = E_c \cos[\omega_c t + m_f \sin(\omega_m t)]$$

Parameters:

- **Modulation Index**: $m_f = \Delta f / f_m$
- **Frequency Deviation**: $\Delta f = k_f E_m$
- **Bandwidth**: $BW = 2(\Delta f + f_m)$ (Carson's rule)

Mnemonic

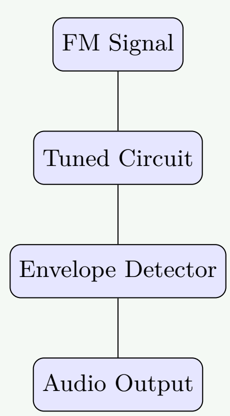
"Frequency Varies with Message - FVM"

Question 3 [a marks]

3 Illustrate Slope detection method of FM demodulation.

Solution

Answer:
Slope Detection Principle:



Working:

- **Tuned Circuit**: Converts frequency variations to amplitude variations.
- **Slope Operation**: Uses slope of resonance curve.
- **Envelope Detection**: Extracts amplitude variations.

Characteristics:

- **Simple Circuit**: Easy to implement.
- **Linear Range**: Limited linear range.
- **Output Distortion**: Higher distortion compared to other methods.

Mnemonic

"Slope Converts Frequency to Amplitude - SCFA"

Question 3 [b marks]

4 Explain different Characteristics of radio receiver.

Solution

Answer:

Characteristic	Definition	Importance
Sensitivity	Minimum input signal for satisfactory output	Better weak signal reception
Selectivity	Ability to select desired signal and reject others	Reduces interference
Fidelity	Faithfulness of reproduction	Better audio quality
Image Frequency Rejection	Rejection of image frequency	Prevents false signals

Mathematical Relations:

- **Sensitivity**: Measured in μV for standard output.
- **Selectivity**: $Q = f_0/BW$.
- **Image Rejection Ratio**: $IRR = \sqrt{1 + Q^2\rho^2}$ (where $\rho = f_{si}/f_s - f_s/f_{si}$).

Mnemonic

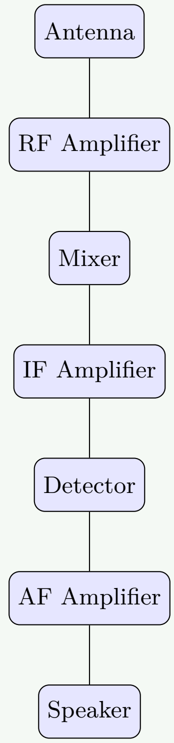
"Sensitive Selective Faithful Image-free - SSFI"

Question 3 [c marks]

7 Write short note on Super heterodyne receiver with suitable block diagram.

Solution

Answer:
Block Diagram:



Working Principle:

- **RF Amplifier**: Amplifies received RF signal.
- **Mixer**: Converts RF to fixed IF frequency.
- **Local Oscillator**: Provides mixing frequency.
- **IF Amplifier**: Main amplification at fixed frequency.
- **Detector**: Recovers modulated signal.
- **AGC**: Maintains constant output level.

Advantages:

- **High Sensitivity**: Better sensitivity than TRF.
- **Good Selectivity**: Better selectivity.
- **Stable Gain**: Stable gain characteristics.

IF Frequency Selection:
Standard IF: 455 kHz for AM, 10.7 MHz for FM.

Mnemonic

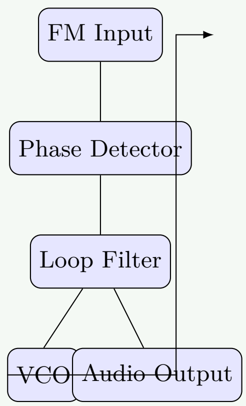
"Mix RF to IF for Better Selectivity - MRIBS"

Question 3 [a marks]

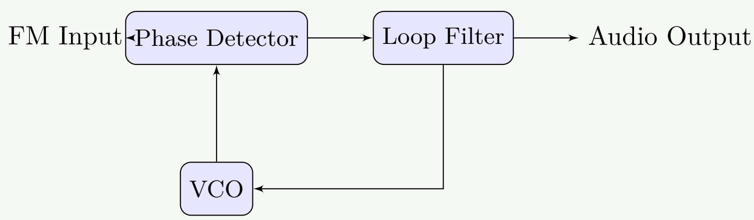
3 Illustrate working of FM demodulator using Phase Locked Loop.

Solution

Answer:
PLL FM Demodulator:



Note: Standard PLL feedback loop is hard to represent in tree structure, using simplified flow.



Working Principle:

- **Phase Detector**: Compares input FM with VCO output.
- **VCO**: Voltage Controlled Oscillator tracks input frequency.
- **Loop Filter**: Removes high frequency components.
- **Lock Condition**: VCO frequency equals input frequency.

Advantages:

- **Linear Demodulation**: Excellent linearity.
- **Low Distortion**: Minimum distortion.
- **Good Tracking**: Excellent frequency tracking.

Mnemonic

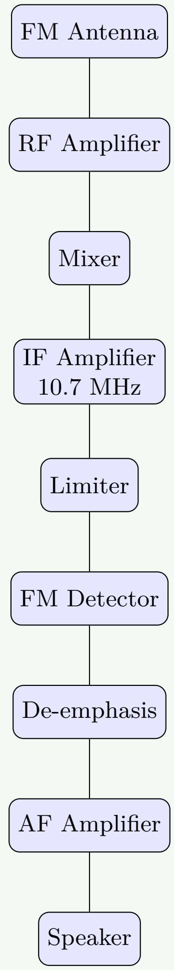
"Phase Lock Tracks Frequency - PLTF"

Question 3 [b marks]

4 Discuss Block diagram of basic FM receiver.

Solution

Answer:
FM Receiver Block Diagram:



Block Functions:

- **RF Amplifier**: Amplifies weak FM signal (88-108 MHz).
- **Mixer**: Converts to IF frequency (10.7 MHz).
- **Limiter**: Removes amplitude variations.
- **FM Detector**: Recovers audio signal.
- **De-emphasis**: Restores original frequency response.

Key Differences from AM Receiver:

- **Higher IF**: 10.7 MHz vs 455 kHz.
- **Limiter Stage**: Additional limiter stage.
- **De-emphasis**: Pre/de-emphasis network.

Mnemonic

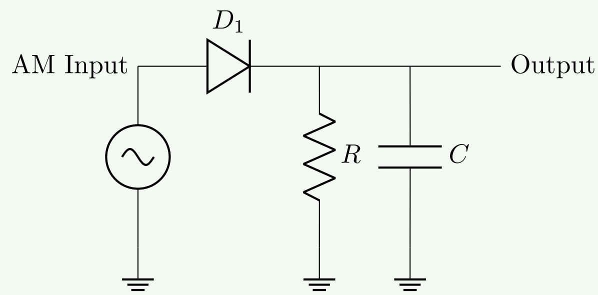
"FM needs Higher IF and Limiting - FHIL"

Question 3 [c marks]

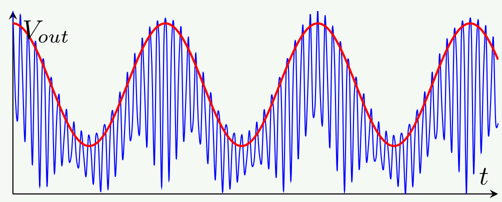
7 Write short note on Envelope detector using diode with suitable circuit diagram and waveform.

Solution

Answer:
Circuit Diagram:



Working Principle:



Operation:

- **Diode Conduction**: Conducts during positive half cycles.
- **Capacitor Charging**: Charges to peak value.
- **RC Discharge**: Discharges through RC circuit.
- **Envelope Following**: Output follows envelope.

Design Considerations:

- **Time Constant**: $RC \gg 1/f_c$ but $RC \ll 1/f_m$.
- **Diode Selection**: Fast recovery diode preferred.
- **Load Resistance**: Should be much larger than diode resistance.

Advantages:

- **Simplicity**: Very simple circuit.
- **Low Cost**: Economical solution.
- **High Efficiency**: Good detection efficiency.

Mnemonic

"Diode Charges, RC Follows Envelope - DCRF"

Question 4 [a marks]

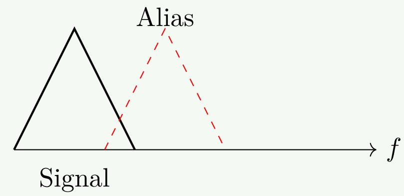
3 Illustrate under sampling, over sampling and critical sampling.

Solution

Answer:

Type	Condition	Result
Under Sampling	$f_s < 2f_m$	Aliasing occurs
Critical Sampling	$f_s = 2f_m$	Just adequate, no margin
Over Sampling	$f_s > 2f_m$	No aliasing, safe margin

Diagram:



- **Aliasing Effect**: Under sampling causes frequency overlap.
- **Nyquist Rate**: Minimum sampling rate $= 2f_m$.

Mnemonic

"Under-Alias, Critical-Just, Over-Safe - UCO"

Question 4 [b marks]

4 State Sampling theorem and define Nyquist rate, Nyquist interval and aliasing error.

Solution

Answer:
Sampling Theorem: "A continuous signal can be completely recovered from its samples if sampling frequency is at least twice the highest frequency component of the signal."
Definitions:

Term	Definition	Formula
Nyquist Rate	Minimum sampling frequency	$f_s = 2f_m$
Nyquist Interval	Maximum sampling interval	$T_s = 1/(2f_m)$
Aliasing Error	Frequency overlap due to under sampling	$f_a = \|f_s - f\|$

Mathematical Expression:
- **Sampling Frequency**: $f_s \geq 2f_m$ (Nyquist criterion).
- **Sampling Period**: $T_s = 1/f_s$.
- **Aliasing Condition**: $f_s < 2f_m$.

Mnemonic

"Sample at twice message frequency - S2M"

Question 4 [c marks]

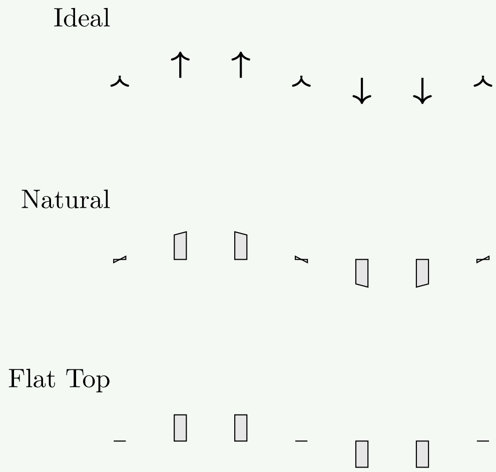
7 Discuss Ideal, Natural and Flat top sampling.

Solution

Answer:
Types of Sampling:

Type	Characteristics	Mathematical Expression
Ideal Sampling	Impulse train multiplication	$x_s(t) = x(t) \cdot \delta_T(t)$
Natural Sampling	Variable width pulses	Top follows signal
Flat Top Sampling	Constant amplitude pulses	Sample and hold

Waveforms:



Frequency Spectrum:

- **Ideal**: Exact spectral replication.
- **Natural**: Slight spectral modification.
- **Flat Top**: Aperture effect ($Sa(\pi f T/2)$) present.

Mnemonic

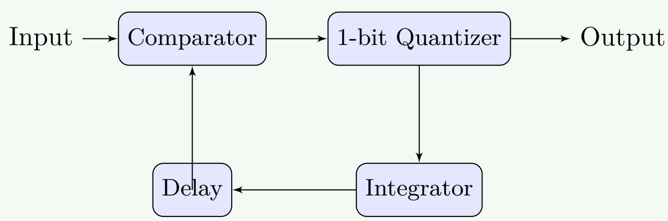
"Ideal-Impulse, Natural-Variable, Flat-Constant - IVF"

Question 4 [a marks]

3 Illustrate the working of Delta modulator with suitable block diagram.

Solution

Answer:
Delta Modulator Block Diagram:



Working Principle:

- **Comparison**: Input compared with previous integrated output.
- **1-bit Quantization**: Output is $+\Delta$ or $-\Delta$.
- **Integration**: Integrator approximates input signal.

Mnemonic

"Compare, Quantize, Integrate, Feedback - CQIF"

Question 4 [b marks]

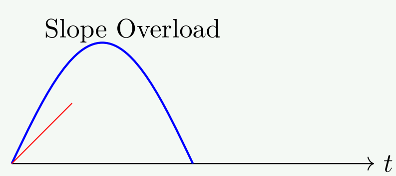
4 Write disadvantages of Delta modulation (DM) with suitable explanation.

Solution

Answer:

Disadvantage	Explanation	Solution
Slope Overload	Cannot track fast changes	Increase step size
Granular Noise	Quantization noise in flat regions	Decrease step size
High Bit Rate	Requires high sampling rate	Use ADPCM

Slope Overload Condition: When $|dx/dt| > \Delta f_s$.
Waveforms:



Mnemonic

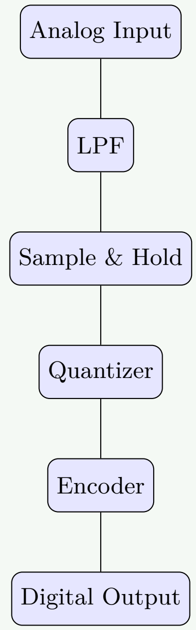
"Slope-Overload, Granular-Noise, High-Bitrate - SOG-H"

Question 4 [c marks]

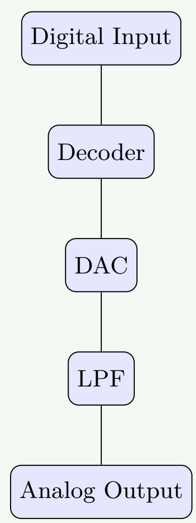
7 Describe functions of each block of pulse code modulation (PCM) transmitter and receiver.

Solution

Answer:
PCM Transmitter:



PCM Receiver:



Block Functions:

- **LPF**: Anti-aliasing filter.
- **Sample & Hold**: Samples signal.
- **Quantizer**: Converts to discrete levels.
- **Encoder**: Converts to binary.
- **Decoder**: Converts binary to levels.
- **DAC**: Digital to Analog.

Mnemonic

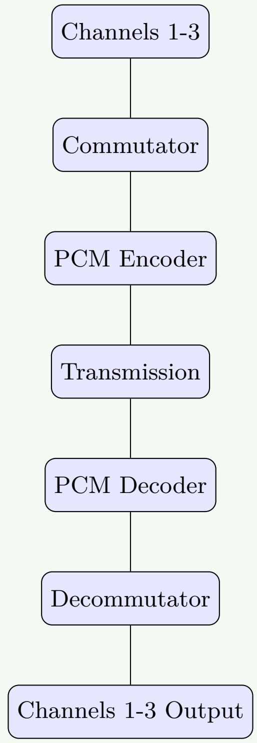
"LSQE for TX; DCF for RX"

Question 5 [a marks]

3 Discuss block diagram of TDM-PCM system in brief.

Solution

Answer:
TDM-PCM System Block Diagram:



System Operation:

- **Commutator**: Sequential sampling.
- **PCM Encoder**: Digitizes samples.
- **Time Division**: Channels get fixed time slots.
- **Decommutator**: Separates channels.

Mnemonic

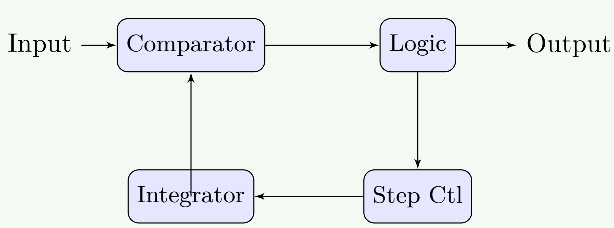
"Time Division Multiple Access - TDMA"

Question 5 [b marks]

4 Write short note on Adaptive delta modulation (ADM).

Solution

Answer:
ADM Block Diagram:



Working Principle:

- **Adaptive Step Size**: Changes based on slope.
- **Slope Overload**: Increases step size.
- **Granular Noise**: Decreases step size.

Mnemonic

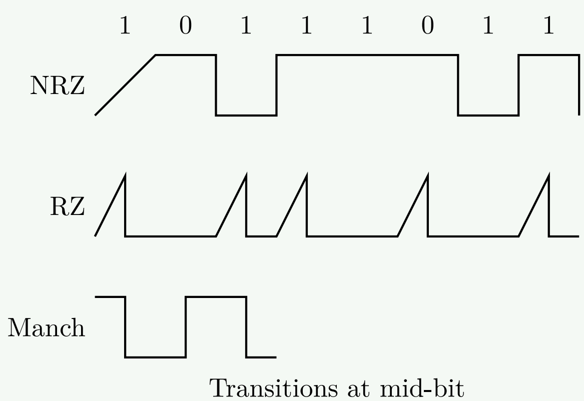
"Adaptive Step size Reduces both Slope-overload and Granular noise - ASRSG"

Question 5 [c marks]

7 Define Line coding. Draw NRZ (unipolar), RZ (unipolar), Manchester coding waveforms for "1 0 1 1 1 0 1 1".

Solution

Answer:
Definition: Line coding is the process of converting digital data into digital signals suitable for transmission.
Waveform Diagrams (Data: 1 0 1 1 1 0 1 1):



Comparison:

Type	Logic 1	Logic 0
NRZ	+V	0V
RZ	+V for T/2	0V
Manchester	High-to-Low	Low-to-High

Mnemonic

"NRZ-Simple, RZ-Return, Manchester-Transition - SRT"

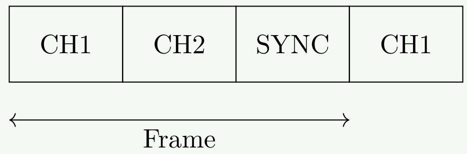
Question 5 [a marks]

3 Describe concept of Time division digital multiplexing.

Solution

Answer:
TDM Concept: Multiple signals transmitted by allocating different time slots.

Frame Structure:



Mnemonic

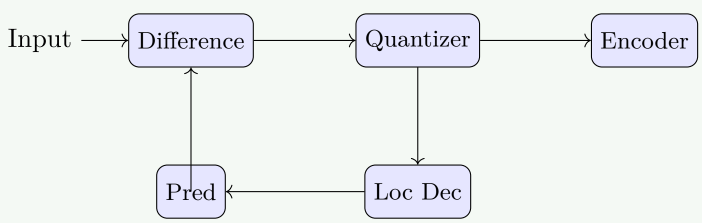
"Time slots Share Single Channel - TSSC"

Question 5 [b marks]

4 Write short note on Differential PCM (DPCM).

Solution

Answer:
DPCM Block Diagram:



Idea: Use prediction to transmit only difference signal, reducing bit rate.

Mnemonic

"Predict Difference, Quantize Less - PDQL"

Question 5 [c marks]

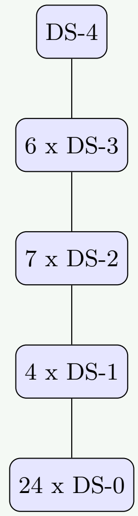
7 Write short note on 4 level digital multiplexing Hierarchy.

Solution

Answer:
Level Structure:

Level	Bit Rate	Voice Ch	Name
Level 0	64 kbps	1	DS-0
Level 1	1.544 Mbps	24	T1
Level 2	6.312 Mbps	96	T2
Level 3	44.736 Mbps	672	T3

Multiplexing Structure:



Mnemonic

"0-1-2-3 levels Build Communication Systems - DS-BCS"