Subject Name Solutions

1333201 – Summer 2025

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Define AM, FM and PM.

Solution

Modulation Type	Definition
AM (Amplitude Modulation)	Process where amplitude of carrier signal varies in accordance with the instantaneous amplitude of the message signal
FM (Frequency Modulation)	Process where frequency of carrier signal varies in accordance with the instantaneous amplitude of the message signal
PM (Phase Modulation)	Process where phase of carrier signal varies in accordance with the instantaneous amplitude of the message signal

Mnemonic

"AFaP" - "Amplitude, Frequency and Phase" are the three parameters changed during modulation.

Question 1(b) [4 marks]

Explain block diagram of communication system.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Information Source] {-{-}{} B[Transmitter]}
    B {-{-}{} C[Channel]}
    C {-{-}{} D[Receiver]}
    D {-{-}{} E[Destination]}
    F[Noise Source] {-{-}{} C}
{Highlighting}
{Shaded}
```

Components of Communication System:

- **Information Source**: Produces message to be communicated
- **Transmitter**: Converts message to signals suitable for transmission
- **Channel**: Medium through which signals travel
- **Receiver**: Extracts original message from received signal
- **Destination**: Person/device for whom message is intended
- **Noise Source**: Unwanted signals that interfere with transmitted signal

Mnemonic

"I Transmit Communication Reliably Despite Noise"

Question 1(c) [7 marks]

Explain Amplitude modulation with waveform and derive voltage equation for modulated signal also Sketch the frequency spectrum of the DSBFC AM.

Solution

Amplitude Modulation is the process where the amplitude of a high-frequency carrier wave varies according to the instantaneous value of the modulating signal.

Waveform and Equation:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph Amplitude Modulation
    A["Message Signal m(t) = Am cos( m·t)"]
    B["Carrier Signal c(t) = Ac cos( c·t)"]
    C["AM Signal s(t) = Ac[1 +  ·cos( m·t)]cos( c·t)"]
    end
{Highlighting}
{Shaded}
```

Derivation of AM equation:

- Carrier signal: c(t) = Ac cos(c · t)
- Modulating signal: m(t) = Am cos(m · t)
- Modulation Index: = Am/Ac
- AM signal: s(t) = Ac[1 + · cos(m · t)]cos(c · t)
- Expanding: s(t) = Ac · cos(c · t) + · Ac/2 · cos[(c+ m)t] + · Ac/2 · cos[(c- m)t]

DSBFC AM Frequency Spectrum:

```
    |
    |       Carrier
    |         |
    |         |
    |         |
    |    LSB  |   USB
    |     |   |    |
    |\_\_\_\_\_|\_\_\_\_|\_\_\_\_|\_\_\_\_\_
         fc{-fm fc  fc+fm}
```

Key Points:

- **LSB (Lower Sideband)**: Located at fc-fm
- **USB (Upper Sideband)**: Located at fc+fm
- **Bandwidth**: 2fm (twice the highest modulating frequency)

Mnemonic

"CARrying Two SideBands" - DSBFC AM carries both sidebands.

Question 1(c OR) [7 marks]

Derive the equation for total power in AM, calculate percentage of power savings in DSBFC And SSBSC.

Solution

Total Power in AM:
For AM signal s(t) = Ac[1 + · cos(m · t)]cos(c · t)

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph AM Power Distribution
    A[Carrier Power: Pc = Ac^{2/2]}
    B[Total Sideband Power: PUSB + PLSB = Pc· ^{2/2]}
    C["Total Power: Pt = Pc(1 +  ^{2/2)"]}
    end
{Highlighting}
{Shaded}
```

Power Calculation:

- Carrier Power: Pc = $Ac^2/2$
- Power in each sideband: PUSB = PLSB = Pc · $^2/4$
- Total Sideband Power: PUSB + PLSB = Pc · $^2/2$
- Total Power: Pt = Pc + PUSB + PLSB = Pc(1 + $^2/2$)

Power Savings:

Modulation	Power Distribution	Power Savings
DSBFC AM	Uses carrier + both sidebands	0% (reference)
SSBSC AM	Uses only one sideband, no carrier	(2 - $^2/2$)/(1 + $^2/2$) × 100%

For = 1, SSBSC saves approximately 85% power compared to DSBFC.

Mnemonic

"SSB Saves Power By Cutting Carrier"

Question 2(a) [3 marks]

Compare AM and FM.

Solution

Parameter	AM	FM
Definition	Amplitude of carrier varies with message signal	Frequency of carrier varies with message signal
Bandwidth	$2 \times messagefrequency$	$2 \times (f + fm)$
Noise Immunity	Poor (noise affects amplitude)	Excellent (noise mainly affects amplitude)
Power Efficiency	Low (carrier contains most power)	High (all transmitted power contains information)
Circuit Complexity	Simple, inexpensive	Complex, expensive

Mnemonic

"AM Needs Power, FM Fights Noise"

Question 2(b) [4 marks]

Draw and explain block diagram for envelope detector.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[AM Signal Input] {-{-}{} B[Diode]}
    B {-{-}{} C[RC Circuit]}
    C {-{-}{} D[Output Signal]}
{Highlighting}
{Shaded}
```

Components of Envelope Detector:

- **Diode**: Rectifies the AM signal (allows current flow in one direction)
- **RC Circuit**: R and C values chosen such that:
  - RC » 1/fc (to filter carrier frequency)
  - RC « 1/fm (to follow the envelope)

Working:

1. Diode conducts during positive half-cycles of carrier
2. Capacitor charges to peak value
3. When input falls, capacitor discharges through resistor
4. Output follows envelope of AM signal

Mnemonic

"Detect, Rect, and Connect" - Detection through Rectification and RC connection.

Question 2(c) [7 marks]

Draw block diagram of FM radio receiver and explain working of each block.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Antenna] {-{-}{} B[RF Amplifier]}
    B {-{-}{} C[Mixer]}
    E[Local Oscillator] {-{-}{} C}
    C {-{-}{} D[IF Amplifier]}
    D {-{-}{} F[Limiter]}
    F {-{-}{} G[FM Detector]}
    G {-{-}{} H[Audio Amplifier]}
    H {-{-}{} I[Speaker]}
{Highlighting}
{Shaded}
```

Working of Each Block:

- **Antenna**: Receives FM broadcast signals (88-108 MHz)
- **RF Amplifier**: Amplifies weak RF signals, provides selectivity
- **Mixer & Local Oscillator**: Converts RF to fixed IF (10.7 MHz) using heterodyning
- **IF Amplifier**: Provides most of receiver's gain and selectivity
- **Limiter**: Removes amplitude variations from FM signal
- **FM Detector**: Converts frequency variations to audio (uses ratio detector/PLL)
- **Audio Amplifier**: Amplifies recovered audio signal
- **Speaker**: Converts electrical signals to sound

Mnemonic

"Really Mighty Instruments Limit Frequency And Make Sound"

Question 2(a OR) [3 marks]

Define Sensitivity, Selectivity, Fidelity for radio receiver.

Solution

Parameter	Definition
Sensitivity	Ability of receiver to amplify weak signals (measured in V)
Selectivity	Ability to separate desired signal from adjacent signals
Fidelity	Ability to reproduce the original signal without distortion

Mnemonic

"SSF" - "Select Signals Faithfully"

Question 2(b OR) [4 marks]

Explain ratio detector for FM.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[FM Input] {-{-}{} B[Secondary Winding]}
    B {-{-}{} C[Diode D1]}
    B {-{-}{} D[Diode D2]}
    C {-{-}{} E[Capacitor C1]}
    D {-{-}{} F[Capacitor C2]}
    E {-{-}{} G[Output]}
    F {-{-}{} G}
    E {-{-}{} H[Stabilizing Capacitor C3]}
    F {-{-}{} H}
{Highlighting}
{Shaded}
```

Working of Ratio Detector:

- Uses balanced circuit with two diodes in series
- Large stabilizing capacitor keeps sum of voltages constant
- Output voltage is proportional to frequency deviation
- Inherently insensitive to amplitude variations (no limiter needed)
- Less susceptible to impulse noise than discriminator

Mnemonic

"RADS" - "Ratio And Diodes Stabilize"

Question 2(c OR) [7 marks]

Draw block diagram of AM radio receiver and explain working of each block.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Antenna] {-{-}{} B[RF Amplifier]}
    B {-{-}{} C[Mixer]}
    E[Local Oscillator] {-{-}{} C}
    C {-{-}{} D[IF Amplifier]}
    D {-{-}{} F[Detector]}
    F {-{-}{} G[AGC]}
    G {-{-}{} B}
    G {-{-}{} D}
    F {-{-}{} H[Audio Amplifier]}
    H {-{-}{} I[Speaker]}
{Highlighting}
{Shaded}
```

Working of Each Block:

- **Antenna**: Intercepts AM broadcast signals (535-1605 kHz)
- **RF Amplifier**: Amplifies weak RF signals with good SNR
- **Mixer & Local Oscillator**: Converts RF to fixed IF (455 kHz)
- **IF Amplifier**: Provides most gain and selectivity at 455 kHz
- **Detector**: Extracts audio from AM signal (envelope detector)
- **AGC (Automatic Gain Control)**: Maintains constant output level
- **Audio Amplifier**: Boosts detected audio to drive speaker
- **Speaker**: Converts electrical signals to sound waves

Mnemonic

"ARMIDAS" - "Amplify, Mix, IF, Detect, Audio, Speak"

Question 3(a) [3 marks]

Describe the Nyquist criteria.

Solution

Nyquist Criteria: To accurately reconstruct a signal from its samples, the sampling frequency (fs) must be at least twice the highest frequency (fmax) present in the signal.

Parameter	Formula	Description
Nyquist Rate	fs $\geq 2fmax$	Minimum sampling rate required
Nyquist Interval	Ts $\leq 1/2fmax$	Maximum time between samples

Consequence if violated: Aliasing occurs - higher frequencies appear as lower frequencies in sampled signal.

Mnemonic

"Sample Double to Dodge Aliasing"

Question 3(b) [4 marks]

Explain Sample and hold Circuit with Waveform.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Analog Input] {-{-}{} B[Electronic Switch]}
    C[Clock] {-{-}{} B}
    B {-{-}{} D[Capacitor]}
    D {-{-}{} E[Buffer]}
    E {-{-}{} F[Output]}
{Highlighting}
{Shaded}
```

Sample and Hold Circuit Operation:

- **Electronic Switch**: Closes briefly during sampling
- **Capacitor**: Stores sampled voltage
- **Buffer Amplifier**: Provides high input impedance and low output impedance

Waveform:

Applications:

- Analog-to-Digital Conversion
- Data Acquisition Systems
- Pulse Amplitude Modulation

Mnemonic

"SCAB" - "Switch, Capacitor And Buffer"

Question 3(c) [7 marks]

Define quantization explain uniform and non-uniform quantization in details.

Solution

Quantization: Process of mapping a large set of input values to a smaller set of discrete output values.

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Continuous Amplitude] {-{-}{} B[Discrete Amplitude]}
    B {-{-}{} C[Digital Code]}
{Highlighting}
{Shaded}
```

Uniform Quantization vs Non-uniform Quantization:

Parameter	Uniform Quantization	Non-uniform Quantization
Step Size	Equal throughout range	Varies (smaller for small signals)
Characteristic	Linear	Non-linear (logarithmic/exponential)
SNR	Poor for small signals	Better for small signals
Implementation	Simple	Complex (companding required)
Applications	Simple signals, images	Speech, audio (-law, A-law)

Quantization Error:

- Difference between original and quantized signal
- Maximum error = /2 (where Q is quantization step size)
- Appears as quantization noise in reconstructed signal

Mnemonic

"UNIQ" - "UNIform has equal steps, non-uniform Quiets noise"

Question 3(a OR) [3 marks]

Explain aliasing error and how to overcome it.

Solution

Aliasing Error: Distortion that occurs when a signal is sampled at a rate lower than twice its highest frequency component.

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Aliasing Error]
    A {-{-}{} B[Original high frequencies appear as false low frequencies]}
    A {-{-}{} C[Causes distortion that cannot be removed after sampling]}
{Highlighting}
{Shaded}
```

How to Overcome Aliasing:

- Use anti-aliasing filter (low-pass) before sampling
- Increase sampling rate above Nyquist rate (fs > 2fmax)
- Bandlimit the input signal before sampling

Mnemonic

"ALIAS" - "Avoid Low sampling by Increasing And Screening"

Question 3(b OR) [4 marks]

Draw following signal in time domain and frequency domain: 1) Sawtooth signal 2) Pulse signal

Solution

Sawtooth Signal:
Time Domain:

```
    /|  /|  /|  /|
   / | / | / | / |
  /  |/  |/  |/  |
     T   2T  3T
```

Frequency Domain:

```
    |
    |
    |{}
    | {}
    |  {}
    |   {}
    |\_\_\_\_{\_\_\_\_\_\_\_\_\_\_\_\_}
    0  f0 2f0 3f0 4f0
```

Pulse Signal:
Time Domain:

```
    | |      | |      | |
    |  |      |  |      |  |
\_\_\_\_|\_|\_\_\_\_\_|\_|\_\_\_\_\_|\_|\_\_\_\_
    T       2T      3T
```

Frequency Domain:

```
    |
    |    sinc function
    |{       /}
    | {     /  }
    |  {\_\_\_/    \_\_\_\_}
    |
    |\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    0   f0    2f0    3f0
```

Mnemonic

"STPF" - "SawTooth slopes down, Pulse has sinc Function"

Question 3(c OR) [7 marks]

Compare PAM, PWM and PPM with waveform.

Solution

Parameter	PAM	PWM	PPM
Full Form	Pulse Amplitude Modulation	Pulse Width Modulation	Pulse Position Modulation
Parameter Varied	Amplitude of pulses	Width/duration of pulses	Position/timing of pulses
Noise Immunity	Poor	Good	Excellent
Bandwidth	Lower	Higher	Highest
Power Efficiency	Low	Medium	High
Demodulation	Simple	Moderate	Complex

Waveforms:

```
Message:    /\/\/\

PAM:        ||  ||   || ||  ||   ||
            ||  ||   || ||  ||   ||

PWM:        ||||| |||  || ||||| |||  ||

PPM:        ||  ||   || ||  ||   ||
            |--|---||-|--|---||
```

Mnemonic

"APP" - "Amplitude, Pulse-width, Position"

Question 4(a) [3 marks]

Explain Space wave propagation.

Solution

Space Wave Propagation: Mode where radio waves travel through lower atmosphere (troposphere) directly or via ground reflection.

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
```

```
graph LR
    A[Transmitter] {-{-}{} B[Direct Wave]}
    A {-{-}{} C[Ground Reflected Wave]}
    B {-{-}{} D[Receiver]}
    C {-{-}{} D}
{Highlighting}
{Shaded}
```

Characteristics:

- Frequency range: VHF, UHF (30 MHz - 3 GHz)
- Limited to line-of-sight distance
- Range $= 4.12(_1 + _2) km (where h_1, h_2 = heights in meters)$
- Affected by terrain, buildings, and atmospheric conditions

Mnemonic

"SLOT" - "Straight Line Over Terrain"

Question 4(b) [4 marks]

Explain working of Differential PCM (DPCM) transmitter.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input Signal] {-{-}{} B[Quantizer]}
    B {-{-}{} C[Encoder]}
    C {-{-}{} D[Output DPCM]}
    C {-{-}{} E[Inverse Quantizer]}
    E {-{-}{} F[Predictor]}
    F {-{-} Predicted value {-}{-}{} G\{Subtractor\}}
    A {-{-}{} G}
    G {-{-} Difference {-}{-}{} B}
{Highlighting}
{Shaded}
```

Working of DPCM Transmitter:

- **Predictor**: Estimates current sample based on previous samples
- **Subtractor**: Computes difference between actual and predicted value
- **Quantizer**: Converts difference signal to discrete levels
- **Encoder**: Converts quantized values to binary code
- **Feedback Loop**: Reconstructs signal as receiver would see it

Advantage: Only difference signal is transmitted, which requires fewer bits

Mnemonic

"SPEQIF" - "Subtract, Predict, Encode, Quantize In Feedback"

Question 4(c) [7 marks]

Explain delta modulator in details also explain slop overload noise and granular noise.

Solution

Delta Modulation (DM): Simplest form of differential PCM where the difference signal is encoded with just 1 bit.

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input Signal] {-{-}{} B\{Comparator\}}
    B {-{-}{} C[1{-}bit Quantizer]}
    C {-{-}{} D[Output DM] }
    C {-{-}{} E[Integrator]}
    E {-{-} Predicted value {-}{-}{} B}
{Highlighting}
{Shaded}
```

Working Principle:

- Compares input signal with integrated version of previous output
- If input > integrated value: transmit 1
- If input < integrated value: transmit 0
- Step size ( ) is fixed

Noise in Delta Modulation:

Type of Noise	Cause	Solution
Slope Overload Noise	Input signal changes faster than can track	Increase step size or sampling frequency
Granular Noise	Step size too large for slowly varying signals	Decrease step size

Mnemonic

"DOGS" - "Delta modulation has Overload and Granular noiseS"

Question 4(a OR) [3 marks]

Explain Ground wave propagation.

Solution

Ground Wave Propagation: Radio wave propagation that follows the curvature of the Earth.

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Transmitter] {-{-}{} B[Ground Wave]}
    B {-{-}{} C[Receiver]}
    D[Earth Surface] {-{-}{-} B}
{Highlighting}
{Shaded}
```

Characteristics:

- Frequency range: LF, MF (30 kHz - 3 MHz)
- Propagates along Earth's surface (vertically polarized)
- Range depends on transmitter power, ground conductivity, frequency
- Signal strength decreases with distance and frequency
- Used for AM broadcasting, marine communication

Mnemonic

"GEL" - "Ground waves follow Earth at Low frequencies"

Question 4(b OR) [4 marks]

Explain ADM transmitter.

Solution

Adaptive Delta Modulation (ADM): Improved version of DM where step size varies according to signal characteristics.

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input Signal] {-{-}{} B\{Comparator\}}
    B {-{-}{} C[1{-}bit Quantizer]}
    C {-{-}{} D[Output ADM]}
    C {-{-}{} E[Step Size Controller]}
    E {-{-}{} F[Integrator]}
    F {-{-} Predicted value {-}{-}{} B}
{Highlighting}
{Shaded}
```

Working of ADM Transmitter:

- **Basic Operation**: Similar to standard DM
- **Step Size Control**: Analyzes recent output bits
- **Adaptation Logic**:
  - If consecutive bits are same: Increase step size
  - If consecutive bits alternate: Decrease step size

Advantages over DM:

- Reduces both slope overload and granular noise
- Better signal tracking
- Improved SNR

Mnemonic

"ASIC" - "Adapt Step-size, Improve Coding"

Question 4(c OR) [7 marks]

Explain Block diagram of basic PCM-TDM system.

Solution

PCM-TDM System: Combines Pulse Code Modulation with Time Division Multiplexing to transmit multiple digital signals over single channel.

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    subgraph "Transmitter"
    A1[Analog Input 1] {-{-}{} B1[Sample \& Hold]}
    A2[Analog Input 2] {-{-}{} B2[Sample \& Hold]}
    A3[Analog Input n] {-{-}{} B3[Sample \& Hold]}
    B1 {-{-}{} C[Multiplexer]}
    B2 {-{-}{} C}
    B3 {-{-}{} C}
    C {-{-}{} D[Quantizer]}
    D {-{-}{} E[Encoder]}
    E {-{-}{} F[Frame Formatter]}
    end
```

```
    F {-{-}{} G[Transmission Channel]}

    subgraph "Receiver"
    G {-{-}{} H[Frame Synchronizer]}
    H {-{-}{} I[Decoder]}
    I {-{-}{} J[Demultiplexer]}
    J {-{-}{} K1[LPF 1]}
    J {-{-}{} K2[LPF 2]}
    J {-{-}{} K3[LPF n]}
    K1 {-{-}{} L1[Output 1]}
    K2 {-{-}{} L2[Output 2]}
    K3 {-{-}{} L3[Output n]}
    end
{Highlighting}
{Shaded}
```

Working of PCM-TDM System:

- **Transmitter**:
  - Multiple analog signals sampled simultaneously
  - Samples time-multiplexed into single stream
  - Stream quantized and encoded into PCM format
  - Framing bits added for synchronization
- **Receiver**:
  - Frame sync detected for alignment
  - PCM stream decoded to recover samples
  - Demultiplexer separates individual channel samples
  - Low-pass filters reconstruct original analog signals

Mnemonic

"SAMPLE-CODE-MUX" - Sampling, Coding, and Multiplexing

Question 5(a) [3 marks]

Define radiation pattern, Directivity and Gain for antenna.

Solution

Parameter	Definition
Radiation Pattern	Graphical representation of radiation properties (field strength or power) as function of space coordinates
Directivity	Ratio of maximum radiation intensity to average radiation intensity
Gain	Product of directivity and efficiency (practical measure of antenna performance)

Relationship: Gain = Directivity $\times Efficiency$

Mnemonic

"RDG" - "Radiation Directs with Gain"

Question 5(b) [4 marks]

Explain Microstrip Antenna with sketch.

Solution

Microstrip (Patch) Antenna: Low-profile antenna consisting of a metal patch on a substrate with ground plane.

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph "Microstrip Antenna Structure"
    direction LR
    A[Radiating Patch]
    B[Dielectric Substrate]
    C[Ground Plane]
    D[Feed Point]

    A {-{-}{-} B}
    B {-{-}{-} C}
    D {-{-}{-} A}
    end
{Highlighting}
{Shaded}
```

Key Features:

- **Patch**: Typically rectangular or circular (/2 in length)
- **Substrate**: Low-loss dielectric material (r = 2.2 to 12)
- **Feeding Methods**: Microstrip line, coaxial probe, aperture coupling
- **Radiation**: Primarily from fringing fields at patch edges

Applications: Mobile devices, GPS, RFID, satellite communications

Mnemonic

"PSDG" - "Patch on Substrate with Dielectric over Ground"

Question 5(c) [7 marks]

Explain PCM transmitter and receiver in details.

Solution

PCM (Pulse Code Modulation) Transmitter:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Analog Input] {-{-}{} B[Anti{-}aliasing Filter]}
    B {-{-}{} C[Sample \& Hold]}
    C {-{-}{} D[Quantizer]}
    D {-{-}{} E[Encoder]}
    E {-{-}{} F[Parallel to Serial]}
    F {-{-}{} G[Line Coder]}
    G {-{-}{} H[PCM Output]}
{Highlighting}
{Shaded}
```

PCM Receiver:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
```

```
graph LR
    A[PCM Input] {-{-}{} B[Regenerative Repeater]}
    B {-{-}{} C[Line Decoder]}
    C {-{-}{} D[Serial to Parallel]}
    D {-{-}{} E[Decoder]}
    E {-{-}{} F[Reconstruction Filter]}
    F {-{-}{} G[Analog Output]}
{Highlighting}
{Shaded}
```

Working Details:

Block	Function
Anti-aliasing Filter	Limits bandwidth to prevent aliasing
Sample & Hold	Takes samples at regular intervals
Quantizer	Assigns discrete amplitude levels
Encoder	Converts levels to binary codes
Line Coder	Converts digital data to transmission format
Regenerative Repeater	Restores signal quality
Decoder	Converts binary to amplitude levels
Reconstruction Filter	Smoothens staircase output to analog

Mnemonic

"SAFE PCR" - "Sample, Amplify, Filter, Encode, Pulse Code Receiver"

Question 5(a OR) [3 marks]

Explain dipole antenna with sketch.

Solution

Dipole Antenna: Simplest and most widely used antenna consisting of two conducting elements.

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Feed Point] {-{-}{-} B[ /4 Wire]}
    A {-{-}{-} C[ /4 Wire]}
    D[Total Length =  /2] {-.{-}{} B}
    D {-.{-}{} C}
{Highlighting}
{Shaded}
```

Key Characteristics:

- **Length**: Typically /2 (half-wavelength dipole)
- **Radiation Pattern**: Figure-8 pattern perpendicular to antenna axis
- **Impedance**: ~73 Ω for half-wave dipole
- **Polarization**: Same as the orientation of the antenna

Applications: Radio broadcasting, TV reception, amateur radio

Mnemonic

"HALF" - "Half-wavelength Antenna Leads Field"

Question 5(b OR) [4 marks]

Explain parabolic reflector antenna With Sketch.

Solution

Parabolic Reflector Antenna: High-gain antenna using parabolic dish to focus electromagnetic waves.

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Feed Horn] {-{-}{} B[Parabolic Reflector]}
    B {-{-}{} C[Focused Beam]}
    D[Focal Point] {-.{-}{} A}
{Highlighting}
{Shaded}
```

Working Principle:

- **Feed**: Located at focal point of parabola
- **Reflector**: Parabolic surface reflects waves in parallel direction
- **Reflection Property**: All paths from focal point to reflector to parallel line are equal

Applications:

- Satellite communications
- Radio astronomy
- Radar systems
- Microwave links

Mnemonic

"PROF" - "Parabola Reflects On Focus"

Question 5(c OR) [7 marks]

Compare PCM, DM, ADM and DPCM.

Solution

Parameter	PCM	DM	ADM	DPCM
Full Form	Pulse Code Modulation	Delta Modulation	Adaptive Delta Modulation	Differential PCM
Bits per Sample	8-16 bits	1 bit	1 bit	3-4 bits
Step Size	Fixed quantization levels	Fixed step size	Variable step size	Fixed quantization of difference
Bandwidth Requirement	Highest	Lowest	Low	Medium
Signal Quality	Excellent	Poor to moderate	Moderate	Good
Implementation Complexity	Moderate	Very simple	Moderate	Complex
Applications	Digital audio, telephony	Simple telemetry	Voice communication	Video, speech

Key Differences:

- **PCM**: Encodes absolute amplitude values
- **DM**: Encodes only 1-bit difference with fixed step
- **ADM**: Improves DM by adapting step size
- **DPCM**: Encodes multi-bit difference signal

Mnemonic

"PAID" - "PCM, ADM, Integrate in DPCM"