Subject Name Solutions

4341106 – Winter 2023

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Define: (1) Directivity, (2) Gain, and (3) HPBW

Solution

Table 1: Key Antenna Parameters

Parameter	Definition
Directivity	Ratio of maximum radiation intensity to average radiation intensity of an antenna
Gain	Ratio of power radiated in a particular direction to the power that would be radiated by an isotropic antenna
HPBW (Half Power Beam Width)	Angular width where radiation intensity is half (3dB less) of the maximum value

Mnemonic

"DGH: Direction Gives Half-power"

Question 1(b) [4 marks]

List the properties of electromagnetic waves

Solution

Table 2: Properties of Electromagnetic Waves

Property	Description
Transverse Waves	Electric and magnetic fields perpendicular to direction of propagation
Velocity	Speed of light (3×10ˆ$8m/s)invacuum$
No Medium Required	Can travel through vacuum, unlike mechanical waves
Polarization	Direction of electric field vector
Energy Transport	Carries energy through space
Reflection/Refraction	Can be reflected and refracted at boundaries
Interference/Diffraction	Show wave-like properties

Mnemonic

"TVNPER: Transverse Velocity No-medium Polarized Energy Reflection"

Question 1(c) [7 marks]

Explain physical concept of generation of Electromagnetic wave

Solution

Diagram: Generation of Electromagnetic Wave

Mermaid Diagram (Code)

```
{Shaded}
```

```
{Highlighting}[]
graph LR
    A[Accelerating Charge] {-{-}{}|Produces| B[Time{-}varying Electric Field]}
    B {-{-}{}|Produces| C[Time{-}varying Magnetic Field]}
    C {-{-}{}|Produces| D[Time{-}varying Electric Field]}
    D {-{-}{} C}
    C {-{-}{} E[Self{-}sustaining EM Wave]}
{Highlighting}
{Shaded}
```

- **Charge Acceleration**: When electric charges accelerate, they generate changing electric fields
- **Field Coupling**: A changing electric field produces a changing magnetic field and vice versa
- **Self-Propagation**: This cyclic generation of fields allows waves to travel without a medium
- **Field Orientation**: Electric and magnetic fields are perpendicular to each other and the direction of propagation
- **Energy Transport**: Energy alternates between electric and magnetic fields as wave propagates

Mnemonic

"CASES: Charge Acceleration Self-propagates Electro-magnetic Signals"

Question 1(c) OR [7 marks]

Explain how electromagnetic field radiated from a center fed dipole

Solution

Diagram: Field Radiation from Center-Fed Dipole

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Alternating Current Input] {-{-}{}|Creates| B[Oscillating Charges]}
    B {-{-}{}|Generates| C[Time{-}varying Electric Field]}
    C {-{-}{}|Generates| D[Time{-}varying Magnetic Field]}
    C {-{-}{} E[EM Wave Radiation]}
    D {-{-}{} E}
{Highlighting}
{Shaded}
```

- **Center Feeding**: AC signal applied at center of dipole creates oscillating current
- **Charge Distribution**: Current creates opposite charges at dipole ends that change with AC frequency
- **Field Generation**: Oscillating charges create time-varying electric field
- **Magnetic Coupling**: Time-varying electric field generates perpendicular magnetic field
- **Near/Far Fields**: Near dipole, fields are complex; far from dipole, fields form uniform radiation pattern
- **Radiation Pattern**: Maximum radiation perpendicular to dipole axis, zero radiation along axis

Mnemonic

"CORONA: Current Oscillates, Radiation Occurs, Near-far Areas"

Question 2(a) [3 marks]

Differentiate the resonant and non-resonant antennas

Solution

Table 3: Resonant vs Non-Resonant Antennas

Feature	Resonant Antennas	Non-Resonant Antennas
Length	Integer multiple of /2	Not related to wavelength
Standing Waves	Present	Not present
Impedance	Resistive (real)	Complex (real + imaginary)
Bandwidth	Narrow	Wide
Example	Half-wave dipole	Rhombic antenna

Mnemonic

"RESI: Resonant Exhibits Standing-waves Impedance-real"

Question 2(b) [4 marks]

Explain Yagi antenna and discuss its radiation characteristics

Solution

Diagram: Yagi-Uda Antenna Structure

```
   Reflector    Driven    Directors
     (R)       Element      (D)
      |          (DE)     |  |  |
      |           |       |  |  |
 {-{-}{-}{-}{-}|{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}|{-}{-}{-}{-}{-}{-}{-}|{-}{-}|{-}{-}|{-}{-}{-}{-}{-}{-
      |           |       |  |  |         Maximum Radiation
      |           |       |  |  |


   Longest        /2     Shortest
```

- **Structure**: Contains one reflector, one driven element, and multiple directors
- **Directivity**: High directivity in direction of directors (8-12dB)
- **Gain**: Higher gain with more directors (up to 15dB)
- **Bandwidth**: 2-5% of center frequency
- **Applications**: TV reception, point-to-point communication, amateur radio

Mnemonic

"DRAGONS: Directional Reflector And Gain-improving Directors Offer Narrow Signals"

Question 2(c) [7 marks]

Describe radiation characteristics of resonant wire antennas and draw the current distribution of /2, 3 /2 and 5 /2 antenna

Solution

Diagram: Current Distribution in Resonant Wire Antennas

```
 /2 Antenna:
     +{-{-}{-}{-}{-}{-}{-}+}
     |        |
     v        v
 {-{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}}
     \^{        \^{}}
     |        |
     +{-{-}{-}{-}{-}{-}{-}+}
     I\_max at center
     Zero at ends

3 /2 Antenna:
```

```
     +{-{-}{-}+{-}{-}{-}+{-}{-}{-}+}
     |   |   |   |
     v   \^{   v   \^{}}
 {-{-}{-}{-}+{-}{-}{-}+{-}{-}{-}+{-}{-}{-}+{-}{-}{-}{-}}
     \^{   v   \^{}   v}
     |   |   |   |
     +{-{-}{-}+{-}{-}{-}+{-}{-}{-}+}
     3 current nodes

5 /2 Antenna:
     +{-{-}{-}+{-}{-}{-}+{-}{-}{-}+{-}{-}{-}+{-}{-}{-}+}
     |   |   |   |   |   |
     v   \^{   v   \^{}   v   \^{}}
 {-{-}{-}{-}+{-}{-}{-}+{-}{-}{-}+{-}{-}{-}+{-}{-}{-}+{-}{-}{-}+{-}{-}{-}{-}}
     \^{   v   \^{}   v   \^{}   v}
     |   |   |   |   |   |
     +{-{-}{-}+{-}{-}{-}+{-}{-}{-}+{-}{-}{-}+{-}{-}{-}+}
     5 current nodes
```

- **Half-Wave (/2)**: Current maximum at center, zero at ends; radiation pattern is figure-eight shaped
- **Three Half-Wave (3 /2)**: Three current maxima, phase reversal at /2 points; multiple lobes in radiation pattern
- **Five Half-Wave (5 /2)**: Five current maxima, more complex radiation pattern with multiple lobes
- **Standing Waves**: All resonant antennas exhibit standing wave current distribution
- **Feed Point**: Usually at current maximum for optimum impedance matching

Mnemonic

"NODE: Number Of Distributions Equals wavelength-multiple"

Question 2(a) OR [3 marks]

Differentiate the broad side and end fire array antennas

Solution

Table 4: Broadside vs End Fire Array Antennas

Feature	Broadside Array	End Fire Array
Maximum Radiation	Perpendicular to array axis	Along array axis
Element Spacing	Typically /2	Typically /4 to /2
Phase Difference	$0°(in-phase)$	$180°(oppositephase)$
Directivity	High	High
Pattern	Bidirectional	Unidirectional

Mnemonic

"PEPS: Perpendicular Elements Produce Sideways radiation"

Question 2(b) OR [4 marks]

Explain loop antenna and discuss its radiation characteristics

Solution

Diagram: Loop Antenna

```
    +{-{-}{-}{-}+}
    |     |
    |     |
```

```
+{-{-}{-}+     +{-}{-}{-}+}
|              |
+{-{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}+}
       |
     Feed
     Point
```

- **Structure**: Closed-loop conductor with circumference of one wavelength or less
- **Types**: Small loops (circumference < /10) and large loops (circumference ≈)
- **Polarization**: Electric field polarized in plane of loop
- **Radiation Pattern**: Figure-eight pattern for small loops, more directional for large loops
- **Applications**: Direction finding, AM reception, RFID tags
- **Impedance**: High impedance for small loops, resonant for large loops

Mnemonic

"SPIRAL: Small Patterns In Receiving And Locating signals"

Question 2(c) OR [7 marks]

Describe radiation characteristics of non resonant wire antennas and draw the radiation pattern of /2, 3 /2 and 5 /2 antenna

Solution

Diagram: Radiation Patterns of Wire Antennas

```
 /2 Antenna Pattern:

    \^{}
    |     .{-.}
    |    /   {}
    |   |     |
{-{-}{-}{-}+{-}{-}{-}+{-}{-}{-}{-}{-}+{-}{-}{-}{-}}
    |   |     |
    |    {   /}
    |     {{-}}
    v

3 /2 Antenna Pattern:

    \^{}
    |    .{-. .{-}.}
    |   /   X   {}
    |  |  / {    |}
{-{-}{-}{-}+{-}{-}+{-}+{-}{-}{-}+{-}+{-}{-}{-}{-}}
    |  |  { /    |}
    |   {   X   /}
    |    {{-} {-}}
    v

5 /2 Antenna Pattern:

    \^{}
    |  .{-. .{-}. .{-}.}
    | /   X   X   {}
    ||  / { /     |}
{-{-}{-}{-}++{-}+{-}{-}{-}+{-}{-}{-}+{-}+{-}{-}}
    ||  { /  /    |}
    | {   X   X   /}
    |  {{-} {-} {-}}
    v
```

- **Non-Resonant Properties**: Traveling waves rather than standing waves
- **/2 Antenna**: Simple bidirectional pattern, maximum radiation perpendicular to wire
- **3 /2 Antenna**: Multiple lobes, more complex pattern with side lobes
- **5 /2 Antenna**: Even more complex pattern with multiple main and side lobes
- **Feed Point Impedance**: Non-resonant, typically requires impedance matching
- **Bandwidth**: Wider than resonant antennas

Mnemonic

"TWIST: Traveling Waves Increase Side-lobe Transmission"

Question 3(a) [3 marks]

Write short note on micro strip (patch) antenna

Solution

Diagram: Microstrip Patch Antenna Structure

```
+{-{-}{-}{-}{-}{-}{-}+}
|       |
| Patch |
|       |
+{-{-}{-}{-}{-}{-}{-}+}
| Substrate
|
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
|Ground Plane|
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

- **Structure**: Metal patch on dielectric substrate with ground plane below
- **Size**: Typically half-wavelength in size
- **Profile**: Low-profile, lightweight, easy to fabricate
- **Radiation**: Radiates from patch edges, omnidirectional or directional patterns
- **Applications**: Mobile devices, satellites, GPS receivers

Mnemonic

"PSALM: Patch Substrate Above Layer of Metal"

Question 3(b) [4 marks]

Explain helical antenna and discuss its radiation characteristics

Solution

Diagram: Helical Antenna

```
     \^{}
      |
    +{-{-}{-}+}
   /     {}
  +       +
 /|       |{}
+ |       | +
| |       | |  {-{-}}
+ |       | +
 {|       |/}
  +       +
   {     /}
    +{-{-}{-}+}
```

```
  Ground Plane
```

- **Structure**: Conducting wire wound in helix shape above ground plane
- **Modes**: Axial mode (end-fire) and normal mode (broadside)
- **Axial Mode**: When circumference $\approx ,radiationalonghelixaxis$
- **Normal Mode**: When circumference « , radiation perpendicular to axis
- **Polarization**: Circular polarization in axial mode
- **Applications**: Satellite communication, space telemetry, radio astronomy

Mnemonic

"MOCHA: Mode Of Circular Helix Antennas"

Question 3(c) [7 marks]

Explain horn antenna and discuss its radiation characteristics

Solution

Diagram: Horn Antenna Types

```
Pyramidal Horn:
    +{-{-}{-}{-}{-}{-}{-}{-}{-}+}
    |        |
    |        |
+{-{-}{-}+        +{-}{-}{-}+}
|                 |
+{-+{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+{-}+}
  |            |
  +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}

Sectoral Horn:
    +{-{-}{-}{-}{-}{-}{-}{-}{-}+}
    |        |
    |        |
+{-{-}{-}+        +{-}{-}{-}+}
|                 |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}

Conical Horn:
      +{-{-}{-}{-}+}
     /      {}
    /        {}
   /          {}
  +            +
  |            |
  +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

- **Structure**: Waveguide with flared end to match impedance with free space
- **Types**: Pyramidal (rectangular), sectoral (E-plane or H-plane), and conical (circular)
- **Directivity**: 10-20 dB, higher than waveguide alone
- **Bandwidth**: Very wide bandwidth
- **Radiation Pattern**: Main lobe with small side lobes
- **Applications**: Microwave communications, radar, satellite tracking, EMC testing
- **Advantages**: High gain, simple construction, low VSWR

Mnemonic

"POWERS: Pyramidal Or Widening End Radiates Strongly"

Question 3(a) OR [3 marks]

Write short note on slot antenna

Solution

Diagram: Slot Antenna

```
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
|                   |
|    +{-{-}{-}{-}{-}{-}{-}{-}+      |}
|    |       |      |
|    |  Slot |      |
|    |       |      |
|    +{-{-}{-}{-}{-}{-}{-}{-}+      |}
|                   |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
 Conducting Surface
```

- **Structure**: Rectangular/circular slot cut in conducting surface
- **Babinet's Principle**: Complementary to dipole antenna
- **Radiation Pattern**: Similar to dipole but with E and H fields interchanged
- **Polarization**: Electric field perpendicular to slot length
- **Impedance**: High impedance compared to dipole
- **Applications**: Aircraft, spacecraft, base stations, flush mounting

Mnemonic

"CROPS: Complementary Radiation Opening Perpendicular to Surface"

Question 3(b) OR [4 marks]

Explain parabolic reflector antenna and discuss its radiation characteristics

Solution

Diagram: Parabolic Reflector Antenna

```
            \^{}
           / {}
          /   {}
         /     {}
        /       {}
       /         {}
      /           {}
     /             {}
    +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
          |  |
          |  |
          +{-{-}+}
          Feed
```

- **Structure**: Parabolic reflector with feed at focal point
- **Working Principle**: Parallel rays from reflector converge at focal point
- **Directivity**: Very high (30-40 dB)
- **Beamwidth**: Very narrow, inversely proportional to diameter
- **Efficiency**: 50-70% depending on feed design
- **Applications**: Satellite communications, radio astronomy, radar systems
- **Types**: Prime focus, Cassegrain, offset feed

Mnemonic

"DISH: Directing Incoming Signals to Hub"

Question 3(c) OR [7 marks]

Describe V and inverted V antenna

Solution

Diagram: V and Inverted V Antennas

```
V Antenna:
       /{}
      /  {}
     /    {}
    /      {}
   /        {}
  +          +
  |          |
  +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
    Feed Point

Inverted V Antenna:
  +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
  |          |
  +          +
   {        /}
    {      /}
     {    /}
      {  /}
       {/}
    Feed Point
```

Table 5: Comparison of V and Inverted V Antennas

Feature	V Antenna	Inverted V Antenna
Shape	Arms extend upward from feed	Arms extend downward from apex
Angle	Typically 90°*betweenarms*	Typically 90-120°*betweenarms*
Height	Requires two tall supports	Requires one tall support
Impedance	40-50 ohms	20-30 ohms
Radiation Pattern	Bidirectional	More omnidirectional
Applications	Directional HF communications	HF amateur radio, limited space

Mnemonic

"VIVA: V Is Vertical Arrangement, Inverted V Aims downward"

Question 4(a) [3 marks]

Define: (1) Reflection, (2) Refraction and (3) Diffraction

Solution

Table 6: Wave Phenomenon Definitions

Phenomenon	Definition
Reflection	Bouncing back of waves when they strike the boundary between two media
Refraction	Bending of waves when they pass from one medium to another with different propagation velocity
Diffraction	Bending of waves around obstacles or through openings

Mnemonic

"RRD: Rebounding, Redirecting, Detour"

Question 4(b) [4 marks]

List HAM radio application for communication

Solution

Table 7: HAM Radio Applications

Application	Description
Emergency Communication	Disaster relief when normal infrastructure fails
DX Communication	Long-distance international communications
Satellite Communication	Using amateur radio satellites for extended range
Digital Modes	Text/data transmission (RTTY, PSK31, FT8)
Morse Code	Traditional CW communication
Voice Communication	Using SSB, FM, AM modulation
Public Service	Supporting events like marathons, parades

Mnemonic

"EDSDMVP: Emergency DX Satellite Digital Morse Voice Public-service"

Question 4(c) [7 marks]

Explain ionosphere's layers and sky wave propagation

Solution

Diagram: Ionospheric Layers and Sky Wave Propagation

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Transmitter] {-{-}{}|Sky Wave| B[F2 Layer: 250{-}400 km]}
    A {-{-}{}|Sky Wave| C[F1 Layer: 150{-}250 km]}
    A {-{-}{}|Sky Wave| D[E Layer: 90{-}150 km]}
    A {-{-}{}|Sky Wave| E[D Layer: 60{-}90 km]}
    B {-{-}{}|Reflection| F[Receiver at long distance]}
    C {-{-}{}|Reflection| F}
    D {-{-}{}|Reflection/Absorption| F}
    E {-{-}{}|Absorption| G[Signal Loss]}
{Highlighting}
{Shaded}
```

- **D Layer (60-90 km)**: Exists during daylight, absorbs HF signals below 10 MHz
- **E Layer (90-150 km)**: Reflects signals 3-5 MHz, stronger during day, sporadic-E in summer
- **F1 Layer (150-250 km)**: Daytime only, merges with F2 at night
- **F2 Layer (250-400 km)**: Main reflecting layer, enables long-distance HF communication
- **Propagation Factors**:
  - **Virtual Height**: Apparent height of reflection
  - **Critical Frequency**: Maximum frequency reflected vertically
  - **MUF**: Maximum Usable Frequency for a given distance
  - **Skip Distance**: Minimum distance for sky wave reception

Mnemonic

"DEFV: D-absorbs, E-reflects, F-provides Very-long-distance"

Question 4(a) OR [3 marks]

Define: (1) MUF, (2) LUF and (3) Skip distance

Solution

Table 8: Ionospheric Propagation Terms

Term	Definition
MUF (Maximum Usable Frequency)	Highest frequency that can be reflected by ionosphere for a given distance and time
LUF (Lowest Usable Frequency)	Lowest frequency that provides adequate signal strength for communication
Skip Distance	Minimum distance from transmitter where sky wave returns to Earth

Mnemonic

"MLS: Maximum-highest, Lowest-minimum, Skip-nearest"

Question 4(b) OR [4 marks]

List HAM radio digital modes of communication

Solution

Table 9: HAM Radio Digital Modes

Digital Mode	Characteristics
FT8	Weak signal, narrow bandwidth, automated exchanges
PSK31	Keyboard-to-keyboard text communication, narrow bandwidth
RTTY	Radio teletype, robust older digital mode
SSTV	Slow Scan Television for image transmission
JT65/JT9	Very weak signal modes for extreme distance
Packet Radio	Computer-based data transmission with error correction
APRS	Automatic Position Reporting System with GPS
Digital Voice	DMR, D-STAR, Fusion, P25 digital voice protocols

Mnemonic

"FIRST PAD: FT8 Is RTTY SSTV Then Packet APRS Digital-voice"

Question 4(c) OR [7 marks]

Explain space wave propagation

Solution

Diagram: Space Wave Propagation

Mermaid Diagram (Code)

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

```
    A {-{-}{}|Tropospheric Scatter| C[Extended Range Receiver]}
    A {-{-}{}|Ducting| D[Very Extended Range]}

    subgraph Troposphere
    A
    B
    C
    D
    E[Temperature Inversion Layer]
    end

    A {-{-}{}|Follows| E {-}{-}{}|Waveguide Effect| D}
{Highlighting}
{Shaded}
```

- **Components**: Direct wave, ground-reflected wave, tropospheric waves
- **Line of Sight**: Primary mechanism limited by Earth's curvature
- **Frequency Range**: VHF, UHF, and microwave frequencies
- **Tropospheric Scattering**: Forward scattering extends range beyond horizon
- **Duct Propagation**:
  - Occurs in temperature inversion layers
  - Creates waveguide effect trapping signals
  - Enables very long distance VHF/UHF propagation
- **Factors Affecting**: Antenna height, terrain, atmospheric conditions
- **Applications**: TV broadcasting, microwave links, mobile communications

Mnemonic

"DRIFT: Direct Reflection Inversion Forward Tropospheric"

Question 5(a) [3 marks]

Define: (1) Beam area (2) Beam efficiency, and (3) Effective aperture

Solution

Table 10: Antenna Beam Parameters

Parameter	Definition
Beam Area	Solid angle through which all power radiated by antenna would flow if radiation intensity was constant
Beam Efficiency	Ratio of power in main beam to total radiated power
Effective Aperture	Area over which antenna captures RF energy, related to gain

Mnemonic

"BEA: Beam Efficiency Aperture"

Question 5(b) [4 marks]

Describe need of smart antenna

Solution

Diagram: Smart Antenna Benefits

Mermaid Diagram (Code)

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

```
graph TD
    A[Smart Antenna] {-{-}{}|Provides| B[Increased Capacity]}
    A {-{-}{}|Provides| C[Enhanced Coverage]}
    A {-{-}{}|Reduces| D[Interference]}
    A {-{-}{}|Improves| E[Signal Quality]}
    A {-{-}{}|Saves| F[Battery Power]}
    A {-{-}{}|Enables| G[Spatial Multiplexing]}
{Highlighting}
{Shaded}
```

- **Capacity Improvement**: Serves more users in same bandwidth
- **Coverage Enhancement**: Extends range by focusing energy
- **Interference Reduction**: Nulls out unwanted signals
- **Signal Quality**: Better SNR through beam focusing
- **Energy Efficiency**: Lower transmit power requirements
- **Spatial Multiplexing**: Multiple data streams in same frequency
- **Adaptive Operation**: Dynamically adapts to changing environment

Mnemonic

"PRECISE: Power Reduction, Enhanced Coverage, Interference Suppression, Enhanced Signal"

Question 5(c) [7 marks]

Draw the DTH Receiver indoor and outdoor black diagram and discuss its functions

Solution

Diagram: DTH System Block Diagram

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    subgraph Outdoor Unit
    A[Dish Antenna] {-{-}{}|Collects| B[LNB {-} Low Noise Block]}
    end

    subgraph Indoor Unit
    C[Tuner] {-{-}{} D[Demodulator]}
    D {-{-}{} E[Decoder]}
    E {-{-}{} F[MPEG Processor]}
    F {-{-}{} G[Video/Audio Output]}
    H[Smart Card] {-{-}{} E}
    I[User Interface] {-{-}{} E}
    end

    B {-{-}{}|Coaxial Cable| C}
{Highlighting}
{Shaded}
```

Outdoor Unit Components and Functions:

- **Dish Antenna**: Collects satellite signals, typically 45-90 cm diameter
- **LNB (Low Noise Block)**:
  - Converts high frequency satellite signals (10-12 GHz) to lower IF frequencies (950-2150 MHz)
  - Amplifies weak signals with minimal noise
  - Contains local oscillator and polarization selection

Indoor Unit Components and Functions:

- **Tuner**: Selects desired transponder frequency
- **Demodulator**: Extracts digital signal from modulated carrier
- **Decoder**: Decrypts encrypted channels using smart card authorization

- **MPEG Processor**: Decompresses video/audio data streams
- **User Interface**: On-screen menus, program guide, channel selection
- **Smart Card**: Contains subscription details and decryption keys

Mnemonic

"COLD-TDUMS: Collection, Oscillator, Low-noise, Downconversion - Tuner Demodulator Unscrambler MPEG Smart-card"

Question 5(a) OR [3 marks]

Define: (1) Antenna, (2) Folded dipole, and (3) Antenna array

Solution

Table 11: Antenna Definitions

Term	Definition
Antenna	Device that converts electrical energy to radio waves and vice versa
Folded Dipole	Dipole with ends folded back and connected, forming a loop with higher impedance
Antenna Array	Multiple antennas arranged in specific pattern for improved directivity/gain

Mnemonic

"AFA: Antenna Folded Array"

Question 5(b) OR [4 marks]

Describe application of smart antenna

Solution

Table 12: Smart Antenna Applications

Application	Description
Mobile Communications	Increases capacity, reduces interference in cellular networks
Base Stations	Sector-specific coverage, adaptive beamforming
MIMO Systems	Multiple-input-multiple-output for spatial multiplexing
Radar Systems	Improved target detection and tracking
Satellite Communications	Spot beam generation, interference mitigation
Wi-Fi Networks	Enhanced range and throughput for wireless LANs
IoT Networks	Low-power, long-range connectivity for IoT devices

Mnemonic

"MBMRSWI: Mobile Base MIMO Radar Satellite Wi-Fi IoT"

Question 5(c) OR [7 marks]

Explain Terrestrial mobile communication antennas and also discuss about base station and mobile station antennas

Solution

Diagram: Mobile Communication Antenna Types

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Terrestrial Mobile Antennas] {-{-}{} B[Base Station Antennas]}
    A {-{-}{} C[Mobile Station Antennas]}

    B {-{-}{} D[Panel Antennas]}
    B {-{-}{} E[Sector Antennas]}
    B {-{-}{} F[Omnidirectional Antennas]}
    B {-{-}{} G[Smart Antennas]}

    C {-{-}{} H[Whip Antennas]}
    C {-{-}{} I[Helical Antennas]}
    C {-{-}{} J[Planar Inverted{-}F Antennas]}
    C {-{-}{} K[Internal PCB Antennas]}
{Highlighting}
{Shaded}
```

Base Station Antennas:

- **Panel/Sector Antennas**: $65° - 120° coverage per sector, typically three sectors per site$
- **Characteristics**:
  - High gain (10-18 dBi)
  - Vertical polarization
  - Downtilt capability (mechanical or electrical)
  - Multi-band operation
- **Height**: Mounted on towers 15-50m high for maximum coverage
- **Pattern Control**: Minimizes interference to adjacent cells

Mobile Station Antennas:

- **External Antennas**: Less common today, mainly for vehicles or rural areas
  - Whip antennas (¼ monopoles)
  - Helical designs for flexibility
- **Internal Antennas**: Now dominant in handsets
  - PIFA (Planar Inverted-F Antenna)s
  - PCB trace antennas
  - Characteristics:
    * Small size
    * Multi-band operation
    * Omnidirectional pattern
    * Lower efficiency (typically -3 to -6 dBi)

Mnemonic

"BEST-POMME: Base-station External Sector Tower - Portable Omnidirectional Multi-band Mobile Embedded"