

Subject Name Solutions

4351104 – Winter 2023

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Draw & Explain umbrella cell.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Large Coverage Area] --- B[Umbrella Cell Tower]
    B --- C[Micro Cell 1]
    B --- D[Micro Cell 2]
    B --- E[Micro Cell 3]
    C --- F[Users in Dense Area]
    D --- G[Users in Dense Area]
    E --- H[Users in Dense Area]
{Highlighting}
{Shaded}
```

- **Umbrella Cell:** Large coverage cell overlaying smaller cells
- **Purpose:** Handles overflow traffic from micro/pico cells
- **Coverage:** Provides backup coverage for high-traffic areas

Mnemonic

“Under My Big Umbrella”

Question 1(b) [4 marks]

Define full forms: (i) CCH (ii) TCH (iii) SCH (iv) BCCH

Solution

Acronym	Full Form	Function
CCH	Control Channel	Carries control information
TCH	Traffic Channel	Carries voice/data traffic
SCH	Synchronization Channel	Provides timing sync
BCCH	Broadcast Control Channel	Broadcasts system info

Mnemonic

“Control Traffic Sync Broadcast”

Question 1(c) [7 marks]

What is cell? Explain different types of cells.

Solution

Cell is the basic coverage area served by one base station in cellular communication.

Cell Type	Coverage	Power	Usage
Macro Cell	1-30 km	High	Rural areas
Micro Cell	100m-2km	Medium	Urban areas
Pico Cell	10-100m	Low	Indoor coverage
Femto Cell	10-30m	Very Low	Home/office

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Macro Cell] --{} B[Large Area Coverage]
    C[Micro Cell] --{} D[City Coverage]
    E[Pico Cell] --{} F[Building Coverage]
    G[Femto Cell] --{} H[Room Coverage]
{Highlighting}
{Shaded}
```

- **Function:** Each cell provides wireless service to mobile users
- **Frequency Reuse:** Same frequencies used in non-adjacent cells
- **Handoff:** Users move between cells seamlessly

Mnemonic

“Many Mobile People Find coverage”

Question 1(c OR) [7 marks]

What is handoff? Explain soft and hard handoffs.

Solution

Handoff is the process of transferring an ongoing call from one cell to another as mobile moves.

Feature	Hard Handoff	Soft Handoff
Connection	Break-before-make	Make-before-break
Channels	One at a time	Multiple simultaneously
Technology	GSM, TDMA	CDMA
Quality	Brief interruption	Seamless transition

```
sequenceDiagram
    participant M as Mobile
    participant BS1 as Base Station 1
    participant BS2 as Base Station 2
```

```
Note over M,BS2: Hard Handoff
M{-BS1: Connected}
BS1{-{-}M: Signal weakens}
BS1{-BS2: Handoff request}
M{-BS2: New connection}
```

```
Note over M,BS2: Soft Handoff
M{-BS1: Connected}
M{-BS2: Dual connection}
M{-{-}BS1: Drop weak signal}
```

- **Initiation:** Based on signal strength measurements
- **MAHO:** Mobile Assisted Handoff improves decision accuracy

Mnemonic

“Hard Hurts, Soft Smooth”

Question 2(a) [3 marks]

Define full forms: (i) SIM (ii) LTE (iii) WCDMA

Solution

Acronym	Full Form	Purpose
SIM	Subscriber Identity Module	User authentication
LTE	Long Term Evolution	4G technology
WCDMA	Wideband Code Division Multiple Access	3G standard

Mnemonic

“Subscriber’s Long Wideband connection”

Question 2(b) [4 marks]

Draw mobile handset block diagram.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Antenna] --{-{-}{ B[RF Section]}
    B --{-{-){ C[Baseband Processor]}
    C --{-{-){ D[Audio Section]}
    C --{-{-){ E[Display/Keypad]}
    C --{-{-){ F[Memory]}
    G[Battery] --{-{-){ H[Power Management]}
    H --{-{-){ B}
    H --{-{-){ C}
    H --{-{-){ D}
{Highlighting}
```

{Shaded}

- **RF Section:** Transmits/receives radio signals
- **Baseband:** Processes digital signals and protocols
- **Audio:** Handles voice input/output
- **Power Management:** Controls battery usage efficiently

Mnemonic

“Radio Baseband Audio Power”

Question 2(c) [7 marks]

Explain GSM architecture with diagram.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[MS] --- B[BTS]
    B --- C[BSC]
    C --- D[MSC]
    D --- E[HLR]
    D --- F[VLR]
    D --- G[AuC]
    D --- H[PSTN]

    subgraph BSS
        B
        C
    end

    subgraph NSS
        D
        E
        F
        G
    end
{Highlighting}
{Shaded}
```

Component	Function
MS	Mobile Station (handset)
BTS	Base Transceiver Station
BSC	Base Station Controller
MSC	Mobile Switching Center
HLR	Home Location Register
VLR	Visitor Location Register

- **BSS:** Base Station Subsystem handles radio interface
- **NSS:** Network Switching Subsystem manages calls
- **Authentication:** AuC verifies subscriber identity

Mnemonic

“Mobile Base Network calls Home”

Question 2(a OR) [3 marks]

Define full forms: (i) RSSI (ii) MAHO (iii) NCHO

Solution

Acronym	Full Form	Function
RSSI	Received Signal Strength Indicator	Signal quality measurement
MAHO	Mobile Assisted Handoff	Mobile helps handoff decision
NCHO	Network Controlled Handoff	Network decides handoff

Mnemonic

“Received Mobile Network signals”

Question 2(b OR) [4 marks]

Draw baseband section block diagram.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[ADC/DAC] --> B[DSP]
    B --> C[Channel Codec]
    C --> D[Speech Codec]
    D --> E[Audio Interface]
    E --> F[Protocol Stack]
    F --> G[Control Interface]
{Highlighting}
{Shaded}
```

- **ADC/DAC:** Analog to Digital conversion
- **DSP:** Digital Signal Processor
- **Channel Codec:** Error correction coding
- **Speech Codec:** Voice compression/decompression

Mnemonic

“Analog Digital Speech Protocol”

Question 2(c OR) [7 marks]

Explain GSM signal processing with diagram.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Speech] --> B[Speech Codec]
    B --> C[Channel Codec]
    C --> D[Interleaving]
    D --> E[Burst Formatter]
    E --> F[GMSK Modulator]
    F --> G[RF Transmitter]
{Highlighting}
{Shaded}
```

{Highlighting}
{Shaded}

Stage	Function	Purpose
Speech Codec	Compress voice to 13 kbps	Bandwidth efficiency
Channel Codec	Add error correction	Signal reliability
Interleaving	Distribute burst errors	Error protection
GMSK	Gaussian MSK modulation	Spectral efficiency

- **Processing Rate:** 270.833 kbps gross bit rate
- **Frame Structure:** 8 time slots per TDMA frame
- **Frequency Hopping:** 217 hops per second

Mnemonic

“Speech Channel Interleaves Modulated Radio”

Question 3(a) [3 marks]

Explain cell splitting.

Solution

Cell splitting divides congested cells into smaller cells to increase capacity.

- **Process:** Replace high-power cell with multiple low-power cells
- **Benefit:** Increases system capacity by frequency reuse
- **Implementation:** Reduce antenna height and transmit power

Mnemonic

“Split Small Cells”

Question 3(b) [4 marks]

Explain Li-Ion type batteries used in mobile handset with its advantages and disadvantages.

Solution

Advantages	Disadvantages
High energy density	Safety concerns
No memory effect	Degradation over time
Low self-discharge	Temperature sensitive
Lightweight	Expensive

- **Chemistry:** Lithium ions move between electrodes
- **Voltage:** 3.7V nominal per cell
- **Capacity:** Measured in mAh (milliampere-hours)

Mnemonic

“Light Ion Energy Safety”

Question 3(c) [7 marks]

Explain GPRS.

Solution

GPRS (General Packet Radio Service) provides packet-switched data service over GSM.

Feature	Specification
Data Rate	Up to 171.2 kbps
Technology	Packet switching
Channels	Uses multiple time slots
Billing	Based on data volume

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Mobile] --{} B[BSS]
    B --{} C[PCU]
    C --{} D[SGSN]
    D --{} E[GGSN]
    E --{} F[Internet]
{Highlighting}
{Shaded}
```

- **PCU:** Packet Control Unit manages packet data
- **SGSN:** Serving GPRS Support Node
- **GGSN:** Gateway GPRS Support Node
- **Classes:** Class 1-12 with different speed/slot combinations

Mnemonic

“General Packet Radio Service”

Question 3(a OR) [3 marks]

Explain cell sectoring.

Solution

Cell sectoring divides omnidirectional cell into sectors using directional antennas.

- **Common:** 3-sector (120°) or 6 – sector (60°) configurations
- **Benefit:** Reduces co-channel interference
- **Implementation:** Directional antennas at same site

Mnemonic

“Sector Reduces Interference”

Question 3(b OR) [4 marks]

Explain Li-Po type batteries used in mobile handset with its advantages and disadvantages.

Solution

Advantages	Disadvantages
Flexible shape	Lower energy density
Ultra-thin design	Shorter lifespan
Lightweight	Safety risks
No memory effect	Higher cost

- **Technology:** Lithium Polymer electrolyte
- **Form Factor:** Can be molded into various shapes
- **Voltage:** 3.7V nominal per cell

Mnemonic

“Polymer Flexible Thin Light”

Question 3(c OR) [7 marks]

Explain EDGE.

Solution

EDGE (Enhanced Data rates for GSM Evolution) improves GSM data rates.

Parameter	GSM	EDGE
Modulation	GMSK	8-PSK
Data Rate	9.6 kbps	Up to 384 kbps
Error Correction	Basic	Advanced
Spectrum	Same as GSM	Same as GSM

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Data] --{} B[Adaptive Coding]
    B --{} C[8{}PSK Modulation]
    C --{} D[Link Adaptation]
    D --{} E[Enhanced Reception]
{Highlighting}
{Shaded}
```

- **8-PSK:** 8-Phase Shift Keying provides 3 bits per symbol
- **Link Adaptation:** Adjusts coding scheme based on channel quality
- **Incremental Redundancy:** Improves error correction efficiency

Mnemonic

“Enhanced Data GSM Evolution”

Question 4(a) [3 marks]

Draw DSSS transmitter and receiver block diagram.

Solution

```

Transmitter:
Data {-{-} Spreader {-}{-} Modulator {-}{-} RF Out}
    \^{ }
    |
    PN Code

Receiver:
RF In {-{-} Demodulator {-}{-} Despreader {-}{-} Data Out}
    \^{ }
    |
    PN Code

```

- **Spreader:** Multiplies data with PN sequence

- **Despreader:** Correlates received signal with same PN code
- **Processing Gain:** Ratio of spread to original bandwidth

Mnemonic

“Direct Sequence Spread Spectrum”

Question 4(b) [4 marks]

Compare CDMA and GSM.

Solution

Parameter	CDMA	GSM
Multiple Access	Code Division	Time Division
Capacity	Higher (soft capacity)	Fixed capacity
Handoff	Soft handoff	Hard handoff
Power Control	Critical	Less critical
Frequency Planning	Not required	Required
Voice Quality	Better	Good

Mnemonic

“Code Division vs Time Division”

Question 4(c) [7 marks]

Explain concept of spread spectrum with applications.

Solution

Spread Spectrum spreads signal bandwidth much wider than required for data transmission.

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Narrowband Signal] --{-}{-}{ B[Spreading Code]}
    B --{-}{-}{ C[Wideband Signal]}
    C --{-}{-}{ D[Transmission]}
    D --{-}{-}{ E[Despreading]}
    E --{-}{-}{ F[Original Signal]}
{Highlighting}
{Shaded}
```

Type	Method	Application
DSSS	PN sequence multiplication	CDMA, WiFi
FHSS	Frequency hopping	Bluetooth
THSS	Time hopping	UWB systems

Benefits:

- **Anti-jamming:** Resistant to interference
- **Low Power Density:** Difficult to detect
- **Multiple Access:** Many users share spectrum
- **Multipath Resistance:** Resolves delayed signals

Applications: GPS, WiFi, Bluetooth, Military communications

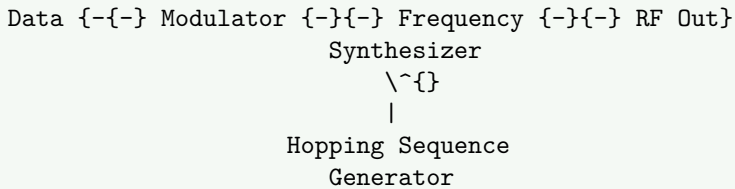
Mnemonic

“Spread Signal Spectrum Security”

Question 4(a OR) [3 marks]

Draw FHSS transmitter block diagram.

Solution



- **Frequency Synthesizer:** Changes carrier frequency rapidly
- **Hopping Sequence:** Pseudo-random frequency pattern
- **Dwell Time:** Time spent on each frequency

Mnemonic

“Frequency Hopping Spread Spectrum”

Question 4(b OR) [4 marks]

Explain call processing in CDMA.

Solution

Phase	Process	Description
System Access	Power control	Mobile adjusts power
Call Setup	Channel assignment	Assign Walsh code
Traffic	Soft handoff	Multiple base stations
Call Release	Power down	Gradual power reduction

- **Rake Receiver:** Combines multipath signals
- **Power Control:** 800 times per second
- **Soft Capacity:** Degrades gracefully with load

Mnemonic

“Code Division Multiple Access”

Question 4(c OR) [7 marks]

Explain HSDPA.

Solution

HSDPA (High Speed Downlink Packet Access) enhances WCDMA downlink data rates.

Feature	Enhancement
Data Rate	Up to 14.4 Mbps
Modulation	16-QAM
HARQ	Hybrid ARQ
Fast Scheduling	2ms TTI

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[NodeB] --{} B[HS{-}DSCH]
    B --{} C[16{-}QAM]
    C --{} D[HARQ]
    D --{} E[Mobile]}
{Highlighting}
{Shaded}
```

- **HS-DSCH**: High Speed Downlink Shared Channel
- **AMC**: Adaptive Modulation and Coding
- **Fast Cell Selection**: Improves cell edge performance
- **MIMO**: Multiple antenna configurations possible

Mnemonic

“High Speed Downlink Packet Access”

Question 5(a) [3 marks]

List LTE specifications.

Solution

Parameter	Specification
Peak Data Rate	300 Mbps DL, 75 Mbps UL
Bandwidth	1.4 to 20 MHz
Latency	<10ms user plane
Mobility	Up to 350 km/h
Spectrum Efficiency	3-4x better than 3G

Mnemonic

“Long Term Evolution specifications”

Question 5(b) [4 marks]

Draw OFDM receiver and explain its working.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[RF Input] --{} B[ADC]
    B --{} C[Remove CP]
    C --{} D[FFT]
    D --{} E[Demodulator]
    E --{} F[Data Output]}
{Highlighting}
{Shaded}
```

- **FFT**: Fast Fourier Transform converts time to frequency domain
- **Cyclic Prefix**: Guards against inter-symbol interference
- **Subcarriers**: Parallel transmission on multiple frequencies

- **Demodulation:** QPSK/16QAM/64QAM per subcarrier

Mnemonic

“Orthogonal Frequency Division Multiplexing”

Question 5(c) [7 marks]

Explain Bluetooth Technology & list its applications.

Solution

Bluetooth is short-range wireless communication technology for personal area networks.

Parameter	Specification
Range	10m (Class 2)
Frequency	2.4 GHz ISM band
Data Rate	Up to 3 Mbps
Topology	Piconet (8 devices)

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Master Device] --> B[Slave 1]
    A --> C[Slave 2]
    A --> D[Slave 3]
    E[Scatternet] --> A
    E --> F[Another Piconet]
{Highlighting}
{Shaded}
```

Protocol Stack:

- **RF Layer:** Physical radio interface
- **Baseband:** Medium access control
- **L2CAP:** Logical Link Control
- **Applications:** Various profiles (A2DP, HID, etc.)

Applications:

- Audio devices (headphones, speakers)
- File transfer between devices
- Input devices (keyboard, mouse)
- Health monitoring devices
- Smart home automation

Mnemonic

“Blue Tooth Personal Area Network”

Question 5(a OR) [3 marks]

List advantages of 5G Technology.

Solution

Advantage	Benefit
Ultra-low latency	<1ms response time
High data rates	Up to 10 Gbps

Massive connectivity	1M devices/km ²
Network slicing	Customized services
Energy efficiency	90% more efficient

Mnemonic

“Fifth Generation advantages”

Question 5(b OR) [4 marks]

Draw OFDM transmitter and explain its working.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Data Input] --> B[Modulator]
    B --> C[IFFT]
    C --> D[Add CP]
    D --> E[DAC]
    E --> F[RF Output]
{Highlighting}
{Shaded}
```

- **Modulation:** Maps bits to symbols (QPSK/QAM)
- **IFFT:** Inverse FFT converts frequency to time domain
- **Cyclic Prefix:** Copies end samples to beginning
- **DAC:** Digital to Analog Converter for transmission

Mnemonic

“Orthogonal Frequency Division Multiplexing Transmitter”

Question 5(c OR) [7 marks]

Explain Zigbee Technology & list its applications.

Solution

Zigbee is low-power wireless mesh networking standard based on IEEE 802.15.4.

Parameter	Specification
Range	10-100m
Data Rate	250 kbps
Power	Very low (battery years)
Topology	Mesh network
Frequency	2.4 GHz globally

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Coordinator] --{} B[Router 1]
    A --{} C[Router 2]
    B --{} D[End Device 1]
    B --{} E[End Device 2]
    C --{} F[End Device 3]
    C --{} G[Router 3]
    G --{} H[End Device 4]
{Highlighting}
{Shaded}
```

Network Roles:

- **Coordinator:** Network manager
- **Router:** Forwards messages
- **End Device:** Simple sensors/actuators

Applications:

- Home automation (lights, thermostats)
- Industrial monitoring
- Smart grid systems
- Healthcare monitoring
- Agricultural sensors
- Building management systems

Features:

- **Self-healing:** Automatic route discovery
- **Low cost:** Simple implementation
- **Secure:** AES encryption
- **Reliable:** Mesh redundancy

Mnemonic

“Zigbee Mesh Network Applications”