

## Question 1(a) [3 marks]

Explain umbrella cell.

Answer:

**Umbrella cell** is a large coverage area cell that overlays smaller cells to provide continuous coverage and handle overflow traffic.

Table: Umbrella Cell Characteristics

Feature	Description
Coverage	Large geographic area
Purpose	Handle overflow traffic from microcells
Antenna	High-power, elevated position
Users	Fast-moving vehicles, emergency calls

- **Large coverage:** Covers wide geographical area with high-power base station
- **Traffic management:** Handles calls when smaller cells are congested
- **Mobility support:** Serves fast-moving users crossing multiple cell boundaries

Mnemonic: "Umbrella Covers Large Areas"

## Question 1(b) [4 marks]

Define cell and cluster.

Answer:

**Cell** and **cluster** are fundamental concepts in cellular communication systems.

Table: Cell vs Cluster Comparison

Parameter	Cell	Cluster
Definition	Single coverage area served by one base station	Group of cells using different frequencies
Size	Limited by antenna power and interference	Contains N cells (typically 3, 4, 7, 12)
Frequency	Uses specific frequency set	Uses all available frequencies once
Purpose	Provide coverage to specific area	Enable frequency reuse pattern

- **Cell:** Geographic area served by single base station with specific frequency allocation
- **Cluster:** Group of adjacent cells that collectively use entire frequency spectrum

- **Frequency reuse:** Same frequencies can be reused in different clusters
- **Pattern repetition:** Cluster pattern repeats throughout coverage area

**Mnemonic:** "Cells Cluster for Complete Coverage"

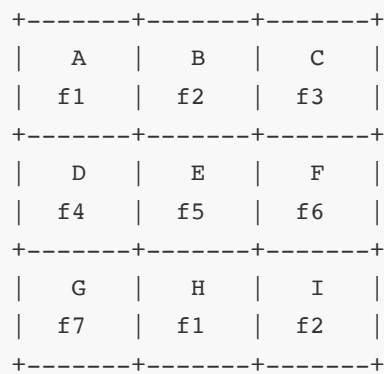
## Question 1(c) [7 marks]

Describe fundamental concept behind cellular communication systems.

**Answer:**

**Cellular communication** divides service area into small cells to maximize spectrum efficiency and capacity.

**Diagram:**



**Table: Cellular System Benefits**

Concept	Advantage
Frequency Reuse	Same frequencies used multiple times
Cell Division	Smaller coverage areas, more capacity
Handoff	Seamless call transfer between cells
Power Control	Reduced interference, longer battery life

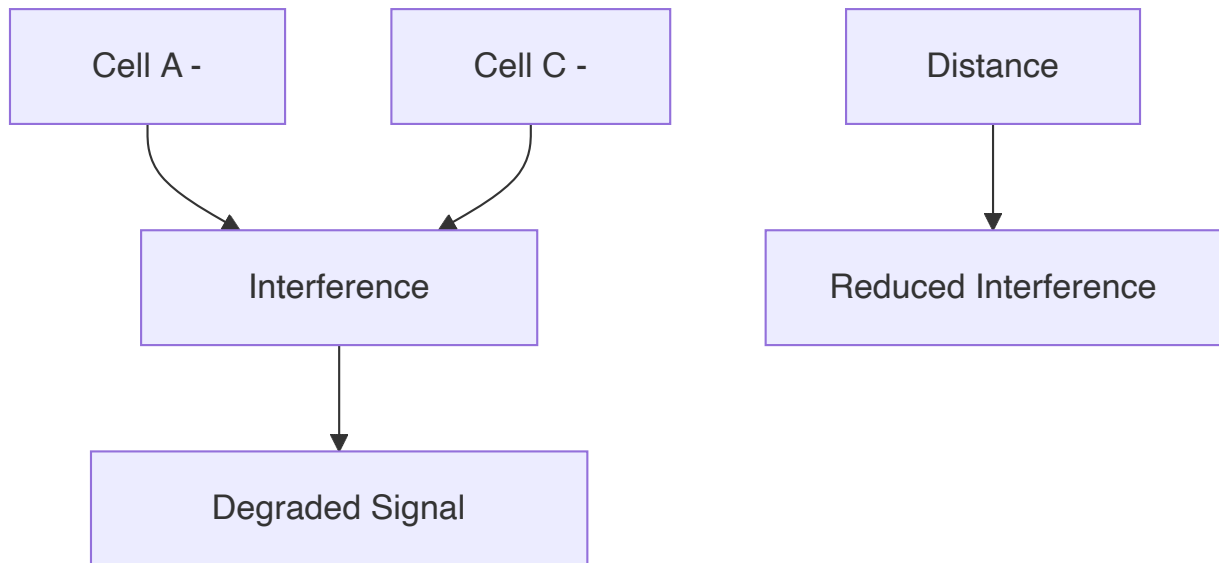
- **Small cell concept:** Service area divided into hexagonal cells for efficient coverage
- **Frequency reuse:** Limited spectrum used multiple times with adequate separation
- **Base station control:** Each cell served by low-power base station
- **Capacity improvement:** More users supported compared to single large coverage area
- **Interference management:** Co-channel interference controlled through proper cell planning

**Mnemonic:** "Small Cells Support Spectrum Sharing Successfully"

## Question 1(c OR) [7 marks]

**Explain co-channel interference in cellular communication.****Answer:**

**Co-channel interference** occurs when cells using same frequencies are too close, causing signal degradation.

**Table: Co-channel Interference Parameters**

Parameter	Description	Impact
<b>Reuse Distance</b>	Distance between co-channel cells	Higher distance = Less interference
<b>C/I Ratio</b>	Carrier to Interference ratio	Must be $\geq 18$ dB for good quality
<b>Cluster Size</b>	Number of cells in cluster	Larger cluster = More separation

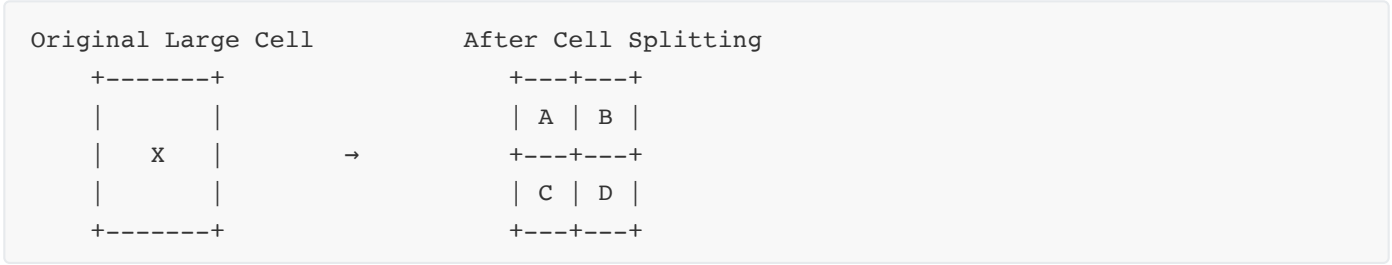
- **Signal overlap:** Same frequency signals from different cells interfere
- **Quality degradation:** Causes call drops and poor voice quality
- **Distance factor:** Interference reduces with square of distance
- **Mitigation methods:** Proper cell planning, power control, antenna design

**Mnemonic:** "Co-channel Causes Call Quality Concerns"

**Question 2(a) [3 marks]****Explain cell splitting.****Answer:**

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

**Diagram:**



- **Capacity increase:** Each new cell handles fewer users with better service quality
- **Power reduction:** New base stations use lower power to cover smaller areas
- **Frequency management:** Original frequencies distributed among new smaller cells

Mnemonic: "Split Cells Serve Subscribers Successfully"

## Question 2(b) [4 marks]

Explain channel assignment strategies.

Answer:

**Channel assignment** strategies determine how frequencies are allocated to cells for optimal performance.

Table: Channel Assignment Strategies

Strategy	Description	Advantages	Disadvantages
Fixed	Channels permanently assigned to cells	Simple, predictable	Inefficient during low traffic
Dynamic	Channels assigned based on demand	Efficient spectrum use	Complex implementation
Hybrid	Combination of fixed and dynamic	Balanced approach	Moderate complexity

- **Fixed assignment:** Each cell has predetermined set of channels
- **Dynamic assignment:** Channels allocated in real-time based on traffic demand
- **Load balancing:** Distributes traffic evenly across available channels
- **Interference avoidance:** Considers co-channel interference in assignment decisions

Mnemonic: "Dynamic Distribution Delivers Optimal Performance"

## Question 2(c) [7 marks]

Calculate voice and control channels per cell for 33MHz bandwidth, 25KHz simplex channels, 7-cell reuse, 1MHz for control.

Answer:

**Calculation** for channel allocation in cellular system.

**Given Data:**

- Total bandwidth = 33 MHz
- Channel bandwidth = 25 KHz (simplex)
- Full duplex requires =  $2 \times 25 \text{ KHz} = 50 \text{ KHz}$
- Control spectrum = 1 MHz
- Cluster size = 7 cells

**Calculations:****Step 1: Total available channels**

Total channels =  $33 \text{ MHz} \div 25 \text{ KHz} = 1320 \text{ channels}$

**Step 2: Control channels**

Control channels =  $1 \text{ MHz} \div 25 \text{ KHz} = 40 \text{ channels}$

**Step 3: Voice channels**

Voice channels =  $1320 - 40 = 1280 \text{ channels}$

**Step 4: Duplex voice channels**

Duplex voice channels =  $1280 \div 2 = 640 \text{ channels}$

**Step 5: Channels per cell**

Voice channels per cell =  $640 \div 7 \approx 91 \text{ channels}$

Control channels per cell =  $40 \div 7 \approx 6 \text{ channels}$

**Final Answer:**

- **Voice channels per cell: 91**
- **Control channels per cell: 6**

**Mnemonic:** "Calculate Carefully for Channel Count"

## Question 2(a OR) [3 marks]

**Write functions of FCCH and SCH in GSM.**

**Answer:**

**FCCH** and **SCH** are essential control channels in GSM system for synchronization.

**Table: FCCH and SCH Functions**

Channel	Full Form	Function
<b>FCCH</b>	Frequency Correction Channel	Provides frequency reference to mobile
<b>SCH</b>	Synchronization Channel	Provides timing and cell identity

- **FCCH function:** Enables mobile to synchronize with base station frequency
- **SCH function:** Carries BSIC (Base Station Identity Code) and frame number

- **Timing correction:** Both channels help mobile achieve proper timing synchronization

**Mnemonic:** "FCCH Fixes Frequency, SCH Synchronizes System"

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## Question 2(b OR) [4 marks]

**Write GSM 900 specifications.**

**Answer:**

**GSM 900** operates in 900 MHz frequency band with specific technical parameters.

**Table: GSM 900 Specifications**

Parameter	Specification
Uplink Frequency	890-915 MHz
Downlink Frequency	935-960 MHz
Duplex Separation	45 MHz
Channel Spacing	200 KHz
Total Channels	124 channels
Access Method	TDMA/FDMA
Modulation	GMSK
Power Classes	2W, 8W, 20W

- **Frequency bands:** Separate uplink and downlink frequencies for full duplex operation
- **TDMA structure:** 8 time slots per carrier frequency

**Mnemonic:** "GSM 900 Gives Great Global Coverage"

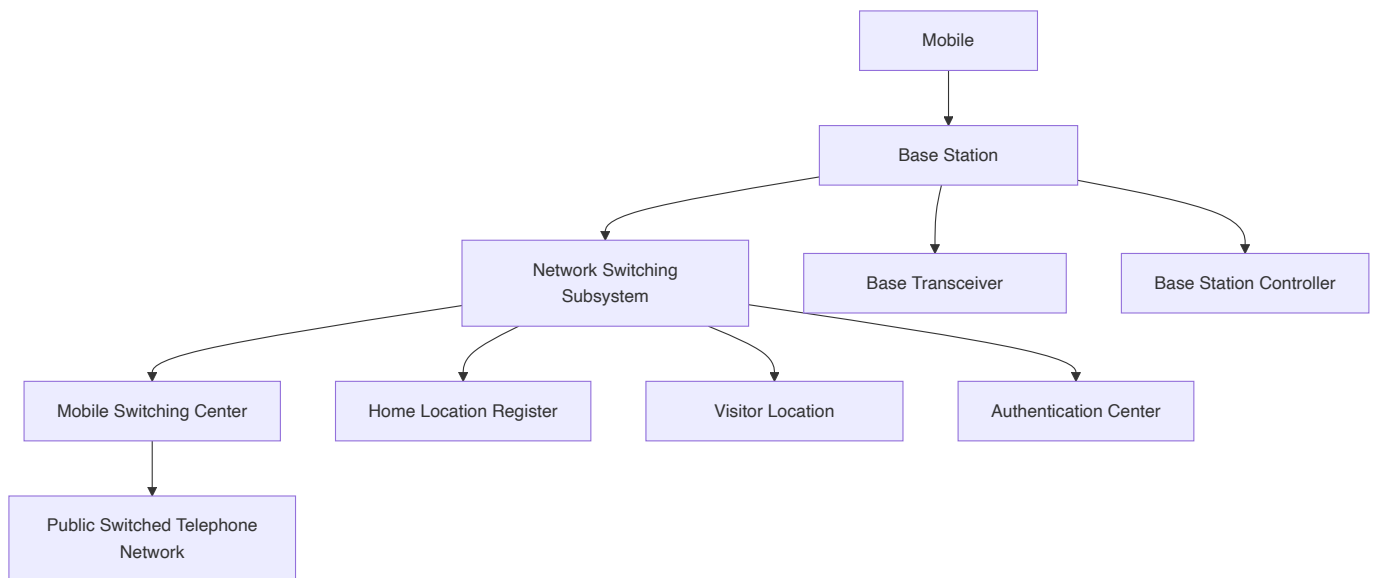
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## Question 2(c OR) [7 marks]

**Draw and explain GSM architecture.**

**Answer:**

**GSM architecture** consists of three main subsystems working together for mobile communication.

**Table: GSM Architecture Components**

Subsystem	Components	Function
<b>Mobile Station</b>	Mobile Equipment + SIM	User interface and identity
<b>BSS</b>	BTS + BSC	Radio interface and control
<b>NSS</b>	MSC, HLR, VLR, AuC	Switching and database management

- **Mobile Station:** Consists of mobile equipment and SIM card for user identification
- **Base Station Subsystem:** Handles radio communication and resource management
- **Network Switching Subsystem:** Manages call switching, routing, and subscriber databases
- **Interfaces:** A-bis (BTS-BSC), A (BSC-MSC) interfaces connect subsystems

**Mnemonic:** "Mobile Base Network - Complete Communication Chain"

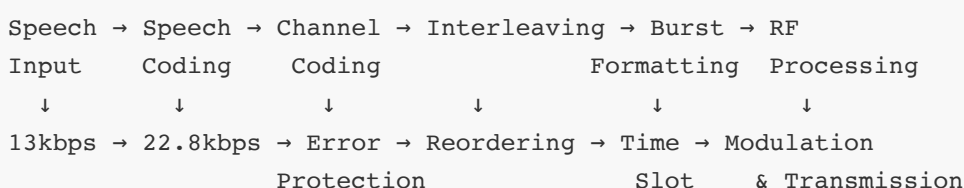
## Question 3(a) [3 marks]

**Draw block diagram of signal processing in GSM.**

**Answer:**

**Signal processing** in GSM involves multiple stages for voice and data transmission.

**Diagram:**



- **Speech coding:** Converts analog speech to 13 kbps digital data using RPE-LTP
- **Channel coding:** Adds error correction bits increasing rate to 22.8 kbps
- **Interleaving:** Reorders data to combat burst errors from fading

**Mnemonic:** "Speech Signals Systematically Processed Successfully"

## Question 3(b) [4 marks]

**Write functions of Common Control Channels in GSM.**

**Answer:**

**Common Control Channels** manage system information and access procedures in GSM.

**Table: Common Control Channels Functions**

Channel	Function
FCCH	Frequency correction and synchronization
SCH	Frame synchronization and cell identification
BCCH	Broadcasts system information and cell parameters
RACH	Random access for call initiation by mobile
AGCH	Assigns dedicated channels to mobiles
PCH	Pages mobiles for incoming calls

- **Broadcast function:** BCCH continuously transmits system information
- **Access management:** RACH allows mobiles to request service
- **Channel assignment:** AGCH allocates resources for active calls
- **Paging service:** PCH notifies mobiles of incoming calls

**Mnemonic:** "Common Channels Control Communication Completely"

## Question 3(c) [7 marks]

**Explain GSM identifiers.**

**Answer:**

**GSM identifiers** uniquely identify subscribers, equipment, and network elements.

**Table: GSM Identifiers**

Identifier	Full Form	Purpose	Format
IMSI	International Mobile Subscriber Identity	Unique subscriber ID	15 digits
IMEI	International Mobile Equipment Identity	Unique equipment ID	15 digits
MSISDN	Mobile Station ISDN Number	Phone number	Variable length
TMSI	Temporary Mobile Subscriber Identity	Temporary ID for security	32 bits
LAI	Location Area Identity	Geographic area identification	MCC+MNC+LAC
BSIC	Base Station Identity Code	Cell identification	6 bits

- **IMSI structure:** MCC (3) + MNC (2-3) + MSIN (9-10 digits)
- **Security purpose:** TMSI protects subscriber identity over radio interface
- **Location management:** LAI helps in efficient paging and location updates
- **Network planning:** BSIC prevents confusion between adjacent cells

**Mnemonic:** "Important Mobile System Identifiers Ensure Security"

## Question 3(a OR) [3 marks]

**Compare Fast and Slow frequency hopping.**

**Answer:**

**Frequency hopping** techniques differ in hopping rate relative to symbol rate.

**Table: Fast vs Slow Frequency Hopping**

Parameter	Fast Hopping	Slow Hopping
Hopping Rate	> Symbol rate	< Symbol rate
Symbols per Hop	< 1	> 1
Complexity	High	Low
Applications	Military, Bluetooth	GSM, CDMA

- **Fast hopping:** Multiple hops per symbol, better security but more complex
- **Slow hopping:** Multiple symbols per hop, simpler implementation

**Mnemonic:** "Fast Frequently Flips, Slow Stays Stable"

## Question 3(b OR) [4 marks]

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**Calculate number of users in GSM 900 band without frequency reuse.**

**Answer:**

**Calculation** for maximum users in GSM 900 without frequency reuse.

**Given GSM 900 Parameters:**

- Uplink: 890-915 MHz (25 MHz)
- Downlink: 935-960 MHz (25 MHz)
- Channel spacing: 200 KHz
- Time slots per channel: 8

**Calculations:**

**Step 1: Available channels**

Total channels =  $25 \text{ MHz} \div 200 \text{ KHz} = 125 \text{ channels}$

**Step 2: Usable channels**

Guard channels removed  $\approx 124 \text{ channels}$

**Step 3: Simultaneous users**

Users per channel = 8 time slots

Total users =  $124 \times 8 = 992 \text{ users}$

**Answer: 992 users can talk simultaneously**

**Mnemonic:** "Calculate Channels Times Time-slots"

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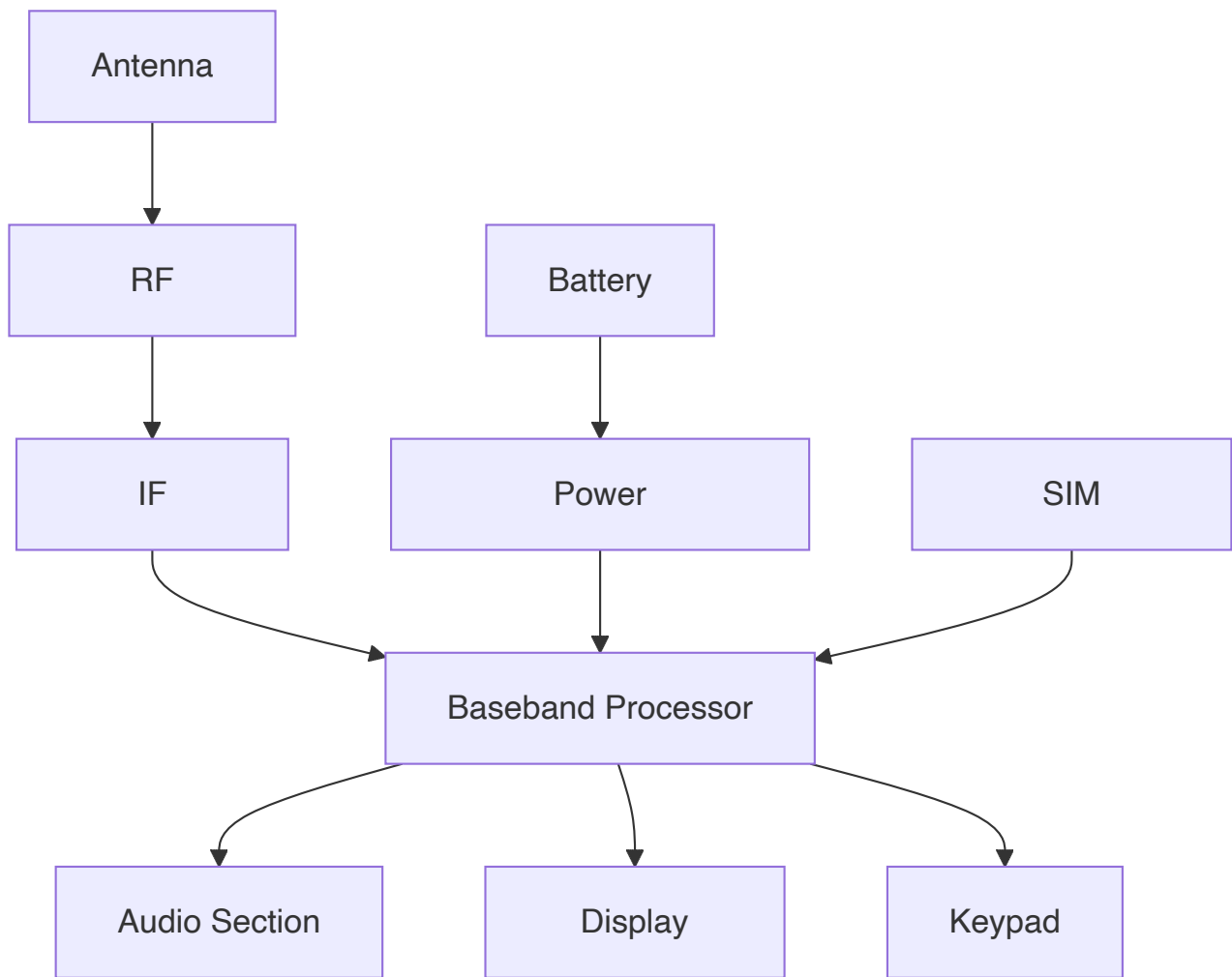
## Question 3(c OR) [7 marks]

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**Draw and explain general block diagram of mobile handset.**

**Answer:**

**Mobile handset** consists of several functional blocks working together.

**Table: Mobile Handset Blocks**

Block	Function
<b>RF Section</b>	Signal transmission and reception
<b>Baseband</b>	Digital signal processing
<b>Audio</b>	Voice input/output processing
<b>Power Management</b>	Battery and power control
<b>User Interface</b>	Display, keypad, speaker, microphone

- **RF processing:** Handles radio frequency transmission and reception
- **Digital processing:** Baseband performs channel coding, speech processing
- **User interface:** Provides interaction through display, keypad, audio
- **Power control:** Manages battery usage and charging functions

**Mnemonic:** "Mobile Manages Multiple Modules Simultaneously"

## Question 4(a) [3 marks]

Write radiation hazards due to mobile.

Answer:

**Radiation hazards** from mobile phones are a health concern due to RF energy exposure.

Table: Mobile Radiation Hazards

Hazard	Effect	Prevention
SAR Exposure	Tissue heating	Use hands-free devices
Brain Effects	Memory, sleep issues	Limit call duration
Cancer Risk	Potential tumor risk	Keep phone away from body

- **SAR (Specific Absorption Rate):** Measures RF energy absorbed by body tissue
- **Thermal effects:** RF energy can cause localized heating of tissues
- **Non-thermal effects:** Possible impacts on cellular functions and DNA

**Mnemonic:** "Safety Awareness Reduces Radiation Risk"

## Question 4(b) [4 marks]

Explain working of baseband section in mobile handset.

Answer:

**Baseband section** performs digital signal processing functions in mobile handset.

Table: Baseband Section Functions

Function	Description
Speech Processing	Encode/decode voice using vocoder
Channel Coding	Add error correction and detection
Modulation	Convert digital data to analog signals
Protocol Processing	Handle signaling and call control

- **Digital signal processor:** Executes speech coding algorithms (GSM: RPE-LTP)
- **Error correction:** Implements convolutional coding for reliable transmission
- **Control functions:** Manages call setup, handoff, and power control
- **Interface:** Connects RF section with user interface components

**Mnemonic:** "Baseband Brings Better Communication Control"

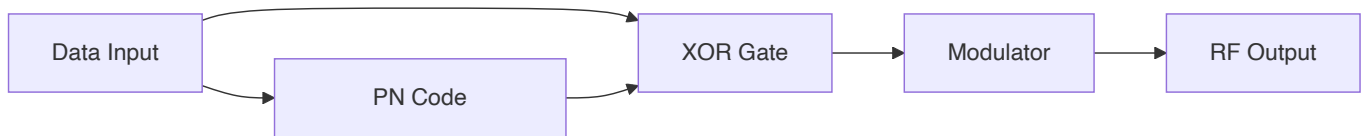
## Question 4(c) [7 marks]

Explain working of DSSS transmitter and receiver.

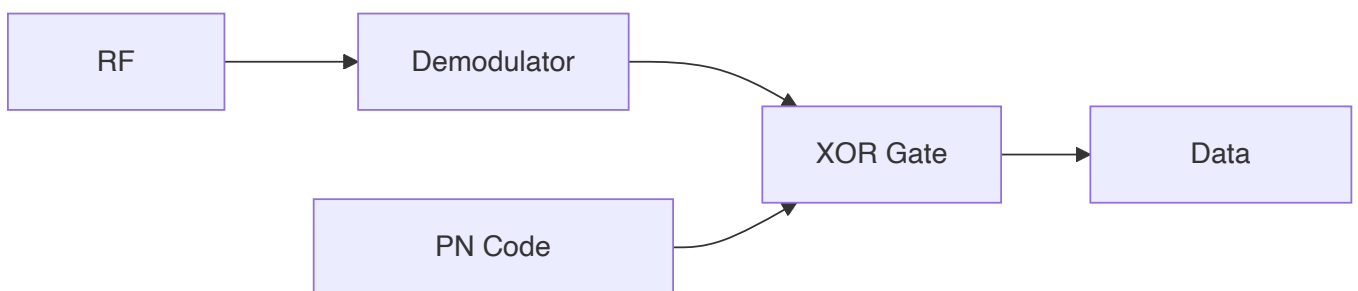
Answer:

**DSSS (Direct Sequence Spread Spectrum)** spreads signal bandwidth using pseudorandom codes.

**Transmitter Diagram:**



**Receiver Diagram:**



**Table: DSSS Process**

Stage	Transmitter	Receiver
<b>Spreading</b>	Data XOR with PN code	Received signal XOR with PN
<b>Modulation</b>	Spread signal modulated	Demodulate received signal
<b>Processing</b>	Bandwidth increased	Original data recovered

- **Spreading process:** Original data XORed with high-rate pseudorandom sequence
- **Bandwidth expansion:** Signal bandwidth increased by processing gain factor
- **Despreading:** Receiver uses same PN code to recover original data
- **Interference rejection:** Spread spectrum provides resistance to jamming

**Mnemonic:** "Direct Sequence Spreads Signals Successfully"

## Question 4(a OR) [3 marks]

Calculate processing gain for DSSS system with 10 Mcps chip rate and 1 Mbps data rate.

Answer:

**Processing gain** determines spread spectrum system's performance improvement.

**Given:**

- Chip rate ( $R_c$ ) = 10 million chips per second =  $10 \times 10^6$  cps
- Data rate ( $R_d$ ) = 1 Mbps =  $1 \times 10^6$  bps

**Calculation:**

Processing Gain ( $G_p$ ) = Chip rate  $\div$  Data rate

$$G_p = R_c \div R_d = (10 \times 10^6) \div (1 \times 10^6) = 10$$

**In dB:**

$$G_p \text{ (dB)} = 10 \log_{10}(10) = 10 \times 1 = 10 \text{ dB}$$

**Answer: Processing Gain = 10 or 10 dB**

**Mnemonic:** "Processing Power Provides Protection"

## Question 4(b OR) [4 marks]

**Explain how data rate is improved in EDGE.**

**Answer:**

**EDGE (Enhanced Data rates for GSM Evolution)** improves data rates through advanced modulation.

**Table: EDGE Improvements**

Parameter	GSM	EDGE	Improvement
Modulation	GMSK	8-PSK	3 bits per symbol vs 1 bit
Data Rate	9.6 kbps	43.2 kbps per slot	~4.5x increase
Coding	Fixed	Adaptive	Link adaptation
Applications	Voice, SMS	Multimedia, Internet	Enhanced services

- **8-PSK modulation:** Transmits 3 bits per symbol instead of 1 bit in GMSK
- **Link adaptation:** Dynamically selects coding scheme based on channel quality
- **Backward compatibility:** Works with existing GSM infrastructure
- **Enhanced applications:** Supports multimedia and higher data rate services

**Mnemonic:** "EDGE Enhances Exchange Efficiently"

## Question 4(c OR) [7 marks]

**Explain call processing in CDMA.**

**Answer:**

**CDMA call processing** involves unique procedures for code-based multiple access.



Table: CDMA Call Processing Stages

Stage	Process	Function
Initialization	Pilot acquisition	Find strongest base station
Idle State	Monitor paging	Listen for incoming calls
Access	Random access	Request service from network
Traffic	Dedicated channel	Active communication
Handoff	Soft handoff	Seamless cell transition

- **Pilot channel:** Provides timing reference and system identification
- **Rake receiver:** Combines multipath signals for improved performance
- **Power control:** Maintains optimal signal levels for all users
- **Soft handoff:** Mobile communicates with multiple base stations simultaneously
- **Code assignment:** Each user assigned unique spreading code

Mnemonic: "CDMA Calls Connect Carefully and Clearly"

## Question 5(a) [3 marks]

Compare CDMA and GSM.

Answer:

CDMA and GSM represent different approaches to cellular communication.

Table: CDMA vs GSM Comparison

Parameter	CDMA	GSM
Access Method	Code Division	Time/Frequency Division
Capacity	Higher	Lower
Handoff	Soft handoff	Hard handoff
Security	Better (spreading codes)	Good (encryption)
Global Usage	Limited	Widespread
Power Control	Continuous	Periodic

- **Multiple access:** CDMA uses unique codes, GSM uses time slots

- **Call quality:** CDMA provides soft handoff, GSM has hard handoff

**Mnemonic:** "Choose CDMA or GSM Carefully"

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## Question 5(b) [4 marks]

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**Write advantages of CDMA.**

**Answer:**

**CDMA advantages** make it suitable for high-capacity cellular systems.

**Table: CDMA Advantages**

Advantage	Benefit
High Capacity	More users per spectrum
Soft Handoff	Seamless call transfer
Variable Rate	Adapts to speech patterns
Privacy	Inherent security through spreading
Multipath Resistance	Uses rake receiver
Power Control	Optimizes battery life
Frequency Planning	Same frequency in all cells

- **Spectrum efficiency:** Higher capacity compared to FDMA/TDMA systems
- **Quality advantage:** Soft handoff eliminates call drops during cell transitions
- **Security benefit:** Spread spectrum provides inherent privacy protection
- **Simplified planning:** No frequency reuse planning required

**Mnemonic:** "CDMA Creates Considerable Communication Capacity"

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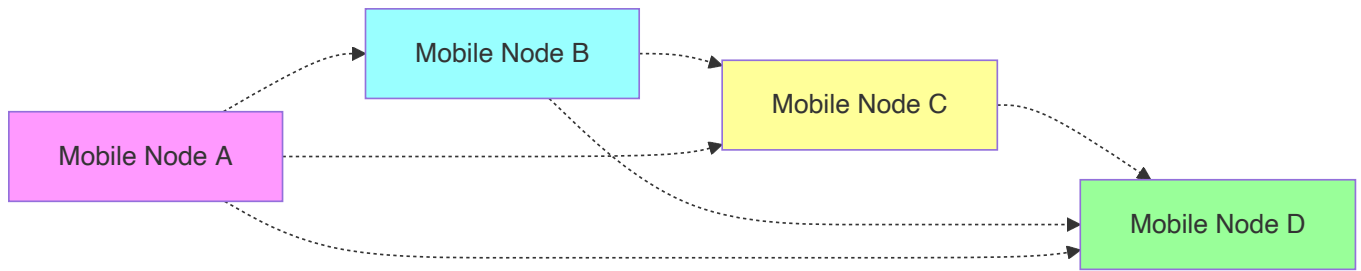
## Question 5(c) [7 marks]

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**Explain MANET in brief and write its applications.**

**Answer:**

**MANET (Mobile Ad Hoc Network)** is infrastructure-less network of mobile devices.



**Table: MANET Characteristics vs Applications**

Characteristic	Feature	Applications
<b>Self-organizing</b>	No fixed infrastructure	Military communications
<b>Dynamic topology</b>	Nodes move freely	Emergency response
<b>Multi-hop routing</b>	Intermediate node relay	Disaster recovery
<b>Distributed control</b>	No central authority	Sensor networks
<b>Resource constraints</b>	Limited battery, bandwidth	Vehicular networks

#### Applications:

- **Military operations:** Battlefield communications without infrastructure
- **Emergency services:** Disaster response and rescue operations
- **Sensor networks:** Environmental monitoring and data collection
- **Vehicular networks:** Car-to-car communication for traffic management
- **Personal area networks:** Device-to-device communication
- **Academic research:** Collaborative computing environments

#### Advantages:

- **Rapid deployment:** No infrastructure setup required
- **Self-healing:** Automatic route reconfiguration when nodes fail
- **Cost effective:** No base station installation costs

#### Disadvantages:

- **Limited bandwidth:** Shared wireless medium
- **Security challenges:** Vulnerable to attacks
- **Power constraints:** Battery-dependent operation

**Mnemonic:** "Mobile Ad Hoc Networks Enable Everywhere"

## Question 5(a OR) [3 marks]

**Write key features of WCDMA.**

**Answer:**

**WCDMA (Wideband CDMA)** is the 3G standard offering enhanced capabilities.

**Table: WCDMA Key Features**

Feature	Specification
Chip Rate	3.84 Mcps
Bandwidth	5 MHz
Data Rates	Up to 2 Mbps
Spreading	Variable spreading factor
Power Control	Fast closed-loop
Handoff	Soft and softer handoff

- **Wideband operation:** 5 MHz bandwidth provides high data rates
- **Variable spreading:** Adapts to different service requirements

**Mnemonic:** "WCDMA Widens Communication Data Magnificently"

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## Question 5(b OR) [4 marks]

**Enlist advantages of 5G.**

**Answer:**

**5G advantages** represent significant improvements over previous generations.

**Table: 5G Advantages**

Advantage	Benefit
Ultra-high Speed	Up to 20 Gbps peak data rate
Low Latency	<1ms for critical applications
Massive IoT	1 million devices per km <sup>2</sup>
Network Slicing	Customized virtual networks
Enhanced Coverage	Better indoor and edge coverage
Energy Efficiency	100x more efficient than 4G
High Reliability	99.999% availability

- **Enhanced mobile broadband:** Supports AR/VR and 4K/8K video streaming

- **Ultra-reliable communications:** Enables autonomous vehicles and remote surgery
- **Massive machine communications:** Supports smart cities and Industry 4.0
- **Flexible network architecture:** Software-defined networking capabilities

**Mnemonic:** "5G Generates Great Gigabit Growth"

## Question 5(c OR) [7 marks]

**Explain working of OFDM with block diagram.**

**Answer:**

**OFDM (Orthogonal Frequency Division Multiplexing)** uses multiple subcarriers for high-speed data transmission.

**OFDM Transmitter:**



**OFDM Receiver:**



**Table: OFDM Process Steps**

Stage	Transmitter Function	Receiver Function
Data Conversion	Serial to parallel conversion	Parallel to serial reconstruction
Modulation	QAM mapping on subcarriers	QAM demapping
Transform	IFFT creates time domain signal	FFT recovers frequency domain
Guard Period	Cyclic prefix prevents ISI	Cyclic prefix removal

**Key Features:**

- **Orthogonal subcarriers:** Multiple parallel low-rate data streams prevent interference
- **FFT/IFFT processing:** Efficient digital implementation using fast transforms
- **Cyclic prefix:** Guard interval prevents inter-symbol interference from multipath
- **Spectral efficiency:** High data rates achieved in limited bandwidth
- **Multipath resistance:** Individual subcarriers experience flat fading

**Applications:**

- **WiFi (802.11):** Wireless LAN communications
- **LTE/4G:** Mobile broadband networks

- **Digital TV:** DVB-T terrestrial broadcasting
- **WiMAX:** Broadband wireless access

**Advantages:**

- **High spectral efficiency:** Optimal bandwidth utilization
- **Robustness:** Resistant to frequency selective fading
- **Flexibility:** Adaptive modulation per subcarrier
- **Implementation:** Digital signal processing simplifies hardware

**Table: OFDM Parameters**

Parameter	Typical Values
Subcarriers	64, 128, 256, 512, 1024
Modulation	BPSK, QPSK, 16-QAM, 64-QAM
Cyclic Prefix	1/4, 1/8, 1/16 of symbol duration
Applications	WiFi, LTE, DVB, WiMAX

**Mnemonic:** "OFDM Offers Outstanding Data Multiplexing"

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