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Unit-I Introduction to Mobile Computing.

Topics:-

- Introduction to Mobile Computing
- Applications of Mobile Computing
- Generations of Mobile Communication Technologies
- Multiplexing: Spread spectrum, MAC Protocols: SDMA, TDMA, FDMA & CDMA

- **Introduction to Mobile Computing:-**
  - Mobile Computing is a technical field that covers the design, development and evaluation of mobile application using appropriate solutions that meet user requirements.
  - It is not a single technology but a combination of three components i.e. handheld computing device, connecting technology, and a centralized information system.
  - It is a technology that allows transmission of data, voice & video via a computer or any other wireless enabled device.
  - Generally a mobile computing system involves a mobile device, such as a laptop computer, tablet or smartphone, and a wireless network connection based on Wi-Fi or cellular wireless technology such as 5G.

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What is Wireless Communication?

- Wireless communication does not require any physical medium for transmission of data. It uses air or space as transmission medium.
- Since, space only allows for signal transmission without any guidance, the medium used in wireless communication is called unguided medium.
- For transmission & reception purposes antennas are used.
- Antenna radiates in the form of electromagnetic waves.
- Hence in wireless communication system both transmitter & receiver has antenna within it.

Advantages of Wireless Communication.

1. Cost
2. Mobility
3. Easy installation
4. Reliability
5. Flexibility.

1. **Cost**:- Wireless communication carries signal through space. Hence it does not require any wire. The cost of cables is reduced as compared to wired communication.

2. **Mobility**:- Wireless communication provides portable devices in use. Hence it provides mobility to the user.

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3. Ease of Installation :- The set up & installation of the wireless network is really easy as compared to wired communication as no cables are involved.

4. Reliability : Reliable communication is achieved by wireless communication. As the cables are not involved, there are no changes of system failure due to cable damage.

5. Flexibility : Wireless communication enables people to communicate regardless of their location.

- Applications of Mobile Computing

1) Enables the business initiatives by supporting mobility of
   - Customers
   - Suppliers & Businesses
   - Employees.
2) Mobile Computing applications
   - Wireless messaging (e.g. SMS)
   - Mobile ecommerce (M-commerce) & its variants
     - Positional commerce (P-commerce)
     - Voice commerce (V-commerce)
     - Television commerce (T-commerce)
3) Mobile ebusiness applications.
4) Specialized applications.
   - location sensitive apps
   - Wireless sensor n/w apps.
   - Mobile agent apps.

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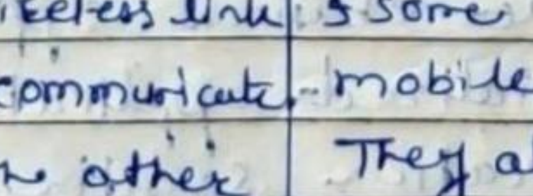
1. Applications of Mobile Computing :-
   - Web or Internet access
   - Global position system (GPS)
   - Emergency services.
   - Entertainment services
   - Educational services.

→ • The concept of Mobile computing can be divided into three parts.
   1) Mobile communication
   2) Mobile Hardware
   3) Mobile software.

Mobile communication can be divided in the following four types.



Fixed & wired	Fixed & Wireless	Mobile & Wired	Mobile & Wireless
↓	↓	↓	↓
The devices are fixed at a position & they are connected through a Physical link to communicate Ex:- Desktop computer	The devices are fixed at a position & they are connected through a wireless link to communicate with the other devices Ex: Communication Towers, Wifi router	In Mobile & wired Configuration some devices are wired & some are mobile. They altoge- -ther make communication with other devices Ex:- Laptops	The devices can communicate with each other irrespective of their position. They can also connect to any n/w Ex:- Wifi dongle.

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Generations of Mobile Communication Technologies :-

0G :- Zero Generation (1970's)

- The first public mobile service was made available after world war II in 1946 in 25 major American cities only.
- It was not based on the cellular approach & hence was not able to support handover mechanism. They are usually referred as radio telephones.
- Technologies used in 0G : PTT (Push to Talk) 1946, MTS (Mobile Telephone service) 1950, IMTS (Improved Mobile Telephone Services) 1960's

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1G : First Generation (1980 to 1990)

- First generation mobiles can be thought of as the basis of today's mobile systems as cellular approach was first developed. In this era during 1950's & 1960's

- The cellular approach increased the spectrum usage efficiently as compared to 0G.

- The basic idea of cellular radiotelephony uses based on frequency reuse scheme used in television stations or radio stations by telecommunication's committees.

- First generation phones were analog cell phones & were able to give the speed upto 2.4 Kbps.

- 1G standards available
  1. AMPS (advanced mobile phone system)
  2. NAMPS (Narrowband advanced mobile phone system)

- Examples of first generation mobile systems like RTMI in Italy, TACS in UK, Radiocom 2000 in France, C-450 in Germany etc.

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2G : Second Generation (1990's)

- Second generation standards use digital modulation techniques & TDMA or CDMA is employed.
- Based on multiple access technology used second generation standards are categorized.
- Major advantage of this gereeation is efficient frequency spectrum utilization.
- It offers at least three times increase in the spectrum efficiency as compared to first gereeation technologies.
- 2G offers better security than 1G.
- Digital technology static & background noise was not a problem
- Better voice quality & SMS facility.
- Reliable handover mechanism.
- Encryption is supported so better security in the system.
- Digital signals consume less battery power
- video data is not supported
- As it makes use of circuit-switching techniques are employed, there is limited internet browsing.

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2.5 G : 2.5 Generation (2000's)

- Few modifications in 2G Infrastructure & software upgrades made high data rate Internet browsing possible.
- 2.5G supports WAP (Wireless Access Protocol) which allows standard web pages to be viewed in a compressed format on mobile.
- The main requirement of 2.5G standard was to support backward compatibility for 2G standards since it would otherwise become very expensive system.
- There are 3 evolutions present for GSM & one for CDMA.

2.5G standards for GSM:-

- HSCSD (High Speed Circuit Switched data)
- GPRS (General Packet Radio service)
- EDGE (Enhanced Data Rate for GSM Evolution)

Advantages

- High data speed
- Supports packet data network communication
- New spectrum is not needed.
- Better freqn spectrum utilization.
- Security of data is better.
- Complex data like video are also supported. MMS is supported.

Disadvantages:-

- New handset is required.
- Does not support Video conferencing.

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3G : Third Generation (2000's) / UMTS

- It allows the use of global freq band of 2000MHz range that will support a single globally accepted wireless communication standard.
- The gradual evolution of GSM, IS-136 & PDC together is W-CDMA (wideband CDMA). It is also called as UMTS. (Universal Mobile Telephone system)

Advantages:-

- Higher data rate than 2.5G.
- Bandwidth, security & reliability is more.
- Supports interoperability among service providers.
- Supports video conferencing services.
- Provides backward compatibility to GSM & CDMA networks.
- Overcrowding of channels is reduced by change in the radio spectrum.

Disadvantages:-

- Cost of upgrading infrastructure is quite high.
- New handsets are needed
- Power consumption is high so large power battery batteries are needed.

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Comparision of Generations of Mobile Communication Technologies

Sl No	Parameter	1G	2G
1.	Implementation year	1984	1991
2.	Standards	NMT, AMPS, NTT, ETACS	GSM, PDC, IS-136, IS95
3.	Technology	Analog cellular	Digital Cellular
4.	Multiple Access technique used	FDMA	TDMA & CDMA
5.	Data rates	2.4 Kbps	14.4 Kbps
6.	Switching method used	Circuit switching	Circuit switching
7.	Operating Spectrum	800 MHz	GSM: 900 MHz, 1800 MHz, CDMA: 800 MHz
8.	Services	Voice	Voice & SMS
9.	Carrier freq / Channel BW	30 KHz	200 KHz
10.	Whether analog or Digital	Analog	Digital

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2.5G	3G	4G	5G
1999	2002	2010	2015
HSCSD, GPRS EDGE	WCDMA, Cdma 2000, IMT 2000	Single unified standard	Single unified standard.
Digital cellular	Wideband CDMA IP	LTE, Wimax	5G. LTE.
TDMA & CDMA	Wideband CDMA	CDMA	.CDMA.
171 Kbps	3.1 Mbps	100 Mbps	Higher than 1Gbps.
Circuit switching for voice & packet switching for data	Packet switching	Packet switching	Packet switching
GSM: 900MHz, 1800MHz CDMA: 800MHz	2100 MHz	850MHz 1800MHz	850MHz, 1800MHz.
voice & data	Integerated high quality of voice & data	Dynamic information acces, wearable devices	Dynamic information acces, wearable devices with AI Capabilities.
200KHz	5MHz	15MHz	28GHz
Digital	Digital	Digital	Digital.

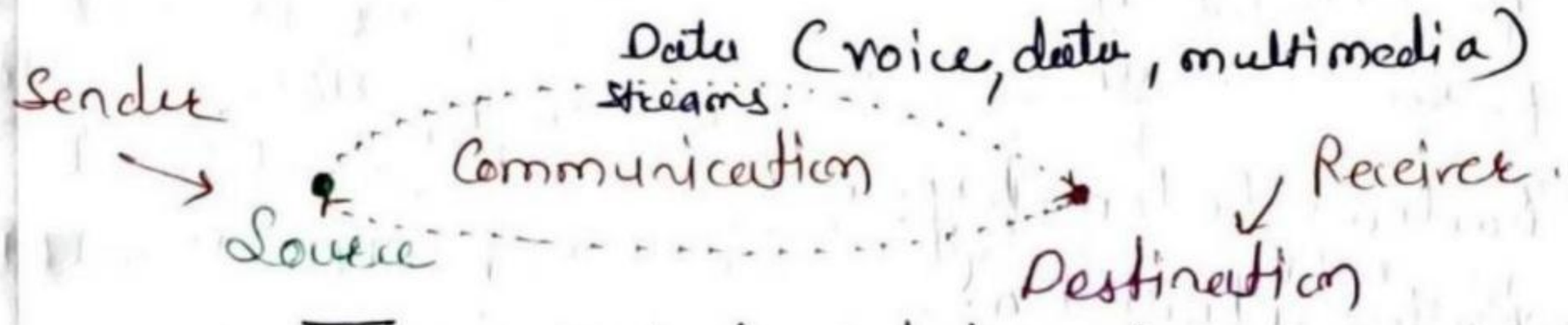
Introduction

Communication System :-

- We are social human being. It is our primary need to communicate with each other. For short distances we can talk directly But for long distances we cannot talk directly due to distance, attenuation of sound.
- The word 'communicate' is illustrated in the English dictionary " as an act of passing news, information, feelings, heat, motion, illness etc ".
- This communication is between two points, these points may be situated on the earth, in the space, in water.
- 1st Telegraphic message by Samuel F.B. Morse in 1836. This is called electrical communication
- The electrical communication means sending, processing & receiving information by electrical means.

Defination :-

- Communication is the process whereby the meaningful information is transferred from one point called source to the other point called destination.

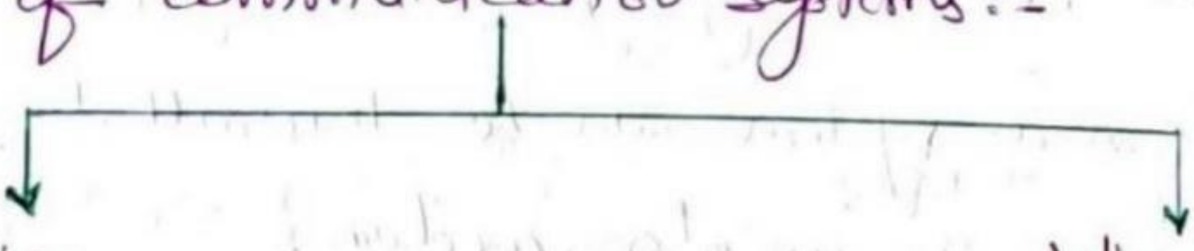


- Two-way transmission & Reception of data streams.

- Communication is a two way transmission & reception of data streams. Voice, data or multimedia streams are transmitted as signals, which are received by a receiver.
- Signals from a system can be transmitted through fibre, coiles or wireless medium.
- The science of communication involving large distance is called Telecommunication. (Tele - long distance)
- Communication is according to regulation, recommended standards & protocals.
- Now-a-days, satellite based fibre optics have made communication more widespread with an emphasis on computers & data communication.

- Depending upon the type of information to be transferred & received diff^ electronic communication systems, namely
  - Radio telephony
  - Telegraphy
  - broadcasting
  - Radar
  - Radio telemetry.
  - Radio Navigation.
  - Computer communication.
  - point to point communication.
  - Mobile communication system
  - Microwave link communication.

Types of Communication systems :-



- In the line, wire Communication, the mode of transmission is a pair of conducting wires or cables or optical fibres known as transmission line.

- In Radio or wireless communication two points are not connected physically
- Wire communication is not possible for long distance.
- Wireless communication is also known as radio Communication, when radio waves are radiated from the transmitter in free space by device Antenna

Wireless Network Genereations :-

Mobile Communication systems transformed the way people exchanged information. Evolution of wireless access technologies is about to reach its fifth genereation with vast improvements in peerformance & efficiency.

- The wireless communication systems that we are using today are results of series of development with advancement of technology at each stage of development.
- Since the mid 1990s, the wireless communication network have experienced tremendous growth.
- There is tremendous growth in cellular & Personal communication services & the number of individual subscribers is exposed 5 billions by 2010.
- New radio spectrum licenses for personal communication services (PCS) in the 1800-2000 MHz freqⁿ bands.
- Such a rapid growth in the cellular telephone subscribers concludes that wireless communication is a robust, viable data & voice transport method.
- It has resulted in development of newer wireless systems and standards for other types of telecommunication traffic other than mobile voice telephone calls.

Comparison between all Mobile Radio Standards.

Sr No	Parameter.	1G	2G	2.5G	3G	4G	5G
1.	Implement-ation year.	1984	1991	1999	2002	2010	2015
2.	Standards.	NMT, AMPS, NTT, ETACS	GSM, PDC, IS 136, IS 95	~~WCDMA~~, ~~cdma2000~~, ~~IMT~~ HSCSD, GPRS, EDGE	WCDMA, CDMA 2000, IMT 2000, TD-SCDMA	single unified Standard	single unified standard.
3.	Technology	Analog Cellular	Digital Cellular	Digital Cellular	wideband CDMA, IP	LTE, Wimax	5G - LTE.
4.	Multiple acess Technique used.	FDMA	TDMA and CDMA	TDMA and CDMA	Wideband CDMA	CDMA	CDMA
5.	Data Rates.	2.4kbps	14.4kbps	171 kbps	3.1Mbps	100Mbps	Higher than 1 Gbps.
6.	Switching method used.	Circuit Switching	Circuit Switching.	Circuit Switching for voic and packet Switching for Data.	Packet Switching	Packet Switch-ing	Packet Switching
7.	Operating Spectrum	800MHz	GSM: 900. MHz, (800MHz) CDMA, 800MHz	GSM: 900MHz, 1800MHz CDMA; 800MHz	2100MHz	850MHz, 1800MHz	850MHz, 1800MHz
8.	Services	voice	voice and SMS	Integrated high voice and data	Integrated high quality of voice and Data.	Dynamic Information access wearable Devices	Dynamic Info access, wear-able Device AI capabilities
9.	Carrier frequency/ Channel Bandwidth	30kHz	200kHz	200kHz	5MHz	15MHz	28 GHz
10.	wheather analog or Digital	Analog	Digital	Digital	Digital	Digital	Digital.

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Multiple • Major Mobile radio Standards in North America

Standard	Type	Year of Introduction	Multiple Acess	frequency Band	Modulation	channel Band-Width.
AMPS	Cellular	1983	FDMA	824-894 MHz	FM	30kHz
NAMPS	Cellular	1992	FDMA	824-894 MHz	FM	10kHz
USPC	Cellular	1991	TDMA	824-894 MHz	$\pi/4$DQPSK	30kHz
CPPD	Cellwar	1993	FH/packet	824-894 MHz	GMSK	30kHz
IS-95	Cellwar/ PCS	1993	CDMA	824-894 MHz 1.8-2.0GHz	QPSK/ BPSK	1.25MHz
GSC	Paging	1970's	Simplex	Several	FSK	12.5MHz
POC-SAG	Paging	1970's	Simplex	Several	FSK	12.5MHz
FLEX	Paging	1993	Simplex	Several	4-FSK	15 kHz
DCS-1900 (GSM)	PCS	1994	TDMA	185-1.99 GHz	GMSK	200kHz
PACS	Cordless/ PCS	1994	TDMA/ FDMA	185-1.99 GHz	$\pi/4$ DQPSK	300kHz
MIRS	SMR/ PCS	1994	TDMA	Several	16-QAM	25kHz
IDens.	SMR/ PCS	1995	TDMA	Several.	16-QAM	25kHz

Major mobile standards in Europe.

Standard	Type	year of Introduction	multiple Access	frequency Band	modulation	Channel Band-width.
ETACS	Cellular	1985	FDMA	900MHz	FM	25KHz
NMT-450	Cellular	1981	FDMA	450-470mHz	FM	25KHz
USDCNMT -900	Cellular	1986	FDMA	890-960MHz	FM	125KHz
GSM	Cellular/ PCS	1990	TDMA	890-960 MHz	GMSK	200KHz
C-450	Cellular	1985	FDMA	450-465-mHz	FM	20KHz 10KHz
ERMES	Paging	1993	FDMA	several	4-FSK	25KHz
CT2	Cordless	1989	FDMA	864-868 MHz	GFSK	100KHz
DECT	Cordless	1993	TDMA	1880 -1900MHz	GFSK	1.728 mH2
DCS-1800	Cordless/ PCS	1993	FDMA	1710-1800 GHz	GMSK	200 KHz

Compare AMPS, NAMPS, GSM & IS-95

Parameter	AMPS	NAMPS	GSM	IS-95
Type	Cellular	Cellular	PCS	Cellular/PCS
Introduced in the year	1983	1992	1994	1993
multiple access method	FDMA	FDMA	TDMA	COMA
Type of modulation	FM	FM	GSMSK	QPSK/BPSK
channel bandwidth	10KH2	10KH2	200KH2	1.25mH2

Mobile Radio Standards :-

Introduction :-

- Digital Mobile Radio (DMR) is an international open digital mobile radio standard defined in the European Telecommunications Standards Institute (ETSI) standards TS 102 361 parts 1-4 and used in commercial products around the world.
- DMR, Digital Mobile Radio is an International digital Radio Standards specified for business mobile developed by ETSI.
- DMR is a digital two-way radio standard offered by ETSI for global use.

Types :-

- Some of the important world-wide mobile radio standards are as under,
  1. AMPS (Advanced Mobile Phone system)
  2. NAMPS (North American Mobile phone system)
  3. IS-95 (Interim standard-95)
  4. GSM (Globle System for Mobile)
  5. DMTS (Universal Mobile Telecommunication System)
  6. CDMA-2000 (Code Division Multiple Access 2000)

- All these mobile radio standards are developed in North America.

Basic Cellular System OR Basic structure of Mobile Phone System :-

Introduction :-

- In 1970, Bell laboratories of US proposed to build the high capacity cellular telephone system & then introduced in the early 1970s.
- AMPS (Advanced Mobile Phone system) which has been available in the US, since 1983.
- A cellular radio system is generally characterized as a high capacity land mobile system in which available frequency spectrum is partitioned into the discrete channels which are assigned in groups to geographic cells covering a cellular Geographic service Area (GSA). The discrete channels are capable of being reused in different cells within the service area.

Concept :-

- In the mobile communication which we are going to study in this either transmitter or the receiver or both are going to be movable.
- Communication points are movable, the communication channel has to be air, that means it is a wireless communication.

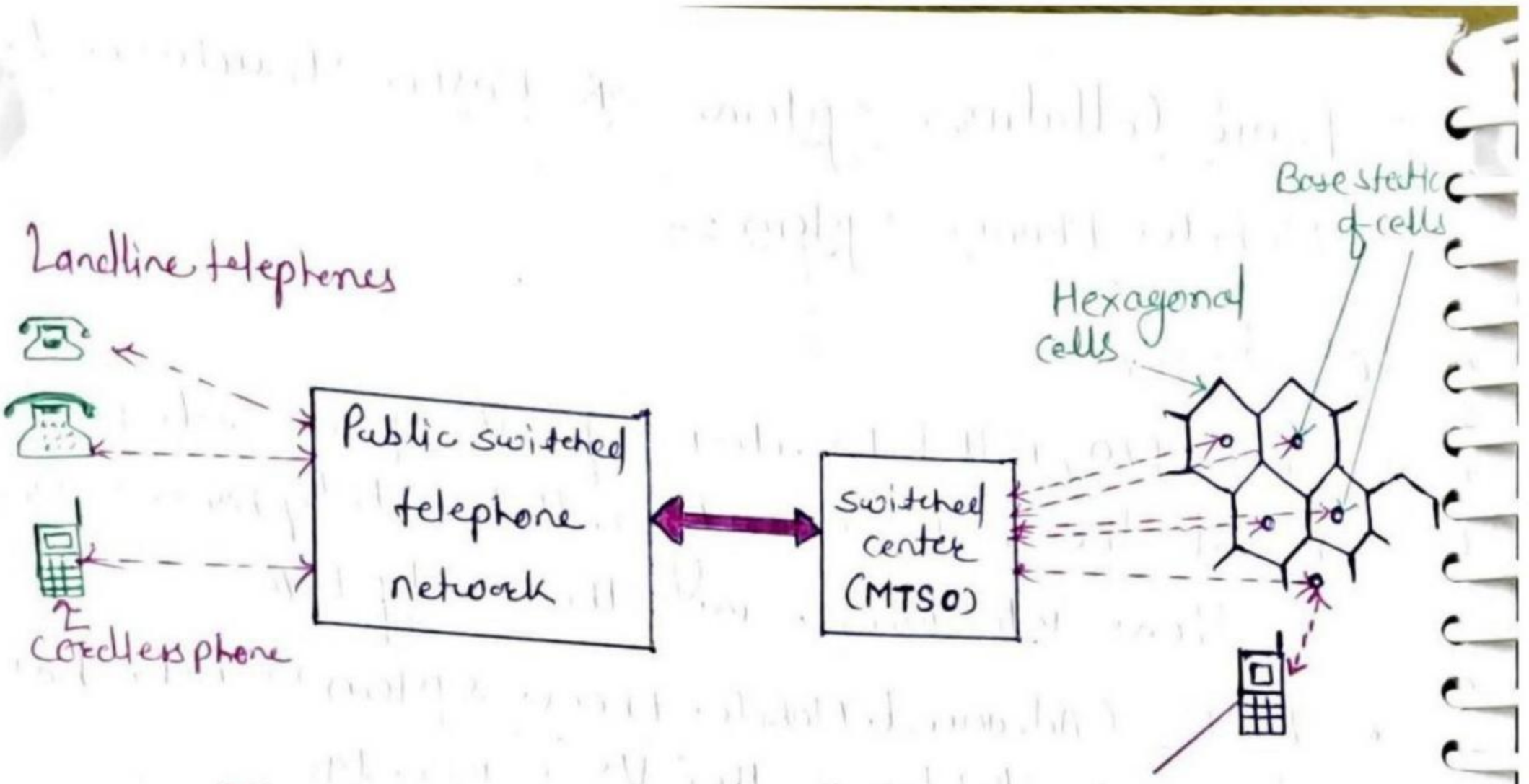

Fig: Basic structure of mobile telephone network

Description :-

- The mobile telephone system has hexagonal shaped cells. Each cell has a base station situated at the center.
- Base stations act as an interface between the mobile phone and the cellular radio system.
- The base stations of all the cells are connected to the switched center. This interface is the bidirectional one. That means this interface exchange of information between the switched center & base stations is a two way.
- The communication area of the mobile communication is divided into hexagonal cells.
- Therefore, the system is named as the cellular radio system.

- The switching center acts as the interface between the Public switched Telephone Network (PSTN) In addition to that it performs the supervision & control operations in the mobile communication system.
- Due to this kind of a system layout, the communication can take place between two mobile subscribers or between a mobile subscriber & a landline telephone as well.
- If a mobile subscriber travels from one cell area to the other then it automatically gets connected to base station of that cell. Thus the service provided to a mobile subscriber is continuous without any break.

Functions of MTSO :-

- The MTSO control all the cells & provides the interface between each cell & the main telephone office.
- As the mobile user from one cell to the next cell, the system automatically switches from one cell to the next.
- The computer at MTSO causes transmission from the mobile user to be switched from the weaker cell to the stronger cell within a very short time.

Introduction :-

The aim of the early mobile radio system was to provide coverage to a large area with the help of a single high power transmitter having an antenna mounted on a tall tower.

This approach had the following disadvantages:-

1. Freq^n reuse was not possible
2. Proper spectrum allocation in proportion with increasing demand was not possible.

- Hence it became necessary to restructure to radio telephone system so as to achieve the following objectives:
  - High capacity
  - To utilize the available radio spectrum effectively.
  - Coverage of large area.
- The major step in this field was the introduction of the cellular concept
- Advantages of cellular concept

(1) Improved user capacity.
(2) No spectral congestion.
(3) No major technological changes.
(4) Efficient utilization of the available spectrum

Cellular concept:-

In the cellular systems, a single High power transmitter is (large cell) is replaced by many low power transmitter (small cells) as shown in fig.

Each small cell provides coverage to a small portion of the entire large service area (large cell)

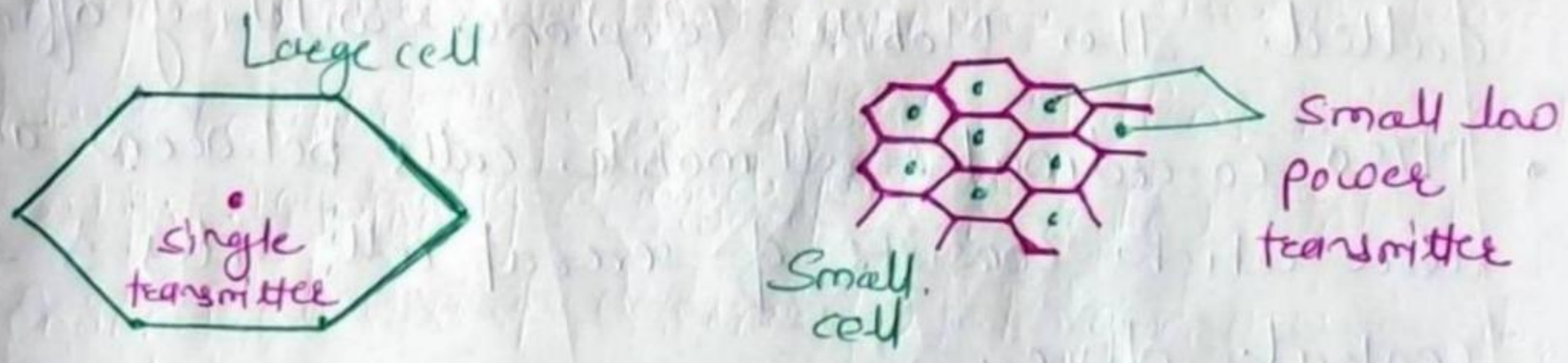

Fig: The cellular concept

Basic Cellular System:-

- Cellular telephone system is a wireless telephone system. It is a multiuser system.
- It is just like cordless phone
- In cell phone distance is not restricted to within home but one can travel in the city or even outside the city without interruption in communication.
- The demand for cellular mobile phone is increasing at alarming level and is likely that wired communication will be replaced by wireless technology.
- In the cellular system city is divided into small areas called "cells".

- Each cell is around 10 square kilometer.
- The cells are normally thought of hexagons.
  Because cell phones & base stations use low power transmitters, the same frequencies can be reused in non-adjacent cell.
- Each cell is linked to central location called the Mobile Telephone switching office (MTSO)
- MTSO co-ordinates all mobile calls between an area which consists of several cell sites & the central office.
- Time & billing information for each mobile unit is accounted for by MTSO.
- At the cell site base station is provided to transmit receive, and switch calls to and from any mobile unit within the cell to the MTSO
- In this manner heavily populated areas can be serviced by several stations, rather than one as used by conventional mobile techniques.
- At the cell site base station is provided to transmit receive, and switch calls to and from any mobile unit within the cell to the MTSO.
- A cell covers only few square kilometer area, thus reducing the power requirements necessary to communicate with cellular telephones.

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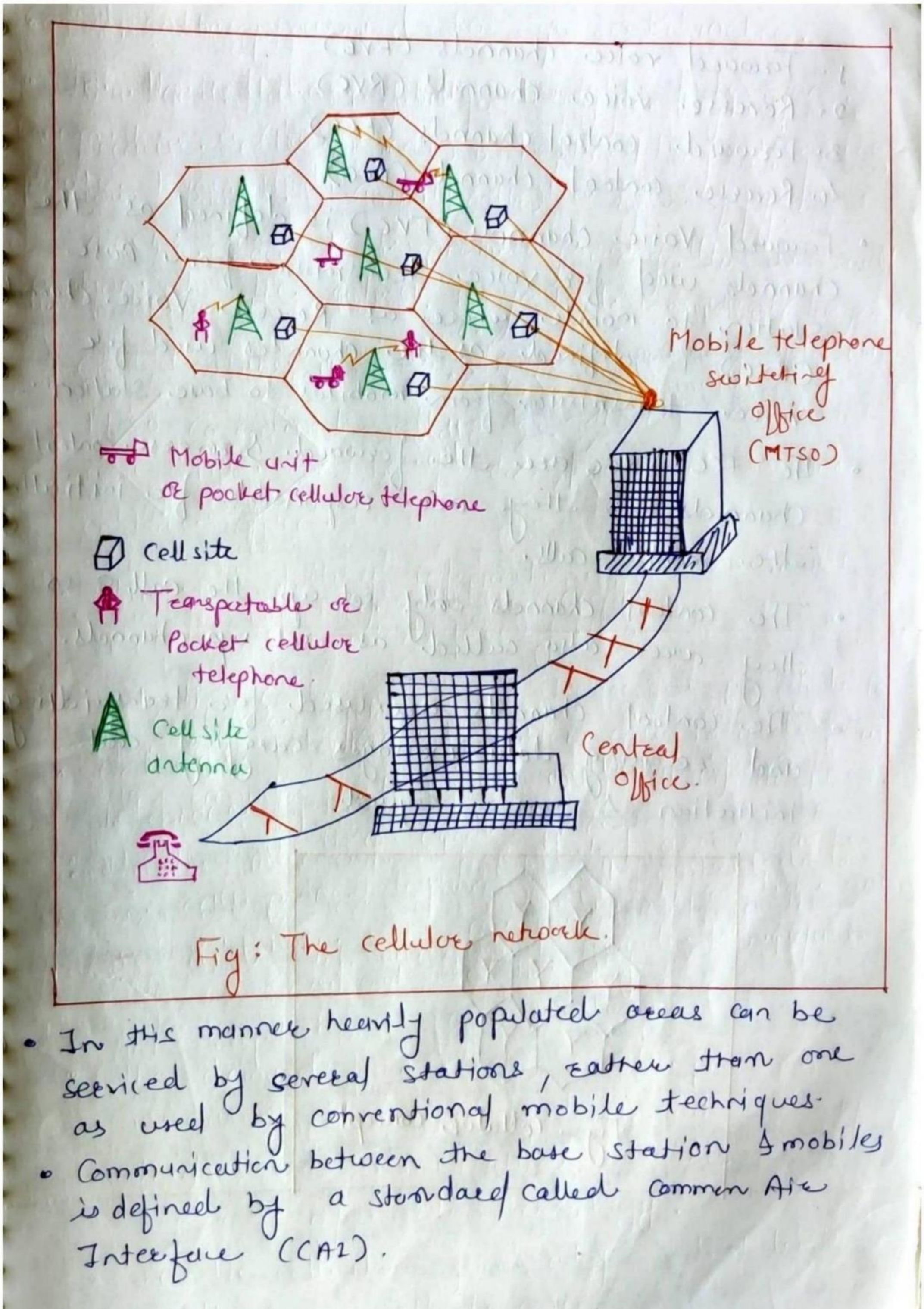

Fig: The cellular network.

- In this manner heavily populated areas can be serviced by several stations, rather than one as used by conventional mobile techniques.
- Communication between the base station & mobiles is defined by a standard called Common Air Interface (CAI).

1. Forwared voice channels (FVC)
2. Reverse voice channels (RVC)
3. Forwared control channels (FCC)
4. Reverse control channels (RCC)

- Forword Voice channels (FVC) is defined as the channels used for voice transmission from Base station to mobile where as Reverse Voice channels (RVC) is defined as the channels used for voice transmission from mobiles to base station.
- The FCC & RCC are the forword & reverse control channels. & they are responsible for initiating the mobile calls.
- The control channels only set up the call & so they are also called as set up channels.
- The control channels are used for transmitting and receiving data messages carrying call initiation & service requests.

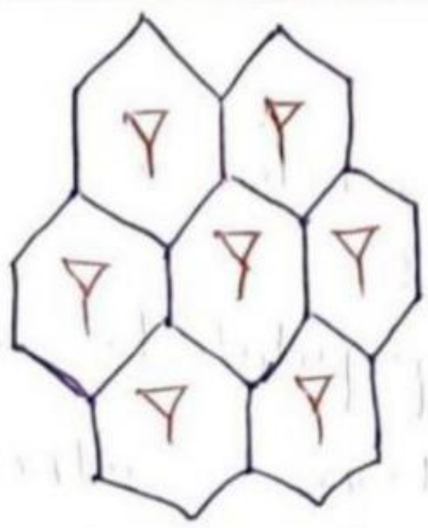

Fig:- Cellular concept

Definition

- The basic geographic unit of a cellular communication system is called as a cell.
- A small geographic area of a base station covered by cellular radio antenna is called a cell.
- The basic geographic unit of cellular communication system is known as a cell.

Cells

Macrocells

(The large cells were called macrocells)

- Radius between 1.5 to 25Km
- Transmission power between 0.1W & 6W.

Microcells

(The smallest cells called microcells)

- Radius of 0.45Km or less than 0.45Km
- Transmitting power bet^{n} 0.1W & 1W.
- Microcells are used mostly in high density area such as large cities & inside buildings.

Picocells

- Sometimes cellular radio signals are very weak, then very small cells called Picocells are used.
- Indoor pico cells are used in the areas like underground malls, use same frequencies as regular cells.

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Shape of a Cell :-

- Shape of cell is hexagonal. Cells have the base stations transmitting over small geographic areas.
- The size of a cell is not fixed. Practically the shape of the cell may not be a perfect hexagon.
- The hexagonal shape has been adopted universally because it allows easy & manageable analysis of a cellular system.
- Hexagon closely approximates a cellular radiation pattern, which would occur for an omni-directional base station antenna & free space propagation.
- So hexagon is a best choice for the geometric shape of a cell.

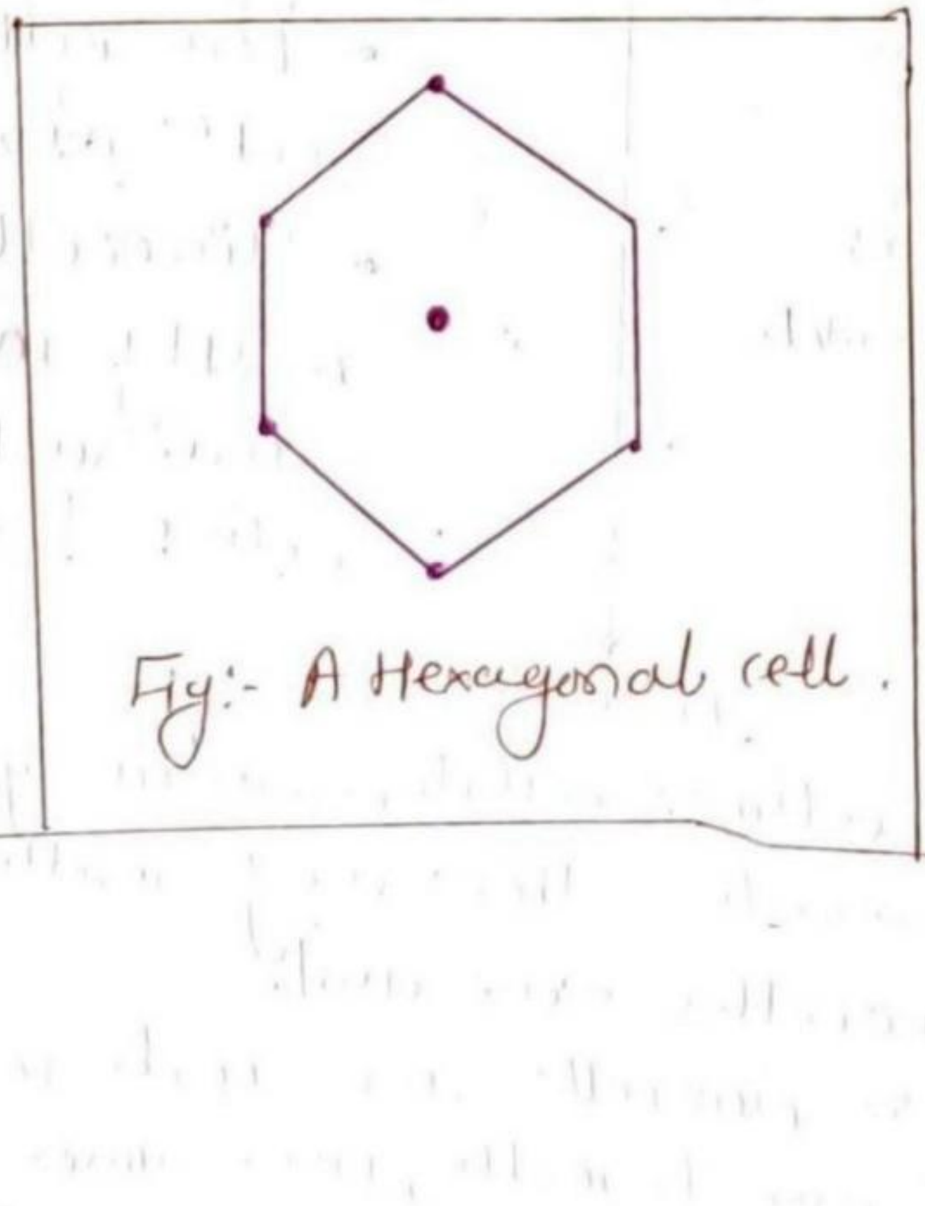
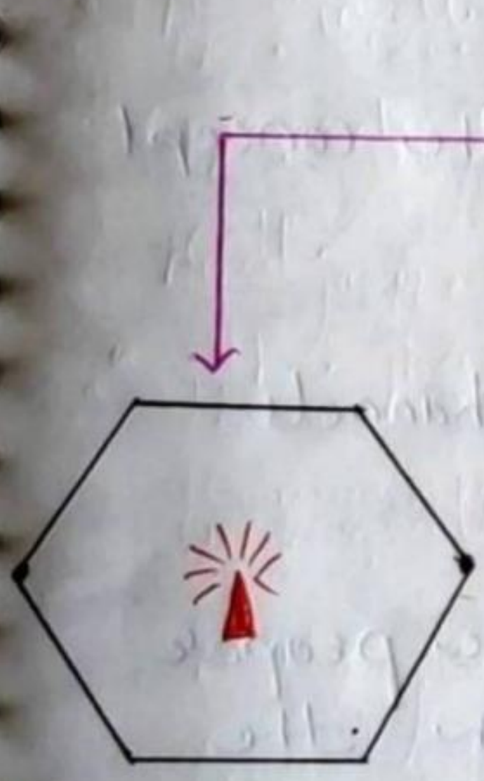


Fig:- A Hexagonal cell.

on the location of base station transmitter Types of cells are as follows.



a) Center excited cell

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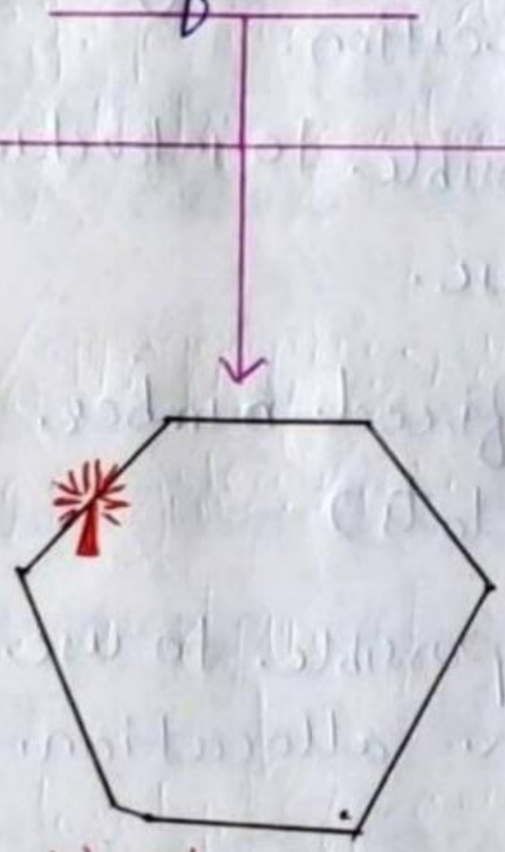
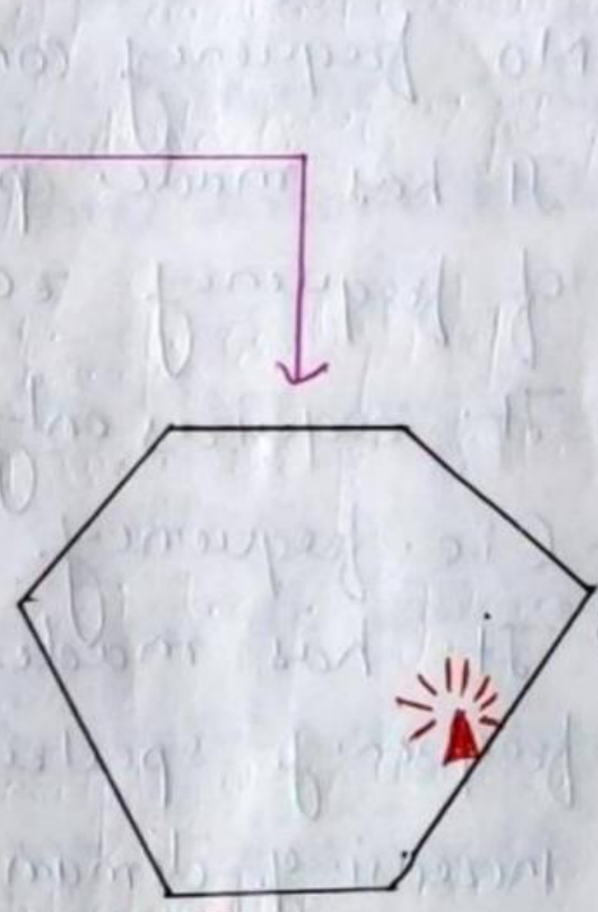
Omnidirectional antennas are used



b) Edge Excited cell

↓

Sectored directional antenna are used



c) Corner excited cell.

↓

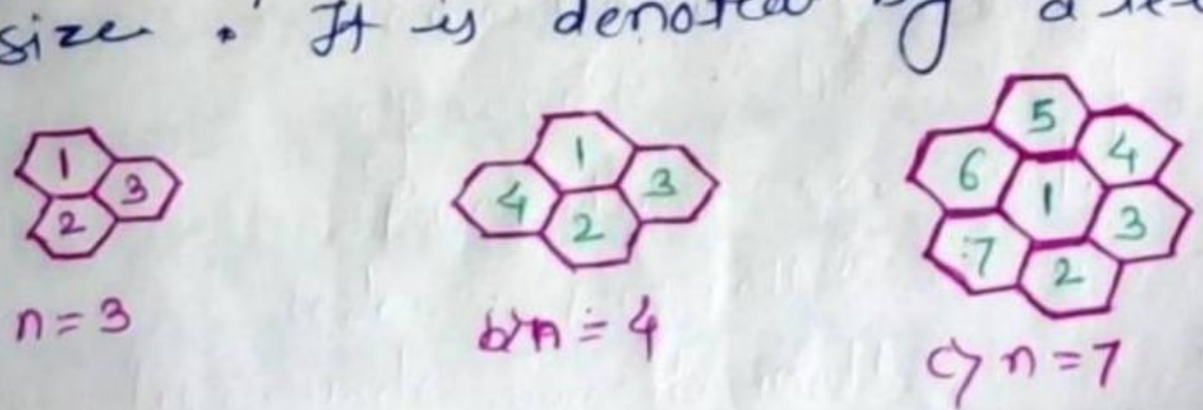
Sectored directional antennas are used.

Cell Cluster :-

<a> A group of cells that uses all the available set of frequencies is known as a cluster.

<b> Effect of cluster size :-

• The cluster size is not fixed, but it depends on the requirement of a particular area of a cluster size. • It is denoted by a letter 'n'



a) n = 3 b) n = 4 c) n = 7

Fig:- Cell clusters for frequency reuse.

Advantages:-

1) It has better user capacity
2) It has higher coverage range & area.
3) No frequency congestion.
4) It has made possible to introduce the concept of frequency reuse.
5) It requires only fixed number of channels (i.e. frequency slots)
6) It has made possible to use the proper frequency spectrum allocation with the increasing demand.
7) It can use low power transmitters.
8) It requires no major technological changes.
9) It has made possible to manufacture the every mobile handset within a country or continent with the same set of channels, so many mobile handset can be used anywhere.

Frequency Reuse Schemes :-

- We can use the concept of frequency reuse in either time domain or in the space domain.
- In the time domain the same frequency is used by different users in different time slots. This is called as time division multiplexing (TDMA)
- There are two categories of frequency reuse in the space domain as follows
  (1) Same frequency is assigned in two different geographical areas. (such as two different cities)
  (2) To use the same frequency repeatedly in a same general area in one system.

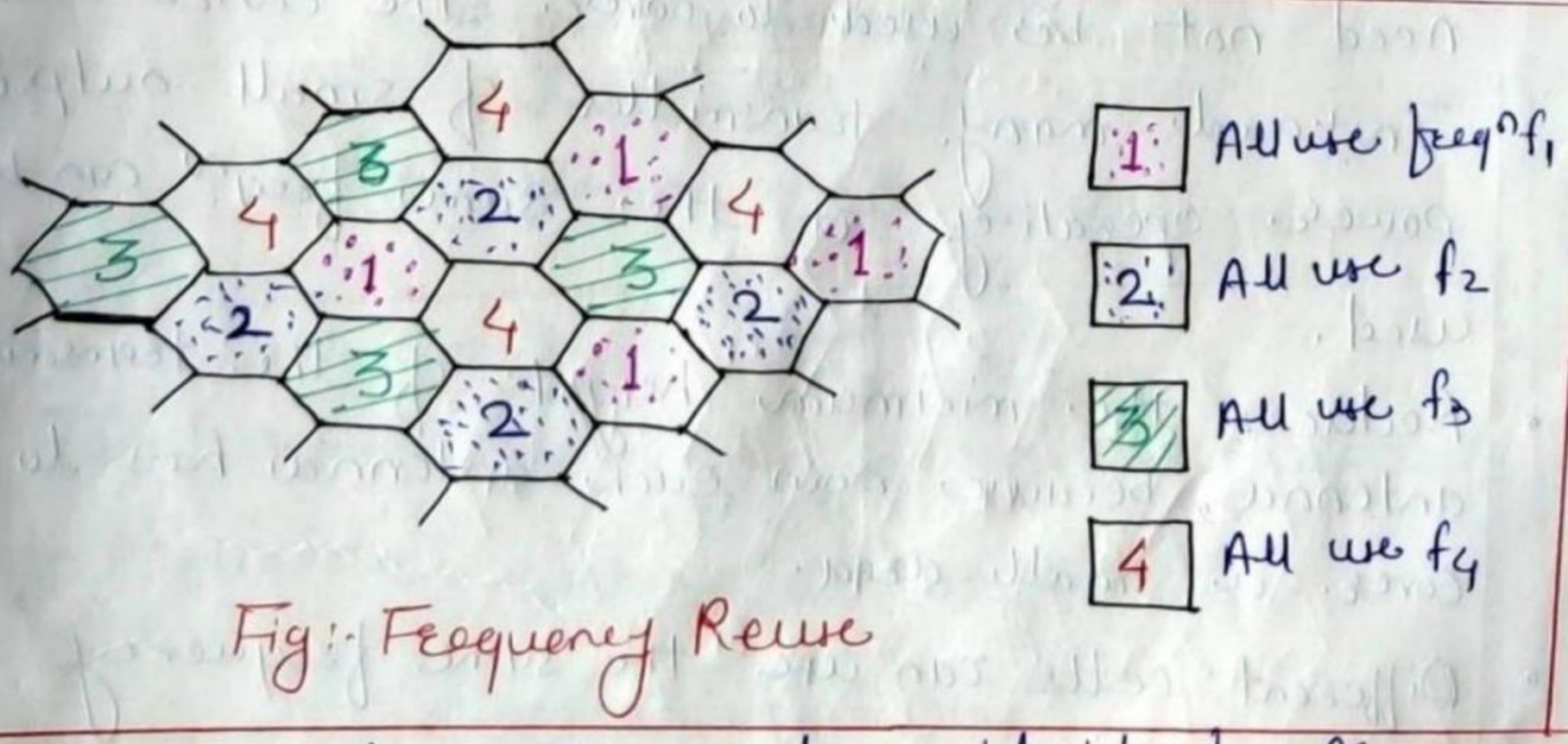


Fig:- Frequency Reuse

- In above fig. The total available freq^n spectrum is divided into 4 cochannels cell groups in the system as shown in fig.
- The cells marked 1 use freq^n f_1, same 2 use freq^n f_2, 3 use freq^n f_3, & so on.

Frequency Reuse :-

- Frequency reuse is the process of using the same radio frequencies on radio transmitter areas within a geographical area that are seperated by sufficient distance to cause minimal interference with each other.
- In frequency reuse concept the radio channels use the same frequency to cover different areas that are physically seperate from each other.
- In freqn reuse it is necessary to see that the co-channel interference is not objectionable
- Frequency reuse is an important concept because in this a single transmitter of higher power need not be used to cover the entire area. Instead many transmitter of small output power operating at the same freqn can be used.
- Reduces the minimum height of the transmitting antenna, because now each antenna has to cover a small area.
- Different cells can use the same frequency simultaneously.
- The advantage of frequency reuse is that it drastically increases the spectrum efficiency.
- The disadvantage is that if the system is not designed properly then cochannel interference may take place.

Frequency Reuse factor (FRF) :-

The frequency reuse factor is the rate at which the same frequency can be used in the network. The freq^n reuse factor should be as large as possible

$FRF = 1/N$; N = cluster size

smallest value of N - for maximum capacity. (4, 7, or 12) = N

Frequency Reuse concept :-

Let a cellular system has a total of S duplex channels available for use.

- Let each cell be allocated a group of k channels ($k < S$) & S channels be divided into N cells.

$\therefore$ S = Total number of channels

N = Number of cells.

K = Number of channels per cell.

$\therefore S = kN$ $\quad\quad$ $\frac{1}{N} = \frac{K}{S}$

Total number of duplex channels or capacity of cellular system (C) is given by.

$$C = M \times k \times N = M \times S.$$

Thus the channels capacity of a cellular system is directly proportional to the value of M i.e. number of times we replicate the cluster in a fixed service area.

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- N is called as the cluster size & its typically value are 4, 7 or 12
- If we reduce the cluster size N then there will be more number of clusters (M increases) & so the capacity of the cellular system also will increase
- But smaller cluster size (small N) leads to increased cochannel interference.
- Value of N, cluster size decided based on these two factors i.e. system capacity & interference.
- Size of N should be as small as possible in order to increase the capacity.

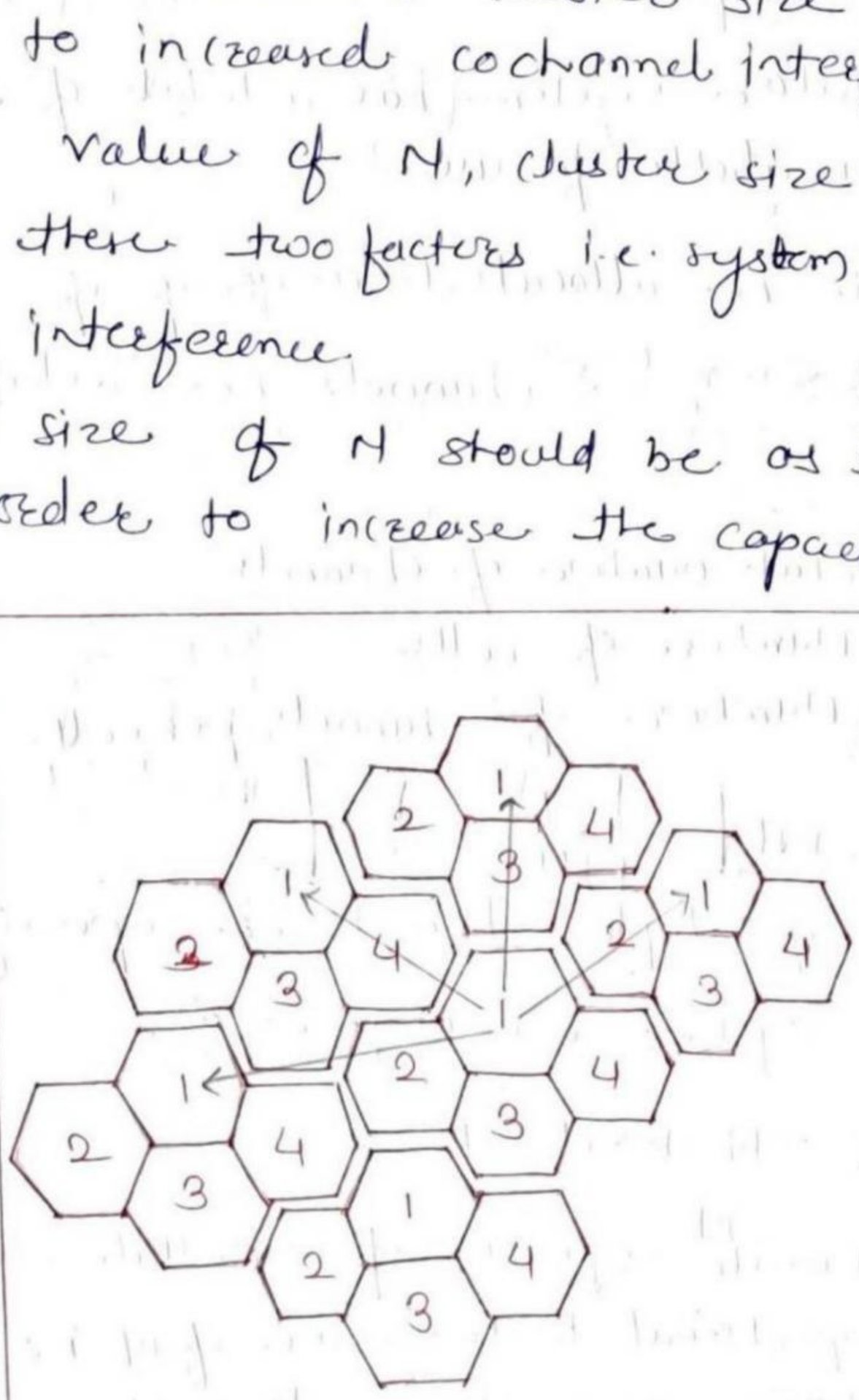

Fig. Frequency reuse pattern for cluster: 4

Hadsoff strategies:-

The call in progress continues irrespective of the the frequency changes from one base station to another base station. Such a call continued process without termination is called as "hand-off".

Concept of Hand off:-

- Assume that there is a call going on between two parties over a voice channel.
- when the mobile unit moves out of coverage area of a particular cell site, the reception becomes weak.
- Then the present cell site will request a handoff.
- The system will switch the call to a new cell site without interrupting the call, this procedure is called as the hand off procedure or handover procedure.
- The user can continue talking without even noticing that the handoff procedure or handover procedure has taken place.
- It increases the effectiveness of the mobile system.

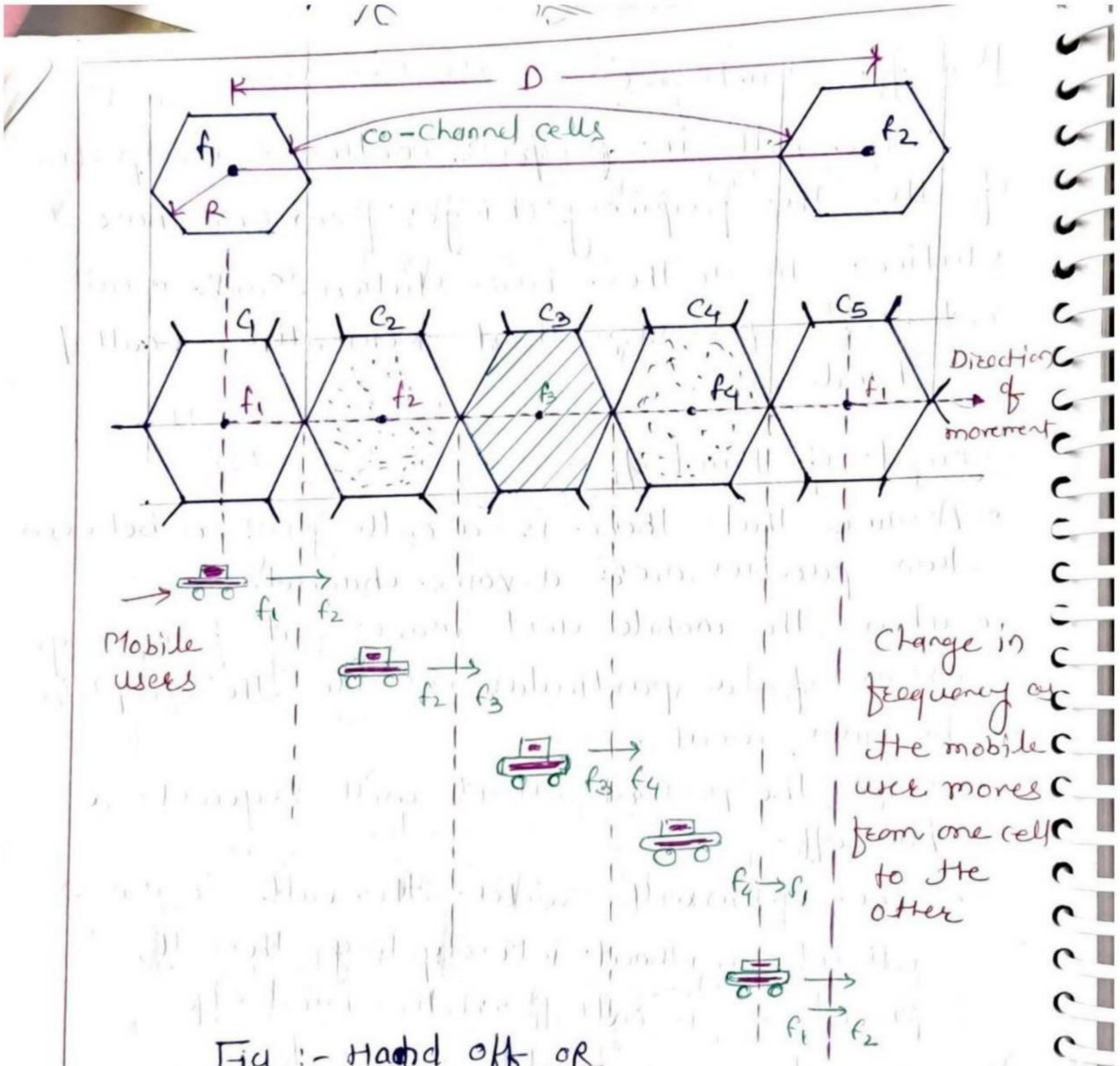

Fig :- Hand off OR Handover procedure

- Fig. shows Hand off procedure clearly.
- shows two cochannels seperated by distance D using freq^n f_1.
- The cells such as C_1, C_2, C_3, C_4, C_5 exist in between the two co-channel using freq^n f_1
- Cells C_1, C_2, C_3, C_4 use diff^n freq^{n}s f_1, f_2, f_3, f_4

Seppose a mobile unit initiates a call in cell C_1 & then moves to cell C_2. Then as it starts going away from C_1, the call is dropped & reinitiated in the freqn channel from f_1 to f_2 when mobile unit moves from C_1 to C_2.

- When mobile unit moves from cell C_2 to C_3 the freqn is changed automatically from f_2 to f_3
- Changing the freqn is done automatically by system & the user dose not even notice it.

Different types of Hand offs:-

- There are various types of Handoffs, in relation with a mobile station (MS).

1) Hard hand off
2) Soft hand off
3) Queued hand off
4) Delayed hand off
5) Forced hand off.

Handoff strategies:-

- It is important to process handoffs in any cellular system.
- In many hand off strategies, higher priority is given to the hand off request than the call initiation request.
- Handoffs should be performed succesfully and they should not be repeated frequently.
- So as to satisfy these requirements, system designers should decide & specify an optimum signal level at which the handoff should be initiated.
- First a minimum signal level for maintaining the call is decided. Then a slightly stronger signal level is used as the hand off threshold.

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- The margin between these two levels is denoted by Δ, given by

$$\Delta = P_{r\,\text{handoffs}} - P_{r\,\text{minimum usable}}$$

Received handoff signal power — Received minimum usable signal power

value of Δ is critical, Δ can not be too small & it can not be too large as well.

- If Δ is too large, then unnecessary handoffs will take place.
- If Δ is too small, then there won't be sufficient time to complete the handoffs & the call may lost due to weak signal.
- Fig (a) which illustrates the improper handoff situation i.e. handoff is not made & signal drops below the minimum signal level. This call is terminated.
- Fig (b), the hand off has taken place as soon as the received signal level drops to the hand off threshold. Note the increase in the signal level at point Y after handoff.
- Before initiating the handoff, it is necessary to ensure that the reduction in the measured signal level is not due to the momentary signal fading & that the drop in signal level is due to the actual movement of the mobile station.

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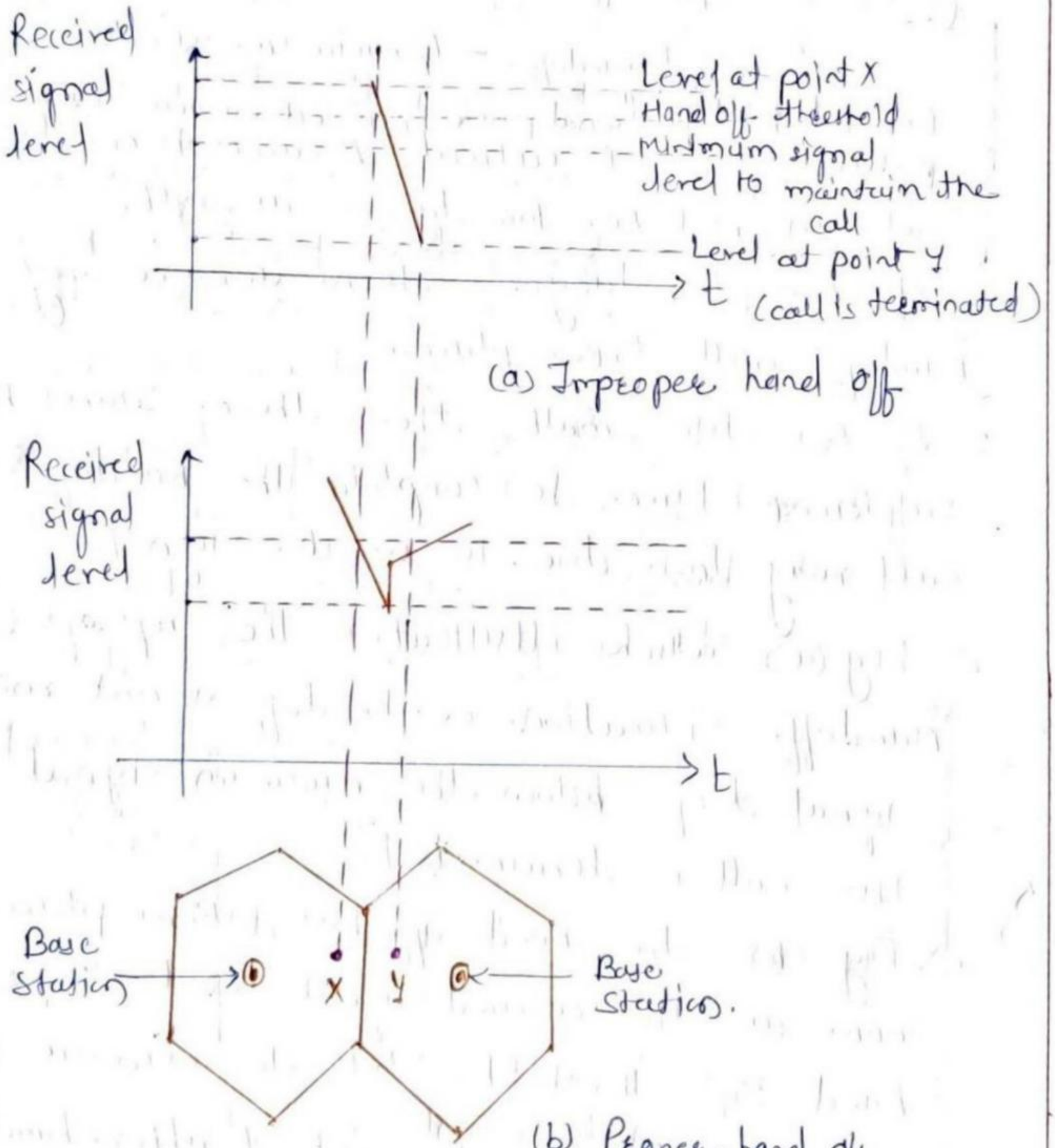

Fig:- Illustration of improper & proper hand off.

Dwell time:- The time duration over which a call may be maintained within a cell without initiating a handoff is called as dwell time. The dwell time depends on propagation, interference, distance between the subscriber & base station etc.

Types of Handoffs :-

1. Hard Hand off
2. Soft Hand off
3. Queued hand off
4. Delayed hand off
5. Forced hand off.

Hard Hand-off :-

- In the first generation analog cellular systems the time to make a handoff is 10 sec.
- In the digital cellular systems like GSM the mobile assists the handoff procedure it requires needs only 1 or 2 sec.
- Different base stations handle the different radio channels during a handoff called hard handoff.
- The hard off is known as hard handoff if a mobile stations transmits between two base stations operating on different frequencies.

Soft hard off :-

- The hard off is known as soft handoff if the MSC starts communication with the older base station.
- In a soft hand off the operating frequencies of the old & new base stations are identical.
- Soft hand off enhances the signal by providing different site selection diversity.

- If the handoff takes place within the same cell then it is known as softer hand off.

3: Delayed hand off:- (Two level handoff)

- In many situations, instead of one level, a two level handoff procedure is used, in order to ensure a higher possibility of a successful handoff.
- A hand off can be delayed if no available cell could accept the call.
- Fig shows a graph of signal strength with two hand offs levels.

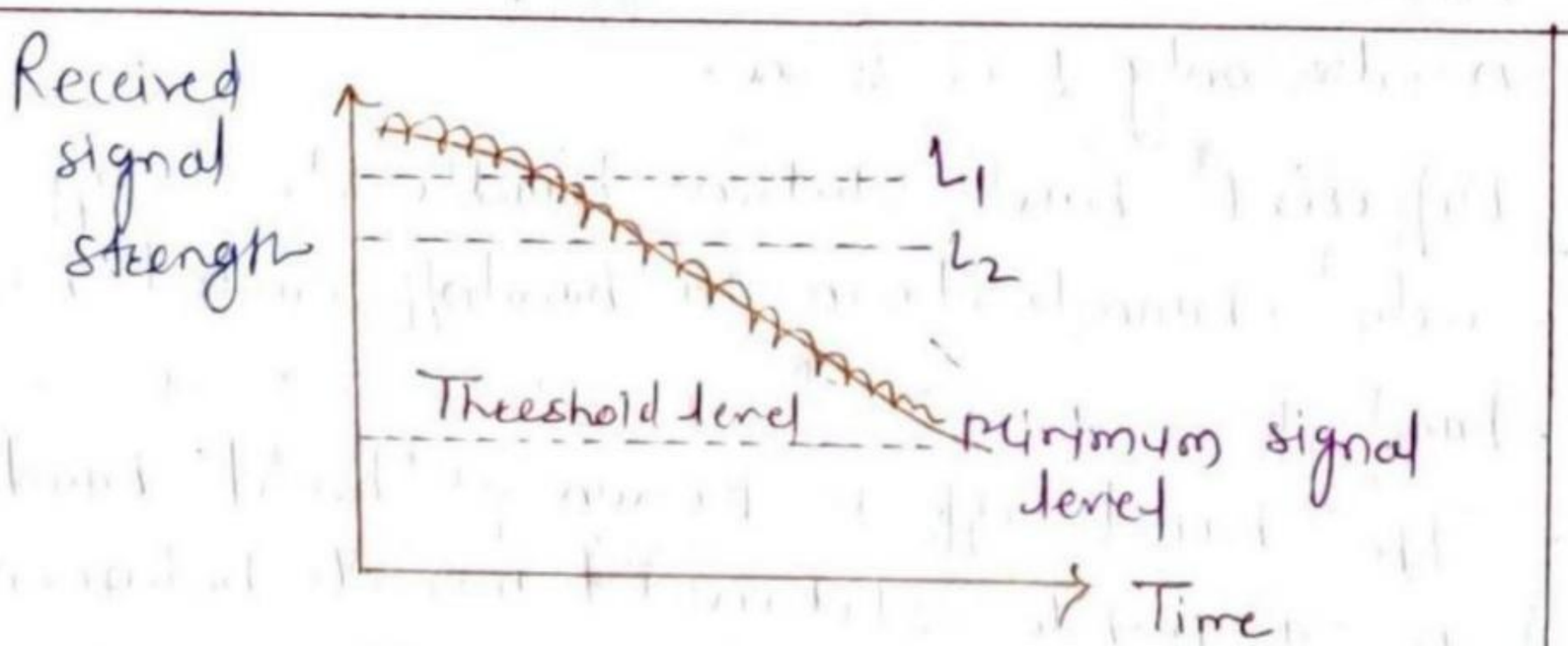

Fig. Two level handoffs.

- when the signal level drops below the first handoff level (L_1), the MS initiates a hand off request.
- If due to some reason the mobile is in a hole (Place in a cell with low signal level) or neighbouring cell is busy then the MS will repeat the handoff request after every 5 seconds.

- But if the signal strength drops further & reaches the second handoff level (L_2) then the handoff will take place without any condition immediately.
- This process is called as delayed handoff.

Advantages:-

- It is possible to delay the handoff if neighbouring cells are busy.
- The number of hand offs required to be carried out will reduce.
- This will allow the processor to handle calls more efficiently.
- It makes the handoff occure at the proper location & eliminates the possible interface in the system.

4. Forced Handoff:-

- A forced handoff is defined as the hand off which would normally occur but is not allowed to happen by force or a handoff that should not occure but is forced to take place.

5. Queued Handoff:-

- In this the MTSO arranges the handoff requests in a queue instead of rejecting them, if it finds that neio cell sites are too busy to makes the handoff possible.

- There handoff requests are then acted upon in a sequential manner.
- Queueing of handoffs is more effective than the two threshold handoff.
- Also a queuing scheme is effective only when the handoff requests arrive at the MTSO in the form of batches or bundles

Mobile Assisted Handoff (MAHO)

- In the second generation (2G) systems, the hand off decisions are assisted by the mobile stations. The mobile assisted hand offs are known as MAHO
- In MAHO, every mobile station measures the power it receives from all the base stations around it & continuously reports these measured power levels to the serving base station.
- If when the power received from the base station of a cell exceeds the power received from current base station then a handoff is initiated.
  - This method reduces the time required to handover the call between the base stations.
  - The handover is done at a faster rate.
  - It is suitable for the microcellular environment where the hand off are frequently done.

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Channel Capacity :-

- The channel capacity is defined as the maximum number of channels that can be provided for a particular frequency band.

- Thus, the capacity of a cellular system is directly proportional to the number of times a cluster is repeated in a fixed service area.
- The factor N is called as the cluster size & is typically 4, 7 or 12.

- The total number of duplex channels in a cellular system is defined as capacity of a cellular system. It is given by,

$$C = MKN = MS \quad \therefore S = KN$$

where M = Number of times the cluster is replicated in a fixed service area

K = Number of channels per cell

N = Number of cells.

S = Total Number of channels in a system.

Co-channel Interference:-

- A number of cells operating at the same set of frequencies are called as the co-channel cells.
- And the interference taking place between the signals originating from the cells is called as the co-channel interference

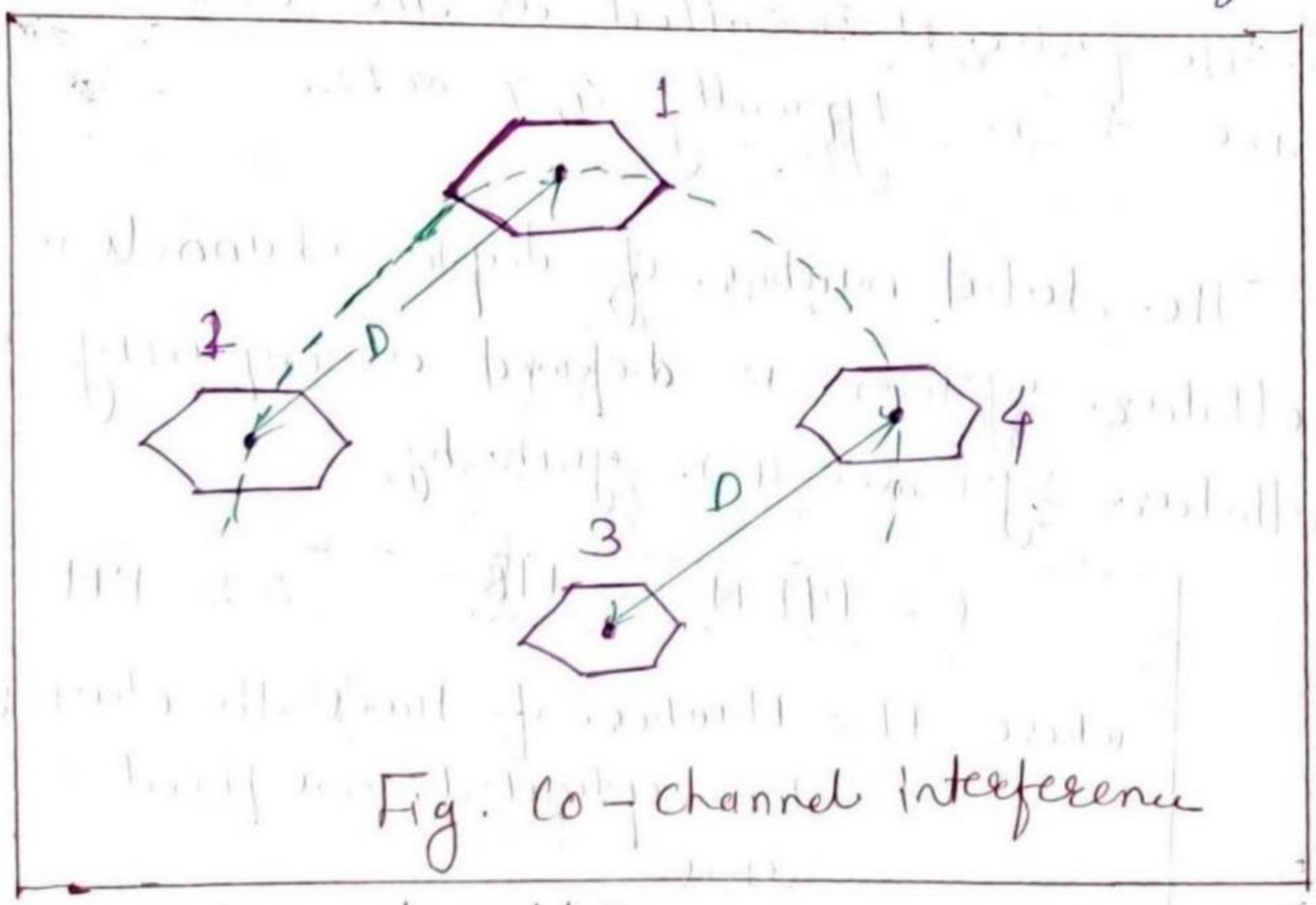

Fig. Co-channel interference

How to reduce it?

- We cann't reduce the co-channel interference by simply increasing the transmitter power for each cell.
- In fact increasing the transmitting power will increase the co-channel interference.
- It can be reduced by seperating the co-channel cells physically by a minimum distance.

- If all the cells are of the same size & all the base stations are transmitting equal amount of power, the co-channel interference ratio is independent of the transmitted power, but it will then be dependent on the cell radius (R) & the distance between centers of the co-channel cells (D) that are closest to each other
- If we increase the ratio D/R then co-channel interference will reduce

---

Co-channel Reuse ratio :-

- A parameter Q called as co-channel reuse ratio is related to the D/R ratio & the cluster size N as follows;

$$Q = \frac{D}{R} = \sqrt{3N}$$

D = Distance between the centers of the nearest co-channel cells.

R = Radius of cell.

Effect of the value of Q :-

- If Q is small then cluster size N will also small & system capacity will be large.
- If Q is large, then cluster size N will be large & the system capacity will be low.

Q Explain frequency reuse concept. Draw the frequency reuse pattern for cluster size 7.

1) The design process of selecting & allocating channel groups for all cellular base station within a system is called as frequency reuse or frequency planning.

2) Cellular radio systems rely on an intelligent allocation & reuse of channels throughout a coverage region.

3) Each cellular base station is allocated a group of radio channels to be used with small geographic area called a cell.

4) Base stations in adjacent cells are assigned channel group which contains completely different channels than neighbouring cells.

5) By limiting the coverage area to boundaries of a cell, same group of channels may be used to cover different cells that are sepeated from each other by distances large enough to keep interference levels within tolerance limits.

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6) If each cell is allotted K sets of channels & S channels are divided among N cells in unique & disjoint groups which have same number of channels, then total number of available channels can be

$$S = KN$$

If cluster is replicated M times then

Capacity $C = MKN$

$$C = MS$$

7) Frequency reuse factor $= \frac{1}{N}$

N = cluster size.

8) The cells which have been allotted same group of channels are called co-channels.

9) The co-channel reuse factor Q is defined as $\boxed{Q = \frac{D}{R}}$

D = minimum safe distance after which group of frequencies can be repeated.

R = cell radius.

Thus small Q means larger capacity as cluster size N is small whereas large value of Q improves transmission quality.

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10) To improve capacity N is usally 4, 7 or 12

11) To improve capacity & efficiency of freqⁿ reuse plan, cell sectoring is employed with omnidirectional antenna.

Diagram:-

Frequency reuse pattern with cluster size 7.

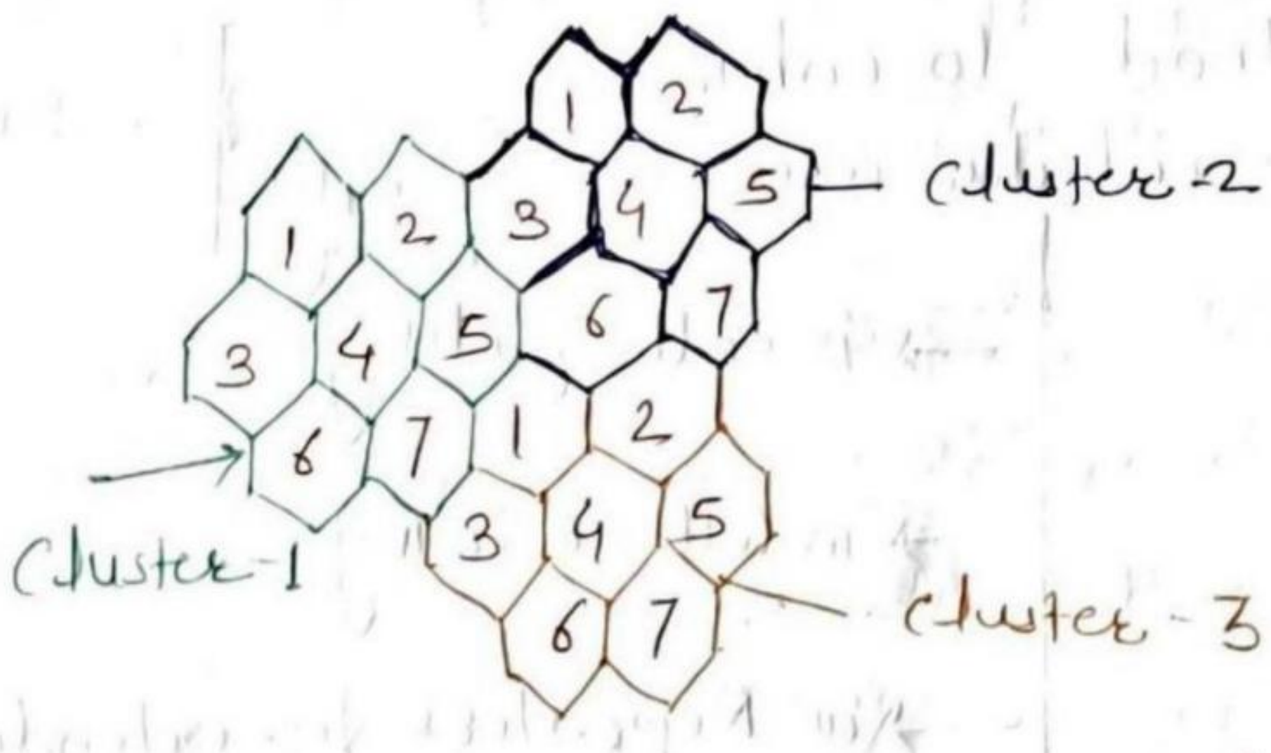


Fig. frequency reuse pattern for cluster: 7

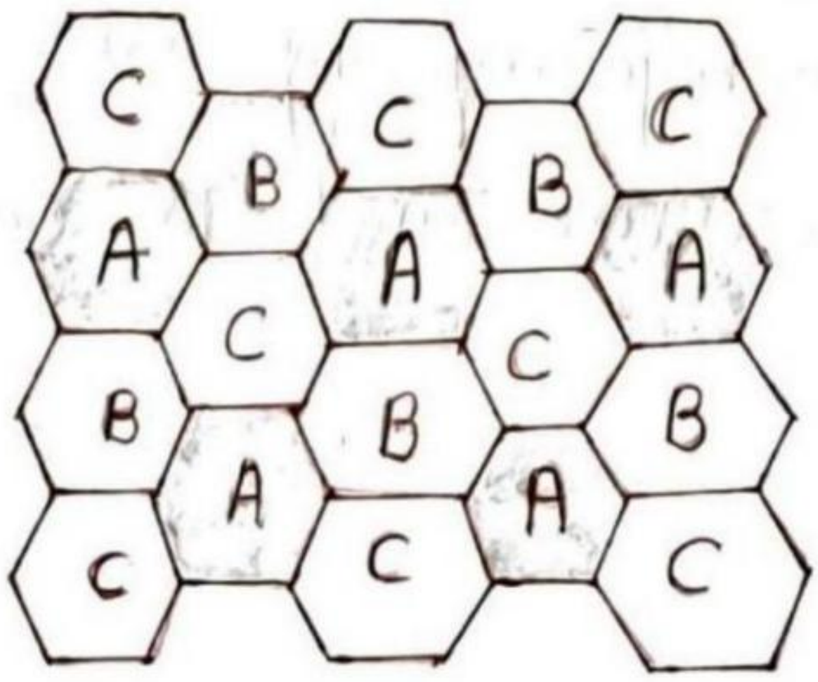


fig. frequency reuse pattern for cluster: 3

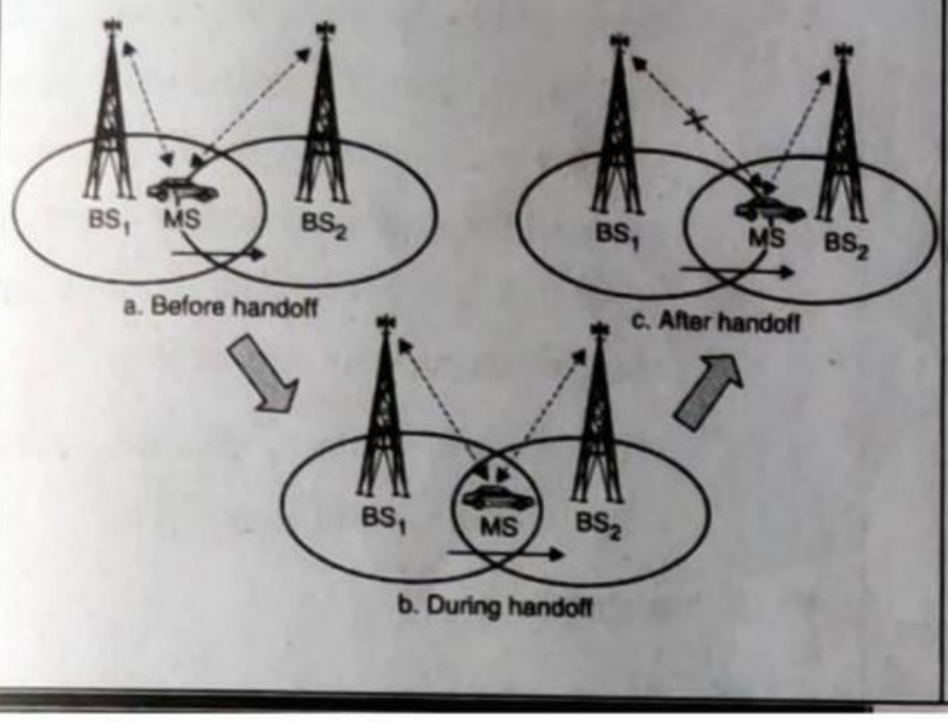
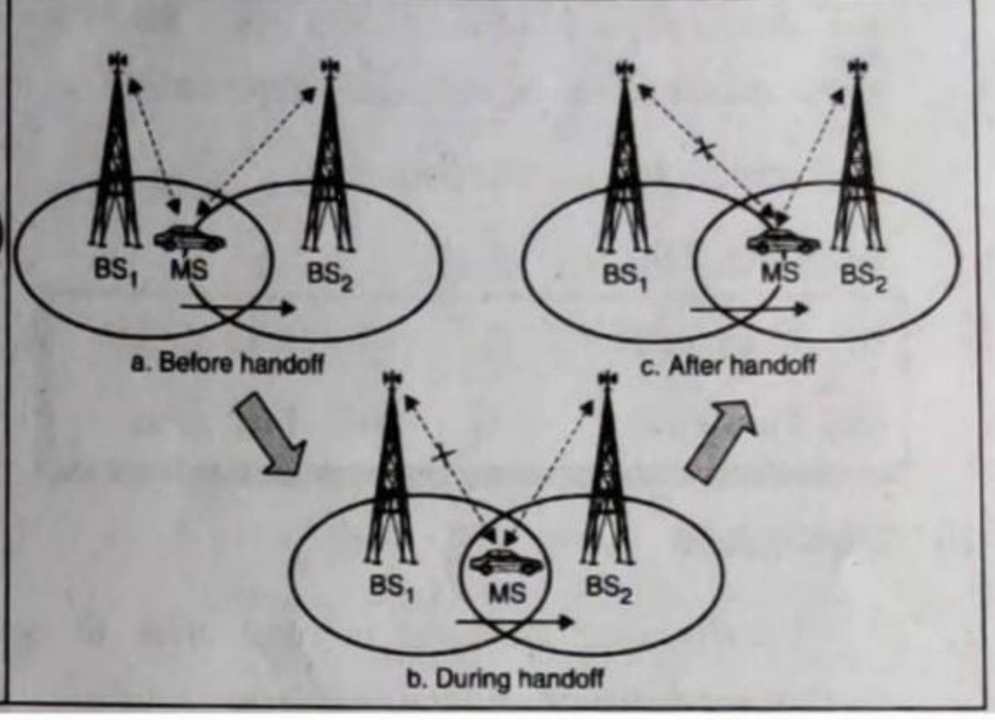
➤ (MSBTE : S-15)

MSBTE Question

Q. 2.7.15 Compare hard handoff and soft hand off operational procedure. (Ref. Sec. 2.7.4) **S-15, 2 Marks**

Table 2.7.1 : Comparison of hard handoff and soft handoff

Sr. No.	Soft Handoff	Hard Handoff
1	Soft handoff refers to the ability of the Mobile Switching Center (MSC) for selecting amongst the different received signals from the base stations.	Different base stations handle the different radio channels during a handoff called hard handoff.
2	It allows the MSC to make a "soft" decision as to which of the user's signal will pass to the PSTN at a glance.	It does not refer to the physical changes in the assigned channel, but a different base station takes care of the radio communication.
3	It is make before break process.	It is break before make process.
4	The mobile transmits and receives from multiple BSs simultaneously.	The mobile connects to single BS at a time.

Sr. No.	Soft Handoff	Hard Handoff
5		

1.24.6 Comparison of Multiple Access Strategies :

Table 1.24.1 : Comparison of SDMA, TDMA, FDMA and CDMA

Sr. No.	Approach	SDMA	TDMA	FDMA	CDMA
1.	Principle	Space is segmented into cells / sectors.	Time is segmented into disjoint time-slots.	Frequency band is segmented into disjoint sub-bands.	Spectrum is spread using orthogonal codes.
2.	Terminals	Only one terminal can be active per cell / sector.	All terminals are active for short periods of time and operate at the same frequency.	Every terminal operates at its own frequency without any interruption.	All terminals can be active at the same place at the same time without interruption.
3.	Signal Separation at receiver	With help of cell structure and directed antennas.	Using synchronization in the time domain.	With help of filters in the frequency domain.	Using code and special receivers.
4.	Advantages	simple, increases capacity per km^2.	Established system, fully digital, flexible.	Simple, established, robust, no synchronization needed.	Flexible, Needs less frequency planning, soft handover.

Sr. No.	Approach	SDMA	TDMA	FDMA	CDMA
5	Disadvantages	Inflexible, fixed antennas.	Synchronization difficult, needs guard time.	Inflexible, Inter modulation distortion, bandwidth is a scarce resource.	Complex receivers, needs more complicated power control for senders.

Definition of Spread Spectrum:-

- In the telecommunication or ratio communi-cation spread spectrum techniques are the methods by which a signal generated with a particular bandwidth is spread deliberately in the frequency domain to produce a signal with much wider bandwidth.

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How is the SS signal Different from the Normal signal?

The SS signal is different from a normal signal, in the following aspects

- This signal occupies a larger BW than that of a normal signal
- The spread spectrum signal invariably uses some kind of coding.
- The spectrum spreading at the transmitter & despreading (opposite to Spreading) at the receiver is obtained with the help of this code word.
- The code word associated with an SS signal is independent of the information carried by the signal.
- The most important point is that

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State applications of spread spectrum modulation.

1. Jam- Resistance communication systems.
2. CDMA Radios
3. High Resolution Ranging : Spread Spectrum Communication is often used in high resolution ranging.
4. It is possible to locate an object with good accuracy using ss techniques.
   For example : GPS (Global positioning System)
5. WLAN : Wireless LAN (Local Area Networks) widely used spread Spectrum communication.
6. Cordless phones
7. Long-range wireless phones for home & industry.
8. Cellular base stations interactions.
9. Bluetooth.

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Classification of the Spread Spectrum Modulation Techniques:-

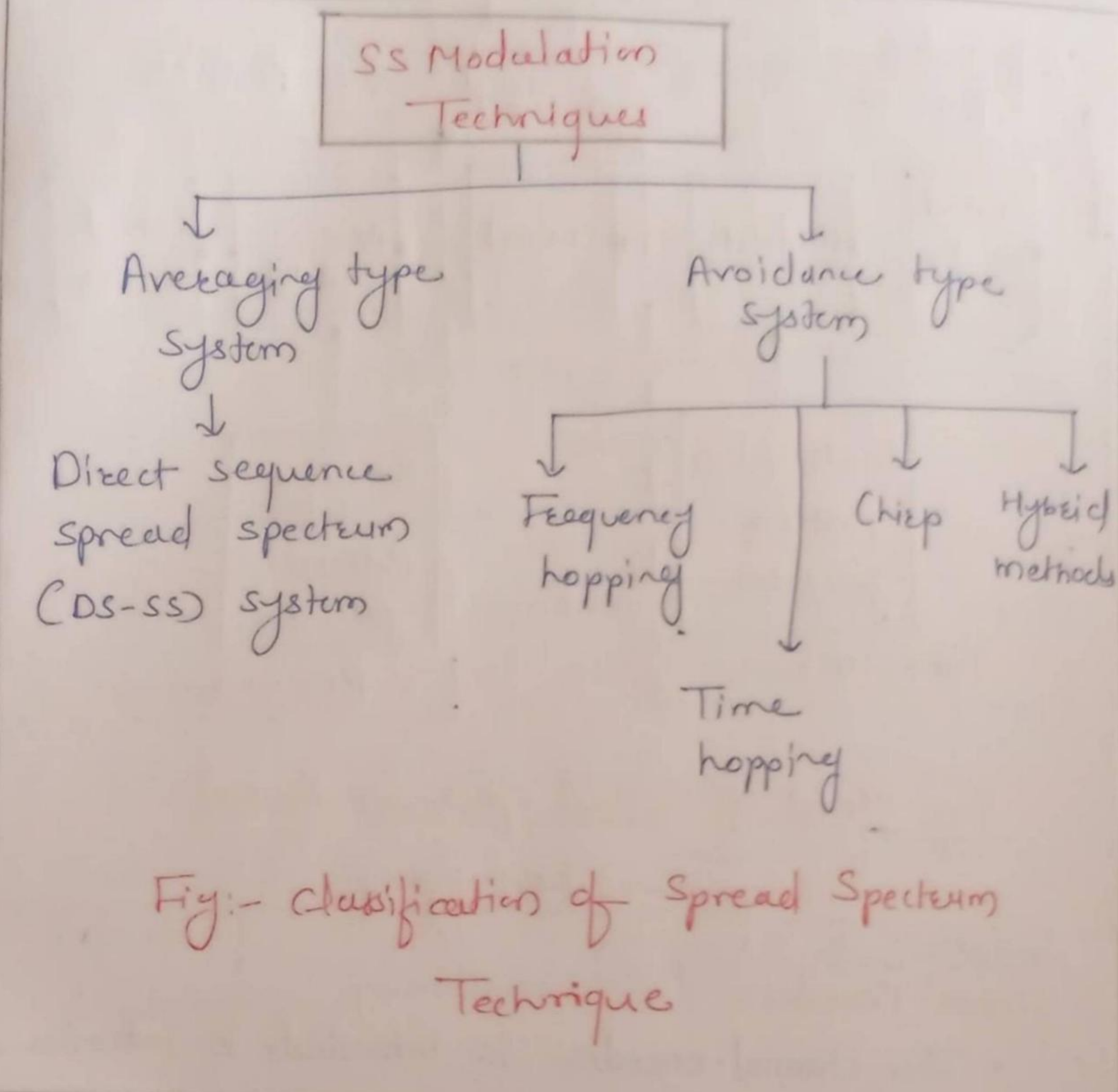

Fig:- Classification of Spread Spectrum Technique

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Block diagram of Spread Spectrum Modulation System :-

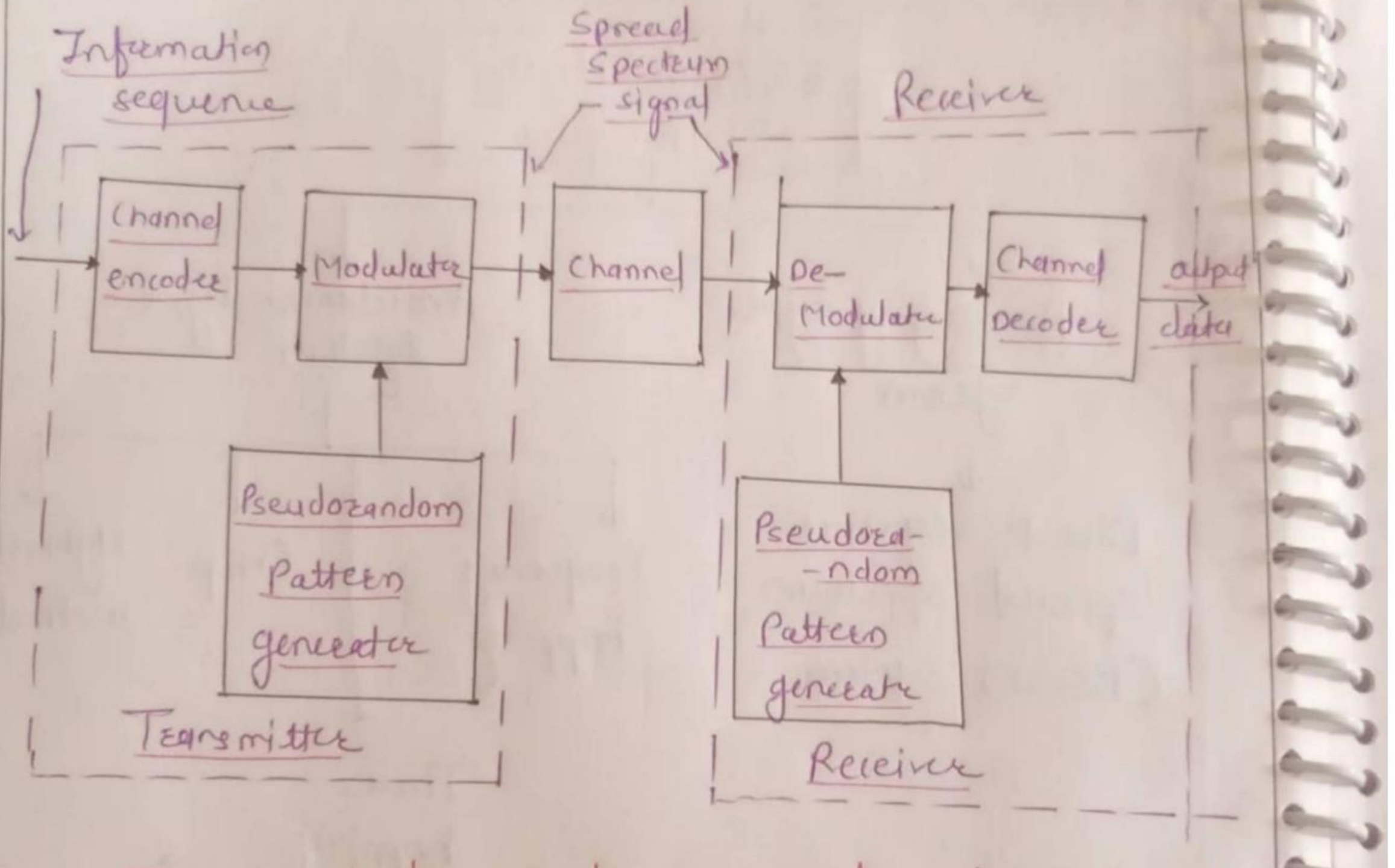

Fig: Model of spread spectrum digital Communication system.

Operation of Transmitter

Channel Encoder:-

- The channel encoder is intended to introduce controlled redundancy into the bit stream at its i/p in order to provide some amount of error-correction capability to the data being transmitted.
- Information sequence is given to channel encoder.

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Pseudorandom Pattern generator :-

- These generators a pseudorandom or pseudonoise (PN) binary sequence.
- It is impressed on the transmitted signal at the modulator.

Modulator :

- Modulator will modulate these signals & this modulated signal along with the pseudo-random sequence travels over the communication channel.
- This sequence spreads the signal randomly over a wide freqn band.
- Thus o/p of the modulator is the modulated signal is a spread spectrum signal.
- Modulation techniques used or PSK & FSK.

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Operation of the Receiver :-

Pseudorandom pattern generator :-

- The pseudorandom sequence is removed from the received signal by the other "Pseudorandom generator" operating at the receiver.
- Pseudorandom pattern generators operate in synchronization with each other.

Demodulator :-

Demodulator will demodulate the ~~signal~~ transmitted signal if & only if a known pseudo-noise sequence has been transmitted along with the information signal.

Channel decoder :-

- The o/p sequence of digits from the demodulator is given to the channel decoder
- Using its knowledge of the type of coding performed by the channel encoder at the transmitting end & using the redundancy introduced by the channel encoder

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it produces as its o/p.

- Two types of interferences are present in the ss. digital communication ie. narrow band & broad band interferences.

Jamming signals:-

- The most important advantage of ss. modulation is that it provides protection against externally generated interfering signal. Such signals called as as a jamming signals.

Defination of jamming:-

An externally generated interfering signal is called as a jamming signal & such as intentional interference is called as jamming.

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Direct Sequence Spread Spectrum (DS-SS) System:-

- One of the important spread spectrum technique is called as "Direct Sequence Spread Spectrum (DS-SS)" technique.
- DSSS used for transmission of signal over a bandpass channel such as the satellite channel.
- BPSK is used for this.

Defination:-

- Direct sequence spread spectrum (DSSS) is a spread spectrum technique in which original data signal is multiplied with a PN spreading code.

This results in a wideband like continuous scrambled signal.

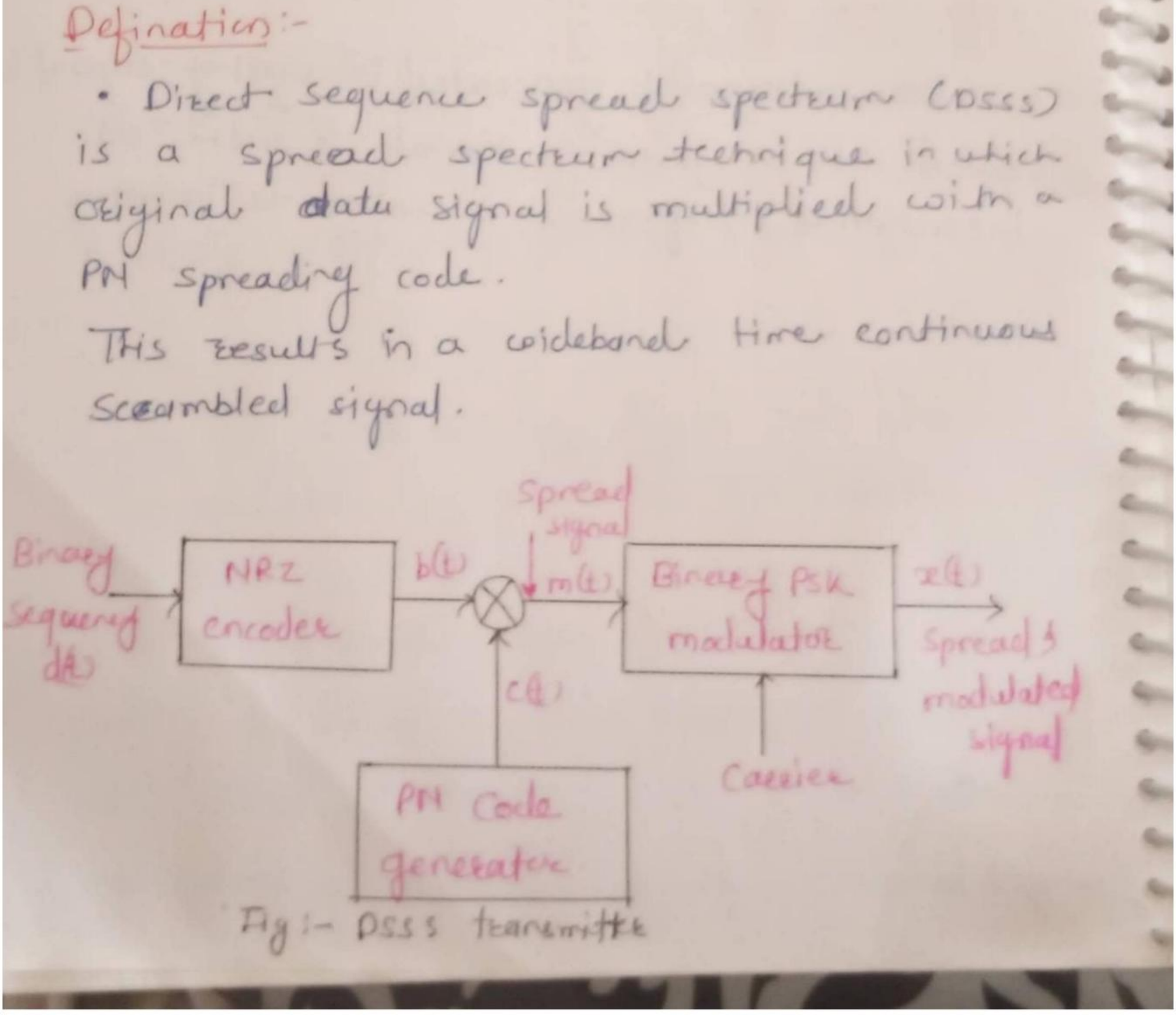

Fig :- DSSS transmitter

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Operation:

- The binary sequence d(t) is converted into NRZ signal b(t) by applying d(t) to the NRZ encoder.
- The NRZ signal b(t) at the output of the NRZ encoder is modulated by using PN sequence c(t) generated by the PN code generator.
- It uses two stages of modulation.
- The first stage uses a product modulator or multiplier with b(t) & c(t) as its i/p & the second stage consists of a BPSK modulator.
- The modulated signal at the o/p of the product modulator m(t) is the spread version of the original i/p & it is used to modulate the carrier of BPSK modulation
- So BPSK modulate spread signal to produce DS-SS BPSK signal.
- The transmitted signal x(t) is thus a DSSS-BPSK signal.

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DS-SS Receiver :-

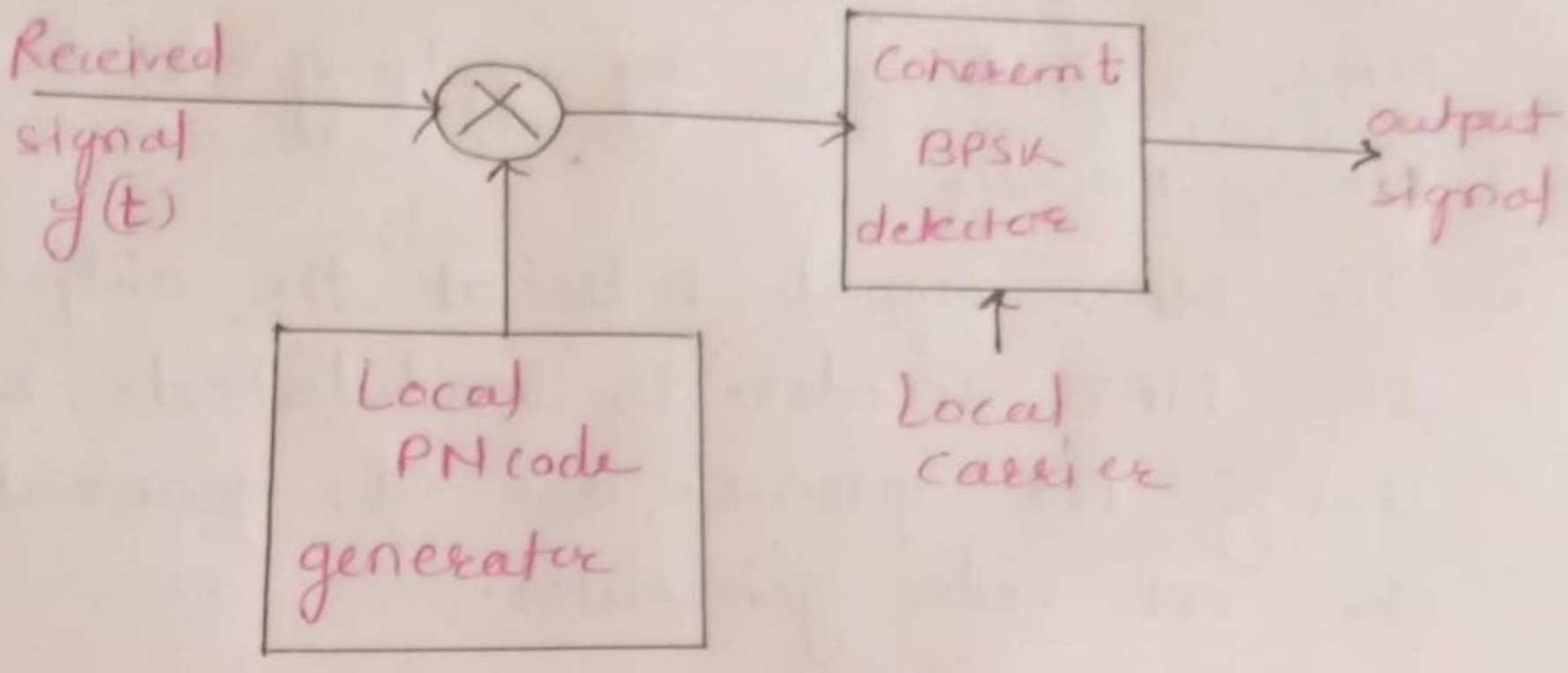

Fig:- The DS-SS Receiver

Operation:-

- At the receiver we have to generate replica of the original PN-sequence used at transmitter.
- Received signal $y(t)$ & locally generated replica of PN-sequence are applied to a multiplier.
- This is the first stage of multiplication.
- multiplier performs de-spreading operation.
- o/p of multiplier is then applied to a coherent BPSK detector with a locally generated synchronous carrier applied to it.
- At o/p we get original data sequence i.e. $d(t)$.

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Explain Fast frequency hoping techniques with suitable waveforms. state its advantages.

- In fast frequency hopping multiple frequencies or hops are used to transmit one symbol.
- The hop rate is Higher than symbol rate but chip rate is equal to hop rate
- For each symbol several hops takes place.
- So several frequencies changes for one symbol such that symbol rate R_s < Hop rate R_h
- A jammer cann't detect this signal because one symbol is transmitted using more than one carrier freqn.

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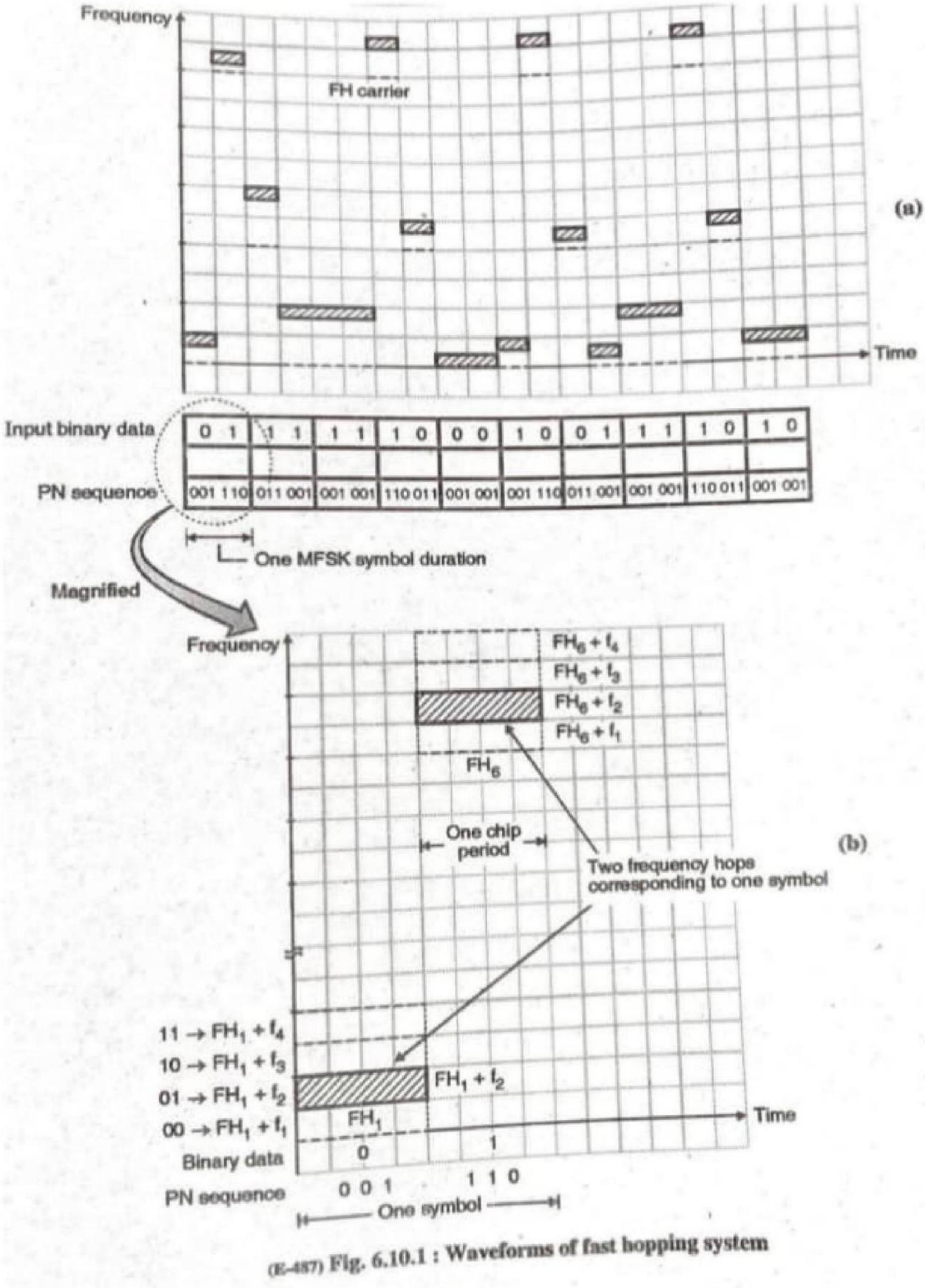

(E-487) **Fig. 6.10.1 : Waveforms of fast hopping system**

Defination of FHSS:-

- FHSS is a method of transmitting radio signals by rapidly switching a carrier among many frequency channels using a PN sequence known to both transmitter & receiver.

Peinciple of operation of (FH-SS) system:-

- In this system the data is used to modulate a carrier.
- The data modulated carrier is then randomly hopped from one frequency to the other.
- Due to this, the spectrum of transmitted signal is spread sequentially rather than instantaneously.

Types of modulation used in (FHSS) Freq^n hopping SS:-

- A common modulation technique used is the M-ary frequency shift keying (MFSK).
- The combination of freq^n hoping (FH) & MFSK is known as FH/MFSK.

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Types of freqⁿ Hopping :-

Depending on the rate of frequency hopping, the FH/MFSK system are classified into two categories.

1. Slow frequency hopping.
2. Fast frequency hopping.

1. Slow frequency hopping :-

- The slow freqⁿ hopping is the type of FHSS in which the symbol rate R_s of the MFSK signal is an integer multiple of the hop rate R_h.
- That means several symbols are transmitted corresponding to each freqⁿ hop.

Each freqⁿ hop ⇒ several symbols

i.e. frequency hopping takes place slowly

2. Fast frequency hopping :-

- It is the type of FHSS in which the hop rate R_h is an integer multiple of the MFSK symbol rate R_s
- That means during the transmission of one symbol, the carrier freqⁿ will hop several times.

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Each symbol transmission ⇒ several freqⁿ hops
- Thus the freqⁿ hopping takes place at a fast rate.

Advantages of FHSS :-

1. The processing gain is higher
2. More secured transmission as only transmitter & receiver are aware of PN codes.
3. Shorter time for acquisition.
4. Robust technology.

Disadvantages :-

1) Bandwidth requirement is more (GHz)
2) Lower coverage range due to High SNR requirement at receiver.
3) Complex & expensive digital freqⁿ synthesizers are required.
4) Data rates are low.

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Differentiate between direct sequence spread spectrum & frequency hopped spread spectrum.

Sr. No.	DSSS	FHSS
1.	PN Sequence of large bandwidth is multiplied with a narrow band information signal	Data bits are transmitted in different frequency slots which are changed by PN sequence.
2.	Chip rate $R_c = \frac{1}{T_c}$	Chip rate $(R_c) = \max(R_h, R_s)$
3.	Modulation technique used BPSK	Modulation technique used M-ary FSK
4.	Long acquisition time	Short acquisition time
5.	DSSS is distance dependant	FHSS, effect of distance is less
6.	Processing gain is less	Processing gain is higher.
7.	Bandwidth required is less than FHSS system	Bandwidth of FHSS system is too high.
8.	Implementation is easy	Implementation is costly.
9.	Processing gain $P_G = \frac{T_b}{T_c} = N$	$P_G = 2$ - Processing gain
10.	Effect of loading less	Effect of loading more

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Unit - IV Multiplexing & Multiple Access Techniques (12 Marks)

Introduction to Multiplexing

Defination:-

- Multiplexing is the process of simultaneously transmitting two or more individual signals over a single communication channel.

Concept of Multiplexing

- Due to multiplexing it is possible to increase the number of communication channels so that more information can be transmitted.
- Applications of multiplexing are in telemetry, telephony & in satellite communication.

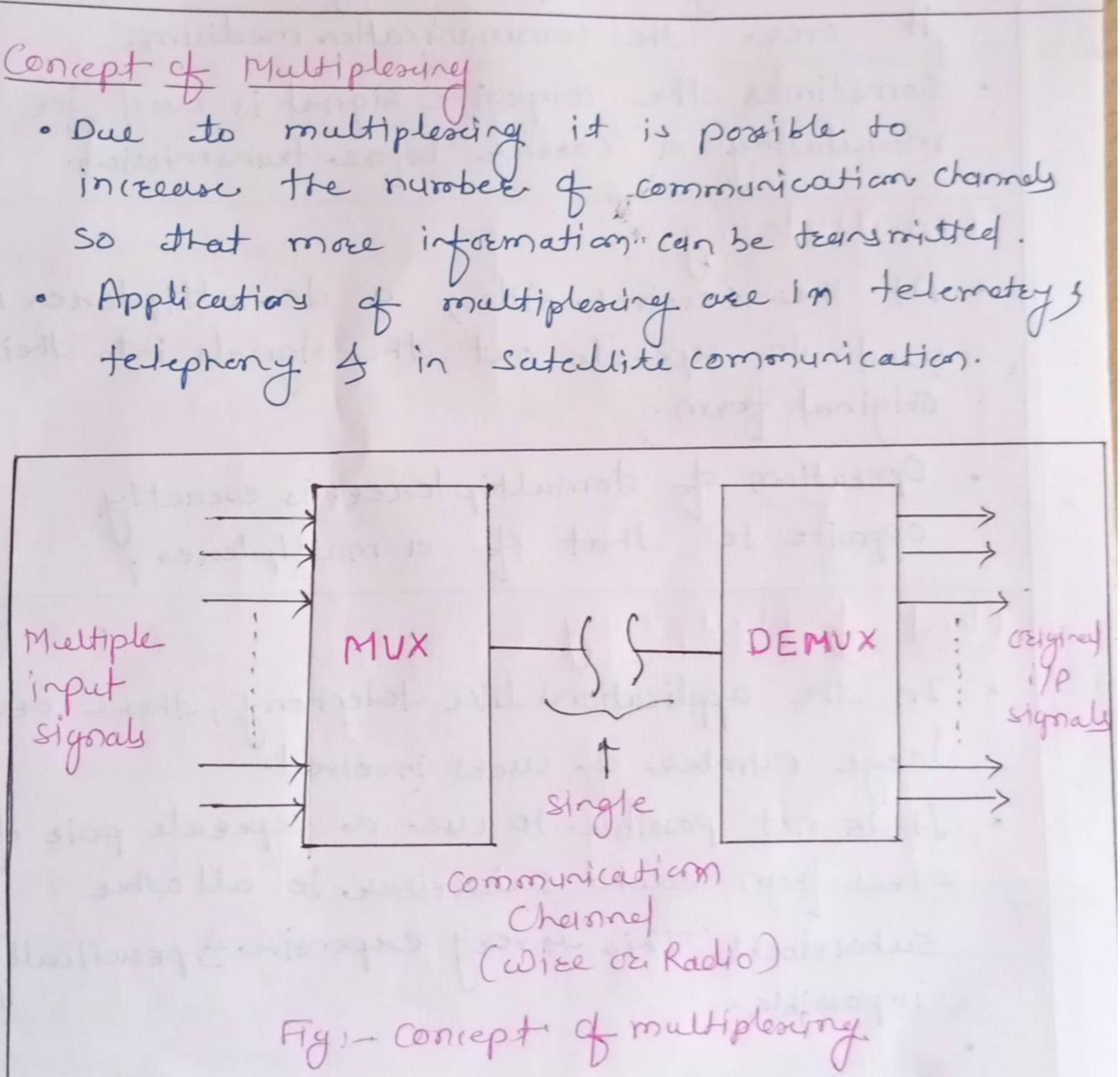


Fig:- Concept of multiplexing.

Multiplexing :-

- The multiplexer receives a large number of different i/p signals
- Multiplexer has only one o/p which is connected to the single communication channel.
- The multiplexer combines all input signals into a single composite signal & transmits it over the communication medium.
- Sometimes the composite signal is used for modulating a carrier before transmission.

Demultiplexing :-

- At the receive side, a demultiplexer is used to seperate out the signals into their original form.
- Operation of demultiplexer is exactly opposite to that of a multiplexer.

Need of Multiplexing :-

- In the applications like telephony, there are large number of users involved.
- It is not possible to use a seperate pair of wires from each subscriber to all other subscribers. This is very expensive & practically impossible.
-

- Instead if we use the peinciple of multiplexing then we can use a common communication medium such as a coaxial cable or an optical fiber cable to carry telephone signals originated from number of subscribers.
- Many signals transmitted over a single communication medium.

Types of Multiplexing:-

There are 3 basic types of multiplexing, They are

1. Frequency Division Multiplexing (FDM)
2. Time Division Multiplexing (TDM)
3. Wavelength Division Multiplexing (WDM)

Classification of Multiplexing:-

Frequency Division Multiplexing :-

Definition :- FDM is the multiplexing technique in which many signals are sent simultaneously in the time domain but are seperated from each other in the frequency domain.

(i.e. at the same time but occupy different slots in the freq^n spectrum)

Spectrum of FDM sig-nal

(Same in time but different slots in the freq^n spectrum)

Fig: Concept of FDM

- The modulation can be AM, SSB, FM or PM. The modulated signals are then added together to form a complex signal which is transmitted over a single channel.

FDM Transmitter:

Block Diagram:-

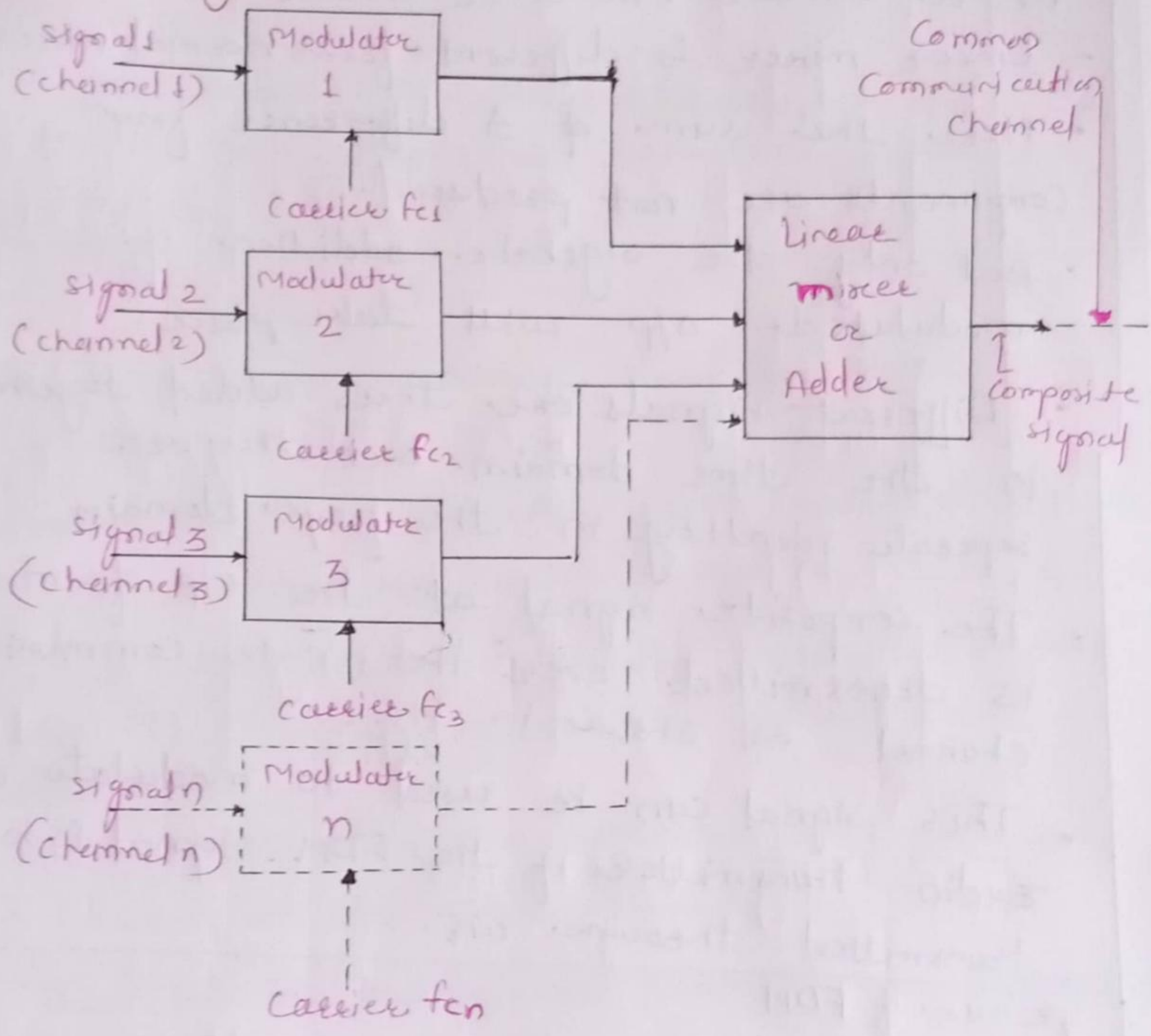
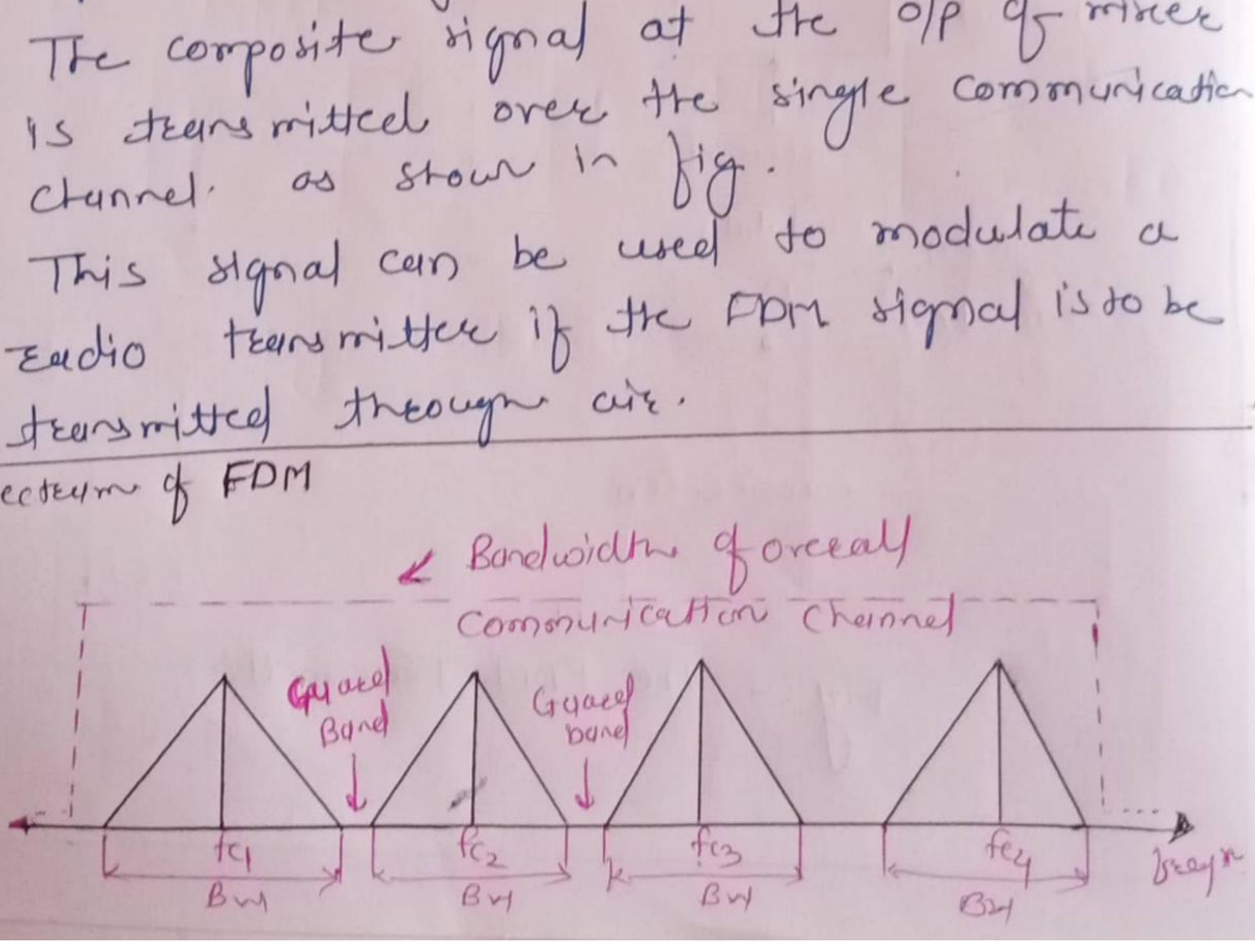


Fig:- The FDM Transmitter.

Operation :-

- Each signal Modulates a seperate carrier.
- The modulator o/p is the modulated signal.
- The modulated signal contains indepandy of corresponding signals.
- The modulator o/ps are added together in a linear mixer or adder.
- Linear mixer is different from normal mixers.
- Here the sum & difference freq^n Components are not produced.
- But only the algebaic addition of modulated o/p will take place.
- Different signals are thus added together in the time domain. but they are seperate identity in the freq^n domain
- The composite signal at the o/p of mixer is transmitted over the single communication channel as shown in fig.
- This signal can be used to modulate a radio transmitter if the FDM signal is to be transmitted through air.

Spectrum of FDM



- It shows that the Bandwidth of the FDM signal is larger than that of the individual signal bandwidths.
- In fact the bandwidth of FDM signal is equal to the sum of individual signal bandwidth & the guard bands.

Guard band :-

- The Guard bands are introduced in order to avoid any interference between adjacent channels.

FDM Receiver :-

- The FDM Receiver consists of Band pass filter, Demodulator.
- Each BPF has a center freq^{n} corresponding to one of the carriers used in the transmitter i.e. $fc_1, fc_2 \cdots fc_n$
- The BPFs have an adequate bandwidth to pass all the channel information without any distortion.
- Each filter will pass through only its channel & reject all the other channels.
- Thus all the multiplexed channels are separated out.
- The channel demodulator then removes the carrier & recovers the original signal back.

FDM Receiver :-

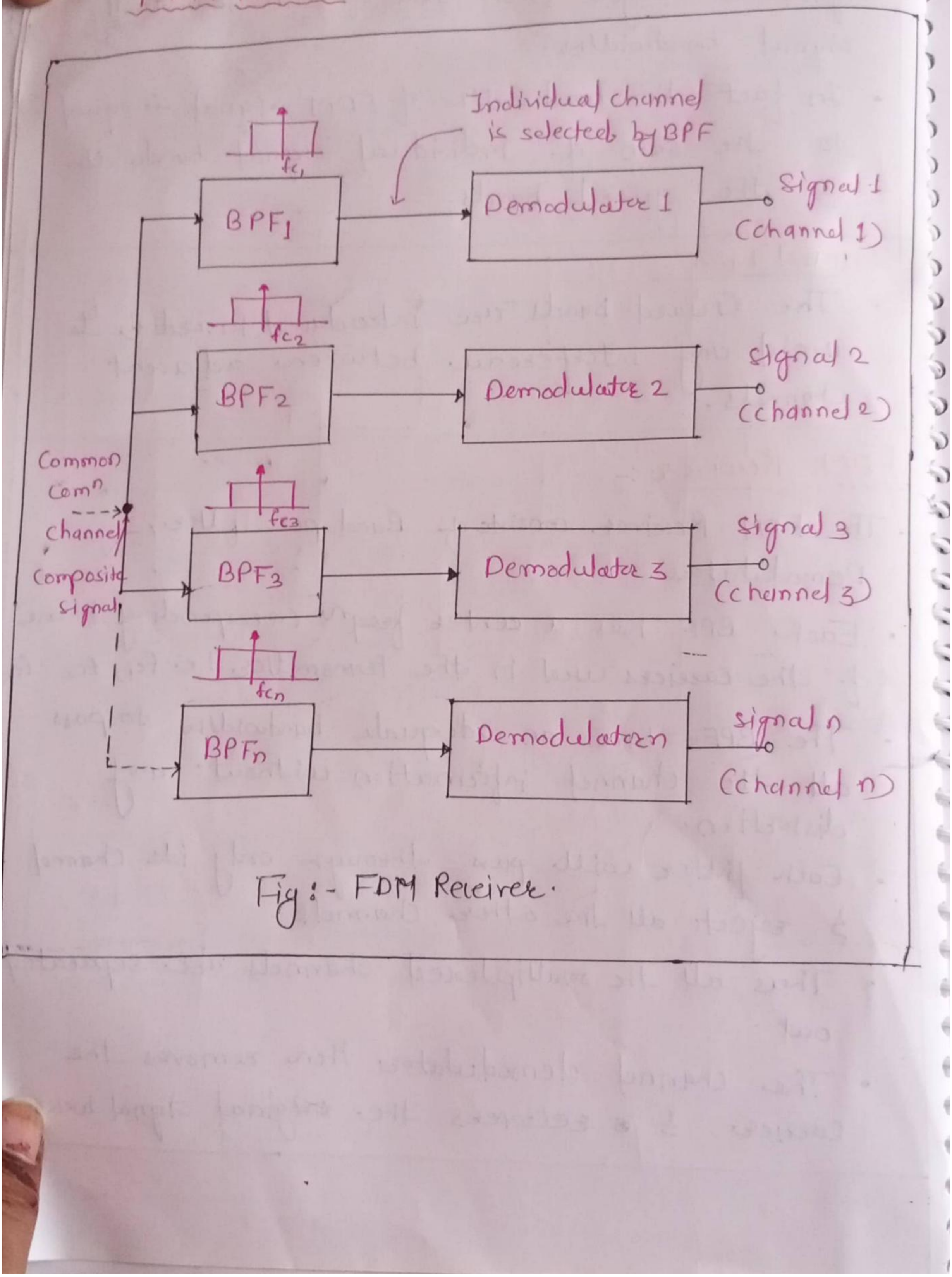


Fig :- FDM Receiver.

Advantages, Disadvantages & Applications of FDM:

Advantages of FDM:-

- A large number of signals (channels) can be transmitted simultaneously.
- FDM does not need synchronization between its transmitter & receiver for proper operation.
- Due to slow narrow band fading only a single channel gets affected.

Disadvantages of FDM:-

- The communication channel must have a very large bandwidth.
- Intermodulation distortion takes place.
- Large number of modulators & filters are required.
- FDM suffers from the problem of crosstalk.
- All the FDM channels gets affected due to wideband fading.

Applications of FDM:-

- Telephone systems
- AM & FM radio broadcasting.
- TV broadcasting.
- First generation of cellular phones used FDM

Synchronous Time Division Multiplexing:-

- The process called multiplexing is used in order to utilize common transmission channel or medium to transmit more than one signals simultaneously.
- TDM is a multiplexing technique in which the signals are sent sequentially instead of sending them simultaneously like FDM.
- Thus each signal will be transmitted for a very short time.
- One cycle or frame is said to be complete when all the signals are transmitted once on the transmission channel.

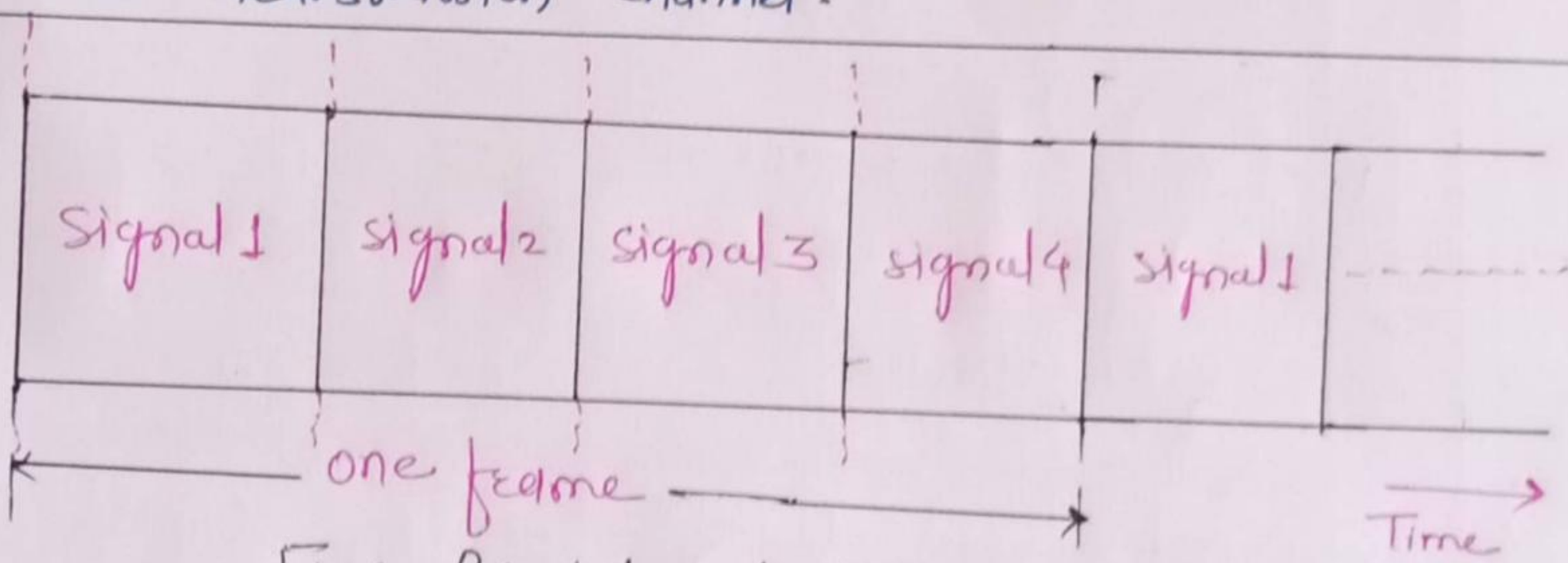


Fig:- Principle of TDM

As shown in fig one transmission of each channel completes one cycle of operation called as a "Frame".

- The TDM system can be used to multiplex analog or digital signals, however it is more suitable for the digital signal multiplexing.

- The data flow of each source (A, B or C) is divided into units (say A_1, A_2 or B_1, C_1 etc)
- Then one unit from each source is taken & combined to form one frame
- The size of each unit such as A_1, B_1 etc. can be 1 bit or several bits.
- In fig 3 i/ps being multiplexed, a frame of TDM will consist of 3 units i.e. one unit from each source.
- Similarly for n number of inputs, each TDM frame will consist of n units.

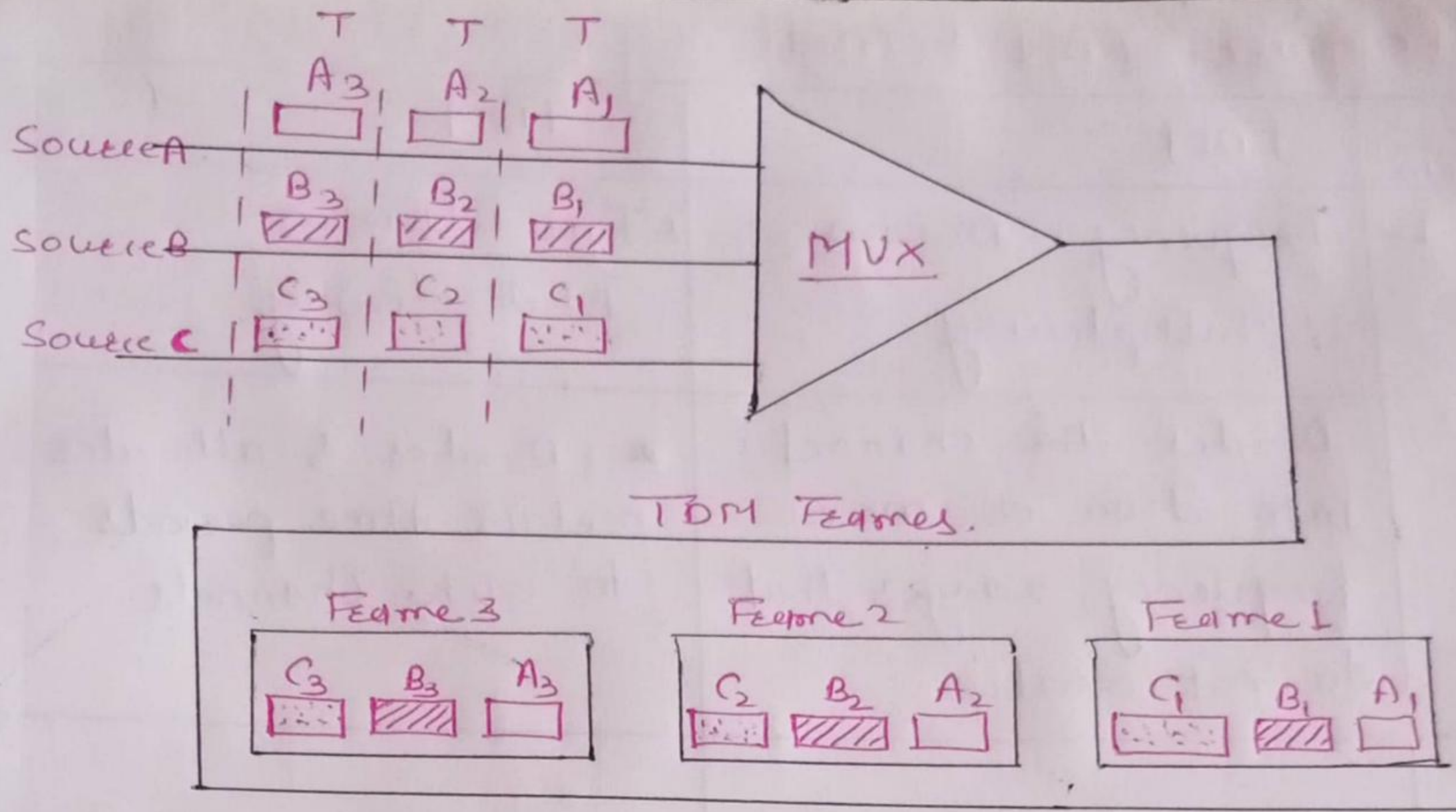


Fig : TDM System.

Compare FDM & TDM.

Sl No	FDM	TDM
1.	Frequency Division Multiplexing	1. Time division Multiplexing.
2.	Divides the channel into two or more frequency ranges that do not overlap	Divides & allocates certain time periods to each channels.
3.	Code word is not required	No coding required.
4.	Needs guard bands to avoid interference	Needs guard time to avoid interference
5.	Problem of Cross talk	No problem of Cross talk.
6.	Cost High	cost low
7.	Complex circuitry in FDM	TDM circuitry is not very complex.
8.	Error control is not possible	Error control is possible.
9.	FDM usually preferred for analog signals.	TDM is preferred for digital signals.
10	Synchronization is not required	Synchronization is required.

Code Division Multiplexing (CDM) :-

Defination:-

- CDMA, code Division multiplexing is a system in which we can transmit signals from a seeies of independent sources at the same time over the same freqⁿ band.
- That means all bandwidths of the system is available to all signals all the time.
- This is accomplished by using orthogonal codes to spread each signal over a large, common freqⁿ band.

Blocks diagram:-

- The most important principale of CDM is that it uses spread spectrum technique for its operation.
- The block dia of CDM is as shown in fig.
- There are N number of users that produce signals that are sent to N number of users.
- The communication should take place between the intended pairs of users only.
- The unintended user should not be able to access the sent information.

- At the sending end each user uses a distinct spreading code to produce its own spread spectrum signal.
- all the N spreading codes are orthogonal codes.
- The spread spectrum signal transmitted by N-users travel on a common communication medium.
- This multiplexed signal is a wideband signal & for a person who does not know the spreading code it appears like a noise signal which doesnot contain any information.
- on the receiving side, B uses the second orthogonal spreading code (B) & applies it to the total received signal.
- This despreads the portion of the signal transmitted from source B to recover the information transmitted by the source B.
- Similarly user A receives the information transmitted by source A only & so on.

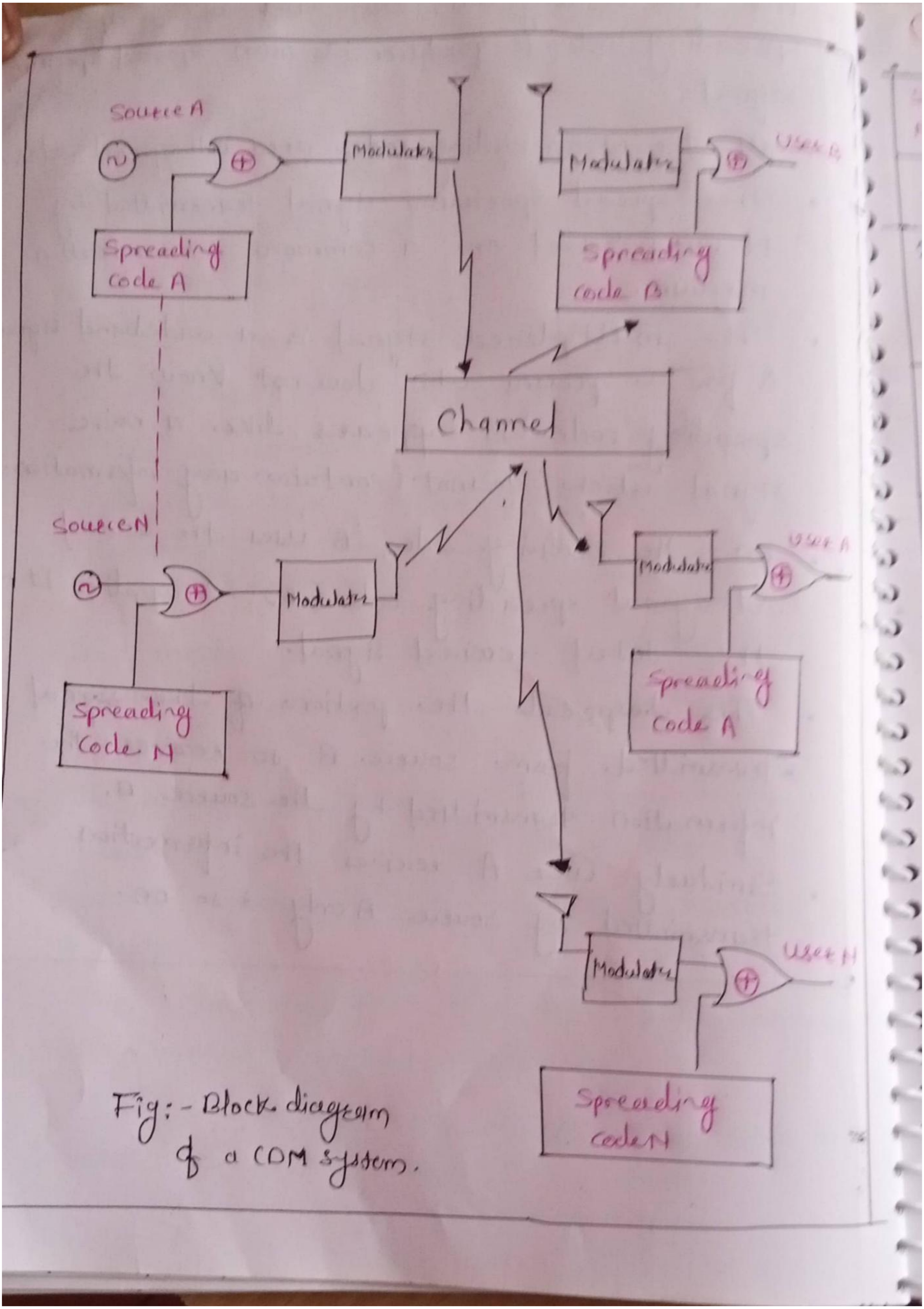


Fig:- Block diagram of a CDM system.

Comparision of FDM & CDM

Sl. No	FDM	CDM.
1.	Freq^n division Multiplexing	Code Division Multiplexing.
2.	we can transmit signals from various sources at the same time	we can transmit diff^n signals in spread spectrum technique.
3.	Different signals use different freq^n bands	All the signals are transmitted at the same freq^n
4.	FDM is preferred for the analog signals	CDM is used for analog & digital signals.
5.	Spread spectrum technique not used.	Spread spectrum technique is used.
6.	Guard bands are used between the adjacent channels.	No guard bands are used.
7.	Noise immunity is low.	Noise immunity is high
8.	No security against unwanted interference.	It provides a high degree of security
9.	less complex system	High complex system.

T- carrier System:-

- When a large number of PCM signals are to be transmitted over a common channel, multiplexing of these PCM signals is required.
- Fig shows the basic time division multiplexing scheme for PCM voice channels called as the T, digital system.
- This system is used to convey a number of voice signals over telephone lines using wideband coaxial cable.

Describe North American (T-carrier) digital multiplexing Hierarchy with neat diagrams.

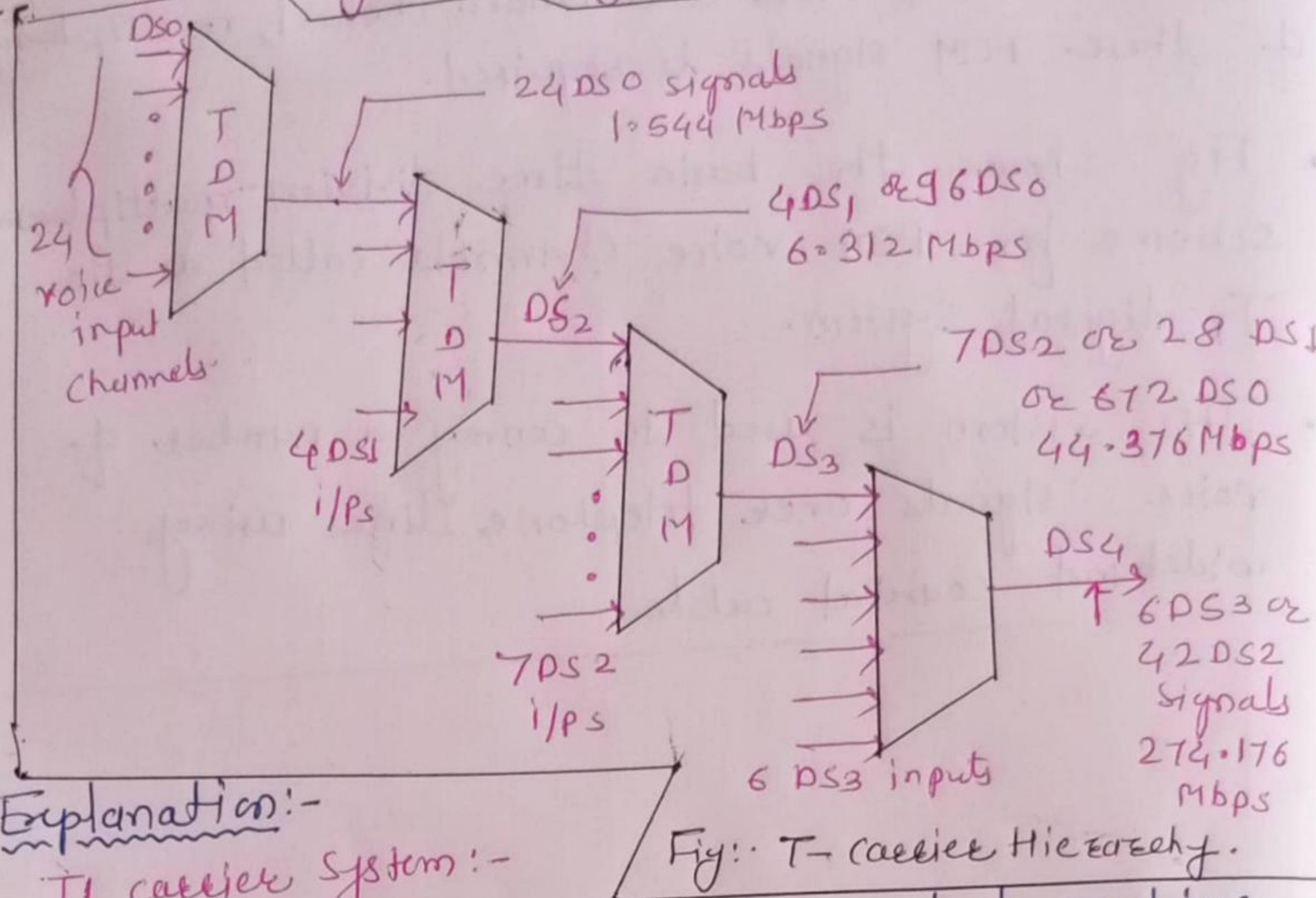


Fig:- T-carrier Hierarchy.

Explanation:-

T1 carrier System:-

→ T1 carrier systems were designed to combine PCM & TDM Techniques for the transmission of 2464 Kbps channels with each channel capable of carrying Digitally Encoded voice band telephone signals or data.

→ The transmission bit rate (line speed) for a T1 carrier is 1.544 Mbps.

→ All 24 DS-0 channels combined has a data rate of 1.544 Mbps, this digital signal level is called DS-1.

→ Therefore T1 lines referred as DS-1 lines.

Table. Relation between DS & T lines.

Service Line			
DS-1	T-1	1.544	24
DS-2	T-2	6.312	96
DS-3	T-3	44.736	672
DS-4	T-4	274.176	4032

DS & T line rates

T2 carrier system: T_2 carriers TDM 96, 64Kbps voice or data channels into a single 6.312 Mbps data signals for transmission over twisted pair copper wire up to 500 miles over a special metallic cable.

T3 carrier system: T_3 carriers Time division multiplex 672 64-Kbps voice or data channels for transmission over a single coaxial cable. The transmission is 44.736 Mbps.

T4 carrier system: T4 carriers TDM 4032 64Kbps voice or data channels for transmitting over a single T4 coaxial cable upto 500mile. The transmission rate is very high i.e. 274.16Kbps.

T5 carrier system: T5 carriers time division multiplex 8064 64Kbps voice or data channels & transmit them at 560.16 Mbps over a single Coaxial cable.

Advantages of WDM:-

1. It works with existing single mode communication fibre
2. Transparent:- It does not depends on the protocol that has to be transparent
3. Scalable:- Instead of switching to a new technology a new channel can easily be added to existing channels.
4. WDM has enhanced capacity.
5. WDM can be used for full duplex transmision with a single fibre.
6. Easy to reconfigure (addition or removal of channels)
7. Less costly.

Difference between Multiple Access & Multiplexing

1. In multiple access the users could share the remote communication channels such as a satellite or radio channel.
2. But In multiplexing the channel such as a telephone channel is shared by users confined to a local site.
3. In a multiplexed system, the requirements of users are generally fixed.
4. But In a multiple access system the requirements of a user change dynamically with time, so the dynamic channel allocation is required to be provided.

Multiple Access Techniques:-

- The multiple access Techniques are the techniques in which the total bandwidth of the common link is shared in the freqn domain, time domain or through codes.
- Depending on the method of sharing there are three channelization techniques.
  1. FDMA: Frequency Division Multiple Access
  2. CDMA: Code Division multiple Access
  3. TDMA: Time Division multiple Access.

Need of Multiple Access system:-

- It is required for multiple users not for one user.
- Multiple users who need to share a wireless communication system then we need to use a multiple access system.

Fig: A multiple access system.

FDMA :- Frequency Division Multiple Access.

The overall channel bandwidth is being shared by the multiple users.

The adjacent freqn bands in the FDMA are very close to each other so to avoid interference guard bands are present betn two bands.

- No code words required
- No synchronization is required.
- Power efficiency is reduced.
- FDMA is an old & proven system.
- It is used for the analog signals.

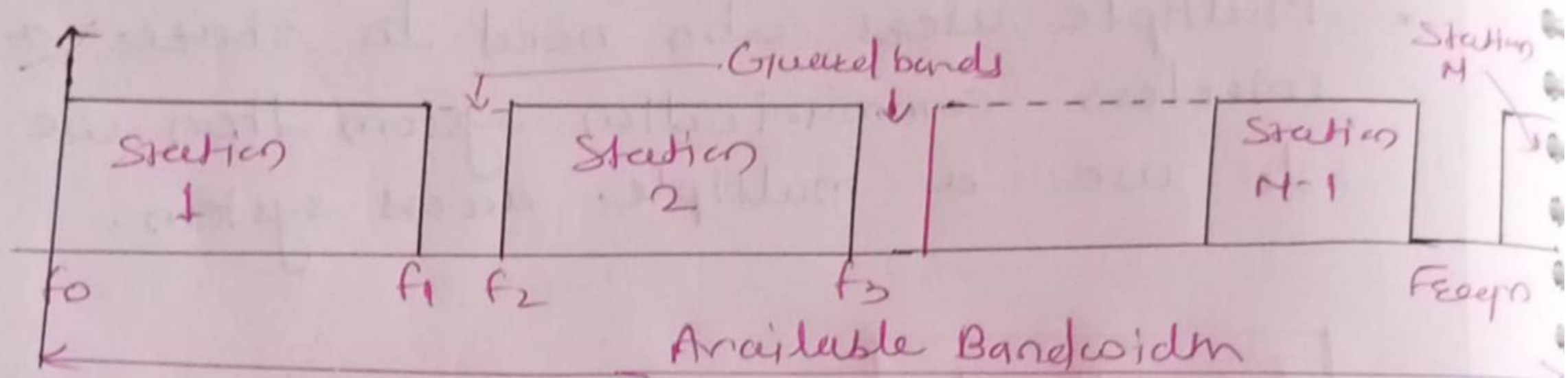


Fig :- Concept of FDMA.

Fig :- FDMA System

Advantages of FDMA :-

- All the stations can operate all 24 hours without having to wait.
- Power required is depend on no. of channels transmitted.
- No synchronization is necessary.
- Signal to Noise ratio is improved.

Disadvantages :-

- Each channel can use only a part of total satellite bandwidth.
- Adjacent channel interference present.
- Require larger BW.
- Intermodulation products are generated.

TDMA :- Time Division Multiple Access :-

- TDMA entire BW can be used by every user one by one.
- The station can use the entire bandwidth only for the allocated time slot.
- At allocated time only it can send data.
- Time is shared freqn is not shared.
- Guard times are inserted betn two adjacent time slots in order to avoid cross talk.
- used in cellular phones & satellite networks
- Synchronization is necessary in TDMA.
- Used for data & digital voice signals.
- Power efficiency is better than FDMA.
- TDMA is a method of time division multiplexing the digitally modulated carriers between various earth stations. In a Satellite network through a common Satellite transponder.
- Each earth station transmits a short burst of digitally modulated carriers during the time slot assigned to it in the TDMA frame. such a time slot is called as epoch.

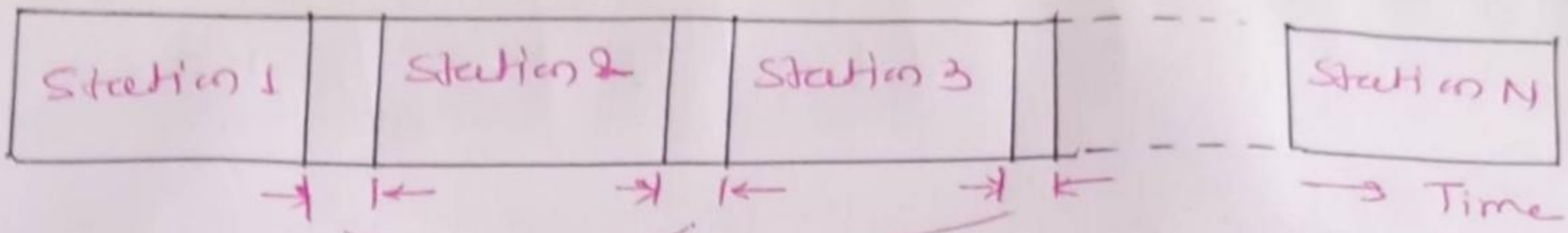


Fig. Concept of TDMA

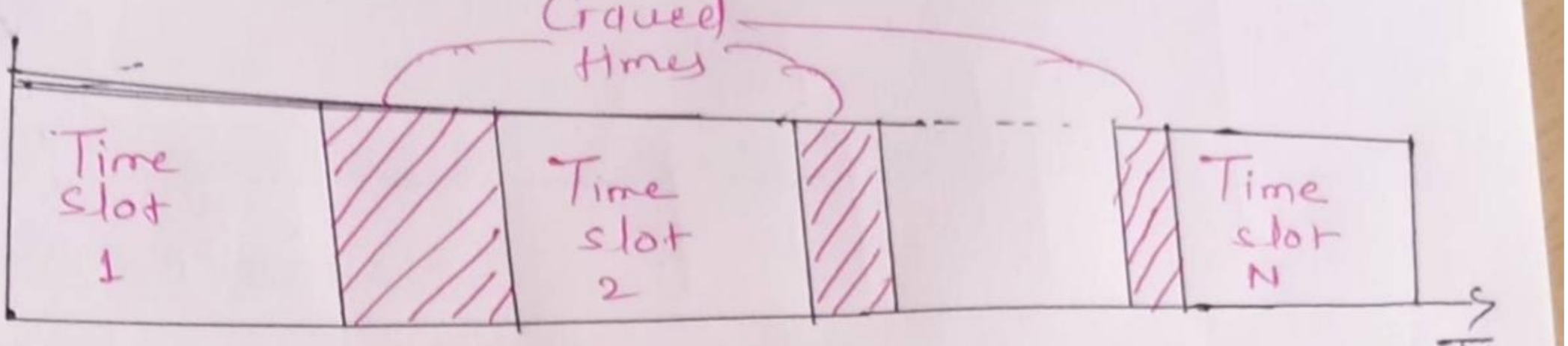


Fig :- TDMA.

Advantages of TDMA:-

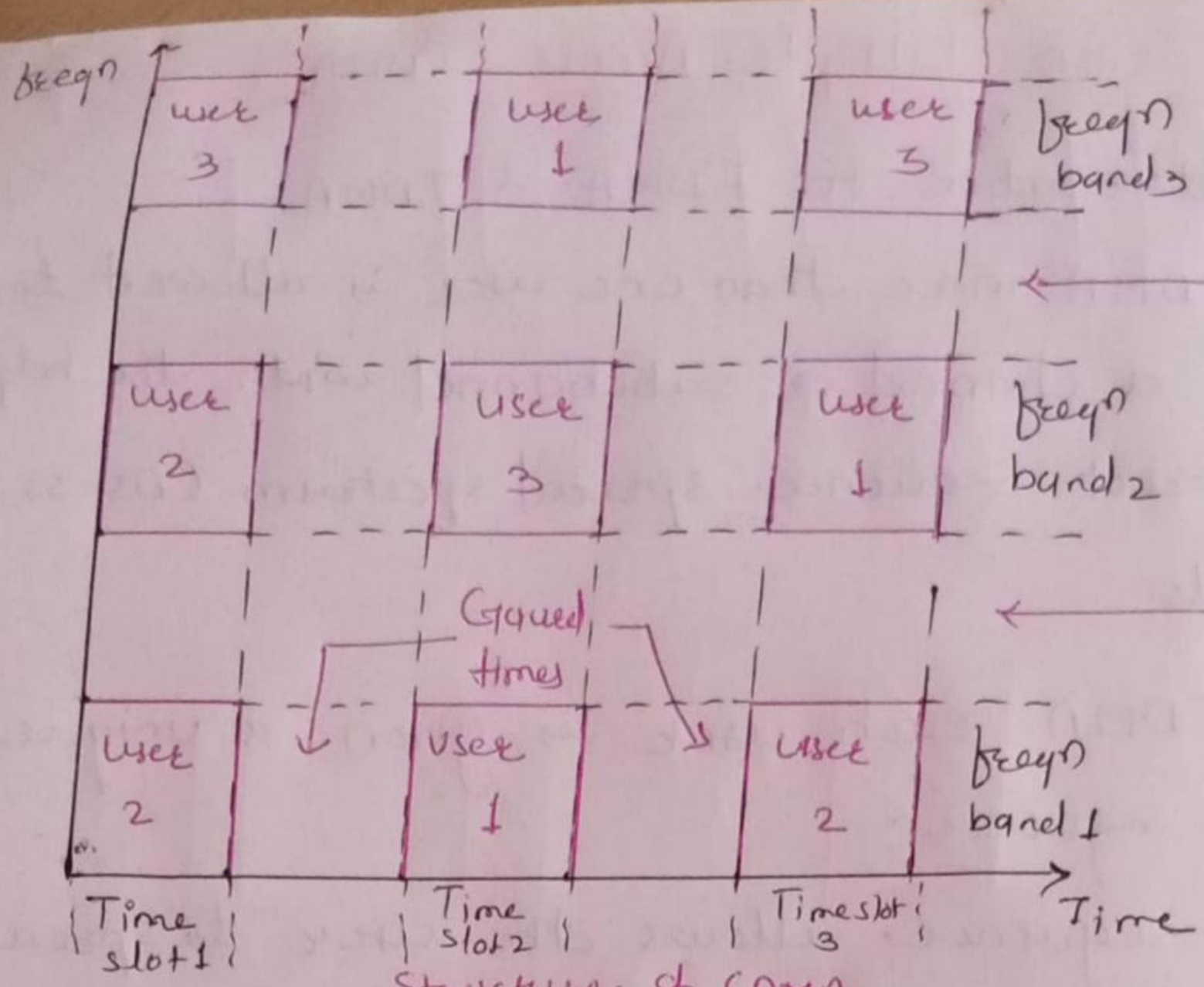
- At any instant of time, the carriers from only one station is present at the transponder. This reduces the intermodulation distortion.
- TDMA is suitable for transmission of digital information
- It is possible to store the digital information, change the rate in TDMA.

Disadvantages:-

1. Precise synchronization is required.
2. Bit & frame timing must be achieved & maintained.

Code Division Multiple Access (CDMA):-

- An alternative to FDMA & TDMA.
- In CDMA more than one user is allowed to share a channel or subchannel with the help of direct sequence spread spectrum (DS-SS) signals.
- In CDMA each user is given a unique code sequence.
- This sequence allows the user to spread the information signal across the assigned freqn band.
- At the receiver the signal is recovered by using the same code sequence.
- At the receiver, all signals are seperated by checking cross correlation of the received signal with each possible user code.
- In CDMA the users access the channel in a random manner.
- They use freqn band as well as time slot.
- So it is necessary to introduce the guard times & guard bands.
- Not needs any synchronization.
- But code sequence is required to use.



Structure of CDMA

Advantages of CDMA:-

- It does not need synchronization.
- More number of users can share the same bandwidth.
- Sharing of bandwidth as well as time is possible.
- Due to codeword allated to each user, cross talk is reduced.

Disadvantages:-

- CDMA system is more complicated.
- Guard band & guard time both are required.

Applications:-

1. Voice services 2. Data services
3. Circuit switched data 4. Packet switched data
5. Message services 6. CDMA Radio.
7. Location based services.

Applications of Multiple Access Techniques

Sr. No.	Cellular System	Multiple Access Technique.
1.	Advanced Mobile phone System (AMPS)	FDMA
2.	Global system for Mobile (GSM)	TDMA
3.	Pacific Digital Cellular (PDC)	TDMA
4.	Cordless Telephone	FDMA
5.	IS-95	CDMA
6.	Wideband CDMA	CDMA
7.	CDMA 2000	CDMA

3. code word & 4. synchronization. **(S-18, 4 Marks)**

Sr. No.	FDMA	TDMA	CDMA
1.	Overall bandwidth is shared among many stations.	Time sharing takes place.	Sharing of bandwidth and time both takes place.
2.	Due to nonlinearity of devices inter modulation products are generated due to interference between adjacent channels.	Due to incorrect synchronization there can be an interference between the adjacent time slots.	Both type of interferences will be present.
3.	Synchronization is not necessary.	Synchronization is essential.	Synchronization is not necessary.
4.	Code word is not required.	Code word is not required	Code words are required.
5.	Guard bands between adjacent channels are necessary.	Guard times between adjacent time slots are necessary.	Guard bands and Guard times both are necessary.
6.	Technique used is to allocate a frequency slot for each user.	Technique used is to allow only one user to transmit at any given time.	Users are given unique codes.

Sr. No.	FDMA	TDMA	CDMA
7.	Power efficiency is low.	Power efficiency is moderate	Power efficiency is high.