

Text Book of

# MOBILE AND WIRELESS COMMUNICATION

**For**

**Third Year Diploma – Semester VI**

**Diploma in Electronics Engineering Groups  
(ECE 605)**

***As Per New Syllabus of SBTE, Jharkhand***

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**Price ₹ 150.00**

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**First Edition : February 2020****© : Author**

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**Published By :  
NIRALI PRAKASHAN****Polyplate****Printed By :  
YOGIRAJ PRINTERS AND BINDERS**

Abhyudaya Pragati, 1312, Shivaji Nagar

Survey No. 10/1A, Ghule Industrial Estate

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## INTRODUCTION TO COMMUNICATION

### Syllabus

A basic cellular system, Performance criteria, Operation of cellular systems, Planning a cellular system, Analog and Digital cellular systems. Examples of Wireless Communication Systems : Paging Systems, Cordless Telephone Systems, Cellular Telephone Systems. Bluetooth and ZigBee.

### 1.1 COMMUNICATION SYSTEMS

#### 1.1.1 Introduction

- Man is a social human being. It is his primary need to communicate with each other day-to-day transactions. For short distances, we can talk directly. But for long distances, we cannot talk directly due to attenuation of sound. The word 'Communicate' is illustrated in the English Dictionary "as an act of passing news, information, feelings, heat, motion, illness etc."
- In a broad sense, the purpose of communication is to establish a link between two points. These points may be situated on the earth, or may not be on the earth and the other in space or both in space. A new era establishing a link between two distant points was born with the successful transmission of the first telegraphic message by *Samuel F.B. Morse* in 1836. This is called *electrical communication*. The *electrical communication* means sending, processing and receiving information by electrical means.

#### 1.1.2 Definition

- **Communication is the process, whereby the meaningful information is transferred from one point (location) called source in space to the other point (location) called destination (or user).**
- **Communication is a two-way transmission and reception of data streams. Voice, data or multimedia streams are transmitted as signals, which are received by a receiver.**
- The signals from a system can be transmitted through a fibre, wire, or wireless medium. During the transmission process, the transmitter sends the signals according to the defined regulations, recommended standards and protocols.
- **The science of communication involving large distance is called Telecommunication.** The word 'tele' means *long distance*.
- Now-a-days, satellite band fibre optics have made communication more widespread with an increasing emphasis on *computers* and other *data communications*. Depending upon the type of information to be transferred and received, different electronic communication systems, namely radio telephony, telegraphy, broadcasting, radar, radio telemetry, radio navigation, computer communication, point-to-point and mobile communication systems, such as microwave links etc. have been developed over the years.

#### 1.1.3 Types

- Depending on the type of communication used for transmission of electromagnetic signals, the communication systems can be classified into two groups as under :
  1. Wire (or Line) communication.
  2. Wireless (or Radio) communication.

### 1. Wire (or Line) Communication :

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

### 2. Wireless Communication :

- **Wireless communication is the transfer of information between two or more points that are not connected physically.**
- Wireless operations permit services such as long range communications that are impossible or impracticable to implement with the use of wires.
- The wireless communication is also known as *radio communication*, when radio waves are radiated from the transmitter in free space the device called *antenna*.

## 1.2 MOBILE RADIO COMMUNICATION

### 1.2.1 History

- The mobile radio communication has started in the year 1888 after the discovery of *radio (electromagnetic)* waves by *Hertz*. Subsequently, *Guglielmo Marconi* demonstrated the *transatlantic radio telephony* in 1901 and new wireless systems have been developed by people throughout the world.
- The first mobile radio communication system was introduced in the year 1920 for police and emergency services in U.S.A. The first mobile radio communication system was introduced in 1946 for public in U.S.A. This has started the *era of public mobile communication system*.
- The *concept of cellular* was developed by AT and T Bell laboratories of USA in the year 1949. Also in the year 1962, the first test was conducted to explore the commercial applications. With the development of highly reliable, small size, solid state radio frequency (RF) hardware and LSI technology, the *wireless (radio) communication* era was born in the year 1970.
- There was no penetration of mobile phones in the market upto 1980s due to high cost and technical challenges. However, in the last 10 years, the development of wireless (radio) communication systems have been automatically very fast. These developments have helped in making wireless (radio) communication systems smaller, portable and reliable.
- The first digital cellular system was released in the 1990 for the Global System for Mobile (GSM) communication system. The digital switching techniques have facilitated the use of easy to use and affordable communication networks. Now the rate of growth of mobile radio communication has been closely linked with the rate of technological *improvements*.

### 1.2.2 Evolution

- The field of wireless communication is grown rapidly due to the development in the supporting technologies. The growth of mobile communication was slow during the early days and its growth rate has been closely linked with to the rate of technological improvements.
- The first mobile radio communication system was introduced in 1946 for public in U.S.A. after, the discovery of *telegraphy* and started the *era of public mobile communication services*. The cellular concept was first developed by the Bell Laboratories of U.S.A. in 1947 and the first test was conducted to explore commercial applications in 1962.
- The Bell Laboratories proposed to build the first high capacity *cellular telephone system* called Advanced Mobile Public System (AMPS) in 1970. Thus, with the development of highly reliable small size (miniature) and solid. State RF hardware, the era of *wireless communication* has started in 1970.
- The first handheld mobile phone was demonstrated by Dr. Martin Cooper of Motorola company using a handset weighing 2.5 lbs i.e. about 1 kg. The World's first *cellular system* was implemented in 1970 by Nippon Telephone and Telegraph (NTT) company of Japan and the Nordiac Mobile Telephone (NTT 450) was developed in 1981.

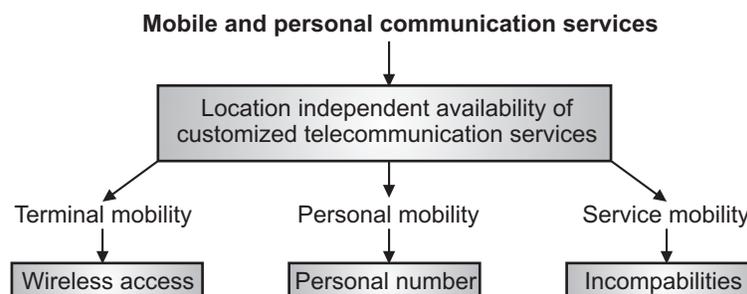
- Since the initial commercial introduction of AMPS service in 1988, the mobile radio communication has seen an explosive growth worldwide. The Dyno TAC 8000 was first mobile phone that was made commercially available in 1983. This was the *first generation* (1G) mobile system, which falls under the category of an analog mobile system.
- The *second generation* (2G) mobile system was considered as a digital mobile system. The *third generation* (3G) digital mobile system called the Personal Digital Cellular (PDC) was developed in Japan and is in full commercial operation.
- The worldwide cellular (mobile) phone users increased from 25000 in 1984 to about 25 million in 1993 and from there the growth rate of about 50% per year is being observed. Currently 5G mobile planar are available, which provides very high speed about few Gbps.

### 1.2.3 Introduction

- The mobile communication began in 1897 and evolved remarkably, since when new wireless systems have been developed by people throughout the world. The development of wireless systems has been dramatically fast in the past 10 years or also.
- The improvements in the RF and digital fabrication technologies, the new large scale circuit integration (LSI) and other miniaturization techniques have helped the development of wireless to a great extent. These developments have helped in making smaller portable and more reliable radio equipments. The digital switching techniques have fascilated the use of a way to use and affordable communication networks.

### 1.2.4 Concept

- **The satellite communication enabling as to provide universal personal communications with terminal mobility, personal mobility and service mobility is called mobile communication.**
- The concepts enabling as to provide universal personal communications are as given below :
  1. Terminal mobility.
  2. Personal mobility.
  3. Service mobility.
- These concepts are being catalyzed at the national, regional and international levels to specify and standardize a range of mobile and personal communication systems and services. The basis for *terminal mobility* and *personal mobility* is the use of wireless access and personal (rather than terminal) numbers respectively. *Service mobility* is based on the emerging Intelligent Network (IN) concepts, which facilitate real time management service profiles. It is shown in Fig. 1.1.



**Fig. 1.1 : Concepts of mobile and personal communication services**

### 1.2.5 Frequencies Used

- For cellular communications, the FCC has proposed 40 MHz of the frequency spectrum ranging from 825 MHz to 845 MHz and 870 MHz to 890 MHz. Full duplex operation is possible by separating transmit and receive signals into separate frequency bands.

- Cellular phone units transmit in the lower bands of frequencies 825 MHz to 845 MHz and receive in the higher band of 870 MHz to 890 MHz. The opposite frequency bands are used by the base units of the cell sites. Within these two bands, 666 separate channels (333 channels per band) have been assigned for voice and control. Each channel occupies a bandwidth of 30 KHz.

### 1.2.6 Advantages

1. It can offer a large variety of data services and supplementary services tailored to system type.
2. It has a high level of security such as authentication, encryption etc.
3. It has a high traffic density and provides more than 500 channels.
4. It has a high coverage range and area.
5. It has a good speech quality with minimized noise.
6. It can be used in any location such as home, office, in public and in transit.
7. It can be used by using devices such as cellular/PCs phone, office wired phone, Personal Digital Assistant (PDA), home phone, fax, multimedia terminal etc.
8. It provides seamless global roaming and improved quality of services to its users.
9. It is compatible with ISDN leading to wider range of services.

### 1.2.7 Applications

1. Paging and short message services.
2. E-mail and Internet/Intranet access.
3. Database access and file transfer.
4. Fleet management and dispatch (tracks, taxis, packages delivery systems etc.).
5. Inventory control (stores, warehouses etc.).
6. Field services.
7. Intelligent highways (e.g. automatic toll collection).
8. Data inputs e.g. hospital patient charts, auto rental returns etc.
9. Credit card authorization (from remote or mobile locations).

## 1.3 WIRELESS COMMUNICATION SYSTEMS

### 1.3.1 Introduction

- In 1897, *Guglieno Marconi* was the first to demonstrate that it was possible to establish a continuous communication system with the ship.
- The present days, wireless communication system has become an essential part of various types of communication devices that permits user.

### 1.3.2 Definition

- **Wireless communication is a type of data communication, that is, performed and delivered wirelessly.**
- This is a *broadband* term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices. The communication or receiving intermediate device captures these signals, creating wireless communication bridge between the sender and receiver device.
- **Any transfer of information between points that do not have a physical connection, like wire, cable, etc. is called wireless communication.**

### 1.3.3 Practical Examples

1. Garage door openers.
  2. Hand-held Walkies-Talkies.
  3. Remote controllers.
  4. Paging systems (Pager).
  5. Cordless telephones.
  6. Cellular telephones.
- However, the cost, complexity, performance and types of services offered by each of these mobile systems are vastly different.

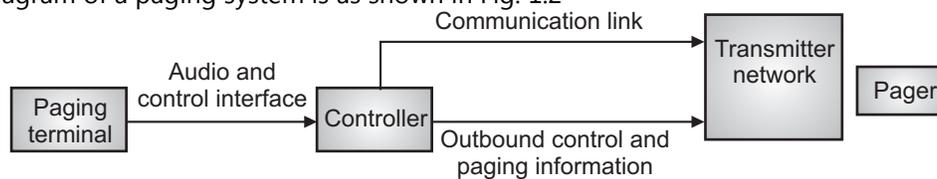
## 1.4 RADIO PAGING SYSTEMS

### 1.4.1 Definition

- **The pager is a specialized miniature radio receiver carried by the user for retrieval of information from the paging terminal.**
- Depending on the *pager* and *system*, the user can receive either an alert, a voice transmission, a numeric display page, or an alpha numeric display page.
- **A pager is a wireless telecommunications device that receives and display alpha numeric or voice messages.**
- One-way pager can only receive messages, while response pagers and two-way pagers can also acknowledge, replay to and originate messages using an internal transmitter.

### 1.4.2 Block Diagram

- The block diagram of a paging system is as shown in Fig. 1.2



**Fig. 1.2 : Functional block diagram of a radio pager system**

- A paging system is composed of the following six basic elements or components :
  1. Paging terminal,
  2. Controller,
  3. Outbound control and paging information channel,
  4. Transmitter network,
  5. Communications link
  6. End user pagers.

### 1.4.3 Description

The function of each block of a radio paging system is described as under :

#### 1. Paging Terminal :

- The paging terminal maintains subscriber pager type and service information. The terminal accepts the paging requests via direct dial-up phone interface or via data entry equipment. The terminal prepares the paging information for transmission and communicates to the controller that it needs access to the infrastructure.
- Terminals can also provide statistics on paging traffic and billing information. The paging terminal is connected to the controller for key requests and control handshakes as well as passing pager address and information for transmission. The terminal is, therefore, co-located to allow for control signal and audio interface.
- The paging terminal provides user access typically by a Video Display Terminal (VDT) for database programming and review purposes. Terminals can usually support a variety of peripherals, such as disk drives, printers, and modem for expanded user capabilities.

**2. Controllers :**

- The controller is the control focal point of the system responsible for recognizing paging terminal requests and keying the transmitters in the proper paging mode, analog or binary. The controller depending on its sophistication is responsible for monitoring transmitter operational performance as well as reporting system level alarms.
- The controller can also perform system level maintenance to compensate for changes in the out bound control and paging information channel. Depending on the type, the controller may or may not store transmitter configuration and operational data, as well as logging station and system alarm information.
- The controller provides user access typically by a Vide Display Terminal (VDT) for database programming and review. More sophisticated controller usually supports a variety of peripherals such as disk drives, printers, and modems for expanded user capabilities.

**3. Outbound Control and Paging Information Channel :**

- The outbound control and paging information channel is the medium by which the controller information is passed on to the transmitters. The most conventional information distribution methods are RF links, dedicated wire lines to each transmitter from the controller site, or satellite up-link and down links. With an RF link system the controller audio is sent to a link transmitter via a wire line connection.
- A link repeater control then be used to listen to the link transmitter to further extend transmission of the information, hence the name repeater. With a wire line system the controller audio is sourced to a data splitter, which then feeds the signal to each transmitter via a dedicated wire line. With a satellite distribution system, the controller information is sent to the satellite up-link location. Each station is equipped with a satellite dish and receiver the recover the controller information.

**4. Transmitter Network :**

- The paging base stations decide control information from the controller for keying in the appropriate mode, analog or binary. The transmitter network in conjunction with the antenna system converts the information from the paging terminal into modulation and RF energy for transmission to the paging receivers.
- The transmitters continually check their operating performance and generate alarms in the event of a degradation in performance. The controller and system configurations determine how and when the alarms are reported.

**5. Communications Link :**

- The communications link is primarily feedback path from the transmitter network to the controller. This communications link is used to transfer the base station status and alarm information from the transmitter network to the controllers for evaluation and reporting. Several communications links may exist from the transmitter network to the controller.
- The communications link can be a one way path from base station to controller or a bi-directional depending on the type of link used. Some common communications links include dedicated wire lines, dial-up plane links, and monitor receivers with dedicated return phone lines.

**6. Pager :**

- The pager is a specialized miniature radio receiver carried by the user for retrieval of information from the paging terminal. Depending on the pager and system, the user can receive either an alert, a voice transmission, a numeric display page, or an alpha-numeric display page.
- The pager is only able to receive pages within the allowable coverage area provided by the transmitter network.

### 1.4.4 Messages to Paging Systems

- One of the following four types of information messages can be delivered in a paging system.
  - (1) Alert tone message
  - (2) Voice message
  - (3) Digital string message
  - (4) Text string message

### 1.4.5 Applications

- (1) Paging systems are typically used to notify a subscriber of the need to call a particular telephone number or travel to a known location to receive further instructions.
- (2) The modern paging systems are used to send News headlines, Stock quotations, and Faxes.

## 1.5 CORDLESS TELEPHONE SYSTEMS

### 1.5.1 Brief History

- The cordless phones first appeared around 1980. The earliest cordless phones operated at frequency of 27 MHz. They had the following problems :
  1. Limited range
  2. Poor sound quality
  3. Poor security.
- In 1986, the Federal Communications Commission (FCC) granted the frequency range of 47-49 MHz. For cordless phone, which improved their interference problem and reduced the power needed to run them. However, the phones still had a limited range and poor sound quality. Because the 43 - 50 MHz cordless phone frequency was becoming increasingly crowded, the FCC granted the frequency range of 900 MHz in 1990.
- This higher frequency allowed cordless phones to be clearer, broadcast a longer distance and chooses from more channels.
- In 1994, digital cordless phones in the 950 MHz frequency range were introduced. Digital signals allowed the phones to be more secured and decrease of eave dropping, it was pretty easy to eave drop an analog cordless phone conversations.
- In 1995, digital spread spectrum (DSS) was introduced for cordless phones. This technology enable of the digital information to spread in pieces over several frequencies between the receiver and the base, thereby making it almost impossible to eaves drop on the cordless conversations. In 1998, the FCC opened up the 2.4 GHz range for cordless phone use. Thus, frequency has increased the distance over which a cordless phone can operate and brought it out of the frequency range of most radio scanners, thereby further increasing security.

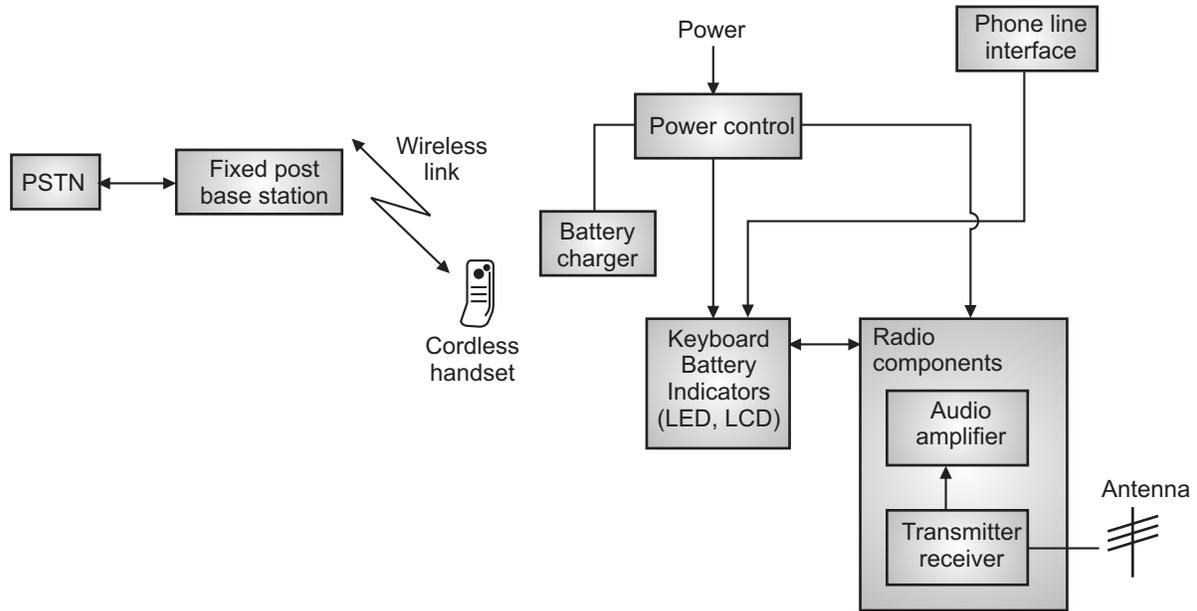
### 1.5.2 Concept

- Cordless Telephone as portable telephone is a telephone with a wireless handset that communicate via *radio waves* with a base station connected to a fixed telephone line, usually within a limited range of its base station.
- A cordless telephone a basically a combination of telephone and radio transmitter/receiver.

### 1.5.3 Features

1. Speaker phone
2. Caller ID
3. Mail box
4. LCD screen
5. Headphone jack
6. Two line support
7. Auto talk.

### 1.5.4 Block Diagram



**Fig. 1.3 : Block diagram of a cordless system**

- The block diagram of a cordless phone system is as shown in Fig. 1.3. It consists of a wireless network, paging system and cellular system.

### 1.5.5 Basic Principle

- The dedicated base station is then connected to a dedicated telephone line with a specific telephone number on the Public Switched Telephone Network (PSTN). In first generation cordless telephone systems (CT 1) manufactured in the 1980s, the portable unit communicates only to the dedicated base unit and only over distance of a few tens of meters.
- Early cordless telephones operate solely as extension telephones to a transceiver connected to a subscriber line on the PSTN and are primarily for in-home use. CT 2 is a second-generation cordless telecommunication system. The digital cordless standards are designed for wireless PABX and key systems, cordless residential telephones and public cordless access (telepoint) services.
- The CT 2 standard originated in the U.K. for providing public telepoint services and was adopted in the year 1992 by ETSI as an interim European standard for cordless communications. The CT 2 plus standard, adopted by Canada, is a fully compatible with CT 2 and provides as standard features more efficient location tracking mechanisms, and faster incoming call delivery and handoff.

### 1.5.6 Working

- A cordless phone has two major parts : (1) Base and (2) Handset. The function of each block of a cordless telephone system is described as under :

**1. Base :**

- The base is attached to the phone jack through a standard of phone wire connection, it looks just like a normal phone. The base receives the incoming call as an electrical signal through the phone line, converts it to an FM radio signal then broadcast that signal.

**2. Handset :**

- The handset receives the radio signal from the base. Converts it to an electrical signal and sends that signal to the speaker, where it is converted into the sound that you hear. When you talk, the handset broadcasts your voice through a second FM radio signal back to the base. The base receives your voice signal, converts it to an electrical signal and sends that signal through the phone line to the other party.
- The base and handset operate on a frequency pair that allows you to talk and listen at the same time, called *duplex* frequency.