A
Text Book
Of

WIRELESS COMMUNICATION

For Fourth Semester Diploma in
Electronics and Communication Engg.

As per new curriculum w.e.f. 2021-22

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9	1.2.4	1.5.7	1. Satellite for voice and data communication, Earth observation. 2. Set top box -concept, block diagram. 3. Set top box - working.	Refer Table 1	1. Video demonstration and documentation of TV Set top box repair. 2. Test and troubleshoot Set top box.
10	1.2	1.5	• Cellular networks, cellularconcept, frequency reuse. • Terminologies used in mobile communication, capacity expansion techniques-cell splitting and cell sectoring. • Handoff strategies, working of atypical cellular system.	Refer Table 1	• Conduct an experiment to understand the working of different sections in a mobilephone using a mobile phone trainer kit. • Conduct an experiment to analyze MIC & Speaker section, Buzzer section using a mobile phone trainer kit.
11	3	7	1. GSM services and features. 2. GSM architecture, working. 3. LTE architecture and working.	Refer Table 1	• Conduct an experiment to analyse vibrator section, LED control section using a mobilephone trainer kit. • Conduct an experiment to analyse the active mode/sleep mode/Partially ON mode while charging of a mobile phone using a mobile phone trainer kit.
12	1.2.4	7	Mobile servicing 1. Mobile displays - working principle.		Video demonstration and documentation of
			• Mobile camera - working principle. • Charging ports & battery -concept	Refer Table 1	• Troubleshooting, testing and replacement of display, front camera. • Troubleshooting, testing and replacement of charging port, battery.
13	1.2.3	7	• IoT - introduction, characteristics of IoT, internet of things. • IoT protocols-MQTT, IoT-functional blocks. • IoT communication models, IoTenabling technologies.	Refer Table 1	1. Build an IoT based simple realtime application using Arduino controller and prepare a report.
Total in hours			39	13	52

CONTENTS

VCB

Week

1

Theory

Practical Experiment

1.1 Wireless Communication :

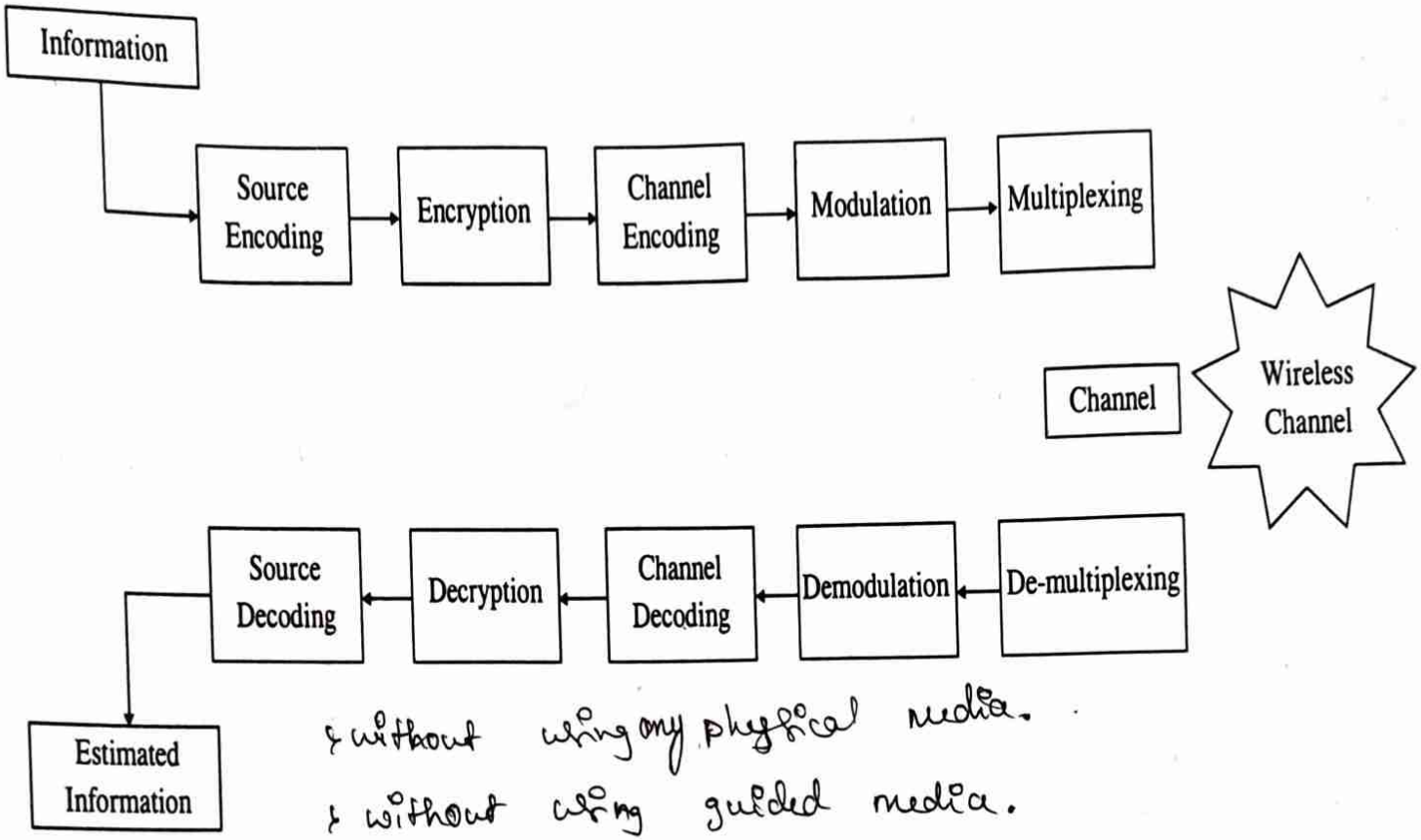
Wireless Communication is the fastest growing and most vibrant technological areas in the communication field. Wireless Communication is a method of transmitting information from one point to other, without using any connection like wires, cables or any physical medium.

Generally, in a communication system, information is transmitted from transmitter to receiver that are placed over a limited distance. With the help of Wireless Communication, the transmitter and receiver can be placed anywhere between few meters (like a T.V. Remote Control) to few thousand kilometers (Satellite Communication).

We live in a World of communication and Wireless Communication, in particular, is a key part of our lives. Some of the commonly used Wireless Communication Systems in our day – to – day life are : Mobile Phones, GPS Receivers, Remote Controls, Bluetooth Audio and Wi-Fi etc.

1.1.1 Block Diagram of Wireless Communication System :

A typical Wireless Communication System can be divided into three elements : the Transmitter, the Channel and the Receiver. The following image shows the block diagram of wireless communication system.



Transmission Path :

A typical transmission path of a Wireless Communication System consists of Encoder, Encryption, Modulation and Multiplexing. The signal from the source is passed through a Source Encoder, which converts the signal in to a suitable form for applying signal processing techniques.

The redundant information from signal is removed in this process in order to maximize the utilization of resources. This signal is then encrypted using an Encryption Standard so that the signal and the information is secured and doesn't allow any unauthorized access.

Channel Encoding is a technique that is applied to the signal to reduce the impairments like noise, interference, etc. During this process, a small amount of redundancy is introduced to the signal so that it becomes robust against noise. Then the signal is modulated using a suitable Modulation Technique (like PSK, FSK and QPSK etc.), so that the signal can be easily transmitted using antenna.

The modulated signal is then multiplexed with other signals using different Multiplexing Techniques like Time Division Multiplexing (TDM) or Frequency Division Multiplexing (FDM) to share the valuable bandwidth.

Channel :

The channel in Wireless Communication indicates the medium of transmission of the signal i.e. open space. A wireless channel is unpredictable and also highly variable and random in nature. A channel may be subject to interference, distortion, noise, scattering etc. and the result is that the received signal may be filled with errors.

Reception Path :

The job of the Receiver is to collect the signal from the channel and reproduce it as the source signal. The reception path of a Wireless Communication System comprises of Demultiplexing, Demodulation, Channel Decoding, Decryption and Source Decoding. From the components of the reception path it is clear that the task of the receiver is just the inverse to that of transmitter.

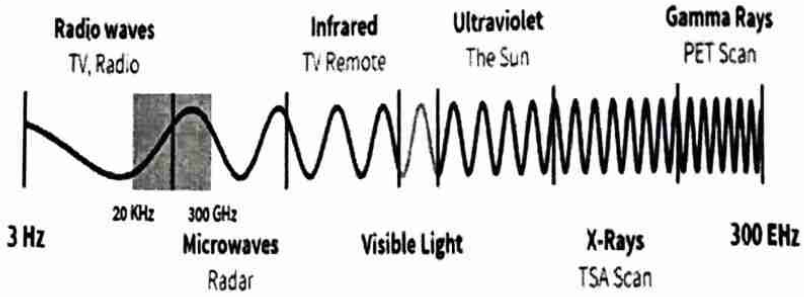
The signal from the channel is received by the Demultiplexer and is separated from other signals. The individual signals are demodulated using appropriate Demodulation Techniques and the original message signal is recovered. The redundant bits from the message are removed using the Channel Decoder.

Since the message is encrypted, Decryption of the signal removes the security and turns it into simple sequence of bits. Finally, this signal is given to the Source Decoder to get back the original transmitted message or signal.

1.1.2 Frequency Spectrum used in Wireless Communication :

Electromagnetic Waves carry the electromagnetic energy of electromagnetic field through space. Electromagnetic Waves include Gamma Rays (γ – Rays), X – Rays, Ultraviolet Rays, Visible Light, Infrared Rays, Microwave Rays and Radio Waves. Electromagnetic Waves (usually Radio Waves) are used in wireless communication to carry the signals.

The full electromagnetic spectrum ranges from three Hz (extremely low frequency) to 300 EHz (gamma rays). The portion used for wireless communication sits within that space and ranges from about 20 KHz to 300 GHz.

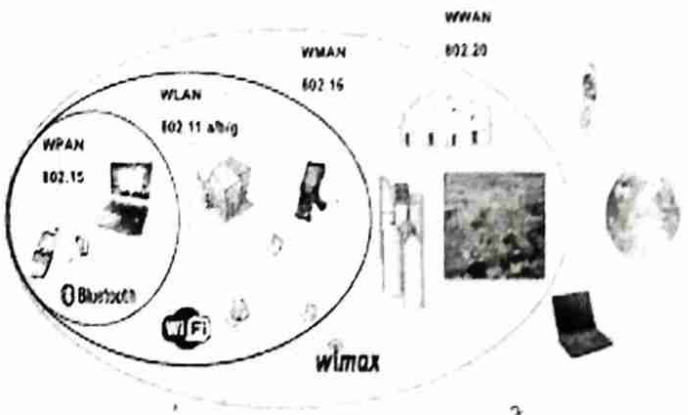


In the radio communication system, the frequencies ranging from a few kilohertz to many gigahertz all are being used for various purposes. Table below presents the details of entire usable frequency spectrum and its applications.

S.No.	Frequency Band	Wavelength	Applications
1.	30 Hz - 300 Hz Extremely low frequencies (ELF)	10^4 km to 10^3 km	Power transmission
2.	300 Hz - 3 kHz, Voice frequencies (VF)	10^3 km to 100 km	Audio applications
3.	3 kHz - 30 kHz, Very low frequencies (VLF)	100 km to 10 km	Submarine communications, Navy, Military communications
4.	30 kHz - 300 kHz, Low frequencies (LF)	10 km to 1 km. Long waves.	Aeronautical and marine navigation, these frequencies act as subcarriers.
5.	300 kHz - 30 MHz Medium frequencies (MF)	1 km to 100 m. Medium waves	AM radio broadcast, Marine and aeronautical communications.
6.	3 MHz - 30 MHz High frequencies (HF)	100 m to 10 m. Short waves	Shortwave transmission, Amateur and CB communication.
7.	30 MHz - 300 MHz Very high frequencies (VHF)	10 m to 1 m	TV broadcasting, FM broadcasting.
8.	300 MHz - 3 GHz Ultra high frequencies (UHF)	1 m to 10 m Microwaves	UHF TV Channels, Cellular phones, Military applications
9.	3 GHz - 30 GHz (SHF)	10^{-1} m to 10^{-2} m	Satellite communications and Radar
10.	30 - 300 GHz (EHF)	10^{-2} m to 10^{-3} m	Satellites and specialized Radars.

1.2 Wireless Network :

Wireless network may be classified into different categories based on the range of operation they offer. The most common classification scheme divides the wireless networks into four categories listed below, together with short examples.



WPANS : Wireless Personal Area Networks :

The two current technologies for wireless personal area networks are Infra Red (IR) and Bluetooth (IEEE 802.15). These will allow the connectivity of personal devices within an area of about 30 feet. However, IR requires a direct line of site and the range is less.

WLANS : Wireless Local Area Networks :

WLANS allow users in a local area, such as a university campus or library, to form a network or gain access to the internet. A temporary network can be formed by a small number of users without the need of an access point; given that they do not need access to network resources.

WMANS : Wireless Metropolitan Area Networks :

This technology allows the connection of multiple networks in a metropolitan area such as different buildings in a city, which can be an alternative or backup to laying copper or fiber cabling.

WWANS : Wireless Wide Area Networks :

These types of networks can be maintained over large areas, such as cities or countries, via multiple satellite systems or antenna sites looked after by an ISP. These types of systems are referred to as 2G (2nd Generation) systems.

The below table gives a brief comparison between WPAN, WLAN, WMAN and WWAN :

Category	Coverage	Examples	Applications
Wireless Personal Area Network (**WPAN**)	Very short - max 10 meters but usually much smaller	Bluetooth, 802.15, IrDA communication	• Data exchange between smartphones • Headsets • Smart watches.
Wireless Local Area Network (**WLAN**)	Moderate - inside the apartments or work places.	802.11 Wi-Fi	Wireless extension of the local network used in- • Enterprises • Markets • Airport • Home.
Wireless Metropolitan Area Network (**WMAN**)	All around the city	Wimax, IEEE 802.16 or proprietary technologies	Between homes and businesses.
Wireless Wide Area Network (**WWAN**)	Throughout the world.	3G, LTE	Wireless access to the internet form.

1.3 WiFi :

Wi-Fi is a popular wireless networking technology. Wi-Fi stands for "wireless fidelity". Wi-Fi was invented by NCR Corporation/AT&T in the Netherlands in 1991. By using this technology we can exchange information between two or more devices. Wi-Fi has been developed for mobile computing devices, such as laptops, but it is now extensively using for mobile applications and consumer electronics like televisions, DVD players, and digital cameras. There should be two possibilities in communicating with the Wi-Fi connection that may be through an access point to the client connection or client to client connection. Hence, Wi-Fi is one type of wireless technology. It is commonly called a wireless LAN (local area network). WiFi technology allows local area networks to operate without cable and wiring.

1.3.1 Features of Wi-Fi :

The main features of Wi-Fi are as follows :

- It is a flexible network connection, no wiring complexities. Can be accessed from anywhere in the Wi-Fi range.
- It does not require regulatory approval for individual users.
- It is scalable, can be expanded by using Wi-Fi Extenders, no limitation.
- It can be set up in an easy and fast way. Just need to configure the SSID and Password.
- Security is a high in Wi-Fi network, its uses **WPA** encryption to encrypt radio signals.
- It is also lower in cost.
- It also can provide Hotspots.

1.3.2 Applications of Wi-Fi :

The main applications of wifi are as follows :

- **Share your internet :** Your PC may be connected with an ethernet cable to a Wi-Fi router and you have yet to take advantage of wireless connectivity in the home.
- **Share resources between PCs :** The most common use for a wireless network is to share resources such as files and printers between computers.
- **Access your files via a NAS drive :** NAS stands for network-attached storage and is, in essence, a hard disk that is connected to a network rather than a PC. You can share files and folders on any PC connected to a wireless network.

- **Print & scan :** Moving around a printer or scanner to use it with your various PCs is a hassle you can do without. Much better is to have a printer or scanner connected to your wireless network so that it can be accessed by any computer.
- **Sync your stuff :** If you have more than one computer you'll probably want to ensure that your music, photos and documents are kept in sync between them. It can be done with wifi.
- **Remote control of your entertainment system :** Having to use several different remote controls - one for the TV, another for the hi-fi and yet another for the DVD player - has never been popular. Universal wifi remotes are available.
- **Listen to music :** A Wi-Fi network allows you to listen to music in any room of the house, and there are several ways to enjoy this freedom.
- **Stream video :** Just as you can stream audio across a Wi-Fi network, you can also stream video. This is an increasingly popular way of accessing your movie collection - you can have your entire collection on tap, without ever having to get up and put a disc into the DVD player.
- **Play online games :** Playing games on your PC doesn't have to be a solitary affair. Virtually all games can also be played with (or against) other players online. What's more, if your laptop, PC or tablet is connected to the internet via your Wi-Fi network, you'll be able to enjoy online gaming from these devices, too.
- **Monitor your home :** If you want to keep an eye on your home or office, your Wi-Fi network can be the

key to your security needs. By adding a so-called IP camera, you'll be able to monitor your property either from a device on the same Wi-Fi network or via the web.

1.3.3 Wi-Fi Hotspot and its Significance :

A WiFi hotspot is created by installing an access point to an internet connection. The access point transmits a wireless signal over a short distance. It typically covers around 300 feet. When a WiFi enabled device such as a Pocket PC encounters a hotspot, the device can then connect to that network wirelessly.

Hence, a hotspot is a physical location where people can access the Internet, typically using Wi-Fi, via a wireless local area network (WLAN) with a router connected to an Internet service provider. Most people refer to these locations as "Wi-Fi hotspots" or "Wi-Fi connections." Simply put, hotspots are the physical places where users can wirelessly connect their mobile devices, such as smartphones and tablets, to the Internet.

A hotspot can be in a private location or a public one, such as in a coffee shop, a hotel, an airport, or even an airplane. While many public hotspots offer free wireless access on an open network, others require payment. Some Hotspots require WEP key to connect, which is considered as private and secure. As for open connections, anyone with a WiFi card can have access to that hotspot. So in order to have internet access under WEP, the user must input the WEP key code.

Practical Experiment 1

Implement WLAN in your computer lab

Note : WLAN can be implemented using different methods depending upon the type of hub/switch/router/modem/repeater/wi-fi adopter/ad-hoc etc. Here I have used two methods: one using switch and another using inbuilt WI-FI adopter with ad-hoc. You can follow any one method.

Aim :

Connect the computers in Local Area Network.

Apparatus Required :

WLAN Hub/Switch

PC Computers.

Method 1 : Using Hub or Switch :

Procedure : On the host computer :

On the host computer, follow these steps to share the Internet connection :

1. Log on to the host computer as Administrator or as Owner.
2. Click **Start**, and then click **Control Panel**.
3. Click **Network and Internet Connections**.
4. Click **Network Connections**.

5. Right-click the connection that you use to connect to the Internet. For example, if you connect to the Internet by using a modem, right-click the connection that you want under Dial-up / other network available.
6. Click **Properties**.
7. Click the **Advanced** tab.
8. Under **Internet Connection Sharing**, select the **Allow other network users to connect through this computer's Internet connection** check box.
9. If you are sharing a dial-up Internet connection, select the **Establish a dial-up connection whenever a computer on my network attempts to access the Internet** check box if you want to permit your computer to automatically connect to the Internet.
10. Click **OK**. You receive the following message :

    When Internet Connection Sharing is enabled, your LAN adapter will be set to use IP address 192.168.0. 1. Your computer may lose connectivity with other computers on your network. If these other computers have static IP addresses, it is a good idea to set them to obtain their IP addresses automatically. Are you sure you want to enable Internet Connection Sharing ?

11. Click **Yes**.

    The connection to the Internet is shared to other computers on the local area network (LAN). The network adapter that is connected to the LAN is configured with a static IP address of 192.168.0. 1 and a subnet mask of 255.255.255.0.

On the client computer :

To connect to the Internet by using the shared connection, you must confirm the LAN adapter IP configuration, and then configure the client computer. To confirm the LAN adapter IP configuration, follow these steps :

1. Log on to the client computer as Administrator or as Owner.
2. Click **Start**, and then click **Control Panel**.
3. Click **Network and Internet Connections**.
4. Click **Network Connections**.
5. Right-click **Local Area Connection** and then click **Properties**.
6. Click the **General** tab, click **Internet Protocol (TCP/IP)** in the **connection uses the following items** list, and then click **Properties**.
7. In the **Internet Protocol (TCP/IP) Properties** dialog box, click **Obtain an IP address automatically** (if it is not already selected), and then click **OK**.

   Note : You can also assign a unique static IP address in the range of 192.168.0.2 to 254. For example, you can assign the following static IP address, subnet mask, and default gateway :
8. IP Address 192.168.31.202.
9. Subnet mask 255.255.255.0.
10. Default gateway 192.168.31.1.

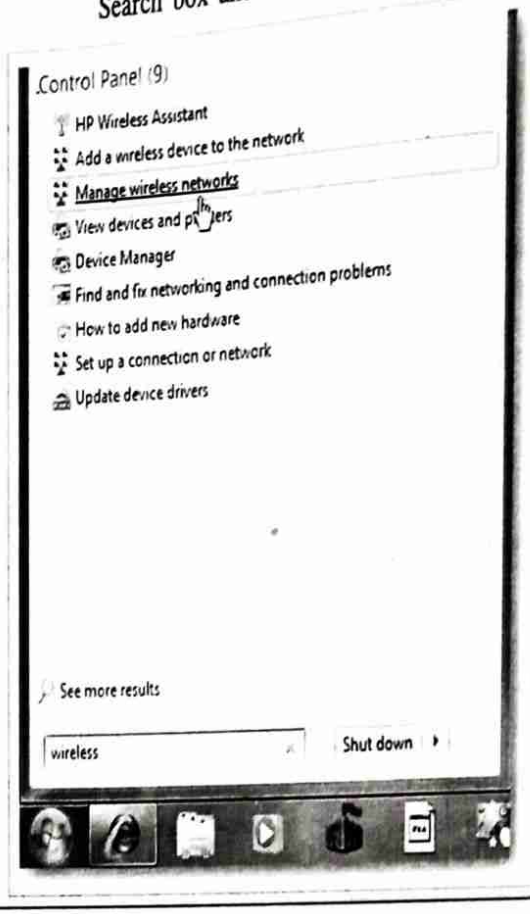
11. In the **Local Area Connection Properties** dialog box, click **OK**.
12. Quit Control Panel.

Method 2 : Using Ad-hoc :

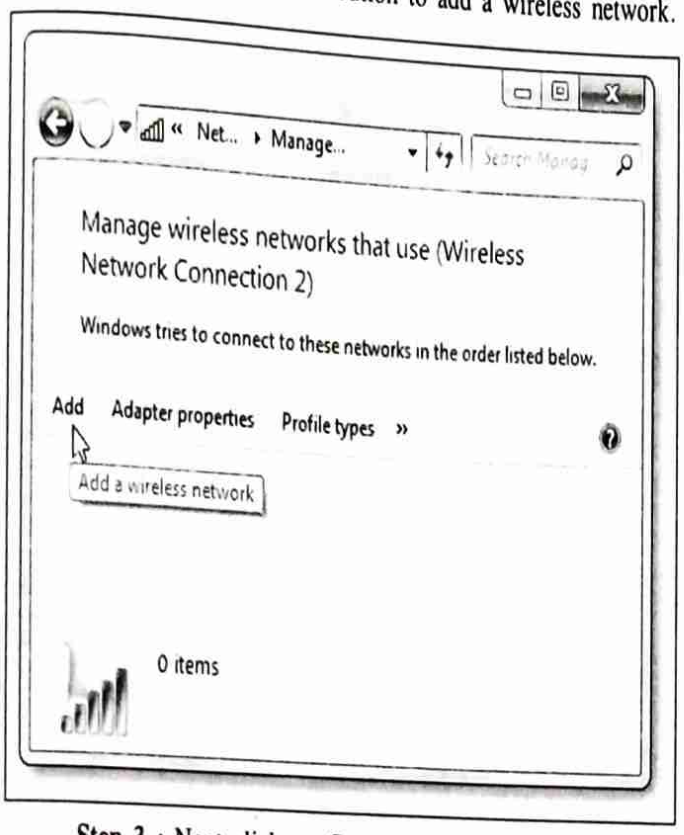
Procedure :

Note : This procedure is followed in windows 7 OS PC. For windows 10, two to three steps is little modified.

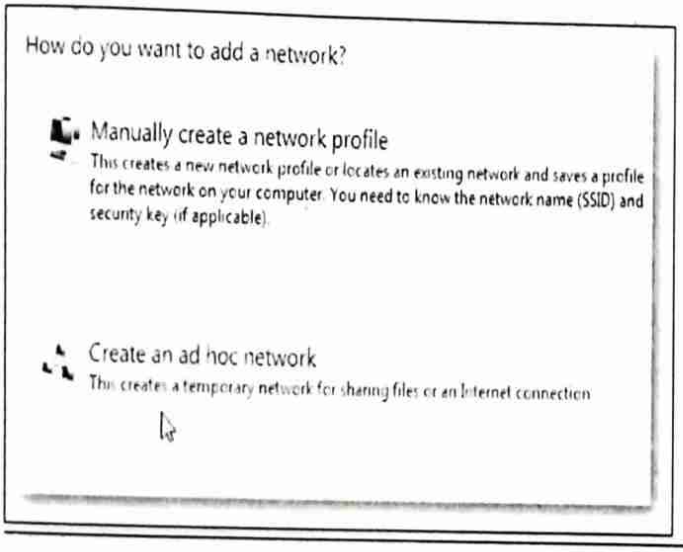
Step 1 : Open the Start Menu and type *wireless* into the Search box and select *Manage wireless networks.*



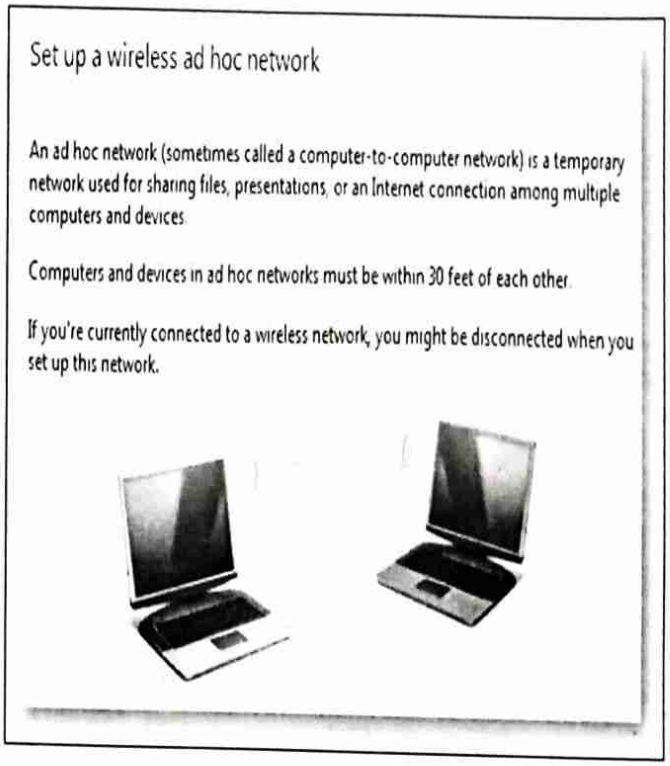
Step 2 : Click the Add button to add a wireless network.



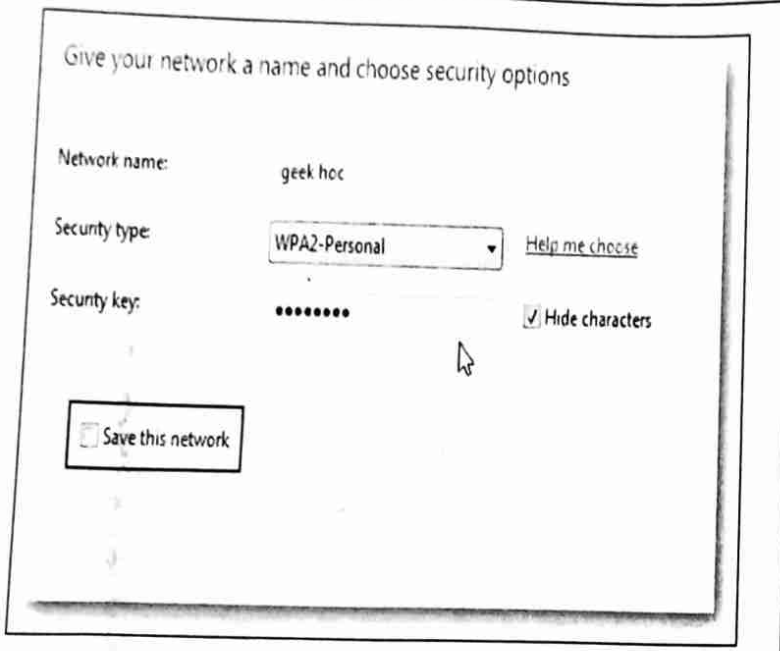
Step 3 : Next click on *Create an ad hoc network...*



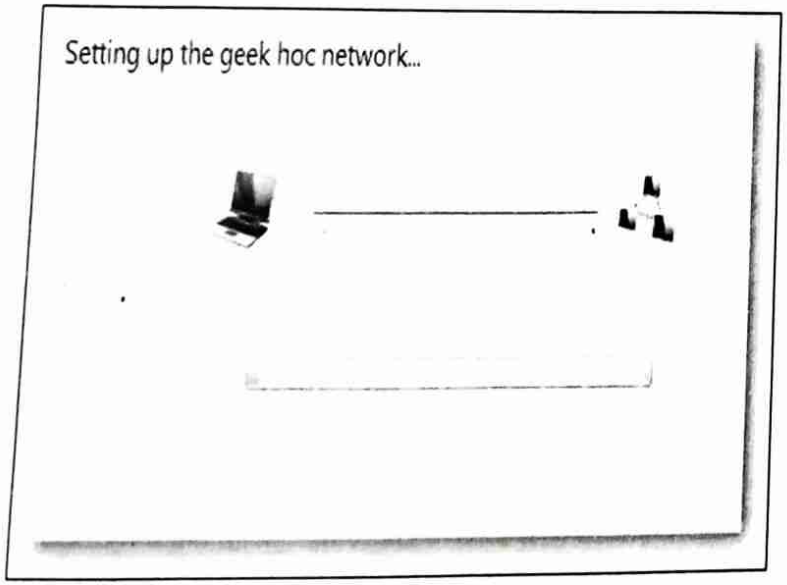
Step 4 : You'll get a message instructing you of what an ad hoc network is...click Next.



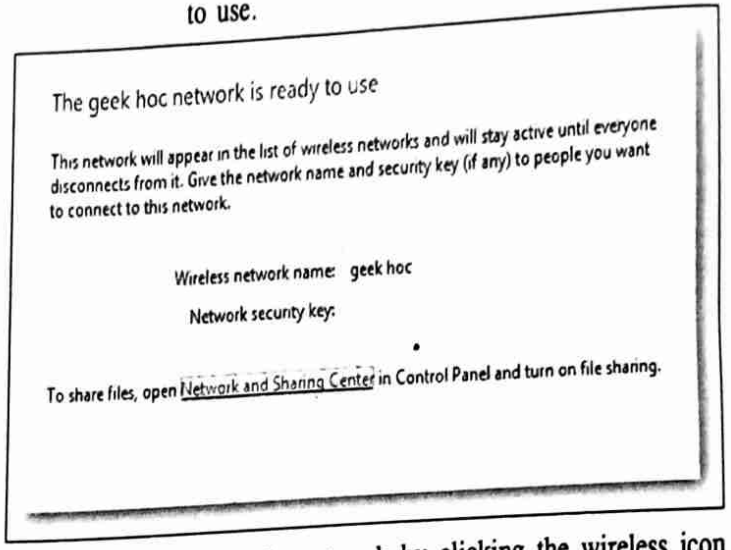
Step 5 : Now give your network a name and choose security options...check *Save this network* if you plan to use it repeatedly so you don't have to set one up each time. The security type will depend on what the wireless adapter is capable of. We found if you're only using it quickly with different types of devices it's easier to have no security. Of course if you are keeping it on for full-time use, you'll definitely want to use security.



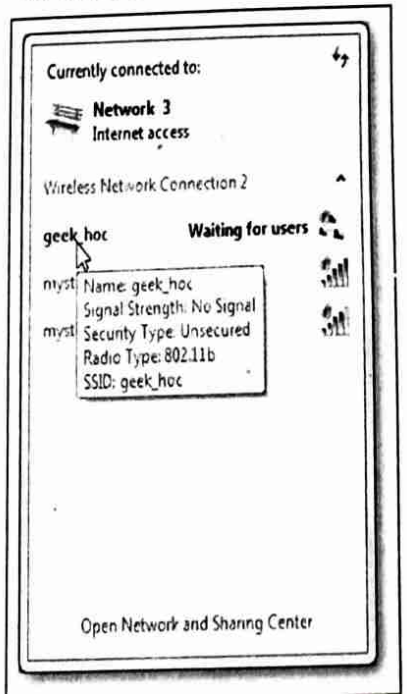
Step 6 : Wait while the network is created...



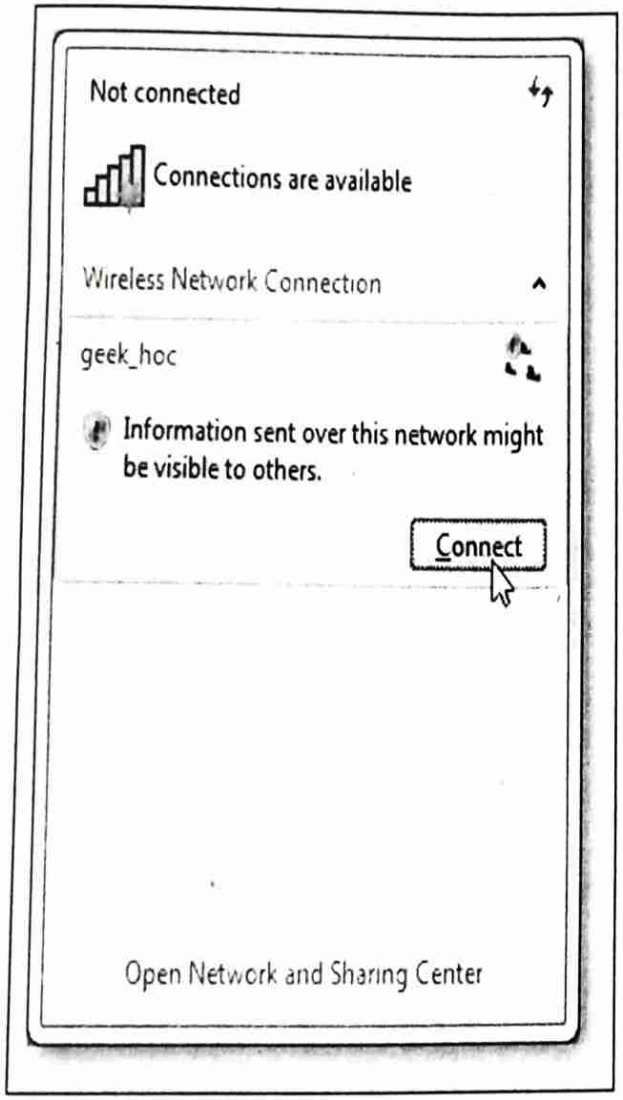
Step 7 : The network was successfully created and is ready to use.



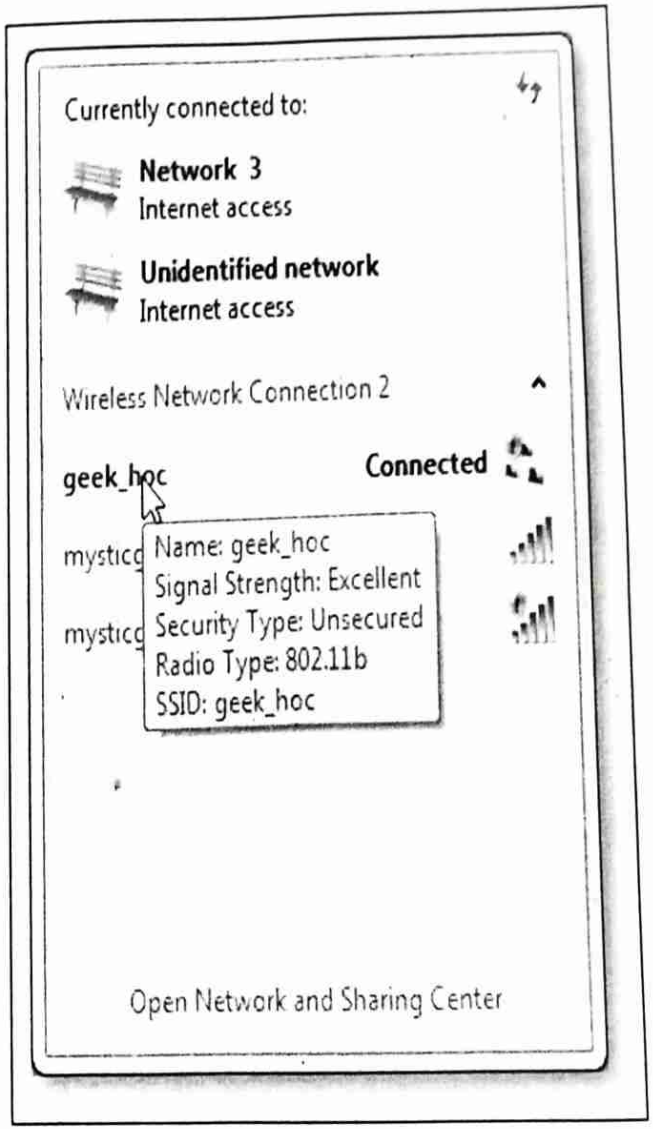
Step 8 : Verify the network by clicking the wireless icon on the Taskbar...here you can see ours is waiting for users to connect.



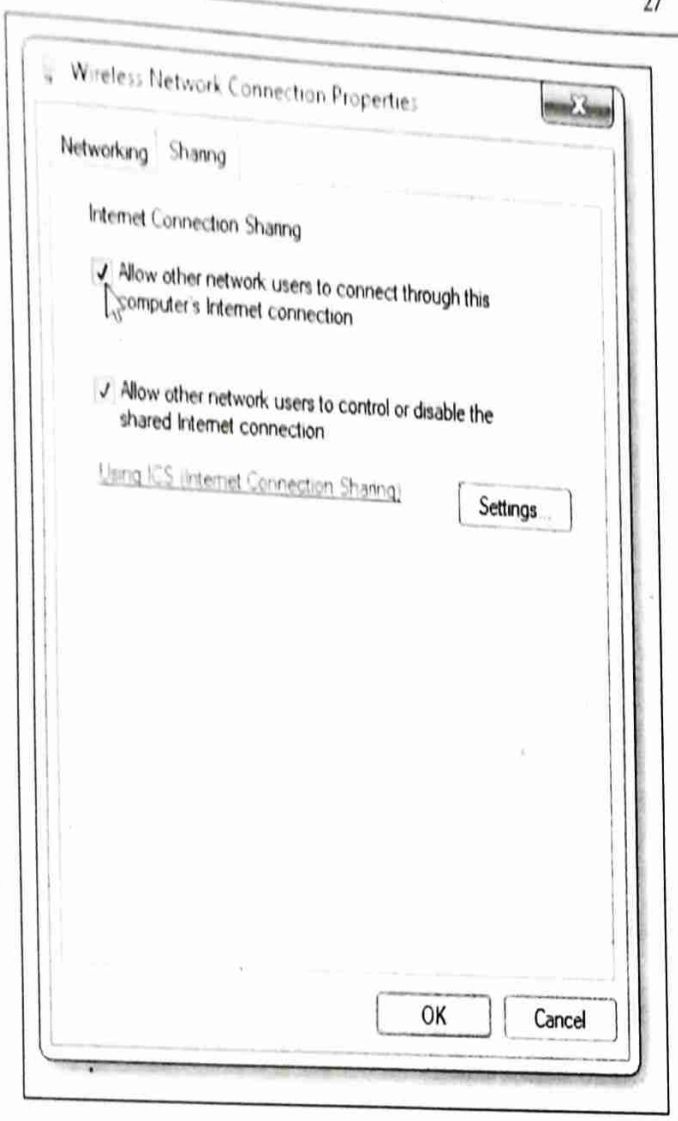
Step 9 : On the Client computer, click on the wireless icon to see available networks and connect to the ad hoc network.



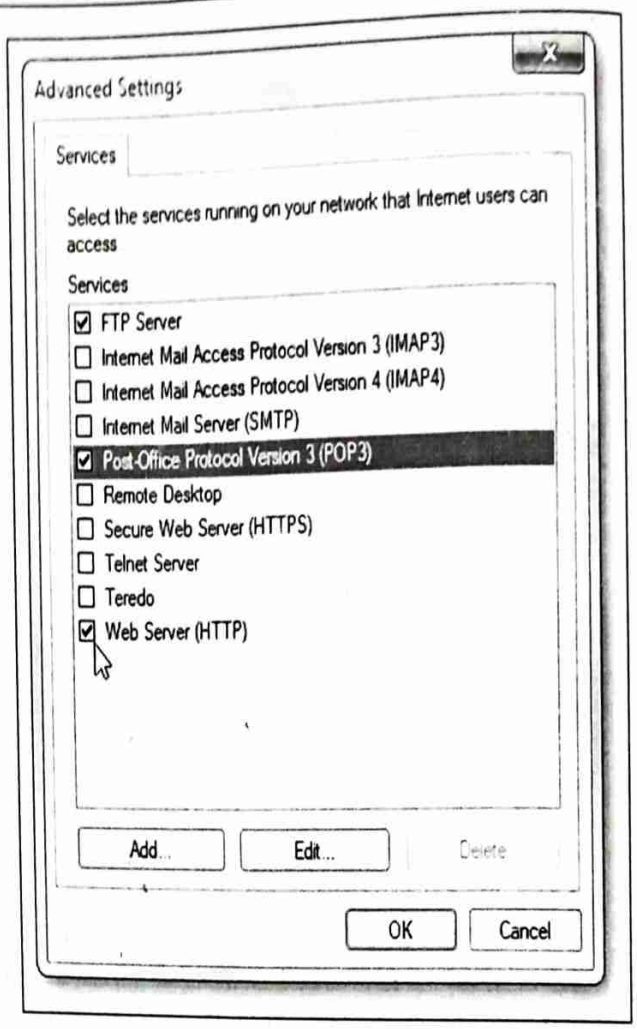
Step 10: Then on the Host machine you will see that the other computer is connected to your ad hoc network.



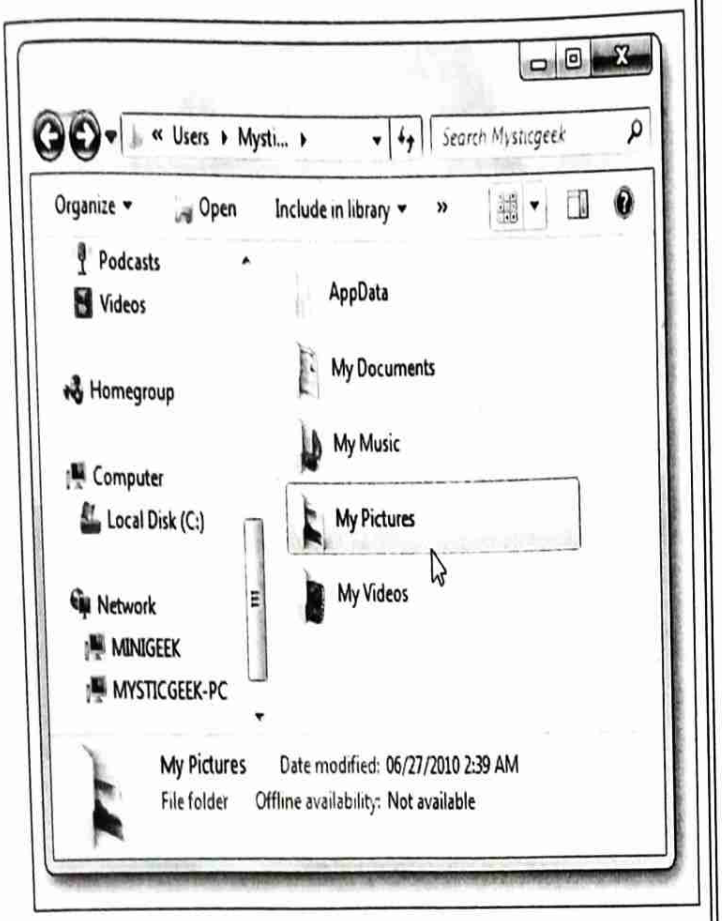
Step 11: At this point you'll be able to share files between machines. To share an Internet connection with other devices, right-click on the Host's wireless adapter icon. go to Properties, click the Sharing tab, and select *Allow other network users to connect through this computer's Internet connection.*



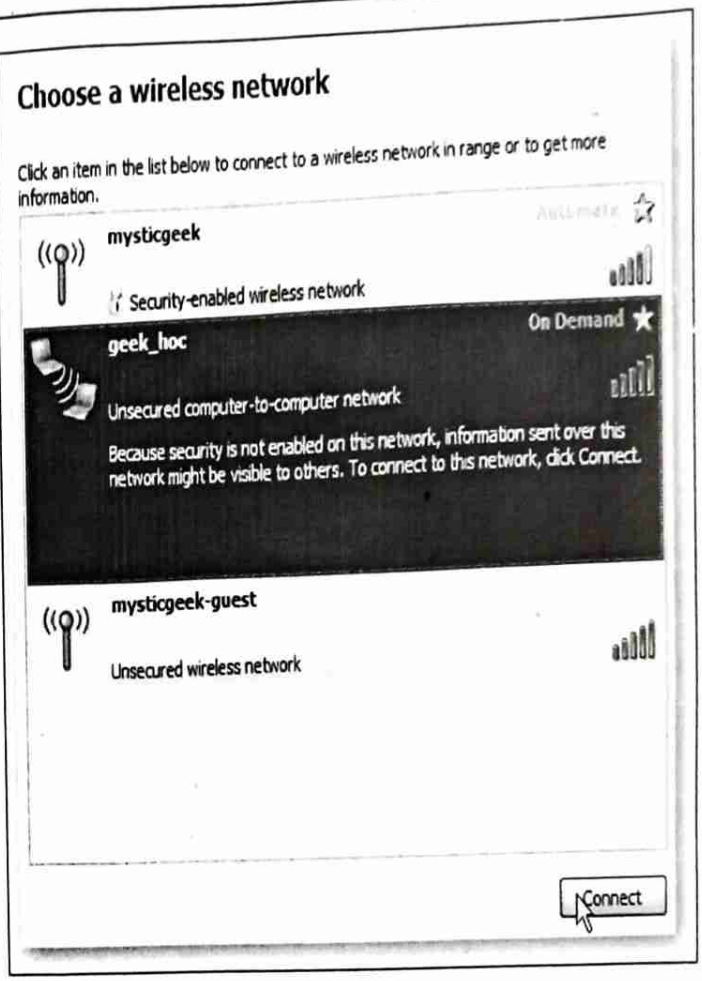
Step 12: In Settings you can select the network services the Client machine can access.



Step 13: Now you can share documents and the Internet connection between machines and devices. In this example we're sharing between a Windows 7 desktop with a wireless card and a Netbook with Windows 7 Home Premium.



Step 14: Of course you can also connect your XP machine too. Here we are connecting an XP Laptop to the ad hoc network.



Procedure to Check Set-up WLAN Public Folder Sharing :

Step 1 : Log in to one of the computers you want to enable sharing on, and then click "Start | Control Panel | Network and Internet | Network and Sharing Center."

Step 2 : Click the "Change advanced sharing settings" link in the left pane, and then click the down arrow next to the network profile labelled "current profile."

Step 3 : Select the "Turn on sharing so anyone with network access can read and write files in the Public folders" option under "Public folder sharing", click "Save changes" and then confirm the operation, if prompted.

Step 4 : Repeat this process on any other computer in your WLAN that you want to transfer files to or from.

Procedure to Transfer the Files :

Step 1 : Click the "Start" menu on the computer you want to transfer files from, and then click "Documents."

Step 2 : Click the "Public Documents" subfolder in the left pane of the Documents window to open it.

Step 3 : Drag and drop the files you want to transfer over your WLAN into the Public Documents window.

Step 4 : Click the "Start" menu on the computer you want to transfer the files to, and then click "Network."

Step 5 : Double-click on the source computer's name, and then double-click the "Public Documents" folder.

Step 6 : Drag and drop the files from the other computer onto your desktop to transfer them over the WLAN.

Result :

WLAN is implemented in computer LAB.

Week

2

Week 2

Theory

2.1 RFID

2.1.1 RFID Concept

2.1.2 RFID Applications

2.2 Bluetooth

2.2.1 Bluetooth Components : Layers and Protocol Stack

2.2.2 Bluetooth Networking

2.2.3 Bluetooth Operation Process-Bluetooth Connections

2.2.4 Bluetooth Applications

2.3 Waveguides

2.3.1 Need/Advantages of Waveguides

2.3.2 Types of Waveguides

Practical Experiment

2.1. Conduct an Experiment to Connect PC to Internet through Bluetooth Access Point of Mobile and Transfer a Text File / Image File / Video File

2.2. Interface RFID Reader for an Application using Arduino Controller

2.1 RFID :

RFID is an acronym for "radio-frequency identification" and refers to a technology whereby digital data encoded in RFID tags or smart labels are captured by a reader via radio waves. RFID is similar to barcoding in that data from a tag or label are captured by a device that stores the data in a database.

2.1.1 RFID Concept :

RFID technology is a simple method of exchanging data between two entities namely a reader/ writer and a tag. This communication allows information about the tag or the element carrying the tag to be determined and in this way it enables processes to be managed more easily.

RFID systems usually comprise an RFID reader/writer with antennas, RFID tags, and RFID application software :

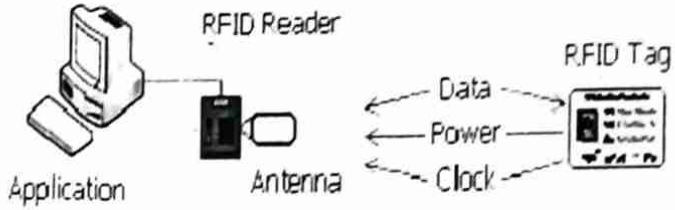


Fig. 2.1 : RFID Reader/Writer

- ***RFID reader / writer :*** The reader write is used to communicate with the tags that may pass within range. The RFID reader writer will normally be located in a fixed position and will be used to interrogate an RFID tag. Dependent upon the application and the format of

the system and the RFID reader / writer, data may also be written to the RFID tag.

- ***RFID tag :*** RFID tags may also be called RFID transponders and are typically located on items that are mobile. They are small and generally cheap so that they can be attached to low cost (or high cost) items that need to have information associated with them. They are also generally considered as being disposable. The RFID tag contains data that is relayed to the reader, and in some systems it may also be possible to update the data within the tag to indicate that the tag and hence the item has undergone a specific stage in a process, etc.
- ***RFID application software :*** Like all systems these days, RFID systems need application software to run the overall system. With many systems there will be a number of different reader / writers and the data to and from these needs to be co-ordinated and analysed.

2.1.2 RFID Applications :

RFID systems can be used in a variety of ways. There are many RFID applications which have gained popularity over the past years :

- Store product identification
- Asset tracking
- Airline baggage identification
- Parts identification
- Production control

- Employee access control
- Supply chain control
- Vehicle tracking
- Livestock identification.

2.2 Bluetooth :

Bluetooth is a standardized protocol for sending and receiving data via a 2.4 GHz wireless link. It's a secure protocol, and it's perfect for short-range, low-power, low-cost, wireless transmissions between electronic devices.

Bluetooth®

Now-a-days bluetooth has become part of our lives due to its immense applications from audio devices which include headsets and mobile phones, home stereos, MP3 players, laptop, desktop, tablets and more. With bluetooth one can transfer data (meeting schedules, phone numbers), audio, graphic images and video from one device to the other provided they are bluetooth compliant. IEEE 802.15.b standard describes detailed bluetooth specifications.

2.2.1 Bluetooth Components : Layers and Protocol Stack :

Bluetooth standard has many protocols that are organized into different layers. The layer structure of Bluetooth does not follow OSI model, TCP/IP model or any other known model. The different layers and Bluetooth protocol architecture is shown in the below figure 2.2.

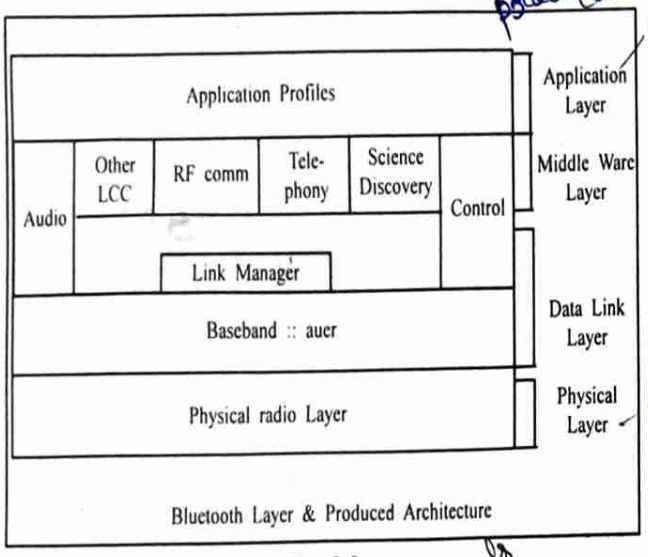


Fig. 2.2

Radio Layer :

- The Bluetooth radio layer corresponds to the physical layer of OSI model.
- It deals with ratio transmission and modulation.
- The radio layer moves data from master to slave or vice versa.

- It is a low power system that uses 2.4 GHz ISM band in a range of 10 meters.
- This band is divided into 79 channels of 1MHz each. Bluetooth uses the Frequency Hopping Spread Spectrum (FHSS) method in the physical layer to avoid interference from other devices or networks.
- Bluetooth hops 1600 times per second, i.e. each device changes its modulation frequency 1600 times per second.
- In order to change bits into a signal, it uses a version of FSK called GFSK i.e. FSK with Gaussian bandwidth filtering.

Baseband Layer :

- Baseband layer is equivalent to the MAC sublayer in LANs.
- Bluetooth uses a form of TDMA called TDD-TDMA (time division duplex TDMA).
- Master and slave stations communicate with each other using time slots.
- The master in each piconet defines the time slot of 625 μsec.
- In TDD- TDMA, communication is half duplex in which receiver can send and receive data but not at the same time.
- If the piconet has only no slave; the master uses even numbered slots (0, 2, 4, ...) and the slave uses odd-numbered slots (1, 3, 5, ...). Both master and slave

communicate in half duplex mode. In slot 0, master sends & secondary receives; in slot 1, secondary sends and primary receives.

- If piconet has more than one slave, the master uses even numbered slots. The slave sends in the next odd-numbered slot if the packet in the previous slot was addressed to it.
- In Baseband layer, two types of links can be created between a master and slave. These are :

1. Asynchronous Connection-less (ACL) :

- It is used for packet switched data that is available at irregular intervals.
- ACL delivers traffic on a best effort basis. Frames can be lost & may have to be retransmitted.
- A slave can have only one ACL link to its master.
- The ACL can achieve a maximum data rate of 721 kbps by using one, three or more slots.

2. Synchronous Connection Oriented (SCO) :

- sco is used for real time data such as sound. It is used where fast delivery is preferred over accurate delivery.
- In an sco link, a physical link is created between the master and slave by reserving specific slots at regular intervals.
- Damaged packet; are not retransmitted over sco links.
- A slave can have three sco links with the master and can send data at 64 Kbps.

Logical Link, Control Adaptation Protocol Layer (L2CAP) :

- The logical unit link control adaptation protocol is equivalent to logical link control sublayer of LAN.
- The ACL link uses L2CAP for data exchange but sco channel does not use it.
- The various function of L2CAP is :

1. Segmentation and reassembly :

- L2CAP receives the packets of upto 64 KB from upper layers and divides them into frames for transmission.
- It adds extra information to define the location of frame in the original packet.
- The L2CAP reassembles the frame into packets again at the destination.

2. Multiplexing :

- L2CAP performs multiplexing at sender side and demultiplexing at receiver side.
- At the sender site, it accepts data from one of the upper layer protocols frames them and deliver them to the Baseband layer.
- At the receiver site, it accepts a frame from the baseband layer, extracts the data, and delivers them to the appropriate protocol layer.

3. **Quality of Service (QOS) :**

- L2CAP handles quality of service requirements, both when links are established and during normal operation.
- It also enables the devices to negotiate the maximum payload size during connection establishment.

2.2.2 Bluetooth Networking :

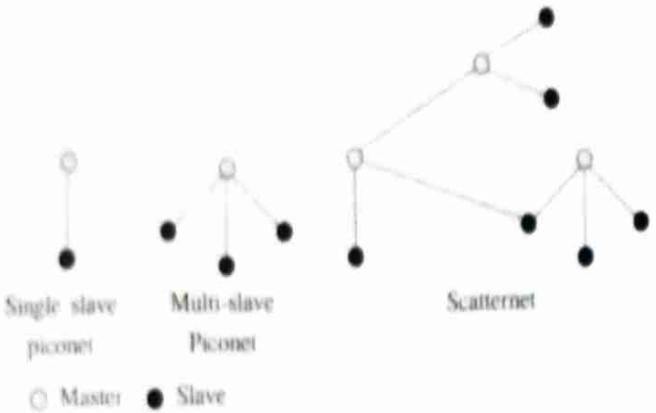


Fig. 2.3

Bluetooth network consists of many bluetooth users. There are two types of network topologies in bluetooth viz.

- Piconet and
- Scatternet

Piconet is formed by one master and one slave as well as one master and multiple slaves. There will be maximum 7 active slaves in the piconet. Hence there will be about 8 maximum devices communicating in a small network referred as piconet. Slaves can only transmit when they have been requested by the master bluetooth device. There will be about 255 slaves in parking state. Active slaves are polled by the master for transmission. Each station will get 8 bit parked address. Total 255 parked slaves are possible in one piconet. The parked station can join in just 2 ms. All the other stations can join in more time. About 10 such piconets exist in the bluetooth radio coverage area.

Combinations of multiple piconets is known as scatternet. A device can participate in multiple piconets. It will timeshare and need to be synchronized with the master of current piconet. It supports data rate based on different versions from 720 kbps to about 24 Mbps. It will have distance coverage to about 1 to 100 meters based on power class supported on bluetooth devices.

2.2.3 Bluetooth Operation Process-Bluetooth Connections :

Creating a Bluetooth connection between two devices is a multi-step process involving three progressive states :

1. **Inquiry** - If two Bluetooth devices know absolutely nothing about each other, one must run an inquiry to try to discover the other. One device sends out the inquiry request, and any device listening for such a request will respond with its address, and possibly its name and other information.
2. **Paging (Connecting)** - Paging is the process of forming a connection between two Bluetooth devices. Before this connection can be initiated, each device needs to know the address of the other (found in the inquiry process).

3. **Connection** - After a device has completed the paging process, it enters the connection state. While connected, a device can either be actively participating or it can be put into a low power sleep mode.
   - **Active Mode** - This is the regular connected mode, where the device is actively transmitting or receiving data.
   - **Sniff Mode** - This is a power-saving mode, where the device is less active. It'll sleep and only listen for transmissions at a set interval (e.g. every 100ms).
   - **Hold Mode** - Hold mode is a temporary, power-saving mode where a device sleeps for a defined period and then returns back to active mode when that interval has passed. The master can command a slave device to hold.
   - **Park Mode** - Park is the deepest of sleep modes. A master can command a slave to "park", and that slave will become inactive until the master tells it to wake back up.

2.2.4 Bluetooth Applications :

Nowadays, Bluetooth technology is used for several computer and non computer application :

- It is used for providing communication between peripheral devices like wireless mouse or keyboard with the computer.

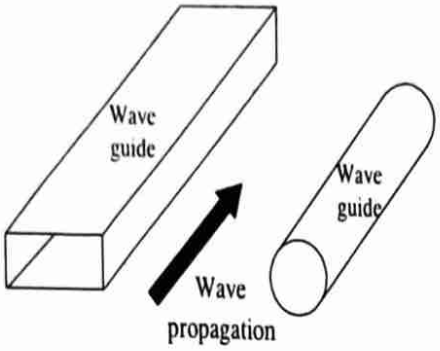
- It is used by modern healthcare devices to send signals to monitors.
- It is used by modern communicating devices like mobile phone, PDAs, palmtops etc. to transfer data rapidly.
- It is used for dial up networking. Thus allowing a notebook computer to call via a mobile phone.
- It is used for cordless telephoning to connect a handset and its local base station.
- It also allows hands-free voice communication with headset.
- It also enables a mobile computer to connect to a fixed LAN.
- It can also be used for file transfer operations from one mobile phone to another.

2.3 Waveguides :

Microwaves propagate through microwave circuits, components and devices, which act as a part of Microwave transmission lines, broadly called as Waveguides.

A hollow metallic tube of uniform cross-section for transmitting electromagnetic waves by successive reflections from the inner walls of the tube is called as a Waveguide.

The following figure shows an example of a waveguide.



Hence, waveguide is generally preferred in microwave communications. Waveguide is a special form of transmission line, which is a hollow metal tube. Unlike a transmission line, a waveguide has no center conductor.

The main characteristics of a Waveguide are :

- The tube wall provides distributed inductance.
- The empty space between the tube walls provide distributed capacitance.
- These are bulky and expensive.

2.3.1 Need/Advantages of Waveguides :

Following are few advantages of Waveguides :

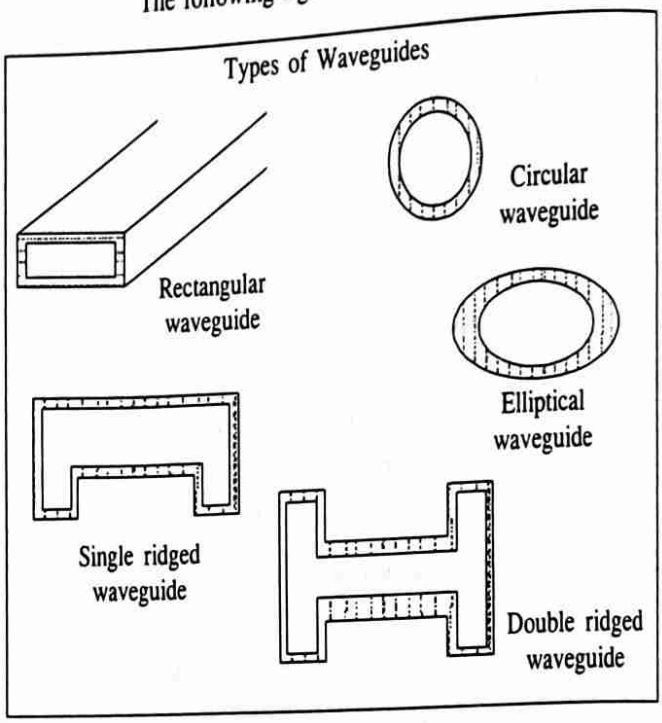
- Waveguides are easy to manufacture
- They can handle very large power (in kilo watts)
- Power loss is very negligible in waveguides.
- They offer very low loss (low value of alpha-attenuation).
- When microwave energy travels through waveguide, it experiences lower losses than a coaxial cable.

2.3.2 Types of Waveguides :

There are five types of waveguides :

- Rectangular waveguide
- Circular waveguide
- Elliptical waveguide
- Single-ridged waveguide
- Double-ridged waveguide

The following figure show the types of waveguides:



The types of waveguides shown above are hollow in the center and made up of copper walls. These have a thin lining of Au or Ag on the inner surface.

Practical Experiment 2.1

Conduct an Experiment to Connect PC to Internet through Bluetooth Access Point of Mobile and Transfer a Text File / Image File / Video File

Aim :

To connect PC to internet through bluetooth access point of mobile and transfer a text file/image file/video file.

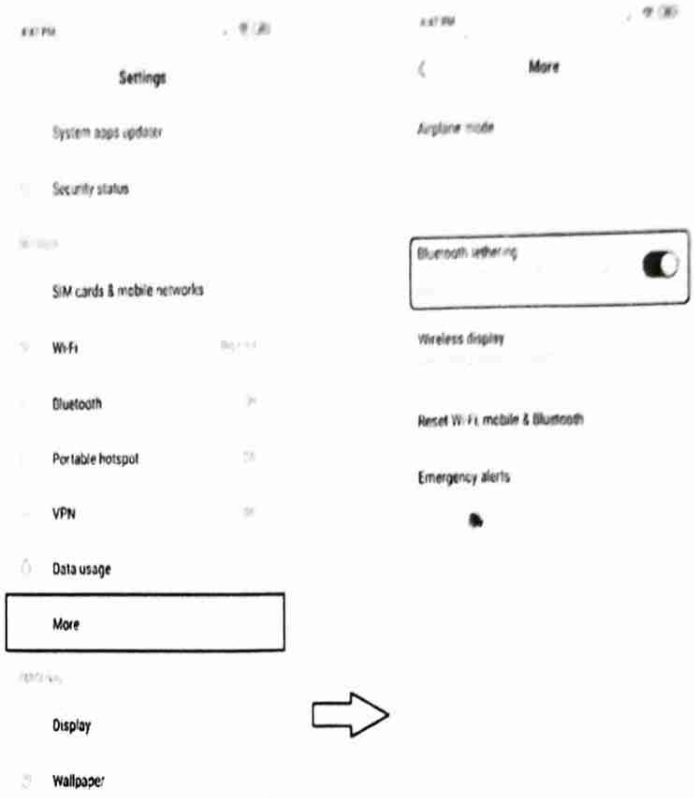
Apparatus Required :

1) An Android Mobile Phone with data pack (Internet access) with Android 4.0 and above version.
2) PC/Laptop with Bluetooth support or USB Bluetooth with a driver.

Procedure :

A] To connect PC to internet through Bluetooth access point of mobile :

Step 1 : Go to the main settings in your mobile smartphone and turn on the data pack. In settings find Bluetooth (more) → Bluetooth tethering.



Step 2 : Turn on the Bluetooth tethering in your smartphone.

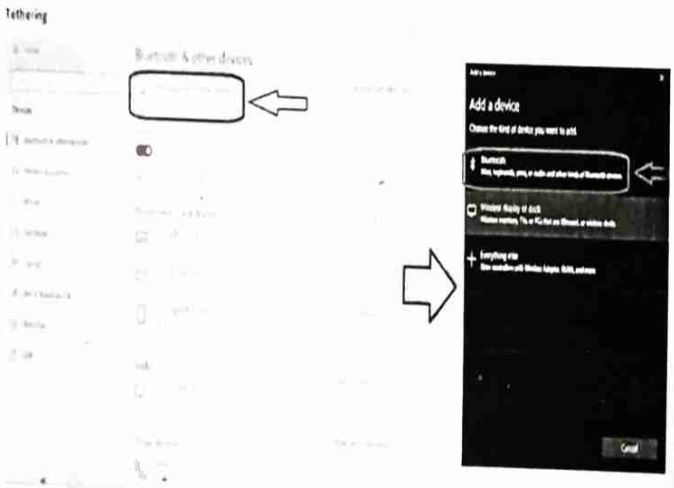
Step 3 : Make sure your PC computer has Bluetooth support. Or connect a USB Bluetooth device to PC and install the supporting driver software.

Step 4 : In your computer, go to the bottom-right corner and look for Bluetooth icon and Right-click and select "add a Bluetooth device".

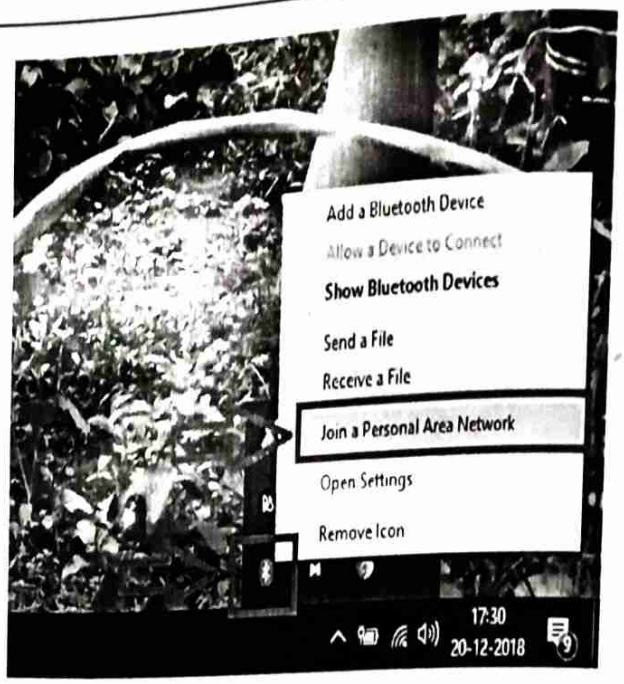
Or

Got to start, search for Bluetooth icon and select "add a Bluetooth device".

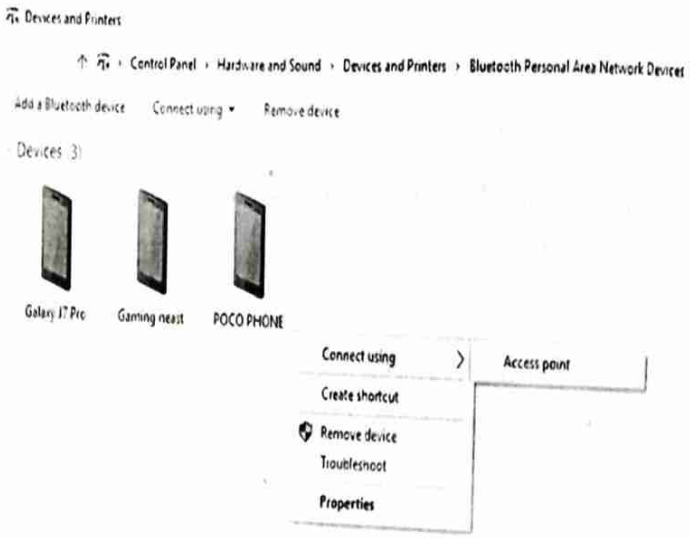
Step 5 : In Bluetooth & other devices, select Add Bluetooth or other devices then select Bluetooth. Now pair your smartphone with windows, accepts it in your PC as well as in smartphone.



Step 6 : Once paired go back to Bluetooth icon in the bottom and select "join Personal Area Network".



Step 7 : Now look for your device and right-click on it then select "connect using" option and select "Access point".



Step 8 : Open the web browser and access the internet in PC.

Procedure :

B] To transfer a text file/image file/video file between PC and Mobile through Bluetooth :

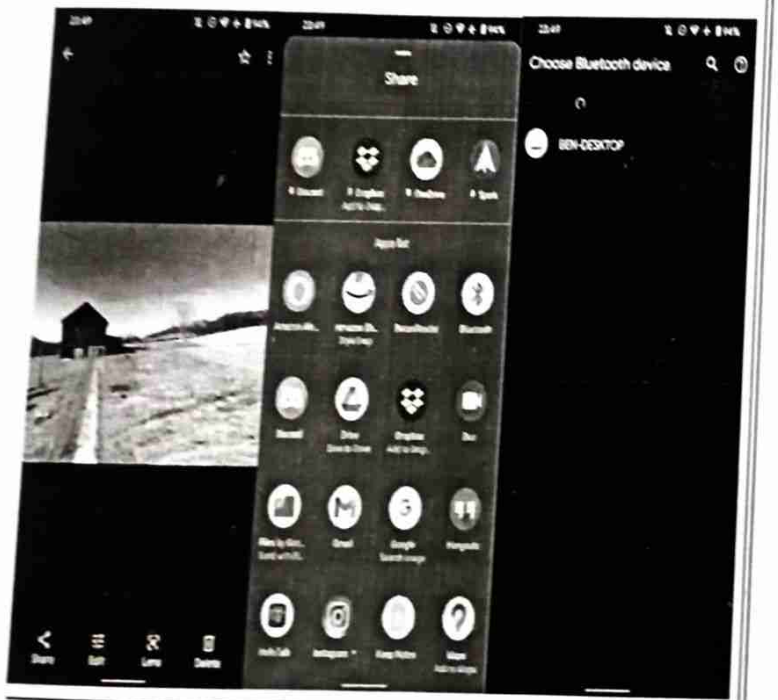
i) Transfer from Phone to PC :

Step 1 : To transfer from your phone, select a text file/ image file/video file whatever app you're using, and choose the option to share it icon.

Step 2 : You see the list of apps you can share with, look and select for the **"Bluetooth".**

Step 3 : Then select your PC as the destination device.

Step 4 : Windows will then request confirmation and start downloading the file. You may be allowed to choose the save location, or it might save to a standard **Downloads** folder.

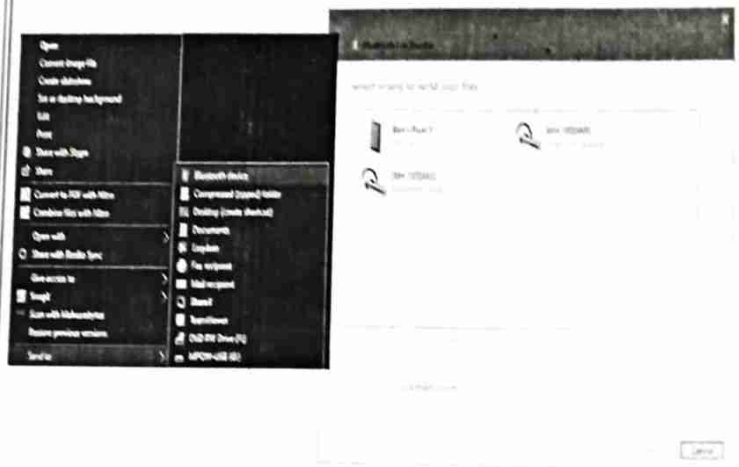


ii) Transfer from PC to Phone :

Step 1 : When transferring a file from your PC to your phone, simply open File Explorer and right-click on the file you want to transfer. Select **Send to → Bluetooth device.**

Step 2 : This will open a new window where you can select the device you want to send to.

Step 3 : Your phone may ask your approval. Once you confirm, the file will transfer over Bluetooth.



Step 4 : You can transfer multiple files in either direction. Just select them all at once and follow the above steps.

Result :

An experiment is conducted and verified to connect PC to internet through Bluetooth access point of mobile and transfer a text file/image file/video file is done.

Practical Experiment 2.2

Interface RFID Reader for an Application using Arduino Controller

Aim/Objective :

Interface RFID Reader for an application using Arduino controller.

Software's Required :

i) Proteus 8 Professional Software

ii) Árduino IDE 1.8.19

Procedure :

- Double click on Proteus 8 icon or Right click on proteus 8 icon → open.
- Click on "New Project" → Give the name for project and path to store the folder. Tick on 'New Project' and click next.
- Tick on "Create a schematic from the selected template". Select "Portrait A4" and click next.
- Tick "DO not create a PCB Layout" and click next.
- Tick "No Firmware project" and click next → Finish.
- Click on a "File" → "New Design" → File → Save Design As → Give name for schematic file.
- Double click on 'P' and then Browse the required components by typing the Components name.

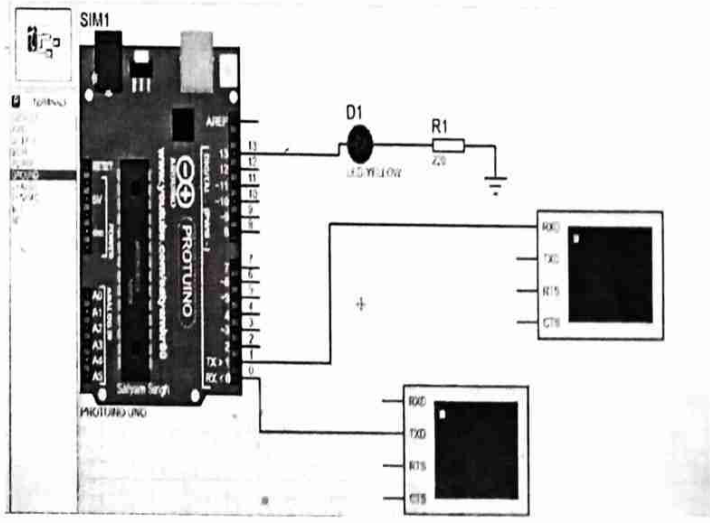
- First Check for Ardino UNO Controller in your Proteus 8 Software if not ***Download Arduino UNO Library Files*** from internet and then add to Proteus Library files to it on library that is ***Localdisk(C)/ Programfiles(x86)/LabcenterElectronics/Proteus8 Professional/Library*** then Paste Libray Files to it.
- Choose or Place Required Components such as Arduino UNO, Animated YELLOW LED & Resistor by double click on 'P' and then Browse the required components by typing the Components name.
- Go to terminals icon → Choose ground.
- Drag all components to Editor window and place the components as per circuit diagram.
- Double click and edit the values of components according to requirements.
- Rig up the circuit using wire and connect all the components as per the circuit diagram.
- Now Click on terminal mode & Select "Virtual Terminal" & Use one terminal as a RFID Reader (Input) & Second Terminal one for Serial Output.
- Connect 1st Terminal TXD to RX of Arduino & Here this terminal is working as EM18 RFID Reader (UART Communication).
- Connect Another Terminal RXD to TX of Arduino & to Show output on detection of valid or Invalid Card/ TAG.

- LED will Glow Only on Detection of Valid Tag ID, Set Resistor Value to 220 Ohm.
- Now Download and install Arduino IDE 1.8.19 on your system and write the code.
- To generate Hex File on Arduino IDE 1.8.19 go to file and choose preferences and then select or tick Compilation tab and then Press ok.
- Now Compile Arduino Code & Copy HEX File Location then Paste it in Proteus inside Arduino Properties.
- For That Double click on Arduino Controller go to Properties and then paste the Hex file Location Link in to it and then press ok.
- As you know we are not using Physical RFID Module, so we will Pass Tag ID through Terminal you can Write Down these TAG Detects on Any Notepad Files.
- Copy any One of the TAG ID and Paste it in First Terminal While Simulation is running.
- As you can See, On the Detection of "INVALID TAG" Printed on Second Terminal.
- Now Copy & Paste Valid TAG ID on detection of valid TAG Will Print "VALID TAG" & YELLOW LED will glow.
- Click on 'Debug' icon and click on 'Run' to run the simulation or press F12.

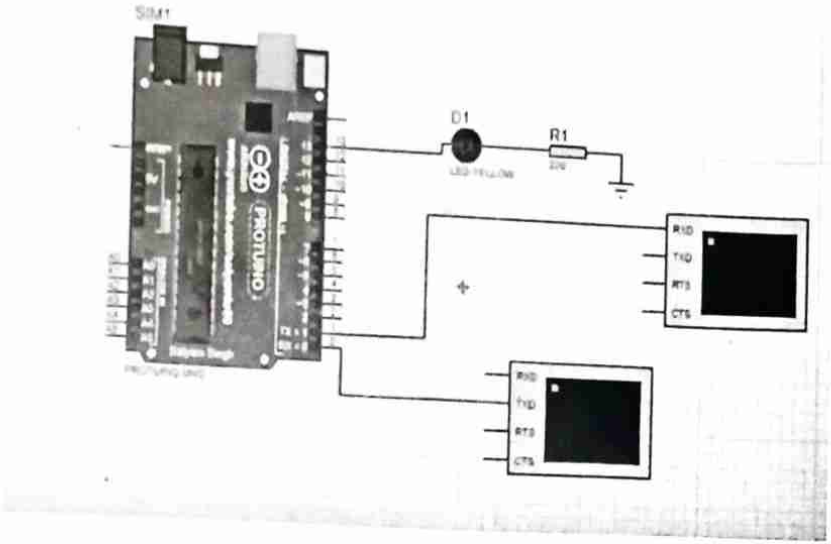
- Copy & Paste RFID NUMBER ON VIRTUAL TERMINAL Input as AB123456779A.
- View the Output as "Invalid Tag" on Virtual Terminal 2.
- Copy and Paste RFID Number on Virtual Terminal INPUT as AB123456789A.
- View the Output as "Valid Tag" on Virtual Terminal 2 and "YELLOW LED" will Glow (ON).
- To stop the simulation press ESC key.
- By using this interface you can Design your own Attendance System, Automatic Gate Control Projects etc.

Procedural Steps illustration using Screen Shots :

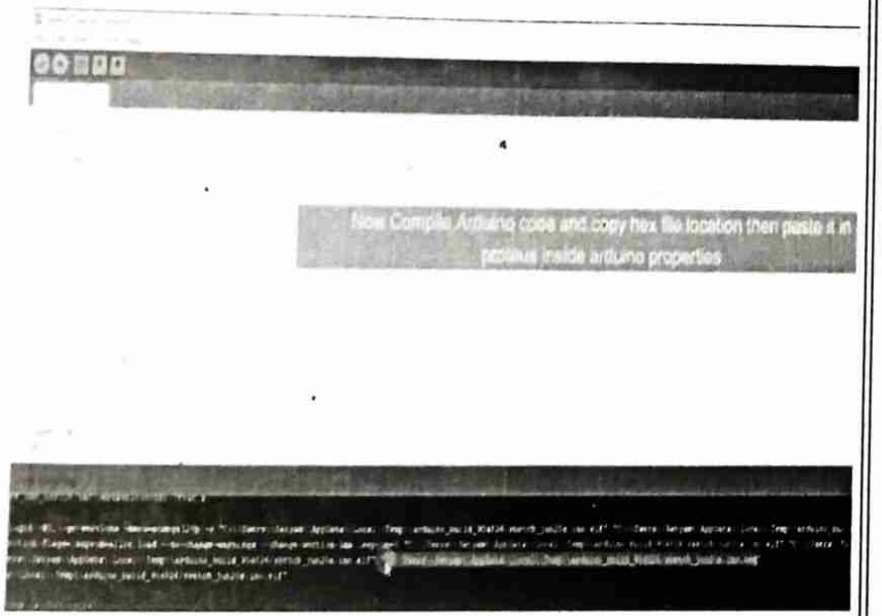
Step 1 : Circuit Diagram/Model Connection RFID INTERFACE.



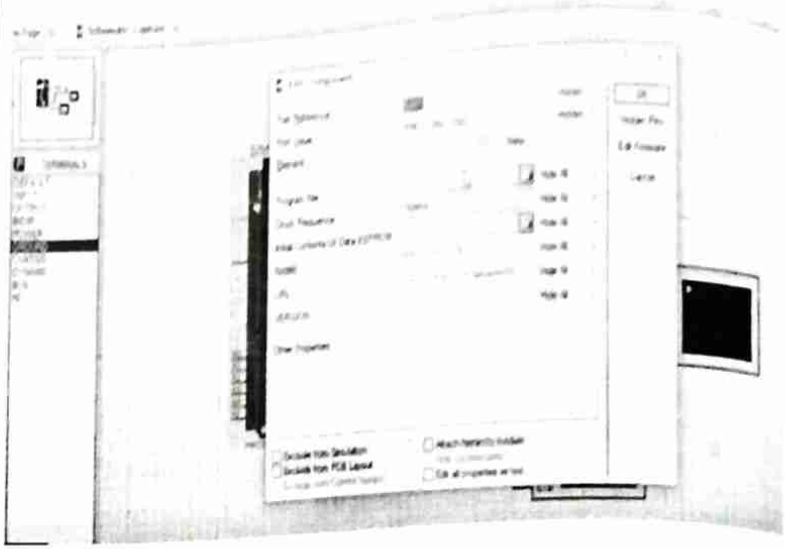
Step 2 : Connection Virtual Terminal for RFID READER/ OUTPUT.



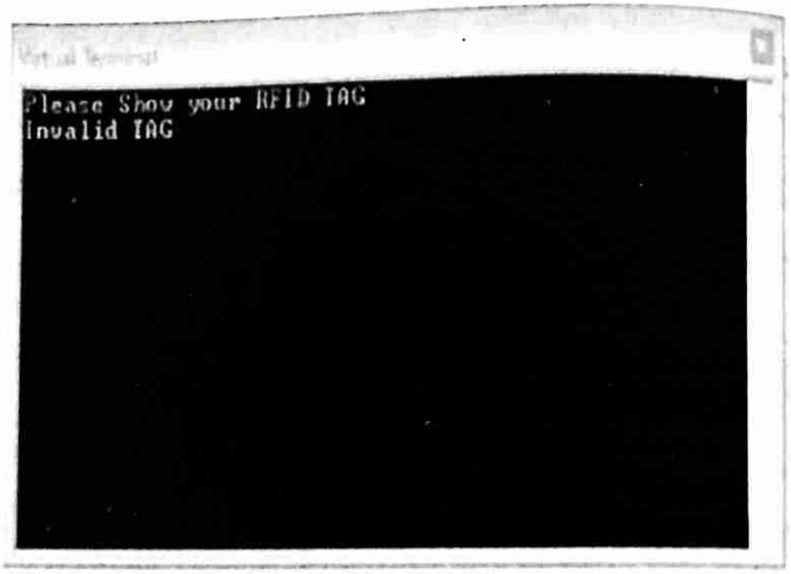
Step 3 : Compile Code on Arduino IDE And Copy Hex File Location.



Step 4 : Then Paste Hex files in to Proteus inside Arduino Controller Properties.

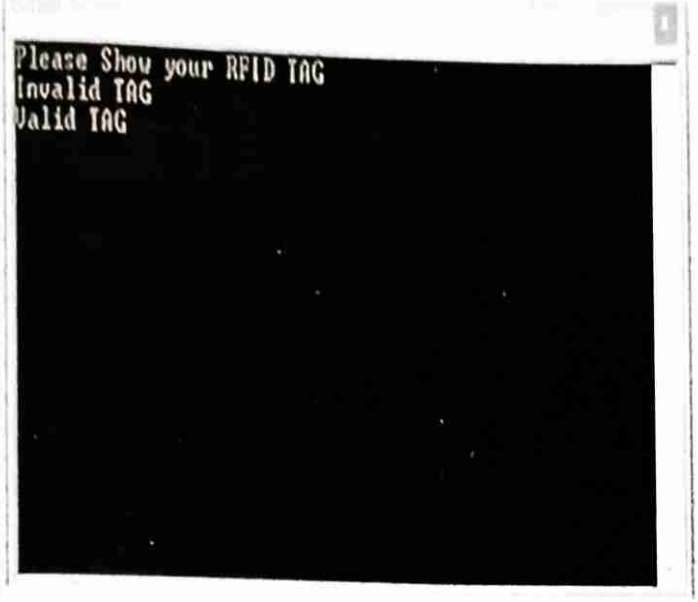


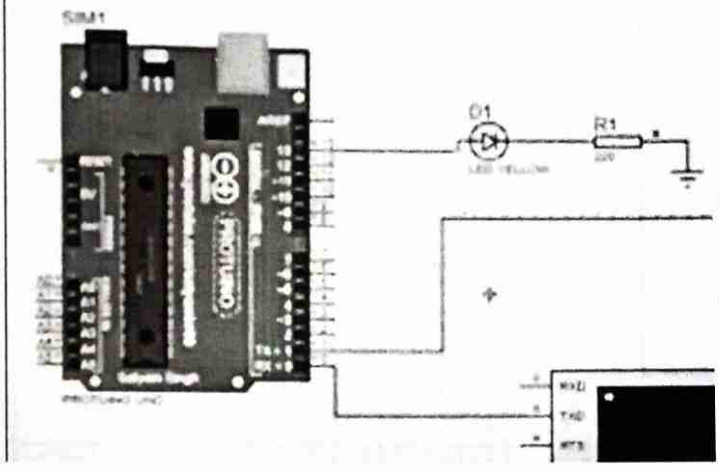
Step 5 : Copy and Paste RFID NUMBER ON INPUT VIRTUAL TERMINAL asAB123456779A.



View the Output as "Invalid Tag" on Virtual Terminal 2.

Step 6 : Copy and Paste RFID Number On INPUT Virtual Terminal as AB123456789A.





View the Output as "Valid Tag" on Virtual Terminal 2 and "YELLOW LED" Will Turn on.

Arduino Code :

```
int count = 0;
char c;
String id;

void setup() {
Serial.begin(9600);
pinMode(13, OUTPUT);
Serial.println("Please scan your RFID TAG");
}
void loop() {
while(Serial.available()>0)
  {
    c = Serial.read();
count++;
id += c;
if(count == 12)
    {
Serial.print(id);
    //break;
if(id=="AB123456789A")
      {
Serial.println("Valid TAG");
digitalWrite(13, HIGH);
      }
else
```

```
        {
digitalWrite(13, LOW);
Serial.println("Invalid TAG");
        }
      }
    }
count = 0;
id="";
```

Result :

Interface RFID Reader for an application using Arduino controller is studied and verified.

Week

3

Week 3

Theory

Practical Experiment

3.1 Video demonstration & documentation on working of
a) Two cavity klystron
b) Reflex klystron

3.2 Video demonstration & documentation on working of
a) Magnetron
b) TWT

3.1 Microwave Signal :

Microwaves refer to the electromagnetic rays with frequencies between 300MHz and 300GHz in the electromagnetic spectrum. Microwaves are small when compared with the waves used in radio broadcasting. Their range is in between the radio waves and infrared waves. Microwaves travel in straight lines and they will be affected lightly by the troposphere. They don't require any medium to travel. Metals will reflect these waves totally. Non-metals such as glass and particles are partially transparent to these waves.

Microwave Frequency Bands :

Microwave signals are often divided into three categories :

- Ultra high frequency (UHF) (0.3 (300 MHz) - 3 GHz)
- Super high frequency (SHF) (3 - 30 GHz); and
- Extremely high frequency (EHF) (30 - 300 GHz)

3.2 Microwave Devices :

Of all the waves found in the electromagnetic spectrum, Microwaves are a special type of electromagnetic radiation that is used in many ways, from cooking simple popcorn to studying the nearby galaxies. Most households these days have a microwave, a device that uses microwave signals to cook food rapidly and efficiently.

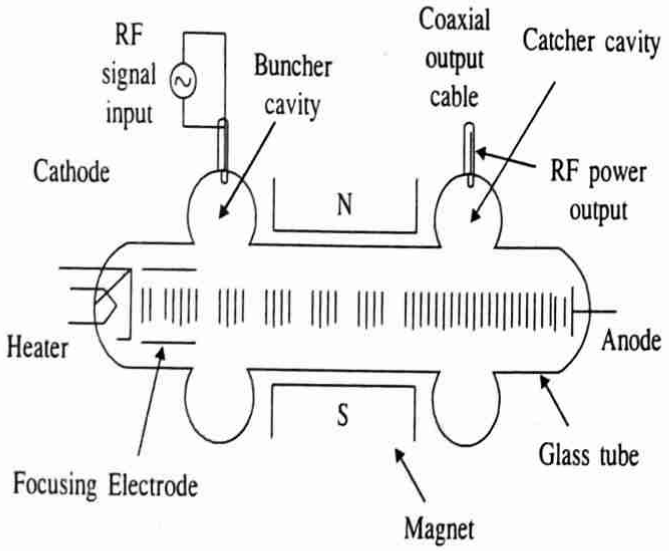
For the generation and amplification of Microwaves, there is a need of some special tubes called as Microwave tubes such as Cavity Klystron, Reflex Klystron, Magnetron, TWT etc.

3.2.1 Two Cavity Klystron :

The essential elements of Klystron are electron beams and cavity resonators. Electron beams are produced from a source and the cavity klystrons are employed to amplify the signals. A collector is present at the end to collect the electrons.

Construction :

As shown in the given diagram. The multi cavity or two cavity klystron consist of a glass envelope in which there is an electron gun composed of heater and cathode.



After the electron gun there are two focusing electrodes used to keep the electron beam in the center around the glass envelope. There are two cavities known as buncher and catcher cavity. Between the cavities around the glass envelope a magnet is used in order to keep the electron beam in the center and in concentrated form at the end inside the glass envelope. There is anode used to attract the electrons emitted from the cathode.

Working :

When switch on the circuit, the electrons starts emitting from the cathode. These electrons move at a uniform speed towards the anode until they are attracted by it. Now we apply the R.F input signal to the buncher cavity with the help of loop coupling. We suppose the negative half cycle of the input signal. When this negative half cycle is applied to the buncher cavity, the negative charges will develop and the speed of electron will be reduced between the cathode and cavity. As a result the bunch of electrons will be formed near the buncher cavity. Now this bunch will travel towards the anode. At the movement when the positive half cycle is applied, the speed of electrons will increase from the previous condition. These electrons will join the bunch produced by negative half cycle and the field strength of the field of the bunch will further increase.

In this manner bunches will continue to be form. When the R.F signal is present at the buncher cavity. When the bunch of electrons reaches in front of catcher cavity, due to its strong field strength the excitation of this cavity will take place and we will get an amplified output from the catcher cavity.

Application :

Some of the applications of two cavity klystrons are as follows :

- UHF TV Transmitter
- Long range radar
- Linear particle accelerator
- Tropo-scatter links
- Earth Station Transmittor.

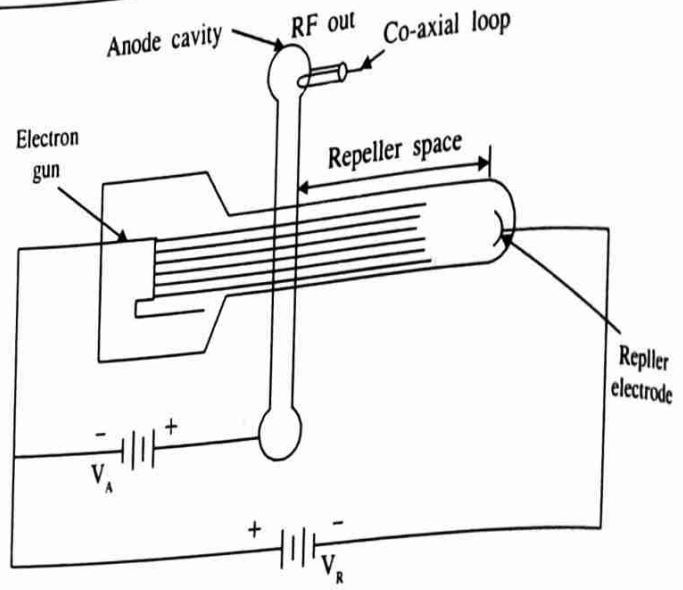
3.2.2 Reflex Klystron :

This microwave generator, is a Klystron that works on reflections and oscillations in a single cavity, which has a variable frequency.

Construction and Working :

Reflex Klystron consists of an electron gun, a cathode filament, an anode cavity, and an electrode at the cathode potential. It provides low power and has low efficiency.

The electron gun emits the electron beam, which passes through the gap in the anode cavity. These electrons travel towards the Repeller electrode, which is at high negative potential. Due to the high negative field, the electrons repel back to the anode cavity. In their return journey, the electrons give more energy to the gap and these oscillations are sustained. The constructional details of this reflex klystron is as shown in the following figure.



Constructional details of Reflex Klystron

It is assumed that oscillations already exist in the tube and they are sustained by its operation. The electrons while passing through the anode cavity, gain some velocity.

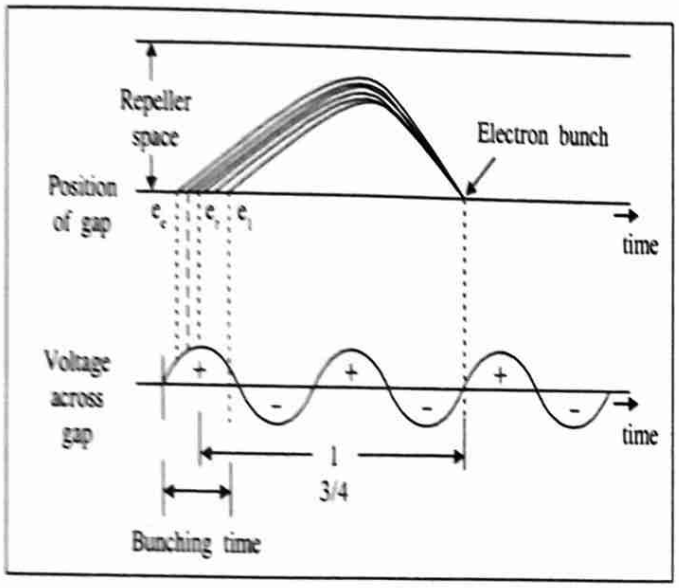
Operation of Reflex Klystron Illustration :

The operation of Reflex Klystron is understood by some assumptions. The electron beam is accelerated towards the anode cavity.

Let us assume that a reference electron e_r crosses the anode cavity but has no extra velocity and it repels back after reaching the Repeller electrode, with the same velocity. Another electron, let's say e_e which has started earlier than this reference electron, reaches the Repeller first, but returns slowly, reaching at the same time as the reference electron.

We have another electron, the late electron e_l, which starts later than both e_r and e_c, however, it moves with greater velocity while returning back, reaching at the same time as e_r and e_c.

Now, these three electrons, namely e_r, e_c and e_l reach the gap at the same time, forming an electron bunch. This travel time is called as transit time, which should have an optimum value. The following figure illustrates this -



Applications :

Reflex Klystron is used in applications where variable frequency is desirable, such as :

- Radio receivers
- Portable microwave links
- Parametric amplifiers

- Local oscillators of microwave receivers
- As a signal source where variable frequency is desirable in microwave generators.

3.2.3 Magnetron :

Magnetrons are the cross-field tubes in which the electric and magnetic fields cross, i.e. run perpendicular to each other.

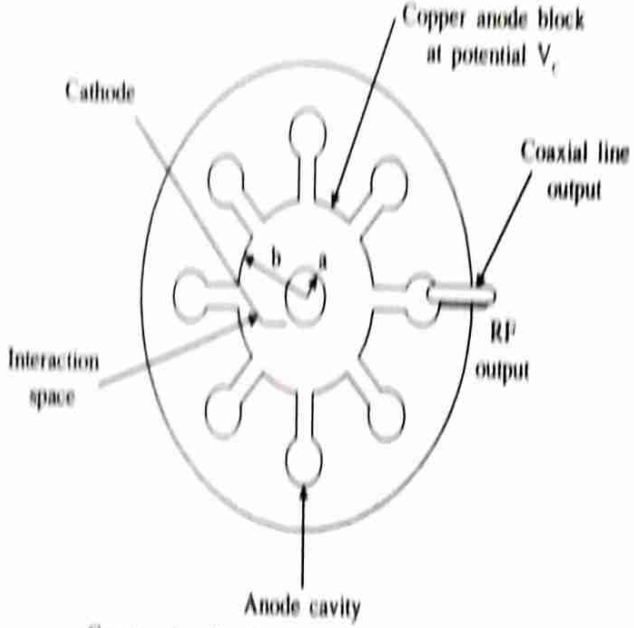
The Magnetron is called as Cavity Magnetron because the anode is made into resonant cavities and a permanent magnet is used to produce a strong magnetic field, where the action of both of these make the device work.

Construction and Working :

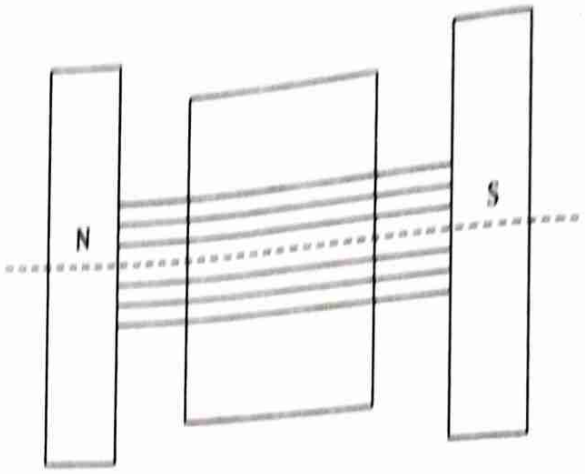
A thick cylindrical cathode is present at the center and a cylindrical block of copper, is fixed axially, which acts as an anode. This anode block is made of a number of slots that acts as resonant anode cavities.

The space present between the anode and cathode is called as Interaction space. The electric field is present radially while the magnetic field is present axially in the cavity magnetron. This magnetic field is produced by a permanent magnet, which is placed such that the magnetic lines are parallel to cathode and perpendicular to the electric field present between the anode and the cathode.

The following figures show the constructional details of a cavity magnetron and the magnetic lines of flux present, axially.



Construction details of a cavity magnetron



Magnetic flux lines in magnetron (axial)

Operation of Cavity Magnetron with Active RF Field Illustration :

Let us assume that initial RF oscillations are present, due to some noise transient. The oscillations are sustained by the operation of the device. There are three kinds of electrons emitted in this process, whose actions are understood as electrons **a**, **b** and **c**, in three different cases.

Case 1 : When oscillations are present, an electron **a**, slows down transferring energy to oscillate. Such electrons that transfer their energy to the oscillations are called as **favored electrons**. These electrons are responsible for **bunching effect**.

Case 2 : In this case, another electron, say **b**, takes energy from the oscillations and increases its velocity. As and when this is done -

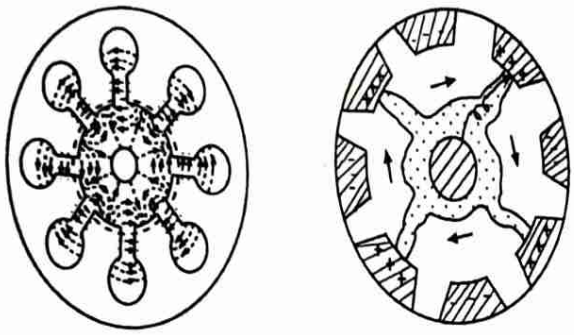
- It bends more sharply.
- It spends little time in interaction space.
- It returns to the cathode.

These electrons are called **as unfavoured electrons**. They don't participate in the bunching effect. Also, these electrons are harmful as they cause "back heating".

Case 3 : In this case, electron **c**, which is emitted a little later, moves faster. It tries to catch up with electron **a**. The next emitted electron **d**, tries to step with **a**. As a result,

the favored electrons **a, c** and **d** form electron bunches or electron clouds. It called as "Phase focusing effect".

This whole process is understood better by taking a look at the following figure.



(A) (B)

Figure A shows the electron movements in different cases while figure B shows the electron clouds formed. These electron clouds occur while the device is in operation. The charges present on the internal surface of these anode segments, follow the oscillations in the cavities. This creates an electric field rotating clockwise, which can be actually seen while performing a practical experiment.

While the electric field is rotating, the magnetic flux lines are formed in parallel to the cathode, under whose combined effect, the electron bunches are formed with four spokes, directed in regular intervals, to the nearest positive anode segment, in spiral trajectories.

Applications :

The main applications of magnetron are as follows :

- Sweep oscillators

- Telemetry
- Missile applications
- Industrial heating
- Micro-ovens.

3.2.4 Travelling Wave Tube (TWT) :

Travelling wave tubes are broadband microwave devices which have no cavity resonators like Klystrons. Amplification is done through the prolonged interaction between an electron beam and Radio Frequency (RF) field.

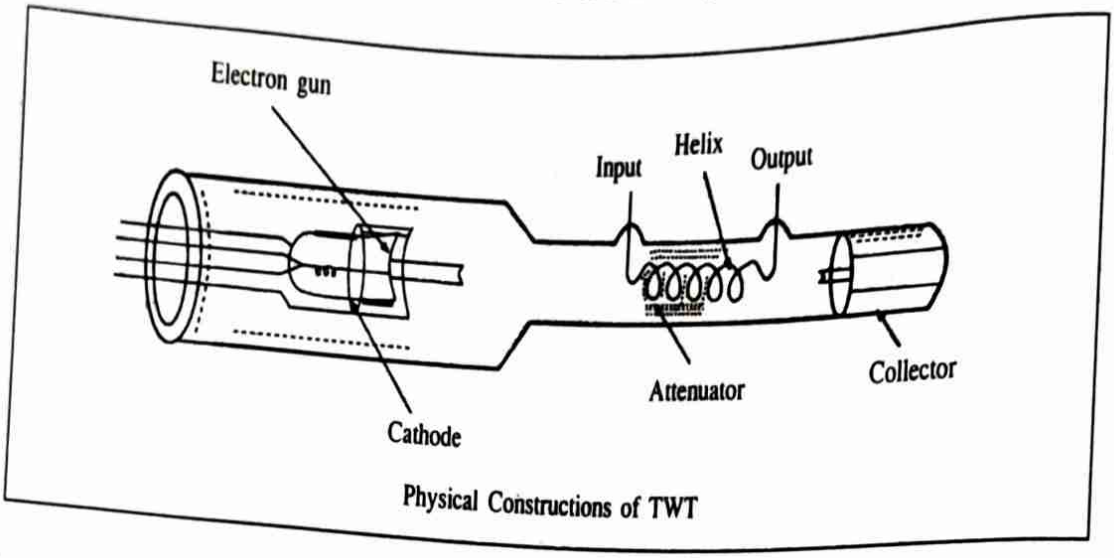
Construction and Working :

Travelling wave tube is a cylindrical structure which contains an electron gun from a cathode tube. It has anode plates, helix and a collector. RF input is sent to one end of the helix and the output is drawn from the other end of the helix.

An electron gun focuses an electron beam with the velocity of light. A magnetic field guides the beam to focus, without scattering. The RF field also propagates with the velocity of light which is retarded by a helix. Helix acts as a slow wave structure. Applied RF field propagated in helix, produces an electric field at the center of the helix.

The resultant electric field due to applied RF signal, travels with the velocity of light multiplied by the ratio of helix pitch to helix circumference. The velocity of electron beam, travelling through the helix, induces energy to the RF waves on the helix.

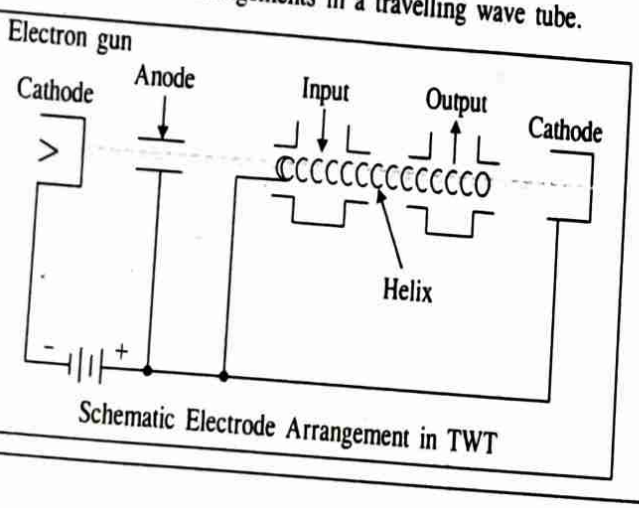
The following figure explains the constructional features of a travelling wave tube.



Physical Constructions of TWT

Thus, the amplified output is obtained at the output of TWT.

In TWT, the electron gun focuses the electron beam, in the gap between the anode plates, to the helix, which is then collected at the collector. The following figure explains the electrode arrangements in a travelling wave tube.



Schematic Electrode Arrangement in TWT

Operation of Travelling Wave Tube Illustration :

The anode plates, when at zero potential, which means when the axial electric field is at a node, the electron beam velocity remains unaffected. When the wave on the axial electric field is at positive antinode, the electron from the electron beam moves in the opposite direction. This electron being accelerated, tries to catch up with the late electron, which encounters the node of the RF axial field.

At the point, where the RF axial field is at negative antinode, the electron referred earlier, tries to overtake due to the negative field effect. The electrons receive modulated velocity. As a cumulative result, a second wave is induced in the helix. The output becomes larger than the input and results in amplification.

Applications of Travelling Wave Tube :

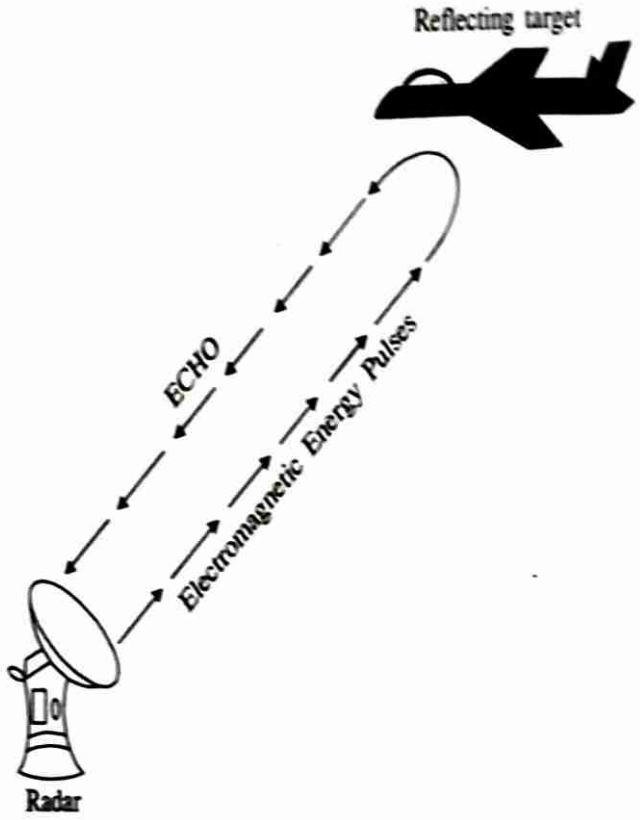
There are many applications of a travelling wave tube. Few of them are as below :

- TWT is used in microwave receivers as a low noise RF amplifier.
- TWTs are also used in wide-band communication links and co-axial cables as repeater amplifiers or intermediate amplifiers to amplify low signals.
- TWTs have a long tube life, due to which they are used as power output tubes in communication satellites.
- Continuous wave high power TWTs are used in Troposcatter links, because of large power and large bandwidths, to scatter to large distances.
- TWTs are used in high power pulsed radars and ground based radars.

3.3 Radar :

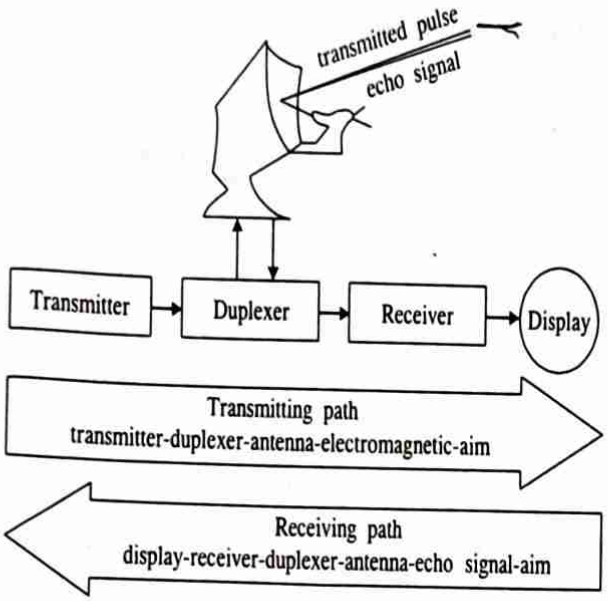
Radar is an acronym for "RAadio Detection And Ranging." A radar system usually operates in the ultra-high-frequency (UHF) or microwave part of the radio-frequency (RF) spectrum, and is used to detect the position and/or movement of objects.

3.3.1 Principle of Operation :



The basic principle of the radar is shown in the figure above. A transmitter generates an electromagnetic signal that is radiated by the antenna into space. A portion of the transmitted electromagnetic energy is reflected back by the target towards the radar. Based on the received target echo signal the receiver made decision for the position, range and direction of the target.

The basic block diagram of RADAR system is shown in the below figure :



Transmitter : The radar transmitter produces the short duration high-power RF pulses of energy that are into space by the antenna.

Duplexer : The duplexer alternately switches the antenna between the transmitter and receiver so that only one antenna need be used. This switching is necessary because the high-power pulses of the transmitter would destroy the receiver if energy were allowed to enter the receiver.

Receiver : The receivers amplify and demodulate the received RF-signals. The receiver provides video signals on the output.

Radar Antenna : The Antenna transfers the transmitter energy to signals in space with the required distribution and efficiency. This process is applied in an identical way on reception.

Indicator : The indicator should present to the observer a continuous, easily understandable, graphic picture of the relative position of radar targets.

3.3.2 Applications of Radar :

The main applications of Radar are :

- Radar systems are widely used in air-traffic control, aircraft navigation, and marine navigation.
  - For example in aviation, aircraft are equipped with radar devices that warn of aircraft or other obstacles in or approaching their path, display weather information, and give accurate altitude readings.
  - Marine radars are used to measure the bearing and distance of ships to prevent collision with other ships, to navigate, and to fix their position at sea when within range of shore or other fixed references such as islands, buoys, and lightships.
- In port or in harbour, vessel traffic service radar systems are used to monitor and regulate ship movements in busy waters.
- High-power radar, using large dish antennas, has been used to measure distances to the moon, other planets, asteroids, and artificial satellites.
- From unmanned space probes, radar has been used to map Venus, whose surface is obscured at visible wave lengths by a thick layer of clouds.

- Radar has been employed by NASA (the U.S. National Aeronautics and Space Administration) to make highly detailed topographical maps of the earth's surface as well.
- Normal radar functions :
  - Range (from pulse delay)
  - Velocity (from Doppler frequency shift)
  - Angular direction (from antenna pointing).

Practical Experiment 3.1

Note : Browse the below sample video links for the given experiment demonstration. The links shown here are sample illustrative only. Users can search such similar videos.

Video Demonstration & Documentation on Working of

a) **Two cavity klystron**

b) **Reflex klystron**

a) **Sample Video Link on Two cavity klystron**

https://youtu.be/yPpreB0_6cA

https://youtu.be/yeUsIKEKYIY

b) **Sample Video Link on Reflex klystron**

https://youtu.be/3MFHFuddLZI

https://youtu.be/XHnnbVpkfU8

Observation/Result :

After watching the above sample demonstration videos or any such similar videos, write a brief note/ summary document in your own sentences about what you understand from the video.

Practical Experiment 3.2

Video Demonstration & Documentation on Working of

a) Magnetron

b) TWT

a) **Sample Video Link on Magnetron**

https://youtu.be/gnPVPfVmFwE

https://youtu.be/HoMnyZIW-q4

b) **Sample Video Link on TWT**

https://youtu.be/s1MJK_HR-v4

https://youtu.be/I-DlgOoz978

Observation/Result :

After watching the above sample demonstration videos or any such similar videos, write a brief note/ summary document in your own sentences about what you understand from the video.

Week

4

Week 4

Theory

Practical Experiment

4.1 Study and Measure the Characteristics of Pulse from Signal generator using CRO

4.2 Conduct an Experiment to use a Smart Phone as CCTV Camera and Connect it to Another Mobile to View the Camera Feed

4.1 Radar Range Equation :

The radar range relates the radar range with the characteristics of transmitter, receiver antenna, target and environment. The radar range equation is useful to understand the maximum range of the radar that can be detected by the radar with their performance parameters. One of the simpler equations of radar theory is the radar range equation.

$$R_{max} = \left[\frac{P_t G}{4\pi} \cdot \frac{\sigma}{4\pi} \cdot \frac{A_e}{S_{min}}\right]^{1/4}$$

where, P_t = Transmitted power

G = Transmitted gain

A_3 = Effective area

S_{min} = Minimum deductable signal

This is the fundamental form of radar range equation. If the antenna is used for both the transmission and receiving purpose, then the transmitted gain (G) can be given in terms of the effective area (A_e).

$$R_{max} = \left[\frac{P_t G^2 \lambda}{(4\pi)^3} \cdot \sigma \cdot \frac{A_e}{S_{min}}\right]^{1/4} \text{ (When G is constant)}$$

$$R_{max} = \left[\frac{P_t}{(4\pi)^3} \cdot \sigma \cdot \frac{A_e^2}{S_{min}}\right]^{1/4} \text{ (When } A_e \text{ is constant)}$$

These three forms of radar range equations are based on the effective area (A_e) and transmitter antenna gain (G).

4.1.1 Factors Influencing the Radar Range :

The main factors that influence the radar range are as follows :

Frequency : The higher the frequency of a radar (radio) wave, the greater is the attenuation (loss in power), regardless of weather. Lower radar frequencies (longer wavelengths) have, therefore, been generally superior for longer detection ranges.

Peak Power : The peak power of a radar is its useful power. Range capabilities of the radar increase with peak power. Doubling the peak power increases the range capabilities by about 25 percent.

Pulse Length : The longer the pulse length, the greater is the range capability of the radar because of the greater amount of energy transmitted.

Pulse Repetition Rate : The pulse repetition rate (PRR) determines the maximum measurable range of the radar. Ample time must be allowed between pulses for an echo to return from any target located within the maximum workable range of the system. Otherwise, echoes returning from the more distant targets are blocked by succeeding transmitted pulses. This necessary time interval determines

the highest PRR that can be used. The PRR must be high enough, however, that sufficient pulses hit the target and enough echoes are returned to the radar. The maximum measurable range can be determined approximately by dividing 81,000 by the PRR.

Beam Width : The more concentrated the beam, the greater is the detection range of the radar.

Target Characteristics : Targets that are large can be seen on the scope at greater ranges, provided line-of-sight exists between the radar antenna and the target. Conducting materials (a ship's steel hull, for example) return relatively strong echoes while non-conducting materials (a wood hull of a fishing boat, for example) return much weaker echoes.

Receiver Sensitivity : The more sensitive receivers provide greater detection ranges but are more subject to jamming.

Antenna Rotation Rate : The more slowly the antenna rotates, the greater is the detection range of the radar. It is apparent that at the higher antenna rotation rates, the maximum ranges at which targets, particularly small targets, may be detected are reduced.

4.2 Pulsed Radar System : Principle and Block Diagram :

The operation of a typical pulse radar may be described with the aid of the block diagram shown in the below figure.

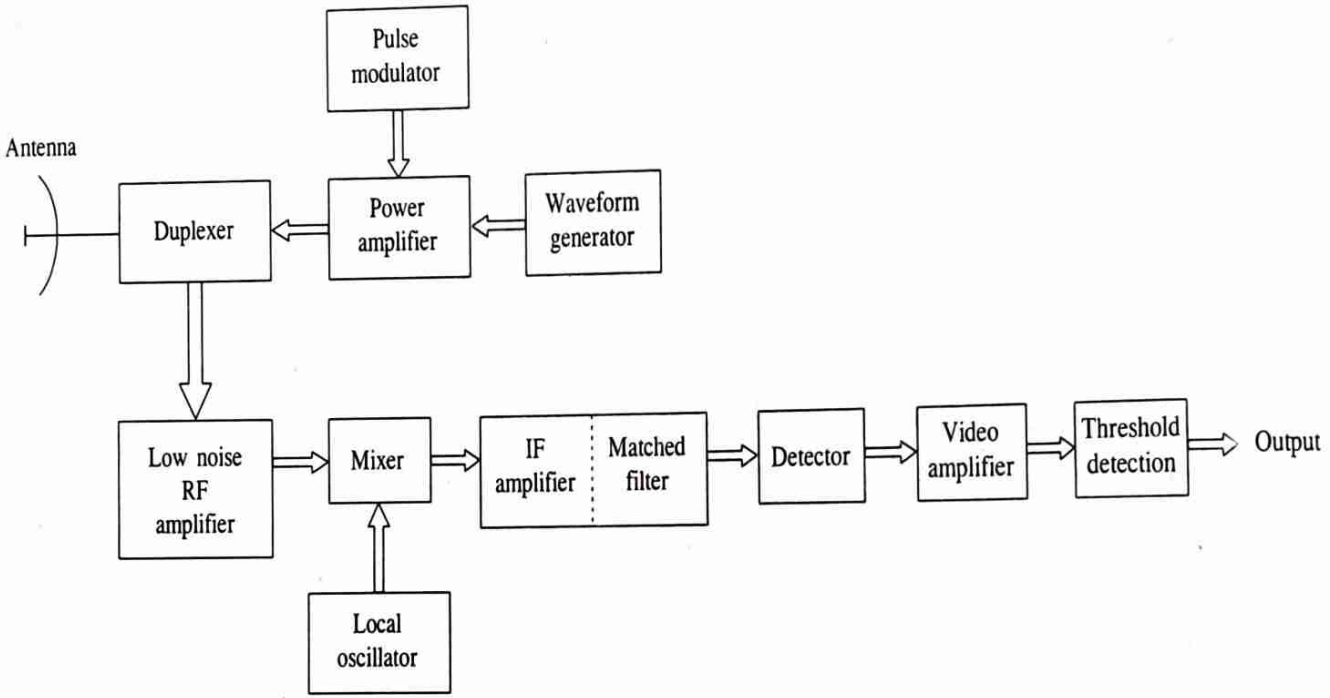


Fig. 4.1 : Block diagram of high power pulse radar

A low power signal is produced by the waveform generator which is given as an input to the power amplifier.

The power amplifier (Such as Klystron, TWT) produces a high power signal, may be in terms of mega-watts. Pulse modulator shown in the block is used as a switch, which will turn on and off the power amplifier.

For both transmission and receiving purpose we will use a single antenna. The operation is achieved by using a duplexer. Duplexer connects the antenna to the transmission section during the process of transmission of the signal. Then it isolates transmission section and connects to the receiver section during the reception of the signal. Antenna used here is usually a parabolic reflector type.

The receiver section is of super heterodyne type. As seen from the block diagram, the first block is a low-noise RF amplifier. Combination of mixer and local oscillator will convert RF signal to an intermediate frequency (IF).

The combination of IF amplifier and Matched filter stage will increase the output signal to noise ratio (S/N).

The output of IF amplifier is connected to a detector. Demodulation of the signal is done here. And then it is fed to video amplifier. The output of video amplifier is given to the threshold detector where it is decided whether the received signal is from a target or just because of the presence of noise. The output pulse is displayed on CRT (Cathode Ray Tube). Commonly used CRT display is PPI (Plan-Position Indicator). Even A-scope display can be used for the same.

4.3 Duplexers :

Duplexer is an electronic switch used whenever a single antenna is used for both transmitting and receiving in a radar. The simplest solution is to use a switch to transfer the antenna connection form the receiver to the transmitter during the transmitted pulse and back to the receiver during the return (echo) pulse.

A duplexer usually contains two switching tubes (spark gaps) connected in a microwave circuit with three terminal transmission lines, one each for the transmitter, receiver and antenna. These circuits may be connected in parallel or in series. One tube is called the TR tube (Transmit-Receiver Tube); the other is called the ATR (Anti-Transmit Receiver).

The TR tube has the primary function of disconnecting the receiver, and the ATR tube of disconnecting the transmitter.

TR and ATR tubes may contain radio active material. TR tubes are usually conventional spark gaps enclosed in

partially evacuated, sealed glass envelopes. The arc is formed as electrons are conducted through the ionized gas or vapor. An ATR tube might use a pure meet gas such as argon.

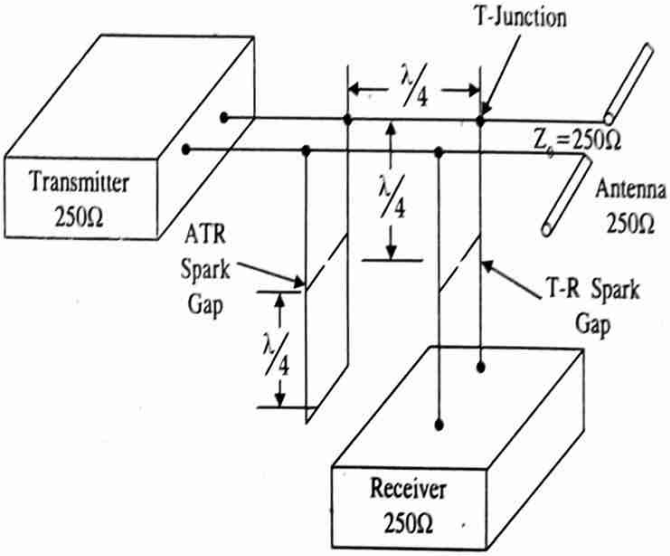


Fig. 4.2

Consider a Branched Type Duplexer system, as shown in fig. 4.2 The TR spark gap is located in the receiver coupling line one quarter wavelength from the T-junction. A half-wave length, closed-end section of transmission line, called a STUB is shunted across the main transmission line, An ATR spark gap is located in this line one-quarter wave-length from the main transmission line and one-quarter wave length from the closed end of the stub. As shown in the figure, antenna impedance, line impedance, and transmitter output impedance, where transmitting are all equal.

The action of the circuit during transmission is shown in figure 4.3.

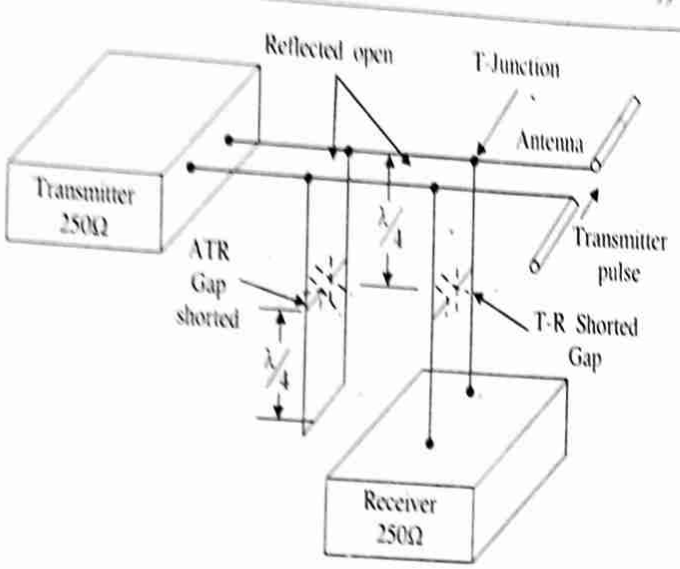


Fig. 4.3

During the transmission pulse, an arc appears across both spark gaps and causes the TR and ATR circuits to act

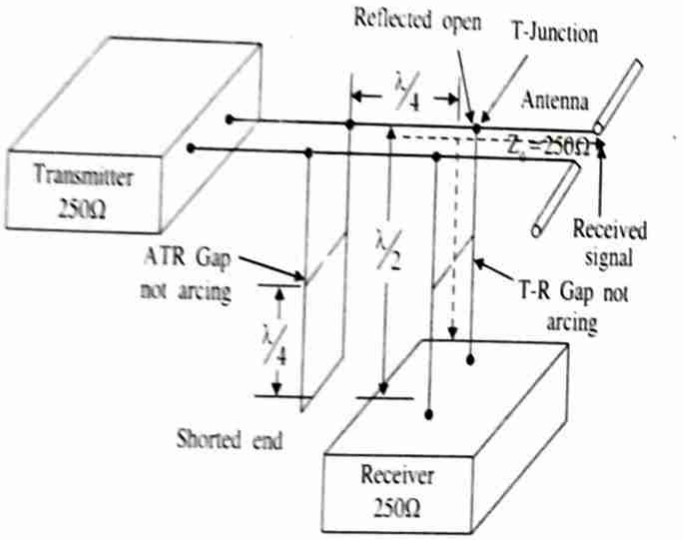


Fig. 4.4

as shown (closes-end) quarter -wave stubs. The circuits ther reflected open circuit to the TR and ATR circuit connections to the main transmission line. None of the transmitted energy can pass through these reflected opens into the ATR stub or into the receiver. Therefore, all of the transmitted energy is divided to the antenna.

During reception, as shown in figure, the amplitude of the received echo is not sufficient to cause an arc across either spark gap. Under this condition the ATR circuit now acts as a half-wave transmission line terminated in a short-circuit. This is reflected as an open circuit at the receiver T-junction, three -quarter wavelengths away. The received echosees an open circuit in the direction of the transmitter. However, the receiver input impedance is matched to the transmission line impedance. So that the entire received signal will go to the receiver with a minimum amount of loss.

4.4 Antenna Scanning and Tracking :

4.4.1 Antenna Scanning :

Radar antennas are often made to scan a given area of the surrounding space, but the actual scanning pattern depends on the application, some typical scanning patterns are shown in the figure.

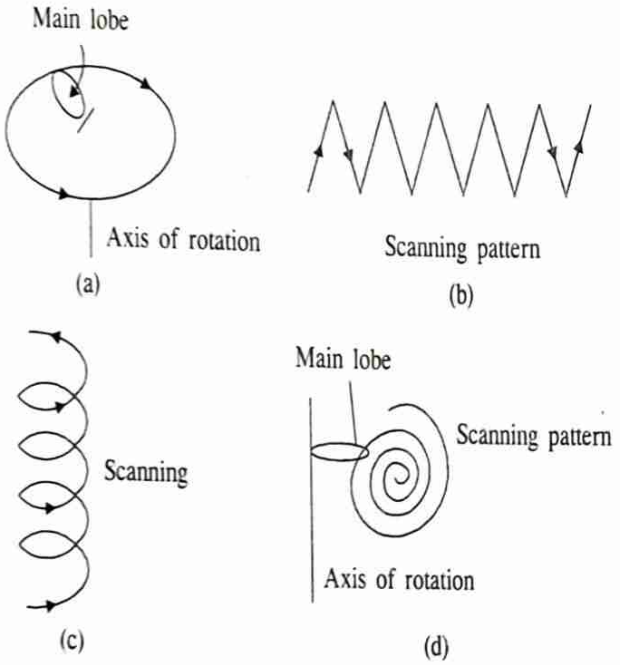


Figure representation antenna scanning patterns
a) Horizontal, b) nodding, c) helical, d) spiral

Fig. 4.5

The horizontal scanning shown in figure 4.5(a) is the simplest and scans only in horizontal plane. It has many applications in searching the horizon, e.g., in ship -to-ship radar.

The nodding scan of figure 4.5(b) is an extension of horizontal scan, the antenna is now rocked rapidly in elevation while it rotates more slowly in azimuth. Scanning in both planes is obtained. This type can be used to scan a limited sector or extended to cover the entire hemisphere.

The helical scanning in figure 4.5(c) is capable of search over the complete hemi-sphere. In this scanning the

elevation of the antenna is raised slowly while it rotate more rapidly in azimuth. The antenna is return to it starting point at the completion of the scanning cycle.

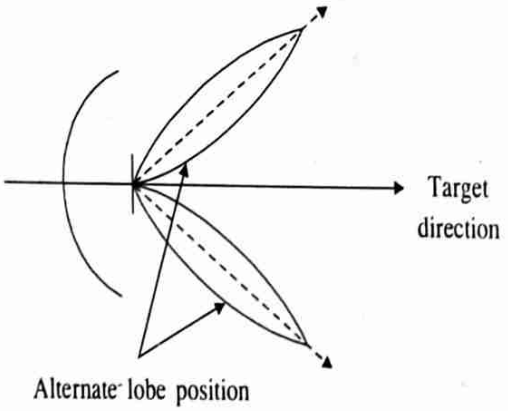
The spiral scan showing the figure 4.5(d) can be used, if a limited area of more or less circular shape is to be covered by the scan.

4.4.2 Antenna Tracking :

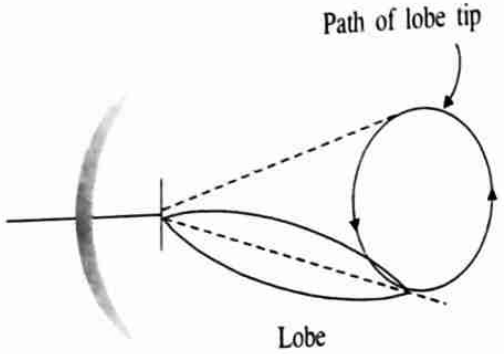
Once target is acquired through scanning method, it may then necessary to locate it very accurately in order to bring weapons upon it. Auxiliary methods of tracking are employed to locate target accurately. The following two methods are found often useful.

- Lobe-switching or sequential lobbing
- Conical scanning

The lobe-switching is the simplest technique and is shown in the figure 4.6(a).



(a)



(b)

Fig. 4.6

In this figure 4.6(a) the direction of the antenna beam is rapidly switched between two position as shown. So that the strength of the echo from the target will fluctuate at the switching rate. Unless the target is exactly midway between the two directions, when this happens, the echo strength will be the same for both antenna positions and then the target will have been tracked with much greater accurately than that obtained by merely pointing the antenna at it.

The conical scanning is a logical extension of lobe switching and is shown in the figure 4.6(b). It is achieved by mounting the parabolic antenna slightly off center and then rotating it about the axis of the parabola, the rotation is slow compared to PRF.

Practical Experiment 4.1

Study and Measure the Characteristics of Pulse from Signal generator using CRO

Aim :

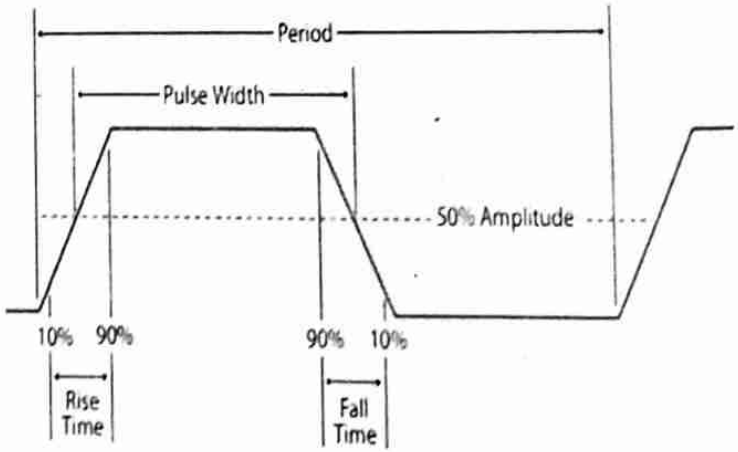
To study and measure the characteristics of pulse from signal generator using CRO.

Apparatus Required :

1. Function generator
2. CRO
3. CRO probes.

Theory :

A **pulse wave** or **pulse train** is a kind of non-sinusoidal waveform that includes square waves (duty cycle of 50%) and similarly periodic but asymmetrical waves (duty cycles other than 50%). Consider the waveform of a pulse



train where the pulse amplitude is positive. The voltage level of the top of the pulse with respect to the ground is the *pulse amplitude*. The first edge of the pulse at $t = 0$ (say) is called the *leading edge*, the rising edge or positive going edge. The second edge, at $t = T_1$, is called the *trailing edge*, the falling edge or the negative going edge.

The time interval from the leading or trailing edge of one pulse to the leading or trailing edge of the next pulse is the *time period T*. The reciprocal of the time period is the *pulse repetition frequency (PRF)*. The time interval from the leading edge to the trailing edge of a pulse is called the *pulse width*.

Circuit diagram :

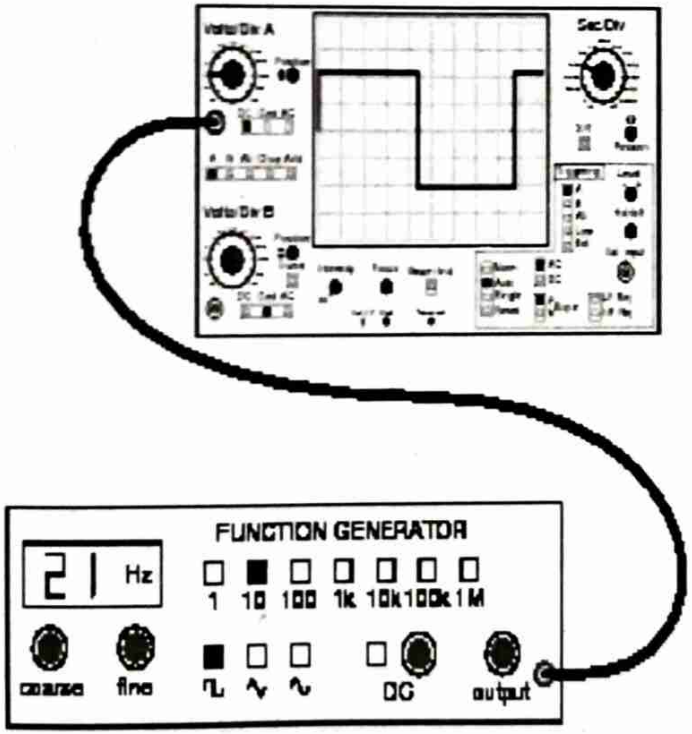


Fig. 4.8

Nature of Graph :

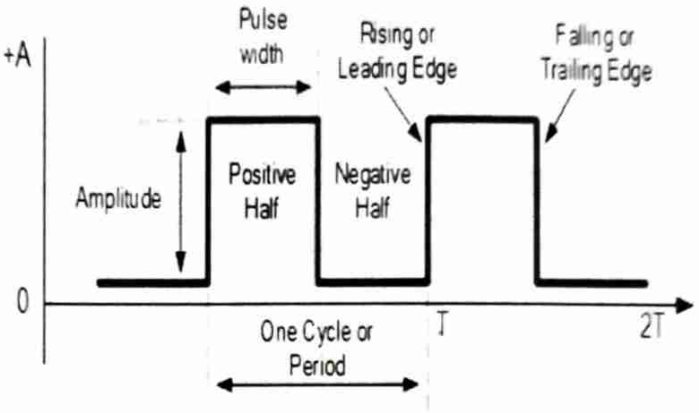


Fig. 4.9

Tabular Column :

Amplitude in volts	ON Time in sec Ton	OFF Time in sec Toff	Time Period (T)=Ton+Toff	Frequency f in Hz F= 1/T

Procedure :

1. Connect the circuit as per circuit diagram.
2. Select the Square wave signal in the signal generator and adjust the required frequency and amplitude voltage.

3. Observe the corresponding signal in the CRO.
4. Note down the amplitude and time in CRO. Calculate frequency.
5. Repeat the step 2 to step 4 for different frequency/ amplitude.

Result :

The characteristics of pulse from signal generator using CRO is studied and measured.

Practical Experiment 4.2

Conduct an Experiment to use a Smart Phone as CCTV Camera and Connect it to Another Mobile to View the Camera Feed

Note: *Number of applications (APPs) available in play store to use smart phone as CCTV. Here I illustrated 2 methods using 2 APPs. You can use only one or can search for different APP in play store.*

Aim :

To use a smart phone as CCTV camera and connect it to another mobile to view the camera feed.

Apparatus Required :

2 smart mobile phones with internet.

Procedure :

Method 1 : Using "Alfred" Application :

One of the best app options for setting up your phone as a CCTVy camera is "Alfred". It's cross-platform, so it doesn't matter if your old phone was an Android phone or iPhone. And the same goes for your new phone.

Alfred is free to use and gives you a remote view of your live feed, motion detection with alerts, free cloud storage, a two-way audio feed and use of both the front and rear cameras. To unlock additional features, like higher-

resolution viewing and recording, zoom capabilities, ad removal and 30-day cloud storage, you can upgrade to Alfred Premium.

Step 1 : Download Alfred (Android, iOS) on both your old and new phones you want to use.

Fig. 4.10

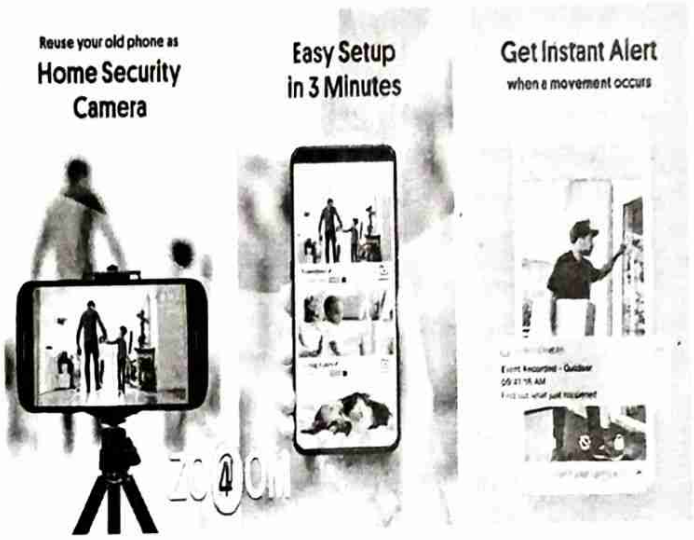
Step 2 : On the new phone, swipe through the introduction and tap **Start**. Select **"Viewer"** and tap **Next**.

Step 3 : Once you get to the sign-in page, click **Sign in with Google** (a Google account is required) and sign in with your Google account credentials.

Step 4 : On the old phone, repeat the same steps, but select as **"Camera"**. And make sure to sign in to the same Google account.

Step 5 : Choose a spot to position your old phone as camera and observe the live in new phone as a viewer.

Step 6 : You can view live, record, talk, get alert, zoom, take screen shots etc.



Method 2 : Using "At Home Video Streamer and At Home Monitor" Applications :

Step 1 : Install "At Home Video Streamer"- Monitor (Android | iOS) on your old smartphone. This handset will be used for streaming the camera feed.

Step 2 : Now, download the "AtHome Monitor" app (Android | iOS) on the device you want to receive the CCTV feed. This phone or tablet will be used for viewing the camera feed.

Step 3 : On the 'camera' and the viewing phone both, launch the respective apps. As soon as it goes online, the At Home Video Streamer will generate a unique Connection ID (CID) along with a username and password. You can enter this information on the phone you'll use to monitor the feed. Or you could just scan the QR code, which saves a fair bit of time.

Step 4 : On the device you'll use to monitor the feed, you need to launch the AtHome Monitor app (called AtHome Camera on iOS) and then you can enter the account details above, or click to add a feed using the QR code generated above. Scan the code and your CCTV streamer and receiver are up and running.

Step 5 : If you want to access the CCTV stream on your desktop computer, all you need to do is download and install the "AtHome Camera desktop client."

Step 6 : If your machine has a webcam then it can scan the QR code just like in step 3; otherwise you'll need to create a username and log-in.

Step 7 : You can add and monitor up to four camera streams in the desktop client. The app is packed with features such as scheduled recording, and two-way talk. You can switch between the front and rear camera and enable the LED flash remotely.

Result :

Smart phone is used as CCTV camera and connected it to another mobile to view the camera feed.

VCB

Week

5

Week 5

Theory

5.1 Special Purpose Radars

5.1.1 CW Doppler Radar

5.1.2 MTI Radar

5.2 Beacons : Secondary Surveillance Radar

5.2.1 Instrument Landing Systems (ILS)

5.3 ZigBee

5.3.1 Zigbee Stack Architecture

5.3.2 ZigBee Applications

Practical Experiment

5.1 a) Video Demonstration and Documentation to understand Radar Scanning and Tracking Systems

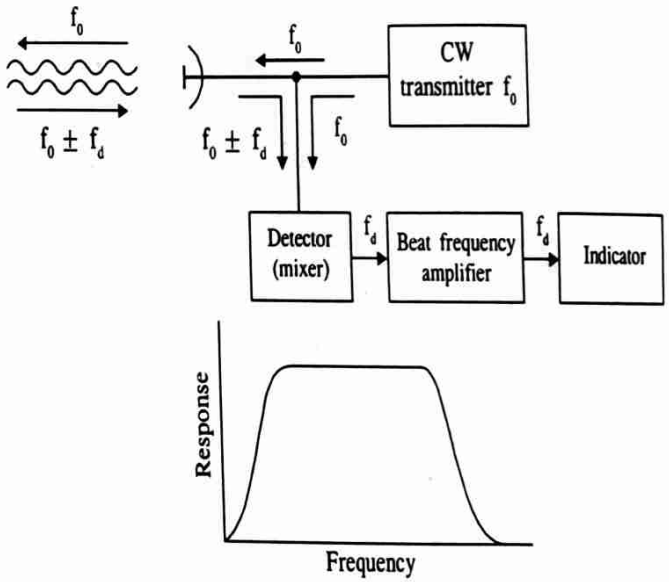
b) Video Demonstration and Documentation to understand the Working of Secondary Surveillance Radar

5.2 Interface Zigbee Module for any Application using Arduino Controller

5.1 Special Purpose Radars :

Radar can be classified based on the function and the waveforms. Some of the special purpose radars such as MTI radar, CW radar, FMCW radar etc.

5.1.1 CW Doppler Radar :



A block diagram of simple CW radar is shown in the above figure. The transmitter generates a continuous (unmodulated) oscillation of frequency f_0, which is radiated by the antenna. A portion of the radiated energy is intercepted by the target and is scattered, some of it in the direction of the radar, where it is collected by the receiving antenna.

If the target is in motion with a velocity V_r relative to the radar, the received signal will be shifted in frequency from the transmitted frequency f_0 by an amount $\pm f_d$.

The plus sign associated with the doppler frequency applies if the distance between target and radar is decreasing (closing target), that is, when the received signal frequency is greater than the transmitted signal frequency.

The minus sign applies if the distance is increasing (receding target).

The received echo signal at a frequency $f_0 \pm f_d$ enters the radar via the antenna and is heterodyned in the detector (mixer) with a portion of the transmitter signal to produce a doppler beat note of frequency f_d. The sign f_d is lost in this process.

The purpose of the doppler amplifier (beat frequency amplifier) is to eliminate echoes from stationary targets and to amplify the doppler echo signal to a level where it can operate and indicating device. Its frequency response characteristics is as shown in the figure above. The low-frequency cut- off must be high enough to reject the d-c component caused by stationary targets, and yet it must be low enough to pass the smallest doppler frequency expected. Sometimes both conditions cannot be met simultaneously and a compromise is necessary. The doppler cutoff frequency (on the higher side) is usually selected to pass the highest doppler frequency expected.

5.1.2 MTI Radar :

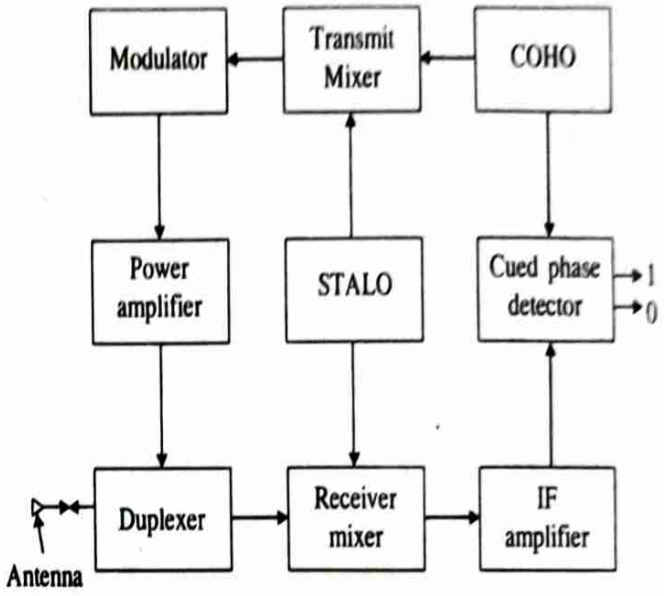


Figure above shows block diagram of the transmitter/ receiver for a moving target indicator (MTI) or pulse-Doppler (PD) radar. Coherency of successive transmit pulses is achieved by a stable local oscillator (STALO) and by a so-called coherent oscillator (COHO) that offsets the STALO frequency by an amount corresponding to the receiver intermediate frequency (IF). The offset is accomplished via the transmit mixer, which outputs the radar frequency (RF). The modulator generates the pulses that are transmitted and received via the antenna and duplexer.

On reception, the pulses are down-converted to IF frequency by the STALO and receiver mixer. The IF signals

are filtered and amplified within the IF amplifier in band-width B. Then, the COHO and IF signals, which are both at IF frequency, are moved (down-converted) with two phase detectors (quad phase detector) to two bipolar video signals (zero center frequency with positive and negative values). The two bipolar signals are in-phase (I) and quadrature (Q) components of the IF signal, in that they are the in-phase and 90 out-of-phase projections of the IF signal onto the COHO signal. Therefore, by forming $\sqrt{I^2+Q^2}$, the root-mean-square (RMS) value, one can in principle obtain the time-dependent IF signal amplitude via a process of linear detection.

5.2 Beacons : Secondary Surveillance Radar :

The radar beacon is a small set of independent radar equipment with a facility for two way transmission in coded form. Therefore beacons are often referred as transponders and also named as secondary surveillance radar system.

The beacons are often located on the target to identify the presence of target in a way better than the usual detection from returned echo signal sometimes beacons are located on the ground at fixed locations to help the targets to identify themselves with respect to beacons.

The radar beacon in its construction, includes a receiver a separate transmitter and an antenna (often omni-directional). Beacons are not transmitting pulses continuously as that of search or tracking radars, but only

respond to the correct interrogation from the main radar. Thus always the beacon action is initiated by the reception of the radar pulse or the coded pulses sent by the interrogating radar (or in some application like pump house, the targets). If this "interrogating" is in a form acceptable to the beacon, the beacon replies by transmitting a pulse or coded information of its own. This reply may on the radar frequency or a different frequency. In the former case, the radar receives handles both target echoes and beacon reply simultaneously. In the later case of reply on different frequency, perhaps assigned to beacons alone, a separate beacon receiver used at interrogating radar.

5.2.1 Instrument Landing Systems (ILS) :

Instrument landing system (ILS) is a ground based radio system designed to provide an aero plane pilot with precise guidance for the final approach in landing. The pilot flies his aircraft along a course delinated by the intersection of two radio beams, one the localizes beam for guidance in the horizontal plane and other the glide slope beam for guidance in the vertical plane. These beams activate an indicator in the aircraft that contains a horizontal needle sensitive to deviations from the glide slope and a vertical needle sensitive to deviations from the localizer path. By keeping both needles centre, the pilot can guide his aircraft down to the end of the landing runway aligned with the runway centre line.

Limitations inherent in the system prevent it from being used safety in locations where the land beyond the approach end of the runway is not level. Also false guidance can result from distortion of the radio beam by nearby buildings or mountains. Newer systems using microwave beams over come most of these limitations. Radio makes beacons are also installed at several locations along the approach path to tell the pilot on the landing approach how far he is from the end of the runway. ILS is an approach rather than a landing system. It is called instrument low approach system (ILAS) by the U.S. military air forces. As a supplementary safety measure especially in band weather and for emergency landings the ground controlled approach (GCA) system is used. Precision radar indicates the location and movement of an aircraft to the ground controller at an airport, enabling him to direct the pilot by voice radio.

5.3 ZigBee :

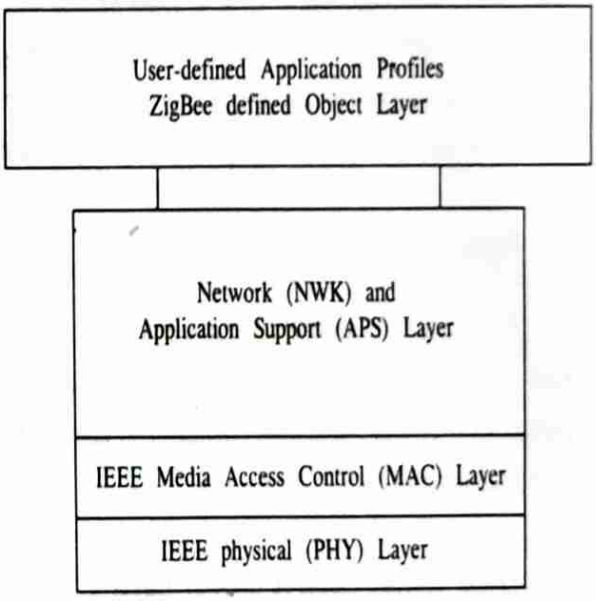
ZigBee is such a standard for embedded application software and has been ratified in late 2004 under IEEE 802.15.4 Wireless Networking Standards.

ZigBee is an established set of specifications for wireless personal area networking (WPAN), i.e., digital radio connections between computers and related devices. This kind of network eliminates use of physical data buses like USB and Ethernet cables. The devices could include telephones, hand-held digital assistants, sensors and controls located within a few meters of each other.

5.3.1 Zigbee Stack Architecture :

Though WPAN implies a reach of only a few meters, 30 feet in the case of ZigBee, the network will have several layers, so designed as to enable intrapersonal communication within the network, connection to a network of higher level and ultimately an uplink to the Web.

The ZigBee Standard has evolved standardized sets of solutions, called 'layers'. These layers facilitate the features that make ZigBee very attractive : low cost, easy implementation, reliable data transfer, short-range operations, very low power consumption and adequate security features.



1. Network and Application Support Layer :

The network layer permits growth of network and high power transmitters. This layer can handle huge

numbers of nodes. This level in the ZigBee architecture includes the ZigBee Device Object (ZDO), user-defined application profile(s) and the Application Support (APS) sub-layer.

The APS sub-layer's responsibilities include maintenance of tables that enable matching between two devices and communication among them, and also discovery, the aspect that identifies other devices that operate in the operating space of any device.

The responsibility of determining the nature of the device (Coordinator / FFD or RFD) in the network, commencing and replying to binding requests and ensuring a secure relationship between devices rests with the ZDO (Zigbee Define Object). The user-defined application refers to the end device that conforms to the ZigBee Standard.

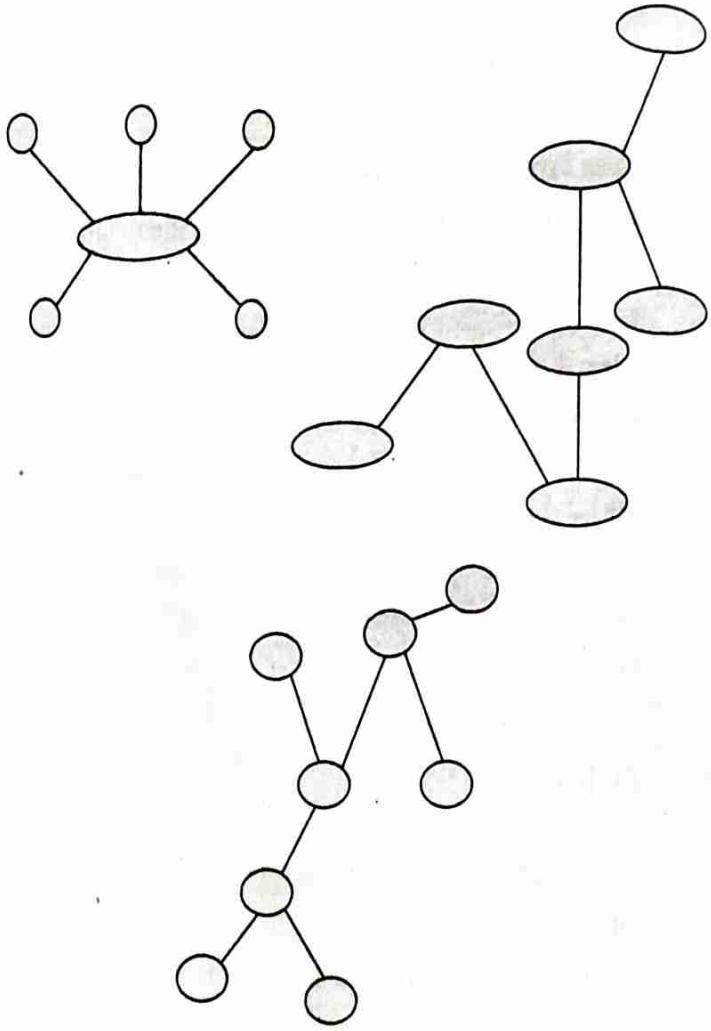
2. Physical (PHY) Layer :

The IEEE802.15.4 PHY physical layer accommodates high levels of integration by using direct sequence to permit simplicity in the analog circuitry and enable cheaper implementations.

3. Media Access Control (MAC) Layer :

The IEEE802.15.4 MAC media access control layer permits use of several topologies without introducing complexity and is meant to work with large numbers of devices.

Different topologies as illustrated below: star, peer-to-peer, mesh.



5.3.2 ZigBee Applications :

The zigbee targets applications "across consumer, commercial, industrial and government markets worldwide".

Practical Experiment 5.1

Note : Browse the below sample video links for the given experiment demonstration. The links shown here are sample illustrative only. Users can search such similar videos.

a) Video Demonstration and Documentation to understand Radar Scanning and Tracking Systems

b) Video Demonstration and Documentation to understand the Working of Secondary Surveillance Radar

a) **Sample Video Link on radar scanning and tracking systems.**

https://youtu.be/J5y0XDZFQug

https://youtu.be/qzBPSG1b5uo

b) **Sample Video Link on working of secondary surveillance radar.**

https://youtu.be/Q4OGZf72Wsc

https://youtu.be/afyMZZsTbfY

Observation/Result :

After watching the above sample demonstration videos or any such similar videos, write a brief note/ summary document in your own sentences about what you understand from the video.

Practical Experiment 5.2

Interface Zigbee Module for any Application using Arduino Controller

Aim/Objective :

Interface Zigbee module for any application using Arduino controller.

Application :

Any datatype can be sent using the UART interface: Here shown how to send 16-bit integers & can be virtually "transmitted" and "received" by the XBees.

Software's Required :

i) Proteus 8 Professional Software
ii) Arduino IDE 1.8.19
iii) XBee Library for Proteus
iv) Genuino Library for Proteus
v) Eltima Virtual Port Driver.

Procedure :

- Double click on Proteus 8 icon or Right click on proteus 8 icon → open.
- Click on "New Project" → Give the name for project and path to store the folder. Tick on 'New Project' and click next

- Tick on "Create a schematic from the selected template". Select "Portrait A4" and click next.
- Tick "DO not create a PCB Layout" and click next.
- Tick "No Firmware project" and click next → Finish.
- Click on a "File" → "New Design" → File → Save Design As → Give name for schematic file.
- Double click on 'P' and then Browse the required components by typing the Components name.
- First Check for Arduino UNO Controller in your Proteus 8 Software if not ***Download Arduino UNO Library Files*** from internet and then add to Proteus Library files to it on library that is ***Localdisk(C)/Programfiles(x86)/LabcenterElectronics/Proteus8 Professional/Library*** then Paste Libray Files to it.
- First Check for Genuino ControllerLibrary for Proteus in your Proteus 8 Software if not ***Download using*** https://www.theengineeringprojects.com/2016/03/genuino-library-proteus.html***Library Files*** from internet and then add to Proteus Library files to it on library that is ***Localdisk(C)/Programfiles(x86)/Labcenter Electronics/Proteus8 Professional/Library*** then Paste Libray Files to it.
- Also, download this XBee Library for Proteus by using on the below link ***http://www.theengineeringprojects.com/2016/01/xbee-library-proteus.html*****then paste to Localdisk(C)/Programfiles(x86)/LabcenterElectronics/Proteus8 *Professional/Library.***

- Choose or Place Required Components such as Arduino Controller as Genuino, Xbee Module & LCD Controller (LM016L) 16*2 Alphanumeric Display by double click on 'P' and then Browse the required components by typing the Components name.
- Go to terminals icon → Choose ground.
- Drag all components to Editor window and place the components as per circuit diagram.
- Double click and edit the values of components according to requirements.
- Rig up the circuit using wire and connect all the components as per the circuit diagram transmitter and Receiver's Section as Separate Projects.
- Now Download and install Arduino IDE 1.8.19 on your system and write the Arduino Code for Transmitter and Receiver.
- To generate Hex File on Arduino IDE 1.8.19 go to file and choose preferences and then select or tick Compilation tab and then Press ok.
- Now Compile Arduino Code & Copy HEX File Location then Paste it in Proteus inside Arduino Properties of TX & RX Arduino Controllers.
- Double click on **Transmitter Arduino Controller** go to Properties and then paste the Hex file Location Link in to it and then press ok.
- Double click on **Receivers Arduino Controller** go to Properties and then paste the Hex file Location Link in to it and then press ok.

- Choose Separately Com Port for Transmitter XBEE Module by double click and choose ***Com Port 1*** on Edit Components.
- Choose Separately Com Port for Receivers XBEE Module by double click and choose ***Com Port 2*** on Edit Components.
- Now Pair both Ports 1 & 2 using Com Ports using ***Virtual Com Port Drivers*** on your System.
- Click on 'Debug' icon and click on 'Run' to run the simulation or press F12 Separately both Transmitter & Receiver's Projects Simulateneously.
- View the output on receivers any data type can be sent using the UART interface here shown how to send 16-bit integers. can be virtually "transmitted" and "received" by the XBees.
- To stop the simulation press ESC key.

Procedural Steps Illustration using Screen Shots :

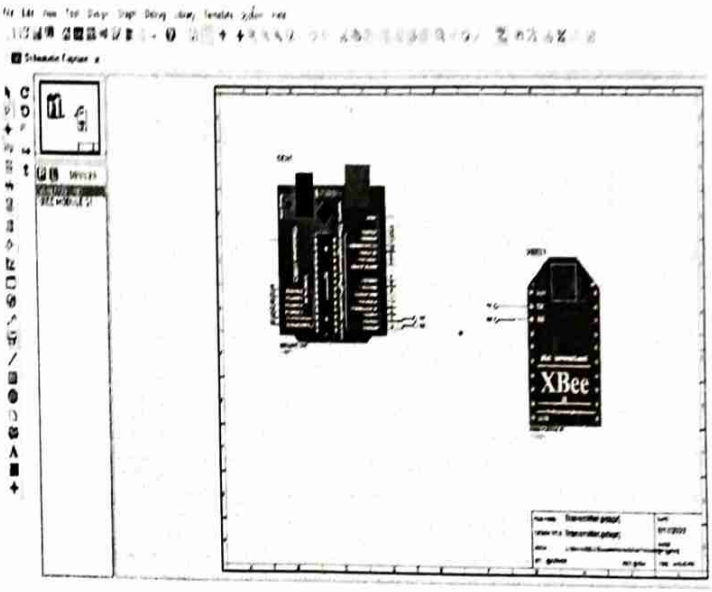
First of all, download the Genuino Library for Proteus from the below Link & add to Proteus 8 Library.

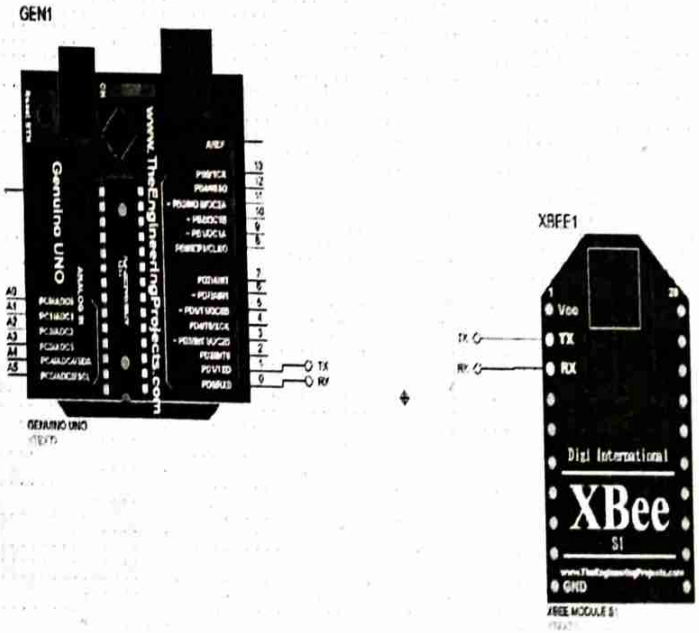
https://www.theengineeringprojects.com/2016/03/genuino-library-proteus.html

Note : 1. The COM Ports must be paired before starting the simulation.

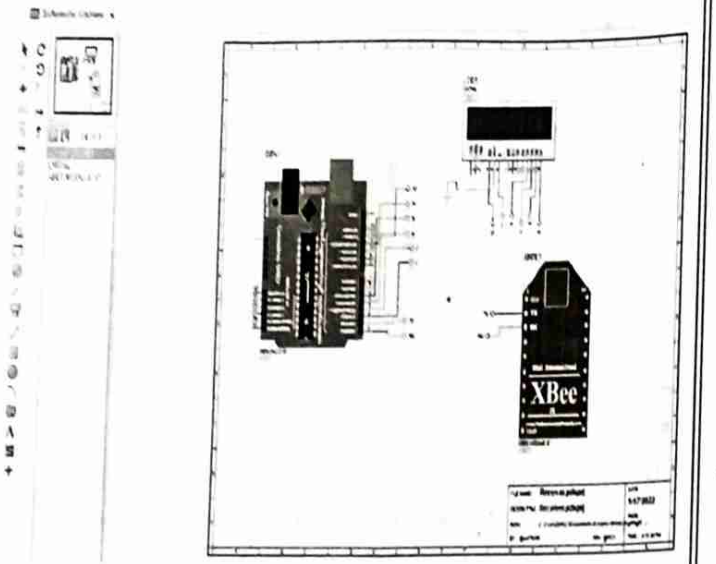
2. In real life, the XBees are to be connected TX to RX and RX to TX however while using the XBee Library in Proteus connections to be followed are TX to TX and RX to RX.

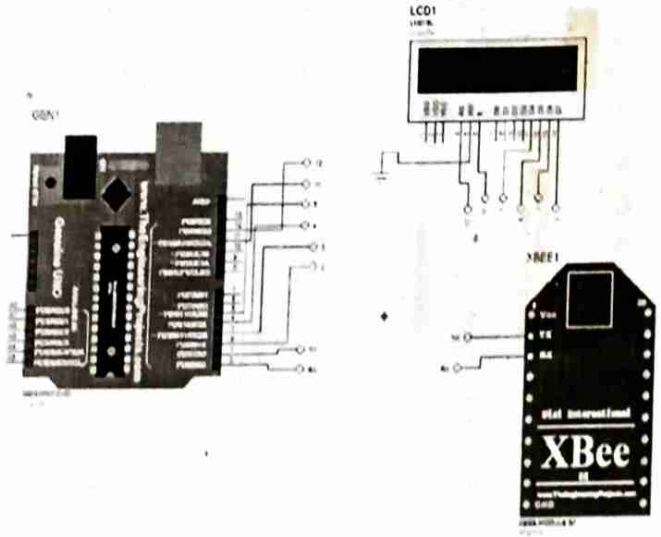
Step 1 : Create Transmitter Section Connection Module Project :



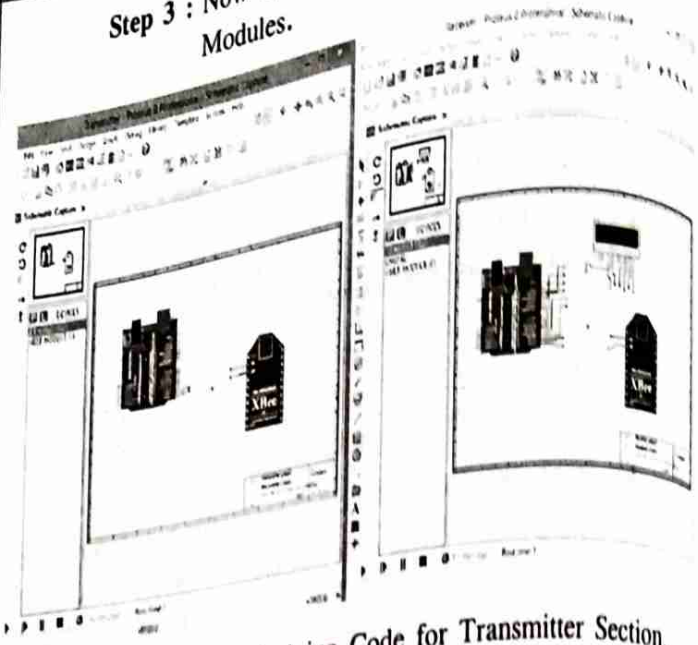


Step 2 : Create Receiver's Section Connection Module Project :



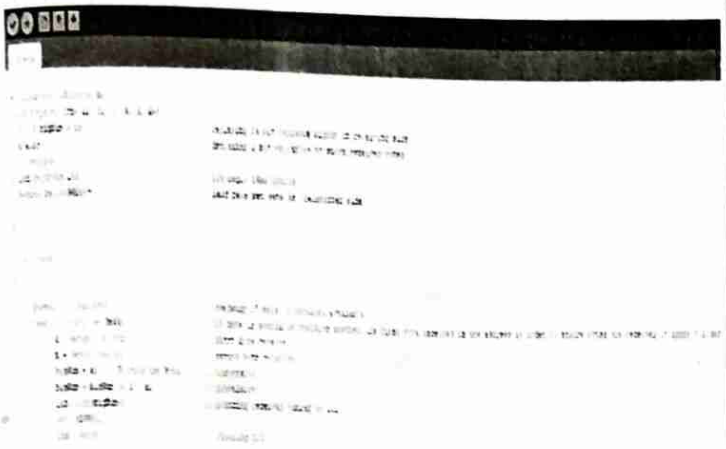


Step 3 : Now Open Both Projects o Transmitter & Receiver Modules.

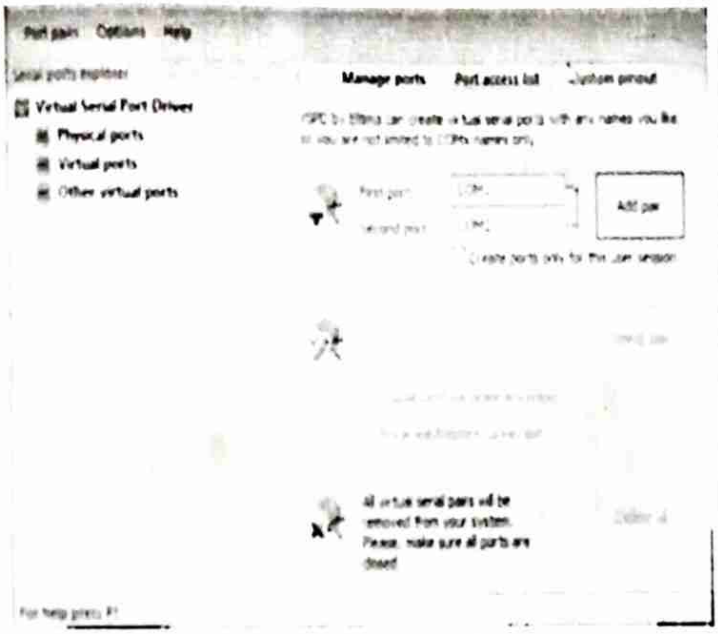


Step 4 : Write Arduino Code for Transmitter Section.

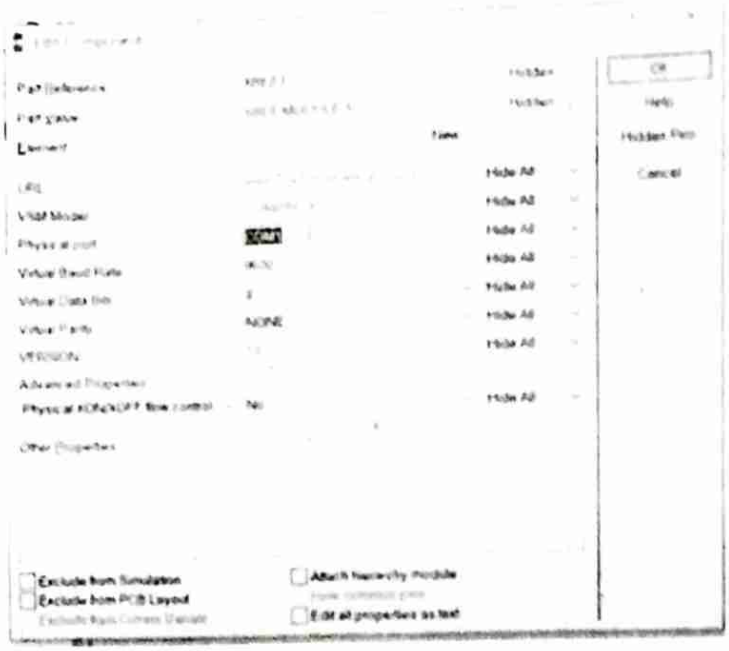
Step 5 : Write Arduino Code for Receivers Section.



Step 6 : The Virtual COM Ports must be paired before starting the simulation :



Step 7 : Transmitter Xbee will have Com Port 1 :



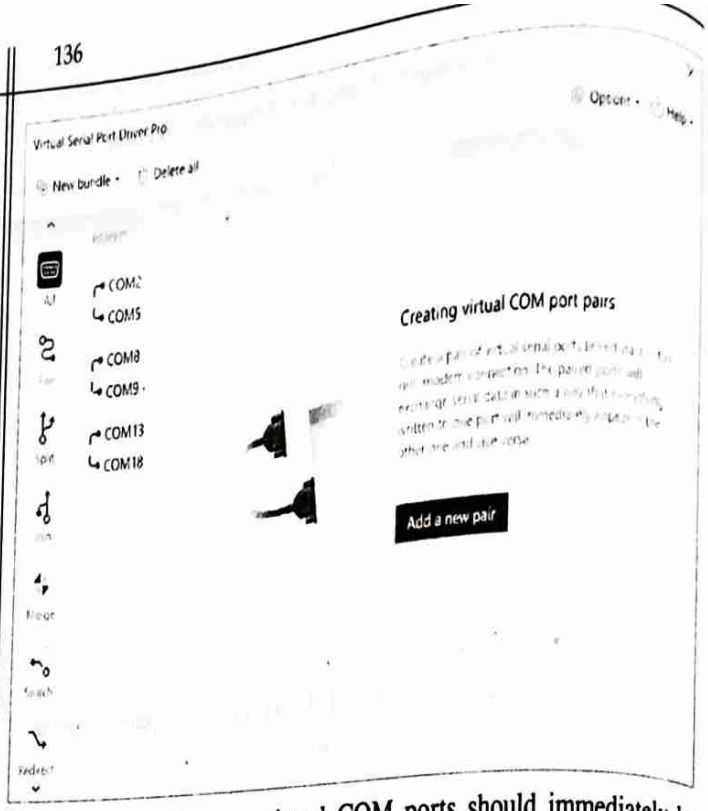
Step 8 : Receivers Xbee will have Com Port 2 :

Step 9 : Eltima Virtual Port Driver (For Com Port Pairing).

https://www.eltima.com/products/vspdxp/

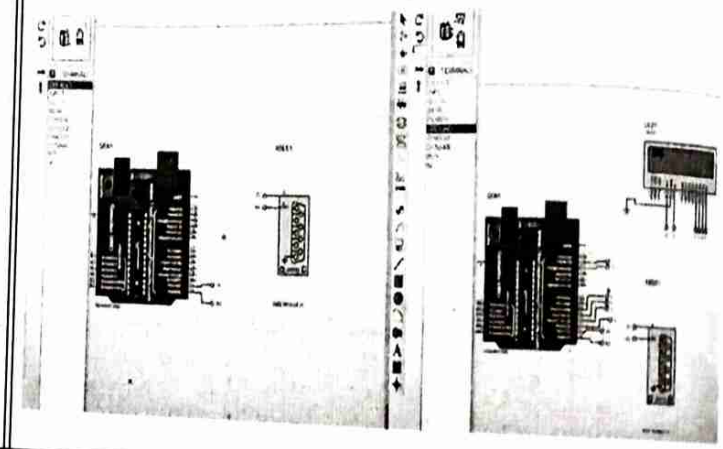
Follow these 4 steps to create a virtual COM port:

- Download and install Virtual Serial Port Driver on your PC.
- Launch the program and open the **"Pair"**, and click **"Add a new pair"**.
- Use predefined names from the drop-down menu or create custom names for your pair of virtual serial ports.
- Click the **"Create"** button.



The new virtual COM ports should immediately be recognized and available through your computer's Device Manager or Serial Ports Explorer.

Step 10: Output :



Arduino Code for Transmitter and Receiver :

Transmitter Code :

```
bytemyArray[3];     // Declaring a byte array of
                       array size 3
int16_tbigNum = 800;  // 16 bit integer to be
                         sent
void setup()
{
Serial.begin(9600); // Setting baud rate to 9600
}

void loop()
{ myArray[0] = 0x44; // array first position or
                       index position [0] filled
                       by address
myArray[1] = (bigNum>> 8)&0xFF; // storing first
                                   byte
myArray[2] = bigNum& 0xFF;     // storing second
                                  byte
Serial.write(myArray, 3); // sending array which
                             will go byte by
                             byte in sequence
delay(100);
}
```


Receivers Code :

```
#include<LiquidCrystal.h>
LiquidCrystallcd(12, 11, 5, 4, 3, 2);
int16_tbigNum = 0; // declaring 16 bit variable
                      bigNum on receiving side
inta,b;           // declaring 8 bit variables
                     to store received bytes
void setup()
{ lcd.begin(16,2);  // lcd begin 16x2 config
Serial.begin(9600); // baud rate set same as
                       transmitter side
}
void loop()
{
if (Serial.available())  // checking if data
                            is received/available
{ if(Serial.read() == 0x44) {   // if data is
                                   available checking
                                   whether the first
                                   byte received is the
                                   address in order to
                                   ensure bytes are re
                                   ceived in correct
                                   order
    a = Serial.read(); // first byte received
    b = Serial.read(); // second byte received
```

```
    bigNum = a; // Storing 1st Byte // conversion
    bigNum = bigNum<< 8 | b;    // conversion
    lcd.print(bigNum);          // printing received
                                   number on LCD
  delay(1000);
  lcd.clear();                  // clearing LCD
        }
   }
}
```

Result :

Interface Zigbee module for an application using Arduino controller is studied and verified.

Week 6

Week 6

Theory

Practical Experiment

6.1 Study the Features and Working of Different Sections in a Satellite Communication Trainer Kit

6.2 Conduct an Experiment to Transmit & Receive Three Separate Signals (Audio, Video and Tone/Voice) Simultaneously through Satellite Link and Perform Link Fail Operations using Satellite Communication Trainer Kit

6.1 Satellite Communication :

Satellite is an object that revolves around some celestial body. Satellites are mainly classified into two types. One is natural satellites and another is artificial satellites. Natural satellites are nature made. One of the best example is our solar system where the earth and other planets revolve around the sun. Here earth and other planets acts as satellites and the sun as celestial body. In the same way moon is a satellite of the earth. Here a balance between the inertia of the revolving satellite and the gravitational pull of the orbited body keeps the satellite in orbit.

Artificial satellites are the man made satellites. Artificial satellites can be launched into orbit for a variety of purposes one of these major applications is communications.

6.1.1 Satellite :

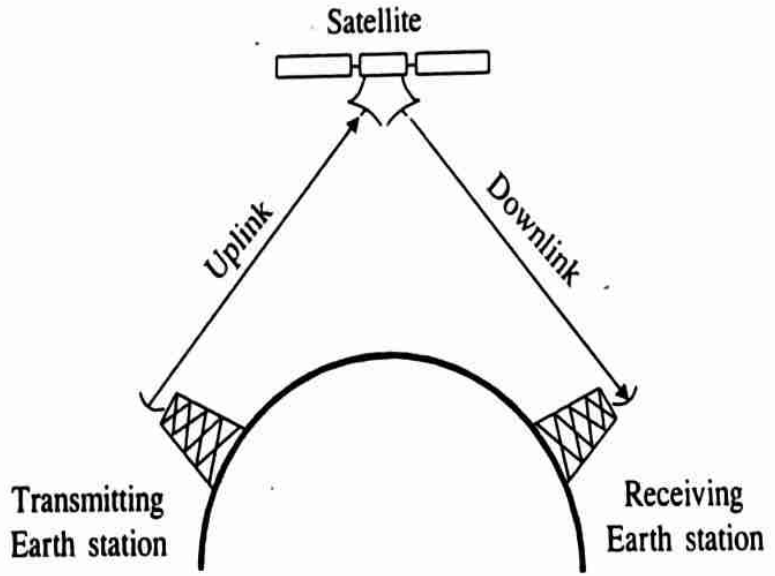


Fig. 6.1

A satellite is a simple or sophisticated electronic gadget placed in space to support possible communication between two points on the earth separated at a distance where the communication is not possible by any terrestrial means. The satellite just receives the electromagnetic signal, process it and retransmit.

6.1.2 Types of Satellite :

There are 2 types of satellite :

1. Passive Satellite
2. Active Satellite.

1. Passive Satellite Systems :

Passive satellite is a system in the space that just reflects energy back towards the earth in a manner similar to target reflection in radar systems. Such satellite systems are simply electro magnetic energy reflectors without any moving mechanical and electronic parts.

2. Active Satellites :

Active satellites are the satellites that uses the energy beamed from the earth at one frequency and increases the signal strength appropriately, then retransmits at some other different frequency.

Active space repeaters receive signals, translate them in frequency or demodulate them, amplify them and then retransmit them at higher levels to a distant space craft or

ground station. The active repeaters have limited dynamic range as well as limited bandwidth and hence can accommodate only a finite number of simultaneous users.

Comparison of Passive and Active Satellites :

Some of the basic differences between the passive and active satellites are as follows :

Passive Satellites	Active Satellites
1. These satellites are simple in design.	1. These satellites are complex in design.
2. Passive satellite supports shorter distance space communication at some received energy.	2. Active satellites supports longer distance space communication at same received energy.
3. The use of different frequency for retransmission is not possible.	3. The use of different frequency for retransmission is possible.
4. Retransmitting signal not provides a great deal of flexibility in many aspects.	4. Retransmitting signal provides a great deal of flexibility in many aspects.
5. Passive satellite uses only single frequency hence no interference.	5. The active satellite uses two separate frequencies, there will be unnoticeable signal interference.

6.1.3 Satellite Orbits Shape :

The path of the satellite around the celestial body is called orbit.

A satellite revolves around the earth in an orbit. The orbit shape is either in circular or in elliptical path. It is possible to calculate the position of a satellite at any given time with the orbit shape.

Circular Orbit :

In a circular orbit the speed of revolution is constant and normally the speed of the satellite is higher when it is close to the earth than when it is far away. Here the height is simply the distance of the satellite from the earth. Geometrically it is considered from the center of the earth.

Elliptical Orbit :

In an elliptical orbit the speed of the orbit is not constant, it changes depending upon the height of the satellite above the earth. Here the centre of the earth is one of the focal points of the ellipse.

6.1.4 Satellite Eclipse, Apogee and Perigee :

The path followed by a satellite around its primary (the earth) is an **ellipse.** Ellipse has two foci - F_1 and F_2, the earth being one of them.

If the distance from the centre of the object to a point on its elliptical path is considered, then the farthest point of an ellipse from the centre is called as **apogee** and the shortest point of an ellipse from the centre is called as **perigee.**

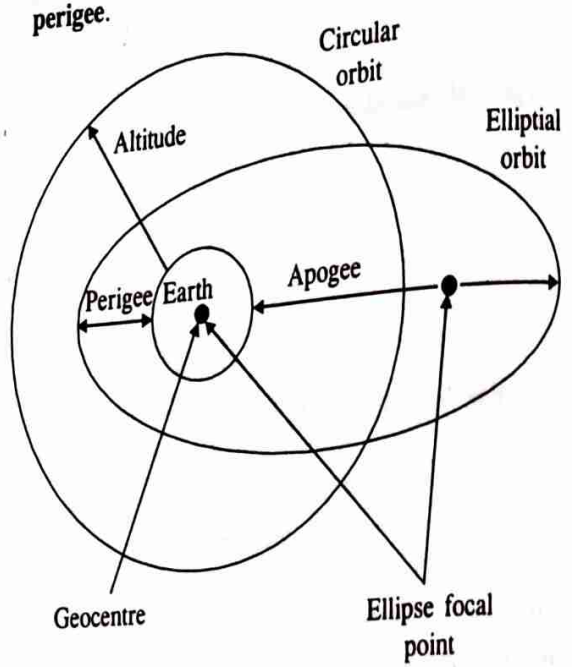


Fig. 6.2

6.1.5 Posigrade and Retrograde :

The orbit is said to be *posigrade* if the satellite revolution is same direction as the earths rotation and is called *retrograde* if the satellite revolution is opposite to that of the direction of earths rotation. But most of the orbits are posigrade.

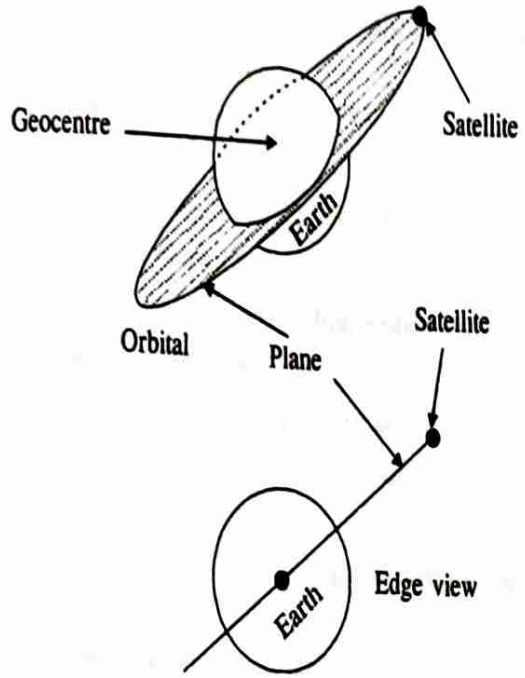


Fig. 6.3

6.1.6 Satellite Angles :

The angle of inclination is the angle between the equatorial plane and the satellite orbital plane as the satellite enters the northern hemisphere. It is clearly illustrated in the below figure 6.4.

The Azimath is simply the angle of an object in the sky along the horizon.

The angle of elevation is the angle that appears between the line from the earth stations antenna to the satellite and the line between the earth's antenna and the earth's horizon. It is clearly illustrated in the below figure 6.5.

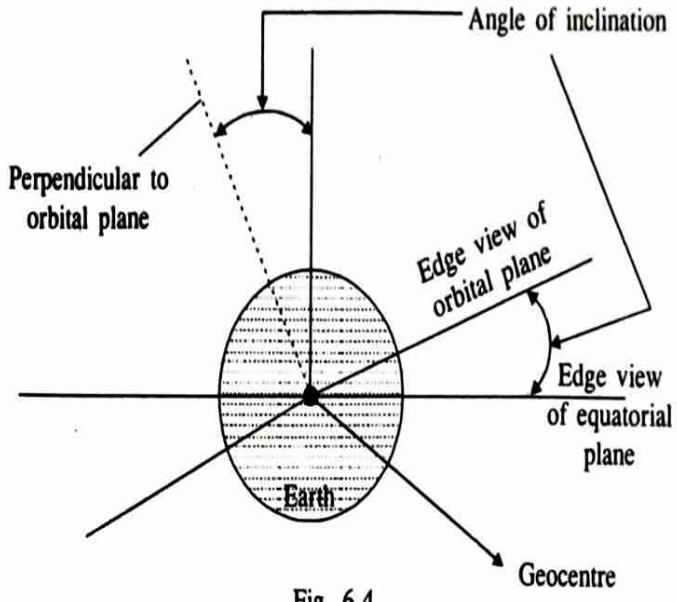


Fig. 6.4

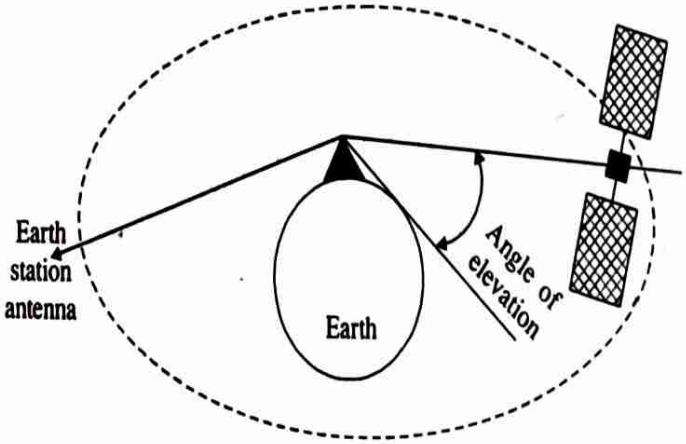


Fig. 6.5

6.1.7 Orbital Period :

There are two methods of measuring the satellite period. They are : 1) Sideral period 2) Synodic period.

The time taken by the satellite to complete one orbit is called the side real period. In determining the side real

period some fixed or apparently motion less external object, such as the sun or a star is used as a reference. But when the artificial satellite is revolving around the earth, the earth itself is rotating.

Synodic period is also called as revolution. One revolution is the period of time that elapse between the successive passes of the satellite over a given meridian of earth longitude.

6.1.8 Uplink and Downlink :

The communication going from a satellite to ground is called downlink and when it is going from ground to a satellite it is called uplink.

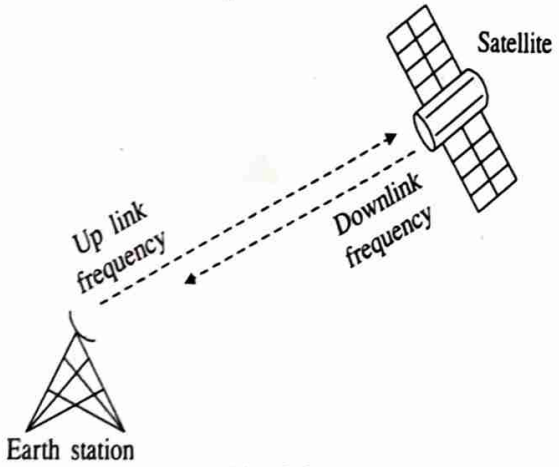


Fig. 6.6

- **Centripetal force :** The force that tends to draw an object moving in a trajectory path, towards itself is called as centripetal force.
- **Centrifugal force :** The force that tends to push an object moving in a trajectory path, away from its position is called as centrifugal force.

6.1.9 Line of Apsides :

The line joining the perigee and apogee through the centre of the earth.

Ascending node : The point where the orbit crosses the equatorial plane going from south to north.

Descending node : The point where the orbit crosses the equatorial plane going from north to south.

Line of nodes : The line joining the ascending and descending nodes through the centre of the earth.

6.1.10 Subsatellite Point :

Point where a straight line drawn from a satellite to the centre of the Earth intersects the Earth's surface is called subsatellite point.

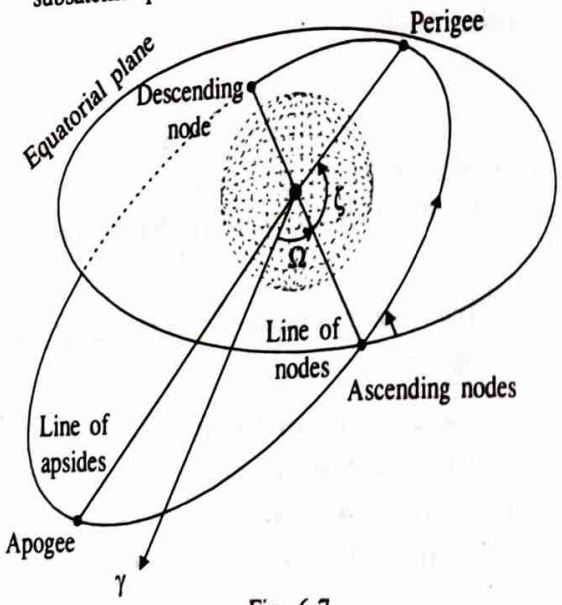


Fig. 6.7

6.2 Earth Orbits :

A satellite when launched into space, needs to be placed in certain orbit to provide a particular way for its revolution, so as to maintain accessibility and serve its purpose whether scientific, military or commercial. Such orbits which are assigned to satellites, with respect to earth are called as Earth Orbits. The satellites in these orbits are Earth Orbit Satellites.

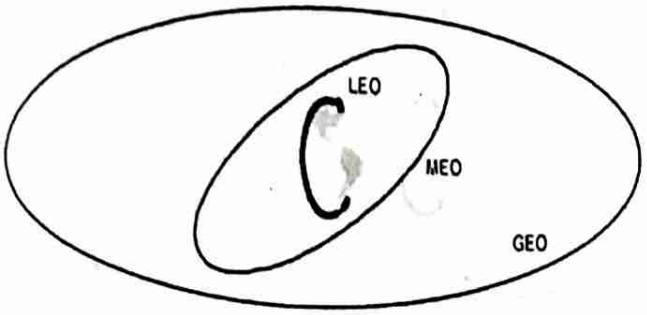


Fig. 6.8

The important kinds of Earth Orbits are :

- Geo-synchronous Earth Orbit (GEO)
- Geo-stationary Earth Orbit (GEO)
- Medium Earth Orbit (MEO)
- Low Earth Orbit (LEO).

6.2.1 Geo-synchronous and Geo stationary Earth Orbit (GEO) Satellites :

A Geo-synchronous Earth orbit Satellite is one which is placed at an altitude of 22,300 miles above the Earth. This

orbit is synchronized with **a side real day** (i.e., 23 hours 56 minutes). This orbit can **have inclination and eccentricity.** It may not be circular. This orbit can be tilted at the poles of the earth. But it appears **stationary** when observed from the Earth.

The same geo-synchronous orbit, if it is circular and in the plane of equator, it is called as geo-stationary orbit. These Satellites are placed at 35,900 kms (same as geosynchronous) above the Earth's Equator and they keep on rotating with respect to earth's direction (west to east). These satellites are considered stationary with respect to earth and hence the name implies.

Geo-Stationary Earth Orbit Satellites are used for weather forecasting, satellite TV, satellite radio and other types of global communications.

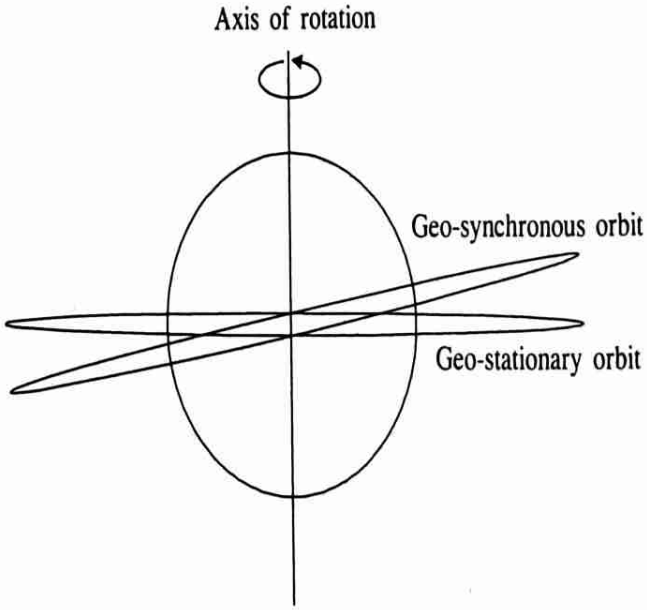


Fig. 6.9

The above figure shows the difference between Geo-synchronous and Geo- Stationary orbits. The Axis of rotation indicates the movement of Earth.

The main point to note here is that every Geo-Stationary orbit is a Geo-Synchronous orbit. But every Geo-Synchronous orbit is NOT a Geo-stationary orbit.

dvantages of GEO :

- It is possible to cover almost all parts of the earth with just 3 geo satellites.
- Antennas need not be adjusted every now and then but can be fixed permanently.
- The life-time of a GEO satellite is quite high usually around 15 years.

isadvantages of GEO :

- Larger antennas are required for northern/southern regions of the earth.
- High buildings in a city limit the transmission quality.
- High transmission power is required.
- These satellites cannot be used for small mobile phones.
- Fixing a satellite at Geo stationary orbit is very expensive.

6.2.2 Medium Earth Orbit (MEO) Satellites :

Medium earth orbit (MEO) satellite networks will orbit at distances of about 8000 miles from earth's surface. Signals transmitted from a MEO satellite travel a shorter distance. This translates to improved signal strength at the receiving end. This shows that smaller, more light weight receiving terminals can be used at the receiving end.

Since the signal is travelling a shorter distance to and from the satellite, there is less transmission delay. **Transmission delay** can be defined as the time it takes for a signal to travel up to a satellite and back down to a receiving station.

For real-time communications, the shorter the transmission delay, the better will be the communication system. As an example, if a GEO satellite requires 0.25 seconds for a round trip, then MEO satellite requires less than 0.1 seconds to complete the same trip. MEOs operates in the frequency range of 2 GHz and above.

Advantages of Medium Earth Orbit :

- Compared to LEO system, MEO requires only a dozen satellites.
- Simple in design.
- Requires very few handovers.

Disadvantages of Medium Earth Orbit :

- Satellites require higher transmission power.
- Special antennas are required.

Low Earth Orbit (LEO) Satellites :

The LEO satellites are mainly classified into three categories namely, little LEOs, big LEOs, and Mega-LEOs. LEOs will orbit at a distance of 500 to 1000 miles above the earth's surface.

This relatively short distance reduces transmission delay to only 0.05 seconds. This further reduces the need for sensitive and bulky receiving equipment. Little LEOs will operate in the 800 MHz (0.8 GHz) range. Big LEOs will operate in the 2 GHz or above range, and Mega-LEOs operates in the 20-30 GHz range.

The higher frequencies associated with **Mega-LEOs** translates into more information carrying capacity and yields to the capability of real-time, low delay video transmission scheme.

ntages of Low Earth Orbit :

- The antennas can have low transmission power of about 1 watt.
- The delay of packets is relatively low.
- Useful for smaller foot prints.

dvantages of Low Earth Orbit :

- If global coverage is required, it requires at least 50 - 200 satellites in this orbit.
- Special handover mechanisms are required.
- These satellites involve complex design.

- Very short life: Time of 5-8 years. Assuming 48 satellites with a life-time of 8 years each, a new satellite is needed every 2 months.
- Data packets should be routed from satellite to satellite.

6.2.4 Differences between GEO, MEO and LEO :

Parameter	LEO	MEO	GEO
Satellite Height	500-1500 km	5000-12000 km	35,800 km
Orbital Period	10-40 minutes	2-8 hours	24 hours
Number of Satellites	40-80	8-20	3
Satellite Life	Short	Long	Long
Number of Handoffs	High	Low	Least(none)
Gateway Cost	Very Expensive	Expensive	Cheap
Propagation Loss	Least	High	Highest

6.3 Station Keeping :

The process of firing the rockets under ground control to maintain or adjust the orbit is referred to as station keeping.

In a geosynchronous satellite, the position of the satellite is supposed to be remain fixed for reliable continuous communications. But the satellite will drift somewhat in its orbit. Orbital drift is caused by the variety of forces, such as,

- The satellite position is affected by the gravitational pull of the sun and moon.
- The earth's gravitational field is not perfectly consistent at all points on the earth because the earth is not a perfect sphere (Fatter around the equator and flatened at the poles).

The orbit of the satellite must be periodically adjusted to overcome the above drift. The rockets or thruster jets, placed at various positions on the satellite is used to speed up or slow down the satellite for the purpose of compensating for orbital drift. Depending upon the accuracy of the orbit, the rockets may be fired as often as every several weeks or as little as once per year. Most satellites have several thruster jets to make various satellite position adjustments possible.

6.3.1 Attitude Control :

Positioning the satellite for optimum performance is called attitude control. The attitude of the satellite must be controlled so that :

- The antennas can be pointed towards the correct locations on earth.
- To keep the satellites solar panels pointed towards the sun, so that maximum power is produced.
- The selected sensors or a TV camera must be pointed in the right direction. Attitude control is maintained by combination of
  - Stabilization techniques and
  - Jet thrusters.

After the satellite is put into stable orbit the attitude of the satellite is first determined right. And then the jet thrusters are actuated to move the satellite to the correct attitude is assumed. After setting the initial attitude of the satellite, it must be maintained in this position by either of the below mentioned two stabilization methods :

- Spin stabilization
- Three axis stabilization.

6.3.2 Thermal Control :

Satellites are subject to large thermal gradients, receiving the sun's radiation on one side while the other side faces into space. In addition, thermal radiation from the earth and the earth's albedo, which is the fraction of the radiation falling on earth which is reflected, can be significant for low-altitude earth-orbiting satellites, although it is negligible for geostationary satellites. Equipment in the satellite also generates heat which has to be removed.

The most important consideration is that the satellite's equipment should operate as nearly as possible in a stable temperature environment often used to remove heat from the communications payload. In order to maintain constant temperature conditions, heaters may be switched on (usually on command from ground) to make up for the heat reduction which occurs when transponders are switched off. In INTELSAT VI, heaters are used to maintain propulsion thrusters and line temperatures.

Practical Experiment 6.1

Study the Features and Working of Different Sections in a Satellite Communication Trainer Kit

Note: Depending upon the kit manufacturing company, working/ procedure varies. Here I took the kit manufactured from Scientech to illustrate working/procedure. Courtesy:Scientech.

Aim/Objective :

Study the features and working of different sections in a satellite communication trainer kit.

Equipment's Needed :

- Uplink Transmitter
- Dish Antennas
- Downlink Receiver
- Connecting cables.

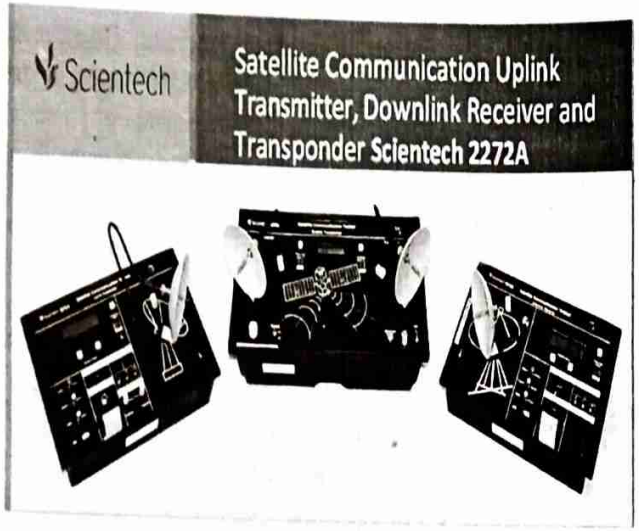
Detailed Product Description Satellite Communication Trainer ST2272 provides an in-depth study of basic Satellite Communication system. It consists of Uplink Transmitter, Satellite Link and Downlink Receiver, which can be conveniently placed in the laboratory. The Satellite can be placed at an elevated position if needed. The Satellite Transponder receives signal from Uplink Transmitter and retransmits at different frequencies to a Downlink Receiver. The Uplink and Downlink frequencies are selectable and carry three signals - Video, Audio/ Voice/ Tone and Data simultaneously. The Operating manual illustrates basic theory

and glossary of Satellite Communication terms along with Experiments. Experiments that can be performed Understanding Basic concepts of Satellite Communication.

To establish a direct communication link between Uplink Transmitter and Down link receiver using tone signal. To setup an Active satellite link and demonstrate Link Fail operations. To establish an AUDIO-VIDEO satellite link between Transmitter and Receiver.And Many More Technical Specification Uplink Transmitter. Transmit 3 signals simultaneously at each up linking frequency 2414 /2432/2450/2468 MHz up linking frequencies selectable by up-down 2 Switch and LED indication. 4 MHz clock frequency.Wide band RF amplifier. No manual matching required. PIC16F84 - 8 Bit RISC processor based PLL. 16 MHz Bandwidth. FM Modulation of Audio and Video. 5/ 5.5/ 8 MHz Audio and Video Modulation Detachable Dish Antenna. Radiated Power output 25 mW (approx.).

Transmit Audio, Video, Digital/Analog data, Tone, Voice Function Generator waveforms etc. Separate terminals provided for Different inputs Power Supply: 230 Volts 10%, 50 Hz. Satellite Link. Transponder with selectable frequency conversion. Choice of 4 downlink frequencies 2414/2432/ 2450/2468 MHz Rotary Switch for selecting uplink frequency. Link Fail Operation. Detachable Dish Antennas. Radiated power 25 mW Approx. with gain control. Power Supply : 230 Volts 10%, 50 Hz. Downlink Receiver Receives and demodulate 3 signals simultaneously. frequencies 2414 /2432/ 2450/2468. -60 dBm (approx.) sensitivity at tuner input. Built in speaker for Audio output.Detachable Dish Antenna. Power Supply : 230 Volts, 10%, 50 Hz.

Scientech 2272A Satellite Communication platform provides an indepth study of basic Satellite Communication system. It consists of Uplink Transmitter, Satellite Linkand Downlink Receiver, which can be conveniently placed in the laboratory. The Satellite can be placed at an elevated, position if needed. The Satellite Transponder receives signal from Uplink Transmitter and retransmits at different frequencies to a Downlink Receiver. The Uplink and Downlink frequencies are selectable and can have variety of signals such as Video, Audio, Voice, Tone, Data and Telemetry (Temperature and Light intensity).



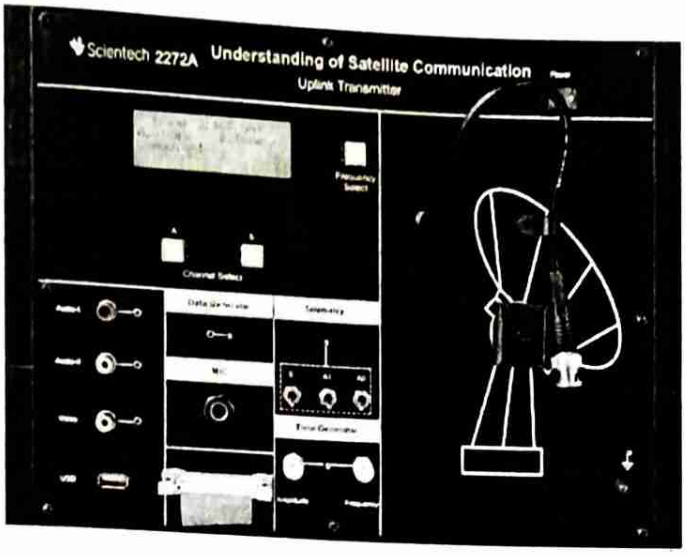
Features :

- Simultaneous communication of three different signals.
- Communicate Audio, Video, Digital data, PC data, Tone, Voice, function generator waveforms etc.

- 2.4 GHz Band PLL microwave operation.
- Communication of external broad band digital
- Choice of different transmitting and receiving fre
- Built-in Speaker and Microphone for Voice co link.
- Remote detection of Light intensity and env temperature.
- Detachable Dish Antenna a teach station.
- USB port for PC communication.

Uplink Transmitter :

- Transmitter with selectable frequency conver
- 2.4 GHz Band uplinks electable frequencies.
- Wide band RF amplifier. No manual matching r
- 16 MHz Bandwidth.
- Frequency selects witch and LED indication.
- FM Modulation of Audio and Video.
- Coverage area 35 m Indoor and 100 moutdoo
- Transmit Audio, Video, Digital data, PC data Voice, function generator waveforms etc.
- Separate section for telemetry operation.



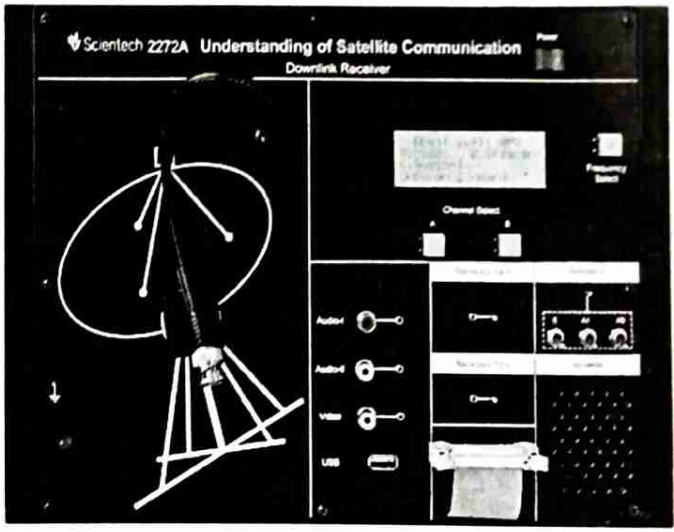
Numeric Indication of Different Sections in the Uplink Transmitter Module :

Inbuilt Tone Generator :

- Frequency - 100 Hz to 1 KHz.
- Amplitude - 0 V to 1 Vpp.
- Separate terminals provided for different inputs.

Satellite Link :

- Transponder with selectable Uplink and downlinks frequency conversion.
- Light and Temperature sensors for telemetry operations.
- Delay knob provided for simulated Transition delay experiment.
- Optional Solar power supply for Transponder Unit.
- Detachable Dish Antennas.



Numeric Indication of Different Sections in the Transponde Module :

Downlink Receiver :

- Receiver with selectable frequency conversion.
- Receives and demodulate three signals simultaneousl
- Builtin speaker for audio and video output.
- Detachable Dish Antenna.
- Power Supply : 230 V AC±10%, 50/60 Hz.

Satellite Receiving System :

Package Contains :

- Audio-Video Cable 2 Pin
- Patch Cord 16" (4 mm)
- Microphone
- Dish Antenna
- USB Cable
- Pencil Cell (Microphone)
- Mains cord
- PC Software.

Scope of Learning :

- Transmitting & receiving three separate Signals (Audio, Video, and Tone/Voice) simultaneously through satellite link and perform Link Fail Operations.
- Transmitting & receiving Function Generator Waveforms through Satellite Link.
- Transmitting and receiving PC data through satellite link.
- Study the delay between Uplink transmitterand Downlink receiver during datat ransmission.
- Send Tele-command and receive Temperature & intensity of light from satellite.
- Calculate the carrier to noise ratio for a satellite link.
- Calculate signal to noise ratio for a satellite link.tec272A.

Practical Experiment 6.2

Conduct an Experiment to Transmit & Receive Three Separate Signals (Audio, Video and Tone/Voice) Simultaneously through Satellite Link and Perform Link Fail Operations using Satellite Communication Trainer Kit

Aim/Objective :

Transmitting and receiving three separate signals (Audio, Video, Tone) simultaneously through satellite link.

Equipments Needed :

- Uplink Transmitter
- Dish Antennas
- Downlink Receiver
- Connecting cables
- Satellite Transponder.

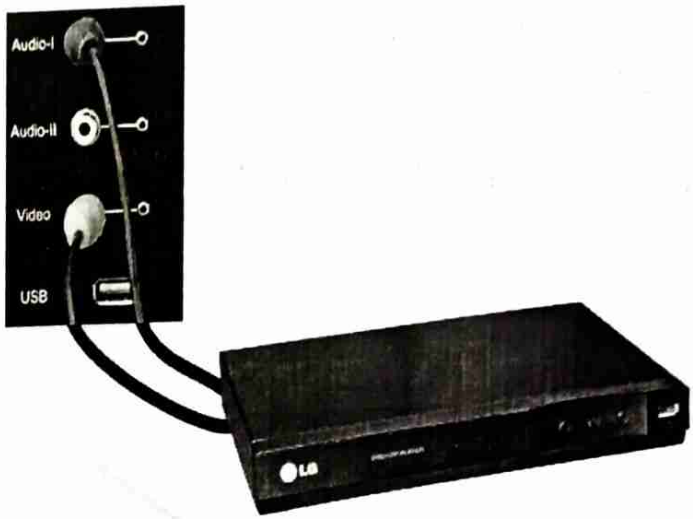
Procedure :

- Once you get the set up ready as per the experiment needs, proceed as follows.
- Carry out the following settings at all three units starting from Uplink Transmitter then Satellite Transponder and at last Downlink Receiver. This sequence of operation must be followed to avoid any kind of improper operation of the system.

Setting at Uplink Transmitter :

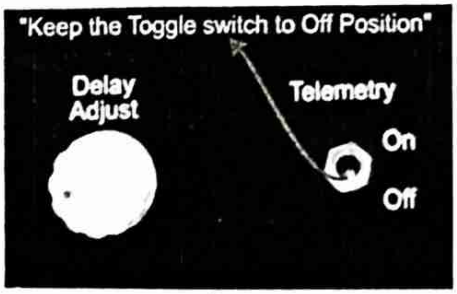
- Now set the "Channel A" to 'Video' mode using the 'Channel Select A' key, so as to transmit video signals from Uplink Transmitter. The video signals are transmitted through 'Video' channel of the transmitter. Similarly set the "Channel B" to 'Tone' mode using the 'Channel Select B' key, so as to transmit tone signal from Uplink Transmitter. The 'Tone' signal is transmitted through 'Audio II' channel of thetransmitter.

- Connect the audio/video signal at the input socket provided on uplink transmitter, video at video input and audio at audio-Iinput.



Setting at Satellite Transponder :

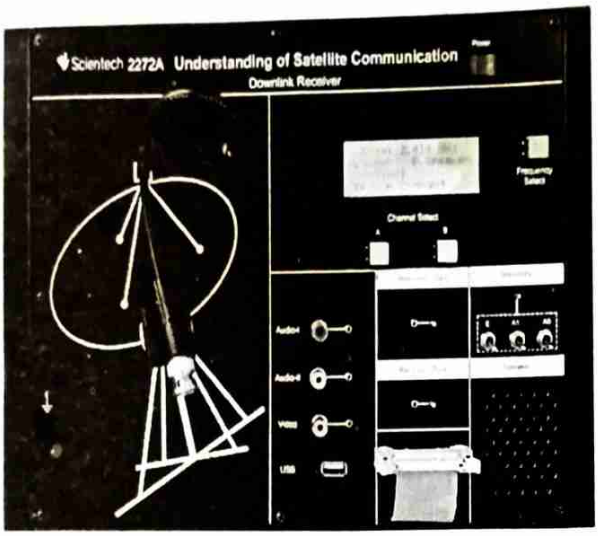
- Keep the toggle switch to 'Telemetry off' position provided at Satellite Transponder unit.



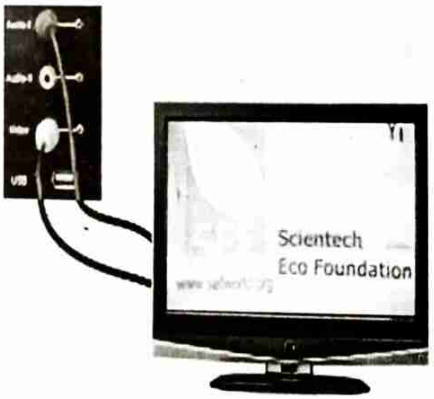
Setting at Downlink Receiver :

- Now set the "Channel A" to 'Video' mode using the 'Channel Select A' key, so as to receive video signals from Uplink Transmitter. The video signals are received through 'Video' channel of the receiver. Similarly Now set the 'Channel B' to 'Speaker' mode

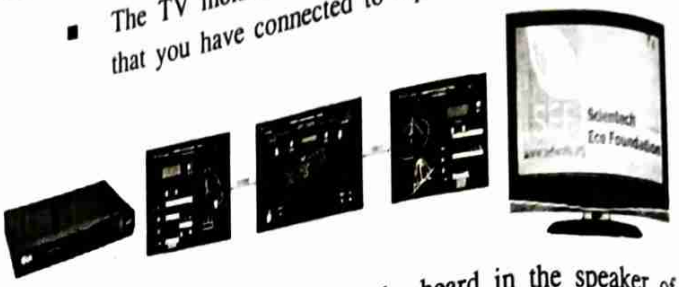
using 'Channel Select B key, so as to hear the tone signal. The Tone signal is switched to Speaker of Receiver.



- Connect TV monitor to the Audio/Video output of Downlink Receiver. (Video from Video Output, audio from Audio I output) Set TV in AV Mode.



- The TV monitor will display video and audio signal that you have connected to Uplink Transmitter input.



- Also the tone signal can be heard in the speaker of receiver.
- Try link fail by using Transponder "OFF".

Result :

Three separate signals (Audio, Video and Tone) are successfully received at Downlink Receiver through satellite communication link.

Procedure to Setup an Active Satellite Link and Demonstrate Link Fail Operations :

1. Place uplink transmitter, transponder and downlink receiver at a convenient distance of 3 meters, in a triangular manner.
2. Set first dish antenna of uplink Transmitter and R1 receiving dish antenna of satellite transponder position in sight.
3. Set X2 transmitting antenna of satellite transponder and R2 dish antenna of downlink receiver position in sight.
4. Set downlink frequency to 2414 MHz by frequency selection switch on board.

5. Now connect tone output signal to tone input socket onboard uplink Transmitter by patch cord.
6. Keep downlink receiver speaker switch in ON position and you will be to hear tone in speaker of receiver.
7. When the frequency combinations of transmitter and receiver are mismatched no signal is received and no tone can be heard on the downlink receiver. This demonstrates satellite link failure operations.

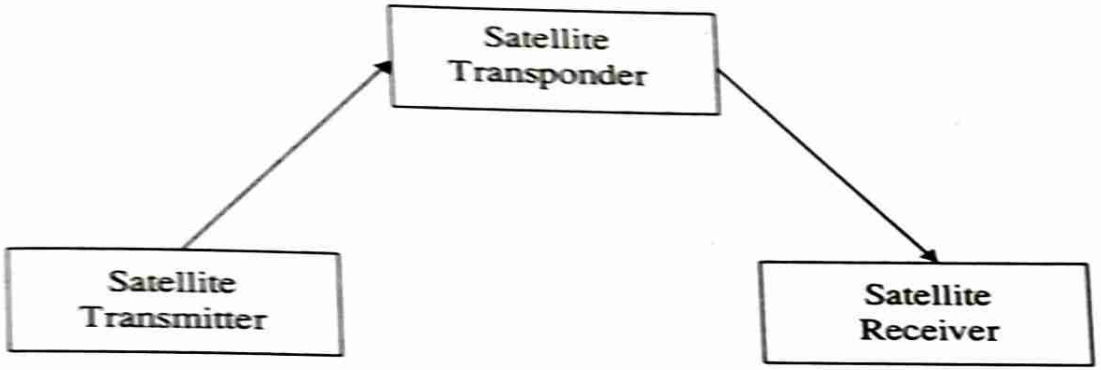


Fig. : Block Diagram of Satellite Communication System

Result :

Hence active satellite link and its failure operation is demonstrated.

Week 7

Week 7

Theory

7.1 Satellite Communication System

7.1.1 Transponder

7.1.2 Types of Transponder/Repeater

7.1.3 Single - Conversion Transponder

7.1.4 Double - Conversion Transponder

7.1.5 Regenerative Transponder

7.2 Increasing Channel Capacity

7.2.1 Frequency Reuse

7.2.2 Spatial Isolation

7.3 Communication Satellite Subsystems

7.4 Earth Stations

7.5 Applications Payload

Practical Experiment

7.1 Find the Delay between Uplink Transmitter and Downlink Receiver during Data Transmission using Satellite Communication Trainer Kit

7.2 Demonstrate Working of Satellite Transponders using Satellite Communication Trainer Kit

7.1 Satellite Communication System :

A satellite communication system does the following operation :

- The satellite receiver picks up the signal from the transmitting earth station.
- It amplifies the signal and translates it to another frequency.
- The satellite transmitter transmits the new frequency signal to the receiving earth station.

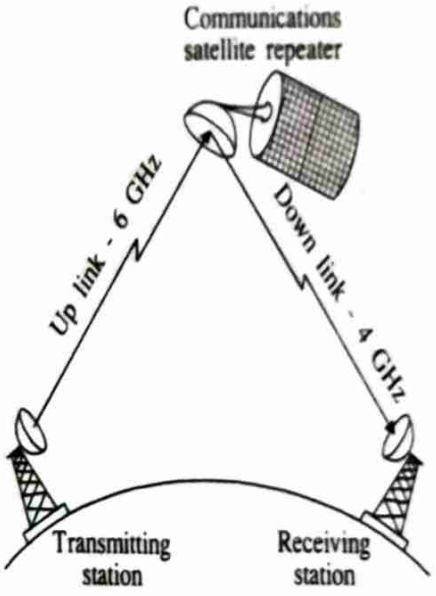


Fig. 7.1

An earth station transmits the information signal to the satellite. The satellite receives this signal amplifies it and then translates it to another frequency. The satellite contains a transmitter which retransmit this new frequency signal to the receiving earth station. The original signal being

transmitted from the earth station to the satellite is called up-link. A typical up-link frequency is 6 GHz. The retransmitted signal from the satellite to the receiving earth stations is called the **downlink.** A typical down-link frequency is 4GHz. Thus from the observation the down-link frequency is always lower than the up-link frequency.

7.1.1 Transponder :

A transponder is the combination of receiver and transmitter in the satellite. The main function of the transponder is the process of the amplification and frequency translation. The reason for the amplification is that the signal has to travel a long distance hence may become weak. To increase the strength of weak signal the amplification is done. The reason for frequency translation is that the transponder cannot transmit and receive on the same frequency since the uplink frequency is different from the down link frequency. The basic operation of the transponder is illustrated in the below figure 7.2.

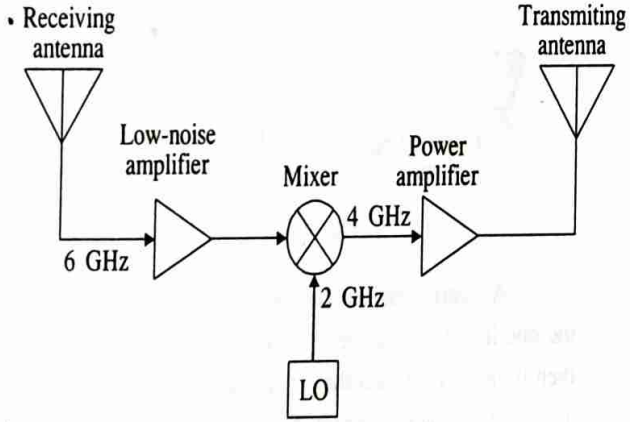


Fig. 7.2 : A satellite transponder

7.1.2 Types of Transponder/Repeater :

There are three basic transponder configurations used in communication satellites. They are as follows :

- Single - Conversion Transponder.
- Double - Conversion Transponder.
- Regenerative Transponder.

7.1.3 Single - Conversion Transponder :

The transponder in which only a single frequency translation process takes from the received signal to the transmitted signal within the satellite is called a single - conversion transponder. The basic block diagram of a single - conversion transponder is shown in the below figure 7.3.

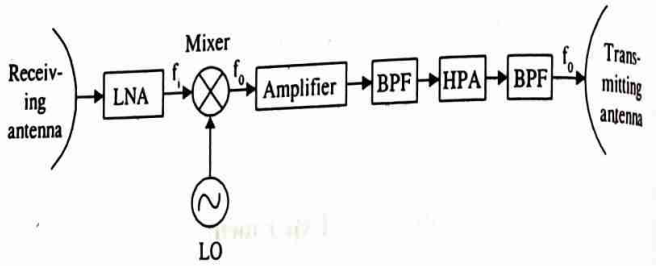


Fig. 7.3

The receiving antenna picks up the up-link signal and the signal is first routed to a low-noise amplifier (LNA). The signal is very weak at the receiving antenna point so the amplifiers with an extremely low noise figure or noise temperature must be used to increase the level of the signal.

After amplifying the signal, it is translated in frequency using mixer circuit. Any original modulation is retained during the frequency translation process. The output of the mixer is again amplified and fed to a bandpass filter. The bandpass filter will remove all except the down-link signal of 4GHz and channelize the output. i.e., the input signals on a specific frequency will be accepted by BPF.

Finally, the down-link signal is amplified by a high-power amplifier (HPA), usually a travelling-wave tube (TWT) is used. The output of the HPA is fed to the band pass filter (BPF) again to eliminate harmonics and inter modulation products which are the unwanted signals that are generated as the result of non-linearities in the TWT. The resulting output is fed to the down-link antenna. In some cases, both the receive and transmit antennas are same. A duplexer is used to separate the transmitting and receiving signal.

7.1.4 Double - Conversion Transponder :

The transponder in which two frequency conversions are carried out from the received signal to the transmitted signal within the satellite is called a double-conversion transponder. The basic block diagram of a double conversion transponder is shown in the above figure 7.4. The basic function circuits of this system are similar to that of a single conversion. The only difference is that here two frequency conversions are carried where as in single conversion transponder only one frequency conversion is carried out.

The receiving antenna receives the up-link signal and fed it to the LNA to increase the level of weak signal. The output of the LNA is routed in to the first mixer. The first mixer translates it into an IF typically 70 and 150 MHz. The output of the first mixer is fed to the IF amplifier to achieve a high gain.

The high gained signal is fed to the second mixer which translates the signal to the output frequency. Then this signal is passed into the BPF to eliminate the unwanted

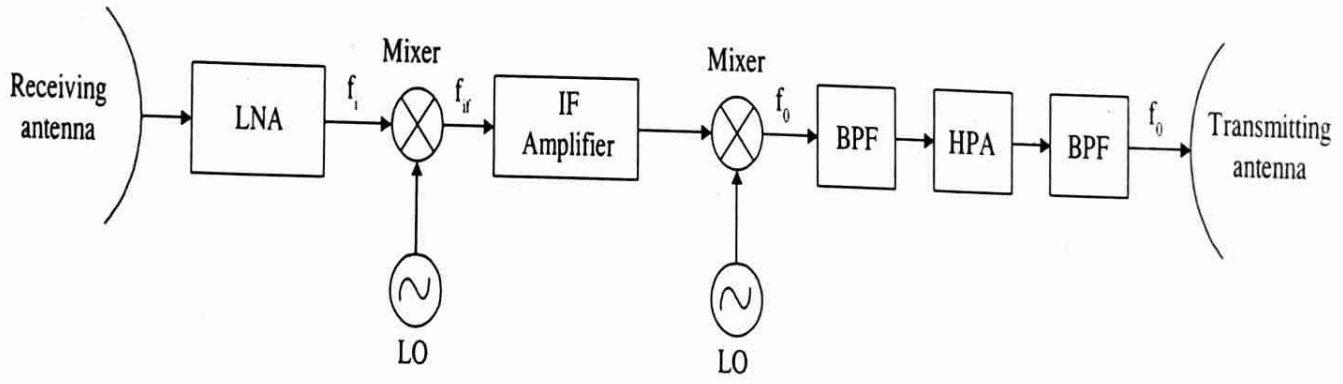


Fig. 7.4

mixer output and produces channelization. This filtered signal is fed to the HPA to increase the signal level and fed into the BPF which removes the harmonics and intermodulation components. Finally, the resulting output is fed to the down-link antenna.

The double-conversion transponder has the greater flexibility in filtering and amplification. And also the amplification and selectivity at the lower IF level is for easier to attain.

7.1.5 Regenerative Transponder :

The transponder which performs the basic amplification and frequency translation function. And the received signal is actually demodulated and then modulated to create the down-link signal. Such a transponder is called regenerative

transponder. The basic block diagram of the regenerat
transponder is shown in the below figure 7.5.

The up-link signal is amplified and frequen
translated by the LNA and mixer circuits respectively as
the earlier two transponder. The output of the mixer
demodulated by the demodulator. Hence the output of
demodulator is the base band signal. The base band sign
is fed to a modulator along with a carrier at the down-li
frequency. The modulation is usually a frequency modulat
The signal is then amplified filtered and transmitted ov
the down link as in the single and double conversi
transponders.

Advantages of Regenerative Over the Other Two :

Some of the advantages of regenerative transpond
over the single-conversion and double conversion transpond
are as follows :

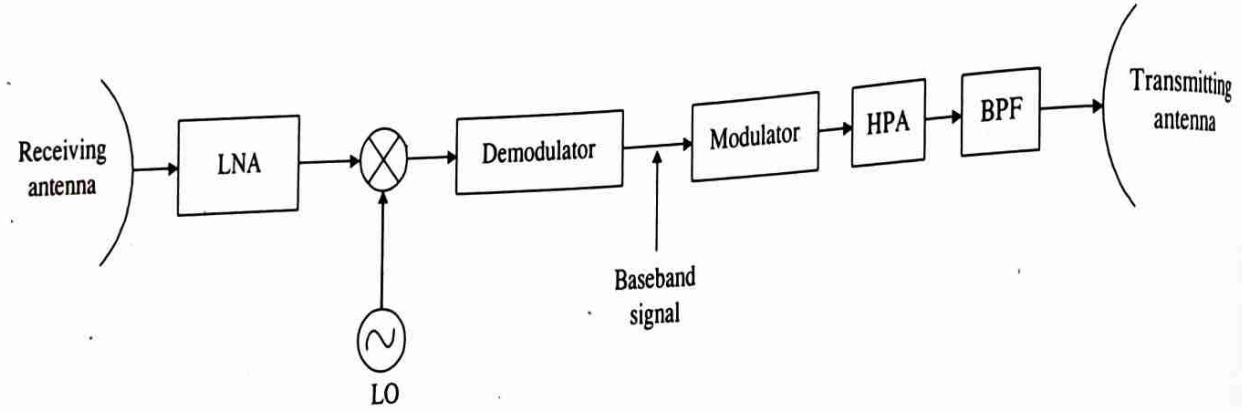


Fig. 7.5

- It permits both the receiver and transmitter sections of the transponder to be optimized. The receiver ends at the demodulator and the transmitter begins at the modulator input.
- The amplification circuits are simpler and less expensive and is easier to obtain the low base band frequencies.
- Signal to noise ratio (S/N) can be improved.
- In multi transponder satellites with input and output switching, the regenerative arrangement is simpler and more flexible to implement.

7.2 Increasing Channel Capacity :

The channel capacity of the satellite is increased to overcome the over loading with traffic Numerous techniques have been developed to increase the bandwidth and signal-carrying capacity of the satellite. The main two techniques are as follows :

- Frequency reuse
- Spatial isolation.

7.2.1 Frequency Reuse :

The frequency reuse effectively doubles the bandwidth and information carrying capacity of a satellite. Here a satellite is provided with two identical sets of 12 transponders. The nth channel in one transponder operates on the same channel as the nth transponder in the other set. A special

antenna techniques are used to separate the two systems although operating on the same frequencies.

A signal that is transmitted with vertical polarization will not be received on an antenna that is horizontally polarized and vice versa. AT microwave frequencies, the polarization can be more accurately controlled. Some types of antennas also use the circular polarization such as left-hand and right-hand circular polarization. An antenna using one cannot work with the other.

Two completely separate sets of transponders operating on the same frequency can be used simultaneously by using transmitting and receiving antennas that are vertically or horizontally polarized or that use left or right hand polarization. Once set of 12 transponders will have a vertically polarized or left hand circular polarized antenna-The other set will use horizontal or right hand circular polarization. The signals will not interfere with one set to other set by careful positioning and orientation of the antenna. For example, if two earth stations transmission the same frequency but with different polarizations, one will be selected by one transponder but rejected by another. In the same way two transponders transmitting signals on the same frequency but with different polarizations will not interfere. In this way, two 500MHz band widths with signal carrying capacity can be included in a satellite.

7.2.2 Spatial Isolation :

Spatial isolation is one more technique whereby additional information carrying channels can be obtained. Here very narrow beam width antennas are used to focus the down-link signals to specific areas of the earth. Such antenna's

are also called as spot-bream antennas. The signals can be confined to a particular area by using such antennas to a particular area.

Hence in this way by using spatial isolation, different earth stations can use the same frequencies and do not

interfere with one another because of the highly directional antennas. Thus, the total band-width or information-carrying capacity of the satellite can be doubled. For example, a satellite could contain up to four sets of 12 transponders each, all using the same frequencies. A total of 48 transponders can be used with frequency reuse techniques as well as spot beams.

7.3 Communication Satellite Subsystems :

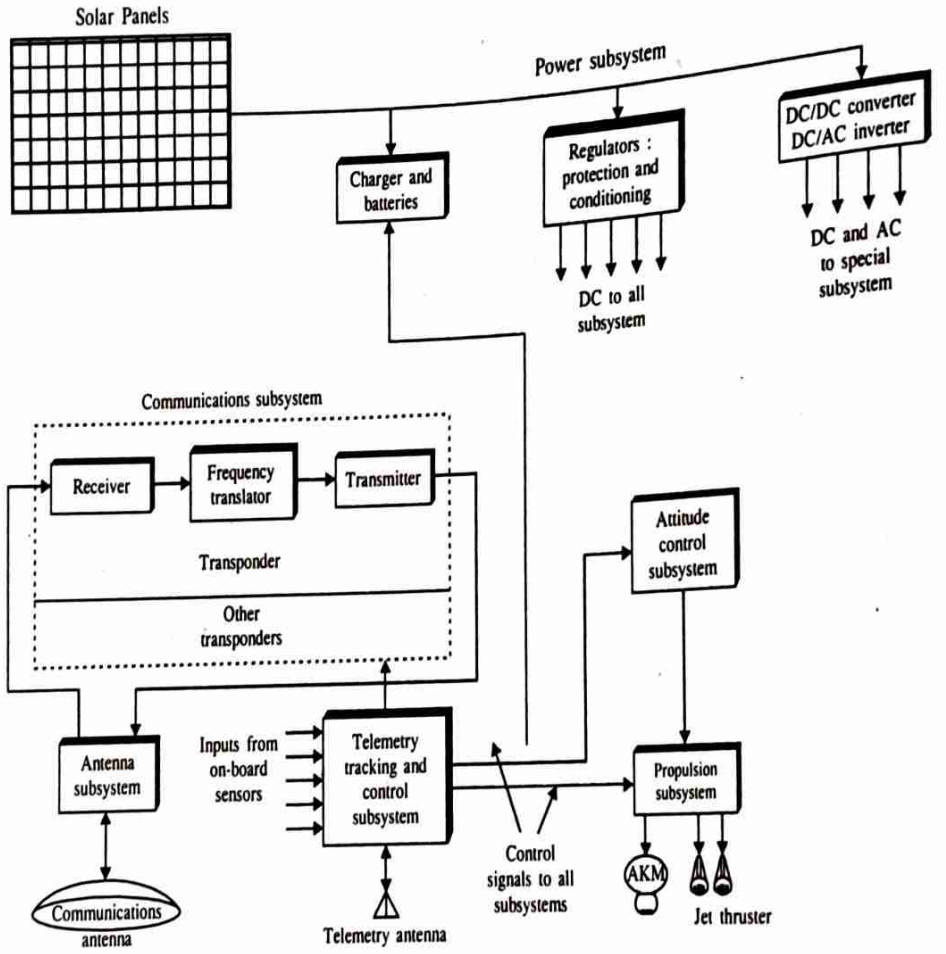


Fig. 7.6

The satellite performs the function of a radio repeater or relay station. Two or more earth stations may communicate with one another through the satellite. The satellite sub-systems architecture and its organization block diagram is shown in the above figure 7.6.

The satellite consists the following subsystems :

- Solar panels.
- Power subsystem.
- Communications subsystem.
- Telemetry, tracking and control subsystem. (TT & C)
- Attitude control subsystem.
- Propulsion subsystem.
- Antenna subsystem.

Each subsystem is discussed briefly as below :

Solar Panels and Power Subsystem :

The solar panels supply the electrical power for the satellite. Here both dc-to-dc converters and dc-to-ac inverters are used to supply special voltages to some subsystems. The solar panels drive the regulators that distribute dc power to all the subsystem. They also charge the batteries that operate the satellite during eclipse periods.

The solar panels are large arrays of photocells connected in various series and parallel circuits to create a powerful source of direct current. These solar panels are capable of generating many kilo watts of power. The dc power is typically used to charge nickel cadmium batteries that act as a buffer. At times when the satellite goes into an

eclipse or when the solar panels are not properly positioned, the batteries take over temporarily and keep the satellite operating. The basic dc voltage from the solar panels is conditioned by passing it through the voltage regular circuits before being used to power individual electronic circuits.

Communication Subsystem :

The communication subsystem is the main subsystem of the satellite. It performs the function of a repeater. It mainly consists of a transponders i.e., Receiver, frequency translator and transmitter. An earth station takes the baseband signals to be transmitted and frequency modulates a microwave carrier. The most common baseband signals are voice, video and computer data. These up-link signals are then amplified, translated in frequency and retransmitted on the down link to one or more earth stations. This is the main function of the transponder. Most advanced communication satellites contain at least 12 transponders and even more. All these transponders operate in the microwave frequency range.

Telemetry, Tracking and Control Subsystem (TTC) :

The Telemetry, Tracking and Control Subsystem allows a ground station to monitor and control conditions the satellite. It typically consists of various electronic sensors for measuring temperature radiation level, power supply voltages and other key operating characteristics.

The satellite contains a command receiver which receives control signals from an earth station transmitter. The control signals are typically made up of various digital

codes that tell the satellite what to do. Usually, the control signals are processed by a non-board computer, where most of the satellites now contain a small digital computer, usually microprocessor base, that acts as a central control unit for the entire satellite. The computer contains a built-in ROM with a master control program. This master control program operates the computer and causes all other sub-systems to be operated as required.

Attitude Control Subsystem :

The attitude control subsystem provides stabilization in orbit and senses changes in orientation. It fires the jet thruster to perform attitude adjustment and station keeping maneuvers that keep the satellite in its assigned orbital position.

Propulsion Subsystem :

A propulsion system is usually the apogee kick motor used to put the satellite into final orbit or it may be one or more liquid or solid propellant rockets that could be used to change the orbit of a satellite or remove the satellite from orbit. The propulsion system is also operated by the on-board computer in response to the command control sub-system.

Antenna Subsystem :

Antenna subsystem uses one or more antennas for receiving signals from the ground station and transmitting

information back to earth. Numerous antennas are generally required because of the various satellite requirements such as relay purposes, telemetry, tracking and control functions. It contains an omni directional antenna that is specifically used on the common receiver.

7.4 Earth Stations :

The earth station is also called as ground station. It is the terrestrial base of the system. The earth station communicates with the satellite to carry out the designated mission. In early days the antenna of the earth station was huge size and hence used to locate in the remote areas. Today earth stations are much less complex and the antennas are smaller. The earth station is made up of a number of subsystems. Most of the subsystems are larger and much more complex. Further, some additional subsystem existing at the earth stations are not applicable to the satellite. The major subsystems that are mainly applicable to the satellite are as follows :

- The antenna subsystem.
- The receive subsystem.
- The transmit subsystem.
- The Ground Communication Equipment (GEC) subsystem.
- The power subsystem.

All the above mentioned subsystems of the earth station are clearly illustrated in the below figure 7.7.

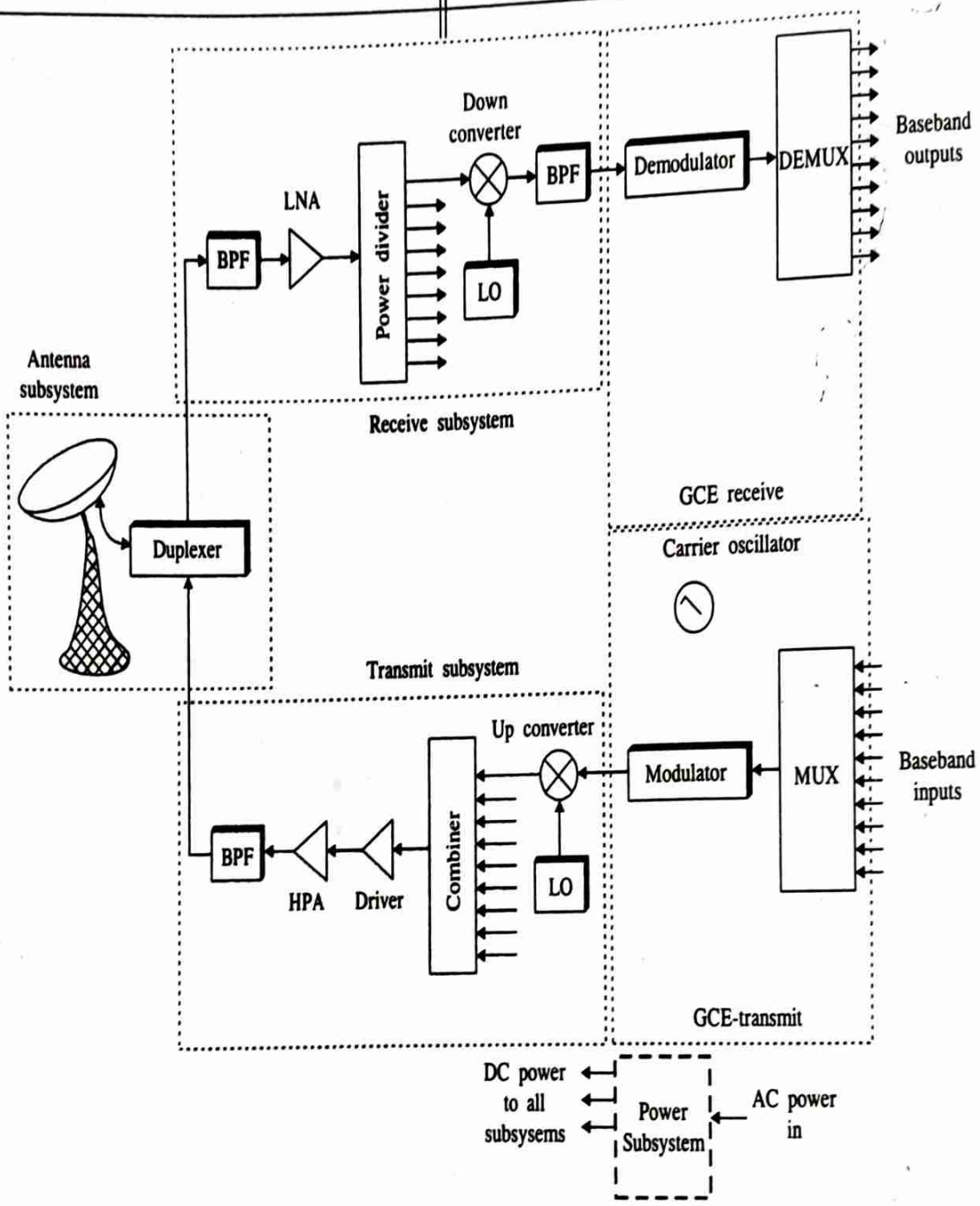

Down
converter
BPF
Demodulator
DEMUX
Baseband
outputs
LNA
BPF
Power divider
LO
Antenna
subsystem
Receive subsystem
GCE receive
Carrier oscillator
Duplexer
Transmit subsystem
Up converter
Modulator
MUX
Baseband
inputs
BPF
HPA
Driver
Combiner
LO
GCE-transmit
DC power
to all
subsysems
Power
Subsystem
AC power
in

Fig. 7.7

Antenna Subsystem :

The antenna subsystem mainly consists of :

- Parabolic reflector
- Duplexer
- Waveguide assembly etc.

The earth station antennas were 80 to 100 ft or more in diameter in early days and is still used in some satellite systems today. Modern satellite uses antennas as small as 2 or 3ft in diameter. The same antenna is used for both transmitting and receiving by a waveguide. A special coupling device called a duplexer used for microwave signals, permits a single antenna to be used for multiple transmitters and/or receivers. But for some applications a separate antenna is used for telemetry and control functions. The duplexer feeds a signal to the band pass filter (BPF) of the receive subsystem and picks up the signal from the output of the band pass filter. (BPF) of the transmit sub-system.

Receive Subsystem :

The receive subsystem consists of :

- Band pass filters (BPF)
- Low Noise Amplifiers (LNA)
- Power divider
- Down converter
- Local oscillator (LO).

The BPF picks up the signal from the duplexer of the antenna subsystem. The BPF blocks the high power transmit signal which can occur simultaneously with reception to prevent overload and damage to the receiver. The output of the BPF is passed into the LNA to increase the level of the signal and then fed to the power divider. Power divider is a waveguide assembly that splits the received signal into smaller but equal power signals. The power divider feeds the signals to the several down converters. Down converters mix the signal with the LOs that translate the received signals down to an IF, usually to 10MHz. This signal is fed to the BPF again to select the proper side bands from the output of the down converter. This filtered signal is fed into the demodulator of the GCE receive subsystem.

Ground Communication Equipment (GCE) Subsystem :

The GCE subsystem consists of :

- GCE receive portion
- GCE transmit portion.

The GCE receive portion consist of demodulators and demux where as the GCE transmit portion consists of mux and the modulators.

The IF signal containing the data is received by the demodulator from the BPF of the receive subsystem. The single is demodulated and fed to the Demux where the original signals are fully obtained. Thus, the outputs of the demux are usually the base band or original communications signals. The actual systems makes use of several demodulation and demultiplexing to obtain the original signals.

The base band signals are applied to the multiplexer of the GCE - transmit which permits multiple signals to be carried on a single channel. The output of the multiplexer fed to a modulator along with the carrier oscillator. The output of the modulator is usually at the 70MHz IF. The actual systems makes use of several multiplexing and modulation circuits. The output of the modulator is fed to the up converter of the transmit subsystem.

Transmit Subsystem :

The transmit subsystem mainly consists of :

- Up converter
- Local Oscillator (LO)
- Combiner
- Driver
- HPA
- Band Pass Filters (BPF).

The up converter picks up the signal from the local oscillator and the output of the modulator. The up converter is used to generate the correct carrier channel. All the up converted signals are then applied to a power combiner. This combiner combines all the RF signals into the final signal to be transmitted. This feeds to a driver circuit and then to the HPA. The HPA is usually the TWT or klystron used to increase the level of the signal. The output of the HPA fed to the band pass filter (BPF) to get the required signal. The signal is fed to the diplexer of the antenna subsystem.

Power Subsystem :

The power subsystem is used to provide the power to all the subsystems of the earth station. The primary sources of power are the standard ac power lines. The power subsystem also consists of emergency power sources such as diesel generators batteries and inverters to ensure continuous operation during power failure.

7.5 Applications Payload :

All satellites have an applications subsystem made up of special components that make the satellite useful for the purpose intended.

- The communications satellite use the subsystem as the transponder to receive and transmit the information.
- The scientific satellite use the subsystem as a special instrumentation package which includes various sensors, signal conditioning electronics, telemetry equipment, tape recorder etc.
- The observation satellite use the subsystem as the television cameras to pick up various conditions on earth and in the atmosphere acting as intelligence gathering or weather monitoring satellite.
- There are many other satellites having variations in the subsystem depending upon its usage.

Practical Experiment 7.1

Note: Depending upon the kit manufacturing company, working/ procedure varies. Here I took the kit manufactured from Scientech to illustrate working/procedure. Courtesy : Scientech.

Find the Delay between Uplink Transmitter and Downlink Receiver during Data Transmission using Satellite Communication Trainer Kit

Aim/Objective :

Study the delay between Uplink Transmitter and Downlink Receiver during data transmission.

Equipments Needed :

- Uplink Transmitter
- Dish Antennas
- Downlink Receiver
- Connecting cables
- Digital Storage Oscilloscope
- Satellite Transponder.

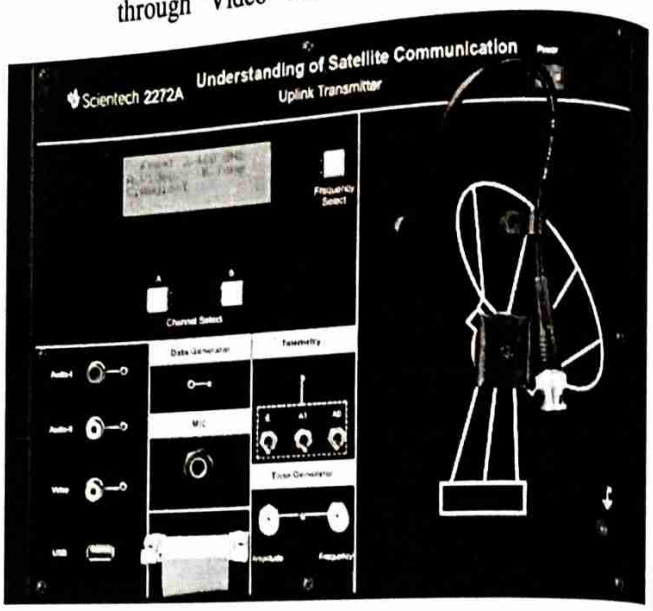
Procedure :

- Once you get the set up ready as per the experiment need, proceed as follows.
- Carry out the following settings at all three units starting from Uplink Transmitter then Satellite Transponder and

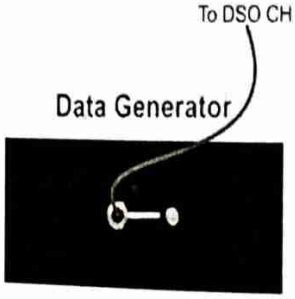
at last Downlink Receiver. This sequence of operation must be followed to avoid any kind of improper operation of the system.

Setting at Uplink Transmitter :

- Now set the "Channel A" to 'Data' mode using the 'Channel Select A' key, so as to transmit data signals from Uplink Transmitter. The data signals are transmitted through 'Video' channel of the transmitter.

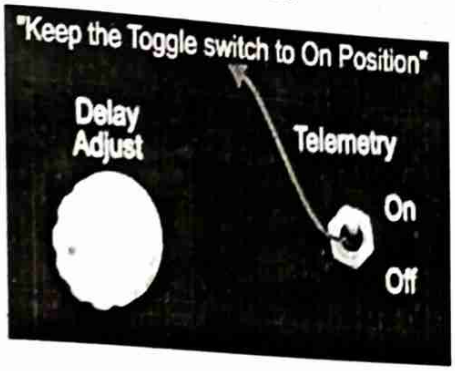


- Connect the DSO CHI to Data Generator testpoint.



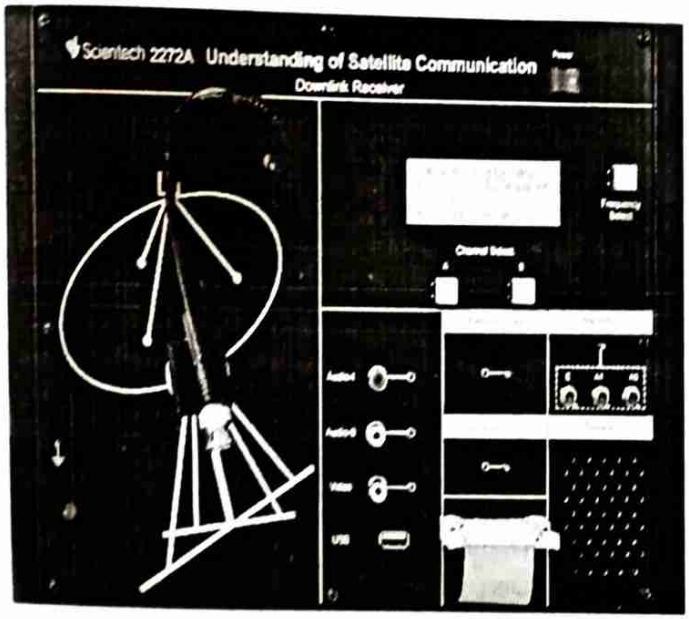
Setting at Satellite Transponder :

- Keep the toggle switch to 'Telemetry On' position prey, at Satellite Transponder unit.

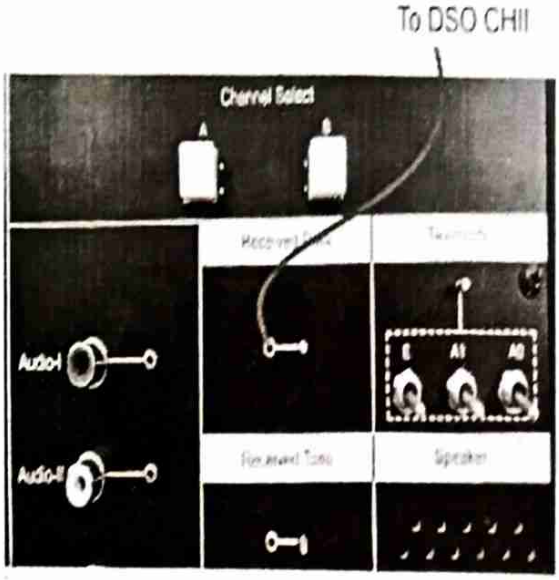


Setting at Downlink Receiver :

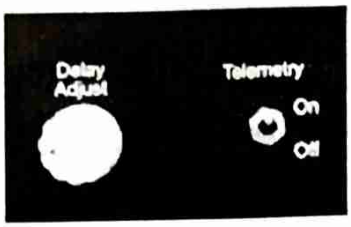
- Now set the "Channel A" to 'Data' mode using the 'Channel Select A' key, so as to receive data signals from Uplink Transmitter. The data signals are received through 'Video' channel of the receiver.

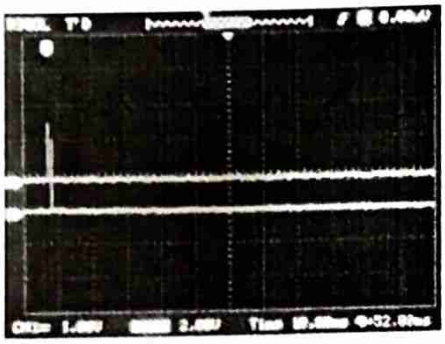


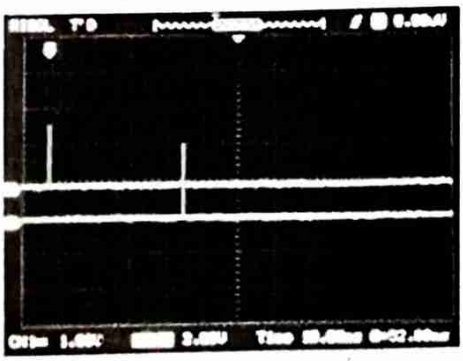
- Connect the DSO CHIT to 'Received Data" section and observe the data.



- The recommended DSO settings are as follows :
  - o Adjust the Time/Div knob at 50 ms.
  - o Adjust Volt/Div. Knob at 2 V.
  - o Set appropriate trigger level, so that the signal becomes stable on screen.
  - o Select Acquisition mode to 'Normal' position.
  - o Select Display 'Persist' to 'Off' position.
- Now gradually rotate the 'Delay Adjust' knob and observe the changes in the delay between the transmitted and received data.







Result :

The delay between Uplink transmitter and Downlink receiver during data transmission using satellite communication trainer kit is studied and verified.

Practical Experiment 7.2

Demonstrate Working of Satellite Transponders using Satellite Communication Trainer Kit

Aim/Objective :

Establishing a direct communication link between Uplink Transmitter and Downlink Receiver using satellite transponders.

Equipments Needed :

- Uplink Transmitter
- Dish Antennas
- Downlink Receiver
- Connecting cables.

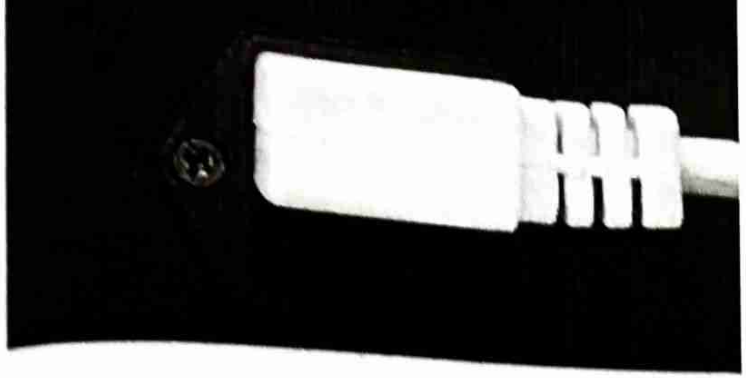
Procedure :

The Satellite Transponder receives signal from Uplink Transmitter and retransmits at different frequencies to a Downlink Receiver. The Uplink and Downlink frequencies are selectable and can have variety of signals such as Video, Audio, Voice, Tone, Data and Telemetry.

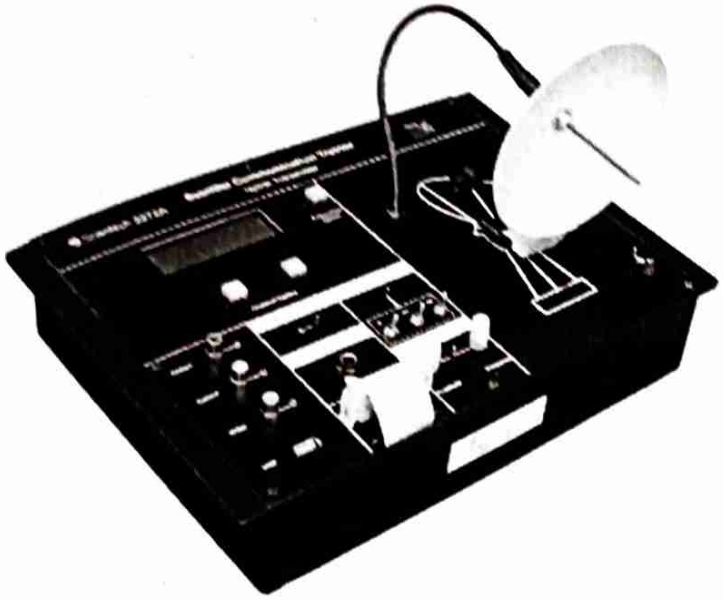
Introduction :

Uplink Transmitter controls Setting at Uplink Transmitter :

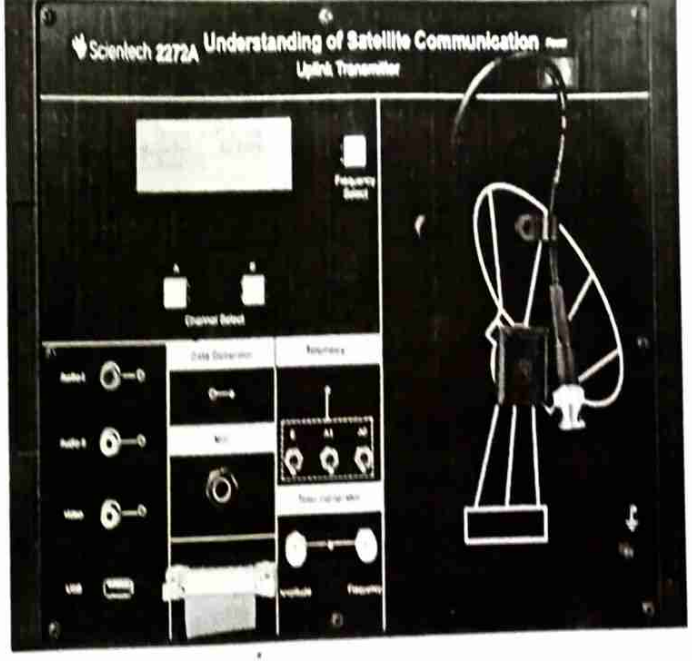
- Connect the Uplink Transmitter to AC Mains.



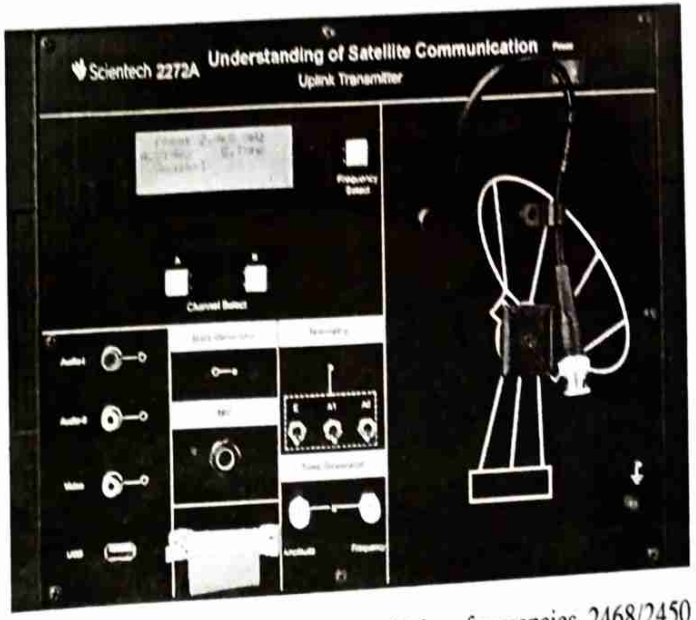
- Attach Antenna to Uplink Transmitter with BNC-BNC lead.



- Switch 'ON' the Uplink Transmitter and frequency display will come on. The transmitting frequency can be selected by 'Frequency Select' key. The available frequencies are 2414/2432/2450/2468 MHz.

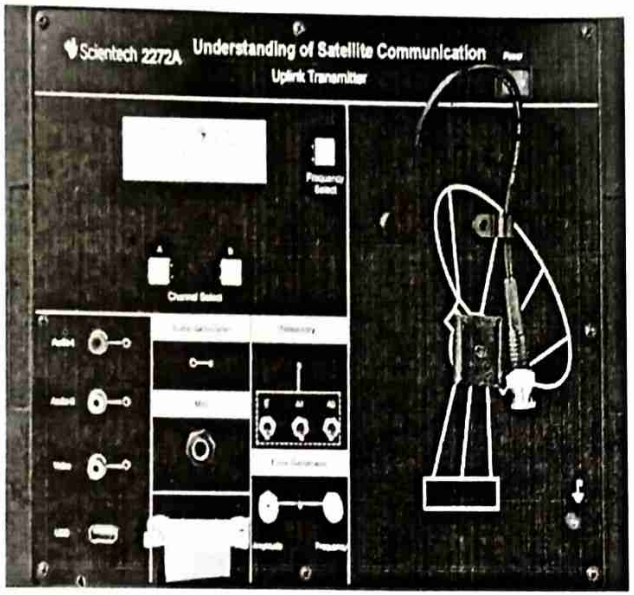


- Select uplink frequency to 2468 MHz.

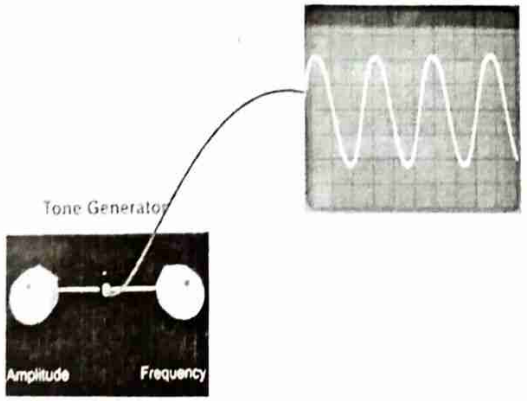


Note: It is suggested to select the higher frequencies 2468/2450 MHz always for Uplink transmission.

- Now set the "Channel B" to 'Tone' mode using the 'Channel Select B' key, so as to transmit tone signal from Uplink Transmitter. The 'Tone' signal is transmitted through 'Audio II' channel of the transmitter.

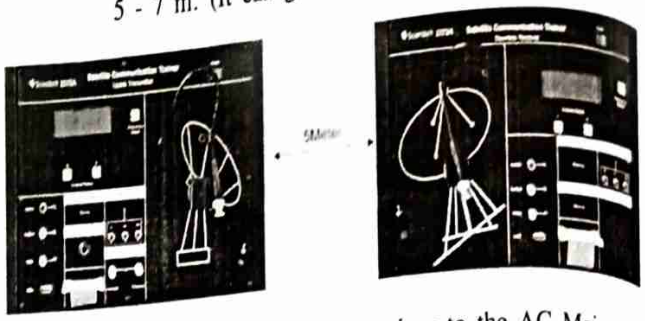


- The tone signal can be observed on oscilloscope at 'Tone Generator' section of Uplink Transmitter.



Setting at Downlink Receiver :

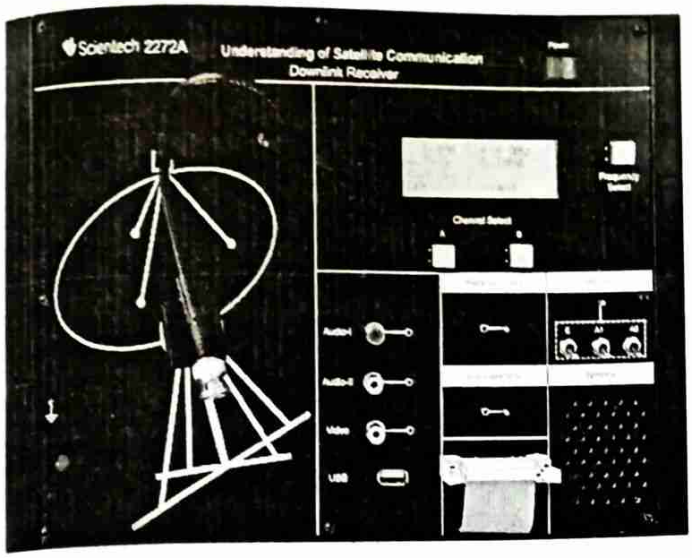
- Place Downlink Receiver at a convenient distance of 5 - 7 m. (It can go even up to 10 m.).



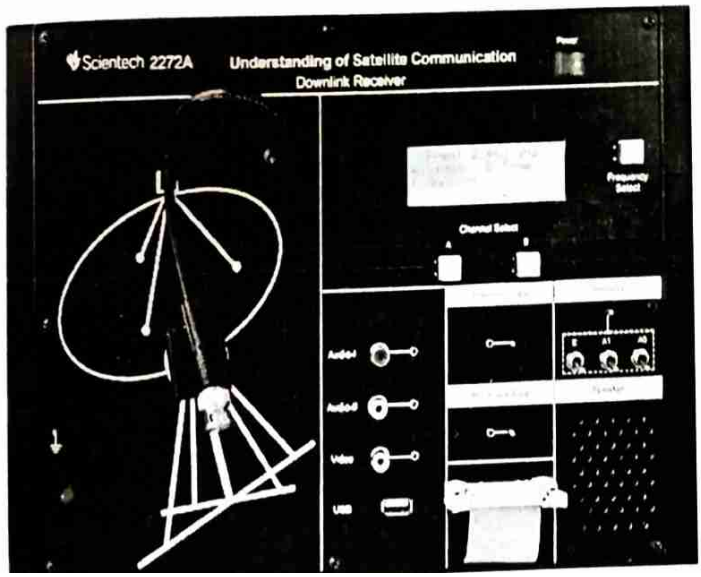
- Connect the Downlink Receiver to the AC Mains.

- Attach Antenna to the Downlink Receiver with BNC. BNC lead.

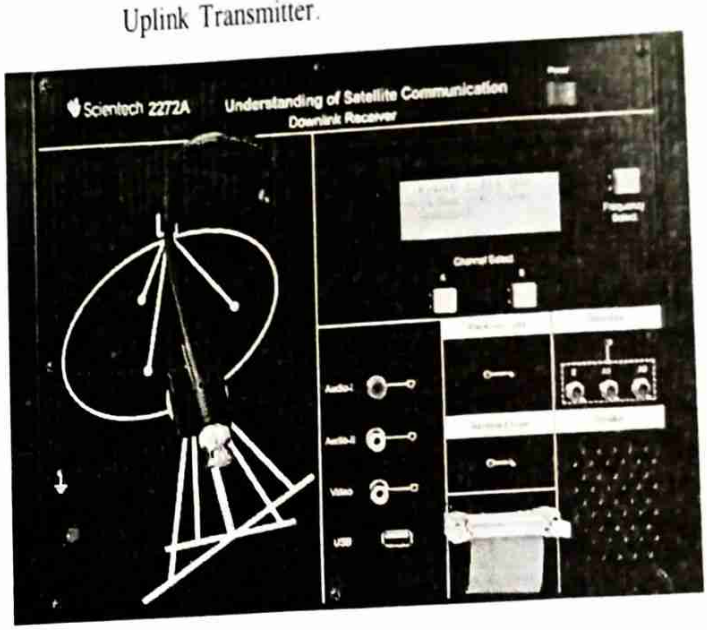
- Switch 'ON' the Downlink Receiver and frequency display will come on. The receiving frequency can be selected by 'Frequency Select' key. The available frequencies are 2414/2432/2450/2468 MHz.



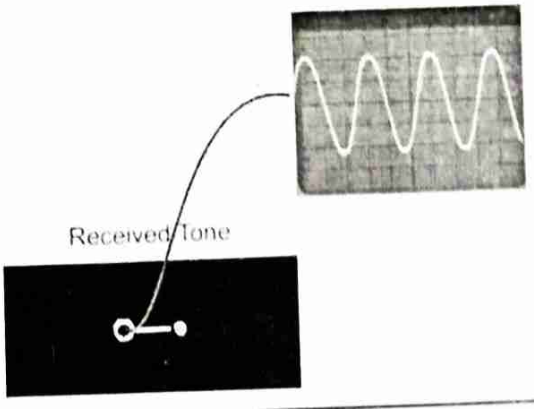
- Select the Downlink Receiver frequency same as to Uplink Transmitting frequency of 2468 MHz.



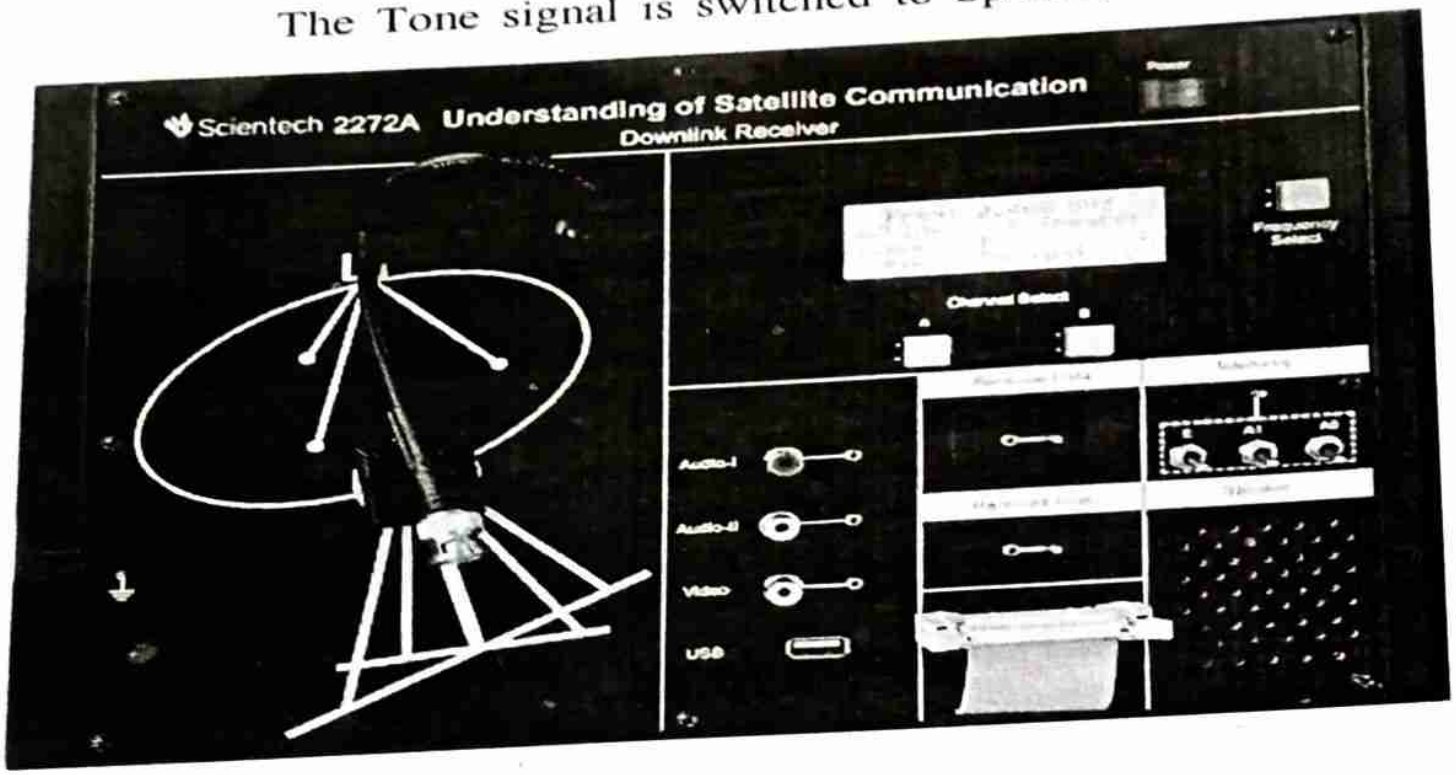
- Now set the 'Channel B' to 'Tone' mode using 'Channel Select B key, on as to receive tone sq.! from Uplink Transmitter.



- The tone signal can be observed on oscilloscope at 'Received Tone' section of Downlink Receiver. Observe the variations in the frequency and the amplitude of the received tone signal by varying the frequency and amplitude of tone signal at 'Tone Generator' section of Uplink Transmitter.



- Now set the 'Channel B' to 'Speaker' mode using 'Channel Select B key, so as to hear the tone signal. The Tone signal is switched to Speaker of Receiver.



Result :

A clear tone indicates that the direct communication link has been successfully setup between Uplink Transmitter and Downlink Receiver using Transponder.

Week

8

Theory

8.1 Global Positioning System (GPS)

8.1.1 Constituents of GPS

8.1.2 GPS Receiver

8.1.3 Applications of GPS

8.2 Satellite for Television Applications

8.2.1 Direct Home Reception (DTH)

8.2.2 Cable TV (CATV)

8.3 Satellite for Military Applications

8.3.1 VSAT Systems

Practical Experiment

8.1 Video demonstration and documentation on
a) Working of GPS System
b) Working of Satellite TV

8.2 Conduct an Experiment to Tabulate Latitude, Longitude, Plus Codes of Different Locations using a GPS Receiver in Mobile Phone and Learn Sharing of Live Locations

Every satellite is designed to perform some specific task. Its predetermined application specifies the kind of equipment it must have on board and its orbit, satellites are useful for many purposes. The main applications for satellites today is communications satellites used for this purpose act as relay stations in the sky. They permit reliable long-distance communications worldwide and solve many of the growing communications needs of industry. In this chapter we illustrated the basic applications of the satellite as television, DTH, telephone, GPS, VSAT etc.

8.1 Global Positioning System (GPS) :

Global positioning is a satellite navigation system. A very accurate digital read out of position is made and is assured to achieve positioning accuracy of 3 m with precise (p) code information. The primary aim of GPS was navigation for most ships and aircraft and is widely used in surveying and many other applications. The characteristic features of GPS are as follows :

- GPS is funded by and controlled by the U.S. Department of Defence (DOD). While there are many thousands of civil users of GPS worldwide, the system was designed for and is operated by the U.S. military.
- GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time.
- Four GPS satellite signals are used to compute positions in three dimensions and the time offset in the receiver clock.

- The reduced cost of GPS receiver made possible its use by a common users in cars and cellular phones.

8.1.1 Constituents of GPS :

Using a specific type and known number of satellites, the GPS can determine an accurate position. The complete GPS system for location identification is identified into three operational phases or segments. They are as follows :

- Space segment
- Control segment
- User segment.

Each of the above mentioned segments is described briefly as below :

Space Segment :

GPS satellites are present in the space segment of the system. The space vehicles (SVs) send radio signals from the space. The nominal GPS operational constellation consists of 24 satellites that orbit the earth in 12 hours.

Control Segment :

The GPS control segment consists of a system of tracking stations located around the world. Schriever Air Force Base in Colorado consists the master control facility location. The signals from the SVs which are incorporated into orbital models for each satellites is measured by these

monitor stations the models compute precise orbital data and SV clock corrections for each satellite.

User Segment :

The GPS user segment consists of the GPS receivers and the user community. GPS receiver convert SV signals into position, velocity and time estimates. Four satellites are required to compute the four dimensions of X,Y,Z position and time. The X, Y, Z represented receivers latitude, longitude and elevation respectively.

8.1.2 GPS Receiver :

The simplified block diagram of the GPS receiver is shown in the below figure 8.1. It is mainly consists the following functional units :

- Clock
- Pre amplifier and down converter
- Data bit demodulator and code control unit
- C/A code generator
- Processing block.

The GPS receiver measures the time delay of the arrival of the bit sequence which is proportional to the distance between the satellite and the GPS receiver. The clock in the receiver is synchronized in turn to the clock on each satellite that the receiver is receiving.

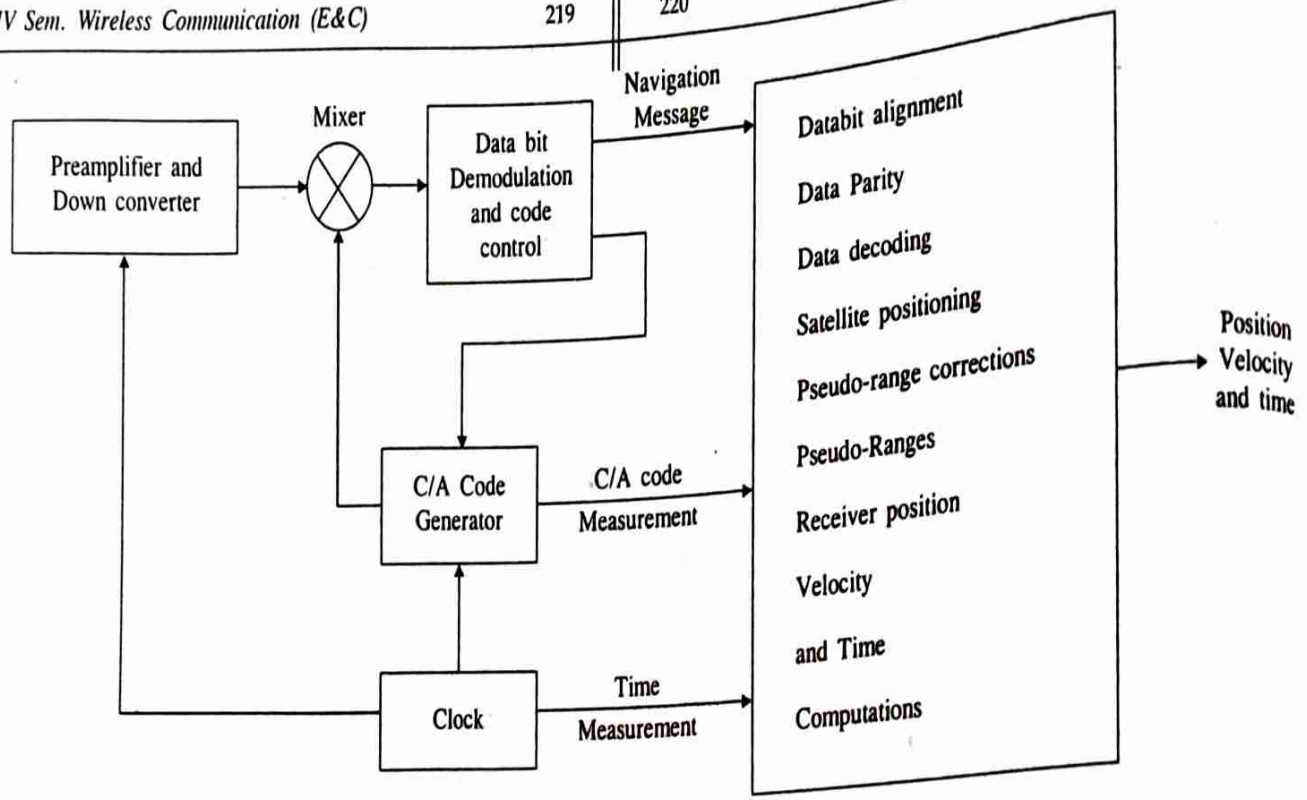


Fig. 8.1

The antenna is typically a circulary polarized patch antenna with LNA mounted on the printed circuit board. The antenna receives the signal and increases its level by the LNA (low noise amplifier). This signal is fed to the pre-amplifier and down converter stage. Here the signal is amplified and down converted into on IF signal. This IF signal is further processed into the Data bit demodulator and code control unit through the mixer circuit.

The IF signal is tracked and measured by the data bit demodulator and code control unit. This unit mainly consists of two phase locked loops operating at a quadrature phase shift i.e., 90^0. A 50 Hz navigation message is demodulated form the GPS carrier based IF signal. The signal 12+Q2 detected from this state is applied to C/A code generator for further processing.

The C/A code generator produces the C/A code sequence for a specific space vehicle under consideration for measurement. The required code bit streams are retrieved from memory in the memory look up scheme where as in hardware implementation, the code chips are shifted in time by slewing the clock that controls the shift registers.

The receiver searches or slides a replica of the code in time until there is correlation with the SV code. When the receiver uses the same code as the SV code and the code begins to line up, some signal power is detected. As the SV and receiver codes line up completely, the spread spectrum carrier signal is de-spread and full signal power is detected.

Processing block is used to receive the signals from the different units namely, data bit demodulation unit, C/A code generator and clock are processed accordingly to get information about parameters position, velocity and time of the GPS receiver carrying vehicle. In modern systems, this unit is implemented with standard algorithms and micro-processors.

8.1.3 Applications of GPS :

GPS has various applications, few of them are as follows :

Time : The free availability of GPS time has enabled the user to determine the precise time without the cost of owning and operating atomic clocks.

Aviation : To increase the safety and efficiency of flight, aviators use the GPS throughout the world.

Rail : To improve safety, security and operational effectiveness the rail systems in many parts of the world use GPS in combination with various sensors computers and communication systems.

Roads and Highways : The accuracy of the GPS offers increased efficiencies and safety for vehicles using highways, streets and mass transit systems.

Agriculture : The development and implementation of precision agricultures or site-specific forming is done by combining the GPS and GIS (Geographic Information Service).

Marine : The GPS provides the fastest and most accurate method for mariners to navigate, measure speed and determine location.

Environment : The GPS data collection systems provide the analysis of environmental concerns.

Public Safety and Disaster Relief : The GPS provides position information of disaster regions and allows to deliver disaster relief more timely. This helps in saving leaves and restoring critical infrastructure.

Recreation : The GPS has eliminated many hazards associated with common recreational activities by providing a capability to determine a precise location.

8.2 Satellite for Television Applications :

Satellite television refers to the use of satellites for relaying the TV programs, live or recorded from, a source point to a large geographical area. Here the satellite receives the telecast data which is beamed up towards it by an uplink and then broadcasts the same by reflecting without any change in the data by a down link.

The following are the few configurations of satellite television :

- DBS system
- CATV system
- DTH system.

8.2.1 Direct Home Reception (DTH) :

As the technology got improved day by day many advancements took in the direct Broadcast satellite (DBS). In the DBS - TV transmissions, they made the receiver as simple as afforded buy a normal customer and use it on his own cast. This came into the existence of direct home reception. In such broadcast system, each house top will have the "receive only" antenna which is capable of receiving TV programs directly from satellites. It is commonly called as DTH (direct-to-home) service. It is clearly illustrated in the below figure 8.2. As the technology developed many companies stated marketing their own "receive only" antenna and decoder set for direct satellite reception.

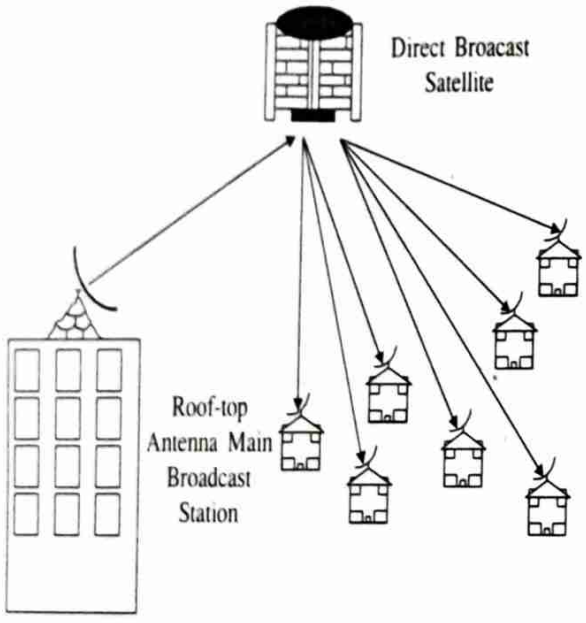


Fig. 8.2

8.2.2 Cable TV (CATV) :

The actual acronym CATV stands for community Antenna Television, which states that a single common receiving antenna is used for the community and the signal is distributed to a large number of house televisions through the network of cables. The main advantage of CATV is that it eliminates the need for an individual roof-top dish antenna to each of the houses of community. This concept is mainly useful for a huge buildings having hundreds of apartments where a single roof-top dish antenna is used at one place and received signal is distributed to all the apartments through the cable network. It is clearly illustrated in the below figure 8.3.

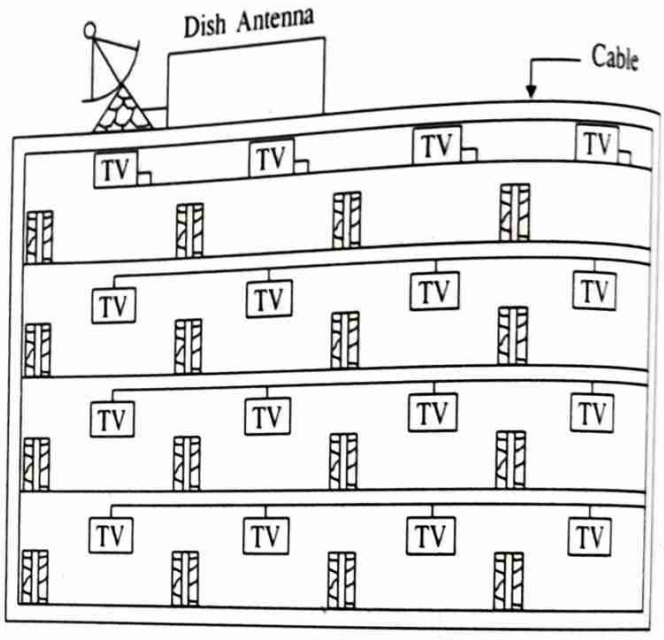


Fig. 8.3

The cable TV operator will have the root of entire cable TV distribution. He owns a roof of receive only earth stations with the capability to receive telecast of one or even more than on satellites, such receive only earth stations can be accomplished by having either many receiving roof-top dish antennas to receive telecasts from different satellites or a single roof-top dish antenna with multiple feeds with each feed is aligned to receive telecast from a particular satellite.

The received signal or signals are transmitted simultaneously over a distribution network of coaxial cables on single point to multi point connectivity basis to a large number of houses. The cable TV operator can also transmit many pre-recorded programs over his distribution network apart from the received telecasts.

8.3 Satellite for Military Applications :

The satellites are used in military applications both at war time and peace time. Some of the military applications are as follows :

- Early warning satellites.
- Reconnaissance and intelligence gathering functions.
- Navigation satellites.
- Command and communication.
- Nuclear detection.
- Meteorological functions.

8.3.1 VSAT Systems :

VSAT is the short form of "Very Small Aperture Terminal". It is a very small aperture terminal satellite system operated in Cu band with earth station antenna diameters of 1 to 2m and transmitters powers of 1 or 2w. Usually the earth stations are organized in a star network in such a system. Data rates from a few thousand bits per second upto 256 Kbps are possible on the links.

The VSAT systems is to bring telecommunication service directly to the end user without any intermediate distribution hierarchy. In many regions of world, geostationary satellites allied to microwave cellular technologies have been used to bypass the traditional analog telephony. The solution is wireless local loop (WLL) coupled with VSAT distribution architecture. In such a system the GEO satellite links a large number of VSATS with main switching center in a large

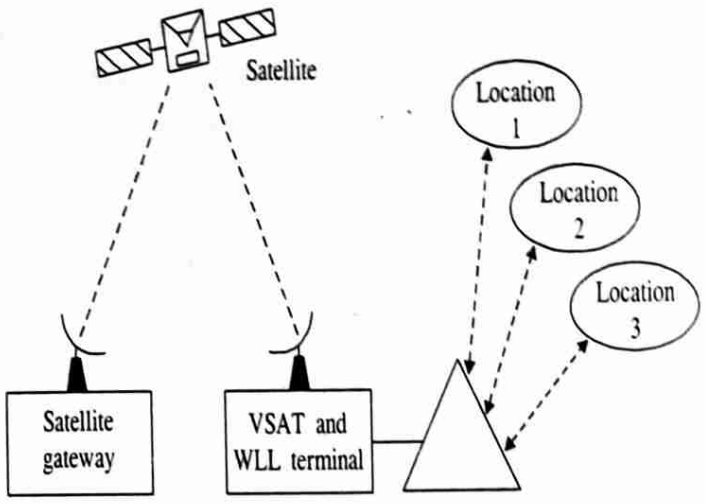


Fig. 8.4

city. Each VSAT acts as the link to the local switching center in the village or rural community with the final mile of the telephony link being carried over a wireless local loop (WLL). The concept is clearly illustrated in the above figure 8.4.

The main characteristics of VSAT/WLL networks are as follows :

- They allow multimedia traffic to be brought directly to the end user, but generally handle only small traffic streams.
- When ever a message is to be sent, the user access the satellite in a demand assigned multiple access (DAMA) mode and receives a short reply in due course.
- The interaction between the VSAT and the main hub earth station in the "point of scale" (POS) is completely automatic and transparent to the user.
- In many circumstances, the traffic in VSAT system is not enough for a dedicated satellite or one full satellite transponder, therefore they are designed around the use of leased transponders in the case of a large network or a fractional transponder lease for a medium to small network.

Practical Experiment 8.1

Video demonstration and documentation on

a) Working of GPS System

b) Working of Satellite TV

Note: Browse the below sample video links for the given experiment demonstration. The links shown here are sample illustrative only. Users can search such similar videos.

a) Sample Video Link on Working of GPS System

https://youtu.be/wCcARVbL_Dk

https://youtu.be/U3eX6QKS9kY

b) Sample Video Link on Working of Satellite TV

https://youtu.be/OpkatIqkLO8

https://youtu.be/n70zjMvm8L0

Observation/Result :

After watching the above sample demonstration videos or any such similar videos, write a brief note summary document in your own sentences about what you understand from the video.

Practical Experiment 8.2

Conduct an Experiment to Tabulate Latitude, Longitude, Plus Codes of Different Locations using a GPS Receiver in Mobile Phone and Learn Sharing of Live Locations

Aim :

To tabulate latitude, longitude, Plus codes of different locations using a GPS receiver in mobile phone and learn sharing of live locations.

Apparatus Required :

Smart Phone with Google Maps App installed and internet data.

Theory :

The exact values of latitude and longitude for a place are crucial while surveying, sharing location, or creating maps. Smartphones have made navigation easier by integrating GPS. But you know you can even get the co-ordinates of your location using your Android or iPhone? Many apps will provide you with the latitude and longitude of a place. You can simply follow the steps to find co-ordinates using your Android, iPhone, or a computer.

Find GPS Co-ordinates using Google Maps :

Anybody using a smartphone is familiar with Google Maps. It not only helps in route planning but also gives

real-time traffic information. Using Google Maps, you can easily find co-ordinates of your location and share it with others. iPhone or Android users can follow these steps to get proper latitude and longitude :

Procedure :

Step 1: Turn ON the GPS in phone settings.

Step 2: Go to Google Maps app on your Smartphone.

Step 3: Enter the location for which you want co-ordinates. You can also tap the "My Location" icon to get your current location.

Step 4: Now Press and hold the place until a red pin appears, but the point shouldn't have another label already present.

Step 5: See the search bar, when you drop in the location, you will find the co-ordinates in search bar.

Step 6: Scroll to get your all GPS co-ordinates latitude, longitude, plus codes and the address.

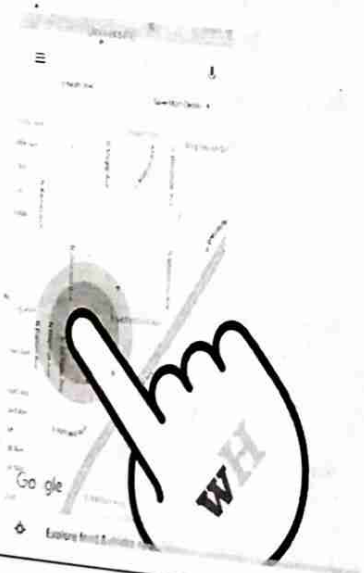
Step 7: Tap on the 'share' option to share the location. Share it with your phone number message/whatsapp/ telegram/mail etc that you can get the drop pin link easily. While sharing your current live location you can set time also.

Step 8: To open the link, now check the link in your messages/whatsapp/telegram/mail where you shared and open it.

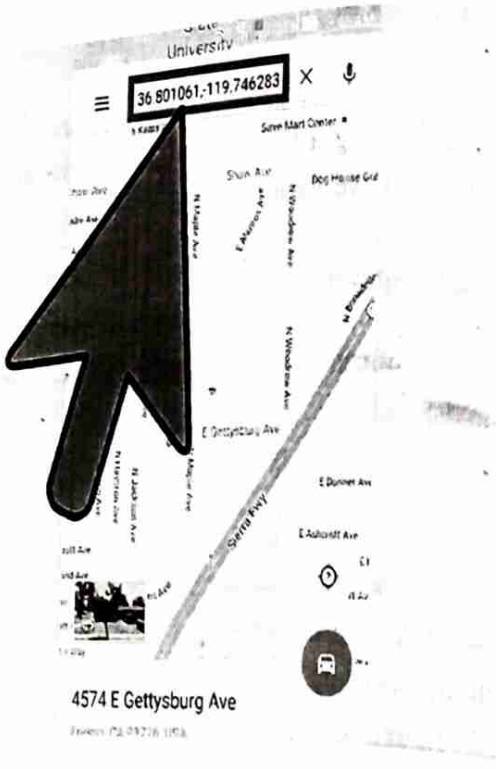
Step 9: When you open the link, Google maps will open. Now you can see latitude and longitude both on your search bar.

Procedural Steps illustration using Screen Shots :

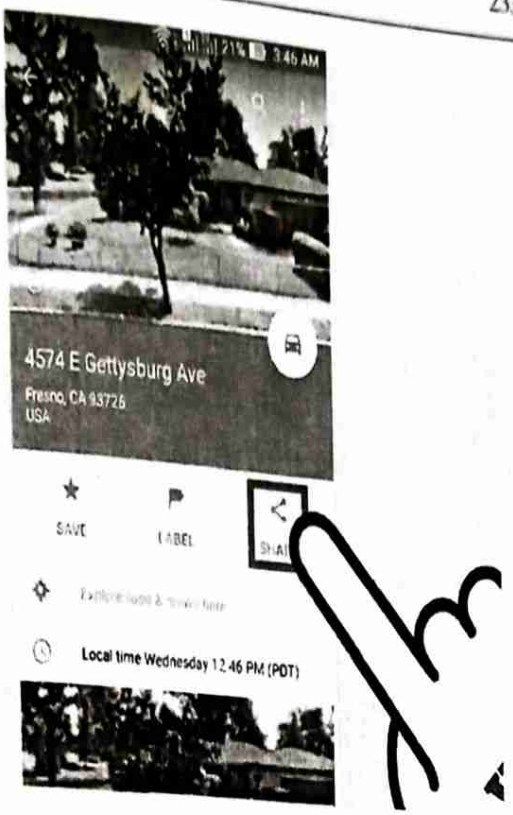
Step 1: Download and open Google Maps. Go to the Play Store (Android), search "Google Maps", and tap the Get/Install button next to the search result to download the app.



Step 2: Drop a pin where you want to get the latitude and longitude. Find the location on the map. Tap and hold down on the screen until a red pin appears at the location. You can also use the search bar to find a specific location such as a business address or park location.



Step 3: View the location's co-ordinates. After you have dropped a pin, look at the search bar at the top of the screen. The location's latitude and longitude will appear in the search bar.



Step 4: Share the location if you like. Tap the "Dropped Pin" tab at the bottom of your screen. Click "Share" and then choose the messaging application you would like to use. Send the message or email to yourself or to a friend. The share will include the location's latitude and longitude. The latitude co-ordinate is traditionally listed first in the co-ordinate pair.

Step 5: While sharing current live location you can choose how long you want to share your location.

Result :

Studied and Verified the process of finding latitude, longitude, Plus codes of different locations using a GPS receiver in mobile phone and sharing of live locations.

VCB

Week 9

Week 9

Theory

Practical Experiment

9.1 Satellite for Voice Communication :

Satellites are used in the applications of the telephone services. Satellites are mainly used for providing the long distance trunk or point-to-point telephone services. Here the satellite serves the purposes of repeater station to complete the link. It is mainly used where the distance between the two telephone exceeds 1000 Kms or where the region to be covered is sparsely populated or has difficult geographical terrain. For example, a typical setup of international telephone service via satellite is shown in the below figure 9.1.

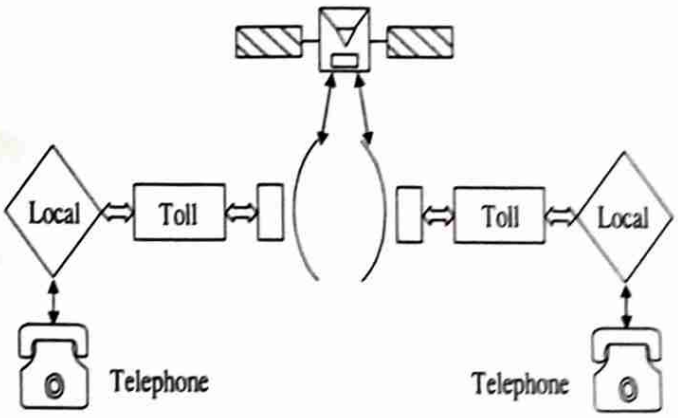


Fig. 9.1

9.2 Satellite for Data Communication :

The developments and advances made in the field of computers and telecommunications lead the data communication services. The main purpose of data communication is to create a link and exchange the data

between the computers or other data processing facilities by a communication channel. The communication channel could be a terrestrial or satellite based. Terrestrial based data communication have comparatively much lower data transfer speed, high cost, lesser reliability and lesser throughput capability. Satellite links are much attractive for data communication because of much higher data transfer rate, higher reliability, higher through put capability. In this text data broadcasting using satellites and the interactive data communication using satellite is described in brief.

9.2.1 Data Broadcasting using Satellites :

Data broadcasting using satellites is the most commonly used data communication application implemented

using a satellite. It is based on point to multi point connectivity configuration as illustrated in the below figure 9.2.

The data from a central database is routed to the earth station which has up-linking capability. This is done via another setup called data packet assembler. The data packet assembler is a data processing device that receives the data to be broadcast, organizes it into packets and places appropriate address bits at the beginning of the each packet. Thus each data packet is self contained with source and destination addresses and therefore can be routed over satellite on any way and finally through a terrestrial packet switched network. To have access of the information only to the authorized users the data packet is coded. But in case of news service, full access to all data is also provided.

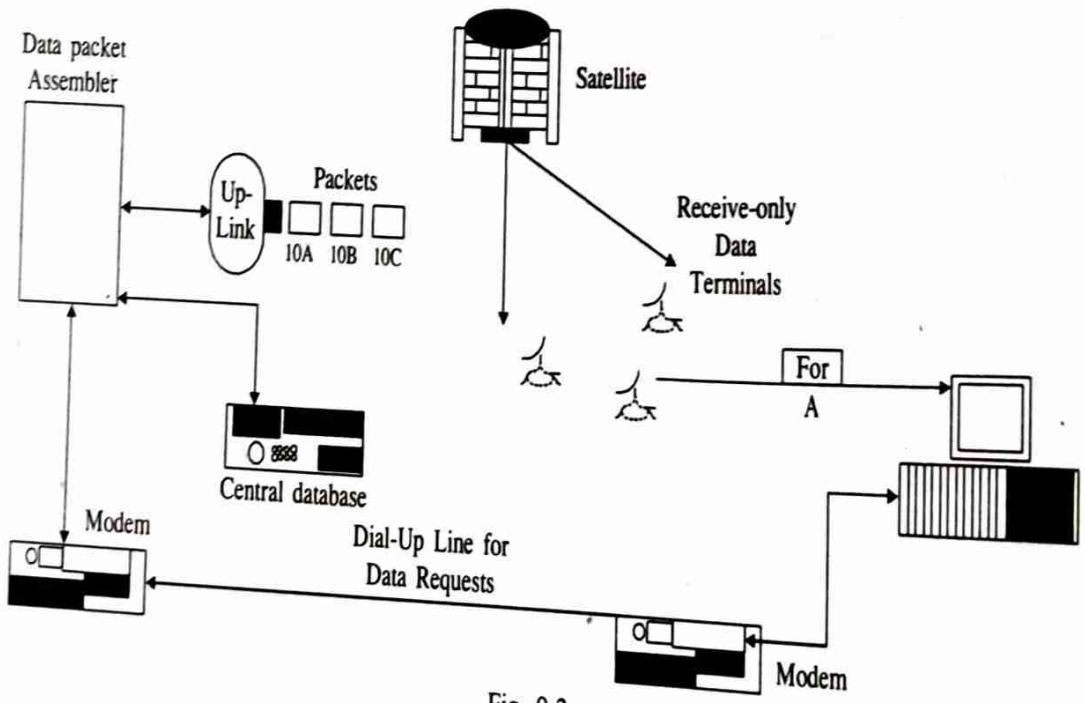


Fig. 9.2

The data beamed up to the satellite is retransmitted back towards the earth and is received by the "receive only" terminals. The "receive only" terminals have digital processing capabilities to identify data packet addressed in them. The respective "receive only" terminal receives the data meant for user terminals linked to them for subsequent delivery.

9.2.2 Interactive Data Communication using Satellite :

Interactive data communication using satellites can able to exchange the data between two terminals i.e., in such a system, the remotely located user terminals not only able to respond back to the central site, they can also exchange information between one another. VSATs (Very Small Aperature Terminals) supporting large number of user terminals is best implemented by such a network system. The typical setup of a interactive data communication is shown in the below figure 9.3.

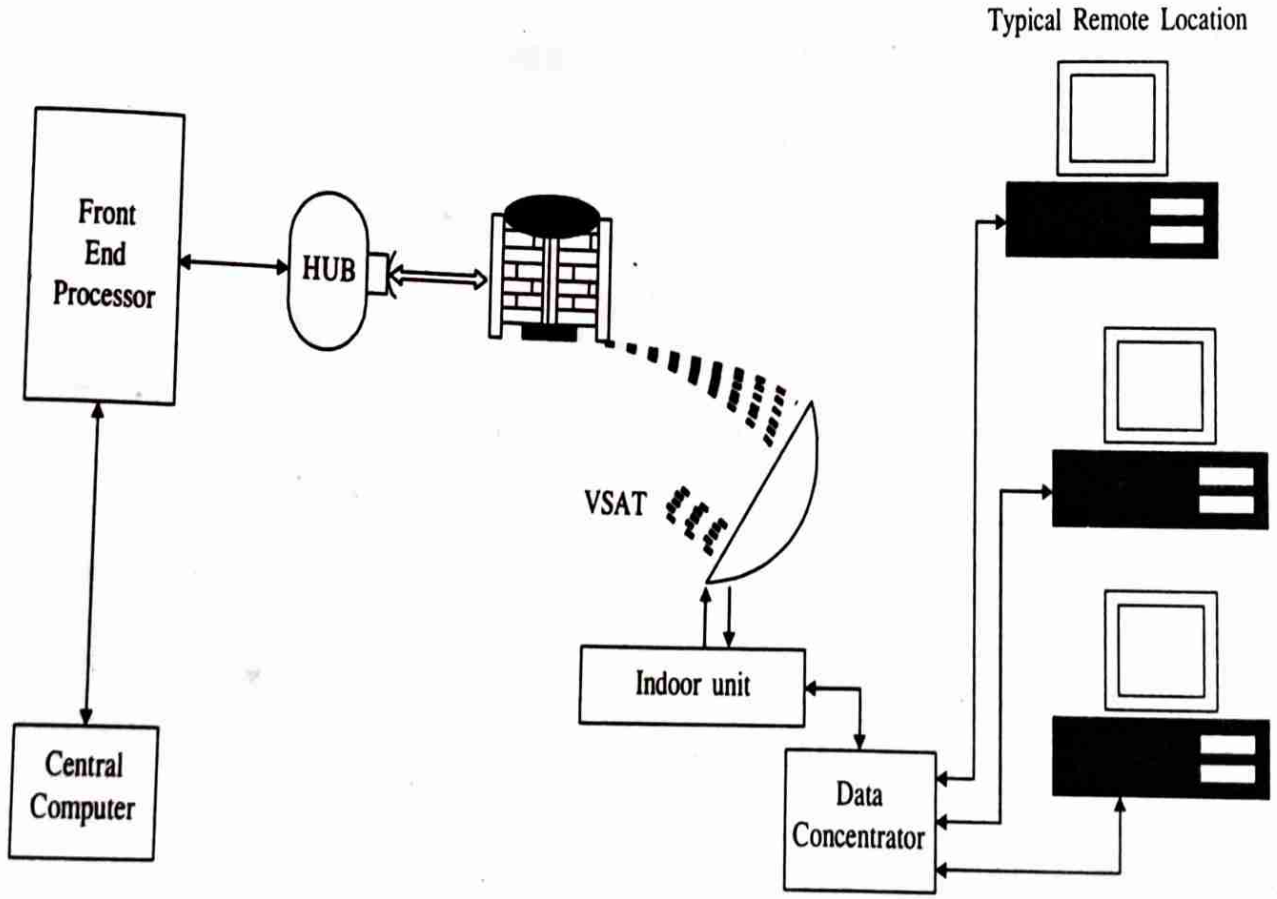


Fig. 9.3

In the interactive data communication there is no need of terrestrial link. When the remote station transmits the information to the central facility of the same satellite, that does the data broadcast. However the data concentrator is used to multiplex the data from different user terminals and imports a single stream of bits to the VASAT indoor electronic unit. It also demultiplexes the data broadcast received from the satellite for delivery to prospective user terminals.

9.2.3 Satellite for Earth Observation :

Variety of earth observation applications are usage by the satellite. Many of the applications are included in the earth observations. Few of them are as follows :

- Monitoring agriculture and forestry.
- Mineral and oil exploration
- Cartography
- Oceanography
- Snow melt
- Monitoring oil pollution and air pollution
- Ice Reconnaissance.

9.3 STB : Set Top Box :

A Set-Top box is a hardware device that allows a digital signal to be received, decoded and displayed on a television. The signal can be a television signal or Internet data and is received via cable or telephone connection.

The digital device which connects between dish antenna and television set and used to select different TV channels as per user choice is called **Set Top Box**. Dish antenna receives satellite signals consisting of different broadcast channels from broadcast channel providers across the globe. With the help of built in tuning circuit, set top box selects one channel among these received channels.

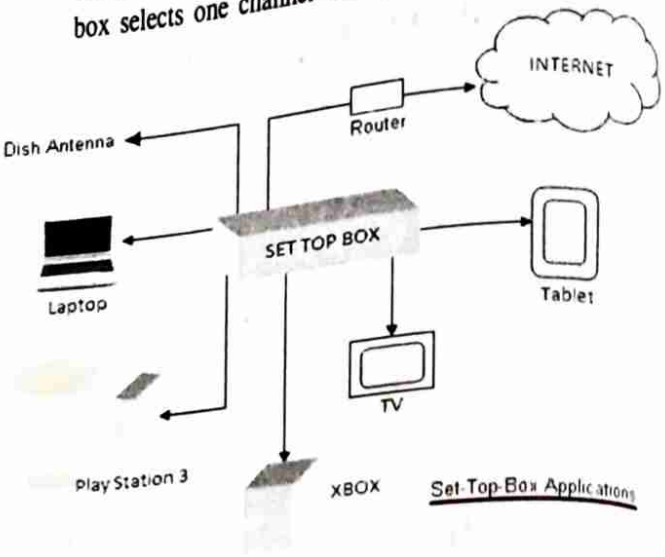


Fig. 9.4 : Basics of STB

Set top boxes are used for for many applications. It includes digital satellite receiver, digital cable receiver, digital terrestrial receiver and digital IP TV. As shown in figure, next generation set top boxes can be connected with many home devices/equipments such as tablet, PS3 play station, laptop, TV, XBOX video game console unit and so on.

Set-top boxes can be divided into several categories ranging from simple boxes that receive and descramble

incoming AV signals, to complex units delivering a slew of services such as video conferencing, home networking, IP telephony, video on demand and satellite broadband TV services.

9.3.1 Set Top Box (STB) Block diagram :

Figure above depicts set top box block diagram. The main specifications can be derived as follows.

- Satellite input with 75 ohm connector of female type
- Output video 1 x RCA type

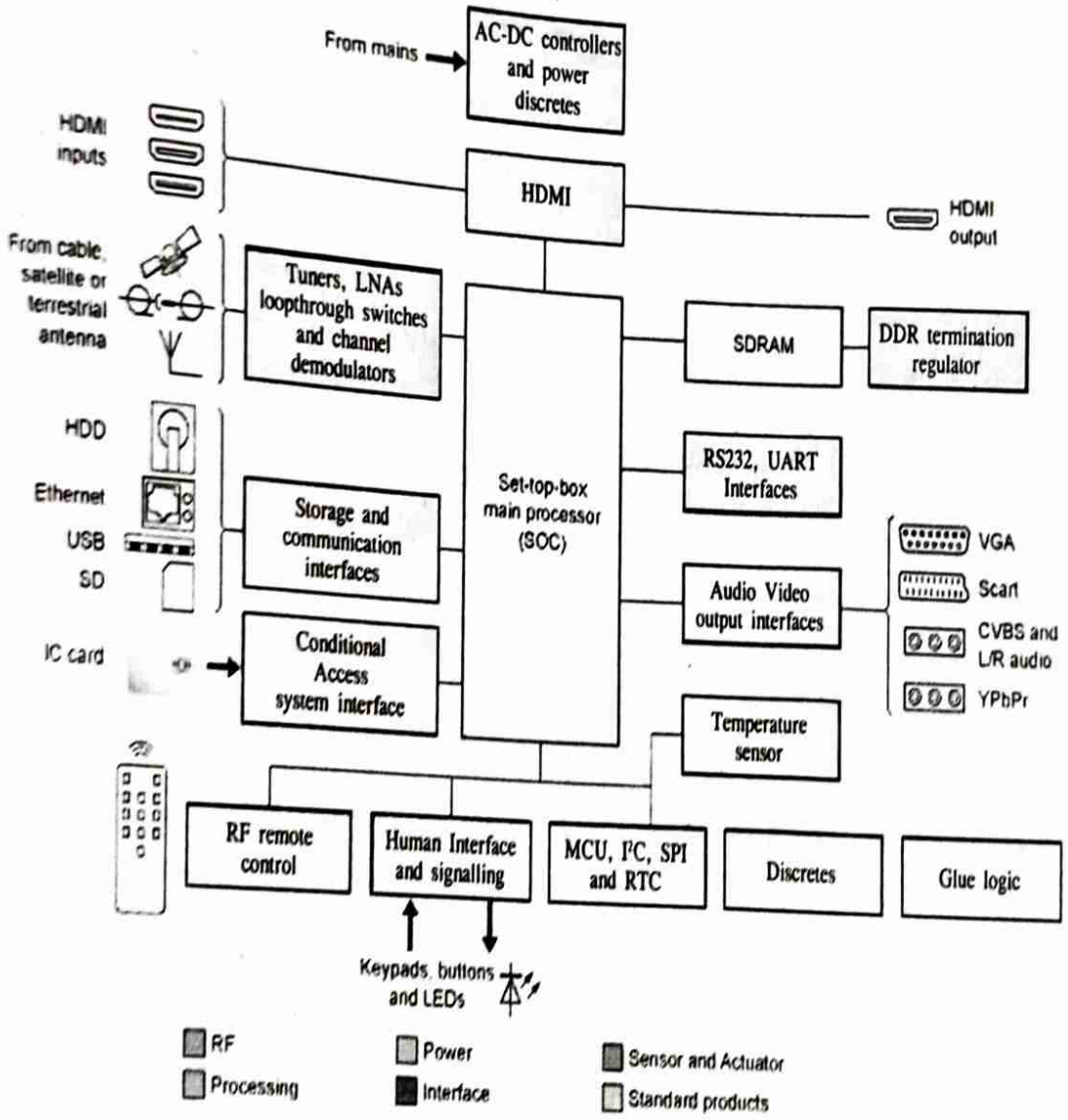


Fig. 9.5

- Output audio 2 x RCA type
- RF output, 75 Ohm male connector
- supports DVB-S System compliant to EN 3000421
- QPSK modulation
- C/N ratio and symbol rate is compliant to DVB-S standard
- Input level per carrier is about -65dBm(Min) and -25dBm(Max)
- supports PAL-B for VHF and PAL-G for UHF in the modulation
- supports RF output channel as VHF 3/4 OR Agile/ UHF.

A Set-Top Box can be considered to be a collection of a number of small functional blocks or modules, with each module performing a well-defined function. A module can be composed of pure hardware or pure software or some combination of both.

Set-Top Box act as an interface between Television and broadcaster. The STB selects the appropriate broadcast TV information by tuning to one of many input channels. The signal is digitally modulated using Quadrature Phase Shift Key (QPSK) for satellite applications, Quadrature Amplitude Modulation (QAM) for cable and Orthogonal Frequency Division Multiplexing (OFDM) for terrestrial.

The information in the selected RF channel is then processed by the demodulator to produce an MPEG-2 Transport Stream (TS) containing the audio, video and other information that relates to the selected TV program.

The STB generally also contains some form of modem to allow it to send and receive interactive data. Conventional telecommunication modems are typically used in satellite and terrestrial STBs while cable STBs generally has a cable modem.

The MPEG demultiplexer selects and decrypts the compressed audio and video for the particular program that the viewer wishes to watch, using decryption keys supplied by the Conditional Access Sub System (CASS). The MPEG decoder then compresses the audio and video information for the selected program.

The Central Processing Unit (CPU) controls the whole operation and performs specific data manipulation function. It generally uses a Real Time Operating System (RTOS) on top of a hardware abstraction layer for the management of the resources and processes of the STB directed by the higher level software.

9.4 Working of STB :

A set-top box (STB) or set-top unit (STU) (one type also colloquially known as a cable box) is an information appliance device that generally contains a TV-tuner input and displays output to a television set and an external source of signal, turning the source signal into content in a form that then be displayed on the television screen or other display device. They are used in cable television, satellite television, and over-the-air television systems, as well as other uses.

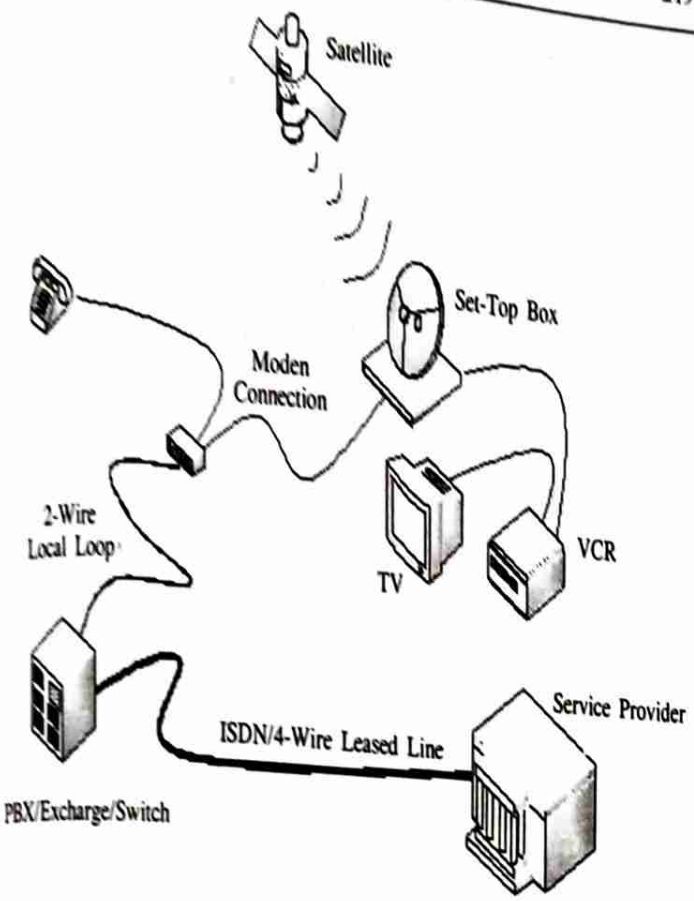


Fig. 9.6 : Working of STB

STB can be operated using front panel or remote control. Input is the RF signal and the range, modulation type depends upon the application we are using. For satellite application 950 to 2150 MHz is the frequency and modulation type is QPSK. For STB for cable application the input frequency range is 110 to 862 MHz and type of Modulation is QAM. While frequency range for STB for terrestrial is 47 to 860 MHz and type of Modulation use for it is COFDM.

Function :

It enables a television set to become a user interface to the Internet and also enables a television set to receive and decode digital television (DTV) broadcasts. A set-top box is necessary to television viewers who wish to use their current analog television sets to receive digital broadcasts.

The set-top box contains a tuner, that tuner decodes the broadcast signal and decodes it in to a format that can be output to a television.

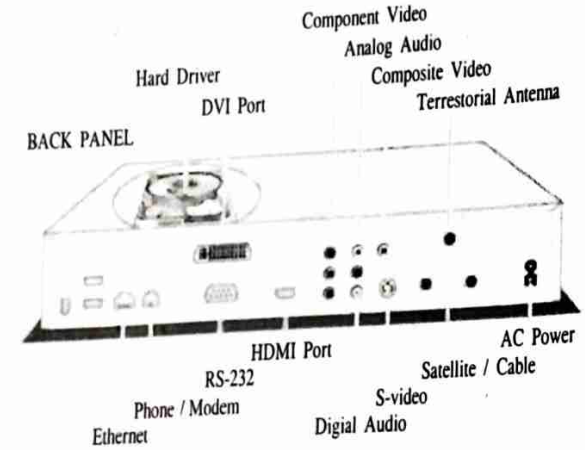
Set-top boxes perform functions that can't be or are not normally done in TVs themselves. The most common function not provided in TVs is tuning satellite broadcasts and cable TV broadcasts (although many European TVs can tune cable as well).

The main function that set-top boxes provide is to provide subscriber management functions. Pay TV content is normally encrypted or scrambled to stop customers getting content for free, the STB device needs to decrypt the content and it receives 'entitlements' from the operator based on the customers subscriptions.

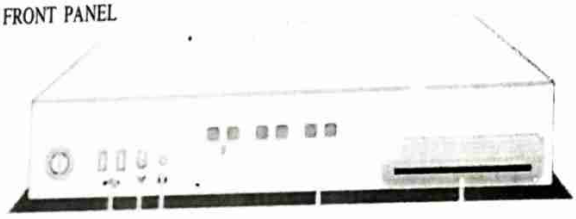
A bonus function that STBs provide to operators is managing the order and appearance of the Programme guide. There is significant value to channels for their position in the Programme guide (and/or channel number). Interactivity and value added services are also sale-able features.

The panel view of STB with TV, Remote and Ports connectors are as shown below :

Antenna wall socket Set-top box or digital TV recorder Analog TV



FRONT PANEL



Headphone Jack Buttons Smart-card Reader
IEEE 1394 FireWire
USB 2.0 Port

Practical Experiment 9.1

Video Demonstration and Documentation of TV Set Top Box Repair

Note : Browse the below sample video links for the given experiment demonstration. The links shown here are sample illustrative only. Users can search such similar videos.

a) **How to Repair TV Set Top Box**

https://youtu.be/Xvh0fGpWDSY

b) **How to Repair a HDTV Set Top Box not power on**

https://youtu.be/4Wk0aQiHYc8

Observation/Result :

After watching the above sample demonstration videos or any such similar videos, write a brief note/ summary document in your own sentences about what you understand from the video.

Practical Experiment 9.2

Test and troubleshoot Set top box

Links :

i) This video provides you with easy steps that help in resolving the no picture or no sound issue when using Set-Top Box on your TV.

https://youtu.be/97Z63eTYghU

ii) How to Connect a Set Top Box to Your TV

https://youtu.be/EMHduwSuyKA

iii) How to Solve Dish TV Booting Problem Dish TV Box Loading Error

https://youtu.be/mlxJ6xdsU-I

Troubleshooting of STB :

In the event of heavy rains and strong winds, signal satellite dish could get misaligned. This will result to a broken TV reception. To re-align your satellite dish, follow these easy steps :

Step 1 : Open your set top box to monitor the quality of your TV signal reception while troubleshooting.

Step 2 : Loosen the bolts of your satellite dish for re-adjustment.

Step 3 : With a help of a compass, turn your dish towards 220 degrees southwest. Doing this will ensure that the dish is pointing towards the communication satellite.

Step 4 : Monitor the quality of the reception.

Step 4.1 : Using your remote control, Click OK and choose Set-up.

Step 4.2 : When asked for a PIN, enter your 4-digit PIN using your remote. Default is 0000 or 9998.

Step 4.3 : Choose Installation Set-Up then Signal Test to view the signal quality meter.

Step 5 : To adjust the signal quality, turn your dish up or down to about 67 degrees until you reach 60 on the Signal Quality meter. Once it reaches 60 and your signal reception is back to normal, proceed to Step 6.

Step 6 : Tighten the bolts of your satellite dish to ensure that you keep the new alignment of your dish.

STB Common Problems and Solutions :

i) STB is not Booting Up :

1) Make sure your STB is plugged in.
2) Check your STB front panel if it is turned on (LED is green).
3) If light is green and still not booting up, perform hard reset by unplugging the STB from the wall socket and plug it back in after 5 seconds.

ii) TV has No Audio and/or Video Output :

A/V Jacks

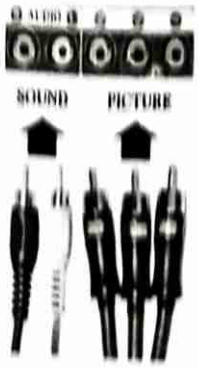
The most common home theater connection. If you can master these connections you can hook up anything at home. Notice the sound and picture are broken out into 3 separate cables. This design improves audio/video quality.

S-Video A/V Jacks

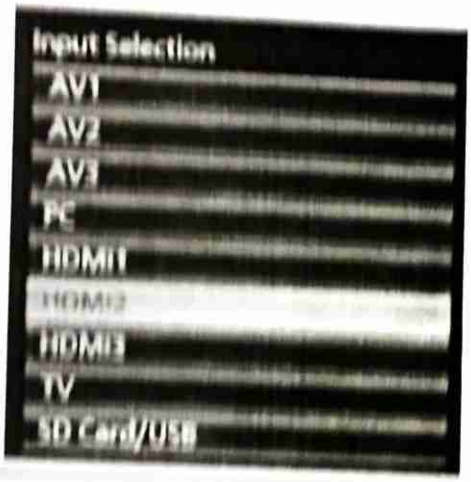
The "S-Video" jack replaced the "yellow" video cable to increase video quality. The cable is actually 2 in 1 sending the color and gray scale to separate cables. This was used for Laser Disc and early DVD.

Component A/V Jacks

The "Component" jack split the video signal into gray scale (green jack), red and blue. This provided the sharpest picture for DVD and more than twice the picture quality than that for HDTV. Top of the line for analog connections.



1. Make sure that your TV is not on standby mode.
2. Check the connections between the STB and TV if firmly and properly connected.
3. On your TV, select the correct Audio/Video input or source (example : AV1, AV2, HDM1).
4. HDM2, etc.



5. Power on the Cignal STB.
6. Check TV and STB volume functions.
7. If issue persists, perform hard reset by unplugging the STB from the wall socket and plug it back in after seconds.

iii) TV is Showing "Technical Problem" Error/Pixelated Pictures/ON and OFF Programming :

1. Check if coaxial cable (RG6) is firmly connected and secured.

2. Press the MENU button on your remote control then navigate to SETTINGS.
3. Key in default PIN as 0000 or 9998.
4. Navigate to the following options SYSTEM SETUP > INSTALLATION SETUP > SATELLITE SETUP > LNB POWERING.

5. Toggle ON/OFF using the LEFT and RIGHT buttons on the remote.
   - o for the Primary STB - must be set to ON
   - o for 2nd/3rd STB - must be set to OFF.

iv) TV Screen is showing an Error Code – E1 / E2 / E11/ E4 / E6 / E14 :

1. Turn the STB off and locate where the smart card is inserted Gently take out the smart card and check for any physical defects.

2. You may try to wipe the gold chip with a soft, dry, non-abrasive cloth to clear any dirt build up.
3. Insert the smart card back to the card slot the same way how it was removed.
4. Make sure that the smart card is properly inserted and seated securedly.

v) Make Sure all the connections are made correct :

The first and most common cause for set top box not working is improper cable connections.

Solution :

- Make sure all the cables are connected in the right ports and none of the connections are broken or obstructed.
- Refer to the user manual if you have any confusion regarding the same.
- All the connections should be tight.
- After doing so, try turning on the box again and check.
- set top box connections.

vi) Insert the card properly :

Another common reason for set top box not working could be a loose card. As you will see on your set top box, there is a slot which contains a card. If this card is not inserted properly, then your box may not work.

Solution :

- Thus to solve this issue, take out the card and then insert it back again tightly.
- Make sure you put the card in the right direction and side.
- Try turning on the box and check whether it is working now.
- set top box card

vii) No power :

Make sure that the set top box is receiving power to function.

Solution :

- For this, ensure that the power supply in which the device is plugged in is working fine.
- For this you can use a multimeter and check for its continuity. Continuity testing is basically checking resistance between two points.
- Take the multimeter and set it in continuity mode and touch the tips of the probes together so that they make a beeping sound.
- If there is no continuity, then you need to repair or replace the supply.
- However if there is continuity, then the issue could be with the power cord.
- Call a professional to check the cord and if it is damaged, then get it repaired or replaced.
- Check the set top box again.

Result :

Troubleshooting and testing of set top box is studied and verified.

Week

10

10.1 Cellular Networks :

4 Cell Phone Generations Compared

Standards	Technology	SMS	Voice Switching	Data Switching	Data Rate
1G AMPS, TACS	Analog	No	Circuit	Circuit	9.6
2G GSM, CDMA, EDGE, GPCS	Digital	Yes	Circuit	Circuit	28.8 Kbps
3G UTMS, CDMA2000, HSPDA, EVDO	Digital	Yes	Circuit	Packet	3M bps
4G LTE Advanced, IEEE 802.16 (WiMax)	Digital	Yes	Packet	Packet	up to 1 Gbps

1 G	* Voice Signals Only * Analogue Cellular Phones * NMT, AMPS
2 G	* Voice & Data Signals * Digital Fidelity Cellular Phones * GSM, CDMA, TDMA
2.5 G	* Enhance 2G * Higher Data Rates * GPRS, EDGE
3 G	* Voice, Data & Video Signals * Video Telephony/Internet Surfing * 3G, W-CDMA, UMTS
4 G	* Enhance 3G/Inter operability Protocol * High Speed & IP-based * 4G, Mobile IP

10.1.1 Cellular Concept :

With limited frequency resource, cellular principle can serve thousands of subscribers at an affordable cost. In a cellular network, total area is subdivided into smaller areas called "cells". Each cell can cover a limited number of mobile subscribers within its boundaries. Each cell can have a base station with a number of RF channels.

Frequencies used in a given cell area will be simultaneously reused at a different cell which is geographically separated. For example, a typical seven-cell pattern can be considered.

10.1.2 Frequency Reuse :

Frequency reuse, or, frequency planning, is a technique of reusing frequencies and channels within a communication system to improve capacity and spectral efficiency.

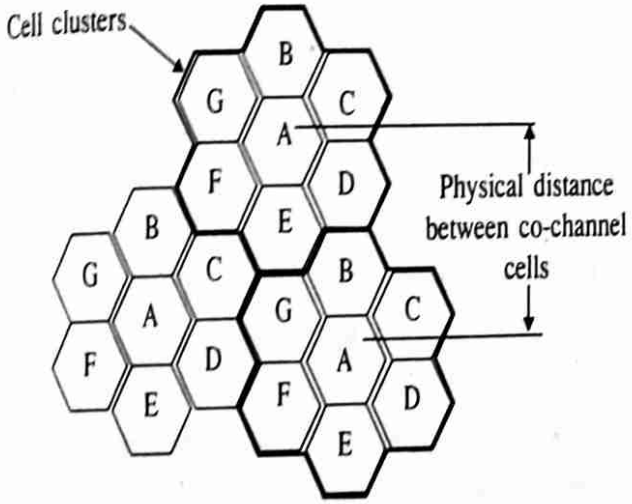


Fig. 10.1

Frequency reuse in mobile cellular systems means that frequencies allocated to the service are reused in a regular pattern of cells, each covered by one base station. The repeating regular pattern of cells is called cluster. Since each cell is designed to use radio frequencies only within its boundaries, the same frequencies can be reused in other cells not far away without interference, in another cluster. Such cells are called 'co-channel' cells. The reuse of frequencies enables a cellular system to handle a huge number of calls with a limited number of channels.

Figure above shows a frequency planning with cluster size of 7, showing the co-channels cells in different clusters by the same letter. The closest distance between the co-channel cells (indifferent clusters) is determined by the choice of the cluster size and the layout of the cell cluster.

10.2 Capacity Expansion Techniques :

When cellular service providers build their networks, their networks are designed to provide coverage to the area of desire with the expectation of possible increase in population in the near future. It may be difficult to predict the need for network expansion or even when network expansion is predictable, the time for network expansion arrives. There are several techniques to expand an already existing network or to add more capacity to a network being built. In the following we discuss two techniques :

- Cell Spilting
- Cell Sectoring.

10.2.1 Cell Splitting :

Reducing the size of cells of a cellular system keeps the SIR constant but results in an expansion of the network capacity because the smaller cells cover less area and therefore more cells would be required to cover the whole region which directly reflects on the network capacity. If the network is already functioning, it may be found that the network needs expansion only in specific regions and not network wide expansion.

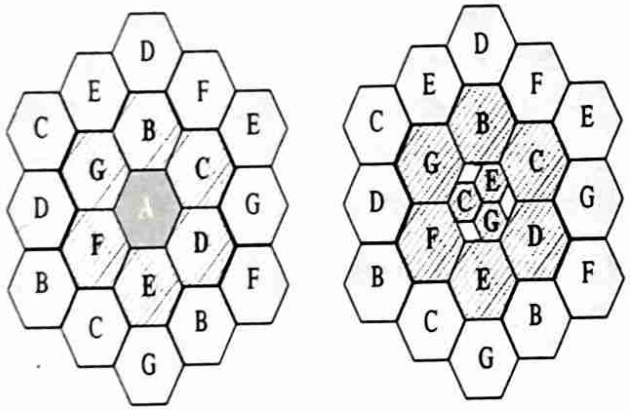


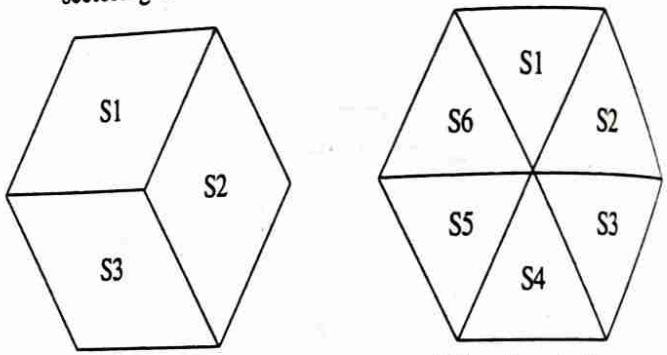
FIg. 10.2

In this case, a cell (or multiple cells) can be split into smaller cells and frequencies are redistributed in a way that does not cause additional interference. This is shown in the above figures. The first figure shows a cell that has reached it capacity and needs to be split. This cell is split into several cells. Since the area of a cell is proportional to R^2. So, reducing the cell radius to one half of its original value, for example, the area of the cell drops to one quarter of its

original value. Therefore, theoretically, 4 of the smaller cells can fit into 1 of the large cells. However, since it is not possible to fit 4 quarter size hexagonal cells completely into 1 full size hexagonal cell, some regions will have to be covered by adjacent cells.

10.2.2 Cell Sectoring :

The sectoring technique increases the capacity via a different strategy. In this method, a cell has the same coverage space but instead of using a single omni directional antenna that transmits in all directions, either 3 or 6 directional antennas are used such that each of these antennas provides coverage to a sector of the hexagon. When 3 directional antennas are used, 120° sectoring is achieved (each antenna covers 120°), and when 6 directional antennas are used, 60° sectoring is achieved (each antenna covers 60°).



120⁰ cell sectoring 60⁰ cell sectoring

Fig. 10.3

- Dividing the cells into sectors actually reduces the network capacity because the channels allocated to a cell are now divided among the different sectors. In fact, handoff

takes place when a cell phone moves from one sector to another in the same cell. The gain in network capacity is achieved by reducing the number of interfering co-channel cells.

10.3 Typical Cellular System :

A cellular network consists of both land and radio based sections. Such a network is commonly referred to as a PLMN - Public Land Mobile Network. The network is composed out of the following entities :

- Mobile Station (MS) - Device used to communicate over the cellular network.
- Base Station Tranceiver (BST) - Transmitter / receiver used to transmit / receive signals over the radio interface section of the network.
- Base Station Controller (BSC) - Controls communication between a group of BST's and a single MSC.
- Mobile Switching Centre (MSC) - The heart of the network, sets up and maintains calls made over the network.
- Public Switched Telephone Network (PSTN) - The land based section of the network.

Figure below illustrates how the entities are related to one another within the network. The BST's and their controlling BSC are often collectively referred to as the Base Station Subsystem (BSS). The cellular topology of the network is a result of limited radio spectrum. In order to use the radio spectrum efficiently, the same frequencies are

re-used in non-adjacent cells. A geographic region is divided up into cells. Each cell has a BST which transmits data via a radio link to MS's within the cell. A group of BST's are connected to a BSC. A group of BSC's are in turn connected to a Mobile Switching Center (MSC) via either microwave links or telephone lines. The MSC connects to the Public Switched Telephone Network (PSTN), which switches calls to other mobile stations or land based telephones.

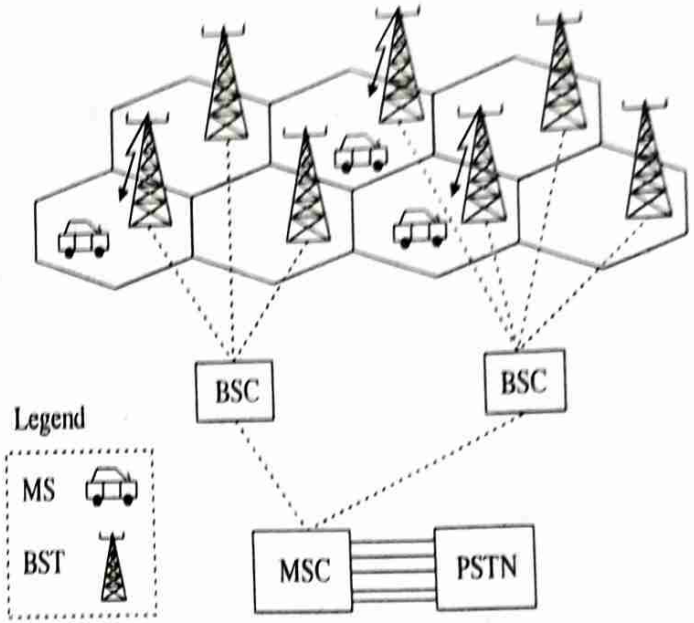


Fig. 10.4

The operation of a cellular network system can best be explained by an example of a mobile station placing a call to another mobile station:

A mobile station places a call by sending a call initiation request to its nearest base station. This request is sent on a special channel, the Reverse Control Channel (RCC). The base station sends the request on to the MSC,

validating the request. Contained in the request is the telephone number of the called party. The MSC uses the number to make a connection to the called party via the PSTN. It first connects itself to the MSC of the called party. Then it instructs the base station and mobile station which placed the call to switch to voice channels. The mobile station which placed the call is then connected to the called station on unused Forward and Backward Voice Channels (FVC, BVC).

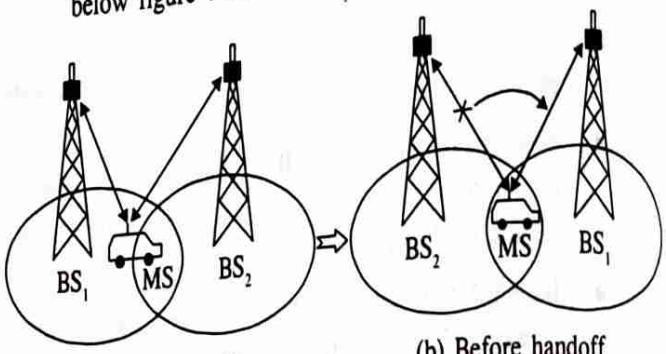
The steps that take place when a mobile station receives an incoming call are as follows :

Mobile stations continually scan the Forward Control Channel (FCC) for paging signals from base stations. When a MSC receives a request for a connection to a mobile station in its area, it sends a broadcast message to all base stations under its control. The message contains the number of the mobile station which is being called. The base stations then broadcast the message on all Forward Control Channels (FCC's). The correct mobile station acknowledges the page, by identifying itself over the Reverse Control Channel (RCC). The MSC receives the acknowledgement via the base station, and instructs the base station and mobile station to switch to an unused voice channel. A data message is then transmitted over the forward voice channel, which instructs the mobile phone to ring.

The steps explained above happen fast enough for the user not to experience any noticeable delay between placing a request for a call and the call being connected.

10.3.1 Handoff Strategies :

When a user moves from one cell to the other, to keep the communication between the user pair, the user channel has to be shifted from one BS to the other without interrupting the call, i.e., when a MS moves into another cell, while the conversation is still in progress, the MSC automatically transfers the call to a new FDD channel without disturbing the conversation. This process is called as handoff. A schematic diagram of handoff is given in the below figure 10.5.



(a) Before handoff (b) Before handoff

Fig. 10.5

Processing of handoff is an important task in any cellular system. Handoffs must be performed successfully and be imperceptible to the users. Once a signal Level is set as the minimum acceptable for good voice quality (Prmin), and then a slightly stronger level is chosen as the threshold (PrH) at which handoff has to be made, as shown in Figure. A parameter, called power margin, defined as is quite an important parameter during the handoff process since this margin can neither be too large nor too small. If Δ is too

small, then there may not be enough time to complete the handoff and the call might be lost even if the user crosses the cell boundary. If Δ is too high on the other hand, then MSC has to be burdened with unnecessary handoffs. This is because MS may not intend to enter the other cell. Therefore Δ should be judiciously chosen to ensure imperceptible handoffs and to meet other objectives.

10.3.2 Factors Influencing Handoffs :

The following factors influence the entire handoff process :

- **Transmitted power :** As we know that the transmission power is different for different cells, the handoff threshold or the power margin varies from cell to cell.
- **Received power :** The received power mostly depends on the Line of Sight (LoS) path between the user and the BS. Especially when the user is on the boundary of Handoff process associated with power levels, when the user is going from i-th cell to j-th cell. The two cells, the LoS path plays a critical role in handoffs and therefore the power margin _ depends on the minimum received power value from cell to cell.
- **Area and shape of the cell :** Apart from the power levels, the cell structure also a plays an important role in the handoff process.
- **Mobility of users :** The number of mobile users entering or going out of a particular cell also fixes the handoff strategy of a cell.

Practical Experiment 10.1

Note : Depending upon the kit manufacturing company, working/ procedure varies. Here I took the kit manufactured from Scientech to illustrate working/procedure. Courtesy:Scientech.

Conduct an Experiment to Understand the Working of Different Sections in a Mobile Phone using a Mobile Phone Trainer Kit

Aim :

Study and identify different blocks of mobile phone units and Sketch the waveforms of different sections in Mobile Communication Trainer board.

Objective :

1. Study and observe Transmitted/Received RF Signal
2. Study and observe Tx IQ/ Rx IQ RF Signals
3. Study and observe signal constellation of GMSK Signal (RxI/Q)
4. Study and observe signal constellation of GMSK signal (TxI/Q)

Tools Required :

- Dual SIM Mobile phone TechBook
- SIM card(s) of any GSM service provider supporting 900/1800 frequency band

- Power Supply for Scientech 2132A with Mains Cord
- Hands freekit
- Spectrum Analyzer (Scientech)

Introduction of Dual SIM Mobile Phone TechBook - Scientech 2132A :

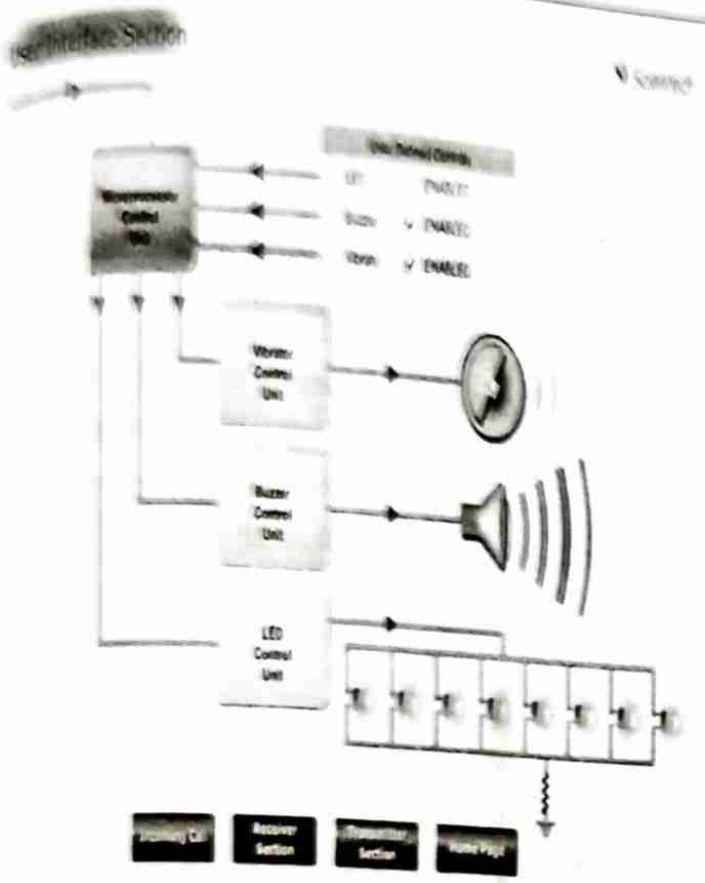
Scientech 2132A Understanding Dual SIM Mobile Phone : TechBook is a unique, self contained, easy to operate, training plat form that demonstrates the complete arrangement of a 2G Dual SIM GSM handset to understand the working of the mobile phone.

Scientech 2132A Understanding Dual SIM Mobile Phone TechBook is the perfect product for today's global technical professional. One of the main features of the TechBook is its real time signals. This realistic class room

training TechBook introduces the user to the fundamental of 2G Dual SIM GSM mobile equipment and clears the concept of underlying GSM technology in simple way. The Keypad of mobile handset, SIM sockets and User Interface section of the mobile phone i.e., Vibrator, Buzzer, Microphone, Speaker, Hands free port and display LEDs have been exposed onboard with switched faults creation facility and 58 test points for signal observation and detailed study. Also its attractive features and self explanatory multi-colored chart containing useful technical information will help user in creating a full understanding of dual SIM mobile phone system.

Features :

- Real time mobile operation
- Operates on dual band frequency network (GSM 900/ DCS1800)
- Colour TFT display
- Full understanding of Dual SIM mobile phone working
- Provides study of all sections in Dual SIM mobile phone
- Tx/ Rx frequency measurement and band verification
- 2G Technology GMSKsignal
- Detail study of User Interface Control signals
- Detail study of Dual SIM Operation
- Battery identification and charging study
- Switched Faults.



Technical Specifications :

- **Cellular System** : EGSM/GSM 900; DCS1800 (2G-Dual Band)
- **Rx Frequency Band** : **EGSM 900** - 925 to 935 MHz **GSM 900** - 935 to 960 MHz **DCS 1800** - 1805 to 1880MHz
- **Tx Frequency Band** : **EGSM 900** - 880 to 890 MHz **GSM 900** - 890 to 915 MHz **DCS 1800** - 1710 to 1785MHz

- **Output Power** : +5... +33dBm/3.2mW.. 2W
- **Channel Spacing** : 200 KHz
- **Display** : TFT, 256K colours, 128X168 Pixels, 2.0"
- **SIM Support** : Smart Dual SIM, Dual stand by (both GSM)
- **Battery type** : Li-Ion 1000mAH
- **CPU** : 208 MHz
- **Sound** : Speaker and Earphone Jack (3.5mm)
- **Onboard Sections** : Keypad, Dual SIM, Charging Circuit, User interface : Buzzer, Vibrator, Mic, Speaker, Hands free port and display LEDs.
- **TestPoints** : 58 nos.
- **Switched Fault** : 35 nos
- **Features that can beSet** : Screen saver, Ring tones, Logos, SMS etc.
- **Power Consumption** : 3.6VA (approximately)
- **Power Supply** : 100 - 260V AC, 50/60 Hz
- **Fuse** : 1 A
- **Dimension (mm)** : W 326 x D 252 113 x H52
- **Weight** : 2.5 Kg (approximately).
- **Operating Condition** : 0-40°C, 85% RH

GSM Technology : Features and Characteristics :

Main technical characteristics of the GSM system are :

GSM radio frequency spectrum :

- For **P-GSM**-900 : 890 - 915 MHz and 935 - 960 MHz
- For **E-GSM** : 880 - 915 MHz and 925 - 960 MHz
- For **R-GSM** : 876 - 915 MHz and 921 - 960 MHz
- For **GSM-1800** : 1710 - 1785 MHz and 1805 - 1880 MHz.
- For **GSM-1900** : 1850-1910 MHz and 1930-1990 MHz.

Different Frequency Bands :

There are three different frequency bands on which mobile phones are usually operates and these are Dual Band, Tri-Band and Quad Band.

DualBand : Supports two frequencies; 900 MHz and 1800 MHz.

Tri-Band : Supports three frequencies; 900 MHz, 1800 MHz and 1900 MHz.

Quad-Band : Supports four frequencies; 850 MHz, 900 MHz, 1800 MHz, 1900 MHz.

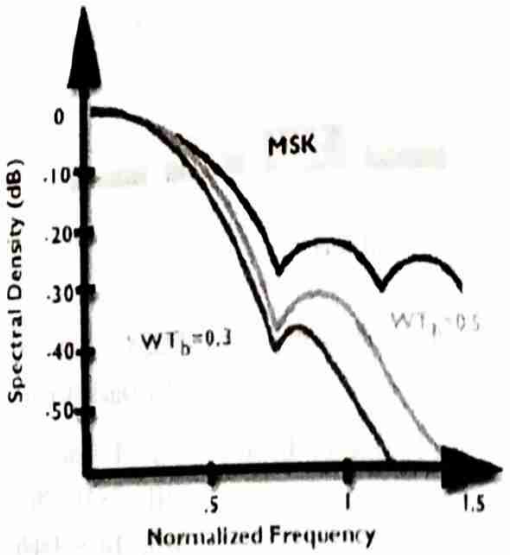
GMSK : Gaussian Minimum Shift Keying :

Even though MSK's power spectrum density falls quite fast, it does not fall fast enough so that interference

between adjacent signals in the frequency band can be avoided. To take care of the problem, the original binary signal is passed through a Gaussian shaped filter before it is modulated with MSK.

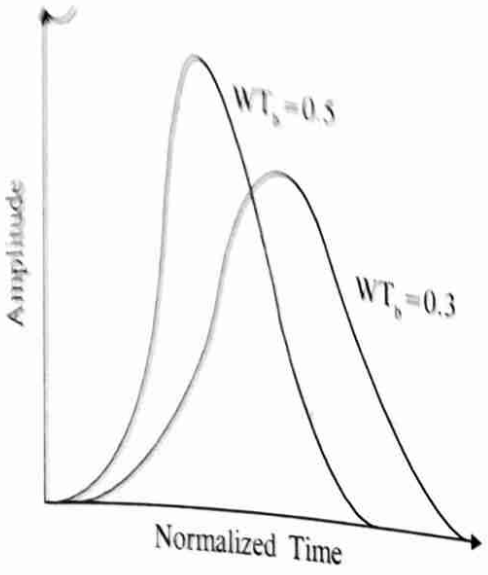
Frequency Response :

The principle parameter in designing an appropriate Gaussian filter is the time bandwidth product WTb. Please see the following figure for the frequency response of different Gaussian filters. Note that MSK has a time-bandwidth product of infinity.



Frequency Response

As can be seen from above, GMSKs power spectrum drops much quicker than MSK's. Furthermore, as WTb is decreased, the roll-off is much quicker.



Time - Domain Response

Since lower time-bandwidth products produce a faster power-spectrum roll-off, why not have very small time-bandwidth products. It happens that with lower time bandwidth products the pulse is spread over a longer time, which can cause inter symbol interference. Therefore as a compromise between spectral efficiency and time-domain performance, an intermediate time-bandwidth product must be chosen.

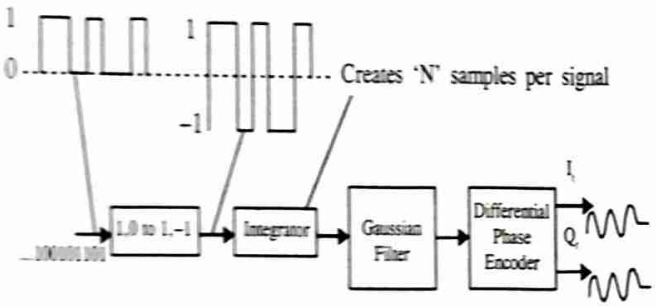
The reliability of a data message produced by a GMSK system is highly dependent on the following :

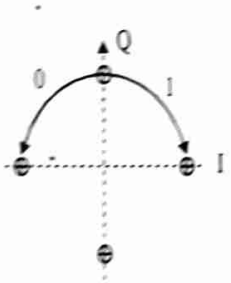
Receiver thermal noise: this is produced partly by the receive antenna and mostly by the radio receiver.

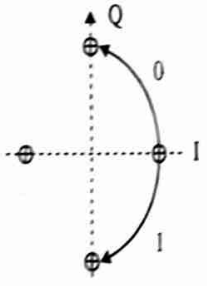
- Channel fading : This is caused by the multipath propagation nature of the radio channel.
- Band limiting : This is mostly associated with the receiver If frequency and phase characteristics.
- DC drifts : May be caused by a number of factors such as temperature variations, asymmetry of the frequency response of the receiver, frequency drifts of the receiver local oscillator.
- Frequency Offset :
  1. This refers to the receiver carrier frequency drift relative to the frequency transmitted caused by the finite stability of all the frequency sources in the receiver. The shift is also caused partly by Doppler shifts, which result due to the relative transmitter/receiver motion.
  2. The frequency offset causes the received IF signal to be off-center with respect to the IF filter response, and this cause more signal distortion.
  3. The frequency offset also results in a proportional DC component at the discriminator output.
- Timing Errors :
  1. The timing reference causes the sampling instants to be offset from the center of the transmit eye.
  2. As GMSK is a filtered version of MSK, this introduces another variable that can be used to describe the exact nature of the GMSK modulation.
  3. This variable is referred to as the BT, where B is the 3dB point of the Gaussian filter, and T is the bit duration. Therefore a BT of infinity would relate to MSK.

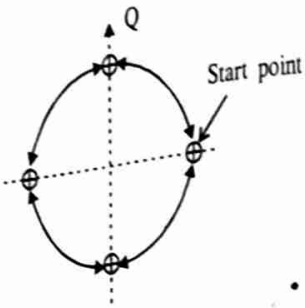
4. The smaller the BT the smaller the spectral density however this comes at a trade off of increased inter-symbol interference.
5. This is because by smoothing the edges of the bit pulses they begin to overlap each other. The greater the smoothing, the greater the overlapping, until eventually individual bits may be undetectable.

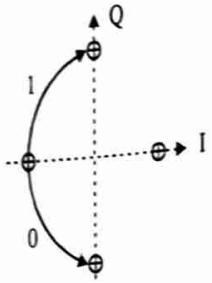
GMSK Modulation

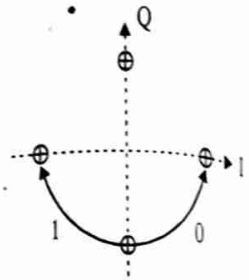












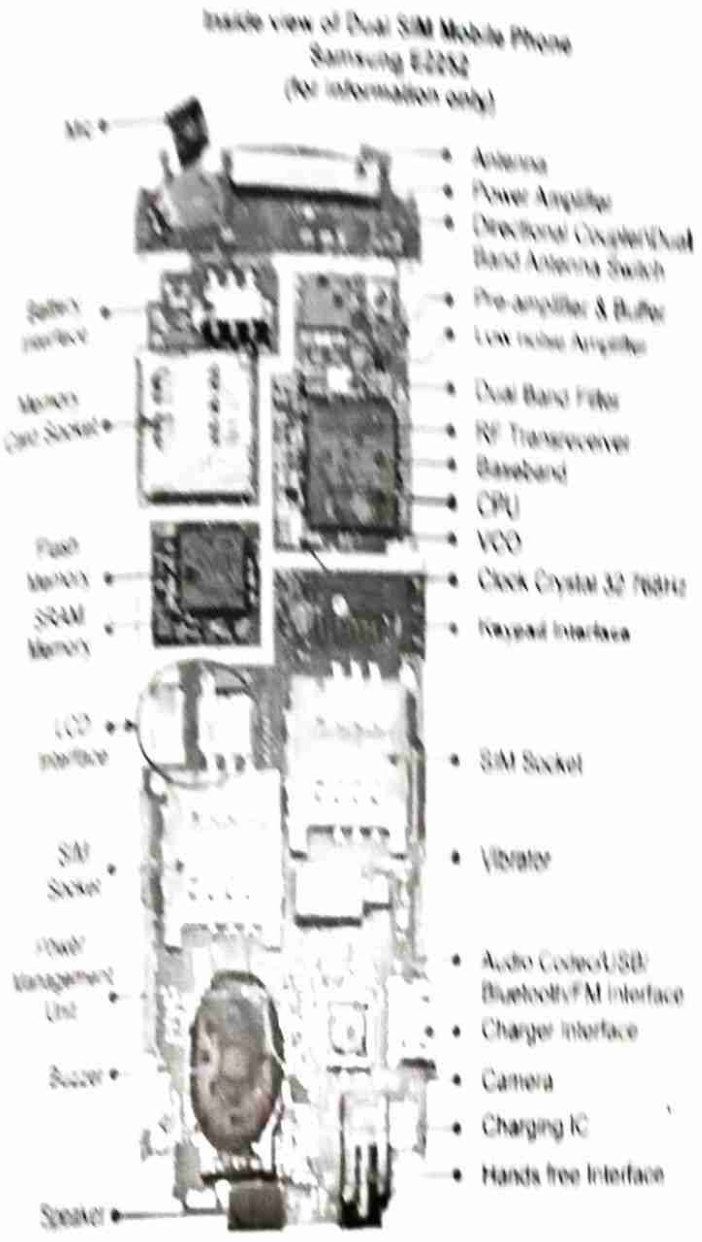
GMSK Consolation

Frequency List :

- GSM band 900MHz - Tx - 880-890 MHz, Rx - 925-960 MHz
- Modulation - GMSK (Gaussian Minimum Shift Keying)
- RF carrier Shift - +67.708 KHz
- GSM data rate - 270.833 Kbit/sec
- Clock frequency - 32.768 KHz
- SIM clock - 3.2 MHz
- VCO signal for Rx - 3700-3840 MHz divided by 4
- VCO signal for Tx - 3520-3660 MHz divided by 4
- VCTXO signal - 26 MHz divided by 2
- System clock - 13 MHz

Component Layout

(For Information Only)



Component Layout

Theory :

Operating Mode :

Dual SIM Mobile Phone training system works in two operating mode that can be selected by a 'Mode Selection Switch' provided on the TechBook at left side near Power connector.

- Battery Mode (Switch Released) : In this mode the TechBook operates with battery supplied & battery can be charged.
- Adapter Mode (Switch Pressed) : In this mode the TechBook operates on external Power Supply. For this connect Scientech 2133A Power Supply with mains cord to TechBook. The TechBook automatically disconnects the battery contacts when the mode is changed from Battery to Adapter. So physical presence of the battery in the battery assembly doesn't have any effect. The charging 'On/Off' switch stops functioning in this mode.
- Switch off the TechBook before switching between the Operating modes.

Operating Condition :

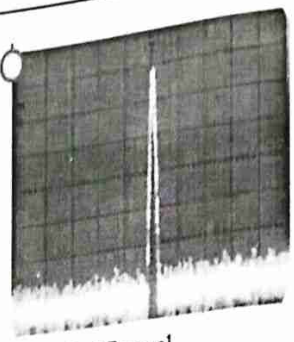
Before performing this experiment, please ensure that;

- Insert SIM card(s) before switching on the TechBook (Most important point to be noted)
- Also ensure that the SIM cards in use should be of any GSM service provider supporting 900/1800 frequency band. (Don't use any SIM of a CDMA service provider)

- Battery should be fully charged if you want to operate the system in 'Battery Mode'.
- To charge the battery; connect Scientech 2132A Power Supply to TechBook with Mains Cord; operate the TechBook in 'Battery Mode' and put the 'Charging Switch to 'On' position.
- While charging the Battery, Communication can be done using theTechBook.
- All the Switch Faults should be in 'Off' Position.

Procedure : Study and observe Transmitted/Received RF Signal :

- Once the Tech Book is initially ready as per the set up given and if it detects the GSM service provider network(s) with sufficient network strength, further experiment can be done with this TechBook as follows.
- Make a Call to the Tech Book or from the TechBook.
- Connect the probe of Spectrum Analyzer at test point 1 to observe the signal to observe the transmitted/received RF signal in the respective Tx/ Rx band.
- Capture the frequency in the range of 900 MHz if the SIM in use is of GSM 900 service provider or in the range of 1800 MHz if it is of GSM 1800 service provider.
- You will receive a fluctuating/ blinking frequency component in the respective range as shown in figure.

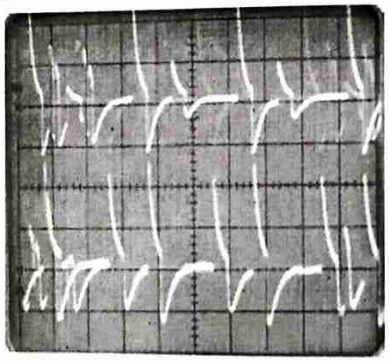


Tx RF signal

Figure 1 : TX RF Signal

Procedure : Study and observe Tx IQ/ Rx IQ RF Signals :

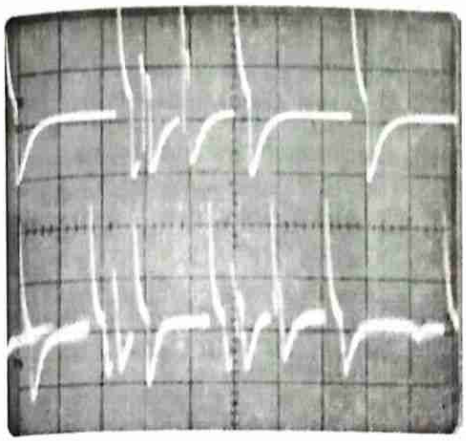
- Once the TechBook is initially ready as per the set up given in operating condition if it detects the GSM service provider network(s) with sufficient network strength, further experiment can be done with this TechBook as follows :
- Make a Call to the TechBook or from the TechBook.
- Connect two probes of Oscilloscope to CH1(Y) at test point 2 (Rx I signal) and CH2(X) at test point 3 (Rx Q signal) to observe them in dual mode as shown in figure.



Rx I/Q Data

Figure 2 : Rx I/Q Data

- Similarly connect two probes of Oscilloscope to CH1(Y) at test point 4 (Tx I signal) and CH2(X) at test point 5 (Tx Q signal) to observe them in dual mode as shown in figure.

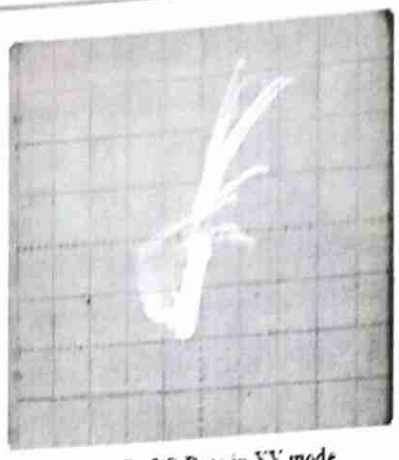


Tx I Q Data

Figure 3 : TX I/Q Data

Procedure: Study and observe signal constellation of GMSK Signal (Rx I/Q) :

- Once the TechBook is initially ready as per the set up and if it detects the GSM service provider network(s) with sufficient network strength, further experiment can be done with this TechBook as follows.
- Make a Call to the TechBook or from the TechBook.
- Connect two probes of Oscilloscope to CH1(Y) at test point 2 (Rx I signal) and CH2(X) at test point 3 (Rx Q signal) and observe them in **XY mode** as shown in figure.

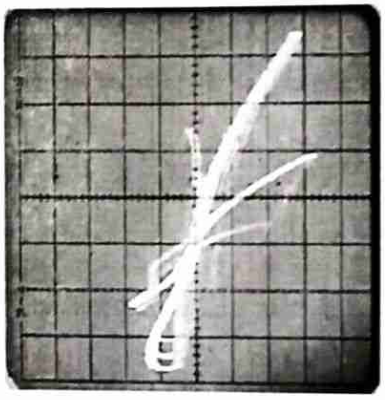


Rx I Q Data in XY mode

Figure 4 : RX I/Q Data in XY mode

Procedure: Study and observe signal constellation of GMSK signal (Tx I/Q) :

- Once the TechBook is initially ready as per the set up and if it detects the GSM service provider network(s) with sufficient network strength, further experiment can be done with this TechBook as follows :
- Make a Call to the TechBook or from thev TechBook.



Tx I Q Data in XY mode

Figure 5 : TX I/Q Data in XY mode

- Connect two probes of Oscilloscope to CH1(Y) at test point 4 (Tx I signal) and CH2(X) at test point 5 (Tx Q signal) and observe them in **XY mode** as shown in figure.

Result :

Studied and identified different blocks of mobile phone units and verified the waveforms of different sections in Mobile Communication Trainer board.

Practical Experiment 10.2

Conduct an Experiment to Analyze MIC & Speaker Section, Buzzer Section using a Mobile Phone Trainer Kit

Aim :

To Study and analyse different User Interface section in Mobile Communication Trainer board.

Objective :

1. Study and analyze the Buzzer in Dual SIM Mobile Phone TechBook.
2. Study and analyze MIC & Speaker section
3. Study and analyze the Hands Free section (MIC/Speaker).

Tools Required :

- Dual SIM Mobile phone TechBook
- SIM card(s) of any GSM service provider supporting 900/1800 frequency band
- Power Supply for Scientech 2132A with Mains Cord
- Hands free kit
- Oscilloscope (Scientech).

Theory :

User Interface section : Buzzer :

This is the circuit which informs the incoming call by ringing the bell or ringtone. This is also used to here the

other tones of the mobile phone like Key tone, Alarm tone, Alert tone etc. Ringer/ Buzzer Control circuit gets the signal form CPU at the time of incoming call. These control signals activate the ringer circuit to provide the pulses to buzzer and it starts ringing. Alerting tones or melodies are generated by a buzzer. Ringing driving circuit is mainly made by CPU, Buzzer driving circuit and Buzzer. Whenever there is an incoming call or message else ringing is software activated. Ringing Driving Control signal that's a PWM signal is obtained from Central Processing Unit (CPU) and given driver circuit. After amplification it reaches at one tapping of buzzer.

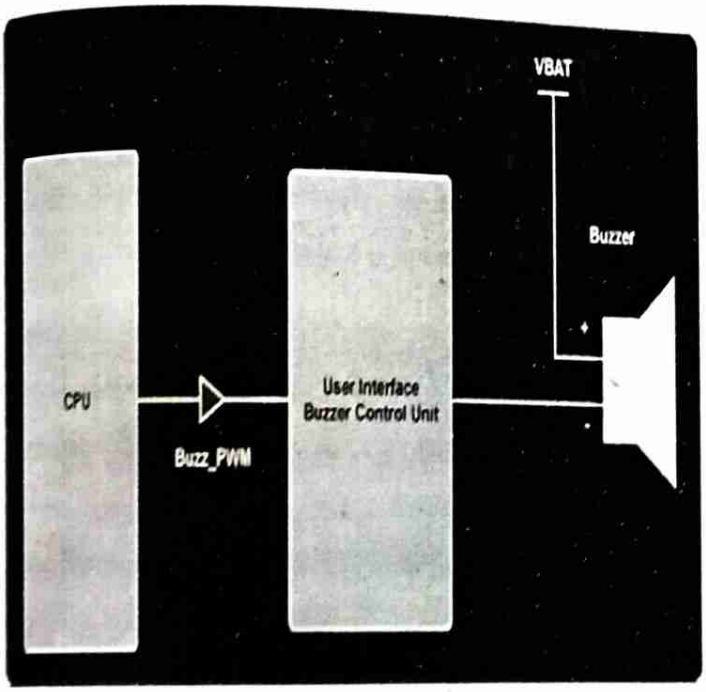


Figure 1 : Block Diagram of Buzzer Control Circuit

Operating Mode :

Operate the TechBook either in Battery mode or in Adaptor mode :

- Adaptor Mode (Switch Pressed) : In this mode the TechBook operates on external Power Supply. For this connect Scientech 2132A Power Supply with mains cord to TechBook. The TechBook automatically disconnects the battery contacts when the mode is changed from Battery to Adaptor. So physical presence of the battery in the battery assembly doesn't have any effect. The charging 'On/Off' switch stops functioning in this mode.
- Switch off the TechBook before switching between the Operating modes.

Operating Condition :

Before performing this experiment, please ensure that :

- Insert SIM card (s) before switching on the TechBook (Most important point to be noted)
- Also ensure that the SIM cards in use should be of any GSM service provider supporting 900/1800 frequency band. (Don't use any SIM of a CDMA service provider)
- Battery should be fully charged if you want to operate the system in 'Battery Mode'.
- To charge the battery; connect Scientech 2132A Power Supply to TechBook with Mains Cord; operate the TechBook in 'Battery Mode' and put the 'Charging Switch to 'On' position.

- While charging the Battery, Communication can be done using the TechBook.
- All the Switch Faults should be in 'Off' Position.

Procedure : Study and analyze the Buzzer in Dual SIM Mobile Phone TechBook :

- Once the TechBook is initially ready as per the set up and if it detects the GSM service provider network(s) with sufficient network strength, further experiment can be done with this TechBook as follows :
- Press "Menu" button.
- Use scroll keys to until you get the option 'Settings'.
- Select 'Sound Profiles' using Up/Down key.
- Select 'Normal' and press 'Edit'. Select 'Call Alert Type' and press 'Change'. Select 'Melody' mode and save.
- Go back and select the 'Voice Call Ringtone'. Press 'Change' and select any ringtone.
- Go back and select Volume and check the volume of Call alert. Save it. Go back to initial window.
- Make a Call to the TechBook.
- You will observe that the Buzzer starts to ring when TechBook is called.
- Observe the Buzzer signal at test point in User Interface Section. It is a PWM signal which is converted to sound as shown in figure.

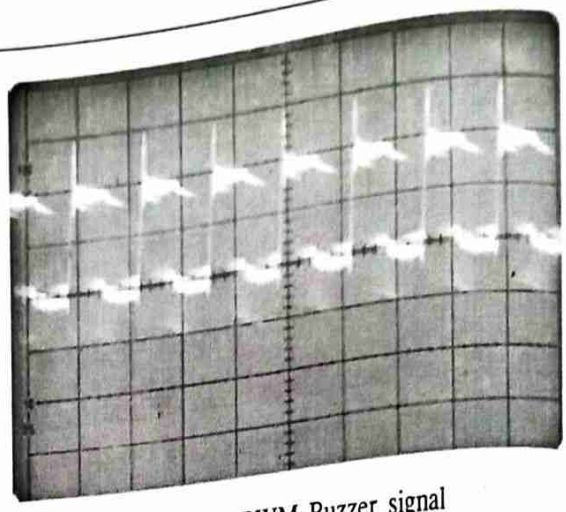


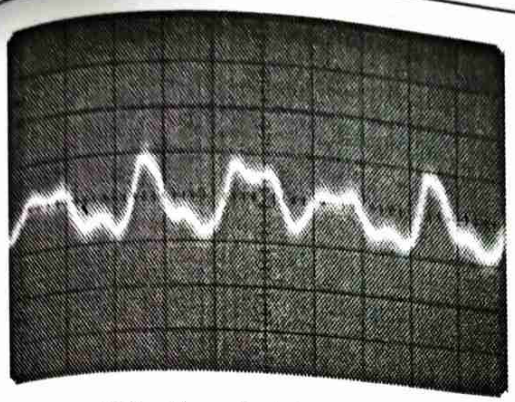
Figure 2 : PWM Buzzer signal

User Interface Section : MIC & Speaker Section :

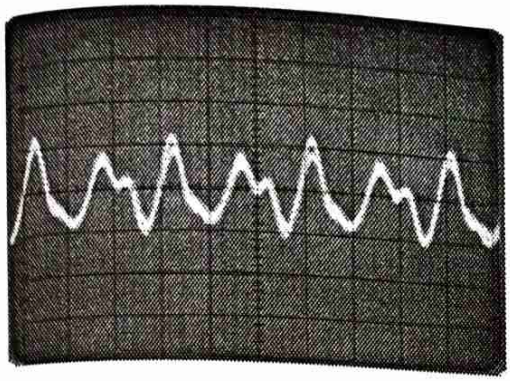
Procedure : Study and Analyze MIC & Speaker Section :

- Once the TechBook is initially ready as per the set up and if it detects the GSM service provider network(s) with sufficient network strength, further experiment can be done with this TechBook as follows :
- Make a Call to the TechBook and receive the call.
- Now the volume of the speaker can be increased or decreased using the Up/Down key. Set the volume level to maximum.
- Observe the received audio signal from caller at the Speaker test point in User Interface section.

Observe the transmitted audio signal from the called party at the MIC test point in User Interface section.



MIC - Transmitted Audio Signal



Speaker - Received Audio Signal

Figure 3

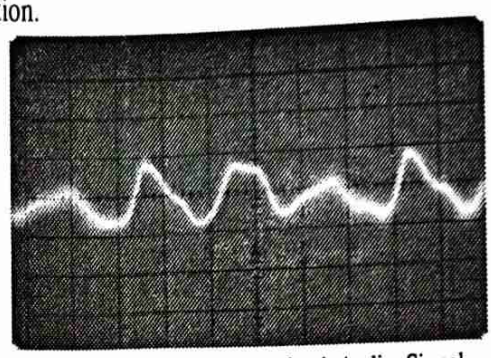
User Interface Section: Hands Free MIC & Speaker section:

Procedure: Study and analyze the Hands Free section (MIC/ Speaker) :

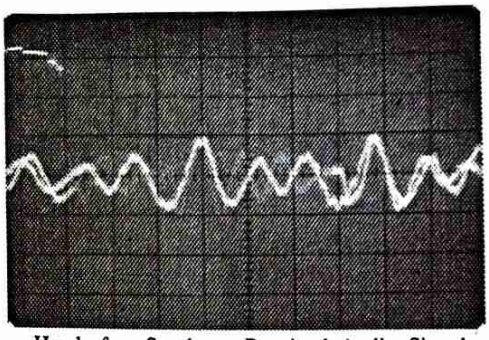
- Once the TechBook is initially ready as per the set up and if it detects the GSM service provider network(s) with sufficient network strength, further experiment can be done with this TechBook as follows :
- Connect the Hands Free kit to Hands Free socket in the user Interface section.

- Make a Call to the TechBook and receive the call.
- Now the volume of the speaker can be increased or decreased using the Up/ Down key. Set the volume level to maximum.
- Observe the received audio signal from caller at the Hands Free Speaker test point in User Interface section.

Observe the transmitted audio signal from the called party at the Hands Free MIC test point in User Interface section.



Hands free MIC - Transmitted Audio Signal



Hands free Speaker - Received Audio Signal

Figure 4

Result :

Studied and analyzed MIC, speaker and Buzzer interface section in Mobile Communication Trainer kit.

Week

11

Theory

11.1 GSM (Global System for Mobile)

11.1.1 General Features of GSM

11.1.2 GSM Services

11.1.3 GSM System Architecture and Working

11.2 LTE (Long Term Evolution)

11.2.1 LTE Architecture and Working

Practical Experiment

11.1 Conduct an Experiment to Analyses Vibrator Section, LED Control Section using a Mobile Phone Trainer Kit

11.2 Conduct an Experiment to Analyze the Active Mode/Sleep Mode/ Partially ON Mode while Charging of a Mobile Phone using a Mobile Phone Trainer Kit

11.1 GSM (Global System for Mobile) :

GSM is a digital cellular system designed to support a wide variety of services, depending on the user contract and the network and mobile equipment capabilities. GSM is a digital mobile communications system based on European standard which has been defined within the framework of the European Telecommunications Standards Institute (ETSI), and in to meantime has been adopted by 396 network operators in 150 countries. It was designed to be compatible with ISDN systems and the services provided by GSM are a subset of the standard ISDN services (speech is the most basic).

11.1.1 General Features of GSM :

GSM (Global System for Mobile Communications) is a second-generation (2G) digital mobile telephones standard using a combination Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) to share the bandwidth among as many subscribers as possible. The main features of GSM are as follows :

- GSM provides only 9.6 kbps data connection. Increase in data rates can be achieved when GSM changes into a radio service based on wide band code division multiple access, and not TDMA.

- GSM digitizes and compresses voice data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900, 1800 or 1,900 MHz frequency bands.
- The uplink and down link frequencies for GSM are different and therefore a channel has a pair of frequencies 80 MHz apart. The separation between uplink and downlink frequencies is called duplex distance.
- In a channel the separation between adjacent carrier frequencies is known as channel separation which is 200 kHz in case of GSM.
- The services supported by GSM are telephony, fax and SMS, call forwarding, caller 10, call waiting and the like.
- GSM supports data at rates up to 9.6 kbps on POTS (Plain Old Telephone Service), ISDN, Packet Switched Public Data Networks, and Circuit Switched Public Data Networks.
- The access methods and protocols for GSM may be fromX.25 or X.32.
- Being a digital system, GSM does not require a modem between subscriber and GSM network. However, an audio modem is required inside the GSM network to establish connection with POTS.

11.1.2 GSM Services :

In the specification of a telecommunication standard such as GSM, the first step is of course the services offered by the system. GSM is a digital cellular system designed to support a wide variety of services, depending on the user contract and the network and mobile equipment capabilities.

In GSM terminology, telecommunication services are divided into three broad categories :

- Bearer services are telecommunication services providing the capability of transmission of signals between access points [the user-network interfaces (UNIs) in ISDN]. For instance, synchronous dedicated packet data access is a bearer service.
- Teleservices are telecommunication services providing the complete capability, including terminal equipment functions, for communication between users according to protocols established by agreement between network operators.
- In addition to these services, supplementary services are defined that modify or supplement a basic telecommunication service.

11.1.3 GSM System Architecture and Working :

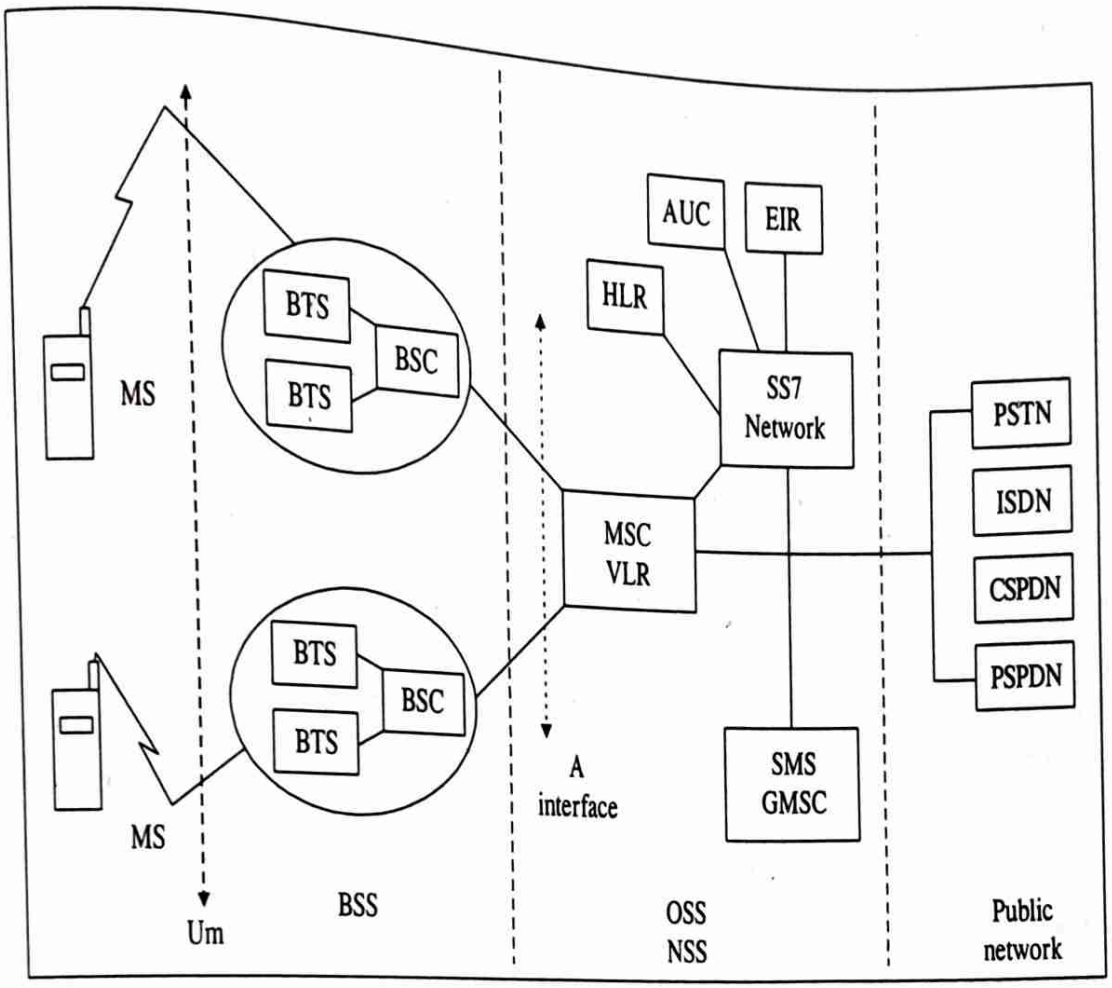


Fig. 11.1

The GSM system architecture includes four subsystems as shown in the above figure as :

- Mobile Station (MS)
- Base Station Subsystem (BSS)
- Network and Switching Subsystem (NSS) and
- Operation Sub-System (OSS).

The MS subsystem involves a radio part, an interface, and a Subscriber Identity Module (SIM). The radio part carries out all the functions related to the radio interface (Um), e.g. receiving and transmitting radio signals, signal processing, frequency hopping, and channel management. The interface to terminal equipment acts as a gateway between the terminal and the radio part. The SIM contains all the subscriber-related information on the MS side of Um

to identify a subscriber and take care of the security. The SIM is implemented as a smart card.

The BSS forms cell structure of GSM network. It includes two types of network elements : the Base Transceiver Station (BTS), and the Base Station Controller (BSC).

The BTS is a transmission component. It carries out radio signal transmission and reception, signal processing, speech encoding and decoding, and transmission rate adaptation. The BSC is a managing component. It is responsible for all the management of the Um, e.g. channel allocation and deallocation, handover, and timing of radio signals. One BTS implements one cell in GSM. A BSC can manage several BTSs.

The NSS comprises the main switching functions of GSM and all the databases needed for subscriber information, mobility management, and interworking. It contains the following databases :

- Home Location Register (HLR),
- Visitor Location Register (VLR),
- Authentication Centre (AUC), and
- Equipment Identity Register (EIR).

The MSC performs the basic switching function by setting up calls to/from MSs.

The GSM system also communicates with other networks such as the Public Switched Telephone Network (PSTN), Integrated Services digital Network (ISDN), Circuit-Switched Public Data Network (CSPDN), and packet-switched public data network (PSPDN).

11.2 LTE (Long Term Evolution) :

LTE stands for Long Term Evolution and it was started as a project in 2004 by telecommunication body known as the Third Generation Partnership Project (3GPP). SAE (System Architecture Evolution) is the corresponding evolution of the GPRS/3G packet core network evolution. The term LTE is typically used to represent both LTE and SAE.

LTE evolved from an earlier 3GPP system known as the Universal Mobile Telecommunication System (UMTS), which in turn evolved from the Global System for Mobile Communications (GSM). Even related specifications were formally known as the evolved UMTS terrestrial radio access (E-UTRA) and evolved UMTS terrestrial radio access network (E-UTRAN). First version of LTE was documented in Release 8 of the 3GPP specifications.

A rapid increase of mobile data usage and emergence of new applications such as MMOG (Multimedia Online Gaming), mobile TV, Web 2.0, streaming contents have motivated the 3rd Generation Partnership Project (3GPP) to work on the Long-Term Evolution (LTE) on the way towards fourth-generation mobile.

The main goal of LTE is to provide a high data rate, low latency and packet optimized radioaccess technology supporting flexible bandwidth deployments. Same time its network architecture has been designed with the goal to support packet-switched traffic with seamless mobility and great quality of service.

11.2.1 LTE Architecture and Working :

The high-level network architecture of LTE is comprised of following three main components :

- The User Equipment (UE).
- The Evolved UMTS Terrestrial Radio Access Network (E-UTRAN).
- The Evolved Packet Core (EPC).

The evolved packet core communicates with packet data networks in the outside world such as the internet, private corporate networks or the IP multimedia subsystem. The interfaces between the different parts of the system are denoted Uu, S1 and SGi as shown below :

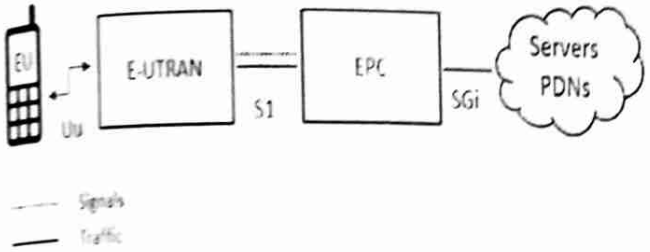


Fig. 11.2

The User Equipment (UE) :

The internal architecture of the user equipment for LTE is identical to the one used by UMTS and GSM which is actually a Mobile Equipment (ME). The mobile equipment comprised of the following important modules :

- **Mobile Termination (MT) :** This handles all the communication functions.
- **Terminal Equipment (TE) :** This terminates the data streams.
- **Universal Integrated Circuit Card (UICC) :** This is also known as the SIM card for LTE equipments. It runs an application known as the Universal Subscriber Identity Module (USIM).

A **USIM** stores user-specific data very similar to 3G SIM card. This keeps information about the user's phone number, home network identity and security keys etc.

The E-UTRAN (The Access Network) :

The architecture of evolved UMTS Terrestrial Radio Access Network (E-UTRAN) has been illustrated below :

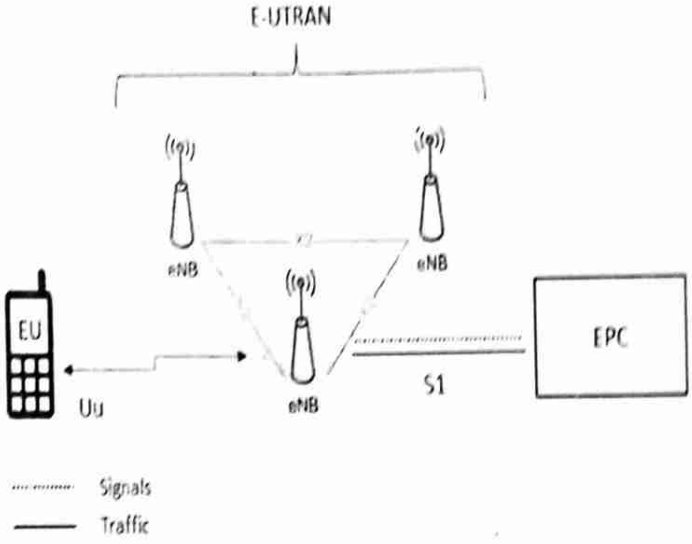


Fig. 11.3

- The E-UTRAN handles the radio communications between the mobile and the evolved packet core and just has one component, the evolved base stations, called eNodeB or eNB.
- Each eNB is a base station that controls the mobiles in one or more cells. The base station that is communicating with a mobile is known as its serving eNB.
- Each eBN connects with the EPC by means of the S1 interface and it can also be connected to nearby base stations by the X2 interface, which is mainly used for signalling and packet forwarding during handover.

The Evolved Packet Core (EPC) (The core network) :

The architecture of Evolved Packet Core (EPC) has been illustrated below :

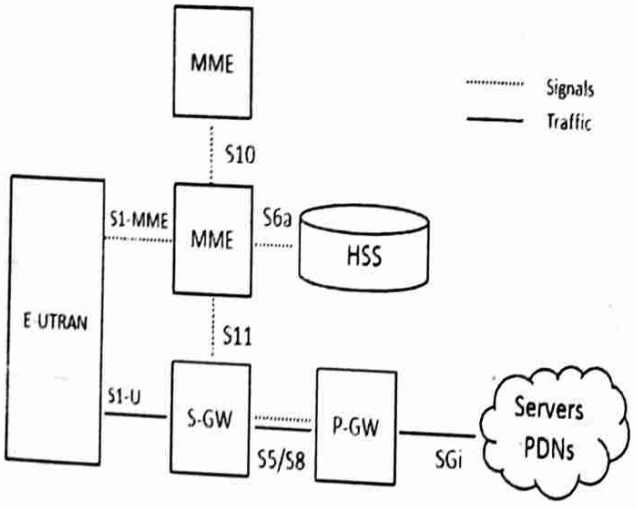


Fig. 11.4

- The Home Subscriber Server (HSS) component has been carried forward from UMTS and GSM and is a central database that contains information about all the network operator's subscribers.
- The Packet Data Network (PDN) Gateway (P-GW) communicates with the outside world i.e. packet data networks PDN, using SGi interface. Each packet data network is identified by an access point name (APN). The PDN gateway has the same role as the GPRS support node (GGSN) and the serving GPRS support node (SGSN) with UMTS and GSM.
- The serving gateway (S-GW) acts as a router, and forwards data between the base station and the PDN gateway.
- The mobility management entity (MME) handles the signaling of message and security, tracking of the user equipment.

The Policy Control and Charging Rules Function (PCRF) is a component which is not shown in the above diagram but it is responsible for policy control decision-making, as well as for controlling the flow-based charging functionalities in the Policy Control Enforcement Function (PCEF), which resides in the P-GW.

Practical Experiment 11.1

Note: Depending upon the kit manufacturing company, working/ procedure varies. Here I took the kit manufactured from Scientech to illustrate working/procedure. Courtesy:Scientech.

Conduct an Experiment to Analyses Vibrator Section, LED Control Section using a Mobile Phone Trainer Kit

Aim :

Study and analyse different User Interface section in Mobile Communication Trainer board.

Objective :

1. Study and analyze the vibrator in Dual SIM Mobile Phone TechBook.
2. Study and analyze the LED control in Dual SIM Mobile Phone.

Tools Required :

- Dual SIM Mobile phone TechBook
- SIM card(s) of any GSM service provider supporting 900/1800 frequency band
- Power Supply for Scientech 2132A with Mains Cord
- Hands freekit
- Oscilloscope (Scientech).

1) User Interface section : Vibrator

Theory :

The function of the Vibrator section is to inform the user at the time of incoming call by vibrations. Vibrator control circuit receives the control signal form the CPU and activates the controlling circuit to provide the operating voltage to the vibrator and vibrator starts to vibrate until it gets the signals from the CPU. The vibrator driving circuit is similar to that of ringer circuit. It is used for giving silent information to user for incoming calls. This is also called Vibra Alert Device. When an incoming call comes then this device gives its information to user by vibrating. V BATT supply is given at other tapping of this vibrator. Operation of turning 'On' Vibrator is controlled by software. A vibra alerting device is similar to the DC motor. In the mobile phone it is used to generate a vibration signal for an incoming call.

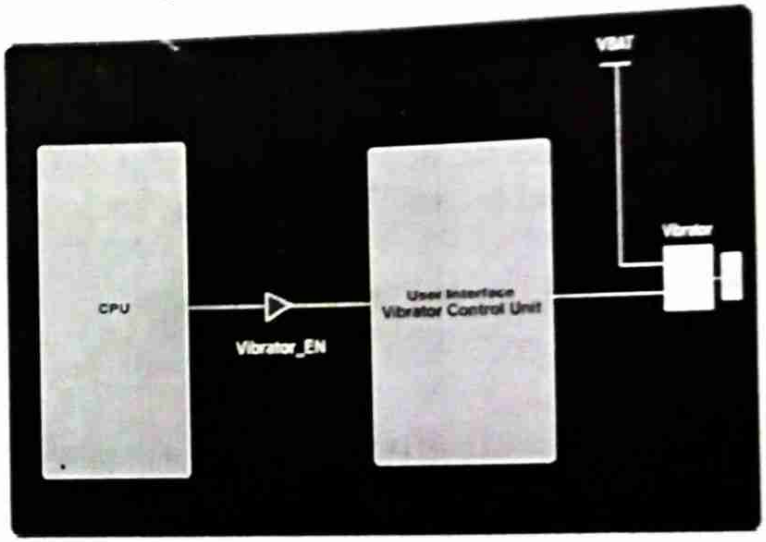


Figure 1 : Block Diagram of Vibrator Control Circuit

Procedure : Study and analyze the vibrator in Dual SIM Mobile Phone TechBook :

- Once the TechBook is initially ready as per the set up and if it detects the GSM service provider network(s) with sufficient network strength, further experiment can be done with this TechBook as follows :
- Press "Menu" button.
- Use scroll keys to until you get the option 'Settings'.
- Select 'Sound Profiles' using Up/Down key.
- Select 'Normal' and press 'Edit'. Select 'Call alert type' and press 'Change'.
- Select 'Vibration' mode and save. Go back to initial window.
- Make a Call to the TechBook.
- You will observe that the vibrator starts to vibrate when TechBook is called.
- Observe the Vibrator signal at test point in User Interface Section. It is a DC voltage which drives the vibrator to vibrate. It is approximately 1.5V to 3V.

2) User Interface Section : LED

Theory :

Light Emitting Diode, helps the user while performing function. The LED in mobile phone is of SMD type instead of traditional LED's due to much compactness required and many mobile specifications. The LED circuit consists of CPU, UI section and LED. The DC signal is made out from CPU whenever handset is switched 'On/Off', Tx/Rx even a key is pressed depending on the menu features. The signal obtained from the CPU is given UI section. The UI section gives output for keypad/Display LED separately but simultaneously. The LED's are connected in parallel. The anode of the LED's is connected to VBAT. Varistors are connected for protection in addition resistors are connected for both (LED & Keypad) LED's for intensity control. The time duration for the LED is software controlled often menu driven.

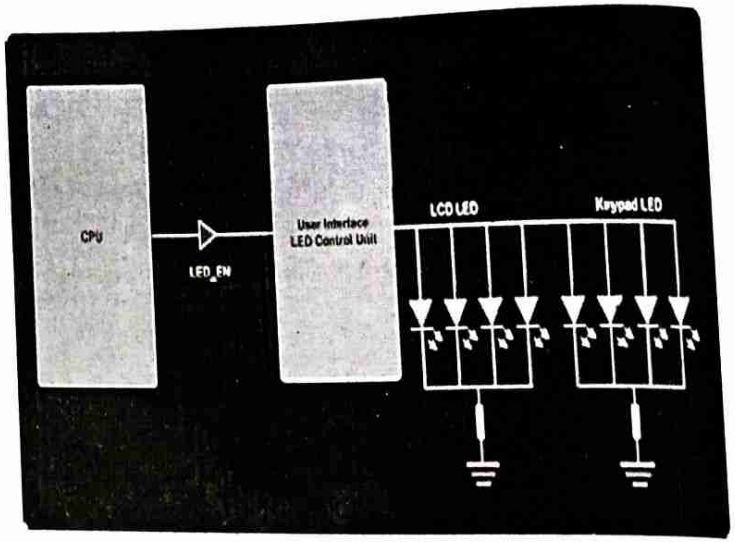


Figure 2 : Block Diagram of LED Control Circuit

Procedure : Study and analyze the LED control in Dual SIM Mobile Phone :

- Once the TechBook is initially ready as per the set up and if it detects the GSM service provider network(s)

with sufficient network strength, further experiment can be done with this TechBook as follows :

- Key pad LED 1 & Key Pad LED 2 are the part of Key pad LED section.
- Whenever we press any key or when we receive a call or message the LEDs glow.
- Observe the controlled LED driving voltage at the test points given in the User Interface section. It is 2V approximately.

Result :

Studied and analyzed vibrator section, LED control section using a mobile phone trainer kit.

Practical Experiment 11.2

Conduct an Experiment to Analyze the Active Mode/ Sleep Mode/Partially ON Mode while Charging of a Mobile Phone using a Mobile Phone Trainer Kit

Aim :

Study and analyze Modes of operation, Active mode/ Acting Dead mode / Sleep mode in Mobile Communication Trainer board.

Objective :

1. Analyze the Active Mode of a mobilePhone
2. Analyze the Acting Dead mode(Partially On) of a mobilephone
3. Analyze the sleep mode of a mobilephone.

Tools required :

- Dual SIM Mobile phone TechBook
- SIM card(s) of any GSM service provider supporting 900/1800 frequency band
- Power Supply for Scientech 2132A with Mains Cord.

Operating Mode :

Operate the TechBook either in Battery mode or in Adaptor mode as instructed in previous experiments.

Procedure: Analyze the Active Mode of a mobile Phone :

- Once the TechBook is initially ready as per the set up and if it detects the GSM service provider network(s) with sufficient network strength, further experiment can be done with this TechBook as follows :
- Measure the voltages at the test points given in Power Management unit and the test points 6, 7, 10 & 11 of LCD display section.
- Call make and Call receive experiment can be done and the signals at the respective test points can be observed.

Procedure : Analyze the Acting Dead mode of a mobile phone:

- Once the TechBook is initially ready as per the set up and if it detects the GSM service provider network(s) with sufficient network strength, further experiment can be done with this TechBook as follows :
- Switch off the TechBook.
- Connect the Scientech 2132A Power Supply with mains cord.
- Do not switch on the TechBook. Only switch on the 'Charger Supply' switch for charging the battery.
- Observe the battery charging status on display.
- Measure the voltages at the test points given in Power Management unit and the test points 6, 7, 10 & 11 of LCD display section.
- Measure the voltages at the battery terminal test points 12 and 13 with respect to ground test point 14.

- Observe that keypad LEDs glow when any key is pressed. And display shows the battery charging status.
- You will observe that the phone acts as it is switched 'Off'. A battery-charging alert is given and a battery charging indication on the display is shown to acknowledge the user that the battery is being charged.

Procedure: Analyze the sleep mode of a mobile phone :

- Once the TechBook is initially ready as per the set up and if it detects the GSM service provider network(s) with sufficient network strength, further experiment can be done with this TechBook as follows :
- Now switch off the TechBook after some seconds.
- Do not remove the battery.
- Measure the voltages at the test points given in Power Management unit. All voltages except VCC will be 0V.
- Measure the voltages at the battery terminal test points 12 and 13 with respect to ground test point 14.
- You will observe that in the sleep mode all the regulators are off sleep mode is activated by the CPU after CPU and DSP clocks have been switched 'Off'.

Result :

Studied and analyzed various modes of operation : Active mode / Acting Dead mode / Sleep mode in Mobile Communication Trainer board.

VCB

Week

12

Theory

Practical Experiment

12.1 Video Demonstration & Documentation on Troubleshooting, Testing and Replacement of Display, Front Camera

12.2 Video Demonstration & Documentation on Troubleshooting, Testing and Replacement of Charging Port, Battery

12.1 Mobile Displays : Working Principle :

There are many types of touch screens (Resistive, Capacitive, Acoustic, Optical Imaging, Infrared) but if for mobile phones there are basically two types of touch screens. They are as follows :

- Resistive Touch screen
- Capacitive Touch screen

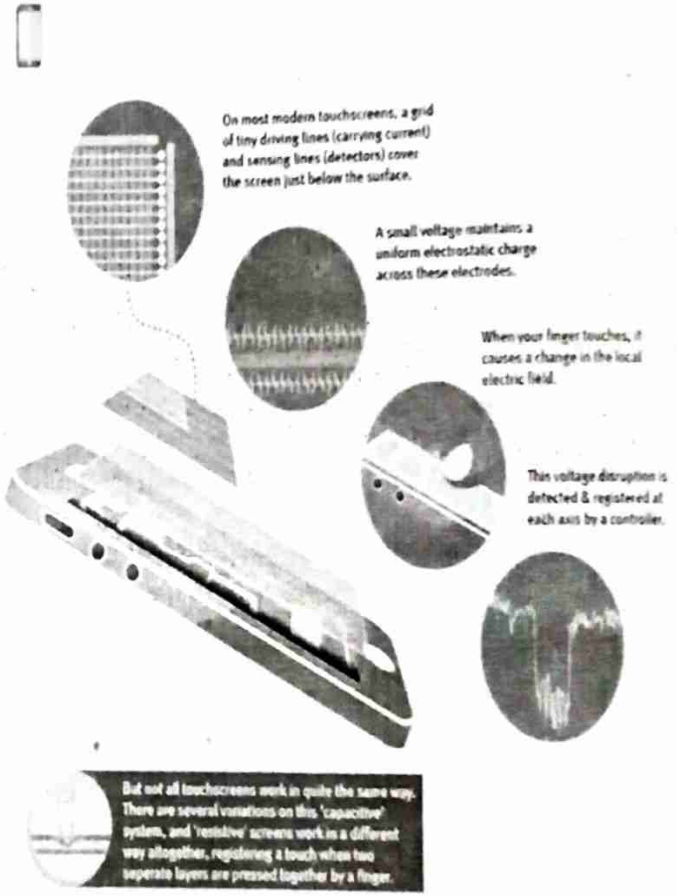


Fig. 12.1

12.1.1 Resistive Touch Screen :

The resistive touch screen resists your touch literally and if you press harder you can feel the screen bent slightly. This is what makes the resistive touch work. There are two layers in the resistive touch, the resistive layer and the conducting layer. These are separated by tiny dots called spacers. The electric current flows through the conductive layer at all times but when you touch the screen i.e. resistive layer, it comes in contact with the conducting layer. Thus the electric current changes at that point and the function corresponding to that point is carried out.

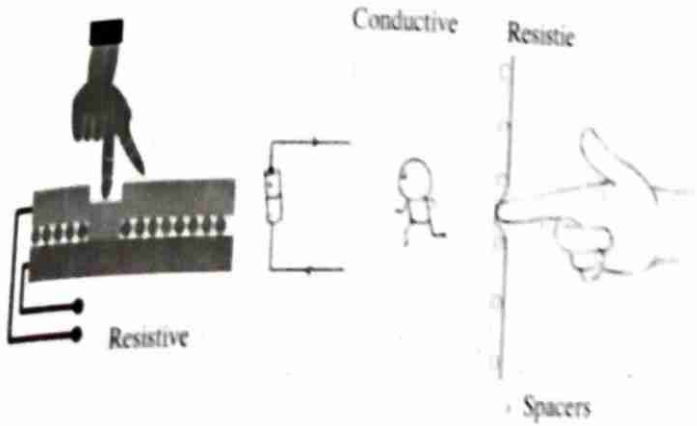


Fig. 12.2

12.1.2 Capacitive Touch Screen :

Unlike Resistive touch Screen, it does not use the pressure of your finger for the flow of electricity. Instead, they work with anything that holds an electric charge, including human skin. They are made from materials like copper and indium tin oxide that hold electric charges in an

electrostatic grid of wire each smaller than a human hair. There's a glass substrate, a conductive layer, a protector, a controller and electrodes at the corners. The electrodes apply a low voltage to the conductive layer to form a electrostatic field. When a finger hits the screen, a tiny electrostatic charge is transferred to the field that completes the circuit. A voltage drop is created at that point. The location of the voltage drop is reported by the controller.

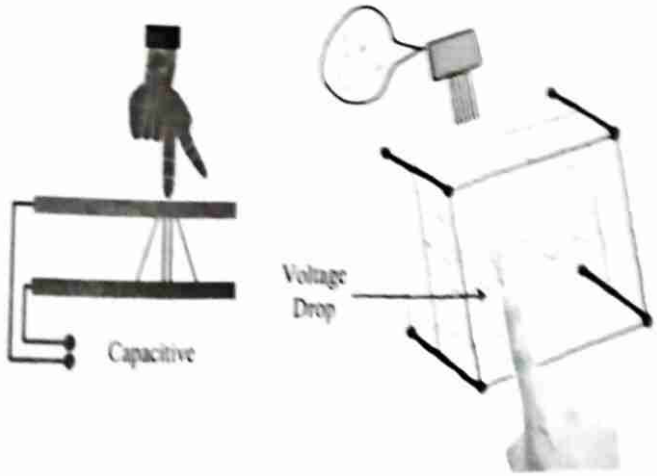


Fig. 12.3

12.2 Mobile Camera : Working Principle :

Mobile camera works exactly like the human eye. Instead of biological processing, it does the digital processing. Before moving towards mobile camera imagine how the human eye works (In laymen way).

1. *Open eyes.*
2. *Light enters in the cornea, adjust by iris and sense by the lens.*
3. *Now the amount of light enters the cornea determine the final image quality.*
4. *The interval of blink determines the how long the cornea is exposed to light.*
5. *Once the light reaches to the retina final image produced with the help of some veins and biological processing.*

The same terminology and processing are used in the camera, but the name of functioning units and parts are different though. Here in the camera, the law of physics and phenomena are working behind the scene. Below figure shows that how mobile camera works.

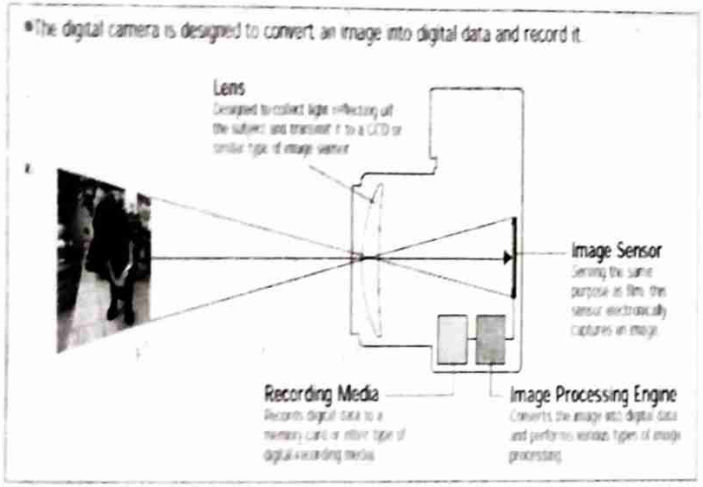


Fig. 12.4

The working principle process is the same for both DSLRs and smartphone cameras as :

1. The user (or smartphone) focuses the lens
2. Light enters the lens
3. The aperture determines the amount of light that reaches the sensor
4. The shutter determines how long the sensor is exposed to light
5. The sensor captures the image
6. The camera's hardware processes and records the image.

Most of the items on this list are handled by relatively simple machines, so their performance is dictated by the laws of physics. That means that there are some observable phenomena that will affect your photos in fairly predictable ways.

For smartphones, most of the problems will arise in steps two through four because the lens, aperture, and sensor are very small—and therefore less able to get the light they need to get the photo you want. There are often tradeoffs that have to be made in order to get usable shots.

12.3 Charging Ports and Battery Concept :

A battery works by converting its stored chemical energy into electrical power. Once the electrolyte of the battery is used up, it needs to be recharged. A battery charger is a device that provides Direct Current (DC) to the battery to restore the used-up electrolyte. So ideally, when all the electrolytes of the battery are restored, it's current supply should stop.

The whole charging process is a combination of charging, stabilizing (optimizing the charging rate), and terminating (knowing when to stop charging). Charge and discharge rates of the batteries are given as C-rate (Charge Rate). It is the measure of the rate at which the battery is charged or discharged with respect to its capacity (measured in Ah). For example, if a fully charged 4Ah battery is discharged at a 4-ampere rate, then it will take an hour to get fully charged. Most modern mobile phones use lithium-ion batteries, which last for a long time when they are frequently charged.

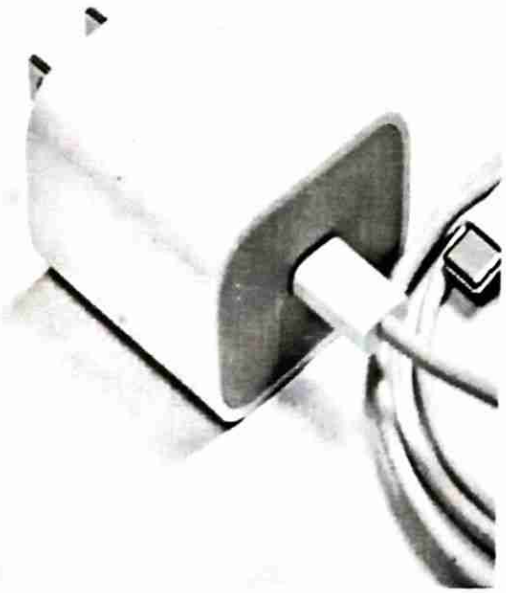


Fig. 12.5

The charging should immediately stop once a battery is fully charged. But standard chargers have no way of knowing when the charging has reached 100 percent, and they keep supplying power to the battery. This is the reason

you see batteries heating up—it's a way to release the extra power supplied to them. Overcharging batteries can not only damage a battery but also reduces its life. There are various types of battery chargers available like a trickle, time-based, simple, smart charger, pulse, motion-powered, solar, fast, and three-stage charger.

A charger is always manufactured for a specific battery based on the amount of current it will provide and the time it will take to fully charge the battery. This means that the charger designed to charge a particular battery may not be suitable for another battery. Manufacturers of gadgets recommend that the same brand of battery charger should be purchased to charge the batteries. You can get the best from your battery charger by not charging different capacities or chemistries of batteries together. This can damage batteries over time.

12.3.1 Choosing the Right Charger :

There are a few factors which need consideration while selecting a battery charger :

- Battery type
- Voltage rating
- Maximum charging current
- Battery size
- Battery capacity in Ampere-hour
- Cost.

A good battery charger will help the batteries to perform well. Avoid overcharging your batteries to increase their life and save them from permanent damage. Good battery life will also help in improving the performance of your electric equipment.

12.3.2 Micro USB Port :

Fig. 12.6

Most Android smartphones, tablets, and other gadgets came with micro-USB ports till 2020. It had the name micro because it is smaller than other USB ports like the USB type A and type B ports. There are different micro-USB ports like the micro-USB 2.0 and micro-USB 3.0. The thing is that the 2.0 port will work with regular USB type-A ports and with USB 3.0 ports. But the micro-USB 3.0 won't work with standard USB type-A ports. The micro-USB cables usually come with a different plug to the other side. Usually, it comes with a regular USB plug to the other side. The micro-USB cables are most likely to damage within a year or so.

12.3.3 USB C Type Port :

The USB C type port is slowly replacing ports like micro-USB in smartphones and other gadgets. The USB C ports are often mentioned as the port of the future. Apart from USB Type-A ports, all other USB ports will be replaced with USB type C ports in the future. It will enhance convenience, and one cable can be used to connect all devices. The C ports are smaller and thinner in size. Earlier, only MacBook used to come only with type C ports. But now, most laptops feature only USB C type ports.

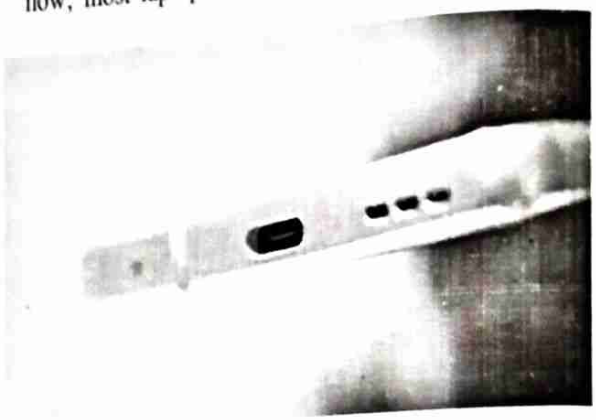


Fig. 12.7

The main advantage of the USB C type ports is that we can plug the cables in both ways. That is, in all other ports, you might have to plug in a specific position. The reason for this is the symmetrical design of the USB type C plugs. There are two types of USB C type cables, i.e., one which comes with the same plug to the other side. And the other cable that comes with a different plug, i.e., a USB plugs.

Practical Experiment 12.1

Note: Browse the below sample video links for the given experiment demonstration. The links shown here are sample illustrative only. Users can search such similar videos.

Video Demonstration & Documentation on Troubleshooting, Testing and Replacement of Display, Front Camera

Sample Video Link on

https://youtu.be/iRMWPCEygbM

https://youtu.be/-gCTVimCxJ4

Observation/Result :

After watching the above sample demonstration videos or any such similar videos, write a brief note/summary document in your own sentences about what you understand from the video.

Practical Experiment 12.2

Video Demonstration & Documentation on Troubleshooting, Testing and Replacement of Charging Port, Battery

Sample Video Link on

https://youtu.be/zuiG8mQoi6k

https://youtu.be/ztcEO-WcT7c

Observation/Result :

After watching the above sample demonstration videos or any such similar videos, write a brief note/ summary document in your own sentences about what you understand from the video.

Week

13

Practical Experiment

Practical Experiment 13.1

Build an IOT Based Simple Real Time Application using Arduino Controller and Prepare a Report

Aim/Objective :

Build an IOT based simple real time application using Arduino controller and prepare a report.

Application :

Control of LED On/Off via IOT Blynk App & Proteus Software using Arduino with Internet of Things in real time Application.

Components/Software's Required :

- Proteus 8 Professional Software
- Arduino IDE 1.8.19 with Blynk Arduino Library
- Virtual Port Emulator
- Arduino UNO R3 Device
- Blynk App in Your Phone
- COMPIM
- LED-Red
- Resistor
- Ground.

Procedure :

- Double click on Proteus 8 icon or Right click on proteus 8 icon → open.
- Click on "New Project" → Give the name for project and path to store the folder. Tick on 'New Project' and click next.
- Tick on "Create a schematic from the selected template". Slect "Portrait A4" and click next.
- Tick "DO not create a PCB Layout" and click next.
- Tick "No Firmware project" and click next → Finish.
- Click on a "File" → "New Design" → File → Save Design As → Give name for schematic file.
- Double click on 'P' and then Browse the required components by typing the Components name.
- First Check for Arduino UNO R3 Controller in your Proteus 8 Software if not ***Download Arduino UNO R3 Library Files*** from internet and then add to Proteus Library files to it on library that is ***Localdisk(C)/ Programfiles(x86)/LabcenterElectronics/Proteus8 Professional/Library*** then Paste Libray Files to it.
- First Check for Genuino Controller Library for Proteus in your Proteus 8 Software if not ***Download using*** https://www.theengineeringprojects.com/2016/03/genuino-library-proteus.html***Library Files*** from internet and then add to Proteus Library files to it on library that is ***Localdisk(C)/Programfiles(x86)/Labcenter Electronics/Proteus8 Professional/Library*** then Paste Libray Files to it.

- Also, download& Installvirtual Serial ports Emulator on your system byusing the link ***https://free-virtual-serial-ports-emulator.en.softonic.com/download.***
- Choose and Place Required Components such as Arduino UNO R3 Controller, Communication Port (COMPIM) & LED-RED, Resistor 330kohm by double click on 'P' and then Browse the required components by typing the Components name using keywords.
- Go to terminals icon → Choose ground.
- Drag all components to Editor window and place the components as per circuit diagram.
- Double click and edit the values of components according to requirements.
- Rig up the circuit using wire and connect all the components as per the circuit diagram.
- Connect RXD (2pin) to O Pin of Arduino UNO R3 & TXD (5Pin) to 1 Pin of Arduino R3.
- Also Connect LEDs to 11,12,13 Pins of Arduino UNO R3.
- Also Double click on LED and edit components as Change LED Module type to Digital.
- Now Double Click on COMPIM and change Values accordingly Physical Port to Com 3, Physical baudrate to 9600, data bits to 8 and Virtual Baud Rate to 9600.
- Now Download and install Arduino IDE 1.8.19 on your system and write the Arduino Code for. Control of LED On/Off via IOT Blynk App.

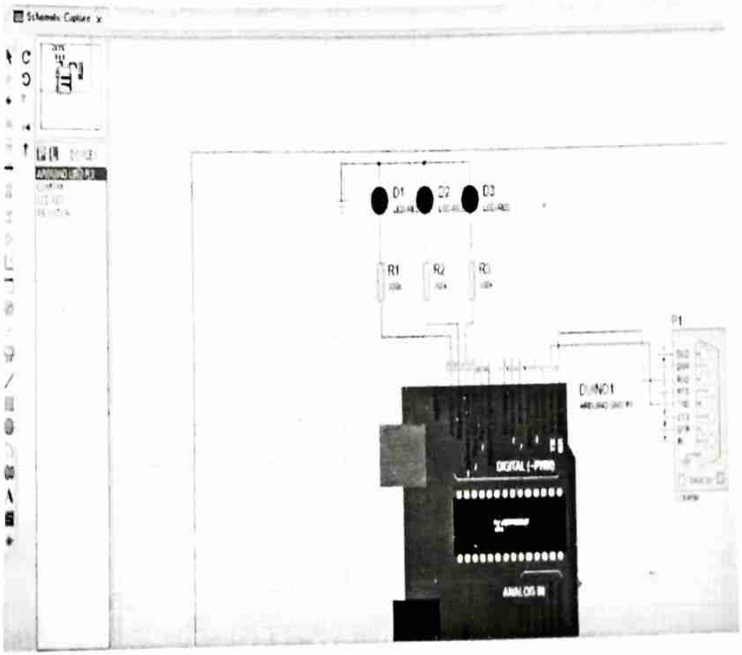
- *Now Connect your system to internet Now* ***Go to Arduino IDE 1.8.19 Tools–Manage Libraries-type Blynk install Latest version 1.0.1 library files to Arduino IDE.***
- To generate Hex File on Arduino IDE 1.8.19 go to file and choose preferences and then select or tick Compilation tab and then Press ok.
- Now Compile Arduino Code & Copy HEX File Location then Paste it in Proteus inside Arduino Properties of Arduino UNO R3 Controllers.
- Now Open your Phone Install Blynk IOT App on your Mobile Get Sign in using email and then create new Project add three Buttons to control LED as Switch (ON/OFF) also Select Appropriate Port Pins as 11, 12 & 13 in Swiches.
- Also Check Your registered email for Authentication Token to Control LED.
- Copy and Replace Authentication Token on the Arduino Code and the get it compile again and generate Hex file and copy and paste link to Arduino UNO R3 Controller.
- Now Open Virtual Terminal Emulator select Create new device and choose device type as Par the Click Next and select Virtual Serial Port1 as Com3 and Virtual Serial Port2 as Com1 and Click on Finish then Click play Button Pairing is ready and then press ok.
- Go to Command Window then type as dir press enter again type as blynk-ser.bat -c COM1 -p 8442 then press enter.

- Now Compile Arduino Code & Copy HEX File Location then Paste it in Proteus inside Arduino Properties of Arduino UNO R3 Controllers.
- Click on 'Debug' icon and click on 'Run' to run the simulation or press F12.
- Open Blynk App On your Mobile and then check for ONLINE Mode Server and change Switch Button to On/Off Mode and view the output accordingly on your Circuit.
- To stop the simulation press ESC key.

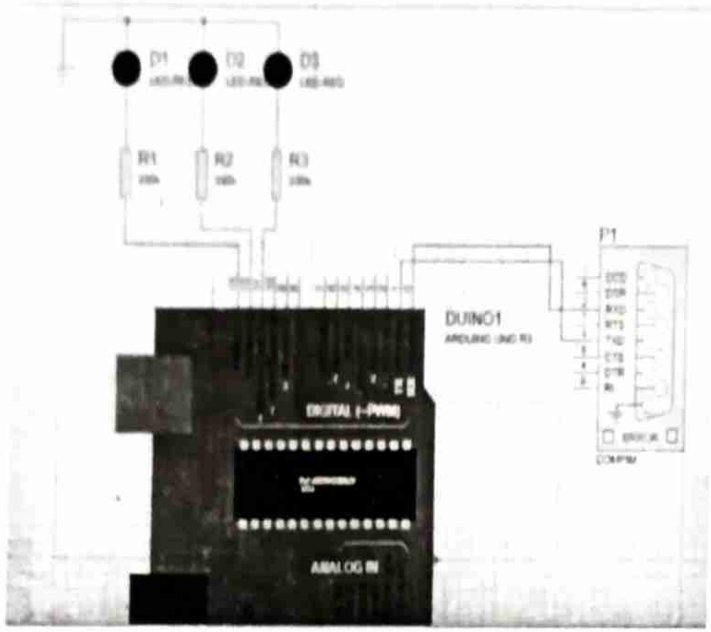
Procedural Steps illustration using Screen Shots :

Steps :

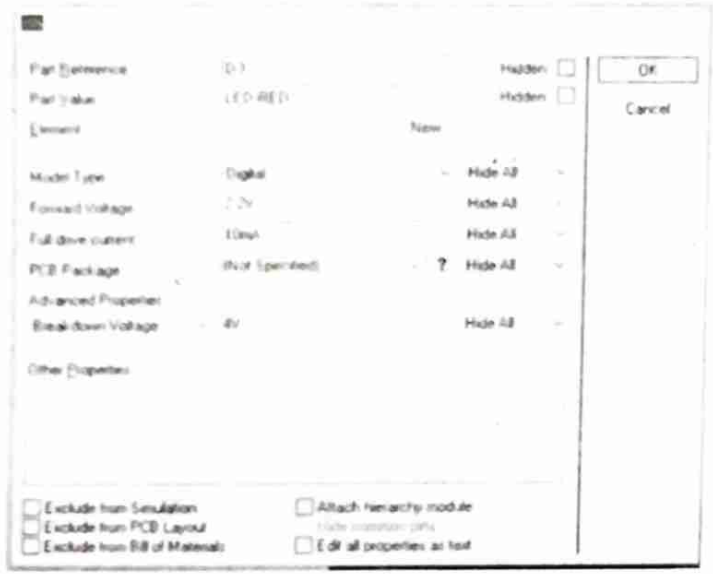
1. Connect the Circuit /Model As per Circuit Diagram.



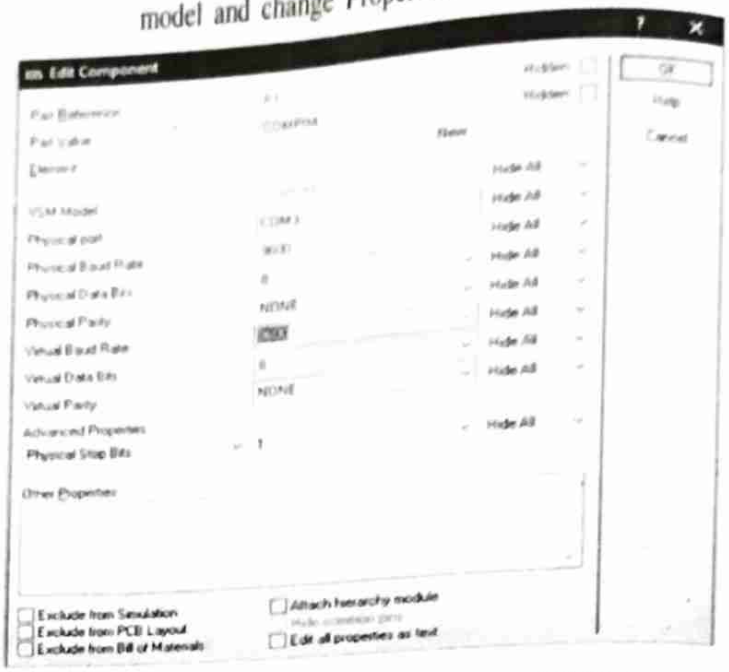
2. Connect the Pins as per this Circuit Diagrams.



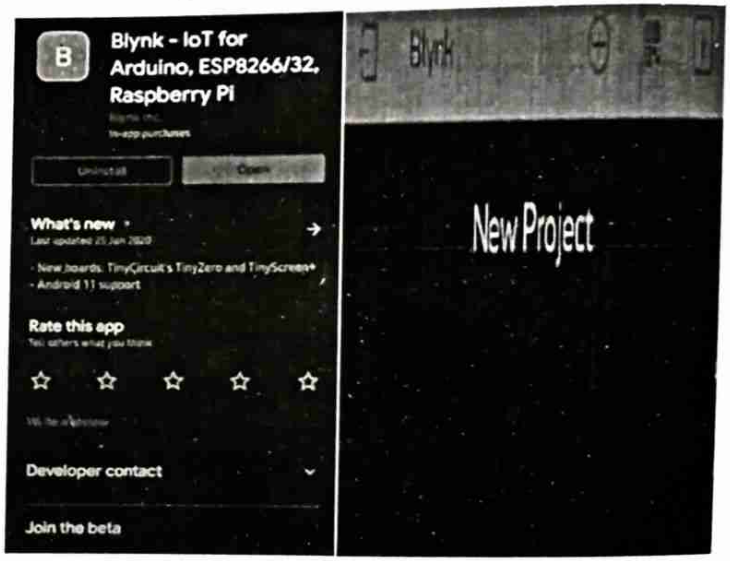
3. Change LED Values by Double click and change Properties/Model Type Digital accordingly as shown.



4. Double Click on COMPIM Communication Interface model and change Properties as shown below.



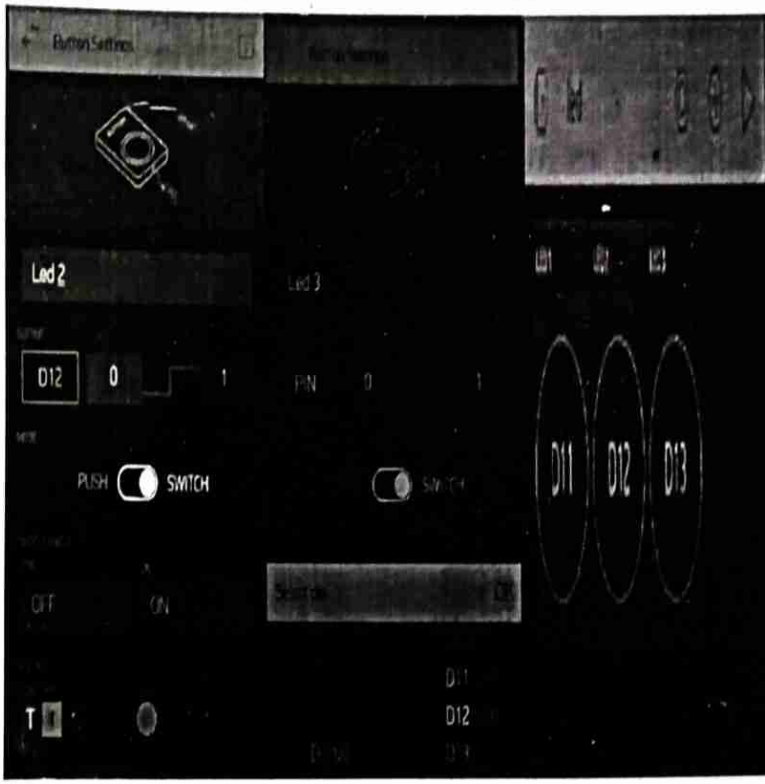
5. Open Your Mobile and Install BLYNK-IOT App and get it sign in using email id and connect with internet using Wi-fi/USB.



6. Create New Project and Name the Project.

7. Check Your registered e-mail for Authentication Token and also add 3 Buttons in the project.

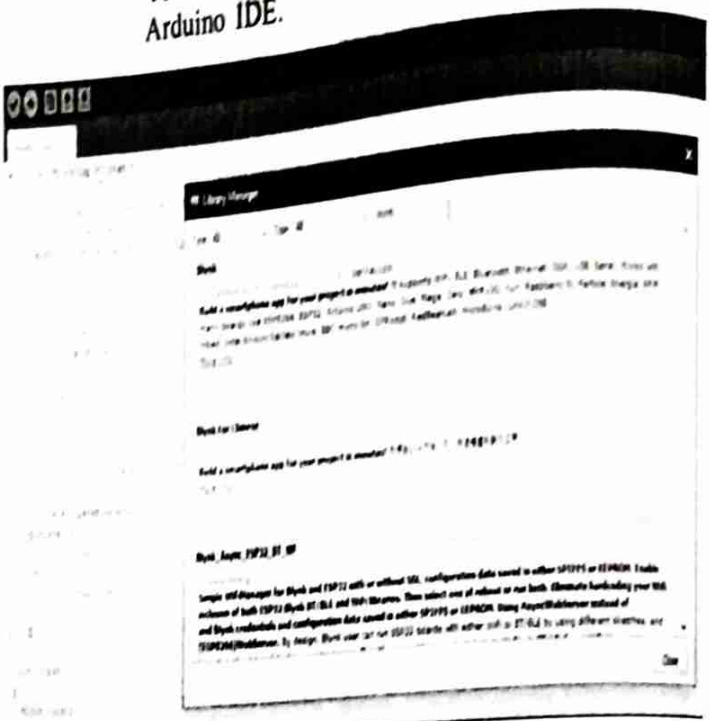
8. Change Button Settings Properties as LED1/LED2/LED3 and Select Port as 11/12/13 pins and change button type to Push Button click ok.



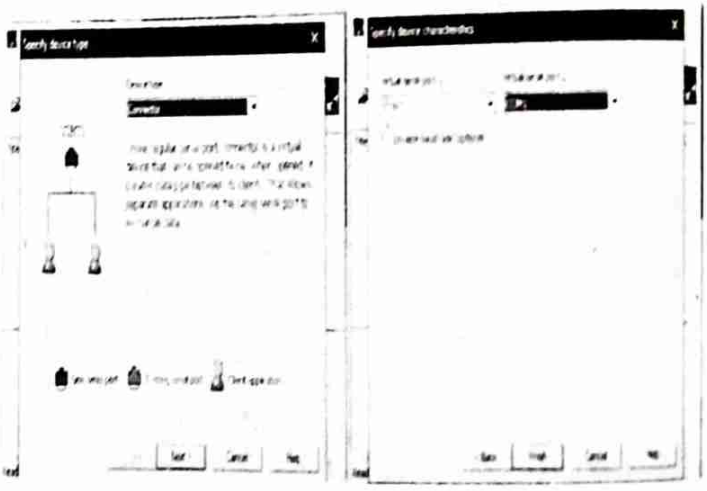
9. Open your email and copy the Authentication Token and paste in to the Arduino Code.

10. Paste Authentication Token in to Arduino Code.

Go to Arduino IDE 1.8.19 Tools - Manage Libraries- type Blynk install Latest version 1.0.1 library files to Arduino IDE.



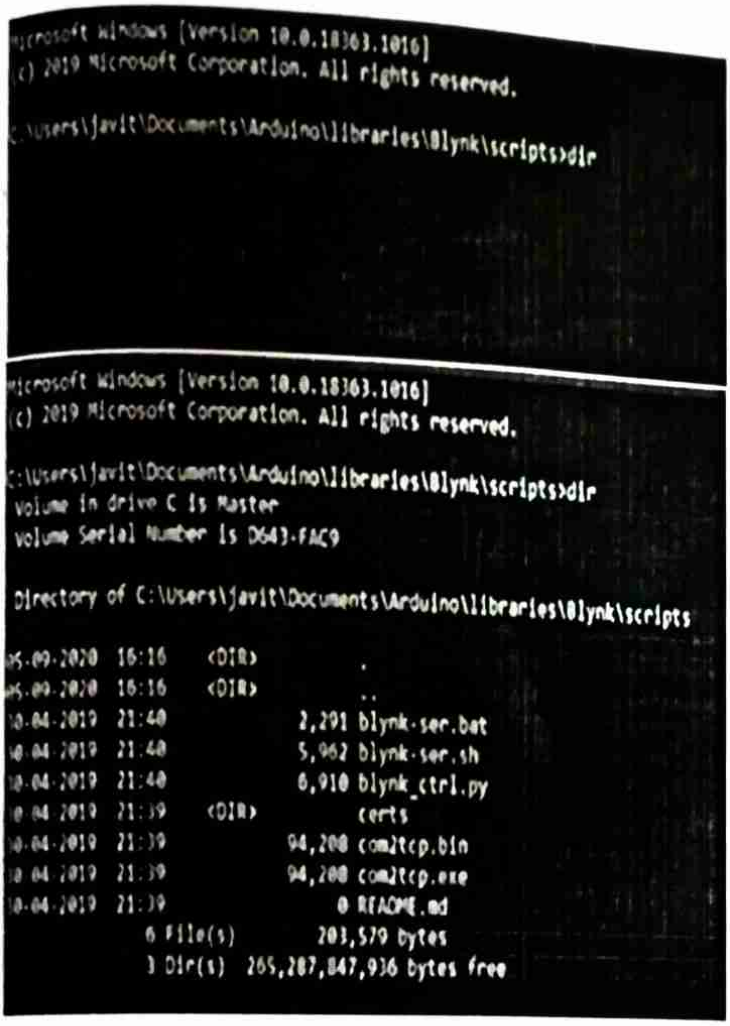
11. Open the Virtual terminal emulator and perform the pairing of Virtual Terminal Ports.



12. Open Command Window then type the commands as follows;

cmd-

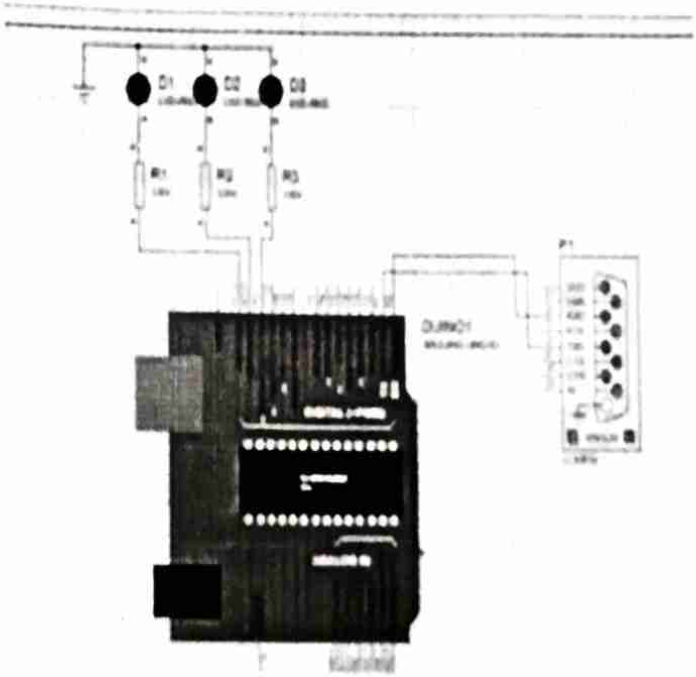
1. dir press enter



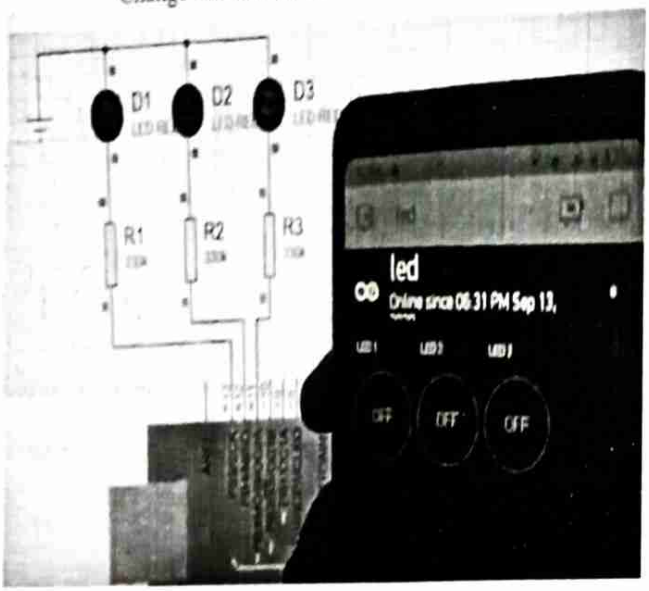
Type as

blynk-ser.bat -c COM1 -p 8442 press enter

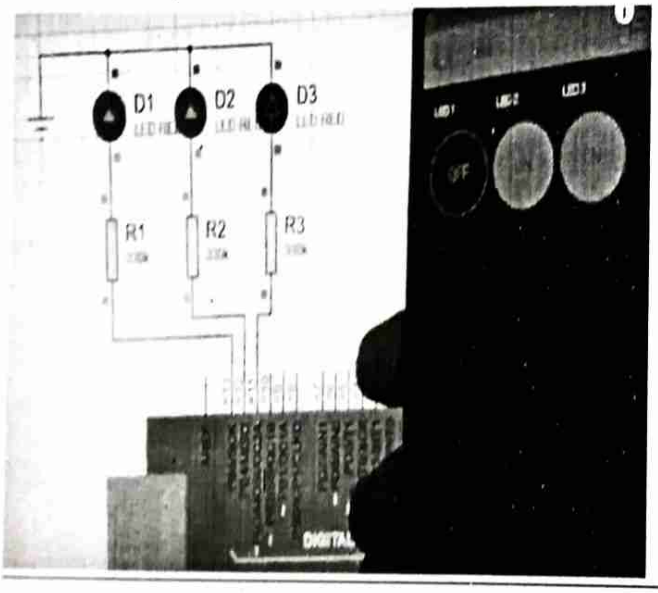
13. Copy and paste the Hexfile Location in to Arduino UNO R3 and then run the simulation.



14. Now open Blynk App on your mobile and wait for Online Mode of Project once get it in to Online then Change the Switch Button ON/OFF Mode.



15. View the output accordingly LED On/Off on the Computer.



Arduino Code :

```
#include <BlynkSimpleStream.h>
 // You should get Auth Token in the Blynk App.
 // Go to the Project Settings (nut icon).
charauth[] = "3NyiiB8i6r6EWvRfuS43nSb8NGexA9KH";
void setup()
 {
Serial.begin(9600);
Blynk.begin(auth, Serial);
pinMode(11, OUTPUT);
pinMode(12, OUTPUT);
pinMode(13, OUTPUT);
 }
 BLYNK_WRITE(V1)      //Button Widget is
                        writing to pin V1
{
intpinData = param.asInt();
if(pinData==1){
digitalWrite(11, HIGH);
}else{
digitalWrite(11, LOW);
  }
}
```

Week 13

```
void loop()

{

Blynk.run();

}
```

Results :

Control of LED On/Off via IOT Blynk App & Proteus Software using Arduino with Internet of Things in real time Application is Verified.