General Knowledge Today

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Contents

Model Questions

Prelims MCQ Topics

Parts of Computer -Input, Output devices, Cold Boot and Warm Boot, Bits and Bytes, Bytes, Octets and Nibble, Computer Memory, LAN, WAN & MANs, Routers & Bridges, Analog versus Digital Signals, Difference between Optical Fibres and Ordinary Cables, Construction material for Optical Fibres, Electromagnetic Spectrum, Frequency and Wavelengths in EM waves, Radio Spectrum, Long wave, medium wave and shortwave radio, sweet spot, Working of Radio sets, Microwaves, Infra Red waves, Night Vision, Thermal Imaging, Mobile telephony basics, 1G to 5G services, Cognitive Radio Technology, CDMA, GSM, GPRS, EDGE, Bluetooth, Wi-Fi, GPS, Standard Positioning and Precision Positioning in GPS, Satellite Television.

Select Topics in Computers

Charles Babbage

Charles Babbage (1791-1871) is known as father of computers. He originated the concept of programmable computer and invented first mechanical computer.

ENIAC and UNIVAC

ENIAC (*electronic Numerical Integrator and Computer*) of 1940s was first functionally useful electronic digital computer. Universal Automatic Computer (UNIVAC) was innovated in 1940s that led to the first commercially successful computer.

Integrated Circuits

Integrated Circuits or Chips are miniaturized electronic circuits that consist of mainly of semiconductor devices. The first integrated circuits contained only a few transistors and so were called "small-scale integration **(SSI)**.

With the increase in number of transistors, they have undergone evolution via medium-scale integration (**MSI**), Large Scale Integration (LSI), Very large-scale integration (VLSI) and ULSI (ultra-large scale integration) which has more than a million transistors.

Parts of a Computer

All general-purpose computers has the following main hardware components.

- **Memory:** Memory enables the computers to store, at least temporarily, data and programs.
- **Mass storage device:** Allows a computer to permanently retain large amounts of data. Common classic mass storage devices include disk drives and tape drives. The latest being the Hard Disks and USB mass storage devices.
- **Input device:** The most usual input devices are a **keyboard and mouse.** They are used to put in data and instructions to computer.
- **Output device:** The most usual output devices are display screens such as Monitor which are of several types now a days and a printer, or other device that lets us see what the computer has accomplished.
- **Central processing unit (CPU)**: This can be called brain of the computer which actually executes the instructions.

Central Processing Unit

A general purpose computer has four main sections: the arithmetic and logic unit (ALU), the control unit, the memory, and the input and output devices (collectively termed I/O). These parts are interconnected by busses, often made of groups of wires. The control unit, ALU, registers, and basic I/O (and often other hardware closely linked with these) is collectively known as a Central Processing Unit (CPU).

Primitive CPUs were comprised of many separate components but since the mid-1970s CPUs have typically been constructed on a single integrated circuit called a microprocessor. CPU plays a role analogous to the brain in the computer.

The CPU can be a single chip or a series of chips that perform arithmetic and logical calculations and that time and control the operations of the other elements of the system. It was the contribution of the miniaturization and integration techniques that made possible the development of the microprocessor. A Microprocessor is a CPU chip that incorporates additional circuitry and memory. Typical CPU chips and microprocessors are composed of four functional sections:

- **Arithmetic/logic unit (ALU):** gives the chip its calculating ability and permits arithmetical and logical operations
- **Registers:** The registers are temporary storage areas that hold data, keep track of instructions and hold the location and results of these operations.
- **Control section:** The control section times and regulates the operations of the entire computer system; its instruction decoder reads the patterns of data in a designated register and translates the pattern into an activity, such as adding or comparing; and its interrupt unit indicates the order in which individual operations use the CPU and regulates the amount of CPU time that each operation may consume.
- **An internal bus:** It's a network of communication lines that connect the internal elements of the processor and also leads to external connectors that link the processor to the other elements of the computer system.

CPU Cache

A CPU cache is a cache used by the central processing unit of a computer to reduce the average time to access memory. The cache is a smaller, faster memory which stores copies of the data from the most frequently used main memory locations.

Motherboard

The motherboard is the main circuit board of the computer and as such acts as the "circulation system" of the computer. All signals used by the computer are processed by the motherboard. Memory chips, the central processor, expansion boards and cables to disk drives all attach to the motherboard. Thus, a motherboard is the data and power infrastructure for the entire computer.

Port

A hardware computer port is a physical interface between a computer and other computers or devices. A software computer port is a virtual data connection between computer programs possibly through a computer network.

USB

USB stands for universal serial Bus and is a common component on new computers. The port looks like a flat slot and there are usually two of them together. These are also called Plug-and-play ports. They are such that once they are in used; the connected devices start handshaking automatically.

BIOS

BIO refers to **basic input/output system** (BIOS). BIOS software is built into the PC, and is the first code run by a PC when powered on, and that is why it is called **boot firmware**. In computing, **firmware** is software that is embedded in a hardware device. Thus, primary function of the BIOS is to set up the hardware and load and start an operating system.

A computer or laptop keeps track of time even when it is switched off. Why?

A desktop PC has a lithium cell or battery (the same is used in digital diaries) called a BIOS cell inside the CPU, and attached to the motherboard, which keeps track of time even after the computer is powered down, whereas in laptops, the battery of the laptop itself is used to keep track of time. This battery also saves the settings required during a boot operation.

What is difference between Cold Boot and Warm Boot?

We actually perform a Cold Boot every time we turn on the power switch of our computer. To "boot" the computer means to start it up and reset the memory and BIOS. Sometimes, the programme running hangs and we press the ctrl-alt-delete keys simultaneously. This is called Warm Boot. So, when a computer stops responding because of memory problems or the "blue screen of death" appears, we need to do a warm boot. The latest operating system Windows 7 responds with task manager when we press the ctrl-alt-delete keys simultaneously. We can choose the not responding programmes to close and continue. However, if the warm boot fails to restart the computer, we need to resort to a cold boot by shutting off the power switch, waiting few seconds and then turning it back on.

CMOS

CMOS is an abbreviation for **Complementary Metal Oxide Semiconductor**. CMOS technology is used in microprocessors, microcontrollers, static RAM, and other digital logic circuits. CMOS uses a complimentary arrangement of NMOS and PMOS, Negative and Positive Metal Oxide Transmitter Circuits. CMOS setup is part of the BIOS program.

Bits and Bytes

A bit refers to binary digit. It is the smallest unit of data in computer, which consists of base 2 digits (i.e. there are only 2 possible values; 0 or 1). There are several units of information which are defined as multiples of bits, such as byte (8 bits), kilobyte, megabyte, gigabyte and terabyte.

1 Byte = 8 Bit

1 Kilobyte = 1,024 Bytes

1 Megabyte = 1,048,576 Bytes

1 Gigabyte = 1,073,741,824 Bytes

1 Terabyte = 1,099,511,627,776 Bytes

What is difference between Bytes, Octets and Nibble?

The term byte initially meant the smallest addressable unit of memory. In the past, 5-,6-,7-,8-, and 9-bit bytes have all been individual bits (bit-addressed machine) or that could only address 16-or 32-bit quantities (bit-addressed machine). The term byte was usually not used at all in connection with bit- and word-addressed machines. However, term octet always refers to an 8-bit quantity. Today, it mostly used in the field of computer networking, where computers with different bytes widths might have to communicate.

A nibble is a four-bit aggregation, or half an octet. As a nibble contains 4 bits, there are sixteen (24) possible values, so a nibble corresponds to a single hexadecimal digit (thus, it is often referred to as a "hex digit" or "hexit"

Memory

Memory refers to the temporary internal storage areas within a computer. The term memory is usually used as shorthand for 'physical memory', which refers to the actual chips capable of holding data. Some computers also use 'virtual memory', which expands physical memory onto a hard drive.

RAM

The main type of memory and the most familiar to users is random access memory (RAM). RAM is the same as main memory. A computer can both write data into RAM and read data from RAM. Every time we turn on a computer, a set of operating instructions is copied from the hard disk into RAM. These instructions, which help control basic computer functions, remain in RAM until the computer is turned off. Most RAM is volatile, which means that it requires a steady flow of electricity to maintain its contents.

ROM (read only memory)

Unlike RAM, ROM is non-volatile and only permits the user to read data. Computers almost always contain a small amount of read-only memory that holds instructions for starting up the computer.

PROM (programmable read-only memory)

A PROM is a memory chip on which you can store a program. Once the PROM has been used, you cannot wipe it clean and use it to store something else. Like ROMs, PROMs are non-volatile.

EPROM (erasable programmable read-only memory)

An EPROM is a special type of PROM that can be erased by exposing it to ultraviolet light. EEPROM (electrically erasable programmable read-only memory): an EEPROM is a special type of PROM that can be erased by exposing it to an electrical charge.

PROM, FPROM and ROM

A programmable read-only memory (PROM) or field programmable read-only memory (FPROM) is a form of digital memory where the setting of each bit is locked by a fuse or antifuse. Such PROMs are used to store programs permanently. Read-only memory means that, unlike the case with conventional memory, the programming cannot be changed (at least not by the end user).

> **Why some data such as picture / videos take more time to copy?**
> All kinds of data are stored internally as binary digits (bits). Procedure for a copying a file is that the computer first copies the file content as bits from the main memory to its RAM buffer and then to the new location in the main memory. In this procedure there is a criterion that only certain amount of bits can be transferred from main memory to RAM at a time which is mentioned by the block size. Ex: 16-bit, 32-bit, 64-bit computers.

Data files are characters or numbers and thus each require just one byte (8 bits) or two bytes (16 bits) respectively, whereas, image files are stored pixel by pixel (smallest unit in the screen) and thus require more number of bits to store them. Thus during copying as more number of bits must be transferred between the main memory and RAM, the time taken for copying pictures is more than simple data files. Also the time taken for copying the same picture varies from computer to computer depending on the block size.

SRAM v/s DRAM v/s VRAM

Dynamic Random Access Memory (DRAM) is a type of random access memory that stores each bit of data in a separate capacitor within an integrated circuit. Its advantage over SRAM is its structural simplicity; only one transistor and a capacitor are required per bit, compared to six transistors in SRAM. VRAM is a dual-ported version of DRAM formerly used in graphics adaptors. It is now almost obsolete, having been superseded by SDRAM and SGRAM. VRAM has two paths (or ports) to its memory array that can be used simultaneously.

Flash Memory

Flash memory is a form of non-volatile computer memory that can be electrically erased and reprogrammed. Flash memory applications include digital audio players, digital cameras and mobile phones. Flash memory is also used is USB flash drives (Thumb drives, handy drive), which are used for general storage and transfer of data between computers. It has also gained some popularity in the gaming market, where it is often of EEPROM or battery-powered SRAM for game save data.

Keyboard

The standard microcomputer keyboard consists of 104 keys arranged in the standard typewriter or QWERTY layout. A separate numeric keypad is at the right side of the keyboard and can be toggled on or off by pressing the "num lock" key. This numeric keypad may not be found in small size laptops and keywords.

QWERTY comes from the first six letters in the top row. It was invented by **C L Sholes** in 1872.

Mouse

A mouse is a handheld device for moving the pointer around the screen. It is a primary component of the windows GUI (Graphical User Interface) environment. The use of the mouse in windows allows the user to point at and clicks on various icons for programs and data files rather than having to type in commands to copy files, open programs, etc. as in the older DOS.

Data Storage

The area within a computer system where data can be left on a longer term basis while it is not needed for processing is called "Data storage". The mass storage devices include the diskettes, Hard Drives, Optical Disks and Magnetic Tapes.

Hard Disk

The hard disk is an internal storage device which holds programs and data used by a computer. It consists of magnetic platters with read/write heads that float above the platters to record and play back data.

Compact Discs

Compact Disc (CD) is an optical disc made of several layers of a type of plastic usually **Polycarbonates**. The outer layers are protection layers, which simply absorb scratches so that the inner layer holding data remains intact.

DVD

Digital Video Disc or Digital Versatile Disc (DVD) is also an optical storage device that looks the same as a compact disc but is able to hold about 15 times as much information and transfer it to the computer about 20 times as fast as a CDROM. The CD and DVD have the same dimensions.

Blu Ray Disc

Blu-ray, also known as Blu-ray Disc is the name of a next-generation optical disc format that has been jointly developed by the Blu-ray Disc Association (BOA). Blu Ray Disk offers more than five times the storage capacity of traditional DVDs and can hold up to 25GB on a single-layer disc and 50GB on a dual-layer disc.

Monitor

Monitor or visual display unit is the most common output device of a computer. It comprises a display device, circuitry, and an enclosure. The display device in modern monitors is typically a thin film transistor liquid crystal display (TFT-LCD) thin panel, while older monitors use a cathode ray tube about as deep as the screen size. The primitive monitors used the Cathode Ray Tubes (CRTs), until they were replaced by LCD monitors.

Cathode Ray Tube

Cathode Ray Tube (CRT) was invented by German physicist Karl Ferdinand Braun in 1897. It is the device that was long used in most computer displays, video monitors, televisions radar displays and oscilloscopes. The CRT has undergone numerous developments until the advent of plasma screens, LCD, TVs, DLP, OLED displays, and other technologies. Technically, CRT has an electronic vacuum tube employing a focused beam of electrons.

LCD TFT Display

Liquid Crystal Display television (LCD TV) is television that uses LCD technology for its visual output. The technology used is generally TFT. TFT refers to a Thin Film Transistor, which is a special kind of field effect transistor made by depositing thin films for the metallic contacts, semiconductor active layer, and dielectric layer. LCD panels are made of two layers of transparent material, which are polarized, and are "glued" together. One of the layers is coated with a special polymer that holds the individual liquid crystals. Current is then passed through individual crystals, which allow the crystals to pass or block light to create images. LCD crystals do not produce their own light, so an external light source, such as florescent bulb is needed for the image created by the LCD to become visible to the viewer. Thus, LCDs use a **strong backlight as the light source** and **control how much of this light is allowed to reach the pixels by selectively allowing the light to reach each pixel.**

Plasma Display Panel (PDP)

We have read above that LCD crystals do not produce their own light, so an external light source, such as florescent bulb is needed for the image created by the LCD to become visible to the viewer. The Plasma television technology is absolutely different from this. The Plasma Display Panel is based loosely on the fluorescent light bulb. The display itself consists of very microscopic cells and within each cell two glass panels are separated by a narrow gap in which neon-xenon gas is injected and sealed in plasma form. Gas is electrically charged at specific intervals and then strikes red, green, and blue phosphors, thus creating a television image. Each group of red, green, and blue phosphors is called a pixel (picture element). Due to presence of its own source of light, PDP suffers from the issues such as **heat generation and screen-burn of static images.**

EFT monitors

All types of monitors are a strain on our eyes. EFT, or Eye Fresh Technology, monitors have a vital coating on the rear that emits anions and far-infrared rays that serve to make the environment fresh and ease the strain on the eyes and relax the eyes and body.

Working of Touchscreen Monitors

In Touch screen Monitors, we can use our finger on the computer screen to navigate through the contents. This type of screens is most commonly visible in Public Information Kiosks and ATMs. The touch screen has 3 main components as follows:

1. **A Touch sensor:** It's a textured coating across the glass face. This coating is sensitive to

pressure and registers the location of the user's finger when it touches the screen.

2. **A controller:** It is a small PC card that connects the touch sensor to the PC. It takes information from the touch sensor and translates it into information that PC can understand.
3. **A Software driver:** Software Driver is a software update for the PC system that allows the touchscreen and computer to work together. It tells the computer's operating system how to interpret the touch event information that is sent from the controller.

Pervasive Computing

Pervasive Computing means Ubiquitous computing or **ubicomp.** It refers to embedding microprocessors in everyday objects so they can communicate information processing thoroughly integrated into everyday objects and activities. Thus Pervasive computing refers to increasing integration of Information Technology into human life and environment.

Applications of Pervasive Computing:

There can be an array of applications for pervasive computing ranging from healthcare, home care, transport and environmental monitoring and agriculture. In Healthcare, it may have applications such as in diagnosis, treatment and management of diseases by remote sensors and monitoring technology. Similarly, Environmental Monitoring Pervasive computing may provide ways to monitor the environment by allowing real-time data collection and analysis via remote, wireless devices.

Software

The computer programme which contains the instructions to make the hardware work is called software. There are two primary software categories viz. Operating Systems or System Software and Application Software.

Operating System handles the essential task such as maintaining file system and coordination of data and memory with CPU, external devices and output devices. For example Windows is an operating system and Microsoft Word is an application.

Programming Languages

A computer needs to be given instructions in a programming language that it understands. Programming languages, like human languages, are defined through the use of syntactic and semantic rules, to determine structure and meaning respectively.

Machine Language

The computer's own binary-based language, or machine language, is difficult for human beings to use. The programmer is required to input every command and all data in binary form. Machine languages are the most primitive types of the computer language.

High Level Languages

The high level languages use the English words such as OPEN, LIST, PRINT, which might stand for an array of instructions. These commands are entered via a keyboard or from a programme in a storage device.

DOS and WINDOWS

DOS stands for disk operating system. The most prevalent form of DOS was manufactured by Microsoft. The last version of DOS to be marketed separately was 6.22 and was used in conjunction with windows 3.11 Windows 95 includes DOS. The main difference between windows and DOS is the ability to "multitask" or use two or more programs or data files simultaneously.

Open Source Software

The DOS and Windows are the proprietary software of Microsoft. Then, we have thousands of Open source software (OSS). The OSS has its underlying 'source code' made available under a license, so that the developers and users are **allowed to adapt and improve it**. Most popular licensing system is GNU General Public License (GNU GPl, or GPL).

Linux

Linux is an open source operating system developed by Linus Torvalds as a version of UNIX that could run on a home computer. He patented Linux in 1991, and then made the system and its code available to others, free of charge, over the Internet. He licensed the system in such a way that anyone can copy and use it, but any improved versions a user creates must be made available to others under the same term, so this was under the GNU GPL.

Networks

A network consists of multiple computers connected using some type of interface, each having one or more interface devices. The primitive computers were the self contained devices in which the data was confined in it. The only way to transfer the data from one machine to another was to take the data in a storage device and send it across the machine. So, this necessity led to invention and development in the networks. In a computer network, the autonomous computers are interconnected and are able to communicate with each other. Networks enable the sharing of data among groups of computers and their users.

LAN, WAN & MANs

Local Area Networks (LANs) is confined to a fairly small geographic area. The clients and servers on a LAN are connected to the same channel, and are typically in the same building or in neighbouring buildings. The Metropolitan Area Networks (MANs) spans a wider area than LAN and Wide Area Networks (WANs) spread over a large geographic area, such as a country or a state.

Routers, Bridges & Backbone

The facilities on most LANs are very powerful. Most organizations do not wish to have small isolated islands of computing facilities confined to the buildings. They want to extend facilities over a wider area so that groups can work without having to be located together. Two or more LANs can be connected with specialized devices called Routers and bridges. Bridge connects LANs of the same type but, router is a more intelligent component that can interconnect many different types of computer network. Then, we can have Backbone Networks, which are high-bandwidth channels that typically connect LANs with each other, and are often referred to as backbones.

Network Protocols

A protocol is more like a language that can be shared by many people. If all the people would like to use the same language, the protocol becomes a standard. The same is applicable with networks. Most networks have one feature in common that they transmit information by breaking the original information into a set of messages (called packets), transmitting these packets sequentially, and then reassembling these packets back into the original information.

Internet

Internet is a network connecting many computer networks and based on a common addressing system and communications protocol.

Select Topics in Telecommunication

Telecommunication refers to the transmission of information over significant distances to communicate. Telecommunications usually includes electrical devices such as telegraphs, telephones, Mobiles, teleprinter, radio, Microwave and infrared communications apart from the fibre optics, internet and satellites.

Components of Digital Telecommunication

The modern telecommunication systems have the following components

- Hardware: such as computer, modems, Radio Sets, Mobile Phones, Television sets etc.
- Media: the wired or wireless media via which the signals are transmitted.
- Networks: network between the devices.
- Protocols: These are the rules that govern the transmission of the signals
- Software that controls the systems.

Analog versus Digital Signals

Information is translated in the form of signals which can be analog or digital. The analog signals are still used but the digital communications have gradually outdated them. Digital systems have many advantages over analog systems. Digital systems provide significantly better clarity for images, data and text, because they can be represented in the digital signals and in that of binary format. This possibility of converting all information in binary format has made it technologically possible to merge TV, Phones, Internet and other services.

The communication is now possible with more speed, accuracy and flexibility similar to comparing CDs with LP recordings.

Advantages and Disadvantages of Digital Communications

Advantages

- Reliable communication; less sensitivity to changes in environmental conditions (temperature, etc.)
- Easy multiplexing
- Easy signaling
- Hook status, address digits, call progress information
- Voice and data integration
- Easy processing like encryption and compression
- Easy system performance monitoring
- Integration of transmission and switching

Disadvantages

- Increased bandwidth is a problem
- 64 KB for a 4 KHz channel, without compression (However, less with compression)
- Need for precision timing
- Bit, character, frame synchronization needed
- Analogue to Digital and Digital to Analogue conversions
- Higher complexity

How Digital Communications work

The Telecommunications devices first covert the different types of information such as video, audio, images, texts etc. into electronic or optical signals. This signal is passed through a source encoder. The source encoder has a number of formulas to reduce the redundant binary information. Then the digitized signal is processed in a channel encoder. The channel encoder introduces redundant information that allows errors to be detected and corrected. Thus, now the signal is encoded. This encoded signal is made suitable for transmission by modulation. The modulation begets the carrier wave. This carrier can be made a part of larger signal which is called Multiplexing. This multiplexed signal is sent into a multiple access transmission channel.

The process is reversed after the transmission. The information is extracted and the device at the receiving end converts the signal back into voice / video or data.

The digital communication makes it possible to send a message from one sender to single receiver or one sender to multiple receivers. They are called point-to-point and point-to-multipoint. The Point-to-multipoint telecommunications are known as broadcasts.

Transmission Media

In the data transmission system, the transmission media is the physical path between the sender and receiver or the transmitter or receiver. There are two types of the transmission media viz. guided and unguided. The Guided medium requires the physical link between the transmitter and receiver and follows a predefined specific physical path such as cable or wire. The Unguided media does not require the physical link such as Radio transmission.

Baseband versus broad band

There are two types of data transmission over the cables viz. Baseband and Broad band. Baseband refers to the analog transmissions with *each wire carrying a single signal*, while the Broadband refers to the digital transmission with wires carrying several signals at the same time.

Optical Fiber System

The optical fibre is the medium for carrying the information from one point to another in the form of light. A basic fiber optic system consists of a transmitting device that converts an electric signal into in light signal and a receiver that accepts the light signal and converts it back to the electric signal. The Optic Fiber System may be from very simple to extremely sophisticated systems. Today, the long-distance telephone cable has now been replaced by Optical Fiber Cable. From the decades of 1980s onwards there has been phenomenal growth in the use & importance of Fiber Optic System.

Difference between Optical Fibres and Ordinary Cables

The difference is that signals are transmitted as light in optic communication. Conventional electronic communication relies on electrons passing through wires. Since fibers transmit signals as light rather than current, they are immune to electromagnetic interference which causes noisy data transmission in wires. Because of this, they are used where data security is critical.

- As no shielding is required against electromagnetic interference; they are smaller and more flexible, which makes installation much easier than metal cables.
- Fiber optic cable is more efficient than other cables as it has lower attenuation, mainly because light is not radiated out in the way that electricity is radiated from copper cables
- Non-conductive nature of fibers avoids spark hazards and damage to electronic equipment from power surges.
- They can transmit signals at higher speeds or over long distances.
- Copper wires are adequate for the vast bulk of computer data transmission over point to point links and local area networks. They react differently to tension as they are elastic and copper is inelastic.
- Optical fibers can be used to sense, illuminate, deliver laser power, display and image as well as to communicate. One disadvantage is that they are more expensive than other cables.

Optical Fibre Cable and Total Internal Reflection

In an optical fiber the light signal undergoes total internal reflection. The light hits the fibers at the glancing angle and is transmitted forward. They have different layers of glass protected in layers of buffers, namely, hard buffer, soft buffer, core glass, and cladding glass. The cladding glass has a low refractive index toward the core glass. When total internal reflection occurs the signal is transmitted. The soft and the hard buffer are protective coating which provide the necessary protection to the inner glass from external environments.

Type of Light Used in Optical Fibre Cable

Please note that Optical communication employs a beam of **modulated monochromatic light** to carry information from transmitter to receiver. The light spectrum spans a tremendous range in the electromagnetic spectrum, i.e. extending from the region of (10^4 gigahertz to 10^9 gigahertz) covering the far infrared to visible to near ultraviolet.

Construction material for Optical Fibres

The Optical Fibers are basically very thin strands of pure glass and many of them have diameter of a human hair. Most of them are made from silica, because of its higher refractive index. Other materials such as **fluorozirconate, fluoroaluminate** and **chalcogenide**, sapphire etc. are also used for making optical fibers for longer-wavelength infrared or other specialized applications.

Optical Fibres and attenuation coefficients

In the making of the Optical Fibers, the attenuation coefficients also matters. The attenuation coefficient is a quantity that characterizes how easily a material or medium can be penetrated by a beam of light, sound, particles or other energy or matter. A large attenuation coefficient means that the beam is quickly "attenuated" (weakened) as it passes through the medium, and a small attenuation coefficient means that the medium is relatively transparent to the beam. The Plastic optical fibers (POF) have higher attenuation coefficients than glass fibers and that is why high attenuation limits the range of POF-based systems.

In comparison, Silica shows extremely low absorption and scattering losses of the order of 0.2 dB/km and has a fairly broad glass transformation range. Silica fiber also has high mechanical strength against both pulling and even bending, provided that the fiber is not too thick and that the surfaces have been well prepared during processing. Silica is also relatively chemically inert. In particular, it is not hygroscopic (does not absorb water), thus is comparatively better.

Doping of Silica

But as above mentioned, the silica has a refractive index of 1.5. For enhancing the quality of the Optical Fiber, the refractive index of the Silica is increased. The method is doping with other materials. These materials include the Germanium dioxide (GeO2) or Aluminum oxide (Al2O3). In certain situations, doping may also be used to lower the reflective index. The material typically used for lowering the refractive index is fluorine or Boron trioxide (B2O3)

Single-Mode and Multimode Fibers

There are two general categories of optical fiber: single-mode and multimode. Multimode fiber allows hundreds of modes of light to propagate through the fiber simultaneously. Additionally, the larger core diameter of multimode fiber facilitates the use of lower-cost optical transmitters.

On the other hand, the single mode fiber allows only one mode of light at a time to propagate and thus has smaller core.

Can we use Optical Fibers in Power transmission?

Yes. By using the photovoltaic cell. The optical fiber can be used to transmit power using a photovoltaic cell to convert the light into electricity, but it is NOT very efficient method. So, it is used in certain situations where it is desirable not to have a metallic conductor. Examples are devices used close to MRI machines, which produce strong magnetic fields.

Electromagnetic Spectrum

When light is passed through a prism, it is separated into all colors of rainbow, which is known as visible spectrum.

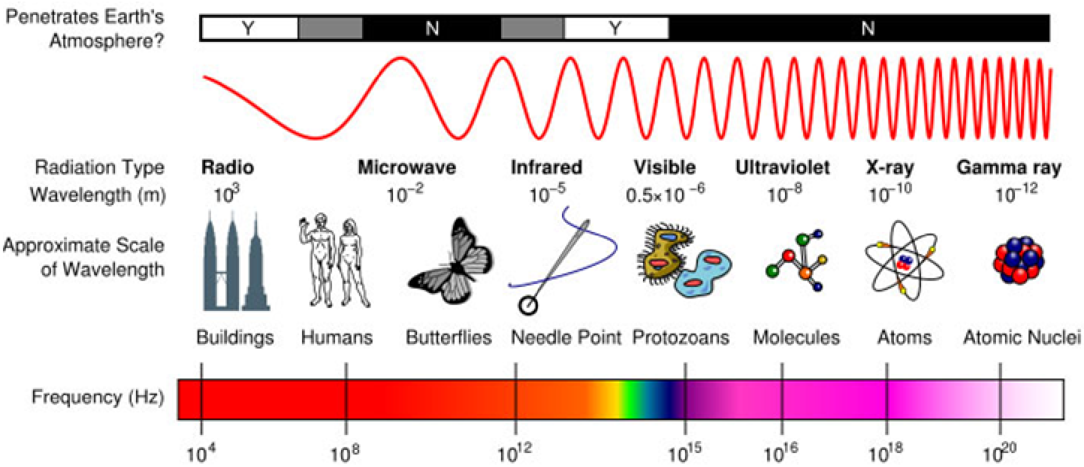
Theory of EM spectrum

There are some properties of light which can be explained by particle nature and other by wave nature. The initial explanations of light said that light consists of tiny particles which they call photons, which travel at a speed of light. When these particles hit something, they get bounced, absorbed or reflected back. When the bounce off from something and enter our eyes, we are able to see something. The above descriptions could not satisfactorily explain why some photons are absorbed and others are reflected.

The theory of Electromagnetic spectrum tried to solve this dilemma. It is based upon the hypothesis that *light is made up of waves*. This theory has been used to explain that longest wavelength of the visible light (red) and shortest wavelengths of the visible light (blue) are absorbed by the green leaves (Chlorophyll) and green light is let reflected so that leaves appear green.

EM spectrum

The electromagnetic spectrum incorporates the range of all electromagnetic radiation, and extends from electric power at the long-wavelength end to gamma radiation at the short-wavelength end. In between, we find radio waves, infra-red, visible light, ultra violet and X-rays used in medical diagnostics. The following graphics shows the general properties of all the wavelengths of the electromagnetic spectrum. All of them are commonly known as Electromagnetic waves.



Electromagnetic waves are defined by their special characteristics, such as frequency, wavelength and amplitude.

Frequency

The frequency refers to the number of waves generated in a set period of time and is measured in Hertz (Hz). 1 Hz means one wave per second, 1 kHz (kilohertz) means one thousand waves per second, 1 MHz (megahertz) means one million waves per second, 1 GHz (gigahertz) means one billion waves per second and so on.

Wavelength

Wavelength is the distance between two waves. There is a fixed mathematical interrelation between the frequency and the wavelength. The higher frequencies have shorter wavelengths and the lower frequencies have longer wavelengths. The wavelength also indicates the ability of the wave to travel in space. A lower frequency wave can reach longer distances than a higher frequency wave. Radio waves are usually specified by frequency rather than wavelength.

Radio waves

Radio waves are waves with wavelengths longer than infrared light. Like all other electromagnetic waves, they travel at the speed of light. The lightning and astronomical objects produce naturally occurring radio waves. The artificially generated radio waves are used for fixed and mobile radio communication, broadcasting, radar and other navigation systems, satellite communication, computer networks and other applications. Different frequencies of radio waves have different propagation characteristics in the Earth's atmosphere.

- Different parts of radio spectrum are allocated to the various services.
- The shortest Radio wavelengths are of a few millimeters while the longest radio waves are several kilometers in length.

- Radio waves were first predicted by mathematical work done in 1865 by James Clerk Maxwell.
- In 1887, Heinrich Hertz demonstrated the reality of Maxwell's electromagnetic waves by experimentally generating radio waves in his laboratory.

Understanding the Radio Spectrum

Part of the electromagnetic spectrum corresponding to **radio frequencies** is called Radio Spectrum. The radio-frequency spectrum (which is simply referred to as spectrum) is only a comparatively small part of the electromagnetic spectrum, covering the range from 3 Hz to 300 GHz. It includes a range of a certain type of electromagnetic waves, called radio waves, generated by transmitters and received by antennas or aerials. The frequencies in the Radio Spectrum are lower than around 300 GHz, which corresponds to wavelengths longer than about 1 mm.

Band

A small section of the spectrum of radio communication frequencies, in which channels are usually used or set aside, is called a Band.

Classification

To prevent interference and allow for efficient use of the radio spectrum, similar services are allocated in bands. For example, broadcasting, mobile radio, or navigation devices, will be allocated in non-overlapping ranges of frequencies. There are 12 bands as per the provisions of the ITU as follows:

ITU Radio Band

Band Number	Symbols	Frequency Range	Wavelength Range
1	ELF	3 to 30 Hz	10,000 to 100,000 km
2	SLF	30 to 300 Hz	1000 to 10,000 km
3	ULF	300 to 3000 Hz	100 to 1000 km
4	VLF	3 to 30 kHz	10 to 100 km
5	LF	30 to 300 kHz	1 to 10 km
6	MF	300 to 3000 kHz	100 to 1000 m
7	HF	3 to 30 MHz	10 to 100 m
8	VHF	30 to 300 MHz	1 to 10 m
9	UHF	300 to 3000 MHz	10 to 100 cm

Band Number	Symbols	Frequency Range	Wavelength Range
10	SHF	3 to 30 GHz	1 to 10 cm
11	EHF	30 to 300 GHz	1 to 10 mm
12	THF	300 to 3000 GHz	0.1 to 1 mm

- So, when we move from ELF to THF, the frequency range increases
- When we move from ELF to THF, the wavelength decreases.

However, the above table gets significantly changed when we refer to the Institute of Electrical and Electronics Engineers (IEEE) specifications. The IEEE has divided the Radio Frequency spectrum into 13 bands starting from the lowest frequency HF Band to Highest Frequency mm Band as follows:

IEEE Radio Spectrum Bands

Band	Frequency range	Origin of name
HF band	3 to 30 MHz	High Frequency
VHF band	30 to 300 MHz	Very High Frequency
UHF band	300 to 1000 MHz	Ultra High Frequency
L band	1 to 2 GHz	Long wave
S band	2 to 4 GHz	Short wave
C band	4 to 8 GHz	Compromise between S and X
X band	8 to 12 GHz	Used in WW II for fire control, X for cross (as in crosshair)
Ku band	12 to 18 GHz	Kurz-under
K band	18 to 27 GHz	German Kurz (short)
Ka band	27 to 40 GHz	Kurz-above
V band	40 to 75 GHz	
W band	75 to 110 GHz	W follows V in the alphabet
mm band	110 to 300 GHz	

But the Radio Society of Great Britain divides these frequencies as follows:

Radio Society of Great Britain

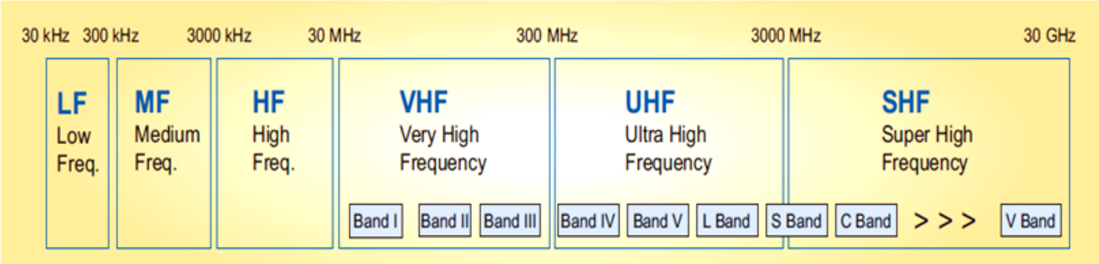
Designation	Frequency range
L band	1 to 2 GHz
S band	2 to 4 GHz
C band	4 to 8 GHz
X band	8 to 12 GHz
Ku band	12 to 18 GHz
K band	18 to 26.5 GHz
Ka band	26.5 to 40 GHz
Q band	33 to 50 GHz
U band	40 to 60 GHz
V band	50 to 75 GHz
E band	60 to 90 GHz
W band	75 to 110 GHz
F band	90 to 140 GHz
D band	110 to 170 GHz

We see that the above classifications of different radio bands have been done on the basis of the wavelength / frequency. On the basis of broadcasting, frequencies the Radio spectrum has been divided into the following parts:

- Long wave AM Radio = 148.5 – 283.5 kHz (LF)
- Medium wave AM Radio = 530 kHz – 1710 kHz (MF)
- Shortwave AM Radio = 3 MHz – 30 MHz (HF)

The radio spectrum has the excellent ability to carry codified information (signals) and that is why it is home of communication technologies such as mobile phones, radio and television broadcasting, two-way radios, broadband services, radar, fixed links, satellite communications, etc. Radio spectrum is a scarce resource, but is relatively cheap to build the infrastructure which can also provide mobility and portability.

As described above, depending on the frequency range, the radio spectrum is divided into frequency bands and sub bands. The following picture tries to simplify the above classifications:



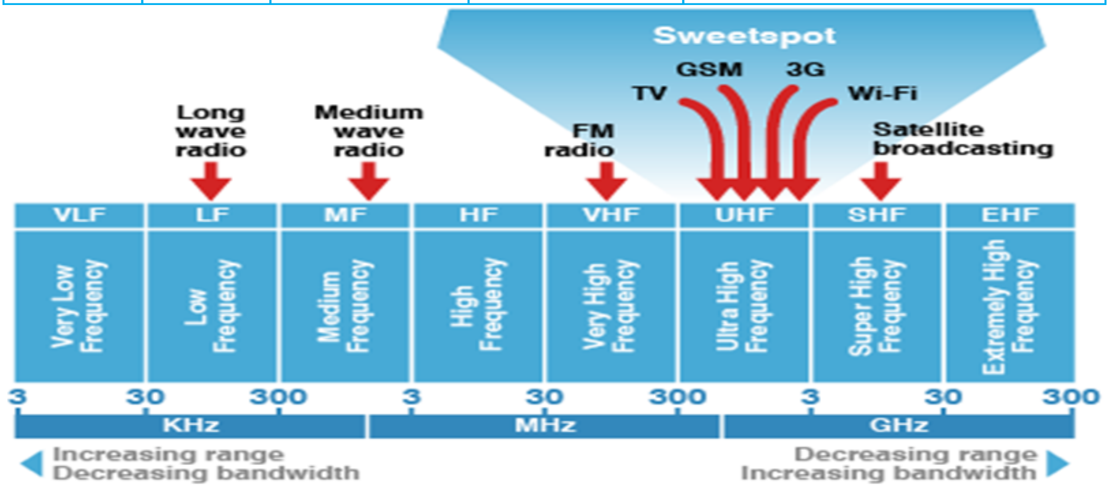
What is sweet spot in Radio Spectrum?

We should know that Low Frequency (LF), Medium Frequency (MF) and High Frequency (HF) broadcasting bands (below 30 MHz) are still used in much the same way as they always have been since the birth of radio broadcasting over 80 years ago for Long Wave (LW), Medium Wave (MW) and Short Wave (SW) analogue broadcasting. Also in the HF band, a growing number of transmissions are being established in digital (DRM) format, primarily for international broadcasting. In the MF band, a limited range of frequencies are available for local analogue Medium Wave (MW) radio services. Please have a look at the following table that shows the general uses of different bands of the Radio spectrum.

Table of ITU Radio Bands

Band Number	Symbols	Frequency Range	Wavelength Range	Typical sources
1	ELF	3 to 30 Hz	10,000 to 100,000 km	deeply-submerged submarine communication
2	SLF	30 to 300 Hz	1000 to 10,000 km	submarine communication, ac power grids
3	ULF	300 to 3000 Hz	100 to 1000 km	earthquakes, earth mode communication
4	VLF	3 to 30 kHz	10 to 100 km	near-surface submarine communication,
5	LF	30 to 300 kHz	1 to 10 km	AM broadcasting, aircraft beacons
6	MF	300 to 3000 kHz	100 to 1000 m	AM broadcasting, aircraft beacons, amateur two-way radio

Band Number	Symbols	Frequency Range	Wavelength Range	Typical sources
7	HF	3 to 30 MHz	10 to 100 m	Skywave long range radio communication: shortwave broadcasting, military, maritime, diplomatic, amateur two-way radio
8	VHF	30 to 300 MHz	1 to 10 m	FM radio broadcast, television broadcast, PMR, DVB-T, MRI
9	UHF	300 to 3000 MHz	10 to 100 cm	PMR, television broadcast, microwave oven, GPS, mobile phone communication (GSM, UMTS, 3G, HSDPA), cordless phones (DECT), WLAN (Wi-Fi 802.11 b/g/n), Bluetooth
10	SHF	3 to 30 GHz	1 to 10 cm	DBS satellite television broadcasting, WLAN (Wi-Fi 802.11 a/n), microwave relays, WiMAX, radars
11	EHF	30 to 300 GHz	1 to 10 mm	microwave relays, intersatellite links, WiMAX, high resolution radar, directed-energy weapon (Active Denial System), Security screening (Millimeter wave scanner)
12	THF	300 to 3000 GHz	0.1 to 1 mm	Terahertz radiation, submillimeter radiation, low Infrared



The highlighted portion of the above spectrum table shows that the maximum number of the popular services such as FM radio broadcast, television broadcast, PMR, DVB-T, MRI, PMR, television broadcast, microwave oven, GPS, mobile phone communication (GSM, UMTS, 3G, HSDPA), cordless phones (DECT), WLAN (Wi-Fi 802.11 b/g/n), Bluetooth falls in the VHF and UHF Band of the Radio Spectrum. This is evident from the following simple picture taken from BBC:

This portion is called "Sweetspot". So, please note that sweetspot is the part of the Radio Spectrum, where most modern communication technologies such as DAB Digital Radio, digital television, 3G mobile phones and WiFi wireless Internet access services operate. The sweetspot, in fact, is the upper part of the Very High Frequency (VHF) band and the whole of the Ultra High Frequency (UHF) band, incorporating frequencies from around 200 MHz to 3 GHz as illustrated in this image.

What are Bands and Channels?

In theory, different communication technologies could exist in any part of the radio spectrum, but then we should note that, more information a signal is to carry, the more bandwidth it needs. In simple terms, bandwidth is the range of frequencies that a signal occupies in the spectrum. For example, an FM radio station might broadcast on a frequency of 92.9 MHz but requires a bandwidth of 0.3 MHz (300 kHz) – the spectrum between 92.8 and 93.0 MHz inclusive. Other stations cannot broadcast on these frequencies within the same area without causing or receiving interference. So for the purpose of the management of the services, the **spectrum bands are divided into channels**. The bandwidth of spectrum channels can vary band by band.

Ground waves

Lower frequencies (between 30 and 3,000 kHz) have the property of following the curvature of the earth via ground wave propagation. This is possible because of the interaction of the radio waves with semi-conductive surface of the earth. The wave "clings" to the surface and thus follows the curvature of the earth.

Why only lower frequencies propagate via ground wave?

Since ground is not a perfect electrical conductor, ground waves are attenuated rapidly as they follow the earth's surface. This attenuation is proportional to the frequency and that is why this mode of propagation is useful for only LF and VLF frequencies.

Line of Sight

Line-of-sight is the direct propagation of radio waves between antennas that are visible to each other. This is one of the most common radio propagation modes at VHF and higher frequencies. Because radio signals can travel through many non-metallic objects, radio can be picked up through walls.

How Radio sets work?

The real nice thing about the radio waves is that they will make the electrons in a piece of copper wire move; this means they are capable of generating the electric currents in the wire. It works both the ways, alternating currents in a copper wire generate electromagnetic waves, and the electronic waves generate the alternating currents. The electric currents at "Radio frequencies" (rf) are used by the radio and television transmitters and receivers.

Each Radio system contains a transmitter that consists of a source of electrical energy, producing alternating current of a desired frequency of oscillation. The transmitter contains a system to modulate (change) some property of the energy produced to impress a signal on it. This modulation might be as simple as turning the energy on and off, or altering more subtle properties such as amplitude, frequency, phase, or combinations of these properties. The transmitter sends the modulated electrical energy to a tuned resonant antenna; this structure converts the rapidly changing alternating current into an electromagnetic wave that can move through free space (sometimes with a particular polarization). When transmitted, the transceiver "modulates" the RF with an alternating current generated by voice in a microphone. The Modulating frequency is called AF or Audio Frequency. Someone listening uses a receiver which can demodulate the Radio signal. The Receiver removes the RF to leave the AF and thus audio signal is fed to a loudspeaker.

The electromagnetic wave is intercepted by a tuned receiving antenna; this structure captures some of the energy of the wave and returns it to the form of oscillating electrical currents. At the receiver, these currents are demodulated, which is conversion to a usable signal form by a detector sub-system. The receiver is "tuned" to respond preferentially to the desired signals, and reject undesired signals.

All radio receptions except FM band are affected when cable TV is switched on. Why?

This is a very simple question related to fundamentals of electromagnetic waves. Whenever we switch on electrical equipment, there are electrical currents in different parts of the circuit, which are associated with a magnetic field in its neighbourhood. The strength of this magnetic field reduces as the distance increases. If the current is alternating current (AC), equipment would work as a source of electromagnetic waves. These waves are called EM noise for other equipments. The AC current generates EM waves at such frequencies that can be detected by a radio receiver tuned to an amplitude-modulated band. In the neighbourhood of a noise producing equipment like a TV, the signal received by the antenna of the radio receiver is altered by the picked up EM waves; and it would be taken by the receiver as the total signal to process.

Why transistor radio gives a clear and loud reception when the antenna is held or touched by hand?

We all know that the antenna of a transistor radio is the first stage which collects the radio signal of all frequencies. The clarity and loudness of the audio depends, among many other factors, on the strength of the signal received by the antenna. If we increase the correction area, the signal received is enhanced. A long stretched conducting wire or a spread out conducting object work as signal enhancer when connected to the antenna. Human body has also some conductivity and when we touch the antenna of an operating radio set, we increase the effective signal collection area and thereby the signal strength gets improved and the loudness increases.

Microwaves

This part of the Radio Spectrum has wavelengths such short that they are easily absorbed by water and this is the core principle that they are used in microwave ovens. **When we keep our food in microwave, the energy of the microwaves is converted into heat and makes the water molecules vibrate faster.**

By "microwaves" we mean the range of radio frequencies between about 1 GHz (one gigahertz, or one billion oscillations per second) and about 300 GHz. Although there is no formal definition of the frequency range for "microwaves", some text books will define all frequencies above 300 MHz as microwaves.

Why Microwaves are considered better than Radio waves for safer communication?

Microwaves are easier to control (than longer wavelengths) because small antennas could detect the waves very well. One advantage of such control is that the energy could be easily confined to a tight beam (narrow beam width). This beam could be focused on another antenna dozens of miles away, making it very difficult for someone to intercept the conversation. Another characteristic is that

because of their high frequency, greater amounts of information could be put on them (increased modulation bandwidth). Both of these advantages (narrow beam width and modulation bandwidth) make microwaves very useful for RADAR as well as communications.

Eventually, these qualities led to the use of microwaves by the telephone companies. They placed towers every 30 to 60 miles each with antennas, receivers and transmitters. These would relay hundreds or even thousands of voice conversations across the country. The ability to modulate with a wide bandwidth permitted so many conversations on just one signal, and the reduction in beam width made this reasonably secure.

Note: Please note that above 100 MHz, the waves travel in straight lines and can therefore be narrowly focused. Concentrating all the energy into a small beam using a parabolic antenna (like the satellite TV dish) gives a much higher signal to noise ratio, but the transmitting and receiving antennas must be accurately aligned with each other.

Use of Microwaves

Please note that microwave transmission is weather and frequency **dependent**. Microwave communication was widely used for long distance telephone communication, cellular telephones, television distribution and other uses that a severe shortage of spectrum has developed.

- Microwave is relatively inexpensive in comparison to fiber optics system. For example, putting up two simple towers and antennas on each one may be cheaper than burying 50 km of fiber through a congested area or up lower a mountain.

- Microwave systems permit data transmission rates of about 16 Giga (1 giga = 109) bits per second. At such high frequencies, microwave systems can carry 250,000 voice channels at the same time.
- This is the core principle that they are mostly used to link big metropolitan cities where have heavy telephone traffic between them.

But, there is a big **limitation**. Since **microwaves travel in a straight line**, if the towers are too far apart, the earth will get in the way. Consequently, repeaters are needed periodically. The higher the towers are, the further apart they can be. The distance between repeaters goes up very roughly with the square root of the tower height. For 100 meter high lowers, repeaters can be spaced 80 km apart.

Infrared Waves

Infrared waves have very short wavelengths, which are longer than the visible light at 0.74 micrometers, and extending conventionally to 300 micrometers. These wavelengths correspond to a frequency range of approximately 1 to 400 THz.

7 bands of Infrared Radiation

The infrared portion of the electromagnetic spectrum is usually divided into three regions; the near-,

mid- and far- infrared, named for their relation to the visible spectrum. The higher energy near-IR, approximately 14000–4000 cm−1 (0.8–2.5 μm wavelength) can excite overtone or harmonic vibrations. The mid-infrared, approximately 4000–400 cm−1 (2.5–25 μm) may be used to study the fundamental vibrations and associated rotational-vibrational structure. The far-infrared, approximately 400–10 cm−1 (25–1000 μm), lying adjacent to the microwave region, has low energy and may be used for rotational spectroscopy.

There are three bands of Infrared radiation as stipulated by the International Commission on Illumination (CIE) as follows:

- IR-A: 700 nm–1400 nm (0.7 μm – 1.4 μm, 215 THz – 430 THz)
- IR-B: 1400 nm–3000 nm (1.4 μm – 3 μm, 100 THz – 215 THz)
- IR-C: 3000 nm–1 mm (3 μm – 1000 μm, 300 GHz – 100 THz)

However, the ISO 20473 standard divides the Infrared as follows:

Designation	Abbreviation	Wavelength
Near Infrared	NIR	0.78 - 3 μm
Mid Infrared	MIR	3 - 50 μm
Far Infrared	FIR	50 - 1000 μm

The Infrared radiation can also be divided into 7 bands for the purpose of Telecommunication as follows:

7 bands of Infrared Radiation

Band	Descriptor	Wavelength range
O band	Original	1260–1360 nm
E band	Extended	1360–1460 nm
S band	Short wavelength	1460–1530 nm
C band	Conventional	1530–1565 nm
L band	Long wavelength	1565–1625 nm
U band	Ultralong wavelength	1625–1675 nm

Applications of Infrared

Infra-red waves have wide ranging uses as follows discussed below

Active-infrared night vision

In this, the camera illuminates the scene at infrared wavelengths invisible to the human eye. Infrared

is used in night vision equipment when there is insufficient visible light to see.

How the Night vision devices work?

Night vision goggles work on the principle of infrared radiation, which radiates from any object in relation to its temperature. A hotter body radiates more infrared radiation. A night vision goggle receives this radiation from the surroundings and makes out places which are comparatively warmer (usually warm-blooded animals like human beings) helping the user to see in the dark or through a fog. Please note that night vision devices operate through a process involving the conversion of ambient light photons into electrons which are then amplified by a chemical and electrical process and then converted back into visible light.

What is difference between night vision and thermal imaging?

Both vision and thermal imaging work on the basis of properties of the infrared radiation but the working is different. Thermal imaging creates images based on differences in surface temperature by detecting infrared radiation (heat) that emanates from objects and their surrounding environment. Thermographic cameras detect radiation in the infrared range of the electromagnetic spectrum (roughly 900–14,000 nanometers or 0.9–14 μm) and produce images of that radiation.

Thermography & Pyrometry

Infrared radiation can be used to remotely determine the temperature of objects. If they are used in case of very hot objects, it is called thermography, while if used in visible, then it is termed pyrometry. Thermography is mainly used in military and industrial applications but the technology is reaching the public in the form of infrared cameras on cars.

Hyperspectral imaging

Hyperspectral imaging collects and processes information from across the electromagnetic spectrum. Much as the human eye sees visible light in three bands (red, green, and blue), spectral imaging divides the spectrum into many more bands. Hyperspectral imaging is gaining importance in the applied spectroscopy. Its applications include biological, mineralogical, defence, and industrial measurements.

Infrared tracking

Infrared tracking, also known as infrared homing, refers to a passive missile guidance system which uses the emission from a target of electromagnetic radiation in the infrared part of the spectrum to track it.

What are Heat seekers?

Missiles which use infrared seeking are often referred to as "heat-seekers", since infrared (IR) is just below the visible spectrum of light in frequency and is radiated strongly by hot bodies. Many objects such as people, vehicle engines, and aircraft generate and retain heat, and as such, are especially visible in the infrared wavelengths of light compared to objects in the background.

Communications

IR data transmission is used in short-range communication among computer peripherals and personal digital assistants. The standards to use these devices are published by IrDA (Infrared Data Association).

How Remote Controls work?

The devices such as Remote Controls use infrared light-emitting diodes (LEDs) to emit infrared radiation which is focused by a plastic lens into a narrow beam. The beam is modulated, i.e. switched on and off, to encode the data. The receiver uses a silicon photodiode to convert the infrared radiation to an electric current. It responds only to the rapidly pulsing signal created by the transmitter, and filters out slowly changing infrared radiation from ambient light. Infrared communications are useful for indoor use in areas of high population density. IR does not penetrate walls and so does not interfere with other devices in adjoining rooms. Infrared is the most common way for remote controls to command appliances. Infrared remote control protocols like RC-5, SIRC, are used to communicate with infrared.

Spectroscopy

Infrared vibrational spectroscopy is a technique which can be used to identify molecules by analysis of their constituent bonds.

Meteorology

The Weather satellites equipped with scanning radiometers produce thermal or infrared images which can then enable a trained analyst to determine cloud heights and types, to calculate land and surface water temperatures, and to locate ocean surface features. The scanning is typically in the range 10.3-12.5 µm (IR4 and IR5 channels). Satellites use sensors whose working principle is based on photoelectric effect, converting radiation reaching the sensor into electric charge, which can then be easily measured and processed.

Essentially, the energy detected over a given spectral band, whether it is in the Thermal / Infrared (or even microwave) band, is converted to an array of digits corresponding to the energy range and radioed to ground stations. After receiving it, those digital values corresponding to the measured energy range (known as grey levels) are finally printed on a computer screen as a picture or as a conventional photograph. The main advantage of infrared is that images can be produced at night, allowing a continuous sequence of weather to be studied.

Climatology

Infrared pictures can depict ocean eddies or vortices and map currents such as the Gulf Stream, even El Niño phenomena can be spotted. Infrared can detect trends in the energy exchange between the earth and the atmosphere. These trends provide information on long term changes in the Earth's climate. It is one of the primary parameters studied in research into global warming together with solar radiation.

Astronomy

Astronomers observe objects in the infrared portion of the electromagnetic spectrum using optical components, including mirrors, lenses and solid state digital detectors. For this reason it is classified as part of optical astronomy. To form an image, the components of an infrared telescope need to be carefully shielded from heat sources, and the detectors are chilled using liquid helium. However, sensitivity of Earth-based infrared telescopes is significantly limited by water vapor in the atmosphere, which absorbs a portion of the infrared radiation arriving from space outside of selected atmospheric windows. It can be partially alleviated by placing the telescope observatory at a high altitude, or by carrying the telescope aloft with a balloon or an aircraft. Space telescopes do not suffer from this handicap, and so outer space is considered the ideal location for infrared astronomy. The Spitzer Space Telescope is a dedicated infrared space observatory currently in orbit around the Sun.

Historical Studies

Use of infrared are made by historians on various types of objects, especially very old written documents such as the Dead Sea Scrolls, the Roman works in the Villa of the Papyri, and the Silk

Road texts found in the Dunhuang Caves. Carbon black used in ink can show up extremely well.

Biology

The pit viper has a pair of infrared sensory pits on its head, however not much details are known about its functionality. The other organisms that have thermo receptive organs are pythons, some boas , the Common Vampire Bat, some beetles, some darkly pigmented butterflies.

Photobiomodulation

It's a chemotherapy induced oral ulceration as well as wound healing that uses near infrared light.

Mobile Telephony

The name Cellular Phone is derived from the partition of a Geographic Region into smaller areas which are called "Cells". The Voice and data exchanged between the Mobile terminal and phone / internet is transmitted via the Mobile Network which consists of Cellular Operator's radio access network and core network.

One of the most popular and common application of the radio waves is in the area of mobile telephony. Today, the mobile telephony uses the cellular radio service but in older times the mobile telephone service consisted of bulky mobile telephone radio units. These two way radio units were able to communicate with each other via a single antenna in a particular area. At that time, these radio signals used to interfere with each other and the limit was thus very limited. The service was unreliable and costly.

Development of 1G, 2G and 3G

The development of 1G mobile phones took place in late 1970s. The 1G mobile devices sent only the "**analogue voice information**" via amplitude modulation (AM), which varies the amplitude of the carrier signal, and frequency modulation (FM), which changes the Frequency of the career signal. In electronics, the analog signal devices were followed by Analog to Digital convertors.

The most important 1G system were

- Advanced Mobile Phone System (AMPS)
- Nordic Mobile Telephone (NMT)
- Total Access Telephone System (TACS).

The devices of the 1G included the Cordless Phone, Paging Systems, Private Mobile Radio, Some primitive mobile systems as mentioned above.

2G

The 2G phase began in the 1990s and much of this technology is still in use. The 2G cell phone features digital voice encoding. Examples include CDMA and GSM. Since its inception, 2G technologies have steadily improved, with increased bandwidth, packet routing, and the introduction of multimedia.

- GSM is most popular standard for mobile telephony systems spread in more than 200 countries / territories. GSM is a cellular network, which means that mobile phones connect to it by searching for cells in the immediate vicinity.

The worldwide presence of GSM means that subscribers can use their phones throughout the world, enabled by international roaming arrangements between mobile network operators.

- GSM networks operate in a number of different carrier frequency ranges and most 2G GSM networks operate in the 900 MHz or 1800 MHz bands.

GSM provides the voice and limited data services and uses the digital modulation for improved audio quality. So this was the beginning of the SMS. The rate was 10 Kbps/user.

2.5G

The GPS was succeeded with GPRS i.e. **General Packet Radio Service**. This is called 2.5G. This enhanced the data transmission capacity of the GSM and added the packet switched capabilities to the existing mobile telephony. So now the systems were able to send emails and Graphics rich data as a higher speed. 2.5 G or GPRS set the preparatory stage for the 3G

- Applications in 2.5 G are : Digital voice and limited data

3G Technology

3G, 4G and 5 G are the generic names for a set of mobile technologies. These use a host of high-tech

infrastructure networks, handsets, base stations, switches and other equipment to allow mobile phones to offer broadband wireless Internet access, data, video, live TV and CD-quality music services. The 3G wireless networks use technologies such as General Packet Radio Service (GPRS); Enhanced Data Rates for Global Evolution (EDGE); UMTS Wideband CDMA (WCDMA) and High Speed Downlink Packet Access. The 3G technology is capable of transferring data at theoretical top speed of just 7.2Mbps.

4G Technology

4G is the short term for fourth-generation; it is a wireless data transmission network. The data transfer speeds here are **four time that of 3G** making **IPTV** and interactive gaming a reality on mobile phones. All this will make the mobile phone much like a digital Swiss Knife: a single wireless device for all our needs. The technology uses Carriers that use orthogonal frequency-division multiplexing (OFDM) instead of time division multiple access (TDMA) or code division multiple access (CDMA).

5G Technology

The term 5G is not used officially and is used in some research papers and projects to denote the next major phase of mobile telecommunications standards beyond the 4G/IMT Advanced standards. Some of the features are lower battery consumption, lower outage probability, better coverage, high bit rates in larger portions of the coverage area, cheaper or no traffic fees due to low infrastructure deployment costs, or higher aggregate capacity for many simultaneous users. Some important other concepts of technology are Cognitive Radio Technology and the WWWW. These two have been discussed here:

WWWW

World Wide Wireless Web (WWWW), is the comprehensive wireless-based web applications that include full multimedia capability beyond 4G speeds and comes under 5G development.

Cognitive Radio Technology

Cognitive Radio Technology or "Smart Radio" or "Intelligent Radio" is a radio that can sense, learn and adapt to the surrounding environment according to its inner and outer stimuli. A primary feature of cognitive radios is the ability to adapt the transmission parameters given a dynamic wireless environment. Please note that Cognitive Radio Technology is based upon the core principles of "Software Defined Radio (SDR)".

How does it work?

As we know that Electromagnetic Spectrum , particularly the Radio Frequency portion of this Spectrum has become the most valuable natural resource in recent times. So, there is a concern about the efficient use of the spectrum. The answer is Cognitive Radio. It can intelligently detect whether any portion of the spectrum is in use or not, and can temporarily latch into or out of it without interfering with the transmissions of other users thereby efficiently utilizing spectrum.

Thus the main objective of the Cognitive Radio is to "efficiently utilize the spectrum".

Does GSM allow signals when we travel in aeroplane?

We should not that territory covered with GSM network is divided into hexagonal cells. The covering diameter of each hexagonal cell may be from 400 m up to 50 km, which consists of base station that provides communication-receive and transmission, and antennae. All GSM cellular communication telephone cells are performed via these antennae and stations, which are regulated by switching centre. Switching centre provides communication between city telephone network, base stations and other cellular communication operators. Every time you switch on your cell phone, the communication is performed with the nearest base station. Hence it is also possible to receive signals on cell phone while travelling in an aeroplane, provided the base station range allows.

Cell phone use during flights is still banned by regulations because it disrupts cell service on the ground and has the potential to interfere with an airplane's navigation and communication instruments.

Advantages and Disadvantages of CDMA

The CDMA Phones don't have SIM cards. The CDMA phones have phone numbers programmed in the handset just as numbers are programmed in SIM cards by the operator. The latest phones have both options. Since all CDMA phones are network locked, there is no necessity for the SIM card provision. As GSM phones are compatible with any operator, who provides the SIM card which enables connectivity to the network. This makes the phone independent of the operator.

A major difference between the CDMA and GSM networks is the handset. In CDMA, the handsets are provided by the operator and they work only on one network unlike in GSM systems.

One of the major advantages of CDMA is "Soft Handoff'. A handoff occurs in any cellular network where a call switches from one -cell site to another as a person travels: In other technologies this handoff occurs when the network informs the phone of the new channel to which it must switch. The phone then stops receiving and transmitting on the old channel and it commences transmitting and receiving on the new channel. This is known as a "Hard Handoff'. In CDMA, however, every site is on the same frequency. In order to begin listening to a new site, the phone only needs to change the pseudo-random sequence it uses to decode the desired data from the jumble of bits sent for everyone else. While a call is in progress the network chooses two or more alternate sites that it feels are handoff candidates. It simultaneously broadcasts a copy of the call on each of these sites. The phone can then pick and choose between the different sources for the call, and move between them whenever it feels like it. It can even combine the data received from two or more different sites to ease the transition from one to the other.

This puts the phone in almost complete control of the handoff process. Such an arrangement should ensure that there is always a new site ready to take over the call at a moment's notice.

CDMA has a very high "spectral efficiency". It can accommodate more users per MHz of bandwidth than any other technology.

Bluetooth

Bluetooth is a low cost, low power, **radio interface** standard for wireless communication over short distances. It's an **open standard for allowing intelligent devices to communicate with each other**. This allows any sort of electronic equipment (from computers and cell phones to keyboards and headphones) to make its own connections, without wires, cables or any direct action from a user. It could allow for replacing many propriety cables that connect one device to another with one universal radio link.

Please note that Bluetooth was originally conceived as a cable replacement technology providing short-Range Wireless Solutions with open specifications, voice and data capability.

Why Bluetooth?

Whenever two devices need to communicate with each other, they have to agree on a number of points before the communication can begin. The first point of agreement is physical: Will they talk over wires, or through some form of wireless signals? If they use wires, how many are required?

Once the physical attributes are decided, there are other questions such as – How much data will be sent at a time? All of the devices in an electronic discussion need to know what the bits mean and whether the message they receive is the same message that was sent. This means developing a set of commands and responses known as a protocol. But Bluetooth offers an obviation to this rule. So, Bluetooth is essentially an OPEN networking standard that works at two levels viz. Physical and Protocol.

Bluetooth networking transmits data via low-power radio waves. It communicates on a frequency of 2.45 gigahertz (actually between 2.402 GHz and 2.480 GHz, to be exact). This frequency band has been set aside by international agreement for the use of industrial, scientific and medical devices (ISM).

Does Bluetooth interfere with other systems?

No. Bluetooth devices avoid interfering with other systems is by sending out very weak signals of about 1 milliwatt. By comparison, the most powerful cell phones can transmit a signal of 3 watts. The low power limits the range of a Bluetooth device to about 10 meters (32 feet), cutting the chances of interference between computer system and portable telephone or television. Even with the low power, Bluetooth doesn't require line of sight between communicating devices.

What is spread-spectrum frequency hopping?

Frequency hoping is a technique for spread spectrum wireless signal transmission. Bluetooth can connect up to eight devices simultaneously, with all of those devices in the same 10-meter (32-foot) radius, but still these devices don't interfer with each other. For this, Bluetooth uses technique called spread-spectrum frequency hopping that makes it rare for more than one device to be transmitting on the same frequency at the same time.

What is Bluejacking?

Since, Bluetooth is a radio wireless technology that allows computers, cell phones, laptops, etc. to exchange or talk to each other in a limited range. Hijacking via Bluetooth is called Bluejacking. It refers to sending unnecessary and anonymous messages by using bluetooth enabled devices as a contact. In order to carry out bluejacking, both devices should be bluetooth enabled and should be within 10 metres of each another. Phone owners who receive bluejack messages should refuse to add those contacts to their address book.

Wi-Fi

Wi-Fi stands for Wireless Fidelity. It is a wireless-based transmission of Internet signals in a form of a radio wave at spot frequency of 2.4 or 5 GHz at a high speed of 11 million bits per second within a range of 100 meters. Within this range, all Wi-Fi enabled computers will be able to access the Internet without any wires, thereby setting up a Wireless Local Area Network (WLAN). The cost effective Wi-Fi technology is being installed in airports, libraries and business organizations. The real significance of Wi-Fi based WLAN technology is its free network movement.

WiMax

WiMax stands for Wireless Interoperability Microwave Access. A faster version of Wi-Fi, WiMax is a wireless technology that offers a faster broadband connection at longer distances of up to 50 kms. The radius of WiMax coverage is measured in square kilometres unlike Wi-Fi, which is measured in square metres.

WiMAX (Worldwide Interoperability for Microwave Access) is a telecommunications protocol that provides fixed and mobile Internet access. WiMAX has the potential to do to broadband Internet access what cell phones have done to phone access. In the same way that many people have given up their "land lines" in favor of cell phones, WiMAX could replace cable and DSL services, providing universal Internet access just about anywhere we go. WiMAX will also be as painless as WiFi as turning a computer on will automatically connect to the closest available WiMAX antenna.

- WiMax delivers low cost, open networks and is the first of all IP mobile internet solution enabling efficient and scalable networks for data, video and voice transmission thus is counted in 4G.
- WiMax is IP based, wireless broadband access technology that provides performance similar to the Wi-Fi networks.

Broadband Wireless Spectrum

Airwaves that enable access to faster internet data at download rates as high as 6-10 MBPS via the wireless medium. Basically, customers can access streaming videos. Technologies such as WiMax, **Long-Term Evolution (LTE)** and Flash-OFDMA support such networks. In India, spectrum winners are expected to use LTE and WiMax. The benefits are improved and faster internet connectivity on the move. To help people in remote and hilly areas, where wire line broadband is out of reach. E-governance and m-commerce will be easier.

Long-Term Evolution (LTE)

LTE is a 4G technology yet to be introduced globally on which companies like Qualcomm plan to offer services. LTE offers speeds up to 100 MBPS, ideal for high-intensity business web access.

LTE v/s WiMax

Please note that Both WiMAX and LTE are 4G cellular broadband networks. The WiMAX provides speed up to 128 mbps of downloading and for uploading it provides the speed of 56 mbps. However, LTE showed an early implementation speed up to 100 mbps downloading and 50 mbps uploading. WiMax is also categorised with improved coverage in Non Line Of Sight (NLOS) environments.

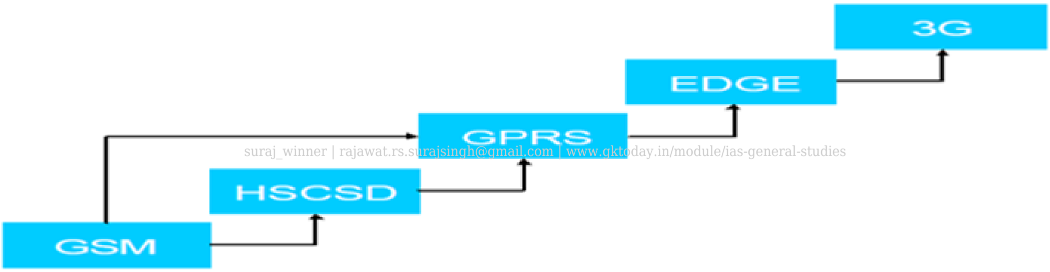
Right now there is an epic battle going on between LTE and WiMAX for 4G supremacy, however, neither of these technologies has emerged as victorious over the other. Please note that WiMAX is developed by the IEEE, while LTE is a proprietory model developed by mobile carriers and equipment vendors. WiMAX is open standard and cheaper instrument.

It seems as though both technologies will become viable 4G access technologies, while WiMAX still maintains its position as an ideal backhaul technology as well. Now, some will claim that either WiMAX or LTE must win from an access perspective, but more and more, that does not seem to be the case.

However, WiMax loses some of its sheen because of the high device costs and absence of VoIP. 3G networks also promise faster data speeds. Exorbitant WiMax fees may make winners price the services at a premium. Seamless connectivity challenges with CDMA devices may prove to be a disadvantage.

GPRS Technology

Sony Ericsson T39m cell phone was the first GPRS enabled phone in world. General Packet Radio Service (GPRS) allows information to be sent and received across a mobile telephone network.



It supplements Circuit Switched Data and Short Message Service. **Please note that GPRS is a 2.5G technology** that supports data transmissions up to 56-114k bit/ sec, though theoretically can provide speed up to 171.2 kbps. So, it is basically a link between GSM and GPRS and many GSM service providers adopted it before jumping to the full 3G technology.

What are packets?

GPRS (general packet radio service) is a packet-based data bearer service for wireless communication services that is delivered as a network overlay for GSM, CDMA and TDMA networks. Packet switching means that data is split into packets that are transmitted separately and then reassembled at the receiving end. GPRS supports the world's leading packet-based Internet communication protocols, Internet protocol (IP) and X.25, a protocol that is used mainly in Europe. This was one of the reasons that made it popular instantly.

Since, cellular networks with GPRS capabilities are wireless extensions of the Internet and X.25 networks, it gives almost instantaneous connection set-up and continuous connection to the Internet.

Difference between GPRS and GSM:

- GPRS is different to GSM because it offers higher bandwidth and, therefore, data speeds.

- GPRS is seamless, immediate and continuous connection to the Internet – 'always on-line'.
- Due to high speed, the new text and visual data and content services such as email, chat, still and moving images, information services (stock prices, weather reports, train times), video conferencing, e-commerce transactions (buying flight and cinema tickets) and Internet-based remote access to corporate intranets and public networks was made possible via GPRS.
- The **major technical difference is that GPRS uses packet-switching rather than circuit-switching,** which means that there is higher radio spectrum efficiency because network resources and bandwidth are only used when data is actually transmitted even though it is always connected.
- GPRS **supports leading Internet communications protocols** – Internet protocol (IP) and X. 25.

Please note that from upgrade from GSM to GPRS needs additional components and protocols to the GSM network – the key elements are SGSN (serving GPRS support node), GGSN (gateway GPRS support node) and a charging gateway. The devices are different devices (not GSM phones). In summary GPRS served as first important step on the path to 3G.

Serving GPRS Support Node

SGSN is the most important element in a GPRS network. It is the service access point for the mobile station. Its main functions include mobility management and registration and authentication. It also interacts with a mobile with packet data flow and functions related to it like compression and ciphering. These are handled by protocols such as the SNDCP (sub-network dependent convergence protocol) and LLC (logical link control). SGSN is also responsible for GTP (gate tunneling protocol) tunneling to the other support nodes.

Gateway GPRS Support Node (GGSN)

The GGSN is connected to the SGSN on the network side and to the outside world external networks such as the Internet and X.25. As it is a gateway to the external networks, its main function is to act as a 'walt' for these external networks in order to protect the GPRS network. When data come from the external network, after verification of the address, the data are forwarded to the SGSN. If the address is found to be invalid, the data are discarded. On the other hand, the SGSN also routes the packets it receives from the mobile to the correct network. Thus, for the outside networks the SGSN acts as a rooter.

High Speed Circuit Switched Data (HSCSD)

Please note that HSCSD (High Speed Circuit Switched Data) comes in between GSM and GPRS. It was the first step towards faster data speeds on GSM circuit switched networks. HSCSD concentrated up to four GSM timeslots and allowed data speeds of up to 64 kbit/s. Today mobiles supporting HSCSD are not available.

Enhanced Data for GSM Evolution (EDGE)

GPRS was followed by EDGE (Enhanced Data for GSM Evolution), which was the second step towards 3G for GSM/GPRS networks. EDGE was able to increase data rates on GSM to 384 kbit/s by bundling up to eight channels or 48 Kbit/s per channel. EDGE was deployed on GSM networks beginning in 2003.

Difference between EDGE and GPRS:

GPRS is based on a modulation technique known as Gaussian minimum-shift keying (GMSK). EDGE is based on a new modulation scheme that allows a much higher bit rate across the air interface – this is called eight-phase-shift keying (8 PSK) modulation. This was the major difference between the two.

Global Positioning System

The Global Positioning System (GPS) is a satellite-based navigation system that was developed by the U.S. Department of Defense (DOD) in the early 1970s. Initially, GPS was developed as a military system to fulfill U.S. military needs. However, it was later made available to civilians. Today GPS is under dual-use system that can be accessed by both military and civilian users. GPS provides continuous positioning and timing information, anywhere in the world under any weather conditions. Because it serves an unlimited number of users as well as being used for security reasons, **GPS is a one-way system**, which means that users can only receive the satellite signals.

GPS normally consists of a constellation of 24 operational satellites. Such constellation, known as the initial operational capability (IOC), was completed by the U.S. Department of Defense (USDOD) in July 1993. The official IOC announcement, however, was made on December 8, 1993. It became fully operational in 1994.

Key Facts

- NAVSTAR is the official U.S. Department of Defense name for GPS
- The first GPS satellite was launched in 1978.
- A full constellation of 24 satellites was achieved in 1994.
- Each satellite is built to last about 10 years. Replacements are constantly being built and launched into orbit.
- A GPS satellite weighs approximately 2,000 pounds and is about 17 feet across with the solar panels extended.
- Transmitter power is only 50 watts or less.

GPS Constellation

To ensure continuous worldwide coverage, GPS satellites are arranged so that four satellites are placed in each of six orbital planes. With such a constellation geometry, four to ten GPS satellites are visible anywhere in the world.

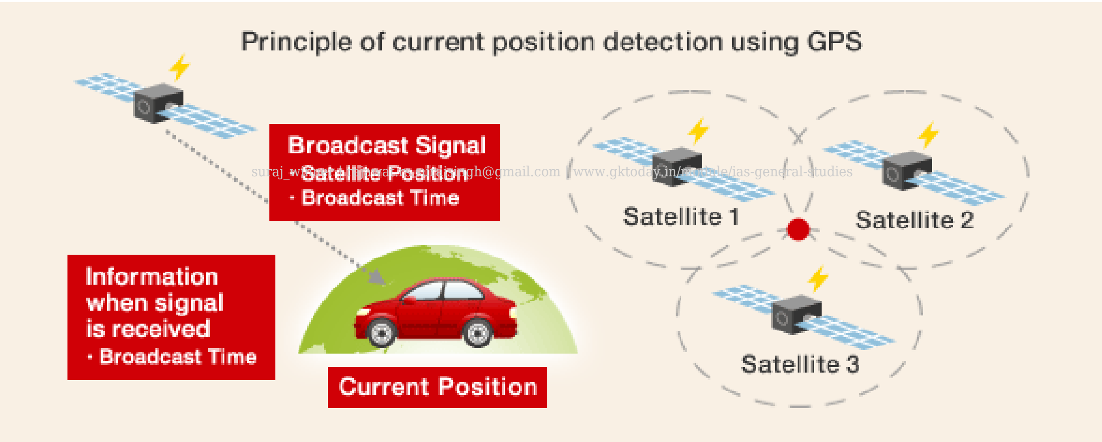
GPS Orbits

GPS satellite orbits are nearly circular (an elliptical shape with a maximum eccentricity is about 0.01), with an inclination of about 55° to the equator. The semimajor axis of a GPS orbit is about 26,560 km (i.e., the satellite altitude of about 20,051 km above the Earth's surface). The corresponding GPS orbital period is about 12 sidereal hours (11 hours, 58 minutes).

GPS Segments

GPS consists of three segments: the **space segment**, the **control segment,** and the **user segment**.

The space segment consists of the 24-satellite constellation. Each GPS satellite transmits a signal, which has a number of components: two sine waves, also known as carrier frequencies, two digital codes, and a navigational message. The codes and the navigation message are added to the carriers as binary biphase modulations. The carriers and the codes are used mainly to determine the distance from the user's receiver to the GPS.



The 24 satellites are arranged in 6 orbital planes of 55- degree inclination, 20,051 kilometers above the Earth.

Each satellite completes one orbit in one-half of a sidereal day and, therefore, passes over the same location on earth once every sidereal day, approximately 23 hours and 56 minutes.

With this orbital configuration and number of satellites, a user at any location on Earth will have at least four satellites in view 24 hours per day

Control Segment

The Control Segment consists of the master control station (MCS), located at Falcon Air Force Base in Colorado Springs, Colorado; remote monitoring stations, located in Hawaii, Diego Garcia, Ascension Island, and Kwajalein; and uplink antennas, located at three of the four remote monitor stations and at the Master Control Segment.

The primary task of the operational control segment is tracking the GPS satellites in order to determine and predict satellite locations, system integrity, behavior of the satellite atomic docks, atmospheric data, the satellite almanac and other considerations.

This information is then packed and uploaded into the GPS satellites through the S-band link. The four stations can track and monitor the whereabouts of each GPS satellite 20 to 21 hours per day. Land-based and space-based communications connect the remote monitoring stations with the MCS.

User Equipment

GPS user equipment includes the Receiver sets that can range from simple devices that provide only basic positioning information to complex multichannel units that track all satellites in view and perform a variety of functions. Most GPS receivers consist of three basic components viz. antenna, receiver-processor unit and control/ display unit.

- Antenna receives the signal and, in some cases, has anti-jamming capabilities
- Receiver-processor unit converts the radio signal to a useable navigation solution
- Control/display unit displays the positioning information and provides an interface for receiver control.

How GPS works

As we studied above, GPS is a network of 24 satellites that orbits the Earth twice a day, transmitting signals back to earth. A GPS receiver locks onto signals from three or more satellites and determines its location, using a method called **trilateration**. The receiver calculates the difference between the time a satellite sent a signal and the time the system received it. Using the information gathered from several signals, the receiver triangulates the exact position. It can even determine how fast one is going and how long it will take to reach one's destination. GPS receiver compares the time a signal was transmitted by a satellite with the time it was received.

The time difference tells the GPS receiver how far away the satellite is.

- Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map. This is the fundamental principle behind GPS.
- A GPS receiver must be locked on to the signal of **at least three satellites** to calculate a 2D position (latitude and longitude) and track movement.
- With four or more satellites in view, the receiver can determine the **user's 3D position** (latitude, longitude and altitude).

Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more.

GPS receiver is only a receiver, without any transmitting capability. The satellites do not contain any databases about the locations or anything. They contain highly precise atomic clocks which generates some code which it keeps transmitting to the earth. The GPS receiver gets that code from multiple satellites which is slightly time-shifted due to difference in the distances of satellites. Using this difference the receiver calculates the longitude and latitude.

What are the GPS Signals?

GPS is a constellation of 24 satellites. It transmits two low power radio signals, designated L1 and L2. Civilian GPS uses the L1 frequency of 1575.42 MHz in the UHF band. The signals travel by line of sight, meaning they will pass through clouds, glass and plastic but will not go through most solid objects such as buildings and mountains.

Standard Positioning System and Precision Positioning Systems in GPS

GPS was originally developed as a military force enhancement system and for exclusive use of military. However, GPS has also demonstrated a significant potential to benefit the civil community in an increasingly large variety of applications. In an effort to make this beneficial service available to the greatest number of users while ensuring that the national security interests of the United States are observed, two GPS services are provided. The Precise Positioning Service (PPS) is available

primarily to the military of the United States and its allies for users properly equipped with PPS receivers. The Standard Positioning Service (SPS) is designed to provide a less accurate positioning capability than PPS for civil and all other users throughout the world.

Global Navigation Satellite System (GNSS)

A satellite navigation system with global coverage may be termed a global navigation satellite system or GNSS. The United States NAVSTAR Global Positioning System (GPS) is the only fully operational GNSS as of now.

China is making its Beidou navigation system and is working towards making it a complete GNSS in near future. Similarly, Galileo is the GNSS of European Union, currently in initial deployment phase, scheduled to be fully operational by 2020 at the earliest.

Russia is on advance stage of achieving full coverage by its GLONASS system. GLONASS has achieved 100% coverage of Russia's territory.

It has 22 operational satellites, short of the 24 satellites needed to provide continuous global coverage, and is expected to be completed during 2011.

The GLONASS satellites designs have undergone several upgrades, the latest is GLONASS-K.

Please note that India is pursuing space cooperation with Russia currently on joint lunar exploration; development of small experimental satellite for space science studies; use of Russian global navigation satellite system (GLONASS); and preliminary studies for human spaceflight.

The Integration of India's Regional Navigational Satellite System with Russia's GLONASS constellation will facilitate reliable and enhanced performance in satellite based navigation, in a seamless manner through dual system receivers.

Satellite Television

Satellite TV is a wireless system for delivering television programming directly to a viewer's house. The limitations of Broadcast TV are because of the curved surface of earth. If Earth were perfectly flat, one could pick up broadcast TV thousands of miles from the source. But because the planet is curved, it eventually breaks the signal's line of sight, thus limiting the signal quality. Satellite TV solves the problems of range and distortion by transmitting broadcast signals from satellites orbiting the Earth.

Definition

Satellite television is television delivered by the means of communications satellite and received by an outdoor antenna, usually a parabolic mirror generally referred to as a satellite dish, and as far as household usage is concerned, a satellite receiver either in the form of an external set-top box or a satellite tuner module built into a TV set. Satellite TV tuners are also available as a card or a USB stick to be attached to a personal computer. In many areas of the world satellite television provides a wide range of channels and services, often to areas that are not serviced by terrestrial or cable providers.

Orbit

The TV satellites either in geosynchronous orbit or naturally highly elliptical (with inclination of +/-63.4 degrees and orbital period of about 12 hours (Molniya orbit) or geostationary orbit, the circular orbit just above earth's equator.

Radio Frequency Band

Early satellite television was broadcast in C-band radio in 4-8 GHz. Today, the Digital broadcast satellite transmits programming in the C-Band or Ku frequency range (12-18GHz) or Both known as Hybrid.

What is Difference between C-Band and Ku-Band?

The early C-band radio signals could be caught by the early satellite TV viewers which were free but the viewers needed to hunt them. The C-Band is still used, in fact, microwave frequencies of the C-band perform better in comparison with Ku band microwave frequencies, under adverse weather conditions, which are used by another large set of communication satellites. The adverse weather conditions, collectively referred to as rain fade, all have to do with moisture in the air, including rain and snow. Ku band is primarily used for satellite communications, most notably for fixed and broadcast services, and for specific applications such as NASA's Tracking Data Relay Satellite used for both space shuttle and ISS communications. Some frequencies in this radio band are used for vehicle speed detection by law enforcement, especially in

Europe. Today Satellite communication uses a Hybrid. Please note that C-band transmission is susceptible to terrestrial interference while Ku-band transmission is affected by rain (as water is an excellent absorber of microwaves at this particular frequency). The latter is even more adversely affected by ice crystals in thunder clouds.

Uplink

The signal in the satellite TV starts with a transmitting antenna located at an uplink facility, which feeds the signal to the satellite. The Uplink satellite dishes are very large, as much as 9 to 12 meters, so that there is accurate aiming and increased signal strength at the satellite. The uplink dish is pointed toward a specific satellite and the uplinked signals are transmitted within a specific frequency range, so as to be received by one of the transponders tuned to that frequency range aboard that satellite.

Transponders

The transponder is a device which automatically responds to incoming signals and 'retransmits' the signals back to Earth. A typical satellite has up to 32 transponders for Ku-band and up to 24 for a C-band only satellite, or more for hybrid satellites. Please note that Transponders "retransmits' the signal to earth at a different frequency band, which is known as Translation. The objective of translation is to avoid interference with the uplink signal. The signal is retransmitted in C-band (4–8 GHz) or Ku-band (12–18 GHz) or both.

Downlink

The leg of the signal path from the satellite to the receiving Earth station is called the downlink.

Role of Dish

The down linked satellite signal is usually quite weak after traveling the great distance. It is collected by using a parabolic receiving dish, which reflects the weak signal to the dish's focal point. At the focal point of the Dish is mounted a feed horn that gathers the signals at or near the focal point and 'conducts' them to a probe or pickup connected to a low-noise block down converter or LNB.

Role of LNB

LNB amplifies the relatively weak signals, filters the block of frequencies in which the satellite TV signals are transmitted, and converts the block of frequencies to a lower frequency range in the L-band range. The evolution of LNBs was one of necessity and invention.

Role of Set Top Box

Set-top box demodulates and converts the signals to the desired form (outputs for television, audio, data, etc.). Sometimes, the receiver includes the capability to unscramble or decrypt the received signal; the receiver is then called an integrated receiver/decoder or IRD.

Impact of Equinox on Geostationary Satellites

Please note that there is a sun outage for all kinds of communications from

Geostationary Satellites, twice a year on equinoxes, when there is temporary disruption of communications satellites. On Equinox, sun goes directly behind the satellite relative to Earth (i.e. within the beam-width of the groundstation antenna) for a short period each day. The Sun's immense power and broad radiation spectrum overload the Earth station's reception circuits with noise because of sun emitting microwaves on the same frequencies used by the satellite's transponders, and, depending on antenna size and other factors, temporarily disrupt or degrade the circuit. The duration of those effects can vary from few minutes to an hour. Sun Outage affects both the C-band and the Ku-band.

Conditional Access System

Conditional Access System (CAS) is the electronic transmission of digital media, especially satellite television signals, through cable to limited subscribers. The signal is scrambled, encrypted and is unavailable for unauthorized reception.

Scrambling is a process in which the picture is altered in such a way that it is impossible to watch those particular channels without being a subscriber. Set-top box (STB) is the best example for it.

We all know that the set-top box (STB) is required to be placed near the TV to receive and decrypt the signal.

Satellite Internet

The DSL and cable Internet access are popular in urban and suburban areas but in rural and remote areas, DSL and cable Internet may not be available. This is because the terrestrial connections are not installed everywhere. The Satellite Internet Access is an answer to this problem. Satellite connection offers Internet to those who live in locations so remote that there are no telephone lines, or even to those who travel in mobile vehicles.

Satellites Used

The service can be provided to users world-wide through **Low Earth Orbit satellites.** The LOE are preferred because – though the **geostationary satellites** can offer higher data speeds, yet their signals cannot reach **some polar regions** of the world. Different types of satellite systems have a wide range of different features and technical limitations, which can greatly affect their usefulness and performance in specific applications.

SkyTerra-1 was launched in mid-November 2010 and will provide service across North America while Hylas-1 was launched at the end of November, 2010 and will target Europe.

Components:

Two-way satellite Internet consists of a Dish, Two Modems (for uplink and Downlink) and Coaxial cables between dish and modem. The satellite Internet uses Internet Protocol (IP) multicasting technology, which means up to 5,000 channels of communication can simultaneously be served by a single satellite. IP multicasting sends data from one point to many points (at the same time) by sending data in compressed format. Compression reduces the size of the data and the bandwidth.

Use of GEO: Problem of Latency:

This is one of the biggest hurdles of the Satellite Internet. Latency means the delay between requesting data and the receipt of a response. Satellite Internet is two way communications unlike the one-way communication in Satellite TV. Compared to ground-based communication, all geostationary satellite communications experience high latency due to the signal having to travel 35,786 km (22,236 mi) to a satellite in geostationary orbit and back to Earth again. The Latency in two way satellite internet access is typically between 1,000–1,400 ms in comparison to the dial-up internet where it is 50–200 ms total latency. This delay can also be irritating and debilitating with interactive applications, such as VoIP, videoconferencing, or other person-to-person communication. Some applications such as Skype will fail. Conversation over a high-latency connection makes communication difficult and may lead to a feeling of mistrust or hesitation, even when both sides are aware of the lag.