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LECTURE NOTES

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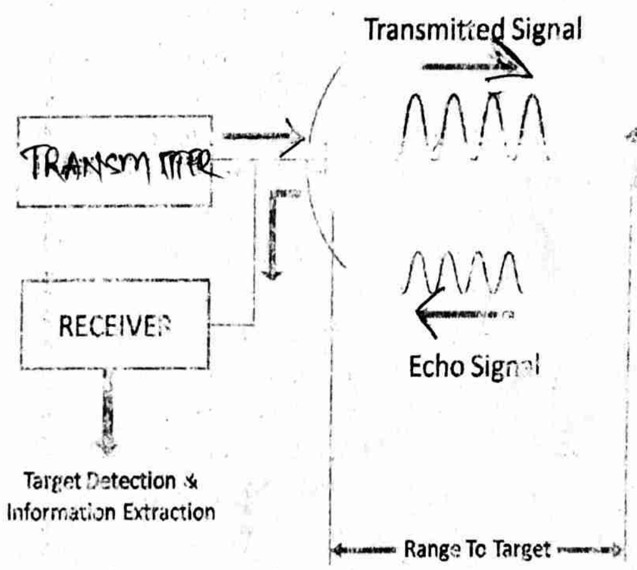
[CHAPTER-1]

RADAR AND NAVIGATION AIDS

- RADAR means Radio Detection and Ranging. It is a device which can detect the presence of Target and measure its Range.
- Radar is an electromagnetic system for detection and location of reflecting objects such as aircrafts, ships, vehicles, people and natural environment etc.
- It operates by transmitting a particular type of wave form (for e.g. pulse modulated sine wave) into space and detects the nature of echo signal reflected form an objects or targets.
- Radar can't recognize colour of objects but it can recognize darkness, fog, smoke, rain, snow etc.

SIMPLE RADAR SYSTEM:-

- A Simple Radar System consists of Transmitter, Receiver and Antenna.
- A Transmitter generates an EM Signal which is radiated into space by transmitting Antenna. A portion of the transmitted energy is intercepted by the target and re-radiated in many directions. The radiation directed towards the Radar is collected by the receiving Antenna and delivers into receiver.
- At the receiver the Signal is processed to detect the presence of target and determines its location.
- A Single Antenna is generally used in a time shared basic for both Transmitting and Receiving when the radar waveform is a repetitive series of pulses.



[BLOCK DIAGRAM OF A SIMPLE RADAR SYSTEM]

- The range or distance to a target is found by measuring the time it takes for the radar signal to travel to the target and return back to the Radar.
- Radar can also provide information about nature of target being observed.
- If the target is in motion, there is a shift in the frequency of the echo signal due to the Doppler Effect. This frequency shift is proportional to the velocity of the target related to the Radar which is known as Radar velocity.

NOTE: Doppler frequency shift is widely used in Radar as the basic for separating desired moving target from fixed(Unwanted) clutter echoes reflected from natural environments such as sec, Lake Etc.

- The range of the target is determined by the time T_R; It is the time taken by the pulse to travels to the target and returns back.
- The EM Wave in the space travel in the speed of light i.e. 3×10^8 m/s. Thus the time taken for the signal to travel to the target located at a Range 'R' and returned back to the Radar can found as: -

$$V=S/T \Rightarrow T=S/V$$

$$\boxed{T_R=2R/C \rightarrow \mathbf{R=CT_R/2}}$$ **[V≡Velocity≡C; S≡Distance≡R; T≡Time≡T_R]**

NOTE:-

$R_{KM} = 0.15\ T_R\ (\mu s)$ $R_{Mtr} = 150\ T_R\ (\mu s)$ $R_{Yard} = 164\ T_R\ (\mu s)$ $R_{Feet} = 492\ T_R\ (\mu s)$

$R_{nmi} = 0.081\ T_R\ (\mu s)$ [nmi= Nautical Miles] $R_{smi} = 0.081\ T_R\ (\mu s)$ [smi= Statute Miles]

Un-Ambiguous Range: -

- Once the signal is radiated into space by Radar, Sufficient time must elapse to allow all echo signals to return to the Radar before the next pulse is transmitted. The rate at which the next pulse transmitted is determined by the longest range at which targets are accepted.
- If the time between pulses T_P is too short an echo signal from long range target might arrive after the transmission of next pulse and we mistakenly associated with that pulse rather than the actual pulse transmitted earlier. This can result an incorrect or ambiguous measurement of Range.
- Echo that arrives after the transmission of next pulse are called second-time around echo. Such an echo would appear to be at a closer range than the actual and its range measurement is called misleading, if it were not known to be second-time around echo.
- Hence the range beyond which the target appears as second-time around echo is called Maximum Unambiguous Range.

$$R_{Unamb} = CT_P/2 = C/2F_P$$

Where, T_p = Pulse Repetition Period. & F_P = Pulse Repetition Frequency.

TYPES Of RADAR: -

- There are basic two types of Radar Detecter
  - Pulse Radar System
  - Contineous Wave (CW) Radar System
- Continuous Wave Radar System again classified into two categories such as: -
  - CW Doppler Radar
  - Frequency Modulated CW Radar (FM-CW Radar).

APPLICATIONS Of RADAR: -

- Radar used in Different Fields like: -
  - Military
  - Remote Sensing
  - Air Traffic Control
  - Law Enforcement
  - Highway Safety
  - Aircraft Safety and Navigation
  - Ship Safety
  - Space Vehicles Control etc.

Performance Factors of RADAR (OR) Radar Range Equations: -

- Radar Equation relates the Range of Radar to the characteristic of Transmitter, Receiver, Antenna, Target, and Environment etc.
- It is used not just as a man for determining the maximum distance from Radar to a Target. But it can serve both as a tool for understanding Radar Operation and a Basic form of Radar Design.
- In this section the simple form of Radar Equation is derived.
- For an isotropic antenna; If the Power of Radar Transmitter is denoted by $\mathbf{P_t}$ then the Power Density (watts per unit area) at a distance 'R' is equal to the Transmitted Power Divided by the Surface Area ($4\pi R^2$) of an Imaginary Sphere with Radius 'R'. Where $\mathcal{P}_i$ = Power Density from Isotropic Antenna.

$$\mathcal{P}_i = \frac{Pt}{4\pi R^2} \quad \text{.. (1)}$$

- Generally Radar uses Directive antennas to channels. In this case the radiated power P_t is in some particular direction. If the gain (G) of an antenna is a measure of increased power radiated in the direction of target as compared with power that would have been radiated. And is defined as,

$$G = \frac{\text{Maximum Power Density Radiated by Directive Antenna}}{\text{Power radiated by a loss less Isotropic Antenna with same Power Input}}$$

- So, The Power Density at the target form an Directive Antenna with a transmitting gain 'G' is

$$\mathcal{P}_D = \frac{P_t G}{4\pi R^2} \quad \text{.................. (2)}$$

- The target intercepts a portion of radiated power and re-radiated it in the various directions. The measure of the amount of incident power intercepted by the target and re-radiated back in the Radar Cross Section (σ) and is defined by the relation.

$$\text{Power Density of the echo signal at Radar} = \frac{P_t G}{4\pi R^2} \times \frac{\sigma}{4\pi R^2} = \frac{P_t G \sigma}{(4\pi R^2)^2} \quad \text{.......... (3)}$$

- The Radar cross section (σ) as unit of area, it is the characteristic of a particular target and a measure of its size as seen by the Radar.
- Like target the Receiving Antenna intercepts a portion of the re-radiated power which is proportional to the Cross Sectional Area of the Receiving Antenna (A_e). The radar antenna captures a portion of the echo power. If the effective area of the cross sectional area of receiving antenna is denoted as A_e. The power receiving by the Radar is

$$\mathcal{P}_r = \frac{P_t G}{4\pi R^2} \times \frac{\sigma}{4\pi R^2} \times A_e \Rightarrow \mathcal{P}_r = \frac{P_t G \sigma A_e}{(4\pi)^2 R^4} \quad \text{.......... (4)}$$

- The Maximum Radar Range i.e. R_{max} is the distance beyond which the target cannot be detected. It occurs when the received echo signal power $\mathcal{P}_r$ just equal to the Minimum Detectable Signal (S_{min}),

$$S_{min} = \frac{P_t G \sigma A_e}{(4\pi)^2 R_{max}^4} \Rightarrow (R_{max})^4 = \frac{P_t G \sigma A_e}{(4\pi)^2 S_{min}}$$

$$\Rightarrow (R_{max}) = \left[\frac{P_t G \sigma A_e}{(4\pi)^2 S_{min}}\right]^{\frac{1}{4}} \quad \text{.......... (5)}$$

- That is the Fundamental of the Radar Equation.

NOTE: - The importment antenna parameters are Transmitting Gain & the Receiving Effective Area.

- Antenna theory give the relation between Transmitting gain & receiving affective area of antenna i.e.,

$$G = \frac{4\pi A_e}{\lambda^2} \quad \& \quad A_e = \frac{G\lambda^2}{4\pi} \quad \text{.......... (6)}$$

- Since the Radar generally use the same antenna both for Transmission and Reception, So we use these values in fundamental equation of Radar.

$$R_{max} = \frac{P_t 4\pi A_e}{\lambda^2} \times \frac{A_e \sigma}{(4\pi)^2 S_{min}} \Rightarrow R_{max} = \left[\frac{P_t A_e^2 \sigma}{4\pi \lambda^2 S_{min}}\right]^{\frac{1}{4}} \quad \text{.......(7)}$$

$$R_{max} = \left[\frac{P_t\left(\frac{G\lambda^2}{4\pi}\right)^2 \sigma}{4\pi\lambda^2 S_{min}}\right]^{\frac{1}{4}} \quad \& \quad R_{max} = \left[\frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 S_{min}}\right]^{\frac{1}{4}} \quad \text{.......(8)}$$

- These simplified versions of Radar equation don't adequately describe the performance of actual Radars, as many important factors are not included. Also Idealized conditions have been employed i.e. neither the Effect of Ground nor Absorption and Interference is taken into account. Hence, the maximum range in practice is often less than that of indicated by the Radar Range Equation.

Important Problems: -

What is the duty cycle of Radar with a pulse width of 3μsec and a PRT of 6ms?

$$\text{As Duty Cycle} = \frac{PW}{PRT} = \frac{\text{PULSE WIDTH}}{\text{PULSE REPETATION TIME}}$$

$$\text{Duty cycle} = \frac{PW}{PRT} = \frac{3\times10^{-6}}{6\times10^{-3}} = 0.5\times10^{-3} = 0.0005$$

Duty cycle also is expressed as ratio of average power to that of peak power.

$$\text{Average power} = \text{Peak Power} \times \text{Duty Cycle}$$

Calculate the average power when peak power is 100kw with PW of 3μs and PRT of 6ms?

$$\text{Duty cycle} = \frac{PW}{PRT} = \frac{3\times10^{-6}}{6\times10^{-3}} = 0.5\times10^{-3} = 0.0005$$

Peak Power = 100kw = 100×10^3 Watt

Average Power = Peak Power × Duty Cycle = $100\times10^3\times0.5\times10^{-3}$ = 50 watt

Calculate the maximum range of a Radar system which operates at 3cm wave length with a pe pulse power of 500kw and its minimum detectable signal S_{min} is 10^{-13}watt, the aperture area of i antenna is $5m^2$ and the Radar cross sectional area of the target is $20m^2$.

Given: Wave length, λ = 3cm = 0.03m

Peak Power, Pt= 500kw =500×10^3watt

Smin=10^{-13}W, Aperture Area (Ae) =$5m^2$ & $\sigma = 20m^2$

$$R_{max} = \left[\frac{Pt\, Ae^2\, \sigma}{4\pi\, \lambda^2 Smin}\right]^{\frac{1}{4}}$$

⇨ $R_{max} = \left[\frac{500\times10^3\times25\times20}{4\pi\times(0.03)^2\times10^{-13}}\right]^{1/4}$ → R_{max} =686km =370nmi

A Radar operating at 10GHz with the peak power of 500kW, the power gain of antenna is 500(and the minimum power at the receiver is 10^{-14}W. Calculate the maximum range of Radar if the affective area of antenna is $10m^2$ and RADAR cross sectional area is $4m^2$?

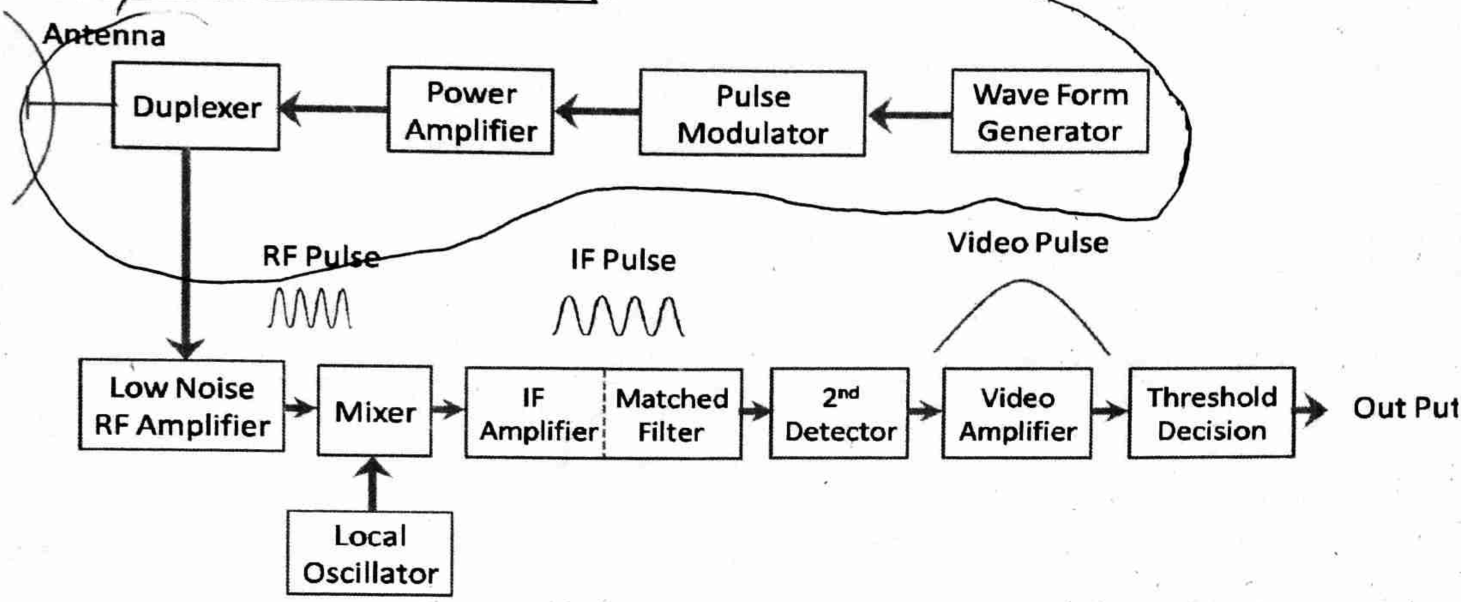
Given: f = 10Ghz = 10×10^9Hz , Pt=500kw= $500\text{x}10^3$ watt

G= 5000, Smin=10^{-14}W, Aperture Area (A_e) =$10m^2$ & $\sigma = 4m^2$

$$(R_{max}) = \left[\frac{Pt\, G\, \sigma\, Ae}{(4\pi)^2 Smin}\right]^{\frac{1}{4}}$$

⇨ $R_{max} = \left[\frac{500\times10^3\times5000\times10\text{x}4}{4\pi\times10^{-14}}\right]^{1/4}$ = 501643.359m = 501.643km

☎ PULSE RADAR SYSTEM:-



[BLOCK DIAGRAM OF A **PULSE MODULATED RADAR** SYSTEM]

- The operation of a typical Pulse Radar System is described by the help of block diagram.
- Generally it consists of Antenna, Transmitter and Receiver which are explained below.

1. ANTENNA: -

- The function of antenna during transmission is to concentrate the radiated energy into a shaped beam which points in the desired direction in the space.
- On reception the antenna collects energy contained in the echo signal and deliveries it to the receiver.
- The two important input parameters of Antenna i.e. Transmitting Gain (G) and Effective Receiving Area (A_e) are proportional to each other.
- An antenna with large effective receiving aperture implies a large transmitting gain.
- Different type of antenna can be used in Radar such as mechanically steered parabolic reflector, electrically steered planned array antenna or electrically steered phase array antenna etc.

2. TRANSMITTER: -

- The Transmitter may be an oscillator such as a Magnetron i.e. pulsed [turned ON and OFF] by the modulator to generate a repetitive train of pulse.
- The Magnetron most widely used for a various microwave generator for Radar.
- A Typical Radar for the detection of aircraft has the following points: -
  - Ranges nearly equal to 100 to 200nmi.
  - Transmitting power in the order of mega watt & Average power in order of several kilowatt;
  - Pulse Width in the order of micro second.
  - Pulse repetition frequency in the order of several 100 pulses per sec.
- Transmitting section consists of Waveform Generator, Pulse Modulator, Power Amplifier & Duplexer.
- The waveform generator generates repetitive train of pulse & is fed to pulse modulator for modulation.
- The pulse modulator modulates the train of pulses and gives the pulse modulated signal to the power amplifier for amplification.
- The power amplifier amplifies the pulse modulated signal and fed to the duplexer. Generally audio frequency amplifier is used for this purpose.
- The duplexer allows a single antenna to be used on a time sharing basis for transmitting and receiving.
- The duplexer is generally a gaseous device that produces a short circuited at input to the antenna During Transmission. So that the high power is flows to the antenna not to the receiver.

- The duplexer protects from damages caused by the high power of the transmitter. It also serves to channel that the returned echo signal to the receiver and not to the transmitter.
- The duplexer might consist of two gassed discharged devices one known as TR (Transmit Receiver) and ATR (Anti-Transmit Receiver).
- The TR protects the receiver during transmitting and the ATR directs the echo signal to the receiver during reception.

3. RECEIVER SECTION: -

- The receiver is usually super heterodyne type. It consists of different part as explained bellow: -
- The 1st stage of the receiver is low noise R.F. transistor amplifier which reduces the noise level.
- The mixer and local oscillator converts the R.F. signal to intermediate frequency where it is amplified by the IF amplifier.
- The signal Bandwidth of a super heterodyne receiver is determined by the bandwidth of the IF stage.
- The IF amplifier is designed as a Matched Filter that is one which maximizes the output peak-signal-to-mean-noise ratio.
- Thus the basic function of matched filter is to maximize the detectability of weak echo signal & attenuates the unwanted signal.
- The IF amplifier is followed by a critical diode which is called the second detector or demodulator. Its purpose is to assist extracting the modulating signal from the modulated signal.
- The combination of IF amplifier, 2nd detector and video amplifier act as an envelope detector to pass pulse modulation (envelop) and reject the carrier frequency.
- To detect the Doppler shift of the echo signal the enveloped detector replaced by phase detector which is different from the envelope detector.
- The combination of the IF amplifier and video amplifier is designed to provide sufficient amplification or gain to raise the level of the input signal to a magnitude where it can be seen in a display.
- At the end of the receiver a decision is made whether a target is present or not. The decision is based on the magnitude of the receiver output.
- If the output is large enough to exceed a pre-determined threshold, the decision is that the target is present. If it does not cross the threshold only noise is assumed to present.
- The display unit is usually a Cathode Ray Tube; the most common form of the CRT is Plane Position Indicator (PPI) which maps location of the target is in Azimuth angle & Range in polar co-ordinates.
- B-scope display is similar to the PPI except that it utilizes the rectangular co-ordinate rather than the polar co-ordinates to display Range **Vs** Angle.
- Another for display is A-scope which plots target Amplitude **Vs** Range for some fixed direction.

☎ CONTINUOUS WAVE RADAR (CW RADAR) :-

- Pulse Radar is used for detection of Stationary Objects; Where as to detect a Moving Target, continuous wave type of Radar is used.
- CW Radar is of Two type: -
  (1) CW Doppler Radar (2) FM CW Radar
- CW Doppler Radar uses the Doppler Effect for the Target Speed Measurement.
- FM CW Radar is used to measure Range as well as Velocity of the Target.

❖ DOPPLER EFFECT:-

- The aperant frequency of electromagnetic or sound waves depends on the relative radial motion of the source or observer. If the source and observer one moving away from each other then the aperant frequency will decrease and when they moving towards each other then the aperant frequency will increase. This phenomenon was postulated by C. Doppler. So it is known as **Doppler Effect**.

- If 'R' is the distance from the Radar to target then the total number of wavelength (λ) contained in the two way path between the Radar and target is $2R/\lambda$.
- Each wavelength corresponds to a phase change of 2π radian then the total phase change in the two way propagation path is equal to ($2\Pi \times 2R/\lambda$) i.e. $\mathbf{\Phi = 4\Pi R/\lambda}$.
- If the target is in motion w.r.t. the Radar then R and Φ are continuously changes. A change in Φ w.r.t. time is equal to frequency and this is known as Doppler Angular Frequency (W_d).

$$\mathbf{W_d = 2\pi f_d = — = — —) = — — = — V_r}$$

Where f_d = Doppler Frequency Shift & V_r = Radial Velocity of the Target w.r.t. Radar

- From the above expression, $f_d = 2V_r/\lambda$. Put $\lambda = C/ft$,We get $f_d = 2V_r f_t/C$.
  Where f_t=Radar frequency or Transmitted frequency.
- If f_d in Hz, V_r in nmi & λ in meter then $\mathbf{f_d = 1.03V_r/\lambda}$.

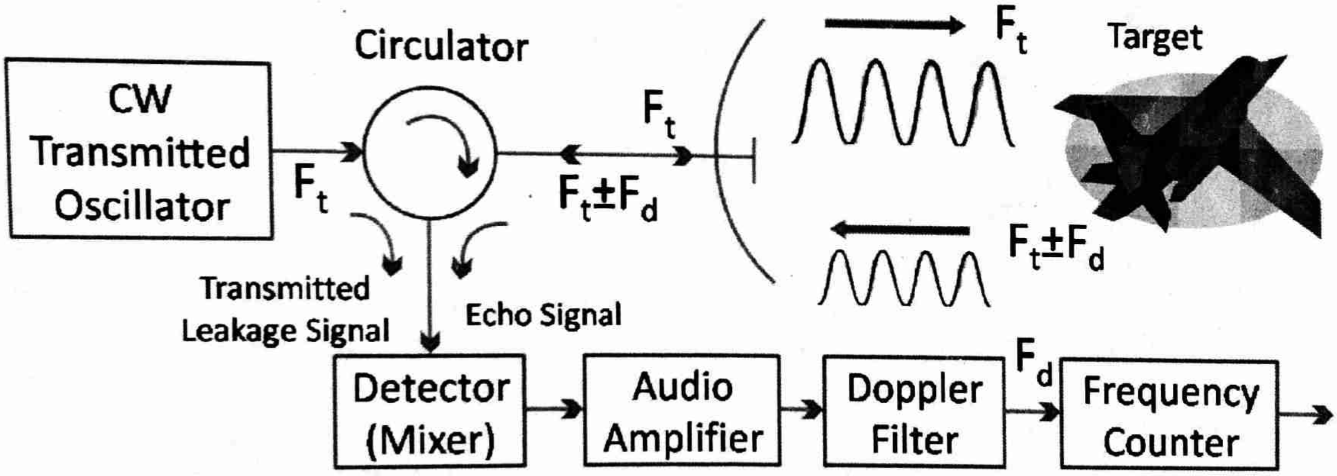
With a CW Transmit frequency of 5GHz, Calculate the Doppler frequency seen by the Stationary Radar when the Target radial velocity is 100km/hr.

Given that f_t = 5 GHz = 5×10^9 Hz ; V_r=100Km/hr = 100x1000/3600 = 27.8m/s ; c = 3×10^8 m/s.

As $\lambda = c/f = (3\times10^8) / (5\times10^9) = 0.06$m

$f_d = 2V_r / \lambda = (2\times 27.8) / 0.06 = 926$ Hz.

1. CW Doppler RADAR:-



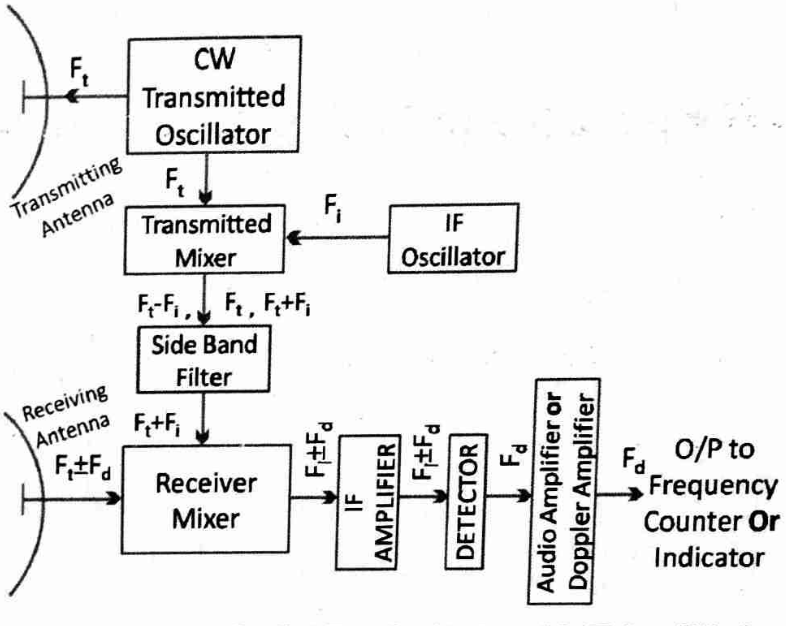
[BLOCK DIAGRAM OF A CW DOPPLER RADAR]

- The CW Transmitter generates a continuous sine wave rather than pulse (Unmodulated) of frequency f_t which is radiated by the antenna. Since, here the transmission is continuous the Circulator is used to provide isolation between transmitter & receiver. For continuous wave the use of duplexer is pointless.
- A Portion of radiated energy is intercepted by the target and scattered. Some of it in the direction of Radar where it is collected by receiving antenna.
- If the target is in motion with a velocity of V_R relative to the Radar, the received signal will be shifted in frequency from the transmitted frequency f_t by an amount of $\pm f_d$.
- The plus (+) sign associated with the Doppler frequency applied, if the distance between the target and the Radar is decreasing (when they moving towards each other) i.e. when the received signal frequency is greater than the transmitted signal frequency. The minus (-) sine applied if the distance is increasing i.e. target is away going from the Radar.
- Hence the received echo signal at the frequency $f_t \pm f_d$ enters to the Radar via antenna.

- This signal is heterodyne in the detector (mixer) with a portion of transmitted signal f_t to produce a Doppler bit of frequency f_d. The sign of the f_d is losses in this process. So we cannot predict whether the target is going away from the Radar or coming towards the Radar.
- The purpose of the Doppler amplifier is to eliminate echoes from stationary target and to amplify the Doppler echo signal to a level where it can operate an indicating device like frequency counter.
- The counter is a normal one except that the output is shown as km or miles/hour rather than the actual frequency in Hz.
- The main disadvantage of simple CW system is its lake of sensitivity. The type of diode detector that is used to accommodate the high incoming frequency and is not a good device for the audio output frequency. Thus an increment is in the following ways.

CW Doppler RADAR With IF AMPLIFIER:-

- A small portion of a transmitter output is mixed with output of local oscillator and the sum is fed to the receiver mixer by the help of sideband filter.
- The receiver mixer also receives the Doppler shifted signal from receiving antenna and produces an output difference frequency i.e. typically 30MHz (Generated by the IF oscillator) $\pm f_d$.
- The output of this mixer is amplified by the amplifier and demodulates again by the detector.
- The signal from the 2nd detector is just the Doppler frequency (f_d).



[Block Diagram of a CW Doppler Radar with IF Amplifier]

- This signal is again amplified by the Doppler amplifier so as to raise the signal level such as to meet the frequency counter or indicator. Its sine is lost so that it not possible to tell whether the target is approaching or receiving.
- Separate receiving and transmitting antenna have been used. A Circulator could be used as shown in simple CW Radar system. Separate antenna is used to increase the isolation between transmitter and receiver section of the Radar.

ADVANTAGES: -

- CW Radar is capable of giving accurate measurement of relative velocity using low transmitting power, simple circuitry low power consumption and equipment whose size is much smaller than that of pulsed Radar equipment.
- It is unaffected by the presence of stationary target.
- With some additional circuitry CW Radar can measure the direction of the target along with its speed.

LIMITATION: -

- It is limited to the maximum power it transmits and this naturally places a limit on its maximum range.
- It is easily confused by the presence of a large number of targets (Although it is capable of delaying with more than one target if special filters are included).
- It is capable of indicating the range of the target. It can only show its velocity because the transmitted signal is Unmodulated.

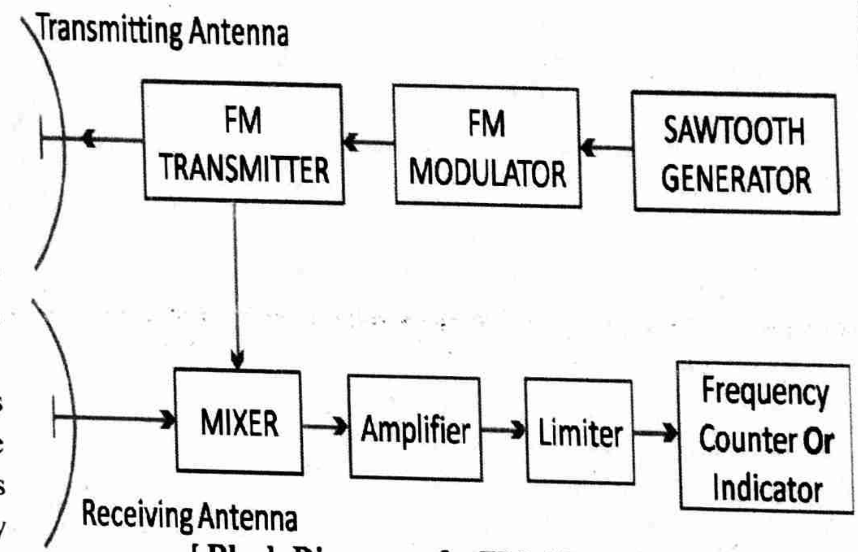
- The receiver cannot sense which particular cycle of oscillation being received at that moment and therefore cannot tell how long ago this particular cycle was transmitted, so that the range cannot be measured.

APPLICATION:-

- It is used in aircraft navigation for speed measurement.
- Another application is in a rate of climb meter for vertical take of planes such as Harrier.
- It is most commonly used in Radar speed meter used by police.

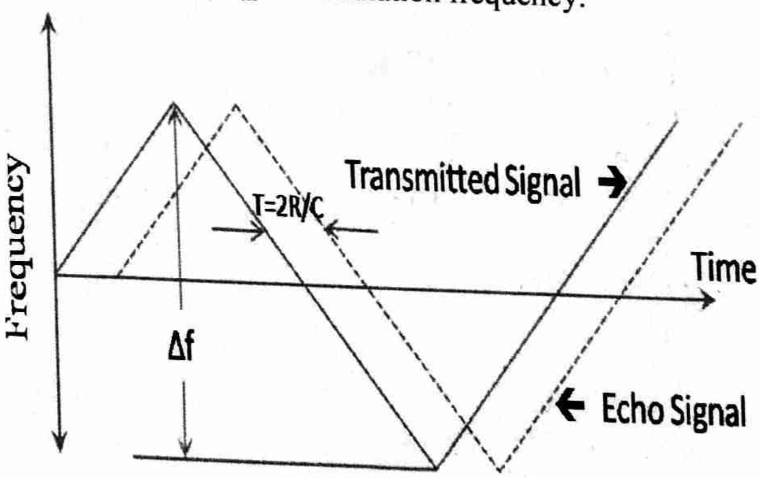
2. FM CW RADAR:-

- The greatest limitation of Doppler radar i.e. it is unable to measure the range is over come if the transmitted carrier is frequency modulate.
- If this is done it would be possible to eliminate difficulty with CW Radar i.e. its inability to distinguish one cycle from other.
- The popular method in CW Radar is to linearly frequency modulated the waveform the modulation is triangular which gives up eventually and comes down.



[Block Diagram of a FM-CW Radar]

- The transmitted signal is shown by the solid triangular waveform and the receiver signal is shown by dashed line. Delay time, $T=2R/C$, Δf = Frequency deviation , F_m = Modulation frequency.
- The target is stationary w.r.t. the plane. A frequency difference proportional to the height of the plane will exist between the receiver and transmitter signal is now being received was sent at a time when the instantaneous frequency was different.
- The rate of change of frequency with time due to the FM process is known the time difference between the sent and received signal may be calculated.



[SAW TOOTH WAVE FORM IN FMCW RADAR]

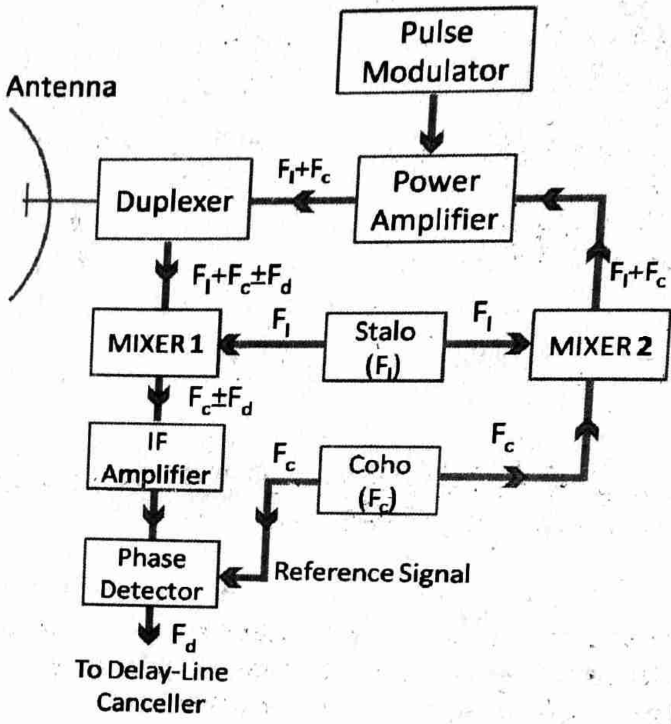
- The above diagram is the block diagram of a common application of the FM CW Radar system. It is also known as air borne altimeter as it is employed for measurement of altitude in air craft. Here we use a saw tooth generator as we employing saw tooth frequency modulation for simplicity.
- A FM transmitter is used in which frequency modulation of the signal can be done and its output is given to the mixer. The output of the mixer which produces the frequency difference (beat frequency) as amplified by amplifier and limited to remove any amplitude fluctuation by limiter.
- This signal is fed to a frequency counter and to an indicator whose output is calibrated in meter or feet.

APPLICATION:-

- FM CW Radar is mostly used in altimeter in aircraft due to shorter range & lower power requirement as compared to pulse Radar. Smaller size for air craft installation & smaller transmitter power.

☎ Moving Target Indicator Radar (MTI):-

- This Radar uses Doppler Effect for its operation many times it is not possible to distinguish a moving target in the presence of static or permanent echoes of comparable appearance on the Radar screen.
- We have seen that in a PPI display, there is a lot of clutter due to this stationary target echoes. When it is desired to remove the clutter due to the stationary target an MTI Radar is employed.
- The basic principle of MTI Radar is to compare a set of received echo with those received during the previous. Sweep and Cancelling out those whose phase has remain unchanged.
- Moving target will give change of phase and are not cancelled thus clutter due to the stationary target are remove from display and this allows easier detection of moving target.
- The side block diagram is the simple block diagram of simple MTI Radar.
- The Transmitter frequency in the MTI Radar System is the sum of the o/p of two oscillators produced in mixer 2.



[BLOCK DIAGRAM OF A **MTI RADAR** SYSTEM]

- The First oscillator is the Stalo (Stable Oscillator) and the Second one is Coho (Coherent Oscillator) which operating same frequency as the intermediate frequency & providing coherent signal.
- The Coho is used for generating the R.F. signal as well as reference signal for the phase detector.
- The output of the duplexer is the combination of transmitted frequency and Doppler shift frequency.
- At the mixer-1 the Stalo frequency (f_L) cancels out and feeds a signal of frequency $f_c \pm f_d$ to I.F amplifier for amplification.
- The reference signal from the Coho and the I.F echo signal are both feed into the mixer called phase detector. The phase detector differs from the normal amplitude detector, since its output is proportional to the phase difference between the two input signals.
- Since the output of this detector is phase sensitive and output will obtain for all fixed or moving target.
- The phase difference between transmitter & receiver signal will be constant for a fixed target where as it will vary for a moving target. This variation of moving target is due to the Doppler frequency shift.
- The delay line canceller not only eliminate the DC component caused by clutter but also it unfortunately rejects the any moving target whose Doppler frequency happens to be same as the PRF (Pulse Repetition Frequency) or multiple of PRF. ($f_d = nf_p$)
- Those related target velocities which result is zero MTI response are called blind speed and is given by

$$V_n = n\lambda/2T = n\lambda f_p/2$$ Where n = 1, 2, 3……

An MTI RADAR operates at frequency 5GHz with a PRF of 800pps. Calculate the lowest three blind speeds of this RADAR.

- Given that : f =5GHz = 5×10^9Hz , PRF =800pps

As $\lambda = c/f = (3\times10^8) / (5\times10^9) = 3/50 = 0.06$m

$V_{n1} = n\lambda f_p/2 = (1\text{x}0.06\text{x}800)/2 = 24$m/s , $V_{n2} = (2\text{x}0.06\text{x}800)/2 = 48$m/s & $V_{n3} = (3\text{x}0.06\text{x}800)/2 = 72$m/s

Radar Aids to Navigation:-

- The position of air craft or a ship can be found by use of radio navigation aids. This is achieved by installation of radio transmitter and receiver at known location on the earth surface as well as at air craft or ship which works in conjunction with those on earth.
- The rectilinear propagation and constant velocity of electromagnetic waves held this system to provide navigation parameter like distance, direction, etc. by direct and indirect measurement of delay occurring between transmission and reception of these waves.
- The measurement of direction, distance and the difference between two transmitters give an indication of the position of an air craft or ship leading to correct navigation.
- Direction finding through radio is one of the very earliest methods of electronic navigational aids widely used in ship and air craft even today.

Aircraft Landing System:-

- Generally there are two types of landing system are used.
  1. I.L.S. (Instrumental Landing System)
  2. M.L.S. (Microwave Landing System)
- Instrument landing system is used for runway navigation in IFR condition in which by using some specified component the landing can be made.
- If this type of system there are two category. In first category it guided on aircraft up to 200ft. In second category it guided an aircraft up to a level of 100ft below which it cannot guided.
- I.L.S. system contains following Components: -
  - i.) Localizer: - In front the pilot with aero plane horizontal position w.r.t. runway centre line.
  - ii.) Glide Slope: - In front the pilot aero plane vertical position w.r.t. ground.
  - iii.) Outer Marker: - It stands in the same line with localizer and the runway center line four to seven miles before the runway. When the aero plane approaches the runway from the right direction it gives a signal by blinking the outer marker line.
  - iv.) Middle Marker: - It is positioned 0.8 miles before the runway when the aero plane is above the middle marker the receiver blinks giving a chance to the pilot weather land or not.
  - v.) Inner Marker: - It is present in the runway when the aero plane touches the runway and stands over it. The receiver blinks the light of inner marker.
  - vi.) Approach Light: - It includes medium or high intensity system for both inside and outside the aero plane.

NAVSAT:-

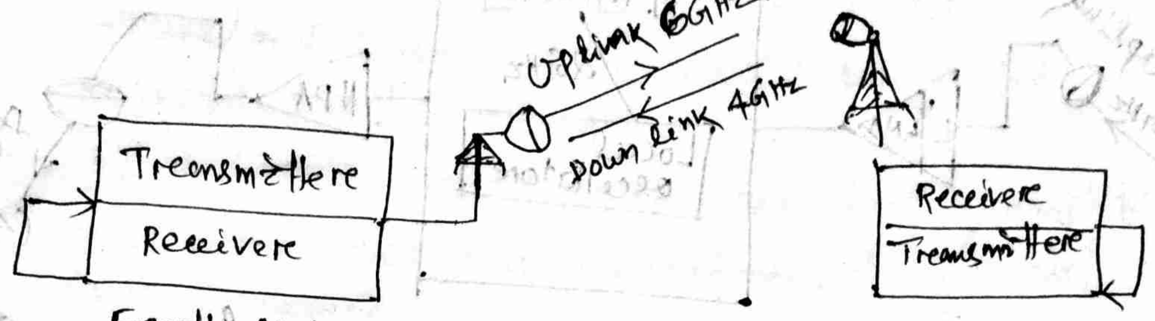
- NAVSTA stands for Navy-Navigation Satellite System. It is developed by USA in 1967 to monitor the military activities and guiding of aero plane & warship. Satellite system means finding out the position of an object from different angles through satellite placed artificially.

Concept & Feature

- NASAT uses the Doppler shift of radio signal transform satellite to measure the relative velocity between the satellite and navigator by knowing the satellite orbit position the navigator position can be determined from the time rate of change of rate to the satellite.
- NAVSAT consists ten orbit satellite and three orbiting space. A network of working station continuously monitors the satellite information. Each satellite is a circular polar orbit at an altitude of 6a. Usually five satellites are operating in the system.
- Generally four satellite can make the constellation and another one is used as a spare to find out the position of a navigator at least information for four satellite taken.
- Each satellite contain receiver to receive the compound from the ground well equipped decoder and memory, control circuit encoder to transmit digital data to phase modulation, ultra stable 5Hz oscillator and a 1.5W transmitter to broadcast the carrier frequency of 150MHz to 400MHz

Satellite Sub-systems

Let us see the whole process of Satellite Communication between the earth station and the remote station Satellite.



=> Satellite Communication is remote system where signals are transmitted and received by usual process of modulation and demodulation respectively.

=> The earth station or Ground station in case of the satellite used for metrological applications contains both transmitter and receivers and larger parabolic disc antenna.

=> The earth station has the following main sub-systems
(1) Antenna Sub-System (2) Power Sub-System.
(3) Transmit Sub-System (4) Ground Communication equipment (GCE)

These are worked by Transpondere.

=> It is the main interface uplink and downlink signal.
=> Transpondere word is made up of two words transmitter and receiver.

In simple way the transpondere performs three main function in Communication Satellite.

1.> To receive up-link frequency (6GHz) and amplify.
2> To convert its frequency to down link (4 GHz)
3> To transmit down link again by amplifying it to switch level.

In this way Transpondere is a repeatere part of Sectellite.

A Transpondere is an electronic circuit which is a combination of transmitter and receiver.

Freequency Convertere 4GHz

⇒ The transpondere receive up-link frequency of 6 GHz with a bandwidth of 500 MHz.

⇒ Since the received signal is weak in amplitude an amplifier known as LNA or Low Noise-Amplifiere amplifies it.

⇒ using a hetoredyne action carriers out frequency translation or conversion (Heterodyne means mixing of frequencies).

⇒ A mixere circuit is mixing received frequency with another frequency generated by its own oscillatore hence known as local oscillatore.

⇒ The output of mixere may certain many resulting frequencies but only difference is coupled (6GHz − 2 GHz = 4GHz) to the next stage.

⇒ The mixer circuit converts up-link frequency 6 GHz into a low downlink frequency 4GHz.

⇒ After conversion a High power amplifier (HPA) transmit it as down link frequency further it amplifies the signal. The necessity of frequency conversion is due to inability of transmission and reception on the same frequency

=> The Satellite cannot transmit and receive the Same frequency.

=> If it uses the Same frequency as uplink and downlink the Same frequency is received by the Satellite itself and will produce interference.

=> It keeps more spacing [6GHz - 4GHz] between the up link and down link to avoid unwanted effects oscillations, etc.

=> In this way the Transponder mainly amplifies the signal it, also use filters to avoid interference.

(c) What is Direct broadcast System (DBS)

Communication satellites located in geostationary orbit above the earth are used to send television signals directly to the homes of viewers - a form of transmission called direct broadcast Satellite (DBS) television. More than 100 programs are available over a Single DBS Service

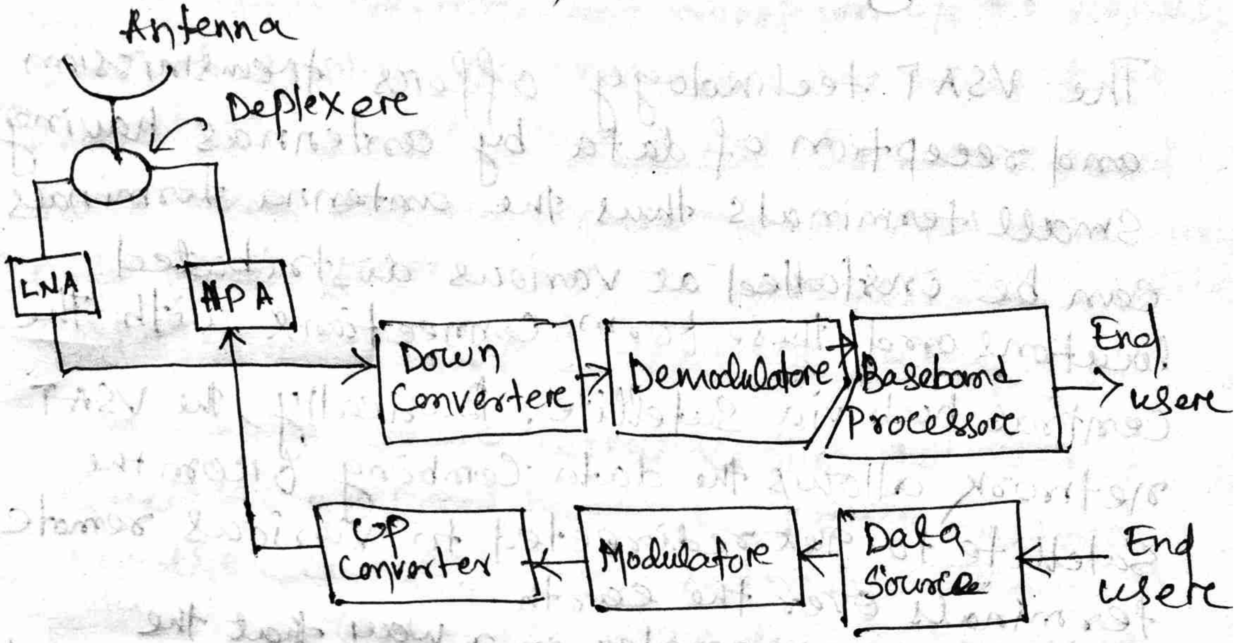
What is the function of broadcast Satellite?

Communications Satellites orbit far above The Earth's Surface and are able to transmit television, radio and even some long-distance telephone signals around the curve of the Earth between distant locations on the Earth's Surface.

What is the main purpose of broadcasting via Satellite?

Satellite television is a Service that delivers television programming to viewers by relaying it from a communications Satellite orbiting the Earth directly to the viewer's location. The Signals are received via an outdoor parabolic antenna commonly referred to as a Satellite dish and a low-noise block down converter.

Block Diagream of very Small Apercure Terminal (VSAT) ->



Block diagream of VSAT transceivere

The ~~are~~ above figure shows Block diagream of VSAT transmittere and receivere.

The antenna unit of VSAT is placed on the top of a building and to have maximal gain to system noise temperature of the receiving system at the initial phase, a low noise amplifiere is placed closere to the antenna so as to reduce or eliminate the cable losses before preamplification takes place.

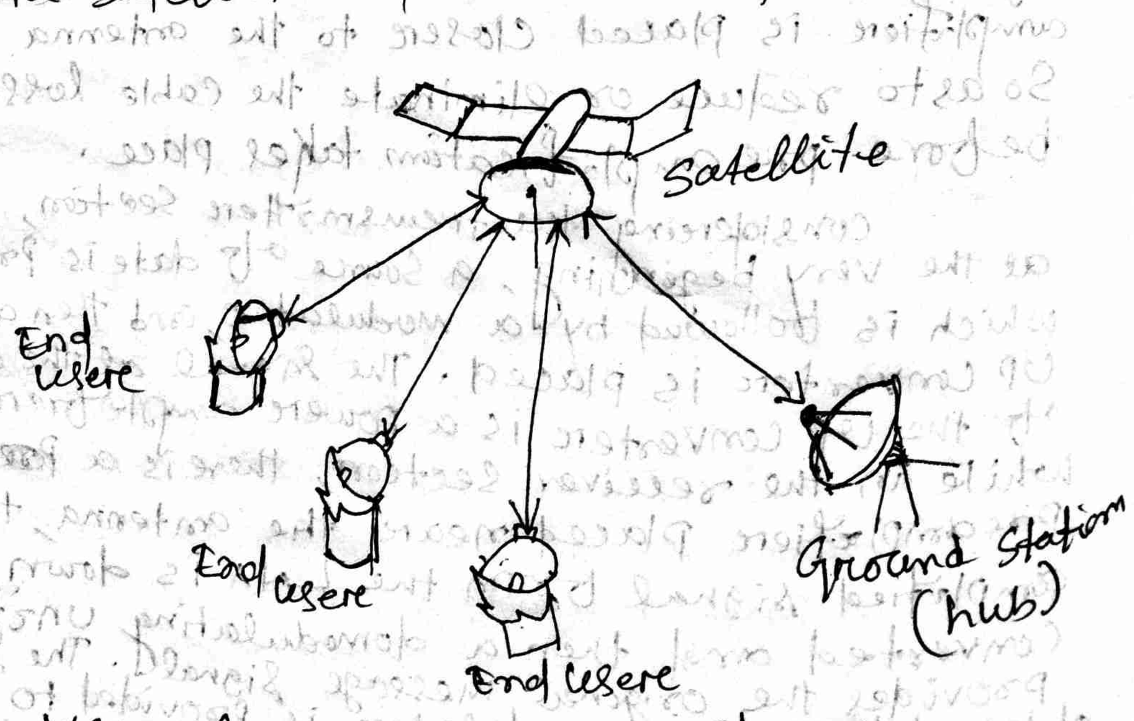
Considering the transmittere section, at the very beginning, a source of date is present which is followed by a modulatore and then a UP convertere is placed. The signal at the output of the UP convertere is a powere amplifiere. While in the receiver section, there is a ~~Pre~~-Preamplefiere placed neare the antenna, the amplified signal from the LNA is down-converted and then a domodulating unit provides the original message signal. The signal obtained from the demodulatore is provided to a baseband processore that acts as the last unit to process the received data and provide it to the end usere.

VSAT

Working preinciple of VSAT System.

The VSAT technology offers tremsmission and reception of data by antennas having small terminals thus the antenna terminals can be installed at various distributed locations and these form connections with the central hub via Satellite. Basically, the VSAT netrrork allows the data Combing from the Satellite to get redirected to various remote terminals over the earth.

It operates in a way that the Satellite transpondere sends a signal towards the transceivere where it receives the signal and the ground station behaves like a hub for the complete netrrork. Through that hub, the complete netrrork is controlled. The figure below represents the interconnection of varicus end usere through the ground station via Satellite in the form of a Star netrrork



VSAT Communication System

In order to have communication between end users, the actual signal is provided to the central hub and the hub then broadcasts it to the various VSATs in the network with the involvement of the satellite. For the transmission and reception of the signals, some multiple acess methods are used. Each end user has its own VSAT. It is to be noted here that due to interconnection of VSATs via hub propagation delay as well as satellite capacity requirement also increases.

In a star network, the double-hop circuit is required however, a mesh network involves a single-hop network.

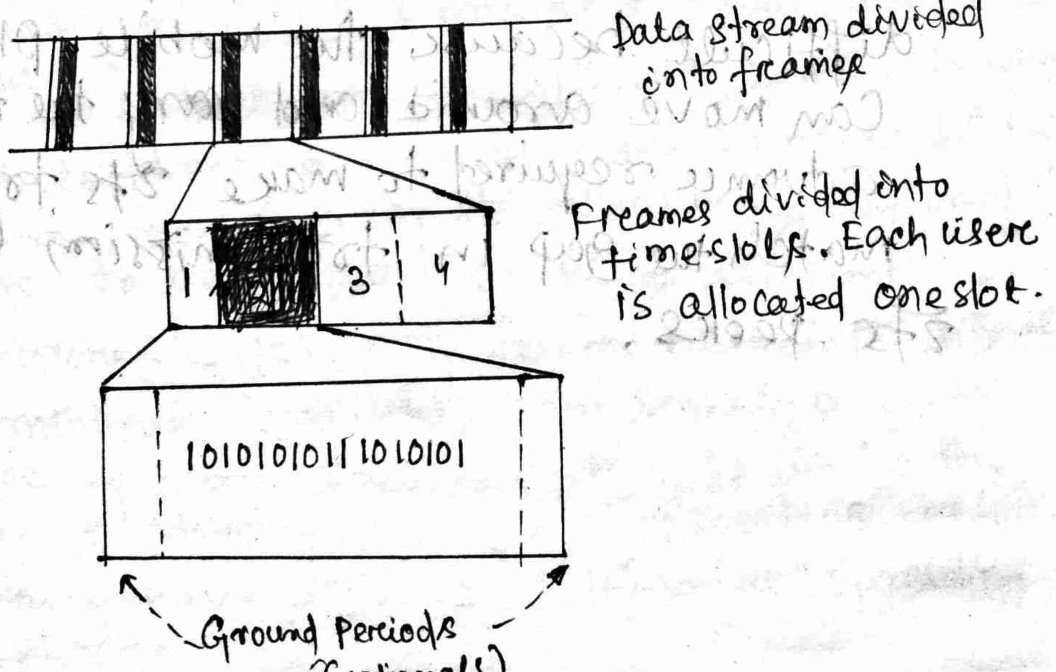
Generally, time division multiple access is used in the downlink mode where a signal from the hub is provided to the individual VSATs. However, offers low efficiency for the uplink mode. FDMA is also famous within the VSAT network.

But the most favorable technique is DAMA. DAMA stands for demand assigned multiple access and suits the operation of the VSAT network because in a VSAT system there exists bursty traffic which is non continuous in nature. In the DAMA technique, assigning of transponder channels is done according to the data priority on the first come first serve format. Hence a continuous connection is not built between the central station and user terminals however, once a frequency band is alloted to a specific terminal then that particular band will only be alloted to other terminals after the session completion of the former.

Basically, the services for data transmission and reception involved in the VSAT network are some kind of credit verification or reservation requests and these are quite random and spontaneous in nature. Hence, alloting time or frequency to perform TDMA or FDMA respectively will ~~some~~ somewhat make the channel utilization improper. Sometimes CDMA in coupling with ALOHA protocol is also used where data packets are transmitted randomly at different time slots.

Time-division multiple access (TDMA) is a channel access method for shared-medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots. The users transmit in rapid succession, one after the other, each using its own time slot. This allows multiple stations to share the same transmission medium (eg. radio frequency channel) while using only a part of its channel capacity.

Dynamic TDMA is a TDMA variant that dynamically reserves a variable number of time slots in each frame to variable bit-rate data streams, based on the traffic demand of each data stream.



(TDMA frame structure showing a data stream divided into frames and those frames divided into time slots)

TDMA is used in digital 2G cellular systems such as Global System for Mobile Communications (GSM), Personal Digital Cellular (PDC) and in the Digital Enhanced Cordless Telecommunication (DECT) standard for portable phones.

TDMA was first used in Satellite Communication systems by Western Union in its Westare 3 Communications Satellite in 1979. It is now used extensively in Satellite Communications.

TDMA is a type of time-division multiplexing (TDM), with the special point that instead of having one transmitter connected to one receivere, there are multiple transmitters. In the case of the uplink from a mobile phone to a base station this becomes particularly difficult because the mobile phone can move around and vary the timing advance required to make its transmission match the gap in transmission from its peers.

channel. It optimizes the use of available bandwidth. The technology is commonly used in ultra-high frequency (UHF) cellular telephone systems, bands ranging between the 800-MHZ and 1.9 GHz.

Working => CDMA allows up to 61 concurrent users in a 1.2288 MHz channel by processing each voice packet with two PN codes. There are 64 Walsh codes available to differentiate between calls and theoritical limits. Operational limits and quality issues will reduce the maximum number of calls somewhat lower than this value.

In fact, many different 'signals' based with different spreading codes can be modulated on the same carrier to allow many different users to be supported. Using different orthogonal codes, interference between the signals is minimal. Conversely, when signals are received from several mobile stations, the base station is capable of isolating each as they have different orthogonal spreading codes.

CDMA

Block Diagram

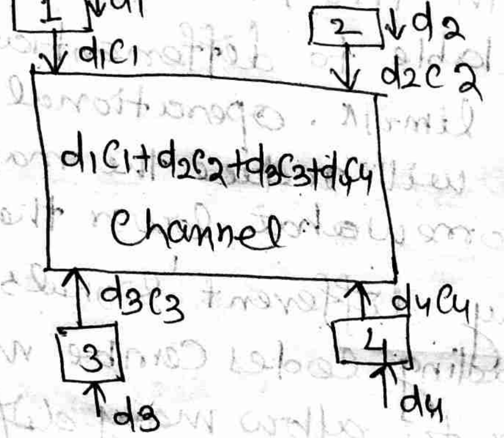
⇒ CDMA is technique where to used orthogonal codes to transmitt different signal over same channel.

⇒ Used in 3rd generation wireless communications CDMA 2000, HSDPA and HSUPA

HSDPA → High speed downlink packet access

HSUPA → High speed uplink packet access

It is used 3G wireless communication.



$c_1, c_2, c_3, c_4 \rightarrow$ Orthogonal Codes

$c_1 \rightarrow 1\ 1\ 1\ 1$

$c_2 \rightarrow 1\ -1\ 1\ -1$

$c_3 \rightarrow 1\ 1\ -1\ -1$

$c_4 \rightarrow 1\ -1\ -1\ 1$

$c_1c_2 = 1+(-1)+1+(-1) = 0$

$c_2c_4 = 1+1+(-1)+(-1) = 0$

$c_3c_3 = 1+1+1+1 = 4$

So, $c_1, c_2, c_3, c_4 \rightarrow$ orthogonal

Let,

I have 4 users [1], [2], [3] and [4] having datas d_1, d_2, d_3 and d_4

Now let suppose the data transmitted by

user [1] to be $a_1 = a(1) \rightarrow d_1$

[2] to be $a_2 = -a(0) \rightarrow d_2$

[3] to be $a_3 = a(1) \rightarrow d_3$

[4] to be $a_4 = a(1) \rightarrow d_4$

Also data transmitted as follows

$1 \rightarrow a$

$0 \rightarrow a$

No transmitt $= 0$

These all the data are combining with the code and given to channel, what will happen the data of any of the usere not silence, every usere have some data, 1st usere have the data(1) which is noted by (a) 2nd usere has the data(0) is noted by (-a) 3rd usere has the data(1) is noted by (a) and

4th usere has the data (1) is noted by (a)

Now in the channel what would I get in channel

channel → $d_1c_1 + d_2c_2 + d_3c_3 + d_4c_4$

→ a(1111) + (-a)(1 -1 1 -1) + a(1 1 -1 -1) + a(1 -1 -1 1)

(CX) → (a a a a) + (-a a -a a) + (a a -a -a) + (a -a -a a)

→ Channel Code

Full Code is present in my channel

At receiver at d2:

Rx(2) → (CX) C_2

→ (a a a a) + (-a a -a a) + (a a -a -a) + (a -a -a a) {1 -1 1 -1}

→ a - a + a - a + -a - a - a - a + a - a - a + a + a + a - a - a

= $-4a/4 = -a$

The usere [2] send (-a) and we also received (-a). This is code division multiple access using pseudo random codes are using direct sequence spread spectrum in CDMA

Advantage of CDMA → CDMA requires all signal must have more or less equal power at the receiver.

→ Flexible transfer may be used. mobile base stations can switch without changing operator. Two base stations receive mobile signal and the mobile receives signals from the two base stations.

→ Transmission Burst - reduces interference.

Disadvantage of CDMA → The code length can be carefully selected. A large code length can induce delay or may cause interference.

→ Time synchronization is required

→ Gradual transfer increases the use of radio resources and may reduce capacity.

What is GPS System and its Working

The navigation system based on Satellite like Global Positioning System (GPS) is made up of a 24 Satellite network located onto orbit through the U.S DOD (Department of Defense). The system is mainly designed for military applications; howevere, the government made the system accessible in the yeare 1980 for civilian use. This system performs on any kind of environment around the world for 365 days at any time. The GPS includes 24 Satellites that rotate around the sphere one time for every 12 hours to offere worldwide time, position and velocity information. The main function of GPS is to identify the locations on the global precisely by determining the distance from the Satellite. This system lets you create otherwise record exact locations on the global and assist you to navigate from those locations. Basically this system was mainly designed for military applications but in the yeare 1980, it was made accessible for civilian use. This article discusses an overeview of the GPS system and its working and uses.

What is GPS system?

Definition: The term GPS full form is "Global Positioning System" which is a Satellite navigation system that furnishes location and time information in all climate conditions to the usere. GPS is used for navigation in planes, ships, cars, and trucks also. The system gives critical abilities to military and civilian users around the globe. GPS provides continuous real-time, 3-dimensional positioning, navigation, and timing worldwide.

How does GPS system work?

The GPS consists of three segments:

- The space segment: the GPS satellites
- The control system, operated by the U.S. military,
- The user segment, which includes both military and civilian users and their GPS equipment.

Space Segment => The space segment is the number of satellites in the constellation. It comprises 29 satellites circling the earth every 12 hours at 12,000 miles in altitude. The function of the space segment is utilized to route/navigation signals and to store and retransmit the route/navigation message sent by the control segment. These transmissions are controlled by highly stable atomic clocks on the satellites. The GPS space segment is formed by a satellite constellation with enough satellites to ensure that the users will have, at least, 4 simultaneous satellite in view from any point at the Earth's surface at any time.

Control Segment => The control segment comprises a master control station and five monitor stations outfitted with atomic clocks that are spread around the globe. The five monitor stations monitor the GPS satellite signals and then send that qualified information to the mastere Control Station where abnormalities are revised and sent back to the GPS Satellites through ground antennas. The control segment also referred to as a monitor station.

Usere Segment -> The usere Segment comprises the GPS receiver, which receives the signals from the GPS Satellites and determines how far away it is from each Satellite. Mainly this Segment is used for the U.S. military, missile guidance systems, civilian applications for GPS in almost every field. Most of the civilians use this from survey to transportation to natural resources and from there to agriculture purpose and mapping too.

Optical transmittere and receivere for intere-Satellite link -> The receivere sensitivity in optical pulse position modulation (PPM) was examined. Comparing to nonreturn to zero optical transmission, the improvement of the receiver sensitivities in a most-likelihood detection-type quaterenary PPM (QPPM) receivere was estimated about 3 dB and in a fixed threshold detection receiver it was estimated about 1.5 dB. A preliminary design of a 400 mb/s QPPM optical intersatellite links (ISL) transceivere was carried out, and the characteristic of the transceivere were estimated. A transceivere proof-of concept model of 100 mb/s QPPM optical transmission in 830 mm wavelength was evaluated through trial production, and a receiver sensitivity of -50.1 dBm at 10 to the -6th bit error rate was obtained. Surveys on optical ISL studies and high-power lasere diodes were carried out and were summarized.

Difference Between optical Fibre and Coaxial cable are metallic cables =>

1> optical fibre carries the signals in optical form which : coaxial cable carries the signal in the form of electricity.

2> Fibre optics cable is made of Glass fibre and plastic. In contrast, the coax cable is made up of Metal wire (copper), plastic and metal mesh braid.

3> The optical fibre is more efficient than coax cable as it has higher noise immunity.

4> optical cable is costlier than coax cable.

5> The effect of bending of the cable is negative in case of an optical fibre. As against, the coaxial cable is unaffected by the bending.

6> The optical fibre provides high bandwidth and data rates. On the contrary, the bandwidth and ... data rates provided by the coax cable are moderately high but lesser than optical cable.

7> Coaxial cable can be easily installed whereas installation of optical cable required's extra effort and care.

8> The optical fibre is lightweight and has a small diameter. Conversely a coaxial cable is heavier and has a large diametere.

Advantages and Disadvantages optical Fibre

Advantages => ① **Noise resistence** => As fibre optic cable uses light rather than electricity, noise is not an issue. External light probably could create some interference, but that is already blocked from the channel by the outer Jacket.

② **Less attenuation** => The transmission distance is remarkably greater than that of any other guided media. In optical fibre cable, a signal can run for miles without needing regeration.

④ **Higher bandwidth** => Fibre-optic cable can carry higher bandwidth.

⑤ **Speed** => It provides higher transmission rates.

Disadvantages => ① **Cost** => optical fibre is expensive because of needs to be manufactured precisely and a lasere light sources costs a lot.

② **Installation and maintenance** => A rough one creacked core of the optical fibre can diffuse the light and ceale the signal. All the Jaints must be perfectly polished, aligned and sealed light-tight. It makes use of unsophisticated tools for cutting and creimping, which makes it more difficult to install and maintain.

③ **Freagility** => Glass fibree is more delicate and easily broken than a wire.

Advantage and Disadvantages of Coaxial Cable =>

Advantages =>

1. **Frequency characteristics =>** Coaxial cable has a bettere frequency characteristics as compared to twisted paire cable.
2. **Susceptibility towards interference and crosstalk =>** It is less susceptible to interference and crosstalk because of concentric construction of the cable.
3. **Signaling =>** Coax cable supports both analog and digetal signalling.
4. **Cost =>** It is cheaper than optical fibre.

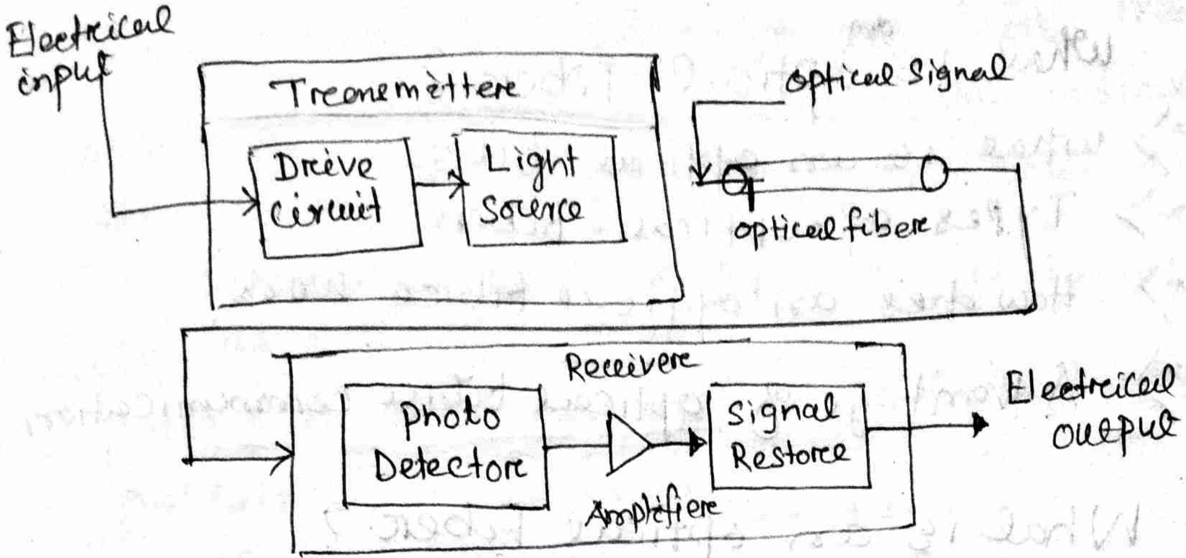
Disadvantages => 1. **Distance travelled by the signal =>** A repeatere is required for every kilometre when the communicating devices are placed at a longere distance.

Conclusion => The optical fibre is more efficient than coaxial cable in terms of data transmission speed, noise and interference resistance, dimensions bandwidth losses etc. But coaxial cable is cheapere, easily available and installed, and bending of the cable does not affect the signalling on the cable.

What is principle of optical fiber communication?

Optical fiber communication is a communication method in which light is used as information carrier and optical fibre is used as a transmission medium. First, an electrical signal is converted into an optical signal, and then an optical signal is transmitted through the optical fiber, which is a type of wired communication. The light can be carried after being modulated. Since the 1980s, fiber-optic communication systems have revolutionized the telecommunications industry and played a very important role in the digital age. Optical fibre communication has large transmission capacity and good confidentiality. Fiber-optic communication has now become the most important form of wired communication today.

In principle, the basic material elements that make up fibre optic communication are fiber optics, light sources, and photodetectors. In addition to classification according to manufacturing process, material composition and optical characteristics, optical fibers are often classified according to their applications, and can be classified into communication optical fibers and sensing optical fibers. The transmission medium fiber is divided into two types: general purpose and special purpose, and the function device fibre refers to an optical fibre for performing functions of amplification, shaping, frequency division, frequency multiplication, modulation, and optical oscillation of light waves, and is often used for a certain functional device.



Principle of optical fiber Communication:

At the transmitting end, the transmitted information (such as voice) is first converted into an electrical signal, and then modulated into the laser beam emitted by the laser, so that the intensity of the light changes with the amplitude (frequency) of the electrical signal, and passes through the optical fiber. The principle of total reflection is transmitted; at the receiving end, after receiving the optical signal, the detector converts it into an electrical signal and after demodulation, restores the original information. Optical communication utilizes the principle of total reflection. When the injection angle of light satisfies certain conditions, light can form total reflection in the optical fiber, thereby achieving the purpose of long distance transmission. The light guiding properties of an optical fiber are based on total reflection of the light ray at the core and cladding interfaces, limiting light transmission in the core. There are two types of light in the fiber, namely meridional and oblique rays. The meridional rays are the light rays on the meridional plane, and the oblique rays are the light that is transmitted through the fiber axis what is an optical Fiber ?

=> what is an optical fiber
=> Types-of-optical-fibere
=> How does an optical fibre work
=> Advantage of optical fibre communication

What is an optical Fiber ?

optical fibere is the techonology associated with data transmission using light pulses travelling along with a long fibere which is usually made of plastic or glass. metal wires are preferred for transmission in optical fiber communication as signals travel with fewer damages. optical fibers are also unaffected by electromagnetic interference. The fiber optical cable uses the application of total internal reflection of light. The fibers are designed such that they facilitate the propagation of light along with the optical fibere depending on the requirement of power and distance of transmission. Single-mode fibere is used for long distance transmission, while multimode fibere is used for shorter distances. The outere cladding of these fiberes needs better protection than metal wires.

Types of optical Fibers

The types of optical fibers depend on the refractive index, materials used, and mode of propagation of light.

The classification based on the refractive index is as follows:

=> Step Index Fibers: It consists of a core surrounded by the cladding which has a single uniform index of refraction.

Graded Index Fibers => The refractive index of the optical fiber decreases as the radial distance from the fiber axis increases.

The classification based on the materials used as follows:

=> Plastic optical Fibers: The polymethylmethacrylate is used as a core material for the transmission of the light.

=> Glass Fibers: It consist of extremely fine glass fibers.

The classification based on the mode of propagation of light is as follows:

Single-Mode Fibers: These fibers are used for long-distance transmission of signals.

Multimode Fibers: These fibers are used for short-distance transmission of signals.

The mode of propagation and refractive index of the core is used to form four combination types of optic fibers as follows:

=> Step index - single mode fibers
=> Graded index - single mode fibers
=> Step index - multimode fibers
=> Graded index - multimode fibers

How Does an optical Fibre work ?

The optical fiber works on the principle of total internal reflection. Light rays can be used to transmit a huge amount of data but there is a problem here- the light rays travel in straight lines. So unless we have a long straight wire without any bends at all harnessing this advantage will be very tedious. Instead, the optical cables are designed such that they bend all the light rays inwards (using TIR). Light rays travel continuously, bouncing off the optical fiber walls and transmitting end to end data. Although light signals do degrade over progressing distances, depending on the purity of the material used, the loss is much less compared to using metal cables. A Fibre optic Relay system consists of the following components:

- ⇒ The Transmitter – It produces the light signals and encodes them to bit to transmit.
- ⇒ The optical Fibre – The medium for transmitting the light pulse (signal).
- ⇒ The optical Receiver – It receives the transmitted light pulse (signal) and decodes them to be bit to use.
- ⇒ The optical Regenerator – Necessary for long distance data transmission.

Advantages of optical Fibre Communication

- ⇒ Economical and cost-effective
- ⇒ Thin and non-flammable
- ⇒ Less power consumption
- ⇒ Less signal degradation
- ⇒ Flexible and lightweight.

Optical Fibere Communication System

Block Diagream ⇒

General Light wave system:

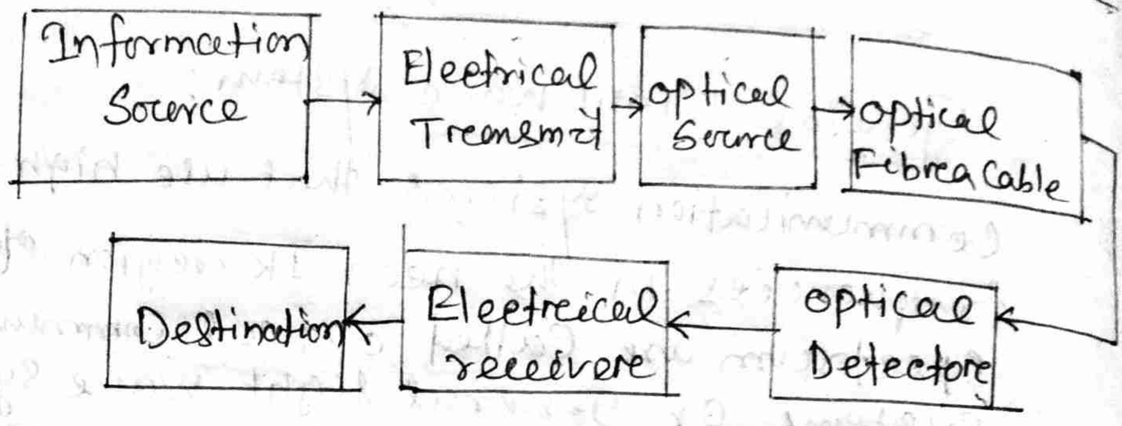
Communication systems that use high carrier frequencies in the near IR region of visible spectrum are called optical communication systems or general light wave systems. Light wave system that employs optical bibre as channel for information transmission is called bibre optics communication systems. The technology to which light is propagated through very fine cylindrical haire like transparent bibres is called bibre optics. optical communication system or light wave system can be broadly classified based on the nature of the communication channel into two.

1. Unguided Systems ⇒ The optical beam emitted by the transmittere or optical signal propagates through air or vacuum. It is less suitable bor broad casting applications since optical beams spreads out mainly in the borward direction. Hence require accurate pointing between transmitter and receiver.

2. Guided Systems ⇒ The optical beam emitted by the transmitter remains spatially confined.

   Eg: Transmission using optical fibers.

Basic optical Fibere Communication System



optical Fibere Communication System
Block Diagram

Information Source => Information Source provides the input Electrical signal.

Electrical Transmitter => Contains electrical stage which drives an optical source to give modulation of light wave carriere.

optical Source => Provides electrical to optical conversion Can be LED's on Lasere.
Requirements are
1. High output powere
2. High linearity.
3. Narrow Spectral width
4. High modulation rate
5. Temperature Stability
6. Long life time.

optical fibers => used as transmission medium to Compensate for losses during transmission repeatres or optical amplifier can be used at regular intervals. Required characteristics are low dispersion, lower fibre non linearity, low attenuation, high optical signal to noise ratio, large repeater span.

Optical detector => detects and convert optical signal to proportional electrical signal.
Eg: photo diodes, photo transistors etc.

Requirements are sensitive at operating wavelength, low power consumption and operating voltage, fast response active area match fibre parameter, temperature stability small size and cost capability of internal gain, low noise.

Repeaters and optical Amplifiers

To compensate for signal degradation in long distance convert optical signal to electrical signal, restores the signal used then converting back to optical signal for further transmission. This method increases cost, complexity and reduces operational bandwidth. optical amplifiers simply amplify the optical signal, they provide improved SNR due to all optical domain operation.

Fibre Couples and Fibre Connectors =>

are used to distribute light from main fibre into one or more branches of ~~be~~ fibres and to convert one fibre with other.

Modes of Propagation

There are three types of modes of propagation of electromagnetic waves: Ground wave propagation, Space wave propagation and skywave propagation.

Electromagnetic waves in the frequency range of a few Hz to about 10^{11} Hz are generally called radio waves. These waves are useful for the transmission of information from one place to another without the help of wire.

Ground wave propagation => When the radio waves from the transmitting antenna propagate along the surface of the earth to reach the receiving antenna, the wave propagation is called ground waves or Surface wave propagation. Ground waves are radio waves that travel or propagate along the surface of the earth. These radio waves induce a current in the ground from which they pass. While propagating through the medium waves will have losses as well as absorption. Therefore there will be a loss of signal or power. The more the frequency of waves the more will be losses. That is why it is favourable only for low frequency waves only. Generally this kind of technique is used for broadcasting purposes.

Space wave propagation ⇒ The radio waves from the transmitting antenna propagate through space, around the ground and reach the receiver either directly or by reflection from the ground, this kind of wave propagation called space wave propagation. It is also called the line of sight propagation. The radio waves which travel directly from the transmitting antenna to the receiving antenna are also called space waves. Wave in the MHz frequency range are used for space wave propagation. We know that our earth is spherical therefore to make the long-distance we need the height of the antenna as long as possible.

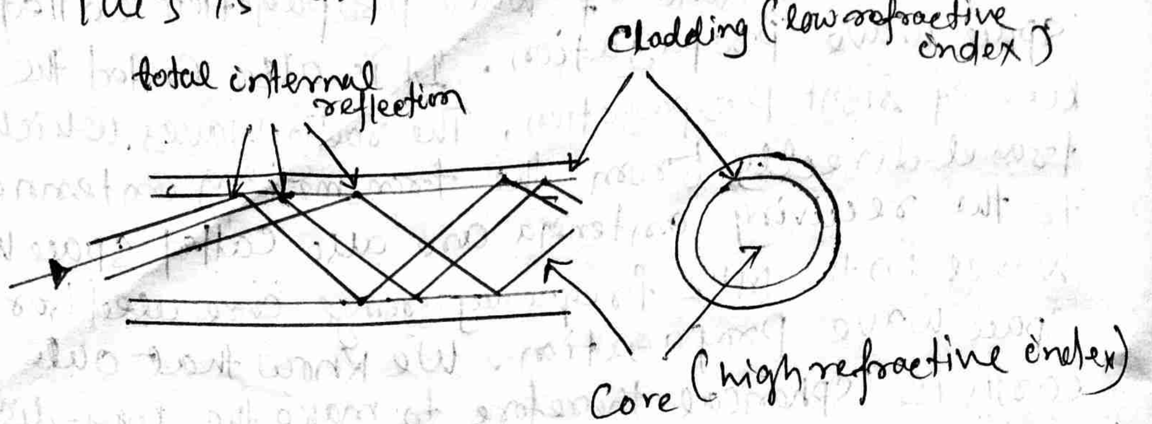
Skywave propagation ⇒ The radio waves from the transmitting antenna propagete through the sky towards the receiver, either directly or by reflection from the ground, this kind of wave propagation is called skywave propagation. It is also called ionospheric wave propagation.

The refractive index of the ionosphere is less than its free space value and it decreases with increases in height. Therefore radio waves go under total internal reflection. Radio waves of frequency less than 3 MHz are observed in the ionosphere and of frequency greater than 30 MHz can pass through the ionosphere after suffering a small deviation.

Note: We should know that loss of energy in ground wave propagation is due to the diffaction effect. Ground waves are are not used in FM to transmitt the signal. In ground waves, the height of antenna is an important factor. In skywave propagation has some threshold value of frequency for the transmission.

HOW OPTICAL FIBER WORKS

optical fibers are based entirely on the principle of total internal reflection. This is explained in following picture.



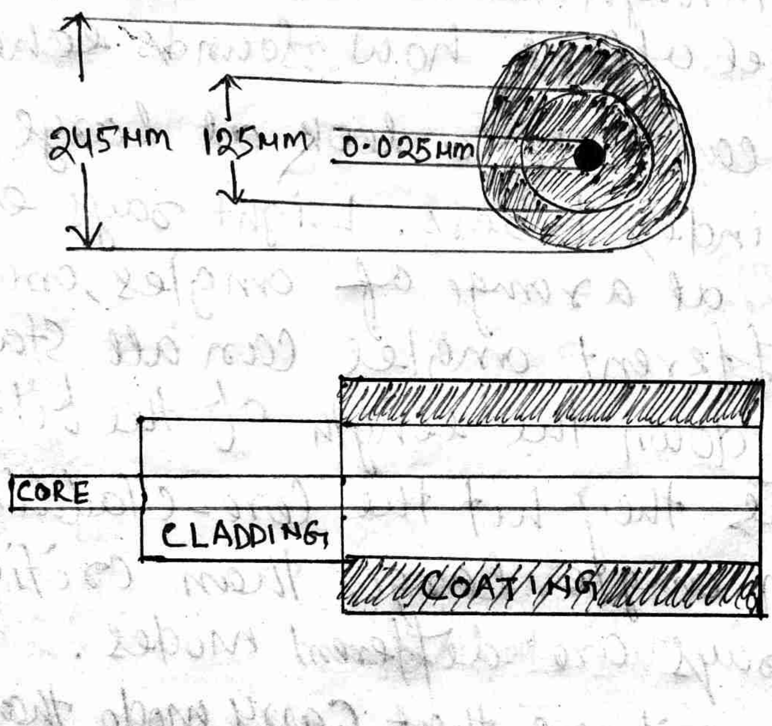
optical fibere is a long, thin strand of very pure class about the diametere of a human hair. optical fibers are arranged in bundles called over long distances.

The Structure of an optical fiber =>

Typical optical fibers are composed of core, cladding buffer coating.

The core is the inner part of the fibere, which guides light. The cladding surrounds the core completely. The refractive index of the core is higher than that of the cladding, so light in the core that strikes the boundary with the cladding at an angle shallower than critical angle will be reflected back into the core by total internal reflection.

For the most common optical glass biber types, which includes 1550nm single mode bibers and 850nm or 1300nm multimode bibers, the core diameter ranges from 8~62.5μm. The most common cladding diameter is 125μm. The material of buffer coating usually is soft or hard plastic such as acrylic, nylon and with diameter ranges from 250μm to 900μm. Buffer coating provides mechanical protection and bending flexibility for the fiber.

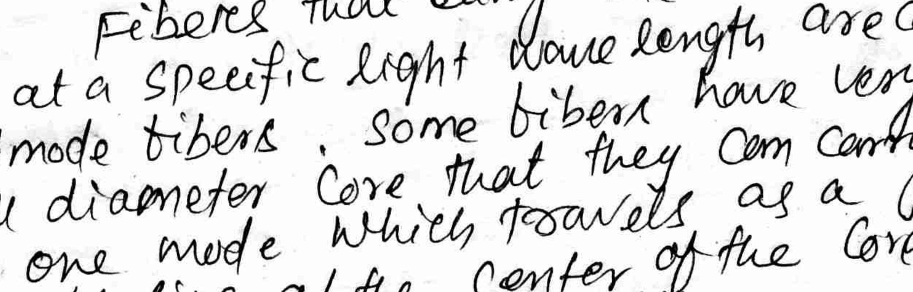


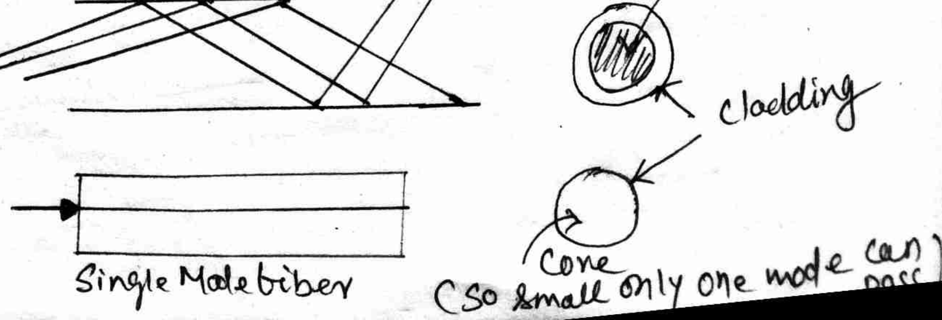
What is Fiber Mode?

An optical fiber guides light waves
in distinct patterns called modes. Modes
describes the distribution of light energy
across the fiber. The precise patterns
depend on the wavelength of light transmitted
and on the variation in refractive index
that shapes the core. In essence, the variations
in refractive index create boundary
conditions that shape how light waves
travel through the fiber, like the walls of
a tunnel affect how sounds echo inside.

We can take a look at large core
step-index fibers. Light rays enter the
fiber at a range of angles, and rays
at different angles can all stably
travel down the length of the fiber as
long as they hit the core-cladding interface
at an angle larger than critical angle.
These rays are different modes.

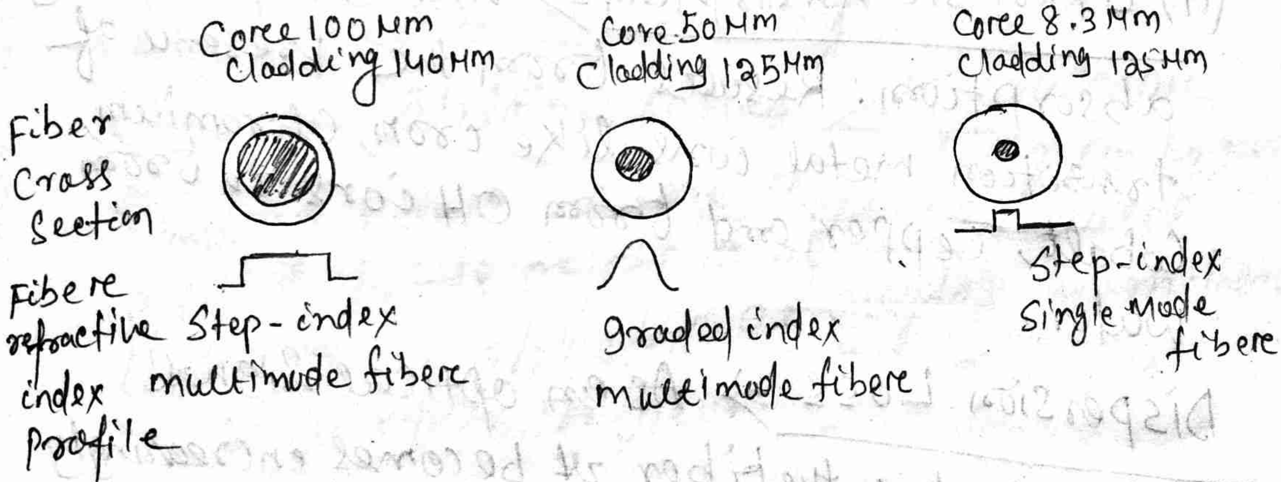
Fibers that carry mode than one
mode at a specific light wave length are called
multimode fibers. Some fibers have very
small diameter core that they can carry
only one mode which travels as a
straight line at the center of the core.
These figures are single mode fibers.





Optical Fiber Index profile

⇒ Index Profile is the refractive index distribution across the core and the cladding of a fibere. Some optical fibere has a step index profile, in which the core has on uniformly distributed index and the cladding has a lower uniformely distributed index. Other optical fibere has a graded index profile in which refractive index varies gradually as a function of radial distance from the fiber centere. Graded-index profiles include power-law index profiles and parabolic index profiles. The following figure shows some common types of index profiles for single mode and multimode fibers.



Attenuation Produces Losses in the System

Absorption losses => Absorption of light energy due to heating of ion impurities results in dimming of light at the end of fiber. Two types: (1) Intrinsic (11) Extrinsic Absorption

(1) Intrinsic Absorption => Caused by the interaction with one or more components of the glass occurs when photon interacts with an electron in the valence band and excites it to a higher energy level near the UV region.

(11) Extrinsic Absorption => Also called impurity absorption. Results from the presence of transition metal ions like iron, chromium, Cobalt, copper and from OH ions i.e from water.

Dispersion Loss => As an optical signal travel along the fiber, it becomes increasingly distored. This distortion is a sequence of intermodal and intramodal dispersion.

Intermodal dispersion => Pulse broadening due to intermodal dispersion results from the propagation delay difference between modes within a multimode fiber.

Material Dispersion => Also known as spectral dispersion or chromatic dispersion. Results because of variation due to refractive index of core as a function of wavelength, because of which pulse spreading occurs even when different wavelengths follow the same path.

Waveguide dispersion => Whenever any optical signal is passed through the optical fiber, practically 80% of optical power is confined to core and rest 20% optical power into cladding.

Scattering Losses => It occurs due to microscopic variations in the material density, compositional fluctuations, structural in homogeneities and manufacturing defects.

Bending losses => The loss which exists when an optical fiber undergoes bending as called bending losses. In fiber bending causes certain modes not to be reflected and therefore causes loss to the cladding.

Core and cladding losses => Microscopic Bending either the core or cladding undergoes bending at its surface. It causes slight bends at its surface. It causes light to be reflected at angles when there is no further reflection.

Attenuation in optical fibere ⇒ In optical fiberes, attenuation is the rate at which the signal light decreases in intensity. For this reason, glass fibere (which has a low attenuation) is used for long-distance fibere optic cables; plastic fibere has a higher attenuation and, hence, shorter range.

Basics of Attenuation ⇒ Attenuation represents the reduction in amplitude of signal. It is also called as the transmission loss and it represents the reduction in intensity of the light rays propagating through it. It is measure with respect to the distance travelled by light rays in optical cable. Attenuation is usually expressed in decibel (db).

Attenuation Calculation

Attenuation loss α_L (dB) is calculated by

$$\alpha_L = 10 \log \frac{P_i}{P_o}$$

where α_L = Attenuation loss in dB

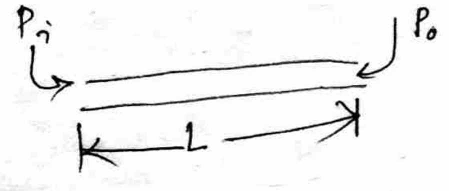
P_i = Input power

P_o = output power

Attenuation coefficient α (dB/Km) is calculated by

$$\alpha = \frac{10}{L} \log \frac{P_i}{P_o}$$

Where L = length of Fiber Cable



Attenuation Factors

Attenuation produces losses in the system.

=> Material Absorption
(i) Intrinsic (ii) Extrinsic

=> Linear Scattering Losses
=> Non linear Scattering Losses
=> Stimulated Raman Scattering Losses
=> Fiber bending Losses
=> Dispersion Losses
(i) chromatic Dispersion
(ii) material Dispersion
(iii) wave guide Dispersion
(iv) Intermodal Dispersion
(v) polarized mode Dispersion

LED and LASER Source in optical Communication =>

INTRODUCTION TO LED => A light-emitting diode (LED) is a two-lead Semiconductor light source that convert an electrical current into light. It is a p-n Junction diode, which emits light when activated.

USE OF "LED" IN OPTICAL FIBER => Light emitters are a key element in any fiber optic System. This component converts the electrical signal into a corresponding light signal that can be injected into the fibere. LEDs are of interest for fiber optics because of five inherent Characteristics (1) They are small. (2) They possess high radiance (ie) They emit lots of light in a small area) (3) The emitting area is small, comparable to the dimensions of optical fibers. (4) They have a very long life, offering high reliability (5) They can be modulated (turned off and on) at high speeds.

LASER => A laser is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation.

LASER Stand for "light amplification by stimulated emission of radiation". It emits light coherently, statial coherence allows a laser to be focused to a tight spot. A laser is a coherent and focus beam of photons.

USE OF 'LASER' IN OPTICA FIBER => It is

necessary that the fibre optic link can operate over great distances and with higher datarates, then lasers are used. The light output is directed to enables a much higher level of efficiency in the transfer of the light onto the fibre optic cable. Lasers have a very narrow spectral bandwidth as a result of the fact that they produce coherent light. This narrow spectral width enables the lasers to transmit data at much higher rates. Laser diodes are often directly modulated. This provides a very simple and effective method of transferring the data onto the optical signal.

Optical detectors - PIN AND APD diodes.

PIN and APD receivers are used to faciliate fiber optic Network.

PIN => A PIN diodes has a wide, undoped intrinsic semiconductor region between a p-type semiconductor and an n-type semiconductor region, hence the name PIN. Because they are used for ohmic contacts, the p-type and n-type regions are typically heavily doped. The wide intrinsic region makes a PIN different from an ordinary p-n diode and makes the PIN diode an inferior rectifier but does make it suitable for attenuators, RF switches, photodetectors and high voltage power electronics application.

PIN diodes are particularly used in RF applications where there are low levels of capacitance

APDs => Avalanche photodiodes (APDs) are widely used in laser-based fiber optic systems to convert optical data into electrical data form. They are high sensitivity, high speed semiconductor light sensors. The main advantages of APD is that it has a greater level of sensitivity compared to PIN.

Also APDs, need a high reverse bias condition to work. That permits avalanche multiplication of the holes and electrons created by the initial electron-hole pair. APDs have an internal region where electron multiplication occurs by application of an external reverse voltage. The resultant gain in the output signal means that low light levels can be measured at high speed.

Application for APDs are laser rangefinders and long-range fiber optic telecommunication.

Splicing of optical fibers =>

Definition: Splicing of optical fibers is a technique used to Join two optical fibers. This technique is used in optical fiber communication, in order to form long optical links for better as well as long distance optical signal transmission. Splicers are basically couplers that form a connection between two fibers or fiber bundles.

APD Connectors => APD is a full plastic ~~connector~~ harsh environment connector series available in 1 to 51-way variants. Engineered for the toughest challenges, it provides a proven, cost-effective, and high quality solution. Compact, lightweight, and easy to assemble, it features a proven bayonet coupling design with reliable sealing up to IP69K and multiple color and coding options. APD Connectors are in cabin-to-chassis and centralized interconnect applications.

Fiber optic Repeaters => Fiber Repeaters are used to extend and repeat ethernet data signals over multimode or single mode fiber up to 160km [100 miles]. If you need to convert single mode to multimode, or extend a multimode network, fiber optic Repeaters are the devices to use. They are the ideal solution to connect different fiber types, distances and wavelengths across a variety of topologies and network architectures for longer data transmission distances.

Concept of Wave Length Division Multiplexing (WDM)

In fiber optic communications, wavelength division multiplexing (WDM) is a technology which multiplexes a number of optical carrier signals onto a single optical fibere by using different wavelengths (i.e. colors) of lasere light. This technique enables bidirectional communications over a single strand of fibere, also called wavelength-division duplexing, as well as multiplication of capacity.

The term WDM is commonly applied to an optical carriere, which is typically described by its wavelength, whereas frequency division multiplexing typically applies to a radio carriere which is more often described by frequency. This is purely conventional because wavelength and frequency communicate the same information. Specifically, frequency (in Hertz, which is cycles per second) multiplied by wavelength (the physical length of one cycle) equals the velocity of the carrier wave. In a vacuum, this is the speed of light, usually denoted by the lower case letter, 'c'. In glass fibere, it is substantially slower, usually about 0.7 times 'c'. The data rate which ideally might be at the carrier frequency, in practical systems is always a fraction of the carrier frequency.

Applications of optical fibers :->

optical fibers (Fiber optics) are long, thin Strands of very pure glass about the diameter of a human hair. They are arranged in a bundles called optical Cables and used to transmitt light signals over long distances.

Main applications of optical fibers are Communication system, medicine, Sensors, military and electronics.

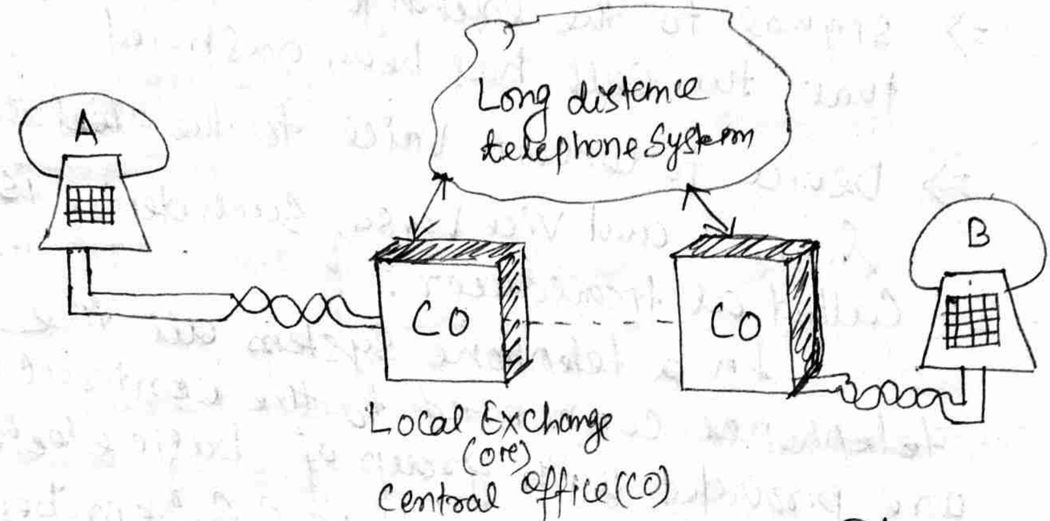
(1) In medical field fiber optics provide a very compact, flexible conduit for light or data delivery in equipment, Surgical, and instrumentation applications.

(2) Telecommunications used as fiber optices is laid and used for transmitting and receiving purpose.

(3) military or government used as hydrophones for seismic and SONAR uses, as wiring in aircraft, Submarines and other vehicles and also for field networking.

TELECOMMUNICATION SYSTEM

Working of Electronic Telephone System =>



Basic Telephone System

As shown in the figure, all the land line telephones are connected with the use of twisted pair cables to the local exchange or central-office (CO). Thousands of lines are connected to the central offices like this. All the COs are connected with the use of some medium either fiber optic or wireless link etc in the large telephone system.

Telephone 'A' and Telephone 'B' are connected with the central office (CO). This two wire twisted pair connection between the telephone set and the central office is referred as the local loop or subscriber loop.

Electronic Telephone => Usually any telephone set will have following basic functions in the transmit and receive direction =>

In the transmit mode,

=> Indication to the users that call can or can not be made by way of dial tones and busy tones respectively.

=> means to send the number to be dialled to the telephone CO or local exchange

In the receive Mode,

=> It should have ringere so that it rings the bell indicating call is received.

=> Signal to the exchange (telephone system) that the call has been answered.

=> Device to convert voice to the electrical signal and vice versa, such device is called as transducer.

In a telephone system all the telephones connected to the central offices are provided with groups of basic electronic circuits referred as SLIC (Subscribere Line Interface Circuits) This SLIC has following basic functions referred as

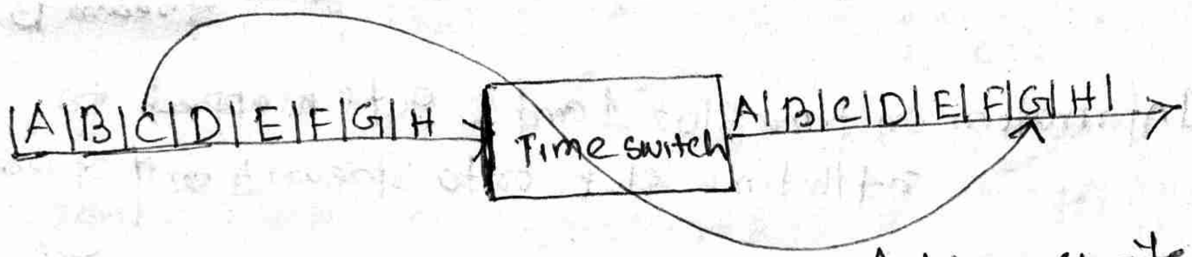
BORSCHT =>

=> Provision of Battery feed.
=> Provision of Overe voltage protection mechanism.
=> Provision of Ringing circuit.
=> Provision of Supervision which takes care of off-hook, ground start and ring trip signaling.
=> Provision of Codec functionalities.
=> Provision of Hybrid and signal conditioning, which takes care of 2 wire to 4wire conversion and vice versa.
=> Provision of Testing the telephone system.

Space Switch Vs Time Switch

Difference between Space Switch and Time Switch =>

Time Switch



The figure-1 depicts concept of time switch. As shown it is basically a time slot interchanger (TSI). A time slot in PCM consists of 8 bits and represents 1 voice channel. The time slot is repeated 8000 times in a second. DS1 has 24 time slots in a frame and E1 has 32 time slots in a frame.

As shown in the figure, connectivity is established between user-C on slot-C to user-G on slot-G. In order to perform time switch operation following steps are needed:

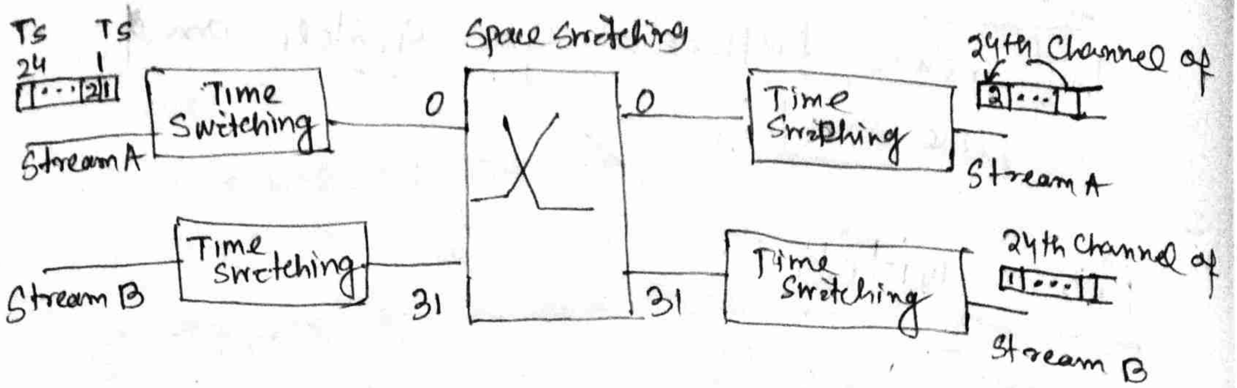
=> memory to store time slot speech data to write and to read at the output for changing the position.

=> memory to store control action to be performed on the stored data.

=> Time slot counter or processor.

Space Switch

Space Switch



Information on time slot 1 and 2 gets mapped to 24th time slot onto Stream A and Stream B

In general, a connection will occupy different time slots on the incoming and outgoing highways. Hence switching network must be able to receive PCM samples from one time slot and retransmit them in a different time slot. This is referred as time slot interchange or simple time switching.

Figure mentions the data transmitted on time slot no 1 and 2 are later transmitted on time slot no 24 of Stream A and Stream B at the output. Consequently, switching network of a tandem exchange or route switch of a local exchange must perform both time switching as well as space switching.

What Does Numbering plan Mean?

A numbering plan is a telecommunication scheme through which telephone numbers are assigned to subscribers and telephony endpoints. Each telephone number is an address assigned to an endpoint in a network through which a designated subscriber can be reached. Depending on the local telephony requirements and network, a numbering plan can follow a number of strategies. A numbering plan is also known as a telephone numbering plan.

Techopedia Explains Numbering plan

A numbering plan can be generally divided into open and closes numbering plans. An open numbering plan can assign various numbers of digits. Numbering plans, in many cases, most significantly depend on the geographical zone of the subscriber: a fixed number of area codes is alloted depending on the state, city or region. Any usere dialing from within a network must ~~first~~ specify the area code if dialing outside their local zone. Not only public switched telephone networks (PSTNs) but private telephone networks employ numbering plan schemes as well.

Country code

Country code are necessary only when dialing telephone numbers in other countries than the originating telephone. These are dialed before the national telephone number. By convention international telephone numbers are indicated in listings by prefixing the country code with a plus sign(+). This reminds the subscriber to dial the international dialing prefix in the country from which the call is placed. For example, the international dialing prefix or access code in all NANP countries is 011, while it is 00 in most European countries. In some GSM networks, it may be possible to dial +, which may be recognized automatically by the network carrier in place of the international access code.

NANP → North American Numbering plan

International numbering plan =>

The E.164 standard of the International Telecommunications Union is an international numbering plan and establishes a country calling code (country code) for each member organization. Country code are prefixes to national telephone number that denote call routing to the network of a subordinate number plan administration typically a country or group of countries with a uniform numbering plan, such as the NANP. E.164 permits a maximum length of 15 digits for the complete international phone number consisting of the country code, the national routing code (area code) and the subscriber number. E.164 does not define regional numbering plans, however it does provide recommendations for new implementations and uniform representation of all telephone numbers.

What is a PBX and How does PBX work?

A private branch exchange (PBX) is a telephone system within an enterprise that switches calls between users on local lines, while enabling all users to share a certain number of external phone lines. In contrast to a public switched telephone network (PSTN), the main purpose of a PBX is to save the cost of requiring a line for each user to the telephone company's central office.

How does PBX work?

Traditional PBX phones systems use landline copper-based telephone lines that enter a business's premises where they are connected to a PBX box. That box contains telephony switches that calls to be distributed to different phones in an office and those phones to access a limited number of outside lines - trunk lines.

An IP PBX, or an Internet protocol PBX uses digital phone signals, rather than analog landlines, to send calls. Because a users can make use of Ethernet cables to connect phones instead of traditional phone ones, no rewiring is needed. IP PBX systems can also be hosted by management service providers. While hosted systems require monthly fees, there are fewer end-users hardware costs associated with their use. Smaller PBX systems often referred to as Virtual PBXs offer hosted services but with fewer features. They are more appropriate for small businesses. Hosted PBX services are sold by numerous providers, including Nextiva, Vonage and RingCentral.

What is EPABX? AND How does it work?

EPABX stands for electronic Private Automatic Branch Exchange which is a private telephone network used by the organization and the companies for various types of communication, either between the employees or outside the clients. PBX which is Private Branch Exchange is a telephone Exchange which is used by a particular office or business opposite to the one that a common carrier or telephone company operates for many companies and businesses for the general public. Private Branch Exchange (PBX) is also known as (PABX) Private Automatic Branch Exchange and (EPABX) Electronic Private Automatic Branch Exchange.

How does this system work?

This telephone system helps businesses to cut cost by using a private branch exchange with the help of this system, businesses aren't required to run a line from every phone in the building to the telephone company's central office. The PBX setup: Initially during the 20th century, PBX used to run on analog techonology, but today it has gone Digital.

The typical private branch exchanges incorporate several phone lines from outside the buildings which terminates at the company exchange. It also includes several internal lines that lead to the exchange for the inside phones. A computer is used that manages the calls and switches them to one line to another based on the number dialed. The digital PBX does not require a human operator.

IP tellephony (Internet protocol telephony)

IP telephony (Internet protocal telephony) is a general term for tehonologies, products and services that use the internet protocal's packet switched connection to support voice calling, voicemail, video calling, video conferencing, faxing and instant messaging.

<u>What is IP telephony?</u>

IP telephony (Internet protocal telephony) is a general term for technoligies, products and services that use the internet protocol's packed switched connections to suppor voice calling, voice mail, video calling and instant messaging (IM).

Traditionally, these communications have been carried over the dedicated circuit-switched connections of the Public switched telephone network (PSTN) using the internet, calls travel as packets of data on shared lines, avoiding the tolls of PSTN.

IP telephony works by converting voice calls, faxes and other information into digital signals. These digital signals travel through IP Networks, such as the internet, as data packets, using IP packet switched connections. Voice features within IP technology - such as voice calls and voice mail - are referred to as voice over IP (VoIP).

IP techonology was introduced in 1991 with the creation of the first VOIP application Speak freely. The next year, Insoft released communique for desktop video conferencing. In 1995 Intel, Microsoft and Radvision began to standardize VOIP systems.

Working preeciple of Internet Telephony

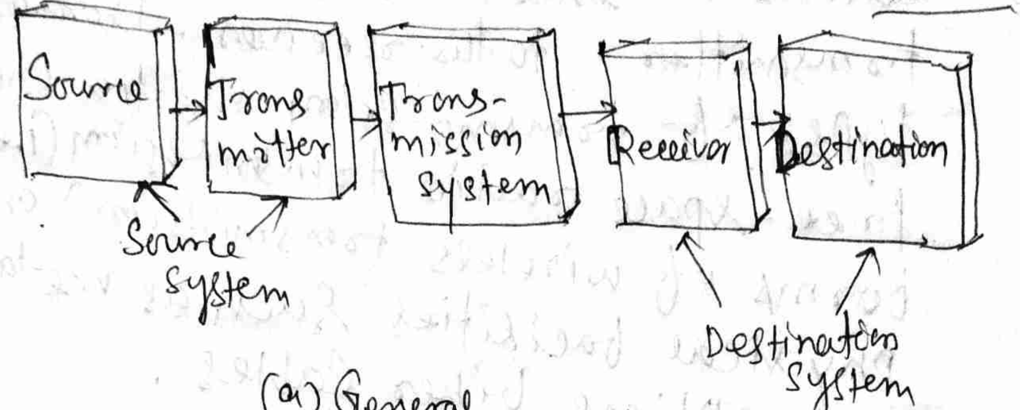
What does internet Telephony mean?

Internet telephony is a type of communications technology that allows voice calls and other telephony services like fax, SMS and other voice massaging applications to be transmitted using the internet as a connection medium. Software under this technology is cost effective and convenient because it allow the use to communicate through fax, voice and video calls any where in the world as long as there is an internet connection. In this way, users are able to bypass the charges that are common in traditional telephone services. However the quality of this service is not as good as that of traditional circuit-switched networks used in traditional telephone services because it is very dependent on the quality and speed of the internet connection.

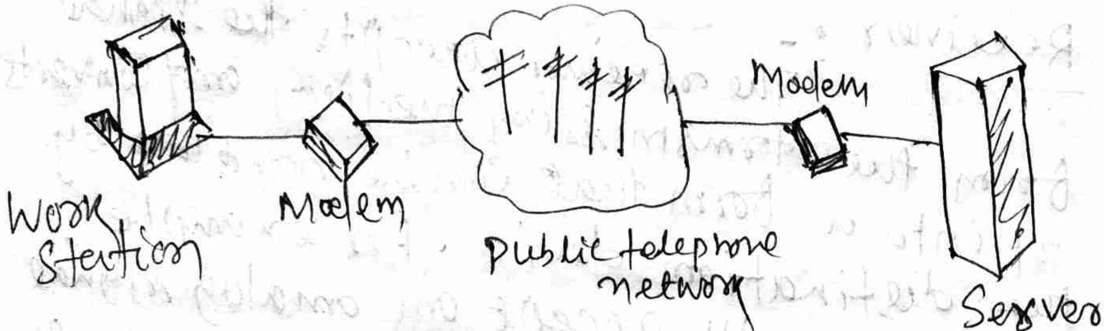
Internet telephony it is also called IP telephony or broadband telephony.

Data Communication Circuit

Simplified block diagram of data Communication network =>



(a) General Blockdiagram



(b) Example

Source :- This device generates the data to be transmitted; examples are mainframe Computer, personal Computer, workstation etc. The Source equipment provides a means for humans to enter data onto system.

Transmitter :- A transmitter transforms and encodes the information in such a way as to produce electromagnetic signals that that Can be transmitted across some sort of transmission system. For example a takes a digital bit stream from an attached device such as a personal computer and transforms that bit stream into an analog signal that Can be handled by the telephone network.

Transmission medium :-

The transmission medium carries the encoded signals from the transmitter to the receiver. Different types of transmission media include free-space radio transmission (i.e all forms of wireless transmission) and physical facilities such as metallic and optical fiber cables.

Receiver :-

The receiver accepts the signal from the transmission medium and converts it into a form that can be handled by the destination device. For example a modem will accept an analog signal coming from a network or transmission line and convert it into a digital bit stream.

Destination :-

Takes the incoming data from the receiver and can be any kind of digital equipment like the source.

Data Communication

Basic Concept of Data Communications

When we communicate, we aree sharing information. This sharing can be local or remote. between individual local communication usually accurs face to face while remote communication takes place over distance. The term Telecommunication, which includes Telephony, Telegraphy and television, means communication at a distance.

The data refers to facts, concept and instruction presented in whatever form is agreed upon by the parties creating and using the data. In the context of computer information system, data represented by binary information units produced and consumed in the form of 0s and 1s.

Data communications is the transfer of data or information between a source and a receiver. The source transmits the dada and the receiver receives it. The actual generation of the information is not part of Data communication nor is the resulting action of the information at the receiver. Data Communication is interested in the transfer of data, the method of transfer and the preservation of the data during the transfer process.

The purpose of data communications is to provide the rules and regulations that allow computers with different disk operating systems, languages, cabling and locations to share resources. The rules and regulations are called protocol and standards in Data Communications.

Data Communication system depends upon the three fundamental characteristics:

(1) <u>Delivery</u> => Data must be deliver to the correct destination.

(2) <u>Accuracy</u> => The data must be deliver accurately.

(3) <u>Timeliness</u> => The data must be deliver timely manner.

Architecture, Protocol and Standards

Architecture => To understanding complex network is understanding their architecture. Architecture is the most universal, high-level, and persistent elements of structure and organization (or principle of structuring and organizing a complex system.)

Protocols => Protocols define how diverse modules interact, and architecture defines how sets of protocols are organized. Architecture usually involves specification of protocols (rules of interaction) more then modules (which obey protocols). In Engineering system architecture must facilitate system level functionality as well as robustness and evolvability to uncertainty and change in components, function and environment.

Standared Protocol => A Standard protocal is a mandated, Fixed procedure for Completing a task. often designe'ated by blow chart or Spelled out in textual steps. Standard protocal may be nationali'ly recognized. There are as many types of Standard protocal as there are tasks associated with them.

Computer Communication => Electronics like telephones, computers and DVD records Communicate by way of data lines. These single lines Provide device to device communication through interconnection. Its standard protocal creates data packets that are scrambled through the lines and reassembled so the receiver can understand the message.

Medical Protocol => Body fluid spills in the emergency room require that environmental specialists follow specific protocal to clean up the mess so patients and hospital personnel are not subjected to infection and viruses such as AIDS. Occupational Safety and Heath Administration clean-up protocal falls under the Standard protocal "Universal Precautions", while hospital clean up policy may fall under de facto Standard protocal.

Data Communications Codes

Data Communications Codes are used to represent characters and symbols such as letters, digits and punctuation marks. Data Communications Codes are called character codes, character sets, symbol codes or character languages. The relationship of bytes to characters is determined by a character code.

DATA CODES :-

This refers to the way in which data is represented. The sender and receiver must use the same code in order to communicate properly. Here, we will briefly look at two common codes, one which was developed earlier on and was widely used in early telegraph systems, and the other which is in widespread use today.

ASCII (American Standard Code for information Interchange)

The ASCII Code is the most popular code for serial data communications today. It is a seven bit code (128 combinations) and thus supports upper and lower case characters, numeric digits, punctuation symbols, and special codes.

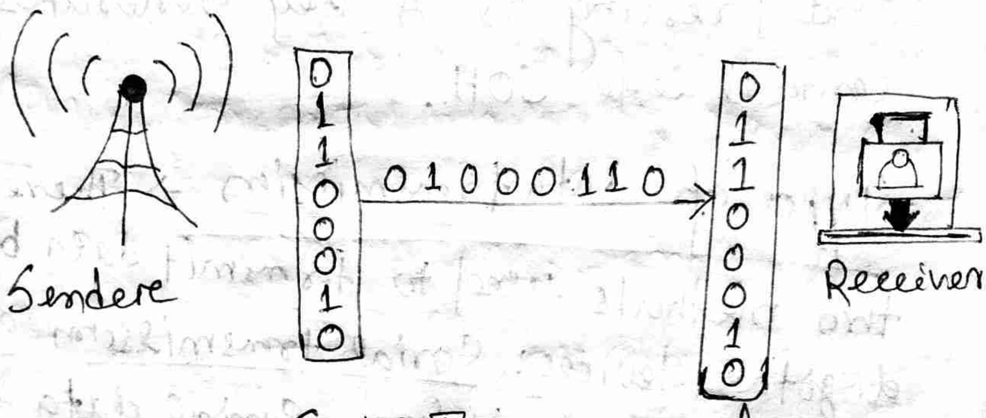
ASCII is also used as the data code for keyboards in computers. Control Codes have values between 00 and 1F (hexadecimal). Control Codes are used in binary synchronous communication and device control codes in communicating with devices such as printers or terminals.

A control code can be generated from a keyboard by holding down the Ctrl key and pressing another key. For instance, holding down the Ctrl key and pressing the A key generates the control code SOH.

• Types of data transmission => There are two methods used to transmit data between digital devices: Serial transmission and Parallel transmission. Serial data transmission sends data bits one after another over a single channel. Parallel data transmission sends multiple data bits at the same time over multiple channels.

What is Sereial transmission?

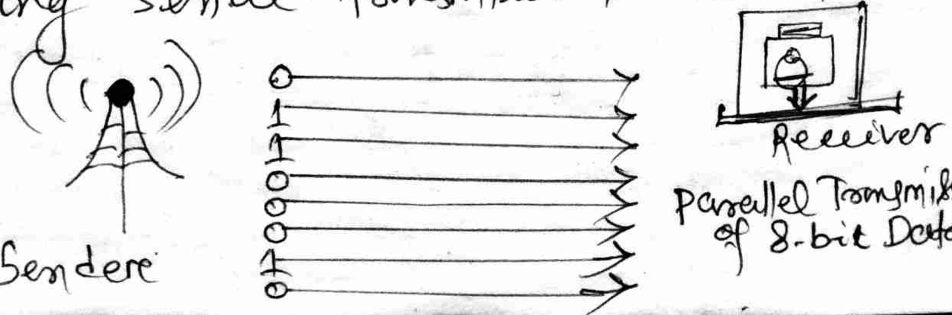
When data is sent or received using serial data transmission, the data bits are organized in a specific order, since they can only be sent one after another. The order of the data bits is important as it indicates how the transmission is organised when it is received. It is viewed as a reliable data transmission method because a data bit is only sent if the previous dada bit has already been received.



Serial Transmission of 8-bit data

What is Parallel transmission?

When data is sent using parallel data transmission, multiple data bits are transmitted over multiple channels at the same time. This means that data can be sent much faster than using serial transmission methods.



Parallel Transmission of 8-bit Data.

Basic Idea of Error Control

What does Error Control (EC) Mean?

Error control is the technique of detecting and correcting blocks of data during communication. In other words, it checks the reliability of characters both at the bit level and packet level. If proper error control is in place, transmitted and received data is ensured to be identical as in many cases communication channels can be highly unreliable.

Basic Idea of Error Detection

What does Error Detection Mean?

In networking, error detection refers to the techniques used to detect noise or other impairments introduced into data while it is transmitted from source to destination. Error detection ensures reliable delivery of data across vulnerable networks.

Error detection minimizes the probability of passing incorrect frames to the destination, known as undetected error probability.

MODEM ⇒ A modulator-demodulator, ore simply a modem

A modem or broadband modem is a hardware device that connects a computer or router to a broadband network. For example, a cable modem and DSL modem are two examples of these types of modems.

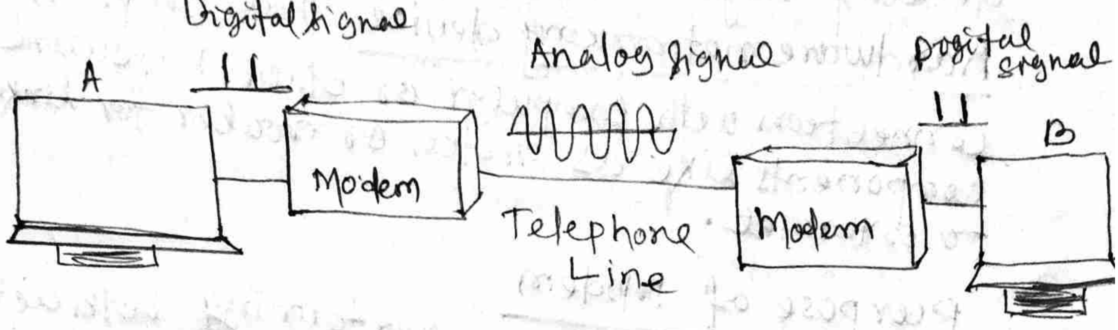
Short for modulator/demodulator, a modem is a hardware device that allows a computer to send and receive information over telephone lines. When a sending signal the device converts ("modulates") digital data to an analog audio signal, and transmits it over a telephone line. Similarly, when an analog signal is received the modem converts it back ("demodulates" it) to a digital signal

Basic Block Diagram of MODEM

Modem is abbreviation for modulator-De-modulator. Modems are used for data transfer from one computer network to another computer network through telephone lines. The computer network works in digital mode, while analog technology is used for carrying massages across phone lines.

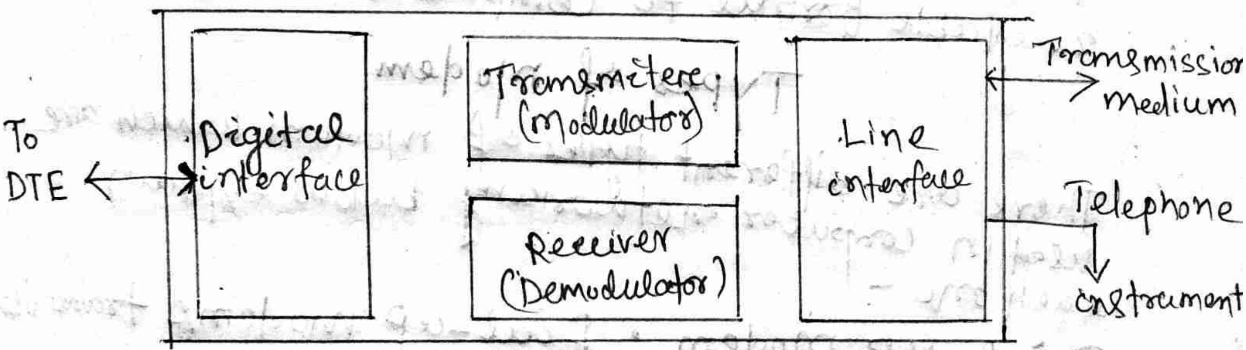
Modulator converts information from digital mode to analog mode at the transmitting end and de-modulator converts the same from analog to digital at receiving end. The process of converting analog signals of one computer network into digital signals of another computer network so they can be processed by a receiving computer is referred to as digitizing

When an analog facility is used for data communication between two digital devices called Data Terminal Equipment (DTE), modems are used at each end. DTE can be a terminal or a computer.



Modulation / Demodulation

The modem at the transmitting end converts the digital signal generated by DTE into an analog signal by modulating a carrier. The modem at the receiving end demodulates digital signal to the DTE.



Block Diagram of a MODEM

The transmission medium between the two modems can be dedicated circuit or a switched telephone circuit. If a switched telephone circuit is used, then the modems are connected to the local telephone exchanges. Whenever data transmission is required connection between the modems is established through telephone exchanges.

What is Modem

Definition: MODEM full form is "Modulator - Demodulator" that means it has ability to modulates and demodulates analog carriere signals for encoding and decoding digital data for executing modem is a hardware networking device that helps to make connection with computer or other hardware components like as switch or router for linking to internet.

Purpose of Modem

Modems are used for performing both activities like as sending and receiving of the digital data in between with multiple computer systems. Then this data is transmitted over the telephone lines with using V.92, to analog modems which helping out for converting those signals back to digital form for readable format to computer.

Types of Modem

There are different types of modem which are used in computer networking below explain each one -

Dial-up Modem: Dial-up modems transmit analog signal via telephone lines. This modem is uses mostly to make connection with ISP using of analog signals. Dial-up modem has two variant like as external or internal modem.

Cable Modem: In the cable modem, to use the coaxial cables those are connected to the back edge of modem.

ADSL Modem: ADSL stands for "Asymmetric Digital Subscriber Line" and these types of modems uses the telephone line for sending and receiving all information. ADSL modems have higher speed compare to conventional voice and modem.

Voice Band Modem :- Most modems are "Voice band"; i.e., they enable digital terminal equipment to communicate over telephone channels, which are designed around the narrow bandwidth requirements of the human voice. Cable modem, on the other hand, support the transmission of data over hybrid fibre-coaxial channels, which were originally designed to provide high-bandwidth television service. Both voiceband and cable modems are marketed as freestanding, book sized modules that plug into a telephone or cable outlet and a port on a personal computer. In addition, voiceband modems are installed as circuit boards directly into computers and fax machines. They are also available as small card-sized units that plug onto laptop computers.

WIRELESS COMMUNICATION

Basic concept of Cell phone

Cellulare telephone, sometimes called mobile telephone, is a type of Short-wave analog or digital telecommunication in which a Subscribere has a wireless connection from a mobile phone to a relatively nearby transmitter. The transmitter's span of coverge is called a Cell. As the cellular telephone usere moves from one cell or area of coverage to another, the telephone is effectively passed on the local cell transmitter.

A cellulare telephone is not to be confused with a cordless telephone (which is simply a phone with a very short wireless connection to a local phone outlet).

The first cellular telephone for commercial use was approved by the Federal Communications Commission (FCC) in 1983.

Frequency Reuse:- Frequency Reuse is the scheme in which allocation and reuse of channels throughout a coverage region is done. Each cellulare base station is allocated a group of radio channel or Frequency Sub-bands to be used within a small geographic area known as a cell. The shape of the cell is Hexagonal. The process of selecting and allocating the frequency sub-bands for all the cellular base station within a system is called Frequency reuse are frequency planning.

Cellulare network in Radio system ⇒

Cellulare radio systems are by ~~far~~ far the most common of all public mobile telephone networks. In a Cellular Radio system, the area to be covered is divided up into a number of small areas called cells, with one radio base station positioned to give radio coverage of each cell. One radio channel is set aside in each cell ~~to~~ to carry signaling information between the network and mobile stations. The signaling procedures for mobile to land and land to mobile call setup depend upon the technical standard of the particular network. Cellular radio re-uses the same radio channels in different cells and because of this re-use, two mobiles using the same channel in different cells may interfere with each other, a phenomenon known as Co-channel interference. The GSM Standard was developed as a joint initiative by the members of the Conference of European Posts and Telecommunications administrations with the eventual aim of building a unified pan European network. The speech coder is a reguler pulse excited lineare predictive coder with long term prediction. This provides a net bit rate of 13kbit/s. The primary purpose of all cellular radio networks is to offer speech telephony service to its customers.

SMS (Short message service) is a text messaging service component of most telephone, internet, and mobile device system. it uses Standardized Communication protocols that let mobile devices exchange short text messages. An intermediary service can facilitate a text-to-voice conversion to be sent to landlines.

MMS (Multimedia Messaging service)

MMS or multimedia Messaging service is an extension of SMS that enables the ability to send text messages that include multimedia content to and from mobile phones.

The rise of smart phones has made it a common occurrence to use MMS to send photos and videos via text message - Camera phones make it possible to capture any moment at any time and immediately share it with friends and family via MMS

1G (First Generation)

- The first generation of cell phone technology.
- only (.. capable of simple phone calls
- used throught the 1980's
- only referred to as 1G once 2G was introduced.
- phased out by 2G in the early 1990's

2G

=> Utilized digital signal processing rather than the analog signaling used in 1G.
=> 2G became very popular because users were capable of connecting their mobile devices to the internet and business networks
=> 2G provided speeds of 125 Kbps (Kilobits per second) to customers at its peak.
=> phased out by 3G in the early 2000's.

3G.

=> 3G set the standards to what we are accustomed [illegible] today including.
- Web Browsing
- Email
- Video Downloading
- Picture Sharing

=> 3G provided speeds 10.8 Mbps (Megabits per second)
=> Still used today in areas incapable of 4G coverage.

4G and 4G LTE

=> First introduced in 2008
=> Mandates the use of IP (Internet protocol) for data traffic.
=> 4G has become synonymous with 4G LTE.
=> 4G has speed of [illegible] - 100 mbps (megabits per second)
=> 4G LTE has introduced in 2010 and has speeds much higher than 100 mbps.

5G

=> Most likely to be introduced by 2021.

=> Paredicted maximum speeds of 1Gbps to 1Gbps (Gigabits per second) to 10 Gbps (Gigabits per second)

=> Many Corporation worldwide are competing to be the leaders of 5G technology development.

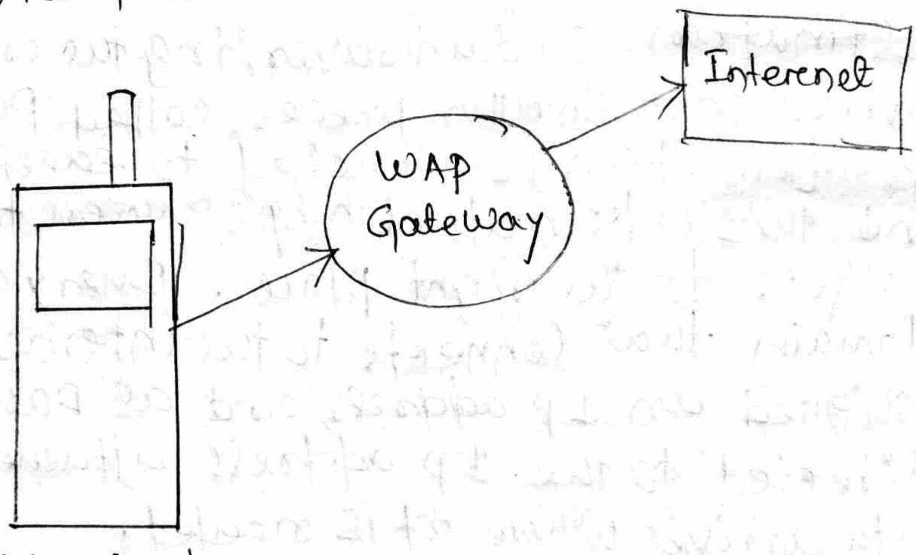
What is the Internet protocol (IP) ?

The Internet protocal (IP) is a protocal, or set of rules, for routing and addressing packets of data so that they can travel across networks and arrive at the correct destination. Data traversing the internet is divided into smaller pieces, called packets. IP information is attached to each packet, and this information helps routers to send packets to the right place. Every device or domain that connects to the internet is assigned an IP address, and as packets are directed to the IP address attached to them, data arrives where it is needed.

Once the packets arrive at their destination, they are handled differently depending on which transport protocal is used in combination with IP. The most common transport protocols are TCP and UDP.

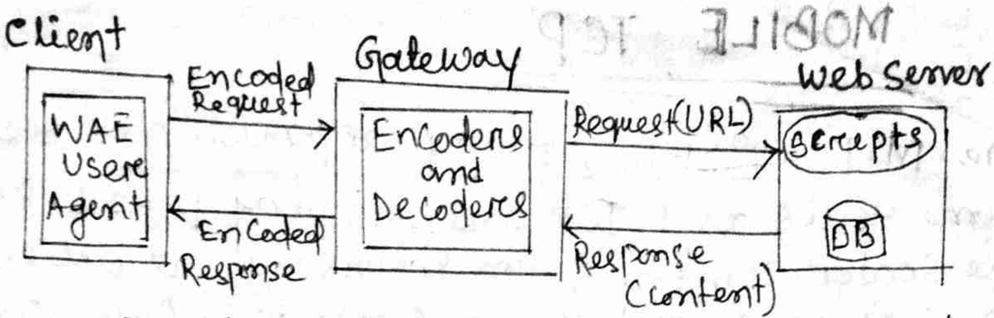
* Working of wireless Application Protocol (WAP) *

WAP Stands for wireless Application protocal. It is a protocal designed for micro-browsers and it enables the access of internet in the mobile devices. It uses the mark up language WML (Wireless Markup Language and not HTML,) WML is defined as XML 1.0 application. It enables creating web application for mobile devices. In 1998 WAP Forum was founded by Ericson, Motorola, Nokia and Unwired planet whose aim was to standardize the various wireless technologies via protocols.



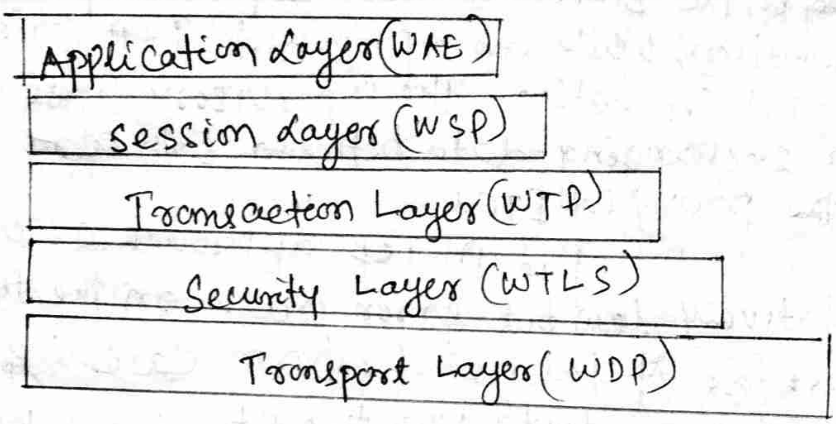
Mobile Devices

WAP model:- The usere opens the mini-browsere in a mobile device. He selects a webhiete that he wants to view. The mobile device stands the URL, encoded request via network to a WAP gateway using WAP protocal.



The WAP gateway translates this WAP request into a conventional HTTP URL request and sends it over the internet. The request reaches to a specified web server and it processes the request just as it would have processed any other request and sends the response back to the mobile device through WAP gatway in WML file which can be seen in the micro-browser.

WAP protocol stack:



1. Application Layer:- This layer contains the wireless Application Environment (WAE). It contains mobile device specifications and content development programming language like WML.
2. Session Layer: This layer contains Wireless Session protocol (WSP). It provides fast connection suspension and reconnection.
3. Transaction Layer: This layer contains Wireless Transaction protocol (WTP). It runs on top of (UDP) (User Datagram protocol) and is a part of TCP/IP and offers transaction support.
4. Security Layer:- This layer contains Wireless Transaction Layer Security (WTLS). It offers data integrity, privacy and authentication.
5. Transport Layer:- This layer contains Wireless Datagram protocol (WDP). It presents consistent data format to higher layers of WAP protocol stack.

MOBILE TCP

TCP/IP ⇒ Transmission control protocol / Internet Protocol

The M-TCP (Mobile TCP) 1 approach has the same goals as I-TCP and snooping TCP: to prevent the sender window from shrinking if bit errors or disconnection but not congestion cause current problems. M-TCP wants to improve overall throught, to lower the delay, to maintain end-to-end semantics of TCP, and to provide a more efficient handover. Additionally, M-TCP is especially adapted to the problems arising from lengthy or frequent disconnections.

M-TCP splits the TCP connection into two parts as I-TCP does. An unmodified TCP is used on the standard host - supervisory host (SH) connection, while an optimized TCP is used on the SH - MH connection. The supervisory host is responsible for exchanging data between both parts similar to the proxy in ITCP.

The M-TCP approach assumes a relatively low bit error rate on the wireless link. Therefore it does not perform catching/retransmission of data via the SH. If a packet is lost on the wireless link, it has to be transmitted by the original sender. This maintains the TCP end-to-end semantics. The SH monitors all packets sent to the MH and Acks returned from the MH. If the SH does not receive an Ack for some time, it assumes that the MH is disconnected. It then chokes the sender by setting the sender's window size to 0 forces the sender to go into persistent mode, i.e. the state of the sender will not change no matter how long the receiver is disconnected. This means that the sender will not try to retransmit data. As soon as the SH (either the old SH or a new SH) detects connectivity again, it reopens the window of the sender to the old value.

The sender can continue sending at full speed. This mechanism does not require changes to the sender's TCP. The wireless side uses an adapted TCP that can recover from packet loss much faster. This modified TCP does not use slow start, thus, M-TCP needs a bandwidth manager to implement fair sharing over the wireless link.

Advantage of M-TCP ① It maintains the TCP end-to-end semantics. The SH does not send any ACK itself but forwards the ACK's from the MH.

② If the MH is disconnected, it avoids useless retransmission, slow starts or breaking connections by simply shrinking the sender's window to 0. Since it does not buffer ~~data~~ data in the SH as I-TCP does, it is not necessary to forward buffers to a new SH. Lost packets will be automatically retransmitted to the new SH.

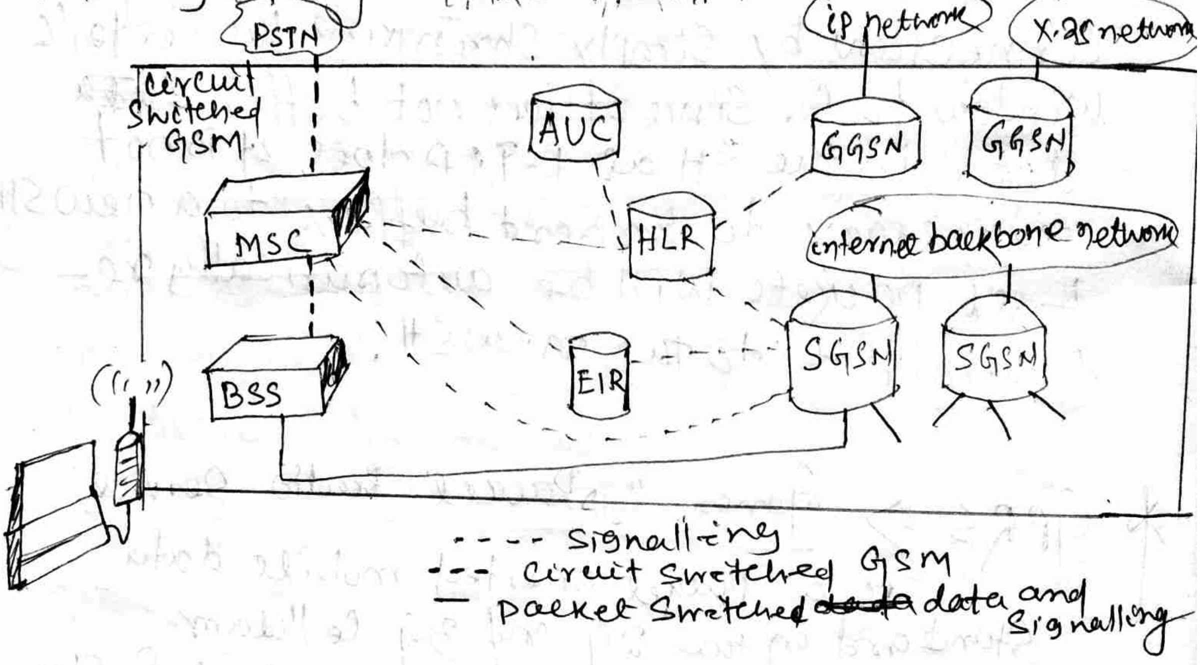
* GPRS => General Packet Radio Service
is a packet oriented mobile data standard on the 2G and 3G cellular communication networks global system for mobile communications (GSM)

General Packet Radio Service (GPRS)

Architecture and features of GPRS

GPRS architecture works on the same procedure like GSM network but, has additional entities that allow packet data transmission. This data network overlaps a second-generation GSM network providing packet data transport at the rates from 9.6 to 171 kbps. Along with the packet data transport the GSM network accommodates multiple users to share the same air interface resources concurrently.

Following is the GPRS Architecture diagram:



GPRS attempts to reuse the existing GSM network elements as much as possible, but to effectively build a packet-based mobile cellular network, some new network elements, interface and protocols for handling packet traffic are required. Therefore GPRS requires modification to numerous GSM network elements as summarized below:

GSM network Element	Modification or upgrade Required for GPRS.
Mobile Station (MS) →	New mobile Station is required to access GPRS Services. These New terminals will be backward Compatible with GSM for voice Calls.
BTS →	A software upgrade is required in the existing Base Transceiver Station (BTS)
BSC →	The base Station Controller (BSC) requires a Software upgrade and the installation of new hardware called the packet control Unit (PCU). The PCU directs the data traffic to the GPRS network and can be separate hardware element associated with the BSC.
GPRS Support Nodes (GSNs) →	The deployment of GPRS required the installation of new core network elements called the Serving GPRS Support node (SGSN) and gateway GPRS Support Node (GGSN).
Databases (HLR, VLR, etc) →	All the databases involved in the network will require Software upgrades to handle the new call models and functions introduced by GPRS.

GPRS Mobile Stations =>

New mobile Stations (MS) are required to us GPRS Services because existing GSM phones do not handle the enhanced air interface or packet data. A variety of MS can exist including a high-speed version of current phones to support high-speed data access, a new PDA device with an embeded GSM phone and PC cards for Laptop Computers. These Mobile Stations are backward compatible for making voice calls using GSM.

GPRS Base Station Subsystem

Each BSC requires the installation of one or more packet control units (PCUs) and a Software upgrade. The PCU provides a Physical and logical data interface to the Base Station Subsystem (BSS) for packet data traffic. The BTS can also require a Software upgrade but typically does not require hardware enhancements.

When either voice or data traffic is originated at the subscriber mobile. It is transported over the air interface to the BTS, and from the BTS to the BSC in the same way as a standard GSM call. However, at the output of the BSC, the traffic is separated; voice is sent to the Mobile Switching center (MSC) per standard GSM and data is sent to a new device called the SGSN via the PCU over a Frame relay interface.

GPRS Support Nodes

Following two new components, called Gateway GPRS Support Nodes (GSNs) and, Serving GPRS Support Node (SGSN) are added:

Gateway GPRS Support Node (GGSN)

The Gateway GPRS Support Node acts as a an interface and a router to external networks. It contains routing information for GPRS mobiles, which is used to tunnel packets through the IP based internal backbone to the correct Serving GPRS Support Node. The GGSN also collects charging information connected to the use of the external data networks and can act as a packet filter for incoming traffic.

Serving GPRS Support Node (SGSN)

The Serving GPRS Support Node is responsible for authentication of GPRS mobiles, registration of mobiles on the network, mobility management and collecting information on charging for the use of the air interface.

Internal Backbone => The internal backbone is an IP based network used to carry packets between different GSNs. Tunnelling is used between SGSNs and GGSNs, so the internal backbone does not need any information about domains outside the GPRS Network. Signalling from a GSN to a MSC, HLR or EIR is done using SS7.

Routing Area => GPRS introduces the concept of a Routing Area. This concept is similar to Location Area in GSM, ~~exp~~ except that it generally contains fewer cells. Because routing areas are smaller than location areas, less radio resources are used while broadcasting a page message.

Wireless Communication and its Standards

Wireless Communication definition => Transfer of information without 'wires' information can be transmitted between two location using a signal that can be either analog or digital in nature. In telecommunication networks, digital transmission is exclusively used. Wireless Communication can take several forms. Microwave radio transmission have been used in used in telecommunication industry for the transport of point - point data where information transmissions occur through carrier signal. Satellite Communication - Low and medium capacity over long distance. Wireless ~~te~~ Technology: To understand wireless technology a basic ~~and~~ understanding of the radio frequency (RF) Spectrum is required. It's rate of oscillations in the range of about 3KHZ - 300GHZ.

CELLULAR TECHONOLOGY => Cellular network is a radio-based technology; radio waves are electromagnetic waves that antenna propagate. most signals are in the 850 MHZ, 900MHZ, 1800MHZ 1900MHZ frequency bands. Mobile radio Transmission System may be classified into: Simplex, ~~Half Du~~ Half-Duplex, Full Duplex, Simplex: One way Communication. Simultaneously transmit and receive Ex: Mobile phone. Applies to FDD and TDD, Frequency Division Duplex and Time Division Duplex

Discuss the GSM (Global System for Mobile) Service and features. =>

What is GSM?

GSM stands for Global System for Mobile Communication. It is a digital cellular technology used for transmitting mobile voice and data services. Important facts about the GSM are given below —

=> The concept of GSM emerged from a cell-based mobile radio system at Bell Laboratories in the early 1970s.

=> GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard.

=> GSM is the most widely accepted standard in telecommunications and it is implemented globally.

=> GSM is a circuit-switched system that divides each 200KHz channel into eight 25KHz time slots. GSM operates on the mobile communication bands 900MHz and 1800MHz in most parts of the world. In the US, GSM operates in the bands 850MHz and 1900MHz.

=> GSM makes use of narrowband Time Division Multiple Access (TDMA) technique for transmitting signals.

=> GSM was developed using digital technology. It has an ability to carry 64kbps to 120mbps of data rates.

=> Presently GSM supports more than one billion mobile subscribers in more than 210 countries throughout the world.

=> GSM provides basic to advanced voice and data services including roaming service. Roaming is the ability to use your GSM phone number in another GSM network.

Why GSM?

Listed below are the features of GSM that account for its popularity and wide acceptance.

- ⇒ Improved Spectrum efficiency.
- ⇒ International roaming.
- ⇒ Low-cost mobile sets and base stations (BSs)
- ⇒ High-quality speech.
- ⇒ Compatibility with integrated Services Digital Network (ISDN) and other telephone company Services.
- ⇒ Support for new Services.

Architecture of GSM System and GSM mobile station and channel types of GSM ⇒

The GSM architecture consists of three major interconnected subsystems that interact with themselves and with users through certain network interface. The subsystems are Base Station Sub System (BSS), Network Switching Subsystem (NSS) and operational Support Subsystem (OSS). Mobile Station (MS) is also a subsystem but it is considered as a part of BSS.

1. Mobile Station (MS): Mobile station is made up of two entities.

A. Mobile equipment (ME):

⇒ It is a portable, vehicle mounted, hand held device.

⇒ It is uniquely indentified by an IMEI number.

⇒ It is used for voice and data transmission. It also monitors power and signal quality of surrounding cells for optimum handover. 160 characters long SMS can also be sent using mobile equipment.

B. Subscriber Identity Module (SIM):

⇒ It is a smart card that contains the International Mobile Subscriber Identity (IMSI) number.

⇒ It allows users to send and receive calls and receive other subscriber services.
It is protected by password or PIN.

⇒ It contains encoded network indentification details. It has key information to activate the phone.

⇒ It can be moved from one mobile to another.

2. Base Station Subsystem (BSS): It is also known as radio Sub System, provides and manages radio transmission paths between the mobile Stations and the mobile Switching Center (MSC). BSS also manages interface between the mobile Station and all other Sub Systems of GSM. It consists of two parts.

A. Base Transceiver Station (BTS):

=> It encodes, multiplexes, modulates and feeds the RF Signal to the antenna.

=> It consists of transceiver units.

=> It Communicates with mobile Stations via radio air interface and also Communicates with BSC via Abis interface.

B. Base Station Controller (BSC):

=> It manages radio resources for BTS. It assigns frequency and time slots for all mobile Stations in its area.

=> It handles call Setup, transcoding and adaptation functionality handover for each MS radio power Control.

=> It Communicates with MSC via A interface and also with BTS.

3. Network Switching Subsystem (NSS):

It manages the Switching functions of the system and allows MSCs to Communicate with other networks such as PSTN and ISDN. It consist of

A. Mobile Switching Centre:

=> It is heart of network. It manages Communication between GSM and other networks.

=> It manages Call Set up function, routing and basic Switching.

=> It performs registration, location up dating and inter BSS and inter MSC call handoff.

=> It provides billing information.

B. Home Location Registers (HLR) :- It is a permanent dadabase about mobile subscriber in a large service area. Its database contains IMSI, IMSISDN, Prepaid/post paid, roaming restrictions, supplementary services.

C. Visitor Location Registers (VLR) :- It is a temporary dadabase which updates whenever new MS enters its area by HLR dada base. It controls mobiles roaming in its area. It reduces number of queries to HLR. Its dadabase contains IMSI, TMSI, IMSISDN, MSRN, location area authentication key.

D. Authentication Centre :- It provides protection against intruders in air interface. It maintains authentication keys and algorithms and provides security triplets.

E. Equipment Identity Registry (EIR):

=> It is a database that is used to track handset using the IMEI number.

=> It is made up of three sub classes - the white list, the black list and the gray list.

4. Operational Support Subsystem (OSS): It supports the operation and maintenance of GSM and allows system engineers to monitor, diagnose and troubleshoot all aspects of GSM system. It supports one or more operation maintenance centres (OMC) which are used to monitor the performance of each MS, BS, BSC and MSC within a GSM system. It has three main functions:

=> To maintain all telecommunication hardware and network operations with a particular market.

⇒ To manage all charging and billing procedures
⇒ To manage all mobile equipment in the system.

Interfaces used for GSM network: (ref fig-2)

1) Um Interface - Used to communicate between BTS with MS

2.) Abis Interface - Used to Communicate BSC to BTS

3.) A interface - used to Communicate BSC and MSC.

4) Singling Protocol (SS7) - used to communicate MSC with other network.

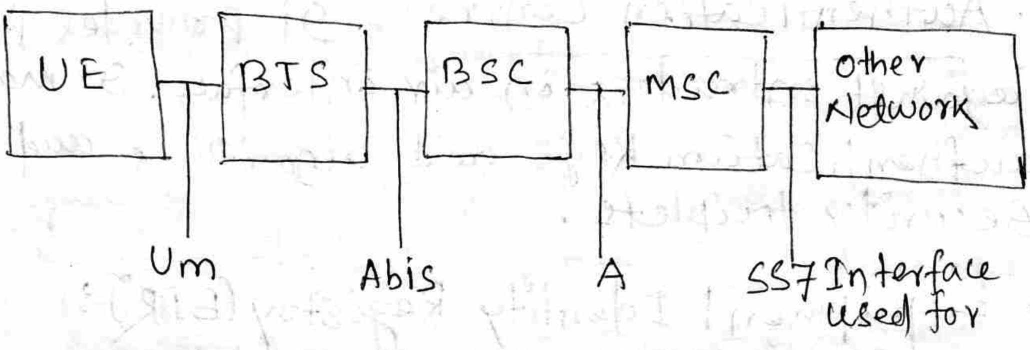


Fig-2 GSM network Interfaces

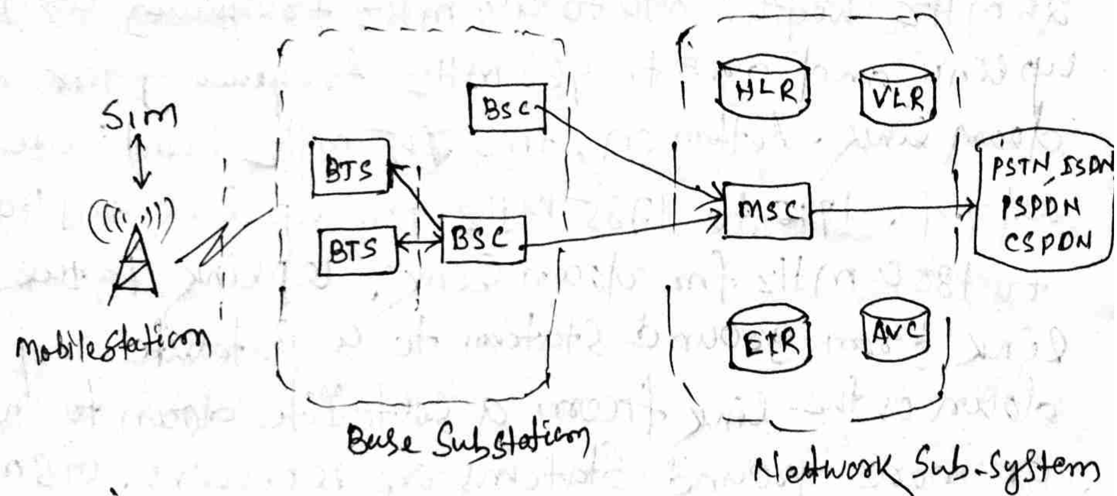
How GSM WORKS =>

GSM Stands for Global System for Mobile Communication. Today, GSM used by more than 800 million end users spread across 190 Countries which represents around 70 percent of today's digital wireless market. So, let's see how it works.

In GSM, geographical area is divided into hexagonal cells whose side depends upon power of transmitter and load on transmitter (Number of end users) At the center of cell, there is a base station consisting of a transceiver (Combination of transmitter and receiver) and an antenna.

Architecture:

Image of GSM Architecture



1. Mobile Station => (MS) It refers for mobile station, simply, it means a mobile phone.
2. Base transreceiver system (BTS) => It maintains the radio component with MS.
3. Base Station Controller (BSC) => Its function is to allocate necessary time slots between the BTS and MSC
4. Home location registerr (HLR) => . It is the reference database for Subscriber Parameter like Subscriber's ID, location, authentication Keyetc.

Visitor location register (VLR) => It contains copy of most of the data stored in HLR which is temporary and exist only until subscriber is active.

Equipment indentity register (EIR) => It is a database which contains a list of valid mobile equipment on the network.

Autentication Center (Auc) => It perform autenticatiom of subscriber.

Working => Gsm is combination of TDMA (Time Division Multiple Access) FDMA (Frequency Division Multiple Access) and Frequency hopping

Initially Gsm use two frequency bands of 25 MHZ width: 890 to 915 MHz frequency band for up link and 935 to 960 MHz frequency for down link. Letter on, two 75 MHz band were added. 1710 to 1785 MHz for up-link and 1805 to 1880 MHz for down link. Uplink is the link from ground station to a satellite and down is the link from a satellite down to one or more ground stations or receivers. Gsm divides the 25 MHZ band into 124 channels each having 200 KHZ width and remaining 200 KHZ is left unused as a guard band to avoid interference.

CDMA Channels (Code division Multiple Access)

CDMA channels can be categoreized as Forward channel and Reverse channel:

Forward channel => The forward channel is the direction of the communication or mobile-to-cell downlink path. It includes the following channels —

Pilot channel — Pilot Channel is a reference channel. It uses the mobile station to acquire the time and as a phase reference for coherent demodulation. It is continuously transmitted by each base station on each active CDMA frequency. And, each mobile station tracks the signal continuously.

Sync channel => Synchronization channel carries a single, repeating message, which gives the information about the time and system configuration to the mobile station. Likewise, the mobile station can have the exact system time by the means of synchronizing to the short code.

Paging channel => paging channel's main objective is to send out pages, that is, notifications of incoming calls, to the mobile stations. The base station uses these pages to transmit system overhead information and mobile station specific messages.

Forward Traffic channel => Forward Traffic channel are code channels. It is used to assign calls, usually voice and signalling traffic to the individual users.

Reverse channel

The reverse channel is the mobile-to-cell direction of communication or the uplink path. It consists of the following channels.

Access channel => Access channel is used by mobile stations to establish a communication with the base station or to answer paging channel messages. The access channel is used for short signalling message exchanges such as call-ups, responses to pages and registrations.

Reverse Traffic channel ⇒ Reverse traffic channel is used by the individual users in their actual calls to transmit traffic from a single mobile station to one or more base stations.