B.Tech. DEGREE EXAMNATION, JANUARY 2023.

Seventh Semester

Electronics and Communication Engineering

Elective: SATELLITE COMMUNICATION SYSTEM

PART A- (10 *2=20)

Answer ALL the questions.

1. **State Kepler's law.(INT 1)**

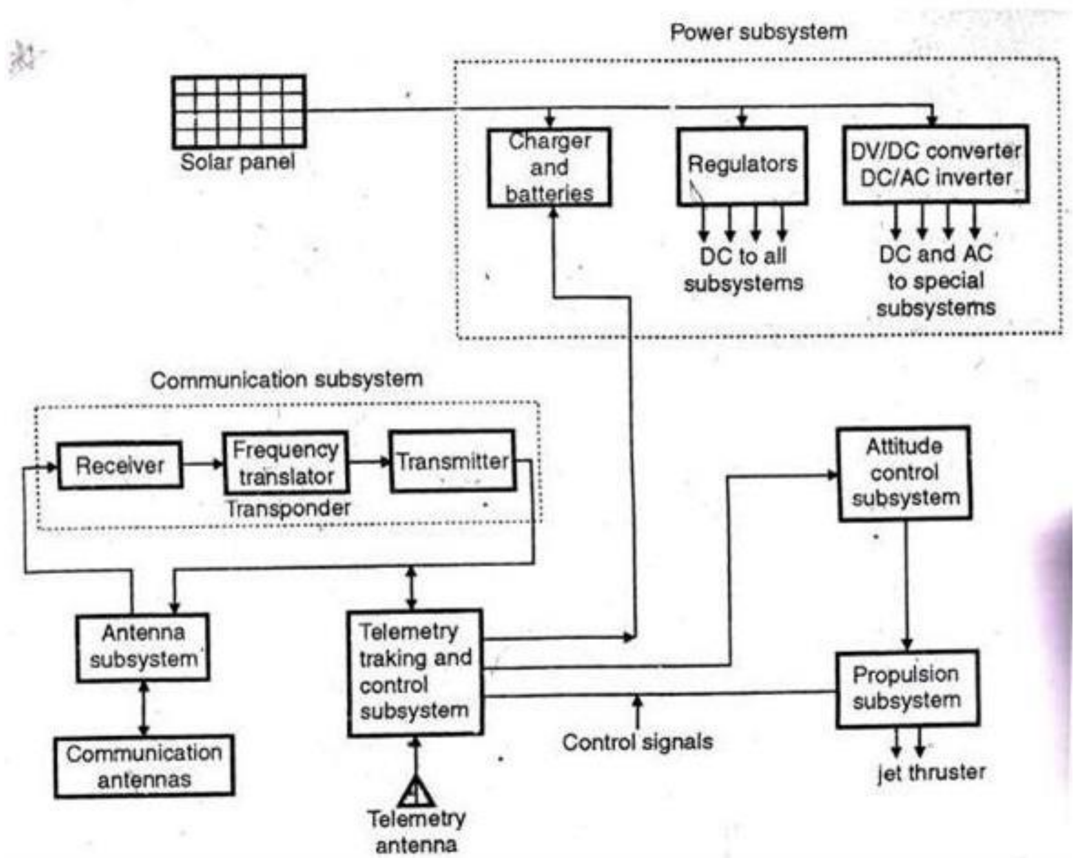
It states that the path followed by the satellite around the primary will be an ellipse. An ellipse has two focal points F1 &F2.The center of mass of the two body system, termed the bary center is always centered on one of the foci.

$$\epsilon = \frac{\sqrt{\alpha^2-\beta^2}}{\alpha}$$

It states that for equal time intervals, the satellite will sweep out equal areas in its orbital plane, focused at the bary center. It states that the square of the periodic time of orbit is perpendicular to the cube of the mean distance between the primary and the satellite.

$$\alpha = AP^{2/3}$$

2. **Draw some common structural type to hold the spacecraft.**



3. **Give the difference between KU-band and the C-band receiver only systems**

   C-BAND:

   • C band is a name given to certain portions of the electromagnetic spectrum, as well as a range of wavelengths of light, used for communications.

   KU-BAND:

   • Ku band is primarily used for satellite communications.

   • The Ku band (pronounced "kay-yoo") is a portion of the electromagnetic spectrum in the microwave range of frequencies.

4. **List out the regions covered by INMARSAT.**

   The Atlantic Ocean Region East (AOR-E)
   Atlantic Ocean Region West (AOR-W)
   Pacific Ocean Region (POR)
   Indian Ocean Region (IOR).

5. **Define single access and multiple accesses.**
   Multiple accesses is a technique that lets multiple mobile users share the allotted spectrum in the most effective manner. Since the spectrum is limited, the sharing is necessary to improve the overall capacity over a geographical area.

6. **What is the need of reference burst in TDMA?**
   In TDMA networks, Reference Burst generated in a primary station is very important because it gives all nodes timing reference and frequency/timing information to enact acquisition and synchronization in the receiver.

7. **Define laser cross link analysis?**
   The Laser Crosslink Atmospheric Sounder (LCAS) is a prototype toward a low-Earth-orbiting (LEO) constellation to concurrently measure both UTLS water vapor and temperature at high vertical resolution, improving temporal and spatial coverage. The two-part approach uses both beam pointing and intensity.

8. **How optical communication is necessary for satellite network?**
   Super high-speed data transmission is one of the prior requirements of optical satellite communication. As satellite communication possesses long-distance, approximately 40,000 kilometers per single trip, ground and satellite stations have to produce lasers to obtain emission power high enough to reach other stations

9. **Write the basic principal of VSAT network.**
   A VSAT consists of two parts: a transceiver placed outdoors in direct line of sight to the satellite, and a device that is placed indoors to interface the

transceiver with the end user's communications device, such as a PC. The transceiver receives or sends a signal to a satellite transponder in the sky.

10. List out the names of any four mobile satellite services.

Avanti.

Globalsat Group.

Iridium Communications.

Inmarsat.

Telespazio.

Thuraya.

Vizada.

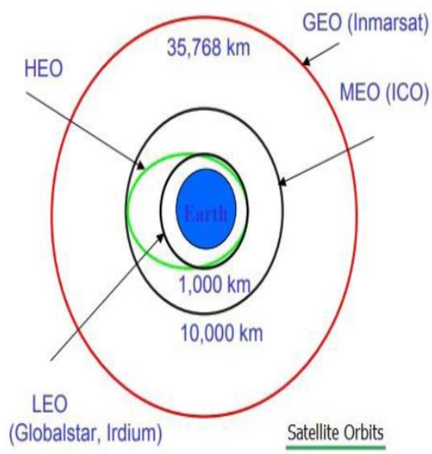
PART A- (11 *5=55)

Answer ALL the questions.

11. Write a detailed note on (A) orbital elements (b) Liquid propulsion.(INT 1)

ORBITAL ELEMENTS:

SATELITE ORBITS:



1. Line of Apsides
2. Ascending Node
3. Descending Node
4. Line of Nodes
5. Inclination
6. Prograde Orbit
7. Retrograde Orbit
8. Semi major axis
9. Eccentricity

1. LINE OF APSIDES

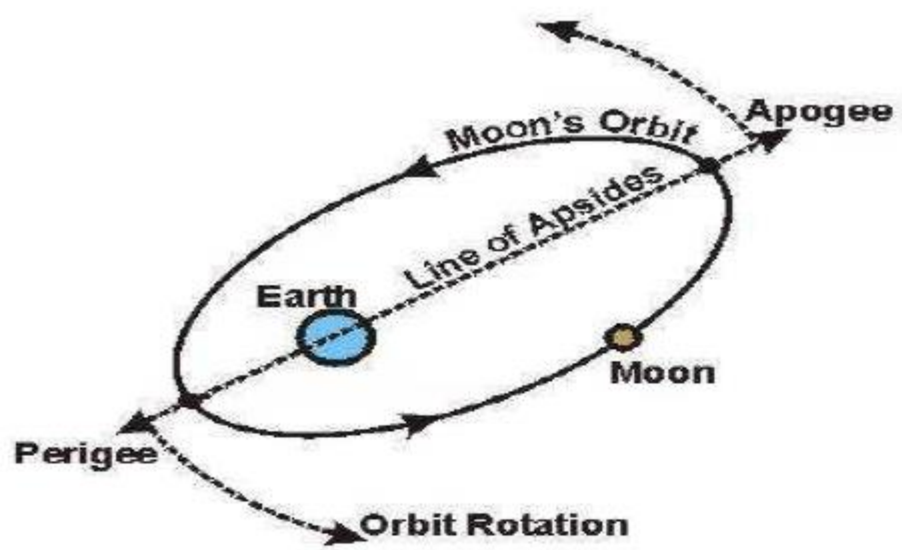
When satellite is in elliptical orbit, the center of earth is one of the focal points of ellipse. In this type of satellite orbit, distance of satellite from earth varies based on its position.

• Two points are very important viz. highest point and lowest point above earth.

A) Apogee- The Point farthest from the earth.
B) Perigee- The Point closest to the earth.

2. ASCENDING NODE:
Line joining perigee and apogee through center of the Earth.
• It is the major axis of the orbit.

• One-half of this line's length is the semi-major axis equivalents to satellite's mean distance from the Earth.



3. ASCENDING NODE:
The point where the orbit crosses the equatorial plane going from north to south.
4. DESCENDING NODE:
The point where the orbit crosses the equatorial plane going from south to north.

5. LINE OF NODES:
The line joining the ascending and descending nodes through the center of Earth.

6. INCLINATION:
• The angle between the orbital plane and the Earth's equatorial plane.

• It’s measured at the ascending node from the equator to the orbit, going from East to North. Also, this angle is commonly denoted as i.

7. PROGRADE ORBIT:

An orbit in which satellite moves in the same direction as the Earth’s rotation. Its inclination is always between 0_0 to 90_0. Many satellites follow this path as Earth’s velocity makes it easier to lunch these satellites.

8. RETROGRADE ORBIT:

An orbit in which satellite moves in the same direction counter to the Earth’s rotation.

9. SEMI MAJOR AXIS:

• The length of Semi-major axis (a) defines the size of satellite’s orbit.

• It is half of the major axis.

• This runs from the center through a focus to the edge of the ellipse.

• So, it is the radius of an orbit at the orbit's two most distant points.

10. ECCENTRICITY:

• The value of **Eccentricity (e)** fixes the shape of satellite’s orbit. This parameter indicates the deviation of the orbit’s shape from a perfect circle.

• If the lengths of semi major axis and semi minor axis of an elliptical orbit area & b, then the mathematical expression for **eccentricity (e)** will be
The value of eccentricity of a circular orbit is **zero**, since both a&b are equal. Whereas, the value of eccentricity of an elliptical orbit lies between zero and one.

(B) LIQUID PROPULSION:

• The Satellite is used for various applications such as communication, space and earth exploration etc.

• The satellite is launched in the space with the help of launch vehicle.

• It is used so that satellite will cross the earth's atmosphere as well as gravitational pull.

• There are two types of launch vehicles viz. expendable type or reusable type.

• The expendable type of vehicles gets destroyed in space after placing the satellite in orbit.

• Arianne and Delta are expendable type of launch vehicles.

• The re-usable type returns to the earth after leaving it at certain altitude above the earth.

• The examples of reusable type are GSLV and PSLV.

• Navigation and guidance of the launch vehicle are important so that satellite can attain needed altitude, orbit path and essential kinematics requirements.

• The satellite launch vehicle is a complex system and consists of following functional modules:

➢Propulsion systems

➢Auto piloting.

➢Aerodynamic structure

➢Interactive steering subsystem

SATELLITE LAUNCH PROCEDURE:

• There are various steps or procedure followed in order to launch satellite in its parking space.

• The four orbit stages involved in the satellite launch procedure are as follows:

1. Circular low earth orbit
2. Hohmann elliptical transfer orbit
3. Intermediate drift orbit
4. Circular Geostationary orbit.

Satellites launch procedure followed by space companies such as ISRO:

Step-1:

• The launch vehicle takes the satellite into low earth orbit.

• The satellite is injected into desired 3-axes stabilized mode to achieve gyro condition using commands issued by launch vehicle to carry pyro firing.

Step-2:

• After satellite reaches apogee AKM is fired for long duration to take satellite to intermediate orbit.

• This intermediate orbit is referred as transfer orbit.

• AKM is the short form of Apogee Kick Motor which contains liquid fuel.

Step-3:

• The second apogee motor firing is carried out so that satellite attains needed angular velocity and acceleration for Geo-synchronization.

• This helps satellite to be in LOS from central earth stations.

• If required it is tracked through other countries earth stations.

Step-4:

• Further stabilization and attitude control is achieved using control of momentum/reaction wheels.

• Antennas and transponders are turned on which brings satellite into stabilized geostationary orbit.

• Examples of geostationary satellites are INTELSAT, COMSAT, INSAT etc.

Once the satellite is placed in the parking space (i.e. designated orbit), following activities need to be performed as part of maintenance.

• Orbit maintenance.

• Attitude maintenance.

• Thermal management.

• Power management.

• Battery maintenance.

• Payload operations.

• Software requirement.

12. (a) Discuss in details about telemetry and tracking. (INT 1)

TELEMETRY, TRACKING & COMMAND SUBSYSTEM:

• For the successful operation of a communication satellite, the TT & c subsystem is essential.

• It involves both the earth station & the space craft.

• The main functions of a space craft management are given below:

l. To control the orbit and attitude of the satellite

2. To monitor the status of all the sensors in the satellite.

3. To switch on/off some sections in communication system.

TELEMETRY SYSTEM:

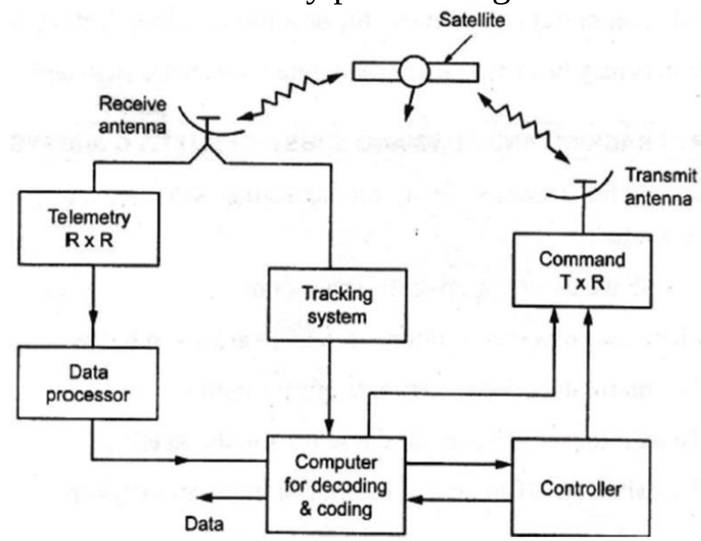
The telemetry system is present in the satellite, this subsystem collects data from many/all sensors present in the satellite and retransmit it into the earth station.

The data's from all the sensors are given to the telemetry unit, and this unit digitize the data and transmit the data using FSK or PSK.

• To maintain a high carrier to noise ratio, low data rate is normally used.

• At the controlling earth station a computer can be used to monitor, store and decode the telemetry data, so that the status of the space craft is immediately determined.

Alarms can also be used if any parameter goes outside the allowable limits.



TRACKING:

• Tracking is nothing but to find the position of the satellite in space.

• Tracking is very important during the transfer orbit & drift phase of the satellite launch.

• We know that lots of disturbing forces may change the attitude and orbits satellite, so it is necessary to track the satellite & send correction signals.

Range and the angular measurements from the earth station antenna, is used to determine the orbital elements.

• If sufficient number of earth stations with an adequate separation is observing the satellite, by simultaneous range measurement its position may be established.
• The position of a satellite can be determined within 100 m.

COMMAND:
• The command system is used to make changes in attitude and orbit, and also to control the communication subsystem.

• The shows the operation of the command subsystem.

• From the block diagram it is observed that,

• The status of the various subsystems and sensors are transmitted from the satellites to the earth station.

• The data processor convert the received signal in to digital format& decryption encryption are performed here.

• Then the data is given to the controller and the controller will transmit a control code i.e., command word is sent in a TDM frame to the satellite.

• After checking for validity in satellite, the word is again sent back to the control unit; again it is checked in the computer.

• If it is received correctly, then the execute command is sent to the satellite, then the command is executed.

• This process is used to avoid erroneous command and, the entire; process may take 5 or 10 s.

• The command and telemetry link are usually separated from the communication system.

• During the launch phase, the main TT&C system may not operable' because the satellite does not have the correct attitude and it does not expended its solar sails.

• At this time, a backup System is used to control most important sections of the satellites.

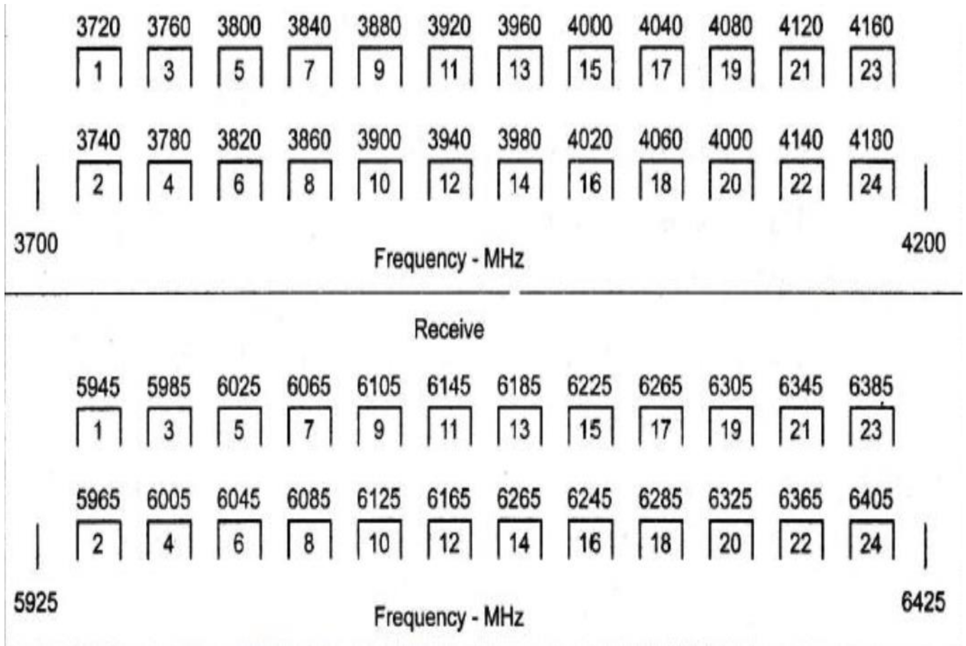
(b) Illustrate the function of an antenna subsystem.

COMMUNICATION SUBSYSTEM:

• ln a communication satellite, the communication subsystem is the important subsystem and all the subsystem are used to support the communication subsystem.

• Below Fig. shows the frequency arrangement satellite communication subsystem for the 6/4 GHz band (C band).

• The entire 500 MHz bandwidth is divided up into channels, 36 or 40 MHz wide, each are handled by a separate transponder.



TRANSPONDER:

• A transponder consist a BPF to select the particular channels band of frequencies.

• A down converter to convert 6 GHz frequency to 4 GHz at the output.
• A communication system may contain make number of transponders, some of them may be spares.
• Typically 12-44 transponders are used. Each transponder are supplied with input from the receive antenna.

• The output of the transponder is given to a switch matrix.

• These switch settings may be controlled from earth station, so that reallocations are possible.

FREQUENCY REUSE:

• The bandwidth allocated for C band service is 500 MHz, this is dividend into sub bands.

• The band width of a typical transponder is 36 MHz and 40 MHz guard band between transponders.

• By using the polarization isolation, the number of transponders used can be doubled.

• Polarization isolation is defined as the same carrier is used with opposite polarization so that the bandwidth may increased.

• For Example the same frequency can be used by more than one transponder.

• If it is linearly polarized, then horizontal & vertical polarization' if it is circularly polarized then right hand polarization or left hand polarization.

• This technique is referred as the frequency reuse.

13. (a) Discuss in details about satellite link design in details.(INT 1)

DOWNLINK ANALYSIS:

- The link through which the satellite transmit the signal and the earth station receive it,
- Subscript D is used to indicate the downlink in the following equation.

$$\left[\frac{C}{N_0}\right]_D = [EIRP]_D + \left[\frac{G}{T}\right]_D - [L]_D - [K]$$

Signal bandwidth is included in this equation, then, it becomes,

$$\left[\frac{C}{N_0}\right]_D = [EIRP]_D + \left[\frac{G}{T}\right]_D - [L]_D - [K] - [B]$$

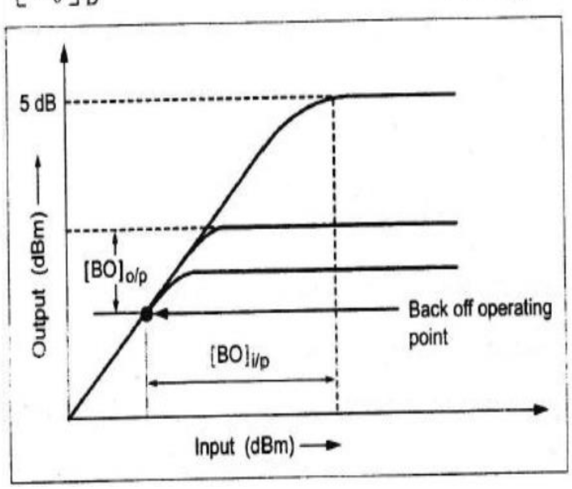
Output Back-off:

The relationship between input and output back off is given as,

$$[BO]_{o/p} = [BO]_{i/p} - 5 \text{ dB}$$

$$[EIRP]_D = [EIRP_{saturation}]_D - [BO]_{o/p}$$

$$\left[\frac{C}{N_0}\right]_D = [EIRP_{saturation}]_D - [BO]_{o/p} + \left[\frac{G}{T}\right]_D - [L]_D - [K]$$



Output Back-Off (OPBO):

• Output back-Off (OPBO) is the power level at the output of RF amplifier relative to maximum output level possible using the RF amplifier.

• EXAMPLE:

• Maximum output level = +40dB m

• Measured output level of RF Amplifier = +34dBm

• Output Back off (OPBO)= 6dB

Satellite TWTA Output:

The power output of TWTA is

$$[P_{TWTA}] = [EIRP]_D - [GT]_D + [\text{Transmit feeder loss}]_D$$

The saturated power output rate is given as,

$$[P_{TWTA}]_S = [P_{TWTA}] + [BO]_{o/p}$$

EFFECTS OF RAIN:

• Above 10 GHz, the rain is very important factor that affects the satellite propagation.

• If a large flat-bottomed vessels open to the rain, the rain rate is defined as the rate at which the water level in the container is rising.

• Its unit is millimeter/hour.

• It is measured for short duration.

Uplink Rain Fade Margin:

• Signal is attenuated and noise temperature is increased due to rain fall.

• [C/No] also decreased due to rain fall.

• The uplink carrier power at the satellite must be within certain limits for some specified mode of operation.

• Uplink power control mechanism is needed to compensate for rain fades.

• The output power from the satellite is monitored by a central control station and by each earth station.

• The output power of the earth station can be increased to compensate the effect of fading.

• The HPA of earth station must have sufficient power to meet the requirement of fade margin.

Downlink Rain Fade Margin:

• The total sky noise temperature is equal to addition of clear sky temperature and rain temperature.

$$T_{sky} = T_{clearsky} + T_{rain}$$

- So, received [C/No] is degraded due to rainfall by two ways,
- By attenuating the carrier wave.
- By increasing the sky noise temperature.
- Noise to carrier ratios are related to clear sky value by using this equation,

$$\left(\frac{N}{C}\right)_{rain} = \left(\frac{N}{C}\right)_{clear\ sky}\left[A + (A-1)\frac{T_a}{T_{sys,\ clear\ sky}}\right]$$

where,

T_a = Apparent absorber temperature

A = Rain attenuation

$T_{sys,\ clearsky}$ = System noise temperature under clear sky condition

• The rain attenuation is entirely absorptive at low frequencies (6/4 GHz) and at 1 mm/h of rainfall rate.

• At higher frequencies, scattering and absorption are having significant values.

• For digital signals, the required [C/No] ratio is determined by BER value.

• To provide the required rain-fade margin, the gain of the receiving antenna is increased.

(b) What are the main elements of a receiver used for obtaining the receiver noise temperatures briefly explain? (INT 1)

Noise Temperature:

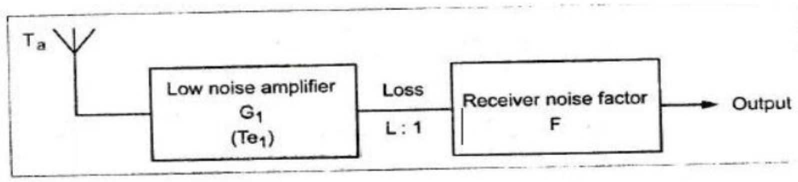


Fig. 6.6. Connection to find overall system noise temperature

It is given as

$$\boxed{T_S = T_a + T_{e1} + \frac{(L-1)\,T_0}{G_1} + \frac{L\,(F-1)\,T_0}{G_1}}$$

T_S = System temperature

F = Noise factor

G_1 = Gain of an amplifier

T_a = Antenna temperature

T_{e1} = Amplifier temperature

CARRIER TO NOISE RATIO:

- Performance of satellite line is measured by carrier to noise ratio, it is given as CNR or C/N

$\frac{C}{N}$ in db is given as $\left[\frac{C}{N}\right]$

$$\left[\frac{C}{N}\right] = [P_R] - [P_N]$$

$$\left[\frac{C}{N}\right] = [EIRP] + [G_R] - [L] - [K] - [T_S] - [$$

$$\left[\frac{G}{T}\right] = [G_R] - [T_S]\,\frac{dB}{K}$$

So, $$\left[\frac{C}{N}\right] = [EIRP] + \left[\frac{G}{T}\right] - [L] - [K] - [B_N]$$

$$P_N = K\,T_N\,B_N = N_0\,B_N$$

So, $$\left[\frac{C}{N}\right] = \left[\frac{C}{N_0 B_N}\right] = \left[\frac{C}{N_0}\right] - [B_N]$$

$$\left[\frac{C}{N_0}\right] = \left[\frac{C}{N}\right] + [B_N] \quad \text{dB Hz.}$$

$$\left[\frac{C}{N_0}\right] = [EIRP] + \left[\frac{G}{T}\right] - [L] - [K]\ \text{dB} \cdot \text{Hz}$$

Eb/No Calculation:

- It is the ratio of signal to noise ratio of the system.
- It can be calculated as follows.
- Available Eb/N_o = Over all downlink (C/N_o) / Input data rate
- Available Eb/N_o (dB)= Over all downlink (C/N_o)(dB) - Input data rate (dB)
- = Over all downlink(C/N_o)(dB) - 10log (input data rate in KB*10^3).

14. Describe the troposphere and Ionosphere effects on radio wave propagation in detail. (INT 1)

Atmospheric layers

The atmosphere can be split up into a variety of different layers according to their properties.

Although there are is a number of different ways of classifying the different atmospheric regions - typically different scientific displaces may have their own nomenclature as a result of their interest in different properties.

The lowest area in the meteorological system is referred to as the Troposphere. This extends to altitudes of around 10km above the Earth's surface. Above this is the Stratosphere that extends from altitudes around 10 to 50km. Above this at altitudes between 50 and 80 km is the Mesosphere and above this is the Thermosphere: named because of the dramatic rise in temperatures here.

From the viewpoint of radio propagation, there are two main areas of interest:

- ***Troposphere:*** As a very approximate rule of thumb, this area of the atmosphere tends to affect signals more above 30 MHz or so.
- ***Ionosphere:*** The ionosphere is the area that enables signals on the short wave bands to traverse major distances. It crosses over the meteorological boundaries and extends from altitudes around 60 km to 700 km. The region gains its name because the air in this region becomes ionised by radiation primarily from the sun. Free electrons in this region have affect radio signals and may be able to refract them back to Earth dependent upon a variety of factors.

Troposphere

The lowest of the layers of the atmosphere is called the troposphere. The troposphere extends from ground level to an altitude of 10 km.

It is within the tropospheric region that what we term the weather, occurs. Low clouds occur at altitudes of up to 2 km and medium level clouds extend to about 4 km. The highest clouds are found at altitudes up to 10 km whereas modern jet airliners fly above this at altitudes of up to 12 km.

Within this region of the atmosphere there is generally a steady fall in temperature with height. This affects radio propagation because it affects the refractive index of the air. This plays a dominant role in radio signal propagation and the radio communications applications that use tropospheric radio-wave propagation. This depends on the temperature, pressure and humidity. When radio communications signals are affected this often occurs at altitudes up to 2 km.

The ionosphere

The ionosphere is the area that is traditionally thought of as providing the means by which long distance communications can be made. It has a major effect on what are normally thought of as the short wave bands, providing a means by which signals appear to be reflected back to earth from layers high above the ground.

The ionosphere has a high level of free electrons and ions - hence the name ionosphere. It is found that the level of electrons sharply increases at altitudes of around 30 km, but it is not until altitudes of around 60km are reached that the free electrons are sufficiently dense to significantly affect radio signals.

The ionization occurs as a result of radiation, mainly from the sun, striking molecules of air with sufficient energy to release electrons and leave positive ions.

Obviously when ions and free electrons meet, then they are likely to recombine, so a state of dynamic equilibrium is set up, but the higher the level of radiation, the more electrons will be freed.

Much of the ionisation is caused by ultraviolet light. As it reaches the higher reaches of the atmosphere it will be at its strongest, but as it hits molecules in there upper reaches where the air is very thin, it will ionize much of the gas. In doing this, the intensity of the radiation is reduced

At the lower levels of the ionosphere, the intensity of the ultraviolet light his much reduced and more penetrating radiation including x-rays and cosmic rays gives rise to much of the ionization.

As a result of many factors it is found that the level of free electrons varies over the ionosphere and there are areas that affect radio signals more than others. These are often referred to as layers, but are possibly more correctly thought of regions as they are quite indistinct in many respects. These layers are given designations D, E, and F1 and F2.

15. What is CDMA? Explain with the aid of DS and FH-CDMA system. (MODEL)

CDMA (Code-Division Multiple Access) refers to any of several protocols used in second-generation (2G) and third-generation (3G) wireless communications. As the term implies, CDMA is a form of multiplexing, which allows numerous signals to occupy a single transmission channel, optimizing the use of available bandwidth.

CDMA concept:

• In code-division multiple access (CDMA) satellite system, uplink stations are identified by uniquely, separable address codes embedded within the carrier waveform.

• Thus, any uplink earth station can access the entire bandwidth of a transponder whenever desired.

• In other words a number of uplink earth stations can access the entire bandwidth of a transponder all the time superimposing their waveforms on the downlink.

• Unlike the DAMA system the CDMA system does not require a centralized satellite network.

• A receiving earth station identifies the carrier intended for it with the proper address code.

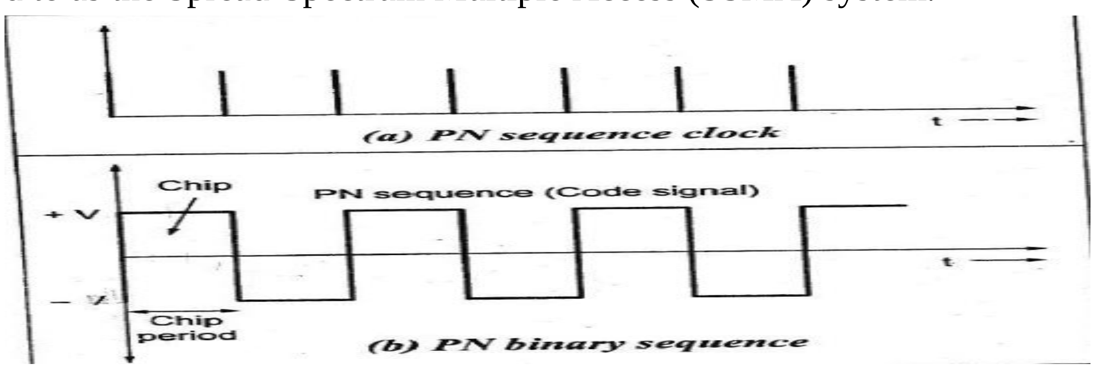
• These address codes are usually in the form of periodic binary sequences that either modulate the carriers directly or change the frequency state of the carriers.

• If the address code directly modulates the carrier, then the system is referred to as the direct sequence CDMA (DS-CDMA).

• If the address code continually changes the frequency of the carrier, then the system is referred to as the Frequency hopped CDMA (FH-CDMA).

• Super imposing the address codes on modulated, uplink carriers generally increases the bandwidth.

• Due to this spreading of the carrier spectrum, the CDMA system is also referred to as the Spread-Spectrum Multiple Access (SSMA) system.



DSSS transmitter:

• In this modulation of a carrier is being done by a digital code sequence whose bit rate is much higher than the information signal band width.

• Here the output of several DS spread spectrum modulators, say N are using their own codes pi(t) where i=1,2... N.

• After combining these together these are transmitted.

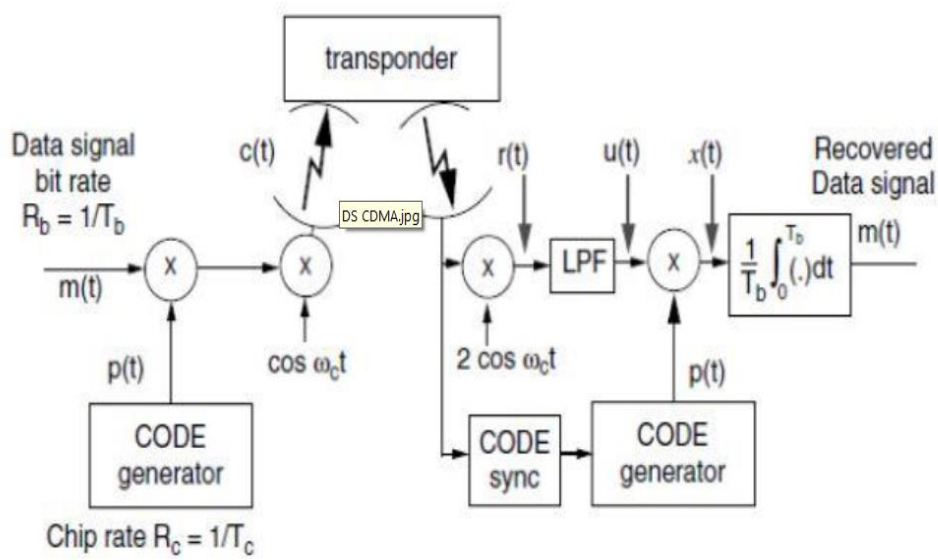
• It should be noted that each of the user is transmitting data at the carrier frequency and each pseudo-random frequency pi(t) has the same chip rate.

• The data rate for each user is also the same Fb.

• It is clear that multiplication of m1(t) produces a signal whose spectrum is the convolution of the spectrum of s1(t) with the spectrum of p1(t).

• Thus assuming that the signal m1(t) is relatively narrow band compared with the code or spreading signal g1(t), the product p1(t)*m1(t) will be approximately the bandwidth of p1(t).

DSSS Block diagram:



DSSS RECEIVER:

• At the receiver side arrangements are being made to receive the message from the desired group.

• Here the corresponding p1(t) is generated at the receiver and is perfectly synchronized with the received signal from the corresponding user.

• The first step in the receiving process is to multiply the incoming signal by p1(t).

• Suppose that signal of p1(t) is to be received, than at the receiver side the incoming signal would be multiplied by p1(t).

• The RF signal is first down converted to IF and then the p1(t) is multiplied to this IF signal and then the product is compared with the received IF signal in the correlator.

• The function of the correlator is to compare the two signals and recover the original signal data.

• Essentially the correlator subtracts the recovered PSK carrier + chip code from the received PSK carrier + chip code + data.

• The resultant is data.

• In fact the output of correlator which is the desired signal occupies the information bandwidth centered at the intermediate frequency.

• It is applied to conventional demodulator with bandwidth just wide enough to accommodate the desperado signal.

• The conventional demodulator has been represented by unit bit decision.

FH-CDMA:

• With frequency hopping, each earth station within a CDMA network is assigned a different frequency hopping pattern.

• Each transmitter switches from one frequency band to the next according to their reassigned pattern.

FH CDMA Transmitter:

• Here in first sequence, frequency band F2 transmits in time slot t1.

• F4 in time slot t2

• F3 in time slot t3

• F5 in time slot t4

• F1 in time slot t5

• F2 in time slot t6

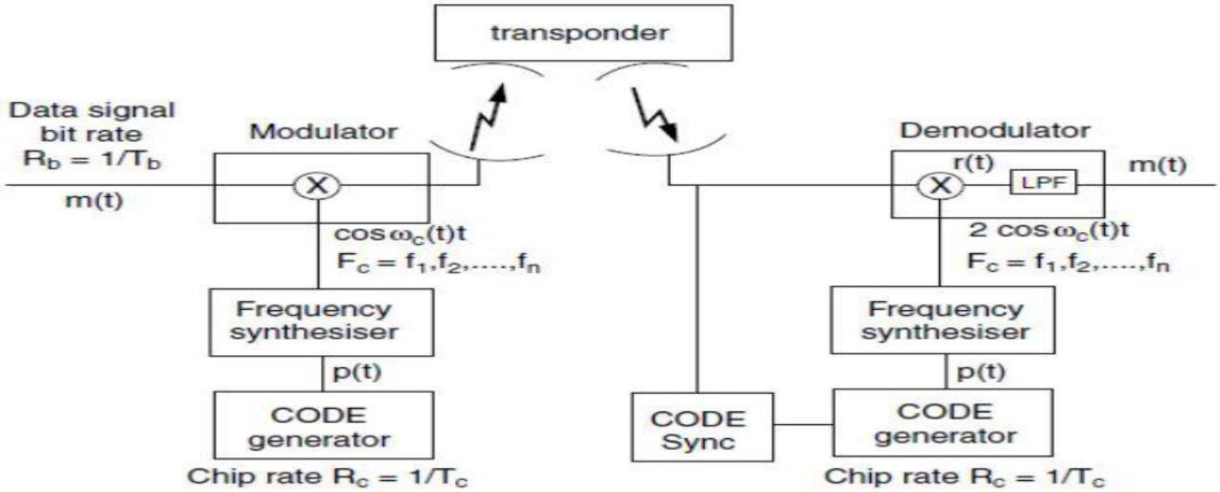
• The resultant pattern is called frequency hopping pattern.

• Actually these FH pattern is determined by a binary code and each station uses a different code sequence.

• It uses a FSK modulator. Thus FH spread spectrum is FM or FSK technique.

• The code pattern generator consists of PN code generator and a frequency synthesizer capable of responding to the coded output from the code generator.

• It must be remembered that the signal to be frequency hopped is usually a BPSK signal although M-ary FSK, MSK may be employed.



RECEIVER:

• A simple block diagram of FH receiver is shown in the figure.

• Here a local frequency synthesizer is switched with a synchronized replica of the transmitted PN code and the resultant signal is multiplied to the received FHSS signal.

• This multiplication removes the frequency hops on the received signal and thus the original modulated signals remains untouched.

• This signal is then applied to the conventional demodulator to get the orthogonal data/information.

Advantages of CDMA:

• It is simple to operate since it does not require any transmission synchronization between stations. The only synchronization is that of the receiver to the sequence of the received carrier.

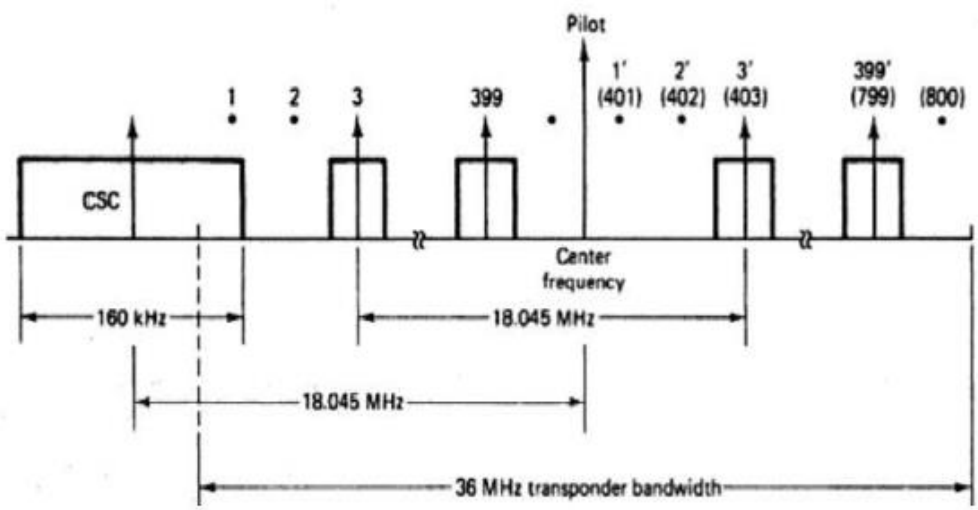
• It offers useful protection properties against interference from other systems and interference due to multiple paths; this makes it attractive for networks of small stations with large antenna beam width and for satellite communication with mobiles.

• It is highly secure.

16. (a) Write a detailed note on SPADE system. (MODEL 2mark)

• Spade Single channel per carrier Pulse code modulated Multiple Access Demand Equipment

• It was developed by comsat. (to use on Intelsat satellites)



 Channeling scheme for spade system:

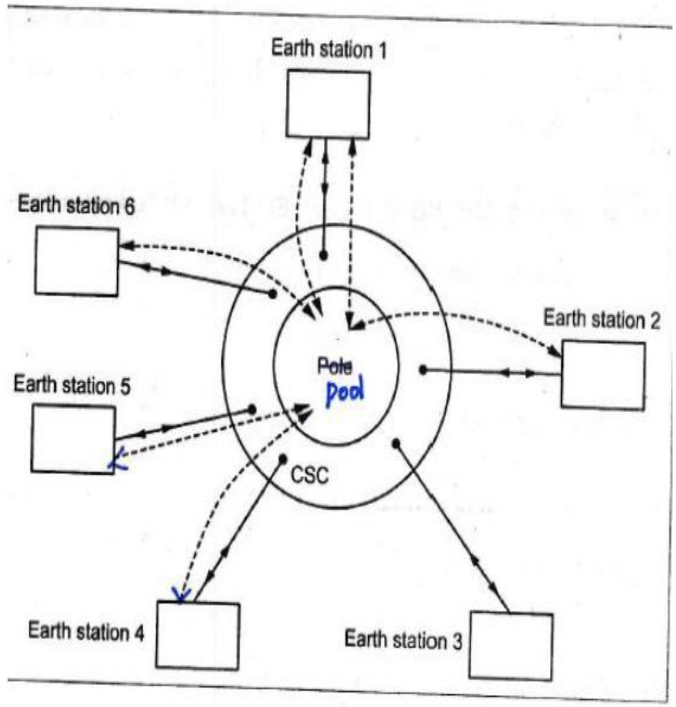
• Common signaling channel (CSC) is needed in this system.

• CSC bandwidth: 160 KHz; Center frequency: 18.045 MHz.

• Voice channel I and channel 2 are left vacant to avoid interference. The corresponding channels 401 and 402 are left vacant.

• Channel 400 and Channel 800 are left vacant to avoid interference.
• So, totally 6 channels are left vacant.
• 794 channels are used.
• All the earth stations are permanently connected through CSC.

➢ SPADE COMMUNICATION SYSTEM:



Six earth stations are connected through CSC.
• Each earth station can generate any one of 794 carrier frequencies using frequency synthesizers.
• The list of currently available frequencies are available with each earth station.
• It is continuously updated.
• For example, a call to earth station 6 is initiated from earth station 3.
• Then station 3 select a currently available frequency pair randomly, and signal this message to station 6 through CSC.
• Station 6 gives acknowledgement through CSC.
• Once the circuit is established, the other earth stations are informed to remove the selected frequency pair from the available list (through csc).
• The round trip time between earth station 3 initiate a call and station 6 acknowledge it will be 600 ms.
• During this round trip time the selected frequency pair may be assigned to another circuit.
• At that time, CSC gives the information to earth station 3 to update and to choose another frequency randomly.
• If a call is completed, then the circuit will be disconnected and the frequency will be returned to the Pool.
• So, signaling information is routed through the CSC.

• Each earth station has DASS unit (Demand Assignment Signaling and Switching unit).
• It is used to perform the functions needed by the CSC.

(b) Describe the antenna systems used in earth station.

EARTH STATION ANTENNAS:

• The most important subsystems of the RF terminal is the earth station antenna.

• It provides a means of transmitting the modulated RF carrier to the satellite with uplink frequency spectrum and receives the RF carrier from the satellite within the downlink frequency spectrum.

The basic requirements of an earth station below: 1. The antenna must have a high directive gain.

• The antenna must focus its radiated energy into a narrow beam to illuminate the satellite antenna in both the transmit and receive modes to provide the required uplink and downlink carrier power.

2. The antenna radiation pattern must have a low side lobe level to reduce interference from unwanted signals and also to minimize interference into other satellites and terrestrial systems. 3. The antenna must be rotated or steered easily so that a tracking system can be employed to point the antenna beam accurately. 4. The antenna must have a low noise temperature.

• The ohmic losses of the antenna must also be minimum.

BASIC TRANSMISSION THEORY:

• In satellite communication systems, there are two types of power calculations.

• Those are transmitting power and receiving power calculations.

• In general, these calculations are called as **Link budget calculations**.

• The unit of power is **decibel**.

1. Equivalent Isotropic Radiated Power (EIRP)

• Maximum power flux density at the distance r from the transmitting antenna is given as,

$$\psi = \frac{G \cdot P}{4\pi r^2}$$

where, G = Gain of the transmitting antenna

P = Transmit power

r = Distance

- Here, G.P is known as EIRP,

EIRP = G.P

- An isotropic radiator with G.P as input power will produce the same flux density.
- If EIRP is given in decibel, then,

[EIRP] = [G] + [P] dB W

- [G] is in dB
- [P] is in dB W
- If the power is given in watts, then, convert it into dB W using l0 log (P in watts)
- For paraboloidal antenna, G is given as,

$$\boxed{G = \eta\,(10.472 f_C D)^2}$$

η = Aperture efficiency

f_C = Carrier frequency

D = Reflector diameter (in meters)

If D is in feets, then, $\boxed{G = \eta\,(3.192 f_c D)^2}$

17. What inter satellite? Explain in detail.(MODEL 2mark)

INTER SATELLITE LINK:

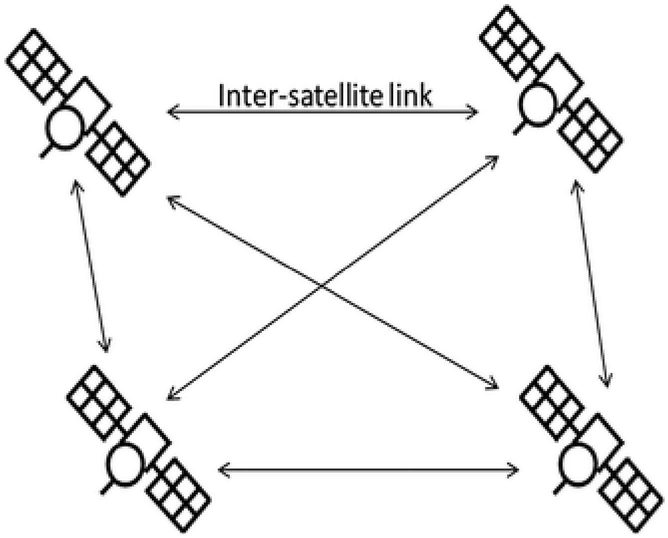
• Also known as "cross linking“

• Intersatellite communication allows satellites in a constellation to link to one another.

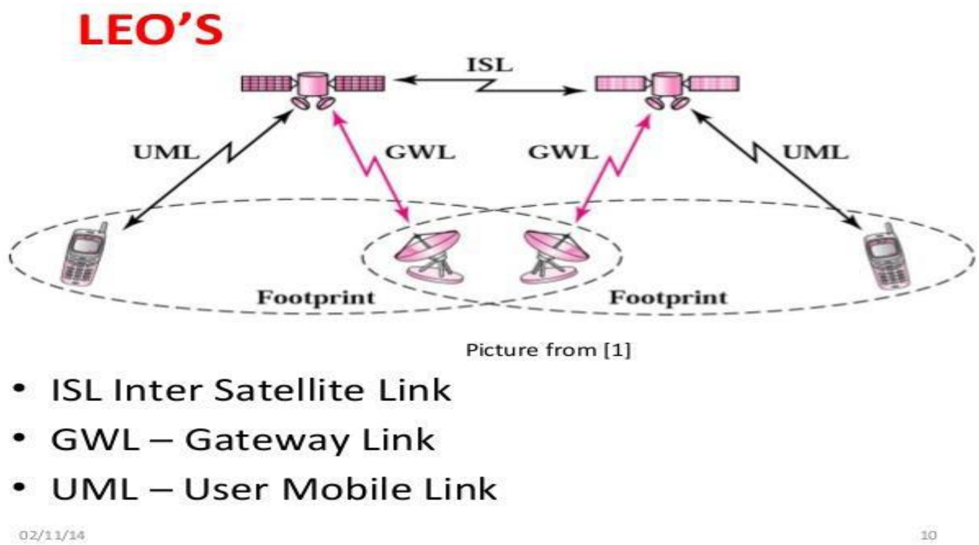
• Since small satellite constellations in low earth orbit are not in constant contact with the ground, intersatellite links allow data to be shared between adjacent satellites.

• An inter-satellite link (ISL) is a wireless link between satellites, and ISLs are now being established in communication satellite constellations and global navigation satellite systems (GNSSs).

• Inter-satellite links (ISLs) are used for ranging and communication between navigation satellites and can also serve space users that are outside the navigation constellation.



LEO’s ISL:



ISL:

• Laser satellite communication involves transmission at frequencies in the 10^14 (optical) range which is around seven or eight orders of magnitude higher than the radio frequency (RF) systems.

• Transmission at such frequencies provides three main advantages, namely the greater bandwidth, smaller beam divergence angles and smaller antennas.

• On a **clear day**, a laser beam can be **transmitted several miles** but when atmospheric conditions involve fog, mist, rain or smog, the transmission is limited to shorter distances.

• In fibre optic communications, laser transmission is carried out through guided media of optical fibres.

• This system is capable of transmitting 4 gigabits of information per second over a span of some 120 km.

• Optical computer solves the problems of slowness and heat build up associated with electronic computers.

• This is because here light is used instead of electrical current.

• Further light being at the upper end of the electromagnetic spectrum can be encoded with much more information.

• Also an optical circuit has a zero resistance to flow and therefore is capable to carry much more information than the equivalent sized electronic circuit.

• There is no problem in using optical signals in parallel channels.

• Being atmospheric dependent, laser communication therefore cannot be used for communication between earth station and a geosynchronous satellite.

• However, it is quite suitable for communication between the satellites themselves or deep space communication.

• A typical example for such a cross satellite laser communication is that shown in Fig.

• Here GSs are the geosynchronous satellites whereas

• ESS are some other satellites (e.g. earth observation or special purpose satellites).

• These ESs communicate to GSs with laser communication and eventually the GSs communicate with the earth station through RF microwave communication.

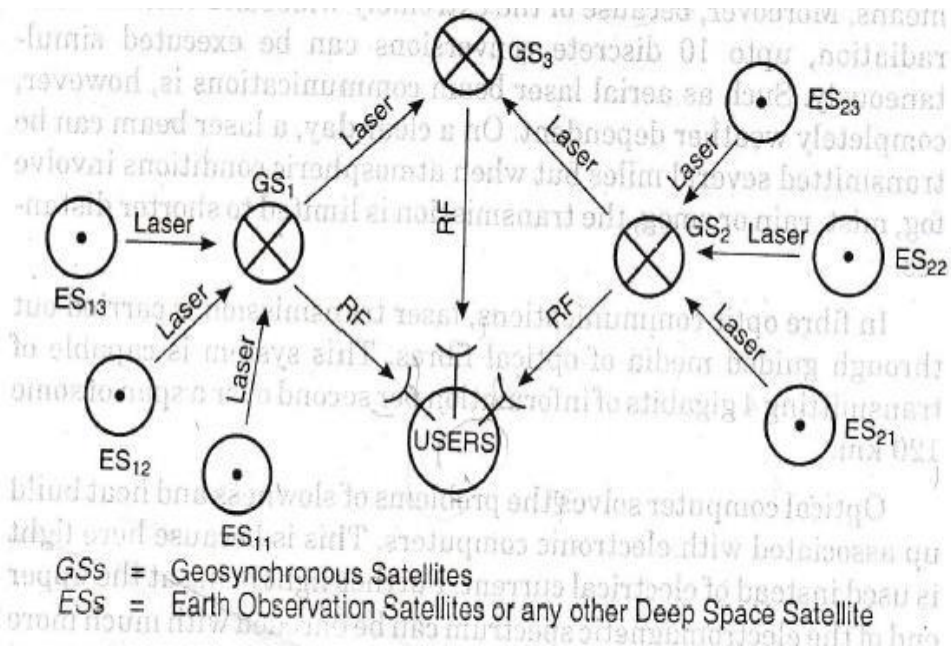
• The optical transmitters and receiver packages are smaller and lighter than the equivalent RF microwave subsystems.

• This helps in reducing the spacecraft cost and weight.

• For deep space communication where the planets desired to be communicated with the earth are quite far, the received signals are very weak and then this intersatellite laser communication solves problem.

• Here the deep space-craft will have deep space optical link with a geosynchronous satellite which provides microwave link to the earth station.

• Conclusively, therefore the laser satellite communication serves for intersatellite communications and here the analysis of cross optical link is necessary.



18. Write a detailed note an optical beam acquisition tracking and pointing. (MODEL)

OPTICAL BEAM ACQUISITION, TRACKING AND POINTING:

• In Optical Satellite Communication the transmitting beam should be quite narrow because it would have maximum power spectrum.

• The narrowness of the optical beam is typically 5 micro radians.

• Notice that this width is several orders of magnitude less than that of a radio beam and this is an advantage for protection against interference between systems.

• But it is also a disadvantage since the beam width is much less than the precision of satellite attitude control (typically 0.1_ or 1.75 m rad).

• Consequently an advanced pointing device is necessary; this is probably the most difficult technical problem.

1. ACQUISITION:

• The beam must be as wide as possible in order to reduce the acquisition time.

• But this requires a high-power laser transmitter.

• A laser of lower mean power can be used which emits pulses of high peak power with a low duty cycle.

• The beam scans the region of space where the receiver is expected to be located.

• When the receiver receives the signal, it enters a tracking phase and transmits in the direction of the received signal.

• On receiving the return signal from the receiver, the transmitter also enters the tracking phase.

• The typical duration of this phase is 10 seconds.

• Before communication can commence, a high power beam laser located on LEO end has to scan over the region of uncertainty until it illuminates the GEO terminal and is detected.

• Once the GEO terminal receives the LEO communication beam it switches from the beacon to the forward link communication beam.

• Communication link between the LEO and GEO space craft is established.

2. TRACKING:

• The beams are reduced to their nominal width.

• Laser transmission becomes continuous.

• In this phase, which extends throughout the following, the pointing error control device must allow for movements of the platform and relative movements of the two satellites.

• In addition, since the relative velocity of the two satellites is not zero, a lead-ahead angle exists between the receiver line of sight and the transmitter line of sight.

• As demonstrated below, the lead-ahead angle is larger than the beam width and must be accurately determined.

• In this mode the on-board disturbances which introduce pointing fitter into the communication beam are alternated by means of a fine pointing control loop (FPL) to enable acceptable communications to be obtained.

• These disturbances are due to thruster firings, solar arrays drive mechanisms, instrument harmonics and other effects.

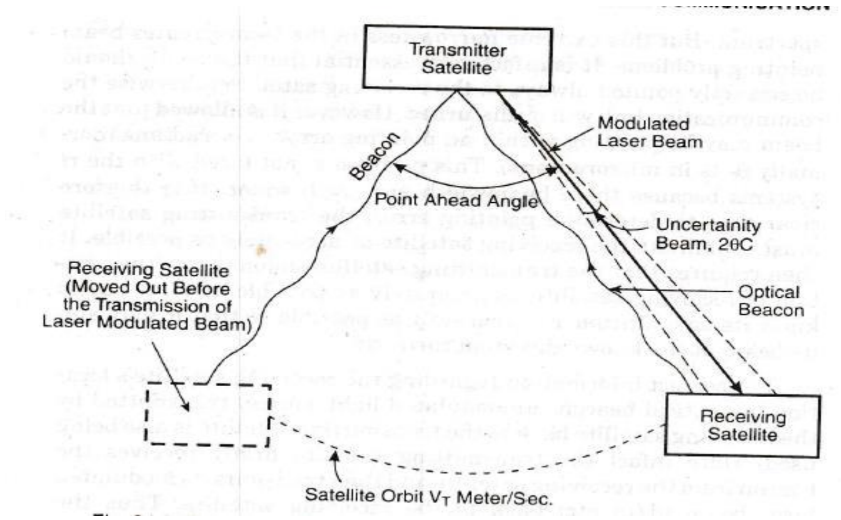
3. POINT AHEAD ANGLE:

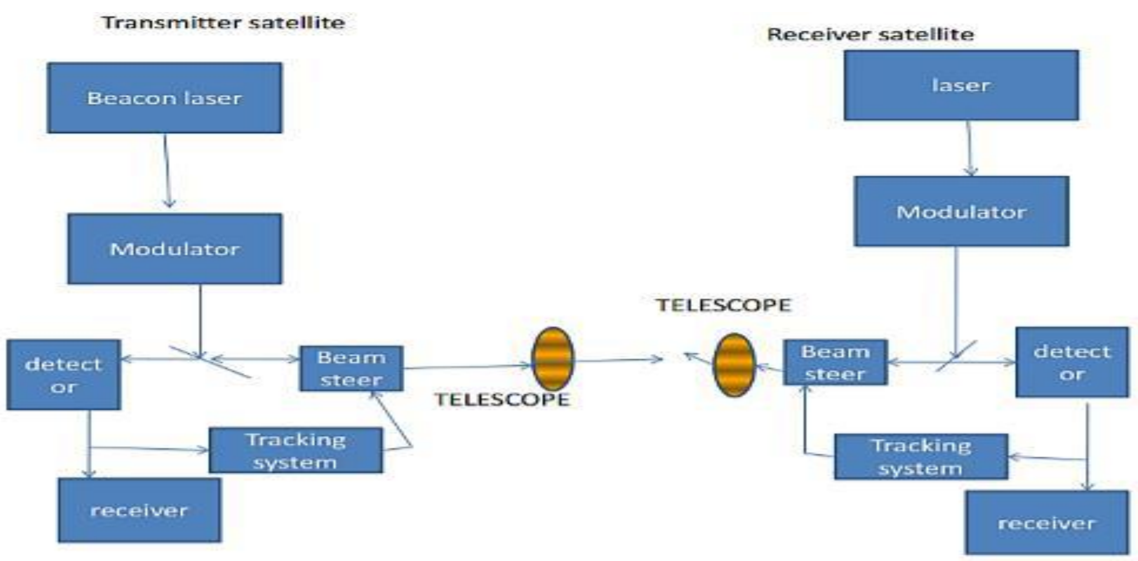
• This is needed because of the relative orbital motion between the satellites which calls for the transmitted beam to be aimed at a point in space where the receiving terminal will be at the time of arrival of the beam

• Point ahead angle= 2Vt /c

• Vt = transverse Velocity component of the satellite.

• C = Speed of light





Optical Link Model

POINTING:

Pointing depends on

➢Accuracy to which one satellite knows the location of the other

➢Accuracy to which it knows its own attitude

➢Accuracy to which it can aim its beam knowing the required direction

19. (a) Describe the broad cast satellite service. (MODEL)

PACKET SATELLITE SERVICES

- The satellite system using packet communication is usually in the form of networks and the most common name of such networks is packet satellite networks. These networks use packet switching for accessing the satellite channel.
- The first kind of such packet network was ARPANET but the use of satellite for packet communication started with the development of ALOHA systems.
- Packet switching involves dividing the data messages into small bursts or information and transmitting them through communication networks to their intended destinations using computer controlled switches.
- A variety of data formats and services may be provided by satellite networks. These may be such as telephony signals, TV (Visual and audio) signals, computer generated signal(computer communication), broadcast data for computer communications, teleprinter, larger screen teleconferencing, interactive education, medical data, emergency services, electronic mail, newspaper boardcast, control data for power systems and utilities, traffic information, weather and land surveillance,navigational data for ships and airplanes and military strategic data
- Satellite channel used with packet switching employs random access. Each station tries to access the satellite through random access in time domain and thus it is multi access broadcast type. In the basic form of random access no network timing is present and each station transmits bursts of packets as necessary at random and some bursts overlap.
- Random access is inefficient because retransmission must occur when packets collide and hence modifications in ALOHA systems have also been developed.

ALOHA

- Here the packets are not being sent in FDMA or TDMA i.e. the user does not wait his 'turn' as in TDMA nor is he assigned a narrow bandwidth as in FDMA. Each station transmits a packet whenever its buffer has one and the stations do not need synchronization.
- The random multiple access schemes works on four different steps, namely the transmission, listening, retransmission and time out. In the transmission step which is the first step, users transmit at any time they desire encoding their transmission with an error detection code.
- In the next step known as listening, the user listens an acknowledgement (ACK) from the receiver. There is a possibility that the packets sent from the different terminals may overlap and result in transmission error. For such a situation of overlapping packets are said to have *collided* and the users receive a negative acknowledgement (NAK).
- After having received NAK, the third step of random access technique is followed by retransmission of collided packets. In order that these retransmitted packets may not collide again, the interval of packet retransmission is randomized in each terminal. In other words now the users retransmit after a *random delay*.

- In case if after a transmission the user does not receive either an ACK or NAK within a specified time, the user retransmits the message. This is the final step of random multiple access and is termed time out. T
- The analysis of ALOHA system involves message arrival statistics. Thus in the above pure ALOHA system only 18% of the channel capacity would be utilized. In other words though in such random access technique control mechanism is simple, the channel capacity gets wasted (or not fully utilized).

Slotted ALOHA (S-ALOHA)

- To improve the usage of channel capacity of Pure ALOHA stem, discussed above, a technique termed *slotted* ALOHA (S-ALOHA) is being utilized. Here a sequence of synchronization pulses is broadcast to all stations and the messages are required to be sent in the slot time between synchronization pulses.
- Messages are transmitted only at the beginning of a time slot and as with the pure ALOHA, packet lengths are constant. This technique reduces the collision rates of packets by half since only messages transmitted in the same slot can interfere with one another.
- A sequence of synchronization pulses is broadcast to all stations and the messages are required to be sent in the slot time between synchronization pulses. It must be remembered that the messages can be started only at the beginning of a time slot and as with the pure ALOHA, packet lengths are constant. This technique reduces the collision rates of packets by half since only messages transmitted in the same slot can interfere with one another.
- The plot of Normalized traffic Vs normalized throughput is shown in fig. Here the maximum value of p is $1/e = 0.37$ which shows an improvement of two times over pure Aloha system.
- Thus in slotted Aloha if a negative Acknowledgement (NAK) occurs; the user retransmits after a random delay of an integer number of slot times.
- The slotted Aloha shows only 36% utilization of the satellite channel.

Reservation-ALOHA(R-ALOHA)

- To increase the utilization of this channel capacity in ALOHA system another scheme known as reservation-ALOHA(R-ALOHA) was utilized.
- The objective of this slot reservation scheme is to reserve a particular time slot for a given station which would ensure that no collision would take place. This reservation of time slot would result in some overhead cost and/or increased complexity of the control mechanisms intransmitting stations.
- These reservation schemes in Aloha system may be implicitor explicit .Actually it is the implicit reservation scheme of Aloha protocol that is called R-ALOHA. In this scheme whenever a station successfully transmits its packets in a slot, all the stations internally assign that slot in subsequent frames for exclusive use by the successful station.

(b) Describe briefly about the role of satellite in future network.

FUTURE Satellite Technology

- Tiny earth-orbiting spacecraft known as nanosatellites are now possible due to breakthroughs in micro electro mechanics that permit engineers to build extremely small yet fully functional devices.
- With today's satellite launch costs averaging around $20,000 per pound lifted into space, nanosatellites could revolutionize the future of space access by significantly reducing the size, mass, power requirements, complexity and ultimately the costs of space systems.
- The small satellite concept fosters a faster evolution in space science and introduces and tests state-of-the-art space technology. Of the technologies required to design a miniaturized and yet autonomous vehicle, nanoelectronics is at the forefront. The field of nanoelectronics is primarily concerned with integrated circuit (IC) technology for scale sizes well below 100 nanometres.
- It is in this realm that the quantum - mechanical nature of the electron becomes of paramount importance. With the tools of quantum physics, reduction in the size of individual transistors has yielded the quantum dot; a three-dimensional structure for confinement of a single electron. The theoretical study in this thesis will show that the

  width in p-n junctions is generally underestimated for curved interfaces by textbook formulas.
- This result is significant for semi-cylindrical quantum dots which is the logical result of continued down scaling in semiconductor devices.

GATEWAY

In telecommunications, the term **gateway** has the following meaning:

- In a communications network, a network node equipped for interfacing with another network that uses different protocols.
- A gateway may contain devices such as protocol translators, impedance matching devices, rate converters, fault isolators, or signal translators as necessary to provide systeminteroperability. It also requires the establishment of mutually acceptable administrative procedures between both networks.
- A protocol translation/mapping gateway interconnects networks with different network protocol technologies by performing the required protocol conversions.
- Loosely, a computer or computer program configured to perform the tasks of a gateway. For a specific case, see default gateway.
- Gateways, also called protocol converters, can operate at any network layer. The activities of a gateway are more complex than that of the router or switch as it communicates using more than one protocol.
- Both the computers of Internet users and the computers that serve pages to users are host nodes, while the nodes that connect the networks in between are gateways. For example, the computers that control traffic between company networks or the computers used by internet service providers (ISPs) to connect users to the internet are gateway nodes.
- In the network for an enterprise, a computer server acting as a gateway node is often also acting as a proxy server and a firewall server. A gateway is often associated with both a router, which knows where to direct a given packet of data that arrives at the gateway, and a switch, which furnishes the actual path in and out of the gateway for a given packet.
- On an IP network, clients should automatically send IP packets with a destination outside a given subnet mask to a network gateway. A subnet mask defines the IP range of a private network. For example, if a private network has a base IP address of 192.168.0.0 and has a subnet mask of 255.255.255.0, then any data going to an IP address outside of 192.168.0.X will be sent to that network's gateway. While forwarding an IP packet to another network, the gateway might or might not perform Network Address Translation.
- A gateway is an essential feature of most routers, although other devices (such as any PC or server) can function as a gateway. A gateway may contain devices such as protocol translators, impedance matching devices, rate converters, fault isolators, or signal translators as necessary to provide system interoperability. It also requires the establishment of mutually acceptable administrative procedures between both networks.

20. Discuss about. (a) ATM over satellite (b) Global positioning satellite system.

ATM over satellite

Asynchronous Transfer Mode (ATM)

- When information is transferred through a network it passes through a number of stages. The information is assembled into *packets*, and in broadband networks the packets are multiplexed to form a single bit stream.
- Then there is the actual transmission of signals from node to node, and at the nodes the signals will undergo some form of switching. The complete process of getting information from source to destination is referred to as a *transfer mode*.
- With the ATM, the packets originating from an individual user do not have to be transmitted at periodic intervals. This is what is meant by *asynchronous*. For comparison, the time division multiplexing described in Sec. 10.4 is a form of *synchronous* transmission.
- Asynchronous transfer mode is commonly denoted by ATM, and the packets are known as *cells*. Cells can be given time slots on demand as and when required.
- The ATM is used in terrestrial networks, to carry a mixture of signals, for example voice, data, video, and images.
- A natural development is to extend the ATM networks to include satellite links to bring the services of ATM to remote or isolated users, and also to provide broadcast facilities.
- Satellite links have the additional advantage of enabling *local area networks* (LANs) that are widely separated geographically to be linked together, thus forming a *wide area network* (WAN).
- ATM over satellite is usually abbreviated as SATM in the literature (for satellite ATM). Satellites may be incorporated into ATM networks in a number of ways, but there are certain problems unique to satellite links that have to be addressed in all cases.
- ATM satellite networks can be broadly classified as
  - *bent pipe architecture*
  - *On-board processing architecture.*

Bent pipe architecture

- The satellite acts as a conduit between two earth stations, which may be fixed or mobile.
- Bent pipe *relay architecture* illustrated in Fig.
- This makes use of geostationary satellites, where the satellite link can be thought of as replacing a terrestrial link between two fixed points.
- The satellite link is likely to operate at a lower bit rate than the terrestrial ATM services connecting through it and some rate adaptation will be necessary. This is provided by the modems.
- The *ATM link accelerator* (ALA), provides the adaptive error-control coding mentioned earlier. Cell switching (using the VPI and VCI fields) is carried out at the ATM end stations, not in the satellite.

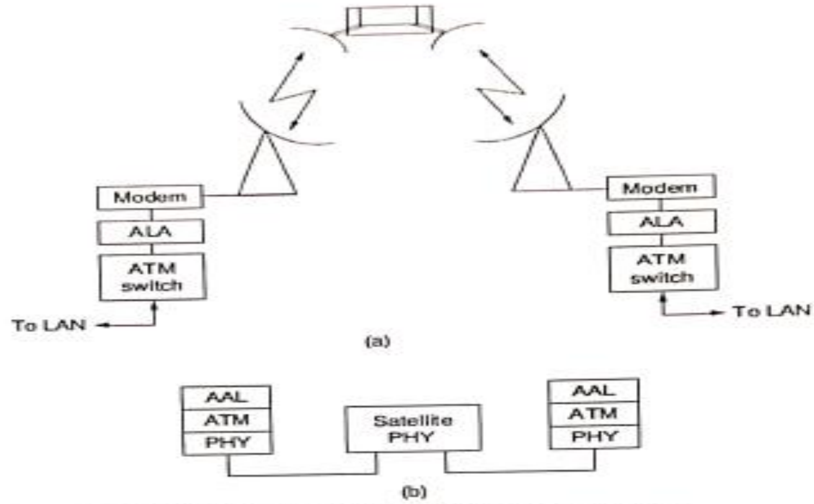


Figure 15.6 (a) "Bent pipe" satellite relay; (b) layer architecture.

GLOBAL POSITIONING SATELLITE SYSTEM (GPS)

In the GPS system, at an altitude of 20,000 km, a constellation ie. a group of 24 satellites circle the earth in six near circular inclined orbits, with 4 in each orbit. The ascending nodes of the orbits are separated by 60° and the inclination of each orbit is 55°. By receiving signals from any four of these satellites, the receiver position in latitude, longitude and altitude can be determined accurately.

Terrestrial Surveying Method

In terrestrial surveying method, geodetic position markers are used instead of satellites. In this method, it's enough to have only 3 markers to determine the latitude, longitude and altitude. This is done by means of triangulation.

But in GPS, a time marker is also required in addition with the position markers to get simultaneous measurements from 4 satellites.

Requirements

- The GPS system uses one-way transmissions ie. from satellites to users. Therefore, the user needs only a GPS receiver, not a transmitter.
- The receiver should be able to measure time. From this time, the propagation delay and hence the range to each satellite can be determined.
- Each satellite broadcast its ephemerisie the table of its orbital elements. From this, the satellite position can be calculated. From all these, the position of the observer (user) can be computed accurately.

ECEF Coordinate System

The GPS uses the geocentric-equatorial coordinate system. It is called the earth-centered, earth fixed (ECEF) coordinate system. Here, the range from an observer to a satellite ρ_{on} is obtained from,

$$\rho_{on}^2 = (x_n - x_o)^2 + (y_n - y_o)^2 + (z_n - z_o)^2 \qquad -(1)$$

Where, (x_n, y_n, z_n) –Coordinates for the satellite 'n'

(x_o, y_o, z_o) – Coordinates for the observer 'o'

Using this, the position of the observer can be calculated.

Since the satellites are moving, their positions must be tracked accurately. Also, the satellite orbits can be predicted from the orbital parameters and these parameters are continually updated and sent to the satellites by a master control station.

GPS Transmitter and Receiver

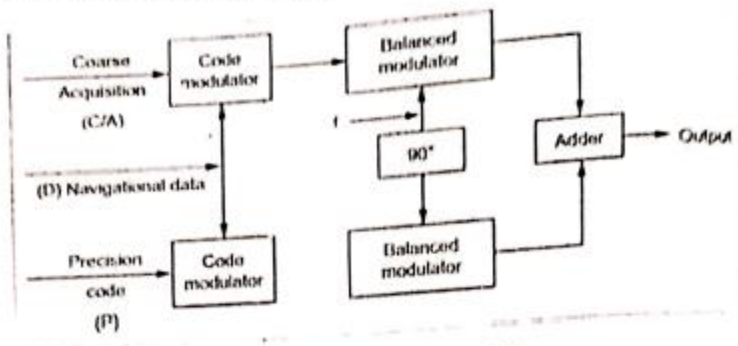


Fig. 8.9. GPS signal generator

GPS RECEIVER

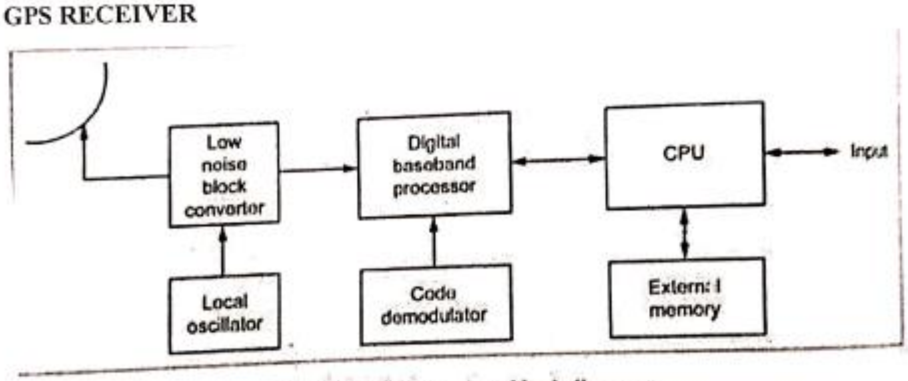


Fig. 8.10. GPS receiver block diagram