Unit- I – Satellite Orbits

Introduction:

Satellite form an essential part of telecommunication systems, carrying large amount of data and telephone traffic in addition to television signals. Satellite offer a number of features because very large areas of earth are visible from a satellite.

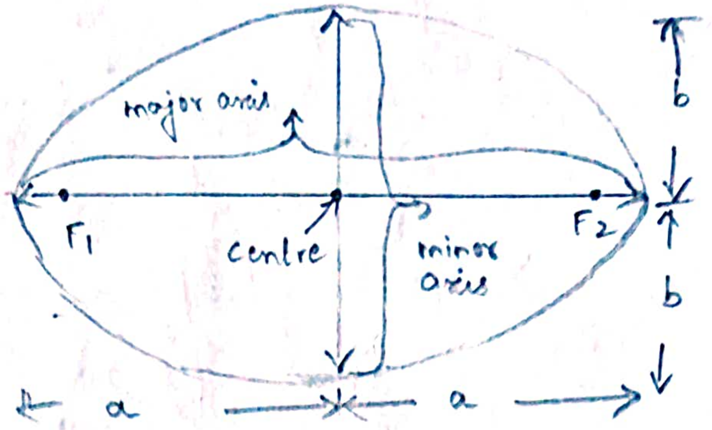
Satellite provides communication links to remote communities in sparsely populated areas that are difficult to access by other means. Satellites are used for remote sensing eg. being the detection of water pollution and monitoring and reporting of weather conditions.

1 Keplers Law:

Satellites orbiting the earth follow the same laws that govern the motion of planets around the Sun. Johannes kepler derive empirically three laws describing planetary motion.

1.1 Keplers First law

Keplers first law states that the path followed by a satellite around the Primary will be an ellipse



An ellipse has two focal points F_1, F_2. The centre of mass of the two body system is termed as bary centre, which is centred on one of the foci. Because of enormous difference between masses of earth and satellite, the centre of mass coincides with centre of the earth which is always the foci.

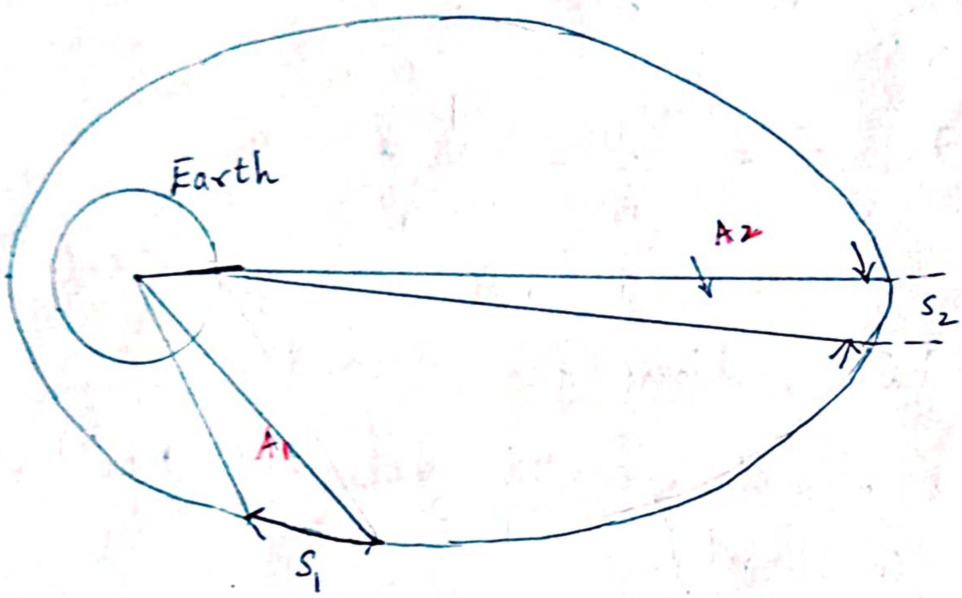
The semimajor axis of the ellipse is denoted by a, and the semiminor axis, by b. The eccentricity e is given by

$$e = \frac{\sqrt{a^2 - b^2}}{a}$$

For an elliptical orbit $0 < e < 1$. when $e = 0$ the orbit becomes circular.

1.2 Kepler's Second Law

Kepler's second law states that, for equal time intervals, a satellite will sweep out equal areas in its orbital plane, focused at the barycentre.



Assume the satellite travels distances S_1 and S_2 metres in 1s, then the areas A_1 and A_2 will be equal. The average velocity in each case is S_1 and S_2 m/s, and because of equal area law, it follows that the velocity at S_2 is less than that at S_1. The satellite takes longer to travel a given distance when it is farther away from earth.

1.3 Kepler's Third Law

Keplers Third law states that the square of the periodic time of orbit is proportional to the cube of the mean distance between the two bodies. The mean distance is equal to the semimajor axis a.

Kepler's third law is written in the form

$$a^3 = \frac{\mu}{n^2} \quad \text{—— ①}$$

n → is the mean motion of the satellite in radians per second

μ → is the earth's geocentric gravitational constant

$$\mu = 3.986005 \times 10^{14} \, m^3/s^2$$

Equn ① applies only to ideal situation with no perturbing forces, such as atmospheric drag. With 'n' radians per second, the orbital period is given by

$$P = \frac{2\pi}{n}$$

Importance of 3rd law is there is fixed relation between period and semimajor axis

1.4 Newtons Law

1.4.1 Newtons First Law

An object at rest will remain at rest unless acted on by an unbalanced force. An object in motion continues in motion with same speed and in the same direction unless acted upon by an unbalanced force. This law is often called "the law of inertia."

1.4.2 Newton's Second law

Acceleration is produced when a force acts on a mass. The greater the mass (of the object being accelerated) the greater the amount of force needed (to accelerate the object)

1.4.3 Newton's Third law

For every action, there is an equal and opposite reaction. This means that for every force there is a reaction force that is equal in size, but opposite in direction. That is to say that whenever an object pushes another object it gets pushed back in the opposite direction equally hard.

1.5 Orbital Parameters

Subsatellite Path:

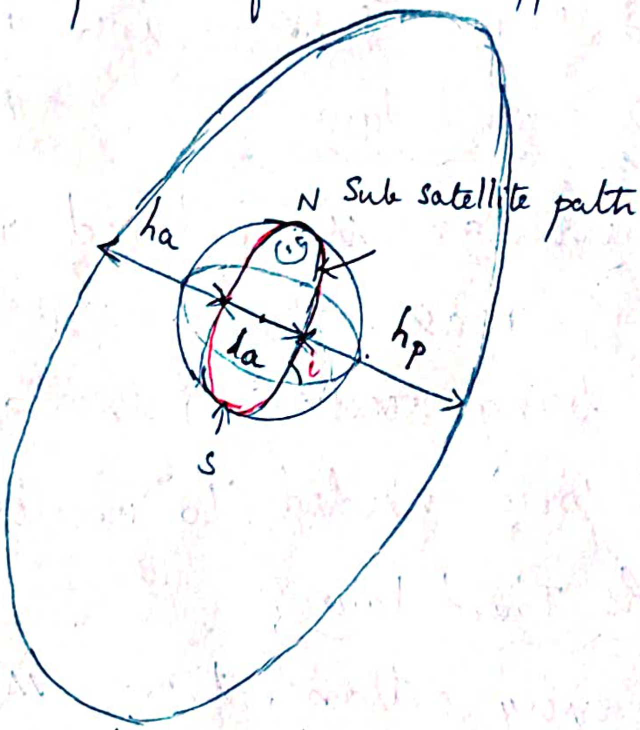
This is the path traced out on the earth's surface directly below the satellite

Apogee:

The point farthest from earth. (h_a)

Perigee:

The point of closest approach to earth (h_p)



Line of apsides:

The line joining the perigee and apogee through the center of the earth. (l_a)

Ascending node

Ascending node:

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

Descending node:

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

Line of nodes:

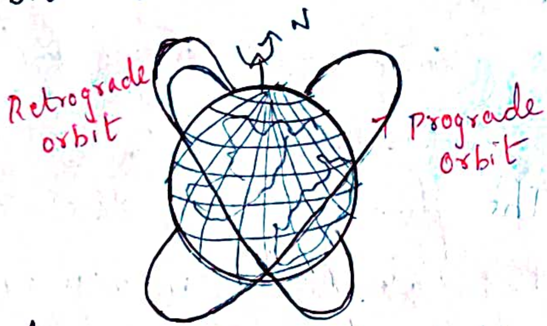
The line joining the ascending and descending nodes through the center of the earth.

Inclination:

The angle between the orbital plane and the earth's equatorial plane. (i)

Prograde orbit:

An orbit in which the satellite moves in the same direction as earth's rotation. The prograde orbit is known as direct orbit. The inclination



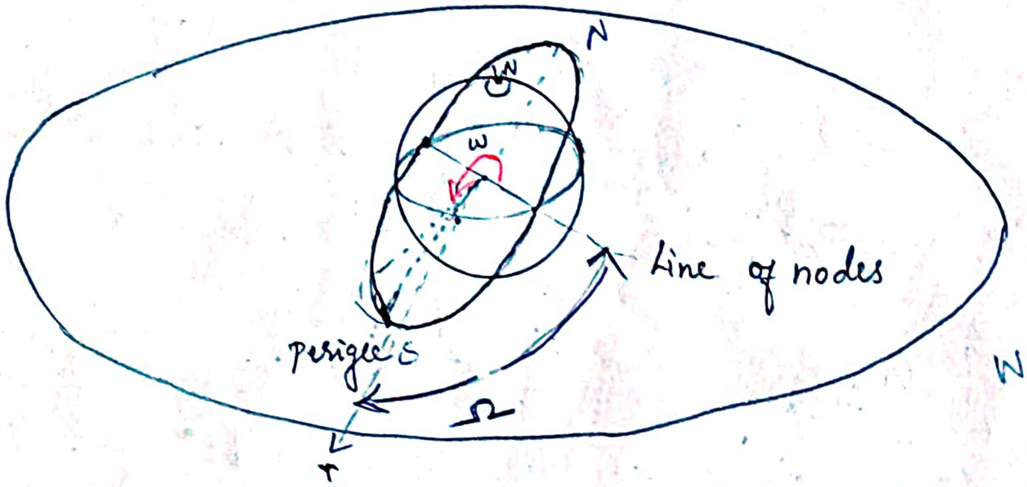
of a prograde orbit lies between 0° and 90°. Most satellites are launched in prograde orbit, as the earth's rotational velocity provides part of orbital velocity.

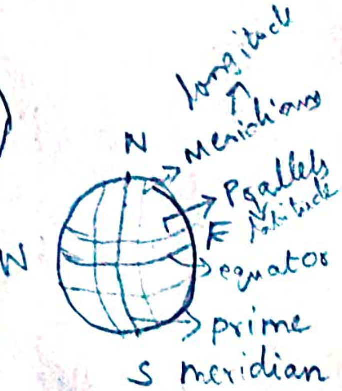
Retrograde orbit:

An orbit in which the satellite moves in a direction counter to the earth's rotation. The inclination of a retrograde orbit always lies between 90° and 180°.

Argument of Perigee:

The angle from ascending node to perigee, measured in the orbital plane at earth's centre, in the direction of satellite motion. The argument of perigee is shown as w.





Right ascension of the ascending node

To define completely the position of the orbit in space, the position of the ascending node is specified. The longitude of the asanding node is not fixed. For absolute measurement a fixed reference is required, and it is the first point of Aries, known as vernal or equinox. The vernal equinox occurs when sun crosses the equator going from South to North and imaginary line drawn from this equatorial crossing through the centre of the Sun points to the first point of Aries. This is the line of Aries

Mean anomaly.

Mean anomaly M gives an average value of the angular position of the satellite with reference to the perigee.

True anomaly

The true anomaly is the angle from perigee to the satellite position, measured at the earth's centre. This gives the true angular position of the satellite in the orbit as a function of time.

1.6 Orbital Perturbations

The Keplerian orbit assumes that the earth is a uniform spherical mass and only force acting is the centrifugal force resulting from satellite motion balancing the gravitational pull of the earth. The gravitational pulls of sun and moon have negligible effect on low orbiting satellites and do affect satellites on geostationary orbit. Atmospheric drag

1.6.1 Effects of nonspherical earth

For a spherical earth of uniform mass, Kepler's third law gives the nominal mean motion n_0 as

$$n_0 = \sqrt{\frac{\mu}{a^3}} \quad \text{--- (1)}$$

Since the earth shape is an oblate spheroid, the mean motion is denoted by

$$n = n_0 \left[1 + \frac{K_1 (1 - 1.5 \sin^2 i)}{a^2 (1 - e^2)^{1.5}} \right] \quad \text{--- (2)}$$

K_1 → is a constant 66,063.1703 km²,

a → semimajor axis

If 'a' is known, mean motion is calulated.
The orbital period taking into account the earth's oblateness is termed as the anomalistic period (P_A)

$$P_A = \frac{2\pi}{n} s \quad \text{——} \quad (3)$$

where n is in radians/sec.
Equn. (2) is solved by finding the roots of following equation.

$$n - \sqrt{\frac{\mu}{a^3}} \left[1 + \frac{k_1 (1 - 1.5 \sin^2 i)}{a^2 (1-e^2)^{1.5}} \right] = 0 \quad \text{—} (4)$$

The oblateness of earth produces two rotations

i) Regression of nodes
ii) Rotation of apsides in the orbital plane

Regression of nodes

The nodes appear to slide along the equator. The right ascension of ascending nodes (Ω) shifts its position.

If the orbit is prograde, the nodes slide westward and if it is retrograde, they slide eastward. The nodes move in a direction opposite to satellite motion, hence it is termed regression of nodes. For polar orbit regression is 0.
These effects depends on mean motion n, semimajor axis 'a' and eccentricity e.

It is grouped into one factor k given by

$$k = \frac{nk_1}{a^2(1-e^2)^2} \quad \text{--- (5)}$$

An approximate expression for rate of change of Ω with respect to time is

$$\frac{d\Omega}{dt} = -k\cos i \quad \text{--- (6)}.$$

where i is inclination.

The rate of change given by equn. (6) is negative the regression is westward, and when the rate is positive, the regression is eastward.

<u>Rotation of line of apsides:</u>

The major effect produced by the equatorial bulge is a rotation of the line of apsides. This line rotates in the orbital plane resulting in the argument of perigee changing with time. The rate of change is given by

$$\frac{d\omega}{dt} = k(2 - 2.5\sin^2 i)$$

The unit for rate of rotation of the line of apsides will be same as 'n'.

If the <u>epoch time</u> (system describing instants time) denoted by t_0, right ascension of ascending node by Ω_0, and argument of perigee by ω_0, the new values for Ω & ω

at time 't' is

$$\Omega = \Omega_0 + \frac{d\Omega}{dt}(t - t_0)$$

$$\omega = \omega_0 + \frac{d\omega}{dt}(t - t_0)$$

The satellite drifts from elliptical path as a result of regression of nodes and latitude of point of closest approach. P_A is the time required to go around the orbital path from perigee to perigee.

In addition to equatorial bulge, the earth is not perfectly cirular in the equatorial plane and it has a small eccentricity of the order of 10^{-5}. This is referred to as equatorial ellipticity.

The gravity gradient resulting from equatorial ellipticity causes satellite from geostationary orbit to drift to two stable points. The two points are separated by 180° on the equator and are approximately 75° E longitude and 105° W longitude. The satellites are prevented from drifting to these points through station keeping mechanism

1.6.2 Atmospheric drag

For near earth satellites, below about 1000km the effects of atmospheric drag are significant. As the drag is greatest at perigee, reduces velocity at this point and the satellite does not reach the same apogee height on successive revolutions. So the semimajor axis and eccentricity are reduced.

An approximate expression for the change of major axis is

$$a \cong a_0 \left[\frac{n_0}{n_0 + n_0'(t-t_0)}\right]^{2/3}$$

where 'o' subscript denote values at the reference time t_0, and n_0' is first derivative of mean motion. The mean anomaly is also changed, an approximate value for change being

$$\delta M = \frac{n_0' (t-t_0)^2}{2}$$

1.7 Station Keeping

The geostationary satellite must be kept in its correct orbital slot. The equatorial ellipticity of the earth causes geostationary satellites to drift slowly along the orbit to one of two stable points at 75°E and 105°W.

To nullify the drift, two types of maneuvers are in practice

i) East-west station keeping maneuvers

ii) North South Station keeping maneuvers

East west station keeping maneuvers:

To counter the drift, an oppositely directed velocity component is imparted to the satellite by means of jets, which are pulsed once every 2 or 3 weeks. This results in satellite drifting back through its nominal station position and recombining the drift until the jets are pulsed once again. Satellites in the 6/4 GHz band must be kept within ±0.1° longitude and 14/12 GHz band, within ±0.05°.

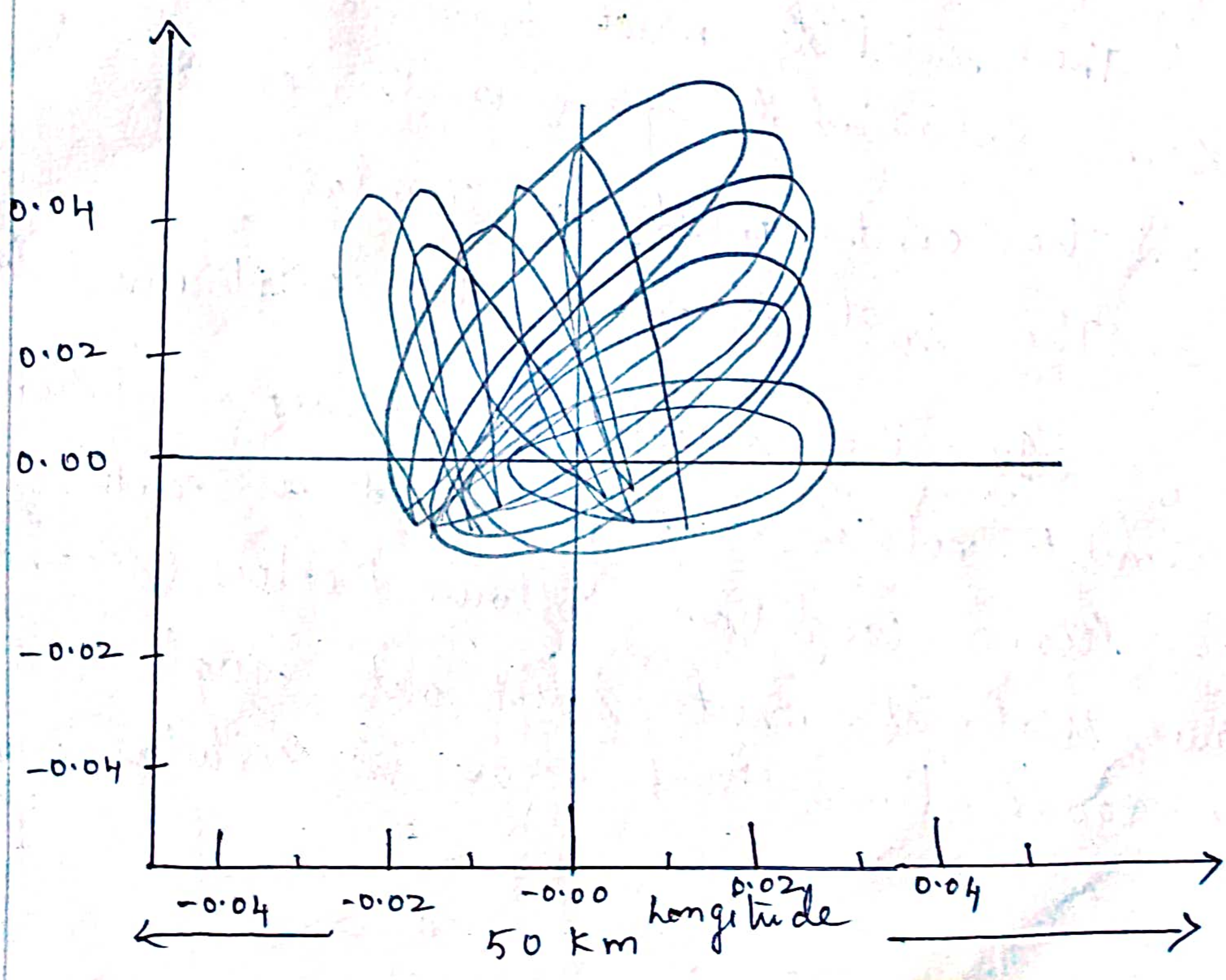
North-south Station keeping Maneuvers

The geostationary satellites also drift in latitude direction because of gravitational force of moon and sun. These forces change the inclination at a rate of 0.85°/year. If left uncorrected, the inclination change will go from 0-14.67° in 26.6 years

To prevent this jet may be pulsed at appropriate time to return inclination to zero. In this maneuvers the fuel consumption are expensive than that of east-west maneuvers. The north south station keeping tolerances are the same as those for east west station keeping ±0.1° in the c band (3.7 to 6.425 GHz) and ±0.05° in the ku band (12.2 to 17.8 GHz).

Orbital correction is carried out by command from TT&C earth station which monitors satellite position.

The fig. shows the latitude and longitude variations for the Anik C_3 satellite.



The satellite is placed in an inclined orbit of about 2·5 to 3°. This type of inclination will dispense the north and south station keeping maneuvers. This allows communication payload (essential data carried within packet or transmit unit) to be increased. But this requires tracking antenna at the ground station.

1.8 Geostationary Orbit

A satellite in a geostationary orbit appears to be stationary with respect to the earth and hence the name geostationary. Three conditions are required for an orbit to be geostationary

1. The satellite must travel eastward at the same rotational speed as the earth
2. The orbit must be circular
3. The inclination of the orbit must be 0.

If the satellite is to appear stationary, it must rotate at same speed as earth. The second condition follows Keplers second law that it must swept out equal areas in equal times that occur in circular orbit.

Keplers third law is used to find the radius of the orbit. The radius is denoted by

$$a_{GSO} = \left(\frac{\mu P}{4\pi^2}\right)^{1/3}$$

P → period for geostationary 23h, 56min 4s

Sub, this value along with μ

$$a_{GSO} = 42164 \text{ km.}$$

The equatorial radius of the earth, to the nearest kilometer, is

$$a_E = 6378 \text{ km}$$

and hence the geostationary height is

$$h_{GSO} = a_{GSO} - a_E$$

$$= 42164 - 6378 = 35786 \text{ km}$$

This value is rounded up to 36,000 km.

Since there is only one possible height, there is only one geostationary orbit. The gravitational forces of Sun and moon causes drift of 0.85° per year inclination. The satellite is maintained within ± 0.1° both latitude and longitude.

1.9 Look angle determination

The look angles for the ground station antenna are the azimuth and elevation angles required at the antenna so that it points directly at the satellite. The look angles were determined in an elliptical orbit and the angles had to change in order to track the satellite. No tracking is necessary for large earth stations used for commercial communication and the antenna beam width is very narrow and tracking mechanism is required to compensate for movement of satellite. With the antennas used for home reception, the antenna beam width is broad and no tracking is necessary. This allows antenna to be fixed in position.

The 3 information needed to determine look angles for geostationary orbit are

1. earth station latitude, λ_E
2. earth station longitude, ϕ_E
3. longitude of subsatellite point, ϕ_{ss}

When calculating look angles for low earth orbit (LEO), it was necessary to take into account the variation in earth's radius.

The average radius of the earth is

$R = 6371$ km

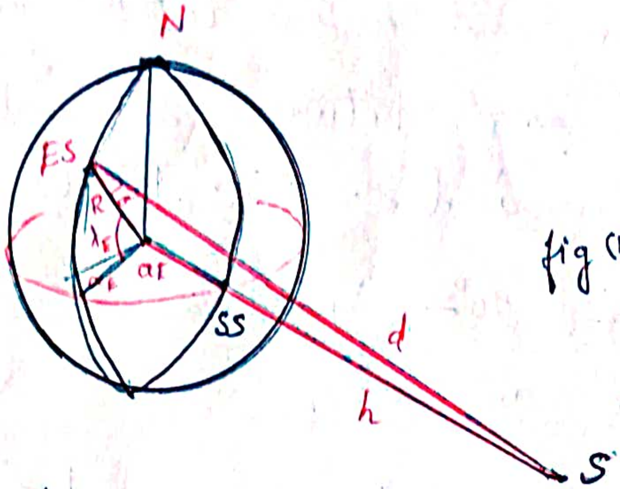


fig (1)

In the above fig ES denotes position of earth station. SS denotes subsatellite point, S the satellite and 'd' range from earth station to the satellite. The angle 'σ' is to be determined.

There are two geometry involved in the fig.(b), the spherical triangle and the plane of triangle fig.(c)

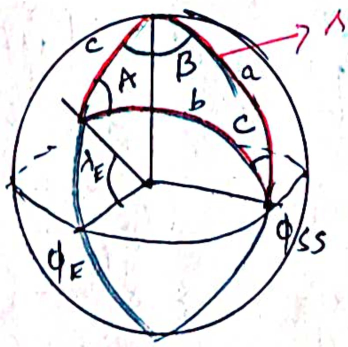


fig (A)

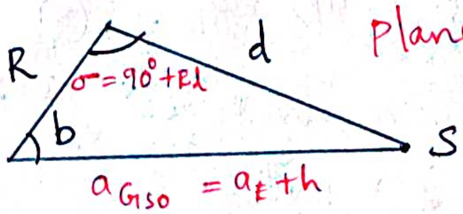


fig (B)

a → is the angle between the radius to the north pole and the radius to the subsatellite pt.

b → is the angle between the radius to the earth station and radius to the subsatellite point.

c → is the angle between the radius to the earth station and radius to the north pole

$c = 90^\circ - \lambda_E$

$a = 90^\circ$

The three angles A, B and C are angle between the planes.

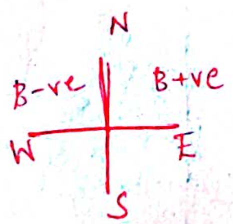
A → is ∠le b/w plane c and b

B → is ∠le b/w plane c and a

C → is ∠le b/w plane b and a

From the fig. $B = \phi_E - \phi_{ss}$. max. value of B is 81.3°.

So from spherical triangle



$a = 90^\circ$ — ①

$c = 90^\circ - \lambda_E$ — ②

$B = \phi_E - \phi_{ss}$ — ③

when earth station is west B is −ve and when east B is +ve.

Napiers rules, are used to solve spherical triangle.

By Napiers rule

$$b = \arccos(\cos B \cos \lambda_E) \quad \text{— (4)}$$

and angle A as

$$A = \arcsin\left(\frac{\sin|B|}{\sin b}\right) \quad \text{— (5)}$$

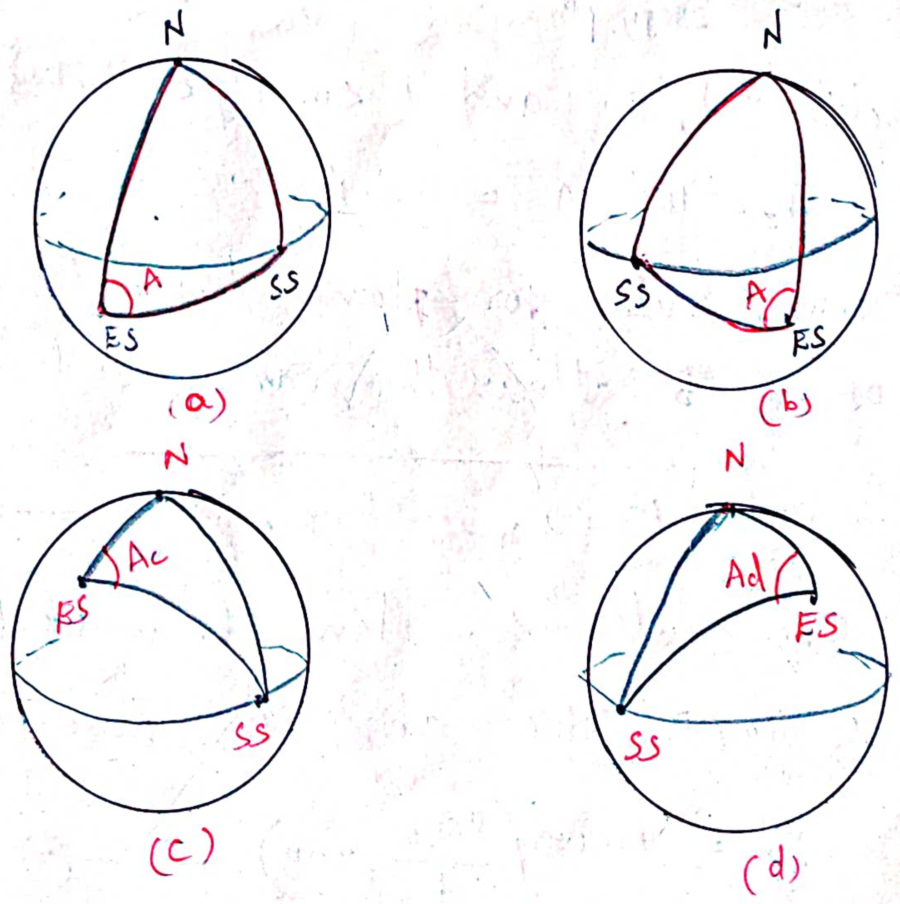
Two values satisfy the above equn. A and $180^\circ - A$

From the fig(a) angle A is acute and azimuth angle is $A_z = A$.

In fig(b) A is acute and azimuth $A_z = 360^\circ - A$.

In fig(c) A_c is obtuse and $A_c = 180^\circ - A$, $A_z = A_c - 180^\circ - A$

In fig(d) Ad is obtuse $A_d = 180^\circ - A$, $A_z = 360^\circ - A_d = 180^\circ + A$



Azimuth Angles A_z from the fig is

fig.	λ_E	B	A_z, degree
a	<0	<0	A
b	<0	>0	$360^\circ - A$
c	>0	<0	$180^\circ - A$
d	>0	>0	$180^\circ + A$

From equn. (4)

$$b = \arccos(\cos B \cos \lambda_E)$$
$$= 36.23^\circ$$

From equn (5)

$$A = \arcsin\left(\frac{\sin|B|}{\sin b}\right)$$
$$= 17.1^\circ$$

By inspection $\lambda_E > 0$ and $B < 0$. Fig c applies

$$A_z = 180^\circ - A = 162.9^\circ$$

Applying cosine rule for plane triangles to the triangle of fig B allows the range of d to

$$d = \sqrt{R^2 + a_{GSO}^2 - 2Ra_{GSO}\cos b} \quad \text{——} (6)$$

Applying sine rule for plane triangles to the triangle of fig (B) the angle of elevation is

$$El = \arccos\left(\frac{a_{GSO}}{d}\sin b\right) \quad \text{——} (7)$$

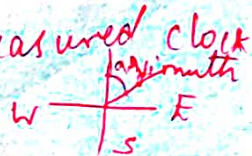
When the earth station is directly under the satellite the elevation is 90°, and azimuth is irrelevant. When the subsatellite point is east of equatorial earth station (B < 0), the azimuth is 90°, when west (B > 0), the azimuth is 270°. For accurate values the range is determined by measurement.

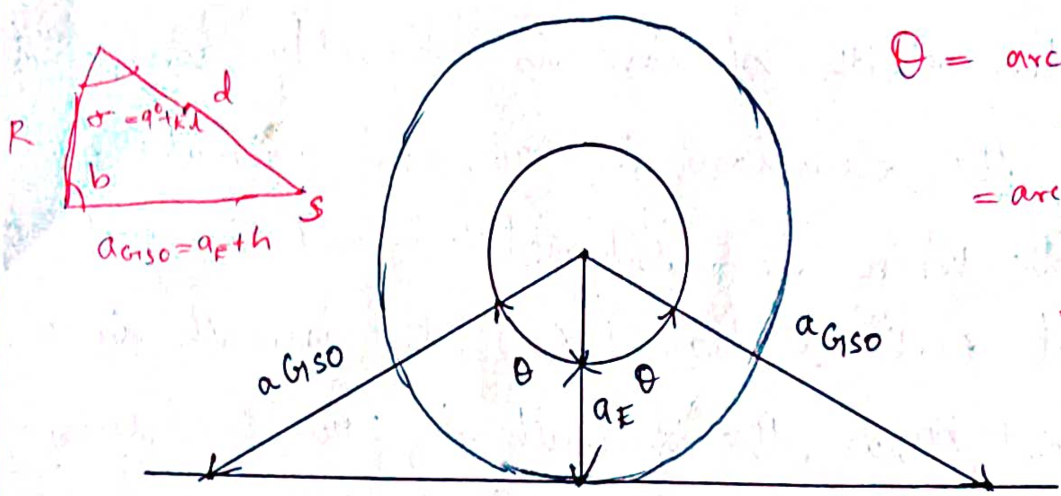
The look angles need not be determined with great precision but are calculated to give expected values for a satellite the longitude of which is close to earth station longitude.

1.10 Limits of Visibility

There will be east and west limits on the geostationary arc visible from any given earth station. The limits will be set by geographic coordinates of earth station and antenna elevation. The lowest elevation is 0, when the antenna is pointing along the horizontal. A quick estimate of longitude limits is made by considering earth station at the equator, with antenna pointing either west or east along the horizontal as shown in the Fig.

Azimuth → defined as horizontal angle measured clockwise from north baseline





$$\theta = \arccos \frac{a_E}{a_{GSO}}$$

$$= \arccos \frac{6378}{42164}$$

$$= 81.3^\circ$$

An earth station could see satellites over a geostationary arc bounded by $\pm 81.3^\circ$ about the earth station longitude. To avoid reception of excessive noise from earth, some minimum value of elevation is used, denoted by El_{min}. A typical value is 5°. The limits of visibility also depend on earth station latitude.

Let S represents the angle subtended at the satellite when angle $\sigma_{min} = 90^\circ + El_{min}$. Applying sine rule

$$S = \arcsin\left(\frac{R}{a_{GSO}} \sin \sigma_{min}\right)$$

If 'S' is known b is found from

$$b = 180 - \sigma_{min} - S \quad \text{and}$$

$$B = \arccos\left(\frac{\cos b}{\cos \lambda_E}\right)$$

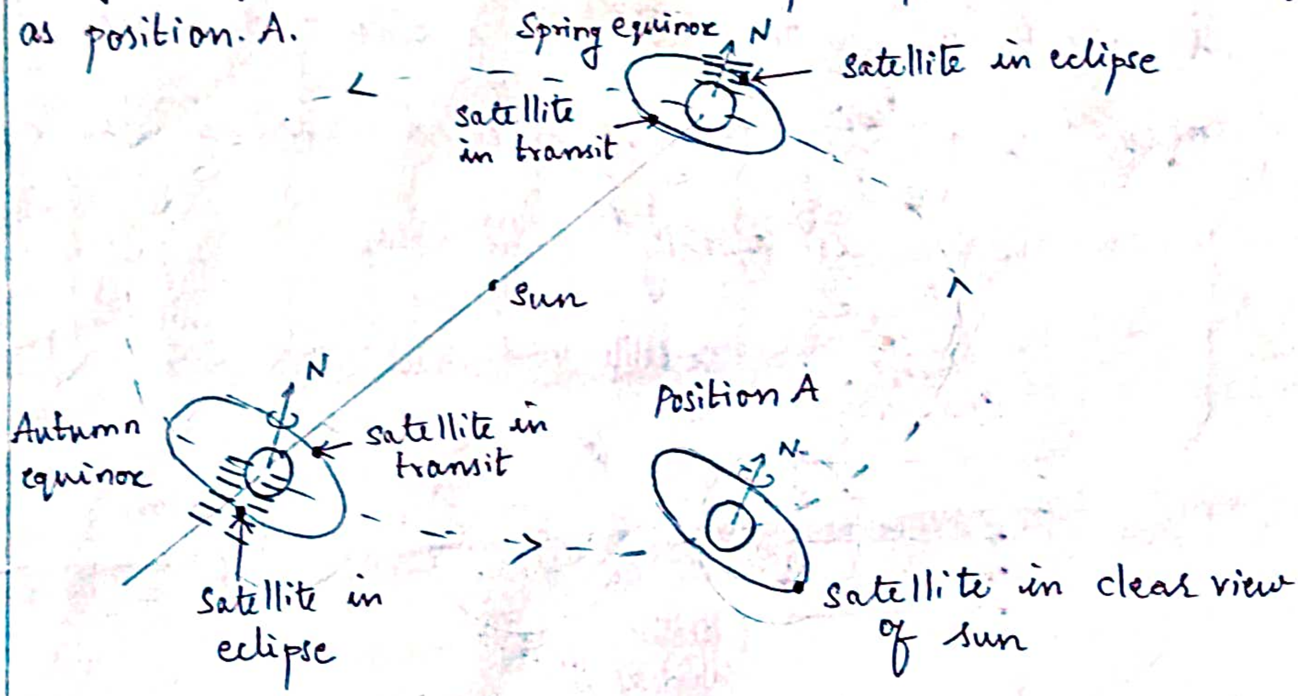
Once 'B' is found, the longitude is determined by

$$\boxed{\phi_E + B = \phi_{SS}}$$

1.11 Earth Eclipse of Satellite

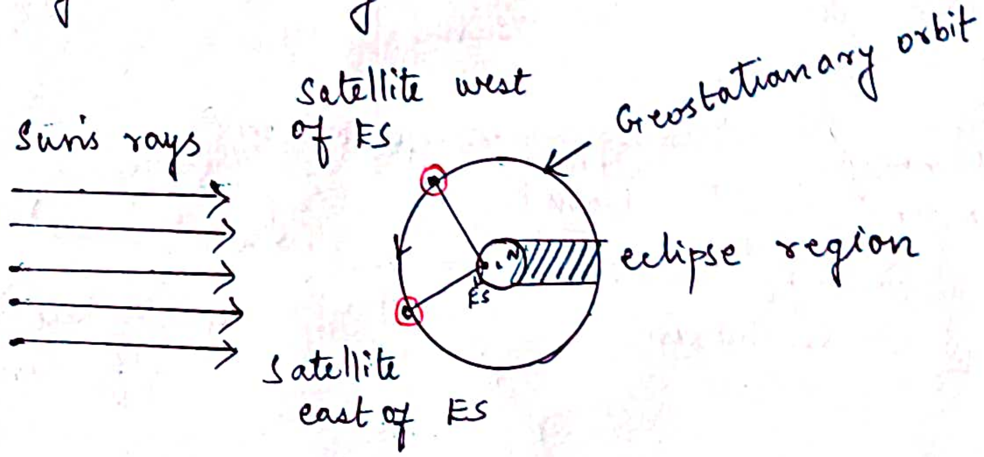
If the earth's equatorial plane coincide with the plane of the earth's orbit around the sun (the ecliptic plane), geostationary satellites would be eclipsed by earth once each day.

The equatorial plane is titled at an angle of 23.4° to the ecliptic plane with view of sun as position. A.



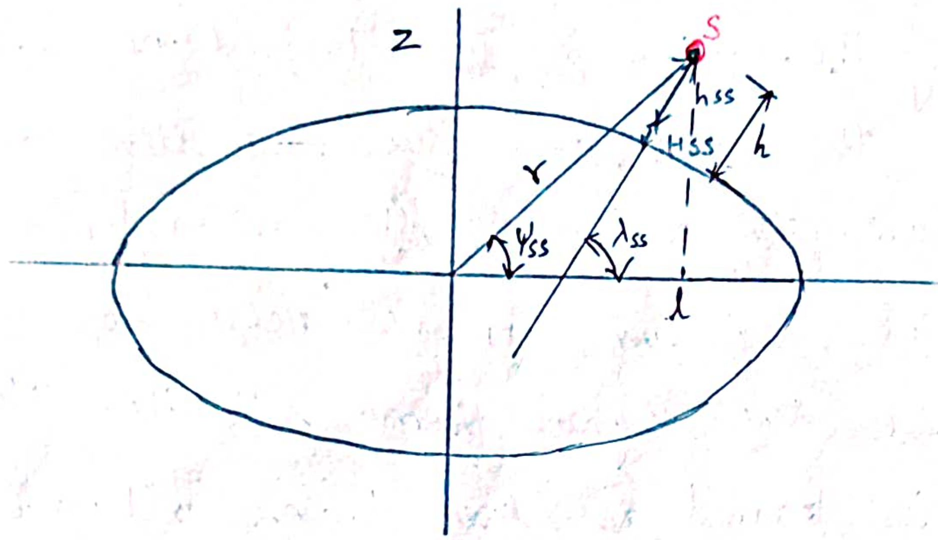
The fig. shows satellite eclipse and satellite sun transit around spring and autumn equinoxes. Around the spring and autumn equinoxes, when sun is crossing equator, the satellite pass into earth's shadow at certain periods called period of eclipse. Eclipses begin 23 days before equinox and end 23 days after equinox. The eclipse lasts about 10 minutes at the beginning and end of eclipse period and increases to maximum duration of about 72 min at full eclipse

During an eclipse, solar cells do not function and operating power is supplied from batteries. When the satellite longitude is east of earth station, the satellite enters eclipse during daylight. When the satellite longitude is west of earth station, eclipse does not occur until the earth station is in darkness when usage is likely to be low.



1.12 The Subsatellite point

The point on the earth vertically under the satellite is referred as the subsatellite point. The latitude and longitude of the subsatellite point and the height of the satellite above the subsatellite is determined from radius vector 'r'. The figure shows the meridian plane which cuts the subsatellite point.



The height of the terrain above the reference ellipsoid at subsatellite point denoted by H_{ss}, and height of satellite above this is h_{ss}, Thus the total height of satellite above reference ellipsoid is

$$h = H_{ss} + h_{ss}$$

$$N = \frac{a_E}{\sqrt{1 + e_E^2 \sin^2 \lambda_{ss}}}$$

$$r_I = (N+h) \cos \lambda_{ss} \cos LST$$

$$r_J = (N+h) \cos \lambda_{ss} \sin LST$$

$$r_K = \left[N(1-e_E^2) + h\right] \sin \lambda_{ss}$$

The East longitude is obtained as

$$EL = LST - GST$$

GST - Green which side real Time

1.13 Sun Transit outage

During the equinoxes, the transit of satellite between the earth and sun, the sun comes within the beamwidth of earth station antenna. During this period, the sun appears noisy source which blanks out the signal from satellite. This effect is termed as "sun transit outage", and it lasts for short periods - each day about 6 days around the equinoxes. The maximum outage time is 10 minutes. The occurrence and duration of sun transit outage depends on latitude of earth station.

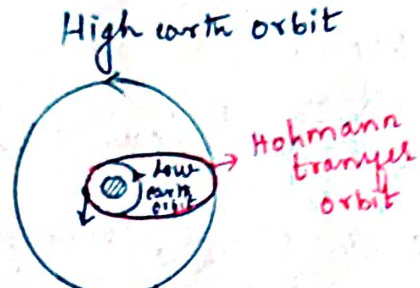
1.14 Launching orbits :- Launching Procedures

Satellites is directly injected into low-altitude orbits, upto about 200 km altitude from a launch vehicle. Launch vehicles may be expendable or reusable. A reusable launch vehicle is also reffered to as Space Transportation System (STS). Examples of Expandable Launch Vehicles (ELV's) are

1. US - Atlas-Centaur and delta rockets
2. European - Ariene rocket.

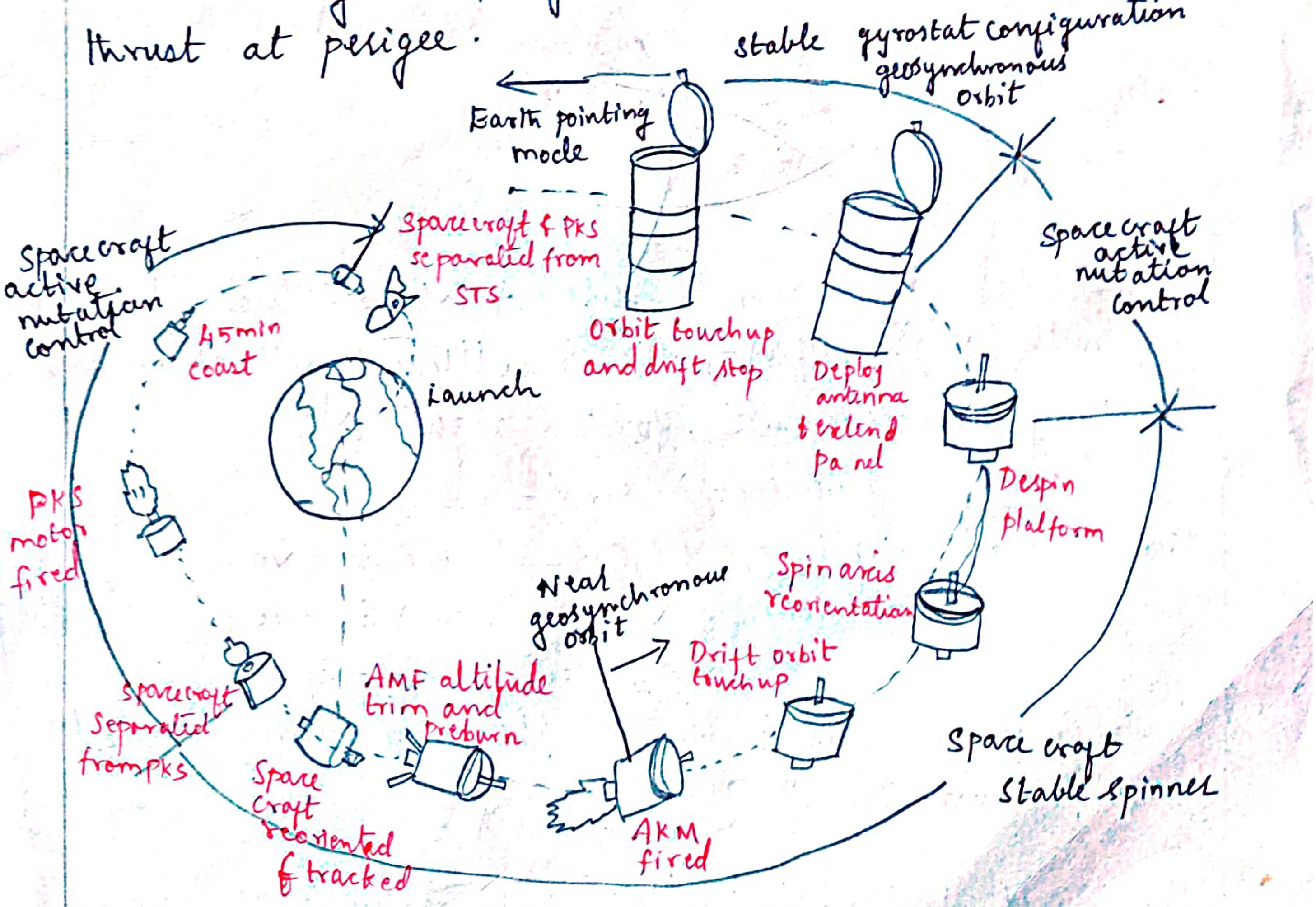
For altitude greater than 200 km launch vehicle is not economical for injection into tranfer orbit.

The transfer orbit is selected to minimize the energy required for transfer and such an orbit is known as Hohmann transfer orbit



Launch Vehicles & Propulsion

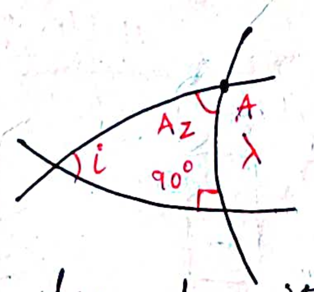
The Hohmann elliptical orbit is tangent to the low altitude orbit at perigee and high altitude orbit at apogee. At the perigee in rocket launch, the rocket injects the satellite with required thrust into transfer orbit. With STS, the satellite must carry a perigee kick motor which imparts thrust at perigee.



At apogee, the apogee kick motor changes the velocity of the satellite, to be placed in the circular orbit.

These are the steps for launching satellite in geosynchronous orbit.

During the launching period, the velocity changes in same plane, change the geometry of the orbit but not its inclination. To change the inclination, the velocity must be changed normal to the orbital plane. Changes in inclination can be made at either one of nodes. The smallest inclination at intial is equal to the latitude of the launch site.



consider a launch site A at altitude 'λ' and azimuth angle of Az, the resulting inclination is i

Applying Nepier's rule, for the right Δ^{le}

$$\cos i = \cos\lambda \sin A_z$$

For prograde orbit $0 \leq i \leq 90^\circ$ — cos i is +ve

$-90 \leq \lambda \leq 90^\circ$ — cos λ is +ve

$0 \leq A_z \leq 180^\circ$ — cos Az is +ve

To minimize i, cos i should be maximum, sin A_z to be maximum or 90° gives

$$\cos i = \cos\lambda$$

The lowest inclination is equal to latitude of launch site $i_{min} = \lambda$

Unit - II

SPACE SEGMENT AND SATELLITE LINK DESIGN

1 Introduction :

Satellite communication system is broadly divided into two segments

i) ground segment

ii) space segment

The space segment includes the satellites and the earth segment, used to monitor and control the space craft. The payload and bus are the equipment present in the satellite.

The payload refers to the equipment used to provide the service for which satellite is launched. The bus refers to the vehicle which carries the payload.

The equipment which provides the connecting link between, satellite's transmit and receive antennas is the transponder.

2 Space Craft Subsystem.

2.1 Structure and Primary Power

• The primary electrical power for operating the electronic equipment is obtained from solar cell. Individual cells generate only small amounts of power. Higher powers can be achieved with solar panels arranged in the form of rectangular solar sails.

In order to maintain service during an eclipse storage batteries must be provided. Ni-cd batteries are used before and $Ni-H_2$ (Nickel Hydrogen) batteries offer significant improvement in power weight ratio.

In HS601, solar panels arranged to track the sun and are capable to provide greater power output (2-6KW).

2.2 Attitude and orbit control

The attitude of a satellite refers to its orientation in space. Much of the equipment carried abroad a satellite is for the purpose of controlling its attitude. Attitude control ensure that directional antennas point in proper directions.

The disturbances torques such as gravitational fields of earth and moon, solar radiation and meteorite impacts alter the attitude. To measure the satellite's orientation in space infrared sensors called horizon detectors are used. For attitude control the control signals transmitted from earth based on data obtained from satellite

controlling torques is generated by
i) Passive attitude control
ii) Active attitude control

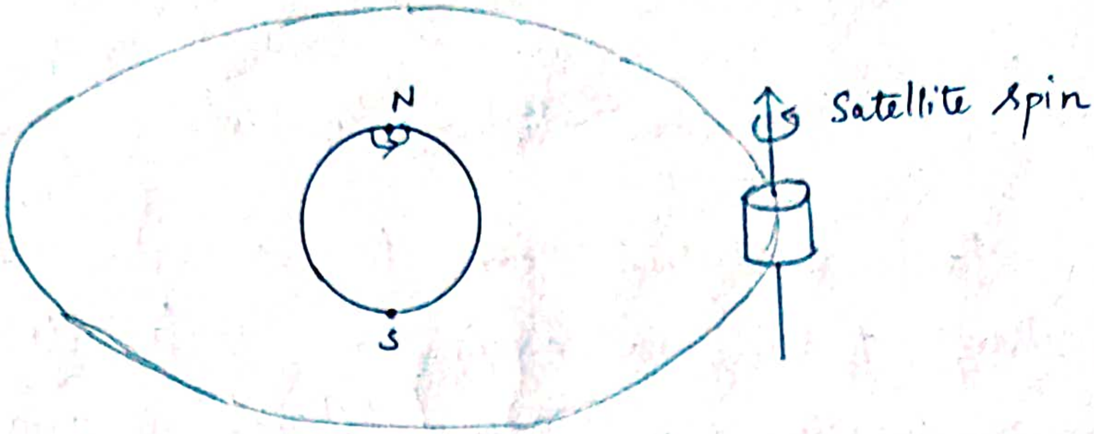
Passive attitude control stabilize the satellite without putting a drain on the satellite's energy supplies. eg. spin stabilization and gravity gradient stabilization

Active attitude control

Corrective torques are applied as required in response to disturbance torque. Momentum wheels, electromagnetic coils and mass expulsion devices are used to generate active torques. One example of momentum wheel control is three axis stabilization.

2.2.1 Spinning satellite stabilization

Spin stabilization is achieved with cylindrical satellites. The satellite is constructed so that it is mechanically balanced about one particular axis and then set spinning around this axis. For geostationary satellite, the spin axis is adjusted parallel to the N-S axis of the earth as shown in the figure



The spin rate is in the range of 50 to 100 rev/min. Spin is intiated during launch phase by means of small gas jets. In the absence of disturbance torques, the satellite would maintain its correct attitude relative to earth.

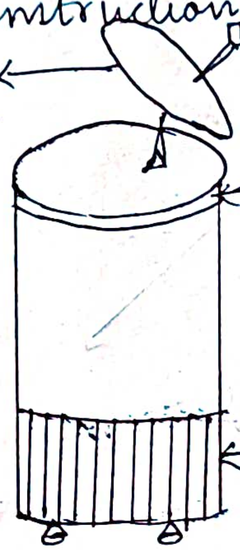
The disturbance will affect the overall spinning rate (i.e) spinning rate decreases and the angular spin axis will change. The disturbances may be external or internal.

The gravitational force of sun and moon solar radiation are examples for external disturbance. Movement of satellite antenna, motor bearing friction gives rise to internal disturbances.

The impulse type thrusters or jets are used to increase the spin rate, and to shift the axis back to its correct N-S orientation.

In spin stabilization entire satellite rotates about an axis.

If an omnidirectional antenna is used the antenna also rotates with the satellite. If a directional antenna is used then the antenna must be made despun, which gives rise to dual spin construction.

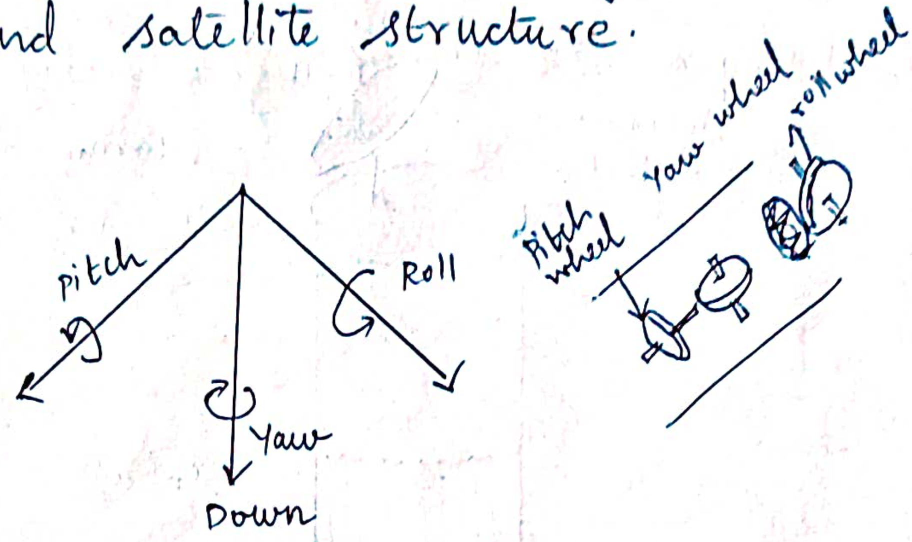


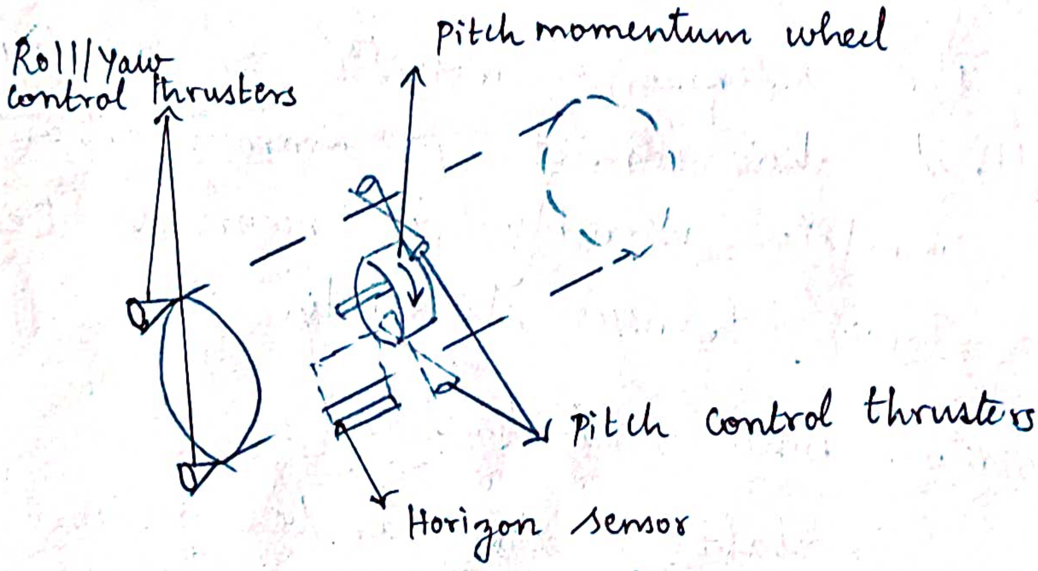
The antenna is mounted on a despun shell, it also consist of communication repeaters. The complete assembly is known as "Bearing and Power Transfer Assembly."

2.2.2 Momentum wheel stabilization

gyroscopic → resists the flow which try to move its axis → so axis lookin same direction

Stability also can be achieved by utilizing gyroscopic effect of spinning flywheel. These are known as body stabilized satellites. The complete unit termed as momentum wheel consists of flywheel, bearing assembly, casing and electric drive motor with control circuitry. The flywheel is attached to the rotor, which consist of permanent magnet providing magnetic field for motor action. The stator of motor is attached to the body of the satellite. Thus the motor provides coupling between the flywheel and satellite structure.





Speed and torque control of motor is exercised throu' currents fed to the stator. The term momentum is reserved for wheels that operate at non zero momentum. This is termed as momentum bias. Such wheel provides passive stabilization for yaw and roll axis. control about pitch is achieved by changing speed of wheel.

When a momentum wheel is operated with zero momentum bias, it is referred to as reaction wheel. Reaction wheels are used in three axis stabilized system, each axis is stabilized by reaction wheel. Disturbances torques cause a cumulative increase in wheel momentum, at some point the wheel saturates. Mass expulsion devices are used to unload the wheel, to remove momentum from it. This mass devices consumes part of satellite fuel supply.

2.3 Thermal control and Propulsion

Satellites are subject to large thermal gradients, receiving suns radiation on one side, other side faces into space. Thermal radiations from the earth and earth's albedo, is significant for low altitude earth orbiting satellites. Equipments in satellite also generates heat which has to be removed. Thermal blankets and shields provide insulation. Radiation mirrors remove heat from communication Payload. To maintain constant temperature conditions heaters are switched on for heat reduction

2.4 Communication Payload and Supporting Subsystems

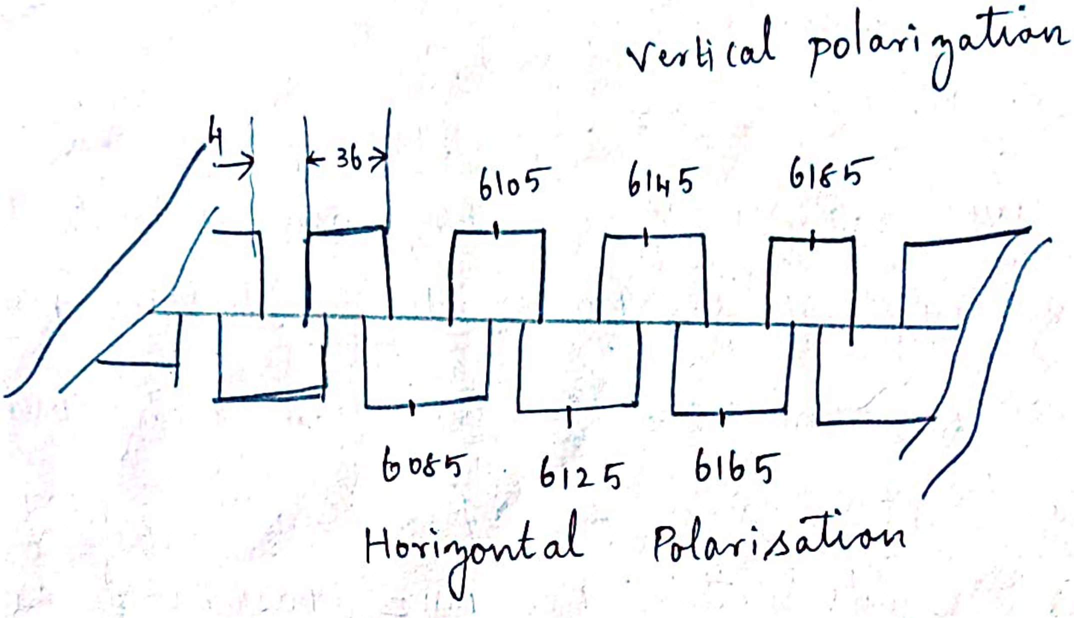
The communication subsystem is the important subsystem and all subsystems are used to support the communication subsystem.

The entire 500 MHZ Bandwidth is divided into channels, 36 or 40 MHz wide, are handled by a separate Transponder.

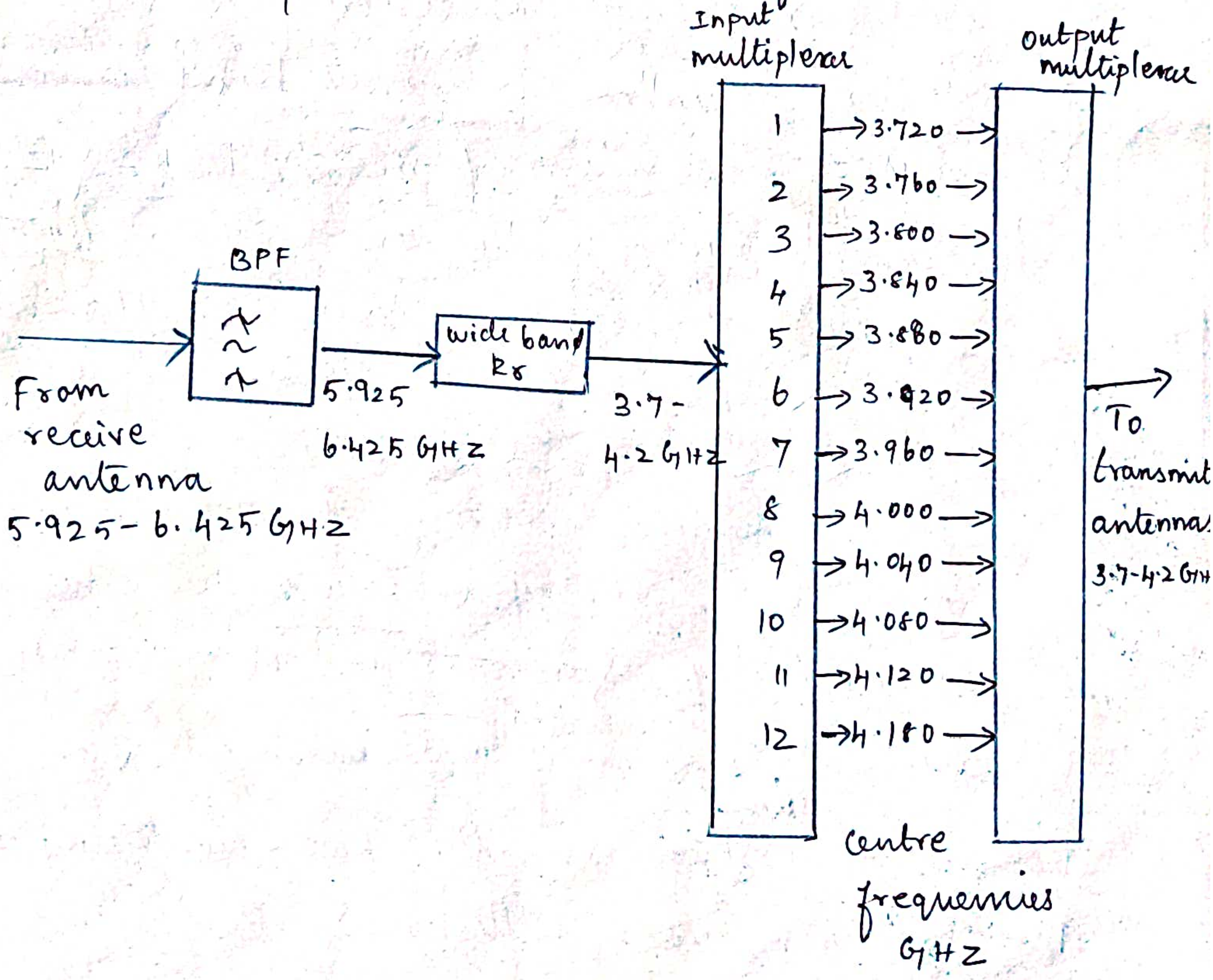
2.4.1 Transponder

A transponder is series of interconnected unit which forms a single communication channel between receive and transmit antennas. The Bandwidth allocated for c band communication is 500 MHz, is divided into subbands.

A typical transponder Bandwidth is 36 MHz, for 4 MHz guard band between transponder 12 transponders are accommodated in 500 MHZ bandwidth. By using Polarization isolation, the ~~no~~ number can be doubled. The carriers with opposite polarization overlap in frequency and is termed as frequency reuse



Frequency reuse is achieved with spot-beam antennas and may combined with polarisation reuse to provide Bandwidth of 2000 MHZ



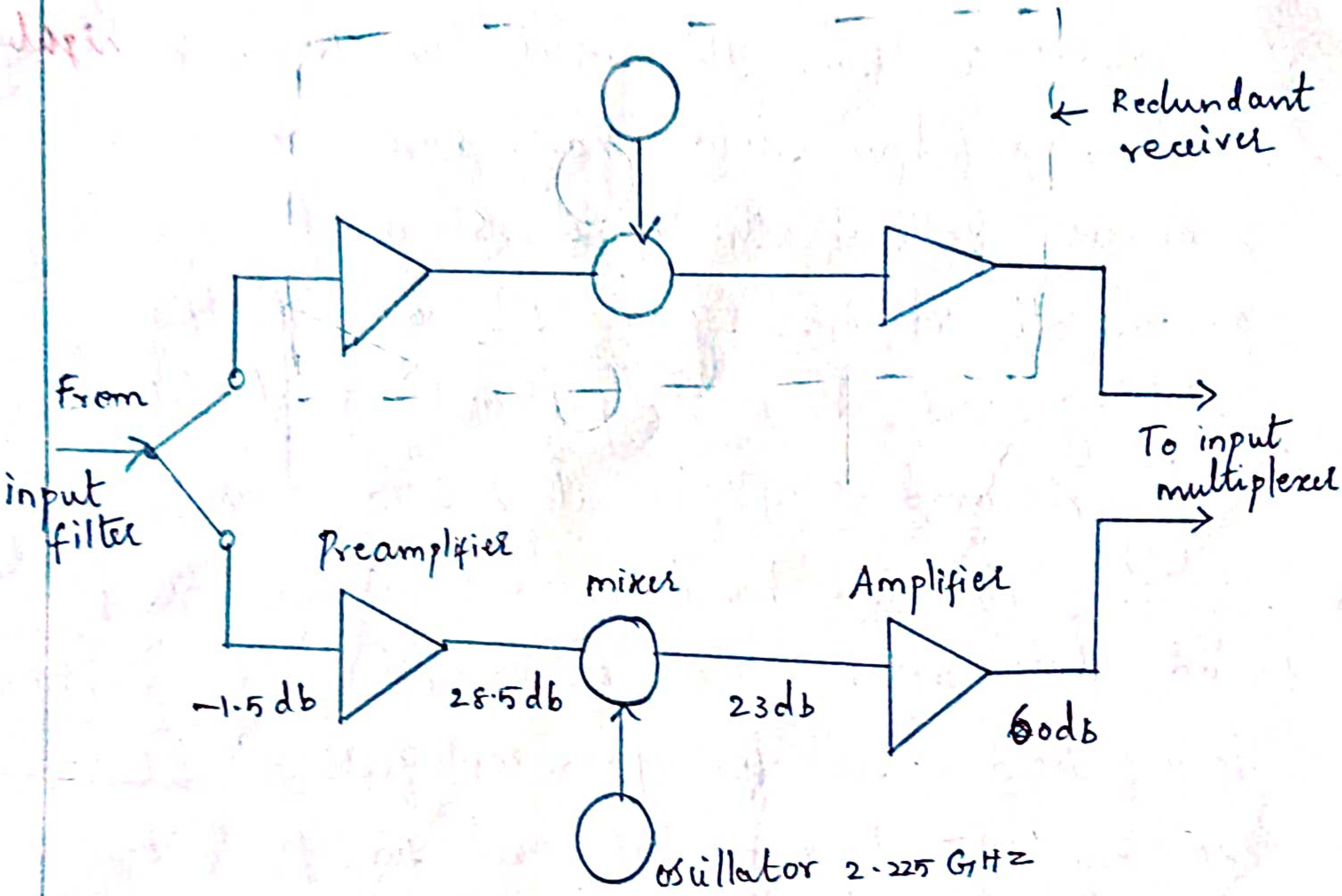
The incoming uplink frequency range is 5.925 to 6.425 GHz. The carriers received on one or more antennas have same polarization. The input filter passes the full 500 MHz band to common receiver while rejecting out of band noise and interference. The modulated carriers within this 500 MHz pass band are amplified and frequency converted in common receivers.

The frequency conversion shifts the carriers to downlink frequency band which is 500 MHz, extending from 3.7 to 4.2 GHz. A transponder may handle one modulated carrier or a number of separate carriers simultaneously.

2.4.2 The wide band Receiver

A duplicate receiver is provided with each original receiver, if one fails the other will be automatically switched on. The fig. shows the block diagram of wide band Receiver.

The first stage is the Low Noise Amplifier. This amplifier adds little noise to the carrier being amplified and provides amplification for carrier to override the higher noise.



A duplicate Receiver is provided, if one fails the other is automatically switched on.

The combination is referred to as redundant receiver, one in use at a given time. The first stage in the receiver is a low noise Amplifier (LNA) which adds little noise to the carrier being amplified, and amplification for carrier to override the higher noise level present in mixer stage.

The LNA feeds into mixer stage, which requires local oscillator (LO) signal for frequency conversion process.

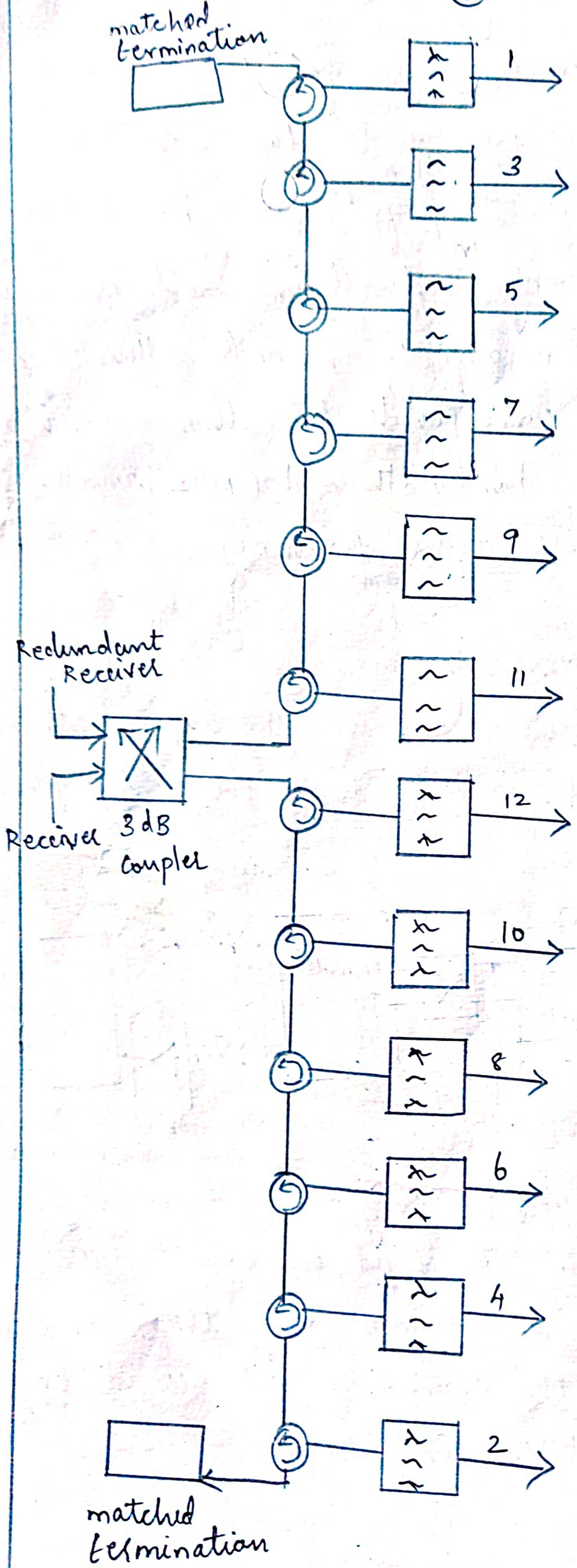
The power drive from LO to the mixer input is about 10 dBm. The oscillator freq. is highly stable and have low phase noise. A second amplifier follows the mixer stage to provide an overall receiver gain of about 60dB.

Splitting gain between preamplifier at 6 GHz and second amplifier at 4 GHz prevents oscillation.

The wide band receiver utilizes only solid state active devices. Tunnel diode amplifiers have been used for preamplifiers at 6 GHz in 6/4 GHz transponders and for parametric amplifiers at 14 GHz in 14/12 GHz transponders. With FET amplifiers better performance are available for both bands.

2.4.3 The input demultiplexer

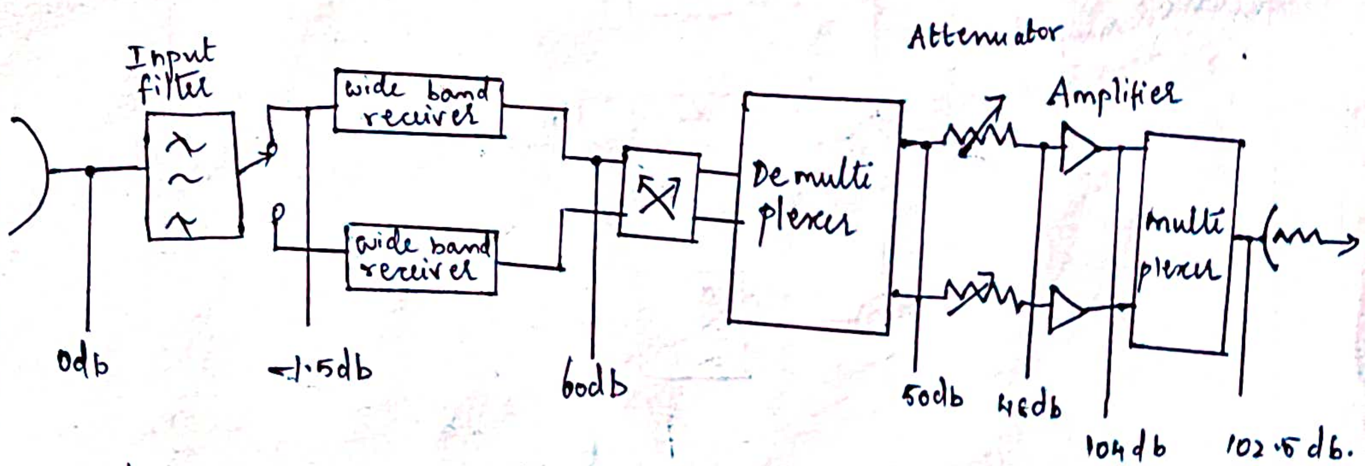
The input demultiplexer separates the broadband input, covering the frequency range 3.7 to 4.2 GHz, into the transponder freq. channel. The separate channels labeled 1 throu' 12 are shown. The channels are arranged in even numbered and odd numbered. This provides greater freq. separation between adjacent channels in a group.


matched termination
1
3
5
7
9
Redundant Receiver
11
Receiver
3 dB coupler
12
10
8
6
4
2
matched termination

The output from receiver is fed to a power splitter, which in turn feeds two separate chains of cirulators. The full broad band signal is transmitted along each chain and channelizing is achieved by means of channel filters. The channel numbers corresponds to those as shown. Each filter has a bandwidth of 36 MHz and is tuned to appropriate center frequency

2.8.4 The Power Amplifier

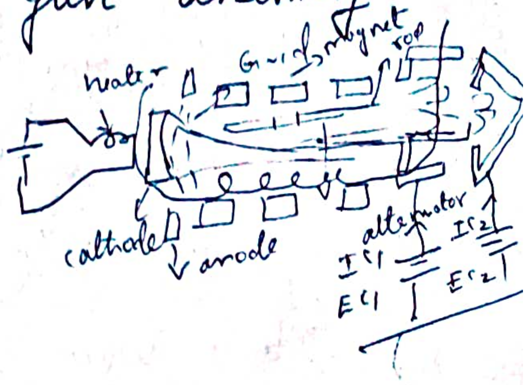
The fig. shows various stages in the transponder, each have a separate power Amplifier



The power amplifiers are proceeded by a attenuator, it may be fixed or variable. The fixed is needed to balance out the variations in the input. The variable is needed to balance out variations in input

The device used as power amplifier is TWTA

In TWTA, the electron beam gun assembly consists of



1. heater
2. cathode
3. Focusing electrode

To confine the beam, that travel along the helix a high magnetic field is required. In ground station it is provided by means of a solenoid and a dc supply. The TWTA uses permanent magnet focusing. The amplified signal is given into helix near cathode which set up travelling wave along the axis.

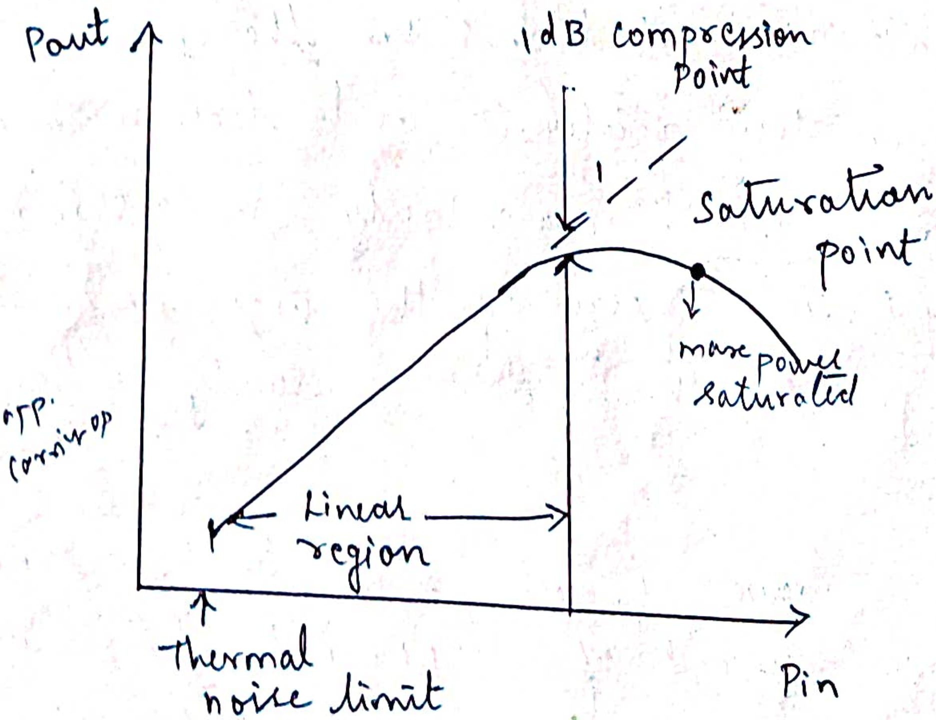
In some regions, the electric field deaccelerate the electrons in the beam and some region they accelerate and electron bunches were formed. The beam velocity is determined by dc potential energy of the wave, which is always greater than phase velocity of travelling wave.

The wave travel around helical path close to the speed of light, but it is the axial component of wave velocity which interact with electron beam

This component is less than the velocity of light approximately in the ratio of helix pitch to circumference. Because of this effective reduction in phase velocity, the helix is reffered to as a slow wave structure.

The advantage of TWT over other types of tube amplifier is that it can provide amplification over wide bandwidth. Input levels to TWT must be controlled which minimize the effects of distortion.

The worst of these result from non linear transfer characteristics. as shown in Fig



Ad
i) wide band app.
ii). multi carrier op

low i/p pow → linear
high i/p pow → power saturated

1dB compression point: The point where transfer curve drops 1dB below extrapolated line interact with electron beam

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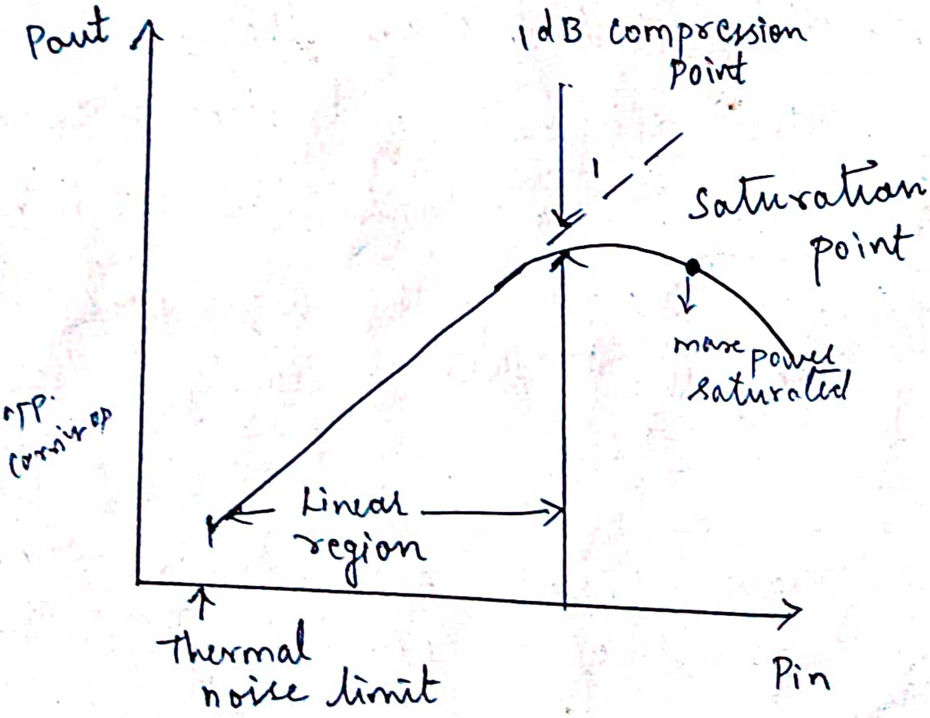


low i/p pow → linear
high i/p pow → power saturated

Ad
1) wide band amp.
2). multi carrier op

1dB compression point: The point where transfer curve drops 1dB below extrapolated line

2.9 TT&C Subsystems - Link Design with and without frequency Reuse

The TT&C subsystems performs several routine functions abroad the space craft. The telemetry is interpreted as measurement at a distance. It refers to the overall operation of generating an electrical signal proportional to the quantity being measured and encoding and transmitting to distant station.

Data transmitted as telemetry signals include altitude information obtained from sun and earth sensors environmental information such as magnetic field intensity and direction, frequency of metiorite impact and so on, and space craft information such as temperatures power supply voltages and stored fuel pressure.

Telemetry and command are complementary functions. The telemetry subsystem transmits information about satellite to the earth, while command subsytem receives command signals from earth station.

Communication transponders switched in and out of circuits, antennas redirected, and station keeping maneuvers carried out on command. To prevent unauthorized commands being received, the command signals are encrypted.

Tracking of satellite is accomplished by having satellite transmit beacon signals received at TT & C earth station. Tracking is important during transfer and drift orbital phases of satellite launch.

The position of geostationary satellite is shifted as a result of various disturbing forces. So it is necessary to track the satellite's movement and send correction signals as required.

2.10 Satellite Uplink and downlink Analysis and Design

Uplink

The uplink of a satellite is the one in which earth station is transmitting the signal and satellite is receiving it specifically that the uplink is being considered.

$$\left[\frac{C}{N_0}\right] = [EIRP] - [LOSSES] + [k]$$

The values to be used are the earth station EIRP, feeder loss and satellite receiver G/T. The free space loss and other losses are calculated for uplink frequency.

2.10.1 Input back off

Number of carriers are present simultaneously in a TWTA, the operating point is backed off to a linear portion of transfer characteristics of to reduce the effects of intermodulation distortion. The multiple carrier operation occurs with Frequency-division multiple access (FDMA). Back off (BO) is allowed for in link budget calculations.

The saturation flux density for single carrier operation is known. Input BO specified for multiple carrier operation, is referred to single carrier saturation level.

The earth station EIRP reduced by specified BO, result in uplink value of

$$[EIRP]_U = [EIRP_S]_U + [BO]_i$$

2.10.2 The earth station HPA:

The earth station HPA has to supply the radiated power plus the transmit feeder losses, denoted by TFL. The power output of HPA is given by

$$[P_{HPA}] = [EIRP] - [G_T] + [TFL]$$

The earth station transmit multiple carriers and its output, denoted by $[BO]_{HPA}$. The earth station HPA rated for saturation power output given by

$$[P_{HPA,sat}] = [P_{HPA}] + [BO]_{HPA}$$

2.10.3 Saturation flux density

The TWTA in satellite transponder exhibits power output saturation. The flux density required at receiving antenna to produce saturation of TWTA is termed as saturation flux density. The flux density in terms of EIRP is

$$\Psi_M = \frac{EIRP}{4\pi r^2}$$

In decibel

$$\Psi_M = [EIRP] + 10 \log \frac{1}{4\pi r^2} \quad \text{--- (2)}$$

For free space loss we have

$$-FSL = 10 \log \frac{\lambda^2}{4\pi} + 10 \log \frac{1}{4\pi r^2} \quad \text{--- (3)}$$

Sub (3) in (2)

$$\Psi_M = [EIRP] - [FSL] - 10 \log \frac{\lambda^2}{4\pi} \quad \text{--- (4)}$$

The effective area of an isotropic antenna is

$$A_0 = 10 \log \frac{\lambda^2}{4\pi} = -21.45 + 20 \log f \quad \text{--- (5)}$$

Sub (5) in (4) and rearranging

$$EIRP = [\Psi_M] + [A_0] + [FSL] \quad \text{--- (6)}$$

Considering the other Propagation loss such as atmospheric absorption loss, polarization mismatch loss, and antenna misalignment loss

$$EIRP = [\Psi_M] + [A_0] + [FSL] + [AA] + [PL] + [AML] \quad \text{--- (7)}$$

In terms of total losses

$$EIRP = [\Psi_M] + [A_0] + [LOSSES] - [RFL] \quad \text{--- (8)}$$

The saturation values are denoted by subscripts,

$$[EIRP]_{S,U} = [\Psi_S] + [A_0] + [LOSSES]_U - [RFL] \quad \text{--- (9)}$$

2.11 $\left[\frac{C}{N}\right]_D = EIRP + \left[\frac{G}{T}\right]_D - [LOSS\ ES]_D - [K] - [B]$ (antenna gain eq.)

Down Link

Downlink is the signal path from satellite towards the earth. The following equation denotes the downlink

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

The values used are

$\frac{C}{N}$ - Carrier to noise density ratio,

B - BW, EIRP of earth station receiver feeder loss and the earth station receiver G/T. The free space and other losses are calculated for downlink frequency.

2.11.1 Output backoff

output BO is not linearly related to input backoff. A rule of thumb, is to take the output BO as point on the curve which is 5 dB below the extrapolated linear portion.

$$[BO_0] = [BO_i] - 5dB$$

If EIRP for saturation condition is specified

$$[EIRP]_D = [EIRP_S]_D - [BO]_0$$

Earth segment

4.1 Earth station Technology -

The earth segment of a satellite communi-cation system consists of the transmit and receive earth stations. Earth stations that are used for logistic support of satellite, such as telemetry, tracking and command functions, are considered as part of space segment.

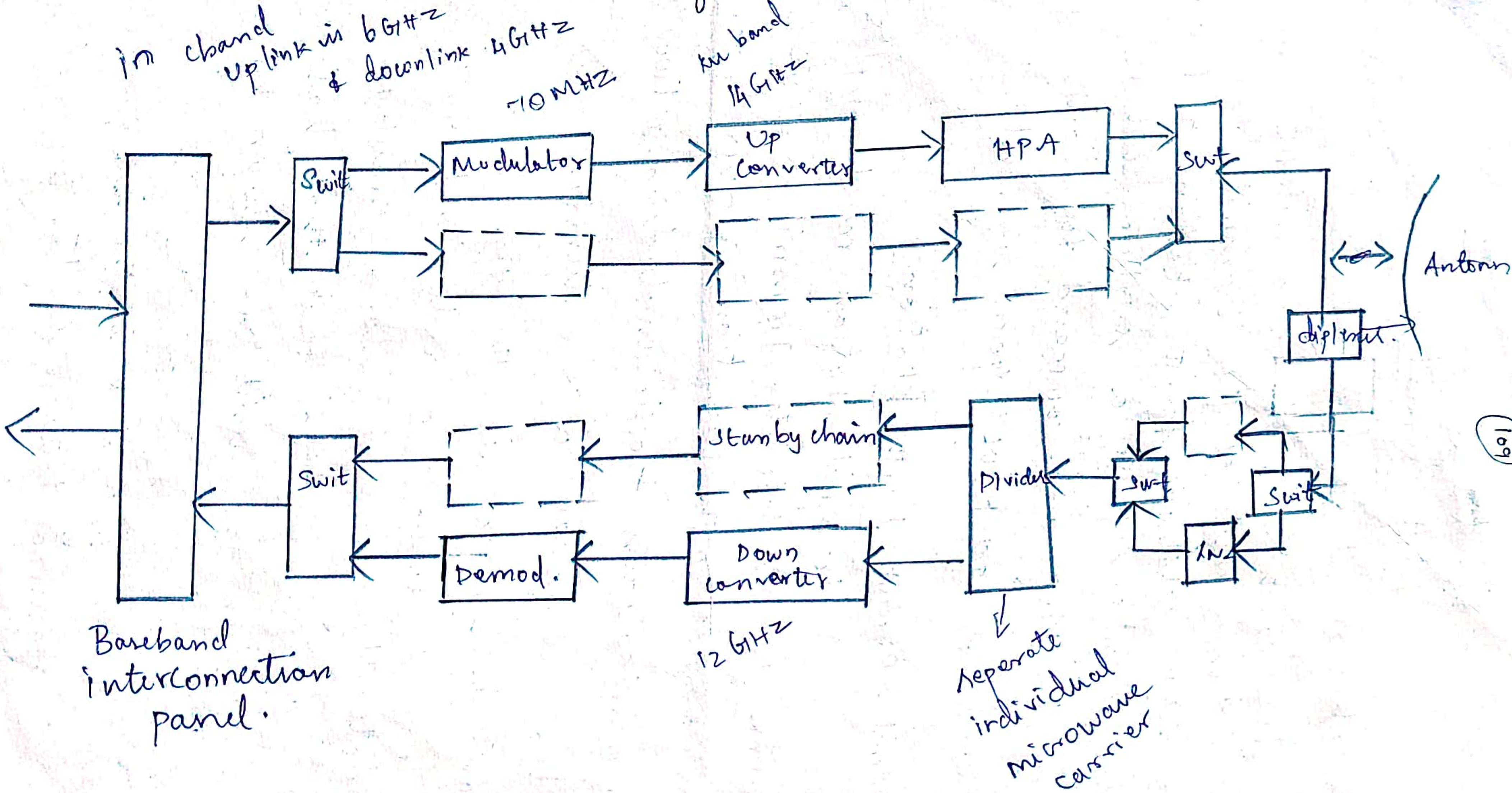
4.2 Transmit - Receive Earth station

A transmit station must complete the uplink to the satellite. Transmit - receive stations provide both functions required for telecommunications traffic, including network T.V. the basic function of a redundant earth station is shown in the fig.

A duplicate or redundant unit is automatically switched into a ciruit to replace a corresponding unit that has failed. Redundant unit are shown by dashed lines.

The first block is the interconnection equipment required between satellite terestrial network.

Basic elements of redundant earth station



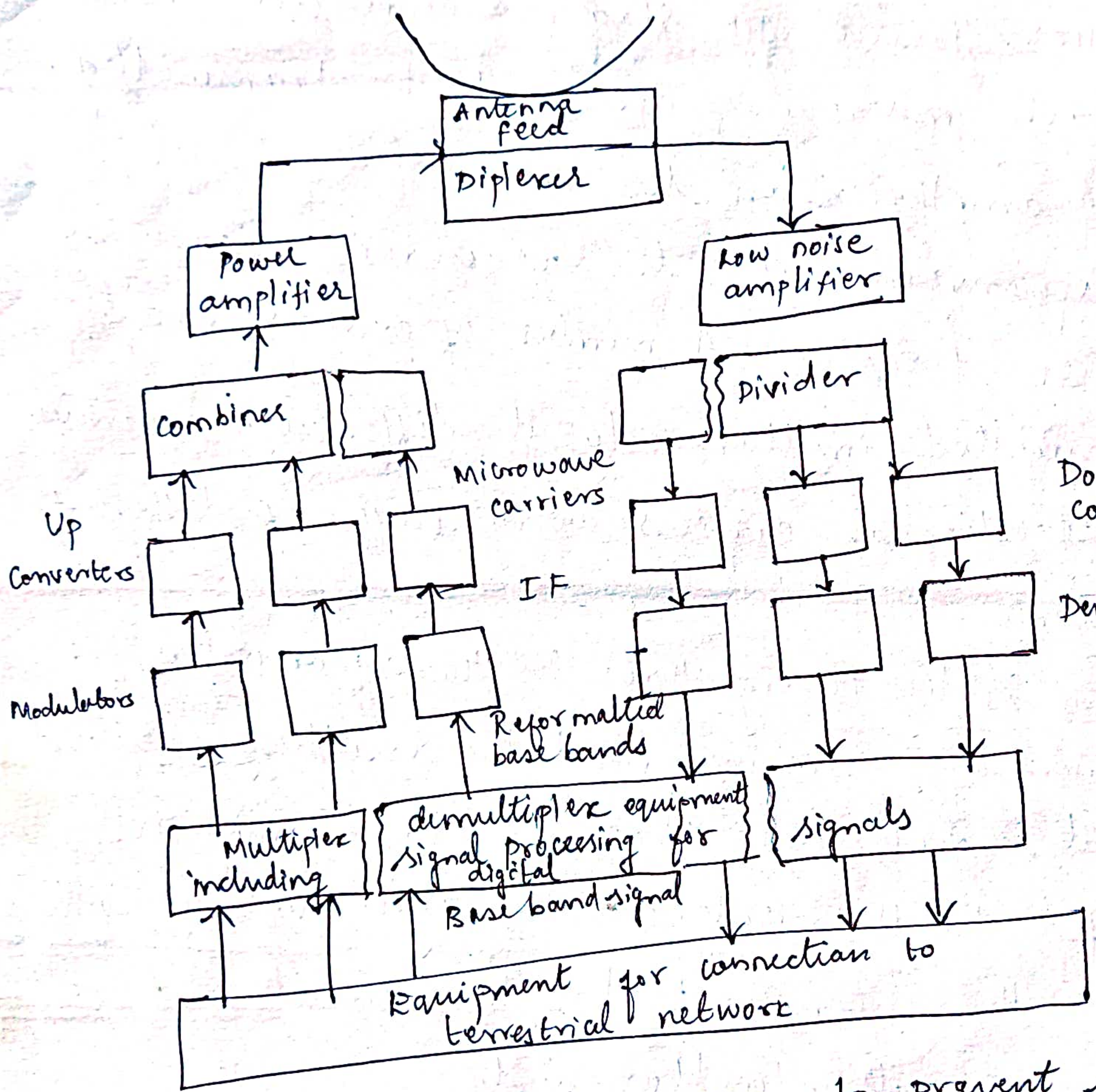
The next block is the multiplexing equipment in which reformatting is carried out. The multiplexed signal is modulated onto a carrier wave at an intermediate frequency 70(MHz). Parallel IF stages are required, one for each microwave carrier to be transmitted. After amplification, the modulated signal is upconverted to the required microwave carrier frequency. A number of carriers are transmitted simultaneously at different frequencies. Multidestination carriers carry traffic of different stations.

After passing through the upconverters, the carriers are combined, and the resulting wideband signal is amplified. The wide band amplifier is fed to the antenna through diplexer, which allows the antenna to handle transmit and receive signals simultaneously

The station's antenna functions in both, the transmit and receive modes, but at different frequencies. In c band, the uplink frequency is 6 GHz and down link frequency is 4 GHz.

In ku band, the uplink frequency is 14 GHz and down link is 12 GHz. High gain antennas are employed in both bands.

Block diagram of transmit receive earth station



A narrow beam is necessary to prevent interference between neighbouring satellite links. In the receive branch, the incoming wide band signal is amplified in an LNA and passed to a divided network which separates out individual microwave carriers. These are down converted to an IF b band and passed on to the multiplex blocks where the multiplexed signals are reformatted as required by the terrestrial network. The incoming microwave carriers will be different in number and traffic.

In a thin route circuit a transponder channel may be occupied by a number of single carriers, each associated with its own voice circuit. This mode of operation is known as single carrier per channel SCPC. A medium route circuit also provides multiple access either on basis of frequency division multiple access (FDMA) or TDMA. Antenna sizes range from 30m for a main station to 10m for a remote station.

In a heavy route system, each satellite channel is capable of carrying over 960 one way voice circuits or single color analog TV signal with associated audio. The antenna diameter for a heavy route circuit is at least 30 m.

4.3 Antenna systems

4.3.1 Receive only Home TV systems (TVRO)

The home TV receivers takes place in the Ku 12-GHz band. This service is known as direct broad cast satellite. There is some variation in the frequency bands assigned to different geographic regions. Large satellite receiving dishes are used to receive downlink TV signals at c band. A single mesh type reflector may be used which focuses the signals into a dual feed horn, one for c band and one for ku band

there is no loss of quality compared to compressed signal

Much of television program originates as first generation signals. also known as master broadcast quality signals. These are transmitted via satellite in the c band to the network head end stations

The advantage of c-band equipment is no loss of quality and large number of satellites are available for reception, subscription services are cheaper than DBS. The c band system appears to be HDTV manufactured by motorola.

This enables reception of

1. Free, analog signals and wild feeds
2. Video cipher II plus subscription services
3. Free Digi chiper 2 services
4. Subscription Digicipher 2 services

brand name for equipment used to scramble analog signal

Digital compression standard

The fig. shows the main units in a home terminal DBS TV receiving system

The outdoor unit

This consists of a receiving antenna feeding directly into a low noise amplifier/ converter combination. A parabolic reflector is generally used with receiving horn mounted at focus.

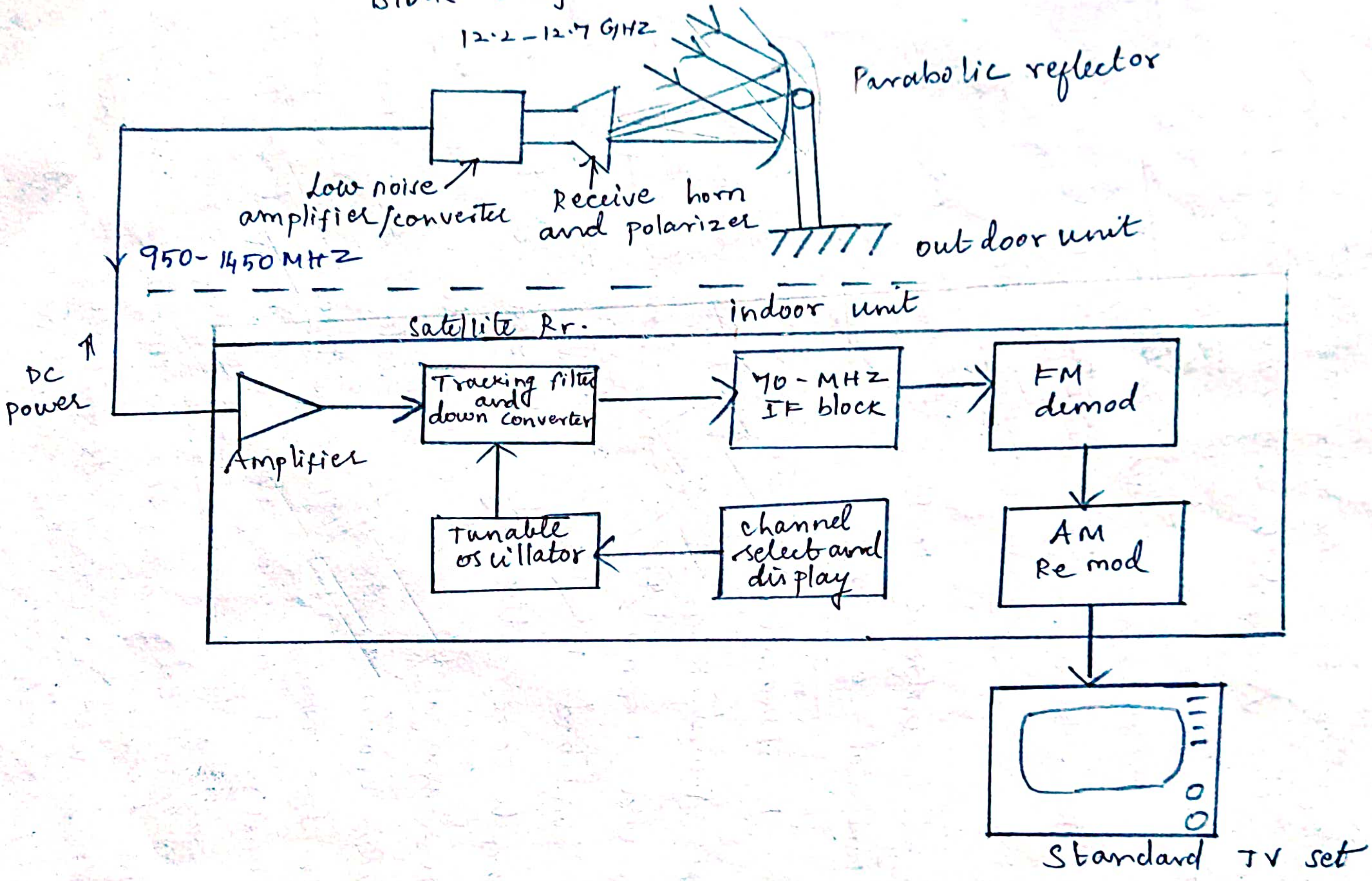
The high gain antenna is not necessary for DBS. Because DBS operate at much higher EIRP.

The isotropic power gain of an antenna is proportional to D/λ^2

D → Diameter of an antenna.

The downlink frequency band is 12.2 to 12.7 GHz It can accomodate 32 TV channels. The polarizer is switched to the desired polarization. The channels are alternately polarized left hand circular LHC and right hand circular to reduce interference. This is known as polarization interleaving. LNB mean Low noise block. It consists of LNA (Low Noise Amplifier) and converter. This Block is used to provide the gain and then it converts the signal to a lower frequency range 950 to 1450 MHz. The coaxial cable is used to carry dc power to the outdoor unit. Low noise amplified signal is given to the cable input

Block Diagram For a home terminal for DBS



The indoor unit :

950 – 1450 MHZ is applied to the indoor unit. This is amplified and given to a tracking filter block. It is used to select the desired channel. By polarization interleaving, half the 32 channels present at the input side of the indoor unit. The selected channel is down converted and intermediate frequency is fixed. Then it is demodulated. In conventional TV amplitude modulation in the form of VSSB is used.

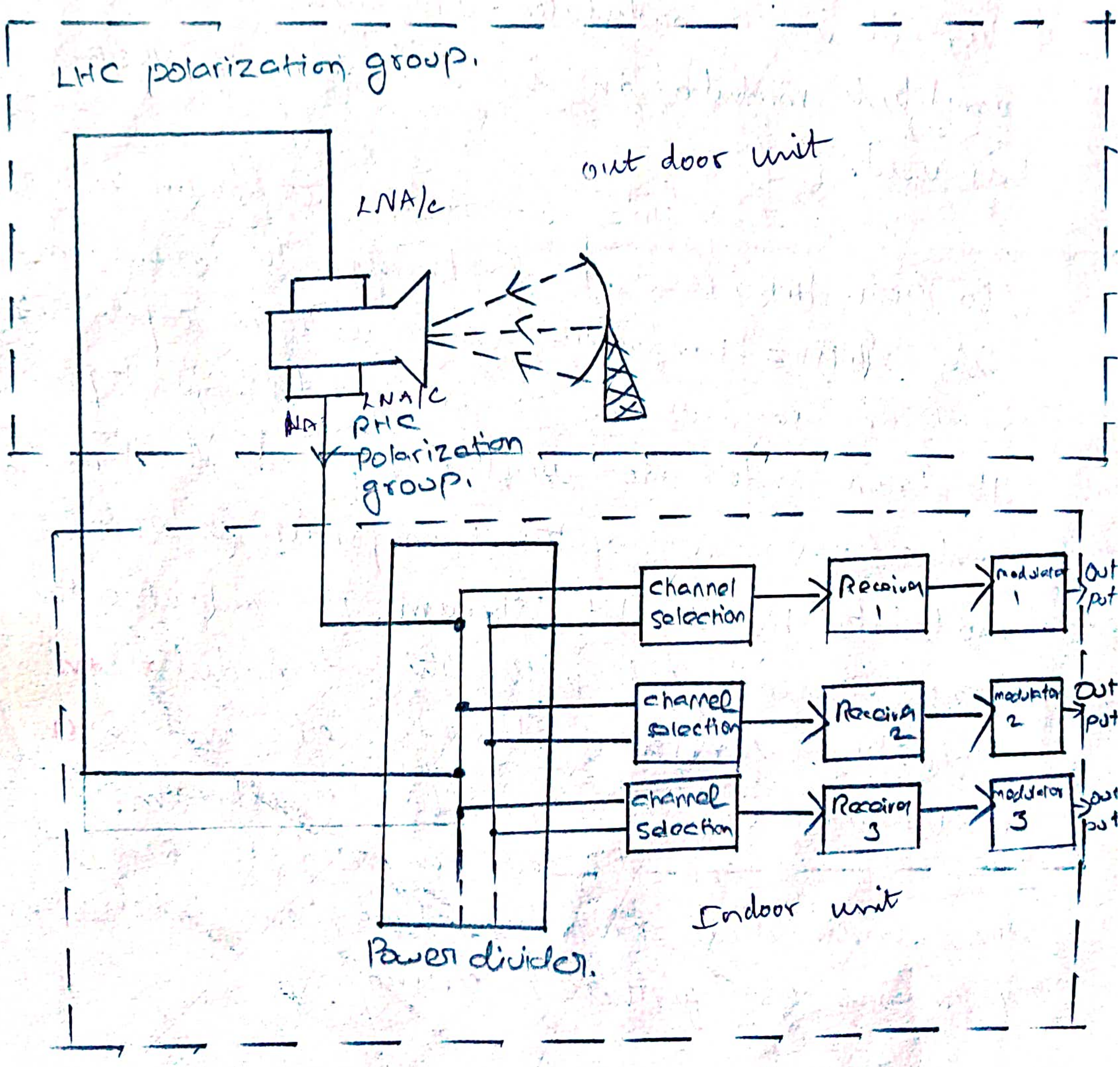
12.2 – 12.7 GHZ freq. band is down converted to 950 – 1450 MHZ. Each transponder maintains its 24 MHZ bandwidth. This unit is capable of receiving any of the 32 transponder. In these 16 transponder are available for single polarization. Centre frequency of the transponder is QPSK modulated by the bit stream. The output of the tuner is connected with the demodulation block. The carrier is demodulated and QPSK modulation is converted to bit stream.

The demultiplexer is used to separate the individual programs. These are stored in memories for further processing

4.3 Master Antenna TV system

MATV is used to provide reception of DBS TV channels to small group of user group to tenants in apartment. It consists of one outdoor unit and Various indoor units. Each user can independently access all the channels.

In MATV separate LNA/c is required for LHC and RHC polarisation. Large antenna is needed to get good SNR.



Unit - III SATELLITE LINK DESIGN

Basic Link Analysis

Link Budget calculations are usually made in decibel or decilog quantities.

Equivalent Isotropic Radiated Power (EIRP)

* EIRP (Equivalent Isotropic Radiated Power) is the Key parameter in link budget calculations
* The maximum power flux density at some distance 'r' from a transmitting antenna of gain 'G' is

$$\psi_M = \frac{G\,P_s}{4\pi r^2}$$

G - is the gain of Transmitting antenna

P - Transmit Power

r - distance from transmitting antenna

* An isotropic radiator with an input power equal to GP_s would produce the same flux density.
* Hence

$$EIRP = GP_s$$

EIRP is expressed in decibels as

$$[EIRP] = [P_s] + [G] \text{ dBW}$$

* For paraboloidal antenna, the isotropic power gain is given by

$$G = \eta\,(10.472\,fD)^2$$

where

f - is carrier frequency in GHz

D - reflector diameter in m

η - aperture efficiency

With Diameter D in feets, the power gain becomes

$$G = \eta (3.192 f D)^2$$

Transmission Losses

* EIRP is the power input to one end of the transmission link.
* Losses will occur on the way and some are constant.
* other losses are estimated from statistical data dependent on weather conditions especially rainfall

Free Space Transmission

→ the power loss resulting from the spreading of signal in space is determined

→ the power flux density at the receiving antenna is

$$\psi_M = \frac{EIRP}{4\pi r^2}$$

→ The received power is

$$P_R = \psi_M A_{eff}$$

$$= \frac{EIRP}{4\pi r^2} \times \frac{\lambda^2 G_R}{4\pi}$$

$$P_R = (EIRP)(G_R)\left(\frac{\lambda}{4\pi r}\right)^2$$

r - is the distance or range between transmit and receive antenna

G_R - isotropic power gain of receiving antenna

→ In decibel, the equation becomes

$$[P_R] = [EIRP] + [G_R] - 10 \log\left(\frac{4\pi r}{\lambda}\right)^2$$

* The free space loss in decibels is given by

$$[FSL] = 10 \log\left(\frac{4\pi r}{\lambda}\right)^2$$

* Substituting $\lambda = c/f$, where $c = 10^8$ m/s, frequency in Megahertz and distance in kilometers, the free space loss is given by

$$[FSL] = 32.4 + 20 \log r + 20 \log f$$

* The received power $[P_R]$ is in dBW if $[EIRP]$ is in dBW, and $[FSL]$ in dB.

$$[P_R] = [EIRP] + [G_R] - [FSL]$$

The equation is applicable to both the uplink and downlink of satellite circuit

Feeder loss

* Losses will occur between the connection of receive antenna and the receiver.
* Such losses will occur in connecting waveguides filters and couplers
* This denoted by [RFL] in dB for receiver feeder loss.
* Similar losses will occur in filters, couplers and waveguides connecting the transmit antenna to high Power Amplifier (HPA) output

Antenna misalignment losses

→ Earth station and satellite antennas aligned for maximum gain

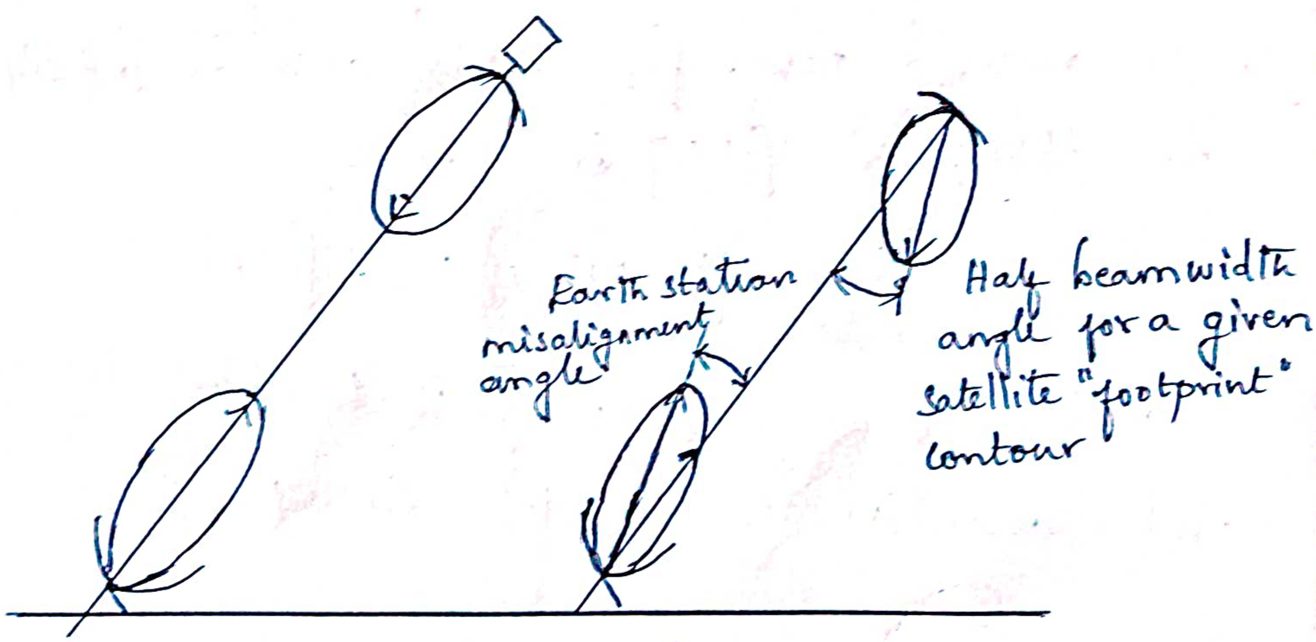


fig (a) fig (b)

→ The two possible sources of off axis loss, one at satellite and one at earth station is shown in the fig.(b)

→ The off axis at the satellite is taken into account by designing the link for operation on actual satellite antenna contour.

→ The antenna misalignment loss [AML], include both pointing and polarization losses resulting from antenna misalignment.

→ The separate antenna misalignment losses for the uplink and downlink is taken.

Fixed atmospheric and Ionospheric losses.

* Atmospheric gases result in losses by absorption
* these losses amount to a fraction of decibel and denoted in decibel by [AA].

The Link Power Budget Equation

* The power at the receiver, which is the power output of the link is [EIRP] − [LOSSES] + [G_R]
* The major source of loss in any ground satellite link in free space spreading loss [FSL] is the basic link power budget equation

→ The losses for clear sky conditions are

$$[LOSSES] = [FSL] + [RFL] + [AML] + [AA] + [PL]$$

The decibel equation for received power is

$$[P_R] = [EIRP] + [G_R] - [LOSSES]$$

$[P_R]$ - received power, dBW

$[EIRP]$ - equivalent isotropic radiated power, dBW

$[FSL]$ - free space spreading loss, dB

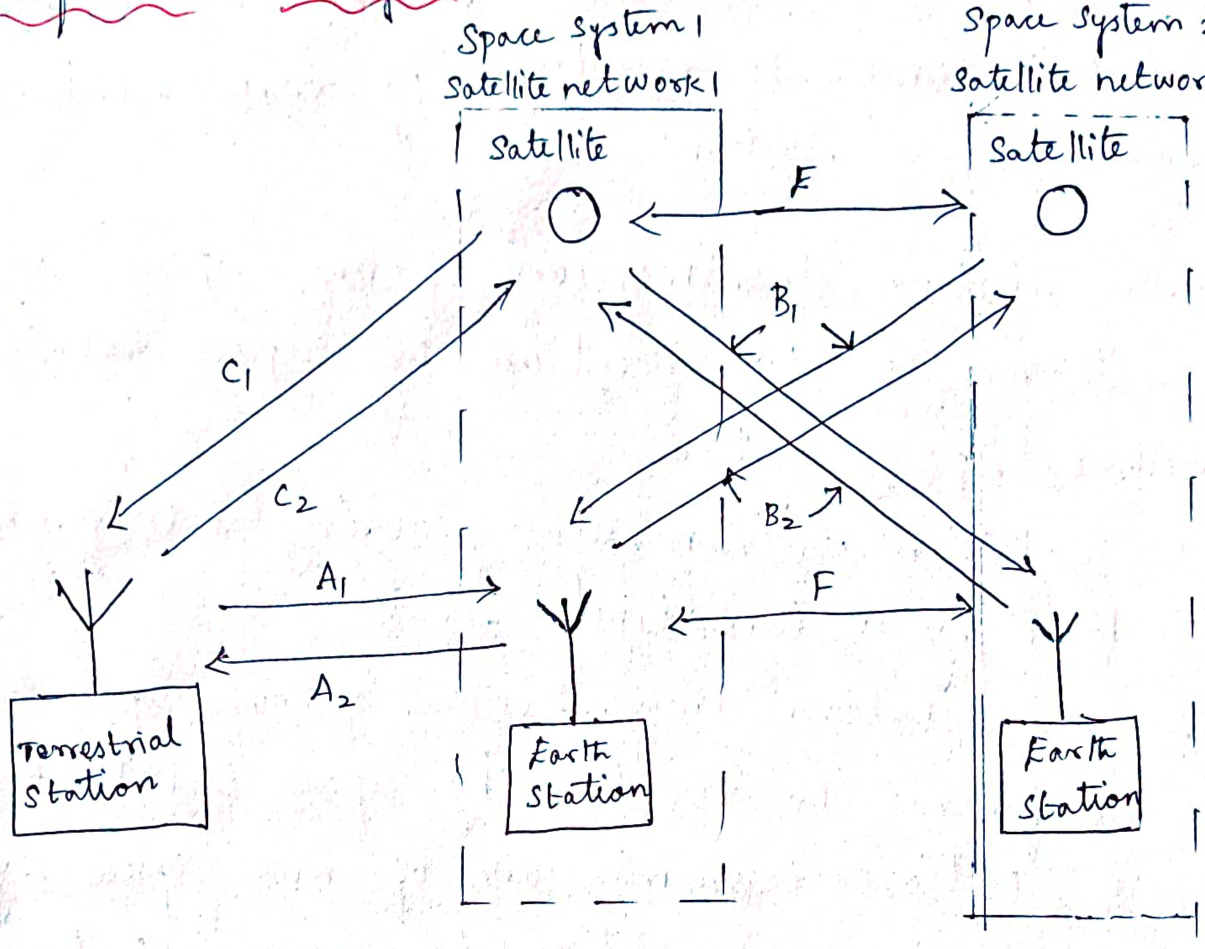
$[RFL]$ - receiver feeder loss in dB

$[AML]$ - antenna misalignment loss in dB

$[AA]$ - atmospheric absorption loss, dB

$[PL]$ - Polarization mismatch loss, dB

Interference Analysis



→ The possible interference paths between services is shown in the fig.

→ Earth stations are associated with satellite circuits and terrestrial stations are associated with ground based circuits

→ The possible modes of interference are as

A_1 : terrestrial station transmission cause interference to reception by earth station.

A_2 : Earth station transmission, cause interference to reception by terrestrial station

B_1 : Space station transmission of one space system cause interference to reception by earth station of another space system

B_2 : earth station transmission of one space system cause interference to reception by space station of another space system

C_1 : space station transmission, causing interference to reception by a terrestrial station

C_2 : terrestrial station transmission, of one space system cause interference to reception by space station

E : space station transmission of one space system cause interference to reception by space station of another space system.

F : earth station transmission of one space system causing interference to reception by earth station of another space system

→ A_1, A_2, C_1 and C_2 are possible mode of interference between space and terrestrial services

→ B_1 and B_2 are possible mode of interference between stations of different space system using separate uplink and downlink frequency bands

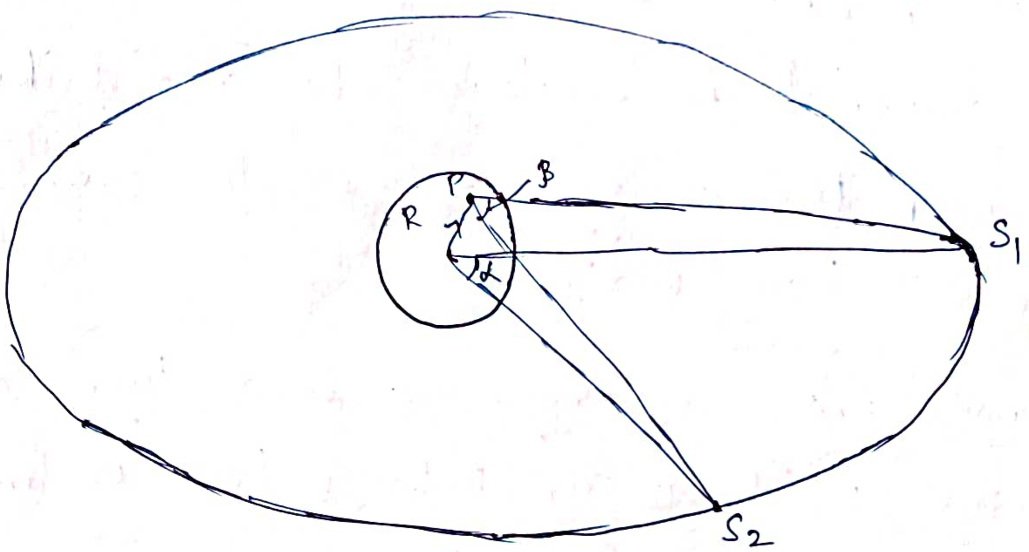
→ E and F are extension to B_1 and B_2 where bidirectional frequency band are used.

Interference between Satellite circuits

→ A satellite circuit may suffer from B_1 and B_2 modes of interference from a number of neighbouring satellite circuits. The resultant effect is termed as aggregate interference

→ Interference is a form of noise, and with noise the system performance is determined by ratio of wanted to interfering powers C/I ratio.

→ The angle subtended by two satellite in geostationary orbit is shown in fig.



→ The orbital separation is defined as the angle "α" subtended at the centre of earth, known as geocentric angle

→ From an earth station at point P the satellite would subtend an angle β, referred as topocentric angle.

→ The Radio Regulation specify maximum limits on radiated powers to reduce the potential interference to acceptable levels

→ Interference occur in coordination between telecommunication administration

→ coordination require both administrators to change or adjust some technical parameters

→ For geostationary satellite, interference modes B_1 and B_2 is set to lower limit to orbital spacing between satellite

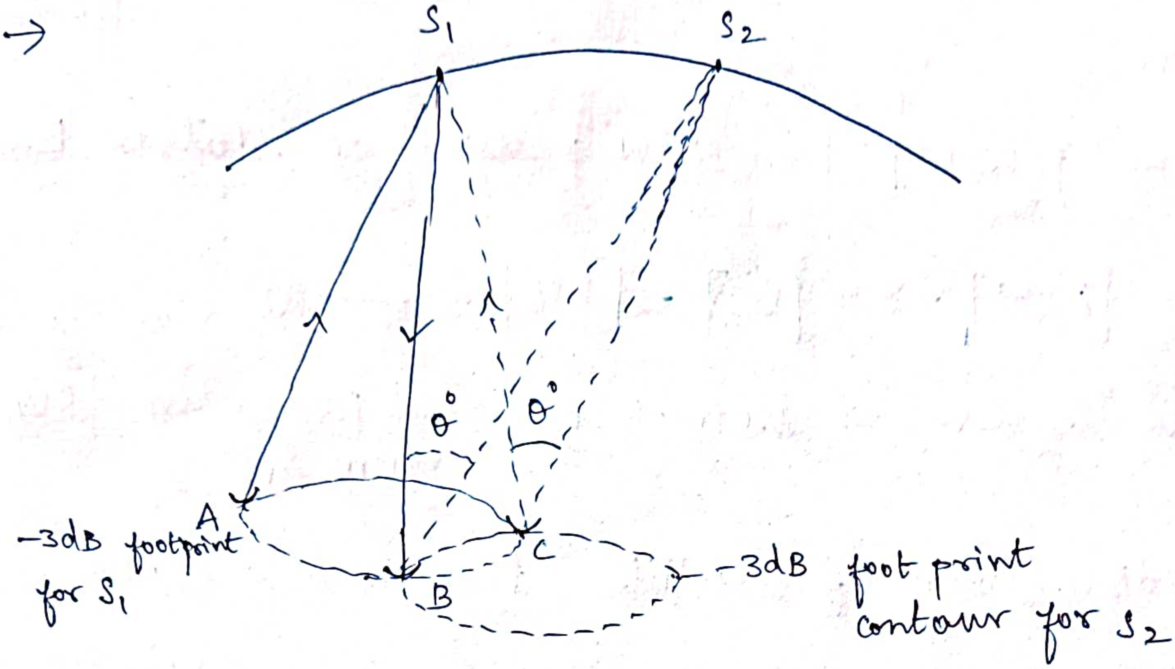
→ Interference with individually owned TVRO receivers occur from terrestrial station transmission in 6/4 GHz band.

→ Energy dispersal is employed to redistribute the transmitted energy more evenly over transmitted Band width

→ Intermodulation Interference is a type of interference which. occur between two or more carriers using a common transponder in a satellite or common high power amplifier in an earth station

→ In practical, the topocentric and geocentric angle assumed to be equal.

→



→ consider S_1 as wanted satellite, S_2 as interfering satellite

→ Antenna 'P' have its main beam directed at S_1 and an off axis at angle θ directed at S_2.

→ 'θ' is the topocentric angle assumed equal to geocentric or orbital spacing angle.

→ The satellite circuit is interferred from earth station A via satellite S_1 to receiving station B

→ B_1 mode of interference occur from satellite S_2 into earth station B.

→ B_2 mode of interference occur from earth station C into satellite S_1.

→ The total interference is the combined effect of these two

→ In interference calculation the earth station assumed to be situated on −3dB contours of satellite footprint

Down link

The carrier power [C] in dBW received at station B is

$$[C] = [EIRP]_1 - 3 + [G_B] - [FSL] \quad \text{—— (1)}$$

$[EIRP]_1$ → is equivalent isotropic radiated power in dBW from S_1

−3 → −3dB contour of satellite transmit antenna

$[G_B]$ → bore sight (on axis) receiving antenna gain at B

[FSL] → is free space loss in dB

The Interferring carrier [I] is given as

$$[I] = [EIRP]_2 - 3 + [G_B(\theta)] - [FSL] - [Y]_D \quad \text{— (2)}$$

$[Y]_D$ → polarisation discrimination

(1) & (2) are combined as

$$[C] - [I] = [EIRP]_1 - [EIRP]_2 + [G_B] - [G_B(\theta)] + [Y]_D$$

$$\left[\frac{C}{I}\right]_D = \Delta[E] + [G_B] - [G_B(\theta)] + [Y]_D$$

D → denotes down link

ΔE → denotes difference between EIRPs of two satellite

Uplink

$$\left[\frac{C}{I}\right]_U = \Delta[P] + [G_A] - [G_C(\theta)] + [Y]_U$$

$\Delta P \rightarrow$ difference in dB between wanted and interferring transmit powers

$[G_A] \rightarrow$ boresight transmit antenna gain at A,

$[G_C(\theta)] \Rightarrow$ the off axis transmit gain at C..

The subscript U denotes Uplink.

Combined $[C/I]$ due to interference.

→ The interference powers is added directly to give total interference at receiver B.

$$\left(\frac{I}{C}\right)_{ant} = \left(\frac{I}{C}\right)_U + \left(\frac{I}{C}\right)_D$$

→ subscript "ant" denotes the combined ratio at the output of station B receiving antenna.

Rain Induced attenuation and Interference

→ In c band and Ku band rainfall is the most significant cause of signal fading.

→ Rainfall results in attenuation of radio waves by scattering and by absorption of energy from the wave.

→ Rain attenuation increases with increasing frequency

→ Rain attenuation is accompanied by noise generation and both attenuation and noise affect satellite performance

→ Rain drops when falling through the atmosphere becomes elliptical rather than spherical.

→ when radio wave passes throu' rain drops, the component of electric field in direction of major axes of raindrop will be affected differently from component along minor axes

→ This produces depolarisation of wave, and the waves become elliptically polarized.

→ For single polarisation the effect is not serious

→ But where frequency reuse is achieved, the use of orthogonal polarisation, depolarizing devices which compensate for rain depolarisation is to be installed.

Uplink rain fade margin

→ Rainfall results in attenuation of signal and increase in noise temperature degrading $[C/N_0]$ at the satellite

→ The increase in noise is due to the satellite antenna pointing towards hot earth.

→ The uplink carrier at satellite is held within certain limits and uplink power control is necessary for rain fades.

→ The power output at satellite is monitored by earth station and power output from any given earth station is increased if required to compensate for fading.

→ Earth station HPA have sufficient reserve power to meet the fade margin

Down link rain fade margin

→ Rainfall introduces attenuation by absorption and scattering of energy

Let $[A]$ → rain attenuation by absorption

power loss is $A = 10^{|A|/10}$

→ The effective noise temperature of rain is

$$T_{rain} = T_a \left(1 - \frac{1}{A}\right)$$

T_a → apparent absorption temperature. It is the measured parameter function of factors like physical temperature and scattering effect of rain. (270 – 290K)

→ The total sky noise temperature is the clear sky temperature T_{cs} plus the rain temperature

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

T_{cs} → clear sky temperature

T_{rain} → rain temperature

T_{sky} → total sky noise temperature

→ Rainfall degrades the received $[C/N_0]$ in two ways

1) By attenuating the carrier wave
2) By increasing the sky noise temperature.

→ The downlink C/N power ratio are related to clear sky value by

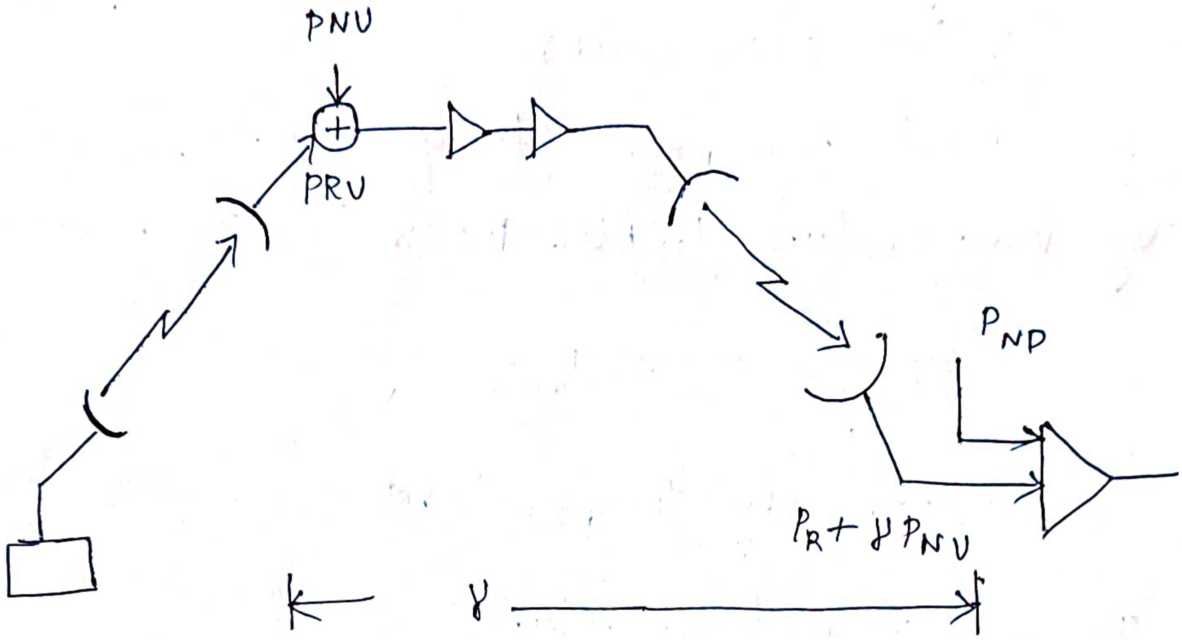
$$\left(\frac{N}{C}\right)_{rain} = \left(\frac{N}{C}\right)_{cs} \left(A + (A-1)\frac{T_a}{T_{s,cs}}\right)$$

CS → denotes clear sky condition

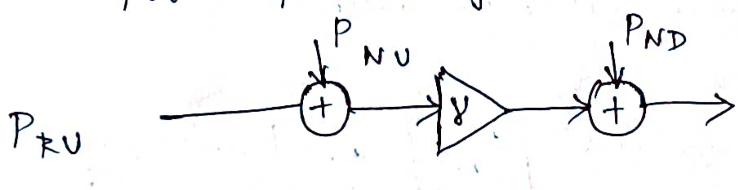
→ At low rainfall rate the rain attenuation is absorptive

→ At high rainfall rate scattering is significant

Combined Uplink and Downlink



Power flow Diagram



$P_R = \gamma P_{RU}$

$P_N = \gamma P_{NU} + P_{ND}$

→ Noise will be introduced on uplink at the satellite receiver i/p

P_{NU} → noise power per unit B.W

P_{RU} → average carrier power

$$\left(C/N_0\right)_U = \frac{P_{RU}}{P_{NU}}$$

The carrier at the end of space link is P_R

P_R → is the received power at downlink, it is equal to γ times the carrier power at i/p

γ → System power gain from satellite input to earth station i/p

→ It also includes satellite transponder and transmit antenna gain, down link losses earth station receive antenna gain and feeder losses.

→ The noise at satellite input also appears at earth station input multiplied by γ. and earth station also includes its own noise

→ Noise to carrier ratio N_o/c is

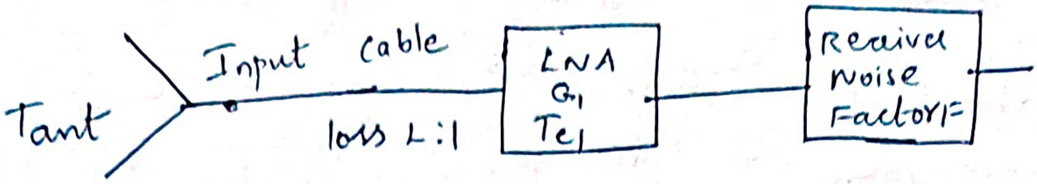
$$\frac{N_o}{c} = \frac{P_N}{P_R}$$

$$= \frac{\gamma P_{NU} + P_{ND}}{P_R} = \frac{\gamma P_{NU}}{\gamma P_{RU}} + \frac{P_{ND}}{P_R}$$

$$= \left(\frac{N_o}{c}\right)_U + \left(\frac{N_o}{c}\right)_D$$

$\left(\frac{N_o}{c}\right)_U$ → uplink noise to carrier ratio

$\left(\frac{N_o}{c}\right)_D$ → Downlink noise to carrier ratio



2.15 Intermodulation and Interference

Intermodulation interference is the undesired combining of several signals in a non linear device which cause interference in adjacent receivers.

Intermodulation distortion is caused from co-channel interference, atmospheric conditions and man made noise generated by medical, welding and heating equipment.

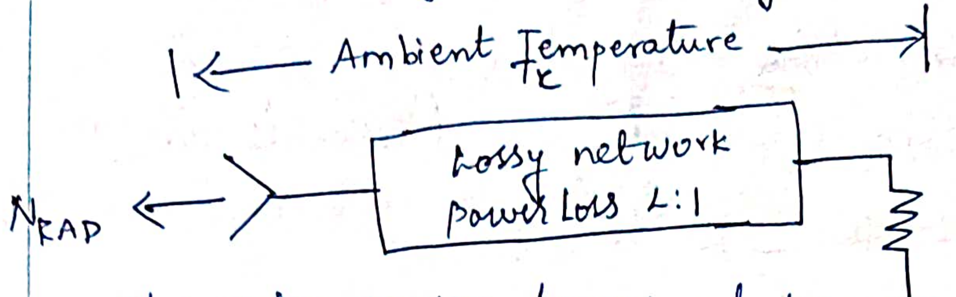
Most intermodulation occurs in transmitters non linear power Amplifier. It can also be produced in rusty or corroded tower joints, guy wires, turnbuckles and anchor rods.

2.16 Propagation characteristics and Frequency considerations

A number of factors resulting from changes in the atmosphere have to be taken into account when designing a satellite communication system in order to avoid impairment of wanted signal.

2.14.6 Noise temperature of absorptive networks

An absorptive network is one which contains resistive elements. Let the n/w be matched at both ends by terminating resistor R_T



$$L = \frac{o/p\ Power}{i/p\ Power}$$

L ↓ power loss

The noise energy transfered from R_T to n/w is kT_x

The noise energy radiated by antenna is

$$N_{rad} = \frac{kT_x}{L} + kT_{NW,o} \quad \text{--- (1)}$$

↳ n/w noise represented at o/p terminals (antenna end)

The available noise energy fed into antenna & radiated is $N_{rad} = kT_x$ → sub in (1).

The equivalent noise temperature of the network referred to output terminals is

$$T_{NW,o} = T_x\left(1 - \frac{1}{L}\right)$$

The equivalent noise temperature referred to network input is

$$T_{NW,i} = T_x(L-1)$$

At room temperature the noise factor of a lossy network is equal to its power loss

$$F = L$$

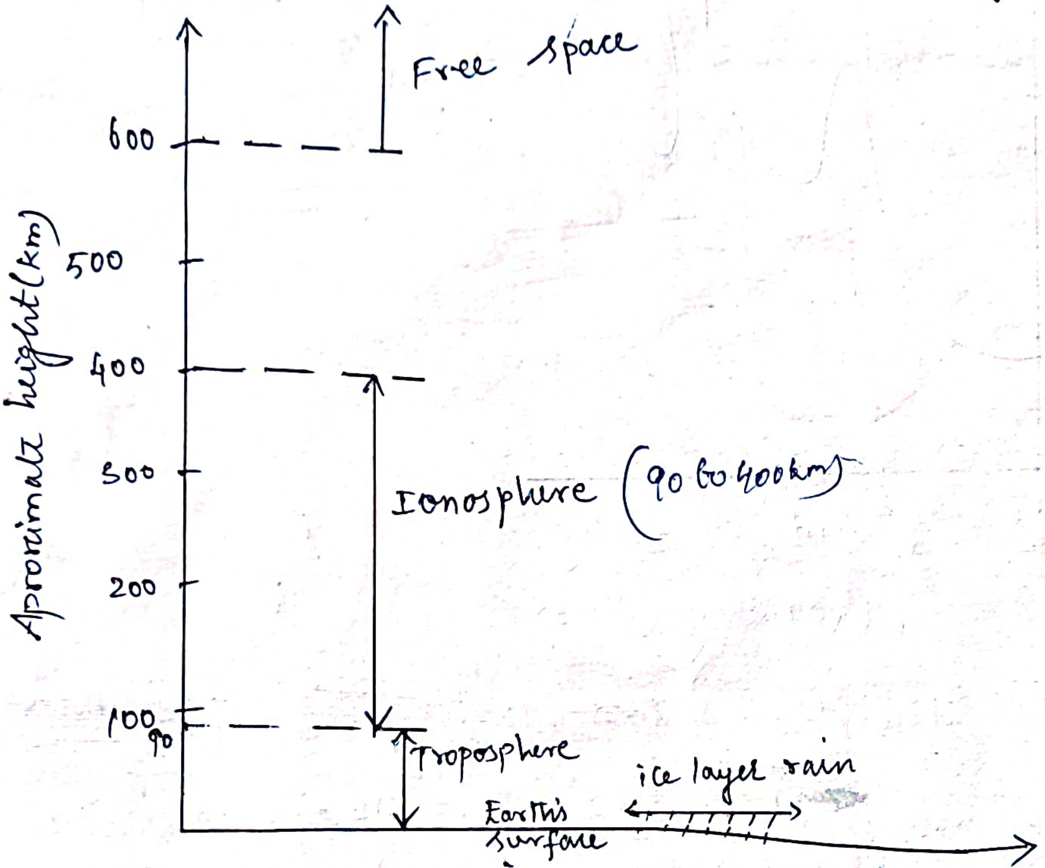
2.14.7 overall system noise temperature

For the system noise temperature referred to i/p

$$T_s = T_{ant} + T_{e_1} + \frac{(L-1)\,T_0}{G_1} + L\frac{(F-1)\,T_0}{G_1}$$

2.1.1 Radio noise

A signal travelling between an earth station and satellite must pass through earth's atmosphere as shown in Fig.



Layers in earth's atmosphere

2.16.1 Atmospheric Losses

Losses occur in earth's atmosphere as a result of energy absorption by atmospheric gases. The weather related losses are referred to as atmospheric attenuation and absorption losses as atmospheric absorption.

The atmospheric absorption loss varies with frequency as shown in the fig.

~~2.15.1 Radio noise~~

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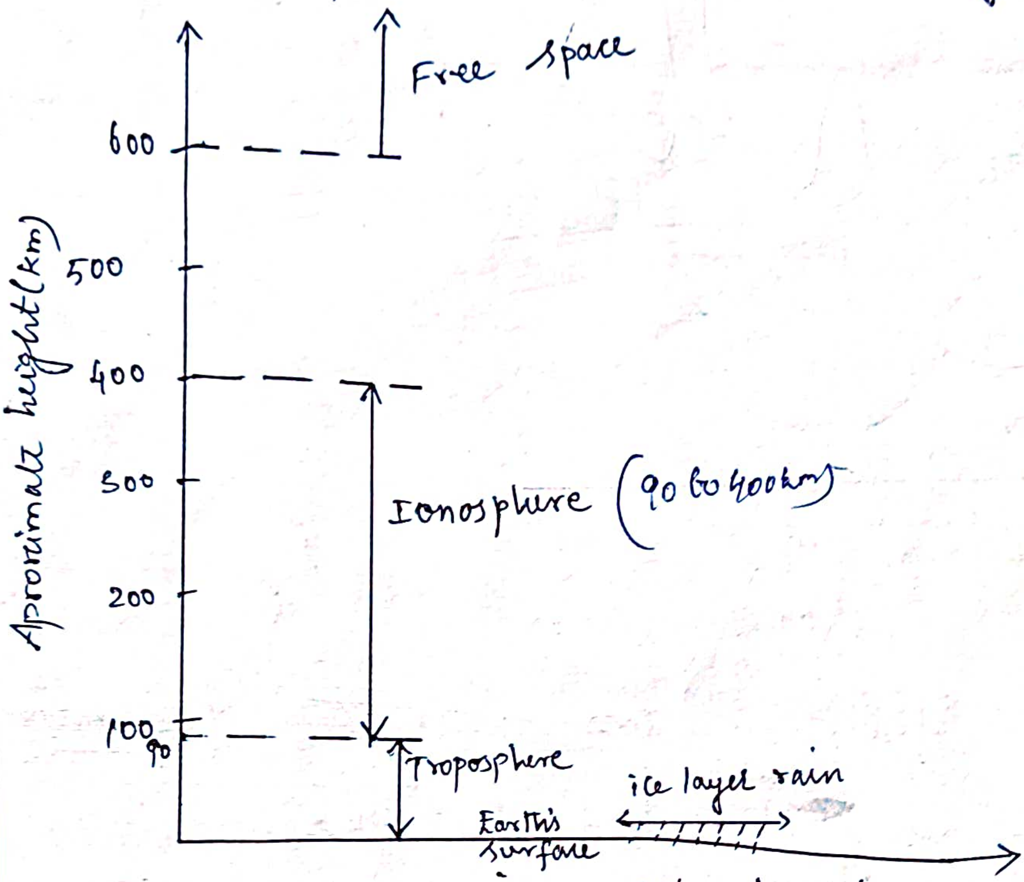

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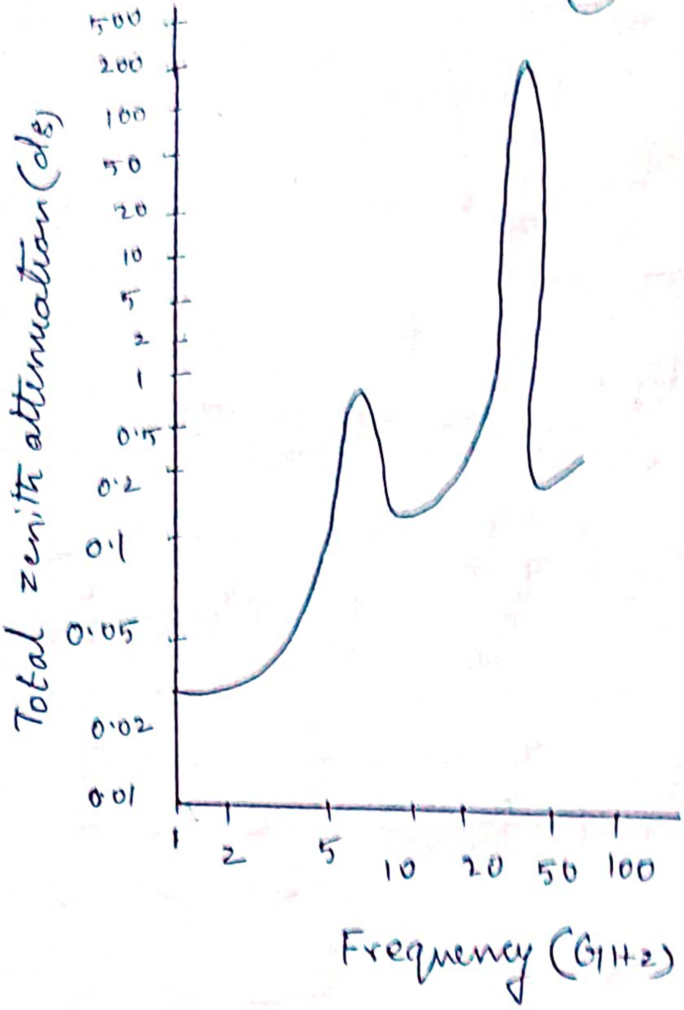


Two absorption peaks is observed in the fig.

the first one at freq 22.3 GHz, resulting from resonance absorption in water vapour (H_2O) and second one at 60 GHz, resulting from resonance absorption in oxygen (O_2).

The absorption loss in decibels is
Consider elevation angle of signals as 100

$$[AA] = [AA]_{90} \operatorname{cosec} El$$

El → angle of elevation.

An effect known as atmospheric oscillation also occur and it is a fading phenomenon. with period of several tens of seconds.

2.16.2 Ionospheric Effects

Radio waves travelling b/w satellites and earth must pass through ionosphere. It is the upper region of earth's atmosphere, ionized by solar radiation. clouds of electrons travel through ionosphere, give rise to fluctuations in the signal. The effect include scintillation, absorption, variation in direction of arrival, propagation delay, dispersion, frequency change and polarization rotation. All these effects decrease as frequency increases.

The scintillation are variations in amplitude phase, polarization or angle of arrival of radio waves. are caused by irregularities in ionosphere which change with time. The main effect is fading of signal

[Synchrotron → emission of relativistic & ultrarelativistic e⁻ gyrating in magnetic field
stray → move away from group]

2.16.3 Rain Attenuation

Rain attenuation is a function of rain rate. Rain rate is the rate at which rain water accumulate in a rain gauge situated at ground.

(gauge → precipitation at certain amount of time)

The percentage time denote by p and rain rate by R_p. The specific attenuation α is

$$\alpha = a R_p^b \ dB/km.$$

a, b depend on frequency and polarisation.

Total attenuation is

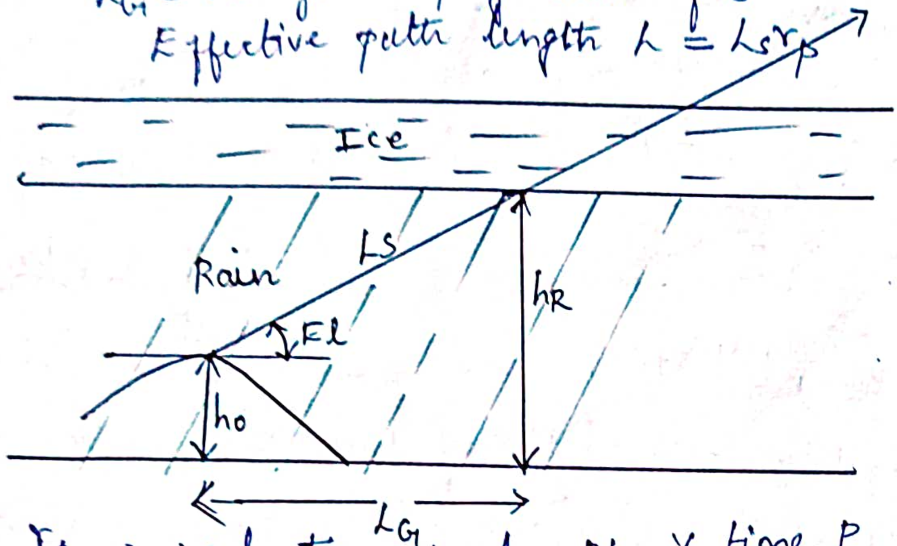
$$A = \alpha L \text{ dB}$$

L – effective path length of signal through the rain. L_s – slant height depends on antenna angle of elevation θ & rain height

The fig. shows geometry of situation

L_G – horizontal projection of L_s

Effective path length $L = L_s r_p$



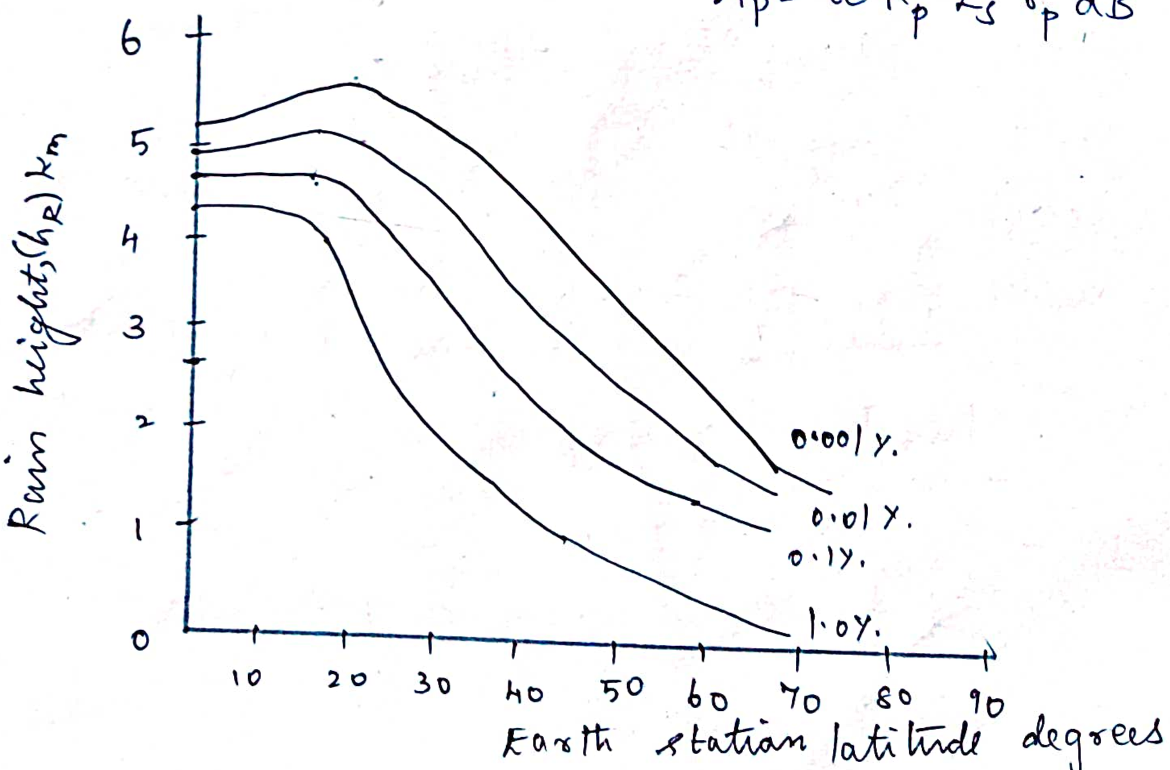
$r_p \rightarrow$ reduction factor of % time P & L_G

The path length is shown as L_s, depends on antenna angle of elevation θ and rain height h_R,

$$L_G = L_s \cos El$$

In the following fig shows h_R for various climate

$$A_p = a R_p^b L_s r_p \text{ dB}$$



For $El \geq 10^6$ it is seen

$$L_S = \frac{h_R - h_0}{\sin El}$$

The effective path length in terms of slant length (L_S)

$$L = L_S \, r_p$$

$r_p \rightarrow$ reduction factor

The horizontal projection is

$$L_G = L_S \cos El$$

The rain attenuation in decibels is given by

$$A_p = a R_p^b \, L_S \, r_p \ \text{dB}$$

$r_p \rightarrow$ reduction factor

$R_p \rightarrow$ rain rate

a, b depends on frequency and polarisation

Link Design with and without frequency Reuse

Uplink :

The uplink of the satellite is the one in which earth station is transmitting the signal and satellite is receiving it.

$$\left[\frac{C}{N_0}\right]_U = [EIRP] - [Loss\ ES] + [K]$$

Down link

Down link is the signal path from satellite towards the earth.

$$\left[\frac{C}{N}\right]_D = [EIRP]_D - [LossES] - k + \left[\frac{G}{T}\right]_D$$

$\frac{C}{N}$ → carrier to noise density ratio

$\frac{G}{T}$ → earth station receiver

EIRP → Equivalent Isotropic Radiated Power

2.12 Link Budget

The power at the receiver, which is the power output of the link is calculated as

$$[EIRP] - [LOSSES] + [G_R]$$

G_R - is receiver antenna gain

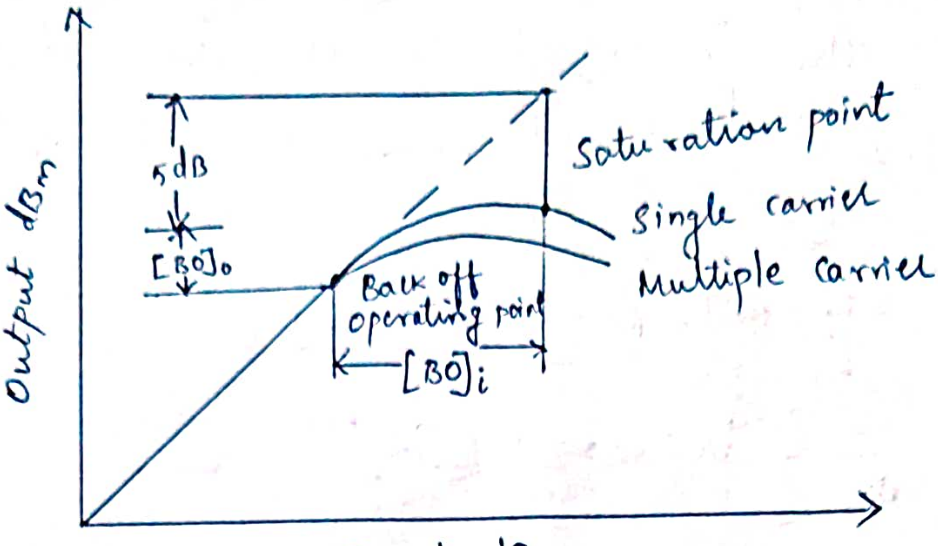
The major source of loss in any ground satellite link is free space spreading loss [FSL]. The other losses are simply added to [FSL]. The losses for clear sky conditions are

$$[LOSSES] = [FSL] + [RFL] + [AML] + [AA] - [PL]$$

The decibel equation for received power is then

$$[P_R] = [EIRP] + [G_R] - [LOSSES]$$

$[P_R]$ → received power, dBW
[EIRP] → equivalent Isotropic Radiated power
[FSL] → free-space spreading loss, dB
[RFL] → receiver feeder loss, dB (losses in connecting wave guide, couplers) etc
[AML] → antenna misalignment loss, dB
[AA] → atmospheric absorption loss, dB
[PL] → polarization mismatch loss, dB



2.11.2 Satellite TWTA output

The satellite power amplifier is a TWTA has to supply the radiated power plus the transmit feeder losses. These losses include the waveguide, filter, and coupler losses between the TWTA output and satellites transmit antenna, the power output of TWTA is given by

$$[P_{TWTA}] = [EIRP]_D - [G_T]_D + [TFL]_D$$

If P_{TWTA} is found, the saturated power output rating of TWTA is

$$[P_{TWTA}]_S = [P_{TWTA}] + [BO]_o$$

and active devices in the receiver. Thermal noise is generated by lossy components of antennas.

The noise power from thermal noise source is given by

$$P_N = k T_N B_N$$

T_N – equivalent noise temperature

B_N – is equivalent noise Bandwidth

$K = 1.38 \times 10^{-23}$ J/K

The noise power spectral density is

$$N_0 = \frac{P_N}{B_N} = k T_N J$$

2.14.2 Antenna Noise

Antennas operating in receiving mode introduce noise into satellite circuit.

Antenna noise is broadly classified into two groups

1) noise originated from antenna losses
2) Sky noise.

Sky noise is used to describe microwave radiation present throughout universe. The equivalent noise temperature of the sky as seen by earth station is shown in fig.

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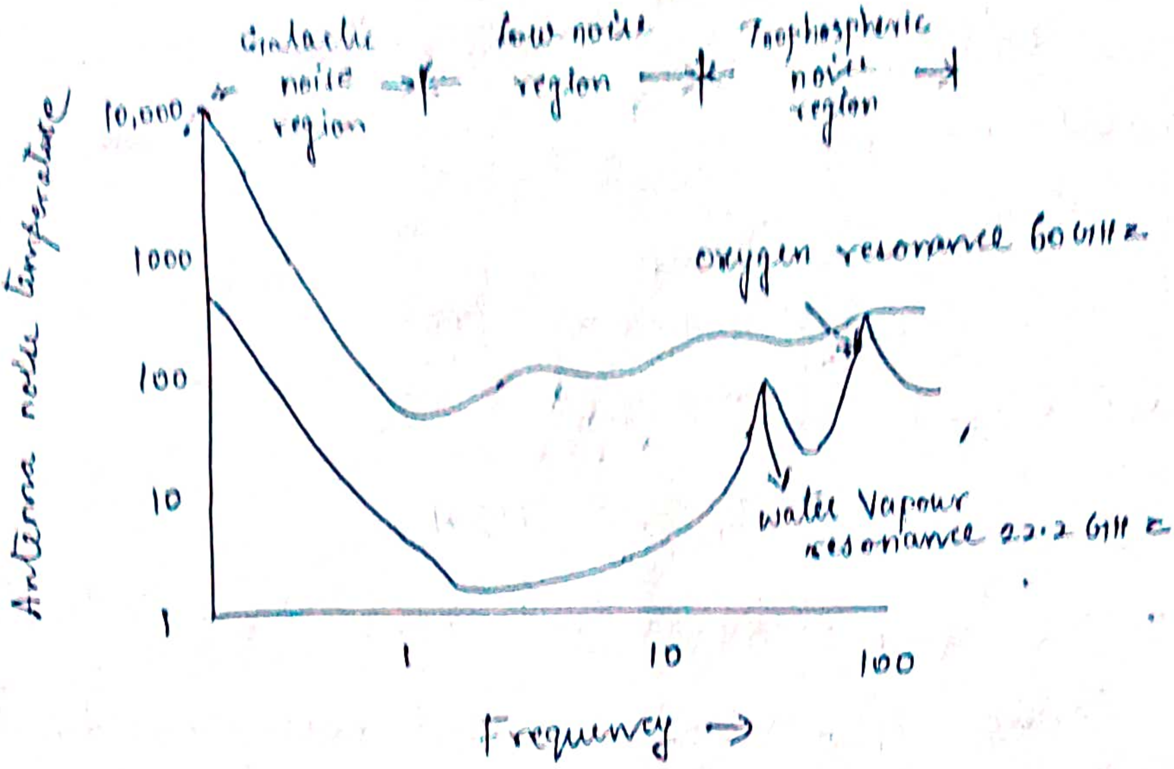
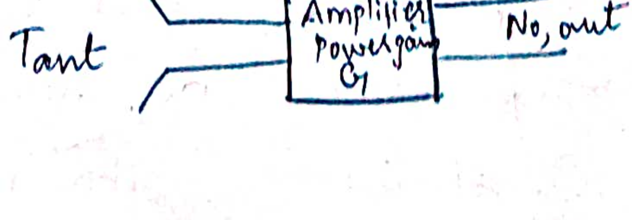


In the fig. the lower graph is for antenna pointing directly overhead, while the upper graph is for antenna pointing above horizon. The graph shows at low frequency end of spectrum the noise decreases with increasing frequency.

2.14.3 Amplifier noise temperature

The available power gain of amplifier is denoted as G. and the noise power output as P_{no}.



The input noise energy coming from the antenna is

$$N_{o,ant} = k\,T_{ant}$$

The output noise is written as (noise temp of antenna; T_e = equivalent i/p noise temperature of amplifier)

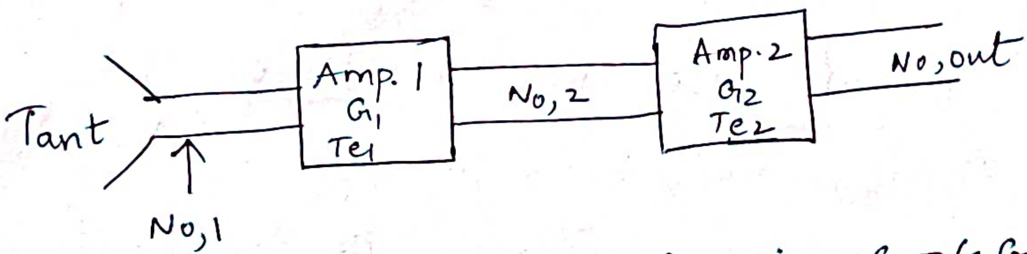
$$N_{o,out} = Gk\,(T_{ant} + T_e)$$

The total noise to i/p is $N_{o\,out}/G$,

$$N_{o\,out}/G = N_{o\,in} = k\,(T_{ant} + T_e)$$

2.14.4 Amplifiers in cascade

The cascade connection is shown in Fig.



The overall gain is $G = G_1 G_2$

The total noise energy referred to amplifier 2 i/p is

$$N_{o,2} = G_1 k\,(T_{ant} + T_{e1}) + k\,T_{e2}$$

The noise energy referred to amplifier 1 input is

$$N_{o,1} = \frac{N_{o,2}}{G_1}$$

$$= k\left(T_{ant} + T_{e1} + \frac{T_{e2}}{G_1}\right)$$

A system noise temperature defined as T_s by

$$N_{o,1} = k\, T_s$$

$$T_s = T_{ant} + T_{e_1} + \frac{T_{e_2}}{G_1}$$

In order to keep overall system noise low the first stage should have high power gain and low noise temperature. The no. of stage in cascade is

$$T_s = T_{ant} + T_{e_1} + \frac{T_{e_2}}{G_1} + \frac{T_{e_3}}{G_1 G_2}$$

2.14.5 Noise factor

In defining noise factor of an amplifier the source is taken at room temperature, T_0.

The output noise from amplifier is

$$N_{o,out} = F G k T_0 \text{ — room temp.}$$

G is available power gain of amplifier and F is its noise factor

$$G k (T_0 + T_e) = F G k T_0$$

$$T_e = (F-1)\, T_0$$

is the direct equivalence between noise factor and noise temperature

The noise figure F is expressed in decibels

$$\text{Noise figure} = [F] = 10 \log F$$

Unit-IV – SATELLITE ACCESS AND CODING METHODS

Introduction :

Communication satellites are used to carry telephone, video and data signals that use both analog and digital modulation techniques

3.1 Modulation and Multiplexing.

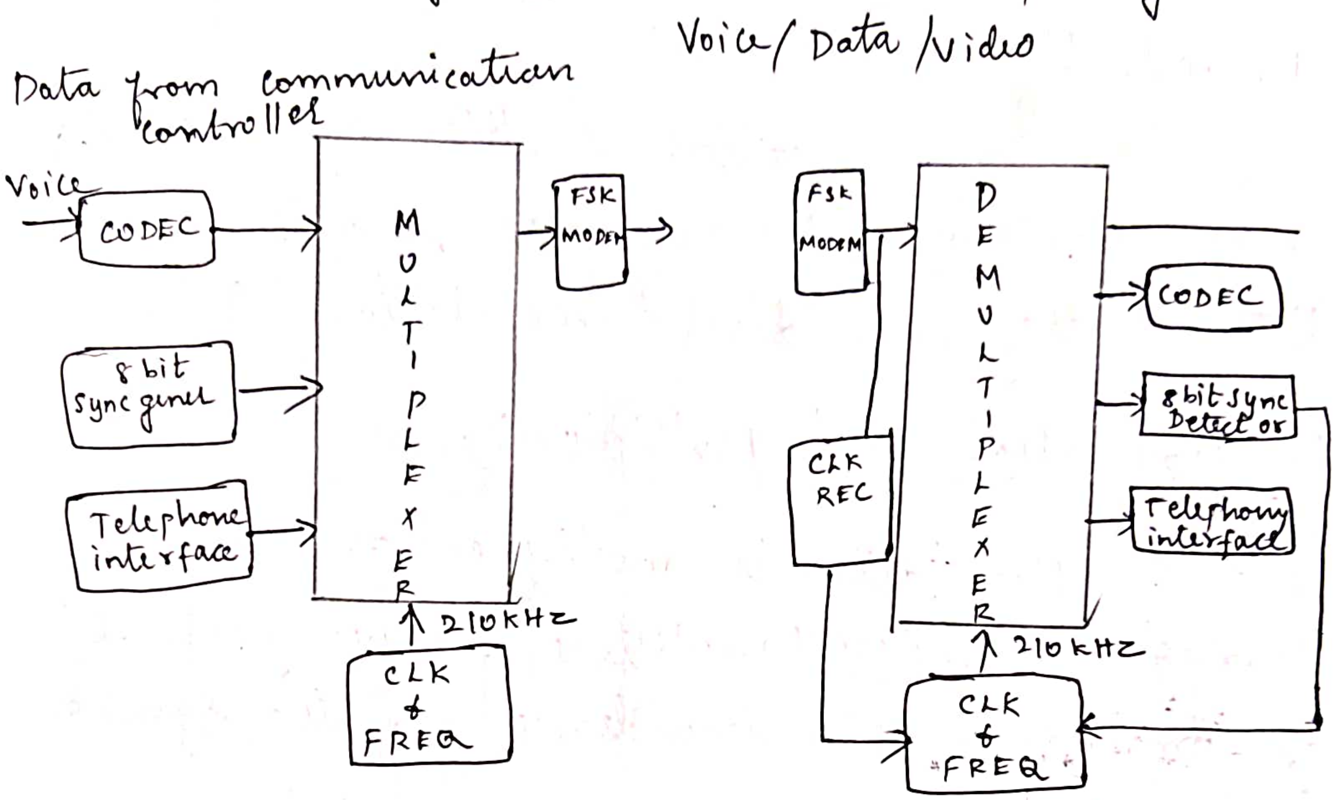
Modulation is modification of a carrier's parameters (amplitude, frequency, phase) or combination in dependence on the symbol to be sent.

Multiplexing is to assign space, time frequency and code to each communication channel with a minimum of interference and maximum of medium utilization

3.2 Voice, Data, video :

The modulation and multiplexing that are used before were analog. The change to digital Voice signal made it easier for long distance. Communication carriers mix digital data and telephone Fibre optic cable Transmission Standards System bit rate, Stuffing bit and words to satellite data stream fill empty bit and word space

Fig. Modulation and Multiplexing



3.3 Analog - digital transmission System

Analog signals are electrical replicas of original signals such as audio and video. Base band signals are those which occupy the lowest band of frequencies. A number analog telephone signals combined to one base band by (Frequency division Multiplexing). smaller band of frequencies is used for normal telephone transmission. The telephone channel is reffered to as voice frequency channel with frequency range of 300 to 3400 HZ

Analog signals converted into digital signal for transmission. A digital signal is a coded version of original data, A number of telephone signals combined into one base band known as Time division Multiplexing (TDM)

3.4 Digital Video Broadcasting

It is the synonym for digital television and for data broadcasting.
Advanced television systems comittee (ATSC) formats for digital television includes HDTV.
Rear Projection CRT (RPTV) sets are least expensive of the big screen suitable for HDTV. The newer technologies are Plasma Displays, liquid crystal displays (LCD) and digital Light Processing (DLP).

Plasma displays are made up of tiny cells coated with red, green and blue phosphorus. The video signals simulates a gas inside the cells, which impacts the phosphorus causing them to glow.

In a LCD light passes throu' a thin sheet of liquid crystal which forms the viewing screen. DLP displays uses digital micro mirror Device (DMD), contains 1.3 million micro mirrors pivoted by 5000 times a second, the pivoting being activated by the video signal. All the displays are activated by digital signals.

Pivot - centre pin or shaft on which mechanism turn or oscillates

3.5 Compression :

Digitizing the audio and video components of a television program allows signal compression to be applied which greatly reduces the bandwidth required. compression is carried ~~to~~ out to Moving Picture Expert Group (MPEG) standards the standards are concerned with bit stream syntax and decoding process.

In DBS system MPEG-2 is used for video compression. The analog outputs from red (R), green (G), blue (B) colour cameras are converted into luminance component (Y) and 2 Chrominance components (C_r) and (C_b)

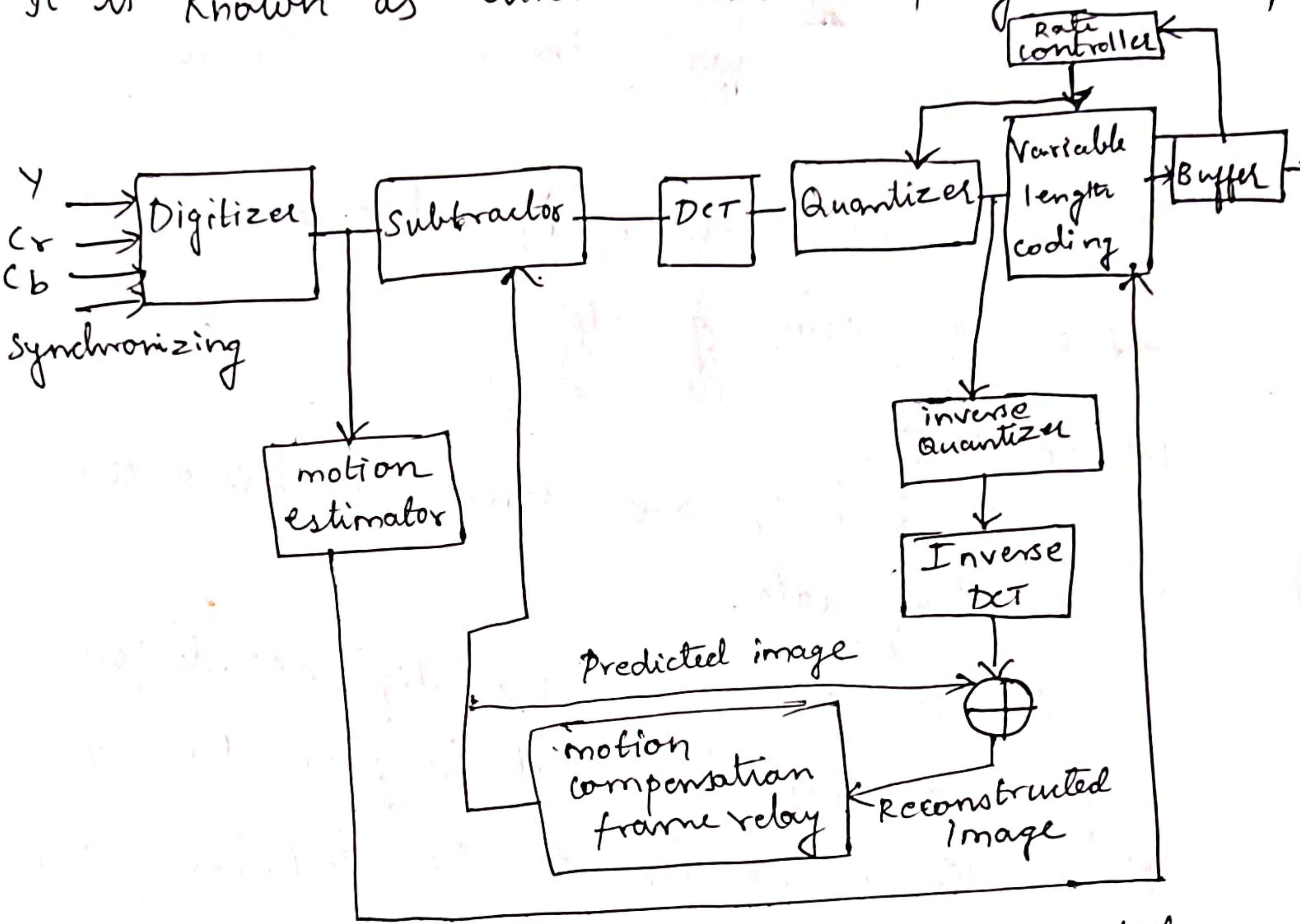
The equation relates 3 primary colour to Y, C_r, C_b is

$$\begin{bmatrix} Y \\ C_r \\ C_b \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.168736 & -0.331264 & 0.5 \\ 0.5 & -0.418688 & -0.081312 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Y, C_r, C_b are given to digitizer block.

Human eye is less sensitive to resolution in colour components of C_r, C_b.

So low sampling rate is used for colour components. It is known as Chroma Sub sampling



MPEG uses 4:2:0 sampling. Sampling is indicated by using Y:U:V ratio.

Y - Luminance sampling rate

U - C_b sampling rate

V - C_r sampling rate

common ratios with digital TV are

4:4:4

4:2:2

4:2:0

4:4:4 Ratio:

Sampling rate of Y, Cr, Cb are equal. Each pixel will get 3 words. If each word = 8 bits (1-byte), each pixel is encoded in 3 bytes

4:2:2 Ratio

Sampling rate of Cb and Cr are equal to half of the sampling rate of Y.

4:2:0 Ratio:

Cb and Cr are sampled at half of the Y sampling rate.

At the output of the digitizer, difference signal is formed at it is given to DCT block. This block converts the difference signal into a spatial frequency.

h(x,y) is converted to H(U,V), u & v are new variables. The variables are known as spatial frequencies.

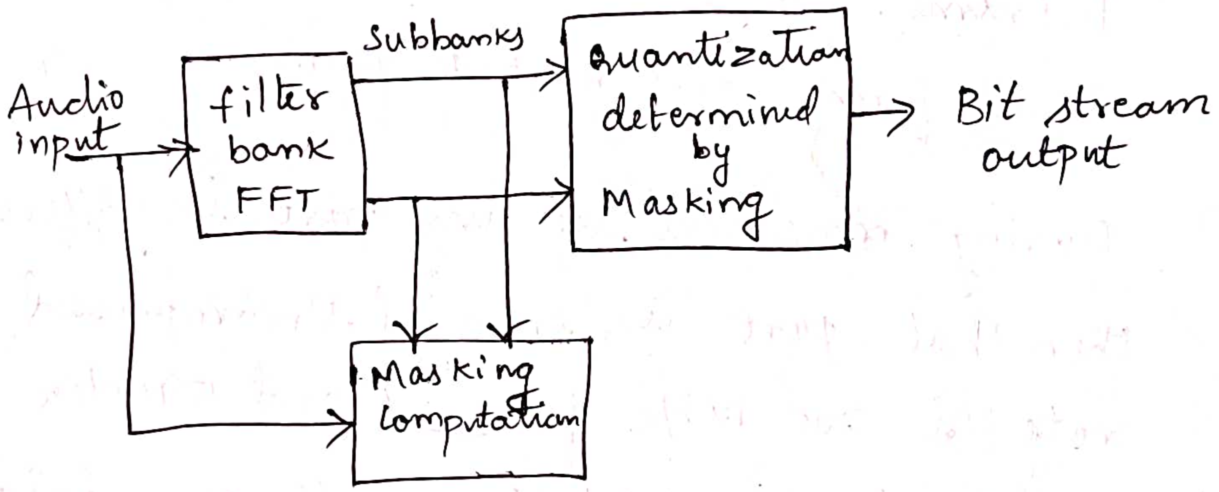
Quantizer is used to quantize H(u,v) into predetermined levels and compression is provided. Compression is also done through motion estimation. It is done by comparing the frames with other frames

If $f_s = 44.1$ KHZ, $n=16$ for stereo CD recording

$$R_B = (44.1 \times 10^3) \times \frac{16}{2} = 1411.2 \text{ kb/s}$$

(2) is used for 2 channels are in stereo. This bit rate is high compared with the channel allowance.

Block diagram of MPEG-1 is shown below



Audio signal input is given to filter bank. It is used to divide the input signal into various sub bands. These sub bands are given to masking computation block. It is used to permit identification of the masking levels. This information is passed to the quantizer. It is used to quantize the sub band coding according to the noise floor. This type of masking is frequency masking

3 types of frames is defined by MPEG-2

I Frame: It is an independent frame. It can be constructed without refering other frames

P Frame: It is compared with previous I Frame. The comparison is done in macro blocks. It consists of 16x16 pixels

B Frame: It is compared with previous I or P frame and next P-frame

During movement, if any part is different then that part is encoded. Uncompressed bit rate is 200 Mb/s for SDTV and 5 Mb/sec for TV channel. It includes audio and data

In DBS System

MPEG1 is used for audio compression

MPEG2 is used for video compression

MPEG 2 is compatible with MPEG-1

The bit rate = R_B

$$R_B = f_s \times n$$

f_s - Sampling frequency

n - number of bits/sample

SDTV - Standard definition Television (SDTV) provides picture quality similar to DVD

The masking effect lasts for a period after the masking signal is removed. This is known as Temporal masking.

In DBS system, 192 kb/s is used as compressed bit rate in MPEG-1. MPEG-4 is developed by video coding experts group VCEG of ITU (International Telecommunication Union) and Telecommunication Standardization sector (ITU-T). It is designated as H.264, AVC, H.262, AVC mean advanced video coding. Its applications are video telephony, video storage, DVD, hard disc etc. MPEG-4 offers great bit rate reduction

3.5.1 Encryption:

It is the most effective way to achieve data security. To read an encrypted data, we must have access to a secret key or password that enables to decrypt it

[In MPEG-2 analog o/p from R, G, B cameras are converted to luminance component Y, C_r & C_b

$$\text{M matrix} = \begin{bmatrix} Y \\ C_r \\ C_b \end{bmatrix} = \begin{bmatrix} 0.2126 & 0.587 & 0.0722 \\ -0.119977 & -0.331264 & 0.523589 \\ 0.561626 & -0.418688 & -0.051498 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

3.6 Multiple Access

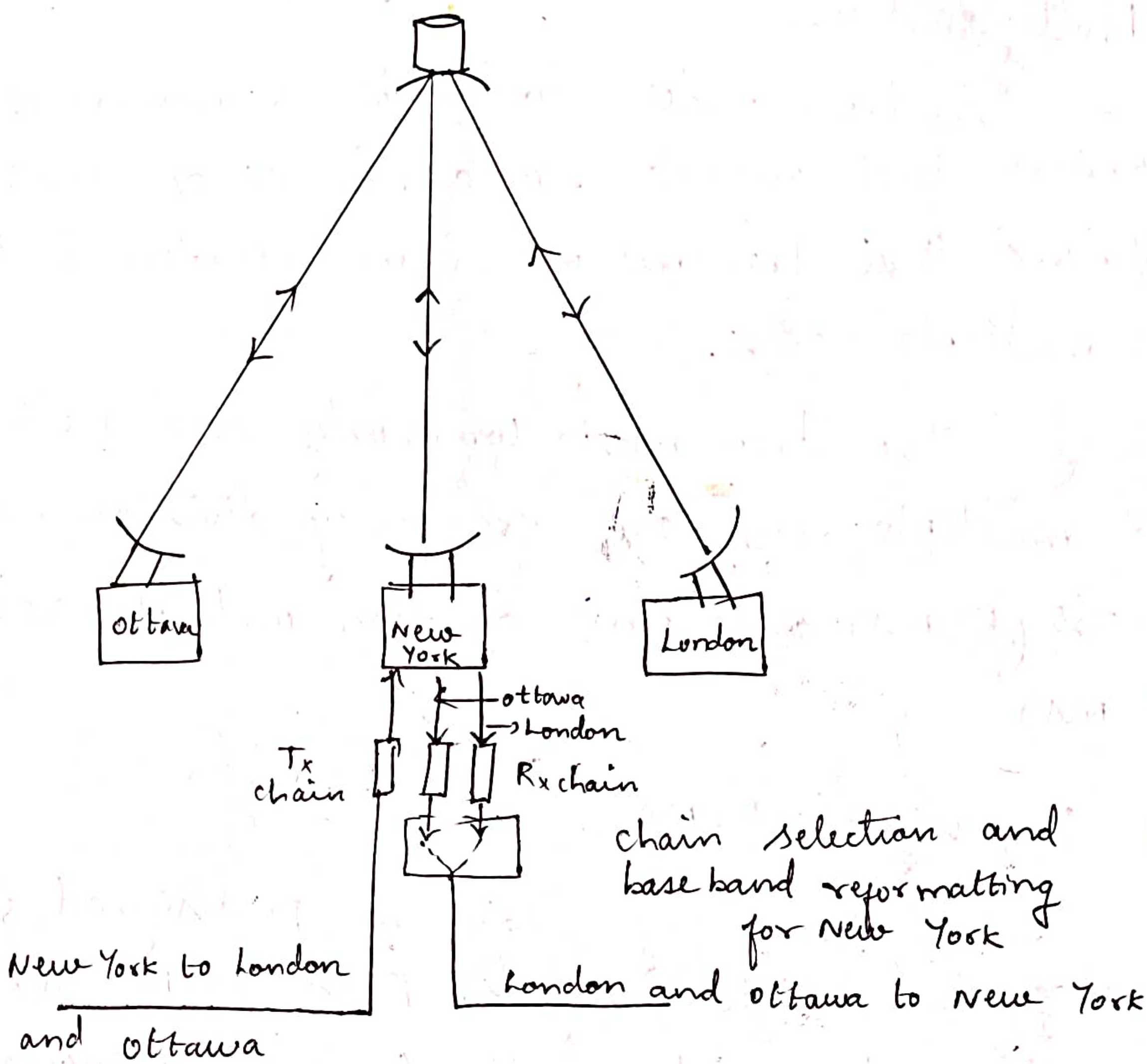
A transponder loaded by a number of carriers that originate from a number of earth station that transmit one or more carriers is termed as multiple access.

The two most commonly used methods of multiple access are frequency division multiple access (FDMA) and time division multiple access (TDMA)

3.6.1 Preassigned FDMA

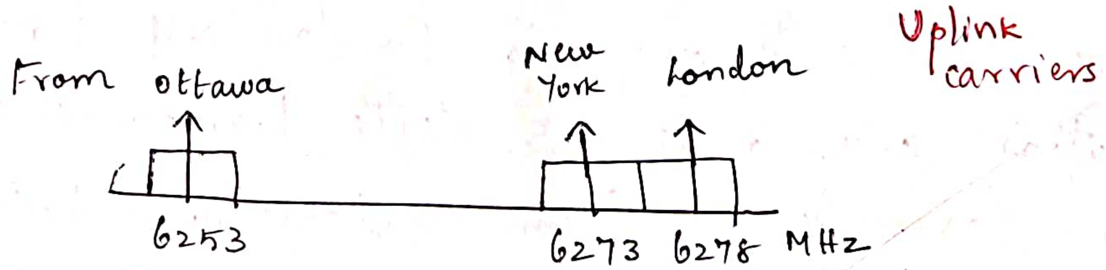
Frequency slots is preassigned to analog and digital signals. Each earth station is assumed to transmit 60 channel supergroup. Each 60 channel supergroup is frequency modulated onto a carrier which is up converted to a frequency in satellite uplink band.

The fig. shows the situations for three earth station, one in Ottawa, one in New York and one in London. All three earth stations access a single satellite transponder channel simultaneously and communicates with both others Each earth station transmits one uplink carrier modulated with a 60 channel super group and receive two simillar downlink carriers



The earth station at New York has one transmit chain that carries traffic for both ottawa and London on the receiver side two receive chain is provided

The Fig shows hypothetical frequency assignment schemes



Preassignment is on the basis of single channel per carrier (SCPC). A single voice (or data) channel may carry hundred of voice channels by this method. The carriers may be frequency modulated or phase shift modulated and an earth station is capable of transmitting one or more SCPC signals simultaneously

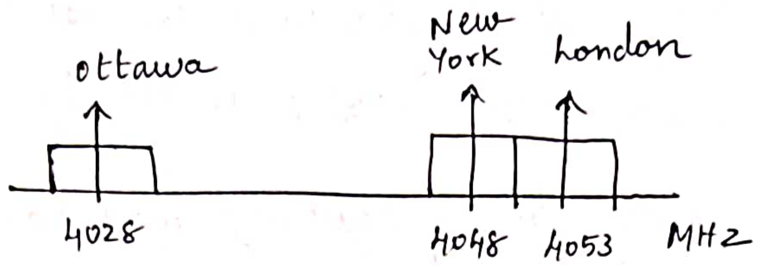
3.6.2 Demand - Assigned FDMA

In demand assigned mode, the transponder frequency is sub-divided into number of channels. A channel is assigned to each carrier in use as SCPC mode

Demand assignment is carried in a number of ways. In polling method, a master earth station polls all earth station in sequence and if a call request is encountered, frequency slots are assigned from pool of available frequencies. This causes delay as earth station increases

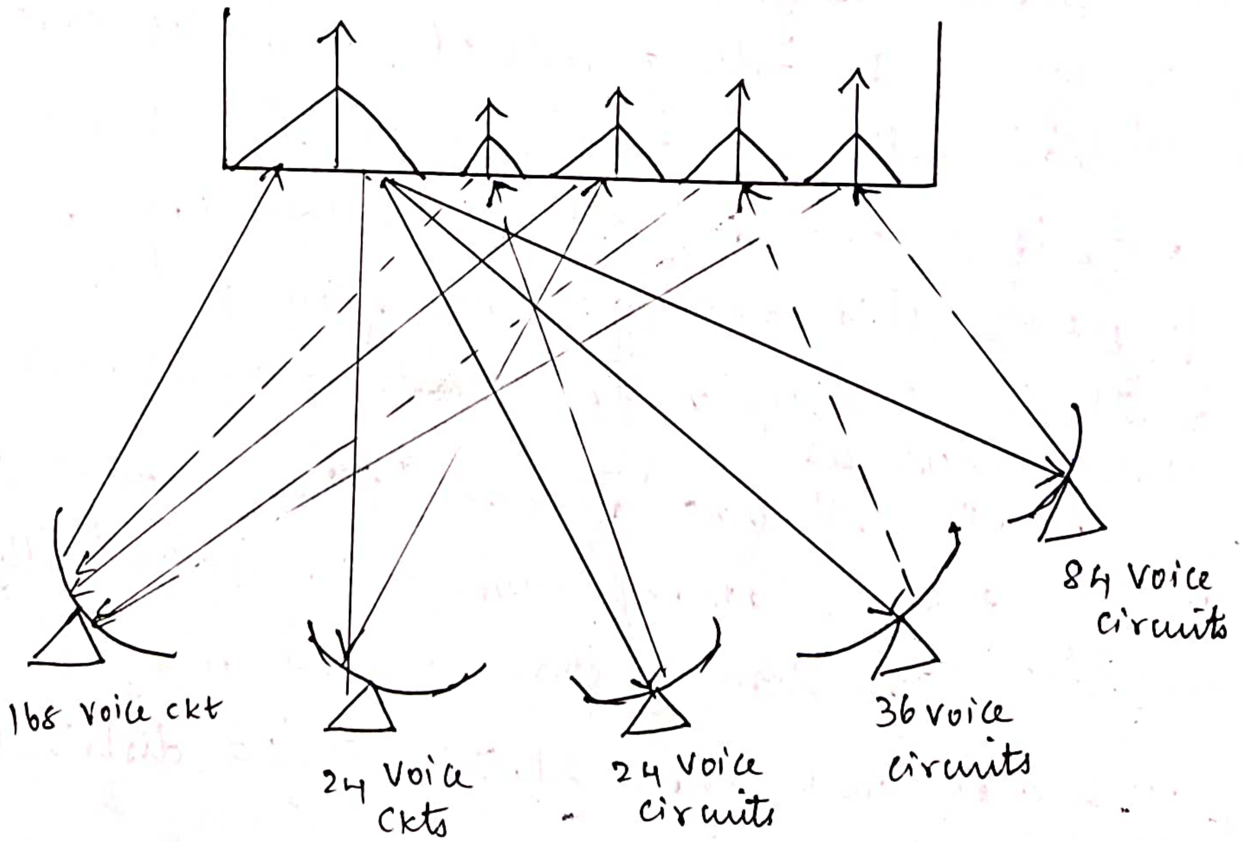
Earth station request calls through the master earth station referred to as centrally controlled random access. Control may be exercised at each earth station called distributed control random access.

Down link



The uplink carrier frequencies of 6253, 6273 and 6278 MHz are translated down to frequencies of 4028, 4048 and 4053 MHz. A 60 channel FDM/FM carrier occupies 5 MHz of transponder Bandwidth

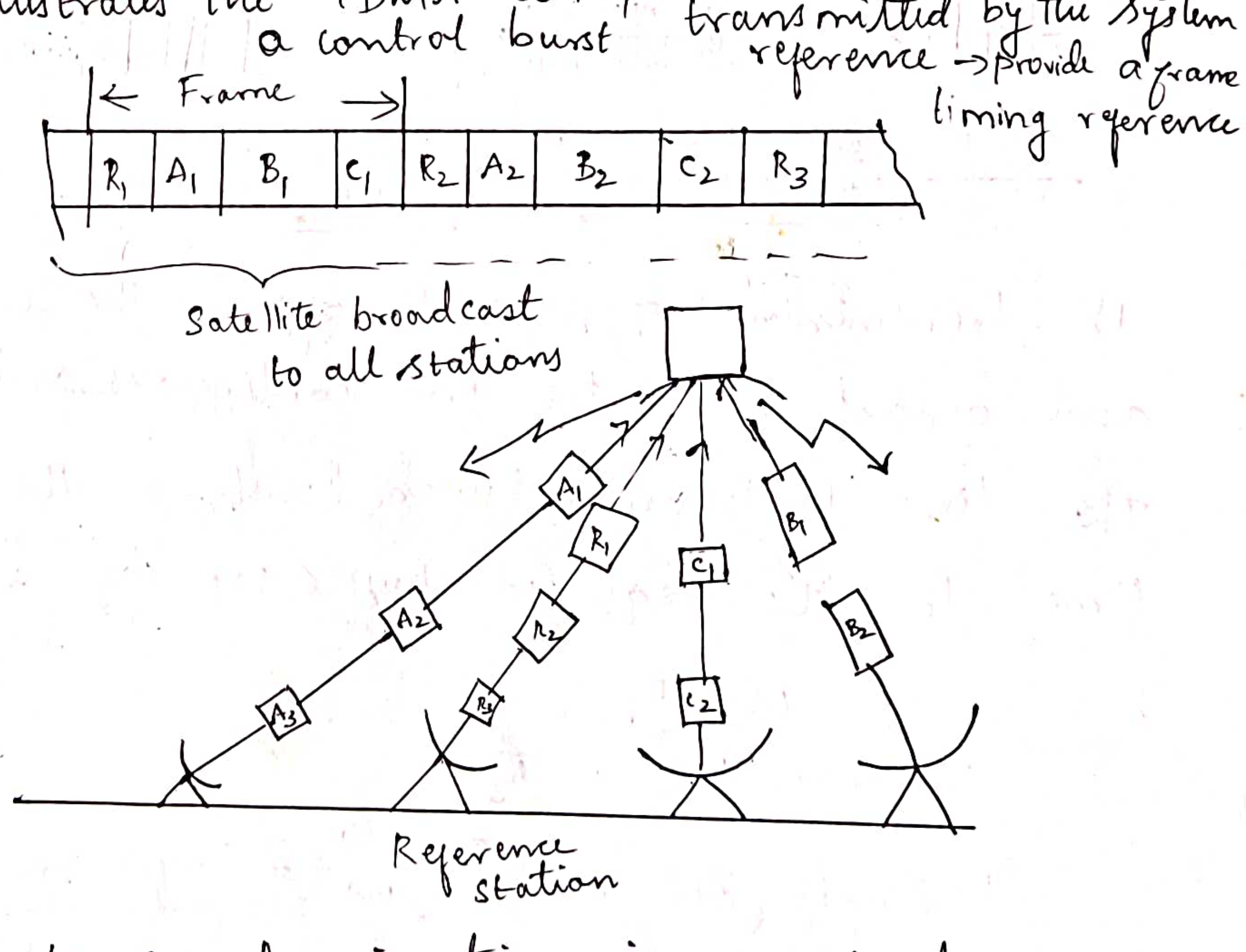
The fig. shows how five carriers are used to support 168 voice channels. The earth station that carries the full load has a G/T of 37.5 dB/K and other four have G/T's of 28 dB/K.



3.7 TDMA

With TDMA (Time Division Multiple Access) only one carrier uses the transponder at any one time and therefore intermodulation from nonlinear amplification of multiple carriers are absent

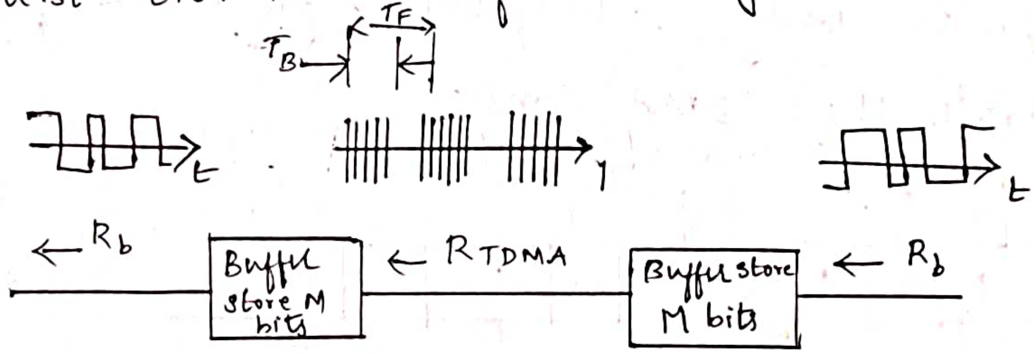
As signal is transmitted in bursts, TDMA is suited only to digital signals. The fig illustrates the TDMA concept



Burst synchronisation is required. One station is solely for transmitting reference burst to which others are synchronised.

The Time interval between one reference burst to the next is termed as frame. A frame contains reference burst R and bursts from other earth stations as shown as A, B and C as shown in the fig.

The fig. illustrates the basic principles of burst transmission for a single channel.



The transmission appears continuous as the input and output bit rates are continuous and equal. The time interval between bursts is the frame time T_F, the required buffer capacity is

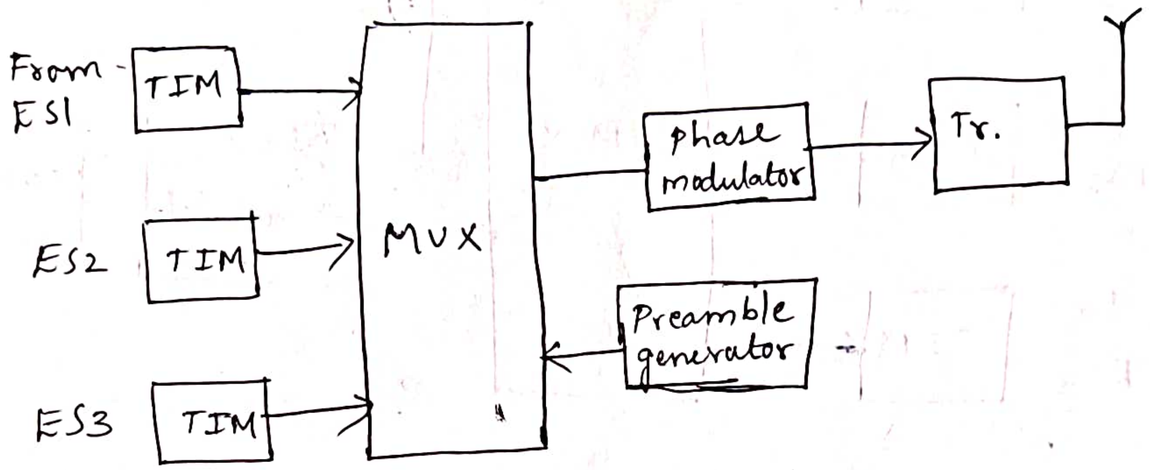
$$M = R_b T_F$$

R_b - input bit rate

$$\text{Burst Bit rate} (R_{TDMA}) = \frac{\text{Buffer capacity} (M)}{\text{Burst time} (T_B)}$$

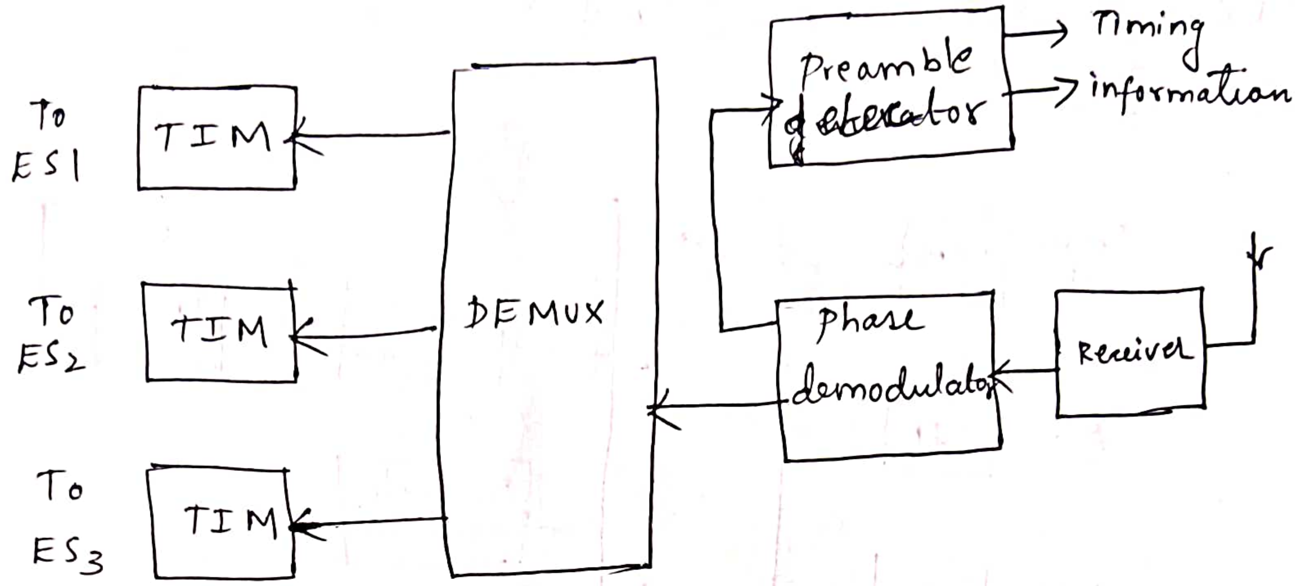
$$\text{Average Bit Rate} = \frac{\text{Buffer Capacity}}{\text{Frame time}}$$

3.7.1 Block Diagram of TDMA System



The continuous bit rate signal is converted into burst mode signal by using transmit terrestrial interface module (TIM). These burst mode signals are multiplexed by using MUX block. The signal for each station appears in its assigned time slot.

At the beginning of each burst, some time slots are used to carry timing and synchronizing information. These time slots are known as pre amble. the output of MUX is given to phase modulator then to transmitter. Finally the burst information is transmitted.



In the reciver side, Multiplexed burst signal are received and given to Phase demodulator RF carrier frequency is converted to intermediate frequency and then it is demodulated

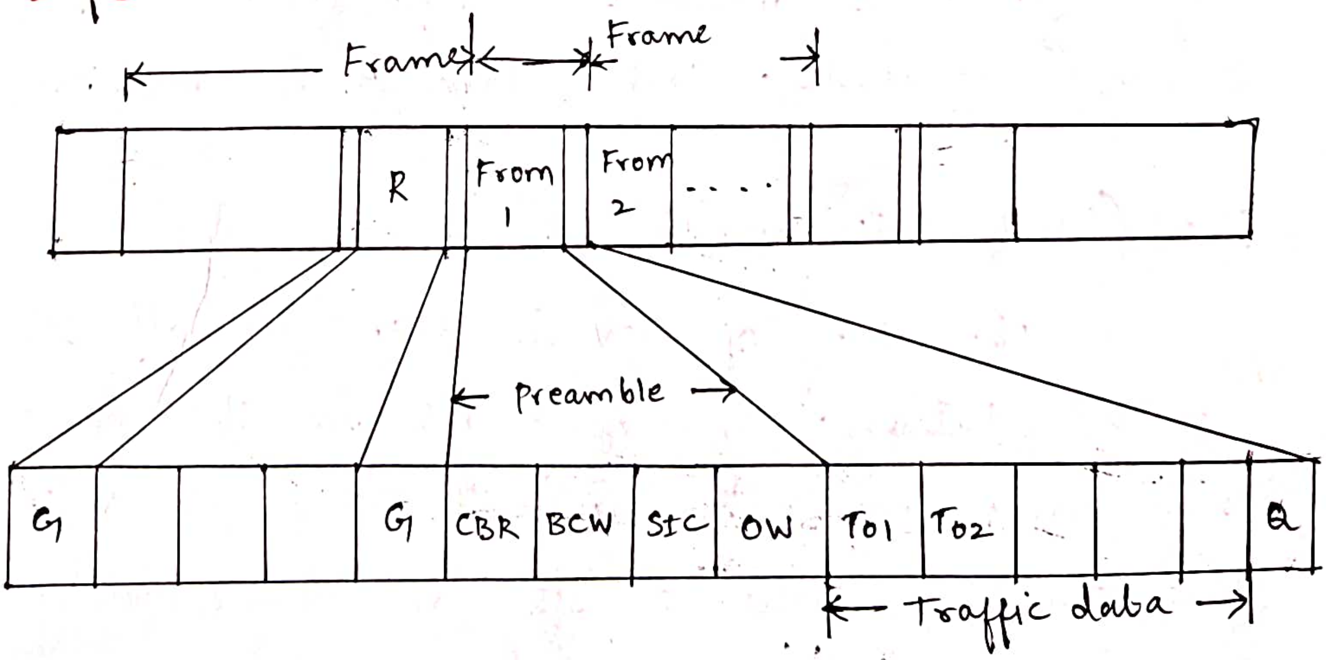
Preamble detector is used to transmit timing information. Demodulated signal is given to DEMUX block. From the demultiplexer, the signal is given to all The earth stations Reference burst is needed at the beginning of each frame for providing timing information for acquisition and synchronization of burst signal

IF → is a freq. to which carrier freq. is shifted as an intermediate

In Intelsat, two reference stations are there. These are known as primary reference stations. One of this is known as master primary. Each primary station has an alternative which is known as secondary reference station.

Two reference bursts are transmitted in each frame. First reference burst is transmitted by primary reference station for acquisition and synchronization. Second reference burst is transmitted by secondary reference station which is used for synchronisation purpose.

3.7.2 Reference burst



G- Guard time

CBR - carrier and bit timing recovery

BCW - Burst code Word

SIC - station Identification code

Q - Post amble

Guard time:

It is used to prevent burst from oveelapping. The guard time varies from burst to burst

CBR: (Carrier bit time recovery)

An unmodulated carrier wave is provided during first part of the CBR time slot. It is used as a synchronizing signal for local osillator in detector circuit.

In the remaining part of CBR time slot the carrier is modulated by a known phase change sequence. So bit timing is recovered

BCW (burst code words)

The copy of BCW is stored in all the earth station. Incoming bits in the burst are compared with BCW. The receiver detects the group of received bits matched with BCW.

SIC (station Identification code):

It identifies the station

G - Guard time

CBR - carrier and bit timing recovery

BCW - Burst code Word

SIC - station Identification code

Q - Post amble

Guard time:

It is used to prevent burst from overlapping. The guard time varies from burst to burst

CBR: (Carrier bit time recovery)

An unmodulated carrier wave is provided during first part of the CBR time slot. It is used as a synchronizing signal for local oscillator in detector circuit.

In the remaining part of CBR time slot the carrier is modulated by a known phase change sequence. So bit timing is recovered

BCW (burst code words)

The copy of BCW is stored in all the earth station. Incoming bits in the burst are compared with BCW. The receiver detects the group of received bits matched with BCW.

SIC (station Identification code):

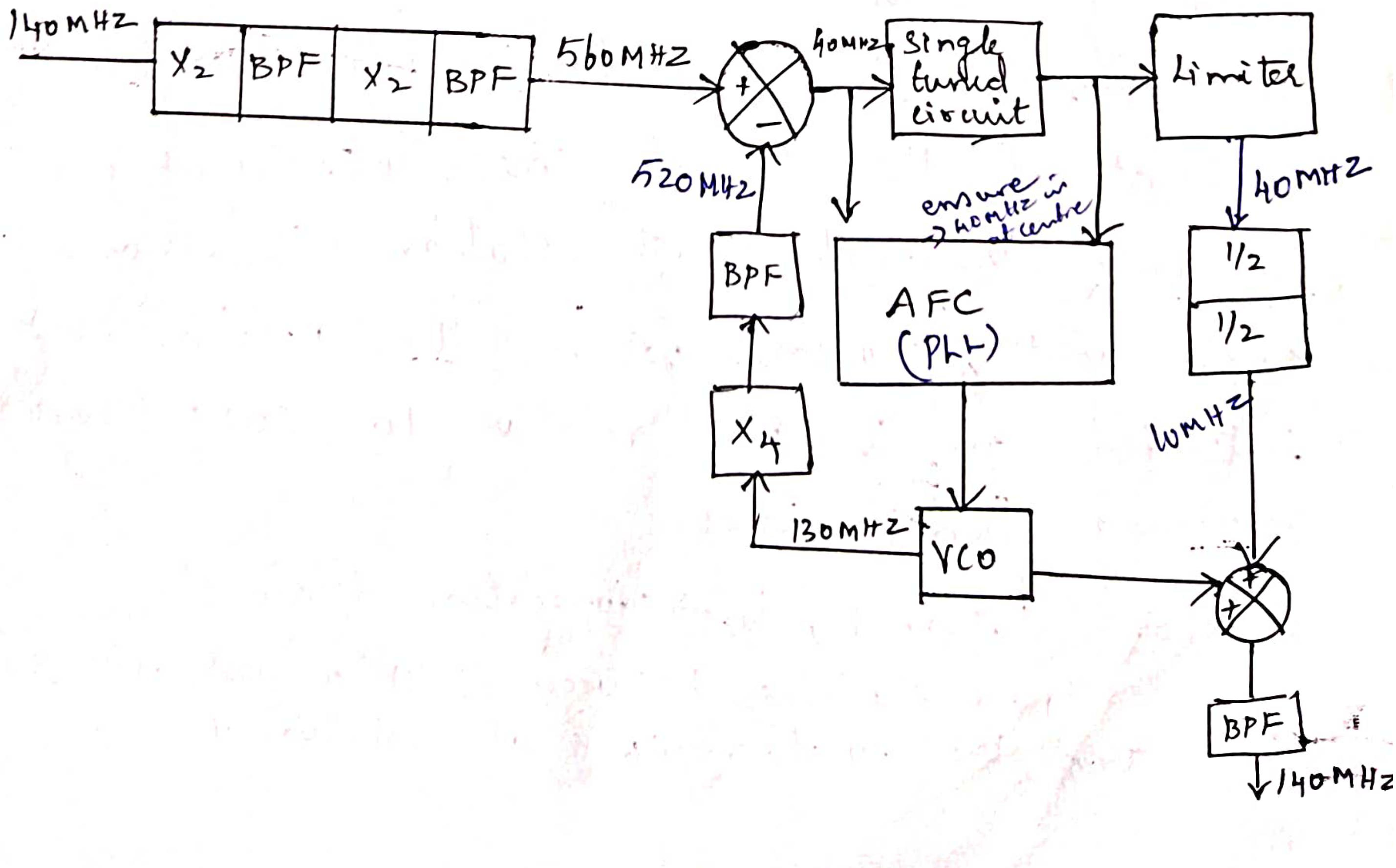
It identifies the station

3.7.4 Carrier Recovery

The carrier Recovery must be Repeated for each burst. It uses PLL (Phase Locked Loop). Large time is required for burst signals to achieve stable operating point. The problem occur when PLL moves to unstable region. This is known as hang up.

Narrowband tuned circuit filter is used for carrier recovery. 140 MHz QPSK signal is applied to two number of multiplier. Finally 560 MHz of frequency is obtained.

AFC (Automatic Frequency control) is connected with Voltage controlled oscillator (VCO).



It is used for frequency conversion. AFC is used to ensure that the 40 MHz input is at the centre of tuned circuit characteristic curve.

If there is any deviation, control voltage is generated and applied to VCO to correct the position.

By using two number of divider circuits, 40 MHz output from single tuned circuit is reduced to 10 MHz.

Finally 130 MHz is added with the 10 MHz to get 140 MHz recovered carrier.

3.7.3 Network Synchronization

Some time slots are alloted to each burst. Network synchronisation is needed to ensure the arrival of bursts at the correct time slot. Burst plan is stored in each earth station. It shows each earth station where the receive burst intended for it are relative to SORF (start of receiving frame) marker.

For station 1, t_1 → propagation delay

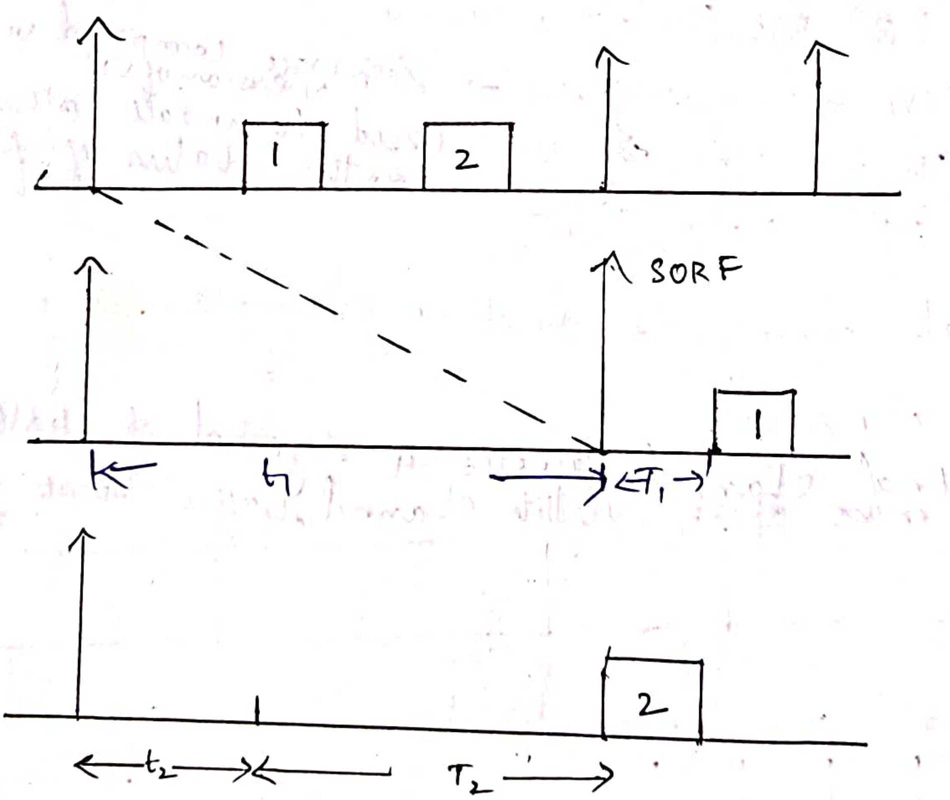
T_1 → The time between SORF marker received and the burst received at station 1

For station 2,

t_2 - Propagation delay

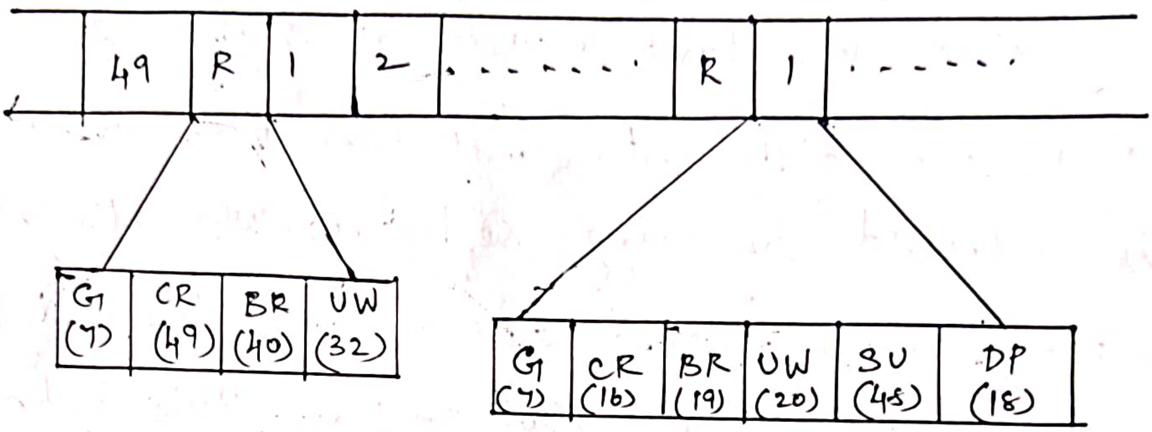
T_2 - The time between SORF marker received and burst received at station 2

t_1, t_2 are different. Burst time plan in TDMA is controlled by using softwares. When the station entered or reentered after a long delay, it has to acquire its correct slot position. This is known as burst position acquisition.



Pre Assigned TDMA

CSC (common signal channel) is the example for pre-assigned TDMA. CSC can accommodate 49 earth station and 1 reference station at a time. 50 bursts can be transmitted in a frame. Each frame consists of 128 bits, Bit rate is 128 KB/sec



G – Guard time

CR – Carrier recovery

BR – Bit timing recovery

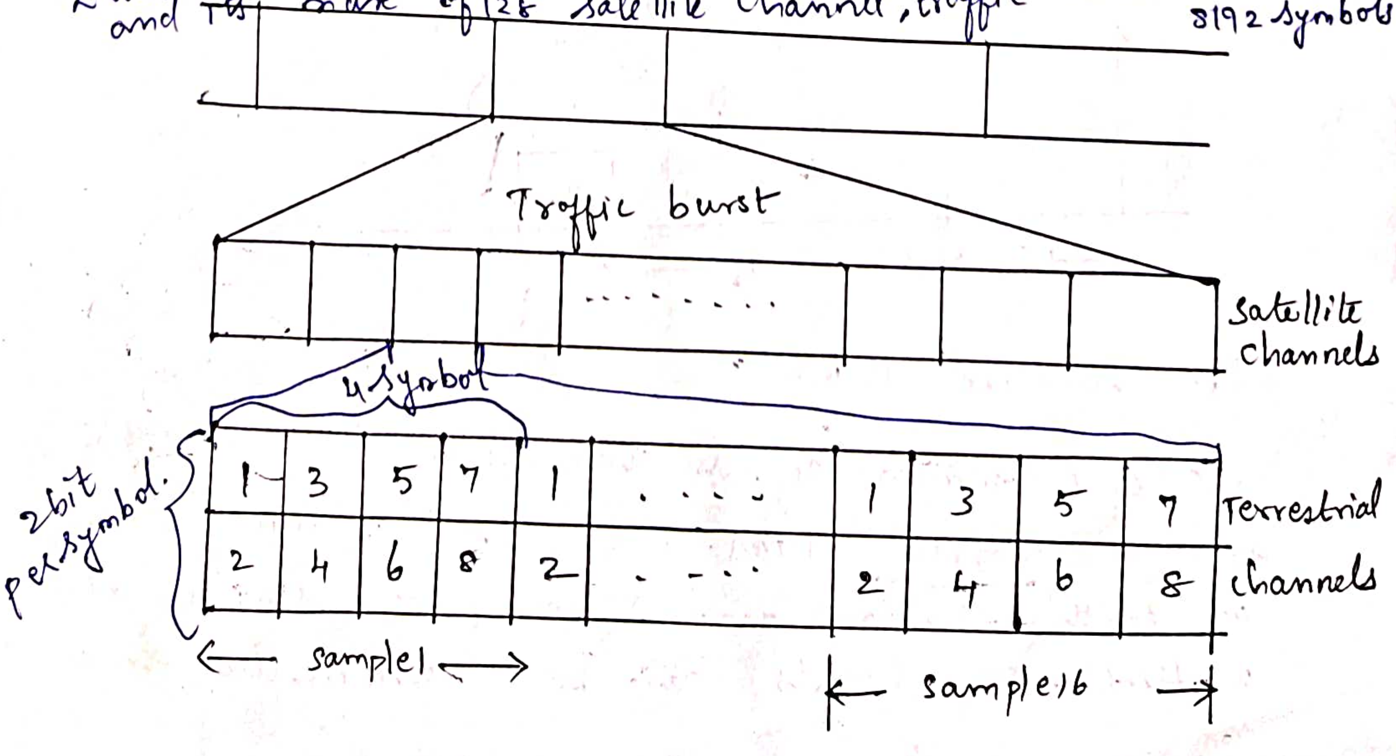
UW – unique Word → sequence compared with stored version of UW

SU – signalling Unit (used to update other station on the status of freq. available)

DP – Data Parity

Intelsat frame is another example for pre assigned TDMA

Each terrestrial channel carries 4 symbol & 4×16 = 64 symbols and [illegible] of 128 satellite channel, traffic burst carries 8192 symbols



TTY: (Tele Type)

It is used to provide telegraph communications between earth station

SC: (Service channel)

It is used to carry various network protocol and alarm messages.

VOW: (voice order wire channel)

It is used to provide voice communication between earth station

3.7.5 Preamble and Postamble

Preamble is the starting portion of a traffic burst. It will not carry any traffic. The difference between preamble and reference burst is that preamble provide order wire channel

Preamble Bit Pattern

G	CBR	UW	TTY	SC	VOW	VOW	Traffic

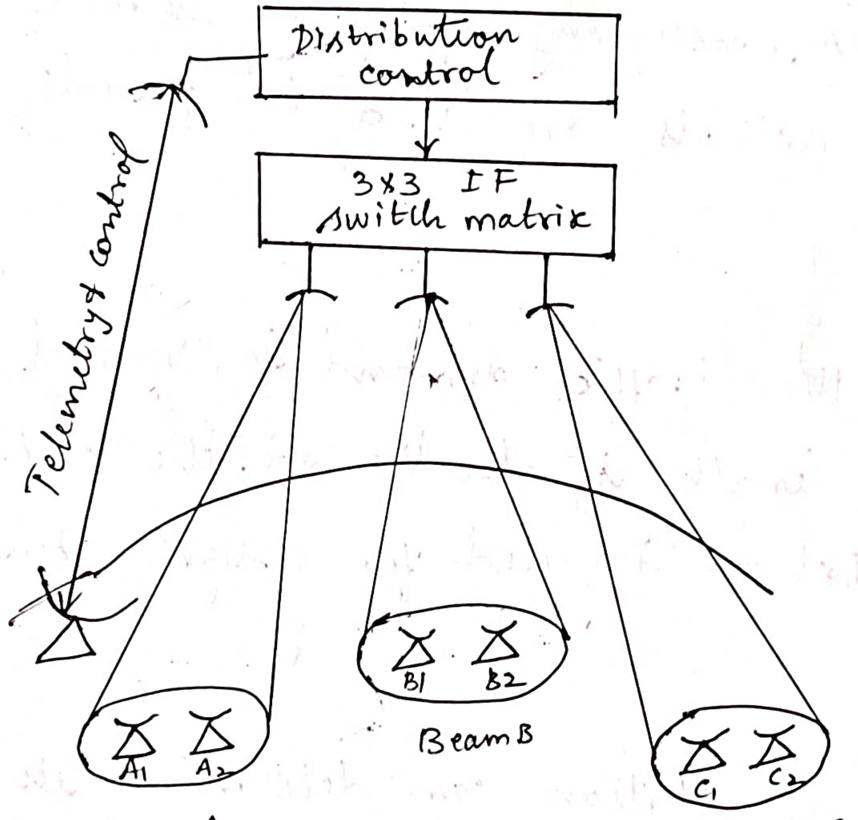
Post Amble:

In some phase detection, some time is alloted before the next burst is received It is known as decoder quenching. This time slot is Post amble

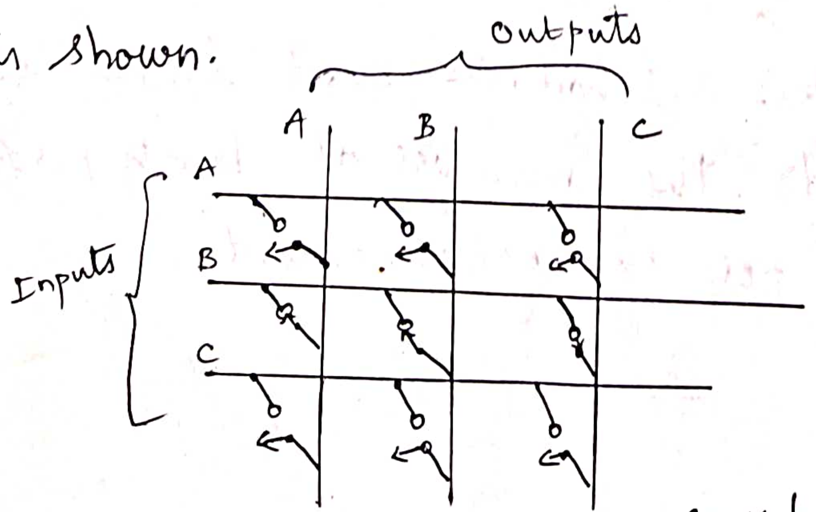
3.7.6 Satellite switched TDMA

Switching the antenna interconnection in synchronism with TDMA frame rate is knownas satellite switched TDMA.

The fig. shows simplified form of SS/TDMA.



Three antenna beams are used, each serving two earth stations. A 3×3 satellite switch matrix is shown.



3×3 Cross bar switch

The traffic burst is divided into time slots. Each channel is divided into terrestrial channels Each slot carry one PCM sample. The sampling rate of PCM is 8KHz

3.7.7 Demand Assigned TDMA

In TDMA, reassigning of channel is more flexible Different methods are used to provide traffic flexibility

Method 1

If the traffic demand is varied then the burst length is also varied. The centralized control station is used for assigning burst length

Method 2

Each station can determine its own burst length requirement. As per the pre assigned scheme, the burst length is assigned

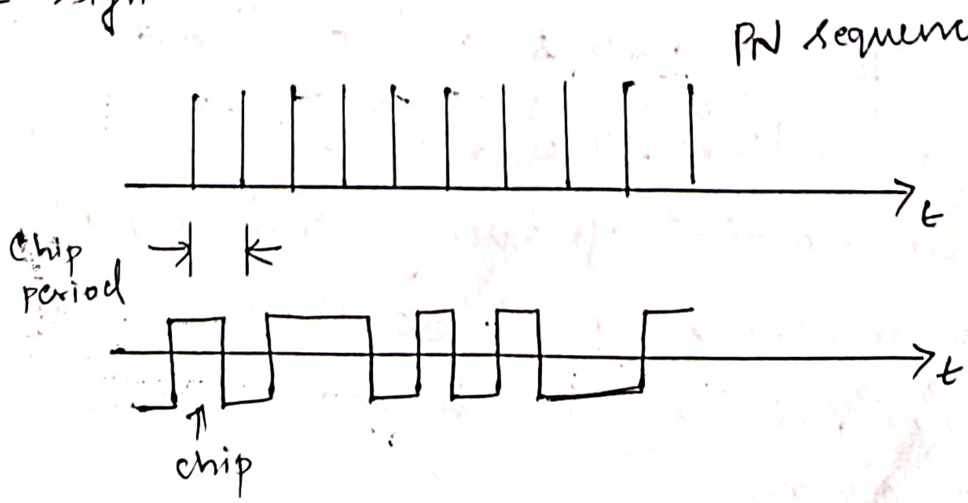
Method 3:

In this method, the burst length is kept constant. The number of bursts per frame is varied as per the requirement

3.8 CDMA (Code Division Multiple Access)

With CDMA, the individual carriers may be present simultaneously within the same rf bandwidth, but each carriers carries a unique code waveform that allows it to be separated from all the others at the receiver. The carrier is modulated in the normal way by the information waveform and then is further modulated by the code waveform to spread the spectrum over the available rf bandwidth. Many of the key properties of CDMA rely on this spectrum spreading, and the systems employing CDMA are known as spread spectrum multiple access (SSMA).

CDMA can be used with analog and digital signals. A polar non return to zero (NRZ) is used for information and BPSK modulation is assumed. The code waveform c(t) is also a polar NRZ signal as sketched.



This is the key component that permits the antenna interconnections to be made on a switched basis. A switch mode is a connectivity arrangement. With three beams, six modes are required for full interconnectivity

	output					
Input	mode 1	mode 2	mode 3	mode 4	mode 5	mode 6
A	A	A	B	C	B	C
B	B	C	A	A	C	B
C	C	B	C	B	A	A

In general for N modes, N! modes are required for full interconnectivity. Full interconnectivity means the signals carried in each beam are transferred to each of the other beams at some time in switching sequence. This includes the loopback connection, where signals are returned.

Because of beam isolation, one frequency is used for all uplinks and a different frequency for all down links. The switching is carried out at intermediate frequency common to uplinks and downlinks. A mode pattern is a repetitive sequence of satellite switch modes, referred as SS/TDMA frames.

3.8. The code signal c(t)

c(t) code signal is represented as chips. chip generation is controlled by a clock chip rate given in chips/second.

chip period $= T_c$

$$T_c = 1/R_c$$

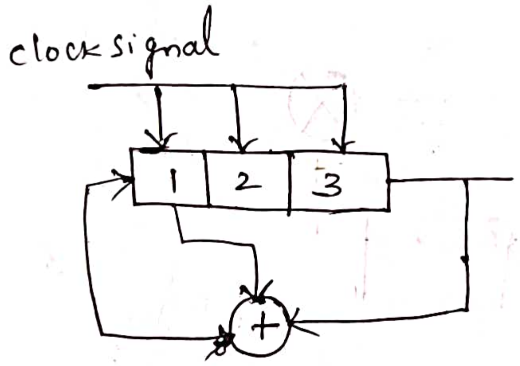
$R_c =$ clock speed

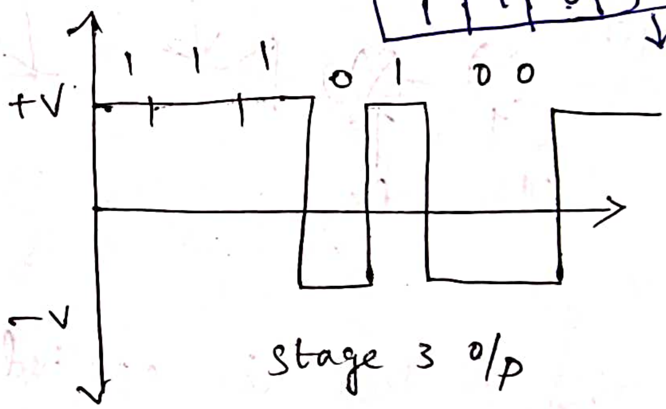
n = stage

1	2	3
1	1	1
0	1	1
1	0	1
0	1	0
0	0	1
1	0	0
1	1	0

(N → max seq. of chip)

Repeat





c(t) is a periodic waveform. Period time for the wave form $= T_N = NT_c$. The codes are generated using shift register. The generator outputs are 111. The binary output sequence is delivered by stage 3. These codes are known as maximal or m sequence codes. Shift register can generate maximum sequence of N chips

$$N = 2^n - 1$$

n – number of stages

The code exhibits noise like properties

These codes are known as pseudo noise codes

Number of binary 1's $= \frac{2^n}{2}$

Number of binary 0's $= \frac{2^n}{2} - 1$

dc offset $= \frac{V}{N}$ ∵ (There is one more +ve chip than −ve)

It is close to zero

+ve is used for binary 1

−ve is used for binary 0

dc offset is used to find the carrier level

The total number of maximal sequences that can be generated by using n-stage shift register is Smax

$$S_{max} = \frac{\phi(N)}{n}$$

$\phi(N)$ = Euler's function

$$\phi(N) = N\left(\frac{P_1 - 1}{P_1}\right) \cdots \left(\frac{P_r - 1}{P_r}\right)$$

$P_1 \ldots P_r$ — prime factors of N

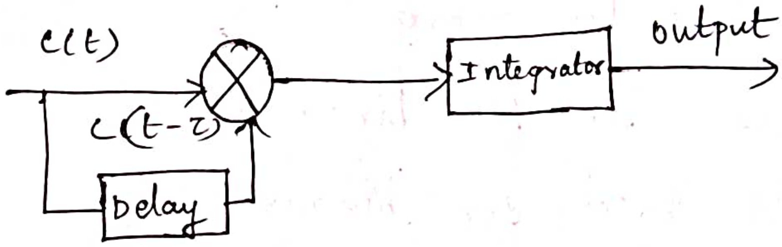
If N = 255, then 3, 5, 17 are prime factors

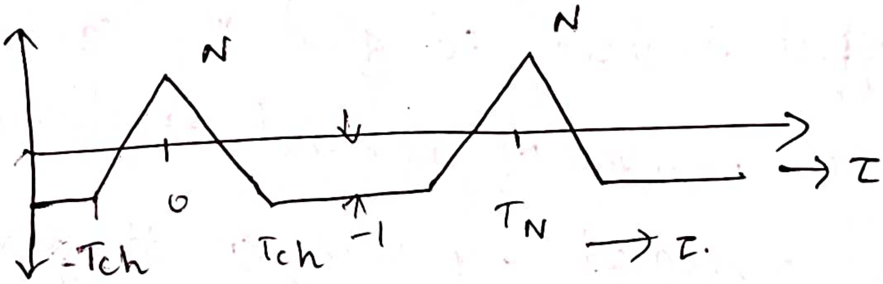
$$\phi(255) = 255\left(\frac{3-1}{3}\right)\left(\frac{5-1}{5}\right)\left(\frac{17-1}{17}\right) = 128$$

$$S_{max} = \frac{\phi(N)}{n} = \frac{\phi(255)}{8} = \frac{128}{8} = 16$$

3.8.3 Acquisition and tracking

The important property of c(t) is autocorrelation function. It is a measure of how the time shifted version of the waveform compares with unshifted version of the wavform





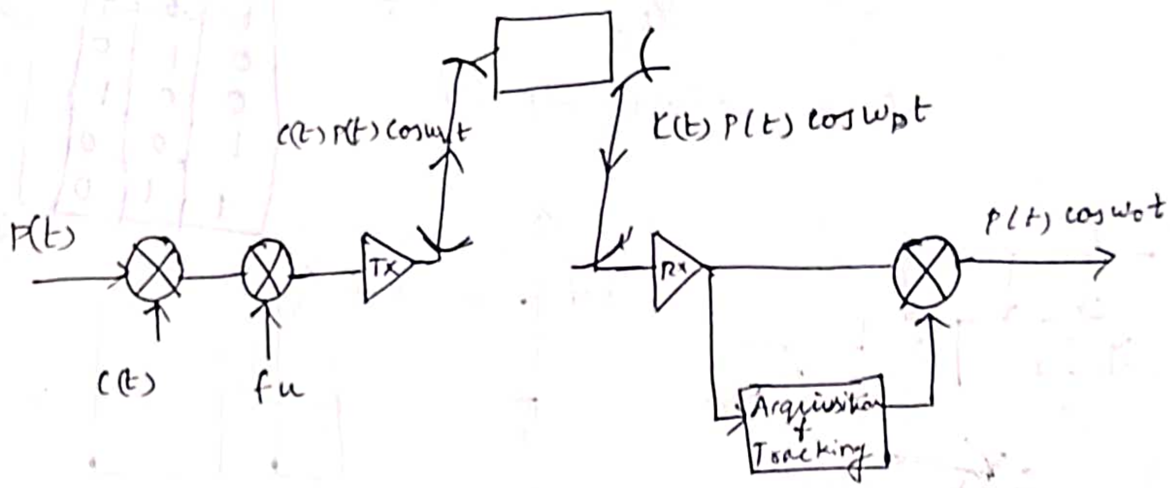
c(t) coded signal is multiplied with its delayed version. The output of integrator is independent of time. One form of acquisition circuit that makes use of autocorrelation is shown in the fig. The output from the first multiplier is

$$e(t) = c(t-\tau)\, c(t)\, p(t) \cos w_D t$$
$$= c(t-\tau)\, c(t) \cos[w_D t + \psi(t)]$$

The information modulation which is BPSK is shown as $\psi(t)$

3.8.2 Direct sequence spread spectrum

In the fig. P(t) is an NRZ binary information signal and c(t) is a NRZ binary code signal these two signals form inputs to a multiplier the output of which is proportional to the product p(t) c(t).



This product is applied to second balanced modulator, the output of which is BPSK signal at the carrier frequency.

The uplink carrier is

$$e_U(t) = c(t)\, p(t) \cos w_U t$$

The downlink carrier is

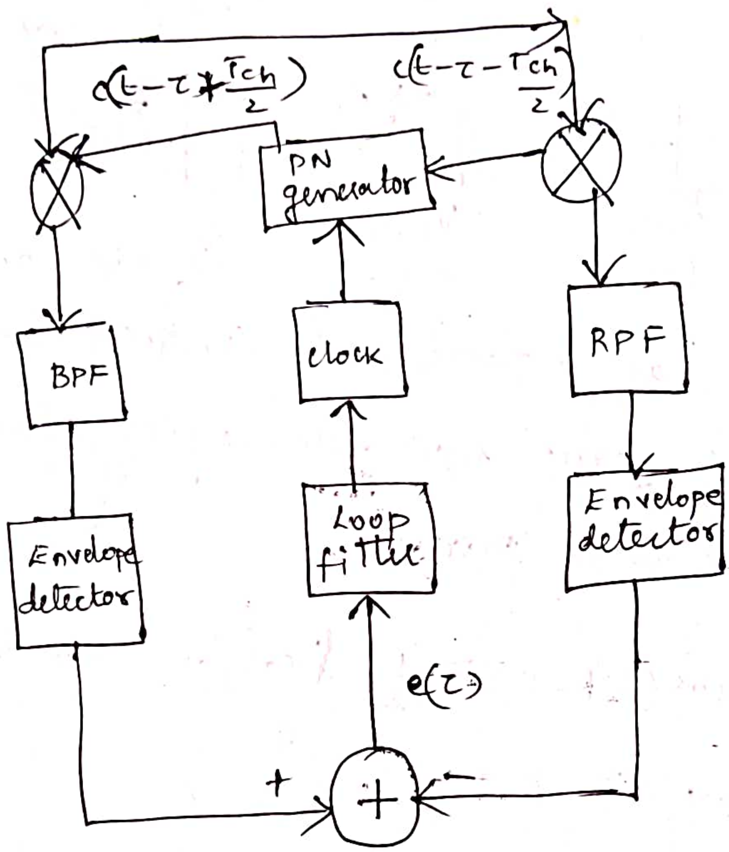
$$e_D(t) = c(t)\, p(t) \cos w_D t$$

The output from the multiplier is

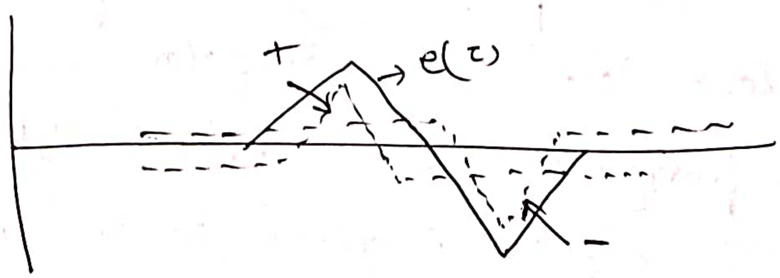
$$c(t)\, e_D(t) = c^2(t)\, p(t) \cos w_D t$$
$$= p(t) \cos w_D t$$

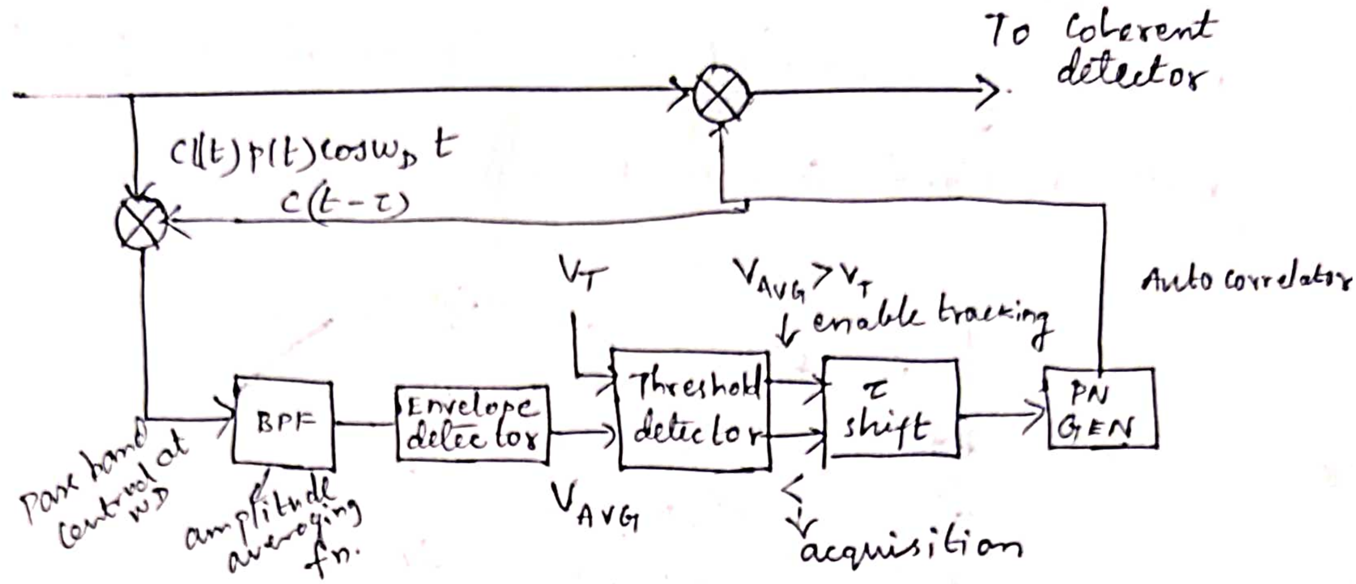
∵ c(t) is exactly in synchronism with transmitted c(t), the product $c^2(t) = 1$.

With control voltage at zero crossover point, the locally generated code signal is in phase with received code signal.



Any drift in phase bring the control voltage back to zero crossover point. The acquisition and tracking circuits correlate the stored version of c(t) at the receiver, with all other waveform being received. Such correlation are termed cross correlation





The BPF has a passband centred on w_D. It performs the amplitude-averaging function on the code signal product.

$$\cos wt \cos(wt-\delta) = \frac{1}{2}\left\{\cos[wt + wt - \delta] + \cos[wt - (wt-\delta)]\right\}$$

$$= \frac{1}{2}\left[\cos(2wt-\delta) + \cos\delta\right]$$

The BPF will reject the high frequency component, leaving only the average component. The envelope detector produces an output proportional to envelope of signal.

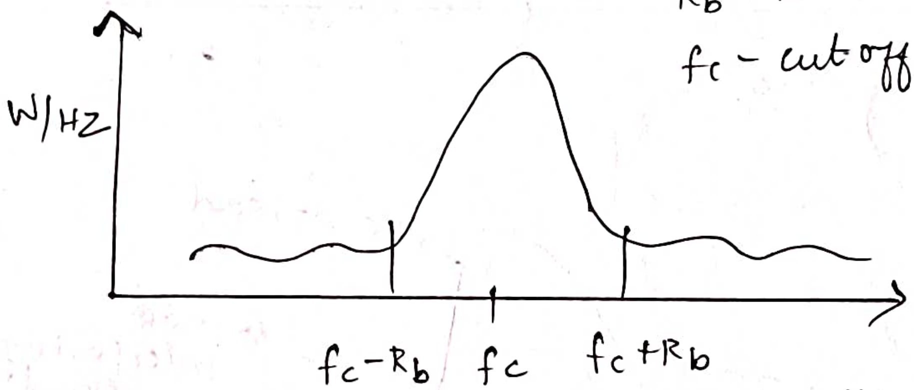
One form of tracking circuit, the delay lock loop. Two correlators are used. The output from correlators are subtracted and difference signals provides control voltage for VCO

3.8.4 Spectrum spreading and despreading

consider BPSK spectrum with R_b as bit rate The main lobe of the power density spectrum is extended from $f_c - R_b$ to $f_c + R_b$

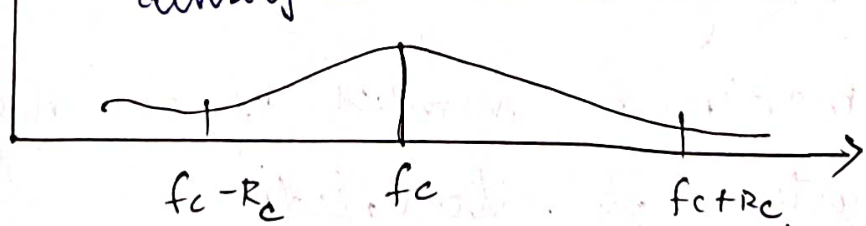
If $c(t)$ is the modulation signal, then power density spectrum is extended by $f_c - R_c$ to $f_c + R_c$

R_b - Bit rate.
f_c - cut off freq.



BPSK without spreading.

For constant carrier power if a signal is forced to occupy wider B.W its spectrum density is reduced.



BPSK with spreading

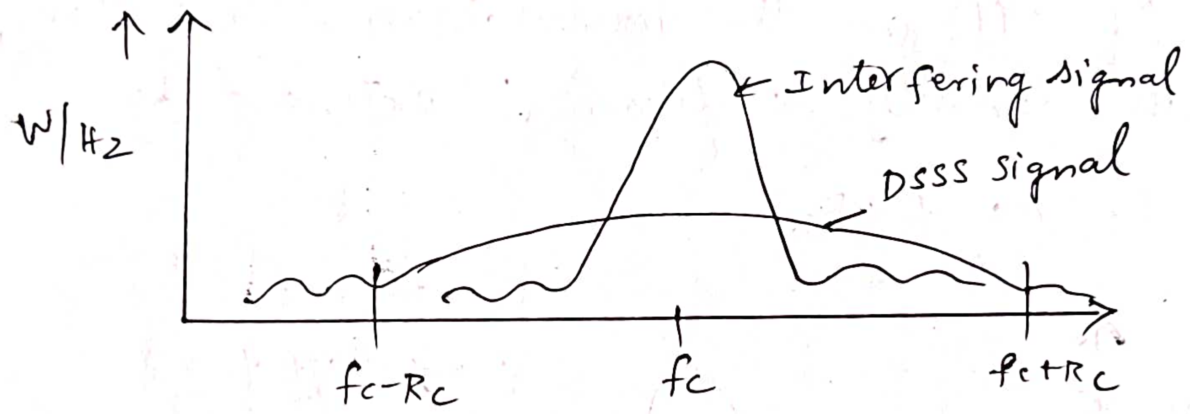
Rc. despreading restores the spectrum of wanted signal reduce interference

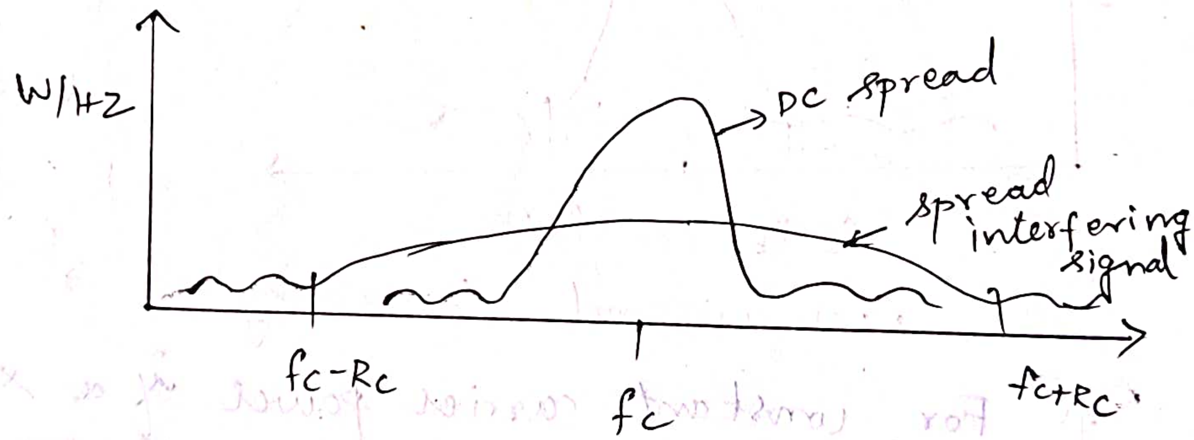
If wider bandwidth is needed, then its spectrum density is reduced.

In DSSS system $R_c >> R_b$

Spectrum density → is a measure of signal's power intensity in frequency domain chip rate is greater than bit rate

The fig. shows the interfering signal. It is not spreaded. After despread operation of desired signal its spectrum is restored.





3.8.5 CDMA Through Put

The maximum number of channels in CDMA system is calculated.

The noise density $N_0 = \frac{P_R(K-1)}{B_N}$

P_R – Receiver power

K – Total number of channels

B_N – Noise Bandwidth

$$E_b - \frac{P_R}{R_b}$$

R_b - Information bit rate

$$E_b = \frac{P_R}{R_b}$$

$$\frac{E_b}{N_0} = \frac{P_R/R_b}{\left(\frac{P_R}{B_N}\right)(k-1)} = \frac{B_N}{R_b(k-1)} \quad \text{— (3)}$$

$$B_{IF} = (1+\rho)R_c \quad \text{—— (4)}$$

I_F bandwidth $= B_{IF}$

ρ - Roll off factor

$$B_N \equiv B_{IF} \quad \text{—— (5)}$$

$$B_N = (1+\rho)R_c \quad \text{—— (6)}$$

sub (6) in (3)

$$\frac{E_b}{N_0} = \frac{(1+\rho)R_c}{R_b(K-1)} \quad \text{—— (7)}$$

$$(K-1)\, R_b = (1+\rho)\, R_c \left(\frac{N_0}{E_b}\right)$$

$$k-1 = (1+\rho)\left(\frac{R_c}{R_b}\right)\left(\frac{N_0}{E_b}\right)$$

The no. of channels is

$$k = 1+\left[(1+\rho)\left(\frac{R_c}{R_b}\right)\left(\frac{N_0}{E_b}\right)\right]$$

Processing gain $G_p = \frac{R_c}{R_b}$

$$k = \left[1 + (1+\rho)(G_p)\left(\frac{N_0}{E_b}\right)\right]$$

Throughput efficiency is

$$\eta = k \cdot \frac{R_b}{R_c}$$

$$\boxed{\eta = \frac{k}{G_p}}$$

R_c – chip rate
R_b – bit rate

Unit - V

Satellite Applications

Introduction:

Satellite offer a number of features not readily available with other means of communications As verylarge areas of earth are visible from a satellite, the satellite can form the star point of communication. satellites are used for remote sensing for dection of water pollution and monitoring and reporting of weather condition.

5.1 INTELSAT

INTELSAT stands for International Telecommunication Satellite. The organisation was created in 1964 and currently has over 140 member countries and more than 40 investing entities. Starting with Early bird satellite in 1965, a succession of satellites has been launched at intervals of a few years. these satellites are in geostationary orbit that they appear to be stationary relative to earth.

INTELSAT covers three main region - the Atlantic Ocean Region (AOR), the Indian Ocean Region (IOR) and the Pacific Ocean Region (POR).

For the Ocean Region the satellites are positioned in geostationary orbit above the particular ocean. INTELSAT satellite 905 is positioned at 335.5° east longitude.

The INTELSAT VII- VII A was launched over a period from October 1993 to June 1996. The VII series has solar sails rather than a cylindrical body. The VII series was planned for service in POR and also some of less demanding services in the AOR. The lifetime of these satellites ranges from 10 to 15 years depending on the launch vehicle. INTEL VII has 18,000 two way telephone circuits achieved with the use of "digital circuit multiplication" The INTEL VIIA has a capacity of 22,500 two way telephone circuits and three TV channels upto 112,500 two way telephone circuits achieved with the use of digital circuit multiplication.

INTEL VIII/VIIIA series of satellite was launched over period February 1997 to June 1998. These satellites provide wider range of services such as internet, DTH, telemedicine, tele education and interactive video and multimedia. The INTELSAT satellites are used for domestic services within any country and regional services

Solar Sails → Liquid crystal panel on edges of sail change the surface reflection by using low amount of electricity to turn on or off

5.2 INSAT System:

INSAT or the Indian National satellite System is a series of multipurpose geostationary satellites launched by ISRO to satisfy the telecommunications, broadcasting, meteorology and search and rescue operation. INSAT is the largest domestic communication system in the Asia Pacific Region. It is a joint venture (undertaking) of Department of space, Department of Telecommunication, India Meteorological Department All India Radio and Doordarshan.

INSAT satellites provide transponders in Various bands (C, S, Extended C and Ku) to serve the television and communication needs of India. Some of the satellites have very high resolution Radiometer, CCD cameras for meteorological imaging.

The Indian National satellite INSAT was commissioned with The launch of INSAT 1B In August 1983 (INSAT-1A). The First satellite was launched in April 1982.

Of the 24 satellites launched 10 are still in operation. INSAT 2 series carries seventeen c band and extended c band Transponders. INSAT 3A was launched by Ariane in April 2003.

INSAT 3E:

Launched in July 2013, INSAT 3D is positioned at 55 degree East longitude and carries 24 Normal c band Transponders with EIRP of 38 Dbw. It is positioned at 82 Degree East longitude

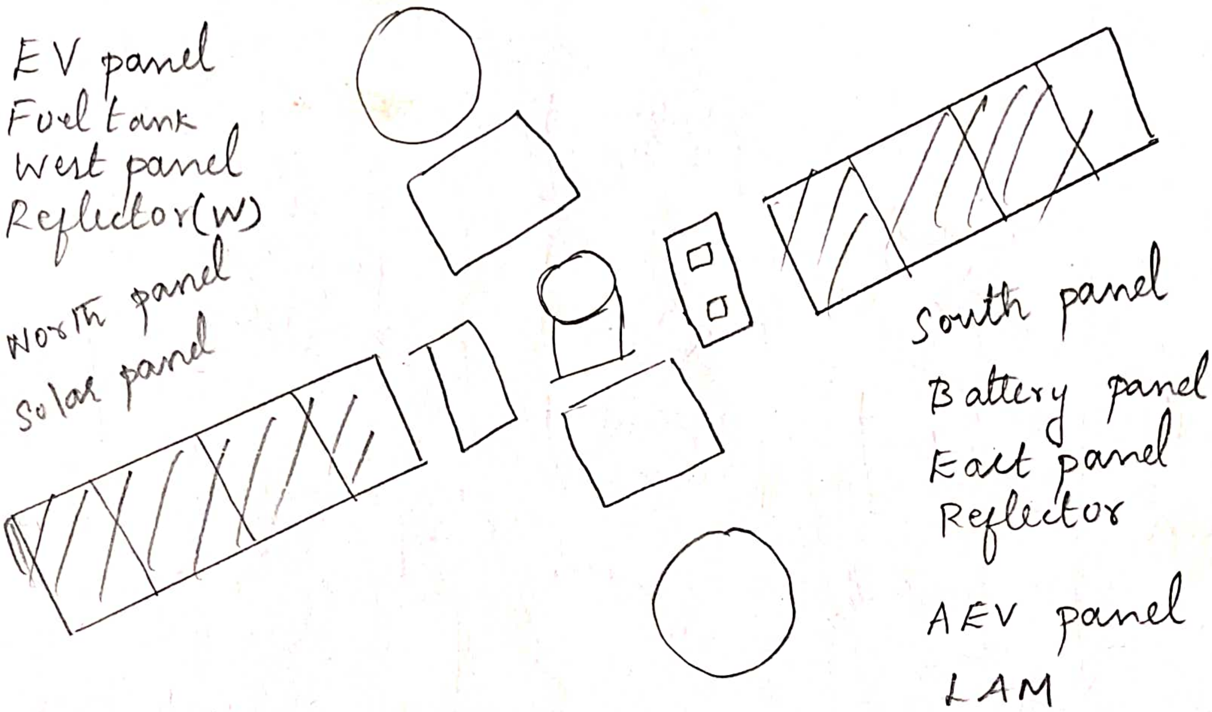
INSAT 3D:

Launched in september 2003 positioned at 55 Degree East Longitude

INSAT 4A :

It is positioned at 83 degree East longitude with INSAT 2E and INSAT 3B. TATA group and STAR uses INSAT 4A for distributing their DTH service.

Fig INSAT 4A



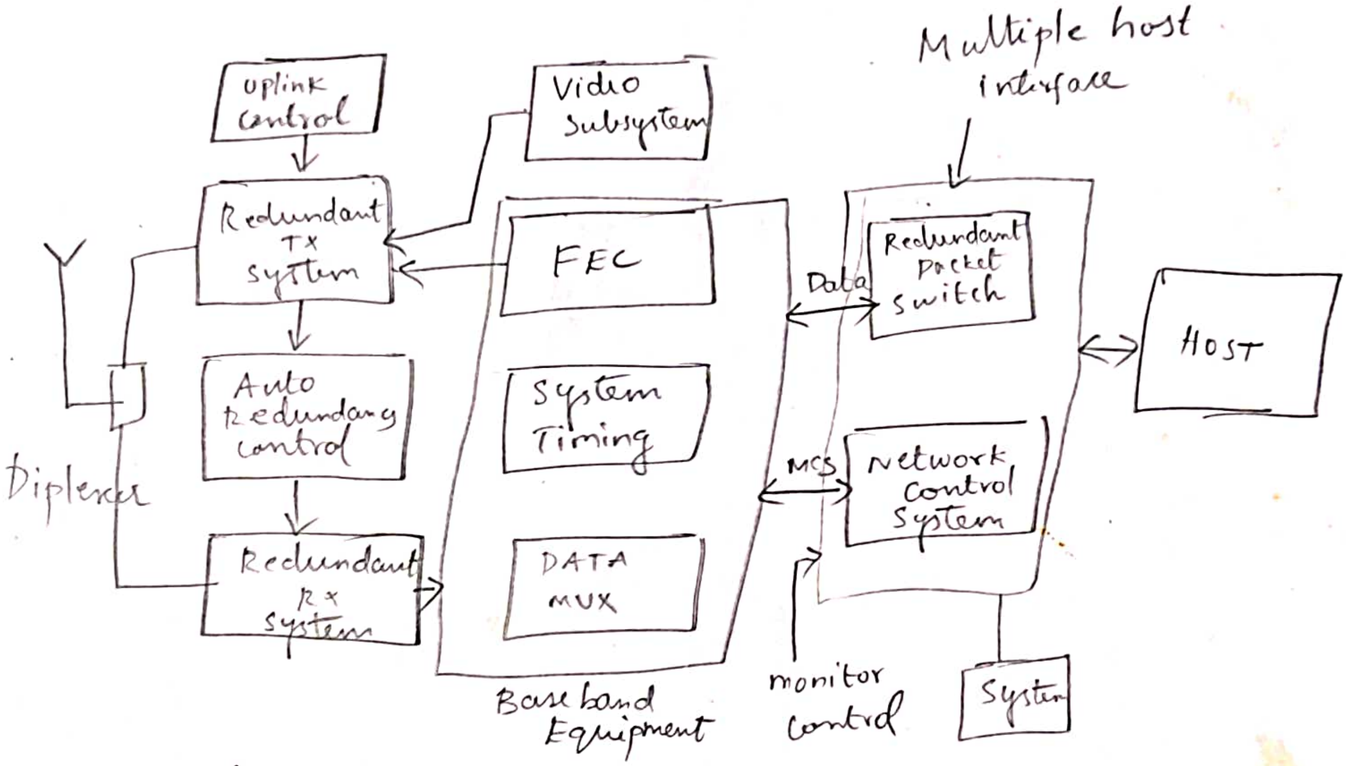
5.3 VSAT :

VSAT stands for very small aperture terminal system. The earth station antennas is less than 2.4 m in diameter. The small TVRO for direct broad cast satellite is labeled as VSAT's. User group include banking and financial institutions, airline hotel booking etc.

5.3.1 VSAT Network:-

The basic structure of VSAT network consists of hub station which provides broadcast facility to all VSAT in the network

VSAT BLOCK DIAGRAM



The hub station is operated by the service provider and shared among a number of user. Time division multiplexe is the normal downlink mode of transmission from hub to VSAT.

A form of demand assigned multiple access (DAMA) is employed in some system in which channel capacity is assigned in response to fluctuating demand of VSAT in the network. Most VSAT system operate in the Ku band, although there are some 'c' band system

5.4 Mobile Satellite Services

5.4.1 GSM :

The "Global system for Mobile communication" protocols are rapidly being adopted to the next generation of wireless telecommunication systems. Analog system capacities are being stressed with more users that can be effectively support by available frequency allocations. By using digital encoding techniques more users can share the same frequencies that had been available in the analog system.

The GSM architechture includes several subsystem:

The Mobile Station (MS):

These digital telephones include vehicle portable and hand held terminals. The Subscriber Identity Module (SIM) is a smartcard that provides custom information about users.

The Base Station Sub System (BSS):

The BSS is the collection of devices that support the switching network radio interface. Major components of the BSS include Base Transceiver station (BTS) that consists of radio modems and antenna equipment. The BTS provides the physical interface to the MS where the BSC is responsible for the link layers services to the MS

The Network and Switching Sub System (NSS):

The NSS provide the switching between the GSM subsystems and external networks along with the database used for additional subscriber and mobility management.

Major components in the NSS include the Mobile Service Switching centre (MSC). Home and visiting Location Registers HLR, VLR The HLR and VLR are interconnected throu telecome Standard signalling System 7 (SS7).

The operation Sub System (OSS)

The OSS provides the Support functions responsible for the management of network maintenance and services. components of OSS are responsible for network operation and maintename, mobile equipment management and subscription management and charging

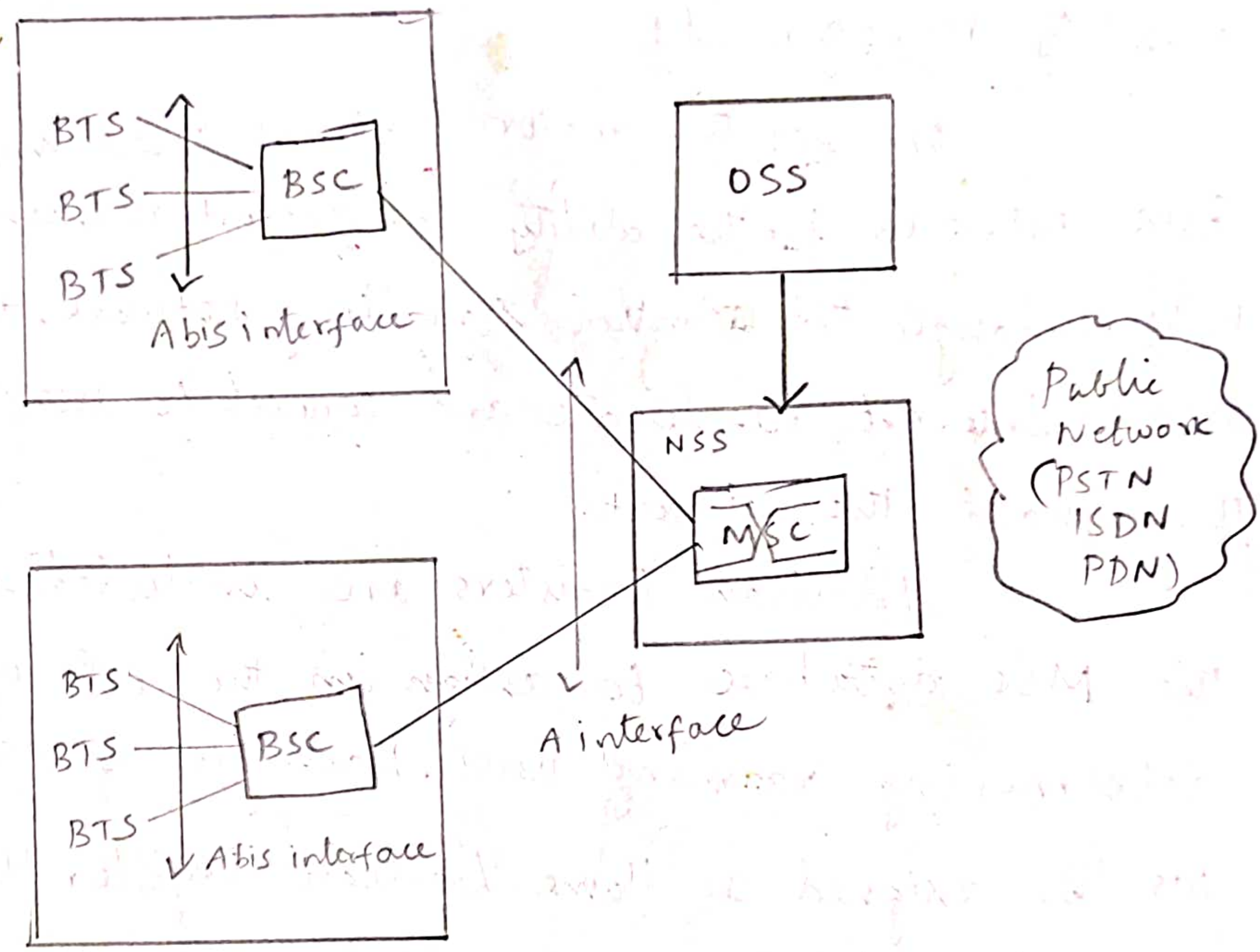
Mobility Management:

One of the major features used in all GSM networks is the ability to support roaming users. Through the control signalling network, the MSC's interact to locate and connect to users throughout the network.

Location Registers are included in the MSC database to assign in the role of determining roaming users. Each user of a GSM MS is assigned a Home Location Register HLR that is used to contain the users location and subscribed services.

GSM Service Security

GSM was designed with a moderate level of service security. GSM uses several cryptographic algorithms for security. The A5/1, A5/2 and A5/3 stream ciphers are used for ensuring over the air voice privacy. GSM uses General Packet Radio Service (GPRS) for data transmission like browsing the web.



GSM Block Diagram

5.5 Global Positioning System (GPS)

GPS (Global Positioning System) is a satellite based navigation system used to locate positions anywhere on earth. It is designed and operated by the U.S department of Defence, it consists of satellites, control and monitor stations and receivers. GPS receiver take information transmitted from the satellite and uses triangulation to

Three segments of GPS

Space segment - Satellites orbiting the earth

The space segment consists of 29 satellites circling the earth every 12 hours at 12,000 miles in altitude. This high altitude allows the signals to cover a greater area. The satellite are arranged in their orbits so a a GPS receiver can receive signal from at least four satellites at any given time. Each satellite contain several atomic blocks.

Control segment - The control and monitoring system

The control segment tracks the satellites and then provides them with corrected orbital and time information. The control segment consists of five unmanned monitor stations and one Master control station. The five unmanned stations monitor GPS satellite and send information to the Master control station where anomalies are corrected and sent back to the GPS satellites calculate users exact location.

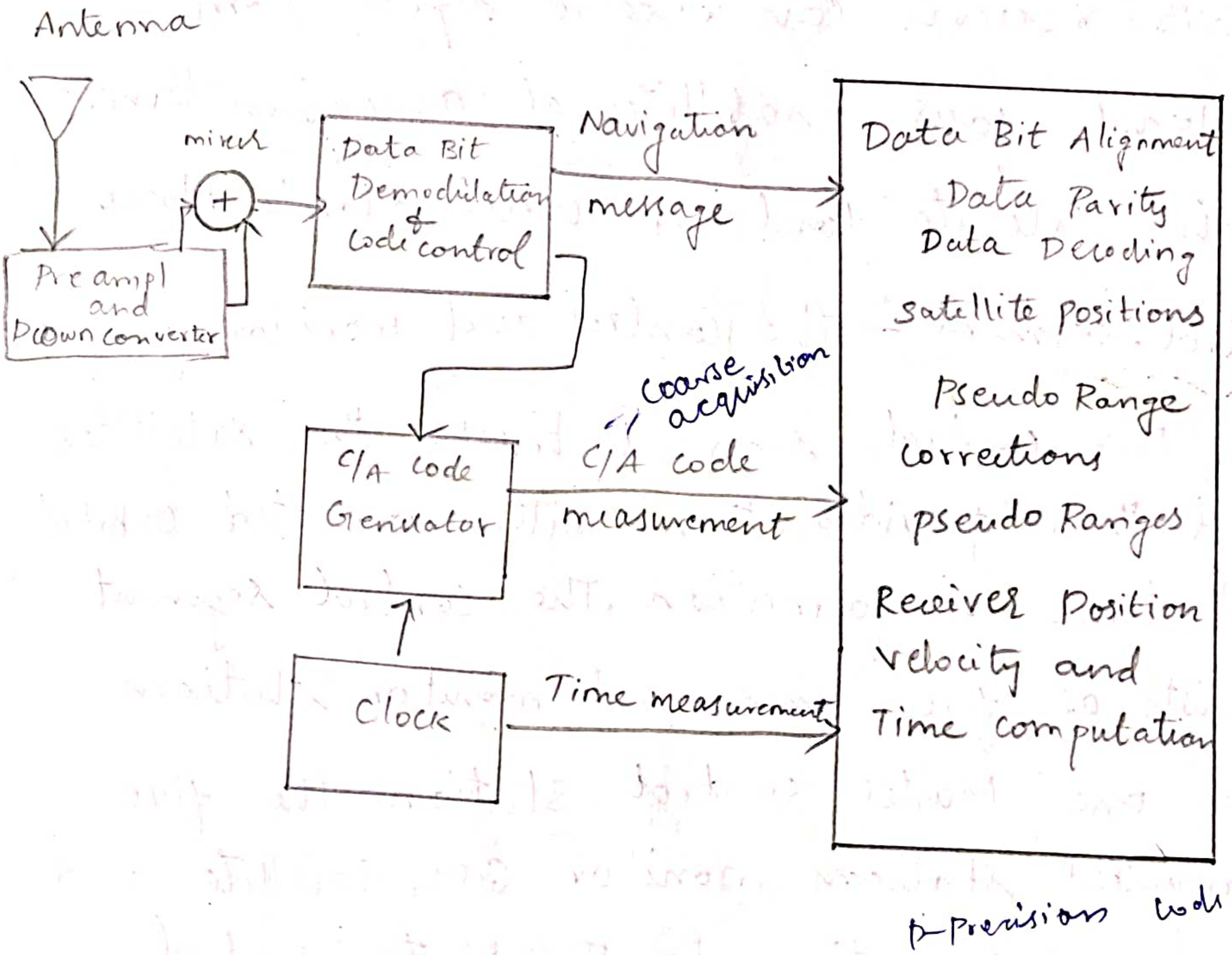
GPS is used to determine position location.

→ To navigate one location to another

→ To create digitized maps

→ To determine distance between two points

BLOCK DIAGRAM of GPS



User Segment :

The user segment consists of the users and their GPS receivers.

How GPS determine a Position

The GPS receiver uses following information to determine a position

→ Precise location of satellite
→ Distance from each satellite
→ Triangulation to determine position

Using a GPS receiver . needs Compass, map, GPS download Cables , extrabatteries.

5.6 INMARSAT:

Indian Maritime Satellite provide satellite communication for GMDSS (Global Maritime Distress and safety system. The service was started from the year 1982. This organisation makes a very big revolution , where the usage grow tremendously. Its headquaters is situated at London , and have more than 100 member countries

Inmarsat services

1. Telephony
2. Telex
3. Fascimile
4. E-mail
5. slow speed data for marine
6. Aeronautical
7. Land mobile

Data servicing includes

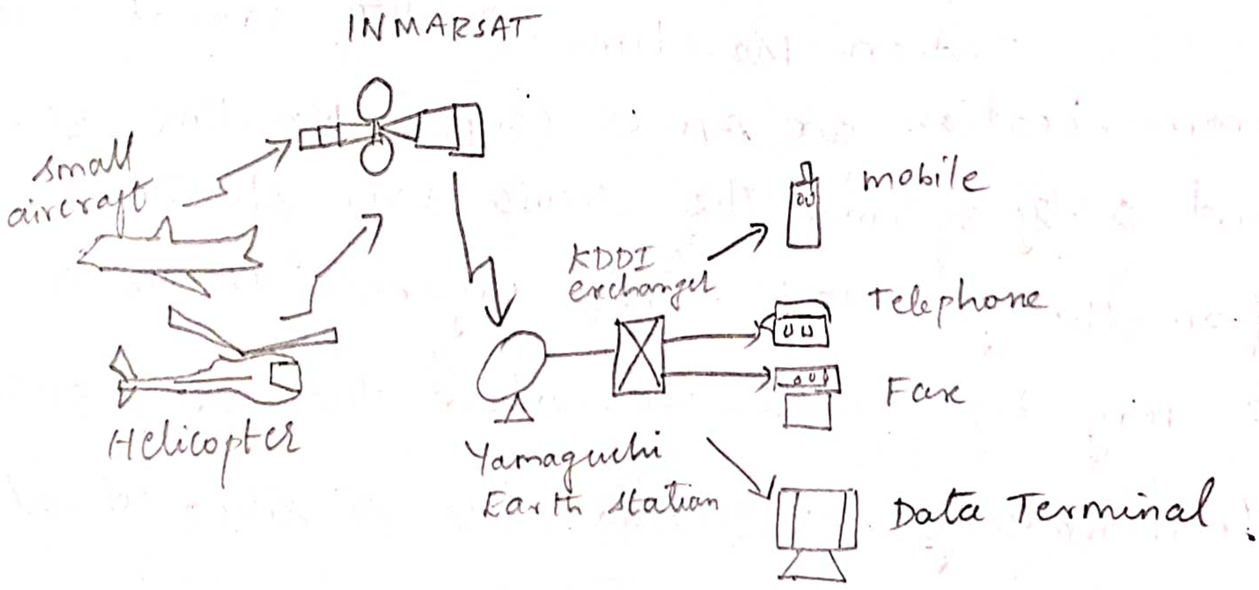
i) Position reporting ii) status monitoring
iii) fleet management

INMARSAT covers the 4 regions

POR - Pacific ocean Region
IOR - Indian Ocean Region
AOR - Atlantic ocean East and West Region

INMARSAT - A, B, C, M, E are various service type

BLOCK DIAGRAM of INMARSAT



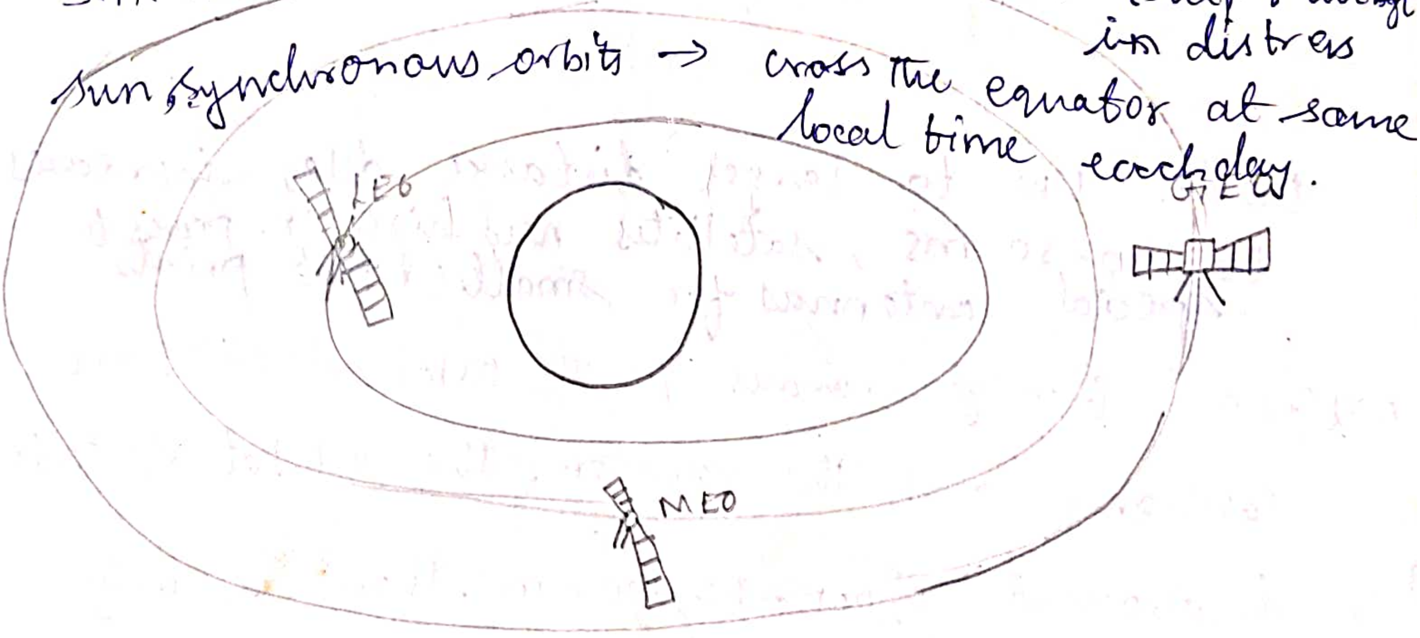
5.7 LEO (Low Earth orbit):

LEO have small area of coverage. They are positioned in an orbit approximately 3000km from surface of the earth. They complete one orbit every 90 minutes. The large majority of satellites are in low earth orbit. The satellite in LEO orbit is visible to a point on the earth for a very short time (10 min)

Polal orbiting satellites placed → polar orbits → 800-900 km (weather forecasting)

SAR SAT → search & rescue sat → locate ship & aircraft in distress

Sun synchronous orbits → cross the equator at same local time each day.



LEO, MEO, GEO orbits

→ Using advanced compression schemes. Tr. rates of about 2,400 bits/s. for voice commn.

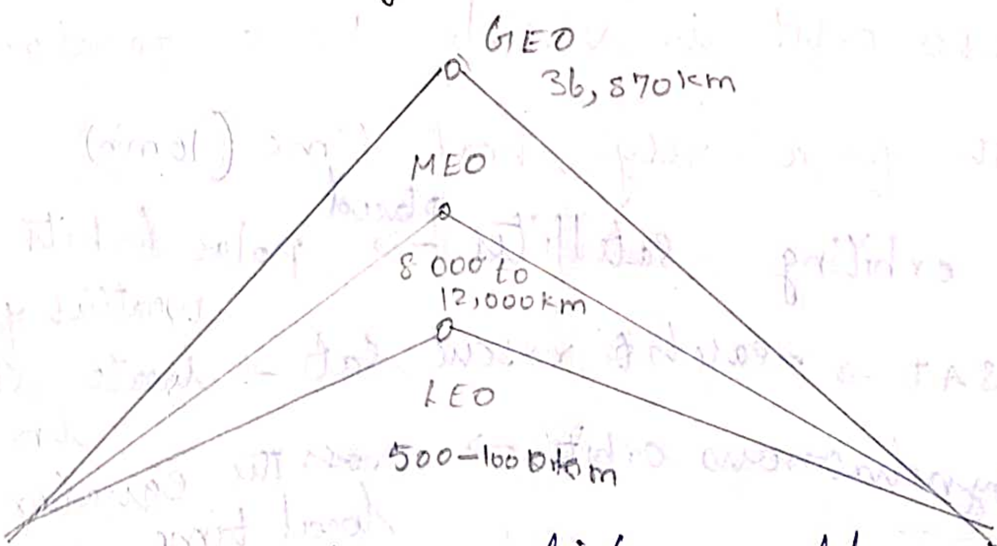
→ delay of packets via LEO is low (10ms)

→ Smaller foot print better freq. reuse

→ LEO provide much higher elevation in polar regions.

5.7.1 MEO (Medium Earth orbit satellites have orbital altitudes between 3,000 and 30,000 km). They are commonly used in navigation systems such as GPS. It requires a dozen satellite more than GEO & less than LEO. Depending on inclination MEO cover larger population

Fig: LEO, MEO & GEO range



Disadv: Due to larger distance delay increases to 70-80 ms, satellites need high Tr. power & special antennas for smaller foot prints

5.7.2 GEO: Geosynchronous Earth orbit satellites are positioned over the equator. The orbital altitude is around 30,000-40,000 km. There is only one geostationary orbit possible around the earth lying on the earth's equatorial plane, the satellite orbit as the same speed of earth and so it appears stationary with respect to a point on earth.

Satellite Navigational System

Benefits :

Enhanced safety, Increased capacity, Reduced Delays, increased flight efficiencies, increased shedule predictability.

5.8 Direct Broad cast Satellite (DBS)

The DBS was called as BSS-TV. It provides 3 services for telecasting audio and video signals directly to end user

BSS-TV — BSS - Broadcast Satellite services.

BSS - HDTV

BSS - AUDIO.

One of the older and existing another service is TVRO. But it is more expensive and need a very big dish.

The band allocated for DBS-TV is 12.2 to 12.7 GHz band. It also incorporates QPSK demodulation, Error control, Decryption, MPEG coding, DSP. The satellite for Direct broadcasting of TV was first launched in 1993

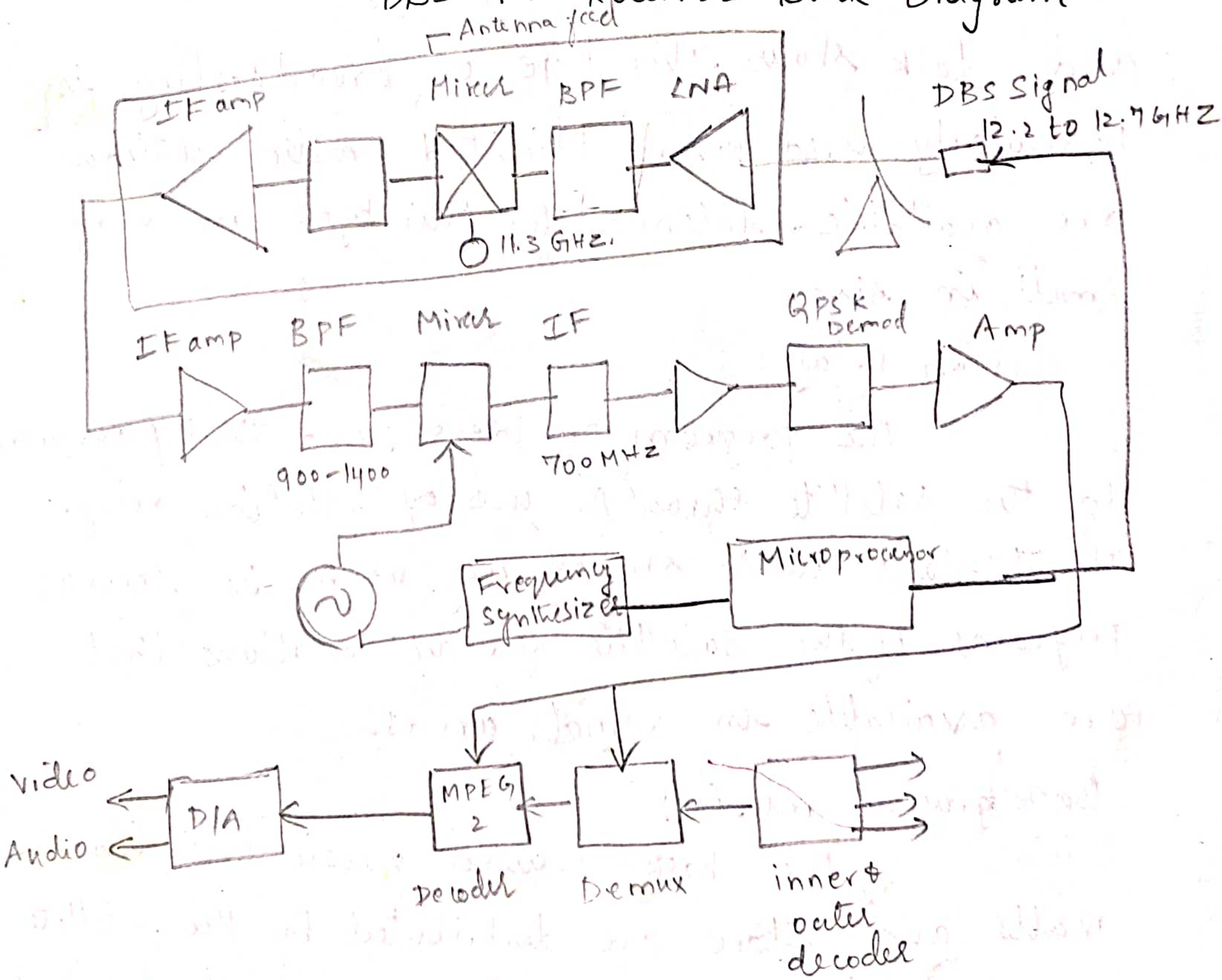
It transmits more than 200 TV channels and audio channels. It is alternate to the cable TV. It uses digital video transmission.

The DBS satellite are placed in geostationary orbits. It uses the high power transponders. Transponder output level 100 to 240W It can carry upto 32 transponder. The stabilization technique used here is 3-axis stabilization Due to the very low flux density at earth surface, very small receiving dishes are enough The diameter range in 0.45 - 0.9m

5.8.1 DBS TV Receiver

The polarization is switched by the set top box receiver. The antenna feeds receives 12.2 to 12.7 GHz and is given to down conversion section. The signal is converted into 900 to 1400 MHz. The set top box receives the entire band and separte the frequencies. Any one frequency can be selected on demand of the user. The set top box receives the entire band and separate the frequencies. After the appropriate frequency selection the signal is demodulated by the QPSK demodulator. The result is obtained in multiplexed form is then error corrected and given to the demultiplexer section. The demultiplexed output is then given into MPEG-2 section and the output is analog video and audio signal.

DBS TV - Receiver Block Diagram



5.9 Digital Audio Broadcast:

The digital audio broad casting throu' satellite is used to provide, high quality audio signals to the consumers. It is also called as SDARS - Satellite Digital Audio Radio Service DARS - Digital Audio Radio service. They are intented mainly for vehicles, some units can be used in home also. It provides more than 100 channels of CD-quality radio music and talk shows. This type of broad casting is particularly used where limited radio stations are available. Antenna for this type are very small in size.

Station Relay:

The program providers send their programmes to the satellite throu' the use of station relay. The Distant audio station may uplink it services programs to the satellite for the stations that are available in remote areas.

Back ground music:

The back ground music used in malls and store are distributed by the satellite. The satellites are used to economically distribute the music to consumers

Retail audio:

This is distribution of company information like inventory price files to its affiliated stores To avail this service a small dish with receiver is needed several SDRS are operating all over the world some are

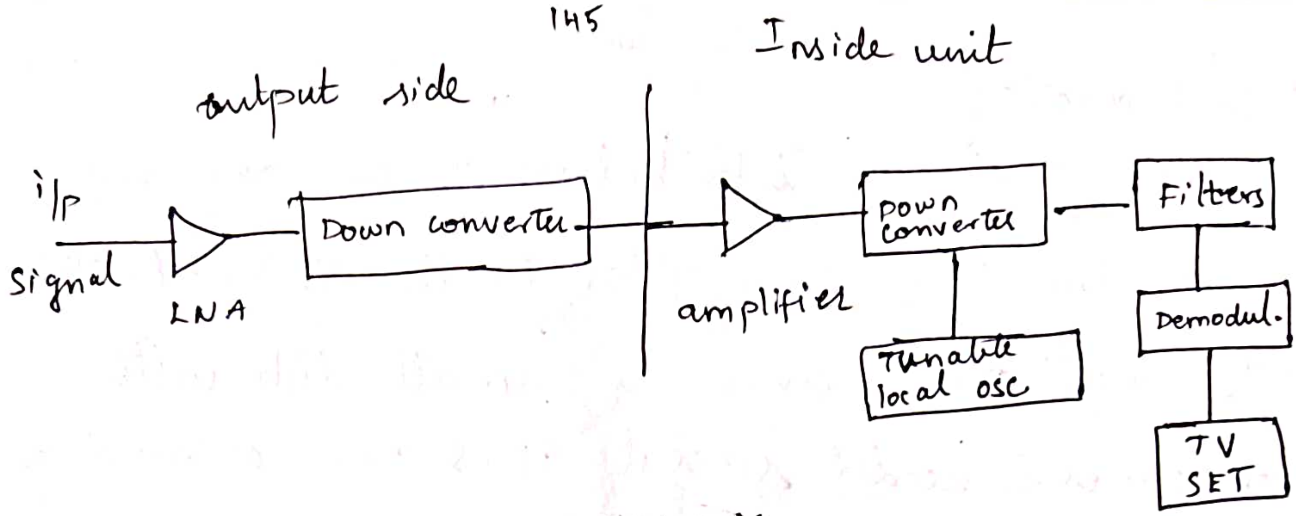
* Sirius, XM radio, Afristar, Asiastar.

5.10 Direct to Home Broadcast (DTH)

DTH stands for Direct to Home television.

DTH is defined as reception of satellite programmes with personal dish in home. DTH broadcasting to home TV receivers takes place in the ku band. DTH were first proposed in India in 1996. The Broadcaster modulates the received signal and transmit is to satellite in ku band.

The DTH consists of broadcasting centre satellites, encoders, multiplexers, modulators and DTH receivers. The encoder converts the audio, video and data signals into digital format and multiplexer mixes these signals. It is used to provide DTH service in high populated area. A multiswitch is a box that contains signal splitters and A/B switches. A output of groups of DTH LNBs are connected to A & B inputs of multiswitch



DTH service

Advantage:

It offers digital quality signals and do not degrade the picture or sound quality. It offers interactive channels and program guides with customer having choice to block out programming which is undesirable.. It provides great advantage to cable industry using other local channels. Availability of satellite broad cast in rural and semi urban areas where cable is difficult to install

5.11 WORLD SPACE SERVICES:

World space is the only global media to offer a satellite radio experience to customers in more than 130 countries.

World space subscribers benefit from a unique combination of local programming. It covers two thirds of globe with 6 beams.

Each beam is capable of delivering upto 80 channels of high quality digital audio and multimedia programming directly to world space satellite. World space is a pioneer of satellite based digital radio services DARS and was intrumental in the development of the technology infrastructure used today by XM satellite Radio

5.12 Buisness Television (BTV)

Buisness television (BTV) is the production and distribution through satellite of video programs for closed user group audiences. It is often has two way audio interaction component made through a simple telephone line. It is used by many industries, firms, car dealers and delivery services.

BTV is an increasing popular method of information delivery for corporation and institutions. BTV provides efficient delivery of specialized program via satellite. BTV has a number of benefits such as reducing travel, immediate delivery and eliminating cassette duplication The programming on BTV is extremely cost effective compared to seminar fees and down time for travel. It is an excellent way to get solid and current information very fast.

BTV provides another piece of the education and another way to provide professional development. BTV network transmit information every buisness day on a broad range and provide instructional courses on various products, market trends, selling and motivation.

5.13 GRAMSAT:

ISRO has come up with concept of dedicated GRAMSAT to eradicate illiteracy in rural belt. This Gramsat satellite is carrying six to eight high powered c band transponders with video compression techniques. The high power c band has enabled even remote areas outside the reach of TV transmitters to receive programmes of their choice in a direct reception mode with dish antenna.

The salient features of GRAMSAT are

Its communication networks are at state level connecting the state capital to district, blocks and enabling reach to villages.

GRAM SAT → launched in May 2002 by Atal Biharee Vajpayee in Orissa

It is providing computer connectivity data broadcasting TV broadcasting facilities. It provides rural education broadcasting. It gives interactive training at district and block levels employing suitable configuration Broadcasting services for rural development. computer interconnectivity and data exchange services. Tele health and Telemedicine services.

Specialised services:

5.14 Email services:

Email service allows Inmarsat users to send and receive e-mail directly through Internet without accessing a public network. It configures an email client to access a Astrium e-mail account. service optimized for use with low bandwidth Inmarsat terminals Filter the e-mail by previewing inbox and deleting unwanted e-mails.

5.15 Video Conferencing:

Video conferencing is used to provide Small full, two way interactivity of satellite broadcast at much lower cost. For video conferencing uses bridging system to connect each site to others.

It is possible to configure a video conferencing bridge to show all sites at the same time on a projection screen or monitor. A bridge can show just the site from which a person is speaking or making a presentation.

5.16 Satellite Internet access

Satellite Internet access is Internet access provided throu' communication satellites. Modern Internet services are provided to users throu' geostationary satellite that offers high data speeds.

Satellite Internet relies on three primary components, a satellite in geostationary orbit a number of ground stations, a VSAT, and a dish antenna. Other components include a modem at user end which links the users network with transceiver and a centralised network operation centre (NOC) for monitoring the entire system