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25th BATCH

COMPUTER AND COMMUNICATION ENGINEERING

International Islamic University Chittagong

COURSE CODE: CCE-4711

COURSE TITLE: Satellite Communication and Radar navigation

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Satellite Communication
CCE-4711

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Mid-Term

Com. = communication
Sat. = satellite

Need of Sat. Com:-

Ground wave propagation:- তরঙ্গ

For frequencies upto 30 MHz. And makes use of the troposphere conditions of the earth.

SPP-22

Sky wave propagation:-

Freq. up to 30-40 MHz & use the ionosphere of the earth.

→ The maximum ~~distance between~~ hop or the station distance is limited to 1500 Km only in both sky & ground wave prop. Sat. Com overcome this limitation. Satellite provide communication for long distances.

Ground wave com to sky wave com → max 1500 Km.

~~How a Satellite works!~~ -

As satellite is located at certain height above the earth. The com. took place between any two earth stations easily via satellite. So, it overcomes the limitation of com. between two earth stations due to earth's curvature.

How a Satellite work?

=> A Satellite is a body that moves around another body in a particular path.

A Com. Satellite is nothing but a Microwave repeater. It helps in TV, Radio, internet etc.

A repeater is a circuit that receives a signal & strength its power & transmits it. But this repeater works as transponder. That means it receives signal & then changes the frequency band.

The signal which goes to space from earth is called uplik freq. & the signal which is received by ground station from satellite is called downlink freq.

And the transmission are called as uplink & downlink respectively.

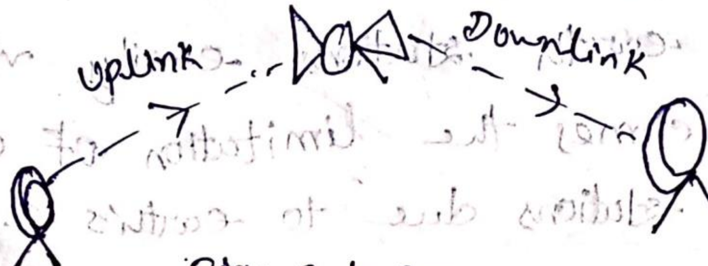


Fig: Sat com.

ork ?

ody that moves around

particular path.

thing but a Microwave

TV, Radio, internet etc.

a circuit that

strength its power

this repeater works as

it receives signal &

quency band.

goes to space from

freq. & the signal

ground station from

downlink freq.

are called as

respectively.

Downlink

Satellite Communication (Orbital Mechanics)

Describe the orbital motion of satellite. There are 6 orbital elements:-

(i) Semi Major axis

(ii) Eccentricity

(iii) Mean Anomaly

(iv) Argument of perigee

(v) Inclination

(vi) Right Ascension of Ascending Node.

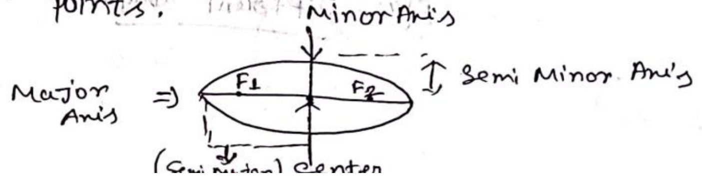
SPR-22

Semi Major Axis

→ Defines the size of satellite's orbit.

→ Half of major axis.

→ Runs from the center through a focus to the edge of the ellipse. It is radius of and orbit at the orbit's two most distant points.



→ Semi Major axis determines Satellite's Orbit.

→ " " " " time period of revolution.

→ In circular orbit semi-major axis = radius of that circular orbit.

$\boxed{\text{Eccentricity}}$ (Orbit এর Shape কে define করে)

→ Fixes the shape of Satellite orbit

→ If the lengths of semi major Axis = a

& " minor " = b

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

→ There are different shape for different Orbits.

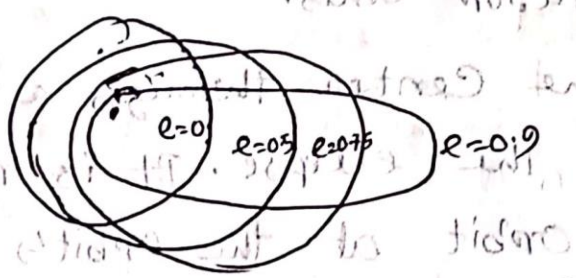


Fig:- Different Shape

Mean Anomaly

→ Gives Average value of the Angular position of the satellite with reference to perigee.

→ If orbit is circular:- Mean Anomaly gives the angular position of the satellite in the orbit.

If orbit is elliptical:- Then calculation of exact position is difficult.

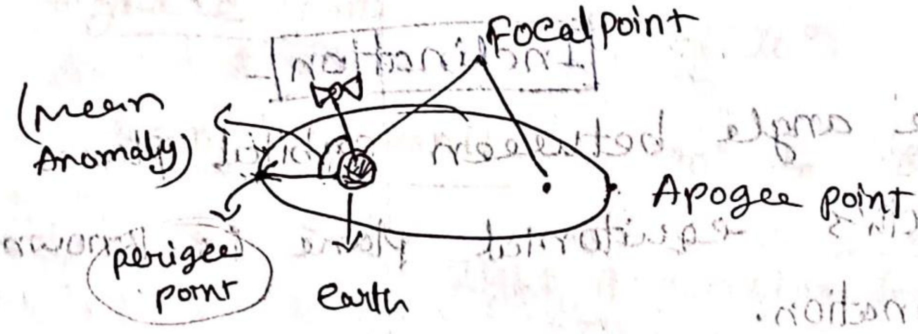


Fig:- Mean Anomaly

perigee point হতে Ascending Node এর দূরত্বকে AOP বলে

Argument of perigee

পৃথিবীর কাছের point Perigee

→ Satellite orbit cuts the equitorial point into two points.

→ (i) Descending Node (North Hemisphere to South Hemisphere)

(ii) Ascending Node (South Hemisphere to North Hemisphere)

→ Denoted by (ω). Angle between Ascending Node & perigee.

→ If both perigee & A. Node are in the same position then $\omega = 0$.

Inclination

→ The angle between orbital plane & Earth's equitorial plane is known as inclination.

(i) It is measured at the Ascending Node with direction being east to North.

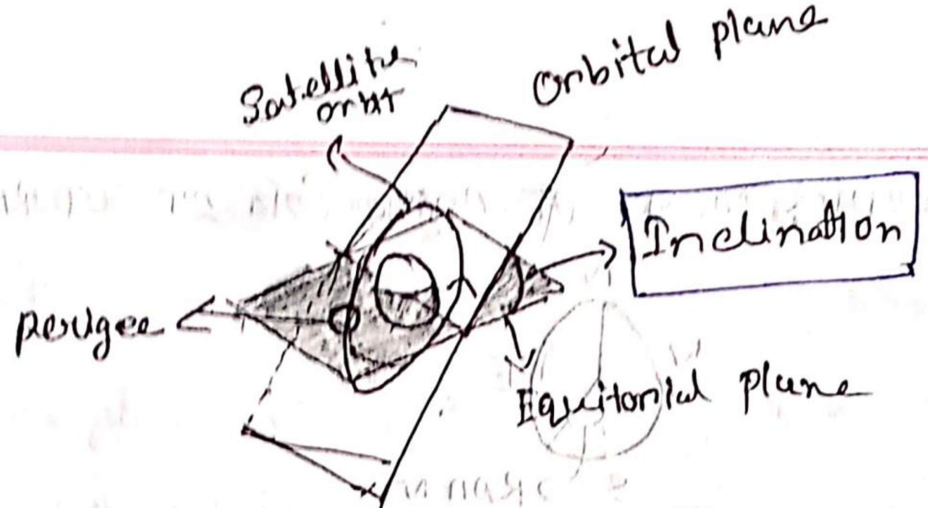


Fig:- Inclination

Four Types (Based on Angle of Inclination)

Aut-22, Spr-22

(i) Equatorial orbit:- Angle inclination either (0° or 180°)

(ii) Polar orbit:- Angle of Inc. 90° (EP & OP Angle)

(iii) Prograde orbit:- 0° & 90°

(iv) Retrograde point:- 90° & 180°

Right Ascension ~~&~~ of Ascending Node (RAAN)

→ Ascending Node the point which ~~crosses~~ is crossed by Satellite in the equitorial plane. While going from ~~Sout~~ Southern to Northern Hemisphere.

→ Ascending Node ↔ East 2 (Descending Node)

N এর আমাদের মাঝে যে Angle তৈরি হয় তা RAAN.

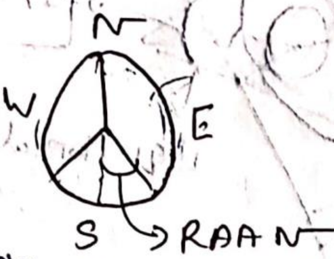


Fig:- RAAN

SPR-22
AUT-22

Orbital Equation

(i) When the satellite revolves around the earth it receives force from earth. Which is called centripetal force.

$$F_1 = \frac{GMm}{R^2}$$

G = Gravitational constant $= 6.673 \times 10^{-11} Nm^2/kg^2$

R = Distance of sat from center of the earth

M = Mass of earth $= 5.98 \times 10^{24}$ kg

m = Mass of sat.

(ii) During its revolving around the earth it receives force from moon & sun which is called centrifugal force.

$$F_2 = \frac{mv^2}{R}$$

Spr-22 Aut-22

Orbital velocity:-

To revolving around the earth in the exact place with certain velocity both centripetal & centrifugal force are equal.

So, $\frac{GMm}{R^2} = \frac{mv^2}{R}$

$\Rightarrow \frac{GM}{R} = v^2$

$\Rightarrow v = \sqrt{\frac{GM}{R}}$

VVIm

Kepler's Law (Spr-22, Aut-22)
(Law of planetary motion)

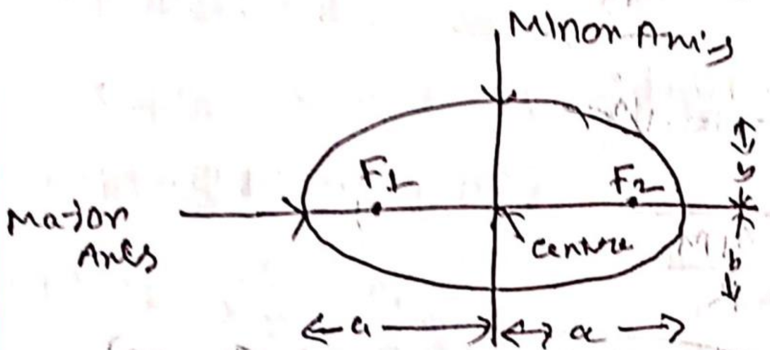
① **First Law:-**

The path followed by a satellite around its primary will be an ellipse. And this ellipse has two focal points F_1 & F_2.
The center of the earth will always present at one of the two foci of the ellipse.

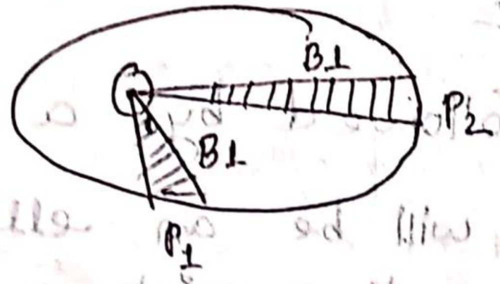
The Farthest point from the center of Object is called as Apogee

And the shortest point of an ellipse from the center is called as perigee

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



⊛ Second Law:-



For equal interval of time the area covered by the satellite will be the same.

Third Law:-

The square of the periodic time of an elliptical orbit is proportional to the cube of its semi major axis length.

For Example:- $T^2 \propto a^3$

$$\Rightarrow T^2 = \left(\frac{4\pi^2}{\mu}\right) a^3$$

proportional constant

μ is kepler's constant & its value is equal to $3.986005 \times 10^{14}\ m^3/sec^2$

$$1 = \left(\frac{2\pi}{T}\right)^2 \left(\frac{a^3}{\mu}\right) \quad [n =$$

$$\Rightarrow 1 = n^2 \left(\frac{a^3}{\mu}\right) \quad [n = \text{mean motion of the satellite}]$$

$$\Rightarrow a^3 = \frac{\mu}{n^2}$$

Aut 22
(Spr 22) (Based on their Advantage)

Earth Orbit Satellites

⇒ Satellite should properly placed in the corresponding orbit after leaving it in space. uses for scientific, military or commercial. The satellites present in those orbits are called as Earth orbit Satellite.

- There are many types of Earth orbit satellite:-

(1) ~~Geo Synchronous~~ Geostationary Synchronous Earth Orbit (GEO) Satellite:

⇒ Placed at an altitude of 22,300 miles above earth surface

⇒ Synchronous with a side real day (23 hours & 56 minutes).

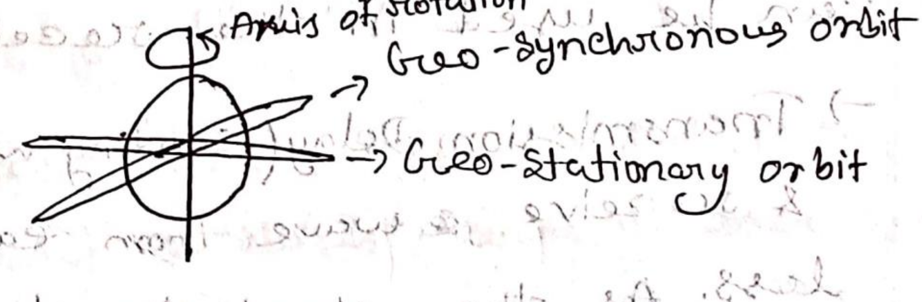
⇒ The orbit have inclination & eccentricity.

→ The orbit can be titled at the poles of the earth. But it appears stationary when observed from the earth.

⇒ The geo-synchronous orbit if it is circular & in the plane of equator It is called as Geostationary orbit. (The satellites are placed at ≈ 35,900 Kms.).

They keep on rotating to Earth's direction East to west.

⇒ The satellite of this orbit have the same angular velocity of the earth. And these satellites are considered as stationary satellite.



(2) ~~MEO~~

→ Advantage is that no need to track the antennas in order to find the position of satellite.

[weather, TV, Sat radio --- etc communications]

(2) Medium Earth orbit Satellite (MEO):

→ Its ~~is~~ ~~orib~~ orbit is 800 miles from earth's space.

→ The signal from this sat. travel short distance as a result signal strength gets improved.

And smaller & light wave receiver can be used in the receiving end.

→ Transmission Delay (sending wave to Earth station & receive ~~a~~ wave from earth station) are less. As the signal travel less distance.

GEO satellite needs 0.25s for a round trip

And MEO " less than ~~0.05~~ 0.1 s " "

→ MEO operate in the frequency range of 2GHz and above.

→ used for High speed Telephone signals.

→ Ten or more MEO satellites are required to cover entire earth.

Low Earth orbit (LEO):-

→ Mainly classified into three categories.

- → Little ~~Lo~~ LEOs.
- → Big LEOs
- → Mega LEOs.

→ Orbits at a distance of 500 to 1000 miles above the earth's surface.

→ These satellites are used for satellite phones & GPS.

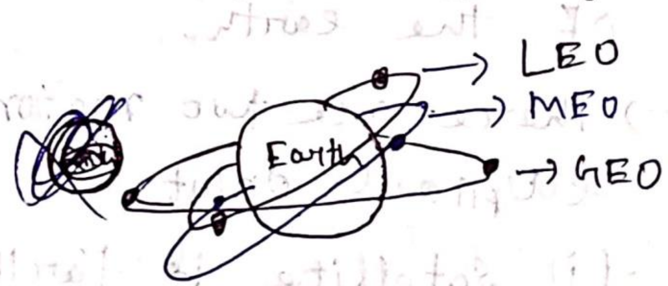
→ The transmission delay is 0.05s.

→ 20 or more satellites needed to cover entire earth.

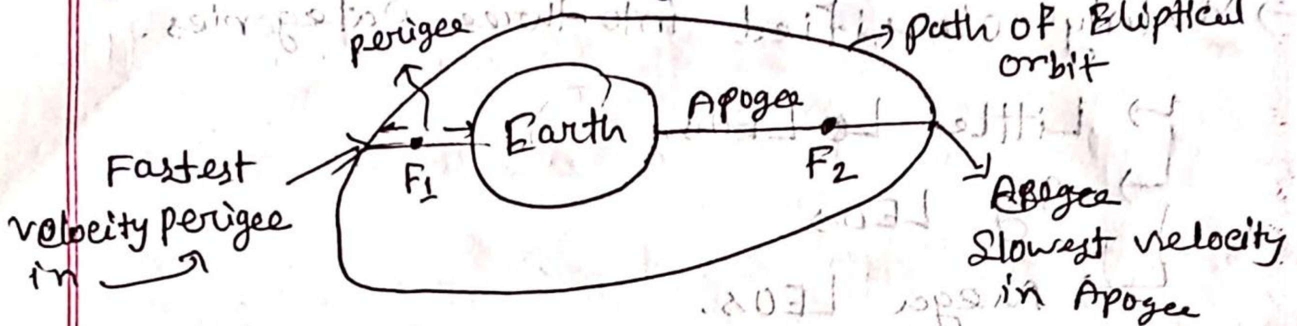
→ Little LEO operates 800 MHz (0.8 GHz) range

→ Big LEO " 2 GHz or above range

→ MEGA LEO " in 20-30 GHz Range.



High Elliptical Orbiting (HEO) Satellite:-



→ HEO orbit satellite swings very close to earth & then goes far distance from earth. And keep repeating it.

→ 18,000 to 35,000 km above the earth surface.

→ Gives better coverage to higher Northern & Southern latitudes.

→ For any ellipse there are two focal points. And one of this is geo-centre of the earth.

→ There are two major points in the elliptical orbit:-

(i) Satellite is farthest from earth. Known as apogee. Satellite moves at its lowest due to low gravitational force

(ii) Other point is perigee which is near to earth & moves very speed due to the force.

Where it moves slowly the view over the operational area most of the time And falling out of view in perigee.

→ By placing a number of satellites in the same orbit but equally spaced apart, permanent coverage can be achieved.

Look Angle Determination

The earth station will receive the maximum signal level if it is directly located under the satellite. Or it won't receive maximum signal.

So, based on this satellite can be placed in a particular orbit. And there are two angles of earth station antenna for this

Which are called as Look Angles.

1) Azimuth Angle:-

The angle between local Horizonal plane and the plane of passing through (Satellite, Earth Station & centre of the earth) is called as Azimuth Angle.

Formula:- $$\boxed{\alpha = 180^\circ + \tan^{-1}\left(\frac{\tan G}{\tan L}\right)}$$

L = Latitude of earth Station Antenna

G = Difference between the postion of Sat. orbit & Earth Station Antenna

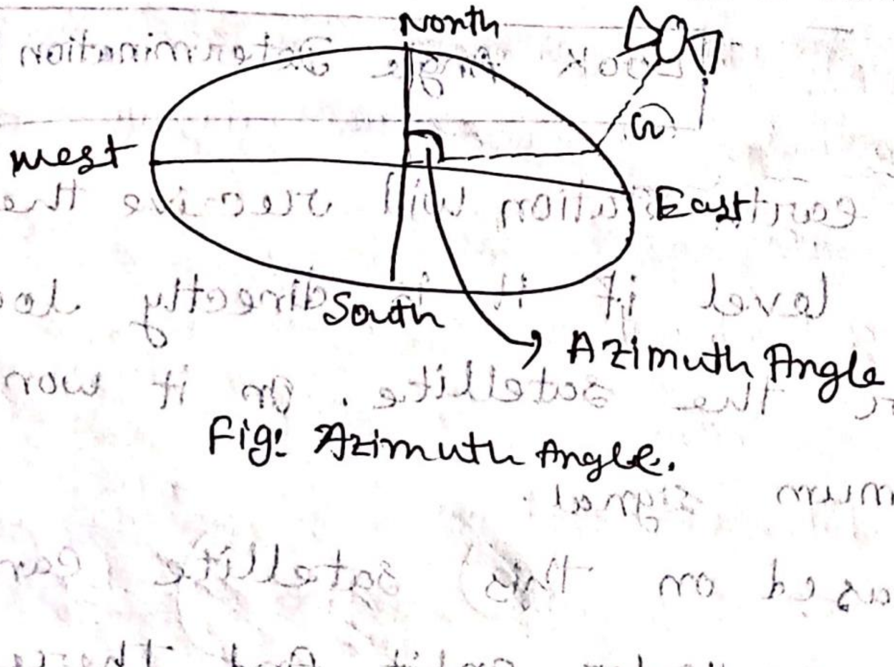


Fig: Azimuth Angle.

(2) Elevation Angle :-

The angle between between vertical plane and line pointing to sat. is called as Elevation Angle.

vertical plane is nothing but the plane which is perpendicular to Horizontal plane.

$$\beta = Tan^{-1}\left(\frac{\cos G \cdot \cos L - 0.15}{\sqrt{1-\cos^2 G \cdot \cos L}}\right)$$

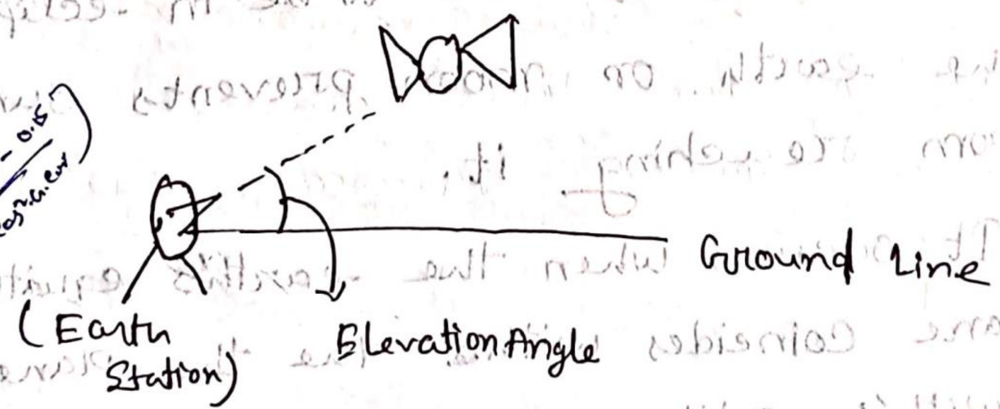


Fig:- Elevation Angle

(3) Limits of visibility :-

East & west limits of geostationary are visible from any given earth station. These limits are set by the geographic coordinates of the earth station & Antenna elevation.

⇒ The lowest elevation is zero but in practise to avoid excess noise from Earth.

⇒ The earth station can see a satellite over a geostationary arc bounded by $\pm$(81.30) about the earth station's longitude.

SPR-2022

Earth Eclipse of Satellite

→ A satellite is said to be in eclipse when the earth or moon prevents sunlight from reaching it.

→ It occurs when the earth's equitorial plane coincides with the ~~the~~ plane of the Earth's orbit around the sun.

→ If the earth's equatorial plane coincides with the plane of earth's orbit around the sun, the geostationary orbit will be eclipsed by the earth. This is called the earth eclipse of satellite.

→ Near the spring & ~~ad~~ autumnal, when the sun is crossing the equator the satellite passes into sun's shadow equinoxes. This happens for some duration of time everyday.

→ This eclipse begin 23 days before equinox & end 23 days after the equinox. It last for almost 10 minutes at the beginning & end of equinox & increase for a maximum period of 72 minutes at a full eclipse.

⇒ When eclipse happens satellite uses its solar power to supply power

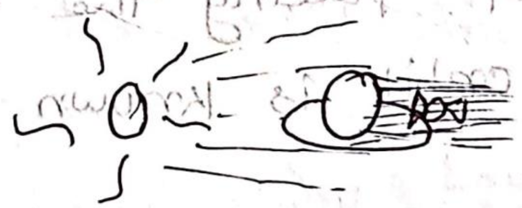
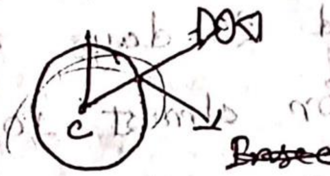


Fig: Earth Eclipse.

Sub satellite point :-

If a straight line is drawn from satellite to the centre of the earth & where the line is intersected ~~insected~~ in earth surface is called sub satellite point.



~~Basee~~ Intersected place is called sub-sat point.

Latitude :- degrees North from equator

Longitude :- Degrees west " Greenwich Meridian.

Launching of Satellite

The process of placing the satellite in a proper orbit is known as launching process.

There are couple of stages :-

1) First stages :- Launch vehicle contains rocket, & fuel for lifting the satellite along with launch vehicle from ground.

Second Stage:- Contains smaller rockets. These are ignited after completion of first stage. They have their own fuel tanks in order to send the satellite into space.

Third ~~Std~~ Stage:- Connected to the satellite fairing made with metal covers it & protect the satellite.

Fourth Stage:- Satellite gets separated from the upper stage of launch vehicle when it reaches to earth's atmosphere. Then the satellite will go to a transfer orbit. This orbit sends the satellite higher into space.

Fig:- Launching of Satellite

Altitude & Orbit control (AOC)

We know that satellite revolves around earth by equal power of ~~to~~ ~~An~~ centripetal & centrifugal force. But during this rotation satellite direction sometimes gets changed by the force. So, to keep the satellite into the right position the AOC system is used. There are two parts in it:-

(i) Altitude Control Subsystem.

(ii) Orbit Control Subsystem.

(I) Altitude Control Subsystem:-

There are two methods

(1) Spinning The Satellite:-

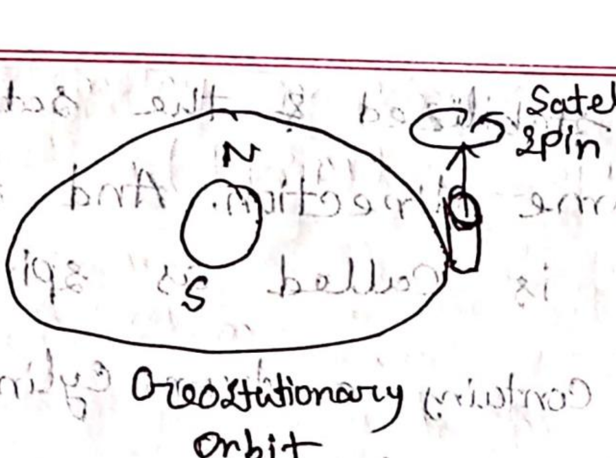
→ The body of the satellite rotates around its spin axis.

→ It can be rotated at 30 to 100 rpm in order to produce a force. Which is gyroscople type. As a result the spin axis gets stabilized & the satellite will point in the same direction. And satellite of this type is called as spinners.

(Spinner contains a drum cylindrical shape. The drum is covered with solar cells. power systems & rockets are present in this drum).

⇒ Communication subsystem is placed on the top of the drum. An electrical motor drives this communication system. The direction of this motor will be opposite to the rotation of satellite body. So that the antennas point to the earth. And the satellite of this kind of operations are called as de-spin.

During the launch period, the satellite spins when the small radial gas jets are operated. After this de-spin system operates in order to make the TTCM subsystem antennas point towards earth station.



Aut-22(3M)

(2) Three Axis Method:-

→ Stabilize satellite using two or more momentum wheels. And this method is called as three axis method.

→ The advantage of this method is that the satellite don't need to spin the three axis are controlled.

The three axis are:

Roll axis:- The axis ~~in which~~ is considered in which the satellite moves in orbital plane.

Yaw Axis:- In the direction towards earth.

Pitch Axis:- The direction which is perpendicular to orbital plane.

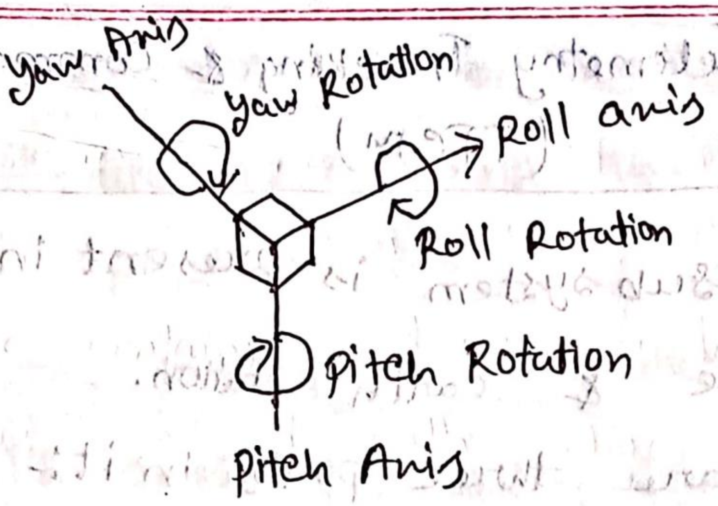


Fig:- Three Axis Method

iii) Orbit Control Subsystem:-

→ It is Important cause it is used to bring satellite into correct orbit when satellite gets deviated from its orbit.

→ TTCM subsystem which is present at earth station monitors the positions of satellite. If there is any change in satellite orbit it sends a signal regarding the correction to Orbit Control Subsystem. It will resolve that issue by bringing the satellite into the correct orbit.

Aut-22 3(a)

Telemetry Tracking & Command Subsystem (TTCM)

TTCM subsystem is present in both Satellite & earth station.

There are three parts in it:-

(i) Telemetry and Monitoring Subsystem.

(ii) Tracking Subsystem

(iii) Commanding Subsystem

SP-22

(i) Telemetry & Monitoring Subsystem:-

Telemetry means measurement at a distance.

~~→ General~~

operations:-

→ Generates an electrical signal, which is proportional to the quantity to be measured.

→ Encoding the electrical signal

→ Transmitting this code for distance

→ Telemetry in Satellite performs 2 operations mainly:-

(i) Receiving Data from sensors

(ii) Transmitting that data to an earth station.

→ Satellite's sensors monitors pressure, temp., status etc. And these datas are sent as FSK or PSK.

→ Telemetry subsystem is remote controlled system. It sends monitoring data from satellite to earth station.

2) Tracking Subsystem:-

→ Useful to know the position & current orbit.

→ Sat. Control center (SCC) monitors the working and status of space segment subsystems with the help of telementry downlink.

→ And controls those subsystems using command uplink.

→ The tracking subsystem is also present in an earth station. It mainly focuses on range & look angles of satellite.

Ex:- Change in the orbital position of sat. Can be identified by using the data obtained from velocity & acceleration sensors that are present on satellite.

→ Tracking Subsystem in earth station keeps ~~to~~ tracking of satellite since its launch.

3) Commanding Subsystem:-

→ To launch the satellite in an orbit and its working in the orbit Commanding subsystem is very necessary.

→ The commanding subsystem is responsible for turning ~~on~~ ON / OFF of other subsystems present in the satellite based on the data getting from telemetry & tracking subsystems.

→ ~~En~~ Control Codes are Converted to Command words.

→ Command words are used to send in the form of TDM frames.

→ The validity of that TDM is checked in ~~Fran~~. sat.

→ After this, command words are sent

back to earth

→ Earth station receives the signal. If earth station receives the same word, then It send an execute instruction to satellite.

→ Satellite execute command.

AKT-22 3(b)

Power System of Satellite

Satellite present in an orbit should be operated continuously during its life span. Mainly solar & rechargeable batteries are used here.

Solar cells:- The solar cells produce electrical power from incident sunlight. Solar cells are used primarily in order to provide power to other ~~sy~~ subsystems of satellite

→ Solar Arrays:-

Two types of solar arrays are used in here.

(i) Cylindrical Solar arrays:-

Used in spinning satellites. Only part of the ~~satellite~~ array will be covered under sunshine. So, it is a drawback of this type.

(ii) Solar Sail:- This one produced more power because all solar cells of solar sail are exposed to sun light.

(2) Rechargeable Batteries:-
During eclipses time, it is difficult to get the power from sun light.
So these batteries are used. These batteries provide powers to other subsystems during launching.

Block Diagram of Transponder

Apr-22
Au-22 (3.5)

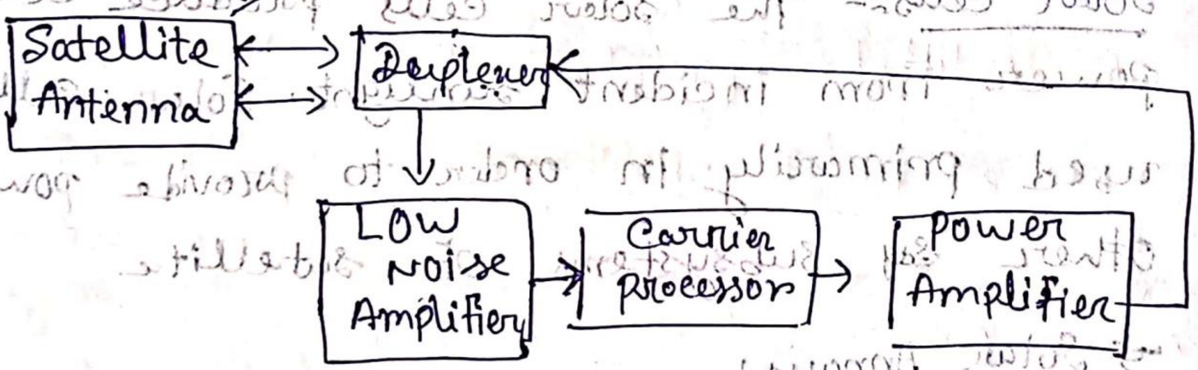
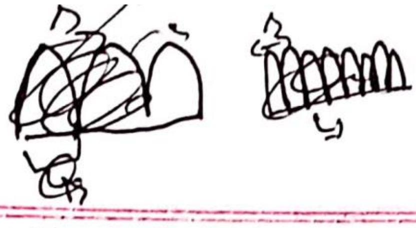


Fig:- Transponder

=) Satellite Antenna:- Earth Station হতে Signal আসে,
আবার Satellite হতে Earth Station এ সেটা পাঠানো হয়



Duplexer:- uplink & Dowlink both signals are received & transmitted respectively by this two way MW gate.

Low Noise Amplifier (LNA):-
It amplifies the weak signal.

Carrier processor:- It converts higher frequency to Down frequency.

Power Amplifier:- It amplifies Lower frequency.

Effects of Non-spherical Earth

⇒ As earth is non-spherical it causes some variations in the path followed by the satellite. As an orbit is not a physical entity rather it is the force resulting from an oblate earth which act on the satellite produce a change in the orbital param.

This is the reason the sat. drifts. as a result of the node & latitude of the point of perigee.

As the orbit itself is moving with respect to the earth the resultings changes are seen.

=) There are another effect called "Satellite Graveyard".

The non - ~~sper~~ spherical leads to the small value of eccentricity (10-5) at the equatorial plane.

And this causes GEO satellite to drift.

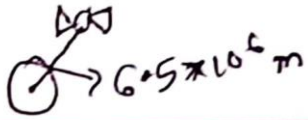
Atmospheric Drag

For low earth orbiting satellites, the effect of atmospheric drag is more pronounces.

The drag (pull towards the earth) has an effect on velocity of satellite (The velocity is reduced).

This leads to change in value of semi-major axis & eccentricity. Sat. in service are maneuverer by the earth station back to their origin.

Math



Aut-22 | Spring-22 | 2(c)

1(c) Calculate the orbital velocity of a satellite which is at a distance of 6.5×10^6 m from the center of the earth has a mass of 5.9722×10^{24} kg. [$G = 6.67408\times10^{-11}\ Nm^2kg^{-2}$]

=) We know,

velocity, $V = \sqrt{\frac{GM}{r}}$ $= \sqrt{\frac{(6.67408\times10^{-11}\times5.9722\times10^{24})}{(6.5\times10^6)}}$ $\simeq 7625.77\ ms^{-1}$	$G = 6.67408\times10^{-11}\ Nm^2kg^{-2}$ $M = 5.9722\times10^{24}$ kg $r = 6.5\times10^6$

(Ans)

Spring-22

Determine the value of eccentricity if the lengths of semi-major = 5 & semi-minor axis = 3.

Ans: We know,

Eccentricity, $e = \frac{\sqrt{a^2-b^2}}{a}$ $= \frac{\sqrt{(5)^2-(3)^2}}{5} = \frac{\sqrt{25-9}}{5}$ $= \frac{\sqrt{16}}{5} = 4/5$	a = Semi-major = 5 b = Semi-Minor = 3

⊛ S = Satellite Longitude in degrees

N = Site Longitude in Degrees

L = Site Lattitude in Degrees

$G = S - N$

Azimuth Angle, $\alpha = 180^\circ + \tan^{-1}\left(\dfrac{\tan G}{\tan L}\right)$

$$= 180^\circ + \tan^{-1}\left(\cancel{\frac{\tan(7)}{\sin\ \tan(35)}}\right)\left(\frac{\tan(5-7)}{\sin(35)}\right)$$

$$= \cancel{181.11 \rightarrow Rad}$$

$= 167.91$ Degree তে করতে হবে

(ইকুয়া, বেলুন)

7) Identify the orbital ~~perturbat~~ perturbations due to gravitational & non-gravitational forces.

⇒ অরবিটাল perturbation Kepler's law & Newtonian Mechanics দ্বারা বর্ণনা এমন এক ভবিষ্যৎবাণী যা আদর্শ কৃত অরবিটাল এর গতি হতে বিচ্যুতি নিয়ে আলোচনা করে।

(1) Gravitational perturbations

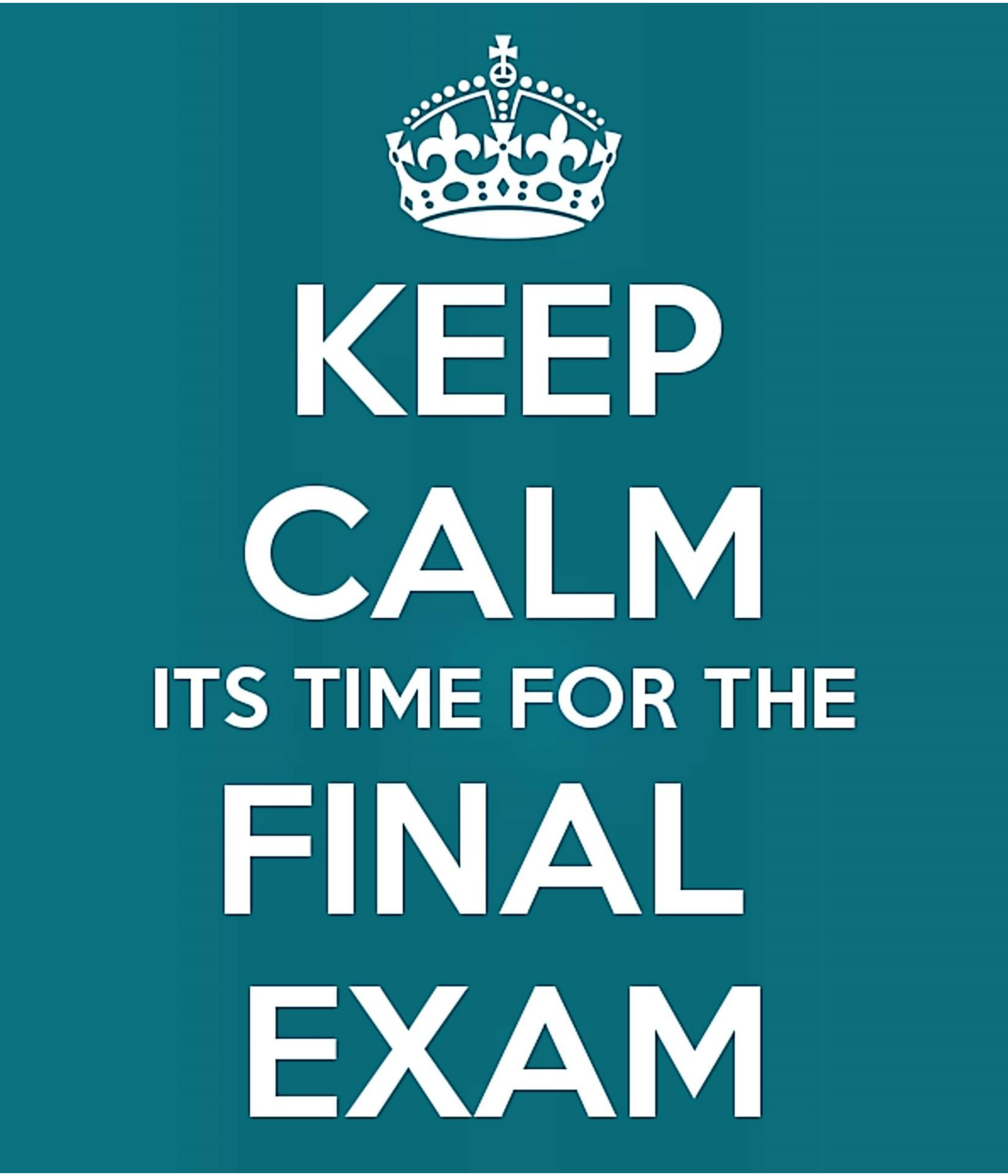
(i) Perturbations from other Celestial Bodies :-

→ গ্রহ (sun), চাঁদ ও অন্যান্য গ্রহাণুর মহাকর্ষীয় প্রভাব মহাকর্ষীয় বস্তুর কক্ষপথ বিচ্যুতি ঘটাতে পারে, আর স্যাটেলাইট এদের কাছে গেলে strong gravitational pull হয়।

(ii) Irregular gravitational force from earth due to non-uniform mass distribution causes perturbations.

(iii) Low orbit satellites affected হয় friction এর কারণে যেটার collision হয় Atoms & ions এর কারণে।

(iv) Solar radiation ~~long~~ pressure large ~~GEO~~ GEO Sat. যেটা বড় Solar Array use করে।


KEEP
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ITS TIME FOR THE
FINAL
EXAM

FINAL

Propagation Effects & their Import on Satellite Earth links:-

Propagation ~~Impairments~~ :-

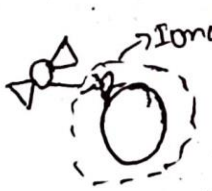
→ propagation is the way radio signals are transmitted from one point to another. (Inside Earth's atmosphere or free space).

→ These are Emf wave. There are some properties like reflection, refraction, diffraction, absorption, polarization & scattering.

→ ~~Th~~

Propagation Impairments & Space Links

→ Signal travelling between earth station & a sattelite must pass through the earth's atmosphere, including ionosphere.



(1) Atmospheric Losses:-

→ Losses occur in the earth's atmosphere as a result of energy absorption by atmospheric gases.

→ There ~~are~~ also lose happens due to weather Conditions, which of course are also atmospheric losses.

→ Rain & other

(2) Ionosphoric Effects:-

→ Radio wave must pass through ionosphere.

→ Ionosphere has been ionized, mainly by solar radiation.

→ During the movement signal may fluctuate (~~cha~~ Frequency, Amplitude etc) might change.

(3) Environmental (Rain & other)

(4) Cloud Attenuation

(5) Ionospheric Scintillation

(6)

Propagation Effects & their impact:-

→ Atmospheric Absorption (gaseous effects)

→ Cloud Attenuation (Aerosolic & Ice particles)

→ ~~To~~ Tropospheric Scintillation (Refractive effect)

→ Faraday Rotation (An Ionospheric effect)

→ Ionospheric Scintillation (A second ionospheric effect)

→ Rain attenuation

→ Rain & Ice crystal Depolarization.

Propagation Impairments:-

(1) Refraction:- Signal এক medium হতে অন্য medium এ যাওয়ার সময় refract হয়। 

(2) Absorption:- Decrease in the amplitude of a radio wave due to an irreversible conversion of energy from the radio wave.

(3) Scattering:- Medium এ কোনো element এর সাথে collide করার পর signal ছড়িয়ে যায়।

(4) Multipath:-

→ Transmit through multiple propagation paths.

→ This can result from refractive index irregularities in the tropo & Ionosphere.

→ Also can happen through terrain & structural scattering on the earth's space.

(5) Scintillation:-

→ Due to small scale irregularities in the transmission path rapid fluctuation in the amplitude & phase happens.

(6) Fading:- Almost similar to scintillation. As changes occur in phase & amplitude but happens in slower method.

(Aut-22)

→ Multipath Diagram:-

⊛ By chosing far distance instead of near one will cause signal loss.

---- ..... পরবর্তী অংশ [ ] পৃ

VSAT Math

Very Small Aperture Terminal

(1) Power Flux Density, $\psi_i = \frac{P_s}{4\pi r^2}$

যদি gain দেওয়া থাকে, $\psi_i = \frac{P_s G_T}{4\pi r^2}$ $G_T \rightarrow$ Transmitter gain, G_R = Receiver "

(2) Antenna gain, $G = \frac{\psi_m}{\psi_i}$ ψ_m = max power flux Density

(*) $P_s G$ একসাথে multiply করলে EIRP (Equivalent Isotropic Radiated power)

(3) $EIRP = G P_s$

In decibles, $[EIRP] = [G] + [P_s]$ dBW (Decible এ লেখালে sum হবে)

(4) Power Delivered to a matched Receiver:

$P_R = \psi_m A_{eff} = \frac{EIRP}{4\pi r^2} \lambda^2 G_R$ [G_R = Receiver Antenna Gain]

$\therefore P_R = (EIRP)(G_R)\left(\frac{\lambda}{4\pi r}\right)^2$ | pathloss, $P_L = \left(\frac{4\pi r}{\lambda}\right)^2$

In decibles,

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

main Formula $\Rightarrow [P_R] = [EIRP]_{dBW} + [G_R]_{dB} - [FSL]_{dB}$

5) Free space loss [FSL]

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

also or, $[FSL] = 20\log\left(\frac{4\pi r}{\lambda}\right)$ এটা log এর formula হতে এসেছে।

(6) Noise Temperature:- কোনো system এর Noise Calculation এর জন্য Noise temperature use হয়।

Noise Temperature, $\boxed{T = T_0 (NF - 1)}$

T_0 = Reference Temp (240K)
= 240K

(7) Noise Figure, $NF = \boxed{(S/N)_{in} / (S/N)_{out}}$ (in dB)

(8) Noise power, $P_n = K T_n B$

T_n = System Temp
B = Noise BW in Hz
K = Boltzman's Constant
$= 1.38 \times 10^{-23}$ J/K
$= -228.6$ dB W/K/Hz

(9) Link Budget:-

Receiving side এর power calculation এর জন্য বিভিন্ন resource দরকার হয়।

$$\text{Power Received at Receiver, } P_{Rx} = (\overbrace{P_{Tx} + G_{Tx}}^{EIRP} - L_{Tx} - \underset{L_P}{L_{FS}} - L_m - L_{Ams} + G_{Rx} - L_{Rx})$$

G_{Tx} = Gain in Transmitter
L_{Tx} = Loss " "
L_{FS} = Free space Loss in power
P_{Tx} = power in Transmitter
L_m = Misselinous Loses
G_{Rx} = Gain in Receiver
L_{Rx} = Loss in Receiver
L_{Ams} → Antenna mismatch Loss

problem-1:- Find pathLoss for an uplink operating at 6GHz with a distance 42,000 km. If earth station EIRP is 120dBW & Antenna gain is 20dB, then what will be Received power in dBM.

=> Here,

$F = 6\,GHz = 6\times10^9\,Hz$

Distance, $R = 42{,}000\,km = 42\times10^7\,m$.

$EIRP = 120\,dBW$

$G_R = 20\,dB$

(a) pathloss = ?

(b) Received power, P_R = ?

(a) pathLoss, $P_L = \left(\frac{4\pi R}{\lambda}\right)^2$

we know, $\lambda = c/F = \frac{3\times10^8}{}$

$$(P_L)_{dB} = 10\log\left(\frac{4\pi R}{\lambda}\right)^2$$

$$= 20\log\left(\frac{4\pi}{\lambda}\right) + 20\log(R)$$

$$= 20\log\left(\frac{4\pi}{c/F}\right) + 20\log(R)$$

$$= 20\log\left(\frac{4\pi}{\frac{3\times10^8}{6\times10^9}}\right) + 20\log(42\times10^7)$$

$$= 220.47\,dB$$

(b) Received power, P_R

$$(P_R)_{dBW} = (EIRP)_{dBW} + (G_R)_{dB} - (P_L)_{dB}$$

$$= 120 + 20 - 220.4 \ dBW$$

$$= -60.4 \ dBW$$

Ex-02: Find the received power for given Satellite

→ Satellite Distance = 40000km

Gain of Antenna at T_x = 17 dB

Gain of Antenna at R_x = 52.3 dB

Radiated power P_T = 10W

Operating frequency = 11 GHz

Atmospheric loss = 4 dB

Losses associated with T_x = 8 dB

Losses " " R_x = 3 dB

⇒ Solution:-

Here,

Satellite Distance, R = 40000 Km = 4×10^7 m

Gain of Antenna at T_x = 17 dB

Gain of Antenna at R_x = 52.3 dB

Radiate power, $RP_{Tx} = 10\ W = 10\ dBW$

Frequency, $f = 11\ GHz = 11 \times 10^9$

Atmospheric loss, $L_A = 4\ dB$

Transmitter loss, $T_x = 8\ dB$

Receiver Loss, $R_x = 3\ dB$

Also,

path Loss, $L_P = 10 \log \left(\frac{4\pi R}{\lambda}\right)^2$

$= 20 \log \frac{4\pi R}{\lambda}$

$= 20 \log \frac{4 \times \pi \times 4 \times 10^7}{c/f}$

$= 20 \log \frac{4 \times \pi \times 4 \times 10^7}{\frac{3 \times 10^8}{11 \times 10^9}} = 205.3\ dB$

We know,

$$(P_{Rx})_{dBW} = (P_{Tx} + G_{Tx} - L_{Tx} - L_p - L_a - L_{Rx} + G_{Rx})\ dBW$$

$$= (10 + 17 - 8 - 205.3 - 4 - 3 + 52.3)\ dBW$$

$$= -141\ dBW$$

problem -03 :-

A certain 6 Hz Satellite uplink has the following data on various gain, losses:-

(1) Earth Station, EIRP = 80dBW

(2) Earth Station Satellite Distance = 35,780 km

[Attenuation -3 loss এর মান (-) হবে] (3) Attenuation due to Atmospheric factors = 2 dB

(4) Satellite Antenna Aperture efficiency (η) = 0.8

(5) " " " area (A_e) = 0.5 m^2

Determine the ~~power~~ received power at the satellite.

$\Rightarrow$ So, Satellite gain, $G = \frac{\eta . 4\pi A_e}{\lambda^2}$

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{6\times10^9}$$

$$\therefore G = \frac{0.8\times4\pi\times0.5}{\left(\frac{3\times10^8}{6\times10^9}\right)^2} = \frac{0.8\times4\pi\times0.5}{0.0025}$$

$$= 2010.62 \text{ dB}$$

$$\therefore 10\log(2010.62) = 33.0332 \text{ dB}$$

Free Space path Loss $= 10 \log \left(\frac{4\pi R}{\lambda} \right)^2$

$= \cancel{10 \log \left(4\pi \right.}$

$= 20 \log \left(\frac{4\pi R}{\lambda} \right)$

$= \cancel{20 \log \left(\frac{4\pi \times 35780 \times 10^3}{0.05} \right) dB}$ dB

meter এ [illegible]

$= 20 \log \left(\frac{4\pi \times 35780 \times 10^3}{0.05} \right)$ dB

$= 199.08$ dB

$\therefore$ Received power at the satellite $= \left(80 + 2 + \cancel{20 \cdot 10.62}^{\,33.03} - 199.08 \right)$

$= -88.05$ dBW

problem - 04:-

Compute the Free Space path loss in details for the Following Conditions:-

(a) For a path length of 10 km at 4 GHz operating Frequency.

(b) Earth Station transmitting Antenna EIRP = 50 dBW Satellite receiving Antenna Gain, 20 dB & received power at Satellite = -120 dBW

Solution:-

(a) For - a:-

Given, $R = 10\ km = ~~10000~~\ 10000\ m$.

$F = 4 \times 10^9\ Hz$

$\lambda = C/F = \frac{3 \times 10^8}{4 \times 10^9} = 0.075\ m$.

(a) path Loss = ~~Lo~~ $20 \log\left(\frac{4\pi R}{\lambda}\right)$

$= 20 \log\left(\frac{4\pi \times 10000}{0.075}\right)$

$= 124.483\ dB$

(b) We know,

$P_{Rx} = (EIRP + G_{Rx} - L_p)$

$\therefore L_p = EIR_p - P_{Rx} + G_{Rx}$

$= (50 + 120 + 20)$ dB

$= 140$ dB

(Ans)

Example-05:-

At the Transmitter, the input S/N is 40 dB. The output S/N is determined as 33.3 dB. What is the noise figure of the system?

=) Given, $(S/N)_{in} = 40dB$, $(S/N)_{out} = 33.3$ dB, NF = ?

We know, $(N/F) = 10\log_{10}\left(\frac{SNR_i}{SNR_o}\right) = 10\log_{10}(40/33.3) = 0.7962$ dB

~~$(S/N)_{in} - (S/N)_{out} = 40 - 33.3 = 6.7$ dB~~

(Ans)

Ex-06:- For a system the Noise temperature is given.

(a) 283 kelvin with a noise BW of 15.5 Hz. Calculate the noise power of the system. $[k = 1.35 \times 10^{-3}$ J/K$]$

=) Given,

$T_p = 283$ K, Boltzmen Constant, $K = 1.35 \times 10^{-3}$

$B = 15.5$ Hz

We know, $P_n = KT_p \times B$

$= 1.35 \times 10^{-3} \times 283 \times 15.5$

$= 6.05 \times 10^{20}$ W.

(Ans)

9-11-23

Troposphoric Scatter:-

→ Method of transmitting & receiving ~~wave~~ microwave radio signals over considerable distances, often up to 300 km.

→ It uses the troposphoric scatter phenomenon, where radio waves at particular frequencies are randomly scattered as they pass through the upper layers of the troposphere.

→ The scattering mode of propagation enables VHF & UHF signals to be transmitted far beyond the normal line-of-sight.

Multipath:-

→ Transmitted radio wave reaching the receiving antenna by two or more propagation paths.

→ Can result refractive index irregularities in the ~~troposhper~~ troposphere or ionosphere. Or from structural & terrain scattering on the earth's surface.

→ There are many things like ionospheric reflection & refraction, And reflection from water bodies & terrestrial objects such as mountains & buildings.

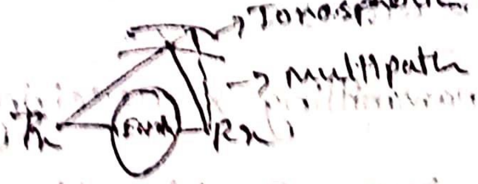


Fig:- Multipath.

Scintillation:-

→ Signal এর Amplitude ও phase খুব দ্রুত পরিবর্তন হয়।

→ Ionosphere এর structure এ produced হয়।

→ Depends on frequency of the used signal & the spatial structure of plasma density & plasma drifts along the propagation path.

Atmospheric Losses:-

→ Different types of atmospheric losses can disturb radio wave transmission in satellite system.

→ Atmospheric absorption.

→ Atmospheric Attenuation

→ Travelling ionospheric disturbances.

Attenuation:-

Attenuation in networking means signal loss, like wifi getting weaker farther from the router. But an amplifier fix this.

Longer distances need stronger cables & more amplifiers, but too many will slow down the signal. In the atmosphere, attenuation happens due to absorption or scattering. Amplification boosts signal strength but can add noise, so software helps to manage this.

Repeaters & boosters are common ways to amplify signals, with antennas often used for wireless boosters.

→ Absorption molecular energy বাড়ায়। সেই সাথে temperature ও বাড়ায় মাত্র হলে signal energy ও বাড়ে।

→ Attenuation snow ও Ice এর ক্ষেত্রে বাদ দেওয়া যায় কারণ wave এ effect পড়ে না।

→ $L_R = \alpha R^b \cdot L = \gamma L$

L_R = The rain attenuation in dB

R = The rain rate in mm per hour

L = An equivalent path length (km)

α, b = empirical coefficient

Causes:-

→ Atmosphere

→ Angle of Elevation

Elevation:-

Angle between center of satellite beam & surface of the earth.

Minimal Elevation:-

→ Elevation needed to at least communicate with the satellite.

→ The elevation angle between the satellite beam & the surface of earth has an impact on the illuminated area.

Atmospheric Attenuation:-

⇒ Earth Atmosphere.

→ There are gaseous absorption

→ Cloud attenuation at the W/V bands can contribute to significant loss (>10dB).

→ Rain attenuation has the most acute

→ Troposphere scintillation is the rapid fluctuations & it can seriously affect the satellite - Earth links at frequencies above 10 GHz and at very low elevation angles (< 25 degrees)

[4] Travelling Ionospheric Disturbances:-

-> Clouds of electrons in the ionosphere that provoke radio signal.

Spring-22

[5] Polarization:-

-> Property of Electromagnetic waves that describes the direction of the transverse electric field.

Necessary to adopt a convention to determine the polarization of the signal. I

Types of Polarization:-

① -> Linear polarization (Horizontal or vertical):-

-> ~~522r~~ Orthogonal Components electric field ~~or~~ are in phase.

-> Direction of the line in the plane depends on the relative amplitudes of the two components.

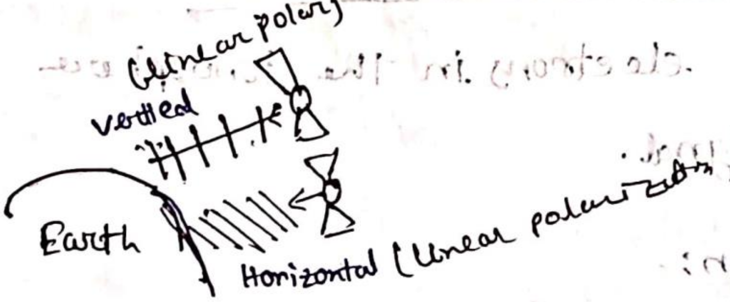
② Circular polarization:-

-> Two components are exactly in 90°

③ Elliptical Polarization:-

-> All other cases

Horizontal & vertical Polarization:-



Tropospheric Scintillation:-

→ More pronounced for higher frequencies

→ ~~Cause~~ Does not Cause depolarization.

→ Due to weather Conditions (Heat & Cool).

→ Refractive index change হলে Signal propagation direction ও change হয়।

Ionospheric scintillation:-

→ Energy from the sun creates problem.

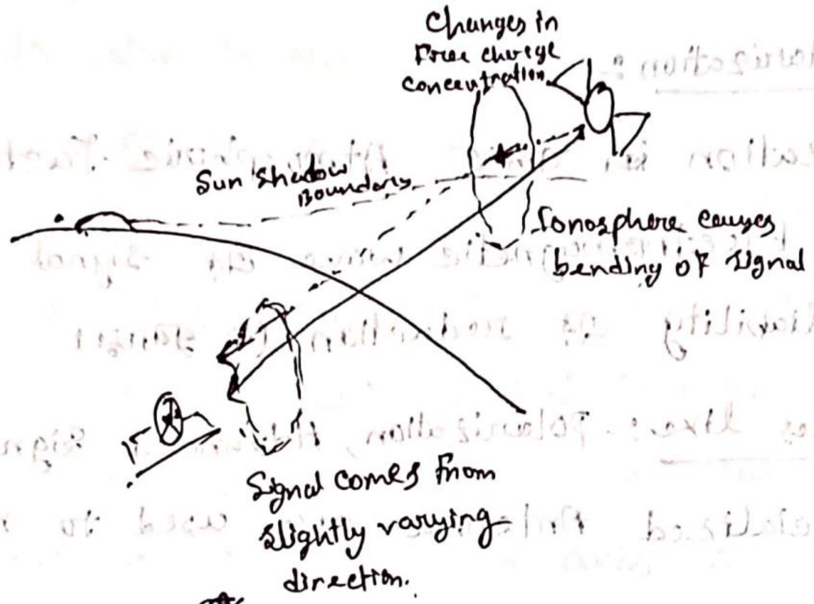
→ Typical range 10^{18} during day, 10^{6} during night.

→ Local sunset এ rapid change হয় Concentration এ।

→ Antenna pattern এর কারণে modulated হয়।

→ Net result are variation OF RSL & down.

→ Varies with sun activity



Faraday Rotation - polarization Loss

→ Radio wave Earth magnetic field দিয়ে যায় এবং Magnetic Field wave এর polarization change করে।

এটার Negative Effects:-

→ Losses থাকে polarization mismatch এর কারণে between Rx & Radio wave.

→ Channel Interference বাড়ায়।

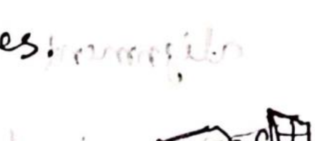
Rotation Angle Depends on:-

→ Length of the path through Ionosphere.

→ Concentration of Ionosphere charges.

→ Operating Frequency

⇒ The effect gets smaller with frequency increases.



[Illustration of Faraday's rotation]

[1] Depolarization :-

Depolarization হলো একটি Atmospheric factors এর কারণে Electromagnetic wave এর signal degradation এবং reliability এর reduction কে বুঝায়।

Techniques like :- polarization, Advanced signal processing & specialized Antenna are used to mitigate it.

Two effects :-

→ Loss in the signal strength because of misalignment of the Antenna.

$$L = 20 \log(\cos T)$$

T = tilt angle relative to the polarization direction induced by rain.

⇒ Due to unique orientation of signals relative to the Earth's local horizontal & vertical directions, specific adjustments in the optics of the earth station antenna are necessary to achieve the required polarization alignment with satellite.

Approximately, 25° relative to the local horizon.

Depolarization losses:-

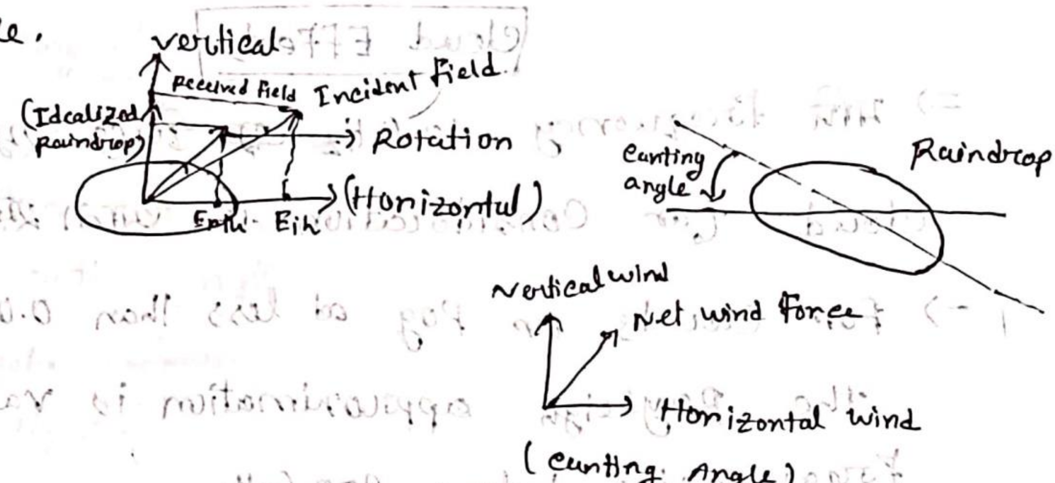
-> Rain affect করে।

-> Rain Horizontal এ বেশি সমস্যা করে vertical এর তুলনায়

-> যদি linearly polarized হয় (wave), তাহলে wave tilts (বাঁকা) towards vertical position.

-> যদি Non-wind condition হয়, এবং rain drop হয় eliptical shape এ তাহলে minor axis in vertical direction হবে।

-> Wind Condition -এ raindrop ellipse changes canting angle.



Rain & Ice Effects

-> Rain 3 way তে affect করে।

(1) Attenuate signal

(2) System noise increase করে।

(3) Polarization change করে।

-> আর এই তিনটি জিনিস Receiving quality কে degrade করে। Absorb করে, Scatter করে।

-> বেশি বৃষ্টি, বেশি attenuate

-> Heavily effects the wireless Communication above 10 GHz.

-> Ku band & Ka band gets affect mostly. Specially above 20 GHz Ka band link fails.

-> 5% or 20% fade may happen by rain, snow/ice.

Cloud Effects

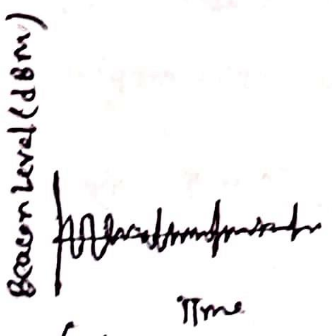
=> যদি frequency 10 GHz এর উপরে হয় তাহলে Cloud কে consideration এ আনা হয়।

-> For clouds or fog of less than 0.01 c.m, the Rayleigh approximation is valid for frequencies below 200 GHz.

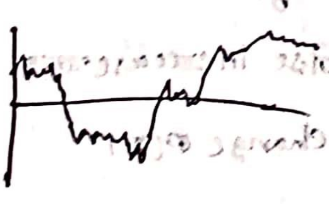
$$A = L K_l \sin\theta \quad (90^\circ \leq \theta \leq 5^\circ)$$

L = Total columnar content of liquid water

K_l = Specific attenuation by water droplet (kg/m²)



(Clear Sky Signal)



(Cloud Attenuation)

Attenuation due to Hydrometeors :-

→ Rain, snow, Ice গুলোর মধ্য দিয়ে যাওয়ার সময় wave Hydrometeors এর কারনে power loss হয়।

দুইটি factor এর জন্য এমনটি হয়।

(1) Energy absorption by the Joule effect by Hydrometeors

(2) Wave diffusion induced by the particles.

Spring-22

Prediction of Rain Attenuation

Factors being affected by Rain :-

→ Frequency of operation.

→ Elevation angle of satellite

→ Slant path length.

→ Rain rate

→ Rain height.

Classification Rainfall :- (i) Straightiform Rain (Medium & Low Intensity)

(ii) Convective Rain (High intensity, Small area)

⇒ নির্দিষ্ট Area তেই Rainfall হওয়ার প্রয়োজন পড়ে না wave attenuation এর জন্য যেহেতু wave টি many miles দূর হতে আসে।

"[redacted]"

=) Rain Fade approximation কে Calculate করতে বিভিন্ন methode use করা হয়। Scattering theory, Raindrop Size Distribution (DSD), Mathematical Forms like Gamma Function, lognormal / exponential Forms are used to model the DSD.

Rain Attenuation prediction Model [redacted]

physical Method:-

→ Need more effort
→ Hard to implementation
→ More cost
→ More reliable.

primary atmospheric effects being characterized at the NASA facilities of interest include the following:-

→ Rain Fade
→ Gaseous Abroption
→ Brightness temperature
→ Phase decorrelation
→ Scintillation
→ Depolarization
→ Site Diversity

"SATELLITE LINK DESIGN"

<u>Uplink</u>:- Transmit earth station to satellite.

<u>Downlink</u>:- Transmit satellite to earth station.

Satellite Link parameters:-

(1) <u>Choice of operating frequency</u>:-

(2) ~~Propagation Considerations~~:-

=> The choice of frequency band from those allocated by ITU for Fixed Satellite Service, The Broadcast Satellite Service (BSS), The Mobile Satellite Service (MSS) is mostly governed by many factors.

=> Lower frequency ব্যবহারে Economic দিক দিয়ে perfect হলে, তাছাড়াও interference-related problem ও কম থাকে।

=> Low frequency তে Low Bandwidth লাগে যা transmission capacity কেও Low করে।

=> Higher frequency তে Higher Bandwidth লাগে কিন্তু কিছু disadvantage ও আছে যা rain এর কারণে হয়।

→ 10 GHz এর উপরে rain can have the effect of reducing isolation.

→ Frequencies less than 10 GHz & elevation angles greater than 5°, atmospheric attenuation is more or less insignificant.

(2) Propagation Consideration:-

⇒ Atmospheric portion এর ভিতর দিয়ে যাওয়া electro-magnetic wave এর জন্য Link design অনেক গুরুত্ব বহন করে।

→ Received ও Transmitted হতে বুঝা যায় যে atmosphere এর effect wave এর উপর কতটুকু হয়।

→ Troposphere few tens ~~ke~~ Kilometers & then the ionosphere extending from about 80 km to 1000 km that do the damage.

→ Signal attenuation happens for scattering, scintillation, Depolarization, rain, absorption etc.

→ Rain effects on frequencies above 10 GHz, Faraday rotation happens in 10 GHz

→ Atmospheric attenuation 3 to 10 GHz window.

(3) Noise Consideration:

-> The quality of signal received at the Earth Station is strongly depend on the carrier-to-noise ratio of the satellite link.

-> Uplink signal depends upon how strong the signal is.

-> In downlink how strongly the satellite can retransmit the signal & then how the destination earth station receives it.

-> Distance যত বেশি uplink & downlink তেমনই weak হবে।

-> Geostationary Satellite Communication systems are vulnerable to noise due to their naturally low received power levels.

-> Received signal is sufficiently weak as compared to the noise level. And it might be impossible to detect the signal.

-> To reduce the noise steps should be taken.

(4) Interference related problem:-

-> Interference বিভিন্ন ভাবে হতে পারে। Two sattellite sharing the same frequency band, Two earth station accessing different satellite in the same frequency band, Interference for Polarization in frequency re-use systems, Channel interference in FDMA.

⇒ Interference between Sat. & terrestrial links.
২টি ধরনের হতে পারে:-

(i) ~~Terrese~~ Terrestrial link transmission interferes with reception at an Earth station

(2) Earth station interferes with ~~feres~~ terrestrial links.

⇒ Inter-sattelite & inter-Earth station interferes is mainly governed by two factors:-

(i) Pointing accuracy of antennas.

(ii) The width of transmit & received beams

(iii) Intersattellite spacing

⇒ Cross polarization interfere হয়

⇒ Coupling of energy occurs due to a finite value of cross polarization discrimination of the earth station & satellite antennas.

→ Intermodulation interference হয় Satellite transponder এ যা ~~Inde~~ Intermodulation product এর কারণে হয়।

[D] Basic Terminology:-

~~Iso~~ Isotropic Radiator:- An Antenna which radiates equally in all directions. But it does not exist practically, It is just a theoretical antenna.

Power Flux Density: - (φ_i)

Isotropic radiator যে কোনো গোলকের (sphere) এর মাঝে বসালে এর power flux density হবে ratio of power flow & unit area.

power flux density, $\varphi_i = \dfrac{P_s}{4\pi r^2}$ | P_s = power flow

Antenna Gain: - (G)

The gain of practical antenna defined as the ratio of max. power flux density of a practical antenna ~~varies with direction~~ & power flux density of isotropic antenna.

Antenna gain, $G = \dfrac{\varphi_m}{\varphi_i}$ | φ_m = power flux density practical antenna
φ_i = power flux density of isotropic radiator.

EIRP (Equivalent Isotropic Radiated Power): -

=) EIRP is a measurement of radiated output power from an ideal isotropic antenna in a single direction.

=) ERP (Effective Radiated power) used to measure RF frequency sources.

→ EIRP & ERP different

EIRP is the main parameter of link budget.

$EIRP = G \cdot P_s$

We can represent EIRP in Decibles,

$[EIRP] = [G] + [P_s]$ dBW

G = Gain of transmitting antenna

P_s = Power of transmitter

Free-space-Transmission:-

⇒ এখানে Isotropic, Tropospheric (rain, snow, atomic, moles) এগুলো আসবেনা। এখানে -tree, hills, buildings, mountains এগুলো ~~আসবে~~ এই FST এর মাধ্যমে নয়।

⇒ We know power flux density of main antenna,

$$\Psi_m = \frac{EIRP}{4\pi r^2} \quad \text{— (1)}$$

We know,

Received antenna is the multiplication of main power flux density & the effective aperture,

$$P_R = \Psi_m \cdot A_{eff}$$

$$= \frac{EIRP}{4\pi r^2} \cdot \frac{\lambda^2 \cdot G}{4\pi}$$

$$= (EIRP)(G)\left(\frac{\lambda}{4\pi r}\right)^2 \quad \text{— (5)}$$

Here,

$$\Psi_M = \frac{GP_s}{4\pi r^2} \quad \text{— (2)}$$

$$EIRP = GP_s \quad \text{— (3)}$$

$$\frac{A_{eff}}{G} = \frac{\lambda^2}{4\pi} \quad \text{— (4)}$$

In eqn (5) there are three terms with the transmitter, receiver & free space, so in dB we get,

$$[P_R] = [EIRP] + [G] - 10\log\left(\frac{4\pi r}{\lambda}\right)^2 \quad \text{--- (6)}$$

We also know, Free Space Loss.

$$[FSL] = 10\log\left(\frac{4\pi r}{\lambda}\right)^2 \quad \text{--- (7)}$$

So, the eqn,

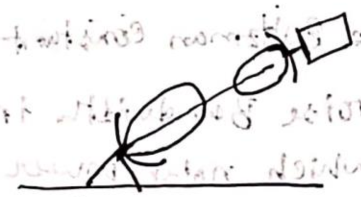
$$[P_R] = [EIRP] + [G] - [FSL] \quad \text{--- (8)}$$

$[P_R]$ = dBW
$[EIRP]$ in dBW
$[FSL]$ in dB

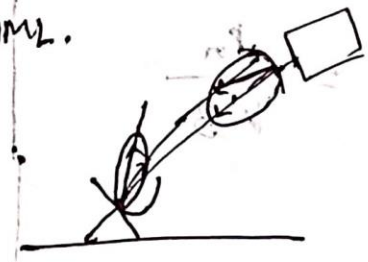
(ii) Antenna Misalignment Losses:-

→ Satellite Link establish পরবর্তী সময় হতে Antenna aligned ঠিক করে maximum gain এর জন্য।

→ pointing losses may result at the antenna from misalignment of polarization direction. The losses of it is small. It denoted by AML.



(a)
(Max gain alignment)



(b) Misalignment

$\cancel{\Phi_M = \frac{G_r P_s}{4\pi r^2}}$

Fixed Atmospheric & Ionospheric Losses:-

Fixed Atmospheric & Ionospheric Losses are components of signal attenuation in satellite communication systems that are relatively constant, regardless of environmental conditions or other influencing factors.

→ Atmospheric gases result in loses by absorption. And

→ losses is described in decibel (dB)

→ The Ionosperic losses happens for ~~depolai~~ depolarization. & in subsequent calculations, the decibel value for this will be denoted by [PL]

Noise Temperature:-

→ A way of determining how much thermal noise is generated by active & passive devices in the receiving system.

$$T_n = \frac{P_n}{KB}$$

P_n = Noise power

K = Boltzman constant

B = Noise Bandwidth in which noise power is measured

T_n = Noise Temp. source in K

Converting noise figure to noise temperature

$$T = T_0 (NF - 1)$$

NF = Linear ratio, no in dB

T_0 = The reference temperature (290 K)

Link Budget:-

A link budget is the term used that accounts for the power received at the receiver. And this accounts for all of the gain & losses from the transmitter to the point at which it is received by the receiver.

- → Keeps log by keeping all entries of losses & gains in signal propagation.
- → Wave attenuates via amplifiers & antennas to increase the gain product & eliminate noise
- → Data can be lost during propagation.
- → Usually made for radio & sattellite service.

Received power (dBm) = Transmitted power (dBm) + gains (dB) − Losses (dB)

$$P_{Rx} = P_{Tx} + G_{Tx} - L_{Tx} - L_{FS} - L_M + G_{RN} - L_{Rx}$$

VSAT (Very Small Aperture Terminal)

Autumn'22 4(a)

=> VSAT is a two way, low cost, ground micro station for transmitting data to & from communication satellite.

-> Has a dish antenna with diameters between 75 c.m to 1m. Access in ~~geosatellite~~ geostationary orbit.

-> It is a technology that is used to manage data while undertaking high-frequency trading activities. It is data transmission technology.

-> ~~Frequency bands~~. C, Ku & Ka.

VSAT Frequency bands:-

The Three main parts of satellite:-

(i) Transponder (ii) Antenna Systems (iii) Solar cells.

Different Frequency bands:-

C bands :- Uplink:- 5.925 GHz to 6.925 GHz

Downlink:- 3.700 to 4.200 GHz

Extend C band:- Uplink:- 6.725 GHz to 7.025 GHz

Downlink:- 4.5 GHz to 4.8 GHz

Ku Band:- Uplink:- 14. GHz to 14.5 GHz

Downlink:- 10.95 to 11.7 GHz

AUT-22 4(b)

4) VSAT System overview:-

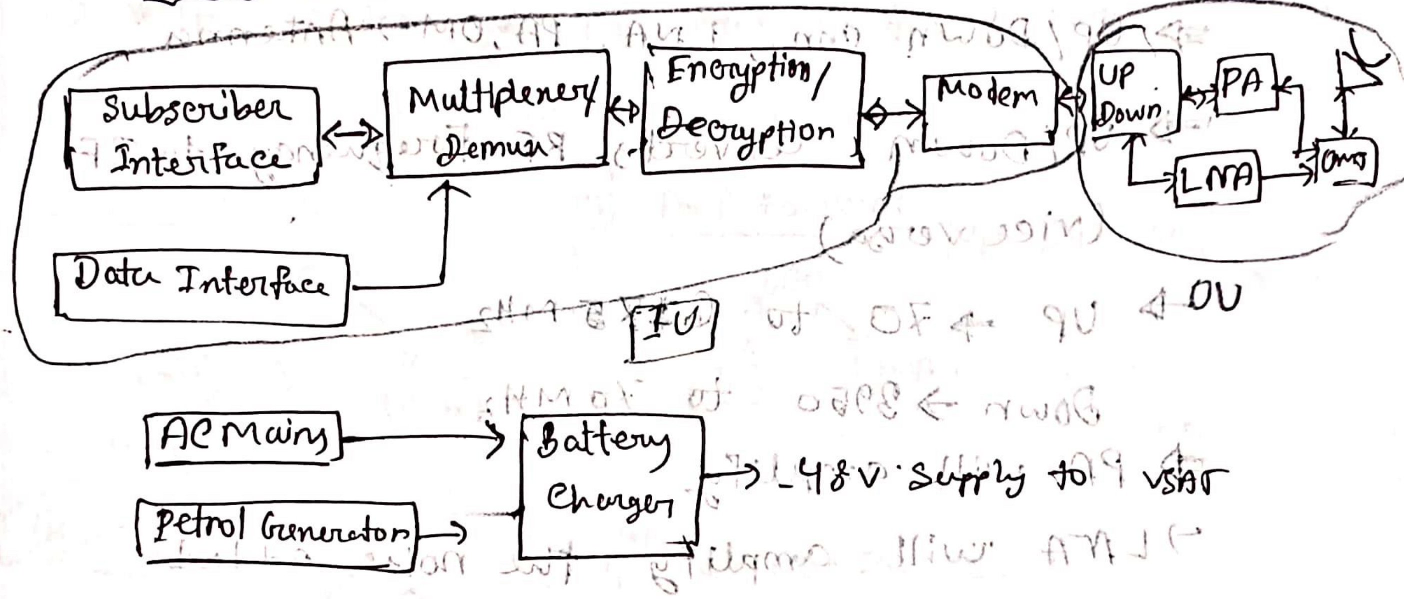


Fig:- VSAT System

Indoor unit:-

→ It is consist of Subscriber, Data Interface, MUX/Demux, Encryption/Decryption, modem.

→ Two signal from SI & DI will enter into the MUX

→ Then it enters into the Encryption unit for security.

→ MODEM is basically performs modulator-demodulator functionality

→ QPSK scheme is used in SAT com. Forward error connection is also employed in modem

→ Communication between VSAT-1 & VSAT-2, modulator frequency of VSAT-1 & demodulator frequency of VSAT-2 need to be same.

→ For RF transceivers need to be setted appropriately.

VSAT Outdoor Unit:-

⇒ UP/DOWN Con., LNA, PA, OM → Antenna

⇒ UP/Down Converts RF Frequency to IF (vice versa)

→ UP → 70 to 6175 MHz

Down → 3950 to 70 MHz

⇒ PA will amplify

→ LNA will amplify the noise added received signal received from the satellite

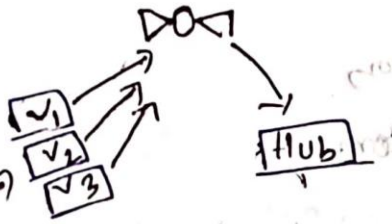
→ VSAT Antenna sizes:- 1.8, 2.4 / 3.8 meters.

⇒ Feed horn in mounted at the focal point of the antenna. made of array of microwave passive components.

VSA Network Architecture

-> 'Hub station', VSATs' are interfaced with satellite to provide service.

(i) Broadcast:-



(ii) Point-to-point:- (V_1 -> SAT -> V_2)

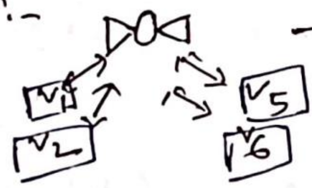
Aut-22 5(b)

(iii) Star:-

-> V_1 - Sat - Hub - Sat - V_2

Aut-22 (5b)

(iv) Mesh:-



-> V_1 - SAT - V_2 - SAT - V_5 ..

(v) Hybrid:- Star + Mesh Combination

Details

Aut-22

Star Topology:

-> 3 component (VSAT, SAT, HUB)

-> VSAT 1 - Satellite - Hub - Satellite - VSAT 2

-> Two hop communicate between any two VSATs

-> Star shape network comprise N VSATs & a hub.

-> Large org (bank centralized data processing)

AUT-22

Mesh Topology:-

→ Communicate directly without hub
→ Complex owing
→ Antenna specification need to be different
→ No Hub
→ VSAT to VSAT communication
→ Suitable for telephony com.

AUT-22 wy

Access Control protocol

→ Application
→ Presentation
→ Session
→ Transport
→ Network
→ Link
→ Physical

22 (2a)

Find pathloss for an uplink operating at 6 GHz. with a distance 42,000 Km. If earth station EIRP is 120 dBW & Antenna gain is 20 dB, then what will be received power in dBM.?

Here,

Frequency, $F = 6\,GHz$

Distance, $R = 42{,}000\ km = 4.2 \times 10^7\ m$.

$EIRP = 120\ dBW$

Antenna gain, $G_r = 20\ dB$

Receive power, $P_R = ?$

pathloss, $P_L = ?$

we know,

$$\text{pathloss } (P_L)_{dB} = 20 \log \left(\frac{4 \pi R}{\lambda} \right)^2$$

$$= 20 \log \left(\frac{4 \cdot \pi \cdot 4.2 \times 10^7}{\lambda} \right)$$

$$= 20 \log \left(\frac{4 \pi \times 4.2 \times 10^7}{\frac{3 \times 10^8}{6 \times 10^9}} \right)$$

$$= 200.46\ dB$$

Here,

$c = 3 \times 10^8\ ms^{-1}$

$F = 6\,GHz$
$= 6 \times 10^9\ Hz$

$\lambda = c/F$
$= \frac{3 \times 10^8}{6 \times 10^9}$

(b) $(P_R)_{dBW} = (EIRP)_{dBW} + (G_r)_{dB} - (P_L)_{dB}$

$= 120 + 20 - 200.46$ dBW

Aut-22 2(b)

$= -60.46$ dBW

(c) Find the received power for given satellite,

→ Satellite Distance, $R = 40,000$ km $= 4 \times 10^7$ m.

Gain of Antenna at $T_x = 17$ dB

Gain of Antenna at $R_x = 52.3$ dB

Radiated power, $P_{Tx} = 10W$

Operating Frequency, $F = 11$ GHz $= 11 \times 10^9$ Hz

Atmospheric loss $= 4$dB

Losses Ass. with $T_x = 8$dB

" " " $R_x = 3$dB

⇒ First of all,

path loss $L_p = 20 \log \left(\frac{4\pi R}{\lambda} \right)$

$\lambda = c/f = \frac{3 \times 10^8}{11 \times 10^9} = 2.73 \times 10^{-2}$

So, $L_p = 20 \log \left(\frac{4 \times \pi \times 4 \times 10^7}{2.73 \times 10^{-2}} \right)$

$= 205.302$ dB

So, power receive, $(P_R)_{dBW} = G_{T_x} + G_{R_x} + P_{T_x} - L_A - L_{T_x} - L_{R_x} - L_P$

$$= (17 + 52.3 + 10 - 4 - 8 - 3 - 205.302)\ dBW$$

$$= -141\ dBW$$

(Ans)

A certain 6/4 GHz satellite uplink has the following:-

(i) Earth station, EIRP = 80 dBW

(2) Earth station satellite Distance, R = 35,780 km

(3) Attenuation due to atmospheric factors = 2 dB

(4) Satellite Antenna aperture efficiency $(\eta) = 0.8$

(5) Satellite " " area, $A_e = 0.5\ m^2$

Determine the required power at the satellite.

⇨ Satellite gain $= \dfrac{\eta \cdot 4\pi \cdot A_e}{\lambda^2}$

$$= \frac{0.8 \times 4\pi \times 0.5}{\left(\frac{c}{f}\right)^2}$$

$$= \frac{0.8 \times 4\pi \times 0.5}{\left(\frac{3 \times 10^8}{6 \times 10^9}\right)^2} = 2010.62\ dB$$

$\therefore 10\log(2010.62) = 33.03\ dB$

Also,
Free space path loss $= 20\log\left(\frac{4\pi R}{\lambda}\right)$

$$= 20\log\left(\frac{4\pi \times 3.58\times10^{7}}{\left(\frac{3\times10^{8}}{6\times10^{9}}\right)}\right)$$

$= 199.08$ dB

$\therefore$ Received power $= (80 - 2 + \overset{33.03}{\cancel{2010.62}} - 199.08)$ dBW

$= \cancel{1889.54} \quad -88.05$ dBW

Q) Compute the free space path loss in details for the following conditions:-

(a) For a path length of 10 km at 4GHz operating frequency.

(b) Earth station transitioning antenna, EIRP= 50 dB

(c) Satellite receiving antenna gain, = 20 dB
received power at satellite = -120 dBW

$F = 4\times10^{9}$ Hz

path length, $R = 10\times1000$ m

EIRP = 50 dB

Antenna gain, $G = 20$

Received power, $P_R = -120$ dBW

$$L_p = 20 \log \left(\frac{4\pi R}{\lambda} \right)$$

$$= 20 \log \left(\frac{4\pi R}{c/f} \right)$$

$$= 20 \log \left(\frac{4\pi \times 10000}{\left(\frac{3\times10^8}{4\times10^9}\right)} \right)$$

$$= 124.483 \text{ dB}$$

We know,

$$P_{Rx} = EIRP + G - L_p$$

$$L_p = EIRP + G - P_{Rx}$$

$$= (50 + 20 + 120) \text{ dB}$$

$$= 190 \text{ dB}$$

Q At the transmitter, the input S/N is 40 dB. The output S/N is determined as 33.3 dB. What is the noise figure of the system?

=) we know,

$$\text{Noise Figure} = \left((S/N)_{in} / (S/N)_{out} \right) \text{ dB}$$

$$= 10 \log \left((40) / (33.3) \right)$$

$$= 10 \log (1.2)$$

$$= 0.792 \text{ dB}$$

Aut-22 (2(c))

For a system the noise temp. @ 283 kelvin with a noise BW of 15.5 Hz. Calculate the noise power of the system. [$K = 1.38 \times 10^{-23}$ J/K]

=) we know,

Noise temperature $= K \cdot T_p \cdot B$

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

$T_p = 283$ K

$B = 15.5$

$= 1.38 \times 10^{-23} \times 283 \times 15.5$

$= 6.05 \times 10^{-20}$ W

Ans

Aut-22 2(a)

Sat TV signal occupies the full transponder bandwidth of 36 MHz, & it must provide C/N ratio at the destination earth station of 22 dB. Given that the total transmission losses are 200 dB & the destination earth station G/T ratio is 31 dB/K, Calculate Sat. EIRP.

=) we know,

EIRP = C/N + G/T − L − F

Here,

$C/N = 22\,dB$

$G/T = 31\,dB/K$

$L = 200\,dB$

$F = 10 \log_{10} (36 \times 10^6)$ MHz to Hz

$= 75.563\,dB$

$\therefore EIRP = 22 + 31 - 200 - 75.563$

$= -222.563\,dB$

$\boxed{\text{Aut-22(1(a))}}$ (why losses are treated quite separately ....)

(i) Fixed losses

1. Consistency:- Atmospheric, Ionosphere these are constant
2. predictability:- Fixed losses can be well characterized & predicted.

(ii) Adverse weather:-

1. Dynamic Nature:- Rain, snow, Those which are dynamic & can change rapidly
2. Intermittent impact:- weather conditions impact on signal quality. And these losses are managed through technology

And by separating losses Engineers can design sat Com systems to account for both fixed losses & losses resulting from adverse weather conditions. The separation allows for more effective planning & optimization of Sat Com systems.

Aut-22 | 1(c)

Counter measure:-

→ Frequency Diversity → Different Freq. Band

→ Power control → To adjust transmitted power

→ Adaptive Coding & Modulation:- Adjust the coding rate & modulation scheme.

→ Spatial diversity → Deploy multiple antennas at both the transmitter & receiver ends to take advantage diversity

→ Polarization Diversity:- This helps to counter the effect of polarization

→ Rain attenation prediction

→ Space diversity. Multiple geostationary sat ব্যবহৃত হয়। যাতে ~~sat~~ satellite এর মধ্যে switch করা যায়।