Unit - 1 Basic Principles & Earth Station

Basic Principles : General Features

- What is Satellite ?

- A satellite is a smaller objects or body that revolves around a much larger object in space in a fixed well defined path.

Or

- The word "satellite" refers to an object that revolves around earth or any other body in space.

- They are of two types :-
  1. Natural Satellites
  2. Artificial Satellites

① Natural Satellites :-

- For example - earth revolves around the sun. So it is a satellite. Moon revolves around earth, so it is also a satellite. But they are Natural satellite.

② Artificial Satellites :-

- Artificial satellites are specially designed & launched into space for a variety of purposes such as weather monitoring, navigation, tv and mobile communication, planetary research etc.

Ex - INSAT,
IRS,
GSAT etc.

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Q. What is mean by satellite communication ? Explain.

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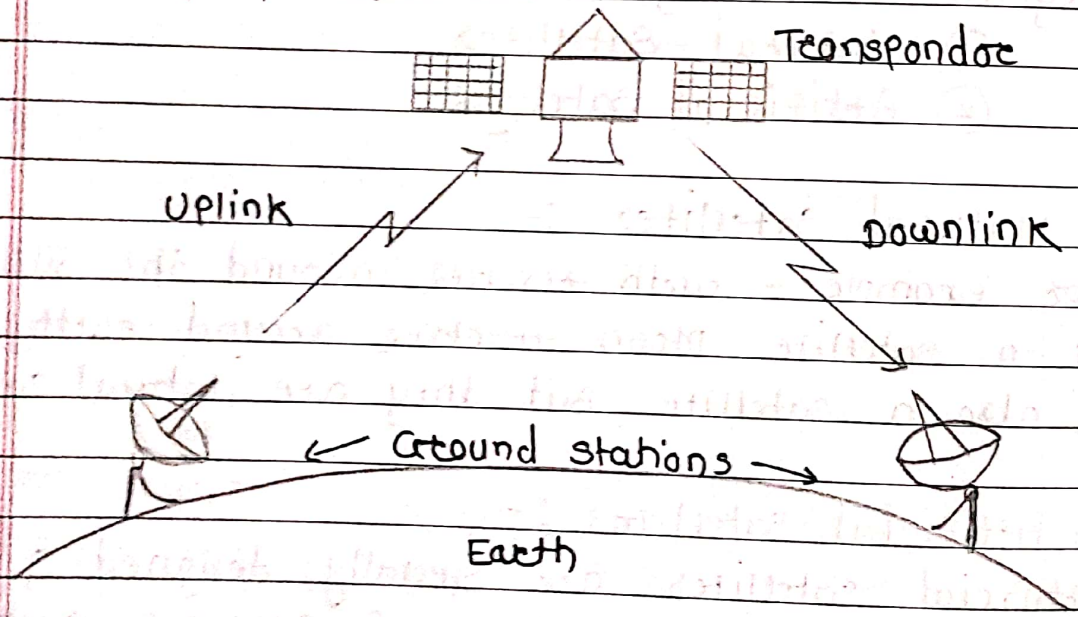
o What is Communication ?

- The word "Communication" refers to the exchang of information between two or more entities through any medium or channel.

o Satellite Communication :-

- If the communication takes place bet^n any two earth stations through a satellite, then it is known as "satellite communication".

- A communication satellite is an artificial satellite used to provide the communication links between various points on earth.



o Basic components :-

Transponder
Uplink
Downlink
Ground station

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- **Transponders :-**
  - It amplifies the incoming signal & changes its frequency for downlink.
  - Units on the satellite that receives signals from the ground station, amplify them & send them back to another ground station.
  - Radio receivers, amplifier & transmitters.
- **Uplink :-**
  - The channel through which the signal is transmitted from Earth station to satellite.
  - Uplink frequency is the frequency of signal sent into the space.
- **Downlink :-**
  - The channel through which the signal is transmitted from satellite to Earth station.
  - Downlink frequency is the frequency at which Earth station receiving a satellite signal.
  - Uplink frequencies are always higher than the downlink frequency.
- **Ground Station :-**
  - Facilities equipped with antennas & receivers to transmit & receives signals from the satellite.

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Ex:- World's first satellite : Sputnik 1, Launched by Soviet Union in 1957.

- India : Aryabhata in 1975

- Indian National satellite (INSAT) one of the largest domestic communications systems placed in Geo-stationary orbit.

o What is the need of satellite communication ?

- Earlier four types of propagations were used for communication i.e ground wave, sky wave, space wave & scattering wave ~~are~~ propagation.

- The maximum distance covered by both of them (Ground wave & sky wave propagation) is limited to 1500 km.

- The ground wave, sky wave, space wave & scattering wave are dependent on earth's curvature & layers of ionosphere for their operations.

- satellite communication overcomes this limitation. It provides communication for long distances, even which is beyond the line of sight.

- Satellites are located at a certain height above earth, where the communication bet^n two stations takes place via the satellite.

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Q. Explain different types of Wave Propagation.

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o History of Satellite Communication :-

- The idea of satellite communication was conceived by Arthur C. Clarke a famous British science fiction writer in year 1945.

- The first satellite was launched in year 1957.

- satellites are specifically made for telecommunication purpose.

- They are used for mobile application such as communication to ships, vehicles, planes, hand-held terminals & for TV & radio broadcasting.

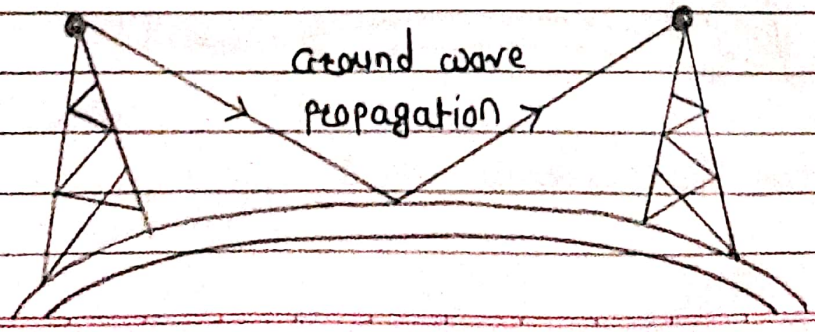
o Types of Wave propagation :-

1. Ground Wave Propagation
2. Sky wave propagation
3. Space wave Propagation
4. Scattering wave Propagation.

1] Ground Wave Propagation :-

- In this mode, the signal travels very close to the earth's surface following its curvature.

- Frequency range : 30 KHz to 3 MHz



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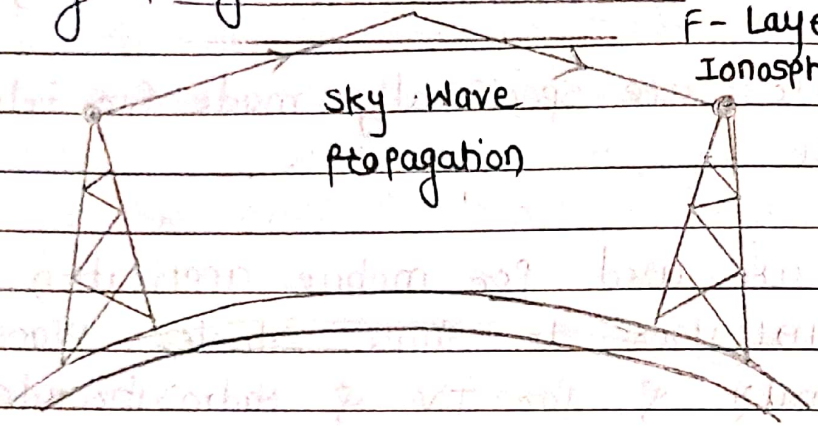
2] Sky Wave Propagation :-

- In this mode, the signals travel from the transmitting antena get reflected from the layer of Ionosphere back to the receiving antenna.

- Frequency Range : 3 MHz to 30 MHz.

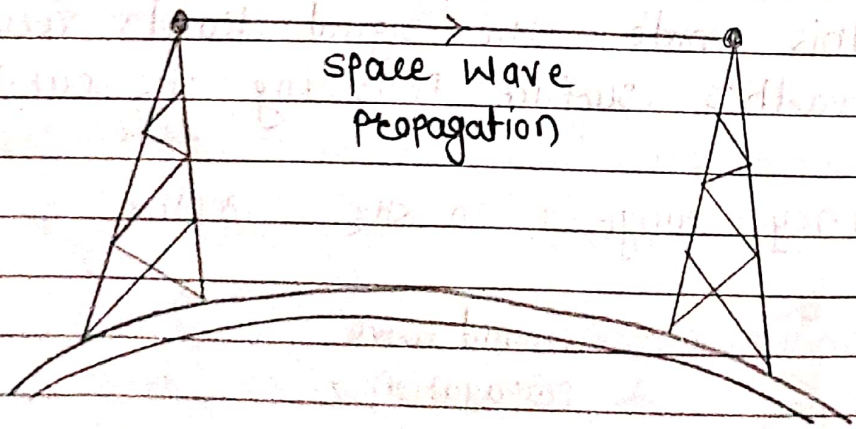


3] Space Wave Propagation :-

- In this mode, the signal waves travel from transmitter to receiver directly in straight path.

- It is also called as Line of sight (LOS) propagation

- Frequency range : > 30 MHz.



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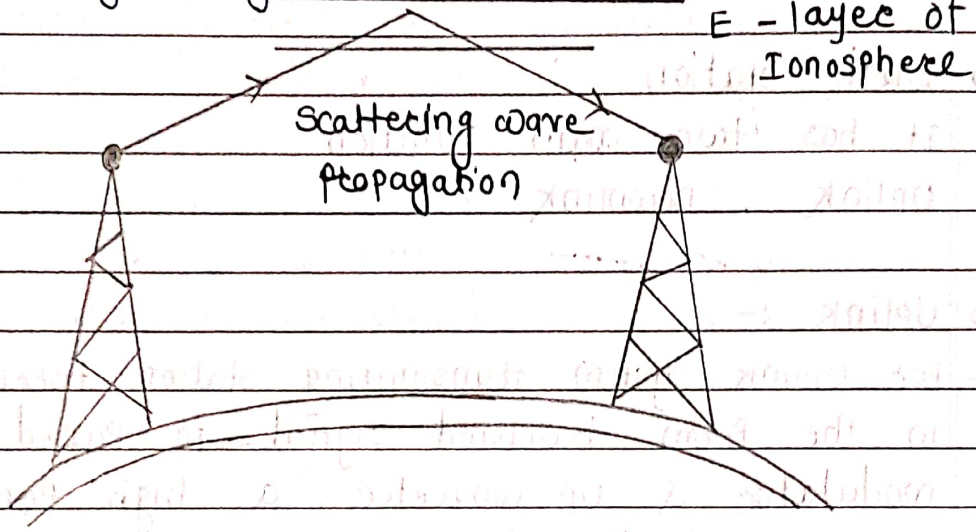
Q. Explain block diagram of satellite communication & its working principle.

4] Scattering Wave Propagation :-

- In this mode, the signals from transmitter get reflected from the E-layer of Ionosphere back to the receiver.

- Frequency Range : > 300 MHz



o Block Diagram of Satellite Communication :-

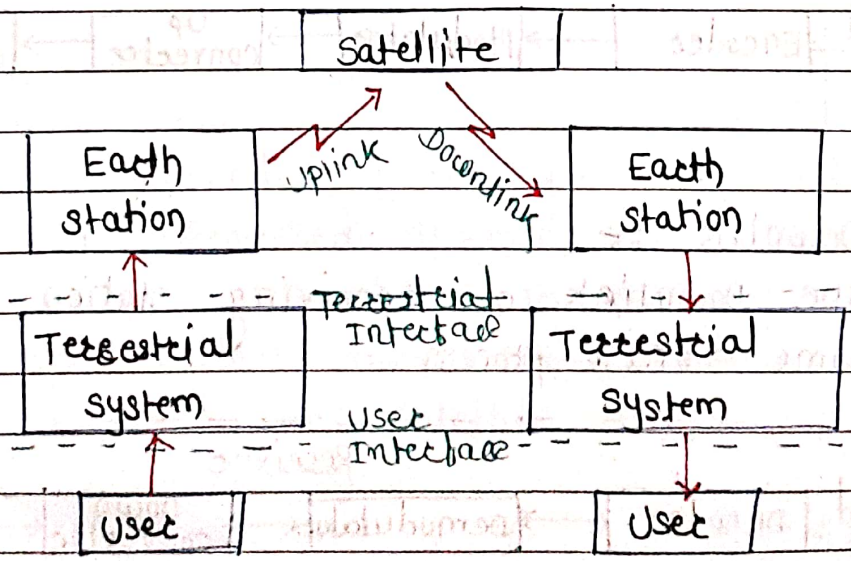


fig :- Block diagram of satellite comm?.

The basic elements of a satellite communication system are :

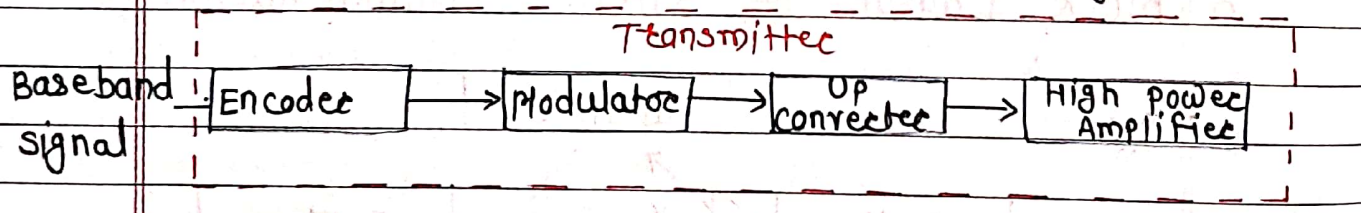
- Earth station
- Satellite
- Terrestrial system
- User

- **Earth station :-**

- It has two main function uplink, Downlink

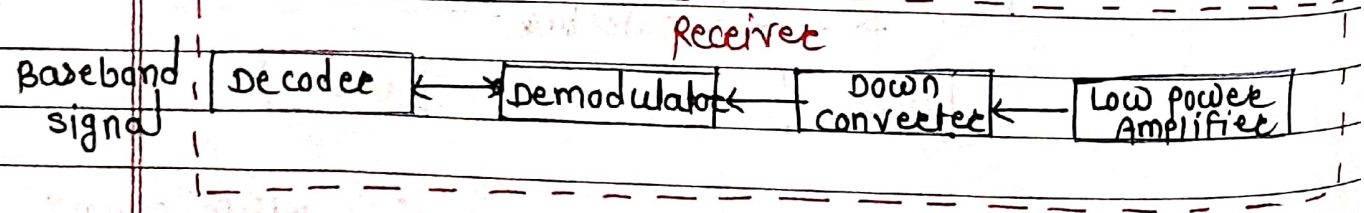
- **Uplink :-**

- For uplink system transmitting station terrestrial data in the form baseband signal is passed through a modulator & up converter, a high power amplifier then passed through antena to orbitting satellite.



- **Downlik :-**

- The Downlink or receiving station work on the same reverse process.



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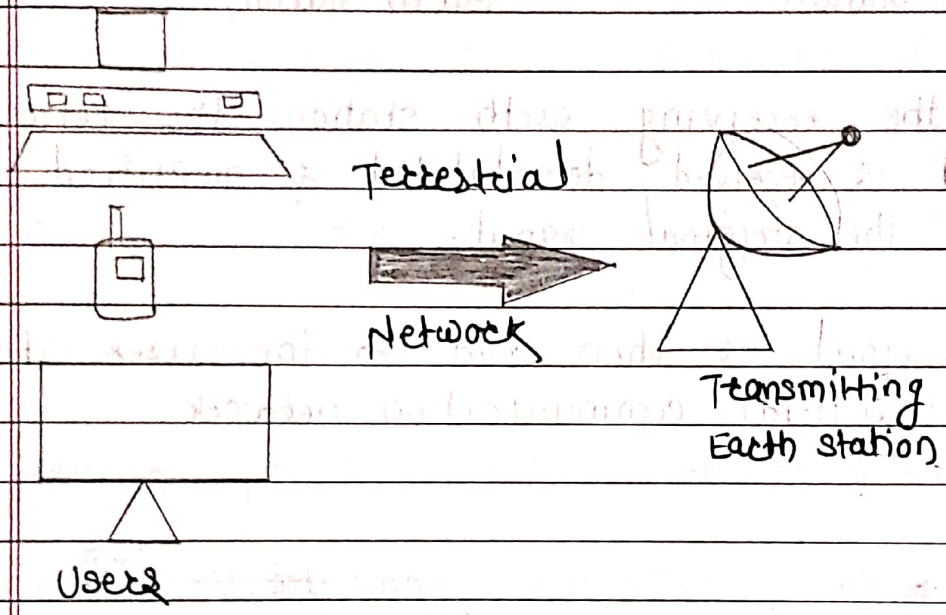
Working principle :-

- The network consists of several earth stations on ground which are linked with a satellite in space.

- The end users are connected to these earth stations through a terrestrial communication network.



- The user generates a message signal which is passed and processed through the terrestrial communication network to the earth station.
- The earth station modulates the signal & sends that signal to the satellite in space on the uplink frequency spectrum.
- The satellite amplifies & processes the signal & retransmits it back on the downlink frequency spectrum.

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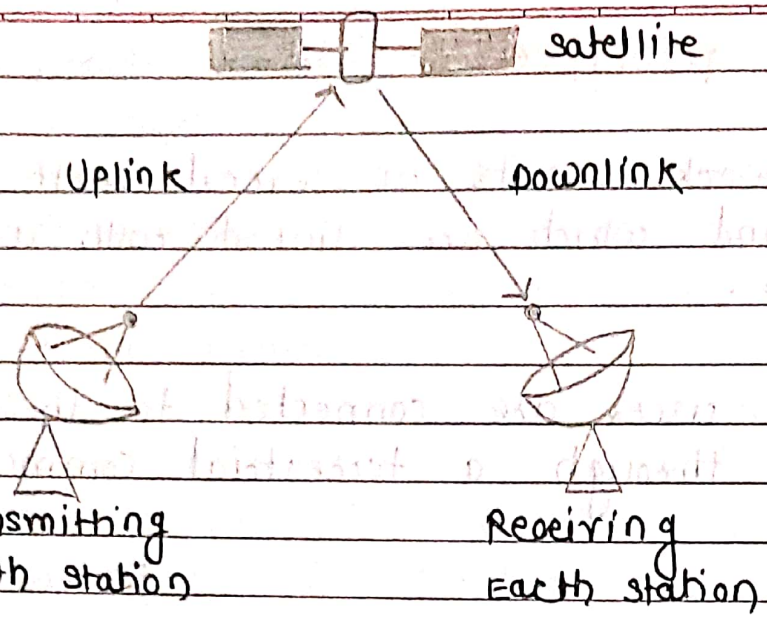
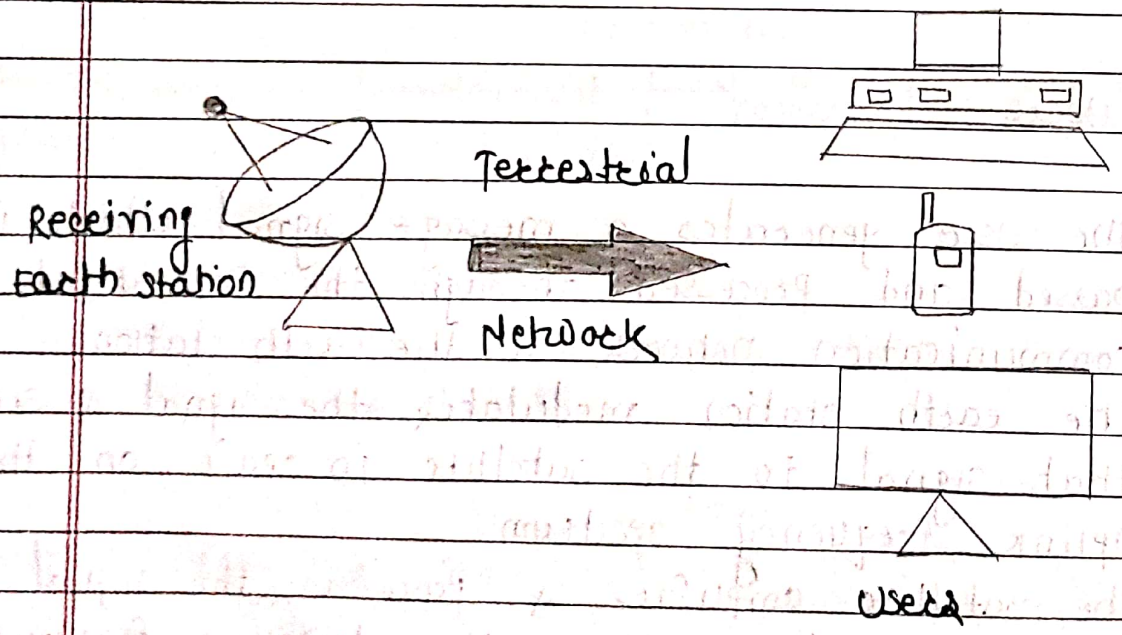


- At the receiving earth station, the retransmitted signal is received, demodulated & amplified to get back the original signal.
- The signal is then sent to the user through the terrestrial communication network.



Advantages of satellite communication :-

- Every corner of the Earth can be covered.
- Maximum bandwidth & reliable.
- communication over a longer distance.
- Point to multipoint communication is possible.
- Area of coverage is more than that of terrestrial systems.
- Circuits for the satellite can be installed easily.
- The resistance of these circuits is excellent.
- satellite cost is independent of the distance.
- sending & receiving information is independent of distance.
- More bandwidth & broadcasting possibilities.
- 24 hours communication can be achieved.

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o Disadvantages of satellite communication :-

- Initial expenditure is high.
- There can be congestion of frequencies.
- Propagation issues and interference may arise.
- Launching of satellites into orbits is an expensive process.
- Propagation delay of satellite systems is more than that conventional terrestrial systems.
- Time delay reduces the efficiency of satellite in data transmission etc.
- Difficult to repair if any problem occurs in a satellite system.
- Transmitter and receiver used in satellite comm^n requires high power & large diameter antennas.
- Due to ageing effect the efficiency of satellite components decreases.
- Free space loss is more.

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Q. What is mean by satellite orbits? Explain different types of satellite orbits.

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- Applications of Satellite communication :-
  - Radio broadcasting.
  - TV broadcasting like direct to home (DTH).
  - Internet application like GPS.
  - Military application.
  - Navigations.
  - Remote sensing applications.
  - Earth observation.
  - Weather condition Monitoring & forecasting.
- Satellite Orbits :-
  - An orbit is the gravitationally curved path of an object around a point in space.
  - Ex :- The orbit of a plane around the centre of the sun in which the earth revolves.

Types of Orbits :-

- Low earth orbit (LEO)
- Medium earth orbit (MEO)
- Geostationary earth orbit (GEO)
- Polar orbit
- Inclined orbit

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o Low earth orbit (LEO) :-

- Satellites orbit close to the Earth, providing low-latency communication but requiring a network of satellites of continuous coverage.

- LEO orbit satellites are much closer to the earth than GEO satellites.

- The distance of the LEO is 500 km to 1500 km above the earth surface.

- LEO satellite don't stay in fixed position relative to the surface and are visible for 15 to 20 min. each round.

o Advantages :-

- A LEO satellite proximity to earth is more compared to a GEO satellite gives better signal strength.

- Better point to point communication.

o Disadvantages :-

- A network of LEO satellites is needed which can be very costly.

- LEO satellites have to compensate for doppler shift cause by their relative movements.

- Atmospheric drag effects LEO satellites causing gradual orbital deterioration.

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o Medium earth orbit (MEO) :-

- Satellites orbit between LEO and ~~MEO~~ GEO, used for navigation and communications.
- The distance of MEO satellite orbit is 8000 to 18000 km above the earth surface.
- MEO satellites are visible for 2 to 8 hours.
- MEO satellites have a larger coverage area than LEO satellites.
- Used in global communication like Email, FAX etc.
- Weaker signal than a LEO satellite.

o GEO - Stationary Earth Orbit (GEO) :-

- Satellites remain in a fixed position relative to the Earth surface
- The distance of this orbit above earth surface 35,786 km.
- Satellite in GEO revolve around the earth at the same speed as the earth rotates.
- It completes one revolution by 24 hours.
- It has larger coverage area.
- Used in global coverage like TV and radio.
- Communication satellites are present in the GEO.

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Q. Explain frequency allocation of satellite services.

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o Polar Orbit :-

- These orbits have an inclination near 90 degrees.
- These satellites take 12 hours to complete one rotation.
- Polar satellites passes above or nearly above both poles of earth.

o Inclined Orbit :-

- A satellite is said to be inclined orbit around earth if the orbit exhibits an angle other than zero degrees to the equatorial plane.

o Frequency allocation for satellite services :-

- Frequency allocation for satellite services is essential to ensure efficient and interference-free operation of satellite communication systems.
- These allocation are regulated by the International Telecommunication Union (ITU) & are divided into different frequency bands, each serving various types of satellite services.
- Allocation of frequencies to satellite services is a complicated process which requires International co-ordination & planning.
- To implement this frequency planning, the world is divided into three regions.

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① Region 1 – Europe, Africa, Mangolia.

② Region 2 – North America, south America, Greenland

③ Region 3 – Asia (excluding region 1 areas), Australia, South West.

- Then within these regions, frequency bands are allocated to various satellite services.

Service provided by satellite :-

① Fixed Satellite Service (FSS) :-

- The FSS provides links for existing telephone networks as well as for transmitting television signals to cable companies for distribution over cable systems.

Ex :- Telephone Networks, TV signal transmission.

② Broadcasting Satellite service (BSS) :-

- Broadcasting satellite services are included mainly for direct broadcast to the home, sometimes referred to as direct broadcast satellite (DBS) service. [in Europe it may be known as DTH (Direct - to - home) service].

Ex :- DBS (direct broadcast to home)

③ Mobile Satellite Services (MSS) :-

- Mobile satellite services would include land mobile, maritime mobile & aeronautical mobile.

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④ Navigational satellite services (NSS) :-

- Navigational satellite services include global positioning systems (GPS), and satellites intended for the meteorological services.

Ex :- GPS (Global positioning system.

⑤ Meteorological satellite services (MSS) :-

- Satellites intended for the meteorological service often provides a search & rescue service.

Ex :- Used for search & rescue service.

o Frequency Band Designations :-

Frequency range, (GHz)	Band designation
0.1 - 0.3	VHF
0.3 - 1.0	UHF
1.0 - 2.0	L
2.0 - 4.0	S
4.0 - 8.0	C
8.0 - 12.0	X
12.0 - 18.0	Ku
18.0 - 27.0	K
27.0 - 40.0	Ka
40.0 - 75	V
75 - 110	W
110 - 300	mm
300 - 3000	µm

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o VHF (Very high frequency) :-

- VHF is the ITU designation for the range of radio frequency electromagnetic waves (radio waves) from 0.1 - 0.3 GHz.
- VHF television antennas used for broadcast television reception. These six antennas are a type known as a yagi antenna, which is widely used at VHF.

o UHF (Ultra high frequency) :-

- UHF is the ITU designation for radio frequencies in the range between 0.3 - 1.0 GHz.
- They are used for television broadcasting, cell phones, satellite communication including GPS; personal radio services including Wifi & bluetooth, walkie-talkie, cordless phones, satellite phones.

o L-band (Long band) :-

- The L-band is the Institute of Electrical and Electronics Engineers (IEEE) designation for the range of frequencies in the radio spectrum from 1 - 2 GHz.

o S-band :-

- The S-band is a designation by the Institute of Electrical and Electronics Engineers (IEEE) for a part of the microwave band of the electromagnetic spectrum covering frequencies from 2 to 4 GHz.

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- C band (communications) :-
- The communications or "C" band of the radio spectrum was originally designated by the IEEE for satellite communications, terrestrial microwave radio and other industrial applications.
- C-band frequencies repurposed for 5G wireless range from 4.0 - 8.0 GHz.

- X band :-
- The X band is the designation for a band of frequencies in the microwave radio region of the electromagnetic spectrum
- The X band is used for radar, satellite comm & wireless computer networks.
- The frequency range is specified by the IEEE as 8.0 - 12.0 GHz.

- Ku band (Kurtz-Under) :-
- The Ku band "Kurtz-Under band" is a portion of the electromagnetic spectrum in the microwave range of frequencies specifically from 12 to 18 GHz.
- It is commonly used for satellite communication including satellite television and internet services.

- K-band :-
- The IEEE K-band is a portion of the radio spectrum in the microwave range of frequencies from 18 to 27 GHz.
- These frequencies experience high atmospheric atten & cannot used for long-distance applications.

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o Ka band (Kurtz - above band) :-
- It refers to a portion of the electromagnetic spectrum in the microwave range of frequencies. specifically from 27.0 - 40.0 GHz.
- The Ka - band used for various high-frequency satellite communication applications, offering higher data rates & bandwidth compared to lower frequency band.

o V band (vee-band) :-
- The V - band is a standard designation by the institute of Electrical & Electronics Engineers (IEEE) for a band of frequencies in the microwave portion of the electromagnetic spectrum ranging from 40 to 75 GHz.

o W band :-
- The W band of microwave part of the electro-magnetic spectrum ranges from 75 - 110 GHz.
- The W band is used for satellite communications, millimeter-wave radar ~~res~~ research, military radar targeting & tracking applications.

o mm band (Millimeter wave) :-
- It also known as Extremely high frequency is the International Telecommunication Union design for the band of radio freq from 110 - 300 GHz
- It is used for witeless high speed communication.

o um band (Micrometer band) :-
- It frequency ranges from 300 - 3000 GHz in infrared portion
- It used in environmental science, military & medical.

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Q Explain properties of satellite communication system

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Properties of satellite communication :-

- Satellite communication possesses several unique properties that make it an essential technology for global telecommunications.

① Wide coverage Area :-

- satellites orbiting the Earth can provide coverage to vast geographical areas, including remote and ~~rural~~ rural regions.
- A single satellite in geostationary orbit can cover about one-third of the Earth surface, making it possible to provide communication services over large distances without the need of extensive ground infrastructure.

② Long-Distance Communication :-

- Satellite relay signals between distant points on the Earth surface, allowing for long-distance communication.
- This is particularly useful for transoceanic and intercontinental communications, where laying physical cables would be impractical and expensive.

③ Reliability :-

- Satellite systems are highly reliable and less vulnerable to terrestrial disasters such as earthquakes, floods & storms.
- They provide consistent and continuous service as they are positioned in space and can maintain operations even during extreme weather conditions on Earth.

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④ Broadcast Capabilities :-
- Satellite can broadcast signals to a wide area, making them ideal for television and radio broadcasting.
- They can simultaneously distribute signal to multiple locations, which is essential for live broadcasts, news & emergency alerts.

⑤ High Bandwidth :-
- Satellites offer high data transmission rates, supporting a range of services including high-speed internet, video conferencing & high-definition television.
- The high bandwidth capacity allows for the tran' of large amounts of data quickly and efficiently.

⑥ Scalability :-
- Satellite networks can be easily scaled to meet increasing demand by launching additional satellites or upgrading existing ones.
- This flexibility allows services providers to expand their coverage & capacity as needed.

⑦ Mobility :-
- Satellites proride communication services to mobile platforms such as ships, aircraft and vehicles.
- This ensures continuous connectivity for users on the move which is crucial for application like maritime communication, in flight internet.

⑧ Global coverage :-
- A network of geostationary, MEO & LEO satellites can achieve near-global coverage.

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Earth Station :-

Introduction :

- An Earth station, also known as a ground station, is a crucial component of satellite comm systems
- An Earth station is a terrestrial terminal station mainly located on the Earth surface. It could even be airborne or maritime.
- Those located on Earth surface could either be fixed or mobile.
- The Earth station is intended for communication with one or more manned or unmanned space stations or with one or more terrestrial stations of the same type via one or more reflecting satellites.
- In most of the applications related to communication satellites, Earth stations transmit to and receive from satellites.
- In some special applications, the Earth station only transmit to or receive from satellites.
- Receive - only Earth station terminals are mainly of relevance in the case of broadcast trans" Transmit - only Earth station terminals are relevant to data gathering applications.

functions of Earth station :-

1. Transmission
2. Reception
3. Tracking and control
4. Data Processing.

Q. Explain Earth station subsystem.

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Earth Station Subsystem :-

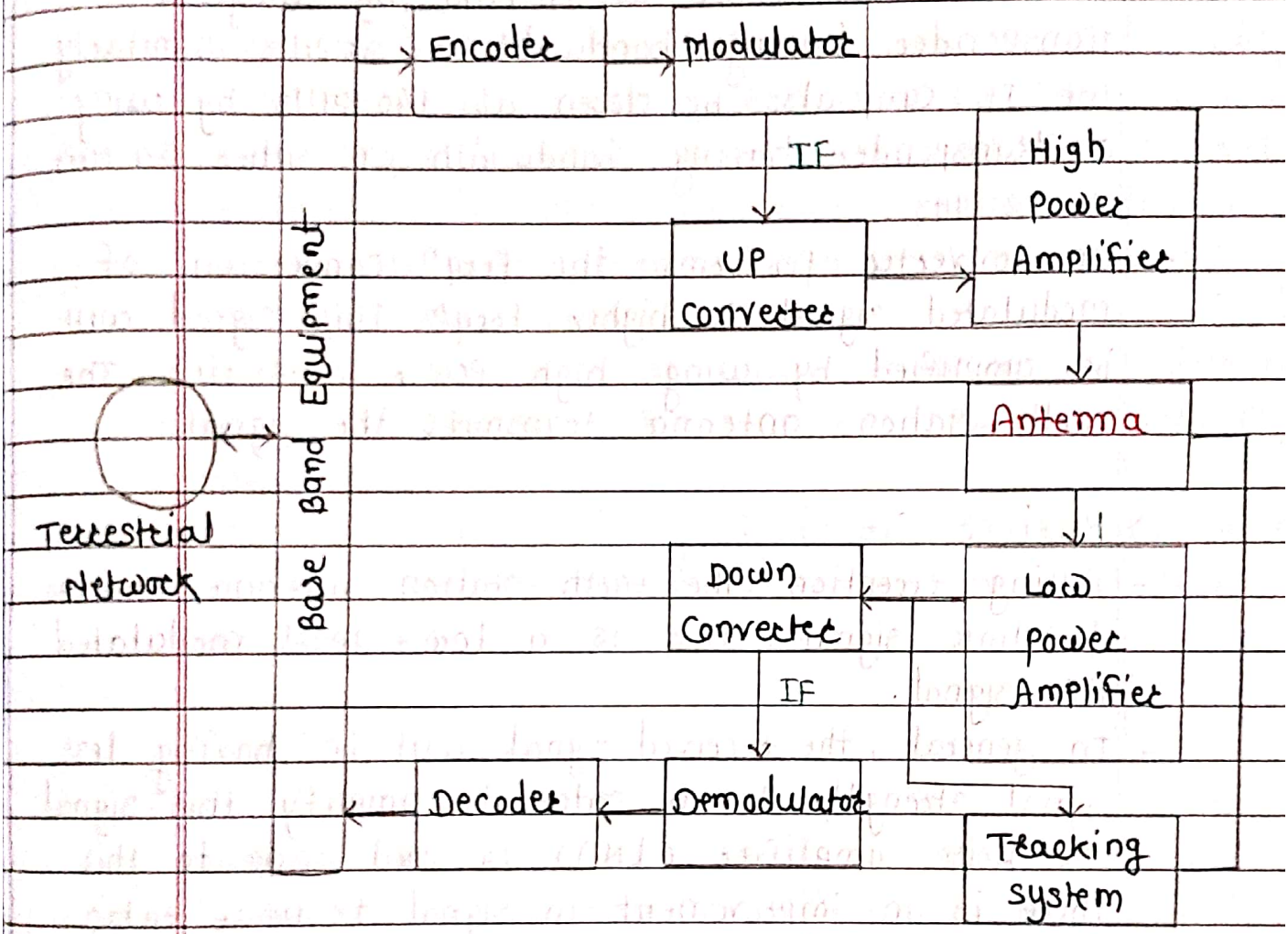

Fig Block diagram of digital earth station

There are four major subsystems that are present in any earth station, Those are transmitter, receiver, antenna & tracking subsystem.

1) Transmitter :-

- The binary (digital) information enters at base band equipment of earth station from terrestrial network. Encoder includes error correction bits in order to minimize bit error rate.

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- In satellite communication the intermediate freq^n (IF) can be closer as 70 MHz by using a transponder having bandwidth of 36 MHz, similarly the IF can also be closen as 140 MHz by using a transponder having bandwidth of either 54 MHz or 72 MHz.
- Up converter performs the freq^n conversion of modulated signal to higher freq^n. This signal will be amplified by using high power amplifier. The earth station antenna transmits the signal.

2) Receiver :-

- During reception, the earth station antenna receives downlink signal. This is a low-level modulated RF signal.
- In general, the received signal will be having less signal strength. So in order to amplify this signal, Low noise amplifier (LNA) is used. Due to this there is an improvement in signal to noise ratio (SNR) value.
- RF signal can be down converted to the Intermedi freq^n (IF) value, which is either 70 or 140 MHz Because is it is easy to demodulate at these intermediate frequency.
- The frequency of decoder is just opposite to that of encoder. so the decoder produces an error free binary information by removing error correction bits & correcting the bit positions if any
- This binary information is given to base band equipment for further processing & then delivered to terrestrial network.

3) Earth station Antenna :-

- The major parts of the Earth station Antenna are feed system & Antenna reflector. These two parts combined together radiates or receives electromagnetic waves. Since the feed system obeys reciprocity theorem, the earth station antennas are suitable for both transmitting & receiving electromagnetic waves.
- Parabolic reflector are used as the main antenna in earth stations. The gain of these reflectors is high.
- They have the ability of focusing a parallel beam into a point at the focus, where the feed system is located.

4) Tracking Subsystem :-

- The tracking subsystem keeps track with the satellite & make sure that the beam comes towards it in order to establish the comm?
- The tracking system present in the earth station performs mainly two functions. Those are satellite acquisition & tracking of satellite. This tracking can be done in one of the following ways.
- Those are automatic tracking &
  manual tracking &
  program tracking.

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Q. Explain different types of earth stations

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Different types of Earth stations :-

- Earth stations are generally categorized on the basis of type of services or functions provided by them, they may sometimes be classified according to the size of the dish antenna.
- Based on the type of service provided by the Earth station, they are classified into following three broad categories :
  1. Fixed satellite service (FSS) Earth station.
  2. Broadcast satellite service (BSS) Earth station;
  3. Mobile satellite service (MSS) Earth station.

- Each stations are also sometimes conveniently categorized into three major functional group depending upon their usage.
  1. single function stations;
  2. Gateway stations;
  3. Teleports.

Fixed satellite service (FSS) Earth station :-

- Under the group of Fss Earth stations, we have the large Earth stations (G/T ≅ 40 dB/K), medium Earth stations (G/T ≅ 30 dB/K), small Earth stations (G/T ≅ 25 dB/K), very small terminals with transmit/receive functions (G/T ≅ 20 dB/K) & very small terminals with receives only functions (G/T ≅ 12 dB/K)
- FSS is a term that is mainly used in North America.

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- The service involves the use of geostationary communication satellites for telephony, data comm? & radio & television broadcast feeds.
- FSS satellites operate in either the C band (3.7-4.2 GHz) or the Ku band (11.45-11.7 GHz).
- FSS satellites operate at relatively lower power levels as compared to BSS satellite.

Broadcast Satellite service (BSS) Earth stations :-

- Under the group of BSS Earth stations, we have large Earth stations (G/T ≅ 15 dB/K) used for community reception & small Earth station (G/T ≅ 8 dB/K) used for individual reception.
- BSS is known by International telecommunications Union (ITU) refers only to the services offered by satellite in specific freq? bands.
- ITU region - 1 (Europe, Russia, Africa) :- (10.7 - 12.75 GHz)
  ITU region - 2 (North & South America) :- (12.2 - 12.7 GHz)
  ITU region - 3 (Asia, Australia) :- (11.7 - 12.2 GHz)
- Under this plan, each country was adopted specific frequencies for use at specific ~~ob~~ orbital locations for domestic services.
- It is also known as DBS (Direct Broadcast service) or more commonly as Direct-to-home (DTH) service.

Mobile Satellite Service (MSS) Earth Stations :-

- Under the group of MSS Earth stations, we have the large Earth stations (G/T ≥ −4 dB/K), medium Earth stations (G/T ≥ −12 dB/K) and small Earth station (G/T ≥ −24 dB/K).
- While both large and medium Earth stations require tracking, small MSS Earth stations are without tracking equipment.
- Satellite phone is the most commonly used mobile satellite service. It is a type of mobile that connects to satellites instead of terrestrial cellular sites.
- Mobile satellites services are provided by both by the geostationary as well as low Earth orbit satellites.

Single function stations :-

- Single function stations are characterized by a single type of link to a satellite or a satellite constellation. These stations may be transmit-only, receive-only or both.
- Ex :- Television receive-only (TVRO) terminals used for TV reception by an individual, satellite radio terminals, receive-only terminals used at a television broadcast station to pickup contribution feed.

Gateway station :-

- Gateway stations serve as an interface between the satellites & the terrestrial networks & also serve as transit points between satellites.

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- These stations are connected to terrestrial n/w by various transmission technologies, both wired such as co-axial cables, optical fibers etc. and wireless such as microwave towers.
- A gateway station receives a large variety of terrestrial signal at any given time. Telephone signals, television signals, data streams.

Teleports :-

- Teleport is a type of gateway station operated by firms that are usually not a part of a specific satellite system.
- Teleports are useful for those companies whose not-too-high requirement of satellite connectivity does not justify having their own dishes.
- They are also useful for business houses located in crowded places inhibiting line-of-sight to the satellite.

chap 1

24/07/24

Assignment No. 1

Q. 1 Explain frequency allocation for satellite services.

Q. 2 What is mean by satellite communication? Explain.

Q. 3 Explain different types of Wave propagation.

Q. 4 What is mean by satellite orbit? Explain different types of satellite orbit.

Q. 5 Explain properties of satellite communication system.

Q. 6 Explain Earth station subsystem.

Q. 7 Explain Block diagram of satellite communication & It's working principle.

Q. 8 Explain different types of earth stations.

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