**EC8094 SATELLITE COMMUNICATION** L T P C
3 0 0 3

**OBJECTIVES:**

The student should be made to:

- Understand the basics of satellite orbits
- Understand the satellite segment and earth segment
- Analyze the various methods of satellite access
- Understand the applications of satellites
- Understand the basics of satellite Networks

**UNIT I SATELLITE ORBITS** **9**

Kepler's Laws, Newton's Law, Orbital Parameters, Orbital Perturbations, Station Keeping, Geo Stationary and Non Geo-Stationary Orbits – Look Angle Determination - Limits of Visibility – Eclipse - Sub Satellite Point – Sun Transit Outage - Launching Procedures - Launch Vehicles and Propulsion.

**UNIT II SPACE SEGMENT** **9**

Spacecraft Technology - Structure, Primary Power, Attitude and Orbit Control, Thermal Control and Propulsion, Communication Payload and Supporting Subsystems, Telemetry, Tracking and Command – Transponders - The Antenna Subsystem.

**UNIT III SATELLITE LINK DESIGN** **9**

Basic Link Analysis, Interference Analysis, Rain Induced Attenuation and Interference, Ionospheric Characteristics, Link Design with and without Frequency Reuse.

**UNIT IV SATELLITE ACCESS AND CODING METHODS** **9**

Modulation and Multiplexing: Voice, Data, Video, and Analog – Digital Transmission System, Digital Video Broadcast, Multiple Access: FDMA, TDMA, CDMA, DAMA Assignment Methods, Compression – Encryption, Coding Schemes.

**UNIT V SATELLITE APPLICATIONS** **9**

INTELSAT Series, INSAT, VSAT, Mobile Satellite Services: GSM, GPS, INMARSAT, LEO, MEO, Satellite Navigational System. GPS Position Location Principles, Differential GPS, Direct Broadcast satellites (DBS/DTH).

TOTAL:45 PERIODS

**OUTCOMES:**

At the end of the course, the student would be able to:

- Analyze the satellite orbits
- Analyze the earth segment and space segment
- Analyze the satellite Link design
- Design various satellite applications

## TEXT BOOKS:

1. Dennis Roddy, “Satellite Communication”, 4th Edition, Mc Graw Hill International, 2006.
2. Timothy,Pratt,Charles,W.Bostain,JeremyE.Allnutt,"SatelliteCommunication”,2ndEdition,Wiley Publications,2002

## REFERENCES:

1. Wilbur L.Pritchard, Hendri G. Suyderhoud, Robert A. Nelson, “Satellite Communication Systems Engineering”, Prentice Hall/Pearson, 2007.
2. N.Agarwal, “Design of Geosynchronous Space Craft”, Prentice Hall, 1986.
3. Bruce R. Elbert, “The Satellite Communication Applications”, Hand Book, Artech House Bostan London, 1997.
4. Tri T. Ha, “Digital Satellite Communication”, II nd edition, 1990.
5. Emanuel Fthenakis, “Manual of Satellite Communications”, Mc Graw Hill Book Co.,1984.
6. Robert G. Winch, “Telecommunication Trans Mission Systems”, Mc Graw-Hill Book Co., 1983.
7. Brian Ackroyd, “World Satellite Communication and earth station Design”, BSP professional Books, 1990.
8. G.B.Bleazard, “Introducing Satellite communications“, NCC Publication, 1985.
9. M.Richharia, “Satellite Communication Systems-Design Principles”, Macmillan 2003.

**Subject Code: EC8094** **Year/Semester: IV /08**
**Subject Name: Satellite Communication** **Subject Handler: Dr. R.Thandaiah Prabu**

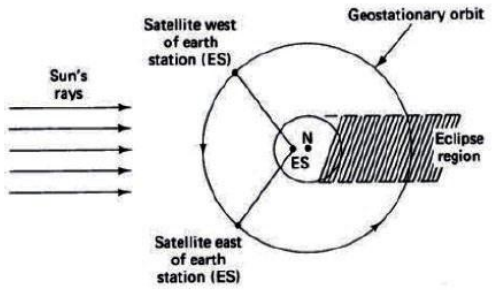
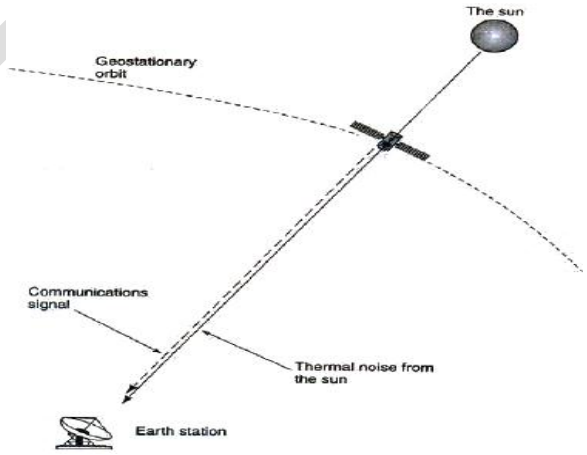
## UNIT I - SATELLITE ORBITS

Kepler's Laws, Newton's Law, Orbital Parameters, Orbital Perturbations, Station Keeping, Geo Stationary and Non Geo-Stationary Orbits – Look Angle Determination - Limits of Visibility – Eclipse - Sub Satellite Point – Sun Transit Outage - Launching Procedures - Launch Vehicles and Propulsion.

### PART * A

| Q.No. | Questions |
|---|---|
| 1. | **What is Satellite?** BTL1<br>An artificial body that is projected from earth to orbit either earth (or) another body of solar systems. Types: Information satellites and Communication Satellites |
| 2 | **Define Satellite Communication.** BTL1<br>It is defined as the use of orbiting satellites to receive, amplify and retransmit data to earth stations. |
| 3 | **State Kepler's first law.** BTL1<br>It states that the path followed by the satellite around the primary will be an ellipse.<br>An ellipse has two focal points F1 and F2. The center of mass of the two body system, termed the barycenter is always centered on one of the foci.<br>e = [square root of (a2– b2) ] / a |
| 4 | **State Kepler's second law.** BTL1<br>It states that for equal time intervals, the satellite will sweep out equal areas in its orbital plane, focused at the barycenter |
| 5 | **State Kepler's third law.** BTL1<br>It states that the square of the periodic time of orbit is perpendicular to the cube of the mean distance between the two bodies.<br>Where, n = Mean motion of the satellite in rad/sec.<br>μ= Earth's geocentric gravitational constant. With the n in radians per sec. the orbital period in second is given by,<br>$a^3 = \frac{\mu}{n^2}$ $p = \frac{2\pi}{n}$ |
| 6 | **Define apogee.** BTL1<br>The point farthest from the earth. |
| 7 | **Define Perigee.** BTL1<br>The point closest from the earth. |
| 8 | **What is line of apsides?** BTL1<br>The line joining the perigee and apogee through the center of the earth. |
| 9 | **Define ascending node.** BTL1<br>The point where the orbit crosses the equatorial plane going from south to north |
| 10 | **Define descending node.** BTL1<br>The point where the orbit crosses the equatorial plane going from north to south |

| | |
|---|---|
| 11 | **Define Inclination.** BTL1<br>The angle between the orbital plane and the earth's equatorial plane. It is measured at the ascending node from the equator to the orbit going from east to north. |
| 12 | **Define mean anomaly.** BTL1<br>It gives an average value of the angular position of the satellite with reference to the perigee. |
| 13 | **Define true anomaly.** BTL1<br>It is the angle from perigee to the satellite position, measured at the earth's center. |
| 14 | **What is meant by azimuth angle?** BTL1<br>It is defined as the angle produced by intersection of local horizontal plane and the plane passing through the earth station, the satellite and center of earth. |
| 15 | **Give the 3 different types of applications with respect to satellite systems.** BTL1<br>• The largest international system (Intelsat)<br>• The domestic satellite system (Dom sat) in U.S.<br>• U.S. National oceanographic and atmospheric administrations (NOAA) |
| 16 | **Mention the 3 regions to allocate the frequency for satellite services.** BTL1<br>• Region1: It covers Europe, Africa and Mangolia<br>• Region2: It covers North & South Ameriaca and Greenland.<br>• Region3: It covers Asia, Australia and South West Pacific. |
| 17 | **Give the types of satellite services.** BTL1<br>• Fixed satellite service,<br>• Broadcasting satellite service<br>• Navigational satellite services,<br>• Mobile satellite service<br>• Meteorological satellite services |
| 18 | **What is mean by Dom sat?** BTL1<br>Domestic Satellites.<br>These are used for voice, data and video transmissions within the country. |
| 19 | **What is mean by INTELSAT & SARSAT ?** BTL1<br>International Telecommunication Satellite, Search and rescue satellite. |
| 20 | **Define polar-orbiting satellites.** BTL1<br>Polar orbiting satellites orbit the earth in such a way as to cover the north and south polar regions. |
| 21 | **Give the advantage of geostationary orbit.** BTL1<br>There is no necessity for tracking antennas to find the satellite positions. |
| 22 | **Define look angles. BTL1**<br>The azimuth and elevation angles of the ground station antenna are termed as look angles. |
| 23 | **Write short notes on station keeping.** BTL1<br>It is the process of maintenance of satellite's attitude against different factors that can cause drift with time. Satellites need to have their orbits adjusted from time to time, because the satellite is initially placed in the correct orbit, natural forces induce a progressive drift. |
| 24 | **What are the geostationary satellites?** BTL1<br>The satellites present in the geostationary orbit are called geostationary satellite.<br>The geostationary orbit is one in which the satellite appears stationary relative to the earth.<br>It lies in equatorial plane and inclination is '0'.<br>The satellite must orbit the earth in the same direction as the earth spin.<br>The orbit is circular. |

| | |
|---|---|
| 25 | **What is sun transit outage.** BTL1<br>The sun transit is nothing but the sun comes within the beam width of the earth station antenna. During this period the sun behaves like an extremely noisy source and it blanks out all the signal from the satellite. This effect is termed as sun transit outage. |
| | **PART * B** |
| 1 | **Describe in details about earth eclipse of satellite and sun transit outage (13 M)** BTL2<br>**Answer: Page: 92-94 - Dennis Roddy**<br>**Eclipse:** GEO eclipsed each day & tilted 23.4°. **(4 M)**<br>Spring equinox & autumnal equinox.<br>Eclipse - solar cells do not function,<br>Operating power - batteries.<br>**(3 M)**<br>  <br><br>**Sun transit outage**<br>Added noise temperature **(3 M)**<br>6000 to 10000 K<br>Depend on - antenna size, elevation angle, location and environment.<br>  <br><br>**(3 M)** |
| 2 | **What are orbital elements? Derive the six orbital elements of satellite from Kepler's three laws of planetary motion. (13 M)** BTL2<br>**Answer: Page: 29- 31, 35 - Dennis Roddy**<br>**The orbital elements: (7 M)**<br>1. The semi major axis (a) – half of major axis<br>2. The eccentricity (e) - oblateness<br>3. The mean anomaly (M) – average angle<br>4. The argument of perigee – line of nodes to perigee |

5. The inclination – angle from equator
6. The right ascension of the ascending node – first time arises to ascending node
1. **Kepler's first law** - Orbit elliptical, sun one of the foci. **(6 M)**
2. **Kepler's second law** - Equal time intervals, satellite will sweep equal areas
3. **Kepler's third law** square of the periodic time of orbit = cube of the mean distance $(D_1/D_2)^3 = (P_1/P_2)^2$

**3** **Explain about Geo-stationary & near Geo-stationary orbits. (13 M)** BTL2
**Answer: Page: 77, 89 - Dennis Roddy**
Satellite follows as it revolves around earth **(3 M)**
**Depending on:** Altitude, Inclination & Orbital Period
Table - **(3 M)**

| Features | GEO | MEO | LEO |
|---|---|---|---|
| **Height (Km's)** | 36000 | 6000 - 12000 | 200 – 3000 |
| **Time per orbit (Hrs)** | 24 | 5 – 12 | 1.5 |
| **Speed (Km's / hr)** | 11000 | 19000 | 27000 |
| **Time Delay (ms)** | 250 | 80 | 10 |
| **Time in Site of Gateway** | Always | 2 – 4 hrs | < 15 min |
| **Satellite for Global Coverage** | 3 | 10 – 12 | 50 – 70 |

**4** **Explain about frequency allocations for satellite services. (13 M)** BTL2
**Answer: Page: 2 Dennis Roddy**
share limited frequency band **(6 M)**
Table - **(7 M)**

| Band | Uplink (GHz) | Downlink (GHz) |
|---|---|---|
| C | 6 | 4 |
| Ku | 14 | 12 |
| Ka | 30 | 20 |
| X | 8.2 | 7.5 |
| S | 40 | 20 |
| Q | 44 | 21 |
| L | 1.525 to 1.559 | 1.626 to 1.660 |

**5** **Explain about the Orbital perturbations in detail (13 M)** BTL2
**Answer: Page: 38 - Dennis Roddy**
Gravitational pull of sun and moon **(2 M)**
Effect of a Non Spherical Earth **(3 M)**
Oblate Spheroid

$$n = n_o\left[1 + \frac{k_1(1 - 1.5\sin^2 i)}{a^2(1 - e^2)^{1.5}}\right]$$

**Anamalistic period** - earth's oblateness **(2 M)**

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

**Regression of the nodes** - opposite to the direction of satellite motion **(2 M)**
**Equatorial ellipticity** - not perfectly circular, eccentricity order $10^{-5}$**. (2 M)**
**Atmospheric drag** - below about 1000 km **(2 M)**

**6** **Determine the limits of visibility for an earth station situated at mean sea level, at latitude**

**48.42° north, and longitude 89.26 degrees west. Assume a minimum angle of elevation of 5°. (13 M)** BTL3

**Answer: Page: 87 - Dennis Roddy**

$$\lambda_E = 48.42°, \Phi E = -89.26°, El\min = 5° \quad \textbf{(1 M)}$$

$$\sigma_{\min} = 90° - El_{\min} = 95° \quad \textbf{(2 M)}$$

$$S = \arcsin\left(\frac{R}{a_{GSO}} \sin \sigma_{\min}\right) = 8.66° \quad \textbf{(2 M)}$$

$$b = 180 - \sigma_{\min} - S = 76.34° \quad \textbf{(2 M)}$$

$$B = \arccos\left(\frac{\cos b}{\cos \lambda_E}\right) = 69.15° \quad \textbf{(2 M)}$$

$$\Phi E + B \approx - 20° \quad \textbf{(2 M)}$$

$$\Phi E - B \approx - 158° \quad \textbf{(2 M)}$$

7 **A geostationary satellite is located at 90°W. Calculate the azimuth angle for an earth station antenna at latitude 35°N and longitude 100°W. And also find the range and antenna elevation angle. (13 M)** BTL3

**Answer: Page: 78 - Dennis Roddy**

$\Phi_{SS}$ = - 90° (West) **,** $\lambda_E$ = 35° (North), $\Phi_E$ = - 100° (West) **(1 M)**

$B = \Phi_E - \Phi_{SS}$ = -100 + 90 = -10° **(2 M)**

$$b = \arccos(\cos \boldsymbol{B} \cos \lambda_E) = 36.23° \textbf{ (2 M)}$$

$$A = \arcsin\left(\frac{\sin|B|}{\sin b}\right) = 17.1° \textbf{ (2 M)}$$

azimuth is, by inspection, $\lambda_E > 0$ *and* $B < 0$*, therefore* $Az = 180° - A = 162.9°$ **(2 M)**

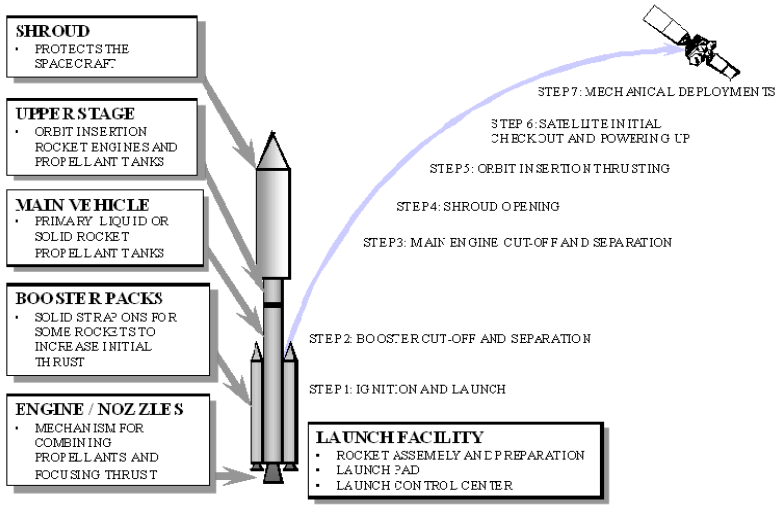
$$d = \sqrt{R^2 + a^2{}_{GSO} - 2Ra_{GSO} \cos b} = 37215 \text{ km } \textbf{(2 M)}$$

$$El = \arccos\left(\frac{a_{GSO}}{d} \sin b\right) = 48° \textbf{(2 M)}$$

**PART * C**

1 **Illustrate the procedures employed for launching spacecraft in GEO orbits. (15 M)** BTL3

Answer: **Page: 94 - Dennis Roddy**

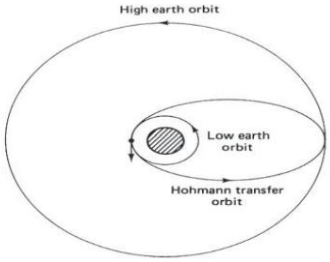



**(8 M)**

Launch vehicles: expendable or reusable. **(1 M)**

Methods of launching a satellite: Using apogee kick motor, Using spacecraft thrusters, Direct insertion to GEO **(1 M)**

**Diagram - (1 M)**




Hohmann transfer orbit – parking orbit **(2 M)**

$$U = \frac{1}{2}\, mv^2 - \frac{GmM}{r}$$ **(2 M)**

Final velocity - sum of the velocity increments of all the stages.

2

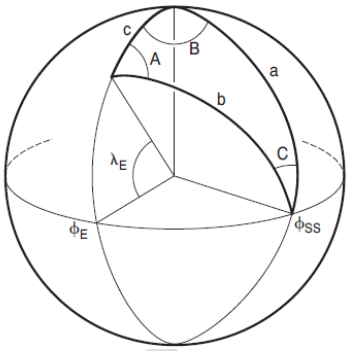
**What are look angles and derive the expressions for azimuth and elevation** BTL2

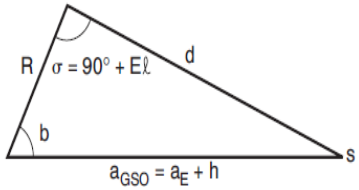
**Answer: Page: 78 - Dennis Roddy**

**Look angles for the geostationary:** latitude $\lambda_{E,}$ longitude $\Phi_E$ , subsatellite point $\Phi_{SS}$ **(5 M)**

**Latitudes:** North - positive angles, south negative angles.

**Longitudes :** East - positive angles, west - negative angles.




**(5 M)**

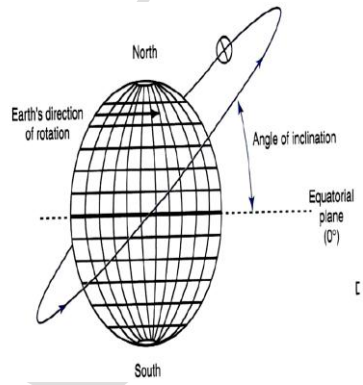
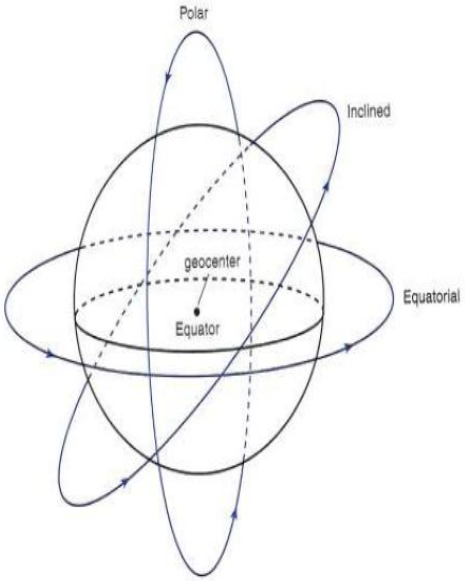
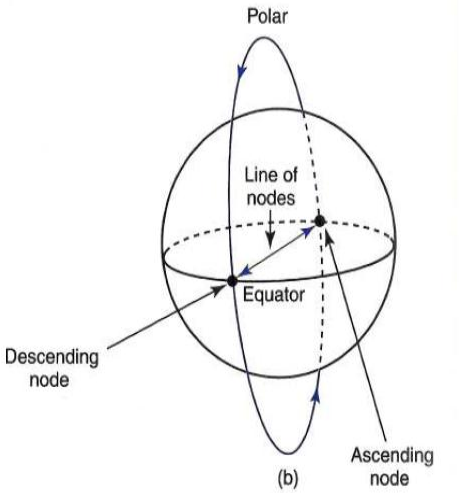
**a = 90°, c = 90°- $\lambda_E$ *and* B= $\Phi_E$ - $\Phi_{SS}$** **(5 M)**

***Napier's rules*** $b = \arccos(\cos \boldsymbol{B} \cos \lambda_E)$

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

| Angle | $\lambda_E$ | B | $A_z$, Degrees |
|---|---|---|---|
| **a** | < 0 | < 0 | A |
| **b** | < 0 | > 0 | 360° - A |
| **c** | > 0 | < 0 | 180° - A |
| **d** | > 0 | > 0 | 180° + A |

**range *d*** $d = \sqrt{R^2 + a^2{}_{GSO} - 2Ra_{GSO} \cos b}$

| | |
|---|---|
| | **Angle of elevation** $El = \arccos\left(\frac{a_{GSO}}{d}\sin b\right)$ |
| 3 | **Illustrate the orbital parameters with suitable diagrams (15 M)** BTL3<br>**Answer: Page: 32 - Dennis Roddy**<br>**Diagram (7 M)**<br>**16 points - (8 M)**<br>1. Sub Satellite Path – Point to trace<br>2. Apogee – Farthest Distance<br>3. Perigee – Closest<br>4. Line of apsides – Joining of Apogee and Perigee<br>5. Ascending node – South to north<br>6. Descending node – North to South<br>7. Line of nodes – Joining of Ascending and Descending<br>8. Inclination – Angle from Equator<br>9. Declination – Angle of Tilt<br>10. Prograde orbit – West to East<br>11. Retrograde orbit – East to West<br>12. Argument of perigee (w) – Line of Nodes to Perigee<br>13. Right ascension of the ascending node (Ω) – First time of arises to ascending node<br>14. Mean Anomaly – Average Angle<br>15. True Anomaly – True Angle<br>  <br>  <br>  |

| UNIT II - SPACE SEGMENT | |
|---|---|
| Spacecraft Technology - Structure, Primary Power, Attitude and Orbit Control, Thermal Control and Propulsion, Communication Payload and Supporting Subsystems, Telemetry, Tracking and Command – Transponders - The Antenna Subsystem. | |
| **PART * A** | |
| **Q.No.** | **Questions** |
| 1. | **Give the two segments of basic satellite communication.** BTL1<br>a. Earth segment (or) ground segment b. Space segment |
| 2 | **Write short notes on attitude control system?** BTL1<br>It is the system that achieves and maintains the required attitudes. The main functions of attitude control system include maintaining accurate satellite position throughout the life span of the system. |
| 3 | **What is declination?** BTL1<br>The angle of tilt is often referred to as the declination which must not be confused with the magnetic declination used in correcting compass readings. |
| 4 | **What is meant by payload?** BTL1<br>It refers to the equipment used to provide the service for which the satellite has been launched. |
| 5 | **What is meant by transponder?** BTL1<br>In a communication satellite, the equipment which provides the connecting link between the satellites transmit and receive antennas is referred to as the transponder. |
| 6 | **Write short notes on station keeping.** BTL1<br>It is the process of maintenance of satellite's attitude against different factors that can cause drift with time. Satellites need to have their orbits adjusted from time to time, because the satellite is initially placed in the correct orbit, natural forces induce a progressive drift. |
| 7 | **What is meant by Pitch angle?** BTL1<br>Movement of a spacecraft about an axis which is perpendicular to its longitudinal axis. It is the degree of elevation or depression. |
| 8 | **What is an propellant?** BTL1<br>A solid or liquid substance burnt in a rocket for the purpose of producing thrust |
| 9 | **What is an Yaw?** BTL1<br>Yaw is the rotation of a vehicle about its vertical axis. |
| 10 | **What is an zero 'g'?** BTL1<br>Zero 'g' is a state when the gravitational attraction is opposed by equal and opposite inertial forces and the body experiences no mechanical stress. |
| 11 | **Describe the spin stabilized satellites.** BTL1<br>In a spin stabilized satellites, the body of the satellite spins at about 30 to 100 rpm about the axis perpendicular to the orbital plane. The satellites arm normally dual spin satellites with a spinning section and a despun section on which antennas are mounted. These are kept stationary with respect to earth by counter rotating the despun section. |
| 12 | **What is meant by frequency reuse?** BTL1<br>The carrier with opposite senses of polarization may overlap in frequency. This technique is known as frequency reuse. |

| | |
|---|---|
| 13 | **What is meant by spot beam antenna?** BTL1<br>A beam generated by a communication satellite antenna of sufficient size that the angular spread of sufficient size that the angular spread of the energy in the beam is very small with the result that a region that is only a few hundred km in diameter is illuminated on earth. |
| 14 | **What is meant by momentum wheel stabilization?** BTL1<br>During the spin stabilization, flywheels may be used rather than spinning the satellite. These flywheels are termed as momentum wheels. |
| 15 | **What is polarization interleaving?** BTL1<br>Overlap occurs between channels, but these are alternatively polarized left hand circular and right hand circular to reduce interference to acceptable levels. This is referred to as polarization interleaving. |
| 16 | **Define S/N ratio.** BTL1<br>The S/N introduced in the preceding section is used to refer to the ratio of signal power to noise power at the receiver output. This is known as S/N ratio. |
| 17 | **What is an intermodulation noise?** BTL1<br>Intermodulation distortion in high power amplifier can result in signal products which appear as noise and it is referred to as intermodulation noise. |
| 18 | **What is an antenna loss?** BTL1<br>It is added to noise received as radiation and the total antenna noise temperature is the sum of the equivalent noise temperature of all these sources. |
| 19 | **What is TWTA?** BTL1<br>TWTA means Traveling Wave Tube Amplifier. The TWTA is widely used in transponder to provide the final output power required to the trans tube and its power supplies. |
| 20 | **What is meant by thermal control and why this is necessary in a satellite?** BTL1<br>Equipment in the satellite generates heat which has to be removed. The element used in the satellite to control thermal heat is called thermal control. The most important consideration is that the satellite's equipment should operate as nearly as possible in a stable temperature environment |
| 21 | **What are the functions carried out in TT&C?** BTL1<br>Telemetry- Gathering or measure information about satellite.<br>Tracking- track the satellite's movement and send correction signals as Required<br>Comment- sends information about the satellite to earth station. |
| 22 | **List out the advantages of TWT.** BTL1<br>The advantage of the TWT over other types of tube amplifiers is that it can provide amplification over a very wide bandwidth. Input levels to the TWT must be carefully controlled, however, to minimize the effects of certain forms of distortion |
| 23 | **Define input back off.** BTL1<br>In a TWTA, the operating point must be backed off to a linear portion of the transfer characteristic to reduce the effects of intermodulation distortion. The point from the saturation point to linear region at the input is called input backoff. |
| 24 | **What is meant by Pitch, yaw and roll axis?** BTL1<br>**Roll, pitch, and yaw axes.** The yaw axis is directed toward the earth's center, the pitch axis is normal to the orbital plane, and the roll axis is perpendicular to the other two.<br>For an equatorial orbit, movement of the satellite about the roll axis moves the antenna footprint north and south; movement about the pitch axis moves the footprint east and west; and movement about the yaw axis rotates the antenna footprint. |

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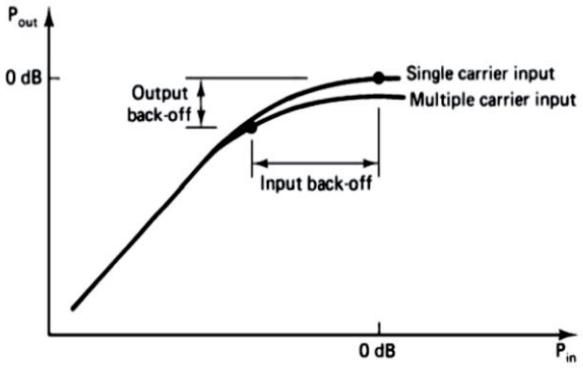
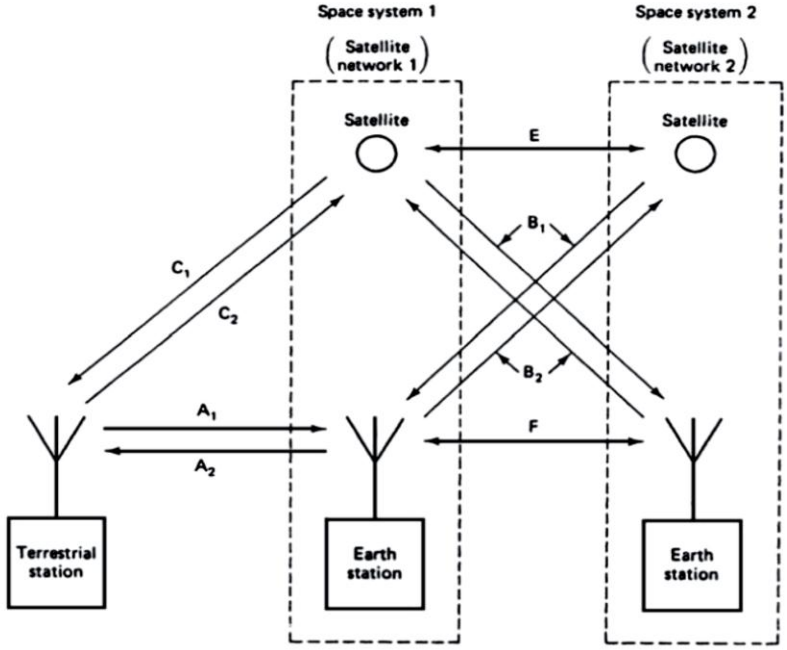
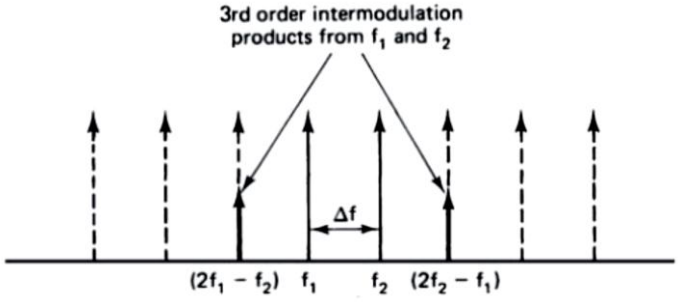
|---|---|
| 25 | **Why the operation near the saturation point of a TWTA is to be avoided when multiple carriers are being amplified simultaneously?** BTL1<br><br>In order to reduce the inter modulation distortion; the operating point of the TWT must be shifted closer to the linear portion of the curve to control the sideband generation. After the modulation due to nonlinear transfer characteristics in the curve.<br><br>  |
| | **PART * B** |
| 1 | **Describe various interference noise in detail. (13 M)** BTL2<br>**Answer: Page: 399 - Dennis Roddy**<br><br>  <br>**(5 M)**<br>***A*1:** Interference - earth station **(8 M)**<br>***A*2:** Interference - terrestrial station<br>***B*1:** Interference - earth station of another space system<br>***B*2:** Interference - space station of another space system<br>***C*1:** Interference - terrestrial station<br>***C*2:** Interference - space station<br>***E:*** Interference - space station of another space system<br>***F:*** Interference - earth station of another space system |

2

**Describe the various Intermodulation Noise in detail (13 M)** BTL 2

**Answer: Page: 383 - Dennis Roddy**

Multiple carriers pass through any device with nonlinear characteristics. **(2 M)**




**(3 M)**

**Intermodulation noise: (8 M)**

Intermodulation products are not distinguishable separately

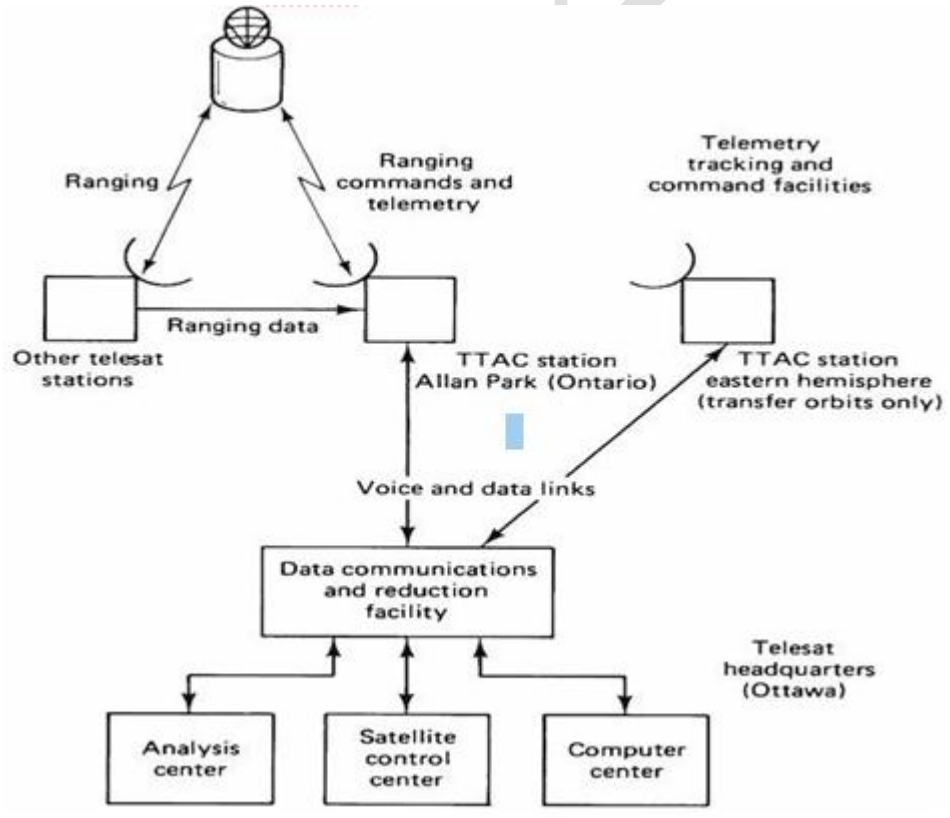
$$\frac{N_o}{C} = \left(\frac{N_o}{C}\right)_U + \left(\frac{N_o}{C}\right)_D + \left(\frac{N_o}{C}\right)_{IM}$$

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

3

**Illustrate the concept of Telemetry, Tracking & Command and explain its blocks (13 M)** BTL3

**Answer: Page: 212 - Dennis Roddy**



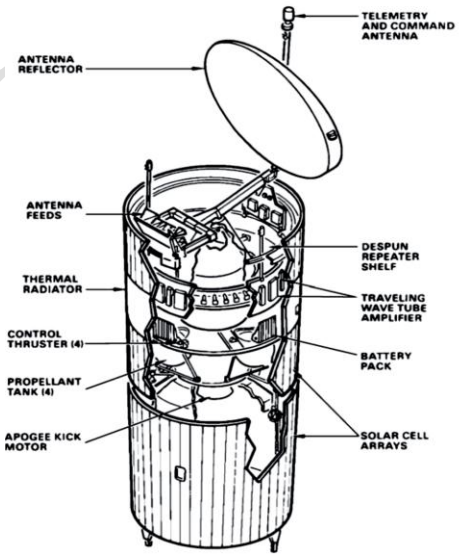

(4M)

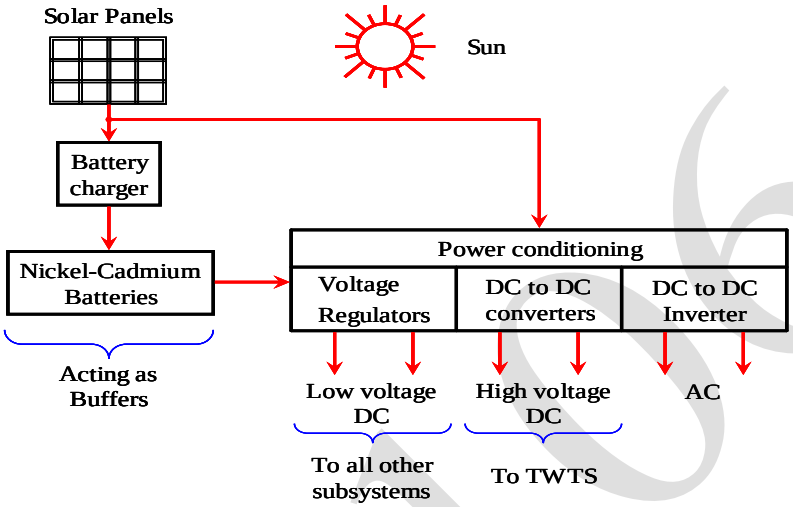
**Telemetry (3 M)**
Attitude Information
Magnetic Field Intensity
Direction and Spacecraft Information
Temperatures
Power Supply Voltages and Stored Fuel Pressure.

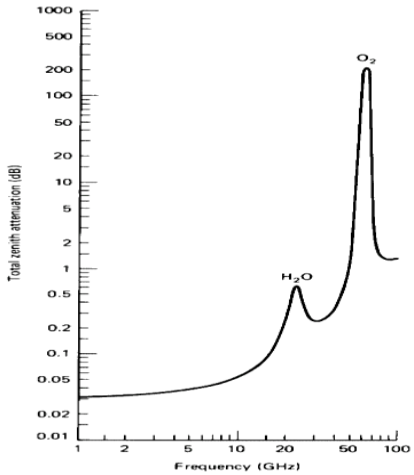
**Tracking (3 M)**
Transfer and drift orbital phases
various disturbing forces
Track the satellite's movement
Send correction signals

**Command (3 M)**
Manual operation
Transponder switching
Station keeping
Attitude changes
Gain control
Redundancy control.
Separation commands,
Antenna and solar panel deployment
Apogee motor firing

4 **Explain Thermal Control & Power Supply in satellite communication system (13 M)** BTL2
**Answer: Page: 199 - Dennis Roddy**
**Thermal Control (6 M)**
Stable temperature environment.
Thermal blankets and shields - provide insulation.



| | |
|---|---|
| | **The Power Supply (7 M)**<br>The primary electrical power - solar cells.<br>Higher power solar cells - ***solar sails.***<br>  <br> |
| 5 | **Briefly explain about design life time and system reliability in satellite communication system (13 M)** BTL2<br>**Answer: Page: 219 - Dennis Roddy**<br>**Design Lifetime (5 M)**<br>1. Type of service to be provided (DTH/DBS)<br>2. communication capacity (Transponder Bandwidth, EIRP)<br>3. coverage area<br>4. technological limitations<br>5. Environmental conditions<br><br>**Environmental conditions (3 M)**<br>1. Zero Gravity<br>2. Atmospheric pressure and temperature<br>3. Space particles<br>4. Magnetic fields<br>5. Other considerations<br><br>**System Reliability (5 M)**<br>Reliability - space craft components.<br>Probability - component or system performs within a specified time t.<br>$R = e^{-\int_0^t \lambda dt}$<br>High failure, low failure and random failures |
| 6 | **Describe the various Propagation factors/ Atmospheric Losses in detail (13 M)** – BTL2<br>**Answer: Page: 103 - 130 - Dennis Roddy**<br>**Atmospheric Attenuation –** weather related losses **(2 M)**<br>**Atmospheric Absorption** - absorption losses**.**<br>Total attenuation A = αL [dB] |




Disturbances: **(2 M)**

- Scintillation;
- Polarization rotation.
- Absorption
- Dispersion
- Frequency change
- Variation in direction of arrival

**Diagram - (3 M)**

Scintillations – variation in amplitude, phase, polarization, or angle **(2 M)**

**Polarization (2 M)**
Property - Electromagnetic waves
Electric and Magnetic - polarization of the signal.

**Types: (2 M)**
Linear polarization
Circular polarization
Elliptical polarization

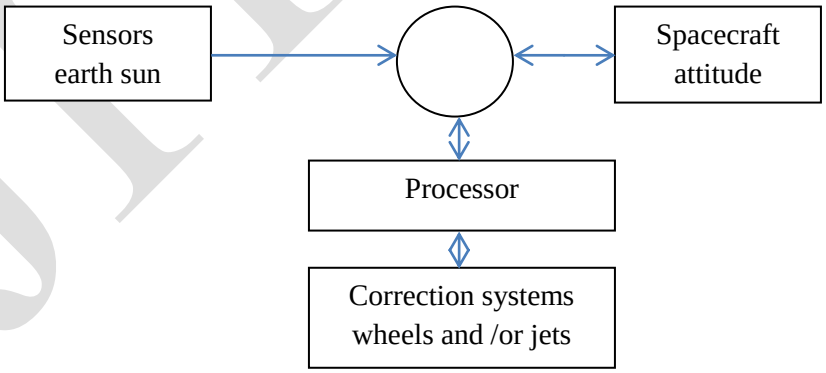
**PART * C**

1 **With a neat block diagram, explain the attitude and orbit control system present in the space segment. (15 M)** – BTL2

**Answer: Page: 202 - Dennis Roddy**

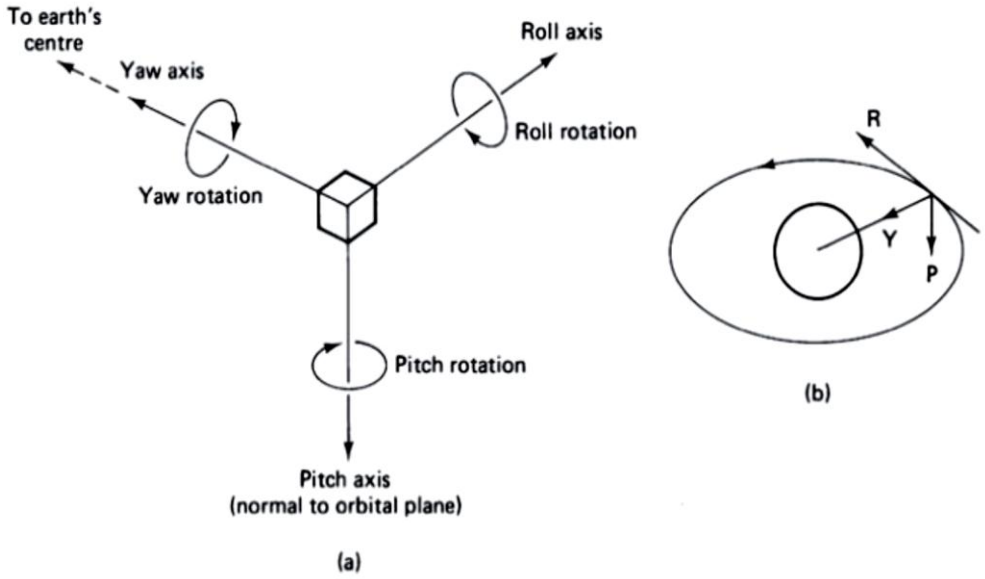
The attitude control subsystem: **(2 M)**

- Antennas – toward the earth
- Solar array - toward the sun.




**(2 M)**

Corrections - spinning momentum wheels or by thrusters, or by some combination.




**(2 M)**

yaw axis - toward the earth's center **(2 M)**
pitch axis - orbital plane
roll axis - perpendicular to the other two.
Roll axis - antenna footprint north and south
pitch axis - footprint east and west
yaw axis - rotates the antenna footprint.

**Methods of stabilization:**

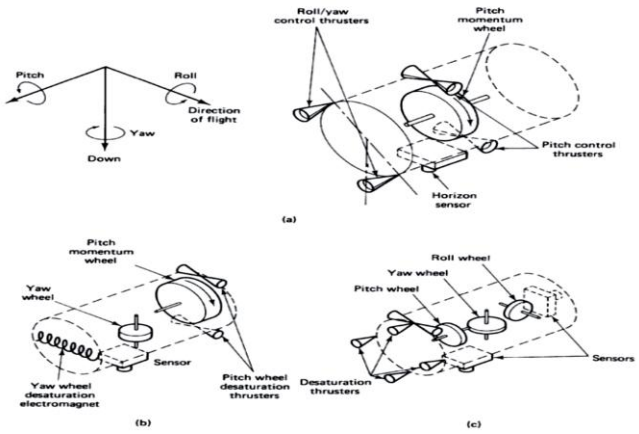
**Passive methods:** Include gravity-gradient stabilization and magnetic damping **(2 M)**

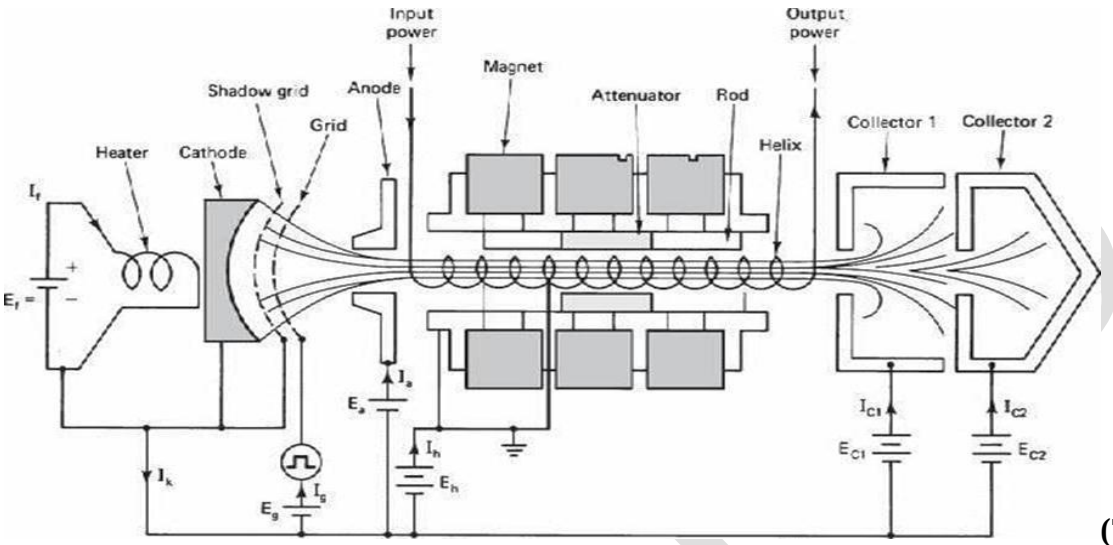
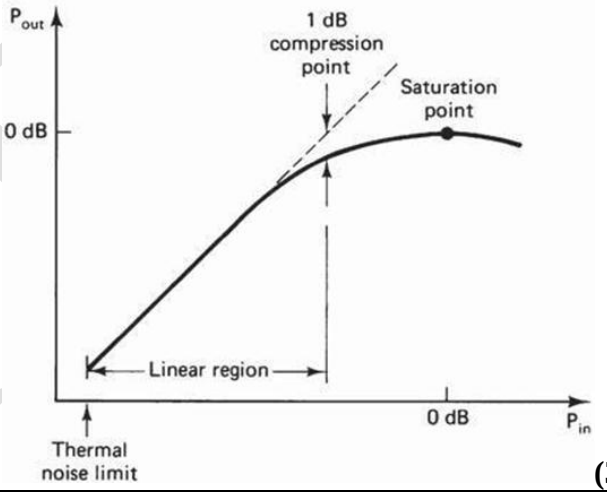
**Active methods:** Include spin stabilization and three axis stabilization.

**Spinning satellite stabilization: (2 M)**

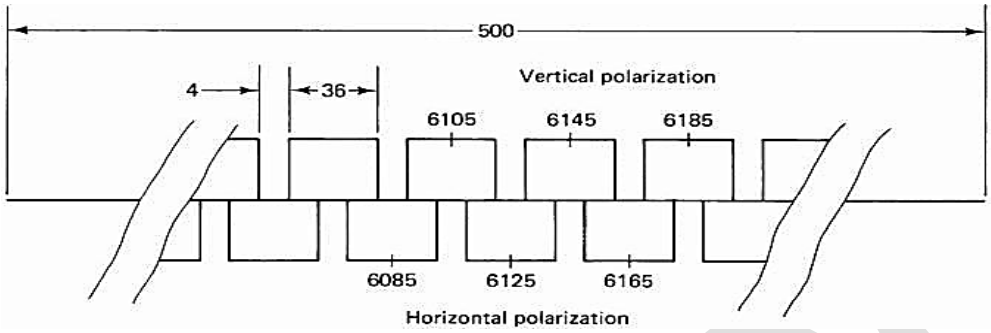
- Cylindrical satellites.
- Mechanically balanced about one particular axis nutation dampers.
- momentum wheels
- Reaction wheel.

**(3 M)**



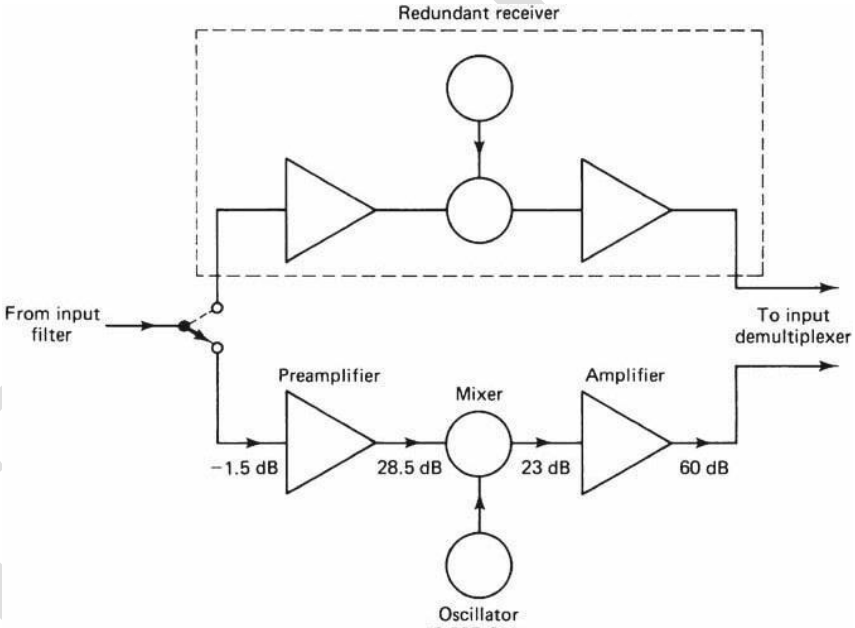
| | |
|---|---|
| 2 | **Describe briefly the most common type of high-power amplifying device used aboard a communication satellite. (15 M)** BTL2<br>**Answer: Page: 218 - Dennis Roddy**<br>  <br><br>**(7 M)**<br>Traveling-wave tube amplifiers (TWTAs) - final output power. **(5 M)**<br>Helix - slow wave structure.<br>Amplification - wide bandwidth.<br>Maximum power output - saturation point.<br>thermal noise limit at the low end - ***1dB compression point***<br>  <br><br>**(3 M)** |
| 3 | **Describe the Communication Payload for the space segment in detail (15 M)** BTL2<br>**Answer: Page: 213 - Dennis Roddy**<br><br>Series of interconnected units **(2 M)**<br>Single communications channel - communications satellite.<br><br>Transponder bandwidth - 36 MHz **(3 M)**<br>4 MHz guard band between transponders |

12 transponders
500-MHz bandwidth

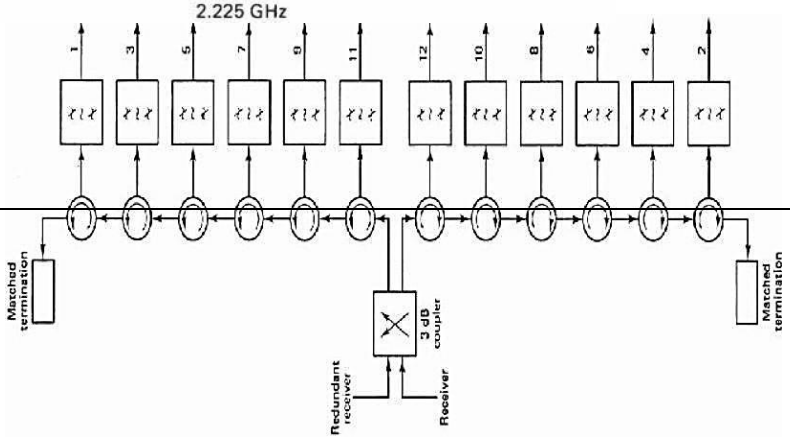



**(2 M)**

**The wideband receiver (4 M)**
duplicate receiver
redundant receiver



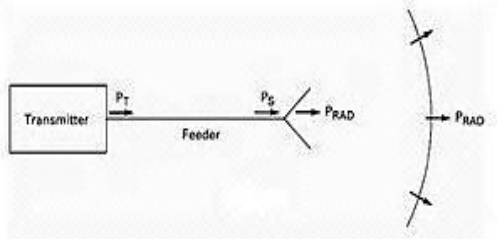

**The input Demultiplexer (4 M)**
Separates the broadband input
Frequency range 3.7 to 4.2 GHz
Greater frequency separation
Adjacent channel interference.



## UNIT III - SATELLITE LINK DESIGN

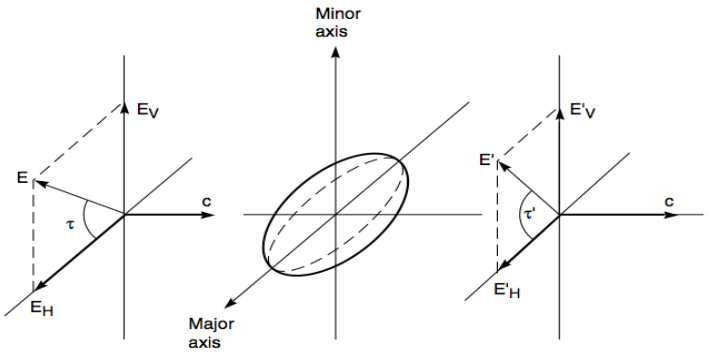
Basic Link Analysis, Interference Analysis, Rain Induced Attenuation and Interference, Ionospheric Characteristics, Link Design with and without Frequency Reuse.

### PART * A

| Q.No. | Questions |
|---|---|
| 1. | **Define Saturation flux density.** BTL1<br>The flux density required at the receiving antenna to produce saturation of TWTA is termed the saturation flux density. |
| 2 | **The range between a ground station and a satellite is 42000 km. Calculate the free space loss a frequency of 6 GHz.** – BTL3<br>[Free space loss] = 32.4 + 20 log 42000 + 20 log 6000 = 200.4 dB |
| 3 | **What is noise power spectral density?** BTL1<br>Noise power per unit Bandwidth is termed as the noise power spectral density. |
| 4 | **Define diplexer & *orthocoupler.*** BTL1<br>The same feed horn may be used to transmit and receive carriers with the same polarization. The transmit and receive signals are separated in a device known as a *diplexer*,<br>The polarization separation takes place in a device known as an *orthocoupler*, or *orthogonal mode transducer* (OMT). Separate horns also may be used for transmit and receive functions, with both horns using the same reflector. |
| 5 | **What is an EIRP?** BTL1<br>EIRP means Equivalent Isotropic Radiated Power<br>An isotropic radiator is one that radiates equally in all directions.<br>It is a measure of radiated or transmitted power of an antenna.<br>$P_t = P_{out}/L_t$ $EIRP = P_t G_t = Gp_s$<br>$Maximum\ flux\ density\ \varphi_m = \frac{Gp_s}{4\pi r^2}$<br>[EIRP] = [$P_S$] + [G] dBW<br>  |
| 6 | **When the available bandwidth is 500 MHz, how many transponder each of bandwidth 36 MHz can be accommodated.** – BTL3<br>500 MHz Bandwidth – 12 transponders<br>12 * 36 MHz + 12*4 MHz (guard time) = 500 MHz |
| 7 | **What is known as polarization interleaving with reference to the downlink frequency?** BTL1<br>Overlap occurs between channels, but these are alternatively polarized left hand circular and right |

| | |
|---|---|
| | hand circular to reduce interference to acceptable levels. This is referred to as polarization interleaving.<br>The downlink frequency band spans a range of 500 MHz are arbitrary polarized, left hand circular polarization and right hand circular polarization to reduce the interference to acceptable levels. |
| 8 | **A satellite downlink of 10GHz operates with a transmit power of 5W and an antenna gain of 48.2 dB. Calculate the EIRP in dBw** – BTL3<br>[EIRP] = [$P_S$] + [G] dBW<br>[EIRP] = 10 log (6W/1W) + 48.2 = 56 dBw |
| 9 | **List the attitude of a satellite controlled through active control.** BTL1<br>• To stabilize the attitude control on spacecraft by spin stabilization<br>• 3 axis stabilization<br>• Momentum wheel stabilization<br>• Reaction wheel<br>• Magnetic torques<br>• Gas jets or thrusters |
| 10 | **Write the objectives with which the downlink of any satellite communication system must be designed** BTL1<br>• Expected performance of the earth station receiver<br>• Frequency band determination<br>• Determine transponder output power from its gain or output backoff<br>• Establish a downlink power and noise budget for the receiving earth station |
| 11 | **Why is noise temperature a useful concept in communication receiver?** BTL1<br>• Noise temperature is a useful concept in communication receivers, since it provides the way of determining how much thermal noise is generated by active and passive devices in the receiving system.<br>• At microwave frequencies, temperature increase can generate electrical noise over a wide bandwidth<br>• C/N ratio requirements met by making the noise level low. |
| 12 | **For a given satellite and signal transmission and signal transmission, what are the earth station parameters affecting the C/N ratio?** BTL1<br>• EIRP – Equivalent Isotropic radiated power<br>• G/T – Gain of the receiving antenna & temperature increase due to losses |
| 13 | **Why thermal control is needed?** BTL1<br>• Equipment in the satellite generates heat which has to be removed. The element used in the satellite to control thermal heat is called thermal control.<br>• In spacecraft, the function of thermal control system is to keep the spacecraft component systems within acceptable temperature ranges during all mission phases.<br>• To maintain the optimum performance and success of the mission.<br>• Protects the equipment from overheating either by thermal insulation from external heat & by proper heat removal from internal sources |
| 14 | **Define sky noise.** BTL1<br>It is a term used to describe the microwave radiation which is present throughout universe and which appears to originate from matter in any form, at finite temperature. |

| | |
|---|---|
| 15 | **Define noise factor.** BTL1<br>An alternative way of representing amplifier noise is by means of its noise factor. In defining the noise factor of an amplifiers, usually taken as 290k |
| 16 | **What is meant by redundant receiver?** BTL1<br>A duplicate receiver is provided so that if one fails, the other is automatically switched in. The combination is referred to as a *redundant receiver*, meaning that although two are provided, only one is in use at a given time. |
| 17 | **An antenna has a noise temperature of 35 K and is matched into a receiver which has a noise temperature of 100 K. Calculate (*a*) the noise power density and (*b*) the noise power for a bandwidth of 36 MHz.** – BTL3<br>$$\boldsymbol{N_o = \frac{P_N}{B_N} = K T_N}$$<br>$$N_o = (35 + 100) * 1.38 * 10^{-23} = 1.86 * 10^{-21}\ J$$<br>$$\boldsymbol{P_N = K T_N B_N}$$<br>$$P_N = 1.86 * 10^{-21} * 36 * 10^6 = 0.067\ pW$$ |
| 18 | **Define Cross-Polarization Discrimination.** BTL1<br>Depolarization can cause interference where orthogonal polarization is used to provide isolation between signals, as in the case of frequency reuse.<br>The most widely used measure to quantify the effects of polarization interference is called Cross-Polarization Discrimination<br>**XPD = 20 log ($E_{11}/E_{12}$)** |
| 19 | **For a satellite circuit the carrier-to-noise ratios are uplink 23 dB, downlink 20 dB, intermodulation 24 dB. Calculate the overall carrier- to-noise ratio in decibels.** – BTL3<br>$$\frac{N_o}{C} = \left(\frac{N_o}{C}\right)_U + \left(\frac{N_o}{C}\right)_D + \left(\frac{N_o}{C}\right)_{IM}$$<br>$$\frac{N_o}{C} = 10^{-2.4} + 10^{-2.3} + 10^{-2} = 0.0019$$<br>$$\left[\frac{C}{N_0}\right] = 10\log(0.0019) = 17.2\ dBHz$$ |
| 20 | **A satellite link operating at 14 GHz has receiver feeder losses of 1.5 dB and a free-space loss of 207 dB. The atmospheric absorption loss is 0.5 dB, and the antenna pointing loss is 0.5 dB. Depolarization losses may be neglected. Calculate the total link loss for clear-sky conditions.** – BTL3<br>**[LOSSES]** = [FSL] + [RFL] + [AML] + [AA]<br>**[LOSSES]** = 207 + 1.5 + 0.5 + 0.5 = 209.5 Db |
| | **PART * B** |
| 1 | **Describe the Effects of Rain in satellite communication system. (13 M)** BTL2<br>**Answer: Page: 375 - Dennis Roddy**<br>Rainfall results - Attenuation **(2 M)**<br>Rain attenuation - Increases frequency<br>Worse – Ku, C band. |




**(3 M)**

**Uplink rain-fade margin (4 M)**
Rainfall Results: Increase Noise Temperature - Degrading [$C/N0$]
Earth Station HPA - Fade Margin Requirement.

**Downlink rain-fade margin (4 M)**

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

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

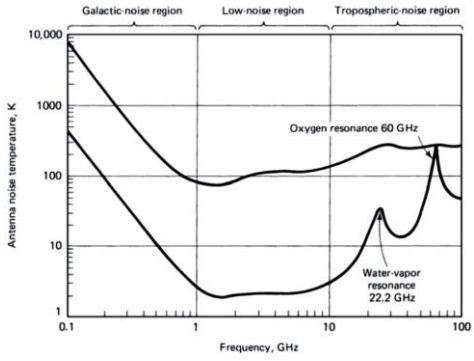
To Avoid: Gain increased
Larger Dish - receiver front end - lower noise temperature.

**Explain the performance impairment with various noise parameters. (13 M)** BTL3
**Answer: Page: 357 - Dennis Roddy**
**SYSTEM NOISE (6 M)**
Receiver power - Pico watts.
Available Noise Power $\boldsymbol{P_N = K\,T_N\,B_N}$
Noise power spectral density $\boldsymbol{N_o = \frac{P_N}{B_N} = K\,T_N}$

Intermodulation Noise: high-power amplifiers - signal products - noise **(2 M)**

Antennas Loss – Alignment **(2 M)**

2 Sky Noise - microwave radiation -finite temperatures.




**(3 M)**

3

**Discuss the various design issues related with uplink design and Input Backoff. (13 M)**
BTL2
**Answer: Page: 367 - Dennis Roddy**
Uplink: Earth station to satellite **(2 M)**

$$\left[\frac{C}{N_0}\right]_U = [\text{EIRP}]_U + \left[\frac{G}{T}\right]_U - [\text{LOSSES}]_U - [\text{K}]$$ **(8 M)**

$$[\varphi_m] = [EIRP] + 10\log\frac{1}{4\pi r^2}$$

$$-[FSL] - 10\log\frac{\lambda^2}{4\pi} = 10\log\frac{1}{4\pi r^2}$$

$$[\varphi_m] = [EIRP] - [FSL] - 10\log\frac{\lambda^2}{4\pi}$$

$$[A_O] = 10\log\frac{\lambda^2}{4\pi}$$

$$[EIRP] = [\varphi_m] + [FSL] + [A_O]$$

$$[EIRP] = [\varphi_m] + [FSL] + [A_O] + [AA] + [PL] + [AML]$$

$$[EIRP]_U = [\varphi_S] + [A_O] + [LOSSES]_U - [RFL]$$

**Input back off:** Earth station EIRP - reduced Back Off **(3 M)**

$$[EIRP]_U = [EIRP_S]_U - [B_O]_i$$

$$\left[\frac{C}{N_0}\right]_U = [\varphi_S] + [A_O] - [B_O]_i + \left[\frac{G}{T}\right]_U - [\text{K}] - [RFL]$$

4

**(i) For a satellite circuit the carrier-to-noise ratios are uplink 23 dB, downlink 20 dB, intermodulation 24 dB. Calculate the overall carrier- to-noise ratio in decibels. (7 M)**
BTL3
**Similar Problem: Page: 366 - Dennis Roddy**

$$\frac{N_o}{C} = \left(\frac{N_o}{C}\right)_U + \left(\frac{N_o}{C}\right)_D + \left(\frac{N_o}{C}\right)_{IM}$$ **(3 M)**

$$\frac{N_o}{C} = 10^{-2.4} + 10^{-2.3} + 10^{-2} = 0.0019$$

$$\left[\frac{C}{N_0}\right] = 10\log(0.0019) = 17.2\ dBHz$$ **(4 M)**

**(ii) Under clear-sky conditions, the downlink [*C*/*N*] is 20 dB, the effective noise temperature of the receiving system being 400 K. If rain attenuation exceeds 1.9 dB for 0.1 percent of the time, calculate the value below which [*C*/*N*] falls for 0.1 percent of the time. Assume *Ta* _ 280 K. (6 M)** – BTL3
**Similar Problem: Page: 363 - Dennis Roddy**

$$T_{rain} = T_a\left(1 - \frac{1}{A}\right)$$ **(3 M)**

$$T_{rain} = 280\left(1 - \frac{1}{1.55}\right) = 99.2\ K$$ **(3 M)**

**PART * C**

1 **Explain the procedures and emphasize the significance for measuring critical satellite parameters $C/N_0$ and G/T. (13 M)** BTL3

**Answer: Page: 366 - Dennis Roddy**

**Carrier to Noise Ratio:** performance of a satellite link **(2 M)**

Link budget calculations - Carrier to Noise Ratio

$$\left[\frac{C}{N_0}\right] = [\boldsymbol{P_R}] - [\boldsymbol{P_N}]$$ **(11 M)**

$$\left[\frac{C}{N_0}\right] = [\text{EIRP}] + [\text{GR}] - [\text{LOSSES}] - [\text{K}] - [\text{T}_S] - [\text{B}_N]$$

$$\left[\frac{\boldsymbol{G}}{\boldsymbol{T}}\right] = [\boldsymbol{G_R}] - [\boldsymbol{T_S}]$$

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

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

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

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

$$\left[\frac{C}{N_0}\right] = \left[\frac{C}{N}\right] + [B_N]$$

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

2 **Derive the Signal Transmission Link-Power Budget to calculate the carrier power. (15 M)** BTL3

**Answer: Page: 356 - Dennis Roddy**

**Carrier Power** - calculation of received signal **(2 M)**

Link Power Budget - transmitted power, losses and gain

**$[P_R] = [EIRP] + [G_R] - [LOSSES]$ (2 M)**

**Link Budget parameters (3 M)**

- EIRP
- Free space path loss
- System noise temperature
- Figure of merit for receiving system

- Carrier to thermal noise ratio Carrier to noise density ratio
- Carrier to noise ratio Transmitter power at the antenna
- Antenna gain compared to isotropic radiator

$$EIRP = P_t G_t = Gp_s \textbf{ (2 M)}$$

$$Maximum\ flux\ density\ \varphi_m = \frac{Gp_s}{4\pi r^2}$$

[EIRP] : [EIRP] = [$P_S$] + [G] dBW

$$G = \eta_I \left(\frac{\pi D}{\lambda}\right)^2$$

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

**Antenna Gain (3 M)**

$$G(\theta) = \frac{P(\theta)}{P_0 / 4\pi}$$

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

**[EIRP]** = [$P_S$] + [G] dBW, where:

**[LOSSES]** = [FSL] + [RFL] + [AML] + [AA] + [PL],

[FSL] - free-space spreading loss
[RFL] - receiver feeder loss
[AML] - antenna misalignment loss
[AA] - atmospheric absorption loss
[PL] -polarization mismatch loss

$$\boxed{P_r = \frac{P_t G_t G_r}{L_p L_a L_{ta} L_{ra} L_{pol} L_{other} L_r}}$$

The transmission formula: **(3 M)**

$$P_r = EIRP - L_{ta} - L_p - L_a - L_{pol} - L_{ra} - L_{other} + G_r - L_r$$

## UNIT IV SATELLITE ACCESS AND CODING METHODS

Modulation and Multiplexing: Voice, Data, Video, and Analog – Digital Transmission System, Digital Video Broadcast, Multiple Access: FDMA, TDMA, CDMA, DAMA Assignment Methods, Compression – Encryption, Coding Schemes.

### PART * A

| Q.No. | Questions |
|---|---|
| 1. | **What is a single mode of operation?** - BTL1<br>A transponder channel abroad a satellite may be fully loaded by a single transmission from an earth station. This is referred to as a single access mode of operation. |
| 2 | **What are the methods of multiple access techniques?** - BTL1<br>FDMA – Frequency Division Multiple Access Techniques<br>TDMA – Time Division Multiple Access Techniques |
| 3 | **What is an CDMA?** - BTL1<br>CDMA – Code Division Multiple Access Techniques<br>In this method, each signal is associated with a particular code that is used to spread the signal in frequency and time. |
| 4 | **Give the types of CDMA.** - BTL1<br>• Spread spectrum multiple access<br>• Pulse address multiple access |
| 5 | **What is SCPC?** - BTL1<br>SCPC means Single Channel Per Carrier. In a thin route circuit, a transponder channel (36 MHz) may be occupied by a number of single carriers, each associated with its own voice circuit. |
| 6 | **What is a thin route service?** - BTL1<br>SCPC systems are widely used on lightly loaded routes, this type of service being referred to as a thin route service. |
| 7 | **What is an TDMA? What are the advantages?** - BTL1<br>• TDMA – Time Division Multiple Access Techniques<br>Only one carrier uses the transponder at any one time, and therefore Inter modulation products, which results from the non -linear amplification of multiple carriers are absent.<br>• **Advantages:** The transponder traveling wave tube can be operated at maximum power output. |
| 8 | **What is preamble?** - BTL1<br>Certain time slots at the beginning of each burst are used to carry timing and synchronizing information. These time slots collectively are referred to as preamble. |
| 9 | **Define guard time.** - BTL1<br>It is necessary to prevent the bursts from overlapping. The guard time will vary from burst to burst depending on the accuracy with which the various bursts can be positioned within each frame. |
| 10 | **What is meant by decoding quenching?** - BTL1<br>In certain phase detection systems, the phase detector must be allowed for some time to recover from one burst before the next burst is received by it. This is known as decoding quenching. |
| 11 | **What is meant by direct closed loop feedback?** - BTL1<br>The timing positions are reckoned from the last bit of the unique word in the preamble. The loop method is also known as direct closed loop feedback. |

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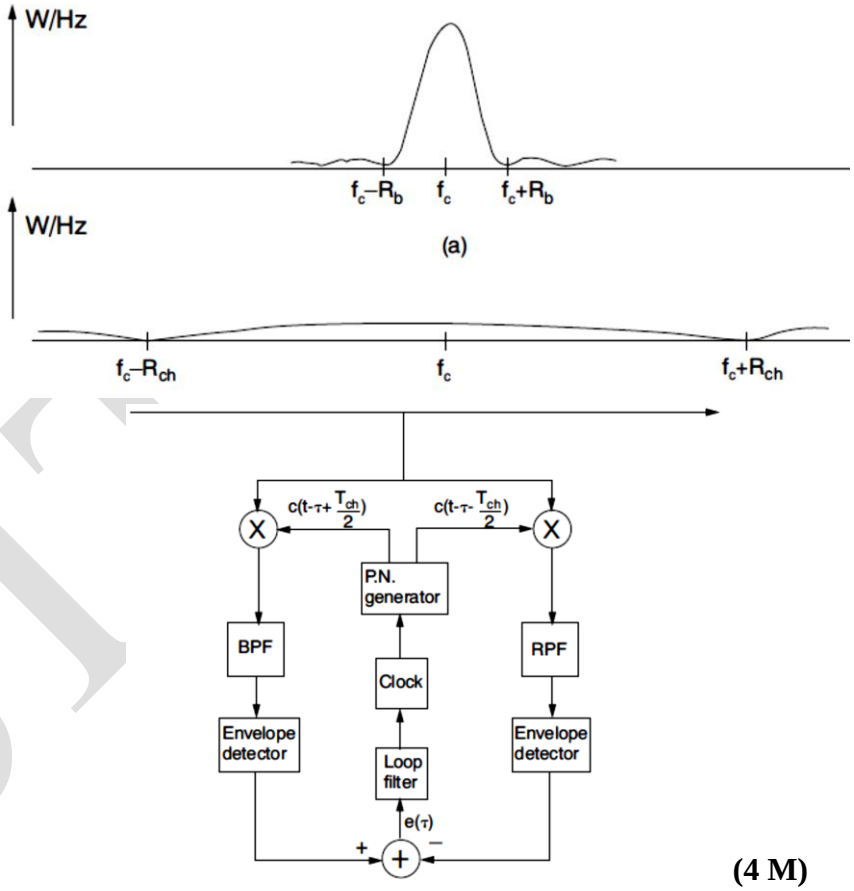
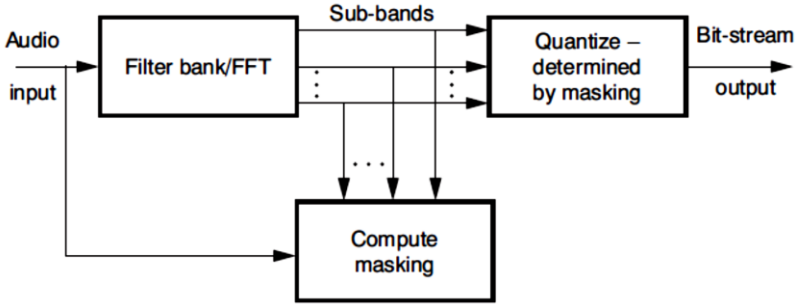
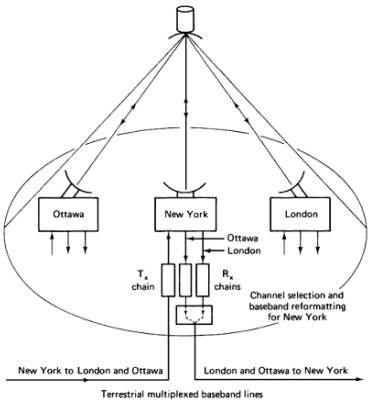
|---|---|
| 12 | **What is meant by feedback closed loop control?** - BTL1<br>The synchronization information is transmitted back to an earth station from a distant that is termed feedback closed loop control. |
| 13 | **Define frame efficiency.** - BTL1<br>It is measure of the fraction of frame time used for the transmission of traffic |
| 14 | **What is meant by digital speech interpolation?** - BTL1<br>The point is that for a significant fraction of the time, the channel is available for other transmission and advantages are taken of this in a form of demand assignment known as digital speech interpolation. |
| 15 | **What is meant by telephone load activity factor?** - BTL1<br>The fraction of time a transmission channel is active is known as the telephone load activity factor. |
| 16 | **What are the types of digital speech interpolation?** - BTL1<br>Digital time assignment speech interpolation, Speech predictive encoded communications |
| 17 | **What is meant by freeze out?** - BTL1<br>It has assumed that a free satellite channel will be found for any incoming speed spurt, but there is a finite probability that all channels will be occupied and the speech spurt lost. Losing a speech spurt in this manner is referred to as freeze out. |
| 18 | **What are the advantages of SPEC method over DSI method?** - BTL1<br>Freeze out does not occur during overload conditions. |
| 19 | **Define satellite switched TDMA?** - BTL1<br>Space Division Multiplexing can be realized by switching the antenna interconnections in synchronism with the TDMA frame rate, this being known as satellite switched TDMA. |
| 20 | **What are SS / TDMA?** - BTL1<br>repetitive sequence of satellite switch modes, also referred to as SS/TDMA |
| 21 | **What is processing gain?** - BTL1<br>The jamming or interference signal energy is reduced by a factor known as the processing gain. |
| 22 | **What is burst code word?** - BTL1<br>It is a binary word, a copy of which is stored at each earth station. |
| 23 | **What is meant by burst position acquisition?** - BTL1<br>A station just entering, or reentering after a long delay to acquire its correct slot position is known as burst position acquisition. |
| 24 | **What is an single access?** - BTL1<br>A transponder channel aboard a satellite may be fully loaded by a single transmission from earth station. |
| 25 | **What is an multiple access technique?** - BTL1<br>A transponder to be loaded by a number of carriers. These may originate from a number of earth station may transmit one or more of the carriers. |
| 26 | **What is meant by space division multiple access?** - BTL1<br>The satellite as a whole to be accessed by earth stations widely separated geographically but transmitting on the same frequency that is known as frequency reuse. This method of access known as space division multiple access. |
| 27 | **What are the limitations of FDMA-satellite access?** - BTL1<br>• If the traffic in the downlink is much heavier than that in the uplink, then FDMA is relatively inefficient. |

| | |
|---|---|
| | • Compared with TDMA, FDMA has less flexibility in reassigning channels.<br>• Carrier frequency assignments are hardware controlled. |
| 28 | **Write about pre-assigned TDMA satellite access.** - BTL1<br>Example for pre-assigned TDMA is CSC for the SPADE network. CSC can accommodate upto 49 earth stations in the network and 1 reference station. All bursts are of equal length. Each burst contains 128 bits. The bit rate is 128 Kb / s. |
| 29 | **Write about demand assigned TDMA satellite access.** - BTL1<br>The burst length may be kept constant and the number of bursts per frame used by the given station is varied when the demand is varied. |
| 30 | **What is an important feature of Intelsat SCPC system?** – BTL1<br>The system is that each channel is voice activated. This means that on a two way telephone conversation only one carriers is operative at any one time. |
| | **PART *B** |
| 1 | **Explain the principle behind spectrum spreading and dispreading and how this is used to minimize interference in a CDMA system. Also determine the throughput efficiency of the system. (13 M)** – BTL 2<br>**Answer: Page: 473 - Dennis Roddy**<br>  <br><br>**(3 M)**<br>**(4 M)**<br>Direct sequence spread spectrum **(6 M)**<br>chip rate > Information bit rate<br>BPF – PN Generator – Envelop Detector<br>CDMA Throughput |

| | |
|---|---|
| | $$N_0 = \frac{(k-1)P_R}{B_N}$$ |
| 2 | **With the neat block diagram explain the system of video compression method using MPEG-1. (13 M)** – BTL 2<br>**Answer: Page: 536 - Dennis Roddy**<br>  <br><br>**(6 M)**<br>Masking tone - Test tone **(7 M)**<br>18 dB - Masking threshold<br>S/N= 6 db<br>Frequency masking<br>Mpeg-1 - DBS systems - 192 kb/s<br>Filter Bank – Quantizer – Masking |
| 3 | **Illustrate pre assigned FDMA and Demand assigned FDMA (13 M)** – BTL 3<br>**Answer: Page: 425 - Dennis Roddy**<br>**pre assigned FDMA (7 M)**<br>Three earth stations – Ottawa - New York - London.<br>single satellite transponder<br>Communicates each other's.<br>  <br><br>**Demand assigned FDMA (6 M)**<br>Transponder frequency bandwidth – subdivided - number of channels.<br>Polling method - master earth station continuously polls - earth stations in sequence<br>Call request – encountered - frequency slots assigned - pool available frequencies. |
| 4 | **Illustrate the pre Assigned and Demand Assigned TDMA (13 M)** – BTL 3<br>**Answer: Page: 452 - Dennis Roddy**<br>CSC - 49 earth stations - network - reference station **(6 M)**<br>50 bursts in a frame. |

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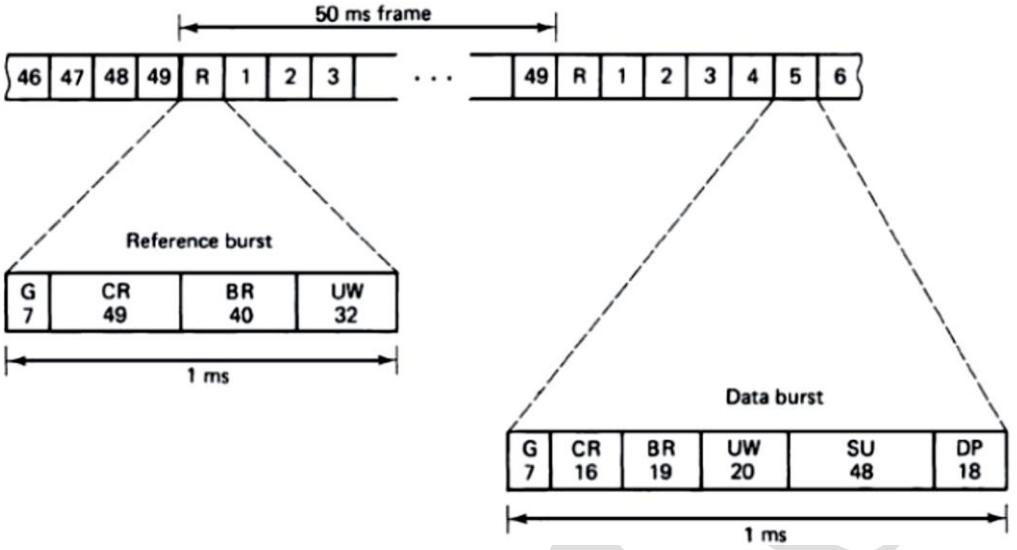
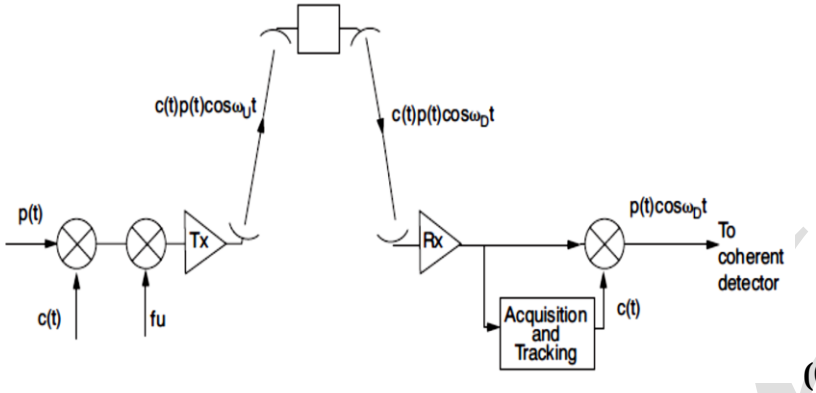
| | Burst length - constant<br>Number of bursts per frame - varied as demand requires.<br>  <br><br>**(7 M)** |
| 5 | **Derive the expression for FDMA Downlink Analysis (13 M)** – BTL 3<br>**Answer: Page: 433 - Dennis Roddy**<br>$\left(\frac{N}{C}\right) = \left(\frac{N}{C}\right)_U + \left(\frac{N}{C}\right)_D + \left(\frac{N}{C}\right)_{IM}$ **(2 M)**<br>$\left(\frac{N}{C}\right)_{REQ} \geq \left(\frac{N}{C}\right)_U + \left(\frac{N}{C}\right)_D + \left(\frac{N}{C}\right)_{IM}$ **(2 M)**<br>$\left(\frac{N}{C}\right)_{REQ} \geq \left(\frac{N}{C}\right)$ **(2 M)**<br>$\left(\frac{N}{C}\right)_{REQ} \geq \left(\frac{N}{C}\right)_D$ **(2 M)**<br>$\left[\frac{C}{N}\right]_D = [\text{EIRP}]_D + \left[\frac{G}{T}\right]_D - [\text{LOSSES}]_D - [K] - [B]$ **(2 M)**<br>$\left[\frac{C}{N}\right]_{REQ} \leq [\text{EIRP}]_{PS} + \left[\frac{G}{T}\right]_D - [\text{LOSSES}]_D - [K] - [B_{TR}]$ **(2 M)**<br>$[B] = [\alpha] + [B_{TR}] - [K]$ **(1 M)** |
| 6 | **Illustrate the Basic CDMA system in detail (13 M)** – BTL 3<br>**Answer: Page: 472 - Dennis Roddy** |




**(6 M)**

Chip Rate: **(7 M)**

$$T_{CH} = \frac{1}{R_{CH}}$$

Periodic Time:

$$T_N = NT_{ch}$$

Maximal sequence: $N = 2^n - 1$

**PART * C**

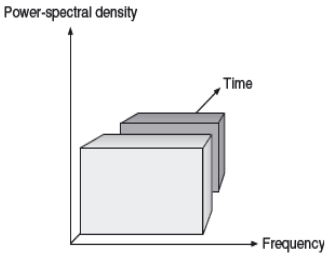
1

**Describe the principles of TDMA, FDMA and CDMA (15 M)** – BTL 2

**Answer: Page: 423 - Dennis Roddy**

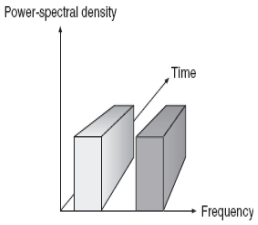
**TDMA (5 M)**

single carrier frequency - several users
System not continuous - bursts.
handoff - simpler
Duplexers - not required.
High transmission rates - FDMA channels.
High synchronization - required



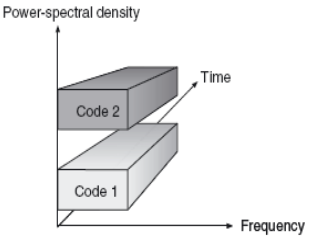

**FDMA (5 M)**

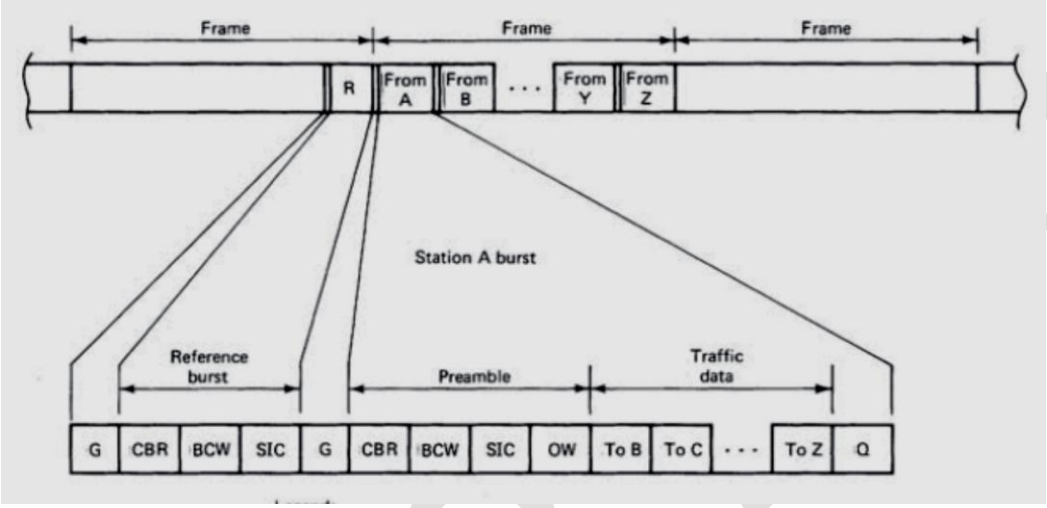
Channel carries - one phone circuit at a time.
channel not in use - cannot be used by other users
Continuous transmission scheme
Narrowband systems.
Inter-symbol interference - low.
Mobile unit - duplexers.
Requires - RF filter - adjacent channel interference



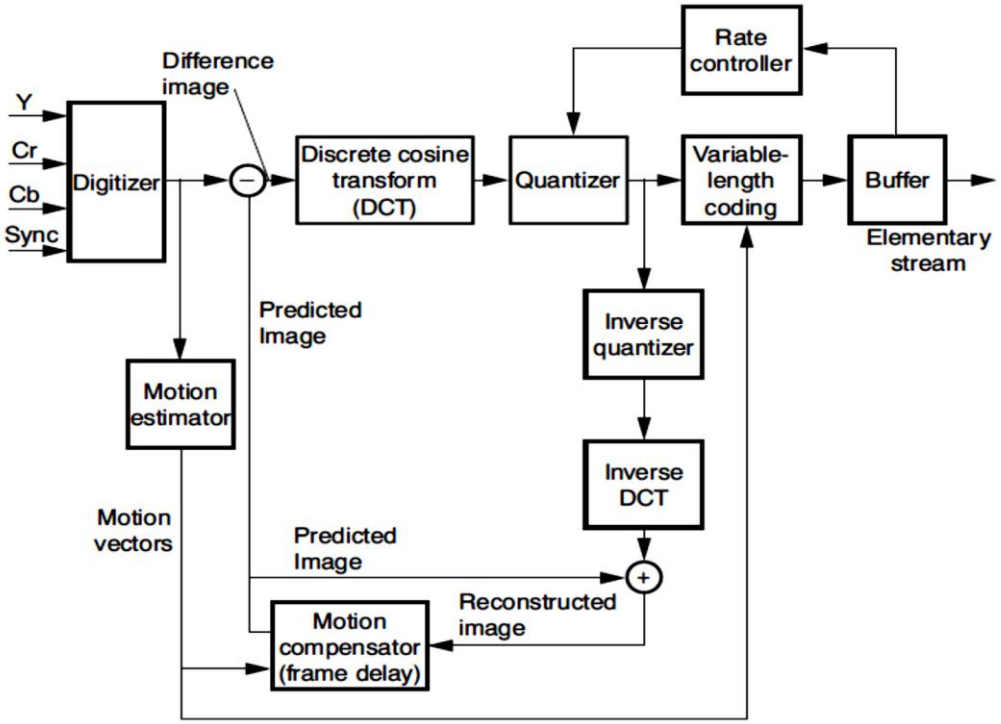

**CDMA (5 M)**

CDMA system - same frequency.
Soft capacity limit.
Frequency dependent transmission impairments
Multipath fading - substantially reduced



| | |
|---|---|
| | Channel data rates - very high<br>Macroscopic spatial diversity - soft handoff.<br>Near far problem occurs - CDMA receiver |
| 2 | **Explain the TDMA burst and frame structure of satellite system. Draw the necessary diagrams. (15 M)** – BTL 2<br>**Answer: Page: 440 - Dennis Roddy**<br>  <br><br>**(7 M)**<br>Explanation of Guard time – G **(8 M)**<br>Carrier and bit-timing recovery - CBR<br>Burst code word - BCW<br>Station identification code - SIC<br>control and delay channel - CDC<br>service channel – SC<br>voice-order-wire channel – VOW<br>Preamble<br>Postamble |
| 3 | **In detail give an account of various compression standards used in the satellite context. (15 M)** – BTL 3<br>**Answer: Page: 536 - Dennis Roddy**<br>**MPEG: (5 M)**<br>International Standards Organization - International Electrochemical Commission - (ISO/IEC)<br>MPEG-2 - video compression<br>**Analog outputs:** red (R) - green (G) - blue (B) color cameras<br>**Convert** - luminance component (Y) - chrominance components (Cr) - (Cb)<br>$\begin{bmatrix} Y \\ Cr \\ Cb \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.168736 & -0.331264 & 0.5 \\ 0.5 & -0.418688 & -0.081312 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$<br>chroma subsampling - Y:U:V<br>Y - luminance sampling rate<br>U - Cb sampling rate<br>V - Cr sampling rate |

Discrete cosine transform (DCT) - spatial frequency Domain **(5 M)**
**Motion estimation:** I – P - B frames.
MPEG-2 - multichannel audio – mono, stereo




**(5 M)**

| UNIT V SATELLITE APPLICATIONS | |
|---|---|
| INTELSAT Series, INSAT, VSAT, Mobile Satellite Services: GSM, GPS, INMARSAT, LEO, MEO, Satellite Navigational System. GPS Position Location Principles, Differential GPS, Direct Broadcast satellites (DBS/DTH). | |
| **PART * A** | |
| **Q.No.** | **Questions** |
| 1. | **Give the 3 different types of applications with respect to satellite systems.** BTL1<br>• The largest international system (Intelsat)<br>• The domestic satellite system (Dom sat) in U.S.<br>• U.S. National oceanographic and atmospheric administrations (NOAA) |
| 2 | **Mention the 3 regions to allocate the frequency for satellite services.** BTL1<br>• Region1: It covers Europe, Africa and Mongolia<br>• Region2: It covers North & South America and Greenland.<br>• Region3: It covers Asia, Australia and South West Pacific. |
| 3 | **Give the types of satellite services.** BTL1<br>• Fixed satellite service<br>• Broadcasting satellite service<br>• Mobile satellite service<br>• Navigational satellite services<br>• Meteorological satellite services |
| 4 | **What is mean by Dom sat?** BTL1<br>Domestic Satellites. These are used for voice, data and video transmissions within the country. |
| 5 | **What is mean by INTELSAT?** BTL1<br>International Telecommunication Satellite. |
| 6 | **What is mean by SARSAT?** BTL1<br>Search and rescue satellite. |
| 7 | **What are the applications of Radarsat?** BTL1<br>• Shipping and fisheries.<br>• Ocean feature mapping<br>• Iceberg detection<br>• Crop monitoring |
| 8 | **What is ECEF?** BTL1<br>The geocentric equatorial coordinate system is used with the GPS system. It is called as earth centered, earth fixed coordinate system. |
| 9 | **What is dilution of precision?** BTL1<br>Position calculations involve range differences and where the ranges are nearly equal; any error is greatly magnified in the difference. This effect, brought a result of the satellite geometry is known as dilution of precision. |
| 10 | **What is PDOP?** BTL1<br>With the GPS system, dilution of position is taken into account through a factor known as the position dilution of precision. |

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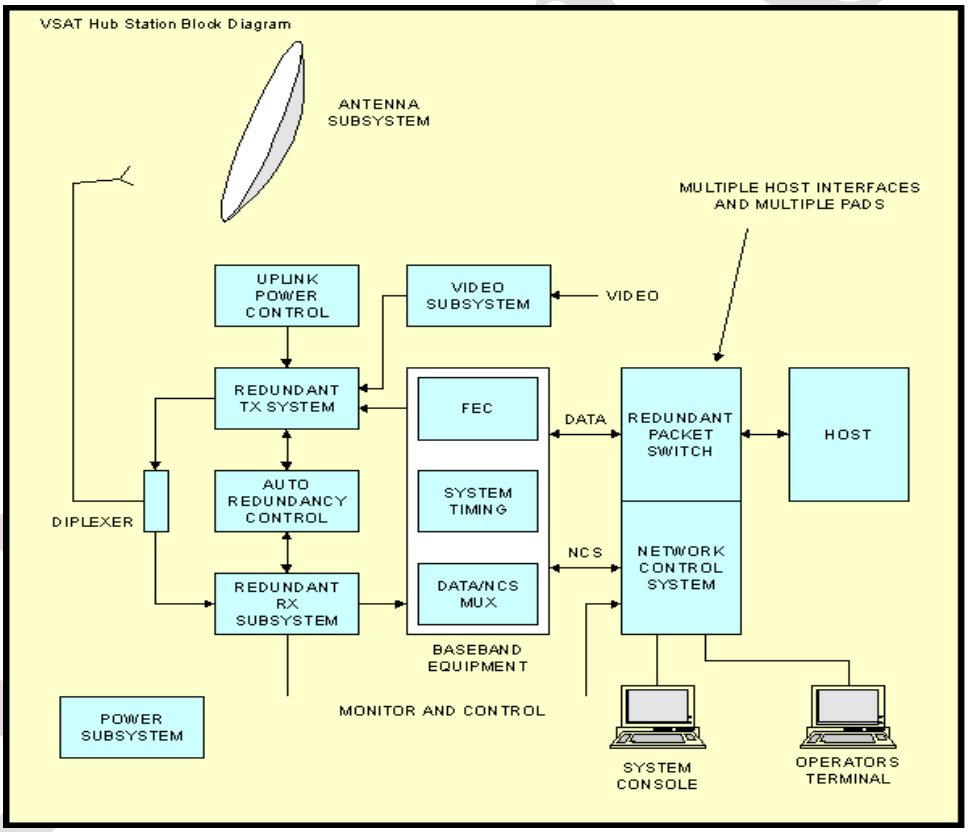
| 11 | **What is DBS?** BTL1<br>Satellites are used to provide the broadcast transmissions. It is used to provide direct transmissions into the home. The service provided is known as Direct Broadcast Satellite services. Example: Audio, TV and internet services. |
| 12 | **Give the frequency range of US DBS systems with high power satellites.** BTL3<br>• Uplink frequency range is 17.3 GHz to 17.8 GHz<br>• Downlink frequency range is 12.2 GHz to 12.7 GHz |
| 13 | **Give the frequency range of US DBS systems with medium power satellites.** BTL3<br>• Uplink frequency range is 14 GHz to 14.5 GHz<br>• Downlink frequency range is 11.7 GHz to 12.2 GHz |
| 14 | **What is DTH?** BTL1<br>DBS television is also known as Direct To Home (DTH).<br>• DTH stands for Direct-To-Home television. DTH is defined as the reception of satellite programmes with a personal dish in an individual home.<br>• DTH Broadcasting to home TV receivers take place in the ku band(12 GHz). This service is known as Direct To Home service. |
| 15 | **Write about bit rates for digital television.** BTL1<br>It depends format of the picture.<br>Uncompressed Bit rate = (Number of pixels in a frame) * (Number of pixels per second) * (Number of bits used to encode each pixel) |
| 16 | **Give the satellite mobile services.** BTL1<br>• DBS – Direct Broadcast satellite<br>• VSATS – Very Small Aperture Terminals<br>• MSATS – Mobile Satellite Service<br>• GPS – Global Positioning Systems<br>• Micro Sats<br>• Orb Comm – Orbital Communications Corporation<br>• Iridium |
| 17 | **What are GCC and GEC?** BTL1<br>• GCC - Gateway Control Centers<br>• GEC – Gateway Earth Stations |
| 18 | **What is INMARSAT?** BTL1<br>It is the first global mobile satellite communication system operated at L band and internationally used by 67 countries for communication between ships and coast so that emergency lifesaving may be provided. Also it provides modern communication services to maritime, land mobile, aeronautical and other users. |
| 19 | **List out the regions covered by INMARSAT.** BTL1<br>• Atlantic ocean region, east (AOR-E)<br>• Atlantic ocean region, west (AOR-W)<br>• Indian ocean region (IOR)<br>• Pacific ocean region (POR) |
| 20 | **What is INSAT?** BTL1<br>INSAT – Indian National Satellite System.<br>INSAT is a Indian National Satellite System for telecommunications, broadcasting, meteorology and search and rescue services. It was commissioned in 1983. INSAT was the largest domestic |

| | |
|---|---|
| | communication system in the Asia-Pacific region. |
| 21 | **What do you meant by VSAT?** BTL1<br>VSAT stands for very small aperture terminal system. The trend is toward even smaller dishes, not more than 1.5 m in diameter |
| 22 | **List out the INSAT series.** BTL1<br>• INSAT -1<br>• INSAT-2<br>• INSAT-2A<br>• INSAT-2E<br>• INSAT-3 |
| 23 | **What is GSM?** BTL1<br>GSM (Global System for Mobile communications: originally from Groupe Spécial Mobile) is the most popular standard for mobile phones in the world. GSM differs from its predecessors in that both signaling and speech channels are digital, and thus is considered a second generation (2G) mobile phone system. This has also meant that data communication was easy to build into the system. |
| 24 | **What is GPRS?** BTL1<br>General packet radio service (GPRS) is a packet oriented mobile data service available to users of the 2G cellular communication systems global system for mobile communications (GSM), as well as in the 3G systems. In the 2G systems, GPRS provides data rates of 56 -114 kbit/s. |
| 25 | **What is GPS?** BTL1<br>In the GPS system, a constellation of 24 satellites circles the earth in near-circular inclined orbits. By receiving signals from at least four of these satellites, the receiver position (latitude, longitude, and altitude) can be determined accurately. In effect, the satellites substitute for the geodetic position markers used in terrestrial surveying. In terrestrial the GPS system uses one-way transmissions, from satellites to users, so that the user does not require a transmitter, only a GPS receiver. |

| | PART *B |
|---|---|
| 1 | **Describe the operation of typical VSAT system. State briefly where VSAT systems and find widest applications. (13 M)** BTL2<br><br>**Answer: Page: 564 - Dennis Roddy**<br><br>Very Small Aperture Terminal System. **(4 M)**<br>smaller dishes - 1.5 m diameter<br>hub station - service provider<br>VSAT systems - Ku band - C-band<br>**Applications: (3 M)**<br>• Supermarket shops<br>• Chemist shops<br>• Small Business<br>• Office<br>• Commercial shipping communications.<br><br>  **(6 M)** |
| 2 | **Explain why a minimum of four satellites are visible at an earth location utilizing the GPS system for position determination. What does the term dilution of precision refer to? (13 M)** BTL2<br>**Answer: Page: 569 - Dennis Roddy**<br>The Global Positioning System - satellite based navigation system **(3 M)**<br>Operated: U.S. Department - Defense |

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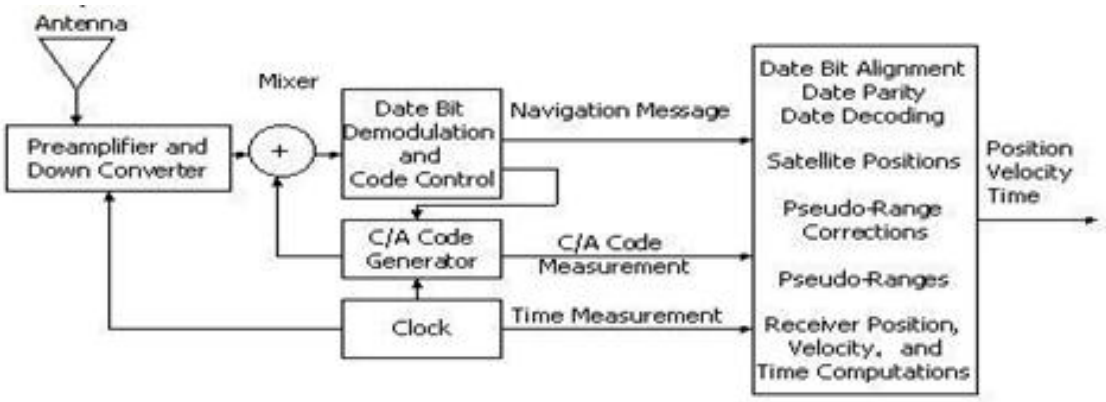
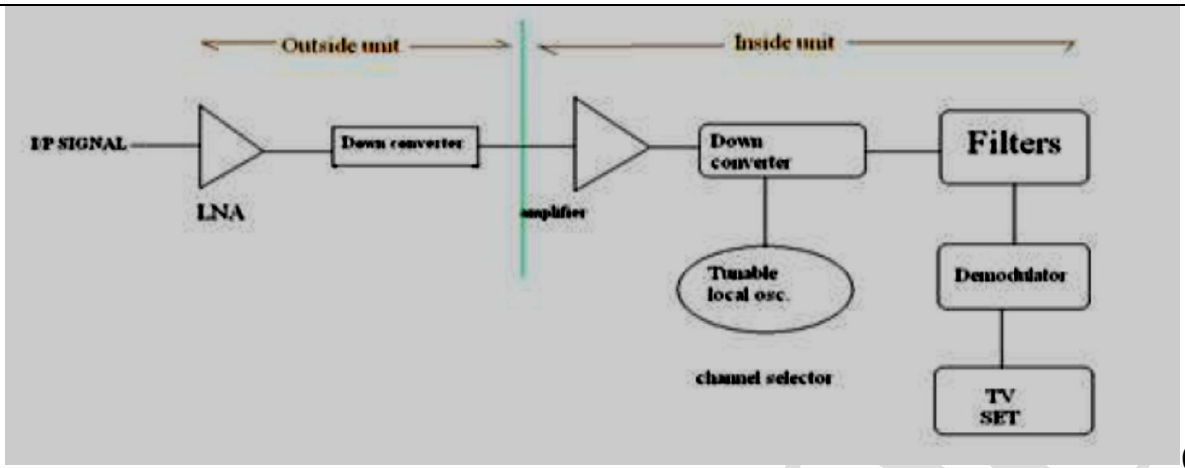
| | Major Components: satellites – control - monitor stations - receivers.<br>Operation - triangulation -exact location.<br>  <br><br>**(4 M)**<br><br>Three Segments of GPS: **(3 M)**<br>Space Segment: Satellites orbit<br>Control Segment: control - monitoring stations<br>User Segment: civilians - military<br><br>To determines a Position: **(3 M)**<br>Precise location s<br>Distance - each satellite<br>Triangulation - determine position |
| 3 | **Illustrate the concept of Direct to home Broadcast (DTH) service. (13 M)** BTL3<br><br>**Answer: Page: 531 - Dennis Roddy**<br>DTH - Direct to Home television. **(4 M)**<br>Reception of satellite programmes - personal dish - individual home.<br>ku band - 12 GHz<br>proposed - 1996.<br>Working principle:<br>KU Band - dish - set top box. |




**(5 M)**

**Advantage: (4 M)**

- Digital quality: picture - sound quality.
- Interactive channels
- provide local channels
- Satellite broadcast: rural - semi-urban areas

4 **Briefly explain about the GRAMSAT and list the silent features. (13 M)** BTL2

**Answer: Page: 492 - Dennis Roddy**

ISRO - GRAMSAT satellites **(4 M)**
Eradicate illiteracy - rural belt
Rural development of the nation.

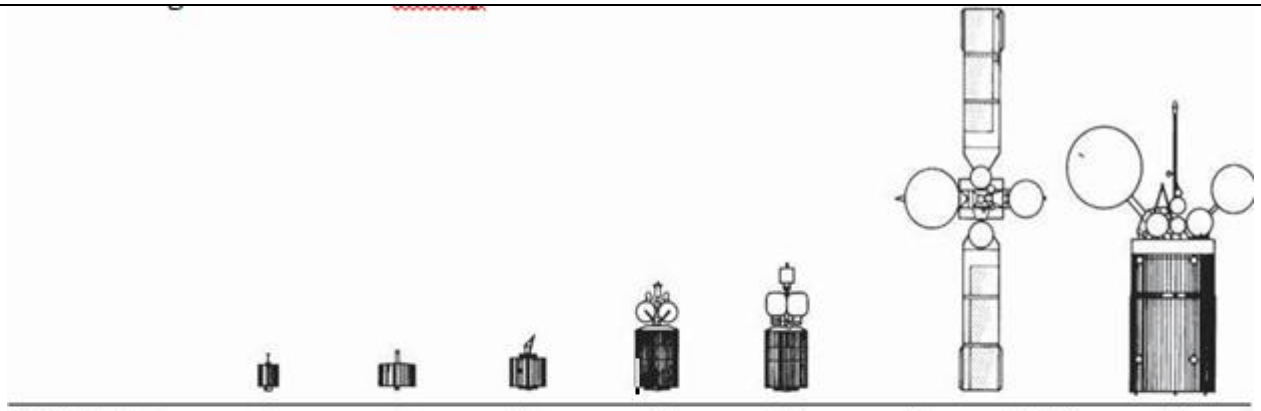
Features of GRAMSAT: **(4 M)**

- Connecting state capital to districts - blocks - villages.
- computer connectivity data broadcasting
- TV-broadcasting facilities: e governance - development information – teleconferencing - helping disaster management.
- Providing rural - education broadcasting.

Gramsat projects **(5 M)**

- Interactive training
- Broadcasting services - rural development
- Computer interconnectivity and data exchange services
- Tele health and telemedicine services

5 **Illustrate the various configurations of INSAT Series. (13 M)** BTL3
**Answer: Page: 487 - Dennis Roddy**



| Designation: Intelsat | I | II | III | IV | IV A | V | V A/V 8 | VI |
|---|---|---|---|---|---|---|---|---|
| Year of first launch | 1965 | 1966 | 1968 | 1971 | 1975 | 1980 | 1984/85 | 1986/87 |
| Prime contractor | Hughes | Hughes | TRW | Hughes | Hughes | Ford Aerospace | Ford Aerospace | Hughes |
| Width (m) | 0.7 | 1.4 | 1.4 | 2.4 | 2.4 | 2.0 | 2.0 | 3.6 |
| Height (m) | 0.6 | 0.7 | 1.0 | 5.3 | 6.8 | 6.4 | 6.4 | 6.4 |
| Launch vehicles | | Thor Delta | | Atlas-Centaur | | Atlas-Centaur and Ariane | Atlas-Centaur and Ariane | STS and Ariane |
| Spacecraft mass in transfer orbit (kg) | 68 | 182 | 293 | 1385 | 1489 | 1946 | 2140 | 12,100/3720 |
| Communications payload mass (kg) | 13 | 36 | 56 | 185 | 190 | 235 | 280 | 800 |
| End-of-life (EOL) power of equinox (W) | 40 | 75 | 134 | 480 | 800 | 1270 | 1270 | 2200 |
| Design lifetime (years) | 1.5 | 3 | 5 | 7 | 7 | 7 | 7 | 10 |
| Capacity (number of voice channels) | 480 | 480 | 2400 | 8000 | 12,000 | 25,000 | 30,000 | 80,000 |
| Bandwidth (MHz) | 50 | 130 | 300 | 500 | 800 | 2137 | 2480 | 3520 |

Any 6 Parameters **(13 M)**

**PART * C**

1

**Briefly explain the following concepts**

**i) Satellite email services (5 M)**

**ii) Internet (5 M)**

**iii) Video conferencing (5 M)** BTL2

**Answer: Page: 488 - Dennis Roddy**

**Satellite-email services: (5 M)**

Internet services - terrestrial networks,

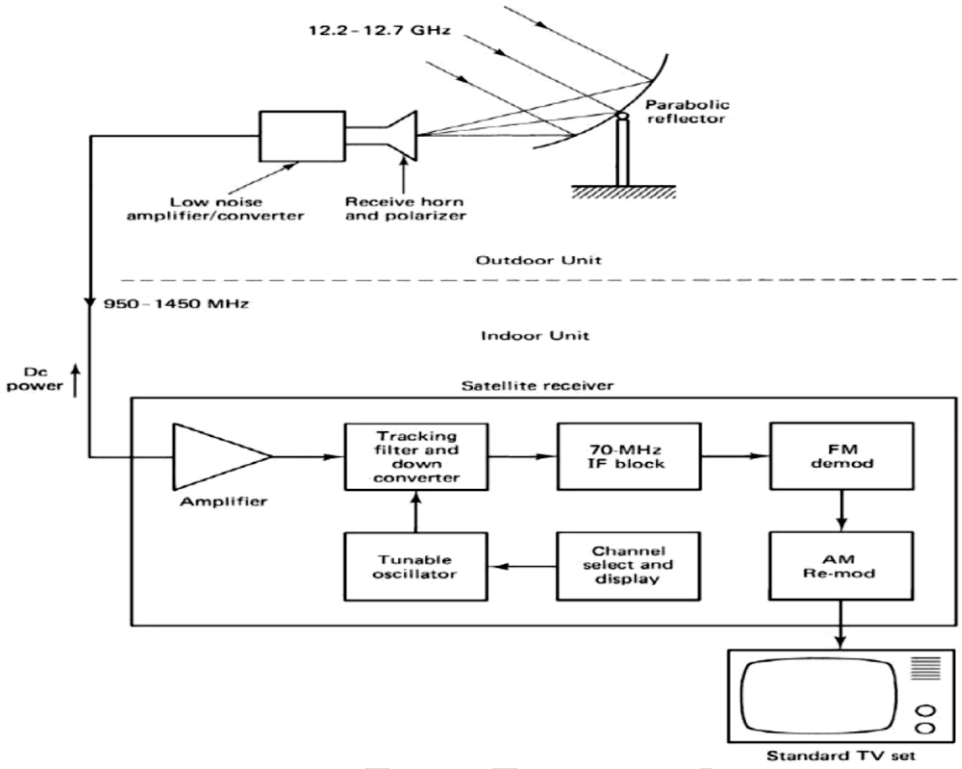
**Features and Benefits**

- No need - configure an e-mail client
- Service - low bandwidth Inmarsat terminals
- previewing Inbox and deleting any unwanted e-mails
- No surcharge – No monthly subscription fees
- Service billed - standard airtime prices.

**Video Conferencing: (5 M)**

Two way interactivity - lower cost.

| | |
|---|---|
| | video conferencing - connect each site<br><br>**Satellite Internet access: (5 M)**<br>Internet access - communications satellites.<br>geostationary satellites - high data speeds , Ka band - downstream data speeds - 50 Mbps. |
| 2 | **Illustrate the concept of GSM architecture and its services. (15 M)** BTL3<br>**Answer: Page: 492 - Dennis Roddy**<br><br>GSM - standard DCS1800 - cellular communications systems<br>**GSM architecture: (5 M)**<br>Mobile Station (MS)<br>Base Station Sub-System (BSS)<br>Network and Switching Sub-System (NSS)<br>Operation Sub -System (OSS)<br><br>**channels air interface: (5 M)**<br>FCCH, SCH, PAGCH, RACH, CBCH, BCCH, FACCH, TCH/F, TCH/H<br><br>**Mobility Management:** ability to support roaming users.<br><br>**Difficulties (5 M)**<br>a. Remote/Rural Areas.<br>b. Time to deploy.<br>c. Areas of 'minor' interest.<br>d. Temporary Coverage.<br><br>**GSM service security:**<br>Cryptographic algorithms - security.<br>A5/1, A5/2, A5/3 - stream ciphers - air voice privacy. |
| 3 | **Illustrate the Direct Broadcast Satellite service in detail. (15 M)** – BTL3<br>**Answer: Page: 209 - Dennis Roddy**<br>Direct broadcast satellite (DBS) service **(2 M)**<br>Directly to home TV receivers<br>Ku (12-GHz) band<br><br>Dish diameter - 1.83 m (6 feet) to about 3 m (10 feet) **(2 M)** |




**(6 M)**

**The outdoor unit: (2 M)**
Gain: 3 m dish - 4 GHz
1 m dish - 12 GHz
Polarization interleaving.
Low-noise amplifier (LNA)

**The Indoor unit: (3 M)**
Range 950 to 1450 MHz.
Tracking filter - desired channel
Polarization interleaving - separate the frequency.
Vestigial single side- band (VSSB)
70 MHz - FM intermediate frequency (IF)