

ROEVER ENGINEERING COLLEGE
DEPARTMENT OF ECE
EC1403 – SATELLITE COMMUNICATION

UNIT I

OVERVIEW OF SATELLITE SYSTEMS, ORBITS AND LAUNCHING METHODS

Introduction – Frequency allocations for satellite services – Intelsat – U.S domsats – Polar orbiting satellites – Problems – Kepler’s first law – Kepler’s second law – Kepler’s third law – Definitions of terms for earth – Orbiting satellites – Orbital elements – Apogee and perigee heights – Orbital perturbations – Effects of a non-spherical earth – Atmospheric drag – Inclined orbits – Calendars – Universal time – Julian dates – Sidereal time – The orbital plane – The geocentric – Equatorial coordinate system – Earth station referred to the IJK frame – The topocentric – Horizon co-ordinate system – The subsatellite point – Predicting satellite position.

PART A

1. What is Satellite? Mention the types.

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. State Kepler’s first law.

It states that the path followed by the satellite around the primary will be an ellipse. 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.

$$e = [\text{square root of } (a^2 - b^2)] / a$$

3. State Kepler’s second law.

It states that for equal time intervals, the satellite will sweep out equal areas in its orbital plane, focused at the barycenter.

4. State Kepler’s third law.

It states that the square of the periodic time of orbit is perpendicular to the cube of the mean distance between the two bodies.

$$a^3 = \mu / n^2$$

Where, n = Mean motion of the satellite in rad/sec.

μ = Earth's geocentric gravitational constant.

With the n in radians per sec. the orbital period in second is given by, $P = 2\pi / n$

5. Define Inclination.

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.

6. Define mean anomaly and true anomaly.

Mean anomaly gives an average value of the angular position of the satellite with reference to the perigee. True anomaly is the angle from perigee to the satellite position, measured at the earth's center

7. Mention the apogee and perigee height.

$$r_a = a(1+e)$$

$$r_p = a(1-e)$$

$$h_a = r_a - R_p$$

$$h_p = r_p - R_p$$

8. What is meant by azimuth angle?

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.

9. Give the 3 different types of applications with respect to satellite systems.

- The largest international system (Intelsat)
- The domestic satellite system (Dom sat) in U.S.
- U.S. National oceanographic and atmospheric administrations (NOAA)

10. Mention the 3 regions to allocate the frequency for satellite services.

- Region1: It covers Europe, Africa and Mangolia

- Region2: It covers North & South America and Greenland.
- Region3: It covers Asia, Australia and South West Pacific.

11. Give the types of satellite services.

- Fixed satellite service
- Broadcasting satellite service
- Mobile satellite service
- Navigational satellite services
- Meteorological satellite services

12. What is mean by Dom sat?

Domestic Satellites. These are used for voice, data and video transmissions within the country. These are launched by GSLV vehicles. They are designed in a manner to continuously monitor the region.

13. What is mean by INTELSAT?

International Telecommunication Satellite. It's a constellation of 17 satellites from U.S and European union. It serves as basis for GPS coordinates all over the world.

14. What is mean by SARSAT?

Search and rescue satellite. They are kind of remote sensing satellites, are useful to find the particular location during catastrophe periods.

15. Define polar-orbiting satellites.

Polar orbiting satellites orbit the earth in such a way as to cover the north and south polar regions.

16. Give the advantage of geostationary orbit.

There is no necessity for tracking antennas to find the satellite positions. They are able to monitor the particular place continuously without the necessity in change of coordinates.

17. Define look angles.

The azimuth and elevation angles of the ground station antenna are termed as look angles.

18. Write short notes on station keeping.

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.

19. What are the geostationary satellites?

The satellites present in the geostationary orbit are called geostationary satellite. The geostationary orbit is one in which the satellite appears stationary relative to the earth. It lies in equatorial plane and inclination is '0'. The satellite must orbit the earth in the same direction as the earth spin. The orbit is circular.

20. What is sun transit outage.

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.Explain about kepler laws in detail

Kepler's laws are:

1. The orbit of every planet is an ellipse with the Sun at one of the two foci.
2. A line joining a planet and the Sun sweeps out equal areas during equal intervals of time.
3. The square of the orbital period of a planet is directly proportional to the cube of the semi-major axis of its orbit.

Kepler's laws are strictly only valid for a lone (not affected by the gravity of other planets) zero-mass object orbiting the Sun; a physical impossibility. Nevertheless, Kepler's laws form a useful starting point to calculating the orbits of planets that do not deviate too much from these restrictions.

First Law

"The orbit of every planet is an ellipse with the Sun at one of the two foci."

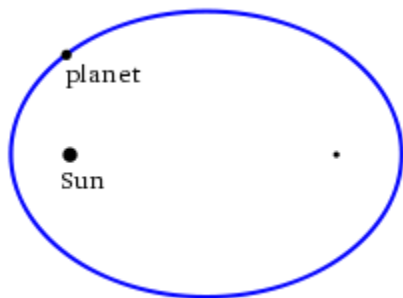
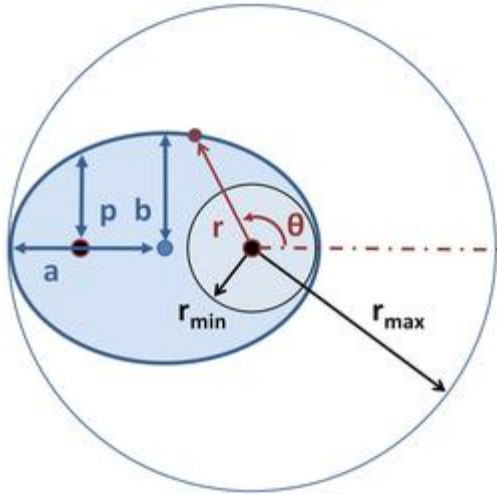


Figure 1: Kepler's first law placing the Sun at the focus of an elliptical orbit

An ellipse is a particular class of mathematical shapes that resemble a stretched out circle. (See the figure to the right.) Note as well that the Sun is not at the center of the ellipse but is at one of the focal points. The other focal point is marked with a lighter dot but is a point that has no physical significance for the orbit. Ellipses have two focal points neither of which are in the center of the ellipse (except for the one special case of the ellipse being a circle). Circles are a special case of an ellipse that are not stretched out and in which both focal points coincide at the center.



Symbolically an ellipse can be represented in polar coordinates as:

$$r = \frac{p}{1 + \varepsilon \cos \theta},$$

where (r, θ) are the polar coordinates (from the focus) for the ellipse, p is the semi-latus rectum, and ε is the eccentricity of the ellipse. For a planet orbiting the Sun then r is the distance from the Sun to the planet and θ is the angle with its vertex at the Sun from the location where the planet is closest to the Sun.

At $\theta = 0^\circ$, perihelion, the distance is minimum

$$r_{\min} = \frac{p}{1 + \varepsilon}.$$

At $\theta = 90^\circ$ and at $\theta = 270^\circ$, the distance is p .

At $\theta = 180^\circ$, aphelion, the distance is maximum

$$r_{\max} = \frac{p}{1 - \varepsilon}.$$

The semi-major axis a is the arithmetic mean between r_{\min} and r_{\max} :

$$r_{\max} - a = a - r_{\min}$$

so

$$a = \frac{p}{1 - \varepsilon^2}.$$

The semi-minor axis b is the geometric mean between r_{\min} and r_{\max} :

$$\frac{r_{\max}}{b} = \frac{b}{r_{\min}}$$

so

$$b = \frac{p}{\sqrt{1 - \varepsilon^2}}.$$

The semi-latus rectum p is the harmonic mean between r_{\min} and r_{\max} :

$$\frac{1}{r_{\min}} - \frac{1}{p} = \frac{1}{p} - \frac{1}{r_{\max}}.$$

The eccentricity ε is the coefficient of variation between r_{\min} and r_{\max} :

$$\varepsilon = \frac{r_{\max} - r_{\min}}{r_{\max} + r_{\min}}.$$

The area of the ellipse is

$$A = \pi ab.$$

The special case of a circle is $\varepsilon = 0$, resulting in $r = p = r_{\min} = r_{\max} = a = b$ and $A = \pi r^2$.

Second law

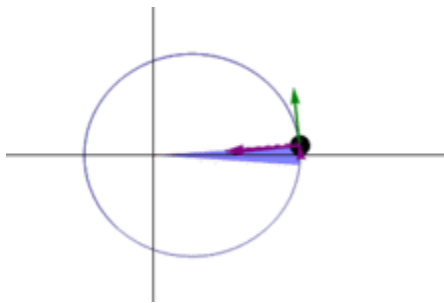


Figure 3: Illustration of Kepler's second law.

"A line joining a planet and the Sun sweeps out equal areas during equal intervals of time."

The planet moves faster near the Sun, so the same area is swept out in a given time as at larger distances, where the planet moves more slowly. The green arrow represents the planet's velocity, and the purple arrows represents the force on the planet.

To understand the second law let us suppose a planet takes one day to travel from point A to point B. The lines from the Sun to points A and B, together with the planet orbit, will define an (roughly triangular) area. This same area will be covered every day regardless of where in its orbit the planet is. Now as the first law states that the planet follows an ellipse, the planet is at different distances from the Sun at different parts in its orbit. So the planet has to move faster when it is closer to the Sun so that it sweeps an equal area.

Kepler's second law is equivalent to the fact that the force perpendicular to the radius vector is zero. The "areal velocity" is proportional to angular momentum, and so for the same reasons, Kepler's second law is also in effect a statement of the conservation of angular momentum.

Symbolically:

$$\frac{d}{dt} \left(\frac{1}{2} r^2 \dot{\theta} \right) = 0,$$

where $\frac{1}{2} r^2 \dot{\theta}$ is the "areal velocity".

This is also known as the law of equal areas. It also applies for parabolic trajectories and hyperbolic trajectories.

Third law

"The square of the orbital period of a planet is directly proportional to the cube of the semi-major axis of its orbit."

The third law, published by Kepler in 1619 [1] captures the relationship between the distance of planets from the Sun, and their orbital periods. For example, suppose planet A is 4 times as far from the Sun as planet B. Then planet A must traverse 4 times the distance of Planet B each orbit, and moreover it turns out that planet A travels at half the speed of planet B, in order to maintain equilibrium with the reduced gravitational centripetal force due to being 4 times further from the Sun. In total it takes $4 \times 2 = 8$ times as long for planet A to travel an orbit, in agreement with the law ($8^2 = 4^3$).

This third law used to be known as the **harmonic law**, because Kepler enunciated it in a laborious attempt to determine what he viewed as the "music of the spheres" according to precise laws, and express it in terms of musical notation.

This third law currently receives additional attention as it can be used to estimate the distance from an exoplanet to its central star, and help to decide if this distance is inside the habitable zone of that star.

2.Explain about various Orbital elements in detail.

Orbital elements are the parameters required to uniquely identify a specific orbit. In celestial mechanics these elements are generally considered in classical two-body systems, where a Kepler orbit is used (derived from Newton's laws of motion and Newton's law of universal gravitation). There are many different ways to mathematically describe the same orbit, but certain schemes each consisting of a set of six parameters are commonly used in astronomy and orbital mechanics.

A real orbit (and its elements) changes over time due to gravitational perturbations by other objects and the effects of relativity. A Keplerian orbit is merely a mathematical approximation at a particular time.

Required parameters

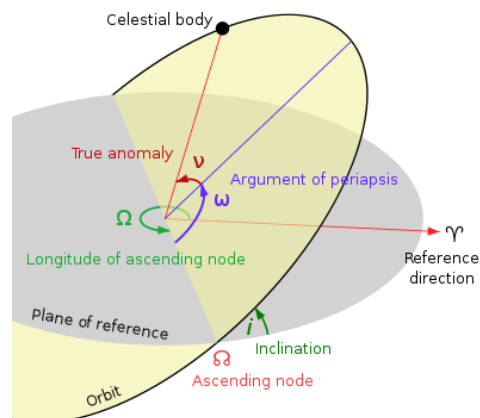
Given an inertial frame of reference and an arbitrary epoch (a specified point in time), exactly six parameters are necessary to unambiguously define an arbitrary and unperturbed orbit.

This is because the problem contains six degrees of freedom. These correspond to the three spatial dimensions which define position (the x , y , z in a Cartesian coordinate system), plus the velocity in each of these dimensions. These can be described as orbital state vectors, but this is often an inconvenient way to represent an orbit, which is why Keplerian elements (described below) are commonly used instead.

Sometimes the epoch is considered a "seventh" orbital parameter, rather than part of the reference frame.

If the epoch is defined to be at the moment when one of the elements is zero, the number of unspecified elements is reduced to five. (The sixth parameter is still necessary to define the orbit; it is merely numerically set to zero by convention or "moved" into the definition of the epoch with respect to real-world clock time.)

Keplerian elements



In this diagram, the orbital plane (yellow) intersects a reference plane (gray). For earth-orbiting satellites, the reference plane is usually the Earth's equatorial plane, and for satellites in solar orbits it is the ecliptic plane. The intersection is called the line of nodes, as it connects the center of mass with the ascending and descending nodes. This plane, together with the Vernal Point, (\mathcal{V}) establishes a reference frame.

When viewed from an inertial frame, two orbiting bodies trace out distinct trajectories. Each of these trajectories has its focus at the common center of mass. When viewed from the non-inertial frame of one body only the trajectory of the opposite body is apparent; Keplerian elements describe these non-inertial trajectories. An orbit has two sets of Keplerian elements depending on which body used as the point of reference. The reference body is called the primary, the other body is called the secondary. The primary is not necessarily more massive than the secondary, even when the bodies are of equal mass, the orbital elements depend on the choice of the primary.

The main two elements that define the shape and size of the ellipse:

- Eccentricity (e) - shape of the ellipse, describing how flattened it is compared with a circle. (not marked in diagram)
- Semimajor axis (a) - the sum of the periapsis and apoapsis distances divided by two. For circular orbits the semimajor axis is the distance between the bodies, not the distance of the bodies to the center of mass.

Two elements define the orientation of the orbital plane in which the ellipse is embedded:

- Inclination - vertical tilt of the ellipse with respect to the reference plane, measured at the ascending node (where the orbit passes upward through the reference plane) (green angle i in diagram).
- Longitude of the ascending node - horizontally orients the ascending node of the ellipse (where the orbit passes upward through the reference plane) with respect to the reference frame's vernal point (green angle Ω in diagram).

And finally:

- Argument of periapsis defines the orientation of the ellipse (in which direction it is flattened compared to a circle) in the orbital plane, as an angle measured from the ascending node to the semimajor axis. (violet angle ω in diagram)
- Mean anomaly at epoch (M_0) defines the position of the orbiting body along the ellipse at a specific time (the "epoch").

The mean anomaly is a mathematically convenient "angle" which varies linearly with time, but which does not correspond to a real geometric angle. It can be converted into the true anomaly ν , which does represent the real geometric angle in the plane of the ellipse, between periapsis (closest approach to the central body) and the position of the orbiting object at any

given time. Thus, the true anomaly is shown as the red angle ν in the diagram, and the mean anomaly is not shown.

The angles of inclination, longitude of the ascending node, and argument of periapsis can also be described as the Euler angles defining the orientation of the orbit relative to the reference coordinate system.

Note that non-elliptic orbits also exist; If the eccentricity is greater than one, the orbit is a hyperbola. If the eccentricity is equal to one and the angular momentum is zero, the orbit is radial. If the eccentricity is one and there is angular momentum, the orbit is a parabola.

Alternative parameterizations

Keplerian elements can be obtained from orbital state vectors (x-y-z coordinates for position and velocity) by manual transformations or with computer software.

Other orbital parameters can be computed from the Keplerian elements such as the period, apoapsis, and periapsis. (When orbiting the earth, the last two terms are known as the apogee and perigee.) It is common to specify the period instead of the semi-major axis in Keplerian element sets, as each can be computed from the other provided the standard gravitational parameter, GM, is given for the central body.

Instead of the mean anomaly at epoch, the mean anomaly M , mean longitude, true anomaly ν_0 , or (rarely) the eccentric anomaly might be used. Using, for example, the "mean anomaly" instead of "mean anomaly at epoch" means that time t must be specified as a "seventh" orbital element. Sometimes it is assumed that mean anomaly is zero at the epoch (by choosing the appropriate definition of the epoch), leaving only the five other orbital elements to be specified.

Euler angle transformations

The angles Ω, i, ω are the Euler angles (α, β, γ with the notations of that article) characterizing the orientation of the coordinate system

$$\hat{x}, \hat{y}, \hat{z} \text{ from the inertial coordinate frame } \hat{I}, \hat{J}, \hat{K}$$

where:

\hat{I}, \hat{J} is in the equatorial plane of the central body and \hat{I} are in the direction of the vernal equinox. \hat{x}, \hat{y} are in the orbital plane and with \hat{x} in the direction to the pericenter.

Then, the transformation from the $\hat{I}, \hat{J}, \hat{K}$ coordinate frame to the $\hat{x}, \hat{y}, \hat{z}$ frame with the Euler angles Ω, i, ω is:

$$\begin{aligned}
x_1 &= \cos \Omega \cdot \cos \omega - \sin \Omega \cdot \cos i \cdot \sin \omega \\
x_2 &= \sin \Omega \cdot \cos \omega + \cos \Omega \cdot \cos i \cdot \sin \omega \\
x_3 &= \sin i \cdot \sin \omega \\
y_1 &= -\cos \Omega \cdot \sin \omega - \sin \Omega \cdot \cos i \cdot \cos \omega \\
y_2 &= -\sin \Omega \cdot \sin \omega + \cos \Omega \cdot \cos i \cdot \cos \omega \\
y_3 &= \sin i \cdot \cos \omega \\
z_1 &= \sin i \cdot \sin \Omega \\
z_2 &= -\sin i \cdot \cos \Omega \\
z_3 &= \cos i \text{ where} \\
\hat{x} &= x_1 \hat{I} + x_2 \hat{J} + x_3 \hat{K} \\
\hat{y} &= y_1 \hat{I} + y_2 \hat{J} + y_3 \hat{K} \\
\hat{z} &= z_1 \hat{I} + z_2 \hat{J} + z_3 \hat{K}
\end{aligned}$$

The transformation from $\hat{x}, \hat{y}, \hat{z}$ to Euler angles Ω, i, ω is:

$$\begin{aligned}
\Omega &= \arg(-z_2, z_1) \\
i &= \arg(z_3, \sqrt{z_1^2 + z_2^2}) \\
\omega &= \arg(y_3, x_3)
\end{aligned}$$

where $\arg(x, y)$ signifies the polar argument that can be computed with the standard function

Orbit prediction

Under ideal conditions of a perfectly spherical central body, and zero perturbations, all orbital elements, with the exception of the Mean anomaly are constants, and Mean anomaly

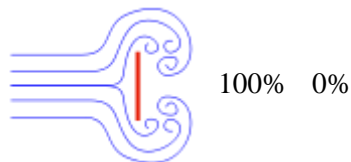
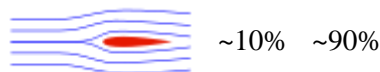
changes linearly with time, with a scaling of $\sqrt{\frac{\mu}{a^3}}$. Hence if at any instant t_0 the orbital parameters are $[e_0, a_0, i_0, \Omega_0, \omega_0, M_0]$, then the elements at time $t_0 + \delta t$ is given by $[e_0, a_0, i_0, \Omega_0, \omega_0, M_0 + \sqrt{\frac{\mu}{a^3}} \delta t]$

3. Write short notes on Atmospheric drag.

Drag (sometimes called **air resistance** or **fluid resistance**) refers to forces that oppose the relative motion of an object through a fluid (a liquid or gas). Drag forces act in a direction opposite to the oncoming flow velocity.^[1] Unlike other resistive forces such as dry friction, which is nearly independent of velocity, drag forces depend on velocity.^[2]

For a solid object moving through a fluid, the drag is the component of the net aerodynamic or hydrodynamic force acting opposite to the direction of the movement. The component perpendicular to this direction is considered lift. Therefore drag opposes the motion of the object, and in a powered vehicle it is overcome by thrust. In astrodynamics, and depending on the situation, **atmospheric drag** can be regarded as an inefficiency requiring expense of additional energy during launch of the space object or as a bonus simplifying return from orbit.

**Shape and Form Skin
flow drag friction**



Types of drag

Types of drag are generally divided into the following categories:

- parasitic drag, consisting of
 - form drag,
 - skin friction,
 - interference drag,
- lift-induced drag, and

- wave drag (aerodynamics) or wave resistance (ship hydrodynamics).

The phrase parasitic drag is mainly used in aerodynamics, since for lifting wings drag is in general small compared to lift. For flow around bluff bodies, drag is most often dominating, and then the qualifier "parasitic" is meaningless. Form drag, skin friction and interference drag on bluff bodies are not coined as being elements of parasitic drag, but directly as elements of drag. Further, lift-induced drag is only relevant when wings or a lifting body are present, and is therefore usually discussed either in the aviation perspective of drag, or in the design of either semi-planing or planing hulls. Wave drag occurs when a solid object is moving through a fluid at or near the speed of sound in that fluid — or in case there is a freely-moving fluid surface with surface waves radiating from the object, e.g. from a ship. Also, the amount of drag experienced by the ship is decided upon by the amount of surface area showing in the direction the ship is heading and the speed it is going up.

For high velocities — or more precisely, at high Reynolds numbers — the overall drag of an object is characterized by a dimensionless number called the drag coefficient, and is calculated using the drag equation. Assuming a more-or-less constant drag coefficient, drag will vary as the square of velocity. Thus, the resultant power needed to overcome this drag will vary as the cube of velocity. The standard equation for drag is one half the coefficient of drag multiplied by the fluid mass density, the cross sectional area of the specified item, and the square of the velocity.

Wind resistance is a layman's term used to describe drag. Its use is often vague, and is usually used in a relative sense (e.g., a badminton shuttlecock has more wind resistance than a squash ball).

Drag at high velocity

The drag equation calculates the force experienced by an object moving through a fluid at relatively large velocity (i.e. high Reynolds number, $Re > \sim 1000$), also called quadratic drag. The equation is attributed to Lord Rayleigh, who originally used L^2 in place of A (L being some length). The force on a moving object due to a fluid is:

$$\mathbf{F}_D = -\frac{1}{2} \rho A C_d (\mathbf{v} \cdot \mathbf{v}) \frac{\mathbf{v}}{\|\mathbf{v}\|},$$

where

\mathbf{F}_D is the force vector of drag,

ρ is the density of the fluid,^[3]

\mathbf{v} is the velocity of the object relative to the fluid,

A is the reference area,

C_d is the drag coefficient (a dimensionless parameter, e.g. 0.25 to 0.45 for a car)

The reference area A is often defined as the area of the orthographic projection of the object — on a plane perpendicular to the direction of motion — e.g. for objects with a simple shape, such as a sphere, this is the cross sectional area. Sometimes different reference areas are given for the same object in which case a drag coefficient corresponding to each of these different areas must be given.

In case of a wing, comparison of the drag to the lift force is easiest when the reference areas are the same, since then the ratio of drag to lift force is just the ratio of drag to lift coefficient.^[4] Therefore, the reference for a wing often is the planform (or wing) area rather than the frontal area.^[5]

For an object with a smooth surface, and non-fixed separation points — like a sphere or circular cylinder — the drag coefficient may vary with Reynolds number R_e , even up to very high values (R_e of the order 10^7).^{[6] [7]} For an object with well-defined fixed separation points, like a circular disk with its plane normal to the flow direction, the drag coefficient is constant for $R_e > 3,500$.^[7] Further the drag coefficient C_d is, in general, a function of the orientation of the flow with respect to the object (apart from symmetrical objects like a sphere).

Power

The power required to overcome the aerodynamic drag is given by:

$$P_d = \mathbf{F}_d \cdot \mathbf{v} = \frac{1}{2} \rho v^3 A C_d$$

Note that the power needed to push an object through a fluid increases as the cube of the velocity. A car cruising on a highway at 50 mph (80 km/h) may require only 10 horsepower (7.5 kW) to overcome air drag, but that same car at 100 mph (160 km/h) requires 80 hp (60 kW). With a doubling of speed the drag (force) quadruples per the formula. Exerting four times the force over a fixed distance produces four times as much work. At twice the speed the work (resulting in displacement over a fixed distance) is done twice as fast. Since power is the rate of doing work, four times the work done in half the time requires eight times the power.

Velocity of a falling object

The velocity as a function of time for an object falling through a non-dense medium, and released at zero relative-velocity $v = 0$ at time $t = 0$, is roughly given by a function involving a hyperbolic tangent (\tanh):

$$v(t) = \sqrt{\frac{2mg}{\rho A C_d}} \tanh \left(t \sqrt{\frac{g \rho C_d A}{2m}} \right).$$

The hyperbolic tangent has a limit value of one, for large time t . In other words, velocity asymptotically approaches a maximum value called the terminal velocity v_t :

$$v_t = \sqrt{\frac{2mg}{\rho AC_d}}$$

For a potato-shaped object of average diameter d and of density ρ_{obj} , terminal velocity is about

$$v_t = \sqrt{gd \frac{\rho_{obj}}{\rho}}$$

For objects of water-like density (raindrops, hail, live objects — animals, birds, insects, etc.) falling in air near the surface of the Earth at sea level, terminal velocity is roughly equal to

$$v_t = 90\sqrt{d},$$

with d in metre and v_t in m/s. For example, for a human body ($d \sim 0.6$ m) $v_t \sim 70$ m/s, for a small animal like a cat ($d \sim 0.2$ m) $v_t \sim 40$ m/s, for a small bird ($d \sim 0.05$ m) $v_t \sim 20$ m/s, for an insect ($d \sim 0.01$ m) $v_t \sim 9$ m/s, and so on. Terminal velocity for very small objects (pollen, etc.) at low Reynolds numbers is determined by Stokes law.

Terminal velocity is higher for larger creatures, and thus potentially more deadly. A creature such as a mouse falling at its terminal velocity is much more likely to survive impact with the ground than a human falling at its terminal velocity. A small animal such as a cricket impacting at its terminal velocity will probably be unharmed. This, combined with the relative ratio of limb cross-sectional area vs. body mass, (commonly referred to as the Square-cube law) explains why small animals can fall from a large height and not be harmed.^[8]

Very low Reynolds numbers — Stokes' drag

The equation for **viscous resistance** or **linear drag** is appropriate for objects or particles moving through a fluid at relatively slow speeds where there is no turbulence (i.e. low Reynolds number, $Re < 1$).^[9] Note that purely laminar flow only exists up to $Re = 0.1$ under this definition. In this case, the force of drag is approximately proportional to velocity, but opposite in direction. The equation for viscous resistance is:^[10]

$$\mathbf{F}_d = -b\mathbf{v}$$

where:

b is a constant that depends on the properties of the fluid and the dimensions of the object, and

\mathbf{v} is the velocity of the object

When an object falls from rest, its velocity will be

$$v(t) = \frac{(\rho - \rho_0)Vg}{b} (1 - e^{-bt/m})$$

which asymptotically approaches the terminal velocity $v_t = \frac{(\rho - \rho_0)Vg}{b}$. For a given b , heavier objects fall faster.

For the special case of small spherical objects moving slowly through a viscous fluid (and thus at small Reynolds number), George Gabriel Stokes derived an expression for the drag constant,

$$b = 6\pi\eta r$$

where:

r is the Stokes radius of the particle, and η is the fluid viscosity.

For example, consider a small sphere with radius $r = 0.5$ micrometre (diameter = $1.0 \mu\text{m}$) moving through water at a velocity v of $10 \mu\text{m/s}$. Using $10^{-3} \text{ Pa}\cdot\text{s}$ as the dynamic viscosity of water in SI units, we find a drag force of 0.09 pN . This is about the drag force that a bacterium experiences as it swims through water..

4. Write short notes on Julian day and dates

Julian day is used in the Julian date (JD) system of time measurement for scientific use by the astronomy community, presenting the interval of time in days and fractions of a day since January 1, 4713 BC Greenwich noon. The use of Julian date to refer to the day-of-year (ordinal date) is usually considered to be incorrect although it is widely used that way. Julian date is recommended for astronomical use by the International Astronomical Union

Historical Julian dates were recorded relative to GMT or Ephemeris Time, but the International Astronomical Union now recommends that Julian Dates be specified in Terrestrial Time, and that when necessary to specify Julian Dates using a different time scale, that the time scale used be indicated when required, such as JD(UT1). The fraction of the day is found by converting the number of hours, minutes, and seconds after noon into the equivalent decimal fraction.

The term Julian date is also used to refer to:

- Julian calendar dates
- ordinal dates (day-of-year)

The use of Julian date to refer to the day-of-year (ordinal date) is usually considered to be incorrect although it is widely used that way in the earth sciences, computer programming, military and the food industry.

The **Julian date** (JD) is the interval of time in days and fractions of a day since January 1, 4713 BC Greenwich noon, Julian proleptic calendar. In precise work, the timescale, e.g., Terrestrial Time (TT) or Universal Time (UT), should be specified.

The **Julian day number** (JDN) is the integer part of the Julian date (JD).^[3] The day commencing at the above-mentioned epoch is JDN 0. Now, at 06:10, Monday June 13, 2011 (UTC) the Julian day number is 2455725. Negative values can be used for dates preceding JD 0, though they predate all recorded history. However, in this case, the JDN is the greatest integer not greater than the Julian date rather than simply the integer part of the JD.

A Julian date of 2454115.05486 means that the date and Universal Time is Sunday January 14, 2007 at 13:18:59.9.

The decimal parts of a Julian date:

0.1 = 2.4 hours or 144 minutes or 8640 seconds

0.01 = 0.24 hours or 14.4 minutes or 864 seconds

0.001 = 0.024 hours or 1.44 minutes or 86.4 seconds

0.0001 = 0.0024 hours or 0.144 minutes or 8.64 seconds

0.00001 = 0.00024 hours or 0.0144 minutes or 0.864 seconds.

Almost 2.5 million Julian days have elapsed since the initial epoch. JDN 2,400,000 was November 16, 1858. JD 2,500,000.0 will occur on August 31, 2132 at noon UT.

If the Julian date of noon is applied to the entire midnight-to-midnight civil day centered on that noon,^[5] rounding Julian dates (fractional days) for the twelve hours before noon up while rounding those after noon down, then the remainder upon division by 7 represents the day of the week (see the table below). Now at 06:10, Monday June 13, 2011 (UTC) the nearest noon JDN is 2455726 yielding a remainder of 0.

The Julian day number can be considered a very simple calendar, where its calendar date is just an integer. This is useful for reference, computations, and conversions. It allows the time between any two dates in history to be computed by simple subtraction.

The Julian day system was introduced by astronomers to provide a single system of dates that could be used when working with different calendars and to unify different historical chronologies. Apart from the choice of the zero point and name, this Julian day and Julian date are not directly related to the Julian calendar, although it is possible to convert any date from one calendar to the other.

Alternatives

Because the starting point or reference epoch is so long ago, numbers in the Julian day can be quite large and cumbersome. A more recent starting point is sometimes used, for instance by dropping the leading digits, in order to fit into limited computer memory with an adequate amount of precision. In the following table, times are given in 24 hour notation.

Name	Epoch	Calculation	Current value	Notes
Julian Date (JD)	12:00 January 1, 4713 BC, Monday		2455725.75703	
Julian Day Number (JDN)	12:00 January 1, 4713 BC, Monday	$JDN = \text{floor}(JD)$	2455725	The day of the epoch is JDN 0. Changes at noon UT or TT. (JDN 0 = November 24, 4714 BC, Gregorian proleptic.)
Reduced Julian Day (RJD)	12:00 November 16, 1858, Tuesday	$RJD = JD - 2400000$	55725.75703	Used by astronomers
Modified Julian Day (MJD)	00:00 November 17, 1858, Wednesday	$MJD = JD - 2400000.5$	55725.25703	Introduced by SAO in 1957, Note that it starts from midnight rather than noon.
Truncated Julian	00:00 May 24,	$TJD = JD -$	15725.25703	- Definition as

Day (TJD)	1968, Friday 00:00 November 10, 1995, Tuesday	2440000.5 TJD = (JD - 0.5) mod 10000	5725.25703	introduced by NASA ^[6] - NIST definition
Dublin Julian Day (DJD)	12:00 December 31, 1899, Sunday	DJD = JD - 2415020	40705.75703	Introduced by the IAU in 1955
Chronological Julian Day (CJD)	00:00 January 1, 4713 BC, Monday	CJD = JD + 0.5 + time zone adjustment	2455726.2570255 (UT)	Specific to time zone; Changes at midnight zone time; UT CJD given
Lilian Day Number	October 15, 1582, Friday (as Day 1)	floor (JD - 2299160.5)	156565	The count of days of the Gregorian calendar for Lilian date reckoned in Universal time.
ANSI Date	January 1, 1601, Monday (as Day 1)	floor (JD - 2305812.5)	149913	The origin of COBOL integer dates
Rata Die	January 1, 1, Monday (as Day 1)	floor (JD - 1721424.5)	734301	The count of days of the Common Era (Gregorian)
Unix Time	January 1, 1970, Thursday	(JD - 2440587.5) 86400	× 1307945407	Counts by the second, not the day

- The **Modified Julian Day** is found by rounding downward. The MJD was introduced by the Smithsonian Astrophysical Observatory in 1957 to record the orbit of Sputnik via an IBM 704 (36-bit machine) and using only 18 bits until August 7, 2576. MJD is the epoch of OpenVMS, using 63-bit date/time postponing the next Y2K campaign to July 31, 31086 02:48:05.47.^[7]
- The **Dublin Julian Day** (DJD) is the number of days that has elapsed since the epoch of the solar and lunar ephemerides used from 1900 through 1983, Newcomb's Tables of the Sun and Ernest W. Brown's Tables of the Motion of the Moon (1919). This epoch was noon UT on January 0, 1900, which is the same as noon UT on December 31, 1899. The DJD was defined by the International Astronomical Union at their 1955 meeting in Dublin, Ireland.^[8]
- The **Chronological Julian Day** was recently proposed by Peter Meyer^{[9][10]} and has been used by some students of the calendar and in some scientific software packages.^[11]
- The **Lilian day number** is a count of days of the Gregorian calendar and not defined relative to the Julian Date. It is an integer applied to a whole day; day 1 was October 15, 1582, which was the day the Gregorian calendar went into effect. The original paper

defining it makes no mention of the time zone, and no mention of time-of-day.^[12] It was named for Aloysius Lilius, the principal author of the Gregorian calendar.

- The **ANSI Date** defines January 1, 1601 as day 1, and is used as the origin of COBOL integer dates. This epoch is the beginning of the previous 400-year cycle of leap years in the Gregorian calendar, which ended with the year 2000.
- **Rata Die** is a system (or more precisely a family of three systems) used in the book *Calendrical Calculations*. It uses the local timezone, and day 1 is January 1, 1, that is, the first day of the Christian or Common Era in the proleptic Gregorian calendar.

The Heliocentric Julian Day (HJD) is the same as the Julian day, but adjusted to the frame of reference of the Sun, and thus can differ from the Julian day by as much as 8.3 minutes, that being the time it takes the Sun's light to reach Earth. As two separate astronomical measurements can exist that were taken when the Earth, astronomical objects, and Sun are in a straight line but the Earth was actually on opposite sides of the Sun for the two measurements, that is at one roughly 500 light seconds nearer to the astronomical object than the Sun for the first measure, then 500 light seconds further from the astronomical object than the Sun for the second measure, then the subsequent light time error between two Julian Day measures can amount to nearly as much as 1000 seconds different relative to the same Heliocentric Julian Day interval which can make a significant difference when measuring temporal phenomena for short period astronomical objects over long time intervals. The Julian day is sometimes referred to as the **Geocentric Julian Day** (GJD) in order to distinguish it from HJD.

5.Explain about sidereal time in detail.

Sidereal time is a time-keeping system astronomers use to keep track of the direction to point their telescopes to view a given star in the night sky. From a given observation point, a star found at one location in the sky will be found at basically the same location at another night when observed at the same sidereal time. This is similar to how the time kept by a sundial can be used to find the location of the Sun. Just as the Sun and Moon appear to rise in the east and set in the west, so do the stars. Both solar time and sidereal time make use of the regularity of the Earth's rotation about its polar axis. The basic difference between the two is that solar time maintains orientation to the Sun while sidereal time maintains orientation to the stars in the night sky. The exact definition of sidereal time fixes it to the vernal equinox. Precession and nutation, though quite small on a daily basis, prevent sidereal time from being a direct measure of the rotation of the Earth relative to inertial space.^[1] Common time on a typical clock measures a slightly longer cycle, accounting not only for the Earth's axial rotation but also for the Earth's annual revolution around the Sun of slightly less than 1 degree per day.

A **sidereal day** is approximately 23 hours, 56 minutes, 4.091 seconds (23.93447 hours or 0.99726957 mean solar days), corresponding to the time it takes for the Earth to complete one rotation relative to the vernal equinox. The vernal equinox itself precesses very slowly in a westward direction relative to the fixed stars, completing one revolution every 26,000 years approximately. As a consequence, the misnamed sidereal day, as "sidereal" is derived from the Latin *sidus* meaning "star", is some 0.008 seconds shorter than the Earth's period of rotation relative to the fixed stars.

The longer true sidereal period is called a **stellar day** by the International Earth Rotation and Reference Systems Service (IERS). It is also referred to as the sidereal period of rotation.

The direction from the Earth to the Sun is constantly changing (because the Earth revolves around the Sun over the course of a year), but the directions from the Earth to the distant stars do not change nearly as much. Therefore the cycle of the apparent motion of the stars around the Earth has a period that is not quite the same as the 24-hour average length of the solar day.

Maps of the stars in the night sky usually make use of declination and right ascension as coordinates. These correspond to latitude and longitude respectively. While declination is measured in degrees, right ascension is measured in units of hours and minutes, because it was most natural to name locations in the sky in connection with the time when they crossed the meridian.

In the sky, the meridian is an imaginary line going from north to south that goes through the point directly overhead, or the zenith. The right ascension of any object currently crossing the meridian is equal to the current local (apparent) sidereal time, ignoring for present purposes that part of the circumpolar region north of the north celestial pole (for an observer in the northern hemisphere) or south of the south celestial pole (for an observer in the southern hemisphere) that is crossing the meridian the other way.

Because the Earth orbits the Sun once a year, the sidereal time at any one place at midnight will be about four minutes later each night, until, after a year has passed, one additional sidereal day has transpired compared to the number of solar days that have gone by.

Sidereal time, at any moment (and at a given locality defined by its geographical longitude), more precisely Local Apparent Sidereal Time (LAST), is defined as the hour angle of the vernal equinox at that locality: it has the same value as the right ascension of any celestial body that is crossing the local meridian at that same moment.

At the moment when the vernal equinox crosses the local meridian, Local Apparent Sidereal Time is 00:00. Greenwich Apparent Sidereal Time (GAST) is the hour angle of the vernal equinox at the prime meridian at Greenwich, England.

Local Sidereal Time at any locality differs from the Greenwich Sidereal Time value of the same moment, by an amount that is proportional to the longitude of the locality. When one moves eastward 15° in longitude, sidereal time is larger by one hour (note that it wraps around at 24 hours). Unlike the reckoning of local solar time in "time zones," incrementing by (usually) one hour, differences in local sidereal time are reckoned based on actual measured longitude, to the accuracy of the measurement of the longitude, not just in whole hours.

Apparent Sidereal Time (Local or at Greenwich) differs from Mean Sidereal Time (for the same locality and moment) by the Equation of the Equinoxes: This is a small difference in Right Ascension R.A. (dRA) (parallel to the equator), not exceeding about +/-1.2 seconds of time, and is due to nutation, the complex 'nodding' motion of the Earth's polar axis of rotation. It corresponds to the current amount of the nutation in (ecliptic) longitude ($d\psi$) and to the current obliquity (ϵ) of the ecliptic, so that $dRA = d\psi * \cos(\epsilon)$.

Greenwich Mean Sidereal Time (GMST) and UT1 differ from each other in rate, with the second of sidereal time a little shorter than that of UT1, so that (as at 2000 January 1 noon) 1.002737909350795 second of mean sidereal time was equal to 1 second of Universal Time (UT1). The ratio is almost constant, varying but only very slightly with time, reaching 1.002737909409795 after a century.^[2]

To an accuracy within 0.1 second per century, Greenwich (Mean) Sidereal Time (in hours and decimal parts of an hour) can be calculated as

$$GMST = 18.697374558 + 24.06570982441908 * D ,$$

where D is the interval, in days including any fraction of a day, since 2000 January 1, at 12h UT (interval counted positive if forwards to a later time than the 2000 reference instant), and the result is freed from any integer multiples of 24 hours to reduce it to a value in the range 0-24.^[3]

In other words, Greenwich Mean Sidereal Time exceeds mean solar time at Greenwich by a difference equal to the longitude of the fictitious mean Sun used for defining mean solar time (with longitude converted to time as usual at the rate of 1 hour for 15 degrees), plus or minus an

offset of 12 hours (because mean solar time is reckoned from 0h midnight, instead of the pre-1925 astronomical tradition where 0h meant noon).

Sidereal time is used at astronomical observatories because sidereal time makes it very easy to work out which astronomical objects will be observable at a given time. Objects are located in the night sky using right ascension and declination relative to the celestial equator (analogous to longitude and latitude on Earth), and when sidereal time is equal to an object's right ascension, the object will be at its highest point in the sky, or culmination, at which time it is usually best placed for observation, as atmospheric extinction is minimised.

Sidereal time is a measure of the position of the Earth in its rotation around its axis, or time measured by the apparent diurnal motion of the vernal equinox, which is very close to, but not identical to, the motion of stars. They differ by the precession of the vernal equinox in right ascension relative to the stars.

Earth's **sidereal day** also differs from its rotation period relative to the background stars by the amount of precession in right ascension during one day (8.4 ms).^[4] Its J2000 mean value is $23^{\text{h}}56^{\text{m}}4.090530833^{\text{s}}$.^[5]

Exact duration and its variation

A mean sidereal day is about 23 h 56 m 4.1 s in length. However, due to variations in the rotation rate of the Earth the rate of an ideal sidereal clock deviates from any simple multiple of a civil clock. In practice, the difference is kept track of by the difference UTC–UT1, which is measured by radio telescopes and kept on file and available to the public at the IERS and at the United States Naval Observatory.

Given a tropical year of 365.242190402 days from Simon et al.^[6] this gives a sidereal day of $86,400 \times \frac{365.242190402}{366.242190402}$, or 86,164.09053 seconds.

According to Aoki et al., an accurate value for the sidereal day at the beginning of 2000 is 1/1.002737909350795 times a mean solar day of 86,400 seconds, which gives 86,164.090530833 seconds. For times within a century of 1984, the ratio only alters in its 11th decimal place. This web-based sidereal time calculator uses a truncated ratio of 1/1.00273790935.

Because this is the period of rotation in a precessing reference frame, it is not directly related to the mean rotation rate of the Earth in an inertial frame, which is given by $\omega = 2\pi/T$ where T is the slightly longer stellar day given by Aoki et al. as 86,164.09890369732 seconds. This can be calculated by noting that ω is the magnitude of the vector sum of the rotations leading to the sidereal day and the precession of that rotation vector. In fact, the period of the Earth's rotation varies on hourly to interannual timescales by around a millisecond,^[7] together with a secular increase in length of day of about 2.3 milliseconds per century, mostly from tidal friction slowing the Earth's rotation.

Sidereal days compared to solar days on other planets

Of the eight solar planets,^[9] all but Venus and Uranus have prograde rotation—that is, they rotate more than once per year in the same direction as they orbit the sun, so the sun rises in the east. Venus and Uranus, however, have retrograde rotation. For prograde rotation, the formula relating the lengths of the sidereal and solar days is

$$\text{number of sidereal days per orbital period} = 1 + \text{number of solar days per orbital period}$$

or equivalently

$$\text{length of solar day} = \frac{\text{length of sidereal day}}{1 - \frac{\text{length of sidereal day}}{\text{orbital period}}}.$$

On the other hand, the formula in the case of retrograde rotation is

$$\text{number of sidereal days per orbital period} = -1 + \text{number of solar days per orbital period}$$

or equivalently

$$\text{length of solar day} = \frac{\text{length of sidereal day}}{1 + \frac{\text{length of sidereal day}}{\text{orbital period}}}.$$

All the solar planets more distant from the sun than Earth are similar to Earth in that, since they experience many rotations per revolution around the sun, there is only a small difference between the length of the sidereal day and that of the solar day—the ratio of the former to the latter never being less than Earth's ratio of .997 . But the situation is quite different for Mercury and Venus. Mercury's sidereal day is about two-thirds of its orbital period, so by the prograde formula its solar day lasts for two revolutions around the sun—three times as long as its sidereal day. Venus rotates retrograde with a sidereal day lasting about 243.0 earth-days, or about 1.08 times its orbital period of 224.7 earth-days; hence by the retrograde formula its solar day is about 116.8 earth-days, and it has about 1.9 solar days per orbital period.

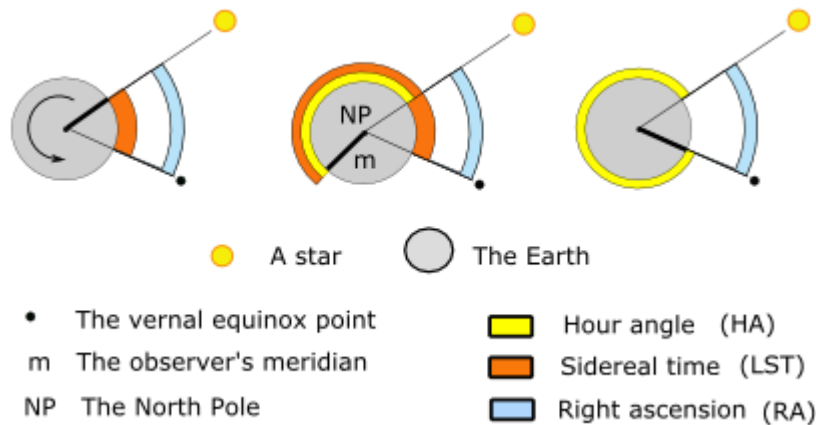
6.Explain about equatorial coordinate and geocentric coordinate system.

The **equatorial coordinate system** is a widely-used method of mapping celestial objects. It functions by projecting the Earth's geographic poles and equator onto the celestial sphere. The projection of the Earth's equator onto the celestial sphere is called the celestial equator. Similarly, the projections of the Earth's north and south geographic poles become the north and south celestial poles, respectively.

The equatorial coordinate system allows all earthbound observers to describe the apparent location in the sky of sufficiently distant objects using the same pair of numbers: the right ascension and declination. For example, a given star has roughly constant equatorial coordinates. In contrast, in the horizontal coordinate system, a star's position in the sky is different based on the geographical latitude and longitude of the observer, and is constantly changing based on the time of day.

The equatorial coordinate system is commonly used by telescopes equipped with equatorial mounts by employing setting circles. Setting circles in conjunction with a star chart or ephemeris allow a telescope to be easily pointed at known objects on the celestial sphere.

Over long periods of time, precession and nutation effects alter the Earth's orbit and thus the apparent location of the stars. Likewise, proper motion of the stars themselves will affect their coordinates as seen from Earth. When considering observations separated by long intervals, it is necessary to specify an epoch (frequently J2000.0, for older data B1950.0) when specifying coordinates of planets, stars, galaxies, etc.



Declination

The latitudinal angle of the equatorial system is called declination (Dec for short). It measures the angle of an object above or below the celestial equator.^{[1][2]} Objects in the northern celestial hemisphere have a positive declination, and those in the southern celestial hemisphere have a negative declination. For example, the north celestial pole has a declination of $+90^\circ$.

Right ascension

The longitudinal angle is called the right ascension (RA for short). It measures the angle of an object east of the apparent location of the center of the Sun at the moment of the March equinox, a position known as the vernal equinox point or the first point of Aries.^[1] The vernal equinox point is one of the two points where the ecliptic intersects with the celestial equator. Unlike geographic longitude, right ascension is usually measured in sidereal hours instead of degrees, because an apparent rotation of the equatorial coordinate system takes 24 hours of sidereal time to complete. There are $(360 \text{ degrees} / 24 \text{ hours}) = 15 \text{ degrees}$ in one hour of right ascension.

Hour angle

When calculating geography-dependent phenomena such as sunrise or moonrise, right ascension may be converted into hour angle as an intermediate step.^[3] A celestial object's hour angle is measured relative to the observer's location on the Earth; a star on the observer's celestial meridian at a given moment in time is said to have a zero hour angle. One sidereal hour later (approximately 0.997269583 solar hours later), the Earth's rotation will make that star appear to the west of the meridian, and that star's hour angle will be +1 sidereal hour.

GEI Coordinates

There are a number of cartesian variants of equatorial coordinates. The most common of these is called the geocentric equatorial inertial (GEI) coordinate system.

- GEI coordinates have the z-axis pointing along the axis of rotation of the earth (north positive), the x-axis pointing in the direction of the Sun during the vernal equinox and the y-axis defined as the cross product of z and x (in that order) to create a right-handed coordinate system. Like the polar variants described above, the direction of the x-axis drifts due to orbital precession and thus an epoch must be specified.
- In this context, J2000.0 can also refer not just to the Julian 2000 Epoch, but also to the entire GEI coordinate frame at that epoch.
- GEI systems are also sometimes "True of Date". This means that the epoch at the exact moment at which the data is collected is used as the epoch of the coordinate system.
- The direction of the x-axis is also described as the first point of the constellation Aries.
- This system is often used for describing the state vectors of spacecraft as well as various phenomena in space physics.^{[4][5][6]}
- In astronomy, **barycentric coordinates** are non-rotating coordinates with origin at the center of mass of two or more bodies.
- Within classical mechanics, this definition simplifies calculations and introduces no known problems. In the General Theory of Relativity, problems arise because, while it is possible, within reasonable approximations, to define the barycentre, the associated coordinate system does not fully reflect the inequality of clock rates at different locations. Brumberg explains how to set up barycentric coordinates in General Theory of Relativity.^[1]
- The coordinate systems involve a world-time, i.e., a global time coordinate that could be set up by telemetry. Individual clocks of similar construction will not agree with this standard, because they are subject to differing gravitational potentials or move at various

velocities, so the world-time must be slaved to some ideal clock; that one is assumed to be very far from the whole self-gravitating system. This time standard is called Barycentric Coordinate Time, abbreviated "TCB."

- Barycentric Osculating Orbital Elements for some objects in the Solar System:^[2]

Object	Semi-major axis (in AU)	Apoapsis (in AU)	Orbital period (in years)
C/2006 P1 (McNaught)	2050	4100	92600
Comet Hyakutake	1700	3410	70000
C/2006 M4 (SWAN)	1300	2600	47000
2006 SQ372	799	1570	22600
2000 OO67	549	1078	12800
90377 Sedna	506	937	11400
2007 TG422	501	967	11200

- For objects at such high eccentricity, the Sun's barycentric coordinates are more stable than heliocentric coordinates.

The **galactic coordinate system** (GCS) is a celestial coordinate system which is centered on the Sun and is aligned with the apparent center of the Milky Way galaxy. The "equator" is aligned to the galactic plane. Similar to geographic coordinates, positions in the galactic coordinate system have latitudes and longitudes.

The equivalent system referred to as J2000 has the north galactic pole at $12^{\text{h}} 51^{\text{m}} 26.282^{\text{s}} +27^{\circ} 07' 42.01''$ (J2000) (192.859508, 27.128336 in decimal degrees), the zero of longitude at the position angle of 122.932° .^[4] The point in the sky at which the galactic latitude and longitude are both zero is $17^{\text{h}} 45^{\text{m}} 37.224^{\text{s}} -28^{\circ} 56' 10.23''$ (J2000) (266.405100, -28.936175 in decimal degrees). This is offset slightly from the radio source Sagittarius A*, which is the best physical marker of the true galactic center. Sagittarius A* is located at $17^{\text{h}} 45^{\text{m}} 40.04^{\text{s}} -29^{\circ} 00' 28.1''$ (J2000), or galactic longitude $359^{\circ} 56' 39.5''$, galactic latitude $-0^{\circ} 2' 46.3''$.^[5]

The galactic equator runs through the following constellations:^[6]

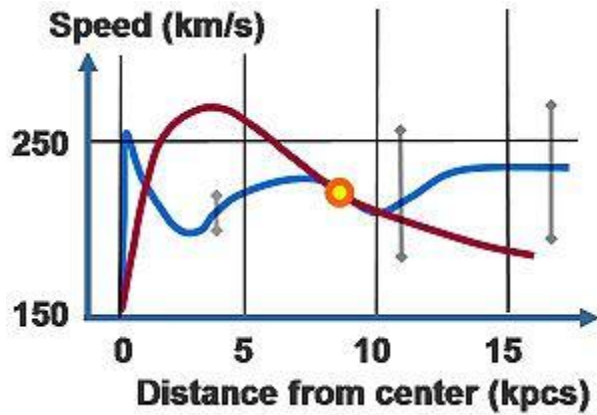
- Sagittarius
- Serpens
- Scutum
- Camelopardalis
- Perseus
- Auriga
- Vela
- Carina
- Crux

- Aquila
- Sagitta
- Vulpecula
- Cygnus
- Cepheus
- Cassiopeia

- Taurus
- Gemini
- Orion
- Monoceros
- Canis Major
- Puppis

- Centaurus
- Circinus
- Norma
- Ara
- Scorpius
- Ophiuchus

Galactic rotation



Galaxy rotation curve for the Milky Way. Vertical axis is speed of rotation about the galactic center. Horizontal axis is distance from the galactic center. The sun is marked with a yellow ball. The observed curve of speed of rotation is blue. The predicted curve based upon stellar mass and gas in the Milky Way is red. Scatter in observations roughly indicated by gray bars. The difference is due to dark matter or perhaps a modification of the law of gravity.^{[7][8][9]}



The anisotropy of the star density in the night sky makes the galactic coordinate system very useful for coordinating surveys, both those which require high densities of stars at low galactic latitudes, and those which require a low density of stars at high galactic latitudes. For this image the Mollweide projection has been applied, typical in maps using galactic coordinates.

The galactic coordinates approximate a coordinate system centered on the Sun's location. While its planets orbit counterclockwise, the Sun itself orbits the galactic center in a nearly circular path called the solar circle in a clockwise direction as viewed from the galactic north pole,^{[10][11]} at a distance of 8 kpc and a velocity of 220 km/s,^[12] which gives an approximate galactic rate of rotation (here at the location of our solar system) of 200 million years/cycle. At other locations the galaxy rotates at a different rate, depending primarily upon the distance from the galactic center. The predicted rate of rotation based upon known mass disagrees with the observed rate, as shown in the galaxy rotation curve and this difference is attributed to dark matter, although other explanations are continually sought, such as changes in the law of gravitation. The differing rates of rotation contribute to the proper motions of the stars

7. Briefly present the overview of Indian satellites.

Indian Satellites

Sl.No.	Satellite	Launch Date	Achievements
1.	Aryabhata	19.04.1975	First Indian satellite. Provided technological experience in building and operating a satellite system. Launched by Russian launch vehicle Intercosmos.
2.	Bhaskara-I	07.06.1979	First experimental remote sensing satellite. Carried TV and microwave cameras. Launched by Russian launch vehicle Intercosmos.
3.	Bhaskara-II	20.11.1981	Second experimental remote sensing satellite similar to Bhaskara-1. Provided experience in building and operating a remote sensing satellite system on an end-to-end basis. Launched by Russian launch vehicle Intercosmos.
4.	Ariane Passenger Payload Experiment (APPLE)	19.06.1981	First experimental communication satellite. Provided experience in building and operating a three-axis stabilised communication satellite. Launched by the European Ariane.
5.	Rohini Technology Payload (RTP)	10.08.1979	Intended for measuring in-flight performance of first experimental flight of SLV-3, the first Indian launch vehicle. Could not be placed in orbit.
6.	Rohini (RS-1)	18.07.1980	Used for measuring in-flight performance of second experimental launch of SLV-3.
7.	Rohini (RS-D1)	31.05.1981	Used for conducting some remote sensing technology studies using a landmark sensor payload. Launched by the first developmental launch of SLV-3
8.	Rohini (RS-D2)	17.04.1983	Identical to RS-D1. Launched by the second developmental launch of SLV-3.
9.	Stretched Rohini Satellite Series (SROSS-1)	24.03.1987	Carried payload for launch vehicle performance monitoring and for Gamma Ray astronomy. Could not be placed in orbit.
10.	Stretched Rohini	13.07.1988	Carried remote sensing payload of German space

	Satellite Series (SROSS-2)		agency in addition to Gamma Ray astronomy payload. Could not be placed in orbit.
11.	Stretched Rohini Satellite Series (SROSS-C)	20.05.1992	Launched by third developmental flight of ASLV. Carried Gamma Ray astronomy and aeronomy payload.
12.	Stretched Rohini Satellite Series (SROSS-C2)	04.05.1994	Launched by fourth developmental flight of ASLV. Identical to SROSS-C. Still in service.

Indian National Satellite System (INSAT)

13.	INSAT-1A	10.04.1982	First operational multi-purpose communication and meteorology satellite procured from USA. Worked only for six months. Launched by US Delta launch vehicle.
14.	INSAT-1B	30.08.1983	Identical to INSAT-1A. Served for more than design life of seven years. Launched by US Space Shuttle.
15.	INSAT-1C	21.07.1988	Same as INSAT-1A. Served for only one and a half years. Launched by European Ariane launch vehicle.
16.	INSAT-1D	12.06.1990	Identical to INSAT-1A. Launched by US Delta launch vehicle. Still in service.
17.	INSAT-2A	10.07.1992	First satellite in the second-generation Indian-built INSAT-2 series. Has enhanced capability than INSAT-1 series. Launched by European Ariane launch vehicle. Still in service.
18.	INSAT-2B	23.07.1993	Second satellite in INSAT-2 series. Identical to INSAT-2A. Launched by European Ariane launch vehicle. Still in service.
19.	INSAT-2C	07.12.1995	Has additional capabilities such as mobile satellite service, business communication and television outreach beyond Indian boundaries. Launched by European launch vehicle. In service.
20.	INSAT-2D	04.06.1997	Same as INSAT-2C. Launched by European launch vehicle Ariane. Inoperable since Oct 4, 97 due to power bus anomaly.
21.	INSAT-2DT	January	Procured in orbit from ARABSAT

		1998	
22.	INSAT-2E	03.04.1999	Multipurpose communication & meteorological satellite launched by Ariane.
23.	INSAT-3B	22.03.2000	Multipurpose communication - business communication, developmental communication and mobile communication purpose.
24.	GSAT-1	18.04.2001	Experimental Satellite for the first developmental flight of Geo-synchronous Satellite Launch Vehicle, GSLV-D1.
25.	INSAT-3C	24.01.2002	To augment the existing INSAT capacity for communication and broadcasting, besides providing continuity of the services of INSAT-2C.
26.	KALPANA-1	12.09.2002	METSAT was the first exclusive meteorological satellite built by ISRO named after Kalpana Chawla.
27.	INSAT-3A	10.04.2003	Multipurpose Satellite for communication and broadcasting, besides providing meteorological services along with INSAT-2E and KALPANA-1.
28.	GSAT-2	08.05.2003	Experimental Satellite for the second developmental test flight of India's Geosynchronous Satellite Launch Vehicle, GSLV
29.	INSAT-3E	28.09.2003	Exclusive communication satellite to augment the existing INSAT System.
30.	EDUSAT	20.09.2004	India's first exclusive educational satellite.
31.	HAMSAT	05.05.2005	Microsatellite for providing satellite based Amateur Radio Services to the national as well as the international community (HAMs).
32.	INSAT-4A	22.12.2005	The most advanced satellite for Direct-to-Home television broadcasting services.
33.	INSAT-4C	10.07.2006	State-of-the-art communication satellite - could not be placed in orbit.
34.	INSAT-4B	12.03.2007	An identical satellite to INSAT-4A further augment the INSAT capacity for Direct-To-Home (DTH) television services and other communications.
35.	INSAT-4CR	02.09.2007	Designed to provide Direct-To-home (DTH) television services, Video Picture Transmission (VPT) and Digital Satellite News Gathering (DSNG), identical to

INSAT- 4C .**Indian Remote Sensing Satellite (IRS)**

36.	IRS-1A	17.03.1988	First operational remote sensing satellite. Launched by a Russian Vostok.
37.	IRS-1B	29.08.1991	Same as IRS-1A. Launched by a Russian Launch vehicle, Vostok. Still in service.
38.	IRS-1E	20.09.1993	Carried remote sensing payloads. Could not be placed in orbit.
39.	IRS-P2	15.10.1994	Carried remote sensing payload. Launched by second developmental flight of PSLV.
40.	IRS-1C	28.12.1995	Carries advanced remote sensing cameras. Launched by Russian Molniya launch vehicle. Still in service.
41.	IRS-P3	21.03.1996	Carries remote sensing payload and an X-ray astronomy payload. Launched by third developmental flight of PSLV. Still in service.
42.	IRS-1D	29.09.1997	Same as IRS-1C. Launched by India's PSLV service. In service.
43.	IRS-P4 Oceansat	26.05.1999	Carries an Ocean Colour Monitor (OCM) and a Multi-frequency Scanning Microwave Radiometer (MSMR), Launched by India's PSLV-C2,
44.	Technology Experiment Satellite (TES)	22.10.2001	Technology Experiment Satellite Launched by PSLV-C3 .
45.	IRS-P6 Resourcesat-1	17.10.2003	Launched by PSLV - C5, carries three camera, names, LISS-4, LISS-3 and AwIFS
46.	CARTOSAT -1	05.05.2005	Launched by PSLV-C6, carries two panchromatic cameras - PAN (fore) and PAN (aft) - with 2.5 meter resolution. The cam mounted with a tilt of +26 deg and -5 deg along the track to provide stereo images.
47.	CARTOSAT - 2	10.01.2007	Launched by PSLV-C7, it is an advanced remote sensing satellite carrying a panchromatic camera capable of providing scene specific spot imageries.
48.	SRE - 1	10.01.2007	Launched by PSLV-C7, Space capsule Recovery Experiment (SRE-1), intended to demonstrate the technology of an orbiting platform for performing experiments in microgravity conditions. SRE-1 was recovered successfully after 12 days over Bay of

			Bengal.
49.	CARTOSAT-2A	28.04.2008	Identical to CARTOSAT - 2, launched by PSLV-C9
50.	IMS-1	28.04.2008	Launched by PSLV-C9 along with CARTOSAT-2A and other Eight Nanosatellites

8.Explain about various frequencies used for satellite Communication.

Frequency Bands for Satellite Communication:-

BAND	DOWNLINK [MHz]	UPLINK [MHz]
UHF-military	250-270	292-312
C-commercial	3700-4200	5925-6425
X-military	7250-7750	7900-8400
Ku-commercial	11700-12200	14000-14500
Ka-commercial	17700-21200	27500-30000
Ka-military	20200-21200	43500-45500

C Band:

C Band is the original frequency allocation for communications satellites.C-Band uses 3.7-4.2GHz for downlink and 5.925-6.425Ghz for uplink. The lower frequencies used by C Band perform better under adverse weather conditions than the Ku band or Ka band frequencies.

C Band Variants

Slight variations of C Band frequencies are approved for use in various parts of the world.

Band	TX Frequency	RX Frequency
Extended C Band	5.850 - 6.425 GHz	3.625 - 4.200 GHz
Super Extended C-Band	5.850 - 6.725 GHz	3.400 - 4.200 GHz
INSAT C-Band	6.725 - 7.025 GHz	4.500 - 4.800 GHz

Palapa C-Band	6.425 - 6.725 GHz	3.400 - 3.700 GHz
Russian C-Band	5.975 - 6.475 GHz	3.650 - 4.150 GHz
LMI C-Band	5.7250 - 6.025 GHz	3.700 - 4.000 GHz

C Band Dishes

C Band requires the use of a large dish, usually 6' across. C Band dishes vary between 3' and 9' across, depending upon signal strength. Because C Band dishes are so much larger than Ku and Ka Band dishes, a C Band dish is sometimes referred to in friendly jest as a BUD (Big Ugly Dish).



Ku band

The Ku band (Kurtz-under band) is primarily used for satellite communications, particularly for editing and broadcasting satellite television. This band is split into multiple segments broken down into geographical regions, as determined by the ITU (International Telecommunication Union). The Ku band is a portion of the electromagnetic spectrum in the microwave range of frequencies ranging from 11.7 to 12.7GHz. (downlink frequencies) and 14 to 14.5GHz (uplink frequencies).

The most common Ku band digital reception format is DVB (main profile video format) .vs the studio profile digital video format or the full-blown Digicipher II 4DTV format. The first commercial television network to extensively utilize the Ku Band for most of its affiliate feeds was NBC, back in 1983. The ITU Region 2 segments covering the majority of the Americas are between 11.7 and 12.2 GHz, with over 21 FSS North American Ku-band satellites currently orbiting.

Each requires a 0.8-m to 1.5-m antenna and carries twelve to twenty four transponders, of which consume 20 to 120 watts (per transponder), for clear reception. The 12.2 to 12.7 GHz segment of the Ku Band spectrum is allocated to the broadcasting satellite service (BSS). These direct broadcast satellites typically carry 16 to 32 transponders. Each provides 27 MHz in bandwidth,

and consumes 100 to 240 watts each, accommodating receiver antennas down to 450 mm (18 inches).

The ITU Region 1 segments of the Ku spectrum represent Africa and Europe (11.45 to 11.7 GHz band range and 12.5 to 12.75 GHz band range) is reserved for the fixed satellite service (FSS), with the uplink frequency range between 14.0 and 14.5 GHz).

Ku Band Difficulties

When frequencies higher than 10 GHz are transmitted and received used in a heavy rain fall area, a noticeable degradation occurs, due to the problems caused by and proportional to the amount of rain fall (commonly known as known as "rain fade").

This problem can be combatted, however, by deploying an appropriate link budget strategy when designing the satellite network, and allocating a higher power consumption to overcome rain fade loss. In terms of end-viewer TV reception, it takes heavy rainfalls in excess of 100 mm per hour to have a noticeable effect.

The higher frequency spectrum of the Ku band is particularly susceptible to signal degradation-considerably more so than C band satellite frequency spectrum, though the Ku band is less vulnerable to rain fade than the Ka band frequency spectrum. A similar phenomena, called "snow fade" (when snow accumulation significantly alters the focal point of your dish) can also occur during Winter Season.

Also, the Ku band satellites typically require considerably more power to transmit than the C band satellites. However, both Ku and Ka band satellite dishes to be smaller (varying in size from 2' to 5' in diameter.)

Ku Band Satellite Service Downlink Usage Frequency Range

The Ku band downlink uses frequencies between 11.7 and 12.7GHz.

The Ku band downlink frequencies are further subdivided according to their assigned use:

Ku Band Usage	Downlink
Fixed Satellite Service	11.7 - 12.2GHz
Broadcast Satellite Service	12.2 - 12.7GHz

Services that can be found on the Ku-band include educational networks, business networks, sports backhauls, tele- conferences, mobile news truck feeds, international programming, and various SCPC (Single Channel Per Carrier) transmissions of analog audio, as well as FM audio services.

If you already have a operational C-band system in place, you can retrofit it to accept Ku band frequencies.

In order to do so, you will need to obtain a Ku-band LNB as well as a C/Ku band feed-horn, plus some coax cable for your Ku-band LNB.

As for the coax cable recommended- RG-6 is optimal for low loss in the 950-1450 frequency range- what Ku-band LNB processes. However, if RG-59 is your only viable option, it'll work in a pinch.

Ku Band Dish Antenna Compatibility

If you have a solid dish, you should have no problem converting from C band, to Ku band. However, with a mesh dish- if the "holes" in the mesh are greater than a quarter inch, the chances of computability are not in your favor, due to the fact that your dish won't reflect Ku-band signals properly.

Therefore, you'll want to strongly consider upgrading to either a solid dish, or a mesh dish in which the hole size under 1/4", and ideally you'll want a dish that is 1 piece (or at least very few pieces); as 4 section dish is more optimal than an 8 section dish.

The fewer the sections, the more accurate your parabola shape is and thereby the more difficult it is for your dish to become warped (the smaller the number of seams- the better). And insofar as dish mounts go, the H2H (Horizon-to-Horizon) dish mount is more desirable than a polar mount.

This is due to the fact that the Ku-band demands that the dish antenna system is well-targeted and able to closely follow the orbital arc, of which the H2H mount does quite admirably, as compared to a polar mount. Also, bear in mind that you will be adjusting both the azimuth and elevation, which can be a bit tricky occasionally.

Importance of Satellite Antenna Dish Parabola

The parabolic shape of your dish is of critical importance, as warpage causes signal degradation via mis-reflection, seriously down-grading your overall system performance. Some tape and string is all that is required to do a quick warpage check and some tape.

Anchor a piece of string, stretched as tight as possible, "north" to "south" across your dish face, edge to edge. You'll want to do the same thing again, with another piece of string, only "east" to "west" across the dish face- at 90 degree angles. Be sure that both strings are tight-

If the strings come together anywhere but the direct center, then your dish has sustained warp damage and needs to be bent back into proper parabola shape, for optimal performance. If they connect in the center of your dish, likely that your dish is not warped.

So therefore, you'll want to use either the tri-supports or quad supports , as they will greatly assist in keeping your Ku-band feed-horn highly stable, even in high winds.

When your button-hook feed moving in the wind, your Ku-band reception can can easily drop out. By putting guy-wires on the button-hook feed, you'll create the much-needed support, in the event you are not able to obtain a tri support or quad support.



Ka band

The Ka band uplink uses frequencies between 27.5GHz and 31GHz and the downlink uses frequencies between 18.3 and 18.8GHz and between 19.7 and 20.2GHz. Ka band dishes can be much smaller than C band dishes. Ka band dishes vary from 2' to 5' in diameter. Ka band satellites typically transmit with much more power than C band satellites. The higher frequencies of Ka band are significantly more vulnerable to signal quality problems caused by rainfall, known as rainfade



L band

L band is a frequency range between 390MHz and 1.55GHz which is used for satellite communications and for terrestrial communications between satellite equipment. The high frequencies utilized by C band, Ku band, and Ka band would suffer from high signal loss when transported over a copper coax cable such as an Intra-Facility Link.

An LNB is used to convert these higher frequency bands to L band, which can be transmitted over the IF and processed by the IDU. Some satellites transmit on L band, such as GPS satellites

S band

S band is a frequency range from approximately 1.55 to 5.2GHz which is used for Digital Audio Radio Satellite (DARS) satellite radio systems such as Sirius Satellite Radio and XM Satellite Radio. S band is also used by some weather and communications satellites.

UNIT II

GEOSTATIONARY ORBIT AND SPACE SEGMENT

Introduction – Antenna look angles – The polar mount antenna – Limits of visibility – Near geostationary orbits – Earth eclipse of satellite – Sun transit outage – Launching orbits – Problems – Power supply – Attitude control – Spinning satellite stabilization – Momentum wheel stabilization – Station keeping – Thermal control – TT&C subsystem – Transponders – Wide band receiver – Input demultiplexer – Power amplifier – Antenna subsystem – Morelos-anik – E-advanced tiros – N spacecraft

PART A

1. Give the two segments of basic satellite communication.

a. Earth segment (or) ground segment

b. Space segment

2. Write short notes on attitude control system.

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?

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?

It refers to the equipment used to provide the service for which the satellite has been launched.

5. What is meant by transponder?

In a communication satellite, the equipment which provides the connecting link between the satellite's transmit and receive antennas is referred to as the transponder.

6. Write short notes on station keeping.

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?

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 zero 'g'?

Zero 'g' is a state when the gravitational attraction is opposed by equal and opposite inertial forces and the body experiences no mechanical stress.

9. Describe the spin stabilized satellites.

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 are 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.

10. What is meant by frequency reuse?

The carrier with opposite senses of polarization may overlap in frequency. This technique is known as frequency reuse.

11. What is meant by spot beam antenna?

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.

12. What is meant by momentum wheel stabilization?

During the spin stabilization, flywheels may be used rather than spinning the satellite. These flywheels are termed as momentum wheels.

13. What is polarization interleaving?

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.

14. Define S/N ratio.

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.

15. What is noise weighting?

The method used to improve the post detection signal to noise ratio is referred to as noise weighting.

16. What is an intermodulation noise?

Intermodulation distortion in high power amplifier can result in signal product which appear as noise and it is referred to as intermodulation noise.

17. What is an antenna loss?

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.

18. Define sky noise.

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.

19. Define noise factor.

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 290 k.

20. What is TWTA?

TWTA means Traveling Wave Tube Amplifier. The TWTA is widely used in transponder to provide the final output power required to the transtube and its power supplies.

PART B

1.Explain the method of calculating antenna look angles with example.

Determination of the Azimuth and Elevation angles (Look Angles)

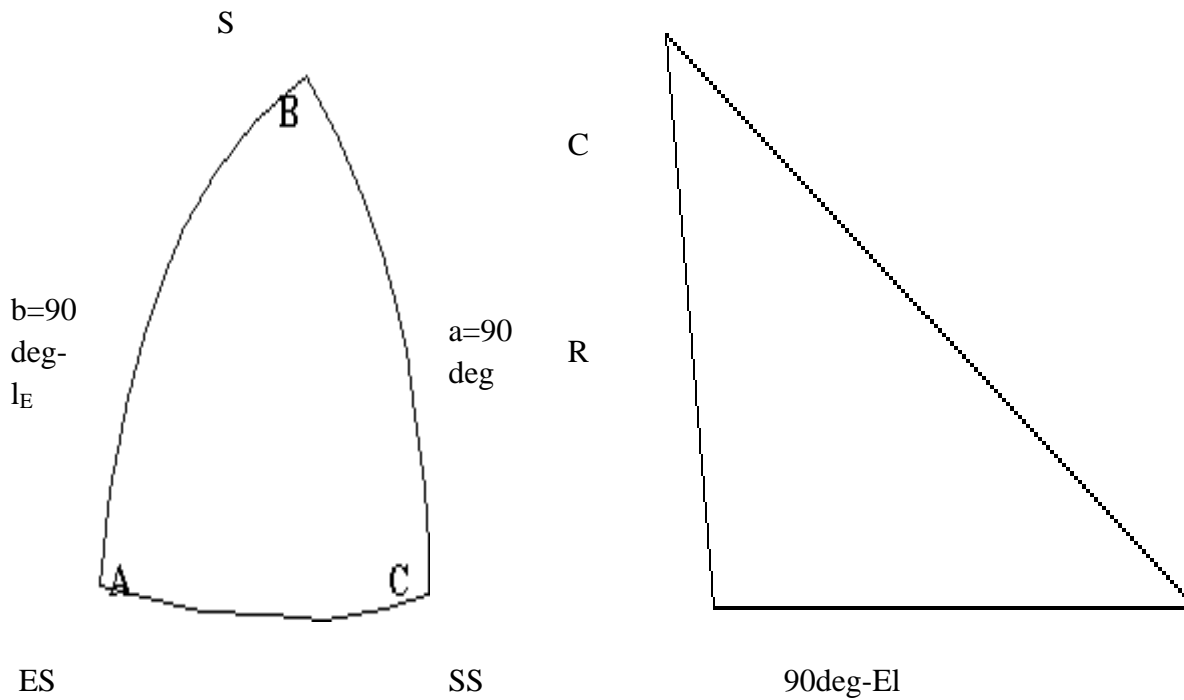


Figure-1 shows spherical triangle bounded by points N, ES, and SS.

Here ES denotes the earth station. The point s denotes the satellite in geostationary orbit, and point SS the sub satellite point. To solve this triangle we have to use Napier's rules. By solving we get following results.

Let l_E represents the latitude of the earth station, f_E represents the longitude and of the earth station, f_s the longitude of sub satellite point, and observing the sign convention stated previously, B can not exceed a theoretical limit of 81.3° , set by horizon. Once angle A is determined, the azimuth angle A_Z can be found. Four situations must be considered, the results for which can be summarized as follows:

- (a) $l_E < 0; B < 0: A_Z = A$
- (b) $l_E < 0; B > 0: A_Z = 360^\circ - A$
- (c) $l_E > 0; B < 0: A_Z = 180^\circ + A$
- (d) $l_E > 0; B > 0: A_Z = 180^\circ - A$

These do not take into account the case when the earth station is on the equator. Obviously, when the sub-satellite, the elevation is 90° and Azimuth is irrelevant. When the west ($B > 0$), the azimuth is 270° .

To find the range and elevation, it is necessary first to find side c of the quadrantal spherical triangle, and then use this in the plane triangle shown in fig. side c is obtained using the rule.

The equatorial radius $R_E = 6378.14$ km, and geostationary height $h = 35,786$ km. Because of the flattening of the earth at the poles, the radius R varies with latitude. R_E is the earth's equatorial radius and R is the radius at the earth station.

The plane triangle shown in fig-2 can be solved using the plane trigonometry. Applying the cosine rule gives the distance d as.

The elevation angle is denoted by EI deg in fig . Application of the sine rule to the plane triangle gives the final elevation.

Example

Determine the look angles and the range for the situation given below.

latitude of the earth station (l_E) = -20 deg Longitude of earth station (f_E) = -30 deg, Longitude of sub satellite point f_s = +30 deg; height = 35,786 km radiuses of earth = 6378.14 km.

Solution:

$$f_E = -20 \text{ deg}$$

$$l_E = -30 \text{ deg}$$

$$f_s = +30 \text{ deg}$$

$$\text{Height} = 35,786 \text{ km}$$

$$\text{Radius of earth} = 6378.14 \text{ km.}$$

From the equation

$$B = -30 - (+30) = -60^\circ$$

From the equation;

$$= -\tan |-60| / \sin(-20)$$

$$= \tan 60 / \sin 20$$

$$= 5.064$$

$$A = \tan^{-1} 5.064$$

$$\text{Azimuth angle } AZ = 78.83 \text{ deg.}$$

From the equation

$$\cos c = \cos(-60) \cos(-20)$$

$$= 0.4698$$

and therefore $\sin c = 0.8827$

$$R_E + h = 42164.14 \text{ km}$$

$$d = \sqrt{6375.64^2 + 42164.14^2 - 2 * 6375.64 * 42164.14 * 0.4698}$$

$$= 39,571 \text{ km}$$

From the equation

$$= 42164.14 * 0.8827 / 39,571$$

$$= 0.9405$$

and the Elevation angle $EI = 18.86 \text{ deg.}$

2.Explain about Polar mount antenna in detail.

A **polar mount** is a movable mount for [satellite dishes](#) that allows the dish to be pointed at many [geostationary satellites](#) by slewing around one axis.^[1] It works by having its slewing axis parallel, or almost parallel, to the [Earth's](#) polar axis so that the attached dish can follow, approximately, the [geostationary orbit](#), which lies in the plane of the [Earth's equator](#).

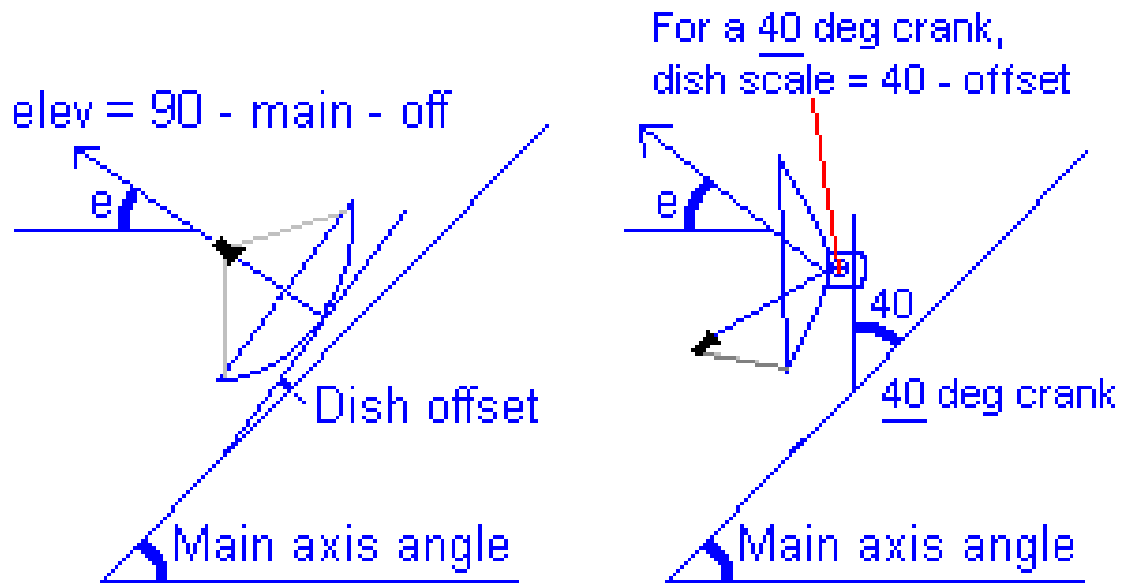
Polar mounts are popular with home [television receive-only](#) (TVRO) satellite systems where they can be used to access the TV signals from many different geostationary satellites.^[2] They are also used in other types of installations such as TV, cable, and telecommunication [Earth stations](#) although those applications usually use more sophisticated [altazimuth](#) or fix angle dedicated mounts.^[3] Polar mounts can use a simplified one axis design because geostationary satellite are fixed in the sky relative to the observing dish and their equatorial orbits puts them all in a common line that can be accessed by swinging the satellite dish along a single arc approximately 90 degrees from the mount's polar axis. This also allows them to use a single positioner to move the antenna in the form of a "[jackscrew](#)" or horizon-to-horizon gear drive. Polar mounts work in a similar way to astronomical [equatorial mounts](#) in that they point at objects at fixed [hour angles](#) that follow the astronomical [right ascension](#) axis. They differ from equatorial mounts in that the objects (satellites) they point at are fixed in position and usually require no tracking, just accurate fixed aiming.

Adjustments

When observed from the equator, geostationary satellites follow exactly the imaginary line of the Earth's equatorial plane on the [celestial sphere](#) (i.e. they follow the [celestial equator](#)). But when observed from other latitudes the fact that geostationary satellites are at a fixed altitude of 35,786 km (22,236 mi) above the Earth's equator, and vary in distance from the satellite dish due to the dish's position in latitude and longitude, means polar mounts need further adjustments to allow one axis slewing:

Declination angle - The declination angle^[4] or just "declination", from the astronomical term [declination](#) for the vertical value (north/south) on the celestial sphere, is a "tipping down" of the dish on the mount to allow it to observe geostationary satellites. When observed from any latitude other than the equator the observer is actually looking "down" on the satellite making it look as if it is just below the celestial equator, an angle from the celestial equator that increases with latitude. Polar mounts have mechanisms that allow the dish to be tipped down in a permanently fixed angle to match the declination angle. Mounts may also have a variable declination control to allow them to point at [geosynchronous satellites](#) in inclined orbits since those satellites have a constantly changing declination.

Declination offset - Because satellites toward the Eastern and Western sky are further away from the observing antenna, there is a change in the declination angle: towards the eastern and western limits the satellites get closer to the celestial equator because they are further out along the lines of [perspective](#). To aim at this apparent shift in the arc of geostationary satellites polar mounts incorporate a slight offset in the angle of their polar axis towards the equator, called a declination offset, to more closely follow this arc.^{[5][6]} Slewing around a fixed axis which is not parallel with the earth's rotation axis causes the dish to aim at a track in the equatorial plane which is (unless the dish is on the equator) an ellipse rather than a circle. Since the geostationary orbit is circular, the mount does not aim precisely at satellites at all longitudes. These slight differences in tracking have negligible effect on home [C-band](#) and [Ku band](#) TVRO dishes since they have relatively wide-beam designs.



Polar mount installation involves pre-setting the two fixed angles shown here. The Main axis angle has a range of movement of approx 90 deg. The antenna swings sideways around this axis. The Dish Offset tilt angle is the amount by which the beam is tipped downwards slightly. This angle is less than 9 degrees. Both of these angles are predetermined exactly by [calculation](#), but it is rarely possible to set the angles with sufficient accuracy (~ 0.2 deg) using scales and protractor. There is a tendency for dishes to sag somewhat and elevation angle scales may be inaccurate by 1 or 2 deg. Some minor adjustments are therefore necessary once satellites are being observed.

The main motor axis angle is the easiest to understand. It is the angle between the motor axis bearing line and the horizontal, in the nearest polar direction. i.e towards the north if you are north of the equator. If there is a main axis scale, the readings may be marked to correspond to this angle or alternatively to 90 minus the angle. Just see what happens when you set it to say 10 deg. If it does not result in the motor axis line sloping low down to the north then read the scale the other way. Set the scale to 80 instead. The angle is preset by calculation and careful adjustment and you can do this adjustment indoors at leisure till you understand clearly what is happening.

Setting the dish elevation is difficult. The easiest case is for an axi-symmetric dish, which has the LNB/Feed on the dish axis, in the middle, normally on three equal length legs. Just set the dish scale, if there is one, to minus 5 deg, for example.

More likely you have an offset dish. In this case you also probably have a motor with a cranked arm on it, typically bent 30 or 40 deg downwards. In this case if you set the dish scale to 30 or 40 the result is zero elevation. You want it set to Angle = 30 minus the small offset angle above. This means the dish is aimed 5 deg lower than a line at right angles to the polar axis. This will aim you correctly at the due south satellite, with the motor central.

Alignment objectives for a polar mount are:

- 1.The Main axis angle must be set exactly.
- 2.The Dish offset tilt angle must be set exactly.
- 3.The central position of the main axis rotation of the mount must accurately point due south (if you are north of the equator)

Set up procedure for polar mount:

An inclinometer (spirit level with scale or similar) is helpful. A plumb bob, i.e. fishing line and weight plus measuring rule and calculator or tan tables is an improvised alternative which can be quite accurate.

Check the ground fixed mount tube is exactly vertical. Apply the inclinometer in several places around the tube. All should read 90.0 deg. Adjust the mount tube if necessary and make sure all foundation bolts are tight.

Set the Main axis angle and the Dish Offset tilt angle as accurately as possible and set the moveable actuator to its middle position. The antenna now points to its highest elevation. If your dish is axi-symmetric (i.e. circular, with the feed in the middle) you can now check that the total elevation angle is correct. Measure elevation angle on the back of the hub of the dish; it should equal $(90 - \text{main angle} - \text{offset angle})$.

Rotate the whole assembly until the antenna points to the south. Aim south using a compass, map, pole star, GPS receiver with the sun display or GPS receiver and walking away several hundred yards southwards while keeping the longitude unchanged. The antenna is now approximately correct and you will probably receive signals from whatever satellites are due south from you. Check with the list of satellites for one with the same (or close) longitude as your site; use your receiver and there is a good chance of verifying that the receive system is working. If you can detect a satellite, note and mark the rotation axis and the other angles all very carefully and exactly so that you can return to them subsequently if you become lost. Try moving the actuator to the far east and west. Can you see satellites there as well ?

Now follows the difficult job of optimising the pointing. There are several methods possible.

S1: Considering the satellites due south from you. Apply hand pressure to the top of the dish away from the satellite so as to tilt the beam upwards slightly. Does the signal increase or decrease?

S2: Considering satellites far to the east. Apply hand pressure to the side of the dish to turn the dish further to the east slightly. Does the signal increase or decrease?

S3: Considering satellites far to the west. Apply hand pressure to the side of the dish to turn the dish further to the west slightly. Does the signal increase or decrease?

Optimise the south pointing first:

Q2 increase, Q3 increase south is OK, no change

Q2 decrease, Q3 decrease south is OK, no change

Q2 increase, Q3 decrease Rotate whole antenna ~0.3 deg to the east

Q2 decrease, Q3 increase Rotate whole antenna ~0.3 deg to the west

Repeat Q2 and Q3 until same results are obtained either side.

Tighten the main rotation bolts firmly. This may increase the elevation angle slightly, so repeat Q1.

Optimise elevation angle:

Q1 increase. Increase main axis elevation to maximise signal.

Q1 decrease. Decrease main axis elevation to maximise signal.

Repeat all above if necessary until good signals are received from all satellites. Once optimised, hand pressures in all three positions should result in little change of the signals.

3.Explain about thermal control system of Satellite.

The obvious objective of the thermal control system (TCS) is to assure that the equipment in and about the spacecraft structure is maintained within temperatures that will provide successful operations. There are many factors that need to be considered in the design of the TCS since satellites in space are subjected to a thermal environment that is very different from that on the Earth where gravity and a fluid medium (air) exists and convection, conduction and radiation are the principal mechanisms for heat transfer.

The "extreme" vacuum in space limits all heat transfer mechanisms to and from the spacecraft and its external environment to that of radiation. The second law of thermodynamics states that the direction of heat flow is invariably from a "hot" to a "cold" body. Thus, a spacecraft will receive

thermal energy from the Sun (the Sun's corona is approximately $6\,000^{\circ}\text{K}$), reflected solar energy from the Earth and Moon, and, depending on the satellite surface temperatures, it will receive or transmit thermal energy with the Earth and Moon. The planets and stars are relatively insignificant in determining the heat balance of a spacecraft.

With regard to the other aspects of the thermal environment, the spacecraft is surrounded by cold space which acts as an infinite thermal "sink" (the estimated temperature of deep space is equivalent to about 4°K).

There are several techniques for controlling thermal radiation exchange of the spacecraft. The geometry or projected area of surfaces directly facing the Sun, the Earth and deep space are important factors. Often, movable shutters or louvers are used to provide some means of dynamic control at the critical surfaces. Also, the spectral absorptivity (α) and emissivity (ϵ) properties of material surfaces or coatings must be carefully selected since there is a significant difference between the α/ϵ values of coatings between solar temperatures (short wavelengths) and infrared temperatures (long wavelengths) associated with the Earth and deep space. Many coatings have been discovered or developed that have unique α/ϵ ratios that selectively either absorb or reflect solar radiation but have opposite properties for infrared radiation.

The main structure of the satellite, which contains the communications and support equipment and "housekeeping" components, is constructed with a combination of thermal insulation and conductive materials so that temperatures within the structure are held within satisfactory limits. Most equipment can tolerate a relatively wide range of temperatures in order to function, but considerations of life expectancy and reliability often impose the need for limited temperature ranges. For example, batteries usually require narrow limits and liquid propellants need a high level of thermal protection.

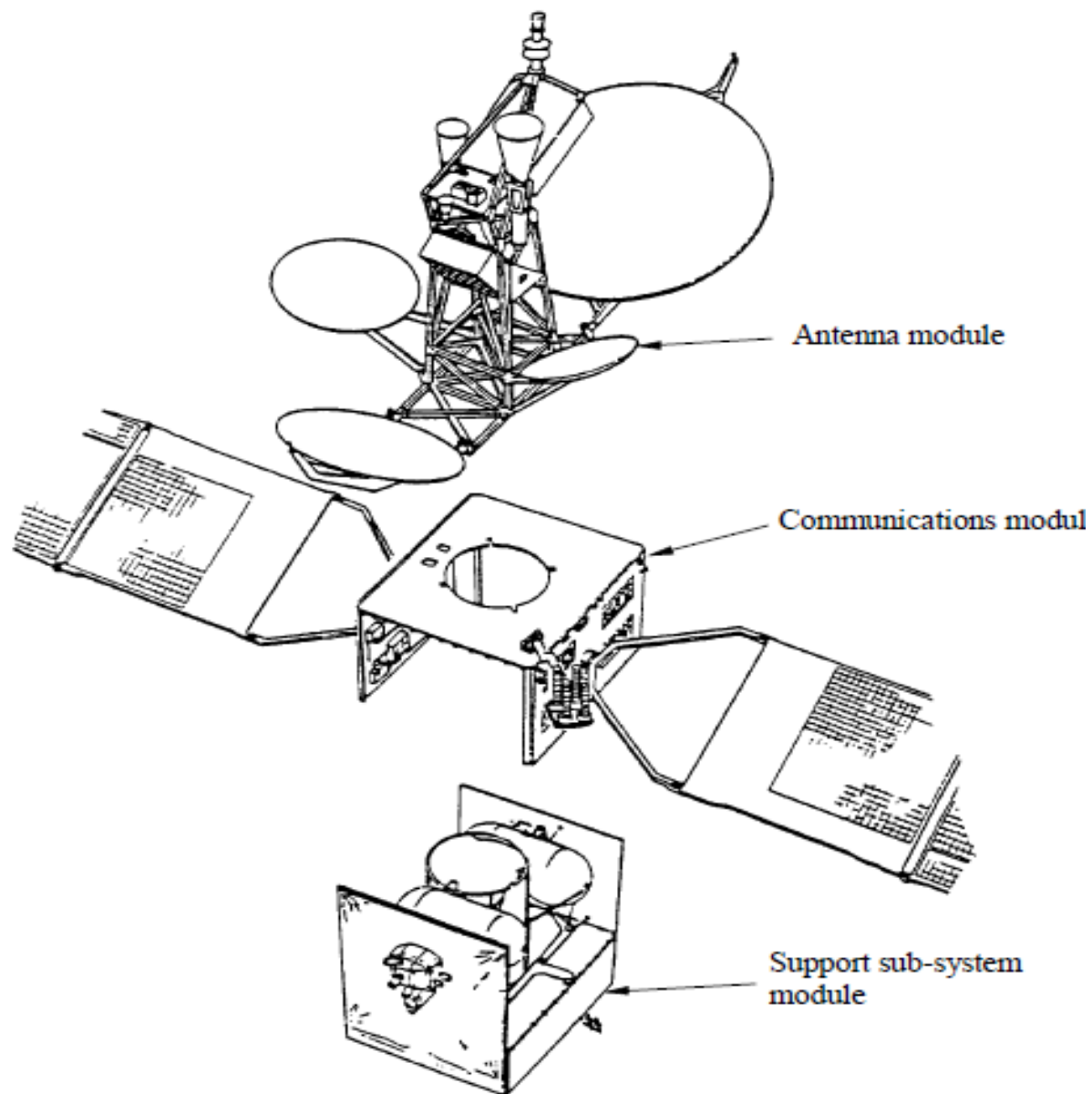
"Super" insulations, with orders of magnitude improved performance over earthly equivalents, are feasible in the vacuum of space. These insulations are made of multiple layers of plastic sheets coated with highly reflective materials, such as aluminized mylar. They are often used on tanks to reduce the rate of evaporation of cryogenic fuels as heat is absorbed from the Sun or Earth or from heat generating equipment.

Heat generated from power amplifiers, motors, heaters, etc. must be conducted or transported to the outside surfaces where it can be dissipated. High power TWTs may require "heat pipes" to convey large amounts of heat to external radiators. Care must be exercised in the design of "joints" since the vacuum of space can negatively affect conduction across metallic interfaces.

External structures, such as solar arrays and antennas, require special considerations since they are subjected to the full radiation environment of an earth satellite. Some of these are evident in Figures 6.8 and 6.9. Solar arrays, which are continuously facing the Sun, need special coatings (optical reflectors, etc.) to limit the absorption of the Sun's rays and radiate this energy to space. Antennas, usually facing the Earth, are subject to continuously varying solar exposures. The antenna structure and thermal design must be such that temperature variations over the surface do not distort the antenna shape beyond its operational design limits. This requires good conductivity properties and special alpha/epsilon coatings.

Finally, it must be recognized that the thermal environment in space for an Earth satellite is constantly changing. Also, each side of a spacecraft may be exposed to its unique environment. The variations likely to be experienced by a spacecraft are:

- 1) Varying solar exposure as the satellite circles the Earth.
- 2) Seasonal variations relative to the Earth and Sun.
- 3) Eclipse periods (72 mins maximum) when the satellite is in the Earth's shadow.
- 4) Varying reflections of solar energy from the Earth due to cloud cover (changing albedo's).



Sat/C6-10

FIGURE 6.10

Exploded view of early three-axis stabilized satellite

4.Explain about Station keeping control in satellites.

6.2.4.3 Orbit (station-keeping) control

On-board propulsion requirements for both geostationary and non-geostationary (LEO, MEO and HEO) satellites account for a significant part of the total mass of a spacecraft system, especially if the operational life extends to ten years and beyond. The importance of these systems to the mission of space systems has resulted in the establishment of several research and development programmes in government (ESA, NASA, NASDA, etc.) and industry to improve performance. A few recent innovations include arcjet thrusters, an advanced solar electric propulsion system, pulsed plasma thrusters (stationary and anode layer thrusters), ion propulsion systems, iridium coated rhenium chambers for chemical propellants, etc. Weight savings by the use of efficient propulsion systems (for final orbit insertion, station-keeping and relocation in orbit) provide such benefits as increased payloads (transponders, etc.), increased life, lower launch requirements, etc. Following is a brief description of the environmental and other factors affecting orbit control [2].

A geostationary satellite is subject to disturbances which tend to change its position in orbit. They lead to spurious orbit plane rotation and semi-major axis and eccentricity errors. As viewed by an observer on the Earth, the satellite displays an oscillatory movement with a periodicity of 24 hours. This motion is characterized by a North-South component due to orbit inclination (the so-called "figure of eight"), and an in-plane component. In turn, this component is made up of a longitudinal drift, due to the semi-major axis variation, and of a daily in-plane oscillation (altitude and longitude) due to the eccentricity error. The most apparent and relevant component of the in-plane oscillation is that in East-West direction.

The objective of orbit control is to maintain the spacecraft inside the allocated position "box" in latitude/longitude (current Radio Regulations only limit the longitudinal variations to $\pm 0.1^\circ$, for satellites using frequencies allocated to the fixed-satellite or broadcasting-satellite service).

The sources of disturbance are:

- the lunisolar attraction. This disturbance tends to rotate the orbit plane about an axis which, on the average is perpendicular to the astronomical direction of the Aries constellation. The corrections must be performed at six or 18 hours sidereal time (which gains one day per year or approximately four minutes a day with respect to solar time) with the direction of thrust along the North (or South) axis. The magnitude of the corrective impulse is around 45 m/s per year, slightly modulated by an 18.7 year cycle of Moon orbit motion.

The disturbance shows up as a sinusoidal daily motion in elevation (latitude), growing in half amplitude by nearly 0.02° per week. It should be noted that there exists an orbit inclined at 8° to the equator on which there is no disturbance at all. (This can only be used with steerable ground antennas or a beamwidth wider than $\pm 8^\circ$):

- the longitudinal component of the acceleration of gravity due to the ellipticity of the Earth's equatorial section known as "Earth triaxiality". It is fixed for a given longitude. Its maximum value is around 2 m/s per year. Corrections must be performed with the direction of thrust along the orbit. Its effect shows up as a uniformly accelerated drift in longitude;
- the effect of the solar radiation pressure which builds up eccentricity in the orbit (by decelerating the spacecraft in the morning and accelerating it in the afternoon). It depends upon the area-to-mass ratio of the spacecraft, mostly dictated by the power-to-mass ratio of the payload. It shows up as a daily oscillation in longitude and altitude, the amplitude of which grows at a rate that is proportional to the area-to-mass ratio of the spacecraft. The correction must be performed with thrust along the orbit.

The corrections for the last two disturbances are conveniently combined, resulting in thrust periods at either six hours solar time or 18 hours solar time (depending upon station longitude), and in a minimum expenditure of propellant.

The duration of the thrusting period (which implies extremely high disturbance torques) is of the order of:

- 30 to 150 s per week since the previous North/South correction, for North-South station-keeping;
- 2 to 20 s per week since the previous East/West correction, for East-West station-keeping.

For most current satellites, the maximum time between corrections to keep within $\pm 0.1^\circ$ is:

- around two months in North/South;
- around two to three weeks in East/West.

The role of the orbit control subsystem is to reduce the amplitude of this undesired movement. Small thrusters are fired at appropriate points in the orbit to provide the required corrective velocity increments. Early systems used monopropellant thrusters in which hydrazine was decomposed at about 1 300 K in a catalyst bed in the rocket chamber. More recently, other propulsion systems have been developed, to either supplement or replace the basic hydrazine system. Examples of the latter are electrically augmented hydrazine thrusters in which the hydrazine is electrically heated (up to 2 500 K or above) after decomposition to increase its enthalpy, and ion engines in which a gas (mercury or xenon) is ionized and then accelerated in an electric field. Both of these have been designed to increase the fuel usage efficiency (specific impulse) during the North-South manoeuvres.

The most common replacement for hydrazine monopropellant reaction control systems is a bipropellant (fuel/oxidizer) system. This type of propulsion system is not only more fuel-efficient than the monopropellant type, but can also be integrated with a liquid apogee motor (see § 6.2.7). Whichever system is used, the thrusters provide attitude control as well as orbit control.

The propellant mass consumed is equivalent to slightly below 2.5% spacecraft mass per year, where the catalytic decomposition of hydrazine is employed, and approximately 1.8% of spacecraft mass per year, with either electrically augmented hydrazine or bipropellant thrusters.

LEO, MEO and HEO satellites that rely on constellation configurations in which the precise maintenance of orbits is required, employ orbit control systems and equipment similar to those for GSO satellites. This would apply to cases of circular orbits in which the inertial forces are small and orbits are designed to be repeatable. In addition to assuring coverage over preferred areas on the Earth, another reason for this type of constellation would be to limit or avoid coverage areas where potential radio interference to and from other radiocommunication systems can occur.

There are some planned non-GSO systems which do not require precise orbit maintenance, thus reducing the housekeeping weight and complexity of the spacecraft compared to those with accurately synchronized orbits. Real time analysis of the orbit parameters would be required to effectively predict communication coverage functions. The initial orbit injection conditions (errors in inclination and altitude) of the satellites are important since they remain with the system throughout its life. The orbit altitude, inclination and orbit plane spacing can affect the drift rates (ascending node and orbit plane spacings) of the satellites and must be carefully selected based on the ultimate accuracy required in predicting the average coverage characteristics and deviations of each satellite in the system [3].

5.Explain about Power supply unit of Satellites.

6.2.5 Power supply

Electrical power requirements for communication satellites have increased considerably during the last 20 years as launch systems have become more powerful and are able to insert payloads into orbit in the order of 2 000 kg to 5 000 kg. A large number of transponders can now be accommodated on a single spacecraft, thus multiplying its communication capacity several-fold compared to early systems. For GSO systems, the introduction of "hybrid" satellites, in which both 6/4 GHz and 14/10-12 GHz are utilized for communication services, have increased the electrical requirements from approximately 1 kW to 15 kW. The number of transponders per spacecraft have more than doubled in this period of time (40 to 50 transponders is commonplace at present) and power amplifiers for each transponder have increased from 10-20 Watts to as much as 60-100 Watts of transmission power. The emerging 30/20 GHz satellite systems that intend to use very small earth station antennas will place increasing burdens on satellite power supplies.

The power requirements of non-GSO satellite systems are generally lower per satellite due to shorter transmission distances, often with less bandwidth availability and fewer transponders, among other factors. However, recent reports on the characteristics of these systems have indicated that power requirements can vary from 0.5 kW ("little" LEOs) to as much as 3 kW ("big" LEOs) per spacecraft. Large satellite "constellations" could demand over 1 megawatt of electrical power [4].

The Sun provides the primary source of power for communication satellites. The choice of systems for converting solar power to electrical power was explored by engineers and scientists during the early years of space systems development when the efficiency of the process was an important consideration. Early experimenters tried to develop heat engine (Carnot) power plants using parabolic solar collectors. Atomic cells or batteries were also considered. All of these approaches were overtaken by solar cells, made of silicon and gallium arsenide wafer-like or coating materials which convert a portion of the Sun's radiation equivalent to approximately 1 kW per square metre of projected area normal to the Sun's rays directly into electrical power. In the ensuing decades, efficiencies of solar cells were increased from a few per cent to slightly over 18%. Increasing the efficiency of these devices is a continuing process of experimentation and development [5].

The principal components of the power supply system of a communication satellite include 1) the power generators, usually solar cell arrays located on the spinning body of a spinning satellite, or on "paddles" for a three-axis stabilized satellite (see Figures 6.2-1 and 6.2-2); 2) electrical storage devices such as batteries for operation during solar eclipses; 3) the electrical harness for conducting electricity to all of the equipment demanding power; 4) the converters and regulators delivering regulated voltages and currents to the equipment; and 5) the electrical control and protection subsystem which is associated with the telecommand and telemetry subsystem.

The equipment requiring electrical power includes 1) the communication system in which transponders demand as much as 70% to 80% of the total power; 2) battery charging, about 5% to 10%; 3) thermal control, about 7% to 12%; 4) tracking, telemetry and control, about 2% to 4%; 5) attitude control and station-keeping, about 3% to 5%; and 6) the remainder, about 2% to 4%.

The satellite power supply components are subject to the same dynamic and environmental constraints as those described in the previous sections. Low mass, long life and reliability are of major importance since the system must function satisfactorily in space for 10 to 15 years without being serviced.

a) Solar array

A necessary consideration for the design of the solar arrays is to assure that sufficient surplus capacity exists initially so that end-of-life performance will meet the communication mission requirements. The electric power supplied depends on the conversion efficiency of the solar cells and the size of the solar array. Although steady progress is being made in improving the performance of solar cells, most existing operational satellites have solar cell systems with overall efficiencies of about 12%.

These are generally made of P type silicon single crystal wafers on which a thin N type layer is created by doping to form a diode. Each cell is covered by a window of molten silica to reduce the effect of radiations in space (30% efficiency loss in five years). An individual solar cell supplies about 50 mW of power (under 0.5 V) and an array is made up of a large number of cells connected in a series/parallel arrangement. For an adjustable array, the end-of-life specific powers are about 21 to 23 W/kg and 60 to 67 W/m².

b) Secondary sources

Since most telecommunication satellite equipment (attitude and orbit control, telecommand, payload, etc.) has to be in permanent operation, energy has to be stored for use during eclipse periods.

Electrochemical generators are best for this purpose. Nearly all telecommunication satellites are equipped with nickel-cadmium batteries, despite their low power-to-weight ratio (35 W/kg), because they are hermetically sealed and have a very long life. During the next decade, they are likely to be replaced by nickel-hydrogen batteries.

The mass of the battery depends, *inter alia* on the utilization factors on the spacecraft – depth of discharge, temperature. The battery life depends on the depth of discharge, i.e. the ratio between the capacity discharged during an eclipse period and the normal capacity. To obtain a lifetime of over five years, the value of the ratio should not be less than 60-70% for the maximum duration of an eclipse period, which is 72 min. The lifetime also depends on the battery temperature, the best results being obtained between +5°C and +15°C.

c) Eclipse periods

When the satellite moves into the shadow of the Sun's rays caused by the Earth, a thermal shock is caused to the satellite components and the solar cells which supply the primary energy are no longer illuminated. This eclipse period is maximum when the Sun is in the direction of the intersection between the ecliptic plane and the equatorial plane, viz. twice a year at the equinoxes (about 21 March and 22 September). On these days, the shaded part of the orbit extends over 17.4° (the angle of the Earth, as seen from a geostationary satellite) and the eclipse lasts 72 min. This maximum duration decreases and the daily eclipses cease when the Sun's inclination from the equatorial plane becomes equal to 8.7° (17.4°/2), i.e. about 21 days before and after each equinox. The middle of the eclipse duration occurs at midnight, satellite longitude time. In consequence, if a regional or national (domestic) satellite can be located west of its service area, the eclipse will occur after midnight local time, and the on-board secondary power source could be reduced (or, even, possibly, omitted) if the traffic at that time does not justify the full communication capacity.

d) Regulators and converters

A battery which supplies power during an eclipse period has to be recharged during the sunlight period. Certain precautions have to be taken while recharging the battery.

Two main procedures are used:

- the battery is connected directly in parallel with the solar array and establishes its potential (unregulated line);

- the solar array is kept at a fixed voltage and a charge control circuit is connected in series with the battery (regulated line).

The advantages of these two types of regulation are as follows:

Regulated line	Unregulated line
Better adaptation of power sources to equipment requirements.	Simplicity of system (although d.c.-d.c. converters are more complex).
Good compatibility with modular and standardization concepts.	Configuration adapted to very highly pulsed load operation (e.g. TDMA).
Possibility, subject to electromagnetic compatibility, of supplying equipment directly from the regulated line.	

As a general rule, power should be supplied to equipment in the form of regulated d.c. voltages. High-efficiency chopping converters are at present used to supply these various voltages.

6.Explain about Altitude Control in Detail.

Spin stabilized structures are usually shaped like drums, in which part of the drum rotates (50-100 rpm), and part is despun so that an antenna mounted in this part is always facing the Earth. The spinning part is covered with solar cells and its spin axis is oriented perpendicular to the Sun (North-South axis for GSO satellites) so that the solar rays are providing maximum energy to the solar cells. The despun part, containing the antennas and some Earth sensors, rotates once with every circling of the Earth. Slip rings are required to conduct electrical power from the spinning solar cell assembly to the despun communications system and antennas. An example of this type of structure is shown in Figure 6.8.

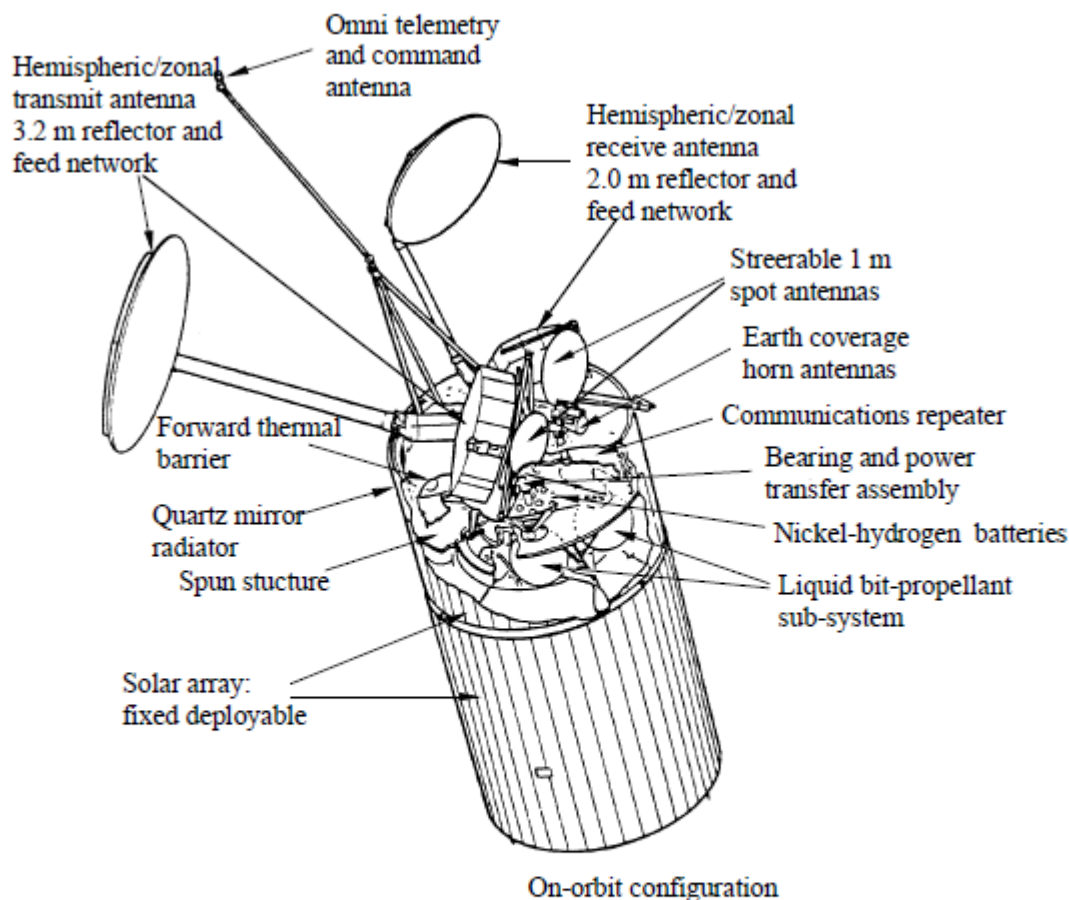
Body stabilized structures are usually shaped like a "box" with square or rectangular sides, and with external attachments to accommodate the subsystems and components that need to function outside of the enclosure. The box rotates once for every circling of the Earth so that the side with externally mounted antennas will always face the Earth. For GSO satellites, the spacecraft appears fixed in space to an observer on the surface of the Earth. This structure utilizes a deployed set of solar panels with solar cells mounted on one side of the panel surfaces. To maintain the cells in a normal position relative to the Sun, the panels, which are oriented with a North-South axis, rotate once per orbit revolution. An example of this type of structure is shown in Figure 6.9. An exploded view showing the various structural components of this type of satellite is shown in Figure 6.10.

Since low mass is an extremely important feature of the spacecraft structure, the main frame is comprised of strong lightweight metals, such as aluminum or magnesium alloys, and composite structures made of special plastic or fibre materials. Auxiliary structures for solar panels, antennas and other relatively large equipment rely on a number of advanced structural designs and materials, such as carbon fibres and epoxy resins. New developments in strong lightweight structures and materials (such as carbon nanotube filaments) are likely to provide significant advances in the future.

The objective of the attitude control subsystem is to maintain the antenna RF beam pointed at the intended areas on Earth. The axis of the antenna-bearing platform carrying the antennas is made to point towards the Earth's centre and the antennas are mounted in relation to this platform so as to be directed towards the area required.

The attitude control procedure involves:

- measuring the attitude of the satellite by sensors;
- comparing the results of these measurements with the required values;
- calculating the corrections to be made to reduce errors;
- introducing these corrections by operating the appropriate torque units.



Sat/C6-08

FIGURE 6.8
Example of spin stabilized satellite

During normal operation, the satellite experiences only smooth cyclic drift disturbances of the order of 10^{-5} Newton metre ($N \cdot m$). However, when station-keeping is performed, torques of the order of $1 N \cdot m$ are applied to the spacecraft (typically for 30 s to 2 min per week, or 0.5 to 2×10^{-4} of total time).

The sensors normally used for attitude measurements are of the infrared type and measure the difference in the infrared signature between space and the Earth's disc in the CO_2 emission/absorption band: (15 ± 1 micron). Since the background noise is of the order of 0.02° (in a

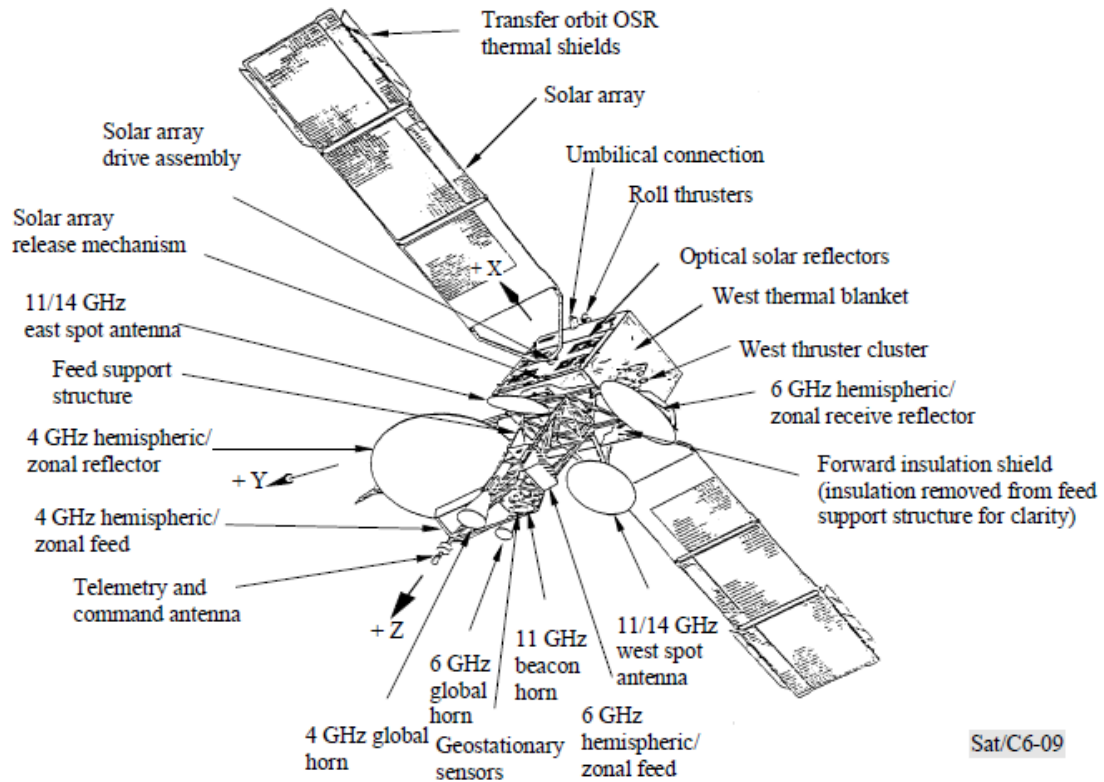


FIGURE 6.9

Example of three-axis stabilized satellite

1 Hz bandwidth) and there are seasonal cyclic variations of the zero and infrequent transient phenomena known as "cold clouds", the typical measurement accuracy that can be obtained is 0.05° . In addition to Earth sensors, Sun sensors are also used to determine body orientation. They can be used to directly measure yaw angle (over much of the daily orbit), as well as to provide additional roll-pitch data.

A higher degree of beam pointing control is used in many domestic and new generation international systems (INTELSAT-VI). This attitude control mode uses a ground-based pilot beam (beacon) which is sensed on board the spacecraft to directly obtain the antenna orientation. When more than one antenna is mounted on the same platform, this approach permits independent control of the orientation of each antenna, in response to the error signals generated by the respective sensor, tracking the same beacon or separate beacons. Motor driven gimbals are required in this case. Such a control system can correct the effects of relative misalignment between the various antennas, due to mechanical errors and thermal variations. This control method can improve the net beam pointing accuracy by a factor of 2 or 3 compared with body orientation. In addition, if pilot beacons from two well separated earth stations are used, direct sensing of beam rotation (yaw) error can also be obtained.

Currently all types of attitude stabilization systems have relied on the conservation of angular momentum in a spinning element. Stabilization systems can be classified in two categories:

- spin stabilization;
- three-axis stabilization.

The principles of attitude control systems can be illustrated by the evolution of the INTELSAT family of satellites:

- INTELSAT-I and II were solid spinners (implying a toroidal antenna directing only some 4% of RF energy to Earth);
- INTELSAT-III, IV and IVA included a despun element ("dual spinners"):
 - an offset parabolic reflector on INTELSAT-III,
 - the entire RF payload in INTELSAT-IV and IVA (while the "platform" remains spun and feeds power to the payload through a slip ring rotary mechanism);
- in INTELSAT-V and VA, the spinning element is reduced to a fast rotating wheel internal to the spacecraft (which allows the use of a solar array pointed permanently to the Sun): this configuration is called "three-axis". In all cases, the angular momentum of the rotating body is nominally normal to the orbit plane.

Whichever stabilization system is used, the drift rate of the platform orientation (due primarily to solar radiation pressure) is of the order of 0.02° per hour. When the drift shows up as an error in the North-South pointing (usually called "roll" error), it is corrected through the use of small jets, magnetic torquers, or altering the position of "solar sails". The errors around the spacecraft/Earth line (undetectable by Earth pointing) are allowed to build up, as such errors have only very small effects on communication performance, and show up within the next six hours as North-South pointing errors.

The pointing errors in the East-West direction (usually called "pitch" errors) are corrected by accelerating/decelerating the relative rotation between the despun and spun elements.

The latter control loop is on board the spacecraft and is always automatic. The correction of the orientation of the angular momentum (precession) can be either automatic on board (usually with the so-called "three-axis configurations") or by ground command (usually with "dual spinners"), or a mixture of the two.

In every case the zero reference can be adjusted by ground command:

- INTELSAT-VI, launched starting from 1989, is a "dual spinner", but it also uses automatic on-board precession control.

The types of stabilization used on spacecraft are as follows:

i) Spin stabilization (see Figure 6.8)

The satellite is rapidly spun around one of its principal axes of inertia. In the absence of any perturbing torque, the satellite attains an angular momentum in a fixed direction in an absolute frame of reference. For a geostationary satellite, therefore, the spin axis (pitch) must be parallel to the axis of the Earth's rotation.

The perturbing torques produce two effects: they reduce the spin speed of the satellite; and they affect the orientation of the spin axis.

Satellites using this type of stabilization generally have a despun platform, one direction of which is servo-controlled so as to point towards the centre of the Earth. This platform usually carries the antennas and the payload. It should be noted that spin stabilization is normally used during the phase between injection into the transfer orbit and arrival in the geostationary orbit, even when the satellite is of the three-axis design. This arrangement neutralizes the effects of the perturbing torques caused by the distance between the direction of thrust of the apogee motor and the centre of mass of the satellite.

The earliest spin stabilized satellites were spun about their axis of maximum moment of inertia, and were thus inherently stable. However, as antenna patterns became more complex and power requirements grew, it became necessary to enlarge both the antenna and solar array drums while still meeting the geometric constraints of the launch vehicles. The resultant spacecraft designs could no longer be spun about the maximum inertia axis, and hence were nutationally unstable. In response, two types of nutation control have been developed: pulsed thruster firings (quantized control) and antenna platform de-spin motor control (linear). The use of these has allowed spin stabilized spacecraft to become more powerful (currently 2-3 kW) and to carry large and complex antenna subsystems.

ii) Three-axis stabilization (see Figure 6.9)

The antenna is part of the satellite, which maintains a fixed orientation with respect to the Earth, except for the solar arrays which are rotated to point towards the Sun.

The simplest method uses a momentum wheel, which simultaneously acts as a gyroscope, as in spin stabilization, and as a drive. Certain perturbing torques can be resisted by changing its spin speed and, consequently, the resulting angular momentum of the satellite. Nutation control systems are also used in three-axis stabilized satellites.

New innovations to reduce fuel requirements of thrusters for attitude corrections include a solar sailing feature (INMARSAT and TELECOM II), a three-axis stabilization system of momentum wheels with magnetic bearings (ETS-VI) and propulsion fuel heaters [1].

7.Explain about various power amplifiers used in Satellites.

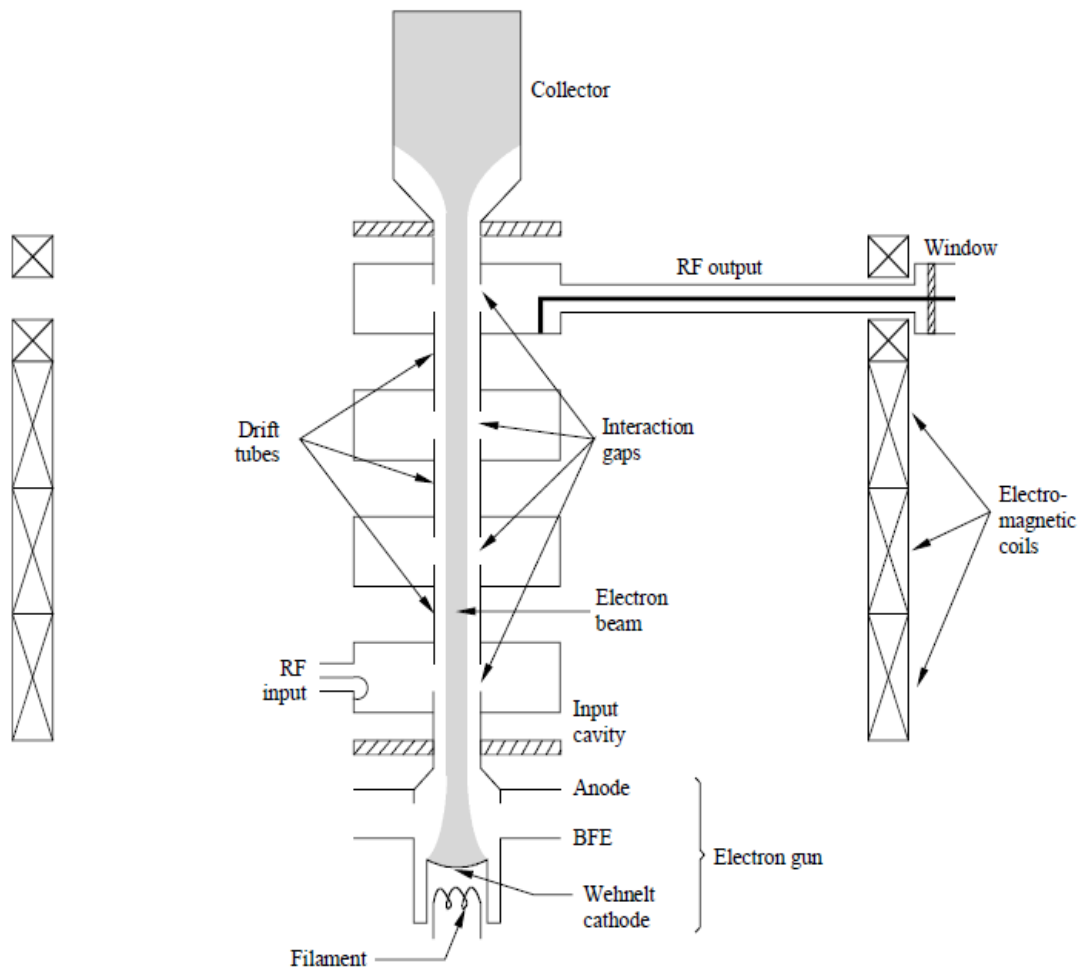
7.4.2.2 Klystron tubes

Klystrons used in earth station HPAs are of the multi-cavity amplifier type. The slow-wave RF structure is composed of a series of cavities, i.e. microwave resonant circuits (e.g. 5 cavities) as represented in Figure 7.27 a). The low level RF input signal excites the input cavity and alternately accelerates and decelerates the electrons passing in the interaction gap, thus creating electron bunching. This induces an RF voltage in the second cavity. An additional modulation of the beam velocity is produced by this resonant voltage which increases the modulation of the beam current.

This amplification process is repeated in each intermediate cavity, thus generating a high power RF voltage which is extracted from the last cavity by the output circuit.

The salient features of klystron tubes and HPAs are given in § 7.1.1.3 b). Other important characteristics are listed below:

- i) Instantaneous bandwidth: the higher the output saturation power, the wider the possible instantaneous bandwidth. In the 6 GHz band, 40 MHz bandwidth is common for output power greater than 300 W (3 kW klystrons with 80 MHz bandwidth are now available). In the 14 GHz band, 80 to 100 MHz bandwidth klystrons are currently available with output power up to 3 kW.
- ii) Tuning range: the operating central frequency of a klystron can be changed by mechanically tuning the cavities. 500 to 600 MHz tuning ranges are common and are usually provided with remote control capability, e.g. with 6 to 24 switchable pre-set frequencies for channel selection.
- iii) Focusing system: permanent magnet focusing is much more simple to operate and maintain than electromagnetic coil focusing. Klystrons with permanent magnet focusing are available up to about 3 kW power.
- iv) Cooling system: in the same way, cooling by forced air is much preferable to cooling by liquid circulation systems. Again, air cooled klystrons are available up to about 3 kW.



Sat/C7-27am

FIGURE 7.27 A)

Schematic cross-section of a klystron BFE: beam focusing electrode

Table 7.7 gives basic data on typical klystron tubes currently available for earth station HPAs in the 6 GHz and 14 GHz bands. Other available klystrons include:

- very high power klystrons at 14 GHz (up to 10 kW);
- klystrons in the 17/18 GHz band (1.5 kW);
- klystron in the 30 GHz band (2 kW).

TABLE 7.7

Klystrons in the 6 GHz, 14 GHz, and 30 GHz bands

Tuning range (GHz)	Output power (W)	Gain (dB)	Instantaneous bandwidth (MHz)
5.925-6.425 ¹	150	50	23
	400	36	42
	750	40	40
	1 000	35	40
	1 500	37	40
	2 000	38	40
	3 000	35-42 ²	40-80 ²
	3 400 14 000 ^{3,4}	40 52	45 70
14-14.5	1 500	40	100
	2 000	40	100
	3 000	42	85
27.5-30.5 ²	350	40	100
	450	40	120
¹ Klystrons are also available in the new increased band: 5.850-6.425 GHz. ² Depending on type and manufacturer. ³ Focusing by electromagnetic coils (all other tubes are focused by permanent magnets). ⁴ Water cooling (all other tubes are air-cooled).			

7.4.2.3 Travelling wave tube

As explained in § 7.1.1.3, the major advantage of the TWT is its intrinsically wide bandwidth. This broadband capability features high operational flexibility:

- any carrier frequency change can be effected, in the whole operational bandwidth (e.g. 500 MHz or more), without any tuning or modification of the HPA system (including the output combiner);
- several carriers at different frequencies can be simultaneously transmitted in the same HPA and, therefore, traffic expansions of an earth station are possible without increasing the number of tubes. Of course, this multiple carrier capability is limited by the overall TWT output power and, more precisely, by the output power available for sufficiently linear operation of the TWT (see § 7.4).

In a TWT, the electron beam interacts with a forward RF wave propagating in the periodic, non-resonant slow-wave structure. Velocity modulation, created along the beam, induces an RF current that excites waves in the structure in both directions. However, the synchronization conditions are such that only forward waves add in phase and are amplified.

Most TWTs use a helicoidal RF transmission line (helix) as a slow wave structure (see Figure 7.27). Modern technologies have improved the heat dissipation along the structure, thus allowing helix TWTs to be used for up to about 3 kW output power at 6 GHz, 1 kW at 14 GHz.

However, at higher frequencies, due to its reduced cross-section dimensions, the helix structure is no longer usable for high power. High power TWTs at 14 GHz (and higher frequencies) use coupled-cavity slow-wave structures.

In TWTs, the electrons when leaving the interaction space retain considerable energy (unlike the case of the klystron). This is why, in many modern tubes, these electrons are collected at a potential below the slow-wave structure potential. This technique, which is called depressed collector operation, reduces the collector heat dissipation and increases the tube efficiency. Further improvement can be obtained with multiple collector stages.

A periodic permanent magnet structure is commonly used for focusing beam to minimize size and weight. A similar cooling technique as used for klystrons can apply to TWTs.

Table 7.8 gives basic data on current typical TWTs used for earth station HPAs in the 6 GHz, 14 GHz and 30 GHz bands. Figure 7.28 gives the power consumption of the various types of HPAs.

UNIT III

EARTH SEGMENT AND SPACE LINK

Introduction – Receive – Only home TV systems – Outdoor unit – Indoor unit for analog (FM) TV – Master antenna TV system – Community antenna TV system – Transmit – Receive earth stations – Problems – Equivalent isotropic radiated power – Transmission losses – Free-space transmission – Feeder losses – Antenna misalignment losses – Fixed atmospheric and ionospheric losses – Link power budget equation – System noise – Antenna noise – Amplifier noise temperature – Amplifiers in cascade – Noise factor – Noise temperature of absorptive networks – Overall system noise temperature – Carrier-to- Noise ratio – Uplink – Saturation flux density – Input back off – The earth station HPA – Downlink – Output back off – Satellite TWTA output – Effects of rain – Uplink rain– Fade margin – Downlink rain – Fade margin – Combined uplink and downlink C/N ratio – Inter modulation noise.

PART A

1. What is a single mode of operation?

A transponder channel aboard 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?

FDMA – Frequency Division Multiple Access Techniques

TDMA – Time Division Multiple Access Techniques

3. What is an CDMA?

CDMA – Code Division Multiple Access Techniques

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.

- Spread spectrum multiple access
- Pulse address multiple access

5. What is SCPC?

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?

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 important feature of Intelsat SCPC system?

The system is that each channel is voice activated. This means that on a two way telephone conversation only one carrier is operative at any one time.

8. What is an TDMA? What are the advantages?

TDMA – Time Division Multiple Access Techniques

Only one carrier uses the transponder at any one time, and therefore intermodulation products, which results from the non-linear amplification of multiple carriers are absent.

Advantages : The transponder traveling wave tube can be operated at maximum power output.

9. What is preamble?

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.

10. Define guard time.

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.

11. What is meant by decoding quenching?

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.

12. What is meant by direct closed loop feedback?

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.

13. What is meant by feedback closed loop control?

The synchronization information is transmitted back to an earth station from a distant, that is termed feedback closed loop control.

14. What is meant by digital speech interpolation?

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 are the types of digital speech interpolation?

- Digital time assignment speech interpolation
- Speech predictive encoded communications

16. Define Saturation flux density.

The flux density required at the receiving antenna to produce saturation of TWTA is termed the saturation flux density

17. What is an multiple access technique?

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. This mode of operation known as multiple access technique.

18. What is meant by space division multiple access?

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.

19. What are the limitations of FDMA-satellite access?

- a. If the traffic in the downlink is much heavier than that in the uplink, then FDMA is relatively inefficient.
- b. Compared with TDMA, FDMA has less flexibility in reassigning channels.
- c. Carrier frequency assignments are hardware controlled.

20. Write about pre-assigned TDMA satellite access.

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.

PART B

1.Explain about indoor and outdoor FM Unit for Satellites.

The communications equipment (GCE) interfaces with:

- the multiplexing/demultiplexing equipment (MUX) (if any) or the connection point to the terrestrial equipment;
- the power amplifier (HPA) system (for transmit GCE) and the low noise amplifier (LNA) system (for receive GCE).

The major functions of the GCE are:

Transmit side

- i) To provide pre-emphasis and RF energy dispersal for the baseband signal, and to add a 60 kHz pilot to the FDM telephone signals (transmit baseband equipment).
- ii) To convert the baseband signal into an FM-modulated signal at an intermediate frequency (IF), e.g. at 70 MHz (FM modulator).
- iii) To filter the IF signal and to provide group delay equalization (GDE) for the complete transmit path (including earth-station equipment and satellite transponder).
- iv) To convert the IF signal into an RF signal (e.g. at 6 GHz) (up converter: U/C).
- v) To switch and combine the RF signals and to send them to the HPA (HPA input combiner).

Receive side

- vi) To separate and switch RF signals (e.g. at 4 GHz) from LNA (or LNA output divider).
- vii) To convert the RF signals into an IF signal (down converter: D/C).
- viii) To filter the IF signal and to provide group delay equalization (GDE) for the earth-station receive equipment.
- ix) To demodulate the IF signal into the baseband signal (demodulator).
- x) To remove emphasis (de-emphasis) and energy dispersal from the received baseband signal, to detect the 60 kHz pilot in the FDM telephone signal and synchronizing pulses in the TV video signal, and to squelch the GCE by monitoring the out-of-band noise (receive baseband equipment).

7.5.2 Frequency converters

7.5.2.1 General description and characteristics

The up converters (U/Cs) translate the IF signals into RF signals, e.g. in the 6 GHz or 14 GHz bands. Conversely, the down converters (D/Cs) translate the RF signals, e.g. in the 4 GHz or 11-12 GHz bands, into IF signals usually at the conventional intermediate frequencies of 70 MHz or 140 MHz. 70 MHz is used for bandwidths up to 36 MHz and 140 MHz for bandwidths up to 72 MHz.

For large RF bandwidths, e.g. 500 MHz, dual conversion converters are used in order to improve the image frequency rejection, i.e. the signal frequency which is symmetrical to the local oscillator frequency.

Up and down converters are usually composed of:

- an RF filter;
- one mixer or two cascaded mixer(s), depending on whether the converter uses single frequency conversion or double frequency conversion (see § 7.5.2.2);
- one or two local oscillator(s) (LOs);
- IF amplifier(s), possibly with automatic gain control;
- IF filters;
- group delay equalizer(s) (GDEs).

The main performance characteristics of the up converters (U/Cs) and down converters (D/Cs) are listed below:

i) Bandwidth

Three bandwidths have to be considered:

- the RF bandwidth, which defines the capability of the converter to cover the operational RF band, i.e. to transmit (or receive), by adjusting the LO's frequency, the various carrier frequencies which are capable of being operated in the satellite communications system;
- the IF total bandwidth, which defines the capability of the converter to cover all the bandwidths of the various carriers which are capable of being transmitted in the satellite communications system. As a typical example, Table 7.10 gives the various FDM-FM carriers in the INTELSAT-V (and also -VA and -VI) systems;
- the instantaneous IF bandwidth. This bandwidth depends on the number of channels (e.g. as given for FDM-FM by column 2 of Table 7.10. The component which restricts the bandwidth of a given carrier is the IF band-pass filter (IF BPF), the characteristics of which are specified (e.g. by INTELSAT) by the bandwidth unit of each carrier capacity (see § 7.5.3.2).

ii) Frequency agility

The frequency and channel capacity plan is often altered as the traffic through the satellite is changed and increased. Up and down converters which can be adjusted in frequency over the whole RF bandwidth are specially useful for making these changes. Variable frequency microwave filters

and frequency synthesizer local oscillators are used to meet the frequency change requirements. As explained below, frequency agility, i.e. the ability to change the RF carrier frequencies, is improved by the use of double conversion U/Cs and D/Cs.

TABLE 7.10

INTELSAT-V, -VA and -VI FDM-FM carriers

Bandwidth unit (MHz)	Number of channels
1.25	12
2.5	24, 36, 48, 60, 72
5.0	60, 72, 96, 132, 192
7.5	96, 132, 192, 252
10.0	132, 192, 252, 312
15.0	252, 312, 372, 432, 492
17.5	312, 372, 432
20.0	432, 492, 552, 612, 792
25.0	432, 492, 552, 612, 792, 973
36.0	792, 972

iii) Equalization

The amplitude-frequency response and group delay of the transmit and receive sections of earth stations are equalized in their respective IF sections. The group delay of satellite transponders is usually equalized in the IF section of the U/C (see § 7.5.3.2).

iv) Linearity

In SCPC systems, a number of carriers are frequency converted by one up or down converter, and intermodulation between carriers can occur. In the transmit section, it is necessary to keep these unwanted intermodulation products negligibly small compared to those in the HPA; therefore, the up converter is required to have good linearity and a sufficiently high intercept point. For a carrier with a large number of channels, good linearity is also necessary to decrease distortion noise caused by the parabolic component of the delay equalizer for the whole system in the IF system and AM-PM conversion occurring in the converter.

2.Explain about uplink and downlink frequency conversions in satellites.

Figure 7.44 shows block diagrams of the three most common types of converters:

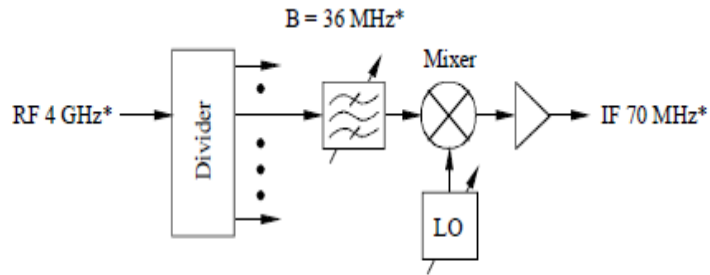
a) is a single frequency conversion down converter. It is a very simple, rugged and economical equipment, but in order to change the frequency in the operating RF band, it is necessary both to tune the local oscillator RF frequency, and to mechanically adjust the narrow-band microwave band-pass filter. In this up converter, the IF signal is mixed with a local frequency which is 70 MHz lower than the output frequency and converted to the required RF signal. In the RF section, there is a band-pass filter with a 40 MHz bandwidth (centre frequency ± 20 MHz) and a rejection filter to suppress any local oscillator frequency leak (below a transmitted e.i.r.p. of +4 dBW). To facilitate frequency change in this type, the microwave filters must have a special mechanical construction.

Up-converter block diagrams would be similar: IF (e.g. 70 MHz) band-pass filter and timer delay equalizer not represented.

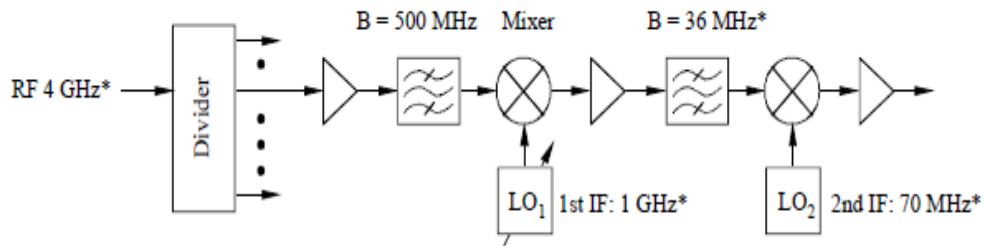
b) is a double frequency conversion down converter. This type of converter features high frequency agility since tuning of the first LO (RF oscillator) is sufficient to change the RF frequency in the whole (i.e. 500 MHz) operational RF band. The two LOs can be derived from the same pilot oscillator. This type of converter is the most commonly used in modern earth stations. In this D/C the 4 GHz receive input signal passes through a microwave filter with a 500 MHz bandwidth, enters a mixer, and is mixed with the first local oscillator frequency (variable) and converted into the first

intermediate frequency (1st IF). The 1st IF signal passes to a band-pass filter with a 40 MHz bandwidth and is converted into a 70 MHz signal at the 2nd mixer (fixed frequency 2nd LO). In this configuration, making the 1st IF higher than the RF bandwidth (500 MHz) avoids image signals and spurious emission (in the case of up converters). The 1st IF is generally in the range of 800 MHz to 1.7 GHz. Frequency can be changed in the 500 MHz band, by only changing the 1st local frequency, without readjusting any filter. Consequently, combined with a frequency synthesizer, this type of converter is very attractive, and satisfies the requirements for quick frequency change and remote frequency control. It is also effective as a single stand-by unit for multiple converters.

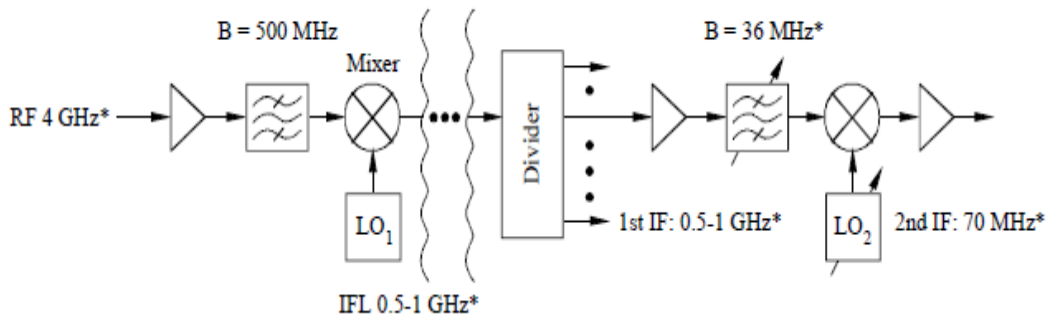
c) is a second type of double frequency conversion down converter. This type does not feature the same frequency agility as the previous type. The frequency of the RF channel is changed in the same way as in the case of a single converter a). However, the adjustable filters and the divider (or combiner for a U/C) are simpler since they operate at a lower frequency (e.g. 1 GHz). This solution can permit a very simple and efficient equipment layout for reception: the RF section (including the microwave wideband filter and the 1st mixer) can be incorporated with the LNA, and directly connected to the antenna receive port. The receive channels can then be connected by a coaxial cable (e.g. at 1 GHz) to the (remote) divider and to the multiple receive chains.



a) Single-frequency conversion



b) Double-frequency conversion (1st type)



c) Double-frequency conversion (2nd type)

LO: Local oscillator
 IFL: Inter-facility link
 *Values given as an example

Sat/C7-44m

FIGURE 7.44

Down-converter block diagrams

c) is a second type of double frequency conversion down converter. This type does not feature the same frequency agility as the previous type. The frequency of the RF channel is changed in the same way as in the case of a single converter a). However, the adjustable filters and the divider (or combiner for a U/C) are simpler since they operate at a lower frequency (e.g. 1 GHz). This solution can permit a very simple and efficient equipment layout for reception: the RF section (including the microwave wideband filter and the 1st mixer) can be incorporated with the LNA, and directly connected to the antenna receive port. The receive channels can then be connected by a coaxial cable (e.g. at 1 GHz) to the (remote) divider and to the multiple receive chains.

7.5.2.3 Local oscillators

The local oscillators used in converters can be driven either by a pilot crystal oscillator or by a frequency synthesizer. In the first case, changing the frequency requires replacement of the crystal (or switching between multiple crystals). In the second case, changing the frequency can be effected very simply by thumbwheels or even by remote control.

The required frequency stability (long term) may range from some $\pm 10^{-5}$ (FDM-FM and TV) to $\pm 3 \cdot 10^{-8}$ (SCPC).

Local oscillators must feature low phase noise at baseband signal frequencies in order to comply with the general requirements on earth-station equipment noise (see § 7.5.3.1). It should be noted that both low phase noise requirements and frequency stability requirements are specially stringent in the case of SCPC transmission and reception. High performance crystal controlled oscillators or frequency synthesizers must be used in this case.

3.Explain about link power budget in satellite.

AN2.4.4 Link budget calculation

For each performance objective, which consists of a BER level not to be exceeded for a given percentage of time $p\%$, link budgets are used to evaluate the available overall carrier-to-noise $(C/T)_{total}$ at the earth-station receiver so as to verify that the required C/T corresponding to the performance objective can be provided.

The carrier-to-noise ratios in the uplink $(C/T)_u$ and in the downlink $(C/T)_d$ are evaluated separately. The total C/T available is given by the equation:

$$(C/T)_{total}^{-1} = (C/T)_u^{-1} + (C/T)_d^{-1} \quad (2)$$

It should be noted that C/T ratios in the above formula are in numerical value.

It is assumed that atmospheric attenuation does not occur simultaneously on both the uplink and the downlink; consequently, two link budgets have to be performed separately for the following configurations:

- i) atmospheric attenuation in the uplink, corresponding to a percentage $p_{up}\%$ of the total time, and clear weather in the downlink;
- ii) clear weather in the uplink and atmospheric attenuation in the downlink, corresponding to a percentage $p_{dw}\%$ of the total time.

The percentage p_{up} and p_{dw} are such that their sum equals the percentage of time fixed by the performance objective:

$$p_{up}\% + p_{dw}\% = p\%$$

The correct split between p_{up} and p_{dw} is that which makes the value of $(C/T)_{total}$ evaluated under configuration i) (attenuation in the uplink) equal to the value of $(C/T)_{total}$ evaluated under configuration ii) (attenuation in the downlink). The assessment of this split is usually performed by iteration on the computer letting p_{up} vary from 0 to p , with p_{dw} given by $p - p_{up}$, until the values of $(C/T)_{total}$ in the two configurations are equal.

For pessimistic purposes, the TDMA link budgets for EUTELSAT II given here have been calculated for the case of the worst climatic conditions experienced in Europe.

Table AN2-4c gives the values of p_{up} and p_{dw} and the values of the atmospheric attenuations corresponding to these percentages of time.

TABLE 2-4C
**Percentages of time and attenuations used in the link budgets
of TDMA via EUTELSAT II***

Performance objective

BER	10^{-3}	10^{-4}	10^{-6}	10^{-7}
p%	0.2	0.3	2	10

Fading in the uplink

P_{up} %	0.12	0.17	1	5
Attenuation corresponding to P_{up} % of the month (dB)	7.2	5.7	1.8	0.8

Fading in the downlink

P_{dw} %	0.08	0.13	1	5
Attenuation corresponding to P_{dw} % of the month (dB)	5.6	4.2	1.3	0.4
G/T degradation of the receive earth station (dB)	2.2	2.0	0.9	0.3

AN2.4.4.1 Fading in the uplink

BER objective	10^{-3}	10^{-4}	10^{-6}	10^{-7}
Percentage of the month	0.2	0.3	2	10

a) Calculation of the carrier-to-noise temperature ratio in the uplink

Earth station

e.i.r.p. (dBW)	83	83	83	83
Loss due to e.i.r.p. instability (dB)	-0.5	-0.5	-0.5	-0.5

Path

Free-space attenuation (dB)	-207.6	-207.6	-207.6	-207.6
Atmospheric absorption (dB)	-0.3	-0.3	-0.3	-0.3
Rain attenuation (dB)	-7.2	-5.7	-1.8	-0.8

Satellite

Minimum G/T (dB(K ⁻¹))	-0.5	-0.5	-0.5	-0.5
Available (C/T) _n (dB(W/K))	-133.1	-131.6	-127.7	-126.7

b) Calculation of the carrier-to-noise temperature in the downlink**Satellite**

Minimum e.i.r.p. (dBW)	42.5	42.5	42.5	42.5
Output power reduction caused by the attenuation in the uplink (dB)	-2.7	-1.9	-0.6	0

Path

Free-space attenuation (dB)	-205.3	-205.3	-205.3	-205.3
Atmospheric absorption (dB)	-0.2	-0.2	-0.2	-0.2

Earth station

Clear sky G/T (dB(K ⁻¹))	37	37	37	37
Available (C/T) _d (dB(W/K))	-128.7	-127.9	-126.6	-126.0

c) Calculation of the total carrier-to-noise temperature ratio

Available (C/T) _{total} (dB(W/K))	-134.4	-133.1	-130.2	-129.3
--------------------------------------------	--------	--------	--------	--------

AN2.4.4.2 Fading in the downlink

BER objective	10 ⁻³	10 ⁻⁴	10 ⁻⁶	10 ⁻⁷
Percentage of the month	0.2	0.3	2	10

a) Calculation of the carrier-to-noise temperature ratio in the uplink**Earth station**

e.i.r.p. (dBW)	83	83	83	83
Loss due to e.i.r.p. instability (dB)	-0.5	-0.5	-0.5	-0.5

Path

Free-space attenuation (dB)	-207.6	-207.6	-207.6	-207.6
Atmospheric absorption (dB)	-0.3	-0.3	-0.3	-0.3

Satellite

Minimum G/T (dB(K ⁻¹))	-0.5	-0.5	-0.5	-0.5
Available (C/T) _n (dB(W/K))	-125.9	-125.9	-125.9	-125.9

b) Calculation of the carrier-to-noise temperature in the downlink

Satellite

Minimum e.i.r.p. (dBW)	42.5	42.5	42.5	42.5
------------------------	------	------	------	------

Path

Free-space attenuation (dB)	-205.3	-205.3	-205.3	-205.3
-----------------------------	--------	--------	--------	--------

Atmospheric absorption (dB)	-0.2	-0.2	-0.2	-0.2
-----------------------------	------	------	------	------

Rain attenuation (dB)	-5.6	-4.2	-1.3	-0.4
-----------------------	------	------	------	------

Earth station

Clear sky G/T (dB(K ⁻¹))	37	37	37	37
--------------------------------------	----	----	----	----

G/T degradation (dB)	-2.2	-2.0	-0.9	-0.3
----------------------	------	------	------	------

Available (C/T) _d (dB(W/K))	-133.8	-132.2	-128.2	-126.7
----------------------------------------	--------	--------	--------	--------

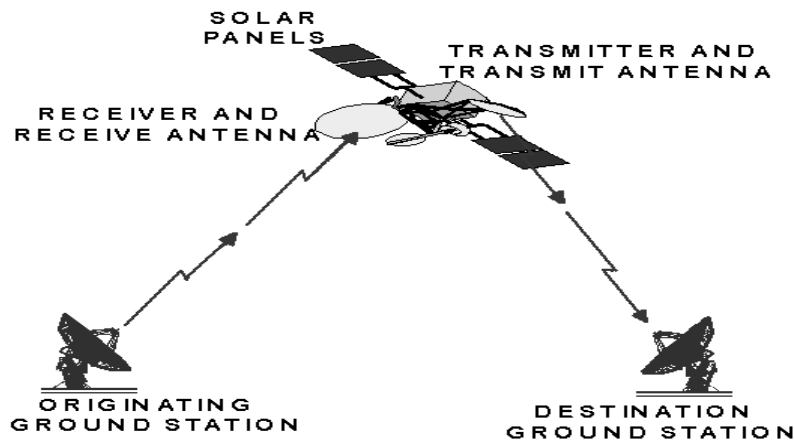
c) Calculation of the total carrier-to-noise temperature ratio

Available (C/T) _{total} (dB(W/K))	-134.4	-133.1	-130.2	-129.3
--------------------------------------------	--------	--------	--------	--------

4.Explain about the basic components of Satellite in detail.

BASIC COMPONENTS OF SATELLITE COMMUNICATION

Every communications satellite in its simplest form (whether low earth or geosynchronous) involves the transmission of information from an originating ground station to the satellite (the uplink), followed by a retransmission of the information from the satellite back to the ground (the downlink). The downlink may either be to a select number of ground stations or it may be broadcast to everyone in a large area. Hence the satellite must have a receiver and a receive antenna, a transmitter and a transmit antenna, some method for connecting the uplink to the downlink for retransmission, and prime electrical power to run all of the electronics. The exact nature of these components will differ, depending on the orbit and the system architecture, but every communications satellite must have these basic components. This is illustrated in the drawing below.



Transmitters:-

The amount of power which a satellite transmitter needs to send out depends a great deal on whether it is in low earth orbit or in geosynchronous orbit. This is a result of the fact that the geosynchronous satellite is at an altitude of 22,300 miles, while the low earth satellite is only a few hundred miles. The geosynchronous satellite is nearly 100 times as far away as the low earth satellite. We can show fairly easily that this means the higher satellite would need almost 10,000 times as much power as the low-orbiting one, if everything else were the same. (Fortunately, of course, we change some other things so that we don't need 10,000 times as much power.)

For either geosynchronous or low earth satellites, the power put out by the satellite transmitter is really puny compared to that of a terrestrial radio station. Your favorite rock station probably boasts of having many kilowatts of power. By contrast, a 200 watt transmitter would be very strong for a satellite.

Antennas:-

One of the biggest differences between a low earth satellite and a geosynchronous satellite is in their antennas. As mentioned earlier, the geosynchronous satellite would require nearly 10,000 times more transmitter power, if all other components were the same. One of the most straightforward ways to make up the difference, however, is through antenna design. Virtually all antennas in use today radiate energy preferentially in some direction.

By doubling the diameter of a reflector antenna (a big "dish") will reduce the area of the beam spot to one fourth of what it would be with a smaller reflector. We describe this in terms of the gain of the antenna. Gain simply tells us how much more power will fall on 1 square centimeter (or square meter or square mile) with this antenna than would fall on that same square centimeter (or square meter or square mile) if the transmitter power were spread uniformly (isotropically) over all directions. The larger antenna described above would have four times the gain of the smaller one. This is one of the primary ways that the geosynchronous satellite makes up for the apparently larger transmitter power which it requires.

One other big difference between the geosynchronous antenna and the low earth antenna is the difficulty of meeting the requirement that the satellite antennas always be "pointed" at the earth. For the geosynchronous satellite, of course, it is relatively easy. As seen from the earth station, the satellite never appears to move any significant distance. As seen from the satellite, the earth station never appears to move. We only need to maintain the orientation of the satellite. The low earth orbiting satellite, on the other hand, as seen from the ground is continuously moving.

Likewise, the earth station, as seen from the satellite is a moving target. As a result, both the earth station and the satellite need some sort of tracking capability which will allow its antennas to follow the target during the time that it is visible. The only alternative is to make that antenna beam so wide that the intended receiver (or transmitter) is always within it. Of course, making

the beam spot larger decreases the antenna gain as the available power is spread over a larger area, which in turn increases the amount of power which the transmitter must provide.

Transponders:-

A transponder is an electronic device that produces a response when it receives a radio-frequency interrogation.



An [Ontario Highway 407](#) toll transponder

In [telecommunication](#), the term transponder (short-for Transmitter-responder and sometimes abbreviated to XPDR, XPNDR or TPDR) has the following meanings:

- An [automatic device](#) that [receives](#), [amplifies](#), and [retransmits](#) a [signal](#) on a different [frequency](#) (see also [broadcast translator](#)).
- An automatic device that transmits a predetermined [message](#) in [response](#) to a predefined received signal.
- A receiver transmitter that will generate a reply signal upon proper [electronic interrogation](#).

A [communications satellite](#)'s [channels](#) are called transponders, because each is a separate [transceiver](#) or [repeater](#). With [digital video data compression](#) and [multiplexing](#), several [video](#) and [audio](#) channels may travel through a single transponder on a single [wideband carrier](#). Original [analog](#) video only has one channel per transponder, with [subcarriers](#) for audio and automatic transmission identification service [ATIS](#). Non-multiplexed [radio stations](#) can also travel in [single channel per carrier](#) (SCPC) mode, with multiple carriers (analog or digital) per transponder. This

allows each station to transmit directly to the satellite, rather than paying for a whole transponder, or using [landlines](#) to send it to an [earth station](#) for multiplexing with other stations.

Power Generation:-

The satellite must generate all of its own power. For a communications satellite, that power usually is generated by large solar panels covered with solar cells. These convert sunlight into electricity. Since there is a practical limit to the how big a solar panel can be, there is also a practical limit to the amount of power which can generated. In addition, unfortunately, transmitters are not very good at converting input power to radiated power so that 1000 watts of power into the transmitter will probably result in only 100 or 150 watts of power being radiated.

We say that transmitters are only 10 or 15% efficient. In practice the solar cells on the most "powerful" satellites generate only a few thousand watts of electrical power. Satellites must also be prepared for those periods when the sun is not visible, usually because the earth is passing between the satellite and the sun. This requires that the satellite have batteries on board which can supply the required power for the necessary time and then recharge by the time of the next period of eclipse.

Satellite Link:-

A [radio](#) link between a transmitting Earth station and a receiving Earth station through one [satellite](#). A satellite link comprises one [uplink](#) and one [downlink](#).

Earth station: -

A [station](#) located either on the Earth's surface or within the major portion of the Earth's atmosphere and intended for communication:

- With one or more space stations; or
- With one or more stations of the same kind by means of one or more reflecting satellites or other objects in space.

5. Write short notes about ,

i) Carrier to Noise Ratio.

ii) Multipath propagation

(i) Carrier to Noise Ratio

In [telecommunications](#), the **carrier-to-noise ratio**, often written CNR or C/N , is the [signal-to-noise ratio](#) (SNR) of a [modulated](#) signal. The term is used to distinguish the CNR of the radio frequency [passband](#) signal from the SNR of an analogue [base band](#) message signal after [demodulation](#), for example an audio frequency analogue message signal. If this distinction is not necessary, the term SNR is often used instead of CNR, with the same definition.

Digitally modulated signals (e.g. [QAM](#) or [PSK](#)) are basically made of two [CW](#) carriers (the [I](#) and [Q](#) components, which are out-of-phase carriers) . In fact, the information (bits or symbols) is carried by given combinations of phase and/or amplitude of the I and Q components. It is for this reason that, in the context of digital modulations, digitally modulated signals are usually referred to as carriers. Therefore, the term carrier-to-noise-ratio (CNR), instead of signal-to-noise-ratio (SNR) is preferred to express the signal quality when the signal has been digitally modulated.

High C/N ratios provide good quality of reception, for example low [bit error rate](#) (BER) of a digital message signal, or high SNR of an analogue message signal.

Definition

The carrier-to-noise ratio is defined as the ratio of the received modulated carrier signal [power](#) C to the received noise power N after the receive filters:

$$\text{CNR} = \frac{C}{N}.$$

When both carrier and noise are measured across the same [impedance](#), this ratio can equivalently be given as:

$$\text{CNR} = \left(\frac{V_C}{V_N} \right)^2 ,$$

where V_C and V_N are the [root mean square](#) (RMS) voltage levels of the carrier signal and noise respectively.

C/N ratios are often specified in [decibels](#) (dB):

$$\text{CNR}_{\text{dB}} = 10 \log_{10} \left(\frac{C}{N} \right) = C_{\text{dB}} - N_{\text{dB}}$$

or in term of voltage:

$$\text{CNR}_{\text{dB}} = 10 \log_{10} \left(\frac{V_C}{V_N} \right)^2 = 20 \log_{10} \left(\frac{V_C}{V_N} \right)$$

The C/N ratio is measured in a manner similar to the way the [signal-to-noise ratio](#) (S/N) is measured, and both specifications give an indication of the quality of a communications channel.

In the famous [Shannon–Hartley theorem](#), the C/N ratio is equivalently to the S/N ratio. The C/N ratio resembles the [carrier-to-interference ratio](#) (C/I, **CIR**), and the [carrier-to-noise-and-interference ratio](#), C/(N+I) or **CNIR**.

(ii) Multipath Propagation

In [wireless telecommunications](#), **multipath** is the [propagation](#) phenomenon that results in [radio signals](#) reaching the receiving [antenna](#) by two or more paths. Causes of multipath include [atmospheric ducting](#), [ionospheric reflection](#) and [refraction](#), and [reflection](#) from water bodies and terrestrial objects such as mountains and buildings.

The effects of multipath include constructive and destructive [interference](#), and [phase shifting](#) of the signal. This causes [Rayleigh fading](#). The standard statistical model of this gives a distribution known as the [Rayleigh distribution](#). Rayleigh [fading](#) with a strong [line of sight](#) content is said to have a [Rician distribution](#), or to be [Rician fading](#).

In [facsimile](#) and [television transmission](#), multipath causes [jitter](#) and [ghosting](#), seen as a faded duplicate image to the right of the main image. Ghosts occur when transmissions bounce off a mountain or other large object, while also arriving at the antenna by a shorter, direct route, with the receiver picking up two signals separated by a delay.

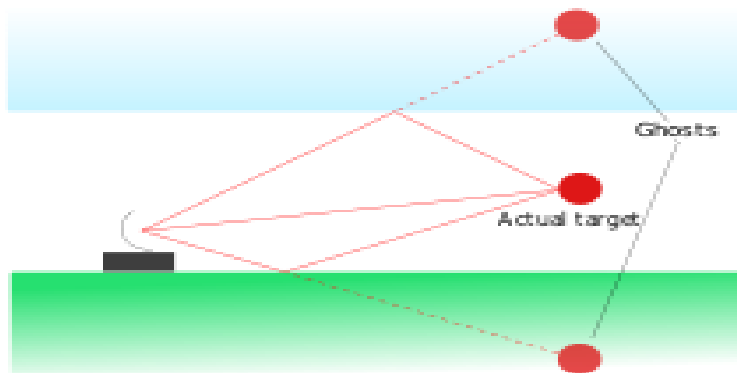


Fig. Radar multipath echoes from an actual target cause ghosts to appear.

In [radar](#) processing, multipath causes ghost targets to appear, deceiving the radar [receiver](#). These ghosts are particularly bothersome since they move and behave like the normal targets (which they echo), and so the receiver has difficulty in isolating the correct target echo. These problems can be overcome by incorporating a ground map of the radar's surroundings and eliminating all echoes which appear to originate below ground or above a certain height.

In digital radio communications (such as [GSM](#)) multipath can cause errors and affect the quality of communications. The errors are due to [intersymbol interference](#) (ISI). [Equalisers](#) are often used to correct the ISI. Alternatively, techniques such as [orthogonal frequency division modulation](#) and [rake receivers](#) may be used.

In a Global Positioning System receiver, Multipath Effect can cause a stationary receiver's output to indicate as if it were randomly jumping about or creeping. When the unit is moving the jumping or creeping is hidden, but it still degrades the displayed accuracy.

At the receiver, due to the presence of the multiple electromagnetic paths, more than one pulse will be received (we suppose here that the [channel](#) has infinite [bandwidth](#), thus the pulse shape is not modified at all), and each one of them will arrive at different times. In fact, since the electromagnetic signals travel at the [speed of light](#), and since every path has a geometrical length possibly different from that of the other ones, there are different air travelling times (consider that, in [free space](#), the light takes 3 μ s to cross a 1 km span). Thus, the received signal will be expressed by

$$y(t) = h(t) = \sum_{n=0}^{N-1} \rho_n e^{j\phi_n} \delta(t - \tau_n)$$

where N is the number of received impulses (equivalent to the number of electromagnetic paths, and possibly very large), τ_n is the time delay of the generic n^{th} impulse, and $\rho_n e^{j\phi_n}$ represent the complex amplitude (i.e., magnitude and phase) of the generic received pulse. As a consequence, $y(t)$ also represents the impulse response function $h(t)$ of the equivalent multipath model.

More in general, in presence of time variation of the geometrical reflection conditions, this impulse response is time varying, and as such we have

$$\tau_n = \tau_n(t)$$

$$\rho_n = \rho_n(t)$$

$$\phi_n = \phi_n(t)$$

Very often, just one parameter is used to denote the severity of multipath conditions: it is called the [multipath time](#), T_M , and it is defined as the time delay existing between the first and the last received impulses

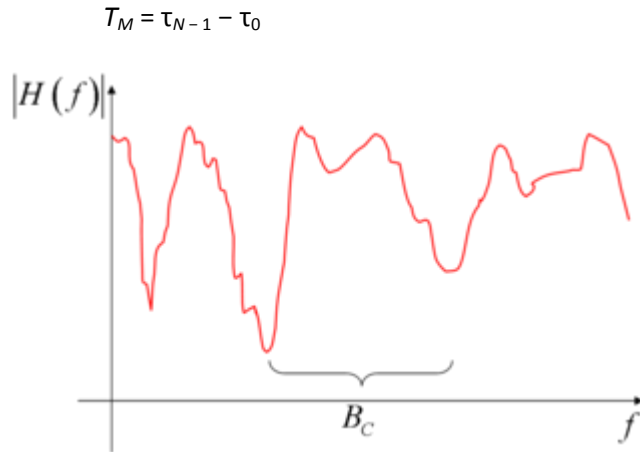


Fig. Mathematical model of the multipath channel transfer function.

In practical conditions and measurement, the multipath time is computed by considering as last impulse the first one which allows to receive a determined amount of the total transmitted power (scaled by the atmospheric and propagation losses), e.g. 99%.

Keeping our aim at linear, time invariant systems, we can also characterize the multipath phenomenon by the channel transfer function $H(f)$, which is defined as the continuous time [Fourier transform](#) of the impulse response $h(t)$

$$H(f) = \mathfrak{F}(h(t)) = \int_{-\infty}^{+\infty} h(t) e^{-j2\pi ft} dt = \sum_{n=0}^{N-1} \rho_n e^{j\phi_n} e^{-j2\pi f\tau_n}$$

where the last right-hand term of the previous equation is easily obtained by remembering that the Fourier transform of a Dirac pulse is a complex exponential function, an [eigenfunction](#) of every linear system.

The obtained channel transfer characteristic has a typical appearance of a sequence of peaks and valleys (also called *notches*); it can be shown that, on average, the distance (in Hz) between two consecutive valleys (or two consecutive peaks), is roughly inversely proportional to the multipath time. The so-called **coherence bandwidth** is thus defined as

$$B_C \approx \frac{1}{T_M}$$

UNIT IV

SATELLITE ACCESS

Single access – Preassigned FDMA, Demand assigned FDMA, SPADE system.
bandwidth – Limited power – Limited TWT amplifier operation, FDMA downlink analysis.

TDMA: Reference burst – Preamble and postamble – Carrier recovery – Network synchronization – Unique word detection – Traffic data – Frame efficiency and channel capacity – Preassigned TDMA – Demand assigned TDMA – Speech interpolation and prediction – Downlink analysis for digital transmission – Calculation of uplink power requirements for FDMA and TDMA – On-board signal processing for TDMA / FDMA operation – Satellite switched TDMA – Code Division Multiple Access – Direct sequence spread spectrum – Code Signal C(T) – Autocorrelation function for C(T) – Acquisition and tracking – Spectrum spreading and despreading – CDMA throughput – Problems – Network layers – TCP link – Satellite links and TCP – Enhancing TCP over satellite channels using standard mechanisms (RFC- 2488) – Requests for comments – Split TCP connections – Asymmetric channels – Proposed systems – Direct broadcast satellite services.

PART A

UNIT – IV

1. Define earth segment.

Earth segment of a satellite communication system consists of transmit earth station and receive earth station.

Example : TV Receive Only systems (TVRO systems)

2. Give the differences between KU-band and the C-band receive only systems.

1. Operating frequency of outdoor unit.
2. Power range
3. Attenuation level

3. What is meant by ODU and IDU.

ODU – The Home Receiver Outdoor Unit

IDU – The Home Receiver Indoor Unit

4. Explain about MATV system.

MATV – Master Antenna TV system.

It is used to provide reception of DBS TV channels to the user group.

Example : Apartment users

It consists of one outdoor unit and various indoor units. Each user can independently access all the channels.

5. Write about CATV system.

CATV – Community Antenna TV system.

As in MATV system, it consists of one outdoor unit and separate feeds for each sense of polarization.

6. Define S/N ratio.

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.

7. What is noise weighting?

The method used to improve the post detection signal to noise ratio is referred to as noise weighting.

8. What is an EIRP?

EIRP means Equivalent Isotropic Radiated Power. It is a measure of radiated or transmitted power of an antenna.

9. What is noise power spectral density?

Noise power per unit Bandwidth is termed as the noise power spectral density.

10. What is an intermodulation noise?

Intermodulation distortion in high power amplifier can result in signal product which appear as noise and it is referred to as intermodulation noise.

11. What is an antenna loss?

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.

12. Define noise factor.

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 290 k.

13. A satellite downlink at 12 GHz operates with a transmit power of 6 W and an antenna gain of 48.2 dB. Calculate the EIRP in dBW.

$$\text{EIRP} = 10 \log 6 + 48.2 = 56 \text{ dBW}$$

14. The range between a ground station and a satellite is 42000 km. Calculate the free space loss a frequency of 6 GHz.

$$[\text{Free space loss}] = 32.4 + 20 \log 42000 + 20 \log 6000 = 200.4 \text{ dB}$$

15. An antenna has a noise temperature of 35 K and it is matched into a receiver which has a noise temperature of 100 K. Calculate the noise power density and the noise power for a BW of 36 MHz.

$$N_0 = (35 + 100) * 1.38 * 10^{-23} = 1.86 * 10^{-21} \text{ J}$$

$$P_N = 1.86 * 10^{-21} * 36 * 10^6 = 0.067 \text{ PW}$$

16. What is meant by frequency reuse?

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.

17. What is DSI?

The DSI gain is the ratio of the number of terrestrial space channels to number of satellite channels. It depends on the number of satellite channels provided as well as the design objectives.

18. What is meant by burst position acquisition?

A station just entering, or reentering after a long delay to acquire its correct slot position is known as burst position acquisition.

19. What is an single access?

A transponder channel aboard a satellite may be fully loaded by a single transmission from earth station.

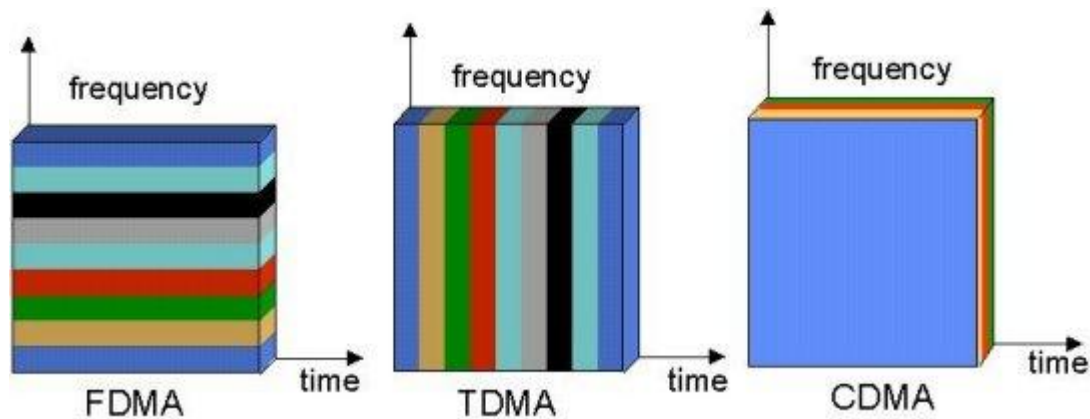
20. What is meant by freeze out?

It has assumed that a free satellite channel will be found for any incoming speech 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.

PART B

1.Explain about CDMA in detail with necessary diagrams

For radio systems there are two resources, frequency and time. Division by frequency, so that each pair of communicators is allocated part of the spectrum for all of the time, results in frequency Division Multiple Access (FDMA). Division by time, so that each pair of communicators is allocated all (or at least a large part) of the spectrum for part of the time results in Time Division Multiple Access (TDMA). In Code Division Multiple Access (CDMA), every communicator will be allocated the entire spectrum all of the time. CDMA uses codes to identify connections.



Multiple Access Schemes

CODING

CDMA uses unique spreading codes to spread the baseband data before transmission. The signal is transmitted in a channel, which is below noise level. The receiver then uses a correlator to despread the wanted signal, which is passed through a narrow bandpass filter. Unwanted signals will not be despread and will not pass through the filter. Codes take the form of a carefully designed one/zero sequence produced at a much higher rate than that of the baseband data. The rate of a spreading code is referred to as chip rate rather than bit rate.

CODES

CDMA codes are not required to provide call security, but create a uniqueness to enable call identification. Codes should not correlate to other codes or time shifted version of itself. Spreading codes are noise like pseudo-random codes, channel codes are designed for maximum separation from each other and cell identification codes are balanced not to correlate to other codes of itself. See codes page for more details.

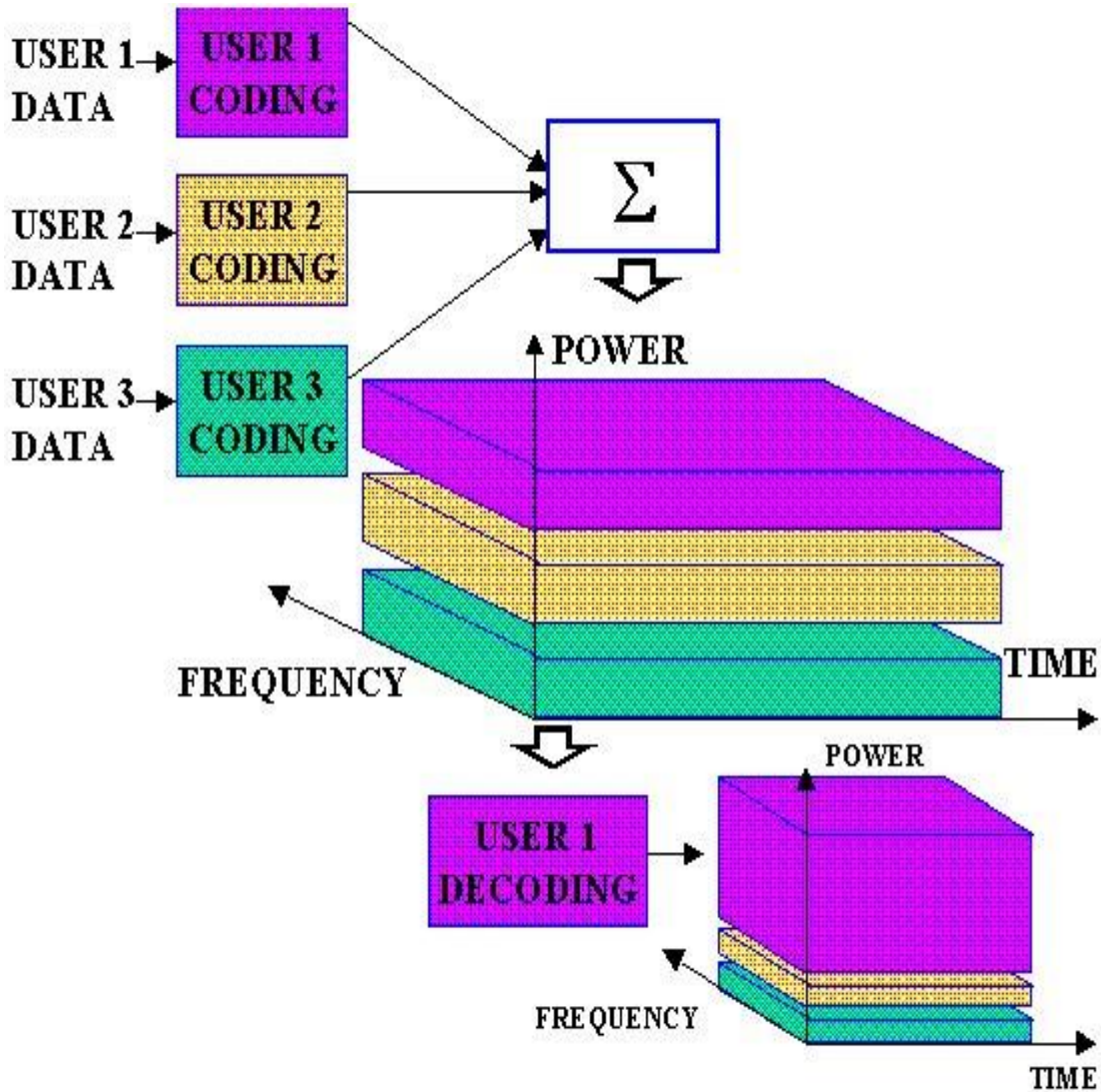


Fig.CDMA spreading

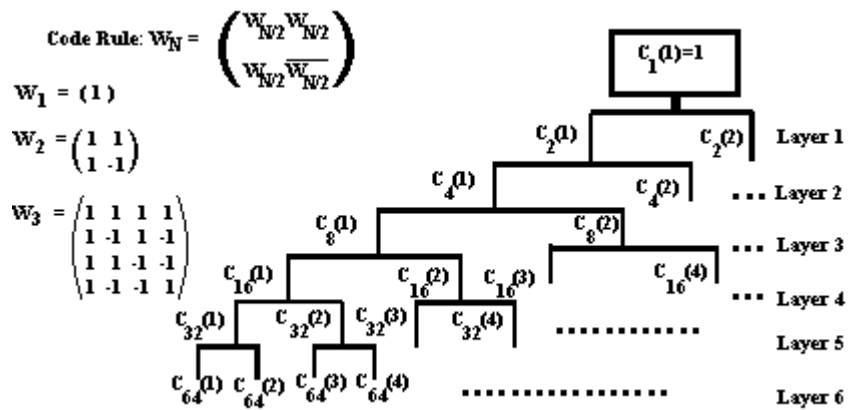
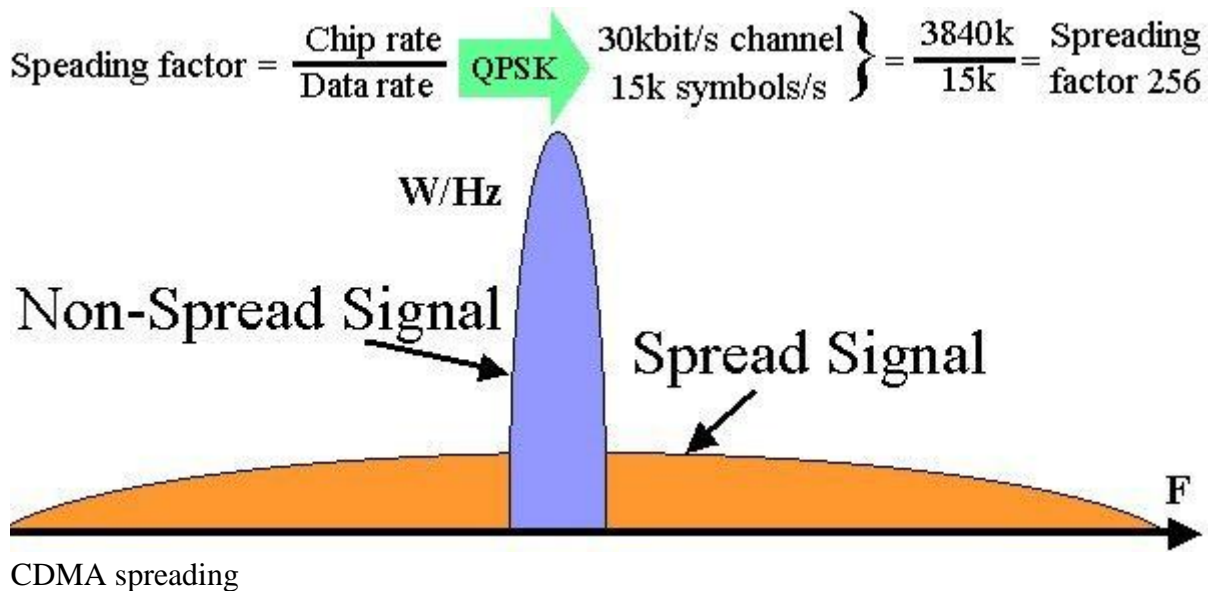


Fig.Example OVSF codes, used in channel coding

THE SPREADING PROCESS

WCDMA uses Direct Sequence spreading, where spreading process is done by directly combining the baseband information to high chip rate binary code. The Spreading Factor is the ratio of the chips (UMTS = 3.84Mchips/s) to baseband information rate. Spreading factors vary from 4 to 512 in FDD UMTS. Spreading process gain can be expressed in dBs (Spreading factor 128 = 21dB gain)



POWER

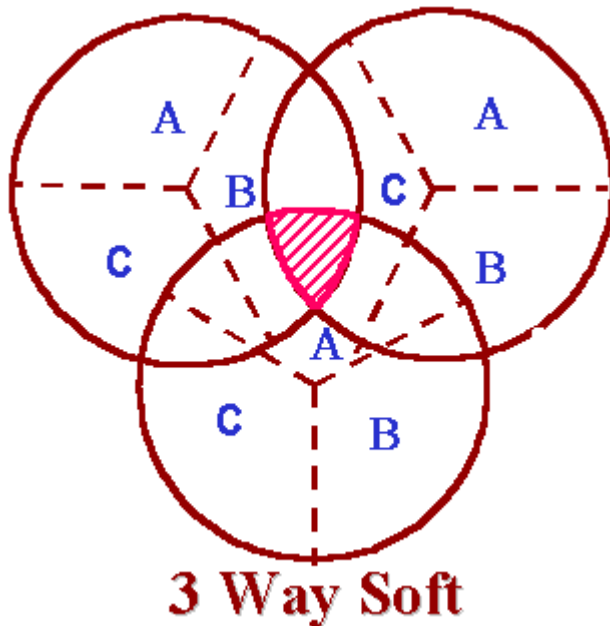
CONTROL

CDMA is interference limited multiple access system. Because all users transmit on the same frequency, internal interference generated by the system is the most significant factor in determining system capacity and call quality. The transmit power for each user must be reduced to **limit interference**, however, the power should be enough to maintain the required E_b/N_0 (signal to noise ratio) for a satisfactory **call quality**. Maximum **capacity** is achieved when E_b/N_0 of every user is at the minimum level needed for the acceptable channel performance. As the MS moves around, the RF environment continuously changes due to fast and slow fading, external interference, shadowing, and other factors. The aim of the dynamic power control is to limit transmitted power on both the links while maintaining link quality under all conditions. Additional advantages are longer mobile battery life and longer life span of BTS power amplifiers

HANDOVER

Handover occurs when a call has to be passed from one cell to another as the user moves between cells. In a traditional "hard" handover, the connection to the current cell is broken, and then the connection to the new cell is made. This is known as a "break-before-make" handover.

Since all cells in CDMA use the same frequency, it is possible to make the connection to the new cell before leaving the current cell. This is known as a "make-before-break" or "soft" handover. Soft handovers require less power, which reduces interference and increases capacity. Mobile can be connected to more than two BTS the handover. "Softer" handover is a special case of soft handover where the radio links that are added and removed belong to the same Node B. See Handover page for more details.



CDMA soft handover

MULTIPATH AND RAKE RECEIVERS

One of the main advantages of CDMA systems is the capability of using signals that arrive in the receivers with different time delays. This phenomenon is called multipath. FDMA and TDMA, which are narrow band systems, cannot discriminate between the multipath arrivals, and resort to equalization to mitigate the negative effects of multipath. Due to its wide bandwidth and rake receivers, CDMA uses the multipath signals and combines them to make an even stronger signal at the receivers. CDMA subscriber units use rake receivers. This is essentially a set of several receivers. One of the receivers (fingers) constantly searches for different multipaths and feeds the information to the other three fingers. Each finger then demodulates the signal corresponding to a strong multipath. The results are then combined together to make the signal stronger..

2. Explain about TDMA in detail.

Time division multiple access (TDMA) is a channel access method for shared medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots. The users transmit in rapid succession, one after the other, each using his own time slot. This allows multiple stations to share the same transmission medium (e.g. radio frequency channel) while using only a part of its channel capacity. TDMA is used in the digital 2G cellular systems such as Global System for Mobile Communications (GSM), IS-136, Personal Digital Cellular (PDC) and iDEN, and in the Digital Enhanced Cordless Telecommunications (DECT) standard for portable phones. It is also used extensively in satellite systems, combat-net radio systems, and PON networks for upstream traffic from premises to the operator. For usage of Dynamic TDMA packet mode communication, see below.

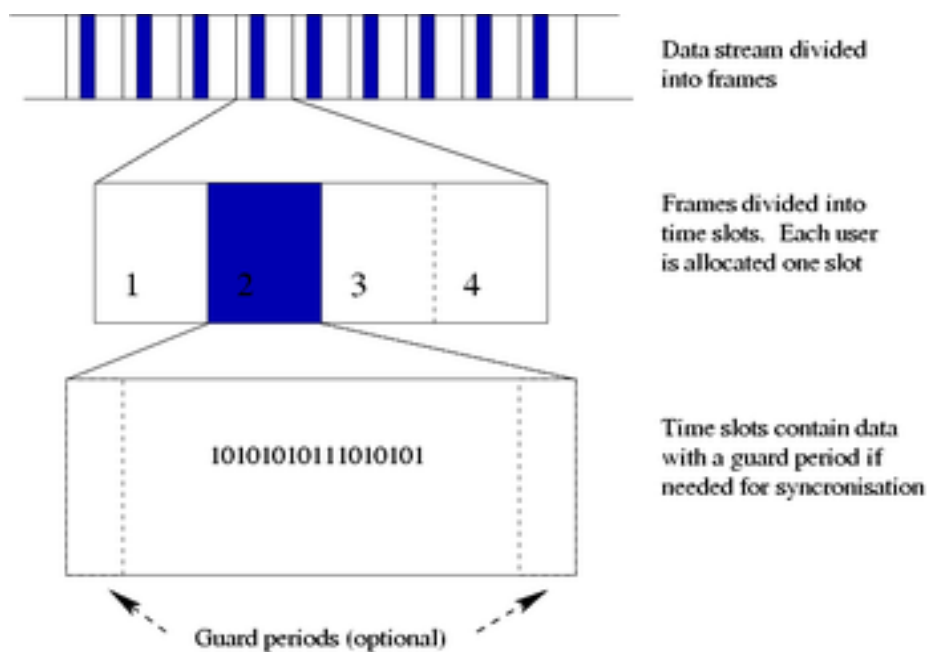


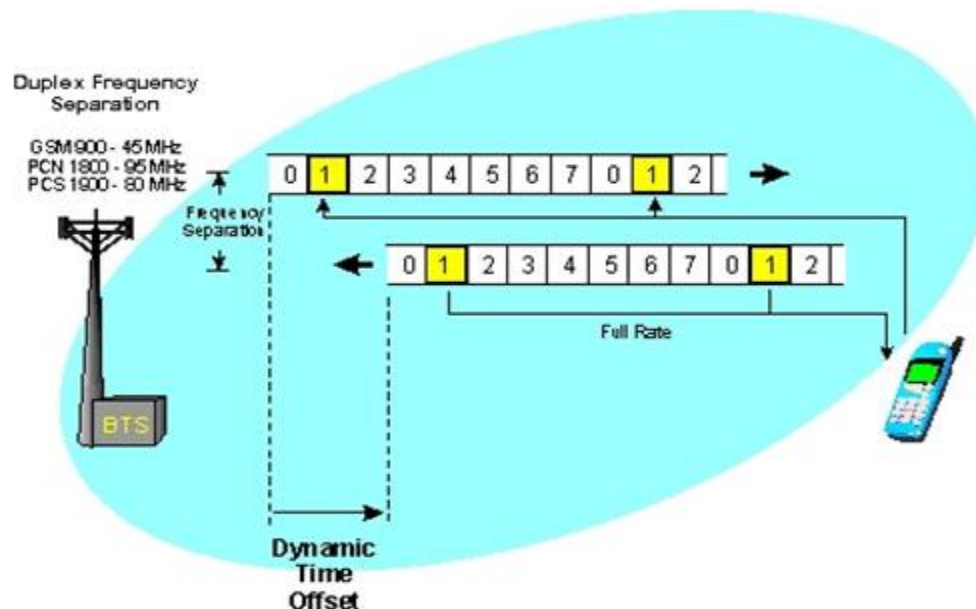
Fig. TDMA frame structure showing a data stream divided into frames and those frames divided into time slots.

TDMA is a type of Time-division multiplexing, with the special point that instead of having one transmitter connected to one receiver, there are multiple transmitters. In the case of the uplink from a mobile phone to a base station this becomes particularly difficult because the mobile phone can move around and vary the timing advance required to make its transmission match the

TDMA characteristics

- Shares single carrier frequency with multiple users
- Non-continuous transmission makes handoff simpler
- Slots can be assigned on demand in dynamic TDMA
- Less stringent power control than CDMA due to reduced intra cell interference

- Higher synchronization overhead than CDMA
- Advanced equalization may be necessary for high data rates if the channel is "frequency selective" and creates Inter symbol interference



- Cell breathing (borrowing resources from adjacent cells) is more complicated than in CDMA
- Frequency/slot allocation complexity
- Pulsating power envelope: Interference with other devices.

Comparison with other multiple-access schemes

In radio systems, TDMA is usually used alongside [Frequency-division multiple access](#) (FDMA) and [Frequency division duplex](#) (FDD); the combination is referred to as FDMA/TDMA/FDD. This is the case in both GSM and IS-136 for example. Exceptions to this include the [DECT](#) and [PHS](#) micro-cellular systems, [UMTS-TDD](#) UMTS variant, and China's [TD-SCDMA](#), which use [Time Division duplexing](#), where different time slots are allocated for the base station and handsets on the same frequency.

A major advantage of TDMA is that the radio part of the mobile only needs to listen and broadcast for its own time slot. For the rest of the time, the mobile can carry out measurements on the network, detecting surrounding transmitters on different frequencies. This allows safe [inter frequency handovers](#), something which is difficult in CDMA systems, not supported at all in [IS-95](#) and supported through complex system additions in [Universal Mobile Telecommunications System](#) (UMTS). This in turn allows for co-existence of [microcell](#) layers with [macro cell](#) layers.

CDMA, by comparison, supports "soft hand-off" which allows a mobile phone to be in communication with up to 6 base stations simultaneously, a type of "same-frequency handover". The incoming packets are compared for quality, and the best one is selected. CDMA's "cell breathing" characteristic, where a terminal on the boundary of two congested cells will be unable to receive a clear signal, can often negate this advantage during peak periods.

A disadvantage of TDMA systems is that they create [interference](#) at a frequency which is directly connected to the time slot length. This is the buzz which can sometimes be heard if a TDMA phone is left next to a radio or speakers.^[1] Another disadvantage is that the "dead time" between time slots limits the potential bandwidth of a TDMA channel. These are implemented in part because of the difficulty in ensuring that different terminals transmit at exactly the times required. Handsets that are moving will need to constantly adjust their timings to ensure their transmission is received at precisely the right time, because as they move further from the base station, their signal will take longer to arrive. This also means that the major TDMA systems have hard limits on cell sizes in terms of range, though in practice the power levels required to receive and transmit over distances greater than the supported range would be mostly impractical anyway.

Dynamic TDMA

In **dynamic time division multiple access**, a scheduling algorithm dynamically reserves a variable number of time slots in each frame to variable bit-rate data streams, based on the traffic demand of each data stream. Dynamic TDMA is used in

- HIPERLAN/2 broadband radio access network.
- IEEE 802.16a WiMax
- Bluetooth
- The Packet radio multiple access (PRMA) method for combined circuit switched voice communication and packet data.
- TD-SCDMA
- ITU-T G.hn

3.Explain about the process of Carrier recovery in modulation process.

A **carrier recovery** system is a [circuit](#) used to estimate and compensate for frequency and phase differences between a received signal's [carrier wave](#) and the receiver's local oscillator for the purpose of coherent [demodulation](#).

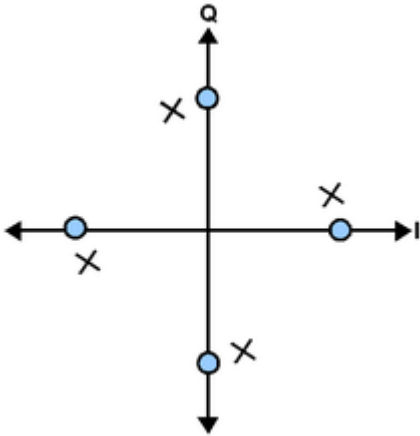


Fig.Example of [QPSK](#) carrier recovery **phase error** causing a fixed rotational offset of the received symbol [constellation](#), X, relative to the intended constellation, O.

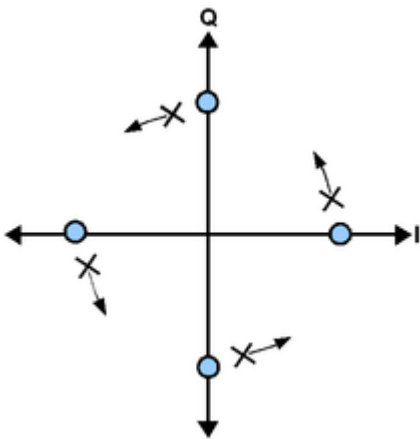


Fig.Example of [QPSK](#) carrier recovery **frequency error** causing rotation of the received symbol [constellation](#), X, relative to the intended constellation, O.

In the transmitter of a communications [carrier system](#), a carrier wave is modulated by a [baseband](#) signal. At the receiver the baseband information is extracted from the incoming modulated waveform. In an ideal communications system the [carrier frequency](#) oscillators of the transmitter and receiver would be perfectly matched in frequency and phase thereby permitting perfect coherent demodulation of the modulated baseband signal. However, transmitters and receivers rarely share the same carrier frequency oscillator. Communications receiver systems

are usually independent of transmitting systems and contain their own oscillators with frequency and phase offsets and instabilities. Doppler shift may also contribute to frequency differences in mobile [radio frequency](#) communications systems. All these frequency and phase variations must be estimated using information in the received signal to reproduce or recover the carrier signal at the receiver and permit coherent

Methods

For a quiet carrier or a signal containing a dominant carrier [spectral line](#), carrier recovery can be accomplished with a simple band-pass filter at the carrier frequency and/or with a [phase-locked loop](#) ^[1].

However, many modulation schemes make this simple approach impractical because most signal power is devoted to modulation—where the information is present—and not to the carrier frequency. Reducing the carrier power results in greater transmitter efficiency. Different methods must be employed to recover the carrier in these conditions.

Non-Data-Aided

Non-data-aided/"blind" carrier recovery methods do not rely on any knowledge of the modulation symbols. They are typically used for simple carrier recovery schemes or as the initial method of coarse carrier frequency recovery ^[2]. [Closed-loop](#) non-data-aided systems are frequently maximum likelihood frequency error detectors ^[2].

Multiply-filter-divide

In this method of non-data-aided carrier recovery a non-linear operation is applied to the modulated signal to create harmonics of the carrier frequency with the modulation removed. The carrier harmonic is then [band-pass filtered](#) and frequency divided to recover the carrier frequency. (This may be followed by a PLL.) Multiply-filter-divide is an example of [open-loop](#) carrier recovery, which is favored in burst transactions since the acquisition time is typically shorter than for close-loop synchronizers.

If the phase-offset/delay of the multiply-filter-divide system is known, it can be compensated for to recover the correct phase. In practice, applying this phase compensation is difficult. In general, the order of the modulation matches the order of the nonlinear operator required to produce a clean carrier harmonic.

$$V_{BPSK}(t) = A(t)\cos(\omega_{RF}t + n\pi); n = 0, 1$$

$$V_{BPSK}^2(t) = A^2(t)\cos^2(\omega_{RF}t + n\pi)$$

$$V_{BPSK}^2(t) = \frac{A^2(t)}{2}[1 + \cos(2\omega_{RF}t + n2\pi)]$$

This produces a signal at twice the RF carrier frequency with no phase modulation (modulo 2π phase is effectively 0 modulation)

For a QPSK signal, we can take the fourth power:

$$V_{QPSK}(t) = A(t)\cos(\omega_{RF}t + n\frac{\pi}{2}); n = 0, 1, 2, 3$$

$$V_{QPSK}^4(t) = A^4(t)\cos^4(\omega_{RF}t + n\frac{\pi}{2})$$

$$V_{QPSK}^4(t) = \frac{A^4(t)}{8}[3 + 4\cos(2\omega_{RF}t + n\pi) + \cos(4\omega_{RF}t + n2\pi)]$$

Two terms (plus a DC component) are produced. An appropriate filter around $4\omega_{RF}$ recovers this frequency.

Costas Loop

Carrier frequency and phase recovery as well as demodulation can be accomplished using a [Costas loop](#) of the appropriate order^[4]. A Costas loop is a cousin of the PLL that uses coherent quadrature signals to measure phase error. This phase error is used to discipline the loop's oscillator. The quadrature signals, once properly aligned/recovered, also successfully demodulate the signal. Costas loop carrier recovery may be used for any M-ary [PSK](#) modulation scheme^[4]. One of the Costas Loop's inherent shortcomings is a $360/M$ degree phase ambiguity present on the demodulated output.

Decision-Directed

At the start of the carrier recovery process it is possible to achieve symbol synchronization prior to full carrier recovery because symbol timing can be determined without knowledge of the carrier phase or the carrier's minor frequency variation/offset^[5]. In decision directed carrier recovery the output of a symbol decoder is fed to a comparison circuit and the phase difference/error between the decoded symbol and the received signal is used to discipline the local oscillator. Decision directed methods are suited to synchronizing frequency differences that are less than the symbol rate because comparisons are performed on symbols at, or near, the symbol rate. Other frequency recovery methods may be necessary to achieve initial frequency acquisition.

A common form of decision directed carrier recovery begins with quadrature phase correlators producing in-phase and quadrature signals representing a symbol coordinate in the [complex plane](#). This point should correspond to a location in the modulation [constellation diagram](#). The phase error between the received value and nearest/decoded symbol is calculated using [arc tangent](#) (or an approximation). However, arc tangent, can only compute a phase correction between 0 and $\pi / 2$. Most [QAM](#) constellations also have $\pi / 2$ phase symmetry. Both of these shortcomings can be overcome by the use of [differential coding](#)^[2].

In low SNR conditions, the symbol decoder will make errors more frequently. Exclusively using the corner symbols in rectangular constellations or giving them more weight versus lower SNR symbols reduces the impact of low SNR decision errors.

4.Explain about FDMA process in Detail.

FDMA was the first multiple access technique employed in satellite communications. Because of its simplicity and flexibility, it remains very commonly used. In FDMA, a different frequency is allocated in a transponder to each carrier (possibly multi-destination) to be transmitted by an earth station, and then a given bandwidth, in proportion with the carrier capacity, is also allocated. Therefore, the satellite resource is used in common (Figure 5.1).

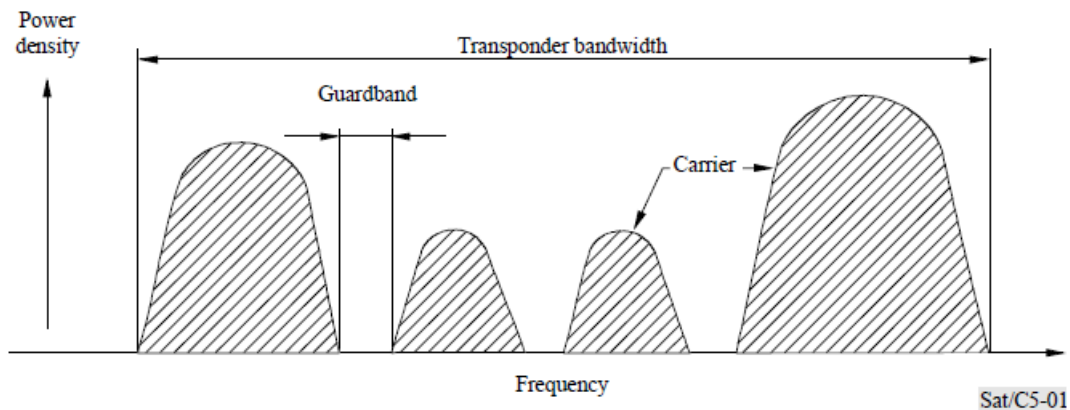


FIGURE 5.1

Frequency plan of a satellite transponder for FDMA transmission

A detrimental effect of this type of multiple access is that, due to non-linearities in the transponder chain and notably in the power amplifier, simultaneously transmitting several carriers in the same

transponder causes intermodulation between these carriers, resulting in unwanted emissions (intermodulation products).

In order to reduce the level of such interference, it is necessary to keep the transmitted power significantly lower than the maximum available output power (saturation). This is called "back-off". Furthermore, the power transmitted by each earth station needs to be controlled.

Intermodulation effects are dealt with in detail in Chapter 2 (§ 2.1.5), Appendix 5.2 and, as concerns these effects in earth stations' power amplifiers, in Chapter 7 (§ 7.4.5.2).

FDMA may be implemented with various modulation-multiplexing methods, the most common being:

- FDM-FM (analogue), in which carriers are frequency-modulated by a frequency division multiplexed baseband signal.
- TDM-PSK (digital), in which carriers are PSK modulated by a time division multiplexed baseband signal.
- SCPC (for earth stations with small traffic), in which each individual telephone (or data) channel modulates the carrier, either by FM (analogue) or PSK (digital).

5.2.1 Multiplexed FDMA

In multiplexed (FDM or TDM) FDMA, each carrier is assigned a separate, non-overlapping frequency channel as shown in Figure 5.1. Power amplifier intermodulation products are controlled to acceptable levels by appropriate frequency selection and/or reduction of input power levels to permit sufficiently linear operation. Although such a control may also be needed in medium and high traffic earth stations¹, this is particularly critical in the satellite transponder where the output power is a very important and costly parameter. Output back-offs up to 3 dB (50% reduction of the output power) could typically be needed.

Signal distortions and adjacent channel interference are also to be accounted for.

The extent of the guardbands depends in part on the residual sidebands in each transmitted signal. They must also take into account the frequency drifts of the satellite and of earth stations' local oscillators. Doppler shifts of the satellite can also be significant for very low data rate transmissions.

Calculations of the effects of intermodulation products created by satellite and earth station amplifiers must also take into account changes in the relative signal strength received at the satellite, due to possible variations in the earth stations e.i.r.p., rain losses, antenna pointing deviations, etc.

FDM-FM multiplexing and modulation are dealt with in Chapter 3 (§ 3.4), Chapter 4 (§ 4.1.1.1), Chapter 7 (§ 7.5.3) and also, as concerns multiplex equipment and baseband formats, in Chapter 8 (§ 8.1.3).

In pace with the current trend towards a general digitalization of telecommunications and also towards ISDN networking, FDM-FM-FDMA, the first and once dominant technique to be implemented in satellite communications (especially in international communications), is now frequently replaced by TDM-PSK-FDMA.

In fact, the use of digital techniques enables significant increases in capacity. TDM-PSK-FDM can be extremely efficient for point-to-point and point-to-multipoint links and also gives the possibility to further increase this traffic capacity by implementing low bit rate encoding (LRE) telephony and digital processing techniques such as digital speech interpolation (DSI) and even digital circuit multiplication equipment (DCME) (see Chapter 3, § 3.3.7).

TDM-PSK multiplexing² and modulation are dealt with in Chapter 3 (§ 3.5), Chapter 4 (§ 4.2), Chapter 7 (§ 7.6.2.2) and, as concerns multiplex equipment, DCME, etc. in Chapter 8 (§§ 8.1.3, 8.1.4, etc.).

In order to optimize the link budget and the power-bandwidth efficiency, forward-error correction (FEC) techniques are very generally applied (Chapter 3, § 3.3.5 and Appendix 3.2). Since various coding methods and code rates are available, the use of FEC makes it possible to adapt the link budget design in a flexible way thanks to a trade-off between the quality (BER) and the occupied bandwidth. FEC encoding can be used either to relax the link budget parameters (e.g. smaller earth stations) or to improve the BER of a given link.

5.2.2 Single Channel Per Carrier (SCPC)

In an SCPC system, each carrier is modulated by only one voice (or low to medium bit rate data) channel. In the case of voice (telephony), the channel can be processed in a number of ways.

Some – older – analogue systems use companded frequency modulation (CFM, see Chapter 3, § 3.2.1), but most systems are digital (PSK modulated). Although some of them remain using

conventional 64 kbit/s pulse code modulation (PCM) with 4-PSK (QPSK) carrier modulation³, 32 kbit/s ADPCM and low bit rate encoding (LRE), combined with powerful FEC schemes and with 4-PSK (QPSK) or 2-PSK (BPSK) are nowadays generally preferred, especially for domestic and very small aperture terminal (VSAT) systems.

In voice transmissions, the carrier is voice activated and this permits up to 60% power saving in the satellite transponder (the carriers are active only 40% of the time on average).

SCPC-CFM systems use bandwidths of 45, 30 or 22.5 kHz per carrier, while bandwidths for digital SCPC (SCPC-PSK) can extend also from 45 kHz (64 kbit/s) down to 22.5 kHz or even less (LRE). A 36 MHz transponder can therefore accommodate from 800 up to 1 600 simultaneous SCPC channels (see Figure 5.2). It is also possible, in FDMA, to share a transponder between a part used for SCPC carriers and another part used for TDM carriers.

Much more details on digital SCPC operation and earth station equipment will be found in Chapter 7 (§ 7.6.2.1).

The assignment of transponder channels to earth stations may be fixed (PAMA) or variable. In the latter case (DAMA), the channel slots of the transponder are assigned to different earth stations according to their instantaneous needs (see below § 5.5).

SCPC systems are cost effective for networks consisting of a significant number of earth stations, each needing to be equipped with a small number of channels (thin route, e.g. rural, telephony). In the case of relatively heavy traffic, TDM-PSK-FDMA systems tend to be more economical.

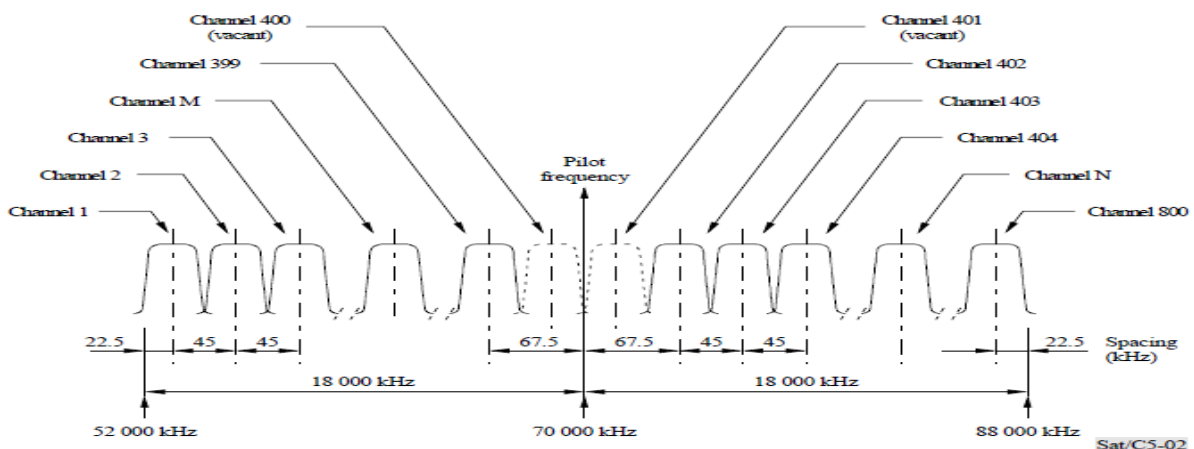


FIGURE 5.2

Typical frequency plan of a satellite transponder for 45 kHz SCPC channels

5.Explain about different types of spreading systems.

The two most common CDMA techniques are based on:

- Direct sequence (DS), also called pseudo-noise (PN) modulation, which is the dominant technique;
- Frequency hopping (FH) modulation.

Although FH systems do find application in satellite communications and other techniques have been proposed, such as time hopping, this section will mostly deal with DS systems.

As a result of these techniques, the transmitted bandwidth (the given allocated bandwidth referred to above) is much larger (e.g. by 10^3 or more) than the baseband bandwidth of the information signal. This is why these processes are also called spread spectrum or spread spectrum multiple access (SSMA) techniques.

Some of the features of CDMA systems are summarized below:

- Unlike FDMA and TDMA, only minimum dynamic (frequency or time) coordination is needed between the various transmitters.
- The system intrinsically accommodates multiple users (each with their own code in the set) and new users can easily be introduced. In principle, no channel assignment control is needed⁶. Only the transmission quality (signal-to-noise) is subject to a gradual degradation when the satellite transponder loading increases. This is because, in a given receiving earth station, each other user signal (not destined to this station) is received as a supplementary unwanted, noise-like, signal (i.e. the other users transmit their signal in the same extended bandwidth).

In fact, the capacity of the system is limited by the quality of transmission which is acceptable in the presence of this "self-noise" or "self-interference" (also called MAI: multiple access interference) caused by the other users of the system:

- The power flux-density (pfd) of the CDMA signals, as received in the service area, is automatically limited, with no need for any other energy dispersal process.
- As already explained, CDMA brings out significant anti-jamming capability.
- It also provides a low probability of intercept by other users and some kind of privacy, due to individual characteristic codes.

As a consequence of these features, CDMA allows a good flexibility in the management of the traffic and of the orbit/spectrum resources.

At present, these advantages prove to be particularly effective in new systems devoted to communications towards very small (possibly handheld) terminals, either for MSS applications⁷ (e.g. the Globalstar system) or for FSS (e.g. the Skybridge system).

5.4.2 Direct sequence systems

Figure 5.7 summarizes the typical operation of a DS system (of course, there can be variations in the block-diagram, e.g. the spreading can be performed after modulation).

The PN code generator generates a pseudo-random binary sequence of length N at a rate R_c , with $R_c = N \cdot R_b$, R_b being the information bit rate. This sequence is combined, i.e. modulo-2 added with the information signal: this means that each information signal bit is cut in N small "chips" (whence the name "chip rate" for R_c), thus spreading the combined signal in a much larger bandwidth $W_{ss} \sim R_c$. This signal modulates, usually by PSK (BPSK or QPSK⁸), the carrier before transmission. At receive, a replica of the PN sequence is generated and combined, by a correlation process, in synchronism with the transmitted sequence. This results in "de-spreading" of the received signal which is restored, by coherent or non-coherent (see below § 5.4.5.2) demodulation.

5.4.3 Frequency Hopping systems

Figure 5.8 summarizes the typical operation of a FH system (again, there can be variations in the block-diagram). The system works similarly to the DS system, since a correlation process ("de-hopping") is also performed at receive. The difference is that here the pseudo-random sequence is used to control a frequency synthesizer, which results in the transmission of each information bit in the form of (N) multiple pulses at different frequencies in an extended bandwidth $W_{ss} = N \cdot \Delta f$ (Δf being the frequency synthesizer step). Note that:

- coherent demodulation is difficult to implement in FH receivers because it is difficult to maintain phase relation between the frequency steps;
- due to the relatively slow operation of frequency synthesizers, DS systems permit higher code rates than FH systems. In fact, combined FH/DS systems have been proposed.

5.4.4 CDMA parameters and performance

In supplement to the spreading factor $M = R_c/R_s$ (where R_s is the symbol rate), the two basic parameters defining CDMA system performance are the processing gain and the jamming margin:

- the so-called processing gain g_p (G_p when expressed in dB) is the ratio of the transmitted (expanded) bandwidth to the information bandwidth (or bit rate)⁹:

$$g_p = W_{ss}/R_b \sim R_c/R_b$$

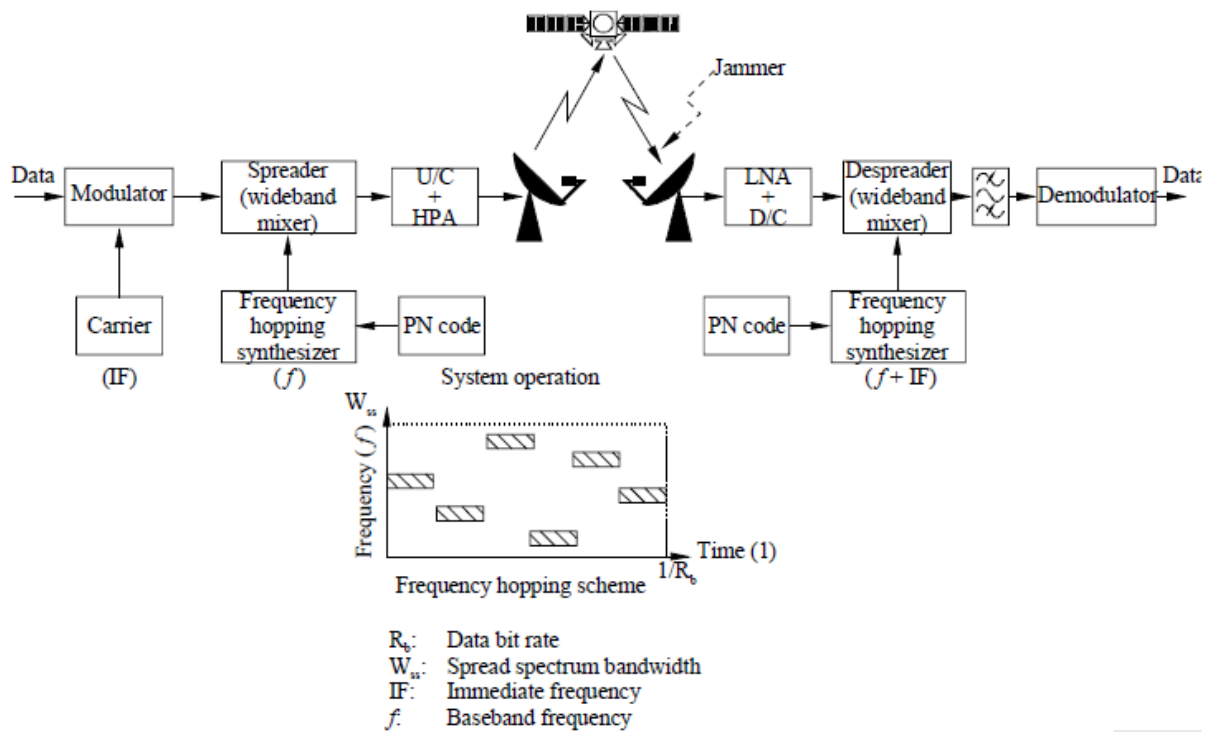
or, in dB:

$$G_p = 10 \log (W_{ss}/R_b) \sim 10 \log (R_c/R_b).$$

This expresses the ratio of the signal-to-noise (or e_b/n_0) of the output signal (after de-spreading) to the signal-to-noise of the signal at the receiver input¹⁰.

Processing gains G_p can typically extend from about 20 dB up to 60 dB.

- the jamming margin m_j (M_j when expressed in dB) is the maximum tolerable interference-to-signal power ratios, i.e. the degree of interference which a CDMA system can accept for a given specified transmission quality (E_b/N_0 , whence BER). By interference, this is meant any type of undesired signal, either "self-noise" due to the other users of the system and/or an external jamming signal (in the same extended bandwidth).



Sat/C5-08

FIGURE 5.8

Frequency hopping (FH) CDMA

If j is the undesired signal power, its spectral density is j/W_{ss} and the total noise density is $n_0 = n_{0Th} + j/W_{ss}$. Assuming that j/W_{ss} is dominant against the thermal noise n_{0Th} and $s = e_b \cdot R_b$ being the desired signal power, then the theoretical jamming margin is:

$$m_j = j/s = (W_{ss} \cdot n_0)/(e_b \cdot R_b) = g_p/(e_b/n_0)$$

or, in dB:

$$M_j = G_p - (E_b/N_0) - L$$

In the last expression, the term L is introduced as an implementation margin (about 1 to 3 dB) representing various losses (spreading and de-spreading, demodulation, etc.).

This expression can also be seen as a rule-of-thumb value of the system capacity, i.e. of the number of users that can be accommodated (assuming that each user is received at the same level and that

there is no external jammer). For example, if the specified E_b/N_0 is 8 dB and $L = 2$ dB, the capacity is about one tenth of the processing gain.

6.Explain about SPADE System in detail.

5.5.4.2 The SPADE system

For international telecommunications, the INTELSAT SPADE system was the first example of a global network operating on the principle described above.

From 1973 onwards, the INTELSAT organization was operating a group of SCPC channels with 4-PSK modulation in DAMA mode, intended to provide operators of standard A stations with an economical means of communication with multiple destinations, if the traffic for each route did not justify an FDM-FM carrier. The network thus developed was known as SPADE (for "SCPC PCM multiple Access Demand assignment Equipment").

This system was characterized by distributed control of frequency allocations, unlike most other DAMA systems operating within domestic networks, which were based on centralized control. In the SPADE system, stations were thus able to configure their own channels, independently of each other. For the sake of system control, all network stations were able to transmit on a 128 kbit/s common channel, with TDMA (one time slot per station).

SPADE system stations consisted of a group of SCPC systems, controlled by a control and switching subassembly. The latter continually updated a table of active frequencies in the system. If a local communication was detected, it chose a new frequency pair from the list of available frequencies, and immediately notified the destination station of this assignment over the common signalling channel. After this, a free SCPC channel could be chosen, and the terrestrial link switched to this channel to set up the communication. Communication release, and setting up a link to a remote communication, were carried out in the same way.

Today, this system is abandoned, and is soon to be replaced by the TRDS system (thin route DAMA System) broadly inspired by the SCPC/DAMA systems for domestic networks, whose precise parameters are presently being finalized.

5.5.4.3 SCPC/DAMA systems for small-scale networks

Two important factors have considerably accelerated the development of low-cost SCPC/DAMA systems: development of digital modulation SCPC channel equipment, and the significant increase in the number of VSAT data type stations which can be used as signalling channels in DAMA systems.

Figure 5.10 shows an example of a small, star network SCPC/DAMA system for telephone applications. All the traffic stations are equipped with SCPC channels, and a signalling channel for receiving signalling information broadcast on a TDM carrier from the central signalling terminal (CST) located in the central station. They then send data packet signalling on a TDMA common

carrier to the CST. This two-way signalling channel is used for demand assignment functions, and also for remote management of traffic stations from the network control centre (NCC) of the central station.

When a communication is detected in a traffic station, the SCPC terminal records the call number, then sends the request to the NCC via the signalling channel and the CST (which acts as a multiplexer for the signalling). The NCC analyses the request and chooses new working frequencies to set up the communication. This allocation is then sent to the traffic stations for action (see Figure 5.11, as an example, which shows the exchanges needed to set up a telephone call using ETSI QSIG signalling).

This is a centralized type system, since the signalling analysis and all allocation decisions are made at a central site (by the CST/NCC pair, in our example). This choice of architecture allows the greatest simplification of the traffic stations, essential in small network systems, and gives optimum use of satellite resources. Conversely, the signalling traffic is greater, and the central site may be a rather weak nodal point.

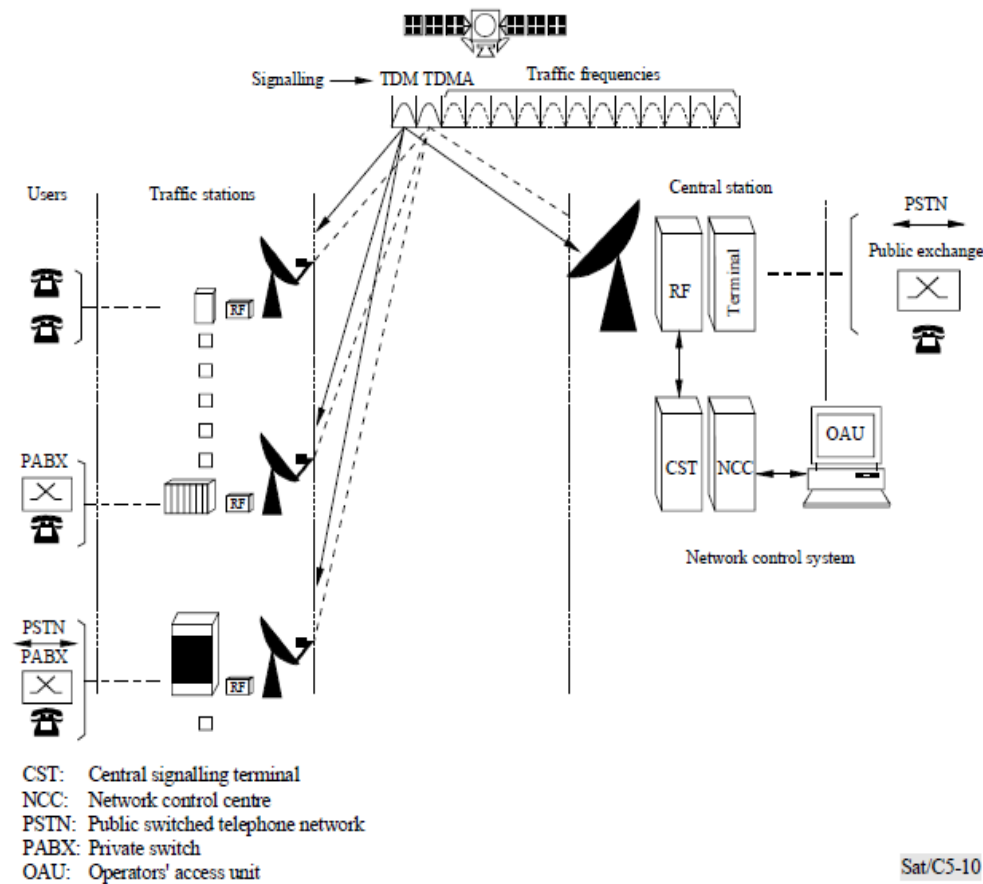
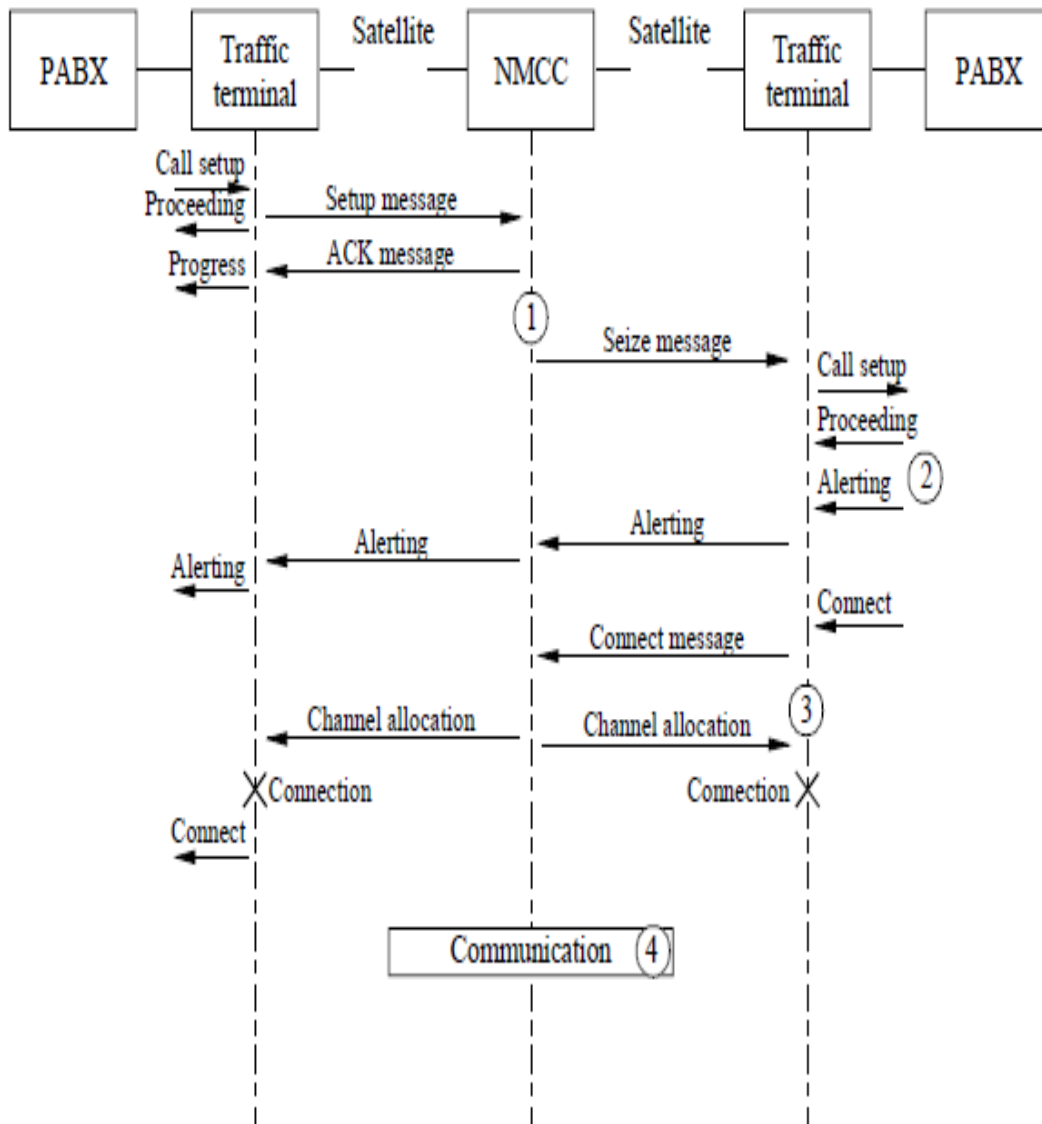


FIGURE 5.10

Example of an SCPC/DAMA for a small, star-configuration telephone system



- ① The NMCC finds the target terminal and seizes a circuit
- ② The PABX rings the final subscriber
- ③ The connect indication provokes the satellite connection
- ④ The communication is switched on

NMCC: Network management control centre

- Signalling control

This function involves detecting a communication request (telephone call, or request for data transmission connection), recording the destination number and the additional information needed to set up the link (quality needed, for example), and then detecting a clear signal to release the link. This function is normally performed by the traffic terminal itself, running suitable software.

- Communication routing

This function involves determining the destination access of the communication, according to the signalling information recorded. This operation relies on a dialling plan, or a list of all the numbers handled by the system, very similar to the operating method of a switching centre. It may be performed by each traffic station or at a central site.

- Resources management

This function involves determining the transmission resources to be used for a new communication, on the satellite segment (frequencies or time slots) and on the ground segment (choice of modems). This operation has a varying degree of complexity, depending on the level of resource optimization required. If the system allows, a decision may be made during this operation to rearrange the resources used by other links (often the case in TDMA/DAMA systems).

- Resource assignment

This function involves configuring various traffic stations, and supervising the establishment and release of the link after configuration.

7.Explain about Demand Assigned TDMA in detail.

In most satellite networks, several stations have to share one transponder, which thus becomes a multiple access transmission resource. Apart from random access systems (Aloha type for example), the methods used for sharing this resource consist of assigning to each station (or channel):

- an available frequency band and power (for frequency division multiple access); or
- a time slot in a frame (for time-division multiple access); or
- a spreader code (for coded multiple access).

The allocation of an operating frequency, time or code for transmission and reception of a signal by a given earth station, obviously establishes the characteristics of each link in the network, as regards capacity and destination.

This allocation may be defined once only, and remain fixed throughout the operational period of the network: this is known as a pre-assigned, multiple-access system (PAMA).

Conversely, this allocation may be established instantaneously for the duration of each transmission or session: this is known as a demand-assignment multiple-access (DAMA) scheme.

The second category of system is more complicated, but in many cases it has the following advantages:

- Economical use of transmission resources

Unused links do not actually consume resources in the satellite in DAMA mode. The reserve capacity on the satellite is not, therefore a function of the number of stations and channels, as in

PAMA mode, but rather, is a function of the overall volume of traffic in the network. Whenever the circuits to be linked are carrying little traffic, there is a gain (see § 5.5.7).

Economies in the sizing of stations

This is especially true in the case of networks using SCPC access, where each channel corresponds to a separate modem in the earth station. When the DAMA is further developed, it is possible to assign an SCPC channel equipment to a circuit only when the link is established. If the circuits to be linked are not very busy, there is a real saving in the number of SCPC channels needed from a particular size of station (see § 5.5.7).

- Improvement in network connectivity

Unless all stations were to be over-engineered, it is rare for a network operating in PAMA mode to be fully meshed (i.e. for direct links to be provided between all stations in the network). Some communications are therefore only possible with a double link. The DAMA mode, on the other hand, allows direct links to be set up on demand between all stations, once radio dimensioning allows.

5.5.2 Functional description of a DAMA system

The following functions are implemented in a DAMA system:

- Signalling control

This function involves detecting a communication request (telephone call, or request for data transmission connection), recording the destination number and the additional information needed to set up the link (quality needed, for example), and then detecting a clear signal to release the link. This function is normally performed by the traffic terminal itself, running suitable software.

- Communication routing

This function involves determining the destination access of the communication, according to the signalling information recorded. This operation relies on a dialling plan, or a list of all the numbers handled by the system, very similar to the operating method of a switching centre. It may be performed by each traffic station or at a central site.

- Resources management

This function involves determining the transmission resources to be used for a new communication, on the satellite segment (frequencies or time slots) and on the ground segment (choice of modems). This operation has a varying degree of complexity, depending on the level of resource optimization required. If the system allows, a decision may be made during this operation to rearrange the resources used by other links (often the case in TDMA/DAMA systems).

- Resource assignment

This function involves configuring various traffic stations, and supervising the establishment and release of the link after configuration.

Figure 5.9 illustrates the relationships between these main functional parts in the context of a link establishment.

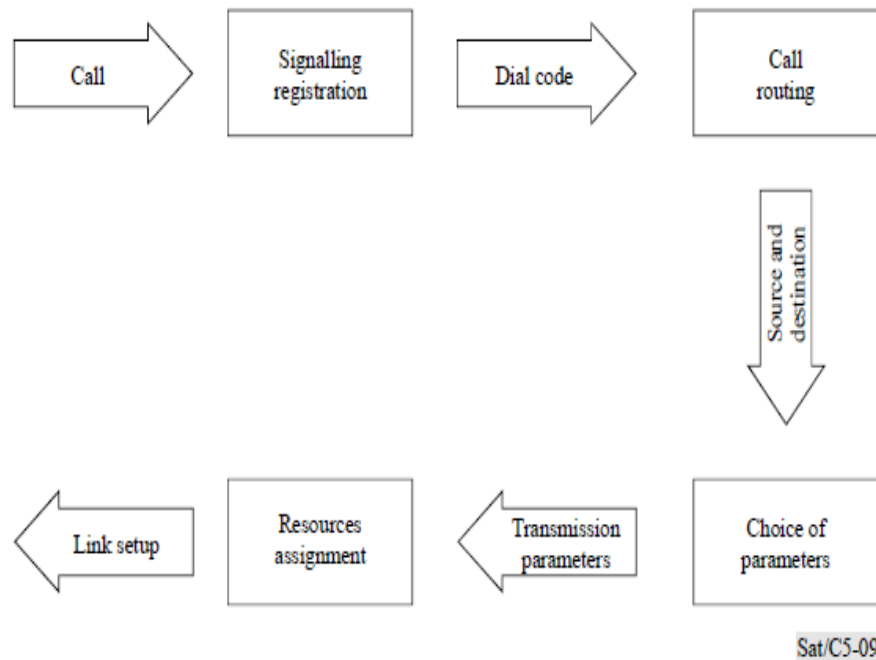


FIGURE 5.9

Main functional blocks of a DAMA system (link establishment)

5.5.3 Services available in DAMA mode

Most services operating in non-permanent circuit mode can be connected to a demand assignment system. Those most frequently met are as follows:

- telephone subscriber service ("long-line" DAMA);
- telephone links between exchanges (public or private);
- data transmission in connected mode;
- videoconferencing.

For data transmission many systems offer telephone modem emulation (usually with Hayes type signal processing). There are also DAMA systems using X.25 protocol (links are set up when the first virtual circuit to the caller is opened).

UNIT V

GEOGRAPHIC INFORMATION SYSTEM

GIS – Components of GIS – Hardware, software and organisational context – Data – Spatial and Non-spatial – Maps – Types of maps – Visual interpretation of satellite images – Elements of interpretation – Interpretation keys characteristics of digital satellite image – Image enhancement – Filtering – Classification – Integration of GIS and remote sensing – Urban applications – Application of remote sensing and GIS – Water resources – Urban analysis – Watershed management – Resources information systems. Global Positioning System (GPS) – An introduction.

PART A

1. Give the 3 different types of applications with respect to satellite systems.

- The largest international system (Intelsat)
- The domestic satellite system (Dom sat) in U.S.
- U.S. National oceanographic and atmospheric administrations (NOAA)

2. Mention the 3 regions to allocate the frequency for satellite services.

- a. Region1: It covers Europe, Africa and Mangolia
- b. Region2: It covers North & South Ameriaca and Greenland.
- c. Region3: It covers Asia, Australia and South West Pacific.

3. Give the types of satellite services.

- a. Fixed satellite service
- b. Broadcasting satellite service
- c. Mobile satellite service
- d. Navigational satellite services
- e. Meteorological satellite services

4. What is mean by Dom sat?

Domestic Satellites. These are used for voice, data and video transmissions within the country. They are launched by GSLV rockets. They are placed at about 36000 km above the earth.

5. What are the applications of Radarsat?

- a. Shipping and fisheries.
- b. Ocean feature mapping
- c. Oil pollution monitoring
- d. Iceberg detection
- e. Crop monitoring

6. What is ECEF?

The geocentric equatorial coordinate system is used with the GPS system. It is called as earth centered, earth fixed coordinate system.

7. What is dilution of precision?

Position calculations involve range differences and where the ranges are nearly equal, any error is greatly magnified in the difference. This effect, brought about as a result of the satellite geometry is known as dilution of precision.

8. What is PDOP?

With the GPS system, dilution of position is taken into account through a factor known as the position dilution of precision.

9. What is DBS?

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.

10. Give the frequency range of US DBS systems with high power satellites.

- a. Uplink frequency range is 17.3 GHz to 17.8 GHz
- b. Downlink frequency range is 12.2 GHz to 12.7 GHz

11. Give the frequency range of US DBS systems with medium power satellites.

- a. Uplink frequency range is 14 GHz to 14.5 GHz
- b. Downlink frequency range is 11.7 GHz to 12.2 GHz

12. Give the satellite mobile services.

- a. DBS – Direct Broadcast satellite
- b. VSATS – Very Small Aperture Terminals
- c. MSATS – Mobile Satellite Service
- d. GPS – Global Positioning Systems
- e. Micro Sats
- f. Orb Comm – Orbital Communications Corporation
- g. Iridium

13. What is INMARSAT?

It is the first global mobile satellite communication system operated at Lband and internationally used by 67 countries for communication between ships and coast so that emergency life saving may be provided. Also it provides modern communication services to maritime, land mobile, aeronautical and other users.

14. List out the regions covered by INMARSAT.

- Atlantic ocean region, east (AOR-E)
- Atlantic ocean region, west (AOR-W)
- Indian ocean region (IOR)
- Pacific ocean region (POR)

15. What is INSAT?

INSAT – Indian National Satellite System. 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.

16. List out the INSAT series.

- INSAT-1
- INSAT-2
- INSAT-2A
- INSAT-2E
- INSAT-3

17. What is GSM?

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.

18. What is GPRS?

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.

19. Define DAB.

DAB - Digital Audio Broadcast.

Digital audio broadcasting (DAB), also known as digital radio and highdefinition radio, is audio broadcasting in which analog audio is converted into a digital signal and transmitted on an assigned channel in the AM or (more usually) FM frequency range. DAB is said to offer compact disc (CD)- quality audio on the FM (frequency modulation) broadcast band and to offer FM-quality audio on the AM (amplitude modulation) broadcast band.

20. What is GRAMSAT?

The Gramsat Programme (GP) is an initiative to provide communication networks at the state level connecting the state capital to districts and blocks. The networks provide Computer Connectivity, Data Broadcasting and TV Broadcasting facilities having applications like e-Governance, National Resource Information System (NRIS), Development Information, Tele-conferencing, Disaster Management, Tele-medicine and Distance Education.

PART B

1. Briefly explain about the features of GIS .

A **geographic information system (GIS)**, **geographical information system**, or **geospatial information system** is a system designed to capture, store, manipulate, analyze, manage and present all types of geographically referenced data.^[1] In the simplest terms, GIS is the merging of cartography, statistical analysis and database technology. GIS may be used in [archaeology](#), [geography](#), [cartography](#), [remote sensing](#), [land surveying](#), [public utility management](#), [natural resource management](#), [precision agriculture](#), [photogrammetry](#), [urban planning](#), [emergency management](#), [GIS in Environmental Contamination](#), [landscape architecture](#), [navigation](#), [aerial video](#) and [localized search engines](#).

A GIS can be thought of as a system - it digitally creates and "manipulates" spatial areas that may be jurisdictional, purpose or application-oriented for which a specific GIS is developed. Hence, a GIS developed for an application, jurisdiction, enterprise or purpose may not be necessarily interoperable or compatible with a GIS that has been developed for some other application, jurisdiction, enterprise, or purpose. What goes beyond a GIS is a [spatial data infrastructure](#) (SDI), a concept that has no such restrictive boundaries.

Therefore, in a general sense, the term describes any [information system](#) that integrates, stores, edits, analyzes, shares and displays [geographic](#) information for informing [decision making](#). GIS applications are tools that allow users to create interactive queries (user-created searches), analyze [spatial](#) information, edit data, maps, and present the results of all these operations.^[2] [Geographic information science](#) is the science underlying the geographic concepts, applications and systems.^[3]

Modern GIS technologies use digital information, for which various digitized data creation methods are used. The most common method of data creation is digitization, where a hard copy map or survey plan is transferred into a digital medium through the use of a computer-aided design (CAD) program, and geo-referencing capabilities. With the wide availability of ortho-rectified imagery (both from satellite and aerial sources), heads-up digitizing is becoming the main avenue through which geographic data is extracted. Heads-up digitizing involves the tracing of geographic data directly on top of the aerial imagery instead of by the traditional method of tracing the geographic form on a separate digitizing tablet (heads-down digitizing).

Relating information from different sources

GIS uses spatio-temporal (space-time) location as the key index variable for all other information. Just as a relational database containing text or numbers can relate many different tables using common key index variables, GIS can relate otherwise unrelated information by using location as the key index variable. The key is the location and/or extent in space-time.

Any variable that can be located spatially, and increasingly also temporally, can be referenced using a GIS. Locations or extents in Earth space-time may be recorded as dates/times of occurrence, and x, y, and z coordinates representing, longitude, latitude, and elevation, respectively. These GIS coordinates may represent other quantified systems of temporo-spatial reference (for example, film frame number, stream gage station, highway mile marker, surveyor

benchmark, building address, street intersection, entrance gate, water depth sounding, POS or CAD drawing origin/units). Units applied to recorded temporal-spatial data can vary widely (even when using exactly the same data, see map projections), but all Earth-based spatial-temporal location and extent references should, ideally, be relatable to one another and ultimately to a "real" physical location or extent in space-time.

Related by accurate spatial information, an incredible variety of real-world and projected past or future data can be analyzed, interpreted and represented to facilitate education and decision making.^[12] This key characteristic of GIS has begun to open new avenues of scientific inquiry into behaviors and patterns of previously considered unrelated real-world information.

GIS Uncertainties

GIS accuracy depends upon source data, and how it is encoded to be data referenced. Land Surveyors have been able to provide a high level of positional accuracy utilizing the GPS derived positions.^[13] [Retrieved from Federal Geographic Data Committee] the high-resolution digital terrain and aerial imagery,^[14] [Retrieved NJGIN] the powerful computers, Web technology, are changing the quality, utility, and expectations of GIS to serve society on a grand scale, but nevertheless there are other source data that has an impact on the overall GIS accuracy like: paper maps that are not found to be very suitable to achieve the desired accuracy since the aging of maps affects their dimensional stability.

In developing a Digital Topographic Data Base for a GIS, topographical maps are the main source of data. Aerial photography and satellite images are extra sources for collecting data and identifying attributes which can be mapped in layers over a location facsimile of scale. The scale of a map and geographical rendering area representation type are very important aspects since the information content depends mainly on the scale set and resulting locatability of the map's representations. In order to digitize a map, the map has to be checked within theoretical dimensions, then scanned into a raster format, and resulting raster data has to be given a theoretical dimension by a rubber sheeting/warping technology process.

Uncertainty is a significant problem in designing a GIS because spatial data tend to be used for purposes for which they were never intended. Some maps were made many decades ago, where at that time the computer industry was not even in its perspective establishments. This has led to historical reference maps without common norms. Map accuracy is a relative issue of minor importance in cartography. All maps are established for communication ends. Maps use a historically constrained technology of pen and paper to communicate a view of the world to their users. Cartographers feel little need to communicate information based on accuracy, for when the same map is digitized and input into a GIS, the mode of use often changes. The new uses extend well beyond a determined domain for which the original map was intended and designed.

A quantitative analysis of maps brings accuracy issues into focus. The electronic and other equipment used to make measurements for GIS is far more precise than the machines of conventional map analysis.^[15] [Retrieved USGS]. The truth is that all geographical data are inherently inaccurate, and these inaccuracies will propagate through GIS operations in ways that

are difficult to predict, yet have goals of conveyance in mind for original design. Accuracy Standards for 1:24000 Scales Map: $1:24,000 \pm 40.00$ feet

This means that when we see a point or attribute on a map, its "probable" location is within a +/- 40 foot area of its rendered reference, according to area representations and scale.

A GIS can also convert existing digital information, which may not yet be in map form, into forms it can recognize, employ for its data analysis processes, and use in forming mapping output. For example, digital satellite images generated through remote sensing can be analyzed to produce a map-like layer of digital information about vegetative covers on land locations. Another fairly recently developed resource for naming GIS location objects is the Getty Thesaurus of Geographic Names (GTGN), which is a structured vocabulary containing about 1,000,000 names and other information about places.^[16]

Likewise, researched census or hydrological tabular data can be displayed in map-like form, serving as layers of thematic information for forming a GIS map.

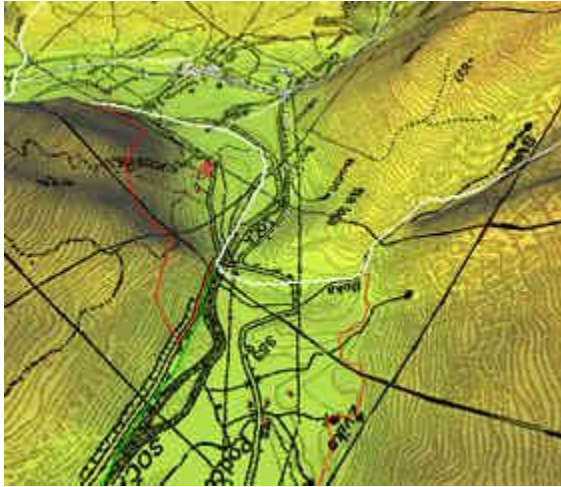
Data representation

GIS data represents real objects (such as roads, land use, elevation, trees, waterways, etc.) with digital data determining the mix. Real objects can be divided into two abstractions: discrete objects (e.g., a house) and continuous fields (such as rainfall amount, or elevations). Traditionally, there are two broad methods used to store data in a GIS for both kinds of abstractions mapping references: raster images and vector. Points, lines, and polygons are the stuff of mapped location attribute references. A new hybrid method of storing data is that of identifying point clouds, which combine three-dimensional points with RGB information at each point, returning a "3D color image". GIS Thematic maps then are becoming more and more realistically visually descriptive of what they set out to show or determine.

Raster

A raster data type is, in essence, any type of digital image represented by reducible and enlargeable grids. Anyone who is familiar with digital photography will recognize the Raster graphics pixel as the smallest individual grid unit building block of an image, usually not readily identified as an artifact shape until an image is produced on a very large scale. A combination of the pixels making up an image color formation scheme will compose details of an image, as is distinct from the commonly used points, lines, and polygon area location symbols of scalable vector graphics as the basis of the vector model of area attribute rendering. While a digital image is concerned with its output blending together its grid based details as an identifiable representation of reality, in a photograph or art image transferred into a computer, the raster data type will reflect a digitized abstraction of reality dealt with by grid populating tones or objects, quantities, cojoined or open boundaries, and map relief schemas. Aerial photos are one commonly used form of raster data, with one primary purpose in mind: to display a detailed image on a map area, or for the purposes of rendering its identifiable objects by digitization. Additional raster data sets used by a GIS will contain information regarding elevation, a digital

elevation model, or reflectance of a particular wavelength of light, Landsat, or other electromagnetic spectrum indicators.



Digital elevation model, map (image), and vector data

Raster data type consists of rows and columns of cells, with each cell storing a single value. Raster data can be images (raster images) with each pixel (or cell) containing a color value. Additional values recorded for each cell may be a discrete value, such as land use, a continuous value, such as temperature, or a null value if no data is available. While a raster cell stores a single value, it can be extended by using raster bands to represent RGB (red, green, blue) colors, colormaps (a mapping between a thematic code and RGB value), or an extended attribute table with one row for each unique cell value. The resolution of the raster data set is its cell width in ground units.

Raster data is stored in various formats; from a standard file-based structure of TIF, JPEG, etc. to binary large object (BLOB) data stored directly in a relational database management system (RDBMS) similar to other vector-based feature classes. Database storage, when properly indexed, typically allows for quicker retrieval of the raster data but can require storage of millions of significantly sized records.

2.Explain about different types of Map Projections in detail.

A *map projection* portrays a three-dimensional object, such as the Earth's globe, in a two-dimensional format. The map projection is quite simply the most intriguing component of coordinate system referencing because it offers a high

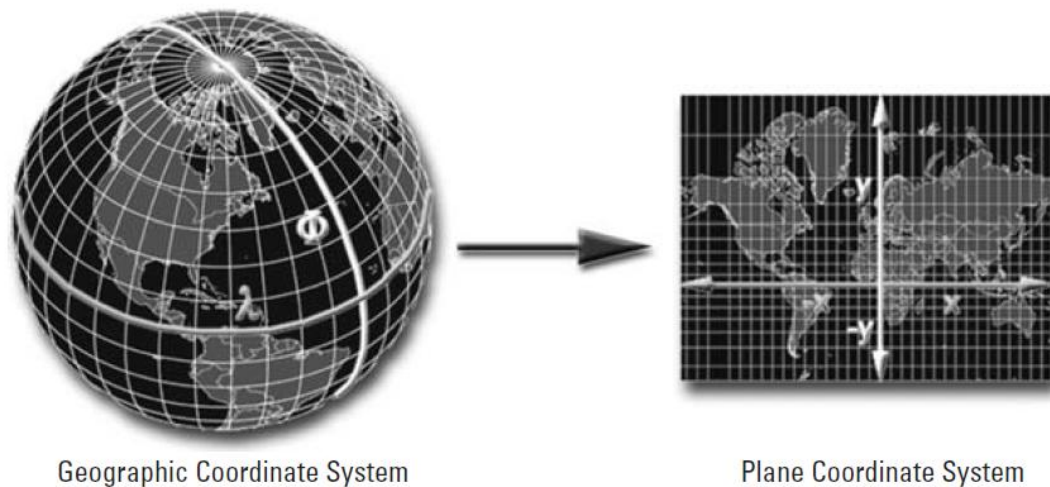


Figure 9.3 Moving from the Earth's geographic coordinate system to the projection's plane coordinate system.

level of flexibility. Projections are wholly graphical, as evident in the highly used Goode Homolosine map projection of the world (Figure 9.4).

The map projection employs projection formulas that perform the critical task of transferring a three-dimensional spheroid onto a two-dimensional plane surface. This is a complex process because the Earth, like other celestial bodies, is a complex object. While the projection is the easiest coordinate system component to visualize, the projection application is the most difficult. As you will quickly discover, an understanding of the projection application is vital to the success and usability of the transformation.

Map projections, by default, are not true or accurate portrayals of the globe. A two-dimensional plane cannot accurately represent large portions of the rounded, curvilinear surface of the Earth. Figures 9.5 and 9.6 illustrate the Mercator model and projection. Notice the shapes of North America and how different they are from in each other.

To show regions of the Earth on any appreciable area with accuracy, geographic data must be drawn to compromise the distortions of shapes, distances, and directions introduced by the spheroid. The various methods of preparing a two-dimensional plane from the surface of the Earth are critical for the accessibility and presentation of GISs.

The map projection is an important element in GIS. As discussed in the previous two chapters, we can comfortably surmise that datum superimposed upon the surface of the Earth's globe, or *ellipsoid of revolution*, establishes vertical and horizontal control for the specific area. The projection transforms this specific area from the curvilinear surface of the ellipse to a flat plane upon which an image is projected. This projected area is then implemented within a GIS.

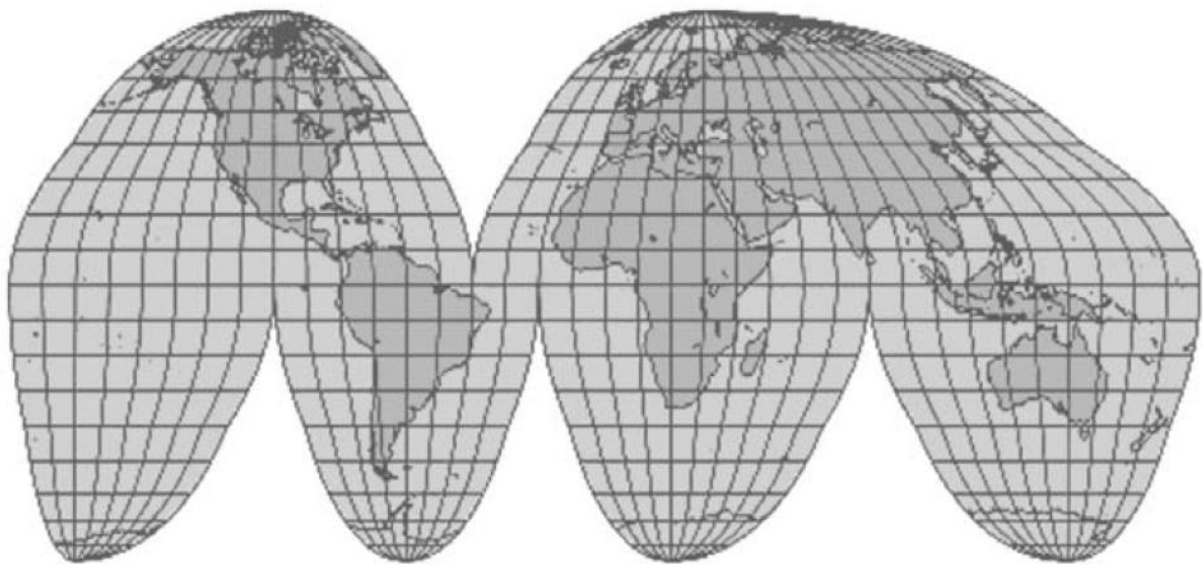


Figure 9.4 A Goode Homolosine 10° equal-area map projection of the Earth.

The Grapefruit Peel Experiment

Let's look at the map projection a different way. Take an ordinary grapefruit and observe its spherical form. This tasty spheroid is a three-dimensional object that is similar, in form, to the Earth's globe. We will make a physical projection of one half of the fruit to help visualize a GIS map projection.

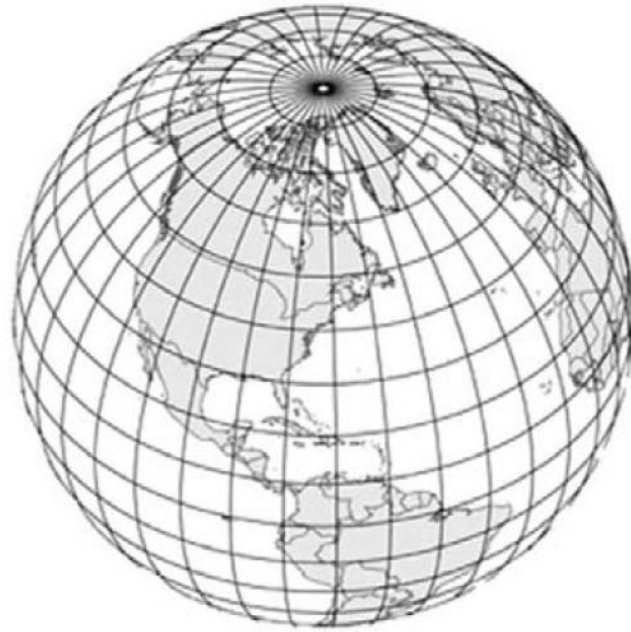


Figure 9.5 Geographic Mercator model.



Figure 9.6 Planar Mercator projection.

Using a flexible measuring tape and marker, draw a two-inch vertical line on the peel close to its “pole.” With a knife, cut the peel perpendicular to the drawn line in one straight cut all around the grapefruit. The drawn line should be away from the peel cut. You can easily imagine each half of the cut grapefruit as a hemisphere. Now, carefully lift off the peel hemisphere (the one with the drawn line) and place it on a flat table so that the widest area is face down on the table. Notice that this object is still three dimensional and has retained the approximate curvature of the grapefruit.

Using the knife, cut the grapefruit’s skin from the pole to the edge, keeping away from the drawn line. This step helps control where the skin will rip. With your palm, push down on the peel until it flattens. Creases and tears will form in various locations to compensate for the flattening of the curvature and to conform to the table surface. Once completely flat and neglecting the peel’s thickness, the object has theoretically become a two-dimensional representation of the grapefruit hemisphere. Now let’s examine this physical projection.

The flattened grapefruit skin does not look like a spheroid anymore and, with the peel’s control cut and tears, has become distorted. Take that measuring tape and remeasure that two-inch drawn line. You will notice it is slightly less than two inches now, or that it is torn. The flattening process distorted the line’s length, which is a measurement of distance, one of the four major map distortions discussed latter in this chapter.

You have now made a physical (and conic type) projection of the grapefruit. A GIS map projection functions in much the same way as the grapefruit peel experiment, though not quite as crude. When projecting a three-dimensional object onto a two-dimensional plane, various distortions and aberrations occur to functionally portray the object. Maps of the Earth’s globe do not precisely depict the real shape of each continent but project the adjusted flat version of the curved landforms. Unlike the grapefruit, tears, aberrations, and distortions can be easily manipulated through projection equations.

Choosing a Map Projection

One of the more difficult parts of the map projection process is the selection of the best projection type for the application. Not only must you fully understand the object being transformed onto the flat surface, but you must also understand the desired properties you want to exhibit.

When choosing a projection, the purpose of the application must first be recognized. Then, once the purpose is understood, a strategic plan can be developed to determine those features that need to be preserved and those features that can be compromised by relative distortion. Even variations of the same projection can be selected for more accurate depictions in specific applications, such as the two Bonne projections in Figure 9.7.

The projection process is, by far, not a natural rearrangement of aspects from the three-dimensional surface. It is a mathematical condition superimposed on a natural surface to accommodate a man-made interpretation. As a result, the projected plane always has some degree of inherent distortion.

There are four important properties of the Earth model that can be tactically preserved during a projection process: *area*, *shape*, *distance*, and *angles*. These four elements are the essential pawns when projecting a surface. You must come to terms with the hard truth involved in portraying the spherical shape of the Earth on a nonspherical surface: Preserving accurate representations of all four elements simultaneously is impossible.

Important, even vital, characteristics for any projection must be identified and specifically defined early in the process. The proper type and classification of projection capable of preserving these characteristics should be tested, selected, and then implemented. If time is taken to accurately plan a projection, control of the projection will be retained and the various ill side effects from the process will be minimized.

Choosing a map projection involves more than planning; it involves decisions and an understanding of how best to represent the spheroid. Aside from manipulating the four projection elements, there are other choices and degrees of flexibility available when creating the best map projection for a particular application. The ability to choose the projection's *type*, *aspect*, and *classification* is the ultimate tool for achieving the desired projection properties and for controlling distortion. The following discussions categorically detail each decision element.

3.Explain the concepts of GPS in nutshell.

The **Global Positioning System (GPS)** is a space-based [global navigation satellite system](#) (GNSS) that provides [location](#) and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the [United States](#) government and is freely accessible by anyone with a GPS receiver.

The GPS project was developed in 1973 to overcome the limitations of previous navigation systems,^[1] integrating ideas from several predecessors, including a number of classified engineering design studies from the 1960s. GPS was created and realized by the [U.S. Department of Defense](#) (USDOD) and was originally run with 24 satellites. It became fully operational in 1994.

In addition to GPS, other systems are in use or under development. The Russian GLObal NAVigation Satellite System ([GLONASS](#)) was in use by only the Russian military, until it was made fully available to civilians in 2007. There are also the planned Chinese [Compass navigation system](#) and the European Union's [Galileo positioning system](#).

Basic concept of GPS

A GPS receiver calculates its position by precisely timing the signals sent by GPS [satellites](#) high above the Earth. Each satellite continually transmits messages that include

- the time the message was transmitted
- precise orbital information (the [ephemeris](#))
- the general system health and rough orbits of all GPS satellites (the almanac).

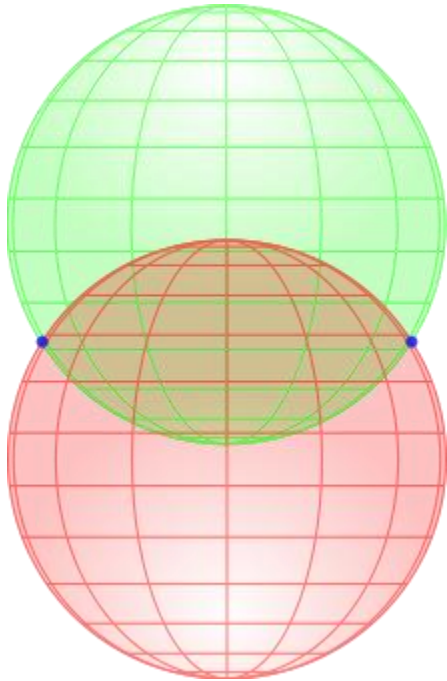
The receiver uses the messages it receives to determine the transit time of each message and computes the distance to each satellite. These distances along with the satellites' locations are used with the possible aid of [trilateration](#), depending on which algorithm is used, to compute the position of the receiver. This position is then displayed, perhaps with a moving map display or latitude and longitude; elevation information may be included. Many GPS units show derived information such as direction and speed, calculated from position changes.

Three satellites might seem enough to solve for position since space has three dimensions and a position near the Earth's surface can be assumed. However, even a very small clock error multiplied by the very large [speed of light](#)^[27] — the speed at which satellite signals propagate — results in a large positional error. Therefore receivers use four or more satellites to solve for the receiver's location and time. The very accurately computed time is effectively hidden by most GPS applications, which use only the location. A few specialized GPS applications do however use the time; these include [time transfer](#), traffic signal timing, and [synchronization of cell phone base stations](#).

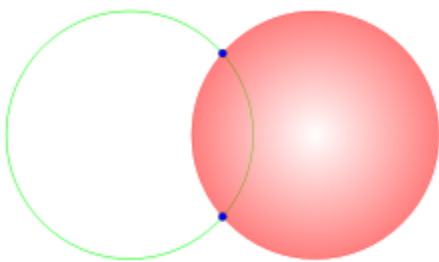
Although four satellites are required for normal operation, fewer apply in special cases. If one variable is already known, a receiver can determine its position using only three satellites. For

example, a ship or aircraft may have known elevation. Some GPS receivers may use additional clues or assumptions (such as reusing the last known altitude, [dead reckoning](#), [inertial navigation](#), or including information from the vehicle computer) to give a less accurate (degraded) position when fewer than four satellites are visible. [\[28\]\[29\]\[30\]](#)

Position calculation introduction



Two sphere surfaces intersecting in a circle



Surface of sphere intersecting a circle (not a solid disk) at two points

To provide an introductory description of how a GPS receiver works, error effects are deferred to a later section. Using messages received from a minimum of four visible satellites, a GPS receiver is able to determine the times sent and then the satellite positions corresponding to these

times sent. The x, y, and z components of position, and the time sent, are designated as $[x_i, y_i, z_i, t_i]$ where the subscript i is the satellite number and has the value 1, 2, 3, or 4. Knowing the indicated time the message was received t_r , the GPS receiver can compute the transit time of the message as $(t_r - t_i)$. Assuming the message traveled at the speed of light, c , the distance traveled or pseudorange, p_i can be computed as $(t_r - t_i)c$.

A satellite's position and pseudorange define a sphere, centered on the satellite, with radius equal to the pseudorange. The position of the receiver is somewhere on the surface of this sphere. Thus with four satellites, the indicated position of the GPS receiver is at or near the intersection of the surfaces of four spheres. In the ideal case of no errors, the GPS receiver would be at a precise intersection of the four surfaces.

If the surfaces of two spheres intersect at more than one point, they intersect in a circle. The article [trilateration](#) shows this mathematically. A figure, Two Sphere Surfaces Intersecting in a Circle, is shown below. Two points where the surfaces of the spheres intersect are clearly shown in the figure. The distance between these two points is the diameter of the circle of intersection. The intersection of a third spherical surface with the first two will be its intersection with that circle; in most cases of practical interest, this means they intersect at two points.^[31] Another figure, Surface of Sphere Intersecting a Circle (not a solid disk) at Two Points, illustrates the intersection. The two intersections are marked with dots. Again the article [trilateration](#) clearly shows this mathematically.

For automobiles and other near-earth vehicles, the correct position of the GPS receiver is the intersection closest to the Earth's surface.^[32] For space vehicles, the intersection farthest from Earth may be the correct one.

The correct position for the GPS receiver is also the intersection closest to the surface of the sphere corresponding to the fourth satellite.

Correcting a GPS receiver's clock

One of the most significant error sources is the GPS receiver's clock. Because of the very large value of the [speed of light](#), c , the estimated distances from the GPS receiver to the satellites, the [pseudoranges](#), are very sensitive to errors in the GPS receiver clock; for example an error of one microsecond (0.000 001 second) corresponds to an error of 300 metres (980 ft). This suggests that an extremely accurate and expensive clock is required for the GPS receiver to work. Because manufacturers prefer to build inexpensive GPS receivers for mass markets, the solution for this dilemma is based on the way sphere surfaces intersect in the GPS problem.

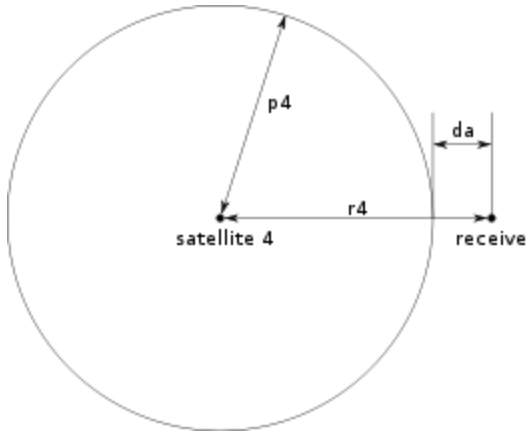


Diagram depicting satellite 4, sphere, p_4 , r_4 , and da

It is likely that the surfaces of the three spheres intersect, because the circle of intersection of the first two spheres is normally quite large, and thus the third sphere surface is likely to intersect this large circle. It is very unlikely that the surface of the sphere corresponding to the fourth satellite will intersect either of the two points of intersection of the first three, because any clock error could cause it to miss intersecting a point. However, the distance from the valid estimate of GPS receiver position to the surface of the sphere corresponding to the fourth satellite can be used to compute a clock correction. Let r_4 denote the distance from the valid estimate of GPS receiver position to the fourth satellite and let p_4 denote the pseudorange of the fourth satellite. Let $da = r_4 - p_4$. da is the distance from the computed GPS receiver position to the surface of the sphere corresponding to the fourth satellite. Thus the quotient, $b = da/c$, provides an estimate of

(correct time) – (time indicated by the receiver's on-board clock), and the GPS receiver clock can be advanced if b is positive or delayed if b is negative.

However, it should be kept in mind that a less simple function of da may be needed to estimate the time error in an iterative algorithm as discussed in the [Navigation equations](#) section.

Structure

The current GPS consists of three major segments. These are the space segment (SS), a control segment (CS), and a user segment (U.S.).^[33] The U.S. Air Force develops, maintains, and operates the space and control segments. GPS satellites [broadcast signals](#) from space, and each GPS receiver uses these signals to calculate its three-dimensional location (latitude, longitude, and altitude) and the current time.^[34]

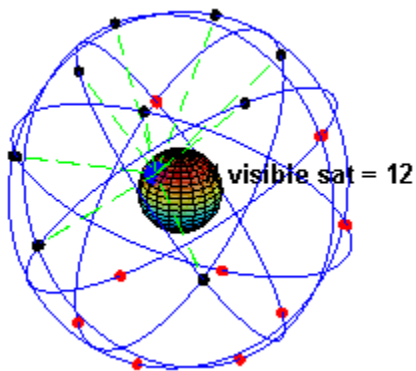
The space segment is composed of 24 to 32 satellites in [medium Earth orbit](#) and also includes the payload adapters to the boosters required to launch them into orbit. The control segment is composed of a master control station, an alternate master control station, and a host of dedicated and shared [ground antennas](#) and monitor stations. The user segment is composed of hundreds of

thousands of U.S. and allied military users of the secure GPS Precise Positioning Service, and tens of millions of civil, commercial, and scientific users of the Standard Positioning Service (see [GPS navigation devices](#)).

Space segment



Unlaunched GPS satellite on display at the [San Diego Air & Space Museum](#)



A visual example of the GPS constellation in motion with the Earth rotating. Notice how the number of satellites in view from a given point on the Earth's surface, in this example at 45°N, changes with time.

The space segment (SS) is composed of the orbiting GPS satellites, or Space Vehicles (SV) in GPS parlance. The GPS design originally called for 24 SVs, eight each in three approximately circular [orbits](#),^[35] but this was modified to six orbits with four satellites each.^[36] The orbits are centered on the Earth, not rotating with the Earth, but instead fixed with respect to the distant stars.^[37] The six orbits have approximately 55° [inclination](#) (tilt relative to Earth's [equator](#)) and are separated by 60° [right ascension](#) of the [ascending node](#) (angle along the equator from a reference point to the orbit's intersection).^[38] The orbits are arranged so that at least six satellites are always within [line of sight](#) from almost everywhere on Earth's surface.^[39] The result of this objective is that the four satellites are not evenly spaced (90 degrees) apart within each orbit. In general terms, the angular difference between satellites in each orbit is 30, 105, 120, and 105 degrees apart which, of course, sum to 360 degrees.

Orbiting at an altitude of approximately 20,200 km (12,600 mi); orbital radius of approximately 26,600 km (16,500 mi), each SV makes two complete orbits each [sidereal day](#), repeating the

same ground track each day.^[40] This was very helpful during development because even with only four satellites, correct alignment means all four are visible from one spot for a few hours each day. For military operations, the ground track repeat can be used to ensure good coverage in combat zones.

As of March 2008,^[41] there are 31 actively broadcasting satellites in the GPS [constellation](#), and two older, retired from active service satellites kept in the constellation as orbital spares. The additional satellites improve the precision of GPS receiver calculations by providing redundant measurements. With the increased number of satellites, the constellation was changed to a nonuniform arrangement. Such an arrangement was shown to improve reliability and availability of the system, relative to a uniform system, when multiple satellites fail.^[42] About nine satellites are visible from any point on the ground at any one time (see animation at right).

Control segment



Ground monitor station used from 1984 to 2007, on display at the [Air Force Space & Missile Museum](#)

The control segment is composed of

1. a master control station (MCS),
2. an alternate master control station,
3. four dedicated ground antennas and
4. six dedicated monitor stations

The MCS can also access U.S. Air Force Satellite Control Network (AFSCN) ground antennas (for additional command and control capability) and NGA ([National Geospatial-Intelligence Agency](#)) monitor stations. The flight paths of the satellites are tracked by dedicated U.S. Air Force monitoring stations in [Hawaii](#), [Kwajalein](#), [Ascension Island](#), [Diego Garcia](#), [Colorado Springs, Colorado](#) and [Cape Canaveral](#), along with shared NGA monitor stations operated in England, Argentina, Ecuador, Bahrain, Australia and Washington DC.^[43] The tracking information is sent to the Air Force Space Command's MCS at [Schriever Air Force Base](#) 25 km (16 miles) ESE of Colorado Springs, which is operated by the [2nd Space Operations Squadron](#) (2 SOPS) of the U.S. Air Force. Then 2 SOPS contacts each GPS satellite regularly with a navigational update using dedicated or shared (AFSCN) ground antennas (GPS dedicated ground antennas are located at Kwajalein, Ascension Island, Diego Garcia, and Cape Canaveral). These updates synchronize the atomic clocks on board the satellites to within a few [nanoseconds](#) of

each other, and adjust the [ephemeris](#) of each satellite's internal orbital model. The updates are created by a [Kalman filter](#) that uses inputs from the ground monitoring stations, [space weather](#) information, and various other inputs.^[44]

Satellite maneuvers are not precise by GPS standards. So to change the orbit of a satellite, the satellite must be marked unhealthy, so receivers will not use it in their calculation. Then the maneuver can be carried out, and the resulting orbit tracked from the ground. Then the new ephemeris is uploaded and the satellite marked healthy again.

User segment



GPS receivers come in a variety of formats, from devices integrated into cars, phones, and watches, to dedicated devices such as those shown here from manufacturers [Trimble](#), [Garmin](#) and [Leica](#) (left to right).

The user segment is composed of hundreds of thousands of U.S. and allied military users of the secure GPS Precise Positioning Service, and tens of millions of civil, commercial and scientific users of the Standard Positioning Service. In general, GPS receivers are composed of an antenna, tuned to the frequencies transmitted by the satellites, receiver-processors, and a highly stable clock (often a [crystal oscillator](#)). They may also include a display for providing location and speed information to the user. A receiver is often described by its number of channels: this signifies how many satellites it can monitor simultaneously. Originally limited to four or five, this has progressively increased over the years so that, as of 2007, receivers typically have between 12 and 20 channels.^[45]



Fig.A typical [OEM](#) GPS receiver module measuring 15×17 mm.

GPS receivers may include an input for differential corrections, using the [RTCM](#) SC-104 format. This is typically in the form of an [RS-232](#) port at 4,800 bit/s speed. Data is actually sent at a much lower rate, which limits the accuracy of the signal sent using RTCM. Receivers with internal DGPS receivers can outperform those using external RTCM data. As of 2006, even low-cost units commonly include [Wide Area Augmentation System](#) (WAAS) receivers.

Many GPS receivers can relay position data to a PC or other device using the [NMEA 0183](#) protocol. Although this protocol is officially defined by the National Marine Electronics Association (NMEA),^[46] references to this protocol have been compiled from public records, allowing open source tools like [gpsd](#) to read the protocol without violating [intellectual property](#) laws. Other proprietary protocols exist as well, such as the [SiRF](#) and [MTK](#) protocols. Receivers can interface with other devices using methods including a serial connection, [USB](#), or [Bluetooth](#).

Applications

While originally a military project, GPS is considered a dual-use technology, meaning it has significant military and civilian applications.

GPS has become a widely deployed and useful tool for commerce, scientific uses, tracking, and surveillance. GPS's accurate time facilitates everyday activities such as banking, mobile phone operations, and even the control of power grids by allowing well synchronized hand-off switching.^[34]

This [antenna](#) is mounted on the roof of a hut containing a scientific experiment needing precise timing.

Many civilian applications use one or more of GPS's three basic components: absolute location, relative movement, and time transfer.

- [Cellular telephony](#): Clock synchronization enables time transfer, which is critical for synchronizing its spreading codes with other base stations to facilitate inter-cell handoff and support hybrid GPS/cellular position detection for [mobile emergency calls](#) and other applications. The first [handsets with integrated GPS](#) launched in the late 1990s. The U.S. [Federal Communications Commission](#) (FCC) mandated the feature in either the handset or in the towers (for use in triangulation) in 2002 so emergency services could locate 911 callers. Third-party software developers later gained access to GPS APIs from [Nextel](#) upon launch, followed by [Sprint](#) in 2006, and [Verizon](#) soon thereafter.
- [Disaster relief/emergency services](#): Depend upon GPS for location and timing capabilities.
- [Geofencing](#): [Vehicle tracking systems](#), [person tracking systems](#), and [pet tracking](#) systems use GPS to locate a vehicle, person, or pet. These devices are attached to the vehicle, person, or the pet collar. The application provides continuous tracking and mobile or Internet updates should the target leave a designated area.^[47]
- [Geotagging](#): Applying location coordinates to digital objects such as photographs and other documents for purposes such as creating map overlays.
- [GPS Aircraft Tracking](#)
- [GPS tours](#): Location determines what content to display; for instance, information about an approaching point of interest.

- [Map-making](#): Both civilian and military cartographers use GPS extensively.
- [Navigation](#): Navigators value digitally precise velocity and orientation measurements.
- [Phasor measurement units](#): GPS enables highly accurate timestamping of power system measurements, making it possible to compute [phasors](#).
- [Recreation](#): For example, [geocaching](#), [geodashing](#), [GPS drawing](#) and [waymarking](#).
- [Surveying](#): Surveyors use absolute locations to make maps and determine property boundaries.
- [Tectonics](#): GPS enables direct fault motion measurement in [earthquakes](#).

4.Explain about few urban applications of GIS.

Though GIS is most commonly classified as a computer or physical science, GIScience opens the gates for the infusion of sociology, the empirical social sciences, and history. GIScience is now used for geoarcheology, psychological analysis, social services, and historical analysis. Additionally, this trend of interdisciplinary applicability is most closely echoed by the field of geostatistics, a discipline offering a synthesis between two disciplines: traditional statistics and geospatial interfaces.

(i)New Jersey Natural gas transmission line property delineation

To prepare for law-mandated public and emergency notifications, New Jersey Natural Gas (NJNG), a utility provider in central New Jersey, required an accurate record of existing properties within 700 feet of its underground gas transmission lines. These central gas lines service a massive area that covers Ocean, Middlesex, Passaic, and Morris counties. NJNG quickly realized the absolute complexity of such a large-scale property (parcel) delineation effort. Accordingly, the New Jersey utility turned to a local geospatial and engineering firm, T&M Associates, Inc., to manipulate the existing data and develop the necessary GIS backbone for the project.

The geospatial system was built upon ESRI's ArcGIS 9 environment. Existing digital parcel information was initially obtained from the state and other sources and imported into the system. Original tax Mylar sheets were scanned into a raster image and consistently referenced with existing tax file naming conventions. This scanned raster image was then rectified with New Jersey's high-resolution orthoimagery (from 2002) and digitized. The digitalization process defined lot lines, boundary lines, and roadways and streams. The outer edges of primary building rooflines (or *footprints*) within the project area were also delineated. The lots created from individual tax sheets were saved as a merged geodatabase file, with adjacent sheets edge matched as necessary. A best-fit approach was used to create the overall parcel layer.

Finally, the parcel layer and subsequent feature attribute table was linked with New Jersey's tax list database, called MOD IV. Unique identifiers and quality assurance protocols were used to facilitate the joining of information, preventing data duplication and parcel ownership errors. In the end, the parcels 700 feet to each side of the transmission lines were successfully delineated and a base GIS was developed for future NJNG efforts.

(ii) Analyzing the rapid closure of a Cincinnati based office depot

In mid-2001, Office Depot, a major chain store for office supplies and equipment, opened a new branch in an eastern suburb of Cincinnati, Illinois. After just six months of operation, the new store closed. Was it a failure in marketing? Was competition surrounding the store too harsh? How could a formidably successful chain have such a fiscal miscalculation? These questions prompted a retail marketing study using GIS analysis tools to offer insight as to the reasons for the store closure.

The branch in question (Beechmont Avenue) was a sister store to five other Office Depots and had competition from five Office Max stores and nine Staples stores in the greater Cincinnati area. The researchers decided to focus on geographic location, since location impacts sales potential and the closure of the Beechmont Avenue branch was related to its low sales potential. The researchers developed a sales potential model within GIS based upon a retail industry standard (D. L. Huff's sales potential model) to evaluate the store's overall performance.

GIS analysis constituted the known spatial distribution and spending habits of potential customers in coincidence with the store's overall highway accessibility, square footage size, approximate travel time, and distance. These characteristics were diagnosed against preopening and postopening data from the Beechmont store, the other greater Cincinnati-based Office Depots, and the area competitors. Through GIS analytical tools and the Huff-based sales model, the researchers were able to ascertain that one reason the store was underperforming was poor customer accessibility. Closing the branch may have been more cost effective than keeping the failing store open, although as noted in the study, if this type of GIS-based analysis had been conducted before opening the branch, management would have saved a great deal of time and money.

(iii) Detailing Areas at high risk for elderly fall injuries to enhance injury prevention programme in Alberta, Canada.

Researchers from the University of Alberta's Division of Emergency Medicine, the Health Surveillance Branch of Alberta Health and Wellness, and the British Columbia Rural and Remote Health Research Institute conducted an investigation detailing the geography of fall injuries in the elderly within Canada's Capital Health Region in Alberta. The researchers used GIS to analyze the spatial character of fall injuries within the study area in an effort to enhance fall prevention methodologies. The data set for this particular study comprised Alberta residents greater than 66 years of age who visited an emergency department for a fall. Postal codes from emergency vehicle and department reports comprised valid location data.

Using GIS, spatial analysis was completed to identify general fall injury patterns and high-incidence areas in both Alberta proper (such as rural and medium-population areas) and within a domicile (such as on a stair or off a ladder). The researchers relied heavily on geographic information products, such as empirical Bayes estimate maps of incidence data. Empirical Bayes estimates invoke British mathematician Thomas Bayes's theory of statistical sampling which states that a probability distribution can be assigned to an unknown parameter in a statistical problem. In this application, the researchers assigned an underlying probability distribution to the fall incidence ratio. In the end, the researchers proved their argument: that fall injuries in the elderly occur in distinguishable areas, making region-specific fall prevention programs possible and definitively beneficial.

5. Explain about Resource management using GIS

Natural resources are said to be the Earth's wondrous gifts to humanity. The soil upon which we walk, the vegetation we utilize, the animals with whom we coexist, and the water we drink are all innate elements to life and the recognized gifts of our planet. Natural resources can be considered the prize possession of all humans, although, throughout the ages, humans have neglected to care for these gifts.

Natural resources encompass rivers and streams, lakes and inlets, landforms, geology, forests and woodlands, mines, wildlife habitats, and ecosystems. The management of these natural earthly gifts involves a deep understanding of each system and a proactive plan for these resources to remain unharmed. Natural resource management covers a large platform for potential analysis, from reclaiming brownfields and facilitating wildlife habitat protection to defining oil spills and delineating land classification. GIS is used by conservationists of all types to define potential infringements upon the resources from nature, as well as any residential, commercial, or industrial imposers. It helps form a stable cadre of geographic information and analysis from which to solidify environmental campaigns or to cast the proverbial stone. Conservationists look toward GIS for the position they need in the fight against combatant corporations, developers, and residents.

But GIS doesn't satisfy just the conservationists; it holds valid analytical and environmental defense support for those on the other end of the conservation fight (i.e., the corporations, developers, and residents). For instance, GIS may be used by a developer to show the self-benefiting, attractive results of little or no intrusion against the natural aesthetics of a lake. Dam owners may use GIS to show how a dam removal would positively affect the area, while not disclosing the owner's high-yielding advantages. Whatever side you are on, GIS proves to be a magnificent propaganda tool.

Many times GIS is used toward natural resources when there is no head-to-head fighting at all, but just as a way to quell rising public concern or help with preemptive actions as to appropriate for the specific natural resources. Energy companies tend to use GIS to explore the impacts of operational by-products, such as the impact of rising waters on wildlife, and uses analysis from the GIS products to determine if actions are warranted.

Case Study: Lebanon Natural Resources Management with Participatory GIS

Entrenched within the Mediterranean, Lebanon boasts a diverse socioeconomic society throughout its relatively small population (4.1 million people). Remarkably, Lebanon is a war-torn land. By 1991, 17 years of war ended, leaving Lebanon overwhelmingly disabled. Its once profitable agricultural industry was deteriorating, and the country looked toward its natural resources for help. However, after years of brutal war, Lebanon's resources were unmanaged and in disrepair.

The Environmental and Sustainable Development Unit (ESDU) at the American University in Beirut took notice and began a series of research programs that meshed technology with community support. The ESDU developed the "participatory GIS" or PGIS, whereby the community provided participatory research, land data, and information for a GIS. The program approach proved highly successful, evidenced by the fact that the ESDU utilized PGIS from 1995 to 2003.

A participatory GIS is a fresh approach to getting relatively accurate measurements and geodata for areas that are hard to measure. The nature of participatory GIS offers many incentives to native volunteers to measure and register land-based and geological features. Such incentives include comprehensive area resource identification and profitable agricultural analysis. In exchange for these incentives is the ability for a highly customized and unique data set. Participatory GISs are gaining popularity in underprivileged communities worldwide and within the GIS community.

Lebanon used PGIS for various natural resource management applications, such as to delineate indigenous agro-ecological zones, plan orchard development, delineate poorly or inappropriately used land, plan rainwater harvesting reservoirs, and develop georeferenced databases for the study area.

Ultimately, PGIS served Lebanon well, providing accurate georeferenced land information that has proved invaluable to researchers, developers, communities, and land stakeholders alike. The participatory GIS information products have given Lebanon a new lease on their natural resources and a feasible approach for socioeconomic growth.

Case Study: Community-Based Natural Resource Management Program in Namibia

In Namibia, Africa, GISs are playing an important role in supporting community decisions as they relate to the management and use of Namibia's natural resources. Namibia's communities are using GIS information products, particularly printed geographic maps, to manage the natural resources on an individual community level. Namibia's Community-Based Natural Resource Management (CBNRM) program involves participants in every community to encourage the proliferation of sustainable development. Namibia's community-based program is very similar to Lebanon's participatory GIS program, but with a heavier focus on natural resources.

The CBNRM's use of geographic data and information is distinct, primarily land-use planning, resource conservation, game and wildlife monitoring, tourist and commercial development, and communication. One of the chief activities threaded throughout the various GIS uses is boundary delineation, especially for conservancy and land development.

Namibia's community GIS program relies heavily on an intercommunity sharing of geographic data, information products, and tools. The program runs on a needs-based approach and involves dedicated community field users who trust the accuracy of the GIS information, have fostered a set process to delineate community needs, and have built a reservoir of information to ensure the program's longevity.

6. Briefly explain about the concepts of satellite image enhancement

Image enhancement encompasses the processes of altering images, whether they be digital photographs, traditional analog photographs, or illustrations. Traditional analog image editing is known as photo retouching, using tools such as an airbrush to modify photographs, or editing illustrations with any traditional art medium. Graphic software programs, which can be broadly grouped into vector graphics editors, raster graphics editors, and 3d modelers, are the primary tools with which a user may manipulate, enhance, and transform images. Many image editing programs are also used to render or create computer art from scratch.

Automatic image enhancement

Camera or computer image editing programs often offer basic automatic image enhancement features that correct color hue and brightness imbalances as well as other image editing features, such as red eye removal, sharpness adjustments, zoom features and automatic cropping. These are called automatic because generally they happen without user interaction or are offered with one click of a button or mouse button or by selecting an option from a menu. Additionally, some automatic editing features offer a combination of editing actions with little or no user interaction.

Digital data compression

Many image file formats use data compression to reduce file size and save storage space. Digital compression of images may take place in the camera, or can be done in the computer with the image editor. When images are stored in JPEG format, compression has already taken place. Both cameras and computer programs allow the user to set the level of compression.

Some compression algorithms, such as those used in PNG file format, are **lossless**, which means no information is lost when the file is saved. By contrast, the JPEG file format uses a **lossy** compression algorithm by which the greater the compression, the more information is lost, ultimately reducing image quality or detail that can not be restored. JPEG uses knowledge of the way the human brain and eyes perceive color to make this loss of detail less noticeable.

Image editor features

Listed below are some of the most used capabilities of the better graphic manipulation programs. The list is by no means all inclusive. There are a myriad of choices associated with the application of most of these features.

Selection

One of the prerequisites for many of the applications mentioned below is a method of selecting part(s) of an image, thus applying a change selectively without affecting the entire picture. Most graphics programs have several means of accomplishing this, such as a marquee tool, lasso tool, magic wand tool, vector-based pen tools as well as more advanced facilities such as edge detection, masking, alpha compositing, and color and channel-based extraction.

Layers

Another feature common to many graphics applications is that of Layers, which are analogous to sheets of transparent acetate (each containing separate elements that make up a combined picture), stacked on top of each other, each capable of being individually positioned, altered and blended with the layers below, without affecting any of the elements on the other layers. This is a fundamental workflow which has become the norm for the majority of programs on the market today, and enables maximum flexibility for the user while maintaining non-destructive editing principles and ease of use.

Image size alteration

Image editors can resize images in a process often called image scaling, making them larger, or smaller. High image resolution cameras can produce large images which are often reduced in size for Internet use. Image editor programs use a mathematical process called resampling to calculate new pixel values whose spacing is larger or smaller than the original pixel values. Images for Internet use are kept small, say 640 x 480 pixels which would equal 0.3 megapixels.

Cropping an image

Digital editors are used to crop images. Cropping creates a new image by selecting a desired rectangular portion from the image being cropped. The unwanted part of the image is discarded. Image cropping does not reduce the resolution of the area cropped. Best results are obtained when the original image has a high resolution. A primary reason for cropping is to improve the image composition in the new image.

Noise reduction

Image editors may feature a number of algorithms which can add or remove noise in an image. JPEG artifacts can be removed; dust and scratches can be removed and an image can be de-speckled. Noise reduction merely estimates the state of the scene without the noise and is not a substitute for obtaining a "cleaner" image. Excessive noise reduction leads to a loss of detail, and its application is hence subject to a trade-off between the undesirability of the noise itself and that of the reduction artifacts.

Noise tends to invade images when pictures are taken in low light settings. A new picture can be given an 'antiquated' effect by adding uniform monochrome noise.

Image orientation

Image editors are capable of altering an image to be rotated in any direction and to any degree. Mirror images can be created and images can be horizontally flipped or vertically flopped. A small rotation of several degrees is often enough to level the horizon, correct verticality (of a building, for example), or both. Rotated images usually require cropping afterwards, in order to remove the resulting gaps at the image edges.

Enhancing images

In computer graphics, the process of improving the quality of a digitally stored image by manipulating the image with software. It is quite easy, for example, to make an image lighter or darker, or to increase or decrease contrast. Advanced photo enhancement software also supports many filters for altering images in various ways.^[1] Programs specialized for image enhancement are sometimes called image editors.

Sharpening and softening images

Graphics programs can be used to both sharpen and blur images in a number of ways, such as unsharp masking or deconvolution.^[2] Portraits often appear more pleasing when selectively softened (particularly the skin and the background) to better make the subject stand out. This can be achieved with a camera by using a large aperture, or in the image editor by making a selection and then blurring it. Edge enhancement is an extremely common technique used to make images appear sharper, although purists frown on the result as appearing unnatural.

