COVENANT UNIVERSITY
NIGERIA

TUTORIAL KIT
OMEGA SEMESTER

PROGRAMME: PHYSICS

COURSE: PHY 423

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PHY 423: Satellite Communication

CONTRIBUTORS: Dr. Omotosho T.V.

(1) What is a communication Satellite?Listtwo broad areas that satellites can bedivided.
(2) Explain the following terms as used in satellite communication:

The space segment

The ground segment

(3) Discuss in details The Satellite Bus and The transponder
(4) List four most commonly used orbits in satellite communications,
(5) Define Kepler's third lawfor artificial satellites orbiting the earth.

i. State the equation
ii. The orbital period in seconds and
iii. Calculate the radius of a circular orbit for which the period is one day. Where [illegible]

(6) Define the following Earth-orbiting Satellites parameters.

i. Subsatellite path
ii. Apogee
iii. Perigee
iv. Line of apsides
v. Prograde orbit

(7) The Table 1 below shows the six orbital elements referred to as the keplerian element set: copy and complete all columns of the table.

Element	Name	Description	Ranges of Values	Undefined
a				
e				
i				
Ω				
ω				
v				

(8) A satellite is orbiting in the equatorial plane with a period from perigee to perigee of 12 h. Given that the eccentricity is 0.002, calculate the semi major axis. The earth's equatorial radius is 6378.1414 km.

(9)Discuss the minimum number of satellites that are needed for global coverage. To facilitate frequency planning, the International Telecommunication Union (ITU)dividedthe worldinto three regions discuss the regions in details.

(10)Explain the termed Sun transit outage for a satellite.

(11) Determine the limits of visibility for an earth station situated at mean sea level, at latitude 48.42° north, and longitude 89.26 degrees west. Assume a minimum angle of elevation of 5°.

(12)List four common types of antennas used in satellite systems and explain the one most commonly used at frequency above 10 GHz.

(13) With the aid of a diagram explain the azimuth and elevation angles for an Earth Station to acommunication satellite.

(14)A satellite link operating at 14 GHz has receiver feeder losses of 1.5 dB and a free-space loss of 207 dB. The atmospheric absorption loss is 0.5 dB, and the antenna pointing loss is 0.5 dB. Depolarization losses may be neglected. Calculate the total link loss for clear-sky conditions.

(15) Define the following terms used to describe the propagation mechanisms, which can affect the characteristics of a radio wave in satellite communication.

I. Absorption
II. Scattering,
III. Refraction,
IV. Diffraction and
V. Multipath.

(16) A signal traveling between an earth station and a satellite must pass through the earths atmosphere, including the ionosphere, and this can introduce certain losses and effects. List four of these losses and explain any two of them.

(17) Explain frequency reuse in satellite communications systems

(18) Explain the goal of multiple access techniques used in satellite communication.

(19) List three multiple access techniques and explain one in detail.

(20) Discussthe four Advantages of CDMA over FDMA or TDMA

SOLUTION

(1) A communications satellite is an orbiting artificial earth satellite that receives a communications signal from a transmitting ground station, amplifies and possibly processes it, then transmits it back to the earth for reception by one or more receiving ground stations. Communications information neither originates nor terminates at the satellite itself. The satellite is an active transmission relay, similar in function to relay towers used in terrestrial microwave communications

Today the world of satellites can be divided into two broad areas: –

i. Scientific satellites and
ii. Applications satellites.

(3) Discuss in details: satellite bus and transponder

The Satellite bus subsystems consists of physical structure of the satellite provides a 'home' for all the components of the satellite and the power subsystem that provides electrical power for operating equipment on a communications satellite primarily from solar cells, which convert incident sunlight into electrical energy.

The transponder: This is the electronics in the satellite that receives the uplink signal, amplifies and possibly processes the signal, and then reformats and transmits the signal back to the ground.

(5) Kepler's third law states that the square of the periodic time of orbit is proportional to the cube of the mean distance between the two bodies..

i. State the equation: $\square^{\square} = \frac{\square}{\square^{\square}}$

ii. The orbital period in seconds

iii. Calculate the radius of a circular orbit for which the period is one day

Solution: There are *24 hours* $\times$ *60 minutes* $\times$ *60 = 86,400* seconds in one day, and therefore the mean motion is

$$n = \frac{2\pi}{86400} = 7.272 \times 10^{-5} \text{ rad/s}$$

From Kepler's third law:

$$a = \left[\frac{3.986005 \times 10^{14}}{(7.272 \times 10^{-5})^2}\right]^{1/3} = \underline{\underline{42{,}241 \text{ km}}}$$

Since the orbit is circular the semi-major axis is also the radius

(7) Table 1 Complete

Element	Name	Description	Ranges of Values	Undefined
a	Semimajor Axis	Size	Depends on conic section	Never
e	Eccentricity	shape	*e=0, circle; 0<e<1 ellipse*	Never
i	inclination	Tilt angle	$0 \le i \le 180$	Never
$\boldsymbol{\Omega}$	Right ascension of the ascending node	Swivel, angle from vemal equinox to ascending node	$0 \le \boldsymbol{\Omega} \le 180$	When $i = 0$ or 180 equatorial orbit
$\boldsymbol{\omega}$	Argument of perigee	Angle from ascending node to perigee	$0 \le \boldsymbol{\omega} \le 180$	When $i = 0$ or 180 equatorial orbit, when *e=0, circle orbit*
v	True Anomaly	Angle from perigee to spacecraft's position	$0 \le \boldsymbol{v} \le 180$	when *e=0, circle orbit*

(9) Minimum of threegeostationary satellites are needed for global coverage.The regions are:

Region 1: Europe, Africa, what was formerly the Soviet Union, and Mongolia
Region 2: North and South America and Greenland
Region 3: Asia (excluding region 1 areas), Australia, and the southwest Pacific.

(11)

Solution Given data:

$\lambda_E = 48.42°; \phi_E = -89.26°; El_{min} = 5°; a_{GSO} = 42164$ km; $R = 6371$ km

$$\sigma_{min} = 90° + El_{min}$$

$$S = \arcsin\left(\frac{6371}{42164}\sin 95°\right) = 8.66°$$

$$b = 180 - 95° - 8.66° = 76.34°$$

$$B = \arccos\left(\frac{\cos 76.34°}{\cos 48.42°}\right) = 69.15°$$

The satellite limit east of the earth station is at

$$\phi_E + B = \underline{\underline{-20°}} \text{ approx.}$$

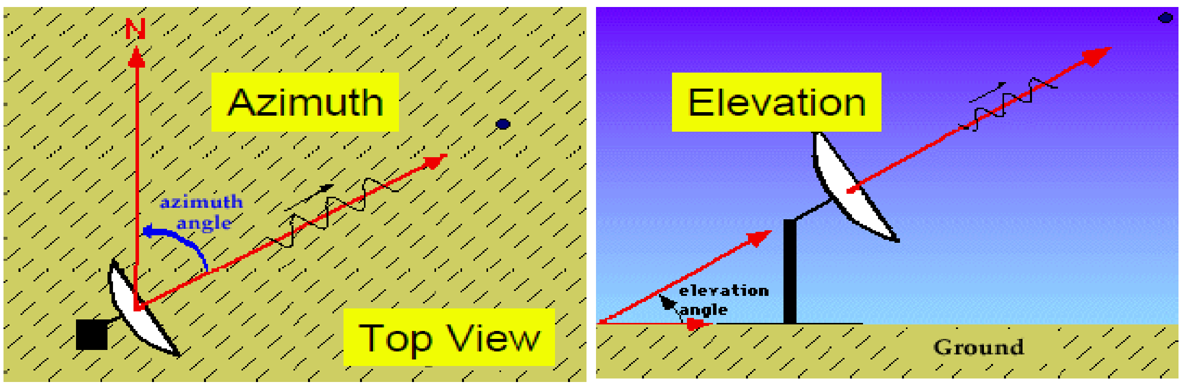
and west of the earth station at

$$\phi_E - B = \underline{\underline{-158°}} \text{ approx.}$$

(13)

Azimuth & Elevation Angles

- Azimuth is the axis of angular rotation
- Elevation is the Angle with respect to the horizon -



(15) terms used to describe the propagation mechanisms
Absorption: A reduction in the amplitude (field strength) of a radiowave caused by an irreversible conversion of energy from the radiowave to matter in the propagation path.
Scattering: A process in which the energy of a radiowave is dispersed in direction due to interaction with inhomogeneities in the propagation medium.
Refraction: A change in the direction of propagation of a radiowave resulting from the spatial variation of refractive index of the medium.
Diffraction: A change in the direction of propagation of a radiowave resulting from the presence of an obstacle, a restricted aperture, or other object in the medium.
Multipath: The propagation condition that results in a transmitted radio wave reaching the receiving antenna by two or more propagation paths. Multipath can result from refractive index irregularities in the troposphere or ionosphere; or from structural and terrain scattering on the earth's surface.

(17) Frequency reuse communications systems employing dual independent orthogonal polarized channels in the same frequency band to increase channel capacity.

(19) Three fundamental techniques are used in the process:

I. Frequency Division Multiple Access (FDMA): systems consist of multiple carriers that are separated by frequency in the transponder. The transmissions can be analog or digital, or combinations of both.
II. Time Division Multiple Access (TDMA): the multiple carriers are separated by TIME in the transponder, presenting only one carrier at any time to the transponder. TDMA is most practical for digital data only, because the transmissions are in a burst mode to provide the time division capability.

III. Code Division Multiple Access (CDMA): is a combination of both frequency and time separation. It is the most complex technique, requiring several levels of synchronization at both the transmission and reception levels. CDMA is implemented for digital data only, and offers the highest power and spectral efficiency operation of the three fundamental techniques