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Course :: Radar & Satellite Communication

Module :: 8^{th}

Date :: 13/04/2020

QNO1:: Part (a)

Explain why some Satellite employ cylindrical solar arrays, whereas other Employ Solar-Sail arrays for the production of primary power. State the typical power output to be expected from each type. why is it necessary for Satellite to carry batteries in addition to Solar-Cell arrays?

Ans::

- Cylindrical Solar array structure is required when the spining Satellite Stabilization is used to ensure Satellite attitude stability This is because the other option (Solar Sail array) is not possible due to spinning. if this stability. Approach is not used, Solar Sail arrays are better as it can produce higher Energy compared to cylindrical structure This is because Sun-tracking can be applied and hence all Cells can generate Energy.

- cylindrical Structure (HS 376):

  760 - 940 watt.

- Solar - Sail structure (HS 601):

  2 - 6 kwatt

- The run the required subsystem and keep it operational during enclipse or emergencies.

part (b)

Explain why an omnidirectional antenna must be used abord a Satellite for telemetry and command during the launched phase. How is the satellite powered during this phase?

Ans:

The omnidirectional antenna is used for TT & C operation during the phase when the satellite has been injected into its parking orbit until it reaches its final position unless the high gain directional antennas are fully deployed and oriented properly, The omnidirectional antenna is The only practicable means of establishing a communication channel for tracking, telemetry and commond operation.

The global for earth coverage antenna has a beam width 17.34° which is the angle subtended by earth of a geostationary Satellite. Any beam width lower Than That would have a smaller coverage area while a beam width larger Than That would lead loss of power.

part (c)

Explain what is meant by frequency reuse, and describe briefly two method by which This can be achieved in Satellite communication system.

Ans:

Frequency Reuse:

Frequency Reuse is The practice of splitting an area into smaller

regions that do not overlap so that each utilizes the full range of frequencies without interference.
The introduction of this concept was a major step in the development of mobile phone technology.
Before the advent of cellular phones, radio telephones and other mobile communication devices relied on a single, central antenna tower to service and entire city. Each phone required a large antenna powerful enough to transmit a signal over the potentially great distance to that tower in addition, there was a limit to the amount of phone traffic that could be supported at a given time because each tower only offered a limited number of channel.

1) Depolarization Model:

Frequency reuse in orthogonal polarization is often employed to increase the capacity of Satellite-based communication system. This techniques is restricted, however, by depolarization of the signal on atmospheric propagation path. The term depolarization and defined the Quantitative metrics associated with it. Various depolarization mechanisms are prevalent in the tropo-sphere. But the most common and important cause of depolarization is rain.
while the former may be represented as function of elevation angle, the wave polarization and the canting angle of the drops.

2) Spatial Separation:

Spatial Separation can allow frequency reuse and the frequency-reuse principle forms the basis of cellular mobile communication and high-capacity multi spot-beam Satellite system. when the wide service coverage, eith provided by a cellular wireless network or a satellite system, is divided into a number of small geographical areas, it is possible to use the same frequency band in more than one area, provided that the areas are sufficiently distance apart. in the context of cellular networks such an area is called a cell where mobile devices are in communication.

QNO 2:

A LEO satellite is in a circular orbit 550km above the earth. Assume the average radius of the is 6378 km. Assume the earth eccentricity is 0.

a) Determine the orbital velocity of the satellite in m/sec.

b) what is the orbital period, in minutes, for the LEO satellite?

c) From the above, determine the orbital angular velocity for the satellite. in radian/sec.

Sol:

-> we have height of orbit from the earth = 550km

-> radius of earth = 6378km

Now, we calculated the total orbital radius

$$r = r_E + h_{orbit}$$

$$r = 550 km + 6378 km$$

$$\boxed{r = 6928 km}$$

a)

The orbital velocity

we have from formula

$$V = \left(\frac{\mu}{r}\right)^{1/2} \text{———} (1)$$

where

μ = The Kepler constant = $3.986004 \times 10^{05} km^3/s^2$

and

r = orbit radius

putting the value eq (1)

$$V = \sqrt{\frac{3.986004 \times 10^5 \, km^2/s^2}{6928}}$$

$$V = \sqrt{\frac{3.986004 \times 10^5 \, km^2/s^2}{6928}}$$

$$v = \sqrt{\frac{3.986004 \times 100000 \ km^2/s^2}{6928}}$$

$$v = \sqrt{\frac{398600.4 \ km^2/s^2}{6928}}$$

$$v = \sqrt{57.534 \ km^2/s^2}$$

$$\boxed{v = 7.585 \ km/s}$$

Now the velocity in m/sec

So

$$v = 7.585 \times 1000 \ m/sec$$

$$\boxed{v = 7585 \ m/sec}$$

b)

The orbital period, from the kepler 3rd law is given by

$$T^2 = \left[\frac{4\pi^2}{\mu}\right] a^3$$

taking square root on b/s

$$\sqrt{T^2} = \sqrt{\left[\frac{4\pi^2}{\mu}\right] a^3}$$

$$T = \sqrt{\left[\frac{4\pi^2}{\mu}\right] a^3}$$

Putting the value μ, r and constant, we have

$r = 6928\,km$

$\mu = 3.986004 \times 10^5\ km^2/s^2$

$\pi = 3.14$

So,

$$T = \sqrt{\left[\frac{4(3.14)^2}{3.986004 \times 10^5\ km^2/s^2}\right](6928)^3}$$

in circular orbit $a = r$

$$T = \sqrt{\frac{4(9.8596)}{3.986004 \times 10^5}\ (6928)^3}$$

$$T = \sqrt{\left[\frac{39.4384}{3.986004 \times 100000}\right](332524490752)}$$

$$T = \sqrt{\frac{1311423387607 3.678}{3.986004 \times 100000}}$$

$$T = \sqrt{\frac{13114233876073.678}{398600.4}}$$

$$T = \sqrt{32900704.254}$$

$$\boxed{T = 5735.913 \text{ sec}}$$

Now, T in minute

$$T = \frac{5735.913 \text{ sec}}{60}$$

$$\boxed{T = 95.59 \text{ minutes}}$$

c) For calculating orbital angular velocity for the Satellite we have

$$T = 5735.915 \text{ sec}$$

As calculated in part (b) and we know, That one revolutation of earth is 2π which takes the time to complete.

Now,

ω = angular velocity

we have

$$\omega = \frac{2\pi}{T}$$

$$\omega = \frac{2(3.14)}{5735.913}$$

$$\omega = \frac{6.28}{5735.913}$$

$$\boxed{\omega = 0.0010948 \text{ rad/sec}}$$ Ans

Q No: 3

The orbit of an-earth-orbiting satellite orbit has an eccentricity of 0.15 and a Semimajor axis of 9000 km. Determine

a) its periodic time

b) The apogee height

c) The prigee height

Sol:

Given Data

$a = r = 9000 km$

$e = 0.15$

$R = 6371 km$

a) Formula

$P \frac{2\pi}{n}$

$n = \sqrt{\frac{m}{a^3}}$

$n = \sqrt{\frac{6371}{(9000)^3}}$

$n = 7.394 \times 10^{-4} rad/sec$

where

$$P^{2(3.14)}_{7.394\times10^{-4}}$$

$$P^{6.28}_{7.394\times10^{-4}}$$

$$\boxed{\therefore\ P = 8{,}497 \text{ sec}}$$

b)

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

$$r_a = 9000(1+0.15)$$

$$r_a = 9000(1.15)$$

$$r_a = 10350 \text{ km}$$

$$\cancel{h_a = 10350}$$

$$h_a = r_a - R$$

$$h_a = 10350 - 6371$$

$$\boxed{h_a = 3979 \text{ km}}$$

c)

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

$$r_p = 9000(1-0.15)$$

$$r_p = 9000(0.85)$$

$$r_p = 7650 \text{ km}$$

$$h_p = r_p - R$$

$$h_p = 7650 - 6371$$

$$\boxed{h_p = 1279 \text{ km}}$$

Q No 4

A communication satellite is located in geostationary orbit at 90°W longitude. Calculate the range, azimuth and elevation angle to the satellite as seen from ground stations located in altitude 35°N and longitude 100°W.

Solution:

Given Data

For satellite:

longitude = 90°W

latitude = 0° (As we assum inclination angle is '0')

Now,

we have to find

- rang, d
- azimuth angle Q_z
- elevation angle, Q

having latitude = 35°N

longtitude = 100°W

$L_E = 35°N = +35$

$l_E = 100°W = -100$

$L_s = 0°$ (inclination angle)

$l_s = 90°W = -90$

First we, find differential longitude

$B = l_E - l_s$

$= (-100) - (-90)$

$= -100 + 90$

$B = -10$

Next, we determine the Earth radius at the Earth station which is R

So, we have

$$R = \sqrt{l^2 + Z^2}$$

$$l = \left(\frac{r_e}{\sqrt{1 - e_e^2 \sin^2(L_E)}} + H \right) \cos(L_E)$$

∴ r_e = Equatorial Radius = 6378.13 km

H = Altitude of Earth Sation = 0

putting the values

$$= \left(\frac{6378.13}{\sqrt{1 - (0.08182)^2 \sin^2 35}} + 0 \right) \cos 35$$

$$= \left[\frac{6378.13}{\sqrt{(1-0.0066945125)(0.3289)}}\right](0.819)$$

$$= \left(\frac{6378.13}{\sqrt{(0.993305)(0.3289)}}\right)(0.819)$$

$$= \left[\frac{6378.13}{\sqrt{0.3266981}}\right](0.819)$$

$$= \left(\frac{6378.13}{0.571575}\right)(0.819)$$

$$= (11158.86804)(0.819)$$

$$\boxed{l = 9139.112924 \text{ km}}$$

Now we find Z, we have

$$Z = \left(\frac{r_e(1-e_e^2)}{\sqrt{1-e_e^2\sin^2(L_E)}} + H\right)\sin(L_E)$$

$$Z = \left[\frac{6378.13\,(1-(0.08182)^2)}{\sqrt{(1-0.0066945124)(0.3289}}\right](0.573)$$

$$Z = \left[\frac{6378.13\,(1-0.0066945124)}{\sqrt{(0.993305)(0.3289)}}\right](0.573)$$

$$Z = \left[\frac{(6378.13)(0.993305)}{\sqrt{(0.993305)(0.3289)}}\right](0.573)$$

$$Z = \left[\frac{6335.4284}{\sqrt{0.3266981}}\right](0.573)$$

$$Z = \left[\frac{6335.4284}{0.571575}\right](0.573)$$

$$Z = (11084.1593)(0.573)$$

$$\boxed{Z = 6351.2232\ \text{km}}$$

Now,

$$R = \sqrt{l^2 + Z^2}$$

$$R = \sqrt{(9139.1129)^2 + (6351.2232)^2}$$

$$R = \sqrt{83523384.5989 + 40338036.1362}$$

$$R = \sqrt{123861420.7351}$$

$$\boxed{R = 11129.3045 \text{ km}}$$

$$\psi_E = \tan(Z/l)$$

$$= \tan^{-1}\left(\frac{6351.2232}{9139.1129}\right)$$

$$\psi_E = \tan^{-1}(0.694)$$

$$\boxed{\psi_E = 34.76^\circ}$$

Find range, d we have

$$d = \sqrt{R^2 + r_s^2 - 2 R r_s \cos(\psi_E) \cos B}$$

$$d = \sqrt{(11129.3042)^2 + (42164.17)^2 - 2(11129.3042)(42164.17) \cos 34.76 \cos(-10)}$$

$$d = \sqrt{123861412 + 1777817232 - 2(469257874.3)(0.821)(0.984)}$$

$$d = \sqrt{123861412 + 1777817232 - 2(379096543.4)}$$

$$d = \sqrt{123861412 + 1777817232 - 758193086.7}$$

$$d = \sqrt{1901678644 - 758193086.7}$$

$$d = \sqrt{1143485557}$$

$$\boxed{d = 33815.46329 \text{ km}}$$

we have to find The elevation angle θ

$$\theta = \cos^{-1}\left(\frac{r_e + h_{GSO}}{d}\sqrt{1 - \cos^2(B)\cos^2(le)}\right)$$

$$= \cos^{-1}\left(\frac{6378.14 + 35786}{33815.466}\sqrt{1 - \cos^2(-10)\cos^2(35)}\right)$$

$$= \cos^{-1}\left(\frac{42164.14}{33815.46}\sqrt{1 - (0.969)(0.671)}\right)$$

$$= \cos^{-1}(1.2468)\sqrt{1 - 0.650199}$$

$$= \cos^{-1}(1.2468)\sqrt{0.349801}$$

$$= \cos^{-1}(1.2468)(0.5914)$$

$$= \cos^{-1}(0.737)$$

$$\boxed{\theta = 42.52^\circ}$$

find The azimuth angle we have need Some parameter to find The azimuth angle. First of all we determine The intermediate angle Ai

$$B = \cos^{-1}(\cos(B)\cos(LE))$$

$$B = \cos^{-1}(\cos(-10)\cos(35))$$

$$B = \cos^{-1}(0.984)(0.819)$$

$$B = \cos^{-1}(0.8058)$$

$$B = 36.30^\circ$$

Now

$$A_i = \sin^{-1}\left(\frac{\sin(B)}{\sin(B)}\right)$$

$$A_i = \sin^{-1}\left(\frac{\sin(-10)}{\sin(36.30)}\right)$$

$$A_i = \sin^{-1}\left(\frac{0.173}{0.592}\right)$$

$A_i = \sin^{-1}(0.292)$

$\boxed{A_i = 16.97^\circ}$

we have the azimuth angle

$\theta_z = 180^\circ - A_i$

$\theta_z = 180^\circ - 16.97^\circ$

$\boxed{\theta_z = 163.03^\circ}$

Answer:

$d = 33815.46329$ km

$\theta = 42.52^\circ$

$\theta_z = 163.03^\circ$