Problem 1 (10 points)

A) Comparisons are sometimes made between satellite and optical fiber communications systems state the area briefly applications for which you feel each system is best suited

Satellite Communications applications are:

→ fixed satellite services
- Broadcasting satellite service
- Mobile satellite services
- Navigation satellite services

Optical fiber Communications

- They highly used in telecommunication Companies
→ They also used in Medical and Scientific
- Industries and Enterprise
- Entertainment
- Military, defense and Aerospace
- Used mainly for landline telephones

(B) Referring to table 1.4 determine the power levels, in watts, for each of three categories

The EIRP ranges in dBW are as follows

High power : 51 - 60 dBW

$$10^{\frac{51}{10}} = 125892.5 W$$

$$10^{\frac{60}{10}} = 1000000 W$$

Medium power 40 - 48 dBW

$$10^{\frac{40}{10}} = 10000 W$$

$$10^{\frac{48}{10}} = 63095.7 W$$

Low power 33 - 37 dBW

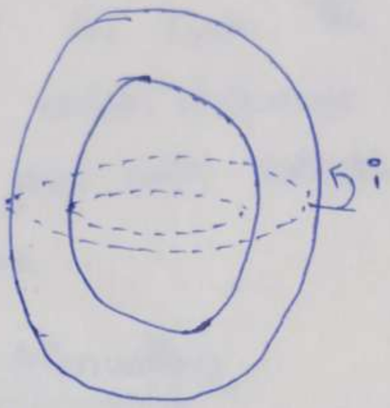
$$10^{\frac{33}{10}} = 1995.26 W$$

$$10^{\frac{37}{10}} = 5011.87 W$$

Problems (2)

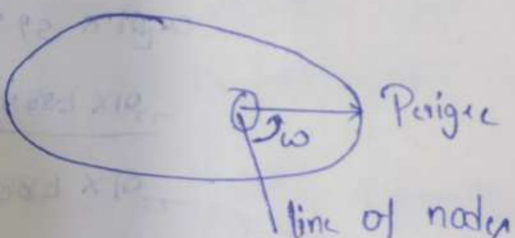
(A) i : inclination angle

This is the angle between the orbital and equatorial planes.



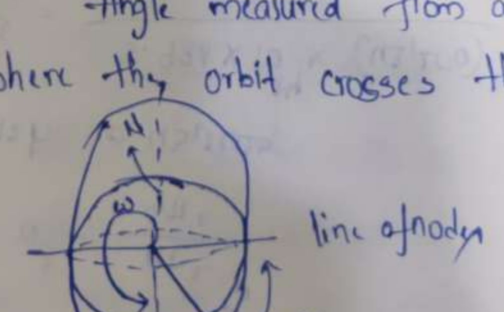
ω Argument of Perigee

The angle measured within the orbital plane from the ascending node to the perigee



Ω Right ascending of the ascending node

Angle measured from a fixed direction in space to where the orbit crosses the reference plane going upward



ω & Ω change with time

$$\frac{d\omega}{dt} \;\&\; \frac{d\Omega}{dt}$$

(b) Given $e = 0.002$

$$\therefore a^3 = \frac{\mu T^2}{4\pi^2}$$

$T = 12h = 43,200s$

$$a^3 = \frac{3.986 \times 10^{14} \times (43,200)^2}{4\pi^2}$$

$$a^3 = \frac{3.986 \times 10^{14} \times 1.868 \times 10^9}{39.478}$$

$$a^3 = 1.887 \times 10^{22}$$

$$a = \sqrt[3]{1.887 \times 10^{22}}$$

$$= 2.65 \times 10^7 m$$

$$= 26,600 km$$

Problems (3)

(A) The figure shows the atmospheric attenuation (dB) versus frequency (GHz) for signals passing through Earth's atmosphere at the Zenith. The curve tells how attenuation increases at certain frequencies due to absorption by atmospheric gases with noticeable peaks for water vapor and oxygen.

Zenith Attenuation

This refers to signal attenuation when the transmission path is perpendicular to the Earth's surface, passing through the shortest path in the atmosphere.

It shows loss (in dB) that signal experience due to absorption and scattering atmospheric constituents.

The figure helps in Inter-satellite Communication

Inter-satellite links helps operate above the atmosphere, this diagram is useful in selecting uplink and downlink frequencies from Earth.

* satellite designers use the figure to minimize communication losses, choosing bands with low Zenith attenuation.
* Inter-satellite communication outside the atmosphere is having negligible attenuation, but understanding these losses is important

(b) latitude 35°N

longitude 100°W

geostationary satellite located at ~~900W~~ 90° W

The difference ~~(between)~~ in longitude

$$\Delta long = |100°W - 90°W| = 10°$$

$$\alpha = \arctan\left(\frac{\tan(\Delta long)}{\sin(latitude)}\right)$$

$$= \arctan\left(\frac{\tan(10°)}{\sin(35°)}\right)$$

$$= \arctan\left(\frac{0.1763}{0.574}\right)$$

$$= \arctan(0.307)$$

$$= 17°$$

$$Azimuth = 180° - \alpha$$

$$= 180° - 17°$$

$$= 163°.$$

Problem 4

(A) Earth Radius $= 6378.137$ km (R_e)

Geostationary orbit radius $= R_e + 35786$ km (R_s)

latitude $= 48.420° N$, longitude $89.260° W$

The minimum angle of elevation of $5°$

The maximum possible elevation is $34.41°$

Minimum elevation is $5°$

$$\Delta\lambda_{max} = 69.14379°$$

$$\lambda_{sat} \in [\lambda_E - \Delta\lambda_{max}, \lambda_E + \Delta\lambda_{max}]$$

$\lambda_E = 89.26° W$

lower limit $= -89.26° - 69.14379°$

$= -158.4038°$

$= 158.40° W$

upper limit $= -89.260° + 69.14379°$

$= -20.1162°$

$= 20.12° W$

GEO satellites with sub-longitudes between $\boxed{158.40° W}$ and $\boxed{20.12° W.}$

No GEO satellite achieves this so the achievable elevation is

$= 34.41°$

(B) Given

- frequency = 12 GHz

$k_H = 0.02386 \quad \alpha_H = 1.1825$

$k_V = 0.02455 \quad \alpha_V = 1.1216$

$h_s = 0.6\ km \quad h_R = 3.0\ km$ angle of Elevation $\theta = 50°$

$$L_s = \frac{h_R - h_s}{\sin\theta} = \frac{3.0 - 0.6}{\sin 50°} = \frac{2.4}{0.766044} = 3.1329\ km$$

$$L_G = L_s \cos\theta = 3.1329 \cdot \cos 50° = 3.1329 \cdot 0.642787 = 2.0120\ km$$

$$\gamma_{R,H} = 0.02386 \times 10^{1.1825} = 0.3632\ dB/km$$

$$\gamma_{RV} = 0.02455 \times 10^{1.1216} = 0.3248\ dB/km$$

$$L_{G,H} = \frac{1}{0.477\, d^{0.633}\, R_{0.01}^{(0.073\alpha)}\, f^{0.123} - 10.579(1 - e^{-0.024d})}$$

$= 3.133$

$L_{G,V} = 3.133$

$A_{0.01H} = 1.1611 \times 3.133 = 3.6378\ km$

$1.1839 \times 3.133 = 3.7092\ km$

Horizontal

$A_p = \boxed{0.8921\ dB}$

$a_v R_{01}^{b} h L_s \gamma_{c1}$

Vertical

$A_p = \boxed{0.7654\ dB}$

Problem (5)

(A) Given latitude is $\Phi = 45°N$ station ...

Problem (5)

(A) Given latitude is $\phi = 45^\circ N$, stationed at $10^\circ E$, received at $5^\circ E$

longitude difference $\Delta\lambda = \lambda_{sat} - \lambda_{site}$

$$= 10^\circ E - 5^\circ E$$

$$= 5^\circ E$$

$$\chi = \arctan\left(\frac{\sin \Delta\lambda}{\tan\phi}\right)$$

$$= \arctan\left(\frac{\sin 5^\circ}{\tan 45^\circ}\right)$$

$$= \arctan\left(\frac{0.08716}{1}\right)$$

$$= \arctan(0.08716)$$

$$= 4.99^\circ \approx 5^\circ$$

linearly polarized with 5° tilted towards East