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Semester 8th

Subject Radar & Satellite

Date 7/Jun/2020.

Department of Electrical Engineering
Assignment
Date: 07/05/2020

Course Details

Course Title:	Radar and Satellite Communications	**Module:**	8th
Instructor:		**Total Marks:**	20
Submission Deadline	05/06/2020		

Student Details

Name: ____________________ **Student ID:** ____________

Student Signature: ____________________

Q1.		Which type of satellite orbit provides the best performance for a communications network for each of the following criteria: (a) Minimum free space path loss. (b) Best coverage of high latitude locations. (c) Full global coverage for a mobile communications network. (d) Minimum latency (time delay) for voice and data networks. (e) Ground terminals with little or no antenna tracking required.	Marks 05 CLO 01
Q2.		An FSS ground terminal located in Chicago, IL, at latitude 41.5◦ N and longitude 87.6◦W has access to two GSO satellites, one stationed at 70◦Wlongitude and the second at 135◦Wlongitude. Which satellite will provide the more reliable link (higher elevation angle) for the ground terminal? The ground terminal elevation above sea level is 0.5 km. Assume 0◦ inclination angle for the satellites.	Marks 05 CLO 03
Q3.		AVSAT receiver consists of a 0.66m diameter antenna, connected to a 4 dB noise figure low noise receiver (LNR) by a cable with a line loss of 1.5 dB. The LNR is connected directly to a downconverter with a 10 dB gain and 2800◦ K noise temperature. The I.F. amplifier following the downconverter has a noise figure of 20 dB. The LNR has a gain of 35 dB. The antenna temperature for the receiver was measured as 65◦ K. (a) Calculate the system noise temperature and system noise figure at the receiver antenna terminals. (b) The receiver operates at a frequency of 12.5 GHz. What is the G/T for the receiver, assuming a 55% antenna efficiency?	Marks 03 CLO 02
Q4.		The downlink transmission rate for a QPSK modulated SCPC satellite link is 60 Mbps. The Eb/No at the ground station receiver is 9.5 dB. a) Calculate the C/No for the link. **b)** Assuming that the uplink noise contribution to the downlink is 1.5 dB, determine the resulting BER for the link.	Marks 02 CLO 02
Q5.		An automobile is moving toward a stationary police radar at 65 statue miles per hour. The car's velocity vector is coincident with the axis of radar. The radar transmits on a frequency of 24.150GHz, in the K-Band. Calculate the frequency of the received echo signal and the Doppler shift?	Marks 02 CLO 02
Q 6		Many tactical radars have antenna beamwidths of about 3°. Determine that how far apart in cross-range must two targets at the same range of 24.5nmi in order to be resolved?	Marks 03 CLO 02

Question No 1:-

Ans:- (A) The LEO Orbit have minimum free space path losses, because thoes orbits are near to the earth and thus losses.

(B) LEO orbit satellite also provide a good coverage high latitude area.

(C) Satellite in GSO orbit give full global covrage for a mobile communication network

(D) LEO Satellite provide ~~mim max~~ minimum latency as they are nearer.

E The GSO orbit the satellite completes its revolution ~~to~~ equal to the earth ~~to~~ ~~e~~ rotation.

Question No 2:-

Solution :-

Data

$L_E = 41.5°N = +41.5$

$l_E = 87.6°W = -87.6$

$H = 0.5 Km$

~~Now~~

Now there are two satellite Sat 1 and

Sat 2 longatitude for Satellite 1

$l_{s1} = 70 W = -70$

For sat 2 $l_{s2} = 135° W = -135$

We know that

$$Q = \cos^{-1}\left(\frac{re + base}{d}\sqrt{1-\cos^2(B) - \cos^2(L_E)}\right)$$

For finding the revolution angle.

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

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

puting the valve we get

$$l = \left(\frac{6378.13}{1-(0.08182)^2 \sin^2(41.5)} + 0.5\right) \cos(41.5)$$

$$l = \left(\frac{6378.13}{\sqrt{1-(6.69\times10^{-3})(0.4390)}} + 0.5\right)(0.745)$$

$$l = \left(\frac{6378.13}{\sqrt{0.99706}} + 0.5\right)(0.7489)$$

$$l = \left(\frac{(6388.21)(0.7489)}{0.99706}\right) + 0.5(0.7489)$$

$$l = \boxed{4784.13 \text{ km}}$$

Now find z.

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

$$z = \left(\frac{6378.13\,(1-69\times10^{-3})}{0.9985} + 0.5\right)(0.6626)$$

$$z = \frac{6335.46}{0.9985} + 0.5\,(0.6626)$$

$$z = (6345.47)(0.6626)$$

$$z = \boxed{4204.51\ \text{km}} \quad \text{(ii)}$$

Now Find R.

$$R = \sqrt{R^2 + z^2}$$

$$R = \sqrt{(4204.15)^2 + (4784.13)^2}$$

$$R = \sqrt{40565804.2}$$

$$\boxed{R = 6369.12\ \text{Km}}$$

$$\psi_E = \tan^{-1}(z/R)$$

$$\psi_E = \tan^{-1}\left(\frac{4204.57}{4784.13}\right)$$

$$\psi_E = \tan^{-1}(0.8788)$$

$$\boxed{\psi_E = 41.31^\circ}$$

Now we find the diffrential longitude for the both satellite.

$$B_1 = l_E + l_{S1}$$

$$= -87.6 - (-135)$$

$$= -87.6 + 135$$

$$= 47.4$$

Now we find ranges.

$$d_1 = \sqrt{R^2 + r_2^2 + 2R_1 r_s \cos\psi_E \cos(B_1)}$$

$$= \sqrt{(6369.12)^2 + (42164.17)^2 - 2(6369.12)(42164.17)\cos(41.31^\circ)\cos(17.6)}$$

$$\boxed{d_1 = 37865.9 \text{ Km}}$$

$$d_2 = \sqrt{R^2 + r_s^2 - 2R \cdot r_s \cos(\psi_E) \cos(\beta_2)}$$

$$d_2 = \sqrt{(6369.12)^2 + (42164.17)^2 - 2(6369.12)(42164.17) \cos(41.31) \cos(47.4)}$$

$$= \boxed{39310.35 \text{ Km}}$$

Now evolution angle :-

$$\theta_1 = \cos^{-1}\left[\frac{r_e + \text{base}}{d_1}\sqrt{1 - \cos^2(17.6)\cos(41.5)}\right]$$

$$= \cos^{-1} \frac{6378.14 + 35786}{37865.9}\sqrt{1-(0.9085)(0.5609)}$$

$$= \cos^{-1}(1.11353)\sqrt{1-(0.5376)}$$

$$= \cos^{-1} 1.11353\sqrt{0.46237}$$

$$Q_1 = \cos^{-1}(1.11353)(0.67998)$$

$$\boxed{Q_1 = 40.78^\circ}$$

$$Q_2 = \cos^{-1}\left(\frac{r_e + base}{d_2}\sqrt{1-\cos^2(B_2)\cos(LE)}\right)$$

$$Q_2 = \cos^{-1}\frac{6378.14 + 85786}{39310.36}\sqrt{1-(0.4582)(0.0605)}$$

$$Q_2 = \cos^{-1}\frac{42164.16}{39310.36}\left(\sqrt{0.74299}\right)$$

$$Q_2 = \cos^{-1}(1.072596)(0.86197)$$

$$Q_2 = \cos^{-1}(0.92454)$$

$$\boxed{Q_2 = 22.39^\circ}$$

As $Q_1 = 40.39^\circ$ so the satellite at $70^\circ w$ has more reliable link as compare to $135^\circ w$.

$Q_2 = 22.39^\circ$

Question No 3:-

Solution:-

Data

Antena Daimeter $d = 0.66m$.

LNR has Noise figure = $NF = 4dB$

Cable line loss $= A = 1.5dB$.

Down converter gain $= G_{DC} = 10dB$.

Down converter temp $= 2800°K$

Amplifier has $NF = 20dB$.

LNR has gain $g = 35dB$.

Antena temp $= 65°K$.

Find

$T_s = ?$

$NF_s = ?$

Formula:-

$$t_s = \left[t_A + t_{LA} + \frac{290(l-1)}{g_{LA}} + \frac{t_{DC}}{1/l\, g_{LA}} + \frac{t_{LE}}{g_{DC}(1/l)g_{LA}}\right] \text{———} ①$$

Now find the value of each gain and Noise temp.

Antena : $t_A = 65°K.$

LNR $t_{LA} = 290\left(10^{NF/10} - 1\right).$

$= 290\left(10^{4/10} - 1\right)$

$= 290(1.51)$

$\boxed{t_{LA} = 438K}$

Parameter : ~~t_{DC}~~ t_{DC} 2600°K

IF Amp = $t_{IF} = 290\left(10^{NF/10} - 1\right) = 290\left(10^{20/10} - 1\right)$

$= 290 \ (99)$

$\boxed{t_{IF} = 28710K}$

IF Amplifier $t_{IF} = 28710°K$

Line $t_{eIN} = 290(L-1)$

$= 290\left(10^{1.5/10} - 1\right)$

$$= 290\,(0.41)$$

$$\boxed{t_{ein} = 119°K}$$

Now we calculate repective gain

Since $G(dB) = 10\log(g)$

$$g_{LA} = 10^{35/10} = 3162$$

$$g_{DC} = 10^{10/10} = 10$$

$$1/l = \frac{1}{10^{1.5/10}} = \frac{1}{10^{0.15}} = 0.707.$$

Now put all above calculator values.

$$t_s = 65 + 438 + \frac{119}{3162} + \frac{2800}{(0.707)(3162)} + \frac{287.10}{10(0.707)(3162)}$$

$$t_s = 65 + 438 + 0.038 + 1.252 + 1.286.$$

$$\boxed{t_s = 505.57\ K}$$

We have system noise formula.

$$N_{ES} = 10 \log (1 + T_S/290)$$

$$N_{ES} = 10 \log (1 + T_S/290)$$

$$= 10 \log (1 + 505.57/290)$$

$$= 10 \log (1 + 1.743)$$

$$= \boxed{4.382 \, dB}$$

(B) Find figure for merit $= M = G/T = ?$

$f = 12.5$ GHz, $\eta_A = 0.55$ $d = 0.66$ m

We first solve for G in dB as:

$$G_r = 10 \log (109.66 \times (12.5)^2 \times (0.66)^2 \times (0.55))$$

$$= 10 \log (4105.05)$$

$$G_r = 36.13 \, dB$$

then T_s =

$T_s = 10 \log (t_s)$

$= 10 \log (505.57)$

$= 27.03$ dB/K.

$M = G/T = G_r - T_s$

$= 36.13 \text{ dB} - 27.03$

$\boxed{G/T = 9.1 \text{ dB/K}}$

Question No 4 :-

Solution :-

Data.

R_b = Bit Rate = ~~60~~ 60 Mbps

$E_b/N_s = 9.5$ dB

(a) Find $C/N_o = ?$

We know that

$$\frac{eb}{n_o} = \frac{1}{Rb}(C/No) \quad — ①.$$

convert it dB.

$$\frac{Eb}{No} = 10 \log (eb/no)$$

$$9.5 = 10 \log (eb/no)$$

$$\boxed{e^b/n_s = 8.912}$$

put the value in eq ①.

$$8.912 = \frac{1}{60 \text{ mbps}} (C/No)$$

$$C/No = \cancel{8.912}\ 8.912 \times 60 \times 10^6 \text{ bps}$$

$$= \cancel{8.912}\ 534.72 \times 10^6$$

$$= 10 \log (534.72 \times 10^6)$$

$$\boxed{\frac{C}{no} = 87.282 \text{ BHz}}$$

(14)

(b) As $\frac{E_b}{N_o} = 9.5\,dB$ and we have

uplink noise contribute to downlink is 1.5 dB

Now

$$\frac{E_b}{N_o} = 9.5\,dB - 1.5\,dB - 8\,dB$$

$$\frac{e_b}{n_o} = 10^{0.8}$$

$$\frac{e_b}{n_o} = 6.309$$

We know that

$$BER \cong \frac{e^{-(e_b/n_o)}}{\sqrt{4\pi\left(\frac{e_b}{n_o}\right)}}$$

$$\cong \frac{e^{-(6.309)}}{\sqrt{4\times(3.14)\times(6.309)}}$$

$$\cong \frac{1.819\times10^{-3}}{8.904}$$

$$\boxed{BER \cong 2.0429\times10^{-4}}$$

Question No 5:-

Solution :- Data

Moving automobile has $V_R = 65$ mph

Radar transmitter freq $= 24.150 GHz$

$f_d = ?$

$f_R = ?$

First we convert V_R from mph to m/s

$$f_d = 2 f_t V_R / c$$

$$= \frac{(2)(24.150 \times 10^9)(29.0576)}{3 \times 10^8}$$

$$\boxed{f_d = 4678.2736 \text{ Hz}}$$

We also know that

$$f_d = f_R - f_T$$

$$f_R = f_d + f_t$$

$= 24.150 + 0.000004678273 6$

$$\boxed{f_R = 24.150004678273 \text{ GHz}}$$

Question No 6 :-

Solution :- Antena beamwidth $= \theta_3 = 3°$

range from order $= R = 24.5$ nmi $= 45,374$ m.

How far apart should be the ~~two~~ targets in the cross-range to be resolved.

$$\Delta x = R\theta_3 \left(\pi/180°\right)$$

$$\Delta x = 45374 \times 3 \times \pi/180$$

$$\Delta x = 2,374.571$$

$$\Delta x = 2400 \text{ m}.$$

If we relate the antenal beamwidth to the ~~band~~ wavelenght of EMW and anteno lenght.

$$Q_3 = \lambda / D_{eff} \text{ (radian)}$$

$$Q_3 = \lambda / D_{eff} \left(180/\lambda\right) \text{ (degree)}$$

λ is signals wavelenght D_{eff} in the effective lenght of antena. the D_{eff} size as about 0.7 times to its actual size. so we can use antena dimension and the ~~cross angle~~ cross-range resolution become.

$$\boxed{\Delta x \cong \frac{R\lambda}{D_{eff}} \text{ (meter)}}$$