BECE 310L — SATELLITE COMMUNICATION

DIGITAL ASSIGNMENT -2

RAHUL KARTHIK. S

21BEC1851

(2)

i) Path Loss

$$L_p = 20 \log \left[\frac{4\pi R}{\lambda} \right]$$

$$= 20 \log \left[\frac{4\pi \times 38 \times 10^6}{0.025} \right]$$

$$= 20 \log \left[19100.88 \times 10^6 \right]$$

$$= 205.6 \text{ dB}$$

~~G_T~~ Receive Antenna Gain $G_r = \eta_A \times \left[\frac{\pi D}{\lambda} \right]^2$

$$= 0.7 \times \left[\frac{\pi \times 0.457}{0.025} \right]^2$$

$$= 0.7 \times [57.43]^2$$

$$= 0.7 \times 3298.011$$

≈ 2309 or ~~33.9~~ 33.6 dB

Downlink Budget gives received power. For 1 dB output backoff of 200 W transponder, atmospheric and miscellaneous loss of 0.9 dB and -4 dB contour.

$$P_r = EIRP + G_r - L_p - \text{Losses} \quad \text{dBW}$$

$$= 22 + 39 + 33.6 - 205.6 - 4.0 - 0.4 - 0.5$$

$P_r = -115.9 \text{ dBW}$

ii) The downlink $(C/N)_{dn}$ in a noise bandwidth of 24 MHz.

Noise Power at the earth station receiver input is :

$N = -228.6 + 21.1 + 73.8 = -133.7 \text{ dBW}$

Hence, the downlink C/N ratio in the earth station receiver is

$C/N = P_r - N = -115.9 + 133.7 = 17.8 \text{ dB}$

iii) The overall $(C/N)_o$ in the earth station receiver

The uplink C/N in the transponder is 24 dB

$$(C/N)_o = \frac{1}{\frac{1}{251.2} + \frac{1}{60.25}} = \frac{1}{0.0206} = 48.6$$

or

~~19.9~~

16.9 dB

2) Uplink Design :

~~2)~~ Noise Power $N = K T_S B_N$

$= -228.6 + 27.0 + 73.0$

$= -128.6 \text{ dBW}$

Uplink Earth Station Transmit Antenna Gain :

$\lambda = 0.02120 \text{ m}$ at 14.15 GHz

$$G_t = 10 \log \left[\eta_A \times \left(\frac{\pi D}{\lambda} \right)^2 \right]$$

$$= 10 \log \left(0.68 \times \left[\frac{\pi \times 5}{0.02120} \right]^2 \right) = 55.7 \text{ dB}$$

Path Loss at 14.15 GHz for typical GEO path length of 38500 km.

$$L_p = 20 \log \left(\frac{\pi R}{\lambda} \right)$$

$$= 20 \log \left[\frac{4\pi \times 38.5 \times 10^6}{0.0212} \right]$$

$$= 207.2 \text{ dB}$$

The uplink power budget includes of 2 dB off-axis, 0.7 dB atmospheric and 0.3 dB misc.

P_t	TBD
G_t	55.7 dB
G_r	31.0 dB
Path Loss	−207.2 dB
Off-axis contour Loss	−2.0 dB
other losses	−1.0 dB
Receiver Power	P_t − 123.5 dBW

We require $(C/N)_{up} = 30$ dB with $N = -128.6$ dBW

So, $P_t = 30 + 123.5 - 128.6 = 24.9$ dBW or 309 W

Downlink Design :

Path Loss $L_p = 207.16 + 20 \log \left[\frac{11.45}{14.15}\right]$

$= 205.3$ dB

The downlink power budget Includes losses of 3 dB ; 0.5 dB atmospheric , 0.2 dB miscellaneous .

Transponder output is 80 W with 1 dB back-off giving $P_t = 19.0$ W

P_t 80 W − 1 dB back-off	19.0 dBW
G_t	31.0 dB
G_r	TBD
Path Loss	− 205.3 dB
Off − axis contour loss	− 3.0 dB
Other losses	− 0.7 dB
Receiver Power	G_t − 159.0 dBW

$(C/N)_0 = 17.0$ dB with $(C/N)_{up} = 30$ dB

$$(C/N)_{dn} = \frac{1}{\frac{1}{(C/N)_0} - \frac{1}{(C/N)_{up}}} = 52.76 \text{ or } 17.2 \text{ dB}$$

Noise Power in the receiver $N = K T_S B_N$ watts

$T_S = 30 + 110$

$= 140$ K

$N = -228.6 + 21.5 + 73.0 = -134.1$ dBW

Gain of Receiving Antenna G_r ~~= 42.1 dB~~

$= 17.2 - 134.1$

$G_r = 42.1$ dB

$$G_r = 42.1 \text{ dB} = 10 \log \left[\eta_A \times \left[\frac{\pi D}{\lambda} \right]^2 \right]$$

$$= 10 \log \left[0.68 \times \left[\frac{\pi D}{0.02620} \right]^2 \right]$$

$$\boxed{D = 1.288 \text{ m}}$$

Rain Effect :

$(C/N)_{ca} = 30$ dB

Rain Attenuation $= 6$ dB

$(C/N)_{RRA} = 30 - 6 = 24$ dB

$(C/N)_o = 17 - 6 = 11$ dB

Uplink Margin $= 11 - 9.5 = 1.5$ dB

The attenuation of 17.5 dB occurs only 0.01% of the time.

This attenuation is excited about 0.01 % of an average year for GEO satellite at 11.45 GHz.

Downlink,

5 dB → Rain Attenuation

$$T_{sky} = 290 \times (1 - 0.282) = 208 \text{ K}$$

$$T_{s\,rain} = 208 + 110 = 318 \text{ K}$$

$$\Delta N = 10 \log \frac{318}{140} = 3.6 \text{ dB}$$

$$\left(\frac{C}{N}\right)_{dn\,rain} = 17.2 - \cancel{8}.6 = 8.6$$

$$\left(\frac{C}{N}\right)_{D} = 30 \text{ dB}$$

To improve overall $\left(\frac{C}{N}\right)$ at receiver o/p ~~to~~ 9.5 dB

Receiving Antenna Gain by 0.9 dB

Antenna Diameter $= 10^{0.9/10}$

1.109 to 1.288 × 1.342

= 1.429 m

Antenna Gain for 1.46 m antenna = 68 %.

$P_r = G_r - 159.0$ dBW

$= -116.8$ BW

$$\boxed{N = -130.6 \text{ BW}}$$

$(C/N)_{dm}$ rain $= 9.6$ dB

Uplink

$(C/N)_{up} = 30$ dB

Overall C/N Ratio $= 9.56$ dB.