Solution

Quiz 2: Mobile Communication Systems

Suppose your NUSTIYan lunar operation is successful in launching Pakistan's first mission in space and now you are designing a wireless link from moon to earth (free space path loss exponent) using carrier frequency of 2.8 GHz. The range is 400,000 km. On the moon, the transmit power is 3000 mW and the antenna gain is 4 dBi. Suppose that a received power of -90 dBm is necessary for you to receive BPSK signal at the desired bit error rate. Assume line losses of 1.5 dB at each end.

a) Evaluate the EIRP in dBW and dBm? (2 Marks)
b) If the effective area of a parabolic dish antenna is the actual area times the antenna efficiency, and the efficiency is 0.75, then evaluate the required diameter of the antenna on the earth? (4 Marks)
c) If log-normal shadowing is also present with σ=7dB, and the outage probability at the receiver is 30%, what is the fraction of area with signal above the threshold? (1 Mark)
d) If a BPSK signal is received at the receiver with above out age probability, solve for the threshold power. (3 Marks)

$f_c = 2.8 \times 10^9$ Hz ; $d = 4 \times 10^8$ meter ; $P_t = 3000mW = 3W$
$= 34.77$ dBm
$= 4.77$ dBW

$G_t = 4$ dBi ; $P_r = -90$ dBm
$= 2.512$; $= 1 \times 10^{-12}$ W

Line losses $= 1.5$ dB $= (1.41W)$

(a) EIRP in dBW & dBm?

loss ↓

$\therefore EIRP = P_t + G_t - L_t$

$$EIRP\ (dBm) = 34.77\ dBm + 4dBi - 1.5dB$$
$$= \boxed{37.3\ dBm}$$

$$EIRP(dBW) = 37.3\ dBm - 30 = \boxed{7.3\ dBW}$$

(b) Diameter of Antenna on earth? $\eta = 0.75$

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L_t L_r} \Rightarrow G_r = \frac{P_r 4\pi^2 d^2 L_t L_r}{P_t G_t \lambda^2}$$

$$G_r = \frac{(1 \times 10^{-12})(4.314)^2 (4 \times 10^8)^2 (1.41)^2}{(3000 \times 10^{-3})(2.51)(0.107)^2}$$

$$G_r = 0.580 \times 10^9$$

$$G_r = \frac{4\pi A_e}{\lambda^2} \Rightarrow A_e = \frac{G_r \lambda^2}{4\pi} \Rightarrow A_e = \frac{(0.580 \times 10^9)(0.107)^2}{(4 \times 3.14)}$$

$$\boxed{A_e = 0.53 \times 10^6 m^2}$$

$$A = \frac{A_e}{\eta} = \frac{0.53 \times 10^6}{0.75} = \boxed{0.706 \times 10^6 m^2}$$

$\because A_e = \eta A$

$\therefore A = \frac{\pi D_r^2}{4}$

$$D_r = \sqrt{4A/\pi} = \sqrt{\frac{4(0.706 \times 10^6)}{3.14}} = \boxed{948.34 \text{ meter}}$$

(c) $\sigma = 7dB$, exponent $= 2$; outage $= 30\%$

$= 7/2 = 3.5$

Boundary coverage $= P(Pr(R) > \gamma) = 100 - 30$
$= 70\%$

Signal Above threshold using Graph

$$\boxed{\approx 88\%}$$

(d) $P[Pr(d) < \gamma] = Q\left[\frac{Pr(d) - \gamma}{\sigma}\right]$

$$0.3 = Q\left[\frac{Pr(d) - \gamma}{7}\right]$$

$$Q^{-1}(0.3) = \frac{-90 - \gamma}{7}$$

$$0.524 \times 7 = -90 - \gamma$$

$$\boxed{\gamma = -93.67 \, dBm}$$

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