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HW 5.

1. Use the exponential function / distribution

$$f(P) = \frac{1}{P_{av}} e^{-P/P_{av}}$$

(a)

$P_{av} = -75\,dBm = 3.16 \times 10^{-8}\,mW$

Package outage rate $\sim 0.1\% = 0.001$

$P(P < P_{th}) = P_{outage}$

$$1 - e^{-\frac{P_{th}}{P_{av}}} = P_{outage} = 0.001$$

$$\therefore e^{-P_{th}/P_{av}} = 0.999 \Rightarrow \frac{P_{th}}{P_{av}} = -\ln(0.999)$$

$$\therefore P_{th} = 3.16 \times 10^{-8}\,mW \times 0.001 = 3.16 \times 10^{-11}\,mW$$

$$SNR = \frac{P_{th}}{N} = \frac{3.16 \times 10^{-11}}{10^{-10}} \simeq 0.316$$

$$\Rightarrow SNR|_{dB\,min} = -5\,dB$$

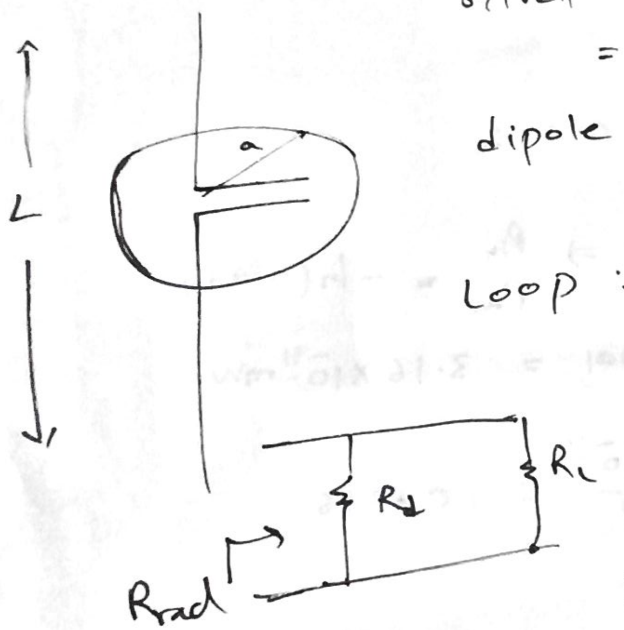
(b) $P_{Tx} \rightarrow P_{av} = -90\,dBm = 10^{-9}\,mW$

$$P(P > P_{th}) = e^{-P_{th}/P_{av}}$$

$$P_{th} = -80\,dBm \text{ (or) } 10^{-8}\,mW$$

$$\therefore P(P > P_{th}) = e^{-10^{-8}/10^{-9}} = e^{-10} \simeq 4.54 \times 10^{-5}$$

2.



Given radiation resistance $= 50\,\Omega$

dipole resistance $R_d = 20\pi^2 \left(\frac{L}{\lambda}\right)^2$

Loop : $R_L = 31200 \left(\frac{S}{\lambda^2}\right)^2$

Using the transmission line model:

$$R_{rad} = R_d \parallel R_L$$

$$= \frac{R_d R_L}{R_d + R_L}$$

$$\left[S = \frac{\lambda L}{4\pi} \right]$$

$$\therefore 50 = \frac{R_d R_L}{R_d + R_L} = \frac{\left(\frac{20\pi^2}{\lambda^2} L^2\right)\left(\frac{31200}{\lambda^4} \frac{\lambda^2 L^2}{16\pi^2}\right)}{(R_d) + (R_L)}$$

$$\frac{\frac{97.192}{\lambda^2} L^2 * \frac{197.78}{\lambda^2} L^4}{\left(\frac{197.192 * 197.78}{\lambda^2}\right) L^4} = \frac{L^2}{\lambda^2}\left(\frac{39000.634}{394.972}\right)$$

$$= 98.743 \frac{L^2}{\lambda^2} \Rightarrow 50\,\Omega$$

$\Rightarrow L \approx 0.71134\lambda$

and $S = \frac{\lambda L}{4\pi} = \left(\frac{0.71134}{4\pi}\right)\lambda^2 = 0.0566\lambda^2$

For obtaining 'S' $= \frac{\lambda L}{4\pi}$; we need consider circularly polarized case with $|E_\theta| = |E_\phi|$

$$|E_\theta| = \left(\frac{j\eta k I L e^{-jkr}}{8\pi r}\sin\theta\right) ; \quad |E_\phi| = \left(\eta \frac{k^2 I S e^{-jkr}}{4\pi r}\sin\theta\right)$$

Now $|E_\theta| = |E_\phi|$ gives

$L = 2kS$ (or) $\frac{\lambda L}{4\pi} = S$