# Mid-Term Exam Solutions

**Q.1** $G = \frac{4\pi}{\lambda^2} A_e = \frac{4\pi\, 0.1}{(3\times10^{-2})^2} = \frac{1.2}{9\times10^{-4}} \simeq 10^3$

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{9\times10^9} \simeq 3\times10^{-2}$$

$$G(\text{dB}) \simeq 30\ \text{dB}$$

$$P_R = P_T G_T G_R \left(\frac{\lambda}{4\pi d}\right)^2 = P_T G_T G_R P_L$$

$S/N = 8$ dB  in dB  $P_R - N = 8$,

$F$ = noise figure

$$N = kTBF \qquad \underbrace{60}$$
$$= -173 + 10\log(10^6) + 8$$
$$= -105 \quad \text{dBm}$$

$$P_L = \left(\frac{\lambda}{4\pi d}\right)^2 = \left(\frac{3\times10^{-2}}{4\pi\ 8\times10^3}\right)^2 \simeq \left(\frac{3\times10^{-2}}{10^5}\right)^2 \simeq \frac{9\times10^{-4}}{10^{10}}$$
$$= \frac{10^{-3}}{10^{10}} \simeq 10^{-13}$$

$$= -130\ \text{dB}$$

$$S+N = P_T + (2\times30) + (-130)$$

$$P_T = 8 - 105 - 60 + 130$$
$$= -27\ \text{dBm}.$$

Q. 2

$$L_{50}(urban)(\text{dB}) = 69.55 + 26.16\log f_c - 13.82\log h_{te} - a(h_{re}) + (44.9 - 6.55\log h_{te})\log d$$

$d = 10\,km \quad \log d = 1.$

$$L(dB)_{\text{after}} = f(h_{re}, f, d) - 13.8\log(h_{te}) - 44.9 - 6.55\log(h_{te})$$

$$= f(\cdot) - (13.8 - 6.55)\log(h_{te})$$

difference due to $h_{te} \approx -20.4\log(h_{te})$

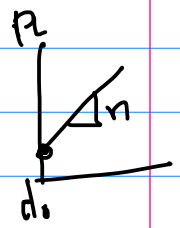
$h_{te2}/h_{te1} = 2 \quad \approx -20.4\,(\log(2) - \log(1))$

$\sim -20.4\log(2) \simeq \underline{6.14}$

difference due to 4 x power $= \underline{6.0\,dB}.$

$n = 2.4$

(b) $P_L \propto \left(\frac{d}{d_0}\right)^n$




$$\left(\frac{d_1}{d_0}\right)^{2.4} = 4 \cdot \left(\frac{d_2}{d_0}\right)^{2.4} \qquad \frac{d_1}{d_2} = 4^{\frac{1}{2.4}} = 1.78$$

$4 = 10^{\left(\frac{6.14}{10}\right)}$


coverage area $\propto d^2$

increase in coverage area $= (1.78)^2$

$= 3.25$

Q. 3: $C = B\log_2(1 + S/N)$ $\qquad \frac{S}{N} = 10^{1.2}$

$\simeq 13$

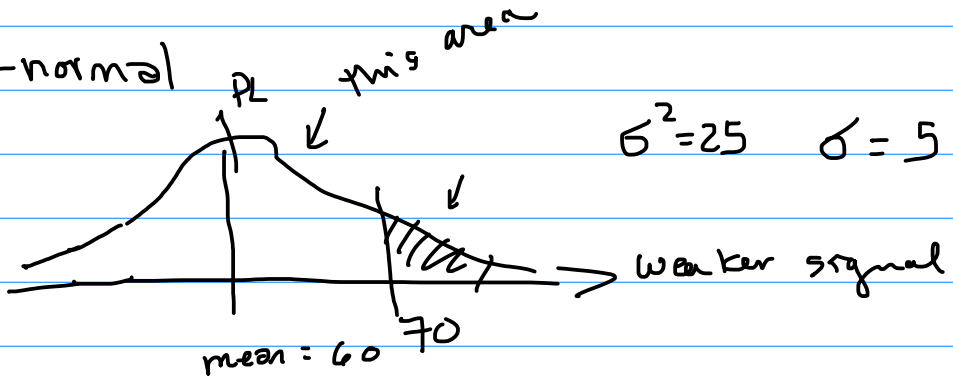
$10^5 \log_2(1 + 13)$

$\simeq 400\ kb/s \Rightarrow$ No, capacity < required data rate, error-free operation not possible.

Q.4

(a) log-normal

(b)




$$P(P_L < 70) = Q\left(\frac{60-70}{5}\right)$$

$$\simeq 98\%$$

(c) $P(20 \text{ working}) = (0.98)^{20} \simeq 65\%$