Exercise 2 in SSY135 Wireless Communications

January 30, 2020

1 Tentative Solutions

1.

(a)

$$\left[\overline{P}_r(R)\right] = [P_t]_{\text{dBm}} + [10\log_{10}K]_{\text{dB}} - 10\gamma\log_{10}(R/d_0) \quad (1)$$

$$\begin{aligned} \left[\overline{P}_r(R)\right] = \quad \mu &= [P_t]_{\text{dBm}} + [10\log_{10}K]_{\text{dB}} - 10\gamma\log_{10}(R/d_0) - \mu_{\text{dB}} \\ \mu &= 40 - 109.53 - 10(3.7)\log_{10}\left(\frac{4\times 10^3}{1\times 10^3}\right) - 10 \\ \mu &= -101.80 \text{ dBm} \end{aligned}$$

$[P_{min}]_{\text{dBm}} = \mu - 15 = -116.8$ dBm,

Evaluate eq. (3.44) from the book, $L_Z = \sqrt{2\pi} f_D \rho e^{-\rho^2}$ where $f_D = \frac{\upsilon \times f_c}{c}$ where $\upsilon = 36$km/h, $f_c = 900$Mhz and c is the velocity of propagation. $\rho = \sqrt{\frac{P_0}{\bar{P}_r}}$ where P_0 is the target power level $P_0 = -116.8$dBm and $\bar{P}_r = \mu = -101.8$dBm from above. Therefore, $L_Z = 12.9562$ crossings per second.

(b) Evaluate eq. (3.47) in the book, $\bar{t}_Z = 0.0024$s. Since $R_b = 1$Mhz, $T_b \ll \bar{t}_Z$ so the system would experience burst error.

2. [E2012-Mar-Q.3] Solution:

P_{out} =Prob$\{\gamma < \gamma_{min}\} = 1 - Q\left(\frac{P_{min} - P_r^{av}}{\sigma_{\psi_{dB}}}\right)$
$\sigma_{\psi_{dB}} = 6$,
$P_{min} = P_r(d = 1000 \,\text{without shadow fading})$
$P_r^{av} = \overline{P}_r(d_{new}^{max})$ + average shadow fading
$= \overline{P}_r(d_{new}^{max}) + 0$
We need to have $P_{out} < 0.02$, which implies
$Q\left(\frac{P_{min} - P_r^{av}}{\sigma_{\psi_{dB}}}\right) \geq 0.98 \Longrightarrow P_r(d = 1000)_{[dB]} - \overline{P}_r(d_{new}^{max})_{[dB]} \geq 6Q^{-1}(0.98)$

$$10\log_{10}\frac{P_r(d = 1000 \,\text{without shadow fading})}{P_r^{av}(d_{new}^{max})} = -12.322 \quad (2)$$

on the other hand,

$$\frac{\overline{P}_r(d = 1000)}{P_r^{av}(d_{new}^{max})} = \left(\frac{d_{new}^{max}}{1000}\right)^2 \quad (3)$$

from equations (1) and (3), we get, $\frac{d_{new}^{max}}{1000} = \sqrt{10^{-1.232}}$
$\Longrightarrow d_{max} = 242$ m.