ECE5884 Wireless Communications – Quiz 2 **1 August 2022**

1. (MATLAB) *randn* returns a random scalar drawn from the standard normal/Gaussian distribution, i.e., mean $\mu = 0$ and standard deviation $\sigma = 1$ denoted as $X \sim \mathcal{N}(0,1)$. By using *randn*, you first generate Gaussian random variable with mean $\mu = 0.5$ and variance $\sigma = 0.75$, i.e., $X \sim \mathcal{N}(0.5, \sqrt{0.75})$. Then, you verify following analytical expressions of PDF and CDF of X by using simulations. You will plot the analytical expression and the simulated curve in the same graph. Please submit MATLAB code too!

$$\text{PDF:} \quad f_X(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}}; -\infty < x < \infty \tag{1}$$

$$\text{CDF:} \quad F_X(x) = \frac{1}{2}\left[1 + \operatorname{erf}\left(\frac{x-\mu}{\sqrt{2}\sigma}\right)\right] = 1 - Q\left(\frac{x-\mu}{\sigma}\right) \tag{2}$$

(Hint: Try to get your plot as follows.) ☺

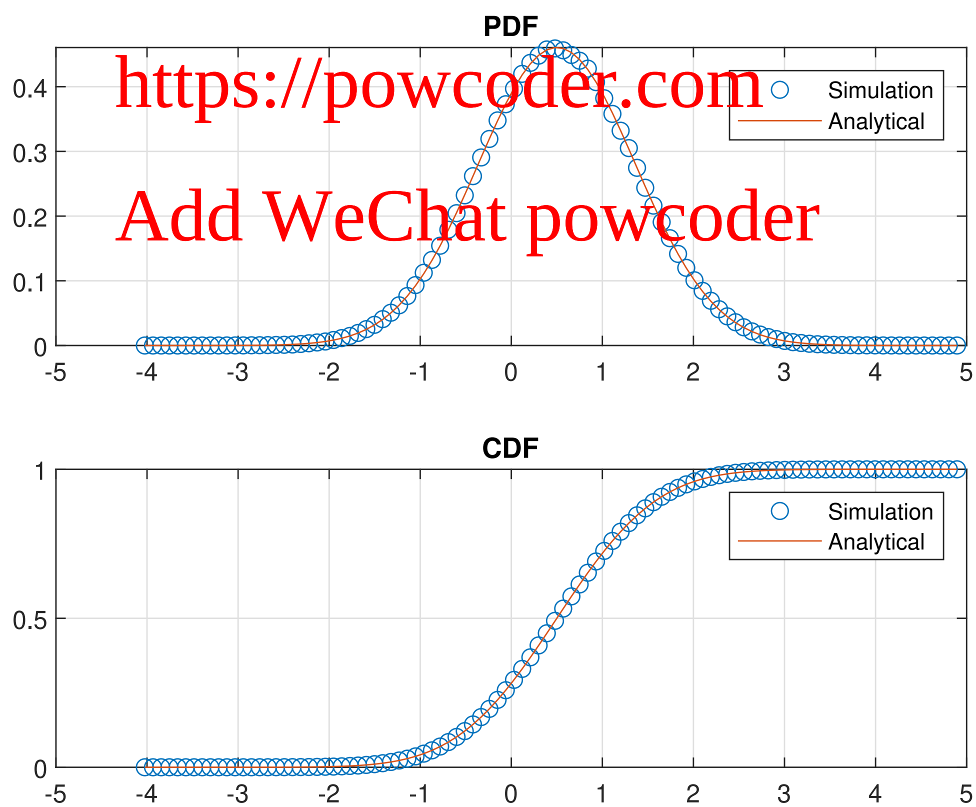

Figure 1: Example.

2. What are the main differences between path loss and shadowing?

3. Why do we need a simplified path loss model?

4. Why do we model shadowing ($\psi = P_t/P_r$) as a random parameter?

5. We have a wireless system with maximum transmit power of $P_t = 10\,\mathrm{mW}$ and the minimum receive power requirement of $P_{min} = -110.5\,\mathrm{dBm}$. This wireless environment is based on combined path loss and shadowing models where we use log-normal shadowing model with mean of $\mu_{\psi_{dB}} = 0\,\mathrm{dB}$ and standard deviation of $\sigma_{\psi_{dB}} = 3.65\,\mathrm{dB}$. Further, we use a simplified path loss model

$$P_r = P_t\, K \left(\frac{d_r}{d}\right)^{\alpha} \tag{3}$$

with $K = -31.54\,\mathrm{dB}$, $d_r = 1\,\mathrm{m}$ and $\alpha = 3.7$.

   (a) Find the outage probability at 160 m. You may start from Eq. (35) in Slide#16. Please provide details of your calculation steps!

   (b) Is this wireless system feasible, if we need the outage probability of the minimum receive power less than 0.02 at 160 m? Please justify your answer!