ECE 531/499, Introduction to Wireless Communications and Networking
Homework Assignment 4, 9/27/2024
Due: 10/1/2024, 7:20 PM
Class notes from:
W4 - Statistical description of the wireless channel v2.0
W5 - Wideband channel characterization

1. For a Rayleigh fading process
   a. Plot the normalized LCR metric versus the normalized envelope.
   b. Plot the normalized ADF versus the normalized envelope.
   c. If the receiver velocity is 30 km/h and the carrier frequency is 3.6GHz, compute the values required for filling the table below.

$r_n\ [dB]$	$r_n\ [lin]$	$N(r_n)$	$t(r_n)$
0			
-3			
-10			

   d. Compute the normalized LCR for $r = 14.1mV$, if the average power of the process is $200mW$.

2. Figure 1 is a snapshot of 1 second of the received envelope (Rayleigh fading) knowing the maximum Doppler shift is 10 Hz.
   a. Find from the figure the number of fades below -5dB (normalized value).
   b. What is the expected value?
   c. Why the difference?
   d. Compute $LCR(r_n = -5dB)$ and compare with the result from the snapshot.

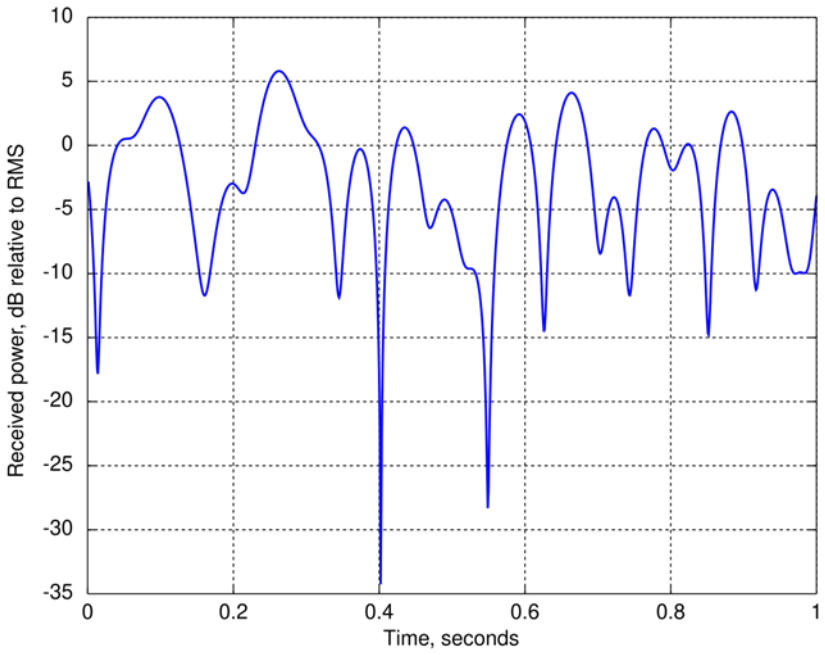

Figure 1

3. Consider a NB simulator
channel simulator using the approach discussed in the class. The output of the simulator are samples of the process $\mathbf{w}(nT) = \mathbf{u}(nT) + j\mathbf{v}(nT)$, for every time instance $T = 3.827ms$. The

simulator uses $N = 10$, the maximum Doppler shift is 100 Hz, and the initial phases $(\gamma_k)_{k=\{0,1,2\}} = \{0.265352, 0.727255, 2.789171\}$.

a. Draw the diagram representing the simulator.
b. What is the expected average power?
c. Compute C_k and S_k and implement the simulator (Excell, Matlab, Python) for producing only 40 samples.
   Hint. For this problem, Excel is recommended as it provides a better visualization of the computation.
d. Plot the first 40 samples after normalization with the expected average power.
e. Compute the expected time averages $\langle \mathbf{u}^2 \rangle$ $\langle \mathbf{v}^2 \rangle$ and $\langle \mathbf{uv} \rangle$ and compare with the variance and correlation for the 40 samples.
f. Compute $R_{\mathbf{w}}(T)$.
g. Plot scatter diagram for $\mathbf{u}$ and $\mathbf{v}$ and compare with the scatter diagram when T-1ms. Comments?

4. Questions
   a. List the system functions used for LTV system.
   b. What variables are used by each of them, and what do they represent?
   c. Show the relationship between the system functions above and draw a picture representing these relations.
   d. If $x(t)$ is the input for the LTV system, write the equation to be used for calculating the output for each of the system functions.
   e. For WB wireless channels, the system functions are stochastic processes, and therefore autocorrelation functions are used. Write the definition for each of these.
   f. What is the fundamental property for a WSS channel?
   g. What is the fundamental property for a US channel?
   h. Write the simplified system functions for a WSSUS channel.