Department of Electrical Engineering, IIT Madras

EE5141: Fundamentals of Wireless and Cellular Communications

Marks 20 **Simulation Assignment # 1** **Mar. 21, 2026**

Kindly Note: This assignment sa#1 is to be submitted by email to the TA, ***Mr. M. Ravi,*** ee24m019@smail.iitm.ac.in*, on or before* ***5pm on Tuesday, March 31, 2026****. Mark the name of the pdf file as* ee5141-sa1-your_rollnumber.pdf*. Your Matlab code must be included as an appendix to your report. Independent work is expected from each student, and access to your running Matlab(or Python) code may be required by us, if such a need arises.*

1. [12 marks] Time-selective Fading: A vehicle is moving with velocity v=30 m/s where the wireless link uses a carrier-frequency of f_c=2GHz and a pass-band message bandwidth of 2W=100KHz. Assume the Jake's PSD.

1a. Simulate and plot one run of a single fading complex-valued path gain (sampled every T_s=1/2W=10µsecs), over N=8000 samples, using each of the 3 following fading models:

(a) Linear Prediction (Levison Algorithm) based noise coloring filter. See class notes. Also refer to [4].

(b) Smith's model (using FFTs) – see Rappaport's book; use N=8192 here. Also see [4]

(c) Modified sum of sinusoids model using [2]. Also see [1] and [3].

1b. Also plot for each case, the auto-correlation function, as well as the cross-correlation between the real and imaginary values of the path gain. Comment.

1c. Repeat **1a.** when the velocity is only v=3m/s. Comment.

1d. Bonus Question [3 marks]: Read Suzuki model in [5] or the flexible approach in [6], and simulate either of them. Can you get the bathtub Jake's PSD as a special case of them? Comment.

2.[4 marks] Frequency-selective Fading: Consider a wide-band signal with pass-band bandwidth 2W=10MHz, which is transmitted over a multi-path model defined by the power delay profile (PDP) as follows:

Path Gain σ_i^2(in dB)	-2	0	-1	-6	-9	-14
Path Delay τ_i (in µsecs)	0	1.8	3.5	5.7	8.1	12.3

Hint: To normalize average channel gain to unity, in each of these models, rescale the (linear value of) the path variance σ_i^2 to ensure that over the L paths, $\sum_{i=0}^{L-1} \sigma_i^2 = 1$. Each zero-mean path gain a_i, where $E[|a_i|^2] = \sigma_i^2$, is a complex Gaussian random variable with each dimension having a variance of $\sigma_i^2/2$. The impulse-response snap-shot $h[n]$, corresponding to the given PDP is obtained by calling a circular Gaussian rv L times, and scaling the gain based on the power profile. The frequency response snap-shot $H[k]$ is obtained by zero-padding plus FFT (of typically large size to visualize shape easily). For the above PDP, take a 2048 point FFT of the instantaneous $h[n]$ (by appropriate zero-padding) to get $H[k]$. Plot in dB scale the squared gain, i.e., $10\log_{10}(|H(k)|^2)$, to interpret the coherence band-width of the model and comment. Repeat over 3 different (independent) channel realisations, and plot on the same figure.

3. [4 marks] Now, for 90Hz maximum Doppler frequency on each path in the PDP as in Pbm. 2, generate frequency *and* time varying fading plots (use 3-D plotting feature in Matlab). Plot the time-varying frequency response, obtained every 5msec, over a duration of 30msecs (i.e., plot 7 consecutive snapshots, obtained at 0msec, 5msec, 10msec,….., up to 30msec). Comment on your results.

References:

[1] Dent & Bottomley; [2] Zheng & Xiao; [3] Andersen et al; [4] Mfeze et al; [5] Patzold et al; [6] IEEE 802.16m contribution. All references are downloadable from the course teaching URL.

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