Wireless Communication Signal Processing - Homework 1

Due on March 21

Mar. 7, 2025

In the following questions, please provide a thorough explanation or outline the calculation process; otherwise, no points will be awarded

1. (100%) Jakes model is an effective channel simulator. The UE is moving at speed v, and the normalized power spectral density (PSD) of the Doppler shift (i.e., the normalized Doppler spectrum) is

$$S_D(f)=\begin{cases}\dfrac{1}{\pi f_{\max}\sqrt{1-\left(f/f_{\max}\right)^2}}, & |f|<f_{\max}\\ 0, & |f|>f_{\max}\end{cases},$$

where $f_{\max}$ is the maximum Doppler shift. Answer the following problems and simulation experiments in (a)-(e).

(a) (20%) Describe the assumption of the Jakes model.

The simulator of the Jakes model has the following structure (Figure 1):

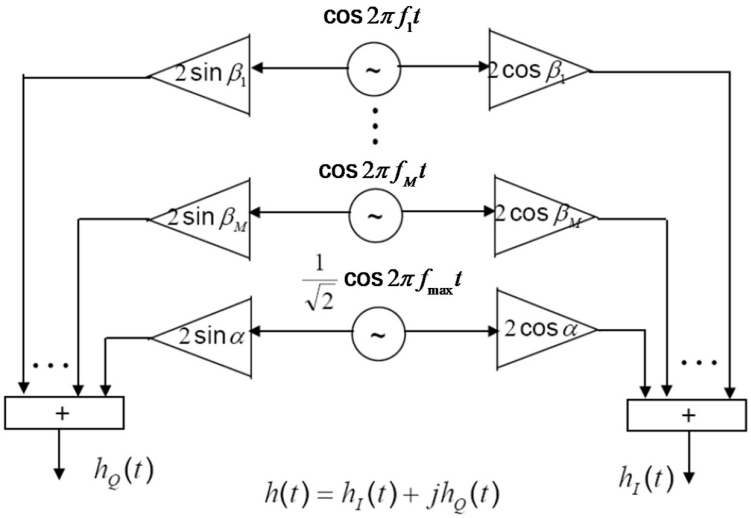

Figure 1

$h(t)$ is a function that describes the time-domain fading effect for a single-tap channel. The given Jakes model subroutines (please see the attached MATLAB code HW1_Jakes_2025.m) generate simulated Rayleigh fading gains with Doppler shift.

Assume that the carrier frequency is 3.5 GHz, and the UE moving speed is 70 km/hr. Use Jakes model to generate a sequence of fading gains with Doppler shift, and use this sequence to do the following:

(b) (20%) Describe how the simulator generates Rayleigh fading gains with Doppler shift.

(c) (60%) Based on $f_{\max} = \nu f_c / c$, try different combinations of parameters and summarize the impact of parameter adjustments on the system.

- Plot the PSD of the fading gain.
- Evaluate the RMS frequency Doppler spread (f_{RMS}).
- Plot the PDF of the magnitude and phase of the fading gain.

Give your COMMENT on each of the simulation results.