Homework 5 submission

ECET 512 — Wireless Systems

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1) Submitted files-

For the assignment following files were submitted :

wo_shadow.jpg- This is graph of received power without shadow and with fading.

wo_fading.jpg- This is graph of received power without fading and with shadow.

wo_shadow_fading.jpg- This is graph of received power without fading and without shadow

shadow_fading.jpg- This is graph of received power with fading and with shadow

doppler.jpg- This graph is of Doppler Envelope.

2) SRC-

fading.m : This code generates graphs for shadowing and fading effects.

rayleighFading.m : This code generates graphs for doppler envelope

testRayleighFading.m : This code passes parameters like carrier frequency and velocity to rayleighFading.m subroutine.

3) Code Explanation

Let us see how graph was generated for Doppler envelope.

The code is as follows :

```
M=15; %number of multipaths

N=10^5; %number of samples to generate

% fd=100; % Maximum doppler spread in hertz

Ts=0.0001; % Sampling period in seconds

fc = 2000000000; %carrier frequency

v = 27.78;   %Velocity of wave in km/h

c = 300000000;  %Speed of light


   %8192 samples

for a = 1:8192

        for n = 1:N  %Simulate Rayleigh channel for 16 scattering paths


lambda = c/fc;  %Wavelength

            alphan = (2*pi*n)/M;  %Doppler shift angle

            fd= (v/lambda)*cos(alphan);  %Doppler frequency

        end

end


 %call subroutine to calculate doppler shift

h=rayleighFading(M,N,fd,Ts);
```

Let us discuss how subroutine function for calculating Rayleigh doppler spread works.

```
function [h]=rayleighFading(M,N,fd,Ts)
% function to generate Rayleigh Fading samples based on Clarke's model
% M = number of multi-paths in the channel
% N = number of samples to generate
% fd = maximum Doppler frequency
% Ts = sampling period
a=0;
b=2*pi;
alpha=a+(b-a)*rand(1,M); %uniformly distributed from 0 to 2 pi
beta=a+(b-a)*rand(1,M); %uniformly distributed from 0 to 2 pi
theta=a+(b-a)*rand(1,M); %uniformly distributed from 0 to 2 pi
m=1:M;
for n=1:N;
x=cos(((2.*m-1)*pi+theta)/(4*M));
h_re(n)=1/sqrt(M)*sum(cos(2*pi*fd*x*n'*Ts+alpha));
h_im(n)=1/sqrt(M)*sum(sin(2*pi*fd*x*n'*Ts+beta));
end
h=h_re+j*h_im;
end
```

The models behind **Rayleigh** or Rician fading assume that many waves arrive each with its own random **angle** of arrival (thus with its own **Doppler shift**).

Thus alpha,beta and gamma are 3 angles required in formula for calculating doppler shift. rand(1,M) induces a randomness in these angles.

h is the final doppler envelope that is generated. It is a complex number.

Absolute value of h is plotted for amplitude response using abs(h).

Phase response is calculated using angle(h).

The code for plotting doppler envelope is as follows :

```
figure;
subplot(2,1,1);
plot([0:N-1]*Ts,10*log10(abs(h)));
title('Amplitude Response of the Flat Fading channel');
xlabel('time in seconds');ylabel('Magnitude');
subplot(2,1,2);
plot([0:N-1]*Ts,angle(h));
title('Phase response of the Flat Fading channel');
xlabel('time in seconds');ylabel('Phase angle');
```

Now let us discuss the code which plots graphs of received power considering the shadowing and fading effects.

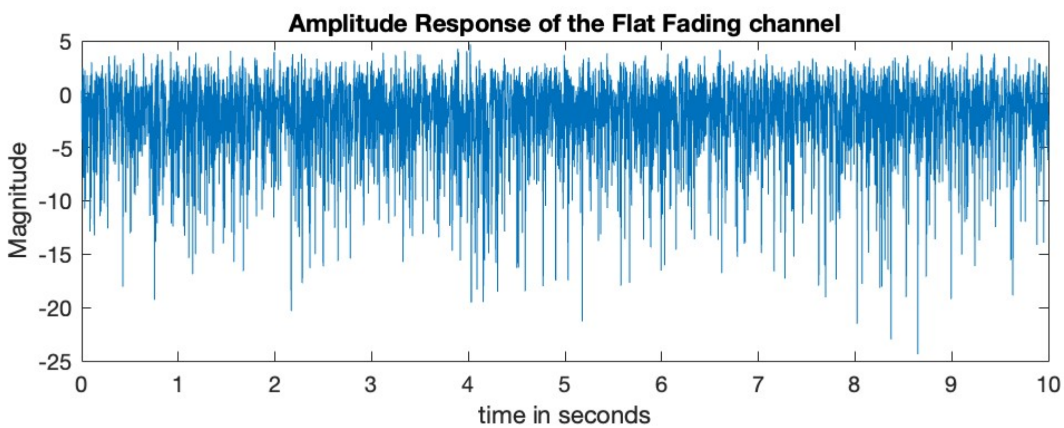
```
B=1:1:100;
% V=8.33;
% T=B/V;

d0=1;
sigma=2;
ple1=3;

GT=1;
GR=1;
s=size(B); % get size of array of real time distances. Size depends on frame rate
index2=s(2); % get size of array B


reference_power=0;  % 10^-3 watts is 0 dBm
shadow = sigma*randn(1,numel(B)); % shadowing


z= abs(sigma*randn(1,numel(B))+1i*sigma*randn(1,numel(B)));




shadow_fading = GT + GR + reference_power -10*ple1*log10(B/d0)  -z -shadow ;
 wo_shadow_fading= GT + GR + reference_power -10*ple1*log10(B/d0);
```

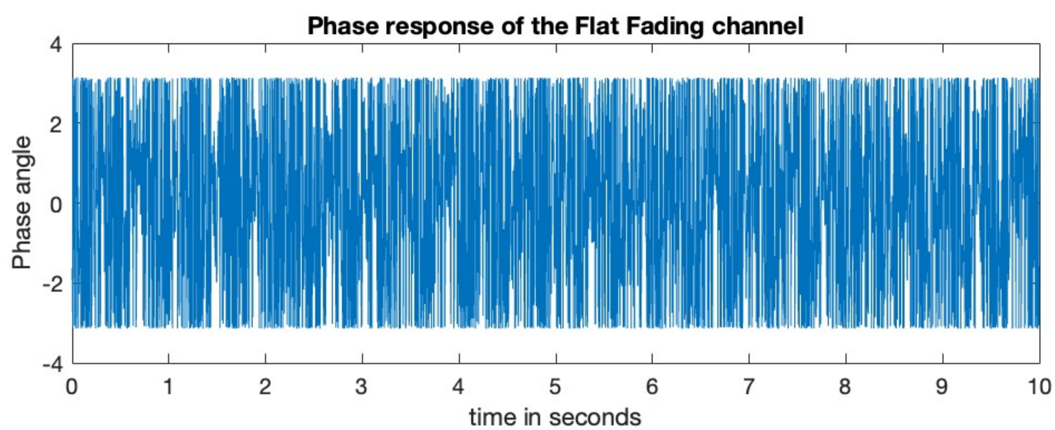
The parameter shadow in above code is for shadowing.

Parameter Z is for fading effect. As seen it is a function of two random variables which simulates Rayleigh flat fading.

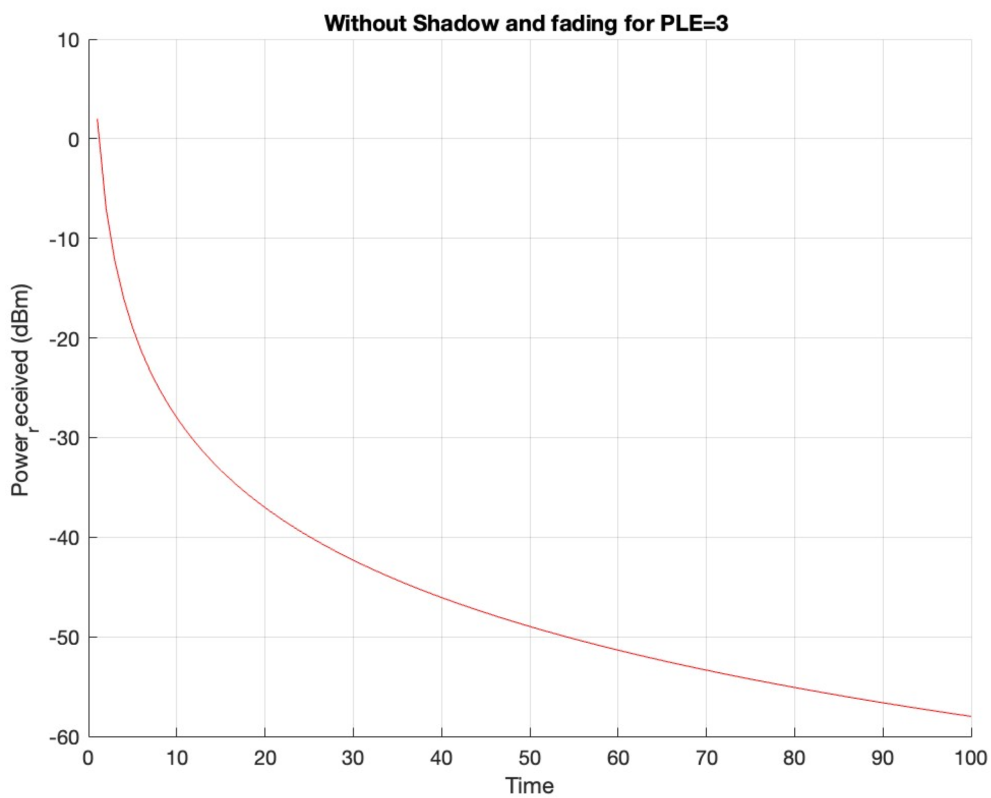
4) Graphs :

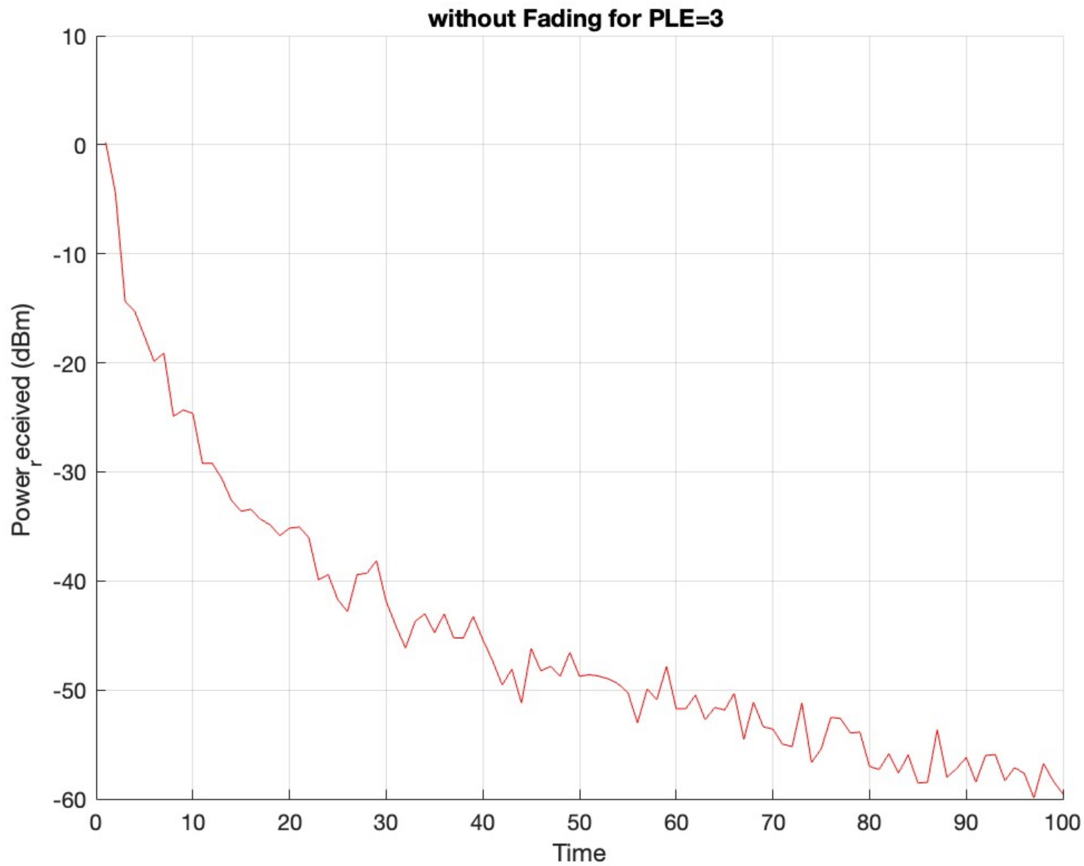
The following graph plots Amplitude and Phase response of Doppler envelope.

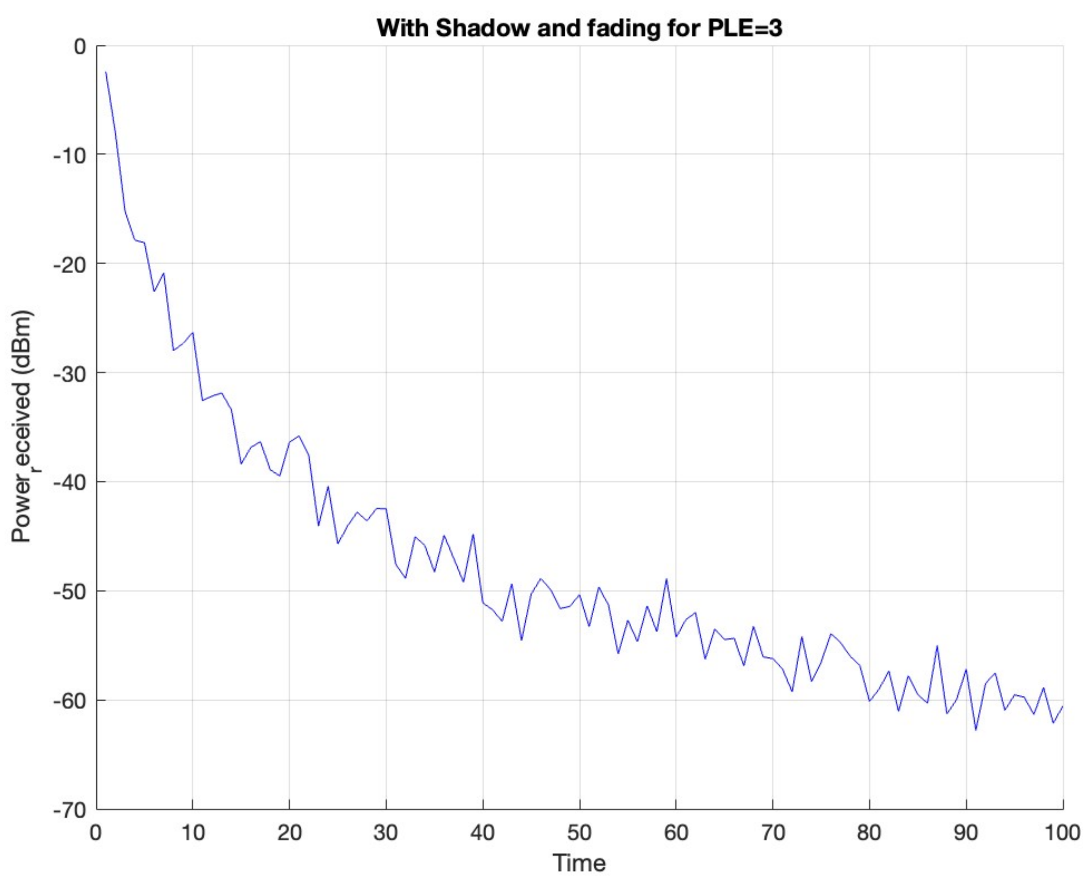


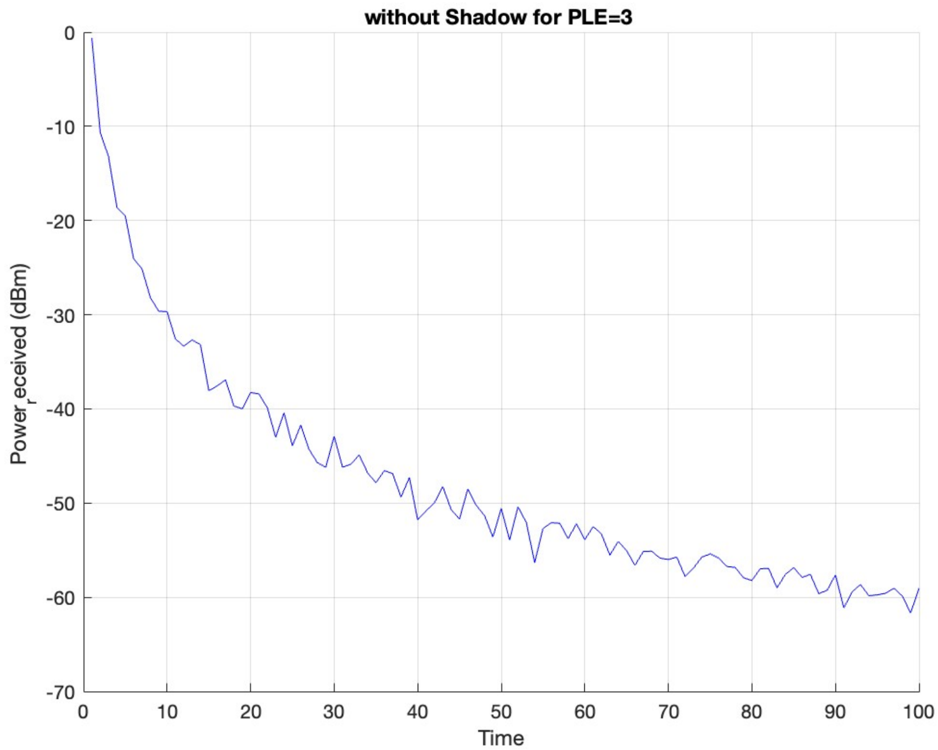


The following 3 graphs are of received power with and without fading and shadowing effects considered.




without Fading for PLE=3
Power_r eceived (dBm)
Time
10
0
-10
-20
-30
-40
-50
-60
0
10
20
30
40
50
60
70
80
90
100


With Shadow and fading for PLE=3
Power_r eceived (dBm)
Time
0
-10
-20
-30
-40
-50
-60
-70
0
10
20
30
40
50
60
70
80
90
100



without Shadow for PLE=3
Power_received (dBm)
Time
0
-10
-20
-30
-40
-50
-60
-70
0
10
20
30
40
50
60
70
80
90
100

5) Discussion-

In this assignment graphs were plotted for Amplitude and Phase response of doppler envelope. Graphs were also plotted considering fading and shadowing effects.

Since both large-scale and small-scale fading occurs in practical situations, the fading margin must account for the combination of the two effects (see also Chapter 3). One possibility is to just add up the fading margin for the Rayleigh distribution and the fading margin for a lognormal distribution.

This method is commonly used because of its simplicity, but overestimates the required fading margin. The more accurate method is based on the cdf of the Suzuki distribution

6) Running the code-

Import all attached code files in MATLAB

Run the fading.m to generate graphs of fading and shadowing.

Run testRayleighFading.m to generate graph of doppler envelope.