KFUPM - COMPUTER ENGINEERING DEPARTMENT

COE-543 – Mobile Computing and Wireless Networking

Assignment 1 – Due Oct 8rd, 2011.

Problem	Total Points	Points
1	40	
2	40	
3	30	
4	30	
Total	140	

Problem 1 (40 points):

The Mobile WiMAX community recommends the usage of the ITU model for modeling multipath for performance evaluation purposes of the Mobile WiMAX system. The model is specified by the following profiles:

Environment	Tap	Channel A			Channel B		
		Relative delay (ns)	Average Power (dB)	RMS (ns)	Relative delay (ns)	Average Power (dB)	RMS (ns)
Indoor office	1	0	0	35	0	0	100
	2	50	-3.0		100	-3.6	
	3	110	-10.0		200	-7.2	
	4	170	-18.0		300	-10.8	
	5	290	-26.0		500	-18.0	
	6	310	-32.0		700	-25.2	
Outdoor to indoor & pedestrian	1	0	0	45	0	0	750
	2	110	-9.7		200	-0.9	
	3	190	-19.2		800	-4.9	
	4	410	-22.8		1200	-8.0	
	5	-	-		2300	-7.8	
	6	-	-		3700	-23.9	
Vehicular	1	0	0	370	0	-2.5	4000
	2	310	-1.0		300	0	
	3	710	-9.0		8900	-12.8	
	4	1090	-10.0		12900	-10.0	
	5	1730	-15.0		17100	-25.2	
	6	2510	-20.0		20000	-16.0	

1) **(10 points)** For channel A, verify that the RMS delay spread figures for the indoor office, pedestrian, and vehicular profiles are equal to 35 ns, 45 ns, and 370 ns, respectively. Estimate the coherence bandwidth for these channels.

2) **(10 points)** Plot the multipath intensity profile function for channel A (pedestrian).

3) **(20 points)** Focusing on the channel A (pedestrian), one can use the Matlab function "`rayleighchan()`" to model a multipath channel. The following code is used to model the required channel.

```
clear all
N = 2000; %number of samples;
OFDMA_Symbol_Time = 102.9e-6;
Tsample = OFDMA_Symbol_Time;
Fdoppler = 10;
PathGainsdB = [0 -9.7 -19.2 -22.8];
RelativeDly = [0 110 190 410]*1e-9; % in nano seconds
c = rayleighchan(Tsample,Fdoppler, RelativeDly, PathGainsdB);
sig = j*ones(N,1); % Signal
y = filter(c,sig); % Pass signal through channel.
c % Display all properties of the channel object.
% Plot power of faded signal, versus sample number.
plot(Tsample*[0:1:N-1],20*log10(abs(y)))
```

In the above code, the signal envelope is sampled every `Tsample` time. The code selects the OFDMA symbol time of 102.9 micro seconds as the sampling time. Since the code generate `N` equal to 2000 samples, then the code produces a trace of the channel fading envelope for a duration of $2000*102.9x10^{-6}$ = 0.218 seconds. The code plots the power of the signal envelope in dB. Remember the power of the signal envelope is proportional to the square of the absolute value of the signal level.

Plot the signal power for three different value of the `Fdoppler` parameter: 1 Hz, 10 Hz, and 100 Hz. Put all three resulting curves on one plot and *comment* on the result in terms of speed of variation of the signal level or power. Estimate the coherence time for *all* three Doppler values.

References:

Overview of Fading Channels:: Channels (Communications Toolbox) – Matlab online help.

Problem 2 (40 points):

The uncorrelated scattering function of an indoor radio channel is defined as the product of a time function $Q(\tau)$ that represents the delay-power spectrum and a frequency function that represents the Doppler spectrum. That is

$$S(\tau,\lambda) = Q(\tau)D(\lambda)$$

Suppose for τ (in nsec) we have:

$$Q(\tau) = \begin{cases} 0.4 & \tau = 50 \\ 0.4 & \tau = 100 \\ 0.2 & \tau = 200 \end{cases}$$

and for λ (in Hz) we have:

$$D(\lambda) = \begin{cases} 0.1 & |\lambda| \le 5\text{Hz} \\ 0 & \text{otherwise} \end{cases}$$

a) (5 points) Plot $Q(\tau)$ and $D(\lambda)$ functions indicating the units on the x and y axes.

b) (2 points) What is the excess delay for the channel?

c) (5 points) Determine the RMS delay spread of the channel?

d) (3 points) What is the maximum Doppler frequency?

e) (5 points) Determine the RMS Doppler spread of the channel?

f) (10 points) In regard to the coherence bandwidth:

1. Define the coherence bandwidth, Bc?
2. What is the phenomenon that is represented by the coherence bandwidth?
3. Using the relation between coherence bandwidth and the signal bandwidth one can classify the channel into two extremes. Specify this classifications and the required relationship between coherence bandwidth and the signal bandwidth for each channel type.
4. Compute is the coherence bandwidth of the channel above?
5. List three mitigation techniques to remedy the adverse effects of the phenomenon specified in f.2?

g) (10 points) In regard to the Doppler spread:

1. Define the coherence time, T_0, for the channel.
2. What is the phenomenon that is represented by the coherence time?
3. Using the relation between coherence time and the signal element duration one can classify the channel into two extremes. Specify this classification and the required relation between coherence time and the signal element duration for each channel type.
4. Compute the coherence time for the channel specified above.
5. List three mitigation techniques to remedy the adverse effects of the phenomenon specified in g.2?

In all the computed quantities, the proper units must be clearly indicated.

Problem 3 (30 points):

The modulation technique used in the existing AMPS network is analog FM. The transmission bandwidth is 30 kHz per channel and the maximum transmitted power is from a mobile user is 3 Watts. The acceptable quality of received SNR is 18 dB and the power of the background noise in the system is -120 dBm. Assuming that the height of the base and mobile station antennas are h_b = 100 m and h_m = 3 m, respectively and the frequency of operation is f = 900 MHz, what is the maximum distance between the mobile station and the base station for an acceptable quality of communication for:

a) Assume free space propagation with transmitter and receiver antenna gains of 2.

b) Use the Hata's equations for Okumura's model in the a large city.

Problem 4: (30 points):

Answer the following questions:

a) Why does multipath in wireless channels limit the maximum symbols transmission rate? How can one overcome this limitation?

b) What is the Doppler spectrum and how one can measure it?

c) What probability distributions are used to model fast fading in LOS situations? What about in obstructed LOS situations?