

# PRACTICAL WORK BOOK

For Academic Session \_\_\_\_\_

Semester \_\_\_\_\_

## WIRELESS & MOBILE COMMUNICATION

(TC-387)

For

BE (TC)

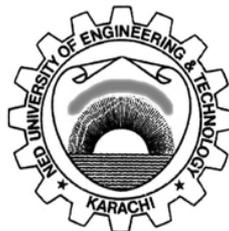
**Name:** \_\_\_\_\_

**Roll Number:** \_\_\_\_\_

**Batch:** \_\_\_\_\_

**Department:** \_\_\_\_\_

**Year:** \_\_\_\_\_



**Department of Electronic Engineering  
NED University of Engineering & Technology, Karachi**

**LABORATORY WORK BOOK**  
**For The Course**  
**TC-387 Wireless & Mobile Communication**

**Prepared By:**  
**Mr. Amir Zeb**

**Reviewed By:**  
**Dr. Muhammad Imran Aslam (Associate Professor)**

**Approved By:**  
**The Board of Studies of Department of Electronic Engineering**

## **INTRODUCTION**

Wireless Mobile/Cellular Communication Practical Workbook covers those practical that are very knowledgeable and quite beneficial in grasping the core objective of the subject. These practical solidify the theoretical and practical concepts that are very essential for the engineering students.

This work book comprise of practical covering the topics of Wireless Mobile/Cellular Communication that are arranged on modern software and trainer boards. Above all this workbook contains a relevant theory about the Lab session.

## CONTENTS

Lab No.	Dated	List of Experiments	Page No.	Remarks
1		Generate binary random sequence with length 10000 What is the distribution? Plot the histogram.	4	
2		Generate a real Gaussian noise sequence with zero mean and variance 1. Verify the sequence has a Gaussian distribution. Plot and compare it with the theoretical Gaussian function. What is the average symbol power of the sequence?	5	
3		Process a binary data stream using a Communication System that consists of a base-band modulator, channel and demodulator. Compute the system's BER (Assume 16-QAM)	6-7	
4		Assume BPSK modulation is used for SNR range of 0-15 dB with a step of 2 dB, length=1000 bits. Simulate BER of the system Plot BER vs. SNR performance for simulated results Plot power spectral density of the transmitted sequence	8	
5		Simulate a QPSK modulation scheme and compare it with BPSK scheme.	9-10	
6		Plot Path loss curve with respect to distance for different values of path loss exponent between 2 to 6	11-12	
7		Create a frequency-flat Rayleigh fading channel object. Uses it to process a DBPSK signal. Compare the BER of the system for different values of SNR Compare the empirical results with theoretical results and plot them.	13-14	
8		Create a Rician fading channel object. Uses it to process a DBPSK signal. Compare the BER of the system for different values of SNR Compare the empirical results with theoretical results and plot them.	15-16	

9		<p>Process a binary data stream using a Communication System that consists of a base-band modulator, channel and demodulator. Now add an error-control encoder and a decoder into the system.</p> <p>Evaluate the BER performance of the coded system, at the SNR range of zero dB to 15 dB.</p> <p>Plot the BER vs. SNR performance and compare it with the un-coded system</p>	17-18	
10		<p>To study the cellular system and to compute the reuse ratio for different cluster size and plot it against different values of N</p>	19	
11		<p>Estimate Path Loss using Okumura Hata model for a Medium size city using given data</p>	20-21	
12		<p>Analysis of Wi-Fi Networks</p>	22-23	
13		<p>Plot the relative power drop of the signal arriving at Mobile Station</p>	24-25	
14		<p>Write a MATLAB program for Rayleigh Fading at 900 MHz, 1800 MHz and 2700MHz. Assuming the receiver replacement rate is 120km/hr.</p>	26-27	

## LAB SESSION 01

### **OBJECT:-**

Generate binary random sequence with length 10000. What is the distribution? Plot the histogram.

### **THEORY:-**

Every communication system has one or more signal sources. This Lab describes how to use the Communications Toolbox to generate random signals, which are useful for simulating signal sources.

### **FUNCTION USED:-**

- rand();
- hist();

### **CODE:-**

```
clc  
  
y= rand(10000,1); (generate random binary number of length 10000)  
  
hist(y);          (plot histogram)
```

### **RESULT:-**

.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....

## LAB SESSION 02

### **OBJECT:-**

Generate a real Gaussian noise sequence with zero mean and variance 1. Verify the sequence has a Gaussian distribution. Plot and compare it with the theoretical Gaussian function. What is the average symbol power of the sequence?

### **THEORY:-**

The wgn function generates random matrices using a white Gaussian noise distribution. You specify the power of the noise in either dBW (decibels relative to a watt), dBm, or linear units. You can generate either real or complex noise.

For example, the command below generates a column vector of length 50 containing real white Gaussian noise whose power is 2 dBW. The function assumes that the load impedance is 1 ohm.

```
y1 = wgn(50,1,2);
```

### **FUNCTION USED:-**

- randn();
- wgn();
- hist();

### **CODE:-**

```
N_seq1=randn(100);  
N_seq2=wgn(100,1,5);  
figure,hist(N_seq1);  
figure,hist(N_seq2);  
x=-10:1:10;  
n=0  
v=1  
p=30*(exp(-(x-n).^2/2))/(v*(sqrt(2*3.14)));  
plot(x,p);
```

### **RESULT:**

.....

.....

.....

.....

.....

## LAB SESSION 03

### OBJECT:-

Process a binary data stream using a Communication System that consists of a base-band modulator, channel and demodulator. Compute the system's BER (Assume 16-QAM)

### THEORY:-

In most media for communication, only a fixed range of frequencies is available for transmission. One way to communicate a message signal whose frequency spectrum does not fall within that fixed frequency range, or one that is otherwise unsuitable for the channel, is to alter a transmittable signal according to the information in your message signal. This alteration is called modulation, and it is the modulated signal that you transmit. The receiver then recovers the original signal through a process called demodulation.

### QUADRATURE AMPLITUDE MODULATION:-

#### Syntax

$y = \text{qammod}(x, M)$   
 $y = \text{qammod}(x, M, \text{ini\_phase})$

#### DESCRIPTION

$y = \text{qammod}(x, M)$  outputs the complex envelope  $y$  of the modulation of the message signal  $x$  using quadrature amplitude modulation.  $M$  is the alphabet size and must be an integer power of 2. The message signal must consist of integers between 0 and  $M-1$ . The signal constellation is rectangular or cross-shaped, and the nearest pair of points in the constellation is separated by 2. If  $x$  is a matrix with multiple rows, then the function processes the columns independently.

$y = \text{qammod}(x, M, \text{ini\_phase})$  specifies the initial phase of the modulated signal in radians

### Filter signal with channel object

#### Syntax

$y = \text{filter}(\text{chan}, x)$

#### Description

$y = \text{filter}(\text{chan}, x)$  processes the baseband signal vector  $x$  with the channel object  $\text{chan}$ . The result is the signal vector  $y$ . The final state of the channel is stored in  $\text{chan}$ . You can construct  $\text{chan}$  using either `rayleighchan` or `ricianchan`. The filter function assumes  $x$  is sampled at frequency  $1/t_s$ , where  $t_s$  equal the Input Sample Period property of  $\text{chan}$ .

If  $\text{chan.ResetBeforeFiltering}$  is 0, then `filter` uses the existing state information in  $\text{chan}$  when starting the filtering operation. As a result, `filter(channels, [x1 x2])` is equivalent to `[filter(channels, x1) filter(channels, x2)]`. To reset  $\text{chan}$  manually, apply the `reset` function to  $\text{chan}$ .

If  $\text{chan.ResetBeforeFiltering}$  is 1, then `filter` resets  $\text{chan}$  before starting the filtering operation, overwriting any previous state information in  $\text{chan}$ .

**Quadrature amplitude demodulation****Syntax:**

$z = \text{qamdemod}(y,M)z = \text{qamdemod}(y,M,\text{ini\_phase})$

**Description**

$z = \text{qamdemod}(y,M)$  demodulates the complex envelope  $y$  of a quadrature amplitude modulated signal.  $M$  is the alphabet size and must be an integer power of 2. The constellation is the same as in `qammod`. If  $y$  is a matrix with multiple rows, then the function processes the columns independently.

$z = \text{qamdemod}(y,M,\text{ini\_phase})$  specifies the initial phase of the modulated signal in radians.

**Compute number of bit errors and bit error rate****Syntax**

$[\text{number},\text{ratio}] = \text{biterr}(x,y)$

$[\text{number},\text{ratio}] = \text{biterr}(x,y,k)$

$[\text{number},\text{ratio}] = \text{biterr}(x,y,k,\text{flg})$

$[\text{number},\text{ratio},\text{individual}] = \text{biterr}(\dots)$

**CODE:**

```
clc;
input=randint(10,10);
m=qammod(input,16);
ch=awgn(m,10,'measured');
output=qamdemod(ch,16);
error=biterr(input,output);
```

**RESULT:**

.....

.....

.....

.....

## LAB SESSION 04

### OBJECT:

Assume BPSK modulation is used for SNR range of 0-15 dB with a step of 2 dB, length=1000 bits. Simulate

1. BER of the system
2. Plot BER vs. SNR performance for simulated results
3. Plot power spectral density of the transmit sequence

### THEORY:

**Compute number of bit errors and bit error rate**

#### Syntax

```
[number,ratio] = biterr(x,y)
[number,ratio] = biterr(x,y,k)
[number,ratio] = biterr(x,y,k,flg)
[number,ratio,individual] = biterr(...)
```

### CODE:

```
a=rand(a6,1);
b=round(a);
m=2;
sx=pskmod(b,m);
snr=-15:2:0;
rxsx=awgn(snr);
EbNo=rxsx./snr;
[ber,err]=biterr(a,rxsx);
ber=berawgn(EbNo,'psk',m,diff);
figure;plot(EbNo,ber);
ber=berawgn(snr,'psk',m,'diff');
figure;plot(snr,ber);
```

### RESULT:

.....

.....

.....

.....

.....

.....

.....

## LAB SESSION 05

### **OBJECT:**

Simulate a QPSK modulation scheme and compare it with BPSK scheme.

### **THEORY:**

Modulation is a process by which a carrier signal is altered according to information in a message signal. The carrier frequency, denoted  $F_c$ , is the frequency of the carrier signal. The sampling rate is the rate at which the message signal is sampled during the simulation. The frequency of the carrier signal is usually much greater than the highest frequency of the input message signal. The Nyquist sampling theorem requires that the simulation sampling rate  $F_s$  be greater than two times the sum of the carrier frequency and the highest frequency of the modulated signal, in order for the demodulator to recover the message correctly.

In most media for communication, only a fixed range of frequencies is available for transmission. One way to communicate a message signal whose frequency spectrum does not fall within that fixed frequency range, or one that is otherwise unsuitable for the channel, is to alter a transmittable signal according to the information in your message signal. This alteration is called modulation, and it is the modulated signal that you transmit. The receiver then recovers the original signal through a process called demodulation.

For a given modulation technique, two ways to simulate modulation techniques are called baseband and passband. Baseband simulation, also known as the lowpass equivalent method, requires less computation. The toolbox used in this lab supports baseband simulation for digital modulation and passband simulation for analog modulation.

### **CODE:**

```
for sn1=0:2:15
x=randint(1,100000);
y=pskmod(x,2);
ynoiseadded=awgn(y,sn1);
z=pskdemod(ynoiseadded,2),
[number,ratio]=biterr(x,z);
plot(sn1,ratio);
hold on;
end
hold on;
for sn1=0:2:15
x=randint(1,100000);
y=pskmod(x,4);
ynoiseadded=awgn(y,sn1);
z=pskdemod(ynoiseadded,4),
[number,ratio]=biterr(x,z);
plot(sn1,ratio);
hold on;
end
```

hold on;

**RESULT:**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

## LAB SESSION 06

### **OBJECT:**

Plot Path loss curve with respect to distance for different values of path loss exponent between 2 to 6

### **THEORY:**

Path loss normally includes propagation losses caused by the natural expansion of the radio wave front in free space (which usually takes the shape of an ever-increasing sphere), absorption losses (sometimes called penetration losses), when the signal passes through media not transparent to electromagnetic waves, diffraction losses when part of the radiowave front is obstructed by an opaque obstacle, and losses caused by other phenomena.

The signal radiated by a transmitter may also travel along many and different paths to a receiver simultaneously; this effect is called multipath. Multipath can either increase or decrease received signal strength, depending on whether the individual multipath wavefronts interfere constructively or destructively. The total power of interfering waves in a Rayleigh fading scenario vary quickly as a function of space (which is known as small scale fading), resulting in fast fades which are very sensitive to receiver position

In the study of wireless communications, path loss can be represented by the path loss exponent, whose value is normally in the range of 2 to 4 (where 2 is for propagation in free space, 4 is for relatively lossy environments and for the case of full specular reflection from the earth surface—the so-called flat-earth model). In some environments, such as buildings, stadiums and other indoor environments, the path loss exponent can reach values in the range of 4 to 6. On the other hand, a tunnel may act as a waveguide, resulting in a path loss exponent less than 2.

Path loss is usually expressed in dB. In its simplest form, the path loss can be calculated using the formula

$$L = 10 n \log_{10}(d) + C$$

where  $L$  is the path loss in decibels,  $n$  is the path loss exponent,  $d$  is the distance between the transmitter and the receiver, usually measured in meters, and  $C$  is a constant which accounts for system losses.

### **CODE:**

.....

.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....

**RESULT:**

.....  
.....  
.....  
.....  
.....

## LAB SESSION 07

### OBJECT:

1. Create a frequency-flat Rayleigh fading channel object.
2. Uses it to process a DBPSK signal.
3. Compare the BER of the system for different values of SNR
4. Compare the empirical results with theoretical results and plot them.

### THEORY:

There exist direct and major reflected paths between a stationary radio transmitter and a moving receiver. Buildings behave as reflectors. The major reflected paths result in the arrival of delayed versions of the signal at the receiver. In addition, the radio signal undergoes scattering on a local scale for each major path. Such local scattering is typically characterized by a large number of reflections by objects near the mobile. These irresolvable components combine at the receiver and give rise to the phenomenon known as multipath fading. Due to this phenomenon, each major path behaves as a discrete fading path. Typically, the fading process is characterized by a Rayleigh distribution for a non-line-of-sight path and a Rician distribution for a line-of-sight path. The relative motion between the transmitter and receiver causes Doppler shifts. Local scattering typically comes from many angles around the mobile. This scenario causes a range of Doppler shifts, known as the Doppler spectrum. The maximum Doppler shift corresponds to the local scattering components whose direction exactly opposes the mobile's trajectory.

### Creating Channel Objects

The `rayleighchan` and `ricianchan` functions create fading channel objects.

The table below indicates the situations in which each function is suitable.

Function	Object	Situation Modeled
<code>rayleighchan</code>	Rayleigh fading channel object	One or more major reflected paths

The command below creates a channel object representing a Rayleigh fading channel that acts on a signal sampled at 100,000 Hz. The maximum Doppler shift of the channel is 130 Hz.

```
c1 = rayleighchan(1/100000,130); % Rayleigh fading channel object
```

The object `c1` is a valid input argument for the `filter` function. After you have created a channel object, you can use the `filter` function to pass a signal through the channel. The arguments to `filter` are the channel object and the signal.

### CODE:

```
clc
c=i*ones(200,1);
chan=rayleighchan(1e-3,100);
```

```
y=(filter(chan,c);  
x=20*(log(abs(y)));  
p=plot(x);
```

**RESULT:**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

## LAB SESSION 08

### OBJECT:

1. Create a Rician fading channel object.
2. Uses it to process a DBPSK signal.
3. Compare the BER of the system for different values of SNR
4. Compare the empirical results with theoretical results and plot them.

### THEORY:

There exist direct and major reflected paths between a stationary radio transmitter and a moving receiver. Buildings behave as reflectors. The major reflected paths result in the arrival of delayed versions of the signal at the receiver. In addition, the radio signal undergoes scattering on a local scale for each major path. Such local scattering is typically characterized by a large number of reflections by objects near the mobile. These irresolvable components combine at the receiver and give rise to the phenomenon known as multipath fading. Due to this phenomenon, each major path behaves as a discrete fading path. Typically, the fading process is characterized by a Rayleigh distribution for a non-line-of-sight path and a Rician distribution for a line-of-sight path. The relative motion between the transmitter and receiver causes Doppler shifts. Local scattering typically comes from many angles around the mobile. This scenario causes a range of Doppler shifts, known as the Doppler spectrum. The maximum Doppler shift corresponds to the local scattering components whose direction exactly opposes the mobile's trajectory.

### Creating Channel Objects

The `rayleighchan` and `ricianchan` functions create fading channel objects.

The table below indicates the situations in which each function is suitable.

Function	Object	Situation Modeled
<code>ricianchan</code>	Rician fading channel object	One direct line-of-sight path, possibly combined with one or more major reflected paths

Construct a Rician fading channel object

#### Syntax

```
chan = ricianchan(ts,fd,k)
chan = ricianchan(ts,fd,k,tau,pdb)
chan = ricianchan
```

### Description

`chan = ricianchan(ts,fd,k)` constructs a frequency-flat ("single path") Rician fading channel object. `ts` is the sample time of the input signal, in seconds. `fd` is the maximum Doppler shift,

in Hertz.  $k$  is the Rician  $K$ -factor. In this channel, the specular component has zero phase and the phase does not change with the Doppler shift. You can model the effect of the channel on a signal  $x$  by using the syntax  $y = \text{filter}(\text{chan},x)$ .

$\text{chan} = \text{ricianchan}(ts,fd,k,\tau,\text{pdb})$  constructs a frequency-selective ("multiple path") fading channel object that models the first discrete path as a Rician fading process and each of the remaining discrete paths as an independent Rayleigh fading process.  $\tau$  is a vector of path delays, each specified in seconds.  $\text{pdb}$  is a vector of average path gains, each specified in dB.

$\text{chan} = \text{ricianchan}$  constructs a frequency-flat channel object with no Doppler shift and a  $K$ -factor of 1. This is a static channel. The sample time of the input signal is irrelevant for frequency-flat static channels.

### CODE:

```
T=[0:1:100];
A=5;
B=10;
Y=A+B*T*I;
Chan= ricianchan(1e-3,100);
Yout= filter(Chan,Y);
Yout1= abs(Yout);
Yout2= 20*log(Yout1);
plot(Yout2);
```

### RESULT

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

## LAB SESSION 09

### Object:

Process a binary data stream using a Communication System that consists of a base-band modulator, channel and demodulator. Now add an error-control encoder and a decoder into the system.

1. Evaluate the BER performance of the coded system, at the SNR range of zero dB to 15 dB.
2. Plot the BER vs. SNR performance and compare it with the un-coded system.

### Theory:

Error-control coding techniques detect and possibly correct errors that occur when messages are transmitted in a digital communication system. To accomplish this, the encoder transmits not only the information symbols, but also one or more redundant symbols. The decoder uses the redundant symbols to detect and possibly correct whatever errors occurred during transmission.

### Block Coding:

Block coding is a special case of error-control coding. Block coding techniques map a fixed number of message symbols to a fixed number of code symbols. A block coder treats each block of data independently and is a memoryless device.

### Convolutional Coding:

Convolutional coding is a special case of error-control coding. Unlike a block coder, a convolutional coder is not a memoryless device. Even though a convolutional coder accepts a fixed number of message symbols and produces a fixed number of code symbols, its computations depend not only on the current set of input symbols but on some of the previous input symbols.

### Parameters for Linear Block Codes:

This subsection describes the items that you might need in order to process  $[n,k]$  cyclic, Hamming, and generic linear block codes.

### Generator Matrix

The process of encoding a message into an  $[n,k]$  linear block code is determined by a  $k$ -by- $n$  generator matrix  $G$ . Specifically, the  $1$ -by- $k$  message vector  $v$  is encoded into the  $1$ -by- $n$  codeword vector  $vG$ . If  $G$  has the form  $[Ik P]$  or  $[P Ik]$ , where  $P$  is some  $k$ -by- $(n-k)$  matrix and  $Ik$  is the  $k$ -by- $k$  identity matrix, then  $G$  is said to be in standard form. Most functions in this toolbox assume that a generator matrix is in standard form when you use it as an input argument.

### Generator Matrix:

The process of encoding a message into an  $[n,k]$  linear block code is determined by a  $k$ -by- $n$  generator matrix  $G$ . Specifically, the  $1$ -by- $k$  message vector  $v$  is encoded into the  $1$ -by- $n$  codeword vector  $vG$ . If  $G$  has the form  $[Ik P]$  or  $[P Ik]$ , where  $P$  is some  $k$ -by- $(n-k)$  matrix and  $Ik$  is the  $k$ -by- $k$  identity matrix, then  $G$  is said to be in standard form.

### CODE:

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**RESULT:**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

## LAB SESSION 10

### **OBJECT:**

To study the cellular system and to compute the reuse ratio for different cluster size and plot it against different values of N.

### **THEORY:**

RF bandwidth has always been the primary constraint in wireless systems; there is never too much. Efficiently using this precious resource involves what is called *frequency reuse*, in which a radio channel is allowed to be simultaneously used by multiple transmitters as long as they are sufficiently separated to avoid interference. The essential idea of cellular radio is to transmit at power levels sufficiently low so as to not interfere with the nearest location at which the same channel is *reused*.

In this way a physical (RF) channel can be used more than once in a given city. The greater the *reuse distance*, the lower the probability of interference. Likewise, the lower the power levels used in cells sharing a common channel, the lower the probability of interference. Thus, a combination of power control and frequency planning is used in cellular systems to prevent interference.

The reuse distance is directly proportional to the cluster size but the relation ship is non linear.

Let D be the reuse distance and R be the radius of the cell then  $D/R = \sqrt{3N}$

### **CODE:**

.....

.....

.....

.....

.....

.....

.....

### **RESULT**

.....

.....

.....

## LAB SESSION 11

**OBJECT:** Estimate Path Loss using Okumura Hata model for a Medium size city using given data

### **THEORY:**

The Okumura Model is a radio propagation model what was initially built using experimental data obtained from the city of Tokyo, Japan. The model is preferably used for estimating path loss with urban structures but not tall blocking structures. The model is built for urban, suburban and open areas.

### **CODE:**

```

clc; clear all;
d=5; % distance in Km
ht = 100 % height of transmitting antenna in m
hr = 1 % height of receiving antenna in m

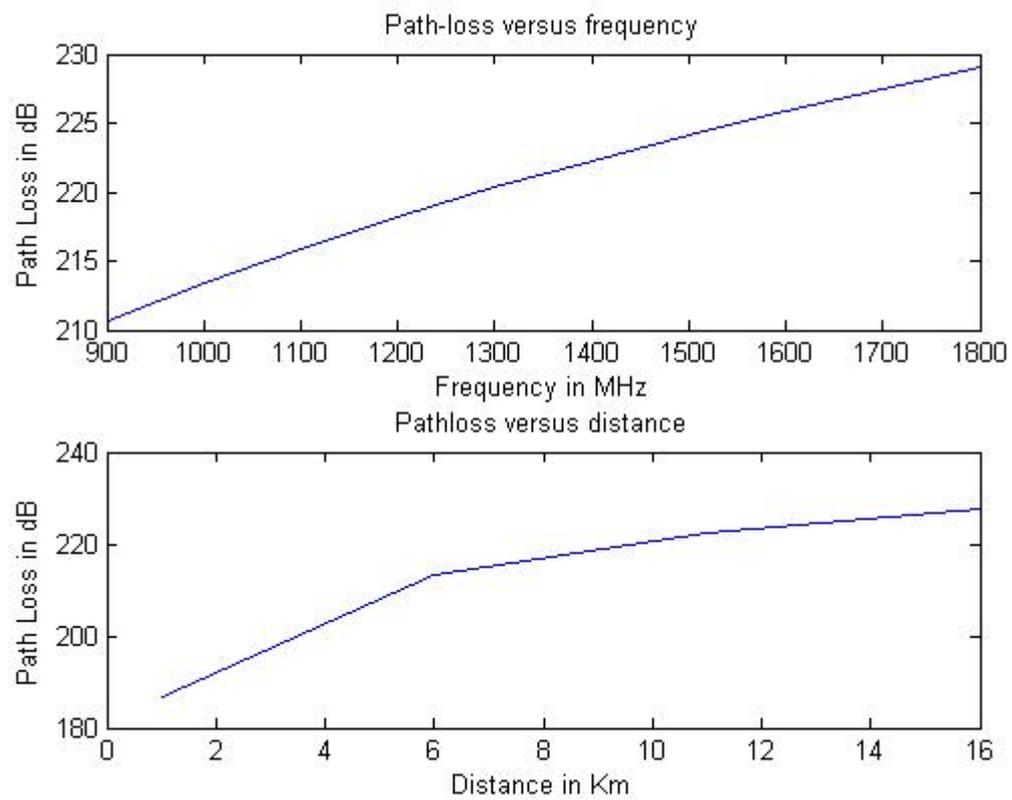
f=900:100:1800;
Ahr=(1.1*log(f) -0.7)*hr -(1.56*log(f)-0.8); % Equation of path loss using Hata Okumura
model:
PL =69.55 +26.16*log(f) -13.83*log(ht)-Ahr +(44.9 -6.55*log(ht))*log(d);
disp(PL)
subplot(2,1,1);
plot(f,PL);
title('Path-loss versus frequency');
xlabel('Frequency in MHz')
ylabel('Path Loss in dB')

d=1:5:20;
f=900; Ahr= (1.1*log(f) -0.7)*hr -(1.56*log(f) -0.8); PL =69.55 +26.16*log(f) -
13.83*log(ht)-Ahr +(44.9 -6.55*log(ht))*log(d);
disp(PL)
subplot(2,1,2);
plot(d,PL);
title('Pathloss versus distance')
xlabel('Distance in Km')
ylabel('Path Loss in dB')

```

**RESULT:**

Path Loss versus frequency and distance is plotted



## **LAB SESSION 12**

**OBJECT:** Analysis of Wi-Fi Networks

### **THEORY:**

Wi-Fi stands for Wireless-Fidelity. Wi-Fi is a term given to certain types of wireless local area networks (WLAN) that follow the standard specifications of IEEE 802.11. The term Wi-Fi was created by an organization called the Wi-Fi Alliance, which oversees tests that certify product interoperability. Wi-Fi uses both single carrier direct-sequence spread spectrum radio technology and multi-carrier OFDM (Orthogonal Frequency Division Multiplexing) radio technology. Wi-Fi has gained acceptance in many businesses, agencies, schools, and homes as an alternative to a wired LAN. Many airports, hotels, and fast-food facilities offer public access to Wi-Fi networks. These locations are known as hot spots. An interconnected area of hot spots and network access points is known as a hot zone.

Uses: A Wi-Fi enabled device such as a PC, game console, mobile phone, MP3 player or PDA can connect to the Internet when within range of a wireless network connected to the Internet. The coverage of one or more interconnected access points - called a hotspot — can comprise an area as small as a single room with wireless-opaque walls or as large as many square miles covered by overlapping access points. Wi-Fi technology has served to set up mesh networks, for example, in London. Both architectures can operate in community networks. A Wi-Fi antenna A roof mounted Wi-Fi antenna.

Benefits: Wi-Fi can be used to deploy Local Area Network (LAN) without physical wires. Thus, these devices allow the users to interconnect without wires. This reduces the deployment cost and expansion cost. Additionally, there are some spots where the wires cannot pass through such as historical monuments, roads, cricket stadiums,

Standard devices: An embedded Router Board 112 with U.FL-RSMA pigtail and R52 mini PCI Wi-Fi card widely used by wireless Internet service providers (WISPs) in the Czech Republic.

### **Hardware:**

The following devices show the Wi-Fi devices hardware.



Wi-Fi enabled device



Wi-Fi network

**RESULT:**

Wi-Fi network analyzed.

## LAB SESSION 13

**OBJECT:** Plot the relative power drop of the signal arriving at MS along:

1. Line of Sight (LOS) (single path)
2.  $d \gg h_1$  and  $h_2$  (two paths - direct and reflected from the ground)

The reflection coefficient  $\underline{a = -1}$ . The BS antenna height equals  $\underline{h_1 = 100 \text{ m}}$ , MS antenna height  $\underline{h_2 = 3 \text{ m}}$ , distance between BS and MS is  $d$ . Power at distance  $d_0$  from BS  $\underline{P_0 = 1 \text{ mW}}$ , carrier frequency  $\underline{f = 800 \text{ MHz}}$ . Plot the relative power drop (**in dB's**) as a function of the distance between Tx and Rx for:

- a)  $\underline{10 < d < 100}$
- b)  $\underline{1000 < d < 10000}$ .
  - Compare the results.
  - Comment on the rate of the power drop (dB/decade).

**Hint:**  $P_{\text{drop}}(\text{dB}) = 10 \log(P_r/P_0)$

### Theory:

The electromagnetic wave propagates following many different paths including line of sight (LOS), reflection, refraction, diffraction, scattering and etc. These different paths have varying lengths. At the receiver these components add up to produce received signal. The interaction between these electromagnetic components creates multipath fading at receiver. Propagation models are typically used to predict average received signal strength at a distance from the transmitter. Propagation models that are used to predict the mean signal strength from an arbitrary transmitter receiver (T-R) separation are known as large scale fading models. On the other hand, models that predict the signal strength over very short travel distances typically a few wavelengths or short time durations on the order of seconds are known as small scale fading.

The necessary formulas for point:

a). LOS propagation:  $\frac{P_R(d)}{P_0} = \frac{1}{d^2}$

b).  $d \gg h$  the above is reduced to:

$$d_1 = d + \frac{(h_1 - h_2)^2}{2d}, \quad \Delta\phi = \frac{2\pi}{\lambda} \frac{2h_1 h_2}{d} \quad \text{and} \quad P_R = P_0 \frac{4h_1^2 h_2^2}{d^4}$$

$$d_2 = d + \frac{(h_1 + h_2)^2}{2d}$$

By substituting  $P_0 = P_T G_T G_R \left( \frac{2\pi}{\lambda} \right)^2$  and expressing  $\lambda$  as a ratio between speed of light and frequency, plot how the relative power drop  $P_r/P_0$  varies depending on the frequency of the radio carrier (choose  $f = 100, 500$  and  $900$  MHz).

Assume  $G_t = G_r = 1.6$ .

**Result: The plots will be submitted for this project.**

**LAB SESSION 14**

**OBJECT:** Write a MATLAB program for Rayleigh Fading at 900 MHz, 1800 MHz and 2700MHz. Assuming the receiver replacement rate is 120km/hr.

**Matlab Code:**

```
clc; clear all;
freq = [(900*10^60);(1800*10^60);(2700*10^60)];
vel = 120; c = (3*10^8); r = 1;

for x = 1:3
    fm(x) = (vel*freq(x)*1000)/(3600*c);
    Nr(x) = sqrt(2*pi)*fm(x)*r*exp(-r^2);
    FD(x) = exp(-1)/(r*fm(x)*sqrt(2*pi));

    end;
    display(fm);
    display(Nr);
    display(FD);
```

**Result:**

fm =

```
1.0e+056 *
    1.0000    2.0000    3.0000
```

Nr =

```
1.0e+056 *
    0.9221    1.8443    2.7664
```

FD =

```
1.0e-056 *
    0.1468    0.0734    0.0489
```