PABNA UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department of

Information and Communication Engineering

Faculty of Engineering and Technology

B.Sc.(Engineering)4th year 1st Semester

Lab Report

Course Code: ICE-4104

Course Title: Cellular and Mobile Communication Sessional

Submitted by:	**Submitted to:**
Md. Abdul Matin **Roll: 190604** **Dept. of Information and Communication Engineering** **Pabna University of Science and Technology** **Pabna-6600,Bangladesh**	**Dr. Md. Imran Hossain** **Associate Professor** **Dept. of Information and Communication Engineering** **Pabna University of Science and Technology** **Pabna-6600, Bangladesh** **Teacher's Signature**

06	If a transmitter produces 50 watts of power, express the transmit power in units of (a) dBm, and (b) dBW. If 50 watts is applied to a unity gain antenna with a 900 MHz carrier frequency, find the received power in dBm at a free space distance of 100 m from the antenna, what is P (10 km)? Assume unity gain for the receiver antenna.	**12-13**
07	Determine the path loss of a 900MHz cellular system in a large city from a base station with the height of 100m and mobile station installed in a vehicle with antenna height of 2m. The distance between mobile and base station is 4Km.	**14**
08	Determine the path loss between base station (BS) and mobile station (MS) of a 1.8GHz PCS system operating in a high-rise urban area. The MS is located in a perpendicular street to the location of the BS. The distances of the BS and MS to the corner of the street are 20 and 30 meters, respectively. The base station height is 20m.	**15**
09	A mobile is located 5 km away from a base station and uses a vertical λ /4 monopole antenna with a gain of 2.55 dB to receive cellular 3 radio signals. The E-field at 1 km from the transmitter is measured to be V/rn. The carrier frequency used for this system is 900 MHz. (a) Find the length and the gain of the receiving antenna. (b) Find the received power at the mobile using the 2-ray ground reflection model assuming the height of the transmitting antenna is 50 m and the receiving antenna is 1.5m above ground.	**16-17**
10	A hexagonal cell within a 4-cell system has a radius of 1.387 km. A total of 60 channels are used within the entire system. If the load per user is 0.029 Erlangs, and λ= call/hour, compute the following for an Erlang C system that has a 5% probability of a delayed call: (a) How many users per square kilometer will this system support? (b) What is the probability that a delayed call will have to wait for more than 10s? (c) What is the probability that a call will be delayed for more than 10 seconds?	**18-19**

Experiment No: 01

Name of the Experiment:

If a total of 33 MHz of bandwidth is allocated to a particular FDD cellular telephone system which uses two 25 kHz simplex channels to provide full duplex voice and control channels, compute the number of channels available per cell if a system uses (a) 4-cell reuse, (b) 7-cell reuse (c) 12-cell reuse. If 1 MHz of the allocated spectrum is dedicated to control channels, determine an equitable distribution of control channels and voice channels in each cell for each of the three systems.

Solution:

Given:

Total bandwidth =33 MHz
Channel bandwidth = 25 kHz *2 simplex channels = 50 kHz/duplex channel
Total available channels = 33,000/50 = 660 channels
(a) For N= 4, total number of channels available per cell = 660/4= 165 channels.
(b)For N=7, total number of channels available per cell = 660/7= 95 channels.
(c) For N = 12, total number of channels available per cell = 660/12 = 55 channels.
A 1 MHz spectrum for control channels implies that there are 1000/50 = 20 control channels out of the 660 channels available. To evenly distribute the control and voice channels, simply allocate the same number of channels in each cell wherever possible. Here, the 660 channels must be evenly distributed to each cell within the cluster. In practice, only the 640 voice channels would be allocated, since the control channels are allocated separately as 1 per cell.

(a) For N = 4, we can have 5 control channels and 160 voice channels per cell. In practice, however, each cell only needs a single control channel (the control channels have a greater reuse distance than the voice channels). Thus, one control channel and 160 voice channels would be assigned to each cell.

(b) For N = 7, 4 cells with 3 control channels and 92 voice channels, 2 cells with 3 control channels and 90 voice channels, and 1 cell with 2 control channels and 92 voice channels could be allocated. In practice, however, each cell would have one control channel, four cells-4vould have 91 voice channels, and three cells would have 92 voice channels.

(c) For N = 12, we can have 8 cells with 2 control channels and 53 voice channels, and 4 cells with 1 control channel and 54 voice channels each. In an actual system, each cell would have 1 control channel, 8 cells would have 53 voice channels, and 4 cells would have 54 voice channels.

Source Code:

```
clc;
clear all;
close all;
```

```
bw=33000;
schannel_bw=25;
disp('Channel Bandwidth..');
dup_ch_bw=2*schannel_bw;
t_ch=(bw/dup_ch_bw);
disp(dup_ch_bw);
disp('Total available channel');
disp(t_ch);
cc_bw=1000;
t_cc=cc_bw/dup_ch_bw;
disp('Total control channel');
disp(t_cc);
N=[4 7 12];
for i=1:3
   ch=t_ch/N(i);
   ch_per_cell=round(ch);
   disp('Channel per cell')
   disp(N(i));
   disp(ch_per_cell);
   c=(t_cc/N(i));
   cc=round(c);
   v=(t_ch-t_cc)/N(i);
   vc=round(v);
   disp('Control channel and voice channel are..');
   disp(cc);
   disp(vc);
end
```

Output:

Channel Bandwidth.. 50 Total available channel 660 Total control channel 20 Channel per cell 4 165 Control channel and voice channel are.. 5 160	Channel per cell 7 94 Control channel and voice channel are 3 91 Channel per cell 12 55 Control channel and voice channel are 2 53

Experiment No: 02

Name of the Experiment:

If a signal to interference ratio of 15 dB is required for satisfactory forward channel performance of a cellular system, what is the frequency reuse factor and cluster size that should be used for maximum capacity if the path loss exponent is (a) n= 4 , (b) n = 3? Assume that there are 6 co-channels cells in the first tier and all of them are at the same distance from the mobile. Use suitable approximations.

Solution:

a) n= 4

First, let us consider a 7-cell reuse pattern.

The co-channel reuse ratio D/R =√3N= 4.583.

The signal-to-noise interference ratio is given by S/I = (1/6)*(4.583) = 75.3 = 18.66 dB.

Since this is greater than the minimum required S/I, N = 7 can be used.

b) n = 3

First, let us consider a 7-cell reuse pattern.

The signal-to-interference ratio is given by

S/I = (l/6)* (4.583) = 16.04 = 12.05 dB.

Since this is less than the minimum required S/I, we need to use a larger N.

The next possible value of N is 12, (i = j = 2).

The corresponding co-channel ratio is D/R = 6.0

The signal-to-interference ratio is given by

$$S/I = (1/6)*6^3 = 36 = 15.56 \text{ dB}.$$

Since this is greater than the minimum required S/I, N = 12 can be used.

Source Code:

```
clc;
clear all;
close all;
R_SI=15;
io=6;
n=[4 3];
for a=1:2
    N=7;
    Q=sqrt(3*N);
    disp('n: ')
    n(a)
    disp('Frequency reuse factor: ')
    Q
    SI=10*(log10((1/io)*(Q^n(a))));
    disp('Signal to interference ratio: ')
    SI
    if(SI<R_SI)
        i=2; j=2;
        N= (i^2)+(i*j)+(j^2);
```

```
        Q=sqrt(3*N);
        disp('n: ')
        n(a)
        disp('Frequency reuse factor: ')
        Q
        SI1=10*(log10((1/io)*(Q^n(a))));
        disp('Signal to interference ratio: ')
        SI1
    end
end
```

Output:

```
N;
ans = 4

Frequency reuse factor:
Q =    4.5826

Signal to interference ratio:
SI =18.6629

n:
ans =  3

Frequency reuse factor:
Q =    4.5826

Signal to interference ratio:
SI =   12.0518
n:

ans =  3

Frequency reuse factor:
Q =    6

Signal to interference ratio:
SI1 =   15.5630
```

Experiment No: 03

Name of the Experiment:

How many users can be supported for 0.5% blocking probability for the following number of trunked channels in a blocked calls cleared system? (a) 1, (b) 5, (c) 10, (d) 20, (e) 100. Assume each user generates 0.1 Erlangs of traffic.

Solution:

From Table 1. we can find the total capacity in Erlangs for the 0.5% GOS for different numbers of channels. By using the relation A = UA_u, we can obtain the total number of users that can be supported in the system.

(a) Given C = 1 = 0.1, GOS = 0.005

From Table 1, we obtain A = 0005.

Therefore, total number of users, U = A/A_u = 0.005/0.1 = 0.05 users.

But, actually one user could be supported on one channel. So, U = 1.

(b) Given C = 5, A_u = 0.1, GOS = 0.005

From Table 1, we obtain A = 1.13.

Therefore, total number of users, U = A/A_u = 1.13/0.1 II users.

(c) Given C = 10, A_u = 0.1, GOS = 0.005

From Table 1, we obtain A = 3.96.

Therefore, total number of users, U = A/A_u = 3.96/0.1 ≈39 users.

(d) Given C = 20. A_u= 0.1, GOS = 0.005

From Table 1, we obtain A = 11.10.

Therefore, total number of users, U = A/A_u = 11.1/0.1 = 110 users.

(e)Given C = 100, = 0.1, GOS = 0.005

From Figure 2.6, we obtain A = 80.9.

Therefore, total number of users, U = A/AU = 80.9/0.1 = 809 users.

Table 1.Capacity of an Erlang B System

Number of Channels C	Capacity (Erlangs) for GOS = 0.01	= 0.005	= 0.002	= 0.001
2	0.153	0.105	0.065	0.046
4	0.869	0.701	0.535	0.439
5	1.36	1.13	0.900	0.762
10	4.46	3.96	3.43	3.09
20	12.0	11.1	10.1	9.41
24	15.3	14.2	13.0	12.2
40	29.0	27.3	25.7	24.5
70	56.1	53.7	51.0	49.2
100	84.1	80.9	77.4	75.2

Source Code:

```
clc;
clear all;
close all;
Gos=0.5/100;
Au=0.1;
A=[0.005 1.13 3.96 11.1 80.9];
c=[1 5 10 20 100];
disp('Blocking probability');
disp(Gos);
disp('Traffic intensity per user ');
disp(Au);
disp('Traffic intensity');
disp(A);
disp('Channel');
disp(c);
U=(A/Au);
u=round(U);
disp('Number of users');
disp(u);
```

Output:

```
Blocking probability
    0.0050

Traffic intensity per user
    0.1000

Traffic intensity
    0.0050    1.1300    3.9600   11.1000   80.9000

Channel
     1     5    10    20   100

Number of users
     0    11    40   111   809
```

Experiment No: 04

Name of the Experiment:

An urban area has a population of 2 million residents. Three competing trunked mobile networks (systems A, B, and C) provide cellular service in this area. System A has 394 cells with 19 channels each, system B has 98 cells with 57 channels each, and system C has 49 cells, each with 100 channels. Find the number of users that can be supported at 2% blocking if each user averages 2 calls per hour at an average call duration of 3 minutes. Assuming that all three trunked systems are operated at maximum capacity, compute the percentage market penetration of each cellular provider.

Solution:

System A

Given:

Probability of blocking = 2% = 0.02

Number of channels per cell used in the system, C = 19

Traffic intensity per user, A_u =λH = 2 x (3/60) = 0.1 Erlangs

For GOS = 0.02 and C = 19, from the Erlang B chart, the total carried traffic, A, is obtained as 12 Erlangs.

Therefore, the number of users that can be supported per cell is

U = A/A_u = 12/at = 120.

Since there are 394 cells, the total number of' subscribers that can be supported by System A is equal to 120 x 394 = 47280.

System B

Given:

Probability of blocking = 2% = 0.02

Number of channels per cell used in the system, C = 57

Traffic intensity per user, A_u = λH = 2 * (3/60) = 0.1 Erlangs

For GOS = 0.02 and C = 57, from the Erlang B chart, the total carried traffic, A, is obtained as 45 Erlangs.

Therefore, the number of users that can be supported per cell is

U = A/A_u= 45/0.1 = 450.

Since there are 98 cells, the total number of subscribers that can be supported by System B is equal to 450 x 98 = 441W.

System C

Given:

Probability of blocking = = 0.02

Number of channels per cell used in the system, C = 100

Traffic intensity per user, = λH = 2 * (3/60) = 0.1 Erlangs

For GOS = 0.02 and C = 100, from the Erlang B chart, the total carried traffic, A, is obtained as 88 Erlangs.

Therefore, the number of users that can be supported per cell is

U = A/A_u = 88/01 = 880.

Since there are 49 cells, the total number of subscribers that can be supported by System C is equal to 880 * 49 = 43,120

Therefore, total number of cellular subscribers that can be supported by these three systems are 47,280 + 44,100 + 43,120 = 134,500 users.

Since there are 2 million residents in the given urban area and the total number of cellular subscribers in System A is equal to 47,280, the percentage market penetration is equal to 47,280/2,000,000 = 2.36%

Similarly, market penetration of System B is equal to 44,100/2,000,000 = 2,205%
and the market penetration of System C is equal to 43,120/2,000,000 = 2356%
The market penetration of the three systems combined is equal to 134,500/2,000,000 = 6.725%

Source Code:

```
clc;
clear all;
close all;
blocking_p= 2/100;
lamda=2;
H=3/60;
Au=lamda*H;
disp('For system A')
channel_a=19;
cell_A=394;
A=12;
disp('Number of users in System A');
Ua=A/Au
disp('Total number of subscriber in system A');
subscriber_A=Ua*cell_A;
disp(subscriber_A);
percentage_market_penetration_for_A=(subscriber_A/2000000)*100

disp('For system B')
channel_b=57;
cell_B=98;
Ab=45;
disp('Number of users in System B');
Ub=Ab/Au
disp('Total number of subscriber in system B');
subscriber_B=Ub*cell_B;
disp(subscriber_B);
percentage_market_penetration_for_B=(subscriber_B/2000000)*100

disp('For system C')
channel_c=100;
cell_C=49;
Ac=88;
disp('Number of users in System C');
Uc=Ac/Au
disp('Total number of subscriber in system C');
subscriber_C=Uc*cell_C;
disp(subscriber_C);
percentage_market_penetration_for_C=(subscriber_C/2000000)*100
```

```
Total_number_of_subscriber= subscriber_A+subscriber_B+subscriber_C
Market_penetration_for_three_system=
(Total_number_of_subscriber/2000000)*100
```

Output:

```
For system A
Number of users in System A
Ua =   120
Total number of subscriber in system A
      47280
percentage_market_penetration_for_A =    2.3640

For system B
Number of users in System B
Ub = 450
Total number of subscriber in system B
      44100
percentage_market_penetration_for_B =    2.2050

For system C
Number of users in System C
Uc =   880

Total number of subscriber in system C        43120

percentage_market_penetration_for_C =    2.1560

Total_number_of_subscriber = 134500

 Market_penetration_for_three_system =    6.7250
```

Experiment No: 05

Name of the Experiment:

A certain city has an area of 1,300 square miles and is covered by a cellular system using a 7-cell reuse pattern. Each cell has a radius of 4 miles and the city is allocated 40 MHz of spectrum with a full duplex channel bandwidth of 60 kHz. Assume a GOS of 2% for an Erlang B system is specified. If the offered traffic per user is 0.03 Erlangs, compute (a) the number of cells in the service area, (b) the number of channels per cell, (c) traffic intensity of each cell, (d) the maximum carried traffic; (e) the total number of users that can be served for 2% GOS, (f') the number of mobiles per channel, and (g) the theoretical maximum number of users that could be served at one time by the system.

Solution:

(a) Given:
Total coverage area = 1300 miles
Cell radius = 4 miles
The area of a cell (hexagon) can be shown to be 2.5981R2, thus each cell covers
2.5981 × (4)2 = 41.57 sqkm.
Hence, the total number of cells are = 1300/41.57 = 31 cells.

(b) The total number of channels per cell (C)
= allocated spectrum I (channel width × frequency reuse factor)
= 40, 000,000/ (60,000 x 7) = 95 channels/cell

(c) Given:
C = 95, and GOS = 0.02
From the Erlang B chart, we have traffic intensity per cell A = 84 Erlangs/cell

(d) Maximum carried traffic = number of cells x traffic intensity per cell
= 31 x 84 = 2604 Erlangs.

(e) Given traffic per user = 0.03 Erlangs
Total number of users = Total traffic / traffic per user = 2604 / 0.02 = 86,800 users.
(1) Number of mobiles per channel = number of users/number of channels = 86,800 / 666 = 130 mobiles/channel.
(g) The theoretical maximum number of served mobiles is the number of available channels in the system (all channels occupied) = C × Nc = 95 × 31 = 2945 users, which is 3.4% of the customer base.

Source Code:

```
clc;
clear all;
close all;
area=1300;
```

```
radius=4;
each_cell_covers=floor(2.5981*radius^2);
disp('(a)');
number_of_cells=floor(area/each_cell_covers)
%b
allocated_spectrum=40000;
channel_width=60;
frequency_reuse_factor=7;
disp('(b)');
number_of_channel_per_cell=floor(allocated_spectrum/(channel_width*frequency_reuse_
factor))
%c
disp('(c)');
traffic_intensity_per_cell=84
%d
disp('(d)');
maximum_carried_traffic=number_of_cells*traffic_intensity_per_cell
%e
traffic_per_user=0.03;
disp('(e)');
total_number_of_user = maximum_carried_traffic/traffic_per_user
%f
number_of_channels=number_of_channel_per_cell*frequency_reuse_factor;
disp('(f)');
number_of_mobile_per_channel=floor( total_number_of_user/number_of_channels)
%g
disp('(g)');
theoritical_maximum_number_of_user_that_could_be_served=
number_of_cells*number_of_channel_per_cell
```

Output:

(a) Number of cells =31 (b) number of channel per cell = 95 (c) Traffic intensity per cel=84 (d) Maximum carried traffic =2604	(e) Total number of user =86800 (f) Number of mobile per channel =130 (g) Theoretical maximum number of user that could be served = 2945

Experiment No: 06

Name of the Experiment:

If a transmitter produces 50 watts of power, express the transmit power in units of (a) dBm, and (b) dBW. If 50 watts is applied to a unity gain antenna with a 900 MHz carrier frequency, find the received power in dBm at a free space distance of 100 m from the antenna, what is P (10 km)? Assume unity gain for the receiver antenna.

Solution:

Given:
Transmitter power, = 50 W
Carrier frequency, = 900 MHz
Using Equation

$$P_r(d)\ \text{dBm} = 10\log\left[\frac{P_r(d_0)}{0.001\ \text{W}}\right] + 20\log\left(\frac{d_0}{d}\right) \qquad d \geq d_0 \geq d_f$$

(a) Transmitter power,

P_t(dBm) = l0log[P_t (mW)/(1mW)].

= 10log[50*10^3]=47.0 dBm.

(b) Transmitter power,

P_t(dBW) = l0log[P_t (W)/(1W)].

= 10log[50] = 17.0 dBW.

The received power can be determined

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L} = \frac{50(1)(1)(1/3)^2}{(4\pi)^2(100)^2(1)} = 3.5 \times 10^{-6}\ \text{W} = 3.5 \times 10^{-3}\ \text{mW}$$

$$P_r(\text{dBm}) = 10\log P_r(\text{mW}) = 10\log\left(3.5 \times 10^{-3}\ \text{mW}\right) = -24.5\ \text{dBm}.$$

The received power at 10 km can be expressed in terms of dBm where d_0= 100 m and d = 10km

$$P_r(10\ \text{km}) = P_r(100) + 20\log\left[\frac{100}{10000}\right] = -24.5\ \text{dBm} - 40\ \text{dB}$$

$$= -64.5\ \text{dBm}.$$

Source Code:

```
clc;
clear all;
close all;
%pt=Transmitted power, fc=carrier frequency in MHz
pt=50;
```

```
fc=900;
gt=1;
gr=1;
d=100;
do=10*10^3;
disp('(a)')
Transmitted_power_in_dBm= ceil(10*log10(50*10^3))
disp('(b)')
Transmitted_power_in_dbW= ceil(10*log10(50))
lamda=(3*10^8)/(900*10^6);
pr_mw=((pt*gt*gr*(lamda^2))/(((4*3.1416)^2)*(d^2)*1))*1000;
received_power_in_dbm = 10*log10(pr_mw)
pr_10km = received_power_in_dbm+(20*log10(d/do))
```

Output:

```
(a)Transmitted_power_in_dBm =  47

(b)Transmitted_power_in_dbW = 17

received_power_in_dbm =-24.5369

pr_10km =-64.5369
```

Experiment No: 07
Name of the Experiment:

Determine the path loss of a 900MHz cellular system in a large city from a base station with the height of 100m and mobile station installed in a vehicle with antenna height of 2m. The distance between mobile and base station is 4Km.

Solution:

Given,

h_re=2m

h_te=100m

f_c=900 MHz

d = 4 km

We calculate the terms in the Okumara-Hata modes as,

a(h_re) = 3.2 〖[log(11.75h_re)] 〗^2– 4.97

= 1.045 dB

L_p=69.55+26.16logf_c-13.82logh_te-a(h_re)+[44.9-6.55logh_te]logd

= 137.3 dB

Source Code:

```
clc;
clear all;
close all;
hre=2;
hte=100;
fc=900;
d=4;
a_hre=3.2*(log10(11.75*hre))^2-4.97
Lp=69.55+26.16*log10(fc)-13.82*log10(hte)-a_hre+(44.9-6.55*log10(hte))*log10(d);
disp('Loss path');
disp(Lp);
```

Output:

```
a_hre =1.0454

Loss path  137.2930
```

Experiment No: 08

Name of the Experiment:

Determine the path loss between base station (BS) and mobile station (MS) of a 1.8GHz PCS system operating in a high-rise urban area. The MS is located in a perpendicular street to the location of the BS. The distances of the BS and MS to the corner of the street are 20 and 30 meters, respectively. The base station height is 20m.

Solution:

Given,

$f_c=1.8$ GHz

$h_b=20$m

The distance of the mobile from the base station is, $d = \sqrt{20^2 + 30^2} = 36.05$m.

Using the appropriate equation, we can write the path loss as:

$$L_p=135.41+12.49\log f_c-4.99\log h_b+[46.84-2.34\log h_b]\log d$$
$$= 68.89 \text{ dB}$$

Source Code:

```
clc;
clear all;
close all;
fc = 1.8;
hb = 20;
%d = distance of mobile from the basee station
d = ((20^2+30^2)^0.5)/1000;
path_loss = 135.41+(12.49*log10(fc))-(4.99*log10(hb))+((46.84-
2.34*log10(hb))*log10(d))
```

Output:

```
path_loss = 68.9079
```

Experiment No: 09

Name of the Experiment:

A mobile is located 5 km away from a base station and uses a vertical λ /4 monopole antenna with a gain of 2.55 dB to receive cellular 3 radio signals. The E-field at 1 km from the transmitter is measured to be V/rn. The carrier frequency used for this system is 900 MHz.

(a) Find the length and the gain of the receiving antenna.

(b) Find the received power at the mobile using the 2-ray ground reflection model assuming the height of the transmitting antenna is 50 m and the receiving antenna is 1.5m above ground.

Solution:

Given:

T-R separation distance = 5 km

E-field at a distance of 1 km = I VIm

Frequency of operation, f = 900 MH

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{900\times10^6} = 0.333 \text{ m}$$

Length of the antenna, L = λ /4 = 0.333/4 = 0.0833 m = 8.33

Gain of λ /4 monopole antenna can be obtained

Gain of antenna =1.8 = 2.55

(b) Since d >>$\sqrt{h_t h_r}$, the electric field is given by

$$E_R(d) \approx \frac{2E_0 d_0}{d}\frac{2\pi h_t h_r}{\lambda d} \approx \frac{k}{d^2} \text{ V/m}$$

$$= \frac{2\times10^{-3}\times1\times10^3}{5\times10^3}\left[\frac{2\pi(50)(1.5)}{0.333\left(5\times10^3\right)}\right]$$

$$= 113.1\times10^{-6} \text{ V/m.}$$

The received power at a distanced can be obtained

$$P_r(d) = \frac{\left(113.1\times10^{-6}\right)^2}{377}\left[\frac{1.8\,(0.333)^2}{4\pi}\right]$$

$$P_r(d = 5\text{ km}) = 5.4\times10^{-13}\text{ W} = -122.68\text{ dBW or } -92.68\text{ dBm.}$$

Source Code:

```
clc;
clear all;
close all;
T_R_field = 5;
E_field = 10^(-3);
f = 900;
do=1000;
lamda=(3*10^8)/(900*10^6);
disp('(a)')
length_of_antenna = lamda/4
gain = (10^(2.55/10))
disp('(b)')
ht=50;
hr=1.5;
d=5*10^3;
Er_d = (2*E_field*do*2*3.1416*ht*hr)/(lamda*d^2)
Ae=(gain*lamda^2)/(4*3.1416);
pr_d=((Er_d^2)/(120*3.1416))*Ae
received_power_at_5km_distance = 10*log10(pr_d)
```

Output:

```
(a)length_of_antenna =0.0833


 gain = 1.7989

(b)Er_d =1.1310e-04


pr_d = 5.3966e-13


received_power_at_5km_distance = -122.6788
```

Experiment No: 10

Name of the Experiment:

A hexagonal cell within a 4-cell system has a radius of 1.387 km. A total of 60 channels are used within the entire system. If the load per user is 0.029 Erlangs, and λ= call/hour, compute the following for an Erlang C system that has a 5% probability of a delayed call:

(a) How many users per square kilometer will this system support?

(b) What is the probability that a delayed call will have to wait for more than 10s?

(c) What is the probability that a call will be delayed for more than 10 seconds?

Solution:

Given,

Cell radius, R = 1.387 km

Area covered per cell is 2.598 x (I 3g7)2 = 5 sq kin

Number of cells per cluster = 4

Total number of channels = 60

Therefore, number of channels per cell = 60 / 4 = 15 channels.

(a) From Erlang C chart, for 5% probability of delay with C = IS, traffic intensity = 9.0 Erlangs.

Therefore, number of users = total traffic intensity I traffic per user

=9.0/0.029 = 310 users = 310 users/S sq km = 62 users/sq km

(b) Given λ = 1 holding time

H = As/A = 0.029 hour = 104.4 seconds.

The probability that a delayed call will have to wait for more than 10 s is

Pr[delay = exp(.—(C.-A)t/H) = exp(—(I5—9.0)I0/l04.4) = 56.29 %

(c) Given Fr1delay >0] = 5% = 0.05

Probability that a call is delayed more than 10 seconds,

Pr{delay> tO] =

= 0.05 x 0.5629 = 2.81%

Source Code:

```
clc;
clear all;
close all;
%R=cell radius, N=total no of channel, n=number of cell per cluster
R=1.387;
n=4;
N=60;
%A=Area covered per cell
A=2.598*R^2;
%c=number of channel per cell
c=N/4;
disp('(a)');
traffic_intensity=9;
load_per_user=0.029;
number_of_users = floor((traffic_intensity/load_per_user)/A)
%b
disp('(b)');
lamda=1;
t=10;
H=(load_per_user/lamda)*3600;
the_probability_to_wait=exp(-(c-traffic_intensity)*t/H)*100
%c
disp('(c)');
p=5/100;
probability_of_delay_more_than_10sec = p*the_probability_to_wait
```

Output:

```
(a) number_of_users = 62


(b)the_probability_to_wait =56.2867


(c)probability_of_delay_more_than_10sec =2.8143
```