Pabna University of Science And Technology

Faculty of Engineering & Technology

Department of Information and Communication Engineering

PRACTICAL LAB REPORT

Course Code: *ICE- 4202.*

Course Title: Wireless Communication Sessional.

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1. A spectrum of 30 MHz is allocated to a wireless FDD cellular 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.

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

3. 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.

4. An urban area has a population of two 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 two calls per hour at an average call duration of three minutes. Assuming that all three trunked systems are operated at maximum capacity, compute the percentage market penetration of each cellular provider.

5. Find the Fraunhofer distance for an antenna with maximum dimension of 1 m and operating frequency of 900 MHz if antennas have unity gain, calculate the path loss.

6. In the U.S digital cellular system if Fc = 900 MHz and the mobile velocity is 70 km/hr., calculate the received carrier frequency if the mobile
   a) directly toward the transmitter,
   b) directly away from the transmitter,
   c) in a direction perpendicular to the direction of the arrival of the transmitted signal.

7. An urban RF radio channels are modelled on SIRCIM and SMRCIM statistical channel models with excess delays as large as 150μs and microcellular channels with excess delays no larger than 4μs. If the multiple path bin is selected at 70, calculate (a) ΔT and (b) the maximum bandwidth which two models can accurately represent. And (c) if the indoor

channel model with excess delays as large as 500 ns exists, calculate the values of (a) and (b).

8. A zero mean sinusoidal message is applied to a transmitter that radiates an AM signal with 400KW power. Compute the carrier power if the signal is modulated on a depth of 0.75.
   a) What percentage of the total power is in the carrier?
   b) Calculate the power in each sideband?
   c) What will be the total power saving if the carrier and one of the sidebands are now suppressed?

9. A sinusoidal modulating signal, m (t) = 8cos (2pi4*103 t +10) is applied to a modulator that has a frequency deviation constant gain of 10 kHz/V. Compute-
   a) The peak frequency deviation.
   b) The modulation index.
   c) The phase modulation index.

10. If GSM uses a frame structure where each frame consists of eight time slots, and each time slot contains 156.25 bits, and data is transmitted at 270.833 kbps in the channel, find
    a) The time duration of a bit,
    b) The time duration of a slot,
    c) The time duration of a frame, and
    d) How long must a user occupying a single time slot wait between two successive transmissions.

1. A normal GSM has 3 start bits, 3 stop bits, 26 training bits for allowing adaptive equalization, 8.25 guard bits, and 2 bursts of 58 bits of encrypted data which is transmitted at 270.833 kbps in the channel. Find
   a) Number of overhead bits per frame, b_{oh};
   b) Total number of bits/frame;
   c) Frame rate;
   d) Time duration of a slot;
   e) Frame efficiency.

Problem 01: A spectrum of 30 MHz is allocated to a wireless FDD cellular 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) Four cell reuse (b) Seven cell reuse and (c) 12-cell reuse.

If 1 MHz of the allocated spectrum is dedicated to control channel determine the equitable distribution of control channels and voice channels in each cell of each of the three systems.

Solution:

Have given, Total bandwidth $= 30$ MHz
$= 30{,}000$ KHz

Channel bandwidth $= 25$ KHz $\times 2$ simple channels
$= 50$ KHz / duplex channel

Total available channels $=$ Total Bandwidth / Channel BW

$$= \frac{30000}{50} = 600 \text{ channels.}$$

If 1 MHz of the allocated spectrum is dedicated to control channels,

i.e. Control channel bandwidth $= 1000$ KHz

The number of available control channel $= 1000/50$
$= 20$ channels

(a) Have given, cluster size, $N = 4$

Total number of channels available per cell $= \dfrac{\text{Total available Channel}}{N}$
$= 600/4$
$= 150$ channels

∴ Equitable distribution of,

Voice channel = $\dfrac{\text{(Total available channels - The number of available Control Channel)}}{N}$

$= \dfrac{600-20}{4} = 145$ channels

Control channel = (Total number of channels available per cell − voice channel)

$= 150 - 145 = 5$ channels

(b) Have given, cluster size, $N = 7$

Total number of channels available per cell = $\dfrac{600}{7} = 85$ channels

∴ Equitable distribution of,

Voice channel = $(600-20)/7$

$= 82$ channels

Control channel = $(85-82) = 3$ channels

(c) Have given cluster size, $N = 12$

Total number of channels available per cell = $600/12$

$= 50$ channels

∴ Equitable distribution of,

Voice channel $= (600-20)/12$

≈ 49 channel

Control channel $= 50 - 49$

$= 1$ channel.

Problem 02: For given path loss exponent (a) n=4 and (b) n=3 find the frequency reuse factor and the cluster size that should be used for maximum capacity. The signal to interference ratio of 15 dB is minimum required for satisfactory forward channel performance of a cellular system. There are six co-channel cells in the first tier, and all of them are at the same distance from the mobile. Use suitable approximations.

Solution:

Have given,

Minimum Required Signal-to-Noise interference ratio, $S/I = 15\,dB$

The number of Co-channel interfering cells, $i_0 = 6$

We know,

Number of cell reuse, $N = i^2 + i*j + j^2$ ———— (i)

First, let us consider a 7-cell reuse pattern, $N = 7$ For $i=1, j=2$

Also, The Frequency Reuse Factor, $Q = \sqrt{3N}$ ———— (ii)

$= 4.583$

(a)

Have given,

Path Loss exponent, $n = 4$

Frequency Reuse Factor, $Q = 4.583$

We know, Signal-to-Noise Interference ratio, $S/R = 10 \log\left(\frac{Q^n}{i_0}\right)$ —(iii)

$= 10 \log\left((4.583)^4/6\right)$

$= 18.66\,dB$

Since this is greater than the minimum required S/I (18.66>15), N=7 can be used.

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(b)

Have given,

Path Loss exponent, $n = 3$

We know,

Signal-to-Noise interference ratio, $S/R = 10 \log ((4.583)^3/6)$

$= 12.05$ dB

Since, this is less than the minimum required S/I ($12.05 < 15$).
We need to use a larger N.

Using equation (i) the next possible value is $N=12$; For $i=j=2$

The corresponding co-channel ratio is given by equation (ii) as-

Frequency reuse Factor, $Q = 6$

Using equation (iii) the Signal-to-interference ratio, $S/I = 15.56$ dB

Since, this is greater than the minimum required S/I ($15.56 > 15$)

$\therefore$ $N = 12$ can be used.

Problem-3: 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:

Have given, Blocking Probability, $P_B = 0.5\%$

Traffic Intensity, $A_u = 0.1$ Erlangs

We know,

For Erlangs B, Grade of service, $GOS = P_B = 0.005$

And, Total number of user, $U = A/A_u$ —— (1)

Where, A = offered Traffic Intensity

Also,

Table-3.1: Capacity of an Erlang B system.

Number of Channels c	Capacity (Erlangs) for GOS
1	0.005
5	1.13
10	3.96
20	11.10
100	80.90

(a) Have given,

Trunked Channels $C = 1$

From table 3.1, For $C=1$, we obtain, $A = 0.005$

From equation (i), we have, Total number of user, $U = \frac{A}{A_u}$

$= 0.05$ users

But actully one user could be supported on one channel, so, $U=1$

(b) Have given,

Trunked channels, $C=5$

From table 3.1, For $C=5$, we obtain, $A=1.13$ Erlang

From equation (i) we have, Total number of users, $U \approx 11$ users

(c) Have given, $C = 5$

From table 3.1, we obtain $A = 3.96$ Erlang

From equation (i) We have- Total number of user, $U = 39$ users

(d) Have given, $C = 20$

From table 3.1, we obtain $A = 11.10$ Erlang

From equation (i) we have, Total number of user, $U \approx 110$ users.

(e) Have given,

Trunked channels, $C=100$

From table 3.1. For $C=100$, we obtain, $A = 80.9$ Erlang

From equation (i) we have

Total number of user, $U = A/A_u$

≈ 809 users.

Experiment 04: An urban area has a population of two million residents. Three competing trunked mobile networks provide cellular services in this area. System A has 394 cells with 19 channels each. System B has 98 cells with 57 channel 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 two calls per hour at an average call duration of three minutes.
Assuming that all three trunked systems are operated at maximum capacity, compute the percentage market penetration of each cellular provider.

Solution:

For system A.

Given, Propability of blocking $= 2\% = 0.02$

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

Traffic intensity per user, $A_u = \lambda H$
$= 2 \times (3/60) = 0.1$ 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

$$U = A/A_u$$
$$= 12/0.1 = 120$$

Since, there are 394 cells, the total number of subscribers that can be supported by system A is equal to 120×394
$= 47280$

For System B;

Given, Probability of blocking $= 2\% = 0.02$
Number of channel per cell used in the system, $C = 57$

Traffic intensity per user, $A_u = \lambda H$

$= 2 \times (3/60) = 0.1$ 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 subscriber that can be supported by system B is equal to $450 \times 98 = 44{,}100$

For System C:

Given, probability of blocking $= 2\% = 0.02$

Number of channel per cell used in the system, $c = 100$

Traffic intensity per user, $A_u = \lambda H = 2 \times (3/60) = 0.1$ Erlang

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 $U = A/A_u = 88/0.1 = 880$

Since, there are 49 cells, the total number of subscriber that can be supported by system C is equal to $880 \times 49 = 43{,}120$

Therefore, the total number of cellular subscriber in System A is equal to 47280 the percentage market penetration is equal to $47280/2000{,}000 = 2.36\%$.

Similarly, market penetration of system B is equal to,

$44100/2000000 = 2.205\%$

and the market penetration of system C is equal to

$43120/2000000 = 2.156\%$

The market penetration of the three system combined is equal to $134500/2000000 = 6.725\%$

Experiment 05: Find the Fraunhofer distance for an antenna with maximum distance of 1 m and operating frequency of 900 MHz. If antennas have unity gain, Calculate the path loss.

Solution:

$$\text{operating frequency}, f = 900 \text{ MHz}$$

$$\text{wavelength}, \lambda = c/f = \frac{3 \times 10^8}{900 \times 10^6}$$

$$= 0.33 \text{ m}$$

$$\text{Fraunhofer distance}, d_f = 2D^2/\lambda$$

$$= \frac{2 \times (1)^2}{0.33}$$

$$= 6 \text{m}$$

$$\text{path loss } P_L (dB) = -10 \log \left[\frac{\lambda^2}{(4\pi)^2 d^2} \right]$$

$$= -10 \log \left[(0.33)^2 / (4 \times 3.14)^2 \times 36 \right]$$

$$= 47 \text{ dB}$$

Problem 06: In the US digital cellular system, if $f_c = 900$ MHz and the mobile velocity is 70 km/hr, calculate the received carrier frequency if the mobile (a) directly toward the transmitter (b) Directly away from the transmitter (c) in a direction perpendicular to the direction of the arrival of the transmitted signal.

Solution:

Given, carrier frequency, $f_c = 900$ MHz

Therefore wavelength, $\lambda = c/f_c = \frac{3 \times 10^8}{900 \times 10^6} = 1/3 = 0.33m$

Vehicle Speed, $v = 70 \times 1000/(60 \times 60) = 19.44$ m/s

(a) The vehicle is moving directly toward the transmitter

The received frequency is, $f = f_c + f_d$

$$= 9 \times 10^6 + \frac{19.44}{0.33} = 900.0000589 \text{MHz}$$

(b) The vehicle is moving directly away from the transmitter

The received frequency is given by $f = f_c - f_d$

$$= 900 \times 10^6 - \frac{19.44}{0.33} = 899.999 \text{MHz}$$

(c) The vehicle is moving perpendicular to the angle of arrival of the transmitted signal.

In this case $\theta = 90°$, $\cos\theta = 0$ and there is no Doppler shift.

The received signal frequency is the same as the transmitted frequency of 900 MHz.

Problem-07: An Urban RF radio channels are modelled on SIRCIM and SMRCIM statistical channel models with excess delays as long as 150 μs and microcellular channel with excess delays no longer than 4 μs. If the multiple path bin is selected at 70.

Calculate, (a) ΔT (b) The maximum bandwidth which two models can accurately represent and (c) if the indoor channel model with excess delays as long as 500 ns exists, Calculate the values of (a) and (b)

Solution:

The maximum excess delay of the channel model is given by

$$\tau_N = N \Delta T$$

(a) Given,

for $\tau_N = 150\ \mu s$, and $N = 70$;

$$\Delta T = \tau_N / N = 2.14\ \mu s$$

(b) The maximum bandwidth that the SMRCIM model can accurately represent is equal to $2/\Delta T = 2/2.14\ \mu s = 0.933$ MHz

For the SMRCIM urban microcell model, $\tau_N = 4\ \mu s$, $\Delta T = \tau_N / N$
$= 57.1 ns$

The maximum RF bandwidth that can be represented is

$$2/\Delta T = (2/57.1) ns = 35\ MHz$$

(c) Similarly, for indoor channel, $\Delta T = \frac{500 \times 10^{-9}}{70} = 7.14\ ns$

The maximum RF bandwidth for the indoor channel model is

$$2/\Delta T = (2/7.14) ns = 280\ MHz.$$

Problem - 08: A zero mean sinosoidal message is applied to a transmitter that radiates an AM signal with 400 KW power. compute the carrier power if the signal is modulated on a depth of 0.75.

a) What percentage of the total power is in the carrier?

b) Calculate the power in each sidebond?

c) What will be the total power solving, if the carrier and one of the sidebonds are now suppressed?

Solution:

Using equation. $P_{AM} = \frac{1}{2} A_c^2 [1 + P_m] = P_c [1 + \frac{k^2}{2}]$

where,

$P_c = A_c^2/2$ is the power in the carrier singnal.

$P_m = (m^2(t))$ is the power in the modulating signal.

$m(t)$ and k is the modulation index.

$$\therefore P_c = \frac{P_{AM}}{1 + k^2/2} = \frac{400}{1 + 0.75^2/2} = 312.5 \text{ KW}$$

a) Total power in the carrier is, $\frac{P_c}{P_{AM}} \times 100 = 78.125\%$

b) Power in each sidebond, $\frac{1}{2}(P_{AM} - P_c) = 0.5 \times (400 - 312.5)$

$= 87.5$ KW.

c) Percentage power saving if one of the sidebond and carrier is suppressed $= [1 - (\frac{87.5}{400})] \times 100\%$

$= 78.125\%$

Problem 09: A sinosoidal modulating signal $m(t) = 8\cos(2\pi 4\times10^3 t + 10)$ is applied to a modulator that has a frequency deviation constant gain of 10 kHz/V. Compute -

a) The peak frequency deviation

b) The modulating index.

c) The phase modulating index.

Solution:

(a) For the given $m(t)$, maximum value is 8V.

Hence, the peak deviation, $\Delta f = 8\,V \times 10\,kHz/V$

$= 80\,kHz$

(b) Frequency modulation index, $\beta_f = \frac{\Delta f}{f_m} = \frac{80}{4}$

$= 20$ ~~kHz~~

(c) Phase modulation index, $\beta_p = k_\theta A_m$

$= 10$ radians/V $\times 8\,V$

$= 80$ radians.

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Problem-10: If GSM uses a frame structure where each frame consists of eight time slots, and each time slot contains 156.25 bit and data is transmitted at 270.833 kbps in the channel, find-

a) The time duration of a bit.

b) The time duration of a slot.

c) The time duration of a frame.

d) How long must a user occupying a single time slot wait between two successive transmissions.

Solution:

a) The time duration of a bit, $T_b = \frac{1}{270.833} = 3.692\ \mu s$.

b) The time duration of a slot, $T_{slot} = 156.25 \times T_b = 0.577$ m

c) The time duration of a frame, $T_f = 8 \times T_{slot} = 4.615$ ms

d) A user has to wait 4.615 ms, the arrival time of a new frame, for its next transmission.

Problem -11: A normal GSM has 3 start bits, 3 stop bits 26 training bits for allowing adaptive equalization, 8.25 guard of bits and 2 bursts of 58 bits of encrypted data which is transmitted at 270.833 kbps in channel. Find-

a) Number of overhead bits per frame, b_{on}

b) Total number of bits/frame

c) Frame rate.

d) Time duration of a slot.

e) Frame efficiency.

Solution:

A time slot has $6+8.25+26+2(58) = 156.25$ bits.

a) Number of overhead bits $b_{on} = 8(6)+8(8.25)+8(26) = 322$ b

b) Number of bit/frame $= 8 \times 156.25$
$= 1250$ bit/frame

c) Frame rate: 270.833 kbps / 1250 bits / frame $= 216.66$ fr

d) Time duration of a slot $= 156.25 \times 1/270.833$
$= 576.92\ \mu s$

e) Frame efficiency, $\eta = [1 - (322/1250)]$
$= 74.24\%$

IMT

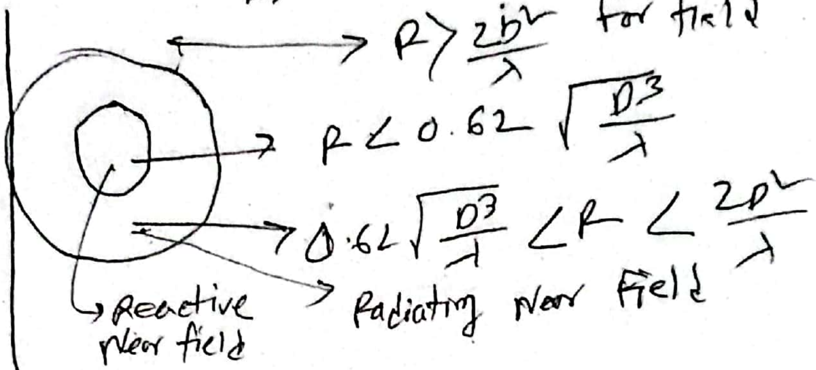
① FDD → provide simultaneous radio transmission channel for the subscriber and the base station.

(ii) pathloss → T−R electromagnetic → গড় of signal power level Transmitter power level এর কিছুটা হ্রাস

3) Trunked channels refer to system where multiple users share a common pool of channels that are dynamically allocated.
→ maximize channel efficiency.

5. Fraunhofer distance → Far field region $R > \frac{2D^2}{\lambda}$; $R \gg D, R \gg \lambda$

Co-channel interference: when two or more transmitters operating on the same frequency channel interfere with each other



7) SIRCIM → Simulation of Indoor Radio Channel Impulse-response model)
is a tool, to simulate and analyze the behavior of radio signals in indoor environment.

SMRCIM → Simulation of mobile radio channel Impulse-response model is a tool model, to simulate the radio channel characteristic.

8) SideBand: band of frequency higher than or lower than the f_c.

9) Peak frequency: at which the amplitude of a signal maximum value.
→ modulation index: carrier signal কতটা modulation হয় পরিমাপ.
Frequency modulation index; $\beta_f = \frac{\Delta f}{f_m}$
phase " " $\beta_p = k_\theta A_m$

10) GSM → Global system for mobile communication (2G)
→ used TDMA Technology
Successive transmission → occur one after another.

11) Adaptive equalization → to the effects of signal distortion কে মোকাবেলা করে