Experiment 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 ~~the~~ channel determine the equitable distribution of control channels and voice channels in each cell of each of the three systems.

⇒ Solution:

Given total bandwidth = 30 MHz

channel Bandwidth = 25 KHz × 2 = 50 KHz / duplex channels

Total available channels = 30000/50 = 600 channels

(a) for N=4,

total number of channels available per cell = 600/4 = 150 channel

(b) for N=7,

total number of channels available per cell = 600/7 = 85 channels

(c) For N=12,

total number of channels available per cell = 600/12 = 50 channels

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A 1 MHz spectrum for control channels implies that there are 1000/50 = 20 control channels out of the 600 channels available.

(a) for N=4, we can have 5 control channels and 145 voice channels per cell.

(b) Total number of voice channels for N=7,
(600-20)/7 = 82 voice channels are to be assigned to each cell approximately, 4 cells with 3 control channels and 82 voice channels and 3 cell with 2 control channels and 82 voice channels are to be assigned along with voice channels.

(c) For N=12, we can have eight cells with two control channels and 48 voice channels, and four cells with one control channels and 49 voice channels

Matlab code:

```
clc
clear all;
close all;
BW = 30000; % Total Bandwidth
CBW = (25X2); % channel Bandwidth
TAC = BW/CBW % total available channel
AS = 10000; % Allocated spectrum
ACCh = AS/CBW; % Available control channel
% for N=4
```

```
N=4;
ch = TAC/N ; %total number of channal available per
                cell.
vch =(TAC -ACCh);/N; % voice channel per cell
cch = ch-vch; % control channel per cell.
fprintf('(a) for N=4\n');
fprintf('Total number of channel available per
     cell = %d \n',ch);
fprind('voice channel per cell =%d\n',vch);
fprintf('control channel per cell =%d\n',ch);

% (b) for N=7
N=7;
ch = floor(TAC/N);
vch = floor((TAC-ACCh)/N);
cch = ch- vch;
fprintf('(b) for N=7\n');
fprintf('total number of channel available per cell
               =%d\n',ch);
fprintf('voice channel per cell =%d\n',vch);
fprintf('control channel percell =%d\n', cch);

%(c) for N=12.
N = 12%
ch = floor (TAC /N);
```

Experiment 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 ~~sa~~ 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 approximation.

⇒ Solution:

(a) $n=4$,

First, let us consider a seven-cell reuse pattern. Frequency reuse factor

Using equation $Q = \frac{D}{R} = \sqrt{3N}$

$= \sqrt{21} = 4.583$

Using equation, $\frac{S}{I} = \frac{(D/R)^4}{i_0} = \frac{(\sqrt{3N})^n}{i_0} = \frac{1}{6} \times (4.583)^4$

$= 75.3 = 18.66 \text{ dB}$

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

(b) $n=3$, first, let us consider a 7-cell reuse pattern

Using equation $\frac{S}{I} = \frac{(D/R)^n}{i_0} = \frac{(\sqrt{3N})^n}{i_0}$, the signal to interference ratio is given by $S/I = \frac{1}{6} \times (4.583)^3$

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$= 16.04 - 12.05$ dB

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

Using equation $N = i^2 + ij + j^2$, the next possible values of N is 12 (where $i = j = 2$)

The corresponding co-channel ratio is given by

$\frac{D}{R} = Q = \sqrt{3N}$ as $D/R = 6.0$

the signal to interference ratio is given by,

$$S/I = \frac{1}{6} \times (6)^3 = 36 = 16.56 \text{ dB}$$

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

Matlab code:

```
clc;
clear all;
close all;
min_SNIdB = 15; % minimum signal to interference
%(a) n=4
n=4;
fprintf('(a) n=4\n');
N=7;
[SNIdB,N] = SNratioFunction(N,n,min_SNIdB);
```

Experiment 3. How many users can be supported for 0.5% blocking probability for the following number of trunked channel 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 the capacity of an erlang B system table we can find the total capacity in Erlangs for 0.5% GOS for different numbers of channels. By using the relation $A = UA_u$, we can obtain the total number of user that can be supported in the system.

(a) given, $C = 1$, $A_u = 0.1$, $GOS = 0.005$

from figure, we obtain $A = 0.005$

therefore total number of users, $U = A/A_u = 0.005/0.1 = 0.05$

But actually one user can be supported, so $U = 1$

(b) Given, $c = 5$, $A_u = 0.1$ $GOS = 0.005$

from figure, we obtain $A = 1.13$

therefore total number of users, $A = A/A_u$

$= 1.13/0.1 = 11$ users

(c) Given, $c = 10$, $A_u = 0.1$ and $GOS = 0.005$

from figure 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 figure, $A = 11.10$
total number of users, $u = A/A_u = 11.1/0.1 = 110$

(e) Given, $c = 100$, $A_u = 0.1$, $GOS = 0.005$
from figure, we obtain, $A = 80.9$
total users $u = A/A_u = 80.9/0.1 = 809$ users

Source code for the Experiment:

```
clc; close all; clear all;
Au = 0.1; GOS = 0.005;
fprintf('(a)\n');
c = 1 ; A = 0.005; U = ceil(A/Au);
fprintf('(b)\n');
c = 5, A = 1.13 ; U = floor (A/Au);
fprintf('(c)\n');
c = 10; Aa = 3.96 ; U = floor (A/Au);
printf ('(d)\n');
c = 20; A = 11.10;
U = floor(A/Au);
fprintf('(e)\n');
c = 100;
```

Experiment 04: An urban area has a population of two million residents. Three competing trunked mobile networks provide cellular service in this area. System A has 394 cells with 19 channel 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:

System A: Given, Blocking probability $= 2\% = 0.02$

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

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

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

Therefore total number of users that can be supported per cell is $U = A/A_u = 12/0.1 = 120$

Since there are 394 cells, total number of subscribers that can be supported by system A $= 120 \times 394$

$= 47280$

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System B:

Given, blocking probability = 2% = 0.02

Number of channel per cell used in the system = 57

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

$= 0.1$ Erlangs

for GOS = 0.02, C = 57, A is equal = 45

Therefore, number of users that can be supported per cell is, $U = A / A_u = 45/0.1 = 450$

Since there are 98 cells, total number of subscriber that can be supported by system $= 450 \times 98 = 44,100$

System C:

Given, blocking probability = 2% = 0.02

Number of channel per cell used in system C = 100

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

For GOS = 0.02 and C = 100, A will be 88 Erlangs

Therefore, total number of user that can be supported per cell by the system $= 880 \times 49 = 43120$

Total number of cellular subscribers $= 47280 + 44100 + 43120$

$= 134500$ users

Market penetration for system A $= 47280/2000000$

$= 2.36\%$

similarly, for system B $= 44100/2000000 = 2.205\%$

for system C $= 43120/2000000 = 2.156\%$

Market penetration of three systems combined is equal to = 134500/2000000 = 6.725%

Source code;

```
clc; close all; clear all;
BP= (2/100);
lambda= 2; H= (3/60);
Au = lambda * H;
TR= 2000000;
fprintf('(a)\n');
c=19;   cell = 394;  GOS= BP;
A= 12;  U= A/Au;
printf('\n The number of user that can be supported
per cell is U=%d; U);
S1 = U* cell;
fprintf('\n Number of subscriber supported by system
    A = %d \n',S1);

fprintf('\n (b)\n');
c=57;  cell =98;  GOS= BP;
A= 45;
fprintf('\n The number of user that can be supported
per cell is u=%d', U);
S2 = U* cell;
```

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

Solution: Operating frequency $f = 900$ MHz

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{900\times10^6} = 0.33\,m$$

Fraunhofer distance, $d_f = \frac{2D^2}{\lambda} = \frac{2\times1^2}{0.33} = 6m$

Path loss, $P_L(dB) = -10\log\left[\lambda^2/(4\pi)^2 d^2\right]$

$$= -10\log\left[(0.33)^2/(4\times3.1416)^2\times36\right]$$

$$= 47\,dB$$

Source code:

```
clc; clear all; close all;
c = 3 * 10^8;
f = 900 * 10^6; D = 1;
lemda = c/f;
df = 2* (D^2) / lemda;
Pλ = -10 * log((Lemda^2)/(((4*pi)^2)*(df^2)));
fprintf('Path loss PL (dB) = %f \n', Pλ);
```

Input and Output:

Path loss $P_L(dB) = 47.0896$.

Experiment 6 : In the US Digital cellular system if $f_c = 900$ MHz and mobile velocity is 70 km/hr. Calculate the received carrier frequency if the mobile (a) directly toward the transmitter (b) directly away from transmitter (c) in a direction perpendicular to the direction of the arrival of the transmitted signal.

Solution : Carrier frequency, $f_c = 900$ MHz

wavelength, $\lambda = \frac{c}{\lambda_c} = \frac{3\times10^8}{900\times10^6} = 0.33$ m

vehicle speed, $v = (70 \times 1000)/(60\times60) = 19.44$ m/s

(a) The vehicle is moving directly toward the transmitter the received frequency is,

$$f = f_c + f_d = 900\times10^6 + \frac{19.44}{0.33} = 900.0000589 \text{ MHz}$$

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

$$f = f_c - f_d = 900\times10^6 - \frac{19.44}{0.33} = 899.9999411 \text{ MHz}$$

(c) The vehicle is moving perpendicular to the angle of arrival of the transmitted signal. In this case, the ~~requi-~~ ~~received~~ $\theta = 90°$, $\cos\theta = 0$, there is no Doppler shift. The ~~The~~ received signal frequency is the same as the transmitted frequency of 900 MHz.

Source Code :

```
clc ; clear all ; close all ;
carrier frequency =900 *10^6 ;
wavelength =(3*10^8)/(900 *10^ 6) ;
vehicle speed = 70 * ( 1000/ (60*60));
```

Experiment 7: An urban RF radio channels are modelled on SIRCIM and SMRCIM statistical channel models with excess delays as large as 150 μs and microcellular channel with excess delays no longer than 4 μs. If the multiple path bin is selected 70. calculate (a) $\Delta\tau$, (b) the maximum band width which two model can accurately represent and (c) if the indoor channel model with excess delays as large as 500 ms exists, calculate the values of (a) and (b).

Solution:

The maximum excess delays of the channel model is given by $\tau_N = N\Delta\tau$

(a) Given, for $\tau_N = 150\mu s$ and $N = 70$,

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

(b) The maximum bandwidth that the SMRCIM model can accurately represent is equal to $2/\Delta\tau =$

$$2/2.14\mu s = 0.933\ MHz$$

for the SMRCIM urban microcell model, $\tau_N = 4\mu s$,

$$\Delta\tau = \tau_N / N = 57.1\ ns$$

The maximum RF bandwidth that can be represented is $= 2/\Delta\tau = 2/57.1 ns = 35\ MHz$

(c) Similarly for indoor channel model is,

$$2/\Delta\tau = 2/7.14\ ns = 280\ MHz$$

Experiment 8 : A zero mean sinusoidal 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 sideband. (c) What will be the total power if the carrier and one of the sidebands are now suppressed?

Solution :

Using equation, $P_{AM} = \frac{1}{2} A_c^2 \left[1 + P_M\right] = P_c\left[1 + \frac{K^2}{2}\right]$

where, $P_c = A_c^2/2$ is the power in the carrier signal

$P_M = (m^2/t)$ is the power in the modulating signal

m(t) and k is the modulation index

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

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

(b) Power in each sideband, $\frac{1}{2}(P_{AM} - P_c) = (0.5) \times (400 - 312.5) = 87.5 \text{ KW}$

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

$= 78.125\%$

Experiment 9 : A sinusoidal modulating signal $m(t) = 8\cos(2\pi 4\times10^3 + 10)$ is applied to a modulator that has a frequency deviation constraint 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, $\Delta f = 8V \times 10\ KHz/V = 80KHz$

(b) Frequency modulation index, $B_f = \frac{\Delta f}{f_m} = \frac{80}{4} = 20$

(c) Phase modulation index, $B_p = K_0 A_m = 10\ radians/V \times 8V = 80$ radians

Source code for the experiment

```
clc; clear all; close all;
Fm = 4;
mt_max_value = 8;
womeca = 10;
disp('(A)');
Peak_deviation_delta_f = mt_max_value* womeca;
disp('(B)');
```