IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 14, Issue 6 Ser. I (Nov. – Dec. 2019), PP 47-56
www.iosrjournals.org

Base Station (BS) Transmitter Power Level by Cell Radius And Path Loss

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Abstract: *When weare planning for cell mobile area, we should put in our consider the traffic and the coverage area by doing analysis using the TDMA – FDMA mobile cellular communication system. In this paper we collaborate with Ooredoo mobile company in Kuwait to see the effect of cell radius on the power can the base station to supply the user by using the path loss and the transmitter power level.*

Date of Submission: 16-11-2019 Date of Acceptance: 02-12-2019

I. Introduction

The rapid growth in demand for mobile communication has led. The engineers to dedicate their times on researches to provide the mobile subscriber the quality of service (QoS), also support wide range of service and improve the system capacity. The small cell system allow greater spectral reuse larger Capacity (11). However, small cell system induce an increasing number of hand off while overlying cell provide coverage and service for higher speed users(5), one of the most major challenges in the cellular system design is to allocate the mobile user (4). Here, will see an overview of different simulation of cell planning in order to provide adequate coverage by seeing the effect of path loss (Rata-Okumura) on the cell in different reign (Urban - Suburban - Rural) and antenna height. Also the effect of cell size on the population (P), average call time (T), subscriber number per cell (SNPC) and call number per hour (n). Also the effect of power transmitter on the path loss (L) and distance from cell radius (R). Also the system capacity on the cell reuse factor (N), also the effect of population on the average call time (T) and cell number (CN) finally the initiation of the handoff with the Received Signal Strength (RSS) to find the distance of the handoff here will use just two algorithms of handoff (6).

a- Received Signal Strength (RSS) with Hystersis(H).
b- Received Signal Strength (RSS) with Hystersis(H) and threshold.

II. The impact of changing the cell size

Cell size is changeable with many factor such as the power level Path loss , the population of the region and time average for each call all these will have a measure impact on the designing the cell size as we will study later on with the experiment on Matlab program. The cell size is different dependent on the region that will be implement on it such as urban need to have small radius cells with many cells to be capable to handle the capacity of area and the path loss cased from high traffic, but in the rural region the cell radius can be wider because of population of the area and the building are less

III.The impact of changing power level

As we know the users are allowed to transmit different types of traffic, such as voice, data, and compressed video. Each types of the text has requirement certain bandwidth among the wireless communication for deferent regions, so what we will be doing in section 4.1.2 that will try to change the parameters such as path loss, and cell radius to see the impact on the power level for three region (urban, suburban, rural)

IV. The impact of changing the path loss

The performances of wireless communication system depend on the mobile radio channel. The radio wave propagation has different mechanisms such reflection, diffraction, and scattering. The propagation models have average signal strength and its variable at a given distance from the transmitter. The different propagation models exist for different types of environment (e.g., urban, rural, suburban), so what will be used here is (Hata Okumura model), to see the impact of changing the parameters, such the distance of mobile from the base station, and antenna height in section 4.1.3. other studies will be held on impact of varies the populations, reuse factor and using the concept of handoff algorithms to find the distance for he mobile station can be tolerate within a cell

V. Cellular System Architecture

Increases in demand and the poor quality of service led the mobile service provider to do research to improve the quality of service (QoS) and to support more users in their system (4). Because the amount of frequency spectrum available for mobile cellular use was limited, efficient use of the required frequency was needed for mobile cellular coverage (4). In modern cellular telephone, rural and urban regions are divided into areas according to specific future needs. The need for each region is planned according to the engineering plan that includes cells, clusters, frequency reuse and handovers (7)

Cells

A cell is the basic geographic unit of a cellular system. The term of cellular comes from the honeycomb shape of the area into which coverage area is divided, it is base station transmitting over small geographic area that are represented as hexagons (10).

Each cell size varies depending on the landscape, because of constraint imposed by natural region also by the human made structure, but to be true the shape of the cell is not a perfect hexagon (10).

Cell size is category in three main parts (3):

I- Macro cells:

It size between 1 to 30 Km radius, which is can be use for large coverage area, where area has no a lot of building and pedestrian.

2- Micro cell:

It size 200 to 2000 m radius which to improve or extend coverage in “hot spot" (i.e., large office building) airports terminals, indoor sporting area shopping center, etc ...

3- Pico cell:

It sizes 2 to 200 m radiuses. Pico cells are used in congested mobile phone areas, such as city centers or at exhibition centers.

They replace the larger micro cells or macro cells in these places as shown in Figure (1) below.

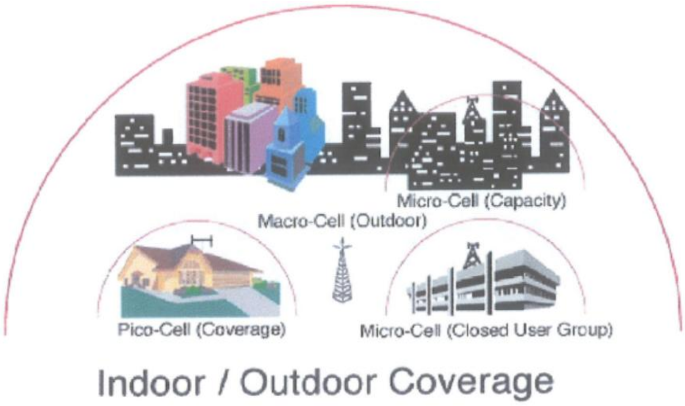

Figure (1) of Pico-Macro-Micro cells

The miniaturization of cell structures allows a great increase in the local capacity mobile phone networks. Talking about decreasing the cell has many advantage or disadvantage. As advantage which to increase the number of the users where the capacity here win increase because of splitting for the original cell, also the power consumption in the mobile will be lower which lead to longer talk time for the user also smaller battery size which the size of the cell phone will be small and more suitable, but the disadvantages of decreasing are the increased the number of the handoff per call (10), also increased the complexity of locating the subscriber ,increase complexity of the frequency planning, finally increase the cost when come by adding more base station (5).

The cellular system design must take into account the different cell size where different propagation environments (or model) between Macro cell, Micro cell and Pico cell (7), also the different cell layout (i.g, micro cells are often confined to one block of an urban street grid). To enhance user capacity, the small Micro cell can be used to complement the large size Macro cells as shown in the below Figure (2).

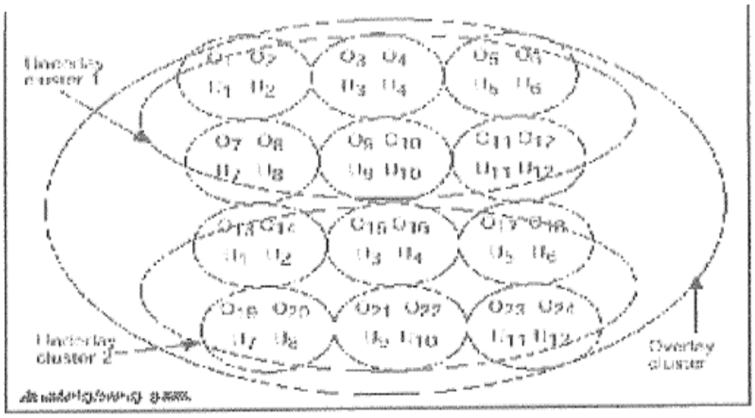

Figure (2) An underlay / overlay system

That will lead to mixed hierarchical cell structure with Macro cells designed to provide increase local capacity (7).

Clusters

The clusters is a group of small of cell, they win shaped as constant number of cell as shown below in Figure (3).

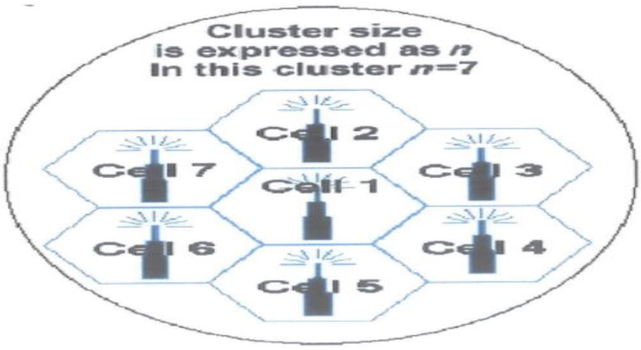

Figure (3): seven cell clusters in a macro cellular system

Can we put the clusters in form as (4):
N=3 cell cluster
N=4 cell cluster
N=7 cell cluster
N= 12 cell cluster
The clusters size (N) is an important system design parameter which is can be too large lead to reduced the system capacity or too small will lead to increase the handoff and switching complexity (4).

Frequency Reuse

Because only a small number of radio channel frequencies were available for mobile system, the engineers had to find out a way to reuse radio channels in order to carry more than one conversation at one time, so the solution is called frequency planning or frequency reuse (9).

Frequency reuse is based on assigning to each cell a group of radio channels used within a small geographic area (l2).

Cells are assigned a group of channels that is completely different from neighboring cells. The coverage area of cells are called the footprint (3), this footprint is limited by a boundary so that the same group of channels can be used in different cells that are far away from each other so that their frequency do not interfere as shown in the Figure (4).

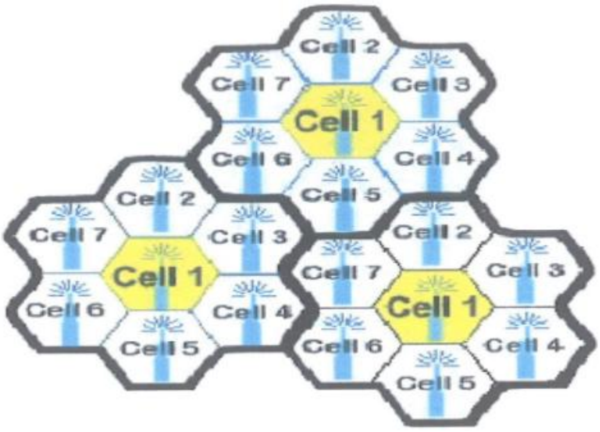

Figure (4): Frequency Reuse

Cell with the same number have the same set of frequency, because the number of available frequency is 7, the frequency reuse factor is 1/7. That is each cell is using 1/7 available cellular channels (10). The way of finding the frequency reuse distance is by finding the frequency reuse pattern (N) as shown in the figure (5) below (10) .

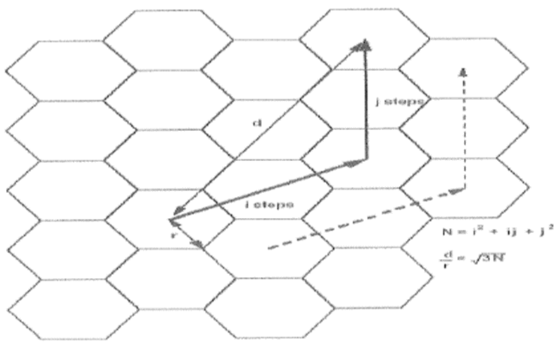

Figure (5): Procedure for finding N (frequency reuse pattern)

In the above figure as you see the i= 2 and j= 2 and the distance between centers is 6 cell radius

N = i + ij + j (1)
And
D/r = Sqrt 4N (2)
D = Sqrt 3Nr (3)

Where:
D: Frequency reuse distance
N: reuse factor
r: radius of the cell

Cell Splitting

Economic consideration made the concept of creating full system with many small areas impractical (10). To overcome this difficulty the engineers developed the idea of cell splitting.

As a service area become fun of users this approach is used to split a single area into srnaller ones, so the urban centers can be split into many area as necessary in order to provide good service level in traffic regions, while use larger cell for rural regions less expensive (l0-2). The Figure (6) below will show the two regions of (rural -urban) distribution cell.

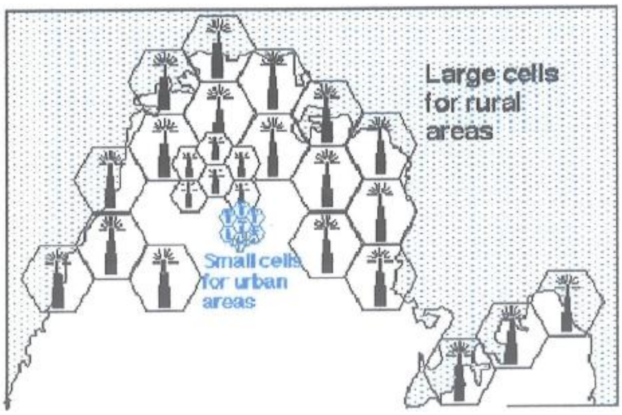

Figure (6): *Cell Splitting*

Handoff

It is a process of transferring a call to another bas station, when a user crosses the boundary between adjacent cells while a call is in progress (2), The handoff can occur even if the user is not actively involved in a, call where the systems will automatically handoff and a user among cells as long as the mobile is trued on and the user is moving where the procedure of handoff are(7):

1- The mobile win try to identify appropriate new base station to handoff
2- The mobile also will try to find available voice channel to switch into if not the mobile will hang with old channel until the power signal become weak below the threshold voltage and the call will be dropped.
3- Also a good issue here of finding the optimal handoff time, it is very important in which to decrease the handoff number.

The handoffs are n10st commonly based on the signal power with threshold voltage, because if the mobile signal power (P_{min}) is become equal to the handoff power (P_{ho}) that will lead the mobile to try to find power signal from the nearest cell to handoff into it.

* There are two discussions should be in mind where try to handoff (7):

The mobile position: is the mobile approaching the cell boundary or not.

Mobile speed: how fast mobile is moving that will lead to have quicker handoffs

* The handoff mechanism can be classified into three types (12):

1- Network controlled handoff (NCHO): the network makes a handoff decision based on measurements of the Received Signal Strength (RSS) of the mobile station (MS) at a number of base station (BS), (Centralized).

2- Mobile assisted handoff (MAHO): distributes the handoff decision process. The mobile station (MS) makes measurements, and the Mobile Switching Center (MSC) makes decisions. 3- Mobile controlled handoff (MCHO): the mobile station (MS) is completely in control of the handoff process (Distributed).

VI. Cell Coverage for Signal and Traffic

The received signals at the base stations and terminals of a wireless information network are complicated to describe (l), There are many of phenomena cause signal strength to vary with terminal position and at any location with time. The properties of the signal path that we consider here the distance between terminal and base station (BS), also the antenna high, base station transmitter power On average, the signal strength at a receiving antenna decreases with distance according to the path loss equation (Hata - Okumura) model (l).

Where the most step for us to design a radio link that win required for us to determine the base station density in different coverage so it will be most i1llportant consideration in the radio coverage planning is the propagation model as we mention that the model will be (Hata- Okumura), because it does fit to all environment (1).

VII. Path Loss

The path loss model is used for several aspects of cell planning such as base station placement, cell sizing, and frequency reuse (2). The path loss model Hata and Okumura can be used for Macrocells, Microcells have different model for line of sight (LOS) and no line of sight (NLOS) propagation (13).

* For LOS propagation two frequently used models are a flat earth model and a two slope model (13), in the flat earth model one direct ray and another reflected ray (with 180 phase shift). However, the main features of path loss can still be described by these empirical models, for certain parameter setting (13).

* For NLOS propagation, LOS propagation is assumed to the street comer. After the corner, propagation path loss is calculated by placing an imaginary transmitter at the corner with the transmit power equal to the power received at the corner from the LOS base station.
The (Hata- Okumura) model can be described as follows (l):

Urban area:

$Lu = 69.55 + 26.16 \text{ Jog } f_c - 13.82 \log h_b - a(h_m) + (44.9 - 6{,}55 \log h_b) \log R$ (dB) (4)

Suburban area:

$Ls = Lu - 2 [\log (f_c / 28)] - 5.4$ (5)

Rural area:

$LR = Lu - 4.78(\log f_c) + 18.33 \log f_c - 40.94$ (6)

Correction factor for a small or medium sized city:

$a (h_m) = (1.1 \log f_c - O.7)h_m - 1.56 \log f_c + 0.8$ (7)

Where:

f_c : is the link frequency (MHz)
h_b : is the base station antenna height(m)
$a (h_m)$: is correction factor for mobile antenna height (dB)
R: is the distance from base station (Km)
h_m: is mobile antenna height (mm)

VIII. The Co-Channel Interference

Where the cellular network are more often limited by problems caused by interference rather than by signal strength problems, Co-channel interference is caused by using the same frequency in the close cell (4). The carrier (C) to interference (I) ratio, CIR is influenced by the location mobile station, local geography and base station output power. In order to calculate the co-channel interference ratio CIR a relationship between the reuse ratio and the reuse factor (N) for different sectored cell (l).

Omnnidirectional cells:

$CIR = 1/ 2(3N- 1) + 2(3N) + 2(3N + 1)$ (8)

120 degree sectored cells:

$CIR = 1/ (3N + 0.7) + (3N)$ (9)

60 degree sectored cells:

$CIR = (3N + 0.7)$ (10)

Cell Radius:

Cell radius is one of the important parameter that will have impact on path loss also the power level of the cell should be transmitted, the below equation is represented the cell radius (l).

$A = nT /3600$ (11)

$SNPC = (1 - P x)/ A$ (12)

$CN = P / (SNPC *ON)$ (13)

$R= RA/ 2.6(CN)$ (14)

Where:
A: Erlang
T: average call time
SNPC: subscriber number per cell
P_x: blocking probability
CN: cell number
P: population of the region
ON: number of the operator RA: area of region
n: call number per hour

Capacity:

Where the capacity (number of traffic channels per cell) (l):

$C = 8 (PFN / N) - 2$ (15)

PFN: possible frequency number
N: reuse factor

Transmitter Power:
The transmitter power has a different equation for different region such as urban, suburban and rural each one has it own equation as shown below (l):

Urban area:

$P_{tu} = P_{rmin} + L_o + L_u – G_t - G_r$ (16)

Suburban area:

$P_{tsu} = P_{rmin} + L_o + L_{su} – G_t - G_r$ (17)

Rural area:

$P_{tr} = P_{rmin} + L_o + L_r – G_t - G_r$ (18)

Where:
P_{rmin}: is minimum receiver sensitivity (- 104 dB)
L_o: additional losses (dB)
G_t: is transmitter antenna gain (dB)
G_r: is receiver antenna gain (dB)

IX. The Simulation Studies (Results)

1- Cell Coverage for Signal and Traffic parameters
The parameters taken from Zain Mobile Phone Company as a new site is being install in a new area, the values are written below:
Cell radius (R) = 205 Km
Link frequency (f_c)= 900MHz
BS antenna height (h_b) = 35 meter
Average call time (T) = 60 min
Number of operator (ON) = 3
Blocking probability (P_x) = 0.02
But the another values have been taken from (1) such as:

PFN = 50
P = 30000
RA = 150
Gt = l0dB
h_m = 3 mm
n = 1
Lo = 6 dB
Prm = -104 dB

2 - Base Station (BS) Transmitter Power Level:
In the simulation part for the Base Station Power Level win divide into two categories:
a-BS Transmitter Power Vs. distance (cell radius) parameters.
fc = 900 MHz , h_b = 35 m, h_m = 3 mm , R_b = 0.01 :0.1 :2500 , P_{rm} = -104 dB , Lo = 6 dB , G_t = 10 dB , G_r = 1.5dB.
Where:
f_c = link frequency (MHz)
h_b = BS antenna height (m)
h_m = mobile antenna height (mm)
R_b = distance from BS (Km.)
P_{rm}= minimum receiver sensitivity (dB)
L_o = additional losses
G_t = transmitter antenna gain (dB)
G_r = receiver antenna gain (dB)

Here will study the BS transmitter power for three regions (urban - suburban - rural) versus the cell radius, The regions will vary from 0 up to 2500 meter, each regions has it is own value of BS transmitter power for example rural will be vary from -99 (dB) to 10 (dB) , the suburban will vary from 60 (dB) to 155 (dB) , urban from 170 (dB) to 270 (dB) as shown in Figure (21) below that impels when the radius get wider the BS transmitter power should be more to cover the whole area to do not have blind spot(area do not get covered), the relationship between BS transmitter power Vs. cell radius is directly proportional any increase in the power will led to increase into the cell radius as shown in figure (7)

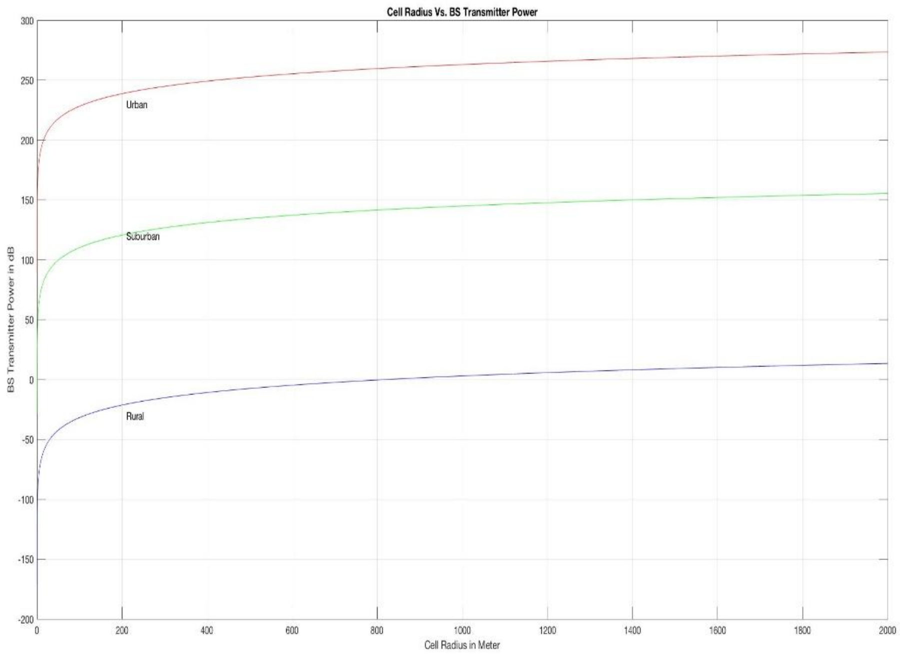

Figure (7) *- BS Transmitter Power (dB) Vs. Cell Radius (meter)*

3 -<u>BS Transmitter Power Vs. Path Loss parameters.</u>

f_c = 900 MHz , h_b = 35m, h_m = 3 mm , R_b = 0.01 :0.1 :2500 , P_{rm} = -104 dB , L_o = 6 dB , G_t = 10 dB , G_r = 1.5 dB.

Where:

f_c = link frequency (MHz)
h_b = BS antenna height (m)
h_m = mobile antenna height (mm)
R_b = distance from BS (Km)
P_{rm} = mininum receiver sensitivity (dB)
L_o = additional losses
G_t = transmitter antenna gain (dB)
G_r = receiver antenna gain (dB)

Here will study the BS transmitter power for three regions (urban - suburban - rural) versus the Path loss.

The regions will vary from 0 up to 2500 ill, that will let the path loss to be vary according to the changing into the cell radius the all three figures are into one graph you can notice that when BS Transmitter power increase will led to increase into the path loss (dB) for example in urban region the BS transmitter power will vary from 220 (dB) to 278 (dB) where the path loss will be changing according to BS transmitter power from 337 (dB) to 387(dB) , also for the suburban region the BS transmitter power will vary from 110 (dB) to 158 (dB) where the path loss will be changing according to BS transmitter power from 219 (dB) to 267 (dB), also for the rural region the BS transmitter power will vary from -33 (dB) to 8 (dB) where the path loss will be changing according to BS transmitter power from 77 (dB) to 127 (dB), the relationship here is directly proportional between the path loss and BS transmitter power as shown in the figure (8) below.

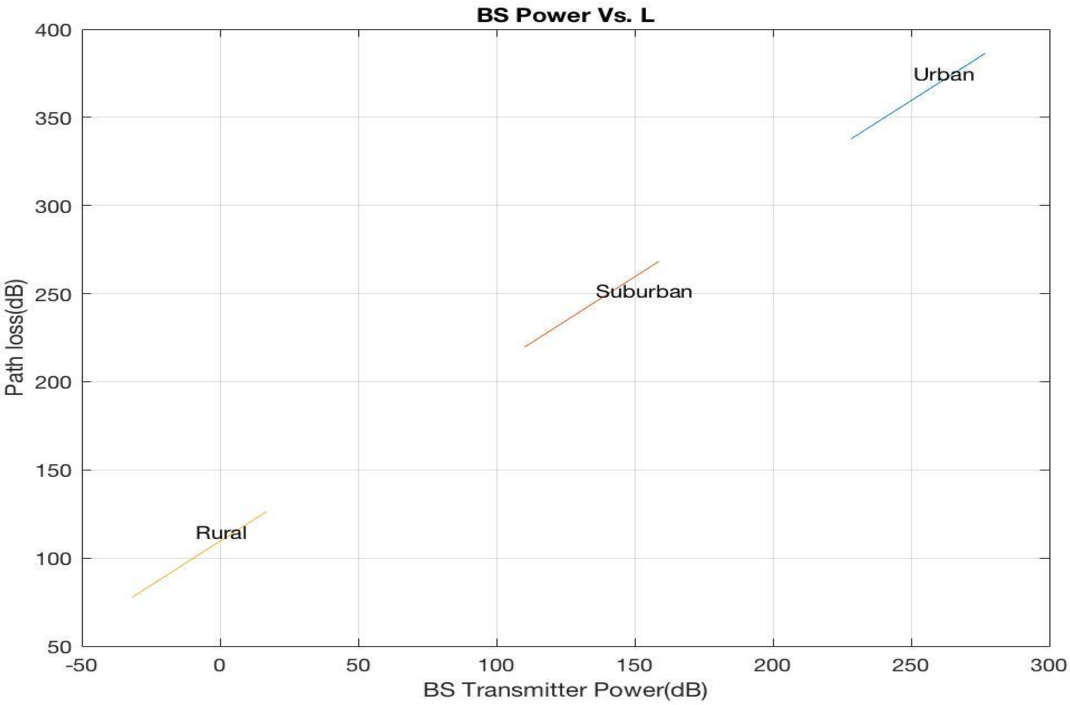

Figure (8) - BS transmitter power (dB) Vs. Path loss (dB) for three regions

XII. Conclusion

The outcome of the work:
The work will be divide into parts.

In this part of sending signals at the base station to the mobile host at certain distance is affected by two factors.

a) Cell Radius where more increasing in the cell radius that should be adjacent the increase in the power level to cover a far distance could the mobile goes within the cell radius also the antenna height should be increase in our simulation was for three region (urban, suburban, rural) in figure (7), the rural region need less power, because it is less fading in the signal than other regions until the three curves become constant after certain cell radius that we measuring in it.

b) Power Transmitter with path loss, here is a directly relation between the both parameters which any increasing the one win led to increase the another the simulation was for three region also, from the figure (8) notice that the region rural has less path loss than become the suburban finally urban which that emphasis the effective of the building on the signal strength.

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IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) is UGC approved Journal with Sl. No. 4198, Journal no. 45125.

Ali Habeb Aseeri. " Base Station (BS) Transmitter Power Level by Cell Radius And Path Loss" IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) 14.6 (2019): 47-56.