A STUDY ON PATH LOSS ANALYSIS FOR GSM MOBILE NETWORKS FOR URBAN, RURAL AND SUBURBAN REGIONS OF KARNATAKA STATE

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ABSTRACT

To establish any mobile network system, the basic task is to foresee the coverage of the proposed system in general. Many such different approaches have been developed, over the past, to predict coverage using what are known as propagation models. In this paper, measurement based path loss example and shadowing parameters are applied on path loss models. Here, the measurements are carried out in urban, rural and suburban areas considering non-line-of-sight terrains with low elevation antennas for the transceiver (Tx) and receiver (Rx)[5]. The impact of multipath are more emphasized in the rural context. This causes higher probability of RF signal errors. On the basis of observation and with the help of clutter, we can present models which give better understanding for urban, rural and suburban regions in Karnataka state at 940 MHz GSM frequency[5],[26][13].

KEYWORDS

BS, Path Loss, Propagation, Model, GSM.

1. INTRODUCTION

Karnataka state is a tropical region, which comes as southern part of India. The Deccan plateau, which is not really flat, gradually rises towards the south west. The plateau is still surrounded with craters in the form of chain of mountains and isolated peaks. Here, rural areas are rich in green vegetation. Urban areas have moderate climatic atmosphere, with most of the localities in flat surface terrains and suburban is the combination of the both [5]. GSM (Global System for Mobile Communications) comes under wireless communication, which depends on the propagation of waves in the free space and providing transmission of data [13],[21]-[26]. It extends service by providing mobility for users, which fulfills the subscribers demand at any terrain covered by wireless network. When we consider the earlier historical legacy, the growth in mobile communications field has now become less. Here, the paramount factor was to serve for high quality and high capacity networks. Estimated coverage precisely has become very pivotal. So, in lieu of accomplishing far more accurate design, coverage of modem cellular networks and signal strength measurements will be considered as source of data, in order to provide reliable and efficient coverage locality. This paper focuses on the comparisons between theoretical and experimental analysis, at channel propagation path loss models at GSM frequency of 940 MHz, for various terrains in Karnataka state. Here, the clutters show the vegetation of the different areas for propagation of RF signals [1],[2],[3],[4],[5],[13],[22]-[29]. Figure 1.a. shows the framework of GSM technology.

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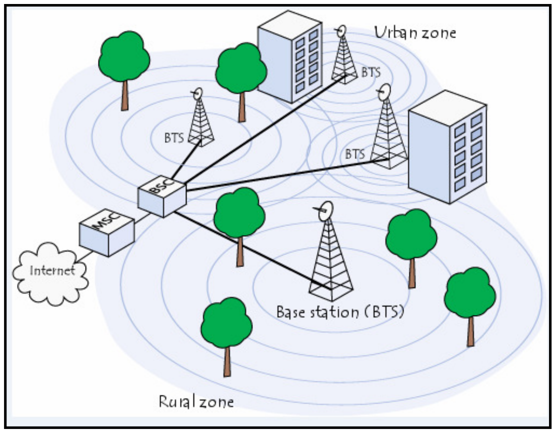

Figure 1.a. GSM framework

2. SIGNIFICANCE OF PROPAGATION FORECAST:

Planning is the key before implementing designs, and also setting up of wireless communication systems. Precise propagation characteristics of the situation should be known. Usually propagation provides two types of data, corresponding to the large-scale path loss and small-scale statistics pertaining to fading issue. Information regarding path-loss is very pivotal, for knowing the coverage of a base-station (BS) and in tuning it. The statistics provided by the small-scale parameters pertain only to local field variations. Also in turn this helps to improvise receiver (Rx) design structure and counter the multipath fading[5],[14],[15]-[34].

3. VARIOUS TYPES PATH-LOSS PREDICTION MODELS

3.1. Empirical Model

It is derived from in-depth field measurements. It is efficient and simple to use. The input data for the empirical models are generally qualitative, also not very correct, for instance like dense urban area, rural area and so on [5]-[16].

3.2. Site-specific models

It is based on numerical methods and the finite difference time-domain (FDTD) method. The input data can be very precise and detailed one [9].

3.3. Theoretical models

It is derived by physical hypothetical assumption, in addition to some moderate conditions. For instance, when we consider the over-rooftop, diffraction model is derived using physical optics, assuming constant heights and spacing of buildings [4].

4. DIFFERENT TYPES OF PROPAGATION PATH-LOSS MODELS:

4.1. Cost Hata 231 model

It is recommended for mathematical expression. To calculate the graphical data precisely, its usage has been put to test at 940 MHz GSM frequency, to foresee the channel path-loss from source distance d which is the transceiver to the destination receiver antenna upto 5 km; transmitter antenna height of 60m and receiver antenna height of 3m. To make a study of path-loss in the GSM frequency range of 940MHz in urban environment, this method is suggested.

$$PL = 48.5+35.9\log10 (f)-14.84\log10 (h_b) – ah_m + (45.8 – 6.58\log10 (h_b)) \log10 d + cm$$

--(5)

where: d=Distance between transmitter and receiver antenna [km]
f: Frequency [MHz]
h_b: Transmitter antenna height [m]
The parameter cm has different values for different environments like 3 dB for urban areas and the remaining parameter ah_m is defined in urban areas as,

$$ah_m = 3.25(\log10(11.80h_r))2- 4.81, \quad \text{for } f > 940 \text{ MHz}$$

[5]-[19].

4.2. Free space model

It emphasizes on how much strength of signal transmission between transceiver and receiver is lost.
To calculate the same, we use the following equation:

$$PL_{FSPL} = 32.48 + 20\log10(d) + 20\log10(f)$$

--(5)

where,
f: Frequency [MHz]
d: Distance between transmitter and receiver [m]
Power is usually expressed in decibels (dBm)
[5],[6]-[8].

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4.3. Ericsson model

To predict the path loss, software is provided for network planning engineers developed by Ericsson company. So, it is called as Ericsson model. The path loss according to this model is given by the equation:

$$PL = a0 + a1.\log10(d) + a2.\log10(h_b) + a3.\log10(h_b).\log10(d) - 3.3(\log10(11.78h_r)^2) + g(f)$$

-- (5)

where g(f) is defined as:

$$g(f) = 44.51\log10(f) - 4.79(\log10(f))^2)$$

-- (5)

and
f =Frequency [MHz]
h_b=Transmission antenna height [m]
h_r=Receiver antenna height [m]
[5],[10],[11]-[25].

4.4. Hata model

It falls under empirical propagation models. It is well suited model for the Ultra High Frequency (UHF) band. Currently, this model is tested with 940 MHz GSM frequency. Here, empirical calculation method is applied to predict the model at, frequency range 940 MHz. In this model, path loss is given by the following equation,

$$PL = A_{fs} + A_{bm} - G_b - G_r$$

-- (8)

where
A_{fs}=Free space attenuation [dB]
A_{bm}= Basic median path loss [dB]
G_b= Transmitter antenna height gain factor and

G_r=Receiver antenna height gain factor
These factors can be divided and given by the equation:
A_{fs} = 93.6 + 20log10+20log10 (f)
A_{bm}= 21.41+9.83log10 (d) +8.782log10 (f) + 9.58[log10 (f)] ^{2}
G_b = log10 (h_b/200){14.865+ 6.1[log10(d)]^2}
When dealing with gain for urban cities, the G_r will be expressed in terms of the following:

$$G_r = [42.58 + 13.7\log10 (f)][\log10 (h_r) – 0.586] \quad \text{-- (8)}$$

For quite large urban areas,
G_r = 0.860h_r – 1.960
where,
d= Distance transmitter and receiver antenna in [km]
f= frequency range in [GHz]
h_b=Transmitter antenna height in [m]
h_r=Receiver antenna height in [m] and
[5],[19],[24],[25],[28]-[35].

4.5. SUI model

This model inherits Hata model's frequency. Hence it is tested with GSM frequency of 940MHz. Little bit of correction in parameters, can be extended up to 3 GHz band frequency. In this model, the BS antenna height can be varied from 10 m to 80 m and at receiver end, the height can vary between 2 m to 20 m.SUI model comes out with three different types of terrain like terrain A dense urban locality, terrain B has hilly regions and terrain C for rural with moderate vegetation. Here, we concentrate on urban path loss with different ranges of receiver antenna height. The general path loss expression of the SUI model is presented as :

$$PL = A + 1Oy\log10 (d /d0) + X_f + X_h + s \quad \text{for } d > d0 \quad \text{-- (5)}$$

where the parameters are as follows,

d= Distance between BS and receiving antenna [m]

d0= 100 [m]

λ=Wave length [m]

X_f=Correction for frequency 940 [MHz]

X_h=Correction for receiving antenna height [m]

s= Correction for shadowing [dB]

and y=Path loss exponent

By statistical method, the random variables are taken as the path loss exponent y and the weak fading standard s is derived. The parameter A is defined as,

$$A = 20\log10 \left(\frac{4\pi d_0}{\lambda}\right) \quad \text{-- (5)}$$

and the path loss exponent y is given as follows,

$$Y_y = a - bh_b + (c/h_b)$$

Here, the parameter h_b is the base station antenna height. This is between 15 m and 90 m range. The constants a, b, and c depend upon the types of terrain, here our study, urban area. The value of parameter γ propagation in an urban area,$6 < \gamma < 9$ for urban NLOS environment. The frequency correction factor X_f and the correction for antenna receiver height

X_h for the model are expressed as follows,

$X_f = 6.2\log10\ (f/2000)$

$X_h = -10.9\log10\ (h_r/2000)$

[5],[12],[15],[16],[17]-[36].

5. METHODOLOGY USED FOR MEASUREMENT

5.1. Configuration of measurement

Here, the parameter consisted of constant transmitter and a receiver mounted to a car. A dipole antenna of omnidirectional quarter-wave with 4 dBi was installed on a tripod and connection is established to the signal transmitter with a 12 meter feeder cable. The continuous narrowband wave signal with GSM frequency of 940 MHz was input given to the Tx antenna with 30 dBm power capacity. The spectrum analyzer inside the car gives details of the timing intervals for every one second. Figure 4.1.a. shows the framework of the above concept [9],[10],[11],[21],[22]-[24].

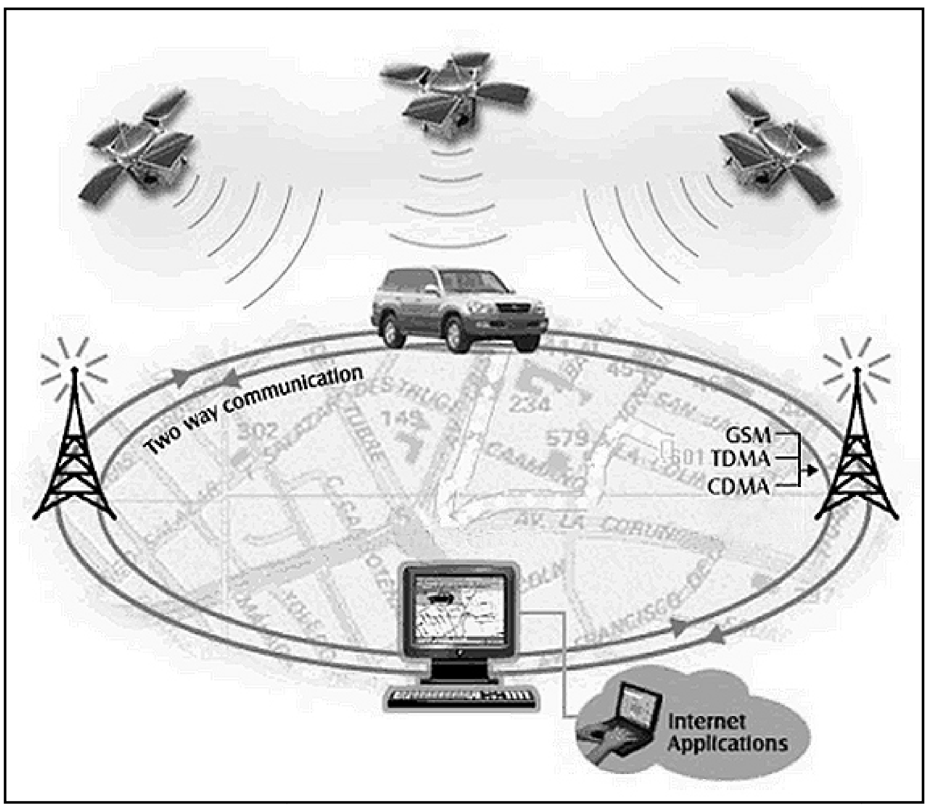


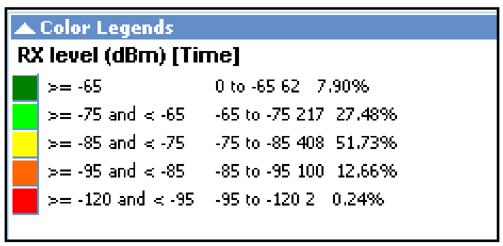
Figure 4.1.a. Measurement framework

5.2. Environmental measurement

With GSM frequency of 940 MHz RF signal, measurement were performed during July 2012 and the measurement campaign consisted of three slightly various propagation environments in MG Road,Bangalore,Karnataka,India;Channapatna, Karnataka,India;Kannaswadi, Karnataka, India. The field measurement survey was performed in Kannaswadi district reflecting a typical suburban region. The second measurement survey was performed in Bangalore district reflecting a typical urban region and the third measurement survey was performed in Channapatna district reflecting a typical rural region.

Typical urban region comprises of blocks of densely constructed buildings. In general, an average building height is more than 20 meters and buildings may have ten to fifteen floors. In conjunction, the region is surrounded by parks and open parking areas. Typically 25% of the area is filled with buildings built of concrete blocks. In rural region with thick vegetation of highly raised trees, some sequence of houses built with huts; and some part of the place with concreted buildings. Around 45% of the area filled with more huts, in contrast with suburban, which is combination of both counterparts [21],[26],[27],[30],[31].

6. AERIAL VIEW OF THE CLUTTER SHOWING VARIOUS TERRAINS



Color Legends

RX level (dBm) [Time]

>= -65	0 to -65 62	7.90%
>= -75 and < -65	-65 to -75 217	27.48%
>= -85 and < -75	-75 to -85 408	51.73%
>= -95 and < -85	-85 to -95 100	12.66%
>= -120 and < -95	-95 to -120 2	0.24%

6. Table gives legends of different variations

Figure 6.a. shows the clutter of propagation signal in urban terrain of MG Road.

Figure 6.a. MG Road, Bangalore, Karnataka, India

Figure 6.b. shows the clutter of propagation signal in rural terrain of Channapatna.

Figure 6.b. Channapatna, Karnataka, India

Figure 6.c. shows the clutter of propagation signal in suburban terrain of Kannaswadi.

Figure 6.c. Kannaswadi, Karnataka, India

7. EQUIPMENT AND MEASUREMENT DETAILS DEPLOYED

To measure, we applied a drive test to measure in the location for which a path loss model is to be designed. Table 7.a. shows the equipment and data used for field measurement in urban area as follows.

Table 7.a. Measurement details for path loss at MG Road

Antenna	Andrews		
Model	65/6deg tilt		
Gain	17 dbi		
Mobile used	C5/antenna 7 dbi		
Distance in km	**Rx level in dBm**	**Tx power in dBM**	**Attenuation in dB**
280	-65	43	22
400	-75	43	32
500	-85	43	42
800	-95	43	52

Table 7.b. shows the equipment and data used for field measurement in rural area as follows.

Table 7.b. Measurement details for path loss at Channapatna

Antenna	Andrews		
Model	65/6deg tilt		
Gain	17 dbi		
Mobile used	C5/antenna 7 dbi		
Distance in km	**Rx level in dBm**	**Tx power in dBM**	**Attenuation in dB**
150	-65	43	22
190	-65	43	22
200	-65	43	22
500	-65 to -75	43	32
1000	-75 to -85	43	42

Table 7.c. shows the equipment and data used for field measurement in suburban area.

Table 7.c. Measurement details for path loss at Kannaswadi

Antenna	Andrews		
Model	65/6deg tilt		
Gain	17 dbi		
Mobile used	C5/antenna 7 dbi		
Distance in km	**Rx level in dBm**	**Tx power in dBM**	**Attenuation in dB**
100	-65	43	22
190	-65	43	22
200	-65	43	22
800	-65 to -75	43	32
1800	-75 to -85	43	42

8. SIMULATED RESULTS OF VARIOUS TERRAINS

The simulated output in Figure 8.a. generated shows the various model path losses in urban areas.

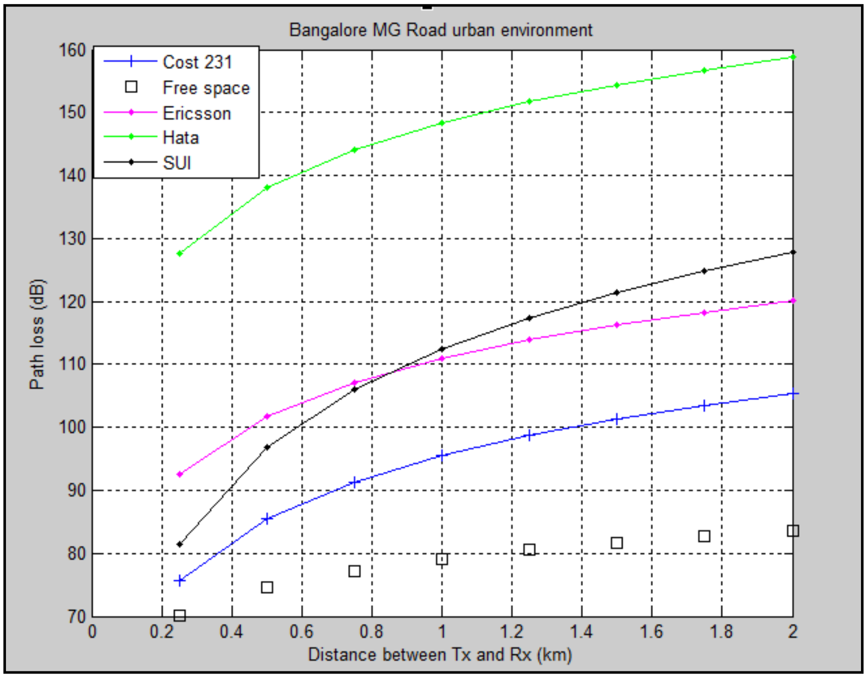


Figure 8.a. Path loss at MG road urban at 940 MHz GSM frequency

The simulated output in Figure 8.b. generated shows the various model path losses in rural areas.

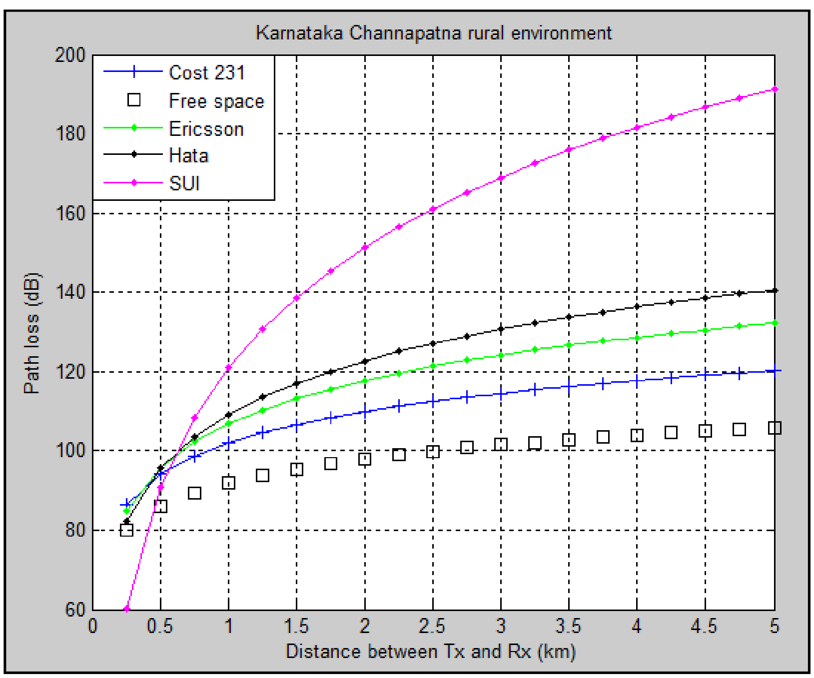


Figure 8.b. Path loss at Channapatna rural at 940 MHz GSM frequency

The simulated output in Figure 8.c. generated shows the various model path losses in suburban areas.

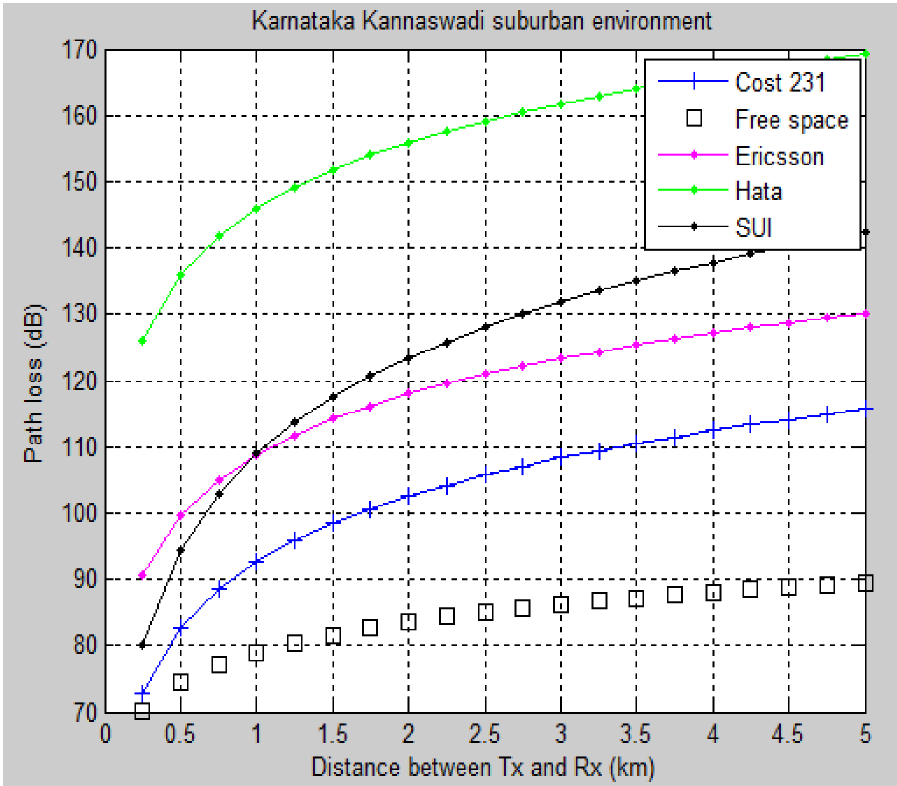


Figure 8.c. . Path loss at Kannaswadi suburban at 940 MHz GSM frequency

9. Analysis of Simulated Results of Various Terrains

The analysis in Figure 9.a. shows the transceiver Tx, receiver Rx and path loss in urban area of MG road.

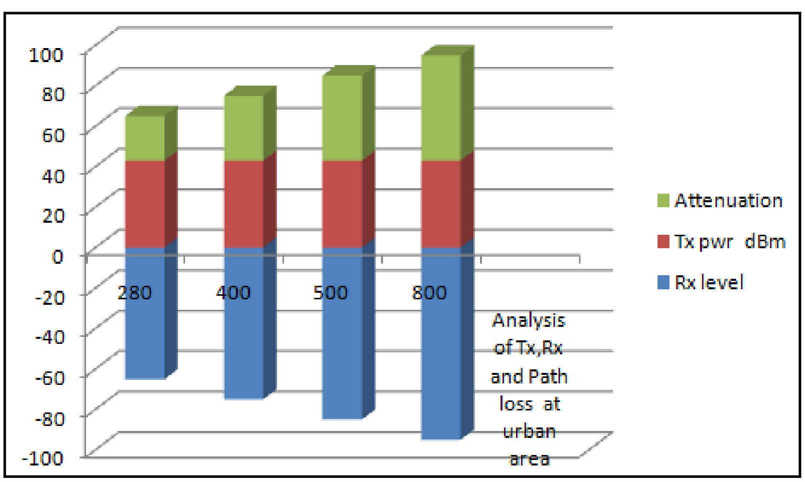


Figure 9.a Analysis of path loss at urban area

The analysis in Figure 9.b. shows the transceiver Tx, receiver Rx and path losses in rural area of Channapatna.

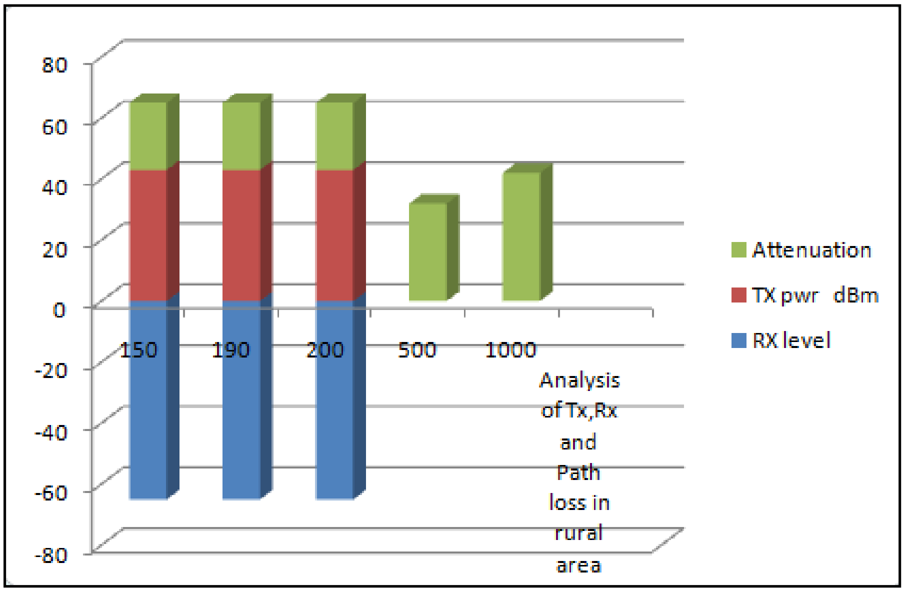


Figure 9.b. Analysis of path loss at rural area

The analysis in Figure 9.c. shows the transceiver Tx, receiver Rx and path loss in suburban area Kannaswadi.

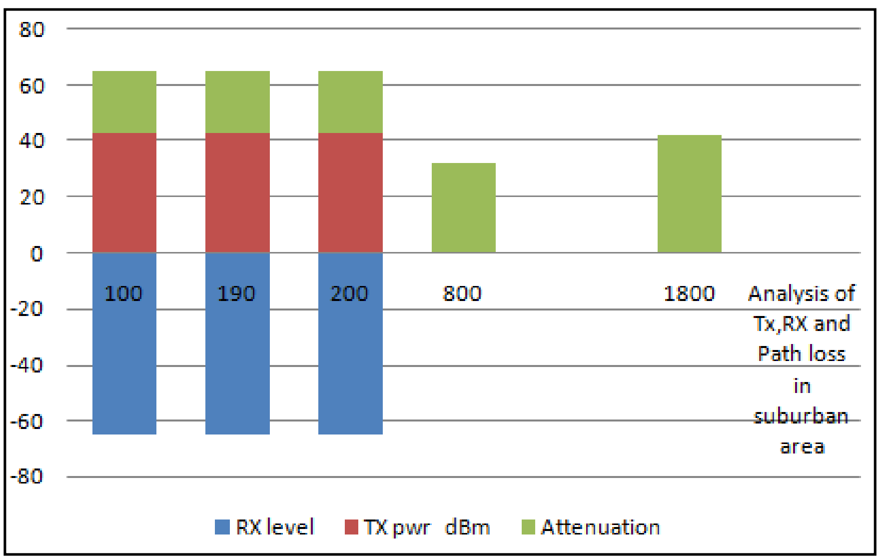


Figure 9.c. Analysis of path loss at suburban area

10. CONCLUSIONS

This work focuses on the path losses of various propagation models. For this, we have chosen three different terrains of Karnataka state like urban (MG Road), rural (Channapatna) and suburban (Kannaswadi). Here, we used drive test for achieving the same. With the help of spectrum analyzer and digital capture map tool, we were able to measure the path loss of various terrain regions and clutter of the same. To the measure the path loss between Tx and Rx, the RF range used was 940 MHz GSM frequency. Free space model path loss is less compared to other with 85 dB in urban, 102 dB in rural and 89 dB in suburban. Hata model is at larger scale with 158 dB in urban area, 139 dB in rural area and 142 dB in suburban area. The SUI model is maximum in scale in case of rural environment. Further, the work is focused on to test with Wimax frequency of these terrains.

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