Outdoor Path Propagation Modelling Building of Rajasthan at Frequencies of 900MHz and 2.1GHz

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Abstract—**Today many models are available for estimating RF signals through path propagation modelling for indoor as well as outdoor scenarios. Since all models are site specific, there is a vital need for simple models especially for environment pertaining to outdoor conditions of dry and hot conditions alike present in Rajasthan. This paper investigates the behaviour of RF frequencies of 900MHz and 2.1GHz, for envisaging the path propagation model. Here we have used a simplistic single slope model and have calculated path loss index for various scenarios in outdoor conditions [1, 11]. This path loss index can be directly used to estimate the received power at any position of cell site in similar outdoor condition modelled in this paper.**

Keywords: Path loss index, LOS, NLOS, Attenuation, propagation models.

I. INTRODUCTION

The astonishing success and tremendous growth of wireless services has paved towards breaking the location barriers. The need of reliable communication does not stop at the door of the building or some part of a building or a tunnel. There is a vital need of simple models which can be applied to envisage the level of signal required at different site of a cell may be in building or outside a building.

The wireless radio channel poses a several challenge as a medium for reliable high-speed communication. It is not only susceptible to noise, interference, and other channel impediments, but these impediments change over time in unpredictable ways. In this paper we will characterize the variation in received signal power over distance due to path loss and shadowing [19]. Path loss is caused by dissipation of the power radiated by the transmitter as well as effects of the propagation channel. Path loss models generally assume that path loss is the same at a given transmit-receive distance [10]. Shadowing is caused by obstacles between the transmitter and receiver that absorb power. When the obstacle absorbs all the power, the signal is blocked. Variation due to path loss occurs over very large distances (100-1000 meters), whereas variation due to shadowing occurs over distances proportional to the length of the obstructing object(10-100 meters in outdoor environments)[2-10].

Various models have been historically used to model path propagation for EM waves. The empirical models are based on measurement data at sites. These measurements thus provide a simplified general model with less accuracy. Semi deterministic models are based on empirical models based on the site they are applied to deterministic models are site specific they require enormous number of geometric information about the site[9]. They are complicated but accurate. We intent to cover the basics of outdoor propagation based on practical parameters obtained by studying a specific college building. A site of specific model will be developed so wireless planning can be done before actual implementation of a real building [11].

1. Propagation Models:- A Theoretical Review

(a) Free Space Model [1,2,3,11]:

In this kind of modeling the received power is a function of transmitted power, antenna gains & distance between transmitter and receiver. The logic is that "the received power decreases as the square of the distance between transmitter & receiver" [1]. Major assumption of this kind of modeling is that there can only be single path without any obstruction between transmitter & receiver.

(b) Two Ray Ground Model [1,2,3,11,18]:

The model assumes that the total received power at the receiver end is the sum of powers due to two paths : first, the direct path between transmitter & receiver ;second, the path obtained by one ground reflection between the same transmitter & receiver separated by same distance as in case first. Another important parameter in this model is the height of location of receiver & transmitter with respect to the ground surface.

(c) Ricean & Rayleigh Fading Models [1,2,3,11,15,17]:

These models are used when multiple propagation paths exist between a transmitter & receiver. If there are multiple indirect paths between transmitter & receiver and no direct path exist between them than Rayleigh fading is said to occur but if there are multiple indirect paths along with one direct path between transmitter & receiver Ricean fading is said to occur. This implies that the phenomenon of multipath propagation gives rise to another feature in radio propagations called as fading. Due to fading effect, signals transmitted from the same transmitter are received at the same receiver with some time delay & thus in order to get an idea of measure of fading it is needed to correlate different signals received at the receiver in time-domain known as time-correlation.[5]

(d) Longley Rice Model[1,2,3]:

This model is only applicable in case of point to point communications & not of use for mobile communications. This covers 40 MHz – 100 MHz band of operation. It takes into account wide range of terrain profiles along with path geometry of terrain & refractivity of troposphere. Basically it deploys geometrical optics along with two-ray ground reflection model. One major limitation of the model is that it does not take any account of building & foliage.

(e) Okumura Model[3, 11]:

An empirical model developed by Okumura was a part of extensive measurement campaign. It is a good model for path loss profile is a simple power law relationship, where exponent coefficient is a function of frequency & antenna height. It is applicable for frequency range from 150 MHz to 1920 MHz also can be extrapolated up to 3GHz, for a distance range of 1Km to 100Km.

(f) Log-distance propagation model [1,2,3,11,13]:

The Log–distance propagation model is based on the theory that; the average received signal power decreases logarithmically with distance (d) between the transmitter and the receiver [8-9]. This can be expressed as;

$$PL\ (dB) = L_0 + 10n \log (d/d_0)$$

Where, PL is the reference path loss, n is the path loss exponent (usually empirically determined by filed measurement), d_0 is the reference distance in (km), d is the distance between transmitter and receiver in (km).

It is important to select a free space reference distance that is appropriate for the propagation environment. In large coverage cellular systems, 1 km reference distances are commonly used, whereas in microcellular systems, much smaller distances (such as 100 m or 1 m) are used. The reference distance should always be in the far field of the antenna so that near-field effects do not alter the reference path loss [8-10].

2. Measurement tools for propagation modeling

Transmitter	*Receiver*	*Antenna*
		

FIGURE 3.1 TRANSMITTER, RECEIVER AND ANTENNA USED FOR INVESTIGATION [1]

(a) Transmitter

The transmitter used for the investigation was an Agilent N9310A RF signal generator which provided a wide frequency range of 9 KHz to 3GHz with power level ranging from -127 to +3dbm. The modulation options available were AM, FM and pulse modulation.[1]

(b) Receiver

The Agilent N9340B is a handheld spectrum analyzer with a frequency range of 100 kHz to 3 GHz, tunable to 9 kHz. It has several different measurement modes. Each mode offers a set of automatic measurements that pre-configure the analyzer settings for ease of use. It provides ultimate measurement flexibility. The typical specifications include frequency range from 9 KHz to 3GHz and -144dbm average noise level with ±1.5 dB amplitude accuracy.[1]

(c)Antenna

At transmitter we used a sector antenna and at receiver we used a monopole antenna of suitable bandwidth at the given frequency of 900MHz & 2.1GHz.[1]

3. MEASUREMENT METHODOLOGY

The investigation was carried out in the campus of Vidya Bhawan Polytechnic College, Udaipur (Raj.). The College building is situated in the heart of city with lot of open plane space /fields around it. The fields are having very less cultivations. The building walls are constructed with bricks and the ceiling with concrete. The transmitter was fixed at a height of 1.5m and the receiver was moved. The readings were taken at a distance of λ/2 separations. [7, 9]

FIGURE 4.1 MEASUREMENT CAMPAIGN

Scenario 1: Single side open gallery on a same floor: This investigation is carried out on the first floor of electronics department. The transmitter was fixed at a height of 3meters. The hand held receiver was slowly moved in LOS, the received power reading were taken at an intervals of λ/2 distance. The corridor was typically open on one side, the open end had concrete pillar at a regular distance of 2.16meters.The other end of the corridor were class rooms with concrete wall and wooden door\window. The investigation was carried out at frequency i.e. 900MHz and 2.1GHz. and the transmitter was kept at 0dB power during the whole investigation**.**

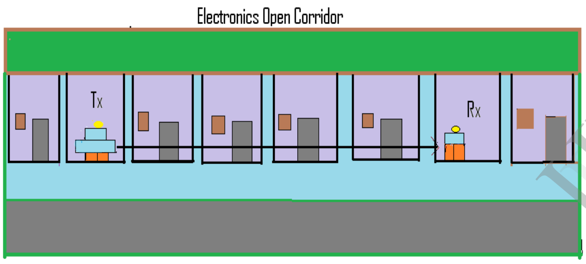

FIGURE 4.2: SCENARIO 1: SINGLE SIDE OPEN GALLERY ON SAME FLOOR:

Scenario 2: single side open gallery with one floor between transmitter and receiver : This investigation is carried out with one floor between transmitter and receiver. The transmitter was fixed at 3meters above the ground. The hand held receiver was slowly moved in NLOS on second floor corridor, the received power readings were taken at an regular interval of λ/2 distance. Both the corridors were same as explained in scenario 1.The investigation was also carried out at frequency i.e. 900MHz and 2.1GHz. and the transmitter kept at 0dB power for the whole investigation.

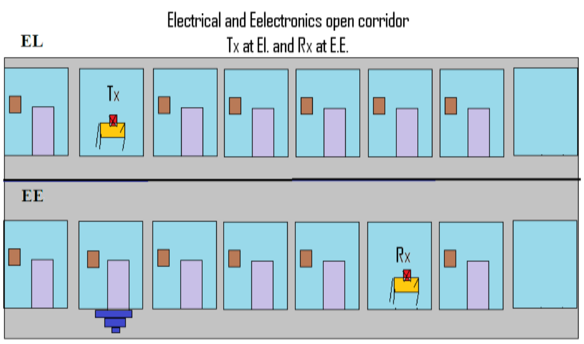

FIGURE 4.3: SCENARIO 2: SINGLE SIDE OPEN GALLERY WITH ONE FLOOR BETWEEN TRANSMITTER AND RECEIVER

Scenario 3: Receiver on open terries with two floor between Transmitter and Receiver: This investigation is carried out on open terries with two floor between transmitter and receiver. The transmitter was fixed at height 3meters above the ground in the ground floor. The hand held receiver was slowly moved in NLOS on terries, the received power reading were taken at an interval of λ/2 distance. The investigation was also carried out at frequency i.e. 900MHz and 2.1GHz. and the transmitter kept at 0dB power during the whole investigation.

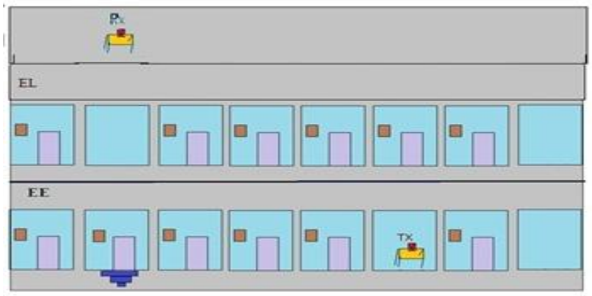

FIGURE 4.4: SCENARIO 3: RECEIVER ON OPEN TERRIES WITH TWO FLOOR BETWEEN TX AND RX

Scenario 4: Transmitter and Receiver in an open field: This investigation is carried out in open field on plane ground and with few trees. The plane ground was rectangular in shape of dimension 56meters and 40 meter. The two storied building on two of its side in 'L' shape. The transmitter was fixed at height 3meters above the ground. The hand held receiver was slowly moved in LOS, the received power reading were taken at an interval of λ/2 distance. The investigation was also carried out at frequency i.e. 900MHz and 2.1GHz and the transmitter kept at 0dB power for the whole investigation.

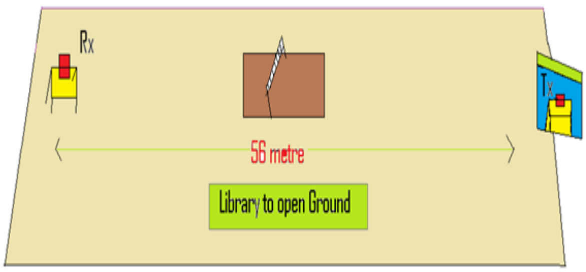

FIGURE 4.5: SCENARIO 4: T_X AND R_X IN AN OPEN FIELD

5. RESULT

Measurement of path loss index using single slope model.

Single Slope Model

The overall mean signal attenuation as a function of distance follows 'a $1\backslash d^n$' law, where d is the distance between the transmitter and the receiver and n is the slope index ranging typically from 2 to 6 depending on the environment.where n = 2 depict the attenuation in free space i.e. fall of 20 dB power per decade of distance, the characterization of signal attenuation with a single decay factor (n) is very useful[10-12]. Once a site specific factor n is estimated, a system designer finds it easy to use the factor for his calculation purpose. Several empirically based path loss models have been developed for different propagation environments, a similar effort has been done for developing models for Indoor, Indoor-Outdoor and Outdoor scenario using field measurements typically at 900 MHz and 2.1 GHz [2, 3, 4, 19].

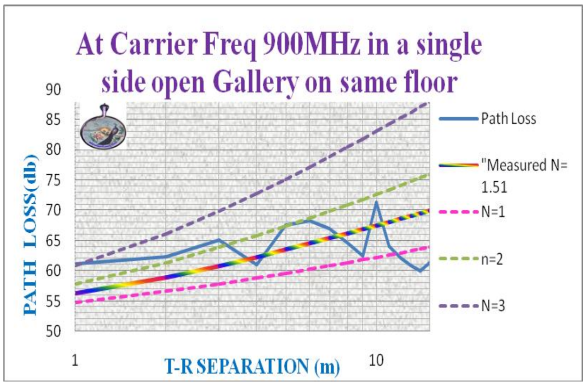

FIGURE 5.1: PATH LOSS V/S T_X-R_X SEPARATION AT FREQUENCY 900MHZ FOR SCENARIO 1

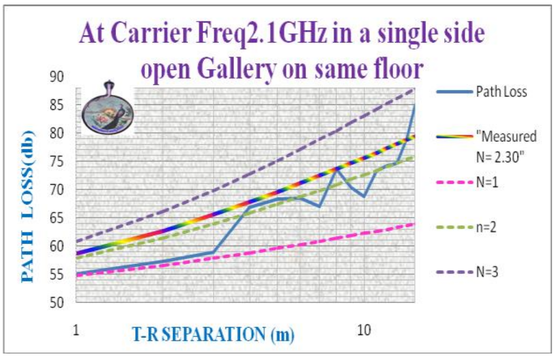

FIG 5.2: PATH LOSS V/S T_X-R_X SEPARATION AT FREQUENCY 2.1GHZ FOR SCENARIO 1

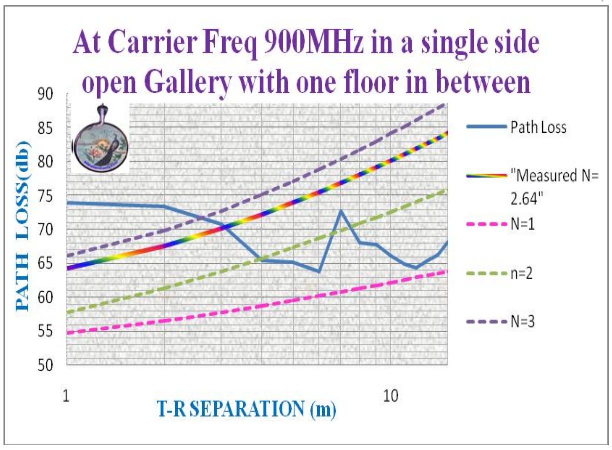

FIG 5.3: PATH LOSS V/S T_X-R_X SEPARATION AT FREQUENCY 900MHZ FOR SCENARIO 2

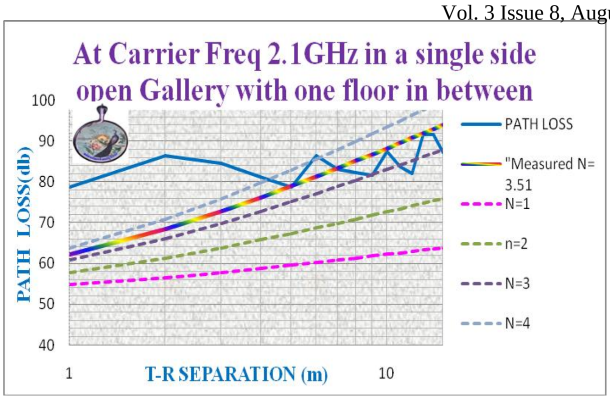

FIG 5.4: PATH LOSS V/S TX-RX SEPARATION AT FREQUENCY 2.1GHZ FOR SCENARIO 2

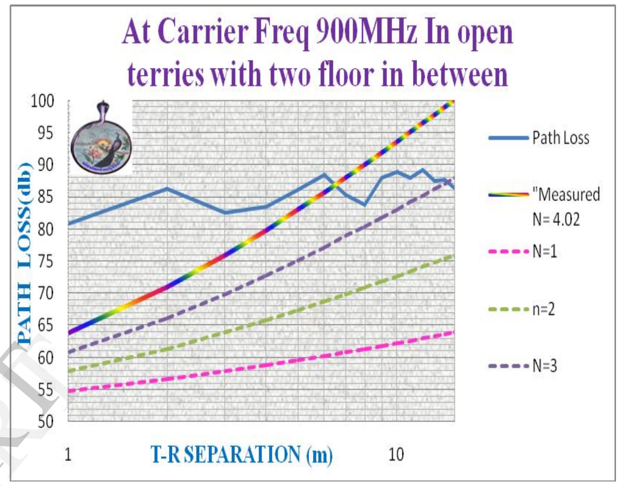

FIG 5.5: PATH LOSS V/S TX-RX SEPARATION AT FREQUENCY 900MHZ FOR SCENARIO 3

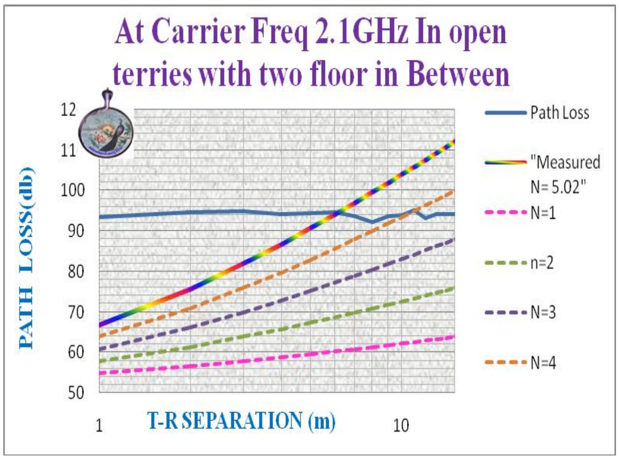

FIG 5.6 : PATH LOSS V/S TX-RX SEPARATION AT FREQUENCY 2.1GHZ FOR SCENARIO 3

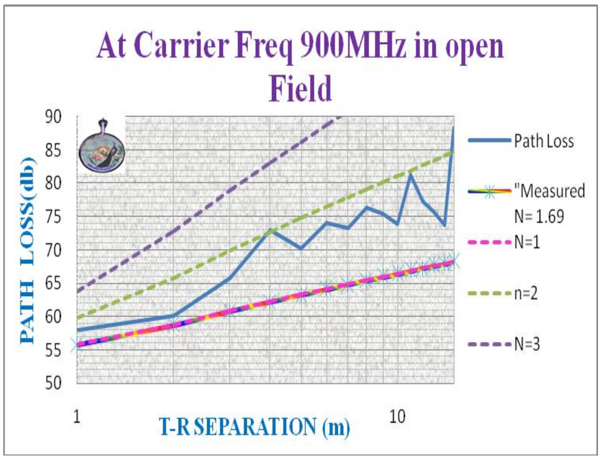

FIG 5.7: PATH LOSS V/S TX-RX SEPARATION AT FREQUENCY 900MHZ FOR SCENARIO 4

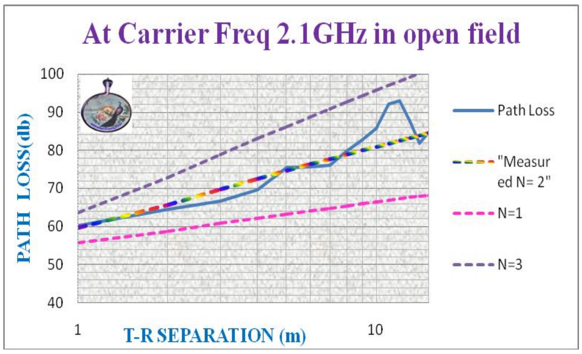

FIG 5.8: PATH LOSS V/S TX-RX SEPARATION AT FREQUENCY 2.1GHZ FOR SCENARIO 4

6. OBSERVATIONS:

Scenarios	Path loss Index	
	Frequency 900MHz	Frequency 2.1 GHz
1. Same floor LOS	n = 1.51	n = 2.3
2. With one floor in between NLOS	n = 2.64	n = 3.51
3. With two floor in between NLOS	n = 4.02	n = 5.02
4. In open field	n = 1.69	n = 2

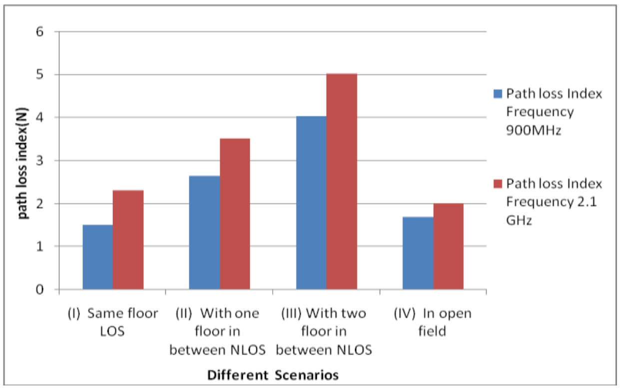

FIGURE 6.1 : PATH LOSS INDEX AT DIFFERENT FREQUENCY AND SCENARIOS

7. CONCLUSION:

The basic aim for this investigation was to determine path loss index using simple single slope attenuation model. The path loss index was determined for two frequencies i.e. at 900MHz and 2.1GHz for both LOS and NLOS scenarios. This path loss index will act as a very simple tool to calculate power at the site of any similar cell, before actual installation of the transmitter and receiver. The experimental finding proved that the path loss index was generally higher by 25% to 50% for 2.1GHz as compare to 900MHz. In scenarios 1 i.e. gallery model the path loss index was even less than 2 which is a free path loss index, this result leads to the conclusion that the gallery effect supports the RF propagation and probably it acts somewhat like a waveguide. Also the path loss index increase substantially as the number of floors increases. The result can be summarized as between transmitter and receiver path loss index increase with frequency and also with number of floors between transmitter and receiver.

8. ACKNOWLEDGEMENTS:

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