Path Loss Models for 5G Millimeter Wave in Urban Microcells at 60GHZ

Prof Jyoti Dange[1],Dr. R.P. Singh[2],Dr. Vikas Gupta[3]
[123]*Electronics and Telecommunication*
[1]*Ace(Malad) SSSUTMS,*[2]*SSSUTMS sehore ,*[3]*VCOE Vasai*
[1]*Mumbai ,India* [2]*Sehore,India*[3] *Thane,India*

Abstract

In this paper we focus on measurement for a future outdoor cellular system at 60 GHZ which directed in an urban microcellular environment with line of sight(LOS) as well as non line of sight (NLOS)situation utilizing different combinations of omnidirectional and directional transmit and receive antennas. .In support of the collected data ,in our research we describe a path loss model generated using the monte carlo simulation suitable for the improvement of fifth generation standard (5G)that shows the distance reliance of received power. This loss is communicated in simple formula as the entirely of an inaccessible of path loss factor and floating intercept that minimize the mean square error fit to the empirical data , here we illustrate the two path loss model demonstrating in two unlike scenario to analysis its different parameter ,such as received power ,path loss and path loss exponent.
Keywords*—60GHz; 5G; millimeter wave; path loss model; NLOS,LOS*

1. Introduction

Millimeter wave communication systems often defined within a frequency range of 30-300 GHZ where a total of 250 GHZ bandwidth are available .These frequency ranges are very significant to expedite the capacity requirement of future 5G networks . The millimeter wave frequency bandwidth coincides with a wavelength of 10 mm at 30 ghz which decreases to 1mm at 300 GHZ.By virtue of recent technology developed in smart phones or other remote devices, mobile data rates for internet access have increased dramatically during the last few decades .As per the industrial forecast,a 1000-crease increment in data traffic of mobile internet can occur in the year between 2010 and 2020[1][2][4].WLAN is base for all the smart devices, for high broadband wireless internet accessibility everywhere at hotspots ,home, shopping mall ,railway station, airport terminal as well as in office.Millimeter wave communication technology attracted a great interest through the academia and also from industry.Wireless Multi input multi output (MIMO) technology which tens to enable growing spectral efficiency and power efficiency is investigated in immense extent which moderately adopted[6] 5G millimeter wave frequency band is viewed likely to meet in new generation WLAN system mostly due to unused wide bandwidth .In 2001 , united state federal communication (FCC)[4] occupy bandwidth in 54-66GHZ band for a unlicensed usage [3] Since all countries like Japan,Australia ,korea and European union[4] also stated to allocate same 60 GHZ band frequency band [4]. Numerous antenna technologies are considered like a viable answer in a matter of contention during the 5G next generation, millimeter wave technology [7]-[11][4].The conventional system of antenna not able to provide high range ,better reliability and high throughput like Multiple antenna systems There are two categories of multiple antennas one is smart antenna system and another is spatial multiplexing based MIMO system[4]. Smart antenna systems produce diversity gain along with fading environment ,antenna gain and interference.The massive exploration and request for high speed data rates and large bandwidth got motivated research in a next generation cellular communication system[2] for 5G cellular systems. The millimeter wave band promises a large spectrum at 60 GHZ and is a massive energy frequency spectrum .

ISSN: 2233-7857 IJFGCN

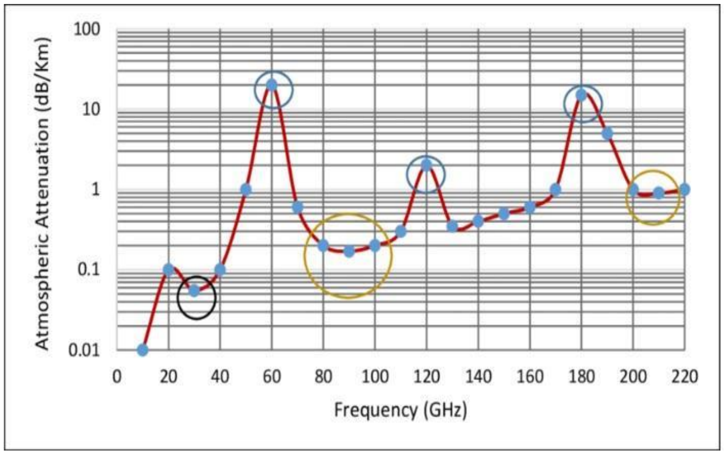


Figure 1. Atmospheric attenuation at different frequencies

Fig. 1: Atmospheric absorption of electromagnetic waves ranging 0 to 220 GHZ at sea level vs frequency, showing the additional path loss [2].

2. Literature Survey

Early to the omnidirectional path loss model [30]described in this paper, 3GPP and WINNER II [12][13][30]are used to provide the path loss model for long scale distance which result into mathematically based path loss model pertinent over a large scale distance in floating point intercept model. In symbolizing the radio wave propagation environment floating point intercept model [10]is completely contrast than the close in reference distance[10]do fitted to the MMSE line .Thus close in reference model become more accurate and such type of accuracy is not maintain in the floating intercept model In diversity to floating intercept model[10] matching to the better error fit to the received path loss ,the close in reference model[3][21]

The two 3GPP and winner II path loss models give channel coefficient based real word propagation measurement in 3G and 4G for the different scenarios in the frequency 1GHZ to 6GHZ and RF frequency bandwidth 5 MHZ to 100 MHZ [12][13]. Although considering all above circumstances ,at millimeter wave frequencies these models are not authentic for channelization.There is a obligation of more exploration for the omnidirectional and directional propagation channel characteristics for the mm wave mobile as well as supporting broadband communication application in dense urban environment .Research is conducted by the SAMSUNG DMC and R&D [13]research team in NLOS environment revelling path loss exponent ,shadowing factor in close -in free space reference model[13].In wideband propagation measurement aal channel model investigating for the increased magnitude order increased in carrier frequency and RF bat 28 GHZ and 73 GHZ for investigating a viability of next generation is carried out in new york city in dense urban environment [14][3] which provide primitive report about the mm wave omnidirectional and spatindwidth convoluted for the faster data rate insistence. To study cellular propagation it is necessary to understand certain related terminology. Propagation path loss describes the attenuation of the signal while propagation in the channel It is required to classify the environment into LOS and NLOS between the transmitter and receiver. NLOS may be divided into necessary and heavily obstructed environment ,where moderate NLOS have small obstruction like tree and building edges that partway clot the optical path between transmitter and receiver and NLOS with heavily obstruction fully block the optical path [14] Future broadband cellular communication N/W require motivation and exploration exploring the underutilizing millimeter wave frequency spectrum. .For designing and operation knowledge about the densely populated environment is essential.

Table 1. Channel model simulator for indoor and outdoor channel model

Sr. No.	Model	Author	References
01	SIRCIM (simulate radio channel impulse response for indoor channel) [5]	Scidel and Rappaport	[5]
02	SMRCIM (Simulate mobile radio channel impulse response for outdoor channels)[20]	Weifeng Huang and Rappaport	[21][22][20]
O3	BERSIM(Bit error rate simulator)simulate mobile radio communication to estimate bit error rate[25]	Fung et al	[23][25]

TableI I describe Channel model simulator for indoor and outdoor channel model.We have mention the several channel simulator developed by previous researcher..Rappaport and scidel developed SIRCIM for a measurement, based on the statistical indoor channel model for very early developed wi-fi .Another simulation software used to generate channel impulse response[5].This model is developed by weifeng Huang and Rappaport.one more model ,BERSIM is a another simulation software used to find out bit error rate. This Simulator used mobile radio communication to simulate and estimate Bit Error Rate.

3. Problem Definition

Path loss is solely identified with the environment where transmitter and receiver conveying data to expected informed target.Path loss model generated utilizing the mix of numerical method and empirical approximation of data measured gather in a channel sounding [15]investigation.As per the required transmitter and receiver partition distance ,radio system engineer desire omnidirectional and directional path loss model to assess all out received power,as reconstruct from the two omnidirectional isotropic transmit and received antenna, that permit them to superimpose self assertive antenna patterns for contemplating different channels with various kind antennas.Radio engineer developed various directional and omnidirectional path loss model on basis of propagation measurement along with the antenna bandwidth ,antenna height,frequency and separation distance.

Only some time prior, ,researchers have concentrated on the rich millimeter wave band as a strong platform in 5G cellular system ,yet just a couple of channel measurement conflicts have directed to get idea about this high frequency system[1][2][7][8]. To produce a dependable path loss model for future MM wave system design ,path loss model must be worked for a link budget and beam strength forecast , with the consideration of directional and omnidirectional antenna array. Many research has been done on propagation measurement to collect the channel model statistics at 60 GHZ.[1][2][7][15][16].The observationally based channel specification from urban environment were investigated to invent path loss model and resulting work has indicated how multiple beam can give cell inclusion expansion upto 80%when four negligible beam are joined.[17]In this urban path loss models at 60 GHZ,the greatest cell span was seen as 200 meter utilizing a solitary 1o-degree beamwidth antenna with end user randomly and consistently disseminated over the territories. Time cluster and spatial cluster are utilize in NYUSIM simulator to model the omnidirectional and path loss model. Angle of arrival(AOA) and angle of departure

ISSN: 2233-7857 IJFGCN

(AOD) [15]are successfully modelled in NYUSIM.This simulator is motivated by the measurement which have shown multiple path in time cluster is arrived at unique pointing angle which is observed due to directional antenna .This feature not noted in 3GPP and WINNER model [18][19] .

4. Proposed Method

4.1Channel Modelling

We perform a simulation of millimeter wave at 60 GHZ through NYUSIM simulator based on Monte Carlo simulation .The simulation has been performed and is dependent on wideband propagation channel measurements in millimeter-wave (mmWave) frequencies [9] in two diverse condition in urban microcell (UMi) like LOS and NLOS.It gives an correct rendering of current channel drive reactions in both existence, just as real signal levels that were estimated with carrier frequencies from 500 MHz to 100 GHz, [3]and RF bandwidths from 0 to 800 MHZ.channel model used is statistical spatial which apply time cluster and spatial lobe to model the path loss model corresponding to departure and arrival angle. The simulation was performed to generate a certain number of samples of channel impulse responses at particular T-R separation distances ,where large numbers of samples and the range of T-R separation distances are to be specified by the user. Multipath propagation is capitalized by multiple transmission and receiving antenna described as multiple input multiple output(MIMO) to multiply radio link capacity.MIMO illustrates the simplest model as shown in fig 1 in a different possible path between transmitter antenna and receiving antenna. MIMO model is described by the following equation

$$Y=H\ mk+n$$

H is the -NrxNt MIMO channel matrix with independent Gaussian components of mean zero and variance one,

Where y is o/p signal vector
H is a channel matrix where with dimension $Nr \times Nt$ channel

hm,k(f) are elements of channel H where m =1, ...,Nt

and k = 1, ..., Nr.

We consider a 4X4 MIMO user system which represents the channel impulse response[29] coupling the jth antenna at the base station to independent and identical gaussian distribution.
we performed a simulation for random MIMO channel realization[3] with 24 input parameter values are described in table II

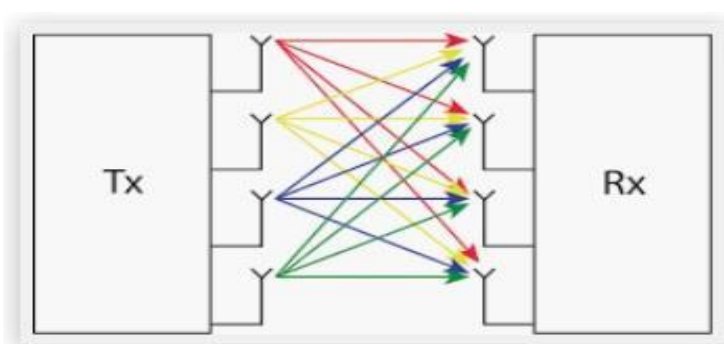


Figure 2 .4x4 mimo system

4.2..Theoretical Path Loss Models

For 60 GHZ there are 4x4 antenna element mounted for transmitter and receiver with about 100 beamwidth for both azimuth and elevation plane .Each transmitter antenna reflected four bem to the receiver side. All four bems are assumed to serve UE simultaneously.Omnidirectional and directional both path loss at an arbitrary distance d both at LOS and NLOS may be estimated using formula equation 1,2,3

$$PL(d)[dB] = PL(d0)+10\ n\log10\ (d/\ d0)+X\sigma\ (d \geq d0) \text{............ (1)}$$

$$\text{where, } PL[dB](d0) = 20\log10(4\pi d0\ /\lambda\ ) \text{.............. (2)}$$

$$\lambda = c/\ fc \text{......................... (3)}$$

where

1) d0 (m) is the free space reference distance
2) λ (m) is the carrier wavelength
3) c =3×108 m/s,
4) fc (Hz) is the RF carrier frequency,
5) n is the path loss exponent
6) Xσ is the typical log-normal random variable with 0 dB mean and standard deviation σ that models large scale fading [16].

   Note that PL(d0) in Eq. 1 models the frequency dependence through λ. In this work, we specify d0 =1m for simplicity [1].

Table 2. Definition related toPath loss model for omnidirectional and directional antennas.

Scenario	Description
LOS	This scenario describe there is no obstacle between transmitter and receiver
NLOS	This scenario describe there is some are obstacles present between transmitter and receiver

In table 2, some terminology related to path loss models are described like LOS and NLOS .Both scenarios are considered for directional and omnidirectional antennas and clear result is shown in all figures from 3 to 8 with respect to absolute propagation time and T- R separation distance. In table 3 different parameters considered for the channel modelling in which 4 transmitter and 4 receiver are considered as we are modelling the 4X4 MIMO system.

Table 3. parameter value for Path loss model for omnidirectional and directional models.

SR NO	PARAMETER	VALUE	SR NO	PARAMETER	VALUE
01	Frequency	28 GHZ	13	TX Array	ULA

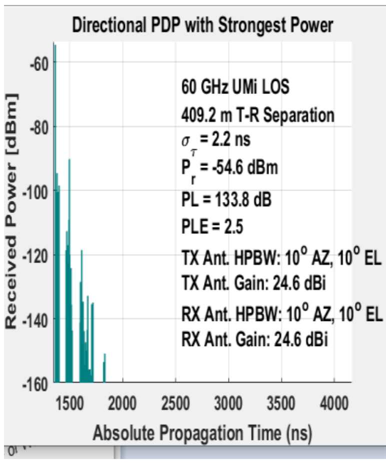
ISSN: 2233-7857 IJFGCN

02	RF bandwidth	800MHZ	14	RX Array	ULA
03	Scenario	LOS	15	Number of Transmitter (Tx)antenna elements Nt	4
04	Environment	UMI	16	Number of Receiver (Rx) Antenna Elements Nr	4
05	Lower Bound of T-RSeparation Distance	100 M	17	TX Antenna Spacing wavelength	0.5
06	Upper Bound of T-R Separation Distance	100 M	18	Rx Antenna Spacing wavelength	0.5
07	T-X POWER	30 DB	19	Number of transmitter (Tx) Antenna elements per row wt=4	4
08	Biometric pressure	1013.25m bar	20	Number of receiver Antenna{Rx) elements per row wr:4	4
09	Humidity	50 %	21	Tx Antenna AzimuthHPbw	10
10	Rain Rate	0mm/hr	22	Transmitter (Tx)Antenna Elevation HPBW	10
11	Polarization	co-pol	23	RX antenna Azimuth HPbw	10
12	Foliage loss	no	24	Tx antenna Tx Antenna Elevation HPBW	10

5. **Result**

Figure . 3 and Figure 4 shows directional and omni-directional power delay profile[5] at 60 GHZ at LOS respectively. . Power delay profile is the signal power distribution distribution over a multipath channel with respect to propagation delay. Figure also gives the value of received power and path loss exponent [27] in LOS environments,

ISSN: 2233-7857 IJFGCN



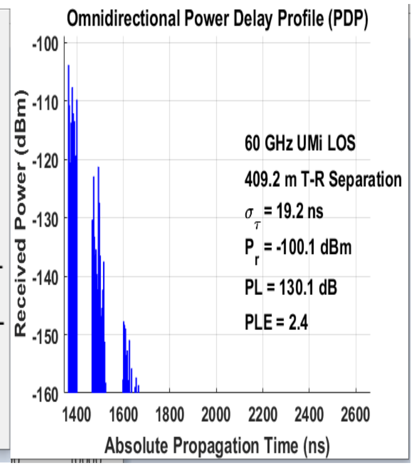


Figure 3 Directional power delay profile with strongest power at 60 GHZ LOS

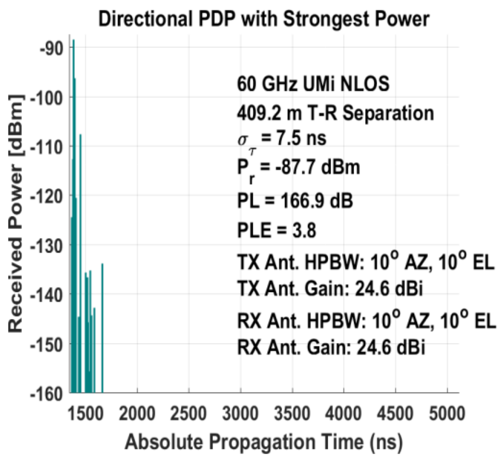
Fig 4 Omnidirectional power delay profile at 60 GHZ LOS

Table 3.: parameter values obtained by performing simulation for Path loss model [24]for omnidirectional and directional both at LOS and NLOS[24] models.

	Omnidirectional			Directional		
parameter	PR(db)	PL(db)	PLE	PR(db)	PL(db)	PLE
LOS	-100.1	130.1	2.4	-54.6	133.8	2.5
NLOS	-134.5	164.5	3.7	-87.7	166.9	3.8

Table III summarize the channel estimation parameters for the pathloss model of 60 GHZ for both LOS and NLOS scenario .Omnidirectional path loss is very less since PLE is less as compared to the path loss of directional antenna . Same impact of PLE is observed in both the cases of NLOS and LOS.

Fig. 5 and Fig. 6 directional and omni-directional power delay profile at 60 GHZ at NLOS respectively. Figure also gives the value of received power and path loss exponent in NLOS environments,



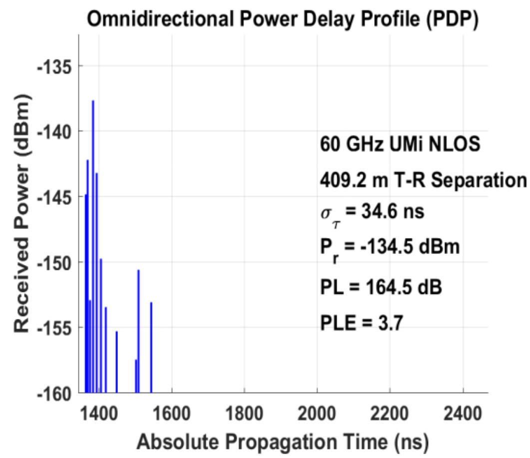
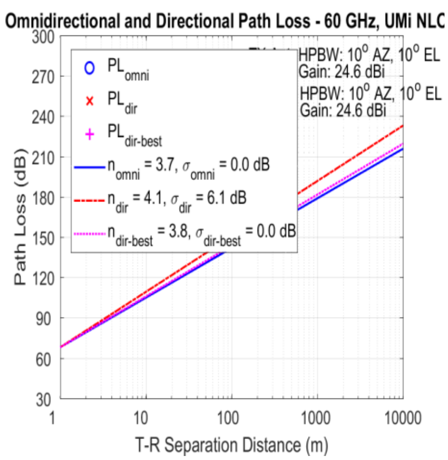


Figure 5. Directional power delay profile LOS with strongest power

Figure 6 .Omnidirectional power delay profile at 60GHZ at 60 GHZ NLOS



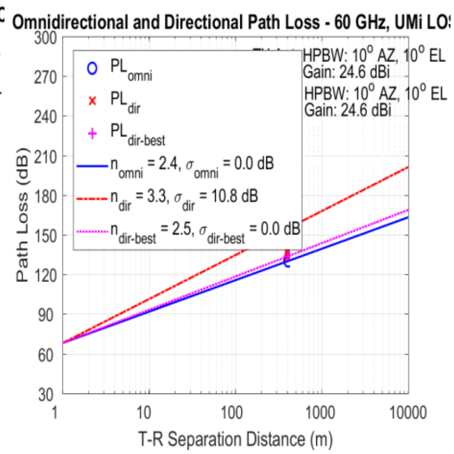


Figure 7 Omnidirectional and Directional path loss model at 60 GHZ NLOS

Fig 8 Omnidirectional and Directional path loss model at 60 GHZ LOS

Fig. 7and Fig. 8 shows Directional and omni-directional path loss model at 60 GHZ at NLOS respectively. Figure also gives transmitter and receive antenna gain in LOS and NLOS.

Conclusion

In this paper,We present 60 GHz omnidirectional and directional power delay profile[13] are presented,It also gives received power, path loss exponent and path loss also at NLOS and LOS.Path loss exponents for 60 GHz vary and it is higher in NLOS. We also present path loss model at 60 GHZ in two different scenario LOS and NLOS with respect to T-R separation distance .It also gives transmitter and receiver antenna gain and best directional path loss exponent.Mobile handset when implemented with the electrically phased on chip antenna array with beamforming and beam combining technologies to allow and evaluate the received power in a specific direction.

References

1) CISCO Cisco Visual Networking Index :Global Mobile Data Traffic Forecast update ,2012-2017[R].2013.
2) ZANDER J.MAHONEN P .Riding .The Data Tsu -nami in The cloud Myths and challenges in The Future Wireless Access[J]IEEE Communication Magazine ,2013,51(3):145-151.

3) Fcc Code Of Federal Regulation ,title 47 Tele Communication ,chapter 1 ,part 15.255 [R].2004
4) Yong S.K.Chong CC An Overview Of Multi Gigabit Wireless Through The Millimeter wave Technology :Potential And Technical Challenges [J]EURASIP journal on Wireless Communication And Networking 2007
5) MIIT XBW 2006 -082 Announcement of Application problem of Micropower (Short Range)Radio Technology at 60ghz band .In Chinese .https ://www.mit.gov.cn/n 11293472/n 11505629/n11506593/n11960250./n11960606/n11960700/n12330791.files/n12330790.pdf
6) FOSCHINI G.J.GANS M J on limits of wire -less communication in the Fading Environment when using the Multiple Antennas[J].Wireless personal communication 1998.693(3):311-335.
7) XU R WANG H TANG M,et al capacity optimization For The Short Range Los 3x2 MIMO Channel [c].The 18 th Asia Pacific Conference on communication (APCC),2012:396-401.
8) TORKILDSON E MADHOW U RODWELL M Indoor Millimeter Wave MIMO feasibility and performance [J]IEEE Transaction on Wireless Communication ,2011,10(12):4150-4160.
9) HANEDA K GUSTAHSON C WYNE S 60 GHZ Spatial radio transmission multiplexing or beamforming [j]?IEEE Transaction on Antenna And Propagation. 2013,61(11):5735-5743
10) LEE S J LEE W Y Capacity Of Multiple Beam Formed Spatial Stream Transmission In Millimeter Wave Communication Channel [J]IET Communication .2013 ,7(12):1263-1268.
11) CELLA T ORTEN P HJELMSTAD J Mimo Geom-erty And Antenna Design For A High Capacity And Improved Coverage In Mm Wave System [J]International Journal Of Antenna And Propagation 2013
12) Y Azar G N Wong K Wong R Mayzus J K Schulz, H Zaho F Gultierreze D Hwang And T S Rapaport ,"28 Ghz Propogation Measurement For Outdoor Cellular Communication Using Steerable Beam Antennas In New York City ,"2013 Ieee International Conference On Communication (2013) Icc ,June 9-13 2013 .
13) T S Rapaport , Et Al Millimeter Wave Mobile Communication For 5g Cellular :It Will Work !Ieee Access Journal .Pp 335-349,Vol 1 ., No 1 ,May 10,2013
14) New York University ,Nyusim ,2016 [Online] Available :https://wireless.engineering.nyu.edu/5g millimeter wave channel modelling software /.
15) 3GPP ,"spatial channel model for multiple input and multiple output mimo simulation ,"3rd generation partnership project 3G PP TR 25.996 SEP 2003 [Online] available :http://www.3gpp.org
16) P . Kyosti And Et Al ,"WINNER II Channel Models ,"European Communication ,IST WINNER ,Tech .Rep .DI1.2.,Sep 2007.[Online]Available :https :// project celticentitive.org/winner+/WINNER2-Deliverables/
17) 3GPP,"Technical Specification Group Radio Access Network ; Study On 3d Channel Model For Lte (Release 12),"3rd Generation Partnership Project TR 36.837v12.2.2.0June 2015 [online]Available :http://www.3gpp.org/dynareport/36873.html
18) T.S. Rappaport et al,"statistical channel impulse response models for factory and open plan building radio communicate system design ,"IEEE Transaction on communication ,vol 39, no.5 ,pp.794-807, May 1991.
19) Wireless valley communication ,Inc ,SMRCIM Plus 4.0(Simulation of Mobile Radio Channel Impulse Response Models)User Manual ,Aug.1990
20) K.Rajendran Et Al ," Concept And Implementation Of Semantic Web Archiving And Simulation System For The Rf Propagation Measurement ,"In 2011 Ieee Vehicular Technology Conference (Vtc Fall),Sept 2011,Pp1-5
21) Fung Et Al., Bit Error Simulation For Pi/4dqpsk Mobile Radio Communications Using Two Ray And Measurement Based Impulse Response Models ,"IEEE Journals On The Selected Areas In Communication ,Vol 11 No.3 ,Pp 393-405 Apr 1993

ISSN: 2233-7857 IJFGCN