A Proposal On Path Loss Modelling In Millimeter Wave Band
For Mobile Communications

N.S.Murtisarma
Sreenidhi Institute of Science and Technology
Yamnampet, Hyderabad-501301.

Abstract: A proposal for carrying out research work in mobile communications is outlined. A sample result on
scintillation is discussed. The result found in agreement with the published plot.

Key words: cellular systems, path loss, millimeter waves, absorption, personel communications.

1. Introduction

In the present cellular systems, frequency bands in VHF range namely, 800 – 900 MHz are used. As the number
of subscribers is growing day by day, the VHF band is unable to meet the demands. As a solution to this
problem, 60GHz frequency band in the millimeter wave spectrum is proposed due to its large bandwidth and
better propagation characteristics than that of visible and infrared spectra.

In the region between 10 and 100 GHz, there are two absorption regions; one is near 222GHz due to
water vapor and the other near 60GHz due to oxygen. The atmospheric absorption depends on the operating g
frequency with a peak loss at 60GHz of 15dB/km. The limited range caused by absorption can be turned into an
advantage in a secure communication system. By using a minimum required range and a narrow band width,
interference transmissions originating outside the links coverage can be avoided. For effective use of these
frequency bands, influence of meteorological conditions has to assess accurately. The advantages of using the
millimeter wave frequency band includes large bandwidth, increasing immunity both to friendly and hostile
interference and it can provide secure communications.

For the estimation of propagation path loss for designing the cellular mobile communication system, Hata
model is widely used. Maximum frequency of operation in model is 1500MHz. At present no model is available
for millimeter wave applications. Hence in this work frequency scaling technique is used to investigate whether
the Hata model can be extended to millimeter wave region.

A. Theoretical background

As per statistics only about one third of business telephones calls succeed in connecting the calling and
called parties. A large portion of business calls failure because people spend much of their time away from their
telephones. The fixed telephone network which provides connection to a place and not to a person is unable to
meet needs of a dynamic person (Seth, 1993). To overcome this constraint, cordless telephony for residential
users and mobile telephones for outdoor car mobile applications were developed. Personal Communication
Network (PCN) will allow a subscriber to be on line irrespective whether he is in office, residence or in transit.

The Oxygen absorption was first studied by Van Vleck (1947). The Oxygen absorption which is of
direct interest to the present discussion has absorption band at 60GHz. The Oxygen molecule (O₂) which is
paramagnetic has a permanent magnetic dipole moment. This is produced by the unpaired spins of two
electrons. This angular spin momentum can be described by a spin quantum number S=1. The rotations of the
oxygen molecule exclusive of spin can be described by the rotational quantum number. The magnetic moment
interacts with the end over end rotations of the oxygen molecule. The two moments combine vectorially to form
a total momentum vector described by the quantum number J which can take on the values J= [N-1, N,
N+1],because the oxygen nucleus is devoid of spin the pauli exclusion principle permits N to assume only odd
values but can vary from 1 to ∞. The energy levels J = N-1 and J=N+1 nearly coincide and differ from J=N by
energy intervals which depend on N and produce resonance frequencies around 60 GHz and also at other
frequencies like 119 GHz.

The attenuation by rain can be predicted accurately if the rain can be precisely described all the way
along the path. Path attenuation is essentially an integral of all the individual increments of rain attenuation
caused by drops encountered along the path. This is the physical approach to predicting rain attenuation.
Unfortunately rain cannot be described accurately along the path without extensive meteorological data bases,
which do not exist in most regions of the world. Most prediction models therefore resort to semi empirical
approaches, which calculate an effective path length through the rain, L eff, over which the rain fall rate is
assumed to be constant. This constant rain fall rate leads to a constant specific attenuation, yR, and the path
attenuation, A, is simply given by
A Proposal On Path Loss Modelling In Millimeter Wave Band For Mobile Communications

Radio transmission in mobile communication systems often takes place over irregular terrain. The terrain profile may vary from a simple curved earth profile to a highly mountainous profile. The presence of trees, buildings and other obstacles are to be taken into account.

A number of propagation models are available to predict path loss over irregular terrain. Most of these models are based on a systematic interpretation of measured data obtained from service area. One of the more popular outdoor propagation models is the longy-Rice model. This model is also known as ITS irregular terrain model. This model is applicable to point-to-point communications in the frequency range from 40 MHz to 100 GHz over different kinds of terrain. Okumara model is one of the most widely used models for signle prediction in urban areas. This model is applicable for frequencies in the range of 150-2000 MHz and distances of 1-100 Km. the Hata (Hata, 1980 ) is an empirical formulation of the graphical path loss information provided by Okumara.

B. National and international status of the proposal.

The expressions for amplitude and phase spectral density functions for complete solution and asymptotic expansion method are obtained (siqueira etal.,1991 ).the millimeter waves in an urban area experiencing fading due to multi path reflections and scattering.(Violette etal.,1988,thmos etal.). for the estimation of propagation path loss for urban, suburban and rural areas, empirical formulae are available at VHF frequencies which are using for designing the present systems(Hata, 1980 ). Various probability distributions like Gaussian distribution, Log normal distribution, Raleigh distribution etc. in radio wave propagation were studied. Besides this, several other papers textbooks and various telemetric and electronics for you were referred.

2. Proposed Methodology

During the early 1980s, analog cellular telephone systems were experiencing rapid growth in Europe, particularly in Scandinavia and the United Kingdom, but also in France and Germany. Each country developed its own system, which was incompatible with everyone else's in equipment and operation. This was an undesirable situation, because not only was the mobile equipment limited to operation within national boundaries, which in a unified Europe were increasingly unimportant, but there was also a very limited market for each type of equipment, so economies of scale and the subsequent savings could not be realized.

An estimation of scintillation effects is to be studied. Attenuation due to oxygen absorption and propagation path loss for urban areas are to be studied. Asymptotic expansion method is used for estimating the spectral density functions. Variance is to be estimated from the spectral density curve. From this information, standard deviation is deduced. Fading level of scintillations is calculated from the standard deviation, which is to be added to the total propagation path loss for developing propagation model.

A. Work elements to realize the proposal

The work is being aimed at developing of path loss model for mobile communication systems. This is planned to achieve through the following tasks

1. The principles of working of various mobile systems will be understood.
2. Rain induced attenuation effects revelent to mobile communications will be surveyed.
3. Investigation of appropriate path loss model at millimeter wave frequencies.
4. The developed model will be validated experimentally.

3. Result and discussion.

3. Result and discussion.

![Figure 1: Log-amplitude scintillation spectrum at 55GHz for a plane wave](image-url)
Fig 1 representing the comparison of log amplitude spectra at 55 GHz for plane wave for wind speeds 1.0 m/s and 2.0 m/s. The plots for the programs asdp55.m and asdpv2.m are super imposed for obtaining the figure. It is observed that the energy content in both the low frequency region and high frequency regions is more for higher wind speeds and left for lesser wind speeds in transition regions. Also noticed that corner frequencies increased with wind speed. Results obtain are matched well with the published results. The log amplitude and phase spectra at 55 GHz, 57 GHz are almost the same which are indistinguishable due to a small change in wave number. In the high frequency the expression for the cross spectral density function for spherical wave case are twice those for the plane wave case. In low frequency region, phase spectrum for both spherical wave and plane waves are the same in low frequency region log amplitude auto spectra for spherical wave is approximately 10 dB lower than plane wave case. For theoretical scintillation spectra, numerical evolutions can not be extended to higher frequency components due to the divergent nature of the confluent hyper geometric function and Meijer’s G function which make the evaluation routines numerically unstable. A fading level of about 30 dB is to be consider for urban environment due to multipath reflections for an operating frequency of 57 GHz. Frequency-scaling techniques can be applied to Hata’s model at 60 GHz. When frequency scaling techniques is applied, obstacles like trees, trucks, buildings etc. can not be scaled when fade margin is considered; total path loss is nearly equal to the path loss with that of Hata model. Gaussian distribution is considered for estimation of scintillation effect on propagation path loss. Amplitude scintillation is of the order of 1.6 dB peak to peak, observed a slight effect on the propagation path loss. It is possible to conclude, a 57 GHz cellular system is ideal choice to meet the increasing demands of the subscribers.

4. Conclusions
A proposal to working in modeling area of mobile communications is outlined. A sample result that was in agreement with the published plot is also presented.

Acknowledgement
The drafted proposal is based on association of Sri J.V. Ram Mohan Rao, BSNL, Hyderabad. Thanks are due to his kind co-operation.

References