Modeling Aspects of Fade at Ku Band of Frequencies

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Abstract: *One of the problems laid down by these millimetre wavelengths (either for terrestrial or satellite telecommunication systems for fixed services) is to mitigate the influence of the atmosphere on propagation. As the operating frequency is increased, the attenuation and scintillation effects of atmospheric gas, clouds and rain become more important. This paper reviews various dynamic aspect of rain attenuation, explaining their meaning and their essence in the design of FMT systems, and presents the details of prediction models for these dynamic aspects like fade slope, fade depth, fade duration, and frequency scaling etc.,*

Keywords: Fade Slope, Fade Dynamics, Propagation Impairments, Satellite Communication.

1. INTRODUCTION

The demand of ultra wide bandwidths for high speed, high quality, and multimedia transmission is driving the use of higher radio frequency spectrum. Satellite systems which are using Ku and Ka b and frequencies to cope with the increasing demands on frequency for larger communications capacity were introduced. Precipitation has become a serious source of attenuation as higher frequencies are being employed for microwave propagation.The primary propagation factors that effect Ka and Ku band earth satellite channels include: Rain attenuation, wet antenna, depolarization due to rain and ice, gaseous absorption, cloud attenuation, atmospheric noise, and troposphere scintillations. Among all these f actors, rain fade presents the most challenging impediment (challenging) to system designers because signal attenuation due to rain is the most severe effect at higher bands. According to many works reported yet [1], rain attenuation at 20 GHz is almost three times that at 11 GHz and it can easily exceed 20 dB in many areas of the world. Rain attenuation is a function of frequency, rain intensity, raindrop size distribution, raindrop temperature, elevation angle and polarization angle. Watson etal., & Leitao and Watson [2] have developed methods for prediction of attenuation due to rainfall in the European region which are in the climatic maps considering the key parameters.

Application of these models leads to know the physical structure of rainfall. There is currently no physical understanding of the statistics of heavy precipitation. Enough data from many locations is required to describe completely the rain process and its effects on the propagation of electromagnetic waves. By attenuation statistics is usually meant the attenuation probability distribution (fading distribution) characterization a particular communication link. The propagation prediction for effects of rain depends on the rain rate statistics. Rainfall rates in tropical regions vary quite significantly from month-month due to season variation. Further, diurnal variation of rainfall rates could be different for different parts of the world. Because of the significant seasonal variation in rain attenuation which causes major system degradation, such as link cutoff events occurring mostly in worst month. The emphasis on worst month statistics was made my workers Timothy etal., [3].Almost all rain attenuation prediction methods require including that of ITU-R [4] requires one minute rainfall rate data (A rainfall rate for only 0.01% of the time is used in ITU-R method).If one minute rainfall rate data is not available for a particular location, then one can use the methods for predicting one minute rainfall rates reported by Rice and Holmberg [5]. A better prediction was suggested by Morita etal., [6] that depending on the area which uses only mean annual rainfall as the meteorological data. And methods for converting one hour rainfall rate to one-minute rainfall rate are also specified by Karasawa[7], Y Hosaya [8] , IEICE. Crane established a global map of 12 rain climate zones with assumed similar statistics [1]. All the above mentioned references can be used as a reference to convert the data and can be compared with the ITU-R models.

Attenuation may also occur when radio waves pass through rain filled clouds passing overhead. Further when radio waves pass through highly charged thunderclouds and the layer of the atmosphere below the clouds they will suffer attenuation and scintillation due it complex refractive indices along the propagation. Attenuation measurements can be carried out with satellite TV signals together with rain rate. And also can be inferred from multi -frequency radar measurements of the variations in scattering cross section with range. If the radiometric measurement on attenuation is available rainfall along the entire trajectory profile can be retrieved [9]. There is requirement to carry out the study on the vertical profile of rainfall rate and attenuation at the Ka b and along the tropical regions.

2.FADE DYNAMICS:

To make operation of modern satellite systems feasible at frequencies above 10GHz, an appropriate fade mitigation technique (FMT) must be adopted. Apart from satisfying availability and QoS specifications, enhancing a satellite system with a FMT leads to realistic fade margins both economically and technically. An overview is given of the available models of different dynamic aspects of atmospheric signal fade :rain fade slope, fade duration slope, and frequency scaling is provided herewith in this paper and in addition, the important models useful for the studies are also presented. Fade slope indicates rate of change of attenuation [10]. Knowledge of this parameter is important for determining the required tracking speed of mitigation techniques. The fade slope depends on attenuation level, on sampling time and on climatic parameters. A few prediction models for this have been published which are listed below.

•Mattriciani-model: empirical expression of slope vs. attenuation [11].

•Timothy/Ong/Choo-model: Empirical expressions of fade slope distribution, dependent

•on attenuation, at 11 GHz [12].

•Several steps of modeling rain attenuation as a Markov chain [13].

•An adaptive method of calculating fade slope [14].

Fade duration indicates the time length during which attenuation will exceed a certain threshold value. This parameter is important for certain communications systems where length of outage time is critical parameter, but also for the design of fade mitigation techniques which make use of shared system resources. The fade duration depends on the attenuation level, frequency and elevation angle.

Several prediction models are available and many measurement results have been published.

•Parboni[15]

•Mattriciani E [16]

•Timothy et al., [17]

The parameters such as fade duration and inter fade duration statistics would be required to give potential customers, a good indication of the time try would have to wait before service id restored before rain stops.

For reliable statistics, many researchers made experiments and provides the final results of data analysis to obtain attenuation cumulative distribution, fade duration fade rate statistics. Knowledge of cumulative distribution of rain attenuation is used to provide an adequate margin in a communication system to achieve a desired availability against impairments imposed by rain. These fade duration statistics give insight into the constitution of total outage in a given period. Whether it is the result of few long fades or many short fades, this will affect the various services differently. Frequency scaling of attenuation provides the possibility to predict the attenuation at on frequency from that measured at another. This can be done either for instantaneous attenuation values („instantaneous frequency scaling") for the probability distribution of attenuation („long term frequency scaling"). Instantaneous frequency scaling is used by fade mitigation techniques which predict the attenuation on link in real time, from the attenuation measured on another link. Long term frequency scaling is useful for predicting the statistics of rain attenuation if the statistics at another frequency is available. Both for instantaneous and long term frequency scaling, many models are available.

•ITU-R

•Laster J D

•Karasawa

•Mattriciani E

3. SITE DIVERSITY GAIN PREDICTION MODELS

Some models for the performance prediction of site diversity systems are present in the literature: they can be classified into empirical and physical models. The former normally use an analytical relationship whose parameters have been obtained throughout a best-fit procedure on many experimental results; the latter start from a model of Sthe rain structure and evaluate its influence on the link(s) under test.

•Allnutt and Rogers [Allnutt and Rogers, 1982]

•EXCELL [Bosisio and Riva, 1998]

•Goldhirsh [Goldhirsh, 1982]

•Hodge [Hodge, 1982]

•ITU-R [ITU-R, 1997b]

•Mass [Mass, 1987]

•Matricciani [Matricciani, 1994]

4. RESEARCH STUDIES ON RAIN DROP SIZE DISTRIBUTION

Studies related to rain attenuation at Ku and Ka frequencies needs to be pursued further not only for operational usage but also for better understanding of the microphysics of clouds. This attenuation differs for one rainfall system to the other, i.e, it changes as a function of rain drop size distribution. Raindrop size distribution at the surface can be studied by using any of the commercial disdrometers. However, the vertical distribution of the DSD is much more difficult to retrieve and is utmost important for attenuation related studies. Radars operating at VHF/UHF band are ideal tools, either in combination or individually, to retrieve vertical profiles of DSD as they measure both ambient air motion and spectral broadening due to hydrometeors, simultaneously The raindrop size distribution function may have a great difference in different regions. There are many raindrop size distributions used in the calculation of possible specific attenuation values. The Laws and Parsons (LP) distribution is a reasonable choice for a mean drop-size spectrum in continental temperate rainfall at a rain rate below about 35 mm/h. The Marshall–Palmer (MP)

5. CONCLUSIONS

This presentation of the is data related to modelling aspects of fade dynamics at ku band of frequencies is divided into three parts with an emphasis on Rain Attenuation, Fade Dynamics Drop Size Distribution and its impact on the communication systems with details of the models. For further research technical specifications that are to be useful in estimation of various fade dynamics studies are to be gathered for modeling purpose.

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