Studies on Characteristics of Rain Fade at 23 GHz for Terresterial Links

Sum Chin Sean, Jafri Din, Tharek A.R, and Mohd. Zoinol Abidin

Wireless Communication Center
Faculty of Electrical Engineering, Universiti Teknologi Malaysia,
81310 Skudai, Johor Bahru.

Email: sumchinsean@hotmail.com, matjoin@hotmail.com

Abstract -Terrestrial links operating at frequencies higher than 10 GHz suffers degradation due to rain. Various researches have been conducted to study rain-induced degradations such as rain attenuation. Apart from rain attenuation, rain fade is also a major factor affecting the performance of a terrestrial microwave link. This paper therefore, seeks to investigate the impacts of rain fade to the performance of terrestrial microwave links. In this paper, rain fade slope and rain fade depth are investigated and analyzed. The superposition of rain attenuation and rain fade is also investigated. Signal fall time and recovery time are also major concern in this paper. All the analysis leads to understanding on the impacts of rain fade on the performance and reliability of microwave terrestrial links.

1.0 Introduction

For terrestrial microwave links operating at frequencies higher than 10 GHz, rain-induced degradations are significant. Major degradations caused by rain that affect the reliability and availability of terrestrial links are rain attenuation and rain fade. In researches to determine rain attenuation, receive signal of a terrestrial link is sampled to an integration time of one minute [1-3]. Besides attenuation, rain fade is another major factor affecting the performance of microwave links. Rain fade is the dynamic fluctuation of receive signal due to inhomogeneities of the signal path, ranging from a few seconds to a few minutes. Rain fade provides additional information on understanding the characteristics of rain-induced degradations.

The next section briefs on the research experimental setup. Then, the following section reports on results and analysis. The analysis is focused on rain fade slope and rain fade depth. Besides that, the relationship between fade slope to fall time and recovery time is discussed. The additional impact due to superposition of fade depth and attenuated signal is also discussed.

2.0 Experimental Setup

The experimental setup of the link consists of a transmitter and a receiver 300 m apart. The diameter of both antennae is 0.6 m. The operating frequency is 23 GHz. The link is applying horizontal polarization. The Automatic Gain Control (AGC) level (in Volts) of the receiver is connected to a data acquisition system continuously. The signal level is collected in one-second integration time. The signal level is then converted into dBm for analysis. The 300 m path length suggests that rain can be assumed homogenous along the signal path. Thus no correction factor both horizontal and vertical is needed. The experimental link setup located in Wireless Communication Center (WCC), UTM Skudai. The data used in this paper is the signal level collected by the data acquisition system throughout the year 1999. The illustration of the setup is shown in Figure 1.

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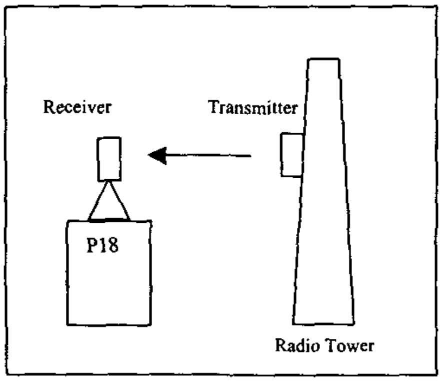

Figure 1 Setup for Experimental Link

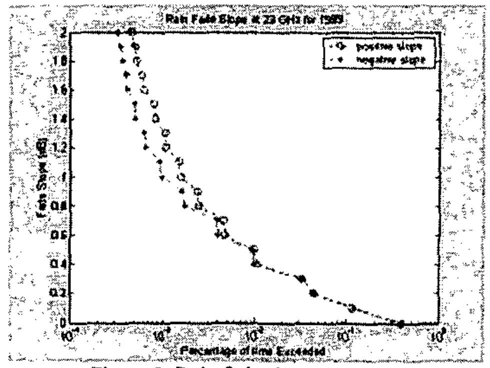

Figure 2 Rain fade slope vs. percentage of time in year 1999

3.0 Results and Analysis

In this section, the results for rain attenuation, rain fade slope and fade depth of the link are presented. Firstly, the positive and negative rain fade slope is analyzed in accordance to rain attenuation to understand the fall time and recovery time of the signal. Then negative rain fade depth is used to predict the impact of the superposition of the fade depth and rain attenuation.

3.1 Rain Fade Slope

The rain fade slope is divided into two parts: the positive fade slope and the negative fade slope. As shown in Figure 2, the positive and negative fade slopes are generally similar at percentage of time higher than 0.01%. The signal fade slope at *0.01% of the time in the year 1999 is 0.5 dB/sec.* The positive and negative fades are similar from this point onwards. At percentage lower than 0.01%, positive slope is generally higher than the negative slope. This means that at this point, the increase of signal magnitude due to rain is steeper compared to the decrease. Further elaboration is made when attenuation is included into the analysis. Fade slope investigation at other frequencies are given in [1] and [2].

3.2 Signal Fall Time and Recovery Time

This section presents a brief picture on the signal fall time and recovery time. The signal drop due to rain attenuation is presented in Figure 3. The attenuation level at 0.01% and 0.001% of time in the year 1999 is 17 and 25 dB respectively. Another research on rain attenuation for Ka band signal is given in [3]. The comparison between *rain attenuation and rain fade slope provides* qualitative information on the total time taken by the signal to fall from clear sky level when rain events occur and the time taken to recover to clear sky level when rain events cease. The rain fade slope and rain attenuation for 0.01% of time in year 1999 are 0.5 dB/sec and 17 dB respectively. Thus the signal fall time can be predicted to be approximately 34 minutes. At this level, due to the similarity of the positive and negative fade slope, the recovery time is also approximately equivalent to the fall time. The fall and recovery time starts to differ at time percentages lower than 0.01%. As shown in Figure 2, the curves for positive and negative fade slope diverge. The fall and recovery time can also be used as additional information to analyze the duration of rain events taking place. The result can also be verified by conventional methods of measuring duration of rain events.

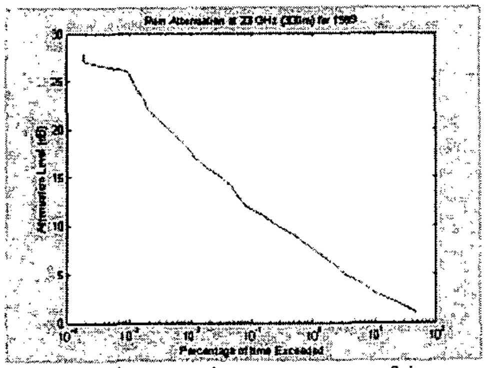

Figure 3 Rain attenuation vs. percentage of time in the year 1999

3.3 Rain fade depth

Compared to fade slope, fade depth is less investigated. A literature review on fade depth is given in [4]. Rain fade depth can also be divided into positive and negative depth. The results of data analysis show that the curves for positive and negative rain fade depth display a difference in approximately 0.2 dB at time percentage lower than 0.01%. At percentages higher than 0.01%, both curves are similar, as shown in Figure 4. At 0.01% of time in year 1999, the fade depth is 0.8 dB. Besides, it can also be observed here that there is a significant similarity between the rain fade slope and rain fade depth data, that is, the positive fade tends to display a higher value than the negative fade.

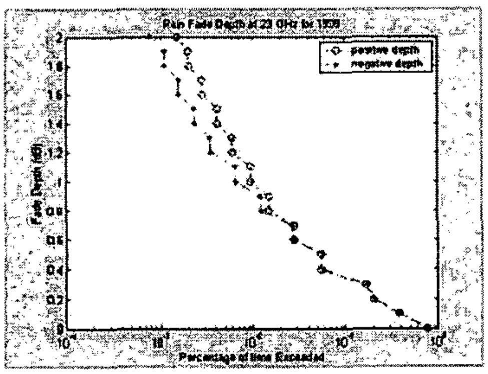

Figure 4 Rain fade depth vs. percentage of time in the year 1999

3.4 Superposition of attenuation and fade depth

The rain attenuation at 0.01% time of year 1999 is 17 dB. The rain fade depth at 0.01% time of year for the same year is 0.8 dB. The combination of the information suggests that when the superposition of rain attenuation and rain fade depth takes place, an additional drop of 0.8 dB may occur at the attenuated signal. The superposition of attenuation and fade depth tends to result in more severe effects to the receive signal in a communication system.

4.0 Conclusion

This research seeks into investigating rain fade phenomena and its characteristics. The different behaviors of rain fade have different impacts in communication links during rain events. As a result, the availability of the system will be affected. In order to design a communication link with satisfactory availability and reliability, understanding the mechanisms of rain fade is essential.

5.0 Reference

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