

CHAPTER 1

INTRODUCTION

This chapter covers the literature review and the significance of this project. It also tells about the outline of this thesis.

1.1 Literature Review

1.1.1 Effect of High Frequencies to Electromagnetic Wave

Since communication at lower frequencies is getting congested, the use of frequencies in higher spectrum band is currently in demand by the designers. Higher bands provide wider spectrum for communication but in contrast it suffer greater propagation loss. This can be easily determined by the below mathematical formula for free space loss:

$$L_s = 32.45 + 20 \log dkm + 20 \log fMHz$$

Higher bands from 1 GHz to 300 GHz are call microwave. Microwave is form of electromagnetic energy and can be described with the term of radio frequency or RF. RF emission and associated phenomena can be discussed in terms of energy, radiation or fields. In term of radio wave propagation, we can define radiation as the propagation of

energy through space in the form of waves or particles [1]. Figure 1.1 below illustrated radiation as waves of electric and magnetic energy moving together through space.

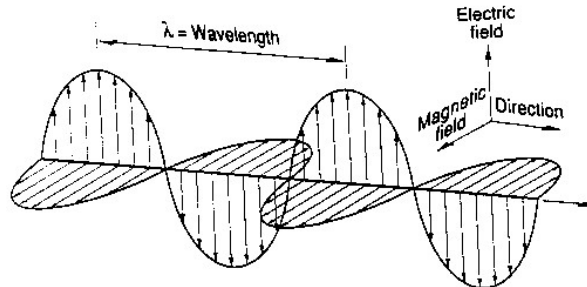


Figure 1.1 Electromagnetic wave

Electromagnetic energy can be characterized by a wavelength and a frequency. The wavelength is the distance covered by a complete electromagnetic wave cycle, while the frequency is the number of electromagnetic waves passing a given point in a second. Electromagnetic waves travel through space at the speed of light. The wavelength and frequency of an electromagnetic wave are inversely related by a simple mathematical formula given below:

$$\lambda = \frac{c}{f}$$

where:

λ = wavelength

c = speed of light

f = frequency

The speed of light in a given medium does not change, resulting in shorter wavelength for high frequency electromagnetic waves. Hence, when operating at high

frequencies, rain becomes a major obstacle as it will scatter the signals when the size of the raindrops is larger than the waves. To make it worse, places experiencing heavy rainfall will suffer greater interference and consequently degrading the signal or waves.

1.1.2 Effect of Rain to Electromagnetic Wave in High Frequencies

When it comes to tropical countries like Malaysia, Indonesia and Thailand, the losses become higher because of heavy rain. It can degrade the radio wave propagation at frequencies 10 GHz and above [2]. To be more specific, propagation of radio waves through the atmosphere above 10GHz involves not only free space loss and loss due to rain, but other factors listed below also contribute to the additional loss [3]:

- i) The gaseous of the homogeneous atmosphere due to resonant and nonresonant polarization mechanism.
- ii) The inhomogeneties in the atmosphere
- iii) The particles due to fog, mist and haze (includes dust, smoke and salt particles in the air)

Earlier approach to deal with rain is on a basis of rainfall given in millimeters per hour. This was usually done with rain gauges, using collected rain averaging over a day or even periods of days. However, for path design above 10 GHz, such statistic are not sufficient where designers may want path availability better than 99.9% and do not want to design using conservative procedures.

A researcher, Hogg, suggests that the use of high speed rain gauges with outputs ready available in computer analysis [3]. These gauges can provide minute by minute analysis of the fall rate, unlike the conventional type of gauges. But it is desirable to have several years' statistics for a specific path to provide necessary and accurate

information on fading caused by rainfall that will determine the parameters such as LOS repeaters, size of antenna and so on.

Realizing the importance of this rainfall data, a large body of information on point rainfall and rain rates has been accumulated since 1940 [3]. This information shows a great variation of short-term rainfall rates from one geographical location to another.

Researchers in countries experiencing heavy rain especially in South East Asia countries including Malaysia have been doing active research regarding rain and its effect to communication system for the past 10 years. The tropical climate makes the research topic relevant to get a better quality of communication in microwave bands throughout the country.

1.2 Problem Statement

Rain attenuation model that has been used worldly is currently base on ITU model. It gives same rain rate for all places in Malaysia. It classified Malaysia under P climatic region where the rain rate for 0.01% of the year ($R_{0.01}$) is given as 145 mm/h [3], [5], [6]. The latest ITU Recommendation notes peninsular Malaysia experiences 120 mm/h rain rate and West Malaysia 100 mm/h for 0.01% of the year [7]. Figure 1.2 shows the latest rain rates in Malaysia and in its neighbours given by ITU.

However, previous study in Malaysia conducted by researches in UTM shows that rain rate is not the same for different places in Malaysia. It is localized where some places experience heavier rainfall compared to other places.

Therefore, the ITU-R model does not give an accurate prediction of rain attenuation in Malaysia, where the attenuation is supposed to be localized base on the data of the rain rate

1.3 Research Objectives

In accordance with active researches in rain that are being done in Malaysia and its relationship with communication, this project is aimed to develop a computer program in order to predict localized rain attenuation for terrestrial microwave links in Peninsular Malaysia. This program will be based on given data. Once the program has been developed, the result from that simulation of the program is compared with ITU-R rain attenuation model.

1.4 Thesis Outline

This thesis consists of five chapters. Chapter 1, which is this chapter, covers the literature review, the significance of this project and the outline of this thesis.

Chapter 2 gives a brief theory of rain attenuation prediction methods. This includes rain attenuation calculation for terrestrial microwave path, path length reduction factor models and rain attenuation models that are widely used nowadays. Comparison between those models is also done and the reasons why the appropriate models are chosen to complete this project are stated.

In Chapter 3, all the methodology adopted in making this project a success is explained. The phases of methodology are written one by one and are also explained

briefly. A little bit of the MATLAB software that is used to build the program is also mentioned and explained.

Chapter 4 covers the results obtained from this project. The results include the program visual design, implementation, testing and user guide to use the program. Analysis of the results is also done by comparing them with the output from ITU-R model.

Conclusion about the research and the results obtained is discussed in Chapter 5. It also covers the proposed future works that can be implemented by future researchers to further enhance this project.

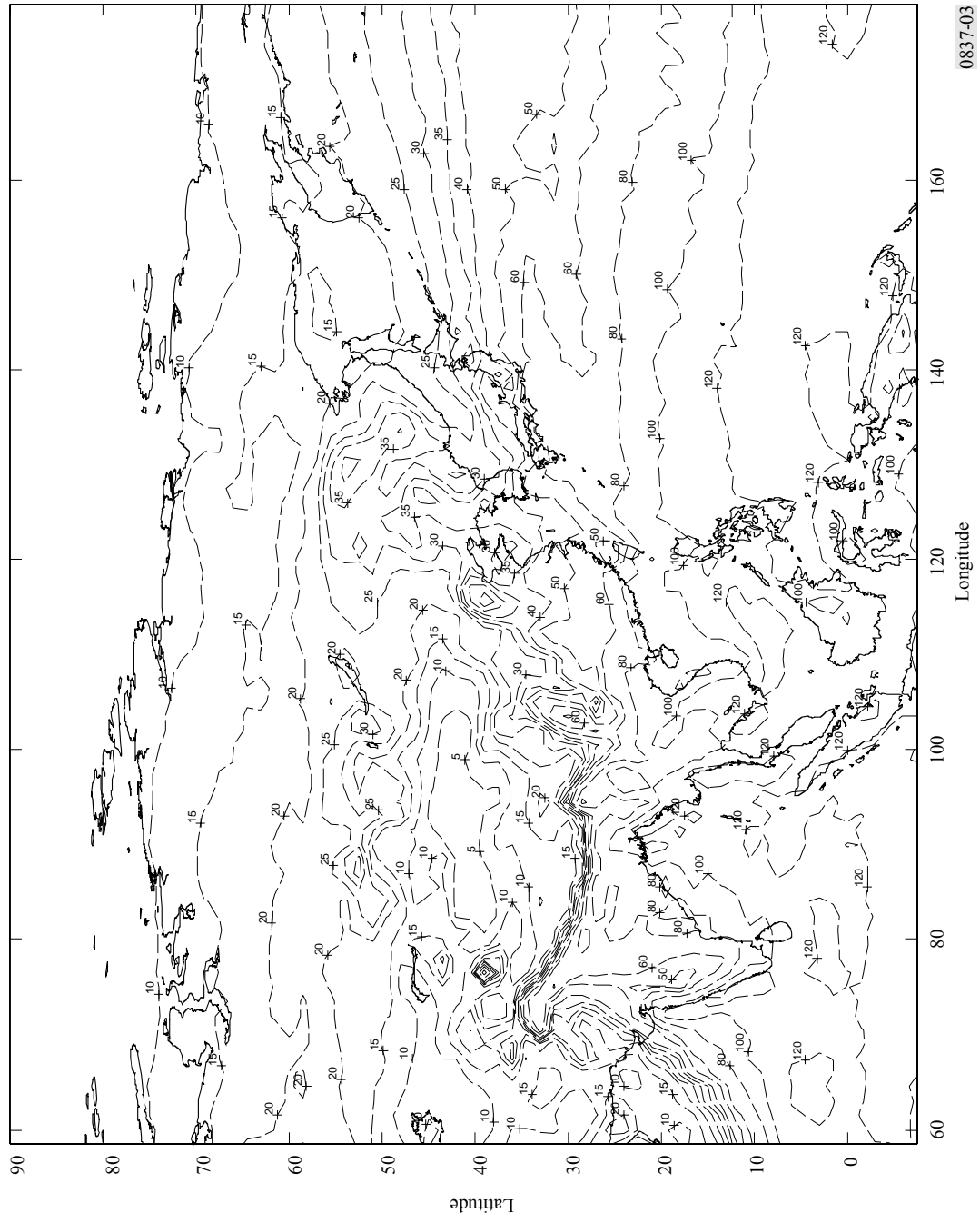


Figure 1.2 Rain rate (mm/h) exceeded for 0.01% of the average year