ANALYSIS OF C-BAND, KU-BAND AND KA-BAND FOR SATELLITE COMMUNICATION IN MALAYSIA

SAZRATULASMA BT MD SAAD

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UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN PENERIMAAN LAPORAN AKHIR PSM

.

Nota: Borang ini mesti ditaip kemas.

Nama Pelajar : SAZRATULASMA BT MD SAAD

No. Matrik Pelajar : B020310051 **Kursus** : 4-BENT

Tajuk Projek : Analysis of C-band, Ku-band and Ka-band for Satellite Communication in Malaysia

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To my beloved mother and father

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ABSTRACT

This case of study is to perform the analysis between Ku-band, Ka-band existing C-band in Malaysia according to their link budget (downlink from satellite to earth station) based on the system of the Very Small Aperture Terminal (VSAT). The analysis is based on the ITU-R model in term of the attenuation causing by atmospheric gases and rain and prediction is done by using MATLAB programming. Modern satellite communication has been made possible by combining skills and knowledge of space technology. But today, the signals many have losses according to our climate (Tropical Region). In some situations, part of the optical channel travels through the atmosphere that occasionally contains water vapor, rain as part of the communication channel causing signal power attenuation and temporal widening. In this analysis, Kuala Lumpur, Alor Setar, Kuantan, Johor Bahru and Kota Bharu are selected in term of different geographical and rainfall rate. Attenuation due to rain is higher at Ku-band (14/12 GHz) compared to C-band (6/4 GHz). Similarly, the attenuation due to rain at Ka-band (30/20 GHz) is 468.921dB is higher compared to Ku-band (14/12 GHz) is 105.7177dB and C-band (6/4 GHz) is 39.6165dB for 2006. For the frequency scaling, the overall analysis for 8 GHz, 12 GHz and 15 GHz Simple Power Law model can be used to scale the frequency. While, for 23 GHz, Battesti model has an experience in scale the frequency.

ABSTRAK

Projek yang dijalankan ini adalah untuk menganalisis Jalur -Ku dan Jalur-Ka untuk digantikan dengan Jalur- C yang sedia digunakan di Malaysia. Analisis ini adalah berdasasrkan VSAT (Very Small Aperture Terminal) sistem. Analsisi ini adalah merujuk kepada model ITU-R (International Telecommunication Union) untuk menganalisa kelemahan penerimaan isyarat yang disebabkan oleh gas dan hujan. Moden satellite menggabungkan pengetahuan dan kemahiran yang tinggi di dalam teknologi angkasa lepas. Namun, pada masa kini, sistem ini mengalami kemerosotan isyarat yang disebabkan gangguan dari hujan dan gas di mana negara kita, merupakan negara yang mempunyai iklim tropika yang menerima jumlah hujan yang tinggi sepanjang tahun. Dalam keadaan yang tertentu, isyarat ini mempunyai wap air yang terkandung, dan menyebabkan gangguan isyarat. Kajian ini memfokuskan kepada lima negeri yang dipilh iaitu Kuala Lumpur, alor Setar, Johor Bharu, Kuantan dan Kota Bharu kerana perbezaan geografi dan penerimaan hujan sepanjang tahun. Gangguan isyarat terhadap hujan adalah lebih tinggi pada Jalur-Ku berbanding Jalur-C. Bagi tahun 2006 gannguan terhadap hujan bagi Jalur-Ka (30/20 GHz) ialah 468.921 dB, lebih timggi berbanding Jalur-Ku (14/12 GHz) 105.7177 dB manakala Jalur-C ialah 39.6165 dB. Bagi frekuensi skala, untuk 8 GHz, 12 GHz dan 15 GHz model ‘Simple Power Law’ sesuai untuk digunakan, manakala bagi frekuensi tinggi, 23 GHz, model Battesti adalah yang terbaik.

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LIST OF COMPENDIOUS

WLL	-Wireless Local Loop
VSAT	- Very Small Aperture Terminal
WINDS	- Wideband Internetworking engineering test and Demonstration Satellite
BER	- Bit Error Rate
C/N	- Carrier to Noise Ratio
ITU-R	- International Telecommunication Union
EIRP	- Effective Isotropic Radiated Power
HPA	- High Power Gain
IF	- Intermediate Frequency
RF	- Radio Frequency
BPF	- Bandpass Filter
LNA	- Low Noise Amplifier
Pw	- Water Density
$R_{0.01}$	- Rainfall Rate
Hs	- Height above mean sea level
SD	- Site Diversity
ULSD	- Uplink Site Diversity
DLSD	- Downlink Site Diversity
SPU	- Signal Processing Unit
DCC	- Diversity Control Centre
DCU	- Diversity Control Unit
SDI	- Site Diversity Interface
SEM	- System Electric Model
STM	- Structure Thermal Model
LG	- Horizontal Projection
EB / NO	- Bit Energy to Power Noise Density

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In recent years, the use of satellite technology has become more attractive and improved the telecommunication scenario in the rural areas. Numerous telecommunication studies on satellite-based have been carried out in the world. The results show that, a satellite-based telecommunication network can provide efficient long distance telecommunication services to rural communities at a lower cost than land-based wired networks. The limitations to provide access of reliable telecommunication to the rural areas are including poor geographic conditions, low-income levels, low population densities and lack of essential social and economic infrastructure such as health, education, electricity, clean water and roads. In Malaysia, there are several options in providing telecommunication service to the rural people.

Wireless Local Loop (WLL) technologies for example, are now being used by Telekom Malaysia (TM) to bring telecommunication service to the rural people. Another wireless technology is by using a Very Small Aperture Terminal (VSAT) system that is provided by TM and also known as TM VSAT. For example, WLL system is usually covers only a few kilometers from base station. Another problem with existing satellite-based system is about rain attenuation for frequency above 10 GHz**.** The rain attenuation that has been used widely is ITU-R model. But some studies in tropical regions show that the model underestimates significantly this value. This makes the link performance are degraded below than predictable level. Presently, TM VSATs are operating at C-band (6/4 GHz) frequencies.

However, due to the congestion in the limited bandwith frequencies that are currently used, there is a demand to upgrade the system to higher frequencies and wider bandwith. The higher frequency bands, which will introduce in the study, are Ku-band (14/12 GHz) and Ka-band (30/20 GHz). This is because these bands offer wider bandwith, higher data rates, and assembled in small sized component, especially in Ka-band.

Frequency scaling method of rain attenuation has been used to obtain a rough estimation of the attenuation statistic at the desired frequency from measured attenuation values at another frequency. Many scaling models have been developed based on the theory and from empirical data from various propagation experiments [1]. In this report, the rain attenuation data was collected throughout Peninsular Malaysia from January 2005 to January 2007 at frequency of 8GHz, 12 GHz, 15GHz and 23 GHz. Then, the comparison has been made between three frequency scaling models and the measured data. The three models are being explained in the next chapter.

In order to overcome the rain attenuation problem in a tropical region area such as Malaysia, site diversity technique can be used different kind of weather. The site diversity technique consists of linking two or more ground stations which receiving the same signal from the same satellite. If this way, if the signal is heavily attenuated in certain path or area, the system will switched to another ground stations. The intense of rain areas often have a horizontal length of not more than a few kilometers. Thus, the ground stations was located at a sufficient distance so that the possibility of rain fade in the downlink signal will be reduced. Diversity systems have not generally been found to be cost effective [2].

Wideband InterNetworking engineering test and Demonstration Satellite (WINDS) as is one of the examples of satellite with Ka-band frequency (30/20 GHz). WINDS is an experimental satellite that enables communications at significantly higher data rates. The satellite employs very advanced technologies in order to realize both very high data rate transmissions and advanced broadband satellite networking. In the Ka-band satellite, there are wide band global channel, small, light weight and mobile, inter-connection among broadband infrastructure and rain countermeasure [3].

1.2 PROJECT OBJECTIVES

The objectives for this project are to perform a prediction and comparative analysis on the results of performance degradation resulting from the atmospheric propagation effects between C-band, Ku-band and Ka-band in Malaysia in term of rain and gaseous attenuation. The performance and comparative are based on the five locations selected in Malaysia. Besides, the objective is to overcome this attenuation by using site diversity and frequency scaling.

1.3 SCOPE OF WORK

The scope of work for this study is to analysis the rain and gaseous attenuation of Ku-band (16/14 GHz) and Ka-band (30/20GHz) system for usage in Malaysia. Thus, several stations in Malaysia have been selected for the study namely Johor Bahru, Kuala Lumpur, Alor Setar, Kuantan, and Kota Bharu. These stations have been selected to represent the geographical location of the Peninsular Malaysia. All the analysis has been done by using MATLAB programming. Frequency scaling is used to analyze the attenuation for uplink and downlink at different frequency.

1.4 PROBLEM STATEMENT

Nowadays, the rapid development in communication satellites has brought congestion to the frequency bands below 10 GHz. This fact has forced to the utilization of higher frequency bands such as Ku-band (14/12 GHz) and Ka-band (20/30 GHz). However, the transmission quality at higher frequency and shorter wavelength (λ) is greatly influenced by rain and gaseous. This effect will cause the signal attenuation and decreased link availability especially in tropical region such as Malaysia. The propagation of radio wave signal between earth station and satellite must pass through the earth's atmosphere. The inhomogeneous and dynamic nature of the atmosphere makes it a non-conducive medium for transmission. Imperfections in the atmosphere come from sources such as the ionosphere, atmospheric gases, ice crystals, hall, snow, cloud cover, and rain.

These natural phenomena cause impairments to the signal such as attenuation, depolarization, delay, dispersion and amplitude scintillation arising from reflection, refraction and absorptions. Thus the system have been designed to overcome this problem by using several techniques such as forward error correcting coding, built-in margin, uplink power control, variable rate coding, diversity techniques or any combinations of these techniques.

1.5 METHODOLOGY

The procedures and methods to be used to achieve the project objectives are as follows. First, the atmospheric gases attenuation and rain attenuation was calculated by referring to the formula based on ITU-R. Next, the atmospheric gases attenuation and rain attenuation was predicted. A database for differences location and for different frequencies of C-band, Ku-band, and Ka-band for the selected state was created. Attenuation in term of the difference frequencies and locations are then was analyzed and compared. Frequencies scaling for rain attenuation for each location are also analyzed and the result was compared with the database. Lastly, suggest the modification on the site diversity technique based on the results to overcome the attenuation.

CHAPTER II

LITERATURE REVIEW

2.1 SATELLITE COMMUNICATION BACKGROUND.

The first artificial satellite was placed in orbit by the Russians in 1957. That satellite, called *Sputnik*, signaled the beginning of an era. The United States, who was behind the Russians, made an all-out effort to catch up and launched *Score* in 1958. That was the first satellite with the primary purpose of communications. The first regular satellite communications service was used by the Navy in 1960. The moon was used to bounce teletypewriter signals between Hawaii and Washington, D.C. During the early 1960s, the Navy used the moon as a medium for passing messages between ships at sea and shore stations. This method of communications proved reliable when other methods failed. Another satellite that provided store and forward transmission was the COURIER satellite (1960), powered relay satellites (TELSTAR and RELAY in 1962) and the first geostationary satellite SYNCOM (1963). In 1965, the first commercial geostationary satellite, INTELSAT 1 (or Early Bird) inaugurated the long series of INTELSATS. The first Soviet communication satellite of the MOLNYA series was launched in the same years [4].

2.1.6 Satellite Communication System.

A satellite communications system uses satellites to relay radio transmissions between earth terminals. The two types of satellites communications are active and passive. A passive satellite only reflects received radio signals back to earth while an active satellite acts as a repeater which it amplifies the signals received and then retransmits them back to earth. This will increases signal strength at the receiving terminal to a higher level than would be available from a passive satellite. A typical operational link involves an active satellite and two or more earth terminals.

Figure 2.1 shows the general satellite communication system. One station transmits to the satellite on a frequency called the uplink frequency. The satellite then amplifies the signal and converts it to the downlink frequency before transmits it back to earth. Next, the signal will be picked up by the receiving terminal [4].

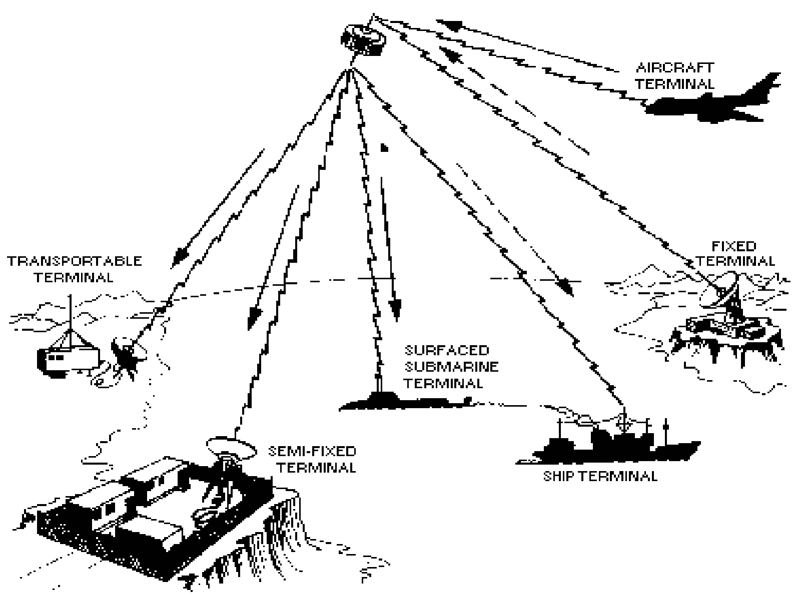

Figure 2.1: Satellite communications system [4].