SAINSTECH
Jurnal Penelitian dan Pengkajian Sains dan Teknologi
Volume 33 No. 1
Maret 2023
SINTA 5

Rain Attenuation Analysis On VSAT KU-BAND Frequency Meteorological Station of Mopah Merauke

Anna Setyawati, Irwan Krisnadi, Abdul Multi, Agus Sofwan

Program Studi Teknik Elektro, Fakultas Teknik Elektro, Institut Sains dan Teknologi Nasional
Jl. Moch. Kahfi II. Kota Jakarta Selatan, Daerah Khusus Ibukota Jakarta
Email: anna.setyawati@bmkg.go.id, iwan.krisnadi.dr@gmail.com, amulti@istn.ac.id, asofwan8@gmail.com

Abstract

BMKG is one of the government agencies that provides Meteorological, Climatological, and Geophysic observation data, sent from each Work Unit or Site Sensor. One of the communication media used is VSAT. The Ku-band channel is one of the frequencies used by the BMKG for communication and data transmission. The Ku-band channel has a weakness for propagation, namely rain attenuation. It is necessary to calculate the effect of rain attenuation on the Ku-band channel, in order to obtain efficient power by each earth station. Model ITU-R P.618-5 is one of the rain attenuation prediction models and is generally used for frequencies up to 30 GHz. One of the BMKG station locations that uses the Ku-Band channel is Mopah Merauke Station. With rainfall data of 80.2 mm/hour in Mopah Merauke, ITU-R P.618-5 produces a rain attenuation of 17.86 dB. While the percentage of error with measurement data is 30.1%.
Keywords: *BMKG, VSAT, Ku-Band, ITU-R P.618-5, Merauke, propagation, attenuation, rain*

Abstrak

BMKG merupakan salah satu instansi pemerintah yang menyediakan data-data pengamatan Meteorologi, Klimatologi, dan Geofisika, yang dikirim dari masing-masing Unit Kerja atau Site Sensor. Salah satu media komunikasi yang dipakai adalah VSAT. Channel Ku-band adalah salah satu frekuensi yang dipakai BMKG untuk komunikasi dan pengiriman data. Channel Ku-band memiliki kelemahan terhadap propagasi, yaitu redaman hujan. Perhitungan pengaruh redaman hujan terhadap channel Ku-band perlu dilakukan, agar diperoleh power yang efisien oleh masing-masing stasiun bumi. Model ITU-R P.618-5 adalah salah satu model prediksi redaman hujan dan secara umum digunakan untuk frekuensi hingga 30 GHz. Salah satu lokasi stasiun BMKG yang menggunakan channel Ku-Band adalah Stasiun Mopah Merauke. Dengan data curah hujan 80.2 mm/jam di Mopah Merauke, ITU-R P.618-5 menghasilkan redaman hujan 17.86 dB. Sedangkan persentase error dengan data pengukuran adalah 30.1%.
Keywords: *BMKG, VSAT, Ku-Band, ITU-R P.618-5, Merauke, propagasi, redaman, hujan*

1. INTRODUCTION

The Meteorology, Climatology and Geophysics Agency (BMKG) is a government agency that provides Meteorological, Climatological and Geophysics observation data sent from each work unit or sensor site. BMKG transmits data through several devices, one of which is using a Very Small Aperture Terminal (VSAT). This communication system is an alternative for long-distance communication that is appropriate for use in Indonesia. The Ku-band VSAT system has several advantages which include flexibility, affordable price, and fast installation. In addition to having advantages, VSAT technology also has several weaknesses, which are mainly related to propagation, namely rain attenuation. The VSAT communication system is very vulnerable to weather conditions, the existing site needs to be studied for rain attenuation. The assessment was carried out by calculating the rain attenuation value using the ITU-R P.618-5 model.

DOI: https://doi.org/10.37277/stch.v33i1 (https://ejournal.istn.ac.id/index.php/sainstech/article/view/1533/1009)

The Nigerian Meteorological Agency in his research K.C. Igwea, O.D. Oyeduma, M.O. Ajewoleb, and A.M. Aibinuc suggested that the propagation of radio waves between terrestrial and earth-space links at frequencies above 10 GHz is affected by the weather, especially rain. Attenuation due to rain is an important propagation effect that must be considered in the design of satellite communication systems. Prediction of rain attenuation for the earth-space relationship in North Central Nigeria on the Ku and Ka bands was investigated using five rain attenuation models: ITU-R P.618 model, Bryant model, Garcia-Lopez model, Svjatogor model and Simple attenuation model (SAM). The main objective is to determine the optimal rain attenuation prediction model for satellite communications.

2. LITERATURE REVIEW

2.1 VSAT / Satellite Communications

Satellite communication does not take into account the distance between the transmitting and receiving stations and the geographical conditions of the area, as in other communication systems. Basically the satellite has a function as a repeater (amplifier) which is a repeater station. A communications satellite is a spacecraft placed in orbit around the earth and in which there are microwave receiving and transmitting equipment capable of relaying (receiving and retransmitting) signals from one point to another on earth. The frequencies used in the VSAT satellite communication system are channel (C-band) and channel (ku-band). C-band has a frequency range of 4 - 6 GHz and ku-band has a frequency range of 12 - 14 GHz. The frequency of 4 GHz in C-band and 12 GHz in Ku-band is the frequency for satellite connection to the intended earth station (downlink), while the frequency of 6 GHz in the C-band and 14 GHz in the ku-band is the frequency for the connection from the ground station to the satellite (uplink).

2.2 The working principle of satellite communication

The basic principle of a satellite is as a repeater (amplifier) which consists of two parts, namely the space segment and the ground segment (GS). The space segment consists of the satellite being controlled and the controlling part, which is the Master Control. GS consists of a receiving device and a transmitting device. The satellite communication system section is described in Figure 1.

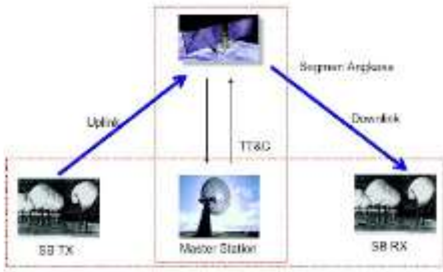

Figure 1. Satellite Communication Architecture

The master control acts as the main controller of the satellite used to keep it in good condition and so that it can operate as planned.

2.3 Wave Propagation

The propagation of electromagnetic waves in free space is strongly influenced by the frequency of these waves. The relationship between frequency and wavelength is expressed as follows :

$$\lambda = \frac{c}{f} \qquad (1)$$

Where:

λ = Wavelength (m)
c = Speed of light ($3x10^8$ m/s)
f = Frequency (Hz)

Propagation of radio waves through obstacles such as rain, fog, and snow will experience signal attenuation, this is due to the absorption of dielectric power caused by water. In addition, there are also losses during direct transmission waves due to the scattering of energy out by raindrops. This happens because the wave propagation must be able to penetrate the layers in the atmosphere, especially in the ionosphere layer which consists of electrons that absorb frequencies.

JS. Mandeep in his study found a strong increase in attenuation between 0.1% and 0.01% of the time (corresponding to attenuation values exceeding about 9 hours and 1 hour throughout the year) and above

DOI: https://doi.org/10.37277/stch.v33i1 (https://ejournal.istn.ac.id/index.php/sainstech/article/view/1533/1009)

0.01% of the time, individual heavy rainfall events dominate and the distribution for each location.

This propagation weakness against rain attenuation led Sun He, Zhang Fen, Jia Chengrui to conduct research. The characteristics of the dual-band C/Ku antenna are analyzed, the feasibility of dual-band simultaneous operation, and solutions are given. In view of the situation that Ku-band satellite communication is greatly affected by rain attenuation, some technical methods and schemes for overcoming rain attenuation are given according to regional characteristics. Through the study of two key technologies, it can provide a basis for better utilization of dual-band satellite resources, and provide a reference method for improving the quality of rain and snow weather communication.

2.4 Damping Model ITU-R P.618-5

N Fadilah and R Pratama in their LAPAN research used BMKG data. They used a comparison of the ITU-R, Global Crane and DAH models. Based on the deviation value between the BMKG rain data and the three methods used, the calculation results with the ITU-R model are the closest. Based on the data generated, the author concludes that the ITU-R model is most suitable for use in Indonesia. This method can be varied International Seminar on Aerospace Science and Technology.

The ITU-R P.618-5 model is one of the rain attenuation prediction models and is generally used for frequencies up to 30 GHz, requiring parameters such as:

R0.01 = Rain intensity (mm/h)
f = frequency (GHz)
φ = latitude of ground station (o)
h_s = ground station height above sea level (km)

According to research conducted by A. Adhikari, S. Das, A. Bhattacharya, and A. Maitra, in Kolkata, India, the ITU-R rain attenuation model has been modified by incorporating an effective inclined path model. The effective slope path has been estimated and modeled in a power law relationship from 2007 to 2008 rainfall data. The methodology has been validated with 2006 measured data. Comparison with ITU-R and SAM clearly shows the improved predictability of the proposed model in current tropical locations. The trajectory geometry for calculating rain attenuation can be seen in Figure 2.

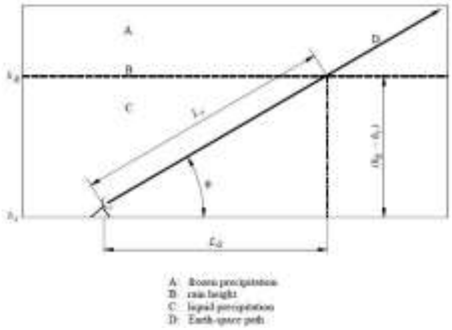

Figure 2. ITU-R Rainfall Damping Trajectory Geometry

Modifications of the ITU-R model have been proposed by V. Ramachandran and V. Kumar in their research. The proposed modification, using breakpoints, proved successful in predicting attenuation exceedance in the tropics. This model can be used to predict attenuation exceedance at a location using only one R0.01 rainfall data available in the ITU-R database.

Meanwhile, according to A. H. Yaccop1, Y. D. Yao, A. F. Ismail, K. Badron, and Mohammad Kamrul Hasan in their research, it can be concluded that local parameters are definitely able to improve the reliability of the latest ITU-R P.618 prediction model and help the future deployment of high-frequency satellite systems in tropical areas. The ITU-R P.618 rain attenuation model uses local parameters (R=164 mm/hr, hR=7.96 km, k=0.8769, α=0.5055) and recommended ITU-R parameters (R=100 mm/hr, hR=4.94 km, k=0.0132, α=1.2391).

3. METHODOLOGY

3.1 Research Stages

The research stages used in this study are as illustrated in Figure 3.1.

The stages of this research will be divided into four major stages. An explanation of the steps at each stage will then be explained in the next sub-chapter. The major stages are:

1. VSAT data collection stage
   VSAT data was obtained from the monitoring results of the BMKG Communication Network Center.

2. Rainfall collection stage
   Automatic Weather Station (AWS) observations at Mopah Merauke.

3. Analysis and discussion
   By modeling VSAT and AWS data comparison.

3.2 VSAT data collection

This research was conducted at Mopah Meteorological Station in Merauke. In this study, VSAT data was obtained from the monitoring results of the BMKG Communication Network Center. The data taken is the carrier to noise ratio (C/N) data with a duration of one month in December 2022. The data has been filtered so that the resulting data matches the actual data available at the site. The visualization of monitoring data can be seen in Figure 3.

Figure 3. Satellite Communication Monitoring

3.3 Rainfall Data Collection

BMKG has a real time observation site for weather parameters in the Automatic weather station and one of them is rainfall data. In this study, rainfall data was taken from AWS Mopah Merauke. The data is taken from the BMKG engineering aws web. The data was taken for one month in December 2022 and has been filtered so that it is the same as VSAT shipping data.

Figure 4. Automatic weather station (BMKG)

3.4 Analysis and Discussion

Describes the results of C/N and rainfall measurements at Mopah Meteorological Station in Merauke that have been carried out and then processed and analyzed. The calculation of attenuation is done by computation using the ITU-R P.618-5 model, the Global Crane model, the SAM Model, and the modified ITU-R model for the tropics.

The measurement location was carried out at the Mopah Merauke Meteorological Station with coordinates 8 ° 31 '12,000 LS and 140 ° 24 '57,600 BT with the satellite used is Telkom 3s which is at position 118 °E. Measurements were made with one month in December 2022.

In accordance with the link budget calculation to obtain the value of EIRP, FSL, G/T, cloud attenuation, atmospheric attenuation, boltzman constant and 10 log B used in determining the rain attenuation value. The values of these parameters are mentioned in Table 1.

Table 1. Link budget

EIRP	=	55	dB
FSL	=	197,8	dBi
G/T	=	8,81	dB
Cloud attenuation	=	0,0231	dB
Atmospheric Attenuation	=	0,1387	dB
Boltzman Constant	=	-228,6	dB/K
10 log B	=	67,6	dB

These values were then computed using python. This computation is done by preparing the C/N measurement datasheet and rainfall data. The data is then compiled to get tables and graphs of the results of data comparison and modeling.

4. ANALYSIS AND DISCUSSION

4.1 Calculation of Ku-band Canal Rain Damping Model

In this journal, the calculation of the rain attenuation model on the Ku-Band channel.

The calculation model used is the ITU-R 618-5 prediction model. Before doing the calculation, several parameters are needed for the calculation, the parameters can be seen in Table 2.

Table 2. Calculation parameters

Parameter	Unit	Value
Frequency (Ku-Band)	12,491	GHz
Elevation angle	74,29	
Latitude of the ground station	8.5184501	BT
Height of ground station above sea level (hs)	0,006	Km
Rainfall (R)	80,2	mm/ hour

4.2 *Rain attenuation calculation of ITU-R model P.618-5*

Rain attenuation calculation steps using the ITU-R P.618-5 model :

1. determine the effective rainfall rate (hR)
2. then calculate the length of the slant path (LS).
3. then calculate the projection of the horizontal line (LG).
4. then calculate the reduction factor (r)
5. then calculate the specific damping (R), with coefficients k and α according to ITU-R recommendation P.838
6. next is to calculate the rain attenuation value

Table 3. Calculation of Rain Attenuation of ITU-R Model P.618-5 Ku-Band Channel.

Rainfall (mm/h)	0	0,7	3,4	5,3	12	19,1	22
Attenuation Rain (dB)	0	0,06	0,415	0,711	1,915	3,355	3,976
Rainfall (mm/h)	30	49,2	51	58,1	62	79,8	80,2
Attenuation Rain (dB)	5,76	10,313	10,751	12,487	13,444	17,774	17,86

5. RESULTS AND DISCUSSION

The conclusions, limitations, and suggestions for future research are as follows.

5.1 *Conclusion*

From the measurement and analysis results, the following conclusions can be drawn :

a. From the analysis, it was found that the measurement methodology implemented was the instantaneous rain attenuation measurement methodology.

b. The instantaneous rain measurement model cannot be compared with the static rain attenuation model.

c. The calculation results of the ITU-R P.618-5 rain attenuation model on the Ku-band channel for 80.2 mm/hour rainfall are : 17.86 dB

d. The results of the comparison of the percentage error of the ITU-R P.618-5 rain attenuation model against measurements on the Ku-Band channel are as follows: 30,1 %

5.2 *Suggestion*

1. Take instantaneous rainfall (R) measurements for one year, in this case measurements can be made using the AWS owned by the BMKG Merauke station and Power Monitoring owned by the Pusjarkom BMKG Center.
2. Take instantaneous rainfall attenuation (A) measurements for one year.
3. Determine the rain attenuation for a certain percent of time (Ap), e.g. for p = 0.01 obtained from the instantaneous rain attenuation (A) measurement done in step 2.
4. Determine the rainfall for a certain percent of time (Rp), for example for p = 0.01 obtained from the instantaneous rainfall (R) measurement results taken in step 1.
5. Calculate the rainfall attenuation for a certain percent of time (Ap) based on the model to be tested by using the rainfall value for the percent of time (Rp) obtained from the calculation results in step 4.
6. Compare the rainfall attenuation values for a given percent of time (Ap) obtained from step 3 and step 5 for several values of percent of time (p).

REFERENCES

Ha, Tri T, "Digital Satellite Communication", McGraw Hill, **1990**.

Recommendation ITU-R, "Rain Attenuation Model '', P series, International Telecommunication Union, **1997**.

Pritchard Wilbur, Suyderhoud G Henri, Nelson A Robert, "Satellite Communication Systems Engineering '', Prentice Hall Inc., New Jersey, **1993**.

Yeo X J, Lee H Y, Ong T J "Modified ITU-R Slant Path Rain Attenuation Model for the Tropical Region", Singapore, Nanyang Technology University, **2009**.

Mandeep, JS, "Analysis of rain attenuation prediction models at Ku-band in Thailand", Advance in Space Research, Malaysia, University Kebangsaan of Malaysia, **2011**

N Fadilah and R Pratama, "Comparison of rain attenuation estimation in high frequency in Indonesia region for LAPAN communication satellite", Journal of Physics: Conference Series, Indonesia, **2018**

K.C. Igwea, O.D. Oyeduma, M.O. Ajewoleb, A.M. Aibinuc, "Evaluation of some rain attenuation prediction models for satellite communication at Ku and Ka bands", Journal of Atmospheric and Solar-Terrestrial Physics, Nigeria, **2019.**

V. Ramachandran and V. Kumar, "Modified rain attenuation model for tropical regions for Ku-Band signals", International Journal of Satellite Communications and Networking, Suva, Fiji, **2006**

A. H. Yaccop, Y. D. Yao, A. F. Ismail, K. Badron, and M. K. Hasan, "Refining Ku-Band Rain Attenuation Prediction using Local Parameters in Tropics", Indian Journal of Science and Technology, Kuala Lumpur, Malaysia, **2016**

Sun He, Zhang Fen, Jia Chengrui, "Research on Key Technologies of C/Ku Dual-Band Satellite Communication", International Conference on Robots & Intelligent System (ICRIS), Jiangyin, China, 2019

A. Adhikari, S. Das, A. Bhattacharya, dan A. Maitra, "Improving Rain Attenuation Estimation: Modelling of Effective Path Length using Kuband Measurements at a Tropical Location", Kalkota, India, 2011