Research Article
Analysis of Worst-month Relationship with Annual Rain Attenuation in Malaysia

Teh Sieh Ting and J.S. Mandeep
Department of Electrical, Electronic and Systems Engineering, Faculty of Engineering and Built
Environment, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

Abstract: The main of this study is to study effect of rain attenuation during the annual and worst month towards communication link especially in the region where heavy rain is a main factor to signal degeration at high frequencies above 10 GHz. Spectral congestion due to the high demand in satellite communication has enforced the development of the conventional frequency bands. Lower frequency band have shifted to higher frequency band such as microwave frequency in order to provide higher data rates as well as wider bandwidths. However, rain fade has become the major hindrance which could cause severe perturbation towards wireless communication tools and satellite communications. Therefore, in this study, analysis of 1 year rain attenuation measurement was done, in order to observe the relationship between the average worst month statistics with the average annual distribution. The result obtained was found to be large different with the one proposed by ITU, hence for better accuracy, the values of Q_1 and β was modified to be adapted in Malaysia.

Keywords: Microwave link, Q factor, rain attenuation, tropical region, worst month

INTRODUCTION

Rain attenuation has been declared by majority of the researchers (Renuka *et al*., 2012; Folasade *et al*., 2012; Chebil and Rahman, 1999) as one of the most important factor that gave severe effect towards the satellite communications signal performance when operating at high frequency above 10 GHz. It has drawn even more researcher's attention when it comes to tropical and equatorial region whereby the average rainfall amount is excessive heavier throughout the year (Mandeep and Zali, 2011). The knowledge of average annual rain attenuation statistic is then required in designing a proper availability and reliable microwave link. However, annual statistics can be very misleading since the impairment might be dominated by only one particular month over the whole year. This had growth the interest in developing a tool known as the "worst month statistic" in order to meet the performance criteria in any months of the year (Mandeep, 2012).

This study presents the analyses related to the worst month statistics at the microwave link which was conducted in University Science Malaysia at Nibong Tebal, Penang. Rain attenuation measurements were collected for 1 year periods (1st January 2009 to 31th December 2009) and it were then used to derive the relationship between the average worst-month statistics with the annual attenuation distribution. This relationship was compared with the origin ITU propose value and it was found that the result yield a negative expectation.

DEFINITION OF WORST MONTH

Worst month or the unfavorable month is defined as the month with highest probability of exceeding that threshold within the period of twelve consecutive calendar months. The concepts of worst month given in (ITU-R P.581-2, 1990) had provided a solution to help the designer who is confronted with high quality intention based on any month. It is also recommended that the worst month concepts can be applied to different types of quantities such as rain rate, rain attenuation and cross polarization. The model for conversion of annual statistics to worst-month statistics (Chebil and Rahman, 1999; Mandeep, 2012) is given as below:

$$Q = X / Y \tag{1}$$

where, X is the average worst-month probability and Y is the average annual probability for the same threshold. Q is the function of the occurrence level and the climatic region. Similar in climatic regions will usually result in similar values of Q. The factor Q may also be expressed in the same manner using the power law relationship (ITU-R P.581-2, 1990):

Corresponding Author: Teh Sieh Ting, Department of Electrical, Electronic and Systems Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

$$Q = Q_1 Y^{-\beta} \qquad (2)$$

For global applications purpose, the value of parameter Q_1 and β is suggested by the ITU are 2.85 and 0.13, respectively, and for more accurate, the values of A and β for various propagation effects and locations is given in ITU-R P.841-4 (2005).

MEASUREMENT DETAILS

Beacon signal strength was collected by a receiver antenna from SuperBird-C satellite which was operating at frequency of 12.255 GHz and it horizontally polarized. The 2.4 m diameter receiver antenna was installed at the roof top of the electrical and electronic school of USM (5.27°N, 100.4°E) with the elevation and azimuth angle of 40.1° and 95.4° respectively. The station height above sea level is 57 m. Sixty successive samples were recorded for each with 1 sec duration and the average of 1 min was also calculated and stored in data acquisition system.

RESULTS AND DISCUSSION

Rain attenuation measurement at USM of the year 2009 was analyzed. The month with the worst performance (highest probability occurrence) was appear in the month of October. The worst month analysis was done on the rain attenuation to obtain the values of Q_1 and β for tropical regions. Figure 1 shows the annual and worst-month rain attenuation exceedance curve. Whereas the Q factor as a function of annual percentage of rain attenuation exceedance in shown in Fig. 2.

The Q factor for rain attenuation was found to follow the power law of the form:

$$Q = 1.7952 \, Y^{-0.097} \qquad (3)$$

and,

$$Q = 2.85 \, Y^{-0.13} \qquad (4)$$

where, Y is the average annual probability. Equation (3) was obtained through measurement and Eq. (4) was the values proposed by ITU for global planning purpose. It can be seen that the proposed ITU values are much higher than the measured data. This indicates that Q factor is climatic dependant. Since, there is large difference between the measured and the proposed ITU value this also indicates that ITU values are not suitable for the use in worst-month analysis for the tropical region. Therefore, new values of Q_1 and β for tropical regions are proposed based on another 3 years data (2006-2008) excerpted from Mandeep (2011). Table 1 shows the measured values for 4 consecutive years at USM.
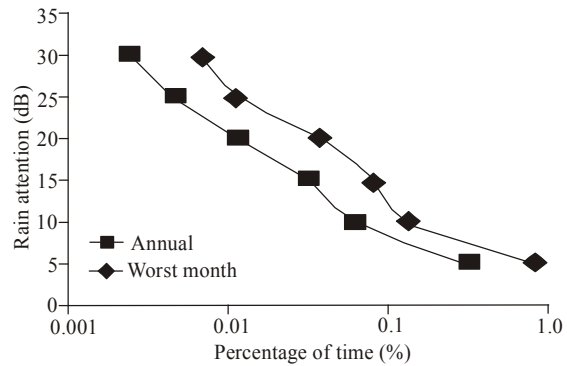

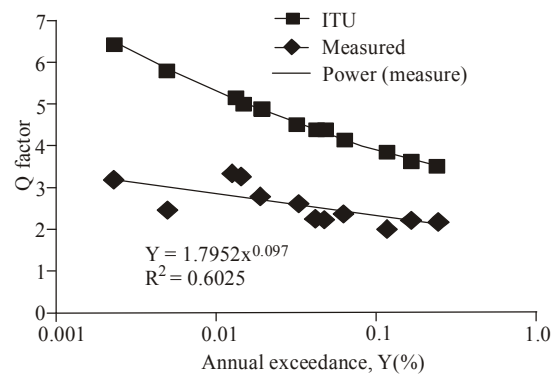Fig. 1: Annual and worst-month rain attenuation exceedance curve

Fig. 2: Q factor as a function of annual percentage of rain attenuation exceedance

Table 1: Measured values for Q_1 and β at USM

Year	Q_1	β
2006	1.6953	0.1060
2007	1.7624	0.0550
2008	1.4547	0.0240
2009	1.7952	0.0970
Average	1.6769	0.0705

The values suggested for worst-month statistics is $Q_1 = 1.6769$ and $\beta = 0.0705$. Whereas, the value proposed by ITU for Indonesia country is $Q_1 = 1.7$ and $\beta = 0.22$. Indonesia is a tropical region which located close to Malaysia. Since the climatic for Indonesia is almost similar to Malaysia, therefore the value can be used to compare with the measured value and it has shows a good response.

CONCLUSION

The conversion method for the worst-month attenuation statistics presented in ITU was found to be not so accurate, hence a new value of Q_1 and β has been proposed based on the local weather information. With these new parameter values, a better precision in estimating the worst-month statistics in Malaysia can be improved.

ACKNOWLEDGMENT

REFERENCES

Chebil, J. and T.A. Rahman, 1999. Worst-month rain statistics for radiowave propagation study in Malaysia [J]. Electron. Lett., 35(17): 1447-1449.

Folasade, A.S., R.M. Mokhtar, W. Ismail, N. Mohamad and J.S. Mandeep, 2012. Ground validation of space-borne satellite rainfall products in Malaysia [J]. Adv. Space Res., 50(9): 1241-1249.

ITU-R P.581-2, 1990. The Concept of Worst Month. RECOMMENDATION ITU- R P.581-2*. Retrieved from: http://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.581-2-199006-I!!PDF-E.pdf.

ITU-R P.841-4, 2005. Conversion of Annual Statistics to Worst-Month Statistics. Retrieved from: http://www.itu.int/rec/R-REC-P.841/.

Mandeep, J.S., 2011. Comparison of rain rate models for equatorial climate in South East Asia [J]. Geofizika, 28(2): 265-274.

Mandeep, J.S., 2012. Analysis of rain attenuation prediction models at Ku-band in Thailand [J]. Adv. Space Res., 49(3): 566-571.

Mandeep, J.S. and R.M. Zali, 2011. Analysis and comparison model for measuring tropospheric scintillation intensity for Ku-band frequency in Malaysia [J]. Earth Sci. Res. J., 15(1): 13-17.

Renuka, N., W. Ismail and J.S. Mandeep, 2012. Rain-induced attenuation for Ku-band satellite communications in the west coast of peninsular Malaysia, Penang [J]. Annales. Telecommun., 67(11-12): 569-573.