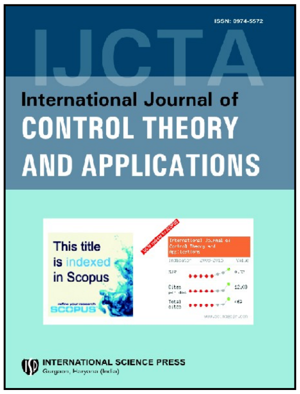

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Reduction of Fade Margin During Signal Reception Using Time Diversity Technique

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Abstract: In satellite communications, the major issue is to receive a reliable signal. But few factors affect the signal from continuous availability. One of the major factors that affect signal availability is rain. Even a small amount of rainfall may cause fading of the transmitted signal because of absorption and scattering by the rain molecules. Fade mitigation techniques are the counter measures to the rain attenuation which are used to reduce signal loss relatively. Time diversity is one of those techniques. Implementation of time diversity on the data collected from experimental setup at KL University is presented. Parameters such as frequency of link, free space path loss, the transmitter power, gain of antenna, distance between receiver and transmitter and cable losses are included in the calculations of Fade margin. Results presented agree with the reduction of signal loss during rain events occurred at the experimental location.

Keyword: time diversity, rain fade, signal availability, mitigation, fade margin

INTRODUCTION

From the past decades, the satellite communication grew heavily in the services offered and it also grew in usages [1]. The usage is increasing day by day. Telephone services are firstly rendered by satellite communications. Later, broadcasting services started the use of satellite communications. Few other services also started its advent. They are fixed satellite services, Direct to home, television broadcasting etc. High definition television and Video on demand are supported now in India. Vast distant communications can be done using SATCOM.

The growth of satellite communications lead to need of much larger frequencies. This growth may lead to use frequencies of above 10 GHz. These are larger than frequencies of C and Ku bands. In order to meet the links requirements of higher capacity, high data rates and high speed is necessary [2] and [3]. But the transmission of the signal at these higher frequencies may lead to loss in signal leading to signal attenuation. Many things come into play like fog, clouds precipitation etc [4] and [5].

The system's ability to perform high gradually decreases mainly because of rain. It acts as a major problem in the transmission process of the signal. The impact on the signal transmitted is mainly more in the places where rainfall is more. Similarly, the impact on the signal transmitted is less on the areas where the rainfall is less. The rainfall is generally more in tropical regions. Tropical regions are shown below in Fig. 1.

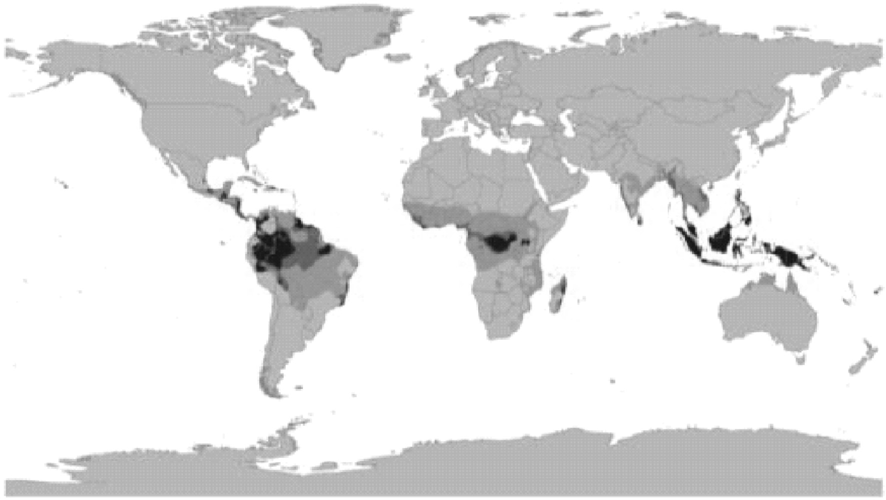

Figure 1: Tropical regions of the world [6]

1. Experimental Data Analysis on Specific Events

Fade margin is the difference between the strength of signal at the receiver end and the minimum signal strength. Fade margin is calculated in decibels (dB). It can be said as the margin between the signal received and minimum signal strength. In order to maintain the signal quality and reduce the loss of signal due to rainfall, few techniques are implemented. These are called as Fade Mitigation Techniques (FMT). These are implemented so that the signals reliability is increased. To maintain the signal quality, and its performance, these techniques are very handful [7] and [8]. Power controls, satellite diversity, time diversity are few fade mitigation techniques. Among these, Time diversity is an important technique and a bit more reliable technique. In all means, it is a promising technique. The expenditure involved is less in time diversity technique. It can as be trusted because it is not necessary to alter the equipment used in the satellite. It is not necessary to design the whole equipment. The redesigning of hardware and synchronization methods are not needed [9]. The memory unit being used will be high as the data will be stored temporarily [10-15]. The technique is unique and the signal is given a bit interval and transmitted. This refers to addition of a time delay.

The ITU-R model [16], [18], [19] is taken as the reference in this model. The attenuation prediction procedures are shown in Fig. 2. The calculation and parameters listed out [17] are used.

(A) Experimental data analysis

The data analysis refers to the calculation of the rain attenuation and also the calculation of fade margin by taking a one day rainfall event on 16th February 2015, 09th May 2015, 06th July 2015, 26th July 2015 and on 25th October, 2015. The intensity of rain is taken in mm/hr. The attenuation is calculated by using the amplitude. The graphs are plotted between the attenuation and time as shown in Fig. 3, Fig. 4, Fig. 5, Fig. 6 and Fig. 7.

(B) Fade Margin

It can be said as the margin below which the received signal can be reduced without loss of the signal. Fade margin is the difference between the strength of signal at the receiver end and the minimum signal strength. Fade margin is calculated in dB. It can be said as the margin between the signal received and minimum signal strength.

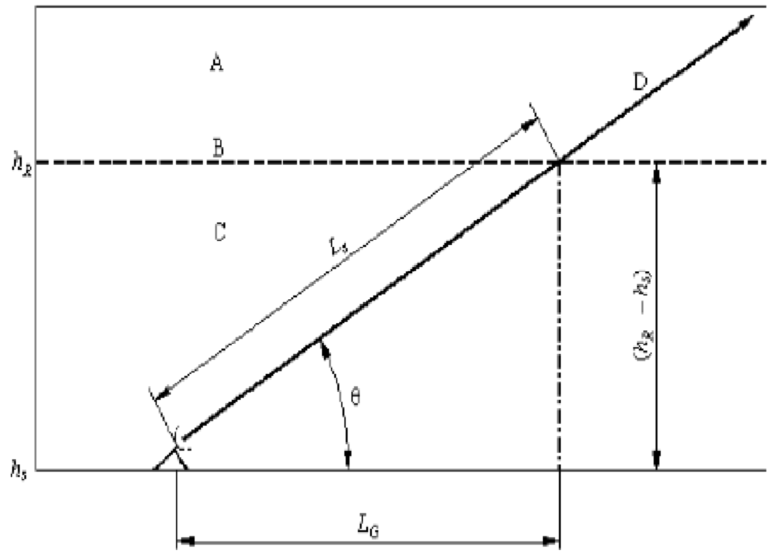

Figure 2: Schematic presentation of Space Earth Path, A: frozen precipitation, B: height of the rain, C: precipitation of the liquid. D: Space earth path, LG: horizontal projection, Hs: the height of the station

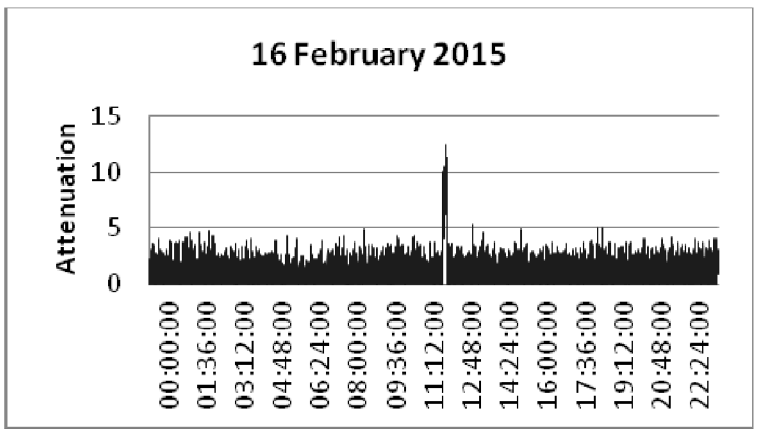

Figure 3: Typical rain event on 16th February, 2015

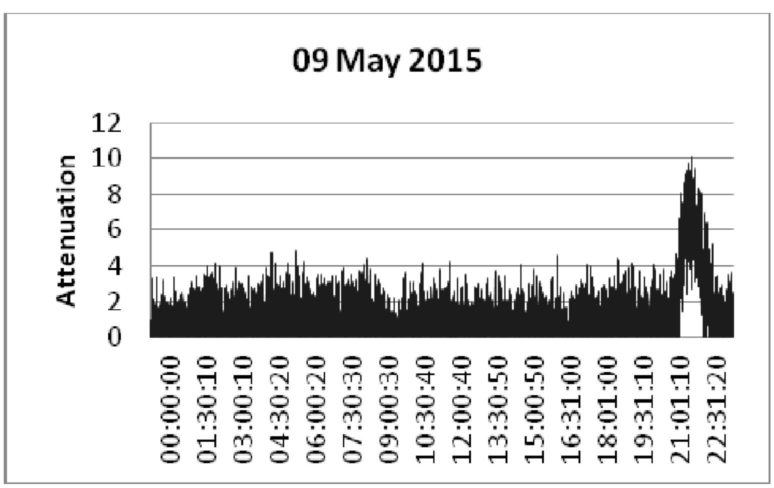

Figure 4: The typical rain event on 09th May, 2015

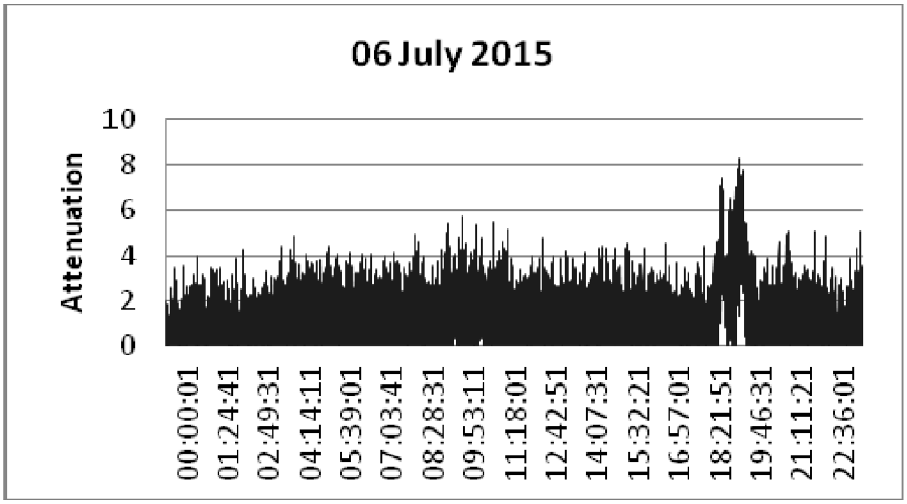

Figure 5: Typical rain event on 06th July, 2015

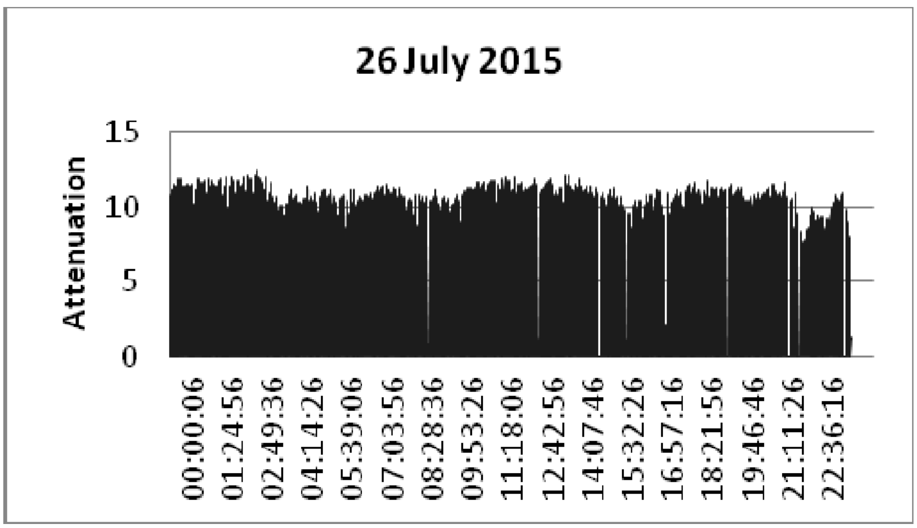

Figure 6: Typical rain event on 26th July, 2015

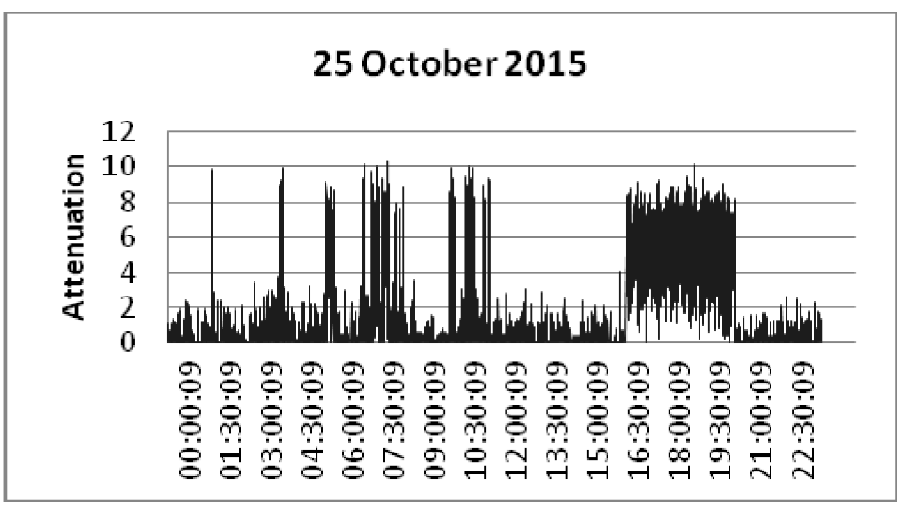

Figure 7: Typical rain event on 25th October, 2015

The greater the fade margin, the greater the availability of link will be. The less the fade margin, the lesser the link availability will be. Fade margin is calculated from the day events mentioned in the experimental data analysis section and is plotted in Fig. 8, Fig. 9, Fig. 10, Fig. 11 and Fig. 12 respectively.

Fade margin depends upon gain of system and also gain of antenna. Fade margin for the given data mathematically represented as:

Fade margin = received signal strength at that point / the minimum signal strength

Fade margin [dB] = Received signal strength at that point [dB] – Minimum signal strength [dB]

The fade margin plotted in the figures (Fig. 8, Fig. 9, Fig. 10, Fig. 11 and Fig. 12) is caluclated on a particular day, at a given time, amplitude, frequency, intensity, attenuation, attenuation (att) > 0 and minimum signal strength. The time, amplitude, frequency, intensity are been take during the rain event and the attenuation is the difference between the average of the amplitude and the amplitude at that point. The values above zero attenuation are marked under attenuation > 0 and the minimum value of signal amplitude is considered as the minimum signal strength for computing fade margin which is the difference between received signal strength at the given time and the minimum signal strength observed during the event.

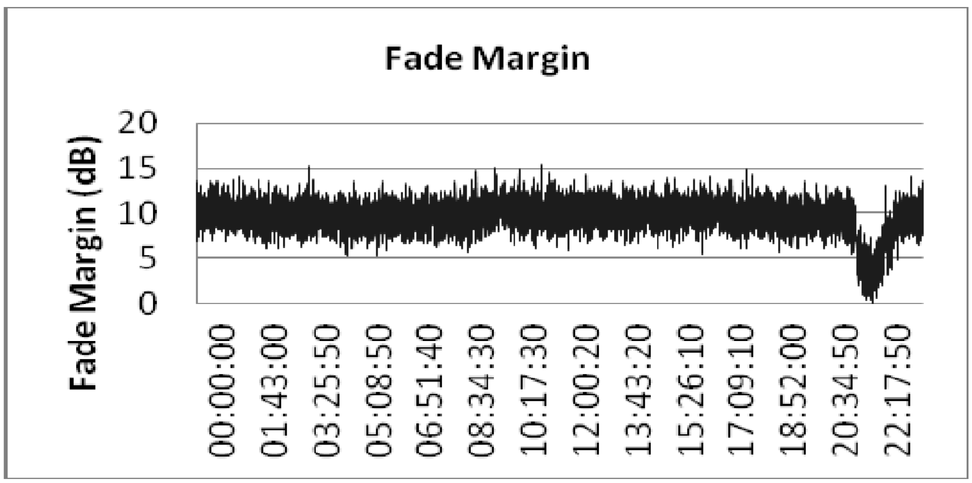

Figure 8: Fade margin on 09th May, 2015

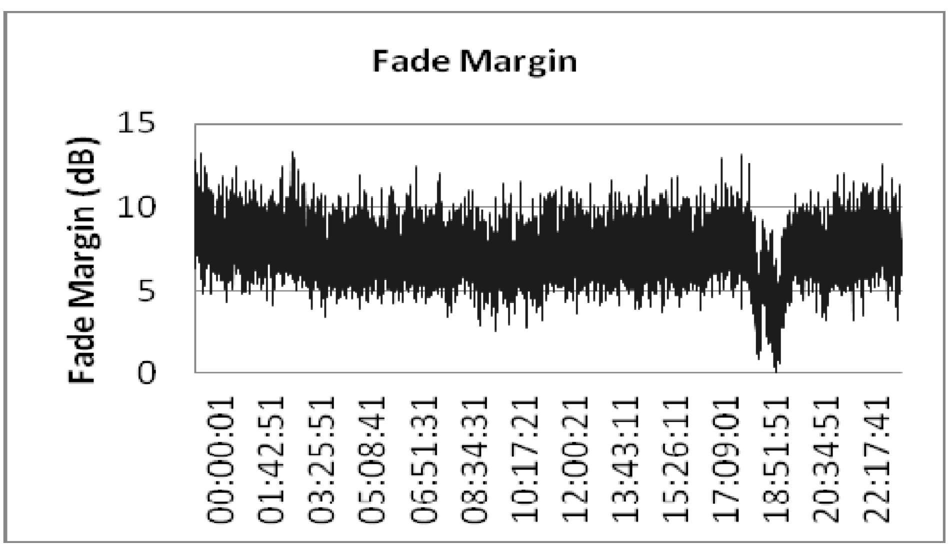

Figure 9: Fade margin on 06th July, 2015

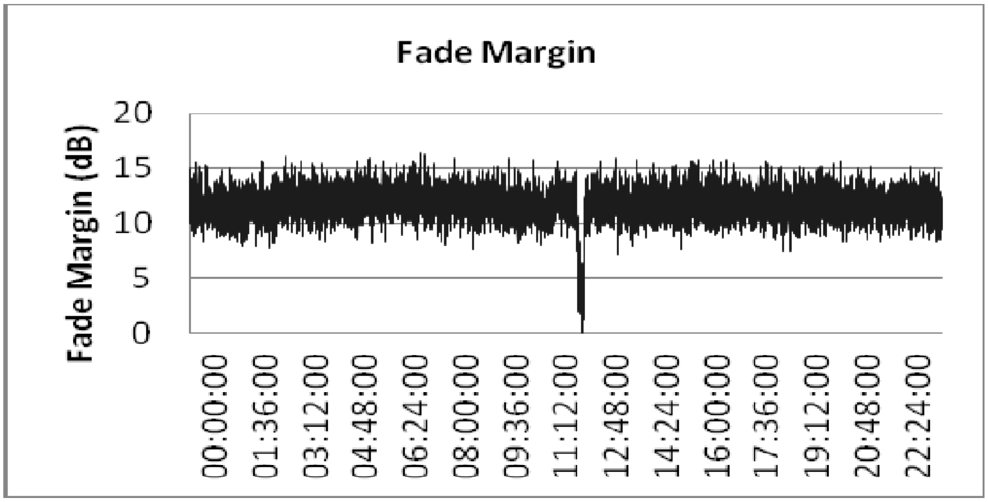

Figure 10: Fade margin on 16th February, 2015

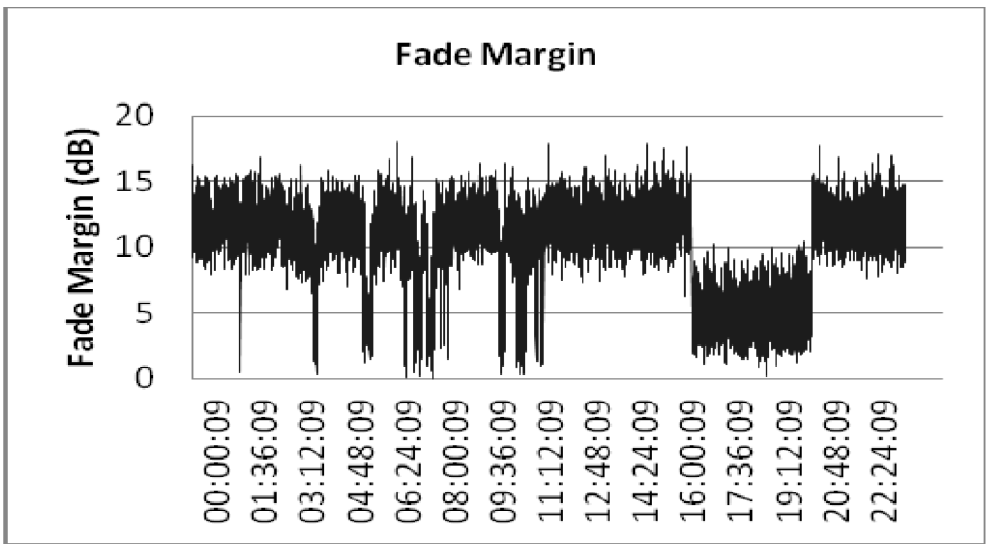

Figure 11: Fade margin on 25th Oct 2015

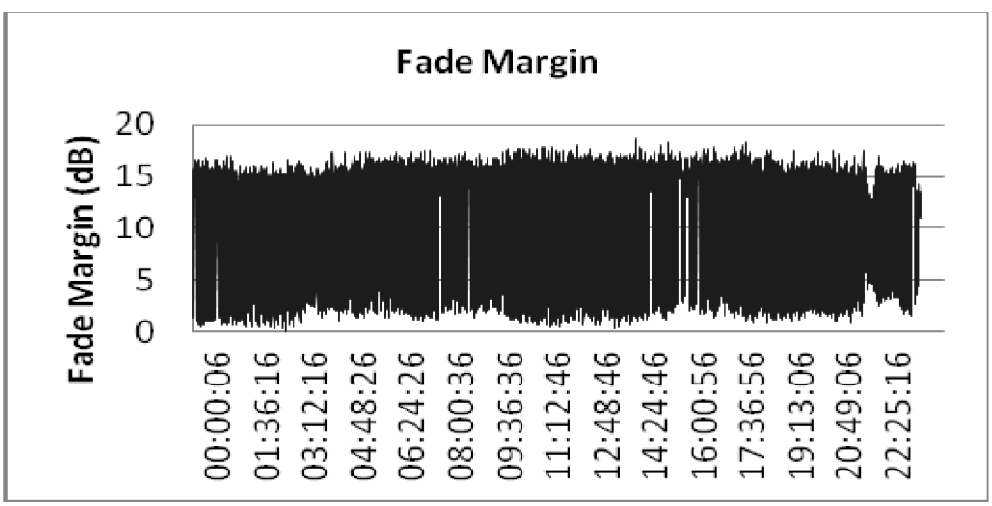

Figure 12: Fade margin on 26th July, 2015

Table 1 shows the data sample on 09th may 2015 which is collected at KL University. The received amplitude of the signal, the down converted signal frequency, intensity of rain during the event occurrence, attenuation caused during the event at each sample collection, minimum signal strength received during the day and the computed fade margin for the event is tabularised.

Table I
A Sample of Data Used for Computing Fade Margin on 09th May 2015

Time	*Amplitude (dB)*	*Frequency (GHz)*	*Intensity (mm/h)*	*Attenuation*	*Attenuation >0*	*minimum signalstrength*	*Fademargin (dB)*
22:17:30	-56.91	1.276	67.255	6.91	6.91	-59.73	2.82
22:17:40	-56.82	1.276	69.176	6.82	6.82	-59.73	2.91
22:17:50	-55.84	1.276	57.577	5.84	5.84	-59.73	3.89
22:18:00	-54.71	1.276	82.736	4.71	4.71	-59.73	5.02
22:18:10	-55.97	1.276	54.359	5.97	5.97	-59.73	3.76
22:18:20	-56.71	1.276	114.767	6.71	6.71	-59.73	3.02
22:18:30	-54.88	1.276	34.136	4.88	4.88	-59.73	4.85
22:18:40	-56.11	1.276	46.116	6.11	6.11	-59.73	3.62
22:18:50	-55.08	1.276	51.718	5.08	5.08	-59.73	4.65
22:19:00	-60.11	1.276	58.333	10.11	10.11	-59.73	-0.38

2. Experimental View of Time Diversity Technique

The time diversity technique includes a delay signal from which the improved signal is to be taken. According to the technique a delay is to be added to the above signal. Here a delay of 10 minutes i.e. $\tau_d = 10$ is considered for the analysis. For reasonable understanding from Fig. 13, Fig. 14, Fig. 15, Fig. 16 and Fig. 17, the data sample where the actual rain attenuation is observed has been considered for plotting the received data, delayed version of this received data and improved version of the received data on a particular date, after implementation of time diversity technique. These figures are plotted correspondingly for the typical rain events which are plotted in the Fig. 3, Fig. 4, Fig. 5, Fig. 6 and Fig. 7 respectively. The received signal is plotted in blue. The delayed signal is plotted in red and the improved signal is plotted in green. The improved versions of the received data in all the subsequent figures show that the signal attenuation is minimized by using the time diversity technique.

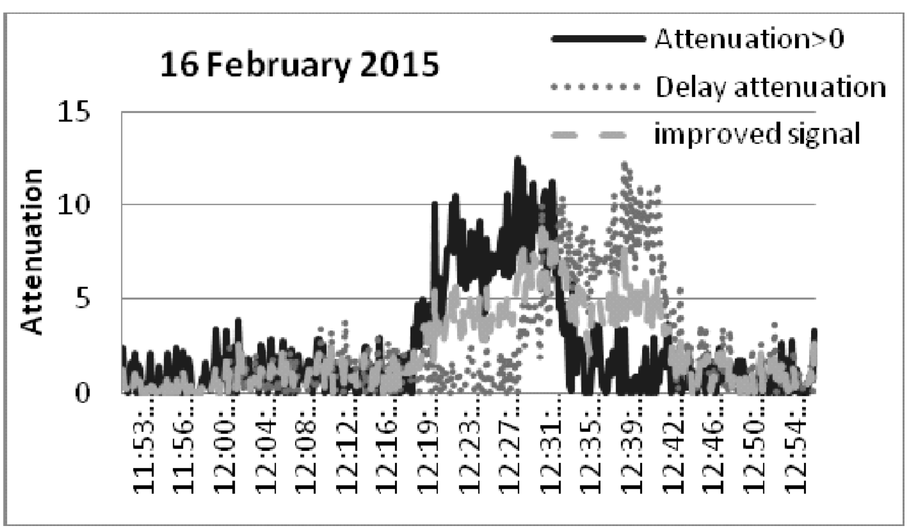

Figure 13: Received, delayed and improved signal on 16 Feb 2015

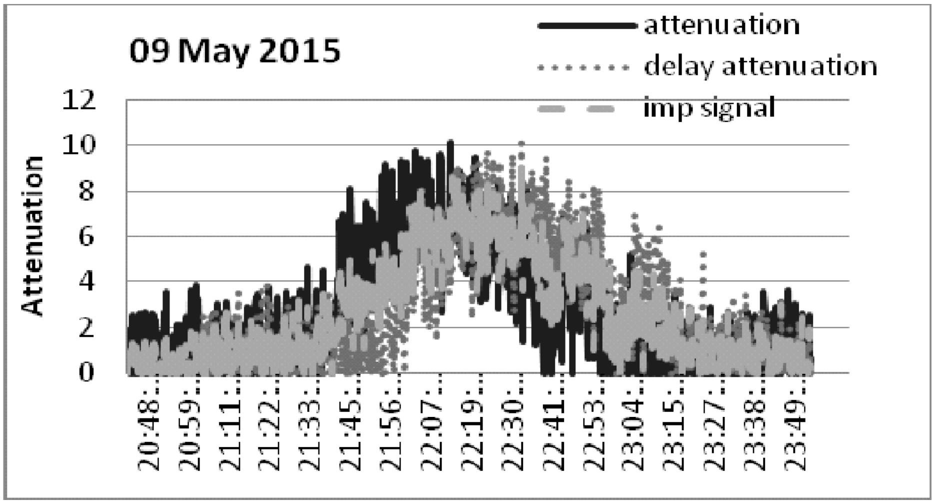

Figure 14: Received, delayed and improved signal on 09 May 2015

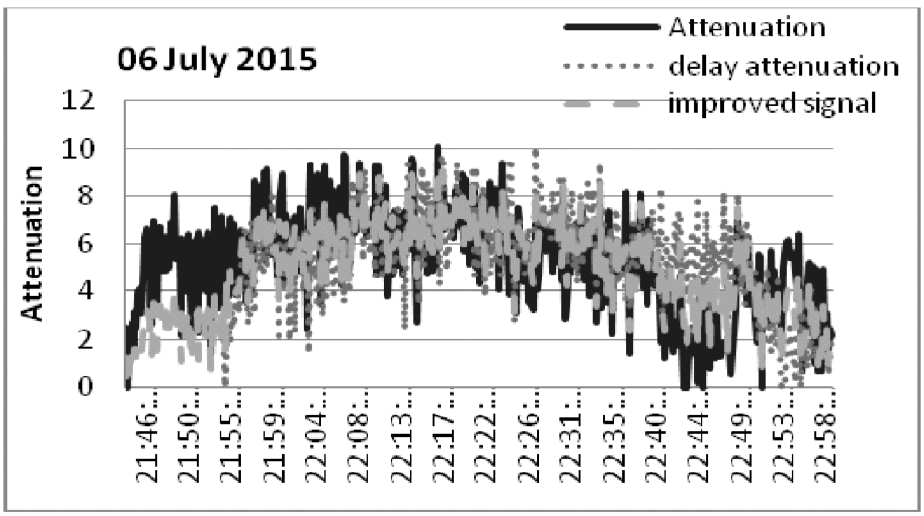

Figure 15: Received, delayed and improved signal on 06 Jul 2015

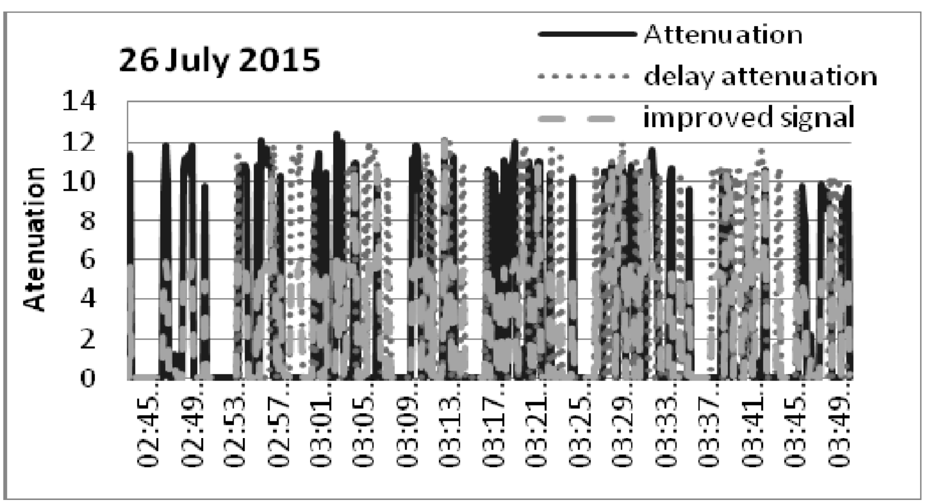

Figure 16: Received, delayed and improved signal on 26 Jul 2015

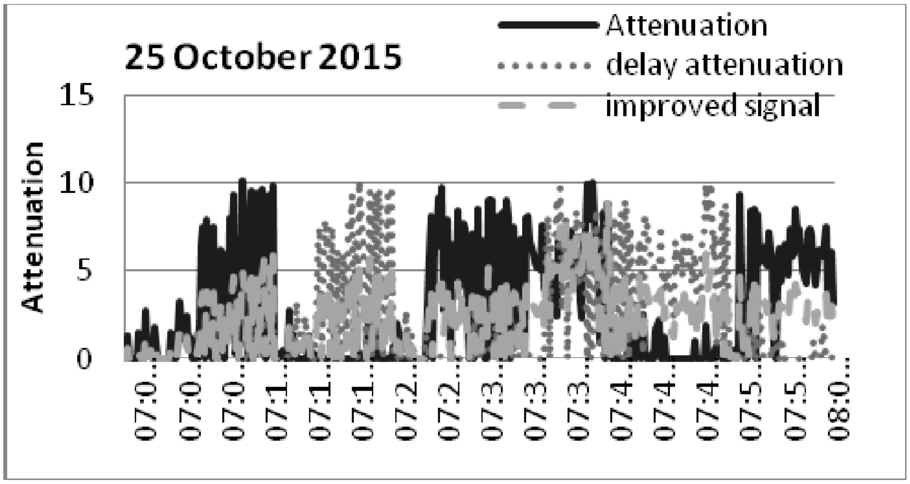

Figure 17: Received, delayed and improved signal on 25 Oct 2015

3. CONCLUSION

On observations during the rain events occurred in the experimental location, the fade margin is calculated from the data that is collected at KL University. If the rain duration is so long there is chance of unavailability of signal. This can be observed from the fade margin which is 11 dB on 16th February 2015, 9 dB on 09th May 2015, 7 dB on 06th July 2015, 11 dB on 26th July 2015 and 10 dB on 25th October 2015 respectively. The Time Diversity technique being a time tolerant technique, it is observed that signal attenuation is controlled to a good extent and thus makes the signal available for user.

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REFERENCES

[1] Wahida M Saad, Md Saad, Ahmad Fadzil Ismail, Khairayu Badron, and Nuurul Hudaa Mohd Sobli, Jafri Din and Tharek Abdul Rahman, "Assessments of Time Diversity Rain Fade Mitigation Technique for V-band Space-Earth Link Operating in Tropical Climate Nurul", *International Journal of Electrical Energy*, Vol. 1, No. 4, December 2013, 268-273.

[2] H. Fukuchi, A. Yoshii, and Y. Suzuki, "Quantitative evaluation of adaptive satellite power control using Japanese rain radar data," in *Proc. 2012 International Symposium on Antennas and Propagation,* 2012, pp. 1469-1472.

[3] R. Nakajo and Y. Maekawa, "Characteristics of rain attenuation time variation in Ka band satellite communications for the kind of rain types in each season," in *Proc. 2012 International Symposium on Antennas and Propagation,* 2012, pp. 1473-1476.

[4] N. B. A. Rahim, H. Dao, M. R. Islam, and A. F. I. Ibrahim, "Prediction of the tropospheric scintillation for earth to satellite link in tropical climate," in *Proc. 2011 4th International Conference on Mechatronics,* 2012*,* pp. 1-6.

[5] Y. Inamori, Y. Shibagaki, and Y. Maekawa, "Rain attenuation characteristics of Ku-band satellite signals in relation to the wind velocities observed on the ground," in *Proc. 2012 International Symposium on Antennas and Propagation,* 2012*,* pp. 1489-1492.

[6] *en.wikipedia.org/wiki/File:Koppen_World_Map_Af_Am_Aw.png*

[7] L. Dossi, G. Tartara, and E. Matricciani, "Frequency diversity in millimeter wave satellite communications," *IEEE Transactions on Aerospace and Electronic Systems*, vol. 28, no. 2, pp. 567-573, Apr. 1992.

[8. E. Matricciani, "Time diversity in satellite links affected by rain: Prediction of the gain at different localities," in *Proc. the Second European Conference on Antennas and Propagation,* 2007, pp. 1-5.

[9] A. D. Panagopoulos, P. D. M. Arapoglou, and P. G. Cottis, "Satellite communications at KU, KA, and V bands: Propagation impairments and mitigation techniques," c*ommunications Surveys & Tutorials, IEEE*, vol. 6, no. 3, pp. 2-14, Third Quarter 2004.

[10] Kilaru A, Avlonitis N, Kotamraju S.K, Otung I, "Rain integration time and percentage probability of rain in Indian subcontinent for satellite communications," International Conference on Electronics and Communication Systems, ICECS 2014, art. no. 6892541.

[11] Potula. Brahmanandam Sree, Yen Hsyang Chu, G. Uma, His Pu Hsia, and Kong Hong Wu, "A global comparative study on the ionospheric measurements between cosmic radio occultation technique and iri model," Journal of Geophysical Research: Space Physics, 2011, Vol. 116, A02310.

[12] Uma, G., J. Y. Liu, S. P. Chen, Y. Y. Sun, P. S. Brahmanandam, and C. H. Lin, "A comparison of the equatorial spread f derived by the international reference ionosphere and the s4 index observed by formosat-3/cosmic during the solar minimum period of 2007–2009," Earth, Planets and Space, 2012, Vol. 64, pp. 467-471.

[13] Brahmanandam, P. S., G. Uma, J. Y. Liu, Y. H. Chu, N. S. M. P. Latha Devi, and Y. Kakinami. "Global s4 index variations observed using formosat 3/cosmic gps ro technique during a solar minimum year." Journal of Geophysical Research: Space Physics, 2012, Vol. 117, No. A9.

[14] Immadi G, Kotamraju S.K, Khan H, Venkata Narayana M, Hemavasavi K, Pooja Naga Sai K, Sirisha N, "Estimation of Ku band satellite signal propagation impairment due to rain in tropical environment using ITU-R," International Journal of Applied Engineering Research, 2014, Vol 9, Issue 20, pp. 7159-7167.

[15] Kilaru A, Kotamraju S.K, Avlonitis N, Sri Kavya K, "Rain rate intensity model for communication link design across the Indian region," Journal of Atmospheric and Solar-Terrestrial Physics, 2016, Vol 145, pp. 136-142.

[16] ITU, International Union of Telecommunications. ITU-R P.618-8 Recommendation: Propagation data and prediction methods required for the design of Earth-space telecommunication systems. France, 2003.

[17] A. F. Ismail, N. W. M. Saad, K. Badron, W. Hashim, and K. Abdullah, "Performance prediction of future V-band Space-Earth link in the tropics," in *Proc. 2012 International Symposium on Telecommunication Technologies,* 2012*,* pp. 187-191.

[18] Kourogiorgas, C. I., Panagopoulos, A. D., Livieratos, S. N., & Chatzarakis, G. E. (2014, August). Time diversity prediction modeling using Copula functions for satellite communication systems operating above 10GHz. In*General Assembly and Scientific Symposium (URSI GASS), 2014 XXXIth URSI* (pp. 1-4). IEEE.

[19] K. Badron, A. F. Ismail, J. Din, and A. R. Tharek, "Rain induced attenuation studies for V-band frequency in tropical regions," in *Proc. the Loughborough Antennas and Propagation Conference,* 2009*,* pp. 689-692.