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Analysis of Long Term Tropospheric Scintillation from Ku-Band Satellite Link in Tropical Climate

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Abstract— **Scintillation is the rapid signal fluctuations of amplitude and phase of a radiowave which can cause signal loss in the transmission path with time. Other propagation factors that contribute to the signal fluctuations must be omitted before using the raw data for scintillation studies. Scintillation occurs continuously whether it is under clear sky condition or raining. Therefore, during raining event, the scintillation data will be accompanied by the signal level attenuation caused by the rain. Hence, attention must be given when analyzing scintillation data during raining event. This paper presents the data analysis of the tropospheric scintillation for earth to satellite link at Ku-band. Eight months (May 2011 till December 2011) data were collected and were analyzed to see the effect of tropospheric scintillation during morning, midday, evening and midnight. In this paper, the scintillation data were analyzed during clear sky condition. Any spurious signals caused by other propagation factors were eliminated accordingly. The experimental data were collected using 2.4 m dish antenna through MEASAT 3 at 10.982 GHz. The elevation angle of the dish antenna is stationed at 77.5°. The findings show that scintillation amplitude during midday is highest if compared to morning, evening and midnight. During midnight, the scintillation amplitudes drop significantly.**

Keywords- scintillation; night; day; Ku-Band

I. INTRODUCTION

Tropospheric scintillation at higher frequencies is the major issues raised in satellite communications systems. At higher frequencies, especially at frequencies above 10 GHz, tropospheric scintillation takes place. Scintillations consist of fades (negative signal level) and enhancements (positive signal level).Whereas scintillation peak to peak amplitude, V_{pp}, is the summation of the magnitudes of maximum and minimum enhancement and fading[1]. Both fades and enhancements contribute to the impairment in the low-margin systems especially at low elevation angle [2].Besides that, they also affect the tracking systems and also fade mitigation techniques [2]. The scintillation measurements at higher frequencies and high elevation angle in tropical climate are very scarce. The rest of the paper is organized as follows: Section 2 discusses on the experimental setup. Section 3 elaborates on the results and analysis. Finally, conclusion is discussed in Section 4.

II. EXPERIMENTAL SETUP

By using 2.4 m dish antenna which is fixed on the rooftop of the IIUM Engineering Building, the Ku-band signal measurements of 10.982 GHz MEASAT 3 TV broadcast signal are done. The dish antenna was used to capture the satellite signals data from MEASAT 3. The dish antenna is stationed at 77.5°. Then, the digital receiver was used to decode the satellite signals from the dish antenna and fed into the spectrum analyzer. The receive signal level has been sampled in 0.1-sec interval using spectrum analyzer. The spectrum analyzer was used to observe the satellite signal levels and omitted any unwanted data accordingly. The signals captured are the beacon signals excluding all the noises in the satellite signals. Figure 1 below depicts the experimental setup diagram[3].

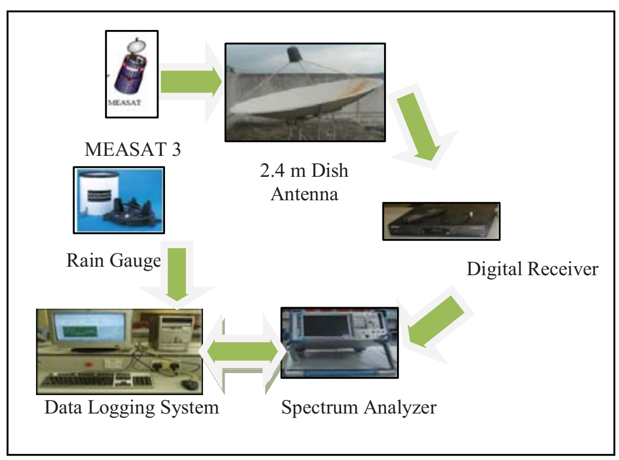

Fig.1 Experimental Setup Diagram

III. RESULTS AND ANALYSIS

Eight months data from May 2011 till December 2011 were used to measure and analyze the scintillation peak to peak amplitudes during morning, midday, evening and midnight. The scintillation peak to peak amplitude can be defined as:

$$X_{pp} = X_{+max} + |X_{-min}| \quad (1)$$

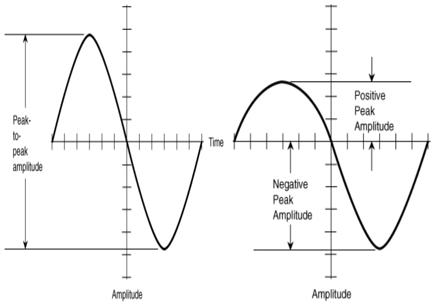

Fig 1 Example of Peak to Peak Amplitude

where, X_+ is the scintillation enhancement and X_- is the scintillation fade. The example of peak to peak amplitude can be seen in Figure 1. By using high pass filter of order 10 with the assistance of Matlab coding, the cut off frequency was obtained. The reason why high pass filter of order 10 was used because the signals were smoothened and it could be viewed easily. This cut

Table 1 Scintillation Amplitudes during morning, midday, evening and midnight from May 2011 till December 2011

Month	V_{pp} Morning(dB)	V_{pp} Midday (dB) 12:00 -1:00 pm	V_{pp} Midday (dB) 1:00-2:00 pm	V_{pp} Midday (dB) 12:00 -7:00 pm	V_{pp} Evening (dB)	V_{pp} Midnight(dB)	V_{pp} Maximum
May 2011	0.15	0.16	0.19	0.18	0.17	0.16	0.30
June 2011	0.36	0.53	0.54	0.52	0.12	0.14	0.85
July 2011	0.46	0.48	0.51	0.50	0.19	0.41	0.69
Aug 2011	0.20	0.52	0.51	0.53	0.35	0.18	0.76
Sep 2011	0.19	0.61	0.62	0.64	0.24	0.17	0.85
Oct 2011	0.33	0.69	0.68	0.72	0.20	0.32	0.90
Nov 2011	0.30	0.98	0.93	1.02	0.23	0.45	1.35
Dec 2011	0.29	0.31	0.32	0.33	0.26	0.21	0.63

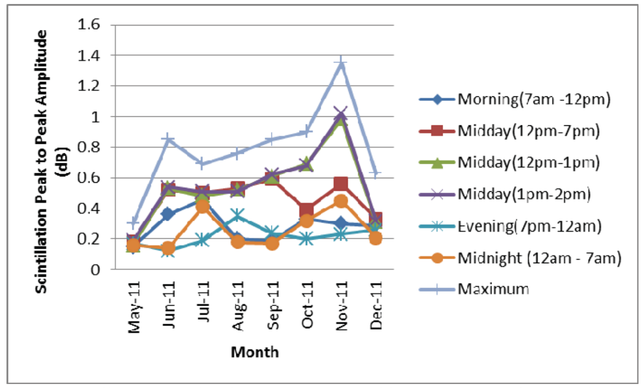

Fig 2 Scintillation Amplitude of Morning, Midday, Evening and Midnight Plot from May 2011 till December 2011

off frequency was obtained with the help of power spectral density plot during raining event. The power spectral density (dB/rad/sample) was extracted using the periodogram method together with a hanning window[4]. Most of the researches done for scintillation were mainly for low elevation angles [1, 5-8]. But in this paper we emphasize on the high elevation angle. A total of 12 different averages cut off frequencies (January 2011 till December 2011) were collected to study the scintillation. This particular cut off frequency was used to separate the scintillation from the rain attenuation [9-16]. The cut off frequency was calculated as 0.13 Hz. It can be described as the appearance of flat region of the scintillation spectrum where the frequency above which the power of all the fourier components drops at least 3 dB below the maximum amplitude Fourier components [9-17].This can be shown in Figure 3. Table 1 depicts the scintillation peak to peak amplitudes, Vpp for morning, midday, evening and midnight from May 2011 till December 2011. Figure 2 depicts the scintillation peak to peak amplitudes plot for May 2011 till December 2011. All these values obtained in Table 1 were calculated based on average of the scintillation peak to peak amplitude for each month. In May 2011, the scintillation amplitudes for morning, midday, evening and midnight are 0.15 dB, 0.18 dB, 0.17 dB and 0.16 dB respectively, whereas for June 2011 till December 2011, the scintillation peak to peak amplitudes for morning, midday, evening and midnight can be seen in Table 1. From Table 1, it can be deduced that scintillation peak to peak amplitudes during midday for the eight consecutive months are the highest if compared to the morning, evening and midnight. Since in Malaysia, the midday starts at 1pm and ends at 2pm, the average values for each period of time starting from 12pm-1pm, 1pm-2pm and 12pm-7pm were taken into account to see whether there are any scintillation variations. As can be seen in Table 1, there are no scintillation variations from the times mentioned before. But still, the scintillations are still the highest at this point of times. The scintillation peak to peak amplitudes drop significantly during midnight from May 2011 till September 2011 then fluctuates accordingly and can be seen in Figure 2. For the morning and evening, the scintillation peak to peak amplitude fluctuates significantly. The reason being is that at midday, the temperature and humidity are highest if compared to the morning, evening and midnight, whereas, during midnight the temperature drops. Scintillation increases with increasing temperature and humidity as mentioned in [6]. Among these eight values for scintillation peak to peak amplitudes, the highest one can be observed in November 2011 with the value of 1.02 dB. Figure 4 till Figure 7 show the scintillation amplitudes for morning, midday, evening and midnight of 3 June 2011.

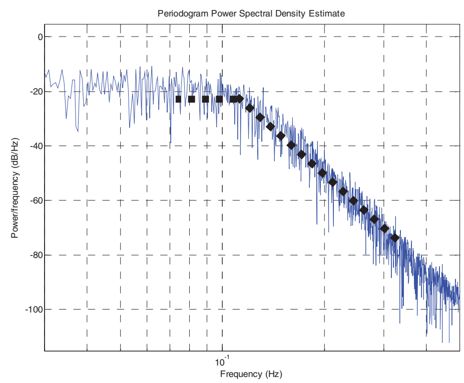

Fig. 3 Power Spectral Density of Scintillation of 10 minutes

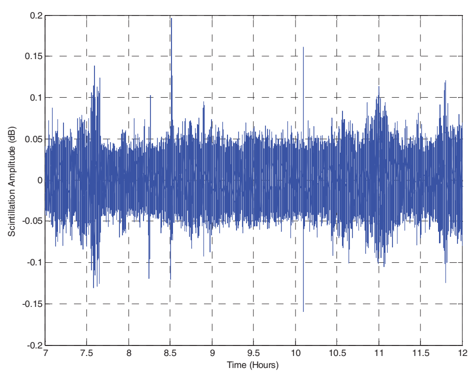

Fig. 4 Scintillation Amplitude during Morning at 7am – 12 pm of 3 June 2011

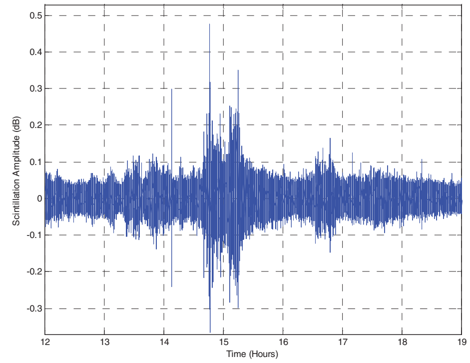

Fig. 5 Scintillation Amplitude during Midday at 12 pm – 7 pm of 3June 2011

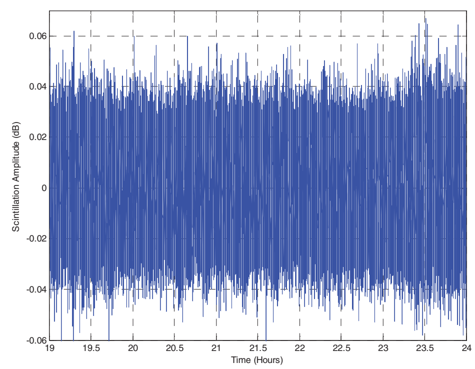

Fig. 6 Scintillation Amplitude during Evening at 7 pm – 12am of 3 June 2011

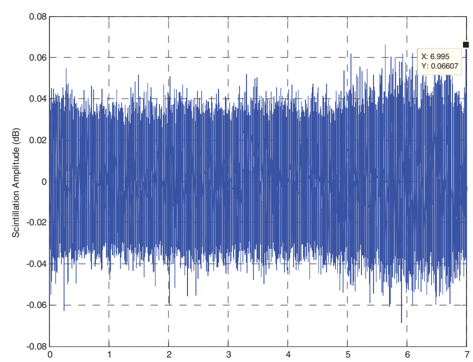

Fig. 7 Scintillation Amplitude during Midnight at 12 am – 7 am of 3 June 2011

IV. CONCLUSION

Scintillation peak to peak amplitudes for morning, midday, evening and midnight for the period of eight months are discussed. The scintillation peak to peak amplitudes during midday are the highest for the eight consecutive months. Among these months, November 2011 gives the highest scintillation peak to peak amplitudes for midday with 1.02 dB.

The scintillation peak to peak amplitudes for morning, midday, evening and midnight from May 2011 till December 2011 are comparable and can be viewed in Table 1. The scintillation peak to peak amplitudes for midnight drop significantly from May 2011 till September 2011 then it fluctuates from October 2011 till December 2011. In a nutshell, research still need to be carried out to analyze and observe more of the scintillation peak to peak amplitudes for a longer period of time.

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