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Measurement Attenuation by Estimate Fade Duration and Number of Fade in Tropical Climate

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Abstract: Attenuation due to rain is a fundamental cause of communication impairment on satellite-earth paths, specifically above 10GHz. Rainfall is a serious source of attenuation at such a frequency. This paper presents the rain fade duration statistics that can be obtained from measured data. These data were interpreted in several groups of attenuation exceeds the threshold, then to analyze the data and get rain fade duration statistics for a period of one year. Eventually, from these measured data, the number of events per year can be estimated; also with these data in per year can be estimated that Monsoon season has a higher number of fade events and longer the fade durations.

Key words: Fade duration % Number of fade % Rain attenuation % Exceeding % Rain rate

INTRODUCTION

In tropical countries and rainy countries that experience high rain fall rate throughout the year such as in Malaysia, rain is an important factor of attenuation and distortion signals in Receiver Systems [1]. The rain is generally measured by the accumulated depth of rainfall in a given time, called rain rate and is expressed in millimeters per hour. Rain effects are dependent on frequency, drop size distribution and rain rate, drop shape, pressure and to a lesser extent ambient temperature. In order to calculate rain induced attenuation, the drop size distribution and drop-fall speed must be found. Also, rain rate can be calculated if both parameters are known [2]. Drop shape is the main cause of differential attenuation on links using orthogonal linear polarizations. Therefore, in the design of radio systems especially in high frequencies, rain attenuation will be an obstacle. Where to rain is one the source of signal loss and attenuation The knowledge of the climate and rainfall pattern is very useful for the study of rain attenuation and rainfall distribution in Malaysia for example the knowledge of the mean annual rainfall distribution and the climate will provide a broad view on the expected rain attenuation learn about the type of rain will give a general idea about the size of the rain cell [3, 4].

The climate in Malaysia is tropical and it is characterized by uniform temperature, high humidity and copious rainfall which arise mainly from the maritime exposure of the country. Also wind is light and variable; some uniform periodic changes in the wind flow patters exist [5].

However, when communication system to use at the KU-band, the strength of the communication signals may be in the short term reduce under heavy rain. For improve these effect du heavy rain in tropical area on communication system, earth stations are designed with more transmit power. Ku-band transmission is virtually immune to adverse weather conditions. One of the most fundamental limitations to the performance of satellite communication will be attenuation due rain also Statistical information will be important necessity designs of the communication systems. This paper presents study of

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number of fade and fades duration statistics of satellite communication channel base on earth? space rain attenuation measurement. Results will be presented for University Sains Malaysia (USM).

MATERIALS AND METHODS

Ku-band beacon signal measurements are conducted at USM. Satellite ground station using SUPERBIRD-C was provided in USM, Penang, Malaysia. The receiver site is located on the roof top of the electrical and electronic school of USM in Nibong Tebal, at 5.17°N and 100.4°E. The receiver antenna has a diameter of 2.4 m also the station height above sea level is 57 m and the antenna elevation angle is approximately 40.1°. The receiver antenna is pointed towards SUPERBIRD-C, located at 144°E. The beacon signal strength was measured using a spectrum analyzer at one minute interval and the beacon frequency is horizontally polarized and it is 12.255 GHz. The ease of use of rain attenuation data for earth space is for 1 year period from January 1, 2007 to December, 2007 in USM [6]. Beacon receiver availability for 2006, 2007 and 2008 was 91%, 98% and93%, respectively. The Downtime due to the calibration of the receiver per day the sky was clear and outage. Uptime of rain gauges on 2006, 2007 and 2008 was 91%, 98% and 93%, respectively [7]. The experimental site was the Universiti Sains Malaysia (USM). Description of the measurement site is presented in Table 3.4. The receiver antennas are pointed towards SUPERBIRD-C located at 144?E for USM. The SUPERBIRD-C is highly reliable three-axis stabilized spacecraft with a transponder RF output power of 90, 60 and 120W, respectively at Ku-Band.

RESULT AND DISCUSSION

On the clear sky of one day, the signal received is above the attenuation threshold, -76.5 dB. So on this weather the satellite link and telecommunication systems are free from any outage due to rain attenuation. But on the rainy sky the signal received is below the attenuation threshold, 76.5 dB. As mentioned previously, this happens due to interference caused by electromagnetic signal and raindrops Transmission through the atmosphere. The transmission is weakened by absorption and scattering of the signal by raindrops, When happened this phenomenon. The more signal attenuated below threshold, the more the system will experience the outage. Thus, the use of suitable compensation techniques such as fade mitigation techniques (FMT) will be needed to maintain reliable system operation. Therefore, one must know the information of fade duration statistics to use the suitable compensation techniques. Number of fade and fade duration statistics can be obtained from studying the number and duration the signal received at receiver below the attenuation threshold. Signal attenuation on a rainy sky show in Fig. 1 for 15 October in 2007.

The result and analysis divided two categories; analysis obtain rain fades statistic for one day and analysis obtain rain fades statistic for one year and comparison between the number of fade and fade duration for attenuation exceeding 1,3,6,9,12,15,18,21 and 30 dB for months in one year. The probability of a fade exceeding a certain duration, given that the fade depth has exceeded a specified threshold. Statistics of fade duration are normally presented as conditional probabilities. Also shown in Table 1 the number of fade duration, for example there are only two events for attenuation exceeding 3dB level and fade duration is 1 minute. Also one events for attenuation exceeding 12dB level and fade duration is 1 and 2 minute.

From analysis fade duration and number of fade after optimization was realized when fade duration increased therefore number of fade decreased. As mentioned, Table 1 showed numbers of events longer than abscissa can be obtained. The Fig. 2 and 3 show fade duration and number of fade for attenuation exceeding 3dB. In these Figures one fade occurred so that fade duration is six minute. As can be seen in first fade duration is 63 minute and so second fade duration is one minute.

The next stage is do analysis and comparison by plotting graphs for each data processed for one year. Where from this graph, information on fade duration statistics can be obtained more precisely and details. The Fig. 4, 5 and 6 showed the number of fade events for exceeding levels versus duration (minute).

Events for attenuation exceeding 1dB level will be a lot because it is near to a threshold level and fade duration is various to minute. For example in Fig. 4, time started from one minute until around 750 minutes and for sample 1201 fade have one minute duration and 309 fade have two minute duration. Also events for attenuation exceeding 15dB level will be less than 1dB. As shown in Fig. 5 and 6, when increasing of fade duration, number of fade was decreasing.

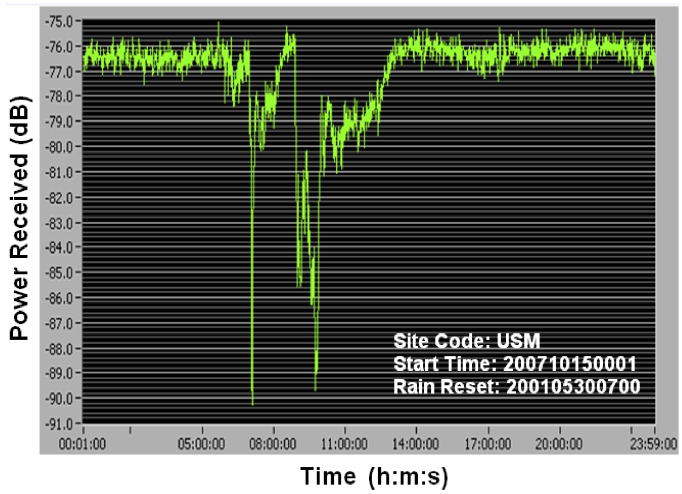

Fig. 1: Received signal on rainy weather

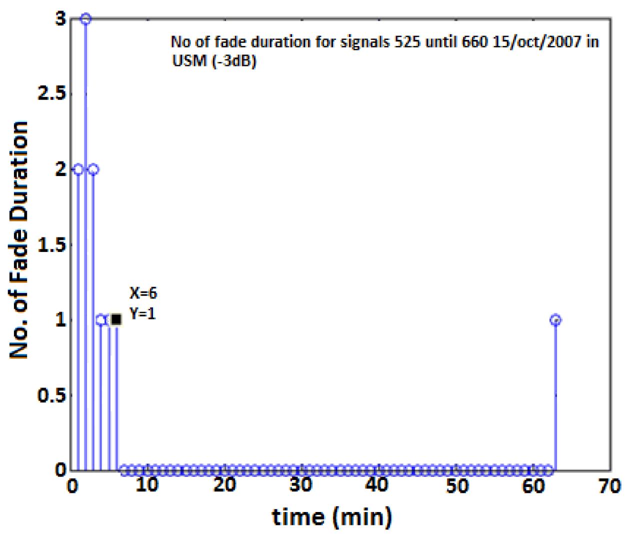

Fig. 2: Number of fade of rain attenuation data between 525 until 660 minute.

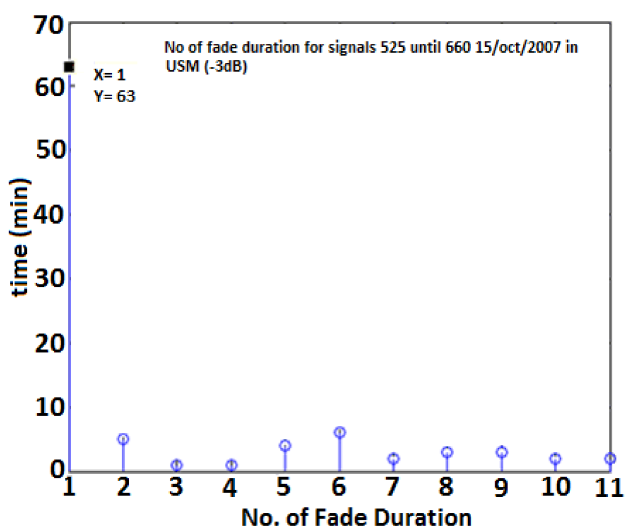

Fig. 3: Number of fade for attenuation exceeding 3dB.

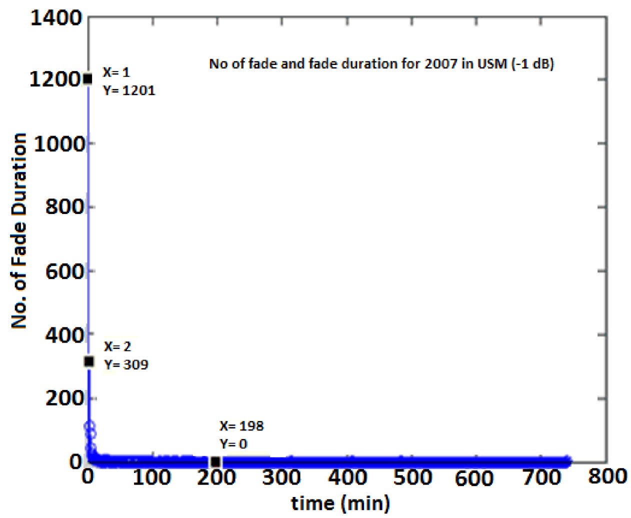

Fig. 4: Number of fade for attenuation exceeding 1dB for one year

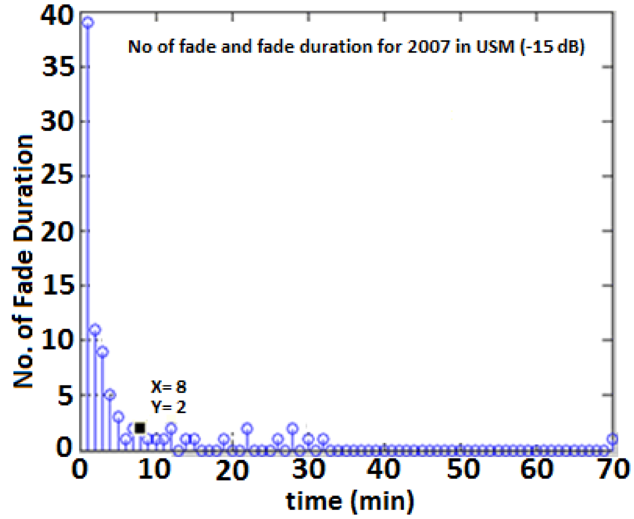

Fig. 5: Number of fade for attenuation exceeding 15dB for one year

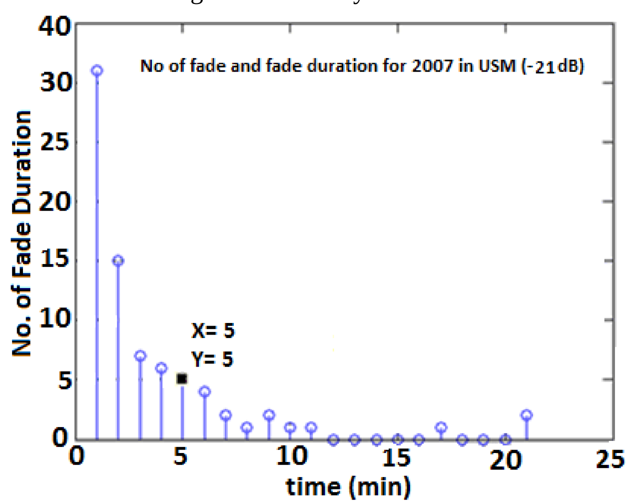

Fig. 6: Number of fade for attenuation exceeding 21dB for one year

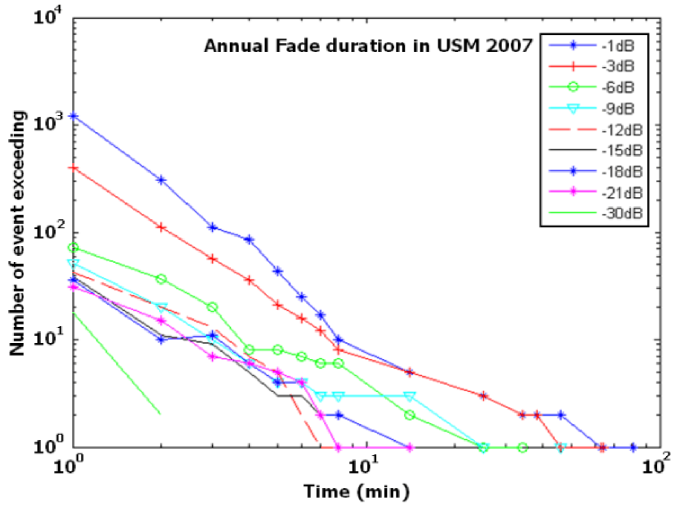

Fig. 7: Fade duration grouping by attenuation levels

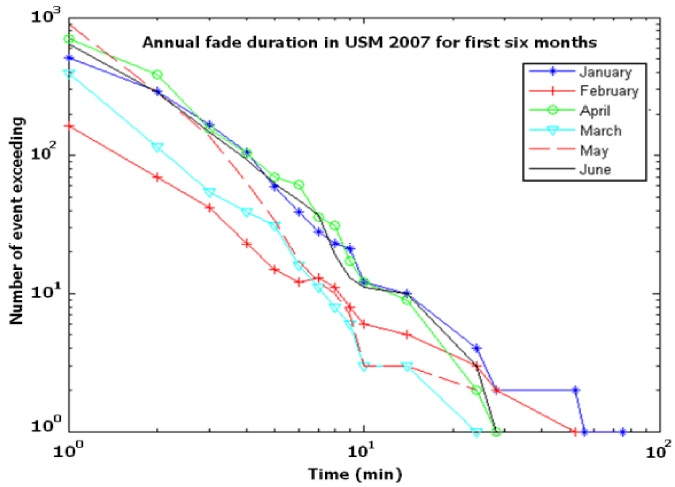

Fig. 8: Fade duration grouping by first six months

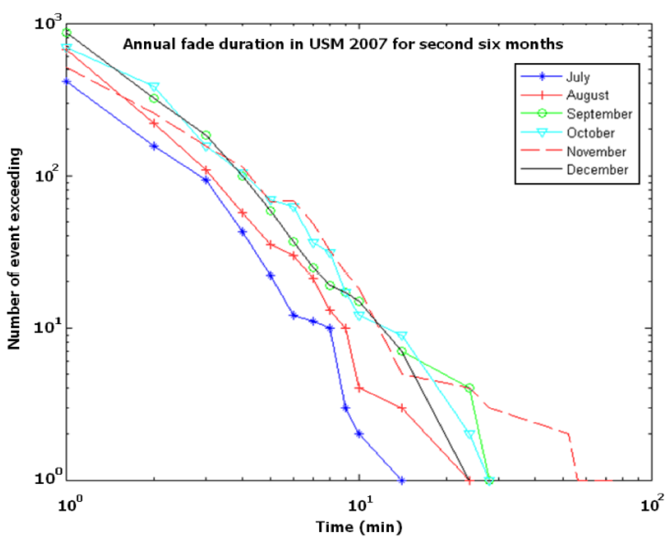

Fig. 9: Fade duration grouping by second six months

Table 1: Analysis fade duration and number of fade for 80 days

Fade duration (min)	Number of fade -3 dB	-6dB	-9dB	-12dB
1	2	0	3	1
2	3	1	0	1
3	2	2	1	0
4	1	0	0	0
5	1	0	0	0
6	1	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	1	0
10	0	0	0	0
11	0	1	0	0
25	0	0	0	0
63	1	0	0	0

Table 2: Number of events for duration exceeds t 1, 3, 6, 9, 12, 15, 18,21and 30 dB for 80 days

Fade duration (Min)	Number of fade -1dB	-3dB	-6 dB	-9 dB	-12 dB	-15 dB	-18 dB	-21 dB	-30 dB
1	1201	399	72	52	43	39	36	31	18
2	309	112	37	20	20	11	10	15	2
3	112	57	20	10	13	9	11	7	0
4	86	36	8	6	7	5	6	6	0
5	44	21	8	4	5	3	4	5	0
6	25	16	7	4	2	3	4	4	0
7	17	12	6	3	1	2	2	2	0
8	10	8	6	3	1	2	2	1	0
14	5	5	2	3	1	1	1	1	0
25	3	3	1	1	0	0	0	0	0
34	2	2	1	0	0	0	0	0	0
38	2	2	0	0	0	0	0	0	0
46	2	1	0	1	0	0	0	0	0
63	1	1	0	0	0	0	0	0	0
64	1	1	0	0	0	0	0	0	0
81	1	0	0	0	0	0	0	0	0
89	0	0	0	0	0	0	0	0	0

In the Table 2 shows in the number of fade and fade duration for which duration exceeds abscissa at 1, 3, 6, 9, 12, 15, 18, 21and 30 dB levels. From this table find out that when the attenuation is increased the time duration will decrease. This is due that the intense rains which cause higher attenuation level only happen in short duration. It is because the higher attenuation depending on rain drops size and also the rain intensity.

Fig. 7 shows the number of events grouped by exceeding levels versus duration (minute). As it was expected the number of events of attenuation exceeding 1dB level is higher than other levels and also the duration of fade events is longer. This is due for attenuation exceeding 21 and 30 dB levels; it needs bigger rain intensity and longer raining time compare to attenuation exceeding 1dB level.

With compared between number of event exceeding -1 dB level, -6 dB level and 30 dB level found out that:

Number of event exceeding of -1 dB > number of event exceeding of -6 dB

Number of event exceeding of -6 dB > number of event exceeding of -30 dB

The Fig. 8 and 9, showed the number of fade events grouped by first six months and second six months. After the comparison between these months, Will realize that months, August, September, October and November are month's number of fade events is higher than other months. In general Malaysia has two season dry and wet season and this is due to monsoon season during these 4 months in Malaysia. The intensities of rain are bigger than normal season and the rain drop size also bigger in monsoon season. Therefore, the number of fade events is higher and the fade durations are longer too. This graph is plotted as number of events versus duration in logarithmic form.

According Fig. 9, months August, September, October and December have heavy Raining in one year because number of fade for fade duration is more than other months. On the other hand the probabilities of the fade occurrence for these months are more. As we know, the probability of the fade occurrence for dry season will be much less than wet season. This graph is plotted as number of events versus duration in logarithmic form. According these results, Number of fade in September is higher than other months in the second six months and in July is less than other months in the second six months.

CONCLUSION

One of the most important cases considered of interference and impairments in terrestrial and satellite communication system operation at frequencies above 10 GHz in tropical area is attenuation due rain. Rain cannot be described accurately along the path. Performance of satellite and terrestrial communications systems, at microwave frequencies depend on degradation signal due rain attenuation. Analysis on the rain attenuation data conducted on an experimental in USM at Ku-Band for one year was use to obtain the fade statistics.

In principal, attenuation is depended on the heavy intensities of the rainfall. Most locations in tropically area should show some seasonality from the effects of the south west monsoon bringing higher rainfall intensities in months around March. Therefore, it was expected during this season, the fade durations are longer and the number of fade events is higher too.

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