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Investigation of Rain Effects over DTH and BER Modeling

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Abstract

The Direct-To-Home (DTH) TV has immensely spread in last five years. The service is very swift and the quality of audio and video is also very high. The cost of DTH set (the small dish, set top box) is very nominal, so anybody can afford it. The main advantage of DTH is that it can be installed anywhere in remote areas. The only bottleneck is the heavy rain and windy weather. During those times, the signal reception becomes week, sometimes it become unavailable. This paper analyzes the rainfall rate of a remote place in heavy raining zone and satellite signal reception in a DTH TV. The paper mainly discusses about the relationship of rain intensity with the signal reception. The bit error rate (BER) is analyzed in different weather conditions. Also the paper focuses on the BER Modeling. The scope of the work is 950-2150 MHz satellite analog downlink signal and heavy raining zone. It is seen that the signal reception is week during windy heavy rain, when Doppler Effect is much higher.

Key words: DTH, Heavy Rain, Signal Reception, Rainfall, BER Modeling.

Introduction

North East India is one of the heavy raining zones in the world. Heavy rain effects communication systems (Das and Purkayastha, 2008). Rain generates a Doppler frequency. Doppler frequency deteriorates the carrier frequency shifting and introduces additional phase noise (Mal *etal.*, 2007). In DTH TV Systems, the fading of signal due to heavy rain is a factor (Schiller, 2003). Moving rain cells will not only attenuate the desired signal but also the interferer, causing variable carrier-to-interference (C/I) conditions (Sinka *et al.*, 2002). The heavy rains do not disturb the carrier wave only but modulated digital data also. When a transmitted bit is changed by any atmospheric obstacle, it is considered as error. The errors are identified as BER.

Assam, India, is under the heavy raining zone where the average rain per year is around 3139 mm (imd website). Due to the heavy rain through out the year, the communications in the range 950-2150 MHz are very much effected in this region. The changing weather and the increasing communications become a challenge today.

Rain Intensity and Communication System

The rain intensity means the instantaneous rate at which rain is falling on a given surface. The rain intensity is recorded for six months in Silchar, Assam (longitude: 92.51 degrees East, latitude: 24.5 degrees North and height: 114.68 m above sea level) (Assam online website). A tipping bucket rain gauge (made: Rainwise Inc., Fig. 5 and Fig. 6) is used to record. The signal is recorded with a DTH antenna (made: Tatasky Ltd., Fig. 7). The signal characteristics are measured using spectrum analyzer (made: Sharp Inc., Fig. 8). Both the rain gauge and the DTH antenna are installed over the roof-top. The experimental setup is displayed in Fig. 1. The rain intensity from June to October, 2009 is very fluctuating and is shown in Fig. 2.

The rainfall of June-October is equally divided into three groups (Table 1).

Table 1: Rainfall Groups

Rainfall Group	Range (in mm)	Weather Condition
Group1	0-0.01	Clear Air
Group2	0.1-4.2	Light Rain & Windy
Group3	4.3-34.8	Heavy Rain & Windy

The average rain intensity is in the range 4.8-7.5 mm. The highest rain intensity recorded is 34.8 mm. The recorded signal quality of the Satellite IN4A-14 using the spectrum analyzer in different weather conditions are tabulated in table 2. The range of BER is 1.0E0 -8.4E-5. The average BER is 4.5E-3.

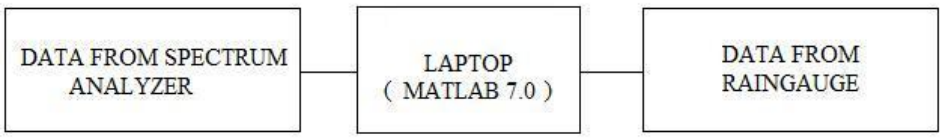

Fig.1: Experimental Setup

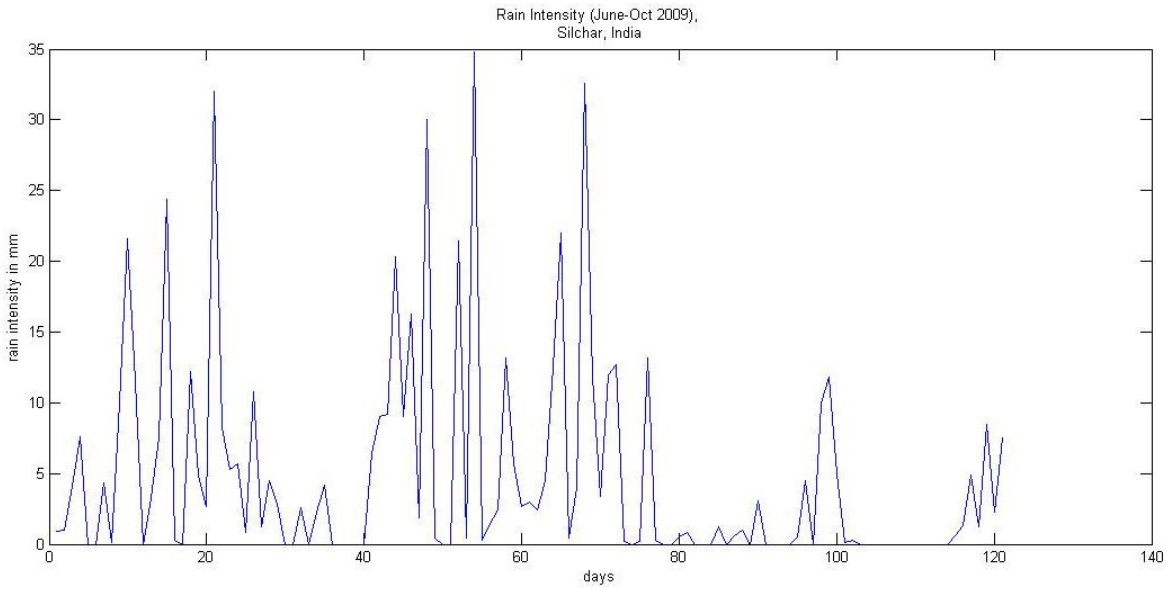

Fig. 2: Rain Intensity from June-October, 2009

The recorded rainfall and BER in both the devices are represented in the figure (Fig. 3). It may be observed that the relationship of rainfall with BER is quite strong and proportional. The figure is generated by the curve fitting tool of MATLAB.

The other figure (Fig. 4) is representing the derivatives of the relation between rainfall and the BER.

Mathematical Modeling of Rainfall with respect to BER

The model gives an idea about the relationship of BER and rainfall (m-zone website), (Lin, 1974), (Maitra *et al.*, 2001), (Ong *et al.*, 2001). The BER modeling is done in MATLAB using the curve fitting tool cftool. In the tool, the rainfall is considered as x-axis and BER as y-axis. It is then fitted in Gaussian model with three set of coefficients a1, a2, a3, b1, b2, b3, c1, c2, c3. The equation (Eq. 1) is the function of the curve fitted.

The coefficients of the function (95% confidence bounds) are:

a1 = 0
b1 = 34.66
c1 = 0.07223
a2 = 0.2342 (-0.7036, 1.172)
b2 = 31.96 (19.39, 44.52)
c2 = 7.185 (-3.91, 18.28)

a3 = 0.8493 (-1.448, 3.147)
b3 = 42.13 (-7.305, 91.56)
c3 = 24.43 (5.98, 42.88)

Goodness of fit: SSE: 0.092, R-square: 0.991, Adjusted R-square: 0.9902, RMSE:0.0318

$$f(x) = a1 \times e^{-\left[\frac{x-b1}{c1}\right]^2} + a2 \times e^{-\left[\frac{x-b2}{c2}\right]^2} + a3 \times e^{-\left[\frac{x-b3}{c3}\right]^2} \quad (1)$$

Table 2: Signal Strength

Signal Level	Signal Strength	Signal Quality	BER	Weather	Rainfall (in mm)
246	100%	40	1.0E-4	Clear Air	0.0
246	100%	40	8.4E-5	Clear Air	0.0
246	100%	40	1.1E-4	Clear Air	0.0
246	100%	40	7.1E-5	Clear Air	0.0
246	100%	50	1.0E-4	Clear Air	0.0
170	60%	30	4.5E-3	Light Rain & Windy	0.1
170	50%	25	1.1E-3	Light Rain & Windy	0.25
170	60%	30	1.0E-3	Light Rain & Windy	2.5
170	50%	25	8.4E-3	Light Rain & Windy	3.1
170	60%	30	4.5E-3	Light Rain & Windy	4.2
100	20%	10	7.1E-1	Heavy Rain & Windy	4.3
100	10%	5	8.4E-1	Heavy Rain & Windy	10.5
100	20%	10	5.5E-1	Heavy Rain & Windy	15.12
100	20%	10	7.1E-1	Heavy Rain & Windy	22.78
0	0%	0	1.0E-0	Heavy Rain & Windy	34.8

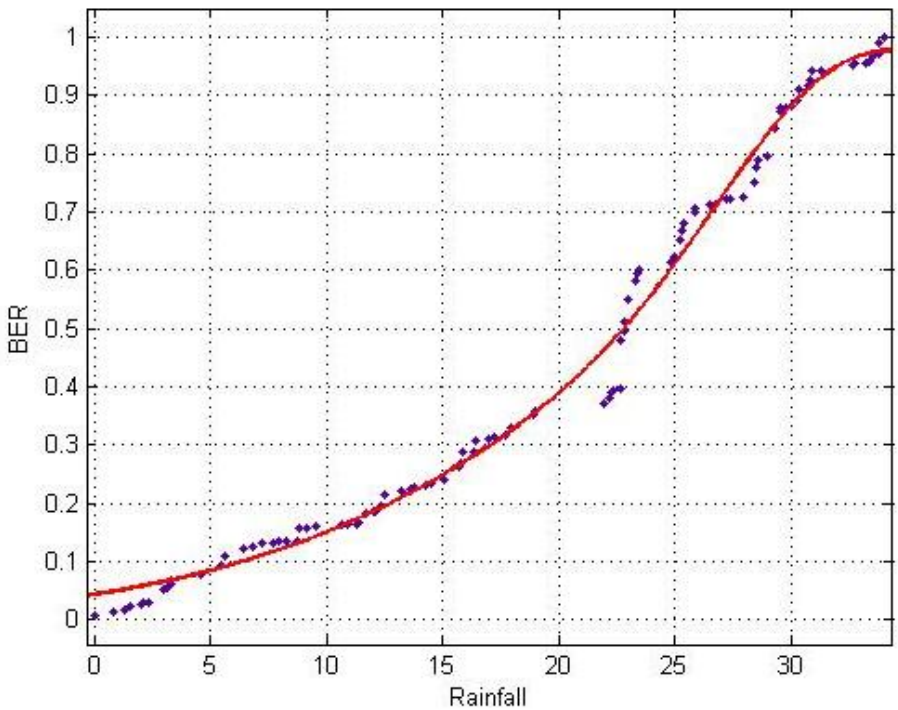

Fig. 3: Relationship of rainfall and BER

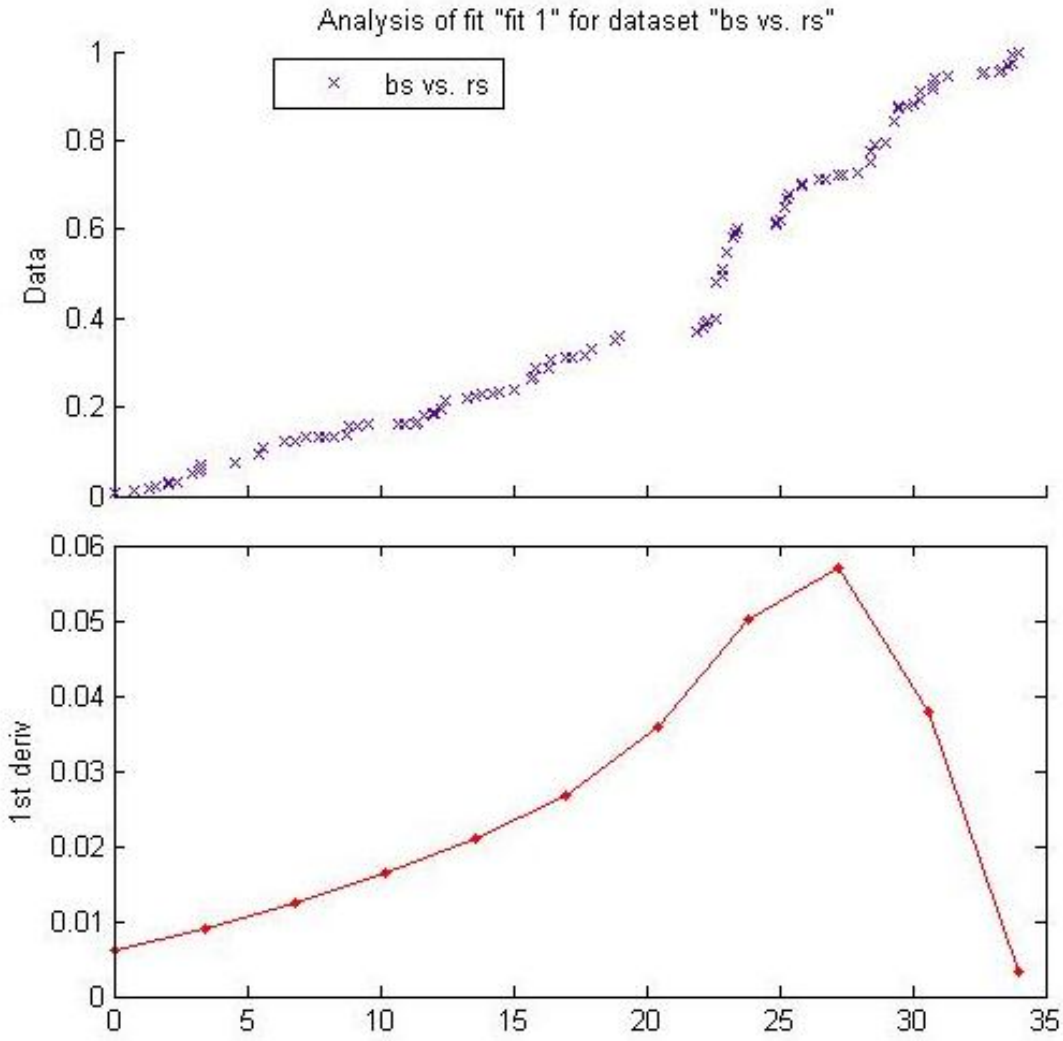

Fig. 4: Gaussian Model of Rainfall and BER

Fig. 5: Rain Gauge

Fig. 6: Rain Gauge Display Unit

Fig. 7: Signal Receiver Antenna

Fig. 8: Spectrum Analyzer

Conclusion

The rainfall and the BER are found much correlated. The particular DTH satellite signal used is of very low frequency. It is found in different literatures that rain effects are very large in higher frequencies. The particular research is very new in the typical region of North Eastern India. This region is special because the highest rainfall area of the world is in the region. The authors are now trying to reduce the BER due to rain using advanced coding techniques.

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