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Rain attenuation at 13 GHz over the line of sight path situated between Panihati and Barrackpore in eastern India

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Abstract : In this paper, results on attenuation measurements at 13 GHz under rainy conditions over another microwave link propagation path (Panihati-Barackpore) located over Kolkata have been presented The link suffers large attenuation due to heavy rain The communication link belongs to an operational agency The microwave amplitude variation was monitored and rain rate measurements were made on twenty four-hour basis by a fast response rain gauge in the monsoon months during 2005 The observed microwave radio signal was characterized with a steady signal level ~ –42 to –43 dBm with fade depth ~1 to 2 dB under non-precipitation condition The results on attenuation have been studied in the light of simultaneous rain rate observations The results on attenuation of radio wave under rainy condition are useful to design and installation of future communication links both for terrestrial and earth space paths in the regions in India where we have rain characteristics similar to Indian eastern coastal station The probability distribution of attenuation and rain rates have been deduced from measured observations

Keywords : Microwave link, terrestrial path, rain rate, rain attenuation

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1. Introduction

In present days scenario of radio communication it has become necessary to provide more channels as per the demand of users. Using higher radio frequencies particularly above 10 GHz can meet such demand. In a tropical country, we have regions where heavy rainfall occurs with high rain intensity. The use of higher frequency in radio wave gives rise to problems like attenuation of radio wave due to rain [1–4] as well as performance deterioration of the links. Though efforts are on to generate more database

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of rain attenuation in microwave frequencies to develop model for estimation of attenuation due to rain over this part of the world But, still there is dearth of the measured results on rain attenuation of radio wave in the tropical regions of India. Recently, some systematic simultaneous monitoring of communication links (having different path length) belonging to different operational agencies at 13 GHz and 18 GHz and measurements of rain rate were undertaken in Indian eastern sector by using terrestrial communication links and some very useful results on attenuation were derived [5–7] Still more measurements on radio signal above 10 GHz are needed over a vast country like India where we have varied total rain fall over different places [8] for better planning of microwave communication links both for terrestrial and earth space paths [9]

The communication link operating at 13 GHz situated between Panihati and Barackpore located in Kolkata (22 32° N, 88 27° E) region was monitored on twenty-four hours basis during July-August 2005 A rapid response rain gauge was also put on operation on continuous basis to measure the rain intensity It has been seen that the signal level is characterized with steady signal of the order ~–42/–43 dBm with a fade depth ~1–2 dB under non-precipitation condition The communication link used to exhibit heavy loss of signal around 20 to 25 dB during heavy rain Attenuation as high as 31 dB has been observed during torrential rain The analysis of the results on signal levels and rain rates has yielded the percentage of time and its association with the particular level of attenuation during monsoon months of July and August over Kolkata region These results are useful to design and install future links over the regions in Indian locations where we have this amount of rainfall

2. Source of data

A strip chart recorder was used to record the radio signal level of the communication link situated between Panihati and Barackpore having path length of 8 km The link belongs to Kolkata Telephones of BSNL The amplitude variation measurements were made on twenty-four hour basis during July-August 2005 at Panihati The transmitter is situated at Barackpore and the receiver is situated at Panihati The rain rate measurements were carried out over Kolkata during July-August 2005 by a rapid response rain gauge having integration time ~10 seconds The rain gauge was located near the receiver site The rapid response rain gauge monitors rain fall rate automatically. The program controls the sampling, storing and printing of the data of rain intensity.

3. Results and discussions

The probability distribution of the rain rate has been derived from the rain rate measurements of all the rain events taken place during July-August 2005 over Kolkata. It would have been more useful and served the purpose better if we could have installed few more rain gauges along the path of the radio system But it is very difficult to do so because lot of infrastructure facilities is required for such purpose More over the long-term probability distribution of rain rate has been established. If long-term probability distributions of rain rate are estimated from rain rate measurements over different locations in a region, we find that there is variation with in 5% in probability distribution of rain rate from one location to another location But, if case (rain event) by case (rain event) over different locations is taken then there exit's some differences

The fast response rain gauge has been used to obtain rainfall rate and correlate them with variations in signal attenuation All the rain events occurred during the course of rain measurements over Kolkata during July-August 2005 were analyzed Different rain event was characterized with different variation of rain rate The minimum rain rate was recorded with fast response was ~4 mm/hr while the maximum rain rate was around ~156 mm/hr The rain rate having low integration time is usually characterized with slow and fast variation The rain rate variation is similar to the amplitude variation of the radio signal Such amplitude variation of radio signal under rainy condition provides information of the fade dynamics of radio signal Fade dynamics are important for the determination of fade margins as well as eventually the performance of the link The cumulative distribution of rain rate, which has been obtained from rain events occurring during July-August 2005, is presented in Figure1 It is seen that the rain rate ~18 mm/hr exceeds for 50% of the time and rain rate ~55 mm/hr exceeds for 5% of time The maximum rain rate obtained was ~156 mm/hr during this period

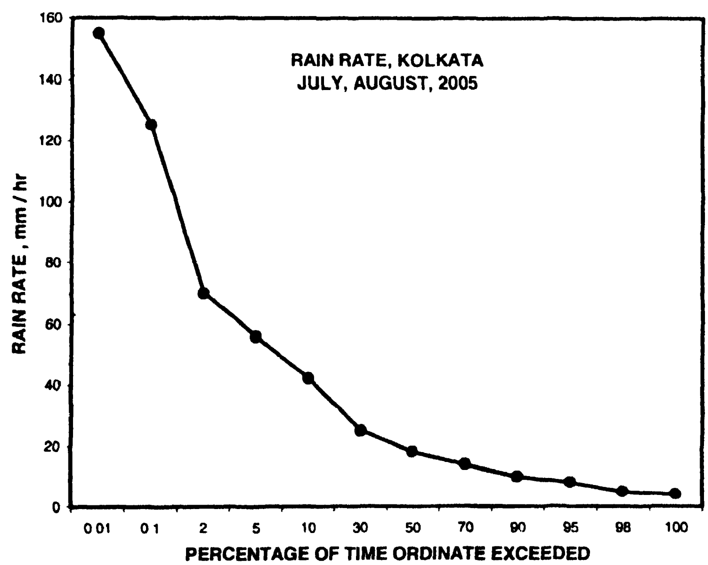
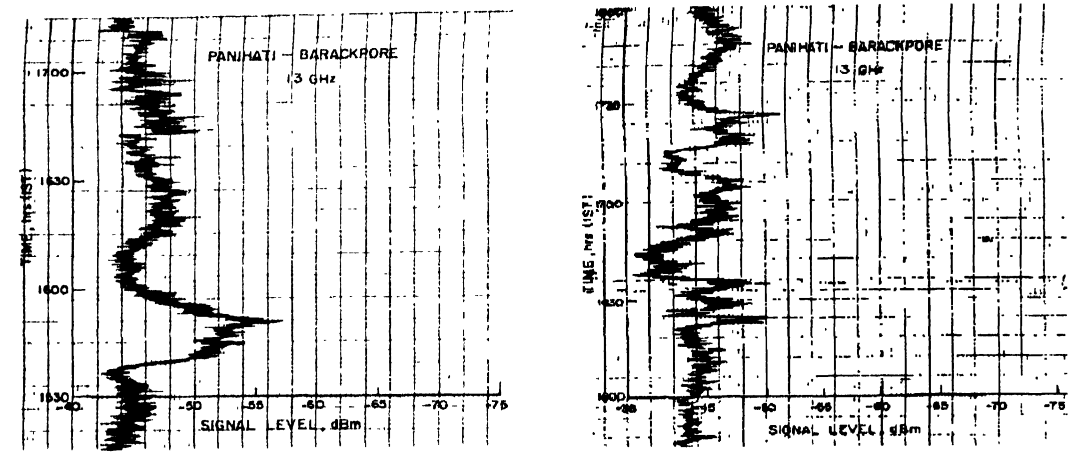


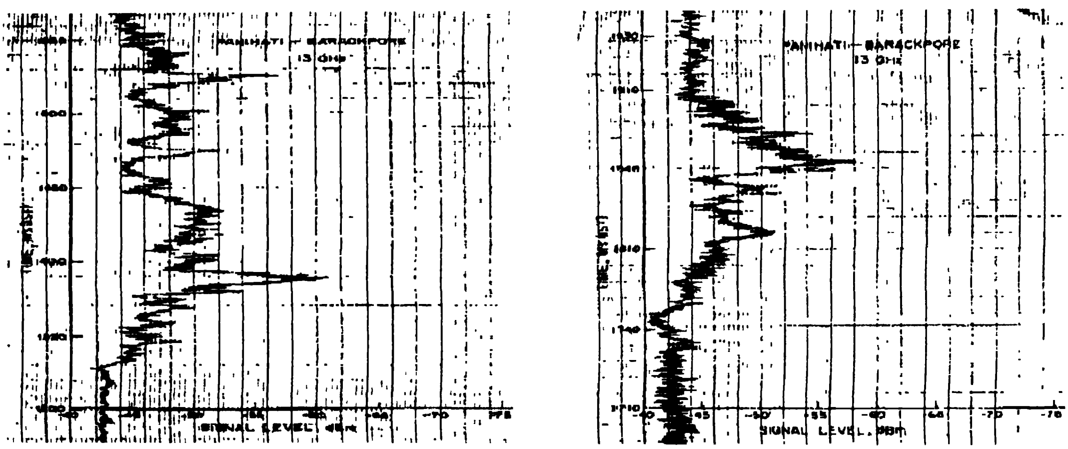
Figure 1. Probability distribution of rain rate during July-August 2005 over Kolkata

The radio signal variation measured during different rainy conditions in July-August 2005 over Panihati-Barackpore communication link is presented in Figures 2–5 It is seen that the radio signal exhibits slow and rapid amplitude variations The cumulative distribution of the signal level has also been obtained during rain events and just prior to start of the rain. It is seen from all such measurements that the signal level varies from ~–42 dBm to –73 dBm It is shown in Figures 2–5 that maximum attenuation during rain varies from ~6 dB to 31 dB.



a

Figure 2. (a, b) Typical amplitude variations over the microwave link under rainy condition where maximum attenuation is 10 dB (Figure a) and 6-8 dB (Figure b).



a h

Figure 3. (a, b) Typical amplitude variations over the microwave link under rainy condition where maximum attenuation is 18 dB (Figure a) and 15 dB (Figure b).

It has been observed that rain occurrence can be categorized in four types such as drizzling, moderate rain, heavy rain and torrential rain. The variation of signals shown in Figures 2–5 is found to be associated with all types of rain. It has been found that the attenuation around ~1–5 dB are associated with low rain rate (from few mm/hr to 20 mm/hr) while attenuation level ~5–10 dB are associated with moderate rain (30 mm/hr to 60 mm/hr). The attenuation 15–20 dB is associated with heavy rainfall (from 70 mm/hr to 120 mm/hr) while the attenuation above ≥ 25 dB is associated with torrential rain (above 135 mm/hr). The results on attenuation have been derived by taking the difference of the normal signal level ~–42.5 dBm and the instantaneous signal level in dBm. If the observed signal level at a time is ~–57.5 dBm then the estimated attenuation is 15 dB.

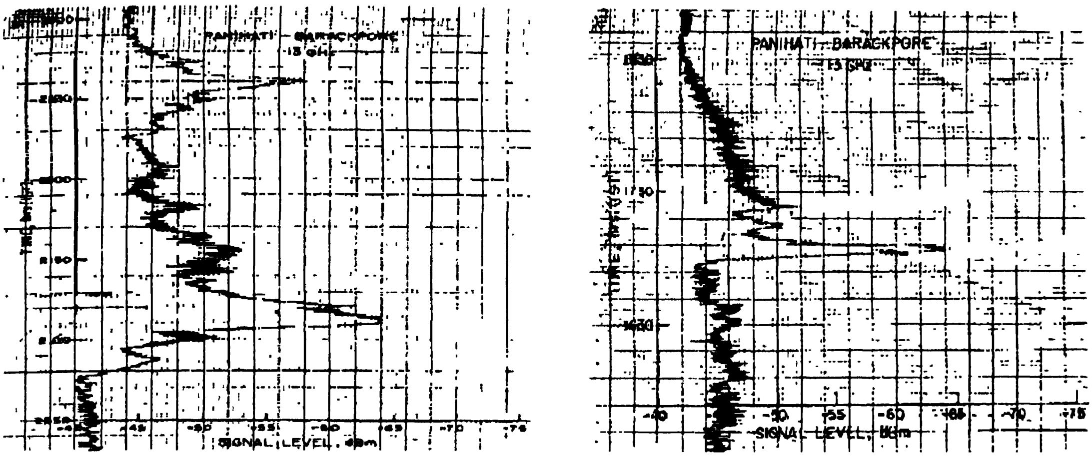
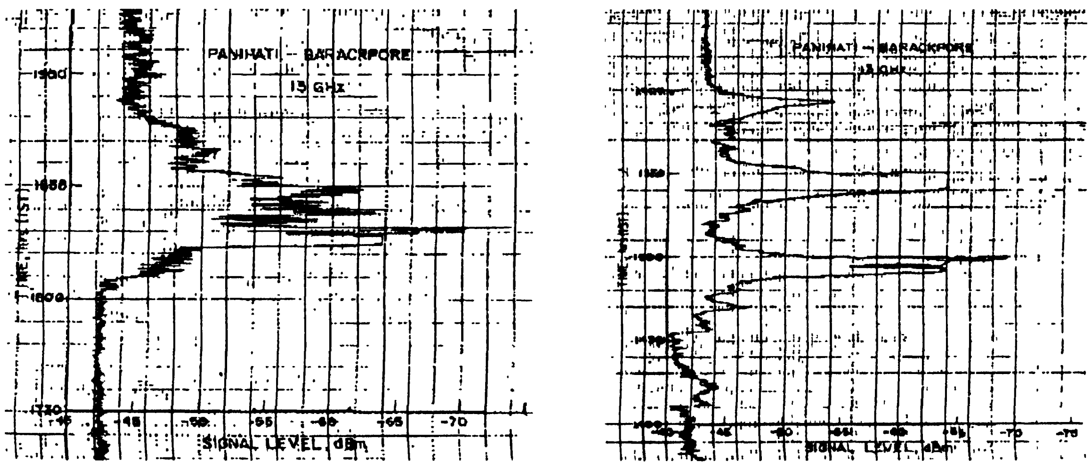


Figure 4. (a, b) Typical amplitude variations over the microwave link under rainy condition where maximum attenuation is 24 dB (Figure a) and 21 dB (Figure b).



b

Figure 5. (a,b) Typical amplitude variations over the microwave link under rainy condition where maximum attenuation is 31 dB (Figure a) and 27 dB (Figure b).

The probability distribution of the observed attenuation is presented in Figure 6. It is seen that under normal condition the measured radio signal level is ~42.5 dBm. It is seen in Figure 6 that the attenuation increases with rain rate. The attenuation of ~5.5 dB is found to be associated with rain rate ~20 mm/hr while the attenuation ~10 dB corresponds with rain rate ~36 mm/hr and attenuation of ~31 dB correlates with rain rate ~158 mm/hr.

The estimated results on specific attenuation at different rain rate derived by using the ITU-R relation (earlier known as CCIR), $A = 0.02515R^{1.164}$ [10] have been compared with the measured results. The specific attenuation in dB/km deduced by using ITU-R is presented in Table 1. The specific attenuation (dB/km) over the link path (measured total attenuation, dB is divided by the link path of 8 km length) is also

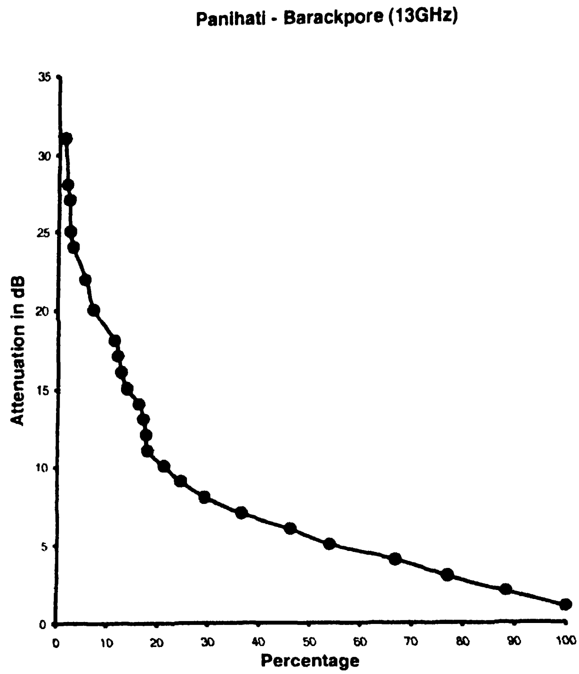


Figure 6. Probability distribution of attenuation results at 13 GHz

presented in Table 1 for comparison with ITU-R results. The specific attenuation deduced by using ITU-R and from the measured total attenuation over the path of length of 8 km shows good agreement upto rain rate 60 mm/h.

Table 1. Specific attenuation in dB/km deduced by using ITU-R and from measured attenuation results

Rain rate in	ITU-R	From measured attenuation results
10 mm/hr	0 367 dB/km	0 312 dB/km
20 mm/hr	0.822 dB/km	0.754 dB/km
30 mm/hr	1.352 dB/km	1.038 dB/km
60 mm/hr	2.953 dB/km	3.008 dB/km
100 mm/hr	5.352 dB/km	3.875 dB/km
130 mm/hr	7.263 dB/km	4.000 dB/km
158 mm/hr	9 115 dB/km	4.062 dB/km

The specific attenuation deduced by ITU-R overestimates as compared to specific attenuation obtained from measured total attenuation. This difference is due to the fact that the path length of the link is of 8 km which is quite large. For higher rain intensity *i.e.* when the rain rate is from 60 mm/hr to 160 mm/hr, the effective rain path length is usually less and is of the order from 3.5 km to 5.5 km depending on rain intensity. If the effective rain path length of rain is taken around 3.5 km to 5.5 km for different high rain intensity then specific attenuation derived from the measured total attenuation results also becomes comparable with the ITU-R results

It is therefore very essential and important to carry out measurements of attenuation of radio wave at frequency above 10 GHz over communication links having varying path length whenever and wherever opportunities are available in different geographical regions over the Indian sub continent

4. Conclusion

The measured results on radio signal and rain rate indicate that during heavy rain, the signals are attenuated heavily as high as ≥ 25 dB These measured results are useful to develop a rain attenuation model for the Indian tropics It is seen from this study as well as from earlier studies that the ITU-R model is not fully valid in India for different type of rainy condition.

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References

[1] H E Green *IEEE Antennas and Propagation Magazine* **46** 31 (2004)

[2] A D Panagopoulos P M Arapoglou and P G Cottis *IEEE Communication Surveys and Tutorials* (3rd Quarter) October (2004)

[3] G Brussard and P A Watson *Atmospheric Modelling and Millimetre Wave Propagation* (UK Chapman and Hall) (1995)

[4] K I Timothy, N C Mondal and S K Sarkar *International Journal of Satellite Communication* **16** 53 (1998)

[5] S K Sarkar, Rajesh Kumar and J Das *Indian J Phys* **77** 271 (2003)

[6] S K Sarkar, R Kumar, I Ahmad, M M Gupta, M V S N Prasad, J Das and A K De *Indian J Radio Space Phys* **33** 176 (2004)

[7] S K Sarkar, Iqbal Ahmad, M M Gupta, M V S N Prasad, J Das, A K De and Rajesh *Indian J Phys* **79** 117 (2005)

[8] *Climatological Tables of Observatories in India* India Meteorological Department (1988)

[9] S K Sarkar Guest Editorial *Indian J Radio Space Phys* **34** 297 (2005)

[10] ITU-R Recommendation (1994)