Seasonal Propagation Fading Characteristic in Line of Sight Radio Link

Naveen Kumar Chaudhary

***Abstract*— Fading is one of the important propagation characteristic that affects line-of-sight (LOS) radio link performance. This paper presents trend of seasonal propagation fading observed in mid Low Super High Frequency (SHF), LOS radio link stationed in Indian semi-desert terrain. The received signal level of LOS radio link was recorded on hourly basis for one complete seasonal cycle to observe the seasonal propagation fading. The result shows that LOS radio links are prone to fading during summer and monsoon seasons in Indian semi-desert region**

***Index Terms*— Bit Error Rate (BER), Fading, line-of-sight radio link, radio link reliabilty, signal attenuation**

I. INTRODUCTION

Line-of-sight radio links are recognized as highly flexible and economical means for providing point-to-point communication and it is used for multiple voice as well as data channels [1-5]. The LOS radios are the only viable source of engineering communication at places where it is difficult to lay optical fiber cables or any other type of line communication due to terrain or geographical constraints. These radio links are expected to operate satisfactorily under local climatic conditions; however it has been observed that reliability of the link is affected by atmospheric conditions [6-9]. The atmospheric conditions and seasonal climatic variations results in received signal fading due to multipath [10-12] In multipath condition several rays with different delays and amplitudes, received by the receiver antenna are destructively or constructively added to the ray of direct LOS path which leads to signal fluctuation [13]. The incidence of multipath fading varies as function of path length, frequency, and terrain conditions [2]. In this paper receive radio signal strength measurement was conducted in Indian semi-desert terrain at 6.8 GHz frequency to analyze the effect of fading on LOS radio link in low Super high frequency(SHF) spectrum. The study was conducted in Shriganganagar region of Rajasthan; the terrain has typical semi-desert profile. There is no much data available in open domain about the trend of fading in LOS radio links at low SHF spectrum in Indian Semi-desert terrain, therefore the results obtained in this paper will help the wireless planners to understand the trend of signal fading in LOS radio link in Indian semi-desert terrain and plan for suitable allowances in advance to counter the effect of seasonal fading which arises due to climatic variations.

Manuscript received July 18, 2016

II. METHODOLOGY TO OBSERVE THE FADING

The LOS radio link stationed in Shriganganagar region of Rajasthan, functional at 6.8 GHz frequency was kept under observation for one complete seasonal cycle 2009-2010 as a part of experimental evaluation to observe the instances of fading due to the erratic radio link performance with the seasonal variation. The net antenna height of the receiver was 179 meters and directional antenna was used in horizontal polarization mode with net antenna gain of 17 dBi. The seasonal cycle as per Indian seasonal calendar consists of four seasons. The months comprising these seasons are shown at table 1. The hourly received signal profile was observed from morning 0500 hours to 2300 hours every day for one complete seasonal cycle. The record of received signal profile was analyzed on monthly as well as seasonal basis. The measurement was conducted with effect from March 2009 - February 2010 which constituted one complete seasonal cycle.

In digital LOS radio links the Bit Error Rate (BER) is the most important parameter which determines the performance of the radio link. On the basis of experimental trials conducted in Indian semi-desert region it was observed that BER varied from 10^{-7} to 10^{-5} when received signal level was in the range -47 dBm to -70 dBm. The BER varied from 10^{-5} to 10^{-3} when received signal level was in the range -71 dBm to -75 dBm. The BER remained 10^{-3} and below when received signal level varied from -76 dBm to -85 dBm. The link performance characterization based on received signal level and BER is shown at table 2.

Table 1: Indian Seasonal Distribution as per months

Season	Months
Summer	March, April, May
Monsoon	June, July August, September
Post-monsoon	October, November
Winter	December, January, February

Table2: Link Performance Characterization based on Received Signal Level

Received Signal Level	Category
-47 dBm to - 70 dBm	Functional
-71 dBm to - 75 dBm	Marginally Functional
-76 dBm to –85 dBm	Prone to Outages

2.1 Link Performance Summer Season 2009

The link performance for each month of the summer season is shown at table 3 and the plot of average received signal level in -dBm for each day of the month for summer season is shown at figure 1.

Table 3:Link Performance for Summer Season 2009

Month	Functional	Marginally	Prone to

	(%)	Functional(%)	Outages (%)
March	100	-	-
April	10	90	-
May	-	100	-

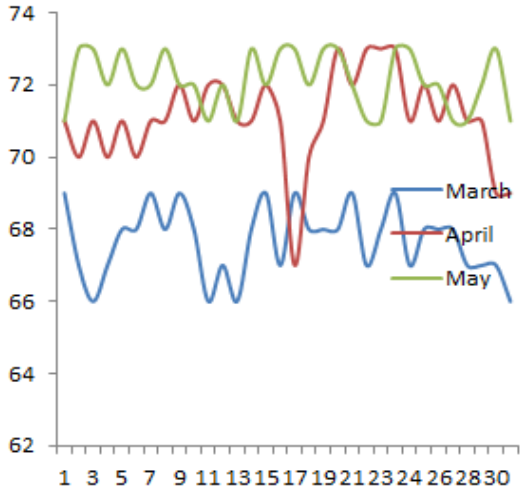

Figure1: Received signal level for summer season 2009

2.2 Link Performance Monsoon Season 2009

The link performance for each month of the monsoon season is shown at table 4, and the plot of average received signal level in -dBm for each day of the month for monsoon season is shown at figure 2.

Table 4:Link Performance for Monsoon Season 2009

Month	Functional (Percentage of time)	Marginally Functional (Percentage of time)	Prone to Outages (Percentage of time)
June	17	87	-
July	70	30	-
August	100	00	-
September	100	00	-

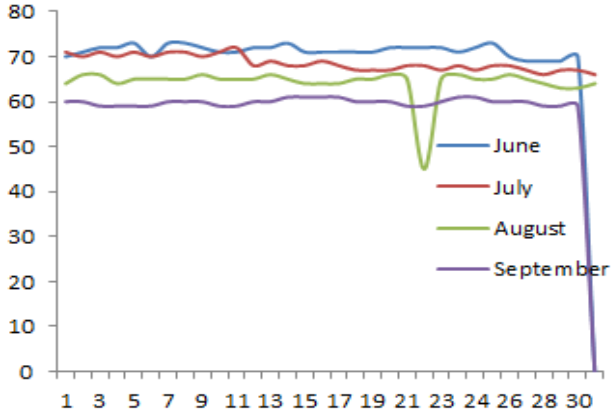

Figure2: Received signal level for monsoon season 2009

2.3 Link Performance for Post- monsoon Season 2009

The link performance for each month of the post-monsoon season is shown at table 4, and the plot of average received signal level in -dBm for each day of the month for post-monsoon season is shown at figure 3.

Table 4:Link Performance for Post-monsoon Season 2009

Month	Functional (Percentage of time)	Marginally Functional (Percentage of time)	Prone to Outages
October	100	-	-
November	96	4	-

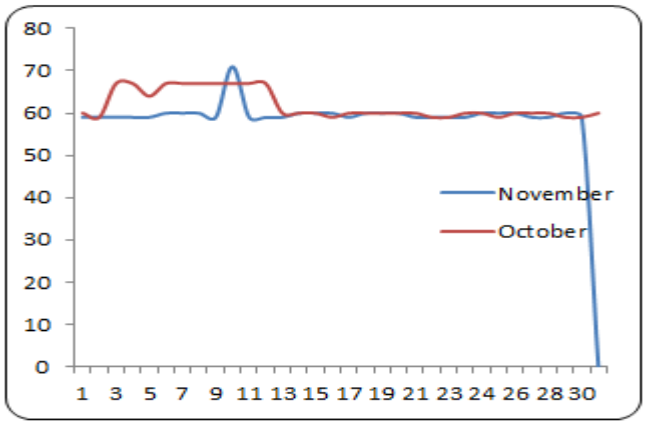

Figure 3: Received signal level for post-monsoon season 2009

2.4 Link Performance for Winter Season 2009-2010

The link performance for each month of the winter season is shown at table 6, and the plot of average received signal level in -dBm for each day of the month for winter season is shown at figure 4.

Table 6:Link Performance for Winter Season 2009-2010

Month	Functional (Percentage of Time)	Marginally Functional (Percentage of Time)	Prone to Outages
December	100	-	-
January	100	-	-
February	100	-	-

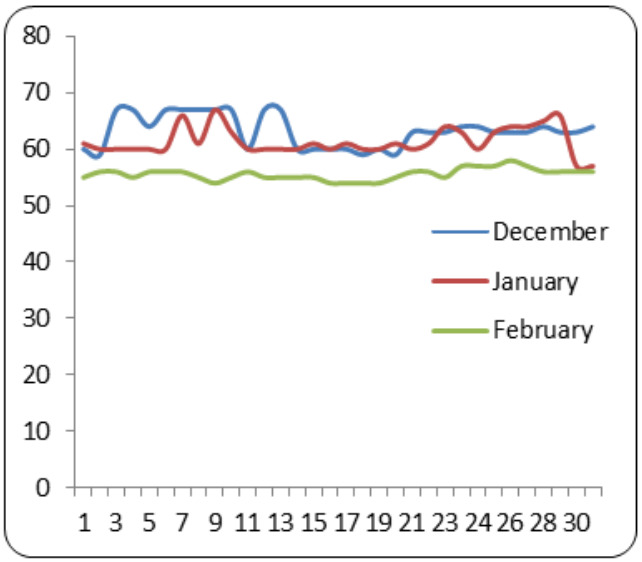

Figure 4: Receive signal level for winter 2009-2010

III. MEASUREMENT RESULT FOR SEASONAL CYCLE 2009-2010

The phenomenon of seasonal multipath fading for complete seasonal cycle 2009-2010, is shown at table 7.

Table 7: Link Performance for Seasonal Cycle 2009-2010

Season	Link Performance (Percentage of time)		
	Functional	Marginally Functional	Prone to Outages
Summer	36.4 %	63.6 %	-
Monsoon	71.75 %	28.25 %	-
Post-Monsoon	98 %	2 %	-
Winter	100 %	-	-

The study results obtained shows that link performance for the seasonal cycle 2009-2010, was in functional range for 76.60% of time, 23.40 % of time link was in marginally functional range and 0% of time the link was in prone to outage range .The further observation shows that the phenomenon of seasonal fading was negligible for winter season, the link performance remained in functional range for all the months of the winter season. The link performance for the summer season remained in marginally functional range for 63.40% of time and 36.60% of time it remained in functional range. The phenomenon of seasonal fading was observed, however the link suffered no outages. The link performance for monsoon and post-monsoon season was tumultuous. In the monsoon season the link was in functional range for 71.75% of time, 29.25% of time the link was in marginally functional range and 0% of time the link was in prone to outage range. In post-monsoon season the link was in functional range for 98% of time, 2 % of time link was in marginally functional range and 0% of time link was in prone to outage range. The phenomenon of signal level variation was observed in summer, monsoon and post-monsoon season. The link performance for seasonal cycle 2009-2010 is shown at figure 5.

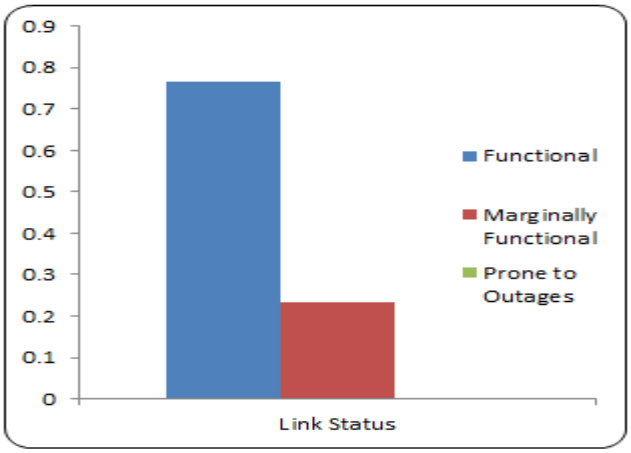

Figure5. Link Performance for seasonal cycle 2009-2010

CONCLUSION

The reliability of LOS radio link depends on many factors however climatic variations are one of the major factors that affect propagation of radio wave in low SHF band. The results obtained in this study shows that the phenomenon of seasonal fading is negligible for winter season; however link performance was moderately affected by seasonal fading in summer as well as monsoon season as link remained in marginally functional range for 63.6% and 28.25 % of time respectively. The LOS radio link planners, while planning LOS radio link in low SHF band should cater for necessary allowances in transmission power to counter the effect of fading in summer and monsoon season. The study results will also help the system engineers to improve the performance of existing LOS radio link functional in low SHF band by increasing the transmission power to appropriate level to counter likely propagation fading in summer and monsoon seasons.

REFERENCES

1. De Dieu, U.J. and N.J.M, "Characterisation and Modelling of large scale fading for radio propogation in Rawanda",Journal of Communication and Networks, 8, pp. 22-30, Feb 2016.[Online]. Available:http://dx.doi.org/10.4236/cn.2016.81003.
2. Jan Bogucki and Ewa Wielowieyska "Emperical seasons's fadings in radio communication at 6 GHz band," Journal of Telecommunication and Information Technology, vol. , pp. 48–52, February 2009.
3. R. H . Anderson , Fixed Broadband Wireless System Design. Chichester, Willey, 2003..
4. R. K. Crane, Propagation Handbook for wireless Communications System Design. London, CRC Press, 2003.
5. Polat Goktas et al, "Multipath fading effect on terrestrial microwave radio links", IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science meeting, pp. 918-919, Vancuber , VC, 19-24 Jul 2015.
6. C. Salema, Microwave Radio Links: From Theory to Design. New Jersey: Wiley, 2003.
7. B.L. Agba, R. Morin, and G. Bergeron, "Comparision of Microwave links prediction methods: Barnett-Vigants vs. ITU models," PIERS proc., Xi'an, China, Mar. 2010.[On-line]. Available:http://piers.org/piersproceeedings/piers2010XianProc/.
8. Tom Garlington Microwave line-of-sight transmission engineering, white paper No: AMSEL-IE-TS-06015, June 2006.
9. J. Frank Jimenez, " Fundamental of Radio Link Engineering," pp 2-17, [Online] Available: www.pathengineering.com. 30 March, 1999
10. International Telecommunication Union Recommendation on propagation data and prediction methods required for design of terrestrial LOS system, ITU-R P.530-13, October 2009. [Online]. Available: http://www.itu.int/rec/R-REC-P.530/en
11. R.L Olsen, B. Segal, New Techniques for Predicting the Multipath Fading Distribution on VHF/UHF/SHF Terrestrial Line-of-Sight Links in Canda, Canadian Journal of Electrical and Computer Engineering, v.17, N.1, 1992, pp.11-23.
12. R.L. Olsen, B. Segal, "Worldwide Techniques for predicting the Multipath Fading Distribution on Terrestrial LOS Links: Background and Results of Tests," IEEE Trans. AP, v.47,N.1, ,pp.157-170, Jan.1999.
13. M. Mohajer, R. Khosravi and M. Khabiri, "Flat fading modelling in fixed microwave radio links based on ITU-R P.530-11," in IEEE, Microwave, Radar & Wireless Communications Conf., MIKON 2006, , pp.423-426,
14. May 2006.

Author

Naveen Kumar Chaudhary obtained his Ph.D (Electronic and Communication Engineering) and ME (Digital Communication) degree from Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, India. He has carried out active research in the field of line-of-sight radio communication, Mobile adhoc networks and wireless access technology. His research interest includes Wireless communication, propagation modeling, Tactical communication networks, MANET and Satellite communications. He is a life member of IETE.