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Performance Analysis of FSO Link in Monsoon (Rainy) Season in Delhi, India

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ABSTRACT- In this paper, we present a comprehensive survey of attenuation due to rain conditions in the months of monsoon in Delhi region. In this paper I used Marshal and Palmer rain distribution model for four specific months of the rainfall i.e. June to September for calculate simulation model for rain attenuation. I analyzed Q-factor of the received signal by varying the transmission wavelength, data rate and range of the FSO system. The simulation results show that for error free transmission of data during the months of rainfall, the transmission signal wavelength in the longer wavelength region at a wavelength of 1300nm and 1550nm is recommended to be used for a maximum data rate of 2.5Gb/s with a maximum transmission range up to 4Km. Delhi being a highly populated (with the IT hub) city the demand for higher and unlimited bandwidth for communication channel is highly required. For this case the communication through FSO is the best alternative solution than optical fiber.

KEYWORDS- FSO, FSO link, Mansoon season, FSO model

I. INTRODUCTION

Delhi is the capital of India, with huge population of 11 million in 2011 standing after Mumbai. With an area of 1484 km sqrs, it has seen a rapid growth up to 26 million in 2016 [1]. In this paper, we are proposing the use of FSO communication by presenting different parameters to be used in Delhi when transmitting data during the heavy rain period months, especially during the periods from June to September. We designed a model of FSO system using Opti-System to establish an FSO link by a range from 0 to 4 km. while transmitting the data on NRZ modulation scheme, and reported analysis of various parameters like transmission power, Bit Error rate (BER),and transmission length[4]. The simulation results shows, for better transmission of data during the heavy rain seasons of the mentioned months above, the transmitting power of 5dBm should be used.

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This power can be implemented within 0 to 4km of the FSO links with an acceptable higher Q-factor. Also, for the transmission links should be n the range of 0 to 4km, a transmission power from the range of -5dBm to 5 dBm can be used respectively. The analysis also found that using FSO for communication is better than optical fiber because it can avoid some challenges such as high cost of digging roads, impractical physical connection between transmitters and receivers and insecure of data. We have collected the rainfall data for the years 2012-2016 during the months of monsoon i.e. June-September in the region and analyzed the extent upto which the performance of the link may be affected considering different values of transmission power, wavelengths, data rates and transmission ranges. Quality-factor (Q-factor) as well as received optical power versus transmission distance has also been analyzed for the system.[8]

II. SYSTEM LAYOUT OF PROPOSED FSO MODEL

Working principle of Free Space Optical Communication (FSO) is that it operates on light propagation in a medium from one point to other. We used optisystem-15 for simulation and performance characterization. Optisystem-15 is an innovative optical simulation package used for FSO designing, testing and optimization of virtually any type of optical system in the physical layer of spectrum of optical networks.

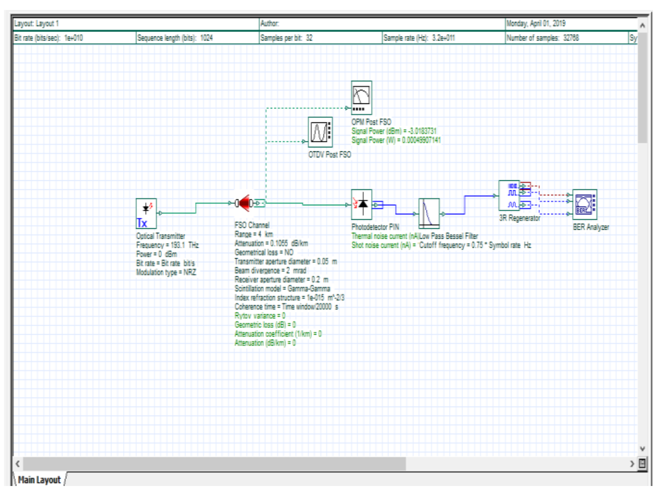

Fig 1: System model analyzing the effect of rain attenuation

III. DEGRADATION OF PERFORMANCE OF FSO LINK DUE EFFECT OF RAIN

As per the dimensions of the raindrop, there are many distribution designs which may determine the Rain attenuation model [2]. We used marshal and palmer distribution model as rain attenuation model for analysis. Marshal and Palmer's distribution model is used to estimate the specific rain attenuation using an empirical formula [3]. The specific attenuation formula for rain effect analysis is:

$$\gamma \text{ (dB/km)} = k R^{\alpha} \quad (1)$$

where k and α are constants whose values depend upon wavelength, temperature and rain drop size distribution and R is the rain rate in (mm/hour). For spherical raindrops and operation at a wavelength of 1550nm, k and α are given as 1.076 and 0.66 respectively [5]. As the statistics given by the meteorological department is month wise in mm, Average Rain per year during the months of monsoon has been computed as depicted in Table.1. It has been further converted to the Average Rain rate i.e. Rain/hour (mm/hr.) per year for the months of rainfall [7]. The specific attenuation in dB/Km per year has been calculated thereafter based on Average Rain rate as shown in Table.2.

Table 1: Rainfall data of Delhi Region for months June-September

Year	Rain (mm)				Average Rain (mm)
	June	July	August	September	
2012	7	113.4	222.6	65.8	408.8
2013	110.9	189.3	177.9	58.4	536.5
2014	27.1	111.1	80.0	71.2	289.4
2015	58.9	268.8	244.7	26.1	598.5

Table.2 Calculation of specific attenuation per year based on average Rain Rate (mm/hr.)

Year	Average Rain (mm)	Average Rain Rate (mm/hour)	Attenuation
2012	408.8	0.1396	0.1055
2013	536.5	0.1832	0.1253
2014	289.4	0.0988	0.0849
2015	598.5	0.2044	0.1342

Average attenuation 0.1225dB/Km

IV. SIMULATION RESULTS

Table 2: Default parameters

Parameter	Value
Data rate	1000
Optical Tx Power	-5dBm to 5dBm
Wavelength	1550nm
Modulation format	NRZ
Transmitter Aperture	0.05m
Receiver Aperture	0.2m
Range	Upto 4Km

Rain attenuation prediction is normally referred as "specific attenuation" which means attenuation per unit length[7]. The most commonly use raindrop size distributions that have been proposed are Marshal and Palmer. In this paper Marshal and Palmer distribution proposed renowned empirical expression by fitting their data and the Laws and Parsons data[9]. The specific attenuation of wireless optical link for rain rate of R mm/hr is given by

Formula $\gamma(\text{dB/km}) = a.Rb$,

Where a & b are power law parameters equal to 0.365, 0.63 respectively.

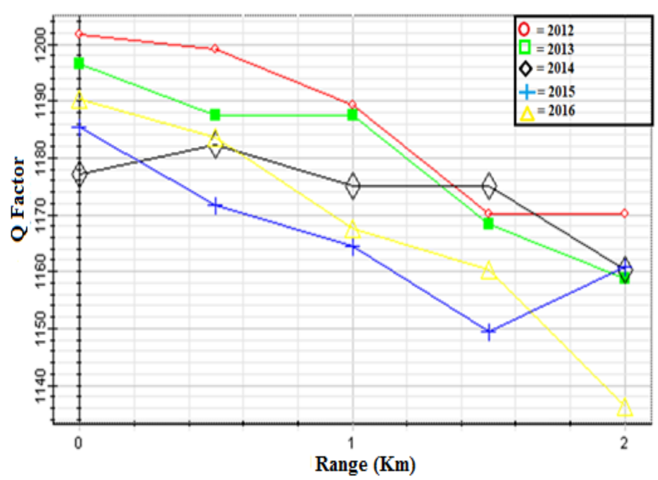

Fig 2: Quality factor of the received signal versus range (different years)

The graph in Fig.2 shows the max Q factor of the received signal versus range as a result of attenuations caused by rain in different years. We can observe an inverse relation between the two factors.

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V. CONCLUSION

In this paper, the rain attenuation used for simulation of the system has been calculated by using Marshal and Palmer rain distribution model model for four specific months of the rainfall i.e. June to September. We analyzed Q-factor of the received signal by varying the transmission wavelength, data rate and range of the FSO system. The simulation results show that for error free transmission of data during the months of rainfall, the transmission signal wavelength in the longer wavelength region at a wavelength of 1300nm and 1550nm is recommended to be used for a maximum data rate of 2.5Gb/s with a maximum transmission range up to 4Km.[6]

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