International J. of Engg. Research & Indu. Appls (IJERIA)
ISSN 0974-1518, Vol.11, No.II (August 2018), pp.1-7

EFFECT OF ATMOSPHERIC ATTENUATION OF FREE SPACE OPTICAL COMMUNICATION SYSTEM FOR NASIRIYAH CITY IN IRAQ

NABIL JALIL AKLO[1] , INAS A.F.AL TAHAR[2] AND WATHEQ ABDULKAREEM NEAMAH[3]
[1]Lecturer, College of Engineering, University of Thi Qar.
[2]Lecturer, College of Engineering, University of Thi Qar
[3]Lecturer, College of Engineering, University of Thi Qar.

Abstract

The purpose of this paper is analysis the performance of Free Space Optical system (FSO) by quantifying several atmospheric effects of Iraq .Rain and haze were measured on terrestrial FSO links located in Nasiriya city. This analysis is transmitter data by method point-to-point FSO links with the measurement of terrestrial FSO link installed at University of Thi Qar campus to brick factory. As well as the result indicated that FSO system can be deployed with reliability in Nasiriya city of Iraq at range 10km using wavelength 1550nm.

Keywords: FSO , laser, propagation, attenuation, atmospheric, transmission…etc.

1. INTRODUCTION

The atmospheric attenuation such as rain and haze affect on laser communications such as Free Space Optical (FSO) communication which also known as Wireless Optical Communication (WOC), Fiber, or Laser Communication. FSO communication regards one of the several forms of wireless communication which witnesses a huge development nowadays. FSO delivers a wide services and needs point-to-point connection between transmitter and receiver at clear atmospheric conditions. FSO is essentially the same as fiber optic transmission, but the difference is that the laser beam is collimated and sent through atmosphere, rather than guided through optical fiber [1]. The FSO technique uses modulated laser beam to transmit carried data from transmitter to a receiver, it is affected by attenuation of the atmosphere due to the unstable weather conditions, where the channel, through which light transmits is not ideal. In this work we will take Nasiriya city as case studies which is difficult to install the technique of fiber optics in it, but FSO technique will solve this problem with same proficiency and quality provided by fiber optics. At same time FSO systems are sensitive to bad weather conditions such as fog, haze, dust, rain and turbulence. All of these factors effect to weaken light and could block the light track in the atmosphere. As a result of these challenges, we will study the weather conditions in detail before set up FSO systems.

2. ATMOSPHERIC ATTENUATION

Atmospheric attenuation is defined as the method by which some or all of the electromagnetic wave energy is lost when crossing the atmosphere. Thus, atmosphere causes signal attenuated and degraded in a FSO system link in several ways, including absorption, scattering, and visibility. All these effects are time-varying and will depend on the local conditions and weather. generally, the atmospheric attenuation is given by the following Beer's law Eq. (1) [2]:

$$\tau = \exp(-\beta L) \qquad (1)$$

Where:

τ: is the atmospheric attenuation.

L: is the distance between Tx and Rx in kilometer.

β : is the total attenuation coefficient given as:

$$\beta = \beta_{abc} + \beta_{scat} \qquad (2)$$

β_{abs} : is the molecular and vaporizer absorption.

β_{scat} : is the molecular and vaporizer scattering.

3. THE CASE STUDYING NASIRIYA CITY OF IRAQ

Optical signal propagation is affected by fog , clouds and dust particles, but major factor of attenuation is rain, haze and distance . It was found that attenuation linearly increases to rainfall rate and distance increasing. Rains fall on different parts of Iraq. Average rain intensity in Nasiriyah is exceeding 0.09% of the year which is estimated at 30 mm/hrs with attenuation of 9dB/km .For this case , the distance between the university of Thi-Qar campus and brick factory at 10km as shown in Figure 1 .

4. RESULTS AND DISCUSSION

FSO system used the laser beam to transmit data through atmosphere. The ruthless atmospheric conditions have bad effects on the transmission efficiency of FSO where these effects could appear in a transmission of lacking quality and failure in communication. Therefore, FSO design requires studying of the local weather conditions of the region.

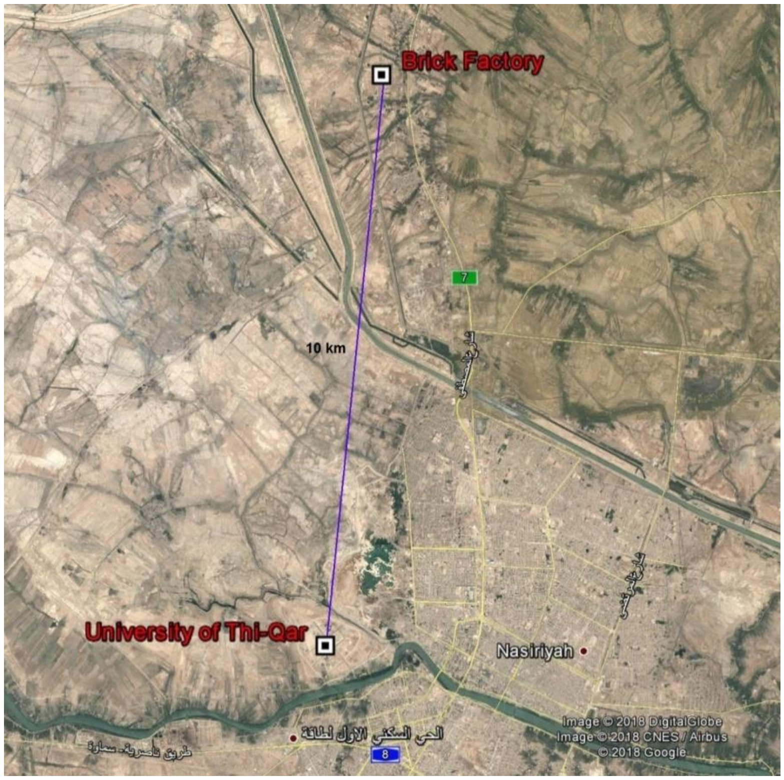

Figure (1) The distance between the university of Thi Qar and the brick factory

Where this help us to define the attenuation effects on FSO communication that occurs to laser beam at this area. In this part of work, we shall discuss the effects of atmospheric attenuation during rainy and hazy days.

Depending on Iraqi meteorological website data we can calculation attenuation on beam propagation in Nasiriya city has been obtained for visibility are listed in table (1) for the year 2015 and for rainfall rate are listed in table (2) for year 2015. Real data has been included in this analysis. Data has been collected and classified into two types:

1. Hazy days data: which has been classified based on low and average visibility.

2. Rainy days data: has been classified based on the rainfall rate for heavy, moderate and light rainfall.

Firstly, we will discuss and analyze the effects of atmospheric attenuation on the FSO system performance during hazy days regarding the distance between transmitter and receiver is 10 km. In Fig.2

represents the atmospheric attenuation versus low visibility. When visibility is 3.5 km, atmospheric attenuation is 7 dB, 6.5dB and 3.8dB for wavelengths 780 nm, 850 nm and 1550 nm respectively.

Table (1). Average visibility in km for Nasiriya city during the year 2015

Month	Average Visibility	Low Visibility
Jan.	9.5	6
Feb.	8.8	4.8
Mar.	9.5	6.2
Apr.	8.5	4.9
May	6.7	6.1
Jun.	8.4	5.2
Jul.	8.5	5
Aug.	9.1	6.9
Sep.	8.9	5.1
Oct.	8.9	3.5
Nov.	9.6	6.9
Dec.	9.4	6.7

Table (2). Rainfall rate (mm) for Nasiriya city during the year 2015

Month	Rainfall rate (mm)
Jan.	0.9
Feb.	12.5
Mar.	7.3
Apr.	1.0
May	0.9
Jun.	0.0
Jul.	0.0
Aug.	0.0
Sep.	0.0
Oct.	24.4
Nov.	8.0
Dec.	30

In Fig.3 represents the atmospheric attenuation versus average visibility when visibility is 6.7 km, atmospheric attenuation is 2dB , 1.8dB and 0.86dB,we note that the atmospheric attenuation inversely proportions with visibility, when the visibility is rise the effect of atmospheric attenuation is rise too. In Fig.4 indicates to the atmospheric attenuation vs link range that extends for 1km to 10km. Atmospheric attenuation for link range 10km at low visibility is 300 dB, 275 dB, 154 dB for wavelengths 780 nm, 850 nm and 1550 nm respectively.

In Fig.5 indicates to the atmospheric attenuation vs link range that extends from 1 km to 10km. Atmospheric attenuation for link range 10 km at average visibility is 90.1 dB, 79 dB, 35 dB for wavelengths 780 nm, 850 nm and 1550 nm respectively. ***The large distance between transmitter and receiver, the more the atmospheric attenuation .*** This means that when the distance between the transmitter and the receiver increases, it is able to reduce the quality of transmission and effectiveness of FSO system. In addition, these readings have proved that the wavelength 1550 nm is capable to reduce the effect of atmospheric attenuation on FSO system.

The distance between transmitter and receiver at low visibility should be reduced to avoid the effect of atmospheric attenuation on FSO system and improve its performance. In this part we will discuss the effects of atmospheric attenuation on the performance of FSO system during rainy days. The effects of atmospheric attenuation on FSO systems during rainy days depended on rainfall rate intensity and raindrop radius.

In Fig.6 indicates the atmospheric attenuation vs rainfall rate. This figure was plotted. The atmospheric attenuation is about 0.18 dB to 0.37 dB for light rain, about 2.1 dB to 2.5 dB for moderate rain and 3.5 dB to 8.9 dB for heavy rain. The highest attenuation is about 8.9 dB in heavy rain.
In Fig.7 indicates the atmospheric attenuation vs link range for 10 km link range the atmospheric attenuation is about 10 dB for light rain, 90 dB for moderate rain and 370 dB for heavy rain.

CONCLUSIONS

In this paper, we focused on haze and rain effects on FSO systems. From the results analysis and data onto the table (1) the haze represented the most important atmospheric scatters. Their attenuation, which can reach about 3.8 dB at 3.5 km with low visibility at which is higher than attenuation at average visibility and value to affects the performance of a FSO link with distances as small. Rain is due to the attenuation at heavy rain 30 mm/hr about 8.9dB in Nasiriya of Iraq.

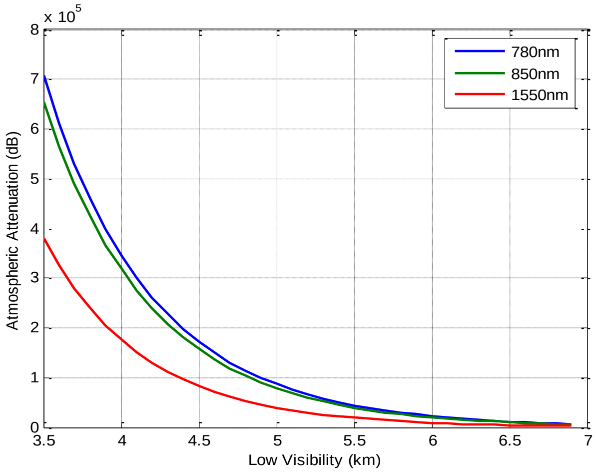

Figure 2. Atmospheric Attenuation (dB) versus low visibility (km)

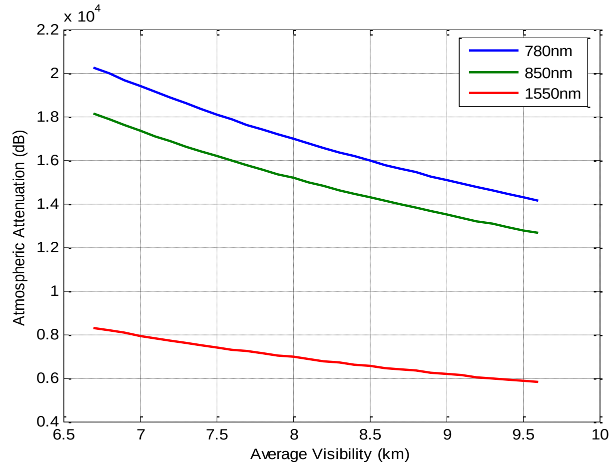

Figure 3. Atmospheric attenuation (dB) versus average visibility (km).

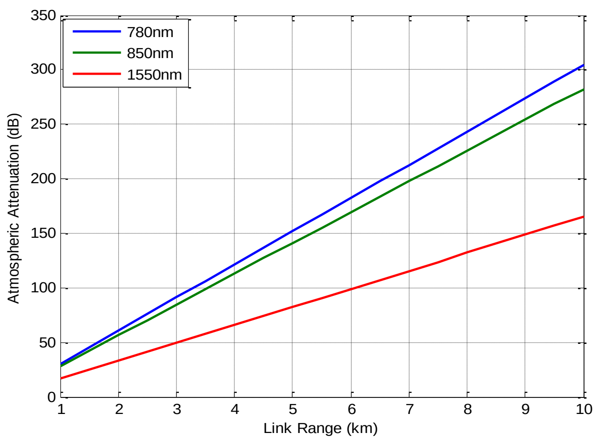

Figure 4. Atmospheric attenuation (dB) versus link range (km) at low visibility.

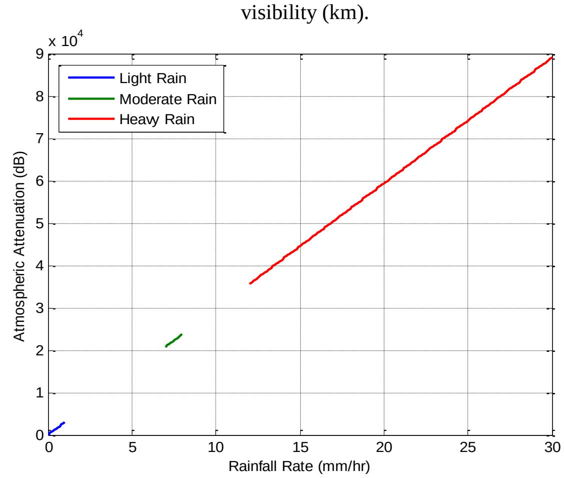

Figure. 5. Atmospheric attenuation (dB) versus link range (km) at average visibility.

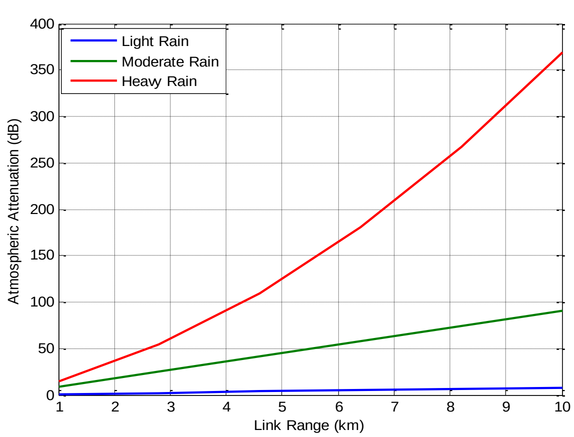

Figure. 6. Atmospheric attenuation (dB) versus rainfall rate (mm/hr).

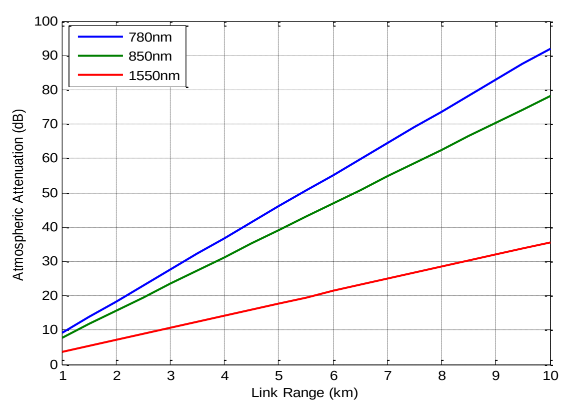

Figure 7. Atmospheric attenuation (dB) versus link range (km).

REFERENCES

[1] Weichel H., "Laser Beam Propagation in the Atmosphere", SPIE, Optical Engineering Press, Vol. TT-3, 1990.

[2] Willebrand, Heinz A., Ghuman B. S. "Fiber Optic Without Fiber Light Pointe Communications", 2001.

[3] A. K. Majumdar, J. C. Ricklin, "Free Space Laser Communications Principles and Advances", Springer ISBN 978-0-387-28652-5, 2008.

[4] S. G. Narasimhan and S. K. Nayar, "Vision and the Atmosphere", 2007.

[5] M. A. Bramson, "in Infrared Radiation", A handbook for Applications, Plenum Press, p. 602, 1969.

[6] Earl J. McCartney, "Optics of the Atmosphere: Scattering by Molecules and Particles", Wiley & Sons, New York, 1997.

[7] B. Bova, S. Rudnicki, "The Story of Light", Source book ISBN, 2001.

[8] P. P. Smyth et. al., "Optical Wireless Local Area Networks Enabling Technologies", BT Technology Journal, 11(2), pp. 56–64, 1993.

[9] M. S. Awan, L. C. Horwath, S. S. Muhammad, E. Leitgeb, F. Nadeem, M. S. Khan,"Characterization of Fog and Snow Attenuations for Free-Space Optical Propagation", Journal, Vol. 4, No. 8, 2009

[10] B. Olivieret, et al., "Free – Space Optics, Propagation and Communication", Book, ISTE, 2006.

[11] H. Willebrand and B. S. Ghuman, "Free-Space Optics Enabling Optical Connectivity in Today’s Networks", SAMS, 0-672-32248-x, 2002.

[12] Achour M., "Simulating Atmospheric Free-Space Optical Propagation part I, Haze, Fog and Low Clouds, Rainfall Attenuation", Optical Wireless Communications, Proceedings of SPIE, 2002.