ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 9, September 2015

Performance Analysis of FSO System using Nakagami m Fading Channel

Sarita[1], Nidhi Mittal[2]

M. Tech Student, ECE, DVIET, Karnal, Haryana, India[1]

Assistant Professor, ECE, DVIET, Karnal, Haryana, India[2]

Abstract: This study carry out the performance analysis of bit error rate of free space optical communication system over Nakagami - m fading channel. In this paper, the performance of free space optical communication in the presence of the atmospheric turbulence is presented. Weak turbulence is modeled as log normal distribution of Nakagami-m channel and strong turbulence is modeled as Gamma-Gamma distribution of Nakagami-m channel. The performance controlling parameters are outage probability and bit error rate. In this case, BER and outage probability is studied with different level of channel turbulence in free space optical communication.

Keywords: Atmospheric turbulence, bit error probability, free space optical system, outage probability, Nakagami m fading channel.

I. INTRODUCTION

Free space optical (FSO) communication is a transmission technology in which optical signal is transmitted through atmosphere. FSO has found attention of many researchers because of its advantages such as being license free, high data rate, quick and easy deployment [1].FSO is used for point to point communication between fixed locations on land and it is also used for communication between moving platforms. Despite of various advantages, the performance of FSO system get severely affected due to some atmospheric conditions referred as atmospheric turbulence [2]. Various statistical models have been proposed to describe the optical channel characteristics with respect to atmospheric turbulence strength [3].
Error control coding is used to mitigate the turbulence induced fading under weak turbulence for Gamma-Gamma turbulence model [4].In this paper, the performance of free space optical communication system in the presence of atmospheric turbulence is represented. Factors affecting the performance of communication channel are presented with Nakagami model. The performance controlling parameters are outage probability and bit error rate (BER). FSO links is assumed under Gamma Gamma distribution in majority of works except in [5]. In the literature on FSO systems, log normal distribution is considered to be commonly used statistical model as it is good under weak turbulence. Disadvantage of log normal distribution is that it fails in moderate and high turbulence conditions. In [6], Karimi investigated the outage probability of two protocols, namely amplify-and-forward and decode-and-forward respectively. Furthermore WiMax is introduced for the terrestrial wireless channels [7]. In a latest work [5], mixed RF/FSO system considered for the analysis of performance of both the systems.
The work [5] elaborates that for all the cases under consideration, lowest outage and bit error rates would not guarantee decreasing the pointing error and using heterodyne detection and not increasing RF link parameter
In this paper, we consider a FSO system where the FSO links experience Gamma Gamma fading. Further the effect of atmospheric turbulence is taken into account for the FSO link. Rayleigh distribution models multipath fading with no line of sight while Ricean distribution requires line of sight. Bandwidth requirement is large for both cases. In previous studies, average error probabilities are carried out using Rayleigh, log normal, Gamma Gamma distribution. Nakagami m distribution is a versatile model because it can model multipath fading that experiences either less or severe fading than that of Rayleigh variates.
The rest of the paper is as follows: section II involves the description of Free space optical system, Section III includes the factors affecting the performance of free space optical system. Section IV represents Nakagami distribution. Section V shows the simulation results with graphical representations. Section V is the conclusion

II. FREE SPACE OPTICAL COMMUNICATION

FSO is wireless laser-based point-to-point communications in which the points have clear line-of-sight between them. Atmospheric turbulence has a significant impact on the quality of a laser beam propagating through the atmosphere over long distances. In the presence of atmospheric turbulence, the received signal exhibits random intensity fluctuations which increase the BER. Performance evaluated under considering the effects of the atmospheric turbulences which is the great challenges for the FSO.

This line-of-sight technology approach uses invisible beams of light to provide optical bandwidth connections. It's capable of sending up to 1.25 Gbps of data, voice, and video communications simultaneously through the air enabling fiber-optic connectivity without requiring physical fiber-optic cable. It enables optical communications at the speed of light. And it forms the basis of a new category of products optical wireless

DOI 10.17148/IJARCCE.2015.4955

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 9, September 2015

products from Light Pointe, the recognized leader in outdoor wireless bridging communications. This site is intended to provide valuable background and resource information on FSO technology. Whether you're a student, an engineer, account manager, partner, or customer, this site provides the FSO insight you may require. And for providing high-speed connections, across Enterprises and between cell-site towers, it is the best technology available.

III. FACTORS AFFECTING FSO SYSTEM

A. Turbulence

Turbulence is generally defined as the changes of the path of light due to the changes of the refractive index of air packets. In a sunny day, some air cells or air pockets heat up. This causes changes in the refractive index along the path of the light while it propagates through the air. The refractive index changes in a random motion because these air pockets are not stable in time and space. This behavior appears as turbulent for outsider observer.

B. Absorption

Absorption occurs when suspended water molecules in the terrestrial atmosphere extinguish photons. This causes a decrease in the power density (attenuation) of the FSO beam and directly affects the availability of a system. Absorption occurs more readily at some wavelengths than others. However, the use of appropriate power, based on atmospheric conditions, and use of spatial diversity (multiple beams within an FSO unit) helps maintain the required level of network availability.

C. Scattering

Scattering is caused when the wavelength collides with the scatterer. The physical size of the scatterer determines the type of scattering. When the scatterer is smaller than the wavelength, this is known as Rayleigh scattering. When the scatterer is of comparable size to the wavelength, this is known as Mie scattering.

When the scatterer is much larger than the wavelength, this is known as non-selective scattering. In scattering-unlike absorption-there is no loss of energy, only a directional redistribution of energy that may have significant reduction in beam intensity for longer distances.

D. Fog

The major challenge to FSO communications is fog. Rain and snow have little effect on FSO, but fog is different. Fog is vapor composed of water droplets, which are only a few hundred microns in diameter but can modify light characteristics or completely hinder the passage of light through a combination of absorption, scattering and reflection. The primary way to counter fog when deploying FSO is through a network design that shortens FSO link distances and adds network redundancies. FSO installations in foggy cities such as San Francisco have successfully achieved carrier-class reliability.

E. Scintillation

Heated air rising from the earth or man-made devices such as heating ducts creates temperature variations among different air pockets. This can cause fluctuations in signal amplitude which leads to "image dancing" at the FSO receiver end. Light Pointe's unique multi-beam system is designed to address the effects of scintillation. Refractive turbulence: Refractive turbulence causes two primary effects on optical beams.

IV. NAKAGAMI DISTRIBUTION

The Nakagami-m distribution is a versatile statistical model because it can model fading amplitudes that experience either less or severe fading than that of Rayleigh variates. The Nakagami-m distribution is suitable for describing statistics of mobile radio transmission in complex media such as the urban environment. Nakagami distribution is related to gamma distribution.

The Nakagami distribution can be generated from the chi distribution. The Nakagami distribution or Nakagami m distribution is a probability density related to the gamma distribution. It has two parameters: a shape parameter m and a second parameter controlling spread Ω. The Nakagami-m random process is defined as an envelope of the sum of 2m independent Gauss random processes, the Nakagami-m distribution is described by the pdf

$$pz(z,\Omega)=\frac{2}{\Gamma(m)}\left(\frac{m}{\Omega}\right)^{m} z2m\text{-}1\exp\left(-\frac{m}{\Omega}z^{2}\right), z>0, m\geq\frac{1}{2} \qquad (1)$$

where z is the received signal level,(.) is the gamma function, m is the parameter of fading depth, defined as:

$$m=\frac{E^{2}[z]}{Var[z^{2}]} \qquad (2)$$

while Ω is average signal power:

$$\Omega = E\,[z2]$$

A. Outage probability

The outage probability, Pout, is defined as the probability that the received SNR per symbol falls below a given threshold-Yth. This probability can be obtained as

$$Pout\ (\gamma th) = F\gamma(\gamma th) \qquad (4)$$

Where

$$F\gamma(\gamma th)=\frac{1}{\prod_{i=1}^{N}\Gamma(m_i}\, G_{1,N+1}^{N,1}\left[\frac{\gamma}{\bar{\gamma}}\prod_{i=1}^{N} m_{i}\ \Big|_{m_1,m_2,\dots\dots,m_N,0}^{1}\right] \qquad (5)$$

B. Average error probability

The most straightforward approach to obtain the ASEP, , is to average the conditional symbol error probability Pse(γ) over the PDF is

$$\overline{P_{se}} = \int_0^{\infty} P_{se}\,(\gamma) f_{\gamma}(\gamma) d\gamma \qquad (6)$$

V. RESULTS

The analysis of free space optical communication system in the presence of atmospheric turbulence is presented over the Nakagami Fading channel model.

 DOI 10.17148/IJARCCE.2015.4955

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 9, September 2015

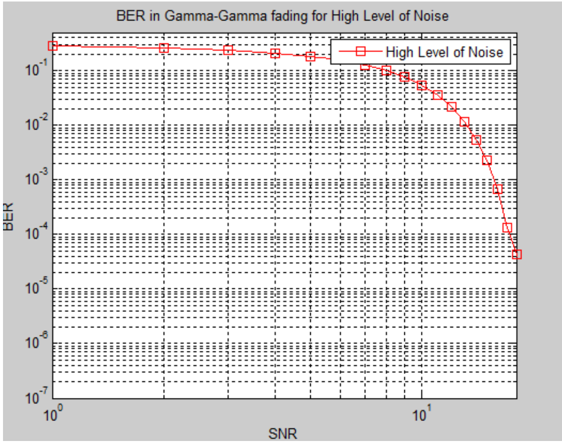


Fig.1 Bit error rate analysis of gamma gamma distribution of Nakagami fading channel over strong turbulence.

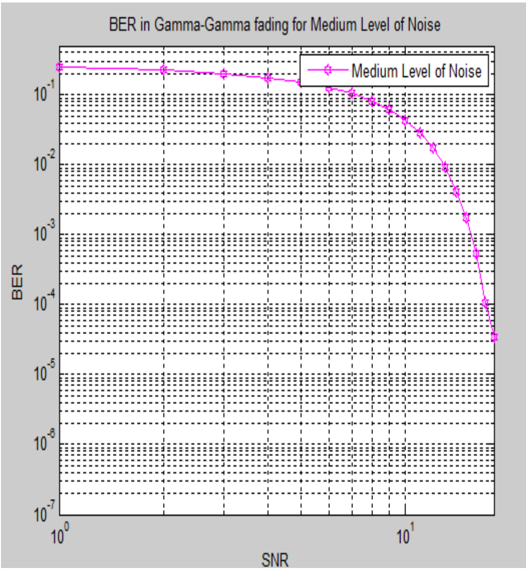


Fig.2 Bit error rate analysis of gamma gamma distribution of Nakagami fading channel over medium turbulence.

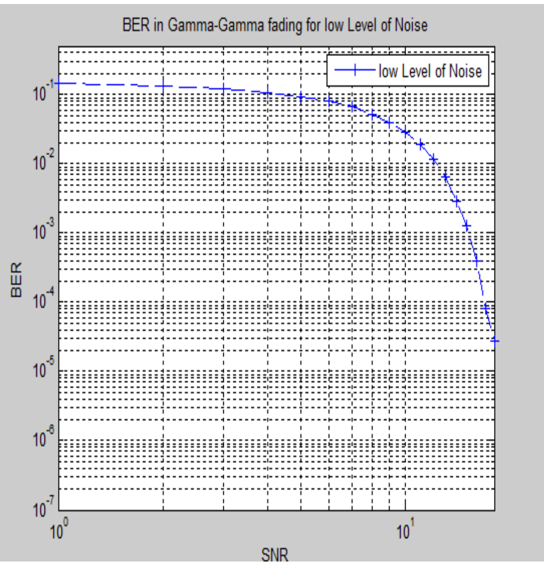


Fig.3 Bit error rate analysis of gamma gamma distribution of Nakagami fading channel over weak turbulence.

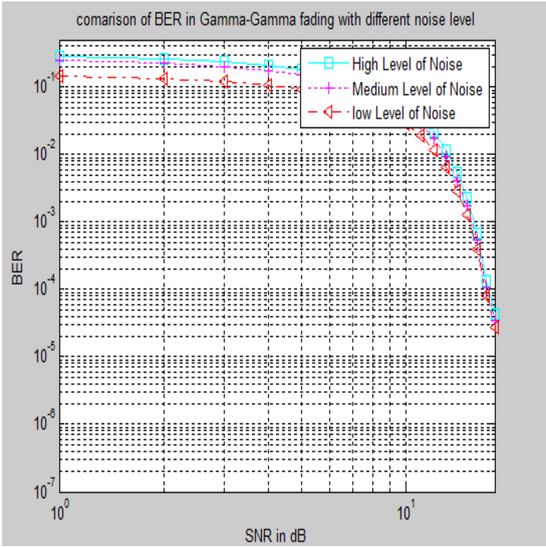


Fig. 4 Comparison of Bit error rate analysis of gamma-gamma distribution of Nakagami fading channel with different level of noise in free space optical communication system.

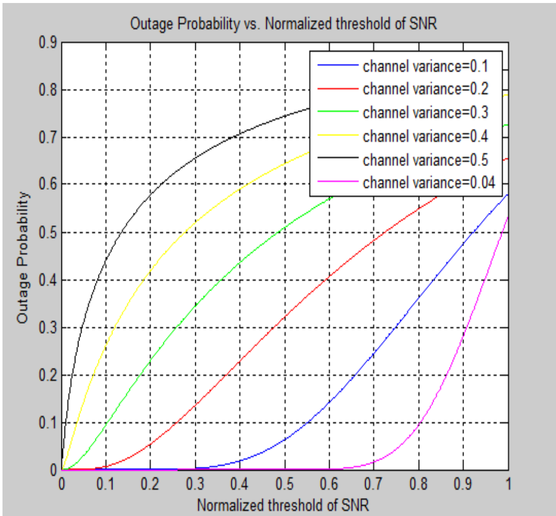
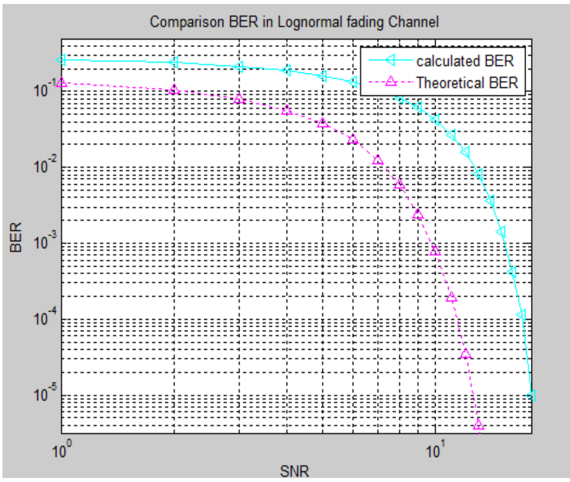


Fig.5 Comparative Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with changing value of channel variance in free space optical communication system.



ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 9, September 2015

Fig. 7 Comparison of Theoretical and calculated Bit error rate analysis of Log normal distribution of Nakagami fading channel.

VI. CONCLUSION

The performance controlling parameters are considered to be outage probability and bit error rate in free space optical communication system. BER and outage probability is studied with different level of channel turbulence in free space optical communication system. We are using different channel models with different level of channel turbulence. The weak turbulence is modeled as log normal distribution of nakagami fading channel.
On the other hand, strong turbulence is modeled as gamma-gamma distribution of nakagami fading channel. Simulation results are presented for nakagami fading channel for different level of channel turbulence. Bit error rate (BER) analysis is presented for the nakagami fading channel and compared with the theoretical BER. Results also shows that as the signal to noise ratio increase BER goes on decreasing and try to approaches the theoretical value.

ACKNOWLEDGEMENT

Apart from my efforts, the success of every work depends on the support and guidance of others. I express my gratitude to the people who have been supported me in the completion of this paper.

REFERENCES

[1] Mai, Vuong V.; Thang, Truong C. ; Pham, Anh T., “Performance of TCP over free-space optical atmospheric turbulence channels”, Journal of Optical Communications and Networking, IEEE/OSA, Vol: 5 , Issue: 11 , Page: 1168 – 1177, 2013.
[2] Shunmuga Lakshmi; P. Kannan, “A literature survey on the performance analysis of FSO links over strong turbulence”,IOSR Journal of electronics and communication engineering , Vol : 3, Issue 5, Page: 05-09, 2012.
[3] Nistazakis, H.E. ; Tsiftsis, T.A. ; Tombras, G.S., “Performance analysis of free space optical communication systems over atmospheric turbulence channels”, Communications, IET , Vol: 3 , Issue: 8 , Page: 1402 – 1409, 2009.
[4] Sandalidis , H.G; Tsiftsis, T.A; Karagiannidis, G.K, “ BER performance of FSO links over strong turbulence channels with pointing errors”.IEEE Volume: 12,Issue :1, Page(s): 44-46 2008.
[5] .Soleimani-Nasab, E ; Uysal.M, “ Generalized performance analysis of mixed RF/FSO system” optical wireless communication 3rd international workshop Page(s) 16-20, 2014.
[6] Karimi, M., Nasiri-kenari, M., “BER Analysis of Cooperative Systems in Free-Space Optical Networks” Journal of Light wave Technology, Vol: 27 , Issue: 24 , Page: 5639 – 5647, 2009.
[7] Bayaki, E. ; Schober, R. ; Mallik, R.K., “Performance analysis of MIMO free-space optical systems in gamma-gamma fading”, IEEE Transactions on Communications, Vol: 57 , Issue: 11 , Page: 3415 – 3424, 2009.