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FREE SPACE OPTICAL COMMUNICATION LINK UNDER THE WEAK ATMOSPHERIC TURBULENCE: LITERATURE REVIEW

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Abstract --- The objective of this project is to analyze the performance analysis of FSO links under weak atmospheric turbulence using different parameters: modulation tech- niques, symbol rate, distance between the FSO links and the wavelength. Due to the influence of turbulence effects, it is necessary to study, theoretically and numerically very carefully before the installation of such a communication system. In this work we discuss the FSO model, turbulence channel model, light source is uses for FSO,and the common parameter values of an FSO communication link is used. The scintillation effect, which results in random and fast fluctuations of the irradiance at the receiver's end. These fluctuations can be studied accurately with statistical methods. Thus, in this work, we use the lognormal distribution for weak turbulence condition.

Keywords---Free space optics,turbulence strength, BER, lognormal distribution, on-off keying modulation, direct detection FSO system, coherent detection FSO system

I. INTRODUCTION

A. OVERVIEW

As the global demand for bandwidth continues to accelerate, it is becoming exceedingly clear that copper/coaxial cables and RF cellular/microwave technologies with such limitations as limited bandwidth, congested spectrum, security issues, expensive licensing and high cost of installation and accessibility to all, cannot meet the upcoming needs. In some countries the network operators are starting to deploy new optical fibre-based access networks where the bandwidth available to customers is being increased dramatically.

Optical wireless communications (OWC) is an innovative technology that has been around for the last three decades and is gaining more attention as the demand for capacity continues to increase OWC is one of the most promising alternative technologies for indoor and outdoor applications. It offers flexible networking solutions that provide cost-effective, highly secure high-speed license-free wireless broadband connectivity for a number of applications, including voice and data, video and entertainment, enterprise connectivity, disaster recovery, illumination and data communications, surveillance and many others.

Due to the unique properties of the optical signal, one can precisely define a footprint and hence can accommodate a number of devices within a small periphery; thus offering a perfect OWC system OWCs, also referred to as free-space optical communication systems for outdoor applications, will play a significant role as a complementary technology to the RF systems in future information superhighways.

B.MOTIVATION

In access networks, the technologies currently in use include the copper and coaxial cables, wireless Internet access, broadband radio frequency (RF)/microwave and optical fibre These technologies, in particular copper/coaxial cables and RF based, have limitations such as a congested spectrum, a lower data rate, an expensive licensing, security issues and a high cost of installation and accessibility to all.

OWC technology is one of the most promising alternative schemes for address- ing the last mile bottleneck in the emerging broadband access markets. OWC offers a flexible networking solution that delivers the truly broadband services Only the OWC technology provides the essential combination of virtues vital to bring the high-speed traffic to the optical fibre backbone. That is offering a license-free spectrum with almost an unlimited data rate, a low cost of development and ease and speediness of installation.

To design efficient optical communication systems, it is imperative that the characteristics of the channel are well understood Characterization of a communi- cation channel is performed by its channel impulse response, which is then used to analyse and offer solutions to the effects of channel distortions. Free-space optical (FSO) communication technology can provide high data rate transfer and can be easily installed, moved or reconfigured as needs change. FSO technologies are intrinsically secure because of the line-of-sight requirement as well as the high directivity of the optical beam. Both of these features create a low probability of intercept (LPI) for the user's data.

II. FSO COMMUNICATION SYSTEM MODEL

In an FSO communication system, a laser source first transmits a narrow beam of modulated light at the transmitter. Then the modulated light beam propagates through free space before being received by the receiver. Fig. 2.1 shows a simplified block diagram of such system, which employs two sets of transceivers for a full-duplex link. For communication purpose, the information can be modulated onto the amplitude, frequency, phase or intensity of the optical carrier. The optical carrier is then transmitted through the atmospheric channel. At the receiver, the incident optical field is col- lected by the lens system, and being converted to electrical signal by the photodetector. The electrical signal is further processed to recover informa-tion.

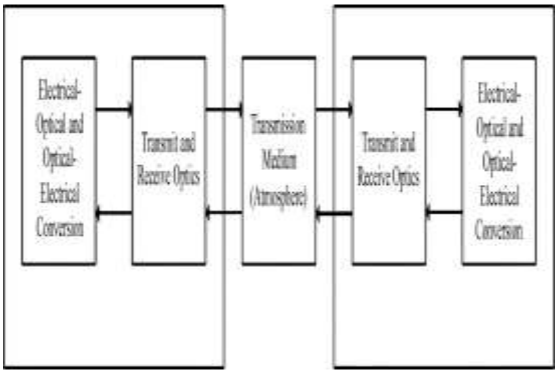


Figure 2.1: Block Diagram of an FSO System.

A. LIGHT SOURCE

classification for optical communications that isbased on availability of light sources, optical fibre attenuation/dispersion, free-space channel losses and detector availability.

Table 1: classification for optical communications

Windows	Wavelength	Application
First window	800-900 nm	widely used in early optical fibre communica- tions
Second window	1260-1360 nm	used in long-haul optical fibre communica- tions
Third window (S-band):	1460-1530 nm	Used in shortdistance optical fibre communication networks Transmissions
Third window (C-band):	1530-1565 nm	the dominant band for longdistance optical fibre communication networks Transmissions at 1550 nm do not pass through the corneal filter, and cannot harm the sensitive retina This means that at these wavelength bands, the emitted optical power could be allowed to reach values up to l0 mW for OWC links
Fourth window (L-band):	1565-1625 nm	for future photonic networks
Fourth window (U-band):	1625-1675 nm	for future photonic networks

B. TURBULENCE CHANNEL MODELS

The atmospheric channel can impose attenuation and scintillation effect on the light beam propagating through it. The attenuation of atmospheric channels is de- termined by the weather condition. Under clear weather conditions, the attenuation is approximately 6.5 dB/km, and at a fog event, the attenuation can be 115 dB/km or even 173 dB/km . Therefore the fog can usually cause outage of the FSOsystem and the link range of FSO is limited. The scintillation effect of atmospheric channels is caused by thermally induced fluctuations in the index of refraction of the air along the transmit path. The time scale of these fluctuations is on the order of milliseconds, approximately equal to the time that takes a volume of air (having the same size as that of the beam) to move across the path. Therefore the time scale is related to the wind speed . We can use scintillation index to describe the strength of turbulence induced fading, which is given as

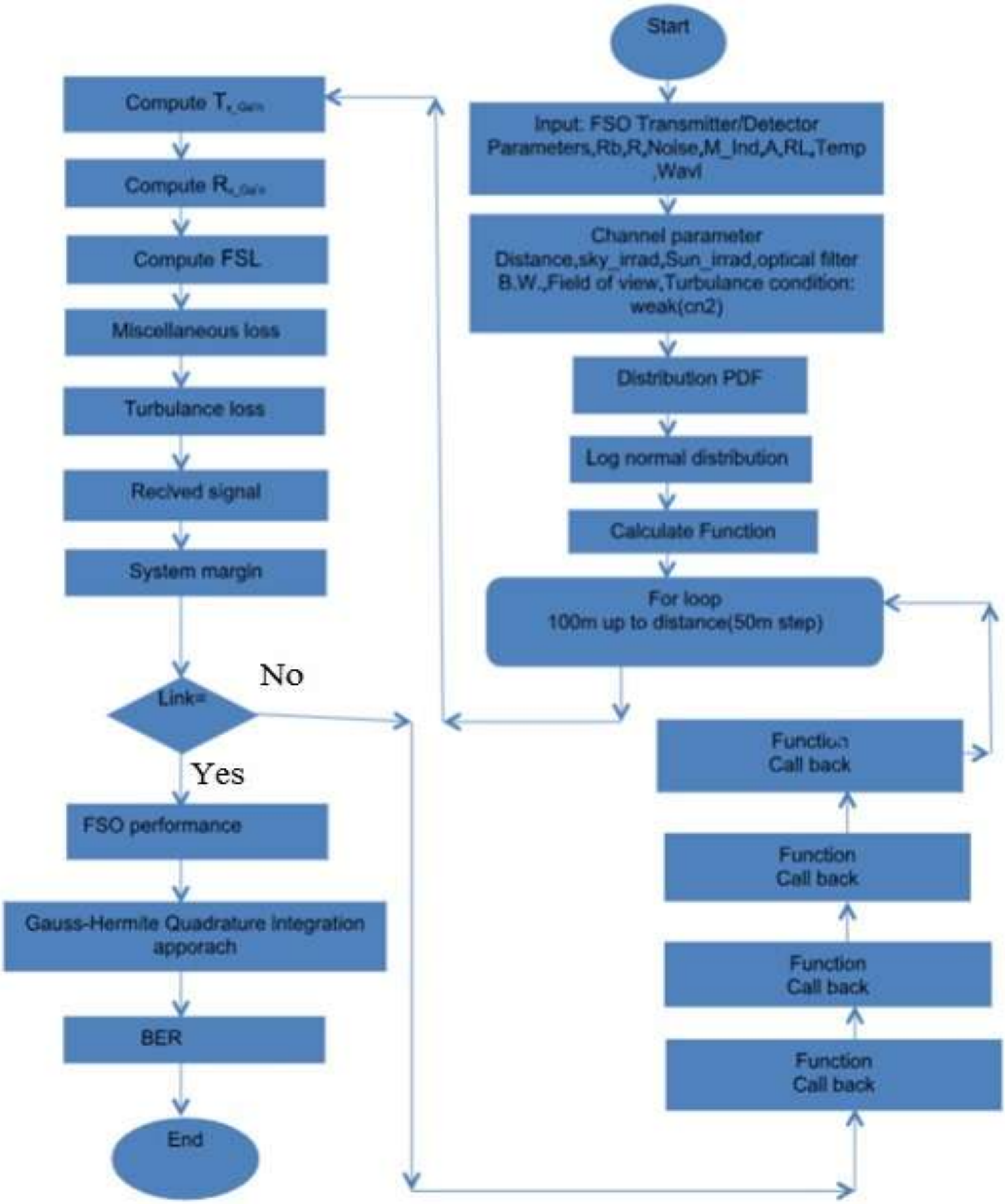
$$\sigma_{si}^2 = \frac{Var\ (I)}{(E[I])^2} = \frac{(E[I^2])}{(E[I])^2} - 1 \qquad (2.1)$$

The scintillation index is the normalized variance of the intensity and is used as a measure of scintillation. Another parameter related to the strength of the turbulence is Rytov variance, which approaches the scintillation index under weak turbulence conditions

$$\sigma_R^2 = 1.23 C_n^2 K^{\frac{7}{6}} Z^{\frac{11}{6}} \qquad (2.2)$$

where C2n is the index of refraction structure parameter of atmosphere, $K = \frac{2\pi}{\lambda}$ is the optical wavenumber with being the wavelength, and z denotes the link distance. Depending on the value of Rytov variance, we can approximatelycategorize the turbulence regime as follows: the weak turbulence regime ($\sigma_R^2 < .3$), the moderate turbulence regime ($0.3 \le \sigma_R^2 < 5$), and the strong turbulence regime($\sigma_R^2 > 5$). Under different levels of scintillation, there are different statistic models to describe the distribution of channel states.

III. FLOW CHART OF PROPOSED RESEARCH



IV. LITERATURE SURVEY

FSO communication systems fascinate because of its capability for mitigating the scarcity of bandwidth and high date rate.FSO can provide data rate on the order of Gbps. Besides, the installation of an FSO system only requires few days, making it flexible and effective for deployment. Recently, the applications of FSO communication systems include high data rate hybrid networks (also known as RF/FSO hybrid communication system) for high speed connection, ultra low latency networks for stock market trading [1], and fast deployed network for communication recovery.

The FSO systems can be categorized by two types: intensity modulation with direct detection (IM/DD) systems and coherent systems. In IM/DD system, the lens system and photodetector operate to detect the instantaneous power in the collected field when it arrives the receiver. In coherent systems, the collected field is optically mixed with a local generated field through a front end mirror before the photodetector. The on-off keying (OOK) modulation is widely used for IM/DD FSO systems, since op- tical communication systems with higher order modulation are complex to implement [9] . In [11] the authors described several communication techniques to mitigate turbulence-induced intensity fluctuations for an IM/DD OOK system. In [12] the building sway problem was studied for an FSO system with OOK modulation. In [10] the authors presented error rate performance bounds for an OOK FSO communication systems over K fading channels. In [14] the pointing error effect on a OOK FSO system was investigated and a statistical model for pointing error factor was derived.. In [15] the authors analyzed the performance of an OOK FSO system with Hoyt distributed misalignments. In [16] the authors conducted experimental evaluation of error performance for IM/DD FSO communication links with different modulation schemes, which include OOK, pulse position modulation (PPM) and binary phase-shift keying (BPSK). In coherent FSO systems, the provision of phase information allows a variety of digital modulation formats in comparison to irradiance modulation with direct detection IM/DD. In such systems, the signal can be amplitude, frequency or phase modulated on the optical carrier. The received signals can be made shot-noise-limited through the use of a local oscillator. Such coherent FSO systems offer excellent background noise rejection capability [16], higher sensitivity, and improved spectral efficiency.

.**Table 2. The common parameter values of an FSO communication link**.

Parameter	Symbol	Value
Symbol Rate	Rb	155Mbps
Spectral radiation of the sky	N (λ)	$10^{-3} w / c.m^2 \mu m Sr$
Spectral radiant emittance of the sun	W(λ)	0. 055 $W/c.m^2 \mu m$
Optical band pass filter B.W at λ=850 nm	Δλ	1mm
Number of subcarrier	N	1
Radiation wavelength PIN photodetector field of view	FOV	.6 rad
Link range	L	1 k.m
Index of refraction structure parameter	C_n^2	$.75 \times 10^{-14} m^{\frac{-2}{3}}$
Load resistance	RL	50Ω
PIN photodetector responsivity	$\Re$	1
Operating temperature	Temp	300k
Optical modulation index	ξ	1

V. CONCLUSION

In this work, we studied an FSO link, types of atmospheric turbulnace,light uses for communication link,and common parameters used in communication link. We try to analyse a basic idea about BER versus irradiant received power performance analysis on the basis of different-different distance is taken,different wavelent is used,different number of symboll is taken and any types of noise is present in the link. The obtained mathematical expressions have been derived for weak turbulence conditions, using the suitable statistical distribution models, i.e., the lognormal or the gamma, respectively, in order to describe accurately the resulting irradiance fluctuations. Based on the obtained mathematical expressions, we design and present an flow chart for the estimation of the performance of the FSO links, taking into account realistic values for its parameters, depending on the specific atmospheric conditions in the place where the FSO link will be installed. Moreover, this computational tool has been designed to estimate the performance results using both the theoretical expressions and the numerical evaluation.

VI. FUTURE WORK

In the future work different diversity techniques will be used, which will help to improve the FSO performance in terms of outage probability, also MIMO will be introduced which will help to enhance the system capacity. Also in future the main aim would be to exploit the fading rather than mitigating the fading, which will further help to improve the system performance

REFRENCES

[1] **Tariq Manzur**, "Free Space Optical Communications (FSO)," *IEEE Trans. Wireless Commun.*, vol. 6, pp. 2813-2819, Aug. 2017.

[2] **K. Prabhu, D. Sriram kumar, T. Srinivas**,"Performance analysis of FSO links under strong atmospheric turbulence conditions using various modulation schemes," *Elsevier Trans. Optik* 125(2014) 5573-5581,May 2014

[3] **S. Bloom, E. Korevaar, J. Schuster, and H.Willebrand**, "Understanding the performance of free-space optics,"*J. Opt. Netw.*, vol. 2, pp. 178-200, June 2003.

[4] **L. C. Andrews, R. L. Phillips, and C. Y. Hopen**, Laser Beam Scintillation With Applications. *SPIE Press*, 2001.

[5] **L. C. Andrews and R. L. Phillips**, Laser Beam Propagation Through Random Media. *SPIE Press*, 2005.

[6] **S. M. Navidpour, M. Uysal, and M. Kavehrad**, "BER performance of free- space optical transmission with spatial diversity," *IEEE Trans. Wireless Com- mun.*, vol. 6, pp. 2813-2819, Aug. 2007.

[7] **T. A. Tsiftsis, H. G. Sandalidis, G. K. Karagiannidis, and M. Uysal**, "Op- tical wireless links with spatial diversity over strong atmospheric turbulence channels," *IEEE Trans. Wireless Commun.*, vol. 8, pp. 951-957, Feb. 2009

[8] **X. Zhu and J. M. Kahn**, "Free-space optical communication through atmo- spheric turbulence channels," *IEEE Trans. Commun.*, vol. 50, pp. 1293-1300, Aug. 2002.

[9] **S. Arnon**, "Optimization of urban optical wireless communication systems," *IEEE Trans. Wireless Commun.*, vol. 2, pp. 626-629, July 2003.

[10] **Uysal, S. M. Navidpour, and J. Li**, "Error rate performance of coded free- space optical links over strong turbulence channels," *IEEE Commun. Lett.*, vol. 8, pp. 635-637, Oct. 2004.

[11] A. A. Farid and S. Hranilovic, "Outage capacity optimization for free- space optical links with pointing errors," *IEEE/OSA J. Lightwave Technol.*, vol. 25, pp. 1702-1710, July 2007.

[12] W. Gappmair, S. Hranilovic, and E. Leitgeb, "Ook performance for terres- trial fso links in turbulent atmosphere with pointing errors modeled by hoyt distributions," *IEEE Commun. Lett.*, vol. 15, pp. 875-877, Aug. 2011.

[13] MS. Rajbhandari, Z. Ghassemlooy, P. A. Haigh, T. Kanesan, and X. Tang, "Experimental error performance of modulation schemes under a con- trolled laboratory turbulence fso channel," *IEEE/OSA J.* Lightwave Technol., vol. 33, pp. 244-250, Jan. 2015

[14] M. Z. Win, C. C. Chen, and R. A. Scholtz, "Optical phase-locked loop for an amplitude modulated communications link using solid-state lasers," *IEEE J. Sel. Areas Commun*., vol. 13, pp. 569-576, Apr. 1995.

[15] K. Kiasaleh, "Performance of coherent dpsk free-space optical commu- nication systems in k-distributed turbulence," *IEEE Trans. Commun.*, vol. 54, pp. 604-607, Apr. 2006.

[16] A. Belmonte and J. Khan, "Performance of synchronous optical receiver- susing atmospheric compensation techniques," *Opt. Express*, vol. 16, pp. 14 151-14 162, Sep. 2008