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Free Space Optics – A Review

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Abstract: Free Space Optical (FSO) Communication is an advanced technique in wireless communication, that uses free space as the transmission medium and provides optical data/signal at a higher data rate over higher links. FSO is a line-of-sight technology, which exhibits transmission between two points without the use of fiber. Today FSO is used as broadband communication for advancement in internet scales. FSO communication links came into the picture because of its benefits like higher bandwidth, low cost, reduced time. Some factors or challenges like atmospheric attenuation, fog, distance, haze, etc.affect the transmission quality and characteristics of FSO systems.
Keywords: FSO, LOS, Wireless.

I. INTRODUCTION

FSO is an advanced wireless communication technique related to outer space, air, vacuum or wireless, with higher bandwidth. It is an Optical technique that works on line of sight (LOS) path propagation in free space for transmission of signal between transmitter and receiver. By using the free space as a channel in FSO, the data/signal/information is sent to establish telecommunication link or computer networking. Thus, where the physical connections are impossible to establish due to any reasons, i.e. rain, fog, etc., FSO technology plays a vital role [1], [2]. This technology is relatively simple and fast as the speed of light. Its capability is approximately equal to 2.5 Gbps of data, and signals through the free space, without the use of optical fiber cable or securing spectrum licenses via optical connectivity. FSO uses lasers/LEDs to provide optical bandwidth connection between transceivers which is quite similar to optical transmission in fiber optics, but the difference is; the medium used. FSO concept is used to reduce the cost, time, and efforts in installation and allow higher data rate up to 1GB/s or beyond [3].
FSO unit consists of an optical transceiver with a LASER/LED transmitter and a receiver. High-power optical source is used by each FSO unit followed by a lens that transmits light via free space to another lens which receives the transmitted light (information). This receiving lens of a high-sensitivity is connected through optical fiber to the system. In FSO technology spectrum licensing is not required. FSO supportable interfaces are also available with different vendors [3].

A. RF v/s FSO

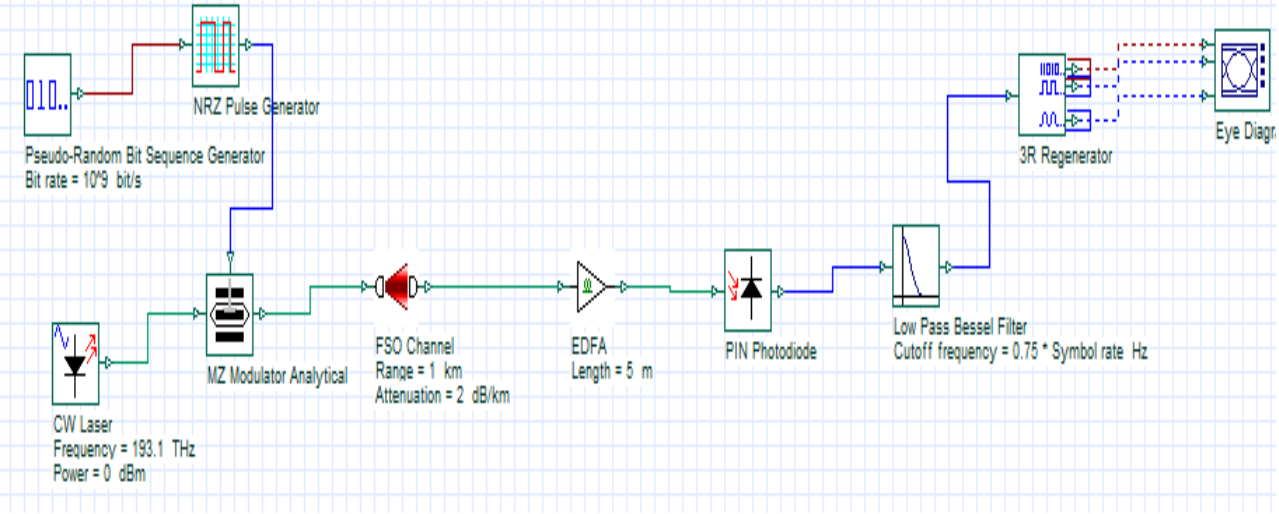
Parameters	RF	FSO
Range	4 km	4 km
Capacity	Allowed Not	Allowed
Data	Rate 100 MB/s	10 GB/s
Spectrum range	2-6 GHz	0.8-1.5 THz
Power	2.31E-02 (J/MB)	2.00E-03 (J/MB)
Output power	50 mWatt	5-500 mWatt
Power Loss	5.7 GHz 108db/km	5-15 dB/km
Security	Low	High
Advantage	No line of sight	Unlicensed band
Limitation	Spectrum	Environment

Table No.1 [4]

Table no. 1 showsa comparison between RF and FSO considering different parameters.

II. BLOCK DIAGRAM

A simple FSO block diagram consists of optical source, modulator, transmitter, atmospheric channel, receiver, demodulator, destination.



(Block Diagrm of Free Space Optical Communication)

III. ADVANTAGES

A. *Licensing:* No requirement of the Federal Communications Commission (FCC) license, reason behind it is that frequencies above 300 GHz are free to regulate. This is the main advantage over the Radio Frequency. It is very difficult and costly to obtain frequency allocation for microwave transmission in urban state, or near airport areas.

B. *Installation:* No requirement of special permission for installation from authorities in case of FSO. To set up its transceiver to transmit and to receive data, FSO systems do not need a specific place rather than it can be simply placed on the roof of a building or behind the window. Installation can be made any time.

C. *Portability:* With respect to portability and deplorability, FSO terminals are suitable for the same. These parameters make FSO suitable for temporary facilities and disaster recovery.

D. *Cost:* Cost is the other great advantage of FSO links. It is the best option to minimize the cost over laying fiber installation through the streets.

E. *High bandwidth:* A very high bandwidth exists or responding to FSO technology, which provide better broadband wireless connections to end-users. As compared to radio frequency (RF) technology which has 622 Mbps, FSO support 2.7 Gbps. And the capability of FSO is growing day by day.

F. *Security:* A very secured communication as compared to Radio Frequency Networks. Optical beams are really minute and invisible, so they cannot be found or detect by spectrum analyzers. Secondly, it is very difficult that receivers would also to be aligned to track the light

IV. DISADVANTAGES

A. *Humidity, Water Vapor & Fog:* Fog and water vapor droplets have significant obstruction to the operating performance in FSO communication. Due to absorption, refraction, or reflection through water droplets, data rate reduces upto an extent. Therefore, in blurry areas, FSO is not the best solution.

B. *Signal Absorption:* Water molecules in the air absorb the energy of light particles which makes an overall loss in power density. Based on atmospheric conditions, the role of force and spatial diversity help to uphold the required level of the net. Absorption and scattering both occur when there is a lot of moisture in the air. Signal strength is decreasing due to absorption.

C. *Signal Scattering:* Scattering happens when certain wavelength collides with an object (scatterer). The type of scattering is determined by the size of scatterer. Unlike absorption, in scattering there is no loss of energy, only redistribution of energy and has a significant effect on beam strength over long distances.

D. *Building sway/seismic activity:* The transmitter and receiver alignment can be disturbed by the movements in the buildings. Beam connectivity is maintained by use of divergent beam. To utilizeultra-high-speed of FSO systems installed on different towers, Light Pointe is developing a tracking device.

E. *Beam Spread: In* FSO links, optical beam travels through the atmosphere at a constant rate of dissipation.

F. *Line-of-Sight Obstructions:* Light has not been able to passing the opaque mediums, objects like birds, planes and people. Due to this reason light beam can be blocked and the services momentarily may get interrupted and the services resume instantly when the light path is cleared. To avoid this problem, we can use multi-beam technology with compatibility of the systems.

G. *Safety:* All Free Space Optics technology is strictly moderated to ensure that the criteria are followed to limit any risks.

V. LITERATURE SURVEY

Sr. No.	Author's Name & Year	Objective	Result & conclusion
1.	Farhana Hossain, Zeenat Afroze on 21 Dec, 2013 [1].	Reducing the effects of Fog on FSO using multiple Tx/Rx TW SOA.	Without TW SOA a simple FSO system even with multiple Tx/Rx does not perform appropriately. At the time of simulation, the signal attenuation can cross 300 dB/km.
2.	Mohammad Ali Khalighi, Murat Uysal On 2014 [5].	To study the terrestrial OWC link works on a near IR band which is used in FSO communication.	To increase the range of FSO the PHY layer design methods and techniques have been studied such as MIMO communication.
3.	Dhaval Shah, Dilip Kumar Kothari 0n 2014 [6].	To study and simulate the design of WDM based FSO links in different rain conditions and measure the parametric optimization of the system.	With a minimum value of the BER (>= 10^{-9}) the maximum range of a system with parametric optimization can be achieved. The simulation can be implemented at 1550 nm wavelength.
4.	Poonam Singal, Saloni Rai, Rahul Punia and Dhrove Kashyap on 3 June, 2015 [7].	Comparing the various transmitters at 1550 nm and 10000 nm and finding the best for the FSO communication.	Using 10000 nm the CW laser is best as compared to LED & VCSEL at 40 dB/km.
5.	Hemani Kaushal and Georges Kaddoum on 16 June, 2015 [8].	To study the challenges of FSO system in terrestrial and space links & performance mitigation techniques to measure the availability and the reliability of the system.	FSO system provides the high bandwidth between the remote sites with a LOS wireless connection. Changes in the upper layers of the TCP model will increase the reliability of the FSO system.
6.	Aditi Malik and Preeti Singh on 29 Sept, 2015 [9].	To reduce the effects of different weather conditions on the FSO system.	The effects of attenuation in the medium can be minimized using different designs i.e., WDM based FSO system, OFDM based FSO system.
7.	Jan Toth, Lubos Ovseník, Jan Turan on 20 Nov, 2015 [10].	To study the basic features of FSO, its merits & demerits, challenges to remove its weaknesses.	The visibility problem of the FSO can be solved using back up links with RF pair. But switching between these two techniques are required.
8.	Mehtab Singh on 2016 [11].	The designing and analysis of the FSO system in different weather conditions and modulation formats has been studied.	As the weather shifts from clear condition to the foggy, Q-factor of Rx and transmission distance decreases. The NRZ modulation format is the best format for FSO system.

9.	Maged Abdullah Esmail, Habib Fathallah on 2016[12].	For fog attenuation improves the wavelength Independent Empirical Model in FSO system.	Better performance having 5 dB average RMSE lower as compared to the average RMSE.
10.	Keun Sonb, Shiwen Maoa on may, 2016 [13].	Classify global FSO system in 3 subsystems and their challenges.	The FSO system range studied in various areas such as home, terrestrial, satellite & optical networks.
11.	Hemani Kaushal and Georges Kaddoum on 22 feb, 2017 [14].	Study the use of backhaul links in space-based optical to increase the capacity whereas decrease the cost of backhaul solutions.	The downlink of FSO backhaul is achieved up to 1.25 Gbps experimentally whereas theoretical study defines the 10 Gbps feasibility for HAP-HAP or HAP-satellite backhaul links.

VI. APPLICATIONS OF FREE SPACE OPTICS

A. *Telecom network extensions:* An extension of any existing telecom network or new network can be deployed by FSO. These links generally do not extend to the ultimate end user, but are more an application for the nucleus of the network.

B. *Military access:* It can connect large area safely in the limited time of deployment and planning. Because FSO is very secure and undetectable system so it is suitable for military services.

C. *Bridging WAN Access:* FSO has high speed data services, which is beneficial for mobile users in the WAN network. For high speed Trunking network it plays a role of backbone for the network [15].

D. *Fiber Complement:* Asa redundant link, FSO system can be deployed because of business applications most operators deploy two fibers to secure a reliable service for any outage conditions [3].

E. *Backhaul:* By deployment of an FSO link between the antenna towers of cellular telephone and the PSTN, the traffic carrying capacity would be increased 1 [6].

F. *LAN to LAN Building Connectivity:* To set up a LAN to LAN connectivity within a building or between the buildings, an FSO link is the good way other than any network.

G. *Enterprise:* FSO has the flexibility by which it can be deployed in various enterprise applications like Storage Area Networks, LAN to LAN connectivity and intra-campus connections.

H. *Last mile connectivity:* FSO links have approach to the end user. Point-to-point, point-to-multipoint, ring or mesh connections includes in FSO. Cost for the FSO also less as compared to other links for the same setup [3].tmospheric channel used as a propagation medium in FSO link and the properties of atmospheric channel is a random function of space and time. Thus, FSO communication is utilized random phenomena which depend upon weather and geographical position. Due to several environmental elements like clouds, snowfall, haze, rain, fog, etc. contributes to limiting the link distance and gets higher attenuation in FSO that could be deployed.

So various challenges faced by FSO links and terrestrial will discuss in this section.

VII. ATMOSPHERIC WEATHER CONDITIONS

FSO link uses atmosphere as a transmission medium for signals. Attenuation is caused by atmospheric medium that occurs due to absorption and scattering. Attenuation is the main challenging factor caused by the weather condition. Fog, heavy snow for temperate regions and heavy rain, haze for tropical regions are main weather conditions which have major effect on FSO link [17].Some of the weather conditions are described below.

A. *Fog:* Fog is a type of vapor, which is composed of water droplets. Mostly visible radiations are attenuated by fog via absorption, scattering, etc. [18] Mie scattering is caused by fog. In dense fog conditions, the visibility is even less than 50 m and attenuation can be measured more than 350 dB/km [19].

B. *Rain:* Rain fall leads to the attenuation in FSO link which is independent of wavelength [20]. Rain impact on FSO is distance, limiting, although this impact is very less as compared to other weather conditions. The reason for this impact is the radius of raindrops (200-2000 um) which is less than the wavelength of light sources [21]. Typically, a rainfall of 2.5 cm/hour has an attenuation of 6dB/km.

C. *Haze:* Atmospheric attenuation is also due to longer availability of haze particles in the air. The value of attenuation depends on the visibility level of haze particles at that time. Performance of FSO system can be checked by two ways: first is by installing the FSO system at that site and secondly by using Kim and Kruse model [22].

D. *Smoke:* Smoke is the factor which targets the visibility of transmission in FS [23]. Causes of smoke generation may be due to combustion of different substances like carbon, glycerol, and household emission.

E. *Sandstorms:* Sandstorms affect the FSO link directly and lead to the attenuation and bit error rate [24]. Dust storms are characterized by two points, first is the size of dust particles and the second is the required speed of wind to blowing particles up during a little slot of time.

F. *Clouds:* Transmission of the data/signals in FSO is partially blocked due to the formation of cloud layers in the atmosphere. The exact calculation of attenuation caused by the cloud layers is very difficult, the reason for this is in homogeneity and diversity of the cloud particles [25].

G. *Snow:* Snow refers to forms of ice crystals that precipitate a variety of sizes and shapes. The geometric scattering is caused by the larger particles of snow. The impact given by the snow particles is similar to the Rayleigh scattering [26]. The attenuation measured by the light snow is an approximately 3dB / km to 30dB/km [27].

VIII. CONCLUSION

FSO communication is capable of providing LOS wireless connection between remote sites with very high bandwidths. This technology is considered to be the promising technology in the near future, which can meet very high speed and huge capacity requirements of the current day communication market. A best conclusion for FSO links is that for a huge explosion in information technology, there is a need to switch from RF domain to the optical domain. FSO system gets affected from various atmospheric phenomena like absorption, scattering, atmospheric turbulence and bad weather conditions. Availability of commercial products like space links and terrestrial is exist in the market. At a very fast speed, FSO technology will bring worldwide telecommunication revolution.

REFERENCES

[1] Farhana Hossain, Zeenat Afroze, “Eliminating the Effect of Fog Attenuation on FSO link by Multiple TX/RX System with Travelling Wave Semiconductor Optical Amplifier”in Proceedings of 2013 2nd International Conference on Advances in Electrical Engineering (ICAEE 2013) 19-21 December, 2013, Dhaka, Bangladesh.

[2] Shalini Khare, Namrata Sahayam, “Analysis of Free Space Optical Communication System for Different Atmospheric Conditions & Modulation Techniques,” in International Journal of Modern Engineering Research (IJMER), vol. 2, Issue. 6,pp. 4149-4152, NovDec 2012.

[3] http://www.laseroptronics.com/index.cfm/id/57-66.htm.

[4] Rayan A. Alsemmeari and Sheikh Tahir Bakhsh, “Free Space Optics Vs Radio Frequency Wireless Communication,” I.J. Information Technology and Computer Science, 2016, 9, 1-8

[5] Mohammad Ali Khalighi and Murat Uysal, “Survey on Free Space Optical Communication: ACommunication Theory Perspective,”IEEE COMMUNICATION SURVEYS & TUTORIALS, VOL. 16, NO. 4, FOURTH QUARTER 2014.

[6] Dhaval Shah and Dilip Kumar Kothari, “Optimization of 2.5 Gbps WDM-FSO link range under different rain conditions in Ahmedabad,” Annual IEEE India Conference (INDICON) 2014.

[7] Poonam Singal, Saloni Rai, Rahul Punia and Dhrove Kashyap, “COMPARISON OF DIFFERENT TRANSMITTERS USING 1550NM AND 10000NM IN FSO COMMUNICATION SYSTEMS,” International Journal of Computer Science & Information Technology (IJCSIT) Vol 7, No 3, June 2015.

[8] Hemani Kaushal and Georges Kaddoum, “Free Space Optical Communication: Challenges and MitigationTechniques,”arXiv:1506.04836v1 [cs.IT] 16 Jun 2015.

[9] Aditi Malik and Preeti Singh, “Free Space Optics: Current Applications and Future Challenges,” HindawiPublishing Corporation International Journal of Optics Volume 2015, Article ID 945483, 7 page

[10] Jan Toth and Lubos Ovseník, Jan Turan, “Advanced Wireless Communication Systems - Free Space Optics,”IEEE 13th International Scientific Conference on Informatics · informatics’2015 · November 18-20 · Poprad. Slovakia.

[11] Mehtab Singh, “Performance Analysis of FSO Link under Different Weather Conditions and ModulationFormats,” International Journal of Signal Processing, Image Processing and Pattern Recognition Vol.9, No.5 (2016)pp.51-5

[12] Maged Abdullah Esmail and Habib Fathallah, “Improved wavelength Independent Empirical model for fogattenuation in FSOcommunication,” 7th International Conference on Information and CommunicationSystems (ICICS) 2016

[13] Keun Son and Shiwen Mao, “A survey of free space optical networks,” Digital Communications andNetworks 3 (2017) 67–77

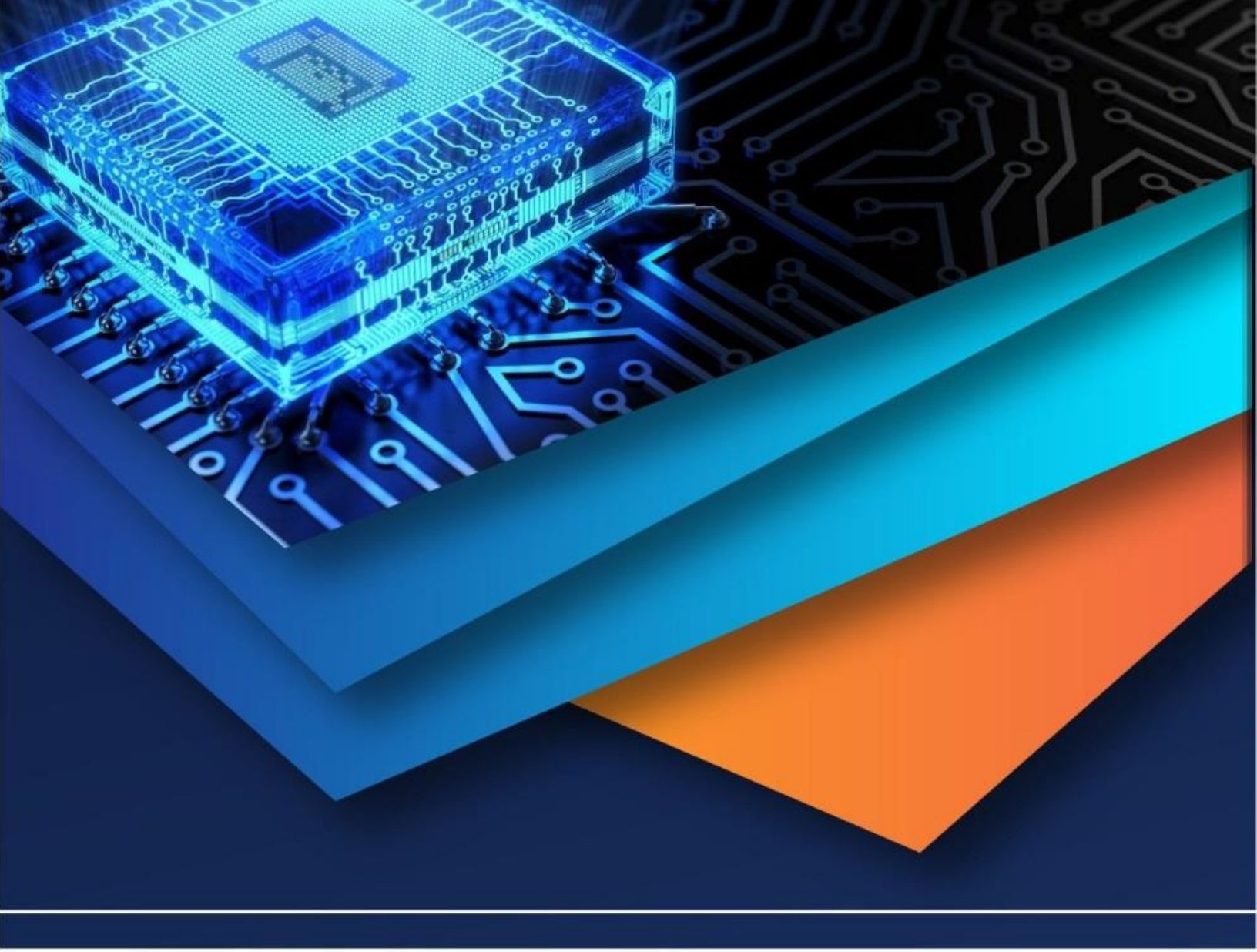
[14] Hemani Kaushal and Georges Kaddoum, “Optical Communication in Space: Challenges and MitigationTechniques,” IEEECOMMUNICATIONS SURVEYS & TUTORIALS, VOL. 19, NO. 1, FIRSTQUARTER 2017.

[15] V. Sharma and G. Kaur, “High speed, long reach OFDM-FSO transmission link incorporating OSSB andOTSB schemes,” Optik, vol.124, no. 23, pp. 6111–6114, 2013.

[16] H. A. Willebrand and B. S. Ghuman, “Fiber optics without fiber,” IEEE Spectrum, vol. 38, no.8,pp.40–45,2001

[17] S. A. Al-Gailani, A. B. Mohammad, and R. Q. Shaddad, “Enhancement of free space optica

[18]] Http://www.laseroptronics.com/index.cfm/id/57-66.htm. link in heavy rainattenuation using multiple beamConcept,Optik, vol. 12no. 21, pp. 4798–4801, 2013
[19] I. I. Kim and M. Achour, "Free-space links address the last-mile problem," vol. 37, 2001
[20] H. A. Fadhil, A. Amphawan, H. A. B. Shamsuddin et al.,"Optimization of free space optics parameters: anOptimum solution for bad weather conditions," Optik, vol. 124, no. 19, pp. 3969–3973, 2013
[21] Achour, M. Simulating Free Space Optical Communication; Part I, Rain Fall Attenuation. In Proc. Spie I031225258 Vol. 3635, 2002
[22] H. A. Fadhil, A. Amphawan, H. A. B. Shamsuddin et al.,"Optimization of free space optics parameters: anOptimum solution for badweather conditions," Optik, vol. 124, no. 19, pp. 3969–3973, 2013
[23] M. Ijaz, Z. Ghassemlooy, J. Pesek, O. Fisher, H. Le Minh, and E. Bentley, "Modeling of fog and smokeAttenuation in free spac
[24] optical communications link under controlled laboratory conditions," Journal ofLightwave Technology, vol. 31, no. 11, Article I6497447, pp. 1720–1726,2013
[25] PHOTONIC SENSORS / Vol. 7, No. 2, 2017: 113–122 Enhancement of FSO Communications Links UnderComplex EnvironmentH. ALNAJJAR*, Ammar A. NOORI*, and Arwa A. MOOSA* Departmentof Network Engineering, Al-iraqia University,Baghdad, Iraq * Corresponding author: Satea H. ALNAJJARE-mail: dr.satea@gmail.com Ammar A. NOORI
[26] K. Rammprasath and S. Prince, "Analyzing the cloud attenuation on the performance of free space opticalcommunication," iProceedings of the 2nd International Conference on Communication and SignalProcessing (ICCSP '13), pp. 791–794, Melmaruvathur,India, April 2013
[27] S. A. Al-Gailani, A. B. Mohammad, R. Q. Shaddad, and M. Jamaludin,"Singleandmultipletransceiversimulationmodules for freespace optical channel in tropicalMalaysian weather," in Proceedings of the IEEE Business Engineering and Industrial Applications
[28] Colloquium (BEIAC '13), pp. 613–616, Langkawi, Malaysia, April 201Akiba, M., Ogawa, K., Walkamori, K., Kodate, K., Ito, S. Measurement And Simulation Of The Effect OfSnow Fall On Free SpacOptical Propagation. Applied Optics, 2008, Vol.47, No.31, P.5736-43.I031225258.



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