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Simulative Analysis of WDM based RoFSO Network

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Abstract: ***The major development in the field of communication is the invention of telegraph in 1837 AD by Samuel Morse. After 40 years, the invention of telephone in 1870 AD by Alexander Graham Bell, gives a boom to communication technology. The other advancement is the development of automatic switch. The first switch developed by Strowger in 1897 AD, was electromechanical step by step switch. This type of communication used wires as a communication medium. Coaxial and twisted pair cables are used to transmit information for short distance at a low bit rate.***
Radio over free space optics (RoFSO) is an emerging technology in the field of optical communication. RoFSO has emerged as front runner technology to support ultra-high speed mobile and excises. This dissertation presents a simulative investigation of the effects of channel spacing in RoFSO based links. The FSO network with 75 GHz channel spacing produces output with approximately 4dBm higher power compared to 25 GHz channel spacing. As the Beam divergence is decreased the RoFSO network performance advances and covers the larger distance. It is concluded as the channel spacing is increased from 25 to 75 GHz, BER drops significantly. It is reported that various channel spacing offers bit error rate (BER) in the range of 10^{-17} to 10^{-3} for a distance of 1Km to 2 Km.
Keywords: Electromechanical, communication, channel, simulative

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I. INTRODUCTION

From the ancient time, the communication is the essential tool for transfer information signals. Smoke signal and flashing light have been used for thousands of years during war to communicate between warships located in sea. The major development in the field of communication is the invention of telegraph in 1837 AD by Samuel Morse. After 40 years, the invention of telephone in 1870 AD by Alexander Graham Bell, gives a boom to communication technology.The other advancement is the development of automatic switch. The first switch developed by Strowger in 1897 AD, was electromechanical step by step switch. This type of communication used wires as a communication medium. Coaxial and twisted pair cables are used to transmit information for short distance at a low bit rate. After some time, these cables were replaced by fiber cable which provides high bandwidth and transmit data at a very high bit rate with low BER

In daily life we have so many types of information sources some of the information sources are given below.

1) *Speech Signal:* The main source of information is speech. Around 90% of information is transported using speech signal.
2) *Video Data:* It could be used in the mobile phone, Television or moving picture.
3) *Facsimile:* It is a transmission of documents at a distant place.
4) *Data:* Data can be a live video or a document depending on the use.

So these are some type of information sources but the choice of communication system depends upon the information source we work with like voice, music, audio or movie. Different sources have different requirement for communication system so that effective communication can take place.

II. LITERATURE REVIEW

In this section, several numbers of papers has been studied. By studying these papers we are able to know that what is going on in this technology and what are current requirements in this field. They provide us a clear picture of the research. Almost 35 papers have been studied in this thesis. A brief summary of these papers are given below:

Mikaelian and KumarKrishnan (2002) studied that electro-optic modulator is best when high speed is main requirement. This was performed using Retro-reflector antenna.

Scott Bloomet.al. (2003) studied the free space optics link and gave the details how it works. They also studied the effect of various weather conditions like fog, haze, rain and clear weather on FSO link. They also studied the atmospheric attenuation, scintillation,

alignment, and turbulence etc. to analyze FSO system performance. It was analyzed that Well-designed FSO systems were capable of delivering 99.9% or better performance at 500–1000-m ranges for the vast majority of cities throughout the world.

Hakki H. Refai, James J. Sluss and et.al. (2005) investigated the use of FSO technology to transport the modulated analog RF signal in line of sight. The advantages of using FSO include increased security and insusceptibility to electromagnetic interference (EMI) .

Juan C. Juarez, et.al. (2006) focused on the capacity of network for this they used different modulation techniques and methods of mitigation to achieve the target.

Mohammad Abtahi, Pascal Lemieuxet.al.(2006) studied the different amplifiers like Erbium dropped fiber amplifier (EDFA) and semiconductor optical amplifier (SOA) in FSO link. They found that EDFA amplifier produces better results.

HU Guo-Yong, Chen Chang-Ying, Chen Zhen-Qiang(2007) proposed red laser as a source for free space optical communication for a wavelength of 650 nm laser utilized on low power in comparison to achieve maximum range of 300m with data rate of 100 mbps.

III. SIMULATION SETUP

This section provides the details of the simulation model of the WDM based RoFSO network used in the OPT SIM software.Four channels WDM system has been implemented in accordance with ITU-T recommendation for channel allocation. A block diagram of WDM based RoFSO network is shown in to the following figure.

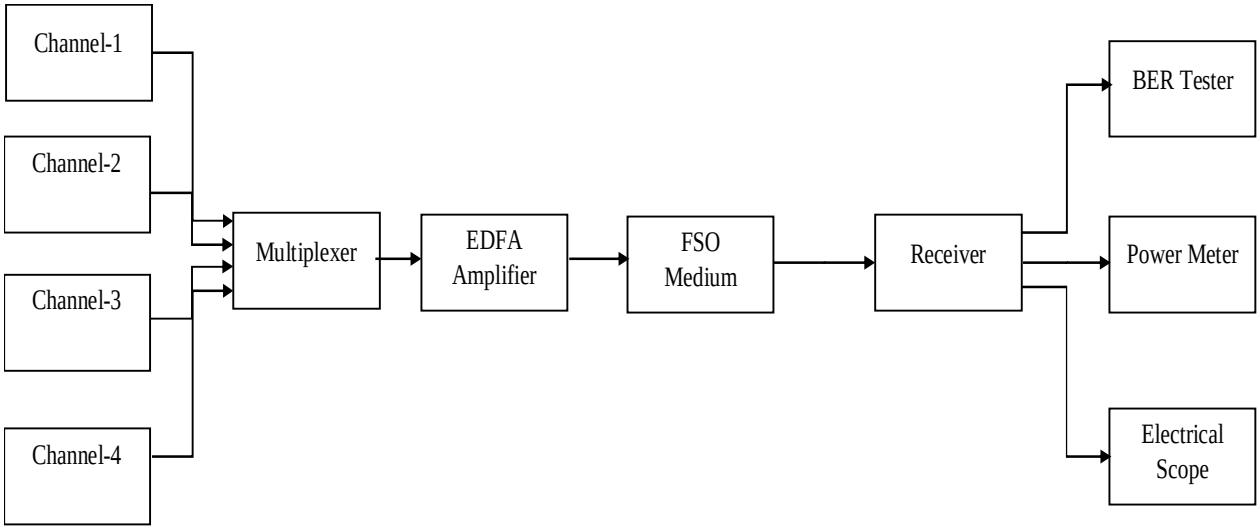

Fig.1: WDM based RoFSO network

A. Parameter

The parameters which are varied during analysis are beam divergence, transmission distance, aperture area, bit rate and additional attenuation. These parameters play an important role to transmit data from one place to other with better signal quality. The value of all parameters is same for various channels spacing so that the better results can be obtained. A table for various parameters values is shown as

Parameters	Value
Beam divergence	0.4 to 0.8 radian
Transmission distance	1 Km to 2 Km
Aperture area	40 to 100 square cm.
Additional attenuation	2 dB
Bit Rate	4 Gbps
Transmission channel wavelength	1550 to 1570 nm

Thus the simulation is done for WDM based FSO system for the various channel spacing. All the parameters remains same except center frequency and bandwidth of the optical filter used in this simulative model due to different channel spacing.

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IV. RESULT AND DISCUSSION

The developed simulative model discussed in previous chapter has been run on OPTSIM platform to analyze the performance of WDM based RoFSO links. In this chapter, the results obtained through simulation has been arranged and discussed. Here the results are discussed for various channel spacing like 2nm(25 GHz), 4nm(50 GHz), 6nm(75 GHz) on the grounds various performance parameter like BER, Q factor and eye diagram.

A. Bit Error Rate

The performance of any communication system is characterized in terms of the probability of errors also called as bit error rate (BER). It is the ratio of the number of bits error detected to the number of bits transmitted. Mathematically, BER can be estimated as

$$BER = \frac{number\ of\ error\ bits}{number\ of\ transmitted\ bits}$$

Calculation of BER is typically a lengthy process but for any communication system its value should be less than 10^{-9} for better signal quality. A sharp increase in FSO system is due to the presence of air pockets, fog etc.

B. Q factor

Thenext performance criteria are the analysis of Q factor or quality factor as its name indicates it gives the information about the signal quality. It is proportional to the system's signal to noise ratio. The Q factor representing the receiver's SNR is given by

$$Q = T_0 \frac{(I_1 - I_0)}{\sigma_0 + \sigma_1}$$

Where T_0 stands for the maximum transmittance, I_1 and I_0 are the average detected signal currents while σ_0 and σ_1 are the standard deviations of the noise values for bits '1' and '0' respectively.

C. Eye diagram

The last performance evaluation criterion used in this thesis is the analysis of eye diagram opening. When the multiple bits of data are transmitted at high rate, it can possibly lead to errors in the interpretation at the receiver which is termed as Inter-Symbol Interference (ISI), this is visualized with the help of eye diagrams.A wide opening of eye diagram describes the superior result of a system having no distortion over transmission.

We discuss these parameters one by one for channel spacing of 25GHz, 50 GHz, and 75GHz on grounds of various parameters like transmission distance, beam divergence and aperture area.

Figure 2 shows the variation of BER w.r.t. distance for channel spacing of 25GHz, 50 GHz, and 75GHz. It has been observed that as the distance increases from 1Km to 2Km BER increases. It has been noted that spacing of 25 GHz supports transmissionup to 1 Km, 50 GHz spacing supports 1.2 Km and 75GHz spacing supports 1.6 Km of transmission at beam divergence of 0.4 radian.

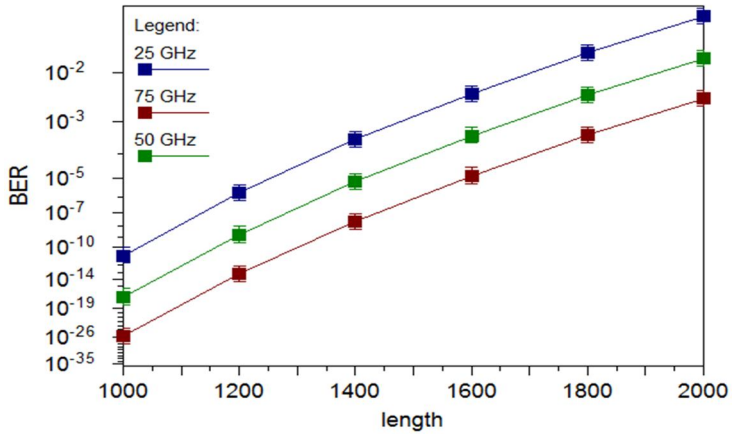


Fig.2: BERvs. Distance at various channel spacing

Figure 3 shows the variation of q factor w.r.t. length for channel spacing of 25GHz, 50 GHz, and 75GHz. From this graph we observed that as the distance increases from 1Km to 2Km Q factor also decreases. 75 GHz channel spacing shows maximum value of Q factor i.e. 10.5 and transmit the data up to the transmission distance of 1.6 Km with an optimal signal quality.

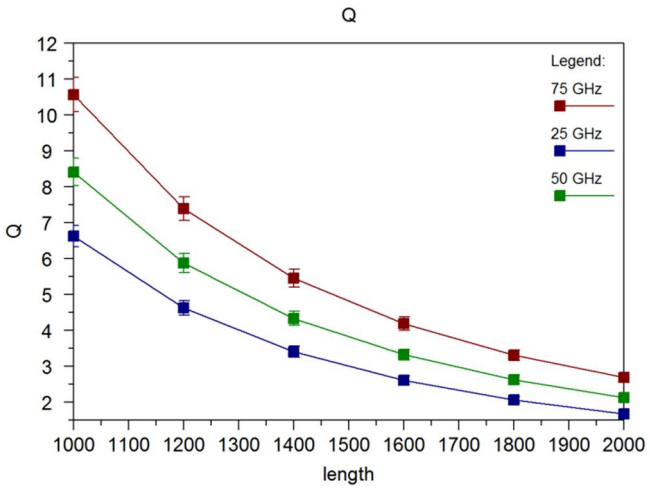
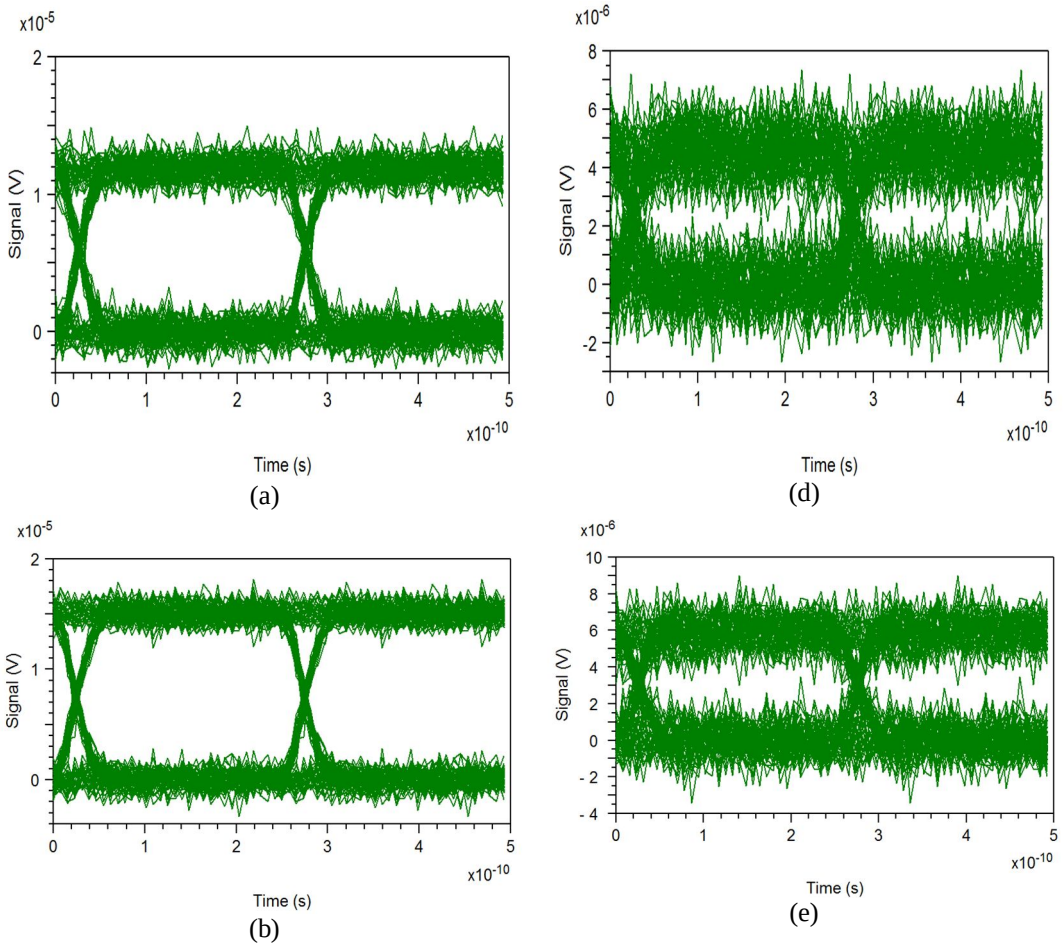
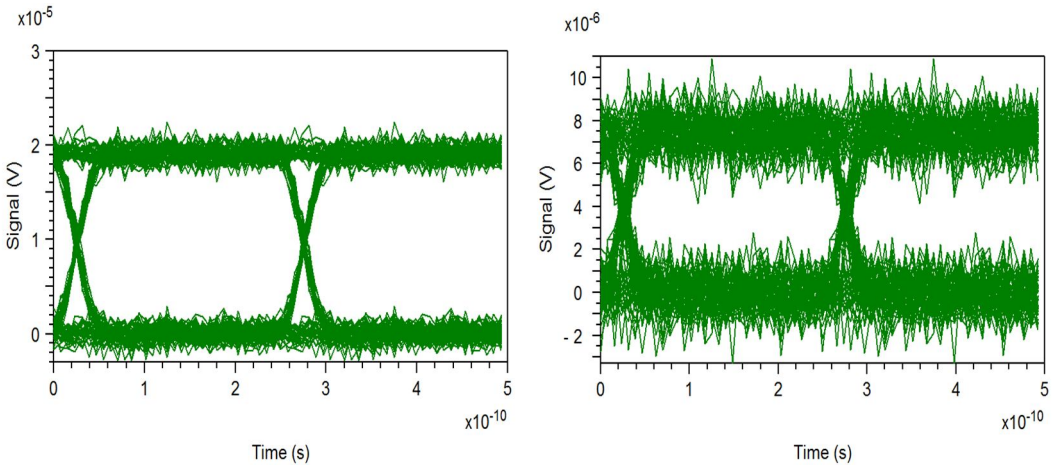


Fig.3: Q factor vs. Distance at various channel spacing

presents the variation of the average received power w.r.t.distance. It is seen that as the distance increases the received power is reduced. It is also found that as distance varied from 1 Km to 2 Km, receivedpower isdecreases from -72 to -84 dBm, for 25 GHz spacing, -70 to 82 dBm, and for 50 GHz spacing and -68 to -80 dBm. Thus larger channel spacing provides higher output power.

Eye diagrams are analyzed for the transmission distance, beam divergence and aperture area of receiver in figure 4 is for various channel spacing. After the carefully investigation of eye diagrams, the results are in cooperated with previous results obtained. From these results it can be said that as larger the channel spacing and aperture area of receiver lesser will be the error.





(c) (f)

Fig.4: Eye diagram for a distance of 1 Km at the spacing of
(a) 25 GHz (b) 50 GHz(c) 75 GHz
Eye diagram for a distance of 1.6 Km at the spacing of
(d) 25 GHz (e) 50 GHz (f) 75 GHz

V. CONCLUSION AND FUTURE SCOPE

Radio over free space optics (RoFSO) is an emerging technology in the field of optical communication. RoFSO has emerged as frontrunner technology to support ultra-high speed mobile and excises.This dissertation presents a simulative investigation of the effects of channel spacing in RoFSO based links. The FSO network with 75 GHz channel spacing produces output with approximately 4dBmhigher power compared to 25 GHz channel spacing. As the Beam divergence is decreased the RoFSO network performance advances and covers the larger distance. It is concluded as the channel spacing is increased from 25 to 75 GHz, BER drops significantly.It is reported that various channel spacing offers bit error rate (BER) in the range of 10^{-17} to 10^{-3} for a distance of 1Km to 2 Km. A huge decrement of BER from 10^{-10} to 10^{-26} is observed when channel spacing is increased from 25 to 75 GHz at a distance of 1 Km. Besides it, it is also revealed that increasing the beam divergence degrades the performance as BER increases heavily. While increasing the receiver aperture area improves the performance of the system. Hence the system performance can be improved by carefully selecting channel spacing along with beam divergence and receiver aperture area.

FSO is growing with very high pace because of its low cost than fiber cables and in lesser time. FSO allows flexibility and fast data transmission up to several Gbps. Different techniques like OFDM-FSO, WDM-FSO based system are new approach to improve the system performance with high speed and longer distance. Now a day's multiple access technique is also used with FSO system by the researchers.The primary driving applications are metropolitan optic network, access and enter prize connectivity. All such features of FSO links make it a strong service provider in 4G and 5G technology.

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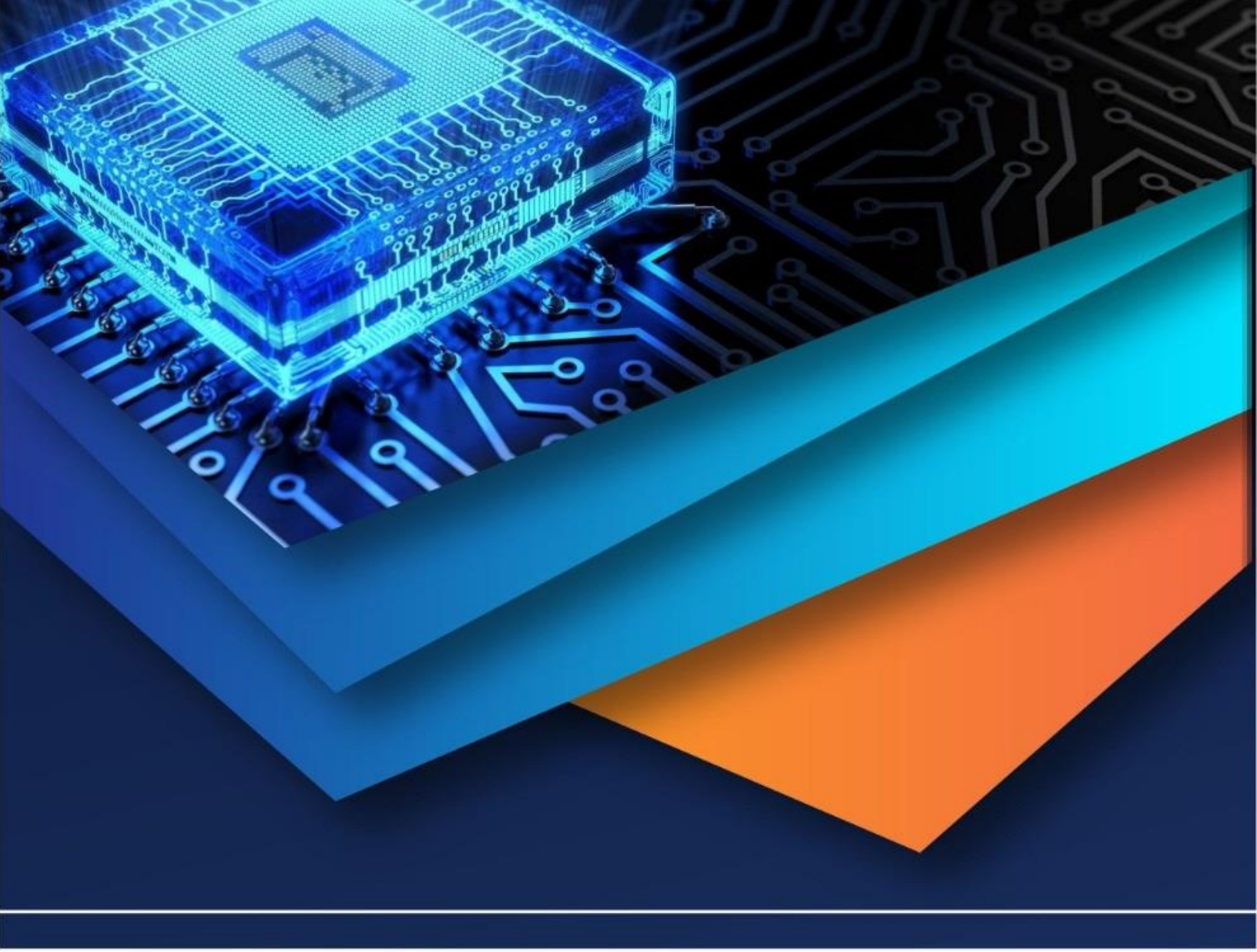

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