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Design of 32 Channel 100 GBPS Optical Network using Fiber Btagg Grating to Compensate Dispersion

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Abstract: The main aim of this paper is to design a 32 channel DWDM system with each channel having 100 Gbps data rate multiplexed with frequency spacing 100 GHz. Methods/Statistical analysis: Dispersion is an important factor to be considered while designing a DWDM system. Dispersion affects the penalties due to various types of fiber nonlinearities. Single mode fiber is preferred for long distance communication over Multimode fiber. In this proposed work Optisystem 7.0 simulator is used to analyze dispersion effect. The system performance is optimized by using Dispersion compensation fiber to compensate for the dispersion produced by single mode fiber. The system performance is limited by the dispersion. In order to compensate this we have used Dispersion compensation fiber, between amplifier is standard single-mode fiber, but at each amplifier location, dispersion compensating fiber having a negative chromatic dispersion is introduced. By using this we have successfully designed a DWDM system with 32 channels each 10 Gbps data rate multiplexed with frequency spacing 100 GHz.

Keywords: BER Analyzer, Q Factor, FBG, DWDM

I. INTRODUCTION

Optical fiber communication is nothing but a method of transmitting information from one place to another by sending light as information carrier through optical fiber. Dense wavelength division multiplexing is a fiber optic transmission technique that employs light wavelength to transmit data parallel by bit or serial by character .DWDM can be used to enabling service provides to accommodate consumer demand for ever increasing amounts of wavelength. As we know that transmit dispersion, polarization mode dispersion and the fiber non-linear effect at high bit rate and the power level There has been a great demand in the increase in data rate due to increase of use of large bandwidth applications and internet[1]. Every human activity now depends on reliable and rapid communication networks. In order to meet these increasing data rate, the increase in bandwidth is the only solution. The bandwidth can be increased in by installing more number of cables, increasing system bit rate to multiplex more signals or multiplex different wavelengths (DWDM). In order to meet this growing demand of bandwidth, a technique which combines various wavelengths together called as Dense Wavelength Division Multiplexing (DWDM) is developed. It is used simultaneously over a single fiber, thereby allowing carriers to increase the data rate by using already laid single fiber. Each information stream is transmitted on a unique wavelength.

A. Fiber Bragg Grating

The fundamental principle behind the operation of an FBG is Fresnel reflection, where light travels in between media’s of different refractive indices and thus may reflect and refract at the interface. A fiber Bragg grating is a reflective device composed of an optical fibre which is having modulation of its core refractive index over a certain length. The grating reflects light propagating through the fiber when its wavelength corresponds to the modulation periodicity[2].

There are six common structures for FBGs:

1) Uniform positive-only index change,
2) Gaussian apodized,
3) Raised-cosine apodized,
4) Chirped
5) Discrete phase shift, and
6) Superstructure

B. Chirped Fiber Bragg Gratings

The most important inclination of chirp FBG than other recommended types are small internal lose and cost efficiency. The refractive index profile of the grating may be varied to add some features, such as a linear variation in the grating period, called a chirp[3].Chirped fiber grating is used to compensate for dispersion. The idea of dispersion compensation using chirped fiber gratings was firstly proposed by Qulette and later demonstrated experimentally by Williams et.al. y. In a chirped FBG, the periodicity of the induced index modulation varies along the grating's length. The maximum reflectivity is obtained at the wavelength providing the Bragg condition

$\lambda_B = 2\eta eff\, \Lambda$ …..[1]

II. SIMULATION MODEL

The simulation setup of an 32 channel DWDM setup. In this set up, at the transmitter side we have used WDM transmitter and WDM mux. The Bit rate used is 100Gb/s. The channel consists of Optical fiber, loop control, The optical channel has two optical fibers of 50 km length, so a total fiber of 150 km is used. Various EDFA's are used to improve the quality of the signal. In addition, Dispersion compensating fiber is also used to tackle the dispersion on the channel. The receiver side consists of WDM demux, optical receivers and BER analyzers for the analysis of WDM link. This entire set up is implemented and analyzed using "Optisystem 7.0". A 32 channel DWDM system is designed with a channel spacing of 100 GHz, at the data rate 100Gbps, with the optimal parameters in both NRZ and RZ modulation format to achieve the maximum transmission distance. Fiber Bragg Grating and Erbium Doped Fiber Amplifier are the key components for the implementation of high data rate long haul optical communication system. The maximum transmission distance that could be achieved is 240 km with NRZ modulation format and RZ modulation format. Fibers are standard single mode fibers SMF with high group velocity dispersion enable larger repeater spacing and larger sign on the transmitted signals. Increasing the capacity of optical systems may require either an increase in the bit rate, usage of WDM or ultimately both. At high bit rates, the modulation format, type of dispersion compensation scheme, and channel power become important issues for optimum system design. In particular, it has been demonstrated numerically and experimentally that the conventional non return-tozero modulation format is superior compared to the return-to-zero modulation when dealing with large DWDM systems, as RZ modulation causes Significant Eye Closure Penalty near channels end. Each span consists of 50 km of SMF in order to fully compensate for the dispersion slope and accumulated dispersion in transmission fiber. The one end of the SMF and another end of EDFA is given to loops control mechanism.. The output of the loop control is given to the one end of the WDM demux [4] .

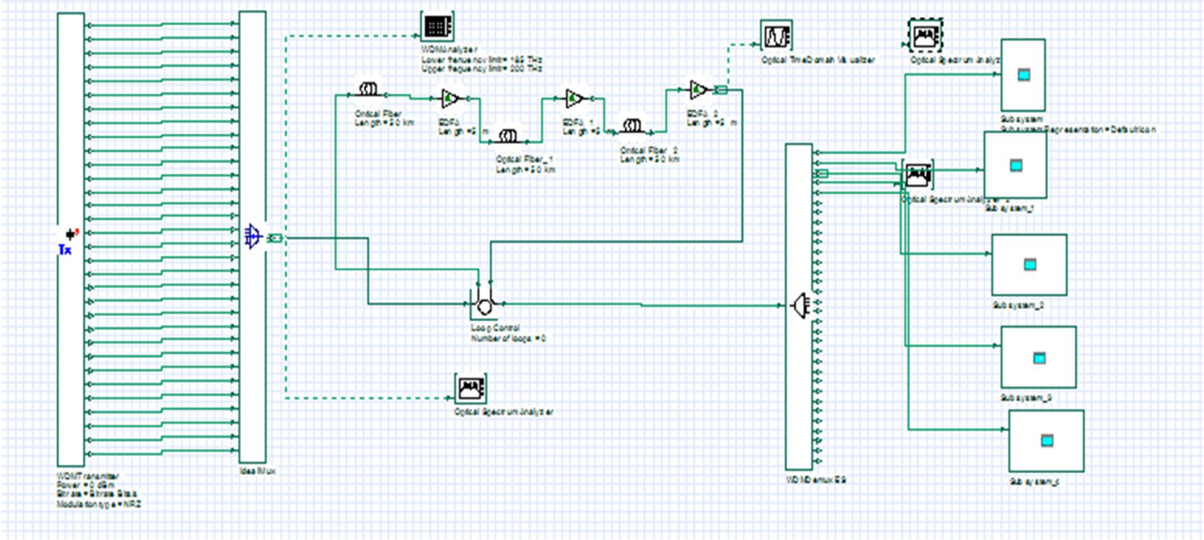
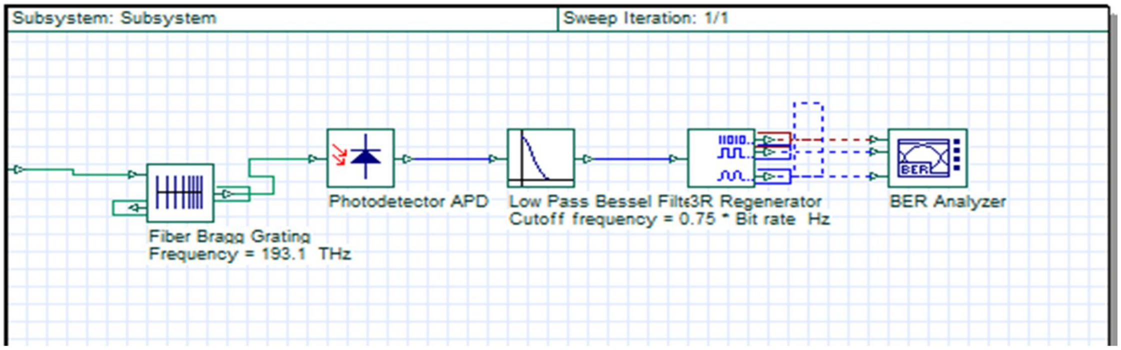


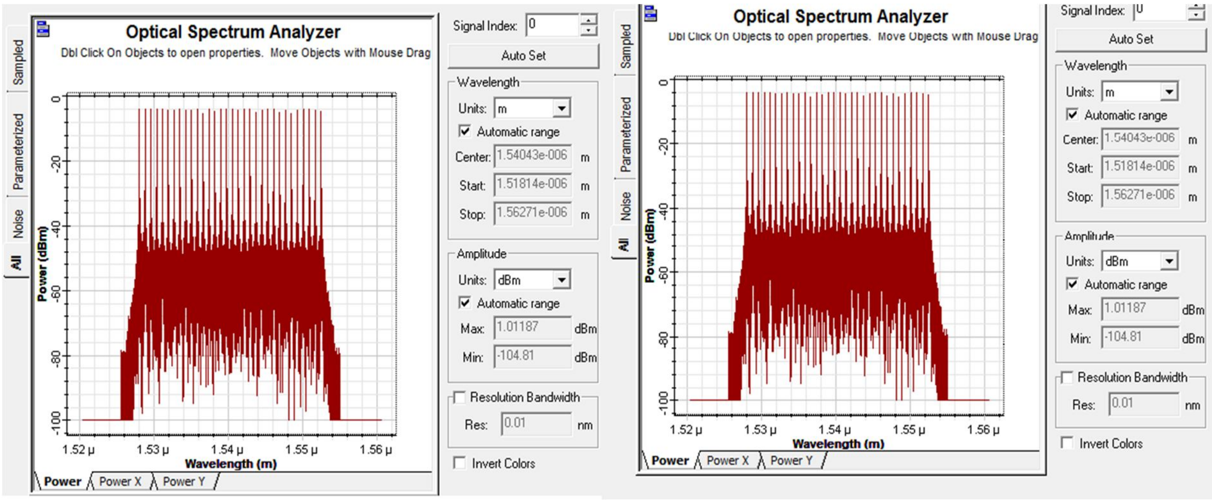
Fig 1: Simulation model

In the receiver side the signal is passed through an WDM demux ,detected by photo detector(PIN) having dark current 10nA & responsively 1A/W . .Now this electrical signal is passed through Low Pass Bessel filter of order 4 to remove the noise. Then 3R generator & BER analyzer are used for eye diagram analysis of signal . The simulation is performed with RZ modulation using Symmetric compensation technique. Optic system provides multiple simulation engines that provide complementary simulation techniques [5]. This enables the greatest flexibility in modeling and simulating systems ranging from short-distance data communication links, to ultra-long-haul DWDM telecom systems, to large metro networks with feedback paths and EDFA transients due to adding and dropping of channels. Simulation results can be plotted in a number of forms including signal waveforms, eye diagrams, signal spectra, OSNR, Poincare sphere, dispersion maps, and more. A wide and complete choice of measurements is available including jitter, eye opening/closure, electrical/optical spectra, chirp, optical instantaneous phase/frequency and power.



III. RESULTS AND ANALYSIS

The simulations are done in Optisystem 7.0 simulator & it has been observed that distance is increased , yet the performance parameters (Q-factor, BER, Threshold Value and Eye-Height) possess better value compared to previous model. Thus the proposed technique is good for long range communication system.



Signal Index: 0
Units: m
☑ Automatic range
Center: 1.54043e-006 m
Start: 1.51814e-006 m
Stop: 1.56271e-006 m
Units: dBm
☑ Automatic range
Max: 1.01187 dBm
Min: -104.81 dBm
☐ Resolution Bandwidth
Res: 0.01 nm
☐ Invert Colors

FIG 2: Output Spectrum of SMF of 50 Km Length (NRZ& RZ Modulation Format)

The eye diagram is also a common indicator of performance in digital transmission systems. The eye diagram is an oscilloscope display of a digital signal, repetitively sampled to get a good representation of its behavior. In this paper we have shown the system performance at different distance i.e at 50km and 150km. The values of maximum Q factor for all channels decrease with the increase of transmission distance.

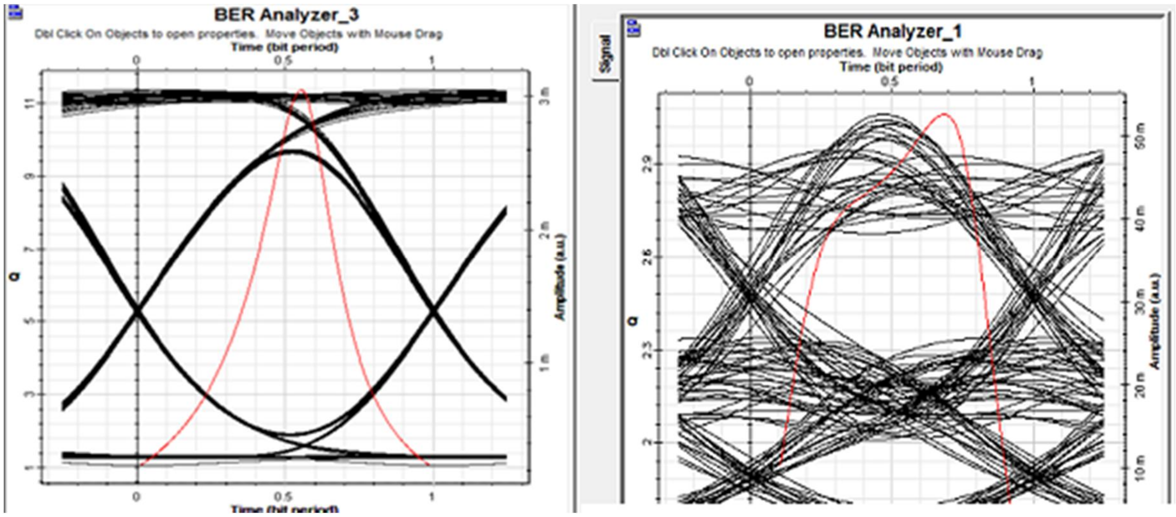


Fig3 Eye diagram after 150 km at channel-1 (RZ & NRZ modulation format)

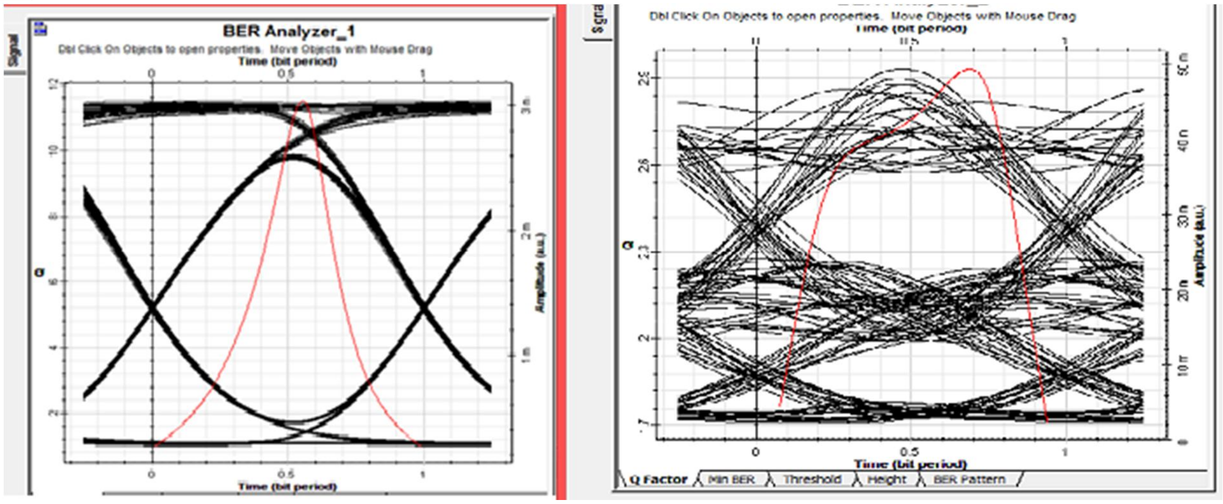


Fig 4: Eye diagram after 150 km at channel-2 (RZ & NRZ modulation format)

A. Comparison Between Simulation Results

Table-1: Q-factor and BER by using NRZ modulation (AT 150KM)

Channel no	Max.Q Factor	Min.BER
1	11.23	2.5028030
2	11.45	5.74329003
3	11.14	6.9279029
4	11.6	2.93324030
5	11.4	1.07216030
13	11.16	3.09836720

Table-2: Q-factor and BER by using RZ modulation (AT 150KM)

Channel no	Max.Q Factor	Min.BER
1	37.1674	1.027e-302
2	43.21690	0
3	37.8767	2.82e-314
4	36.1187	5.41e-314
5	34.7816	2.062e-265
13	37.8385	1.23e-313

Table 2: Q-factor and BER by using NRZ modulation(300 KM)

Channel no	Max.Q Factor	Min. BER
1	3.06143	0.00109969
2	2.93119	0.00168293
3	2.73887	0.00302934
4	2.88589	0.00192527
5	2.90827	0.00264568
13	2.96625	0.00149867

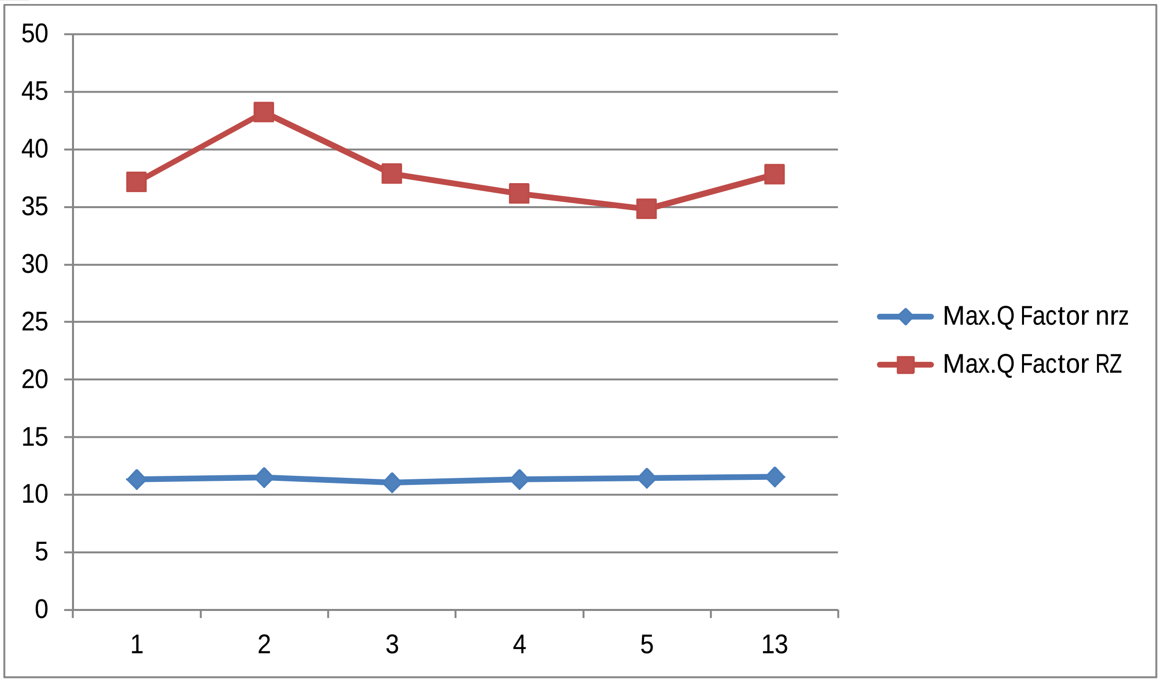


Fig 5: comparison graph between Q-factor for NRZ & RZ modulation Format

IV. CONCLUSION

This chapter provides a summary of the findings of the study which has done so far. Included in the summary are conclusions from observations made during the execution of this study. The study of following objectives is reported. The objective of the thesis is, to observe the performance of 100 Gbps optical communication with the dispersion managed RZ pulse. The RZ pulse is efficient for long-distance, high-bitrate, wavelength in division multiplexed (WDM) transmission dispersion-managed systems[6] . The effect of varying the dispersion parameter of single mode fiber on optical communication system has been noted. It is observed that with increase in the value of dispersion parameter, there is an increase in the average eye opening and Q-factor value. Also a good desirable bit error rate value has been achieved and reported. Timing jitters are reduced with increase in value. The effect of varying duty cycle of the RZ pulse for a fixed value of dispersion parameter has been performed. It has been shown that by reducing the duty cycle, the performance of the system is improved. It is concluded that RZ pulse system enhance the performance of optical communication networks at high bit rate.

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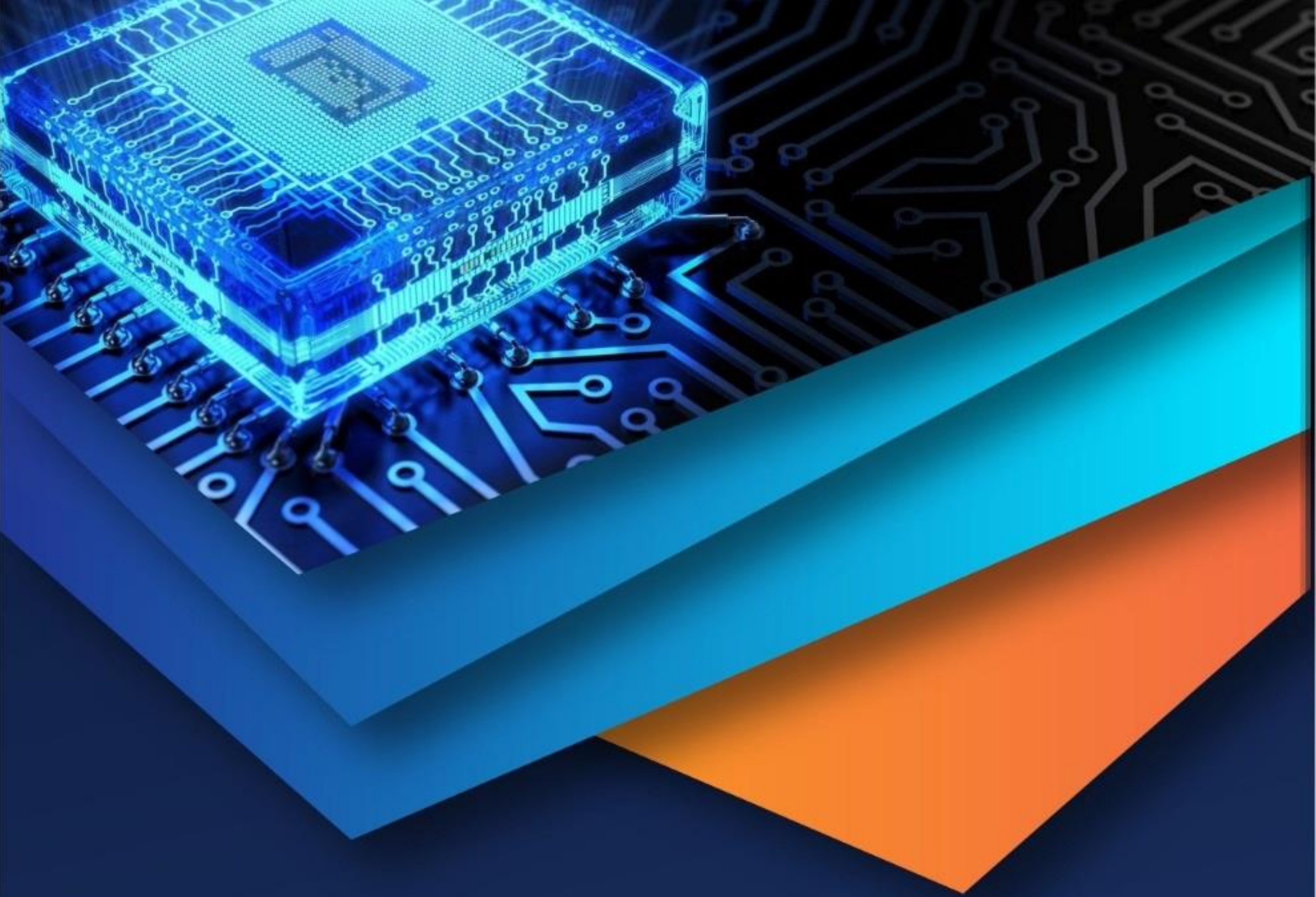

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