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Performance Analysis of 16 Channel WDM System with Modulation Formats

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***Abstract:** In this paper comparative analysis of different modulation formats is performed in 16x20 Gb/s WDM system to find the best transmission frequency. Performance parameters like bit error rate (BER) and Q-factor are analyzed with transmission frequency to compare different modulation formats. Return to zero (RZ) and non-return to zero (NRZ) formats are compared in proposed setup with 200 GHz channel spacing.*
***Keywords:** Wavelength Division Multiplexing (WDM), Return to Zero (RZ), Non Return to Zero (NRZ), Transmission Frequency.*

I. INTRODUCTION

RZ modulation is superior to NRZ signal in many respect. Firstly, it can reduce the intra-channel nonlinear effect. Secondly, it is helpful in combating FWM and XPM when these pulses are overlapping in time domain. Lastly, it is also reducing the inter channel nonlinear effects as compared with NRZ systems [1].RZ signal pulse width is much smaller than NRZ signal pulse width. Due to this reason, NRZ pulses with different wavelengths take much longer time to reach from one place to another than NRZ pulses. Due to this longer duration of pulses, a chance of producing FWM & XPM is increased. This is the reason that NRZ modulation format pulses are vulnerable to inter-channel nonlinear effects [2, 3].

However, for combating with linear cross talks amongst different channels, NRZ signal is superior due to their much narrower bandwidth as compared to RZ signal [4]. But, with the proper use of spectral filtering i.e. properly shaping the pulse at the transmitter, the unwanted components with high frequency can be removed and thus minimizing the linear cross talk among different channels in RZ system.

This further enables popularity of RZ system over NRZ system[5]. It is obvious that RZ format is much more superior than NRZ modulation format due to its numerous advantages as discussed above. But, performance of RZ systems is limited due to intra channel impairments produced due to interaction of nonlinearity and dispersion. So, to improve RZ system performance this impairment should be minimized. However, these sources and mechanism which can degrade system performance due to inter channel and intra channel are studied [6]. A large dispersion effect produces the overlapping of pulses thus broadening the spectrum. This overlapping of pulses produce intra channel interference [7].

II. SYSTEM SETUP FOR NRZ & RZ FORMATS COMPARISON

Fig. 1 provides a 16 -channel WDM system setup operated with data rate of 20 GB/s and channel spacing of 200 GHz. For the proposed system, different modulation formats like NRZ & RZ are compared. The channel frequency is varied between 193 to 195 THz. This system is analyzed with 80 Km transmission distance. EDFA amplifier is used between two SMFs of 40 Km each. In the proposed setup,signals from 16 transmitters are multiplexed in RF combiner. Transmitter section contain a data source(input data), electrical driver (RZ raised cosine), laser source (CW Lorentzian laser) and modulator (Sin^2 Mach-Zehnder modulator).After signal multiplexing in RF combiner, the signal is passed through standard single mode fiber (SSMF) towards receiver section. Receiver section consist of RF splitter which splits the signal to 16 different receivers. Receiver section consists of filters (Super-Gaussian) and photodiodes (PIN).

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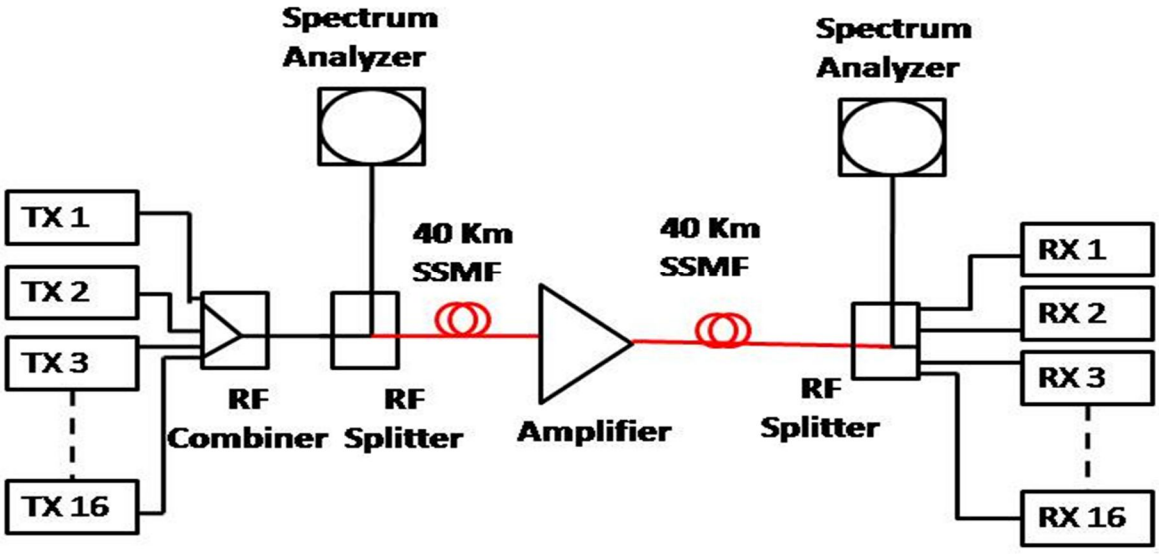


Fig. 1: Setup for Comparing Different Modulation Formats

III. RESULTS & DISCUSSIONS

The performance of the present system is analyzed using different performance metrics that are measured through simulations and reported here. The simulation parameters for 16 x 20 Gb/s WDM Systemare provided in table 1.

Table 1: Simulation parameters for 16 x 20 Gb/s WDM System

Tx Power	Line code	Distance	Bandwidth	Rx Power
32.0371 mW	Variable	80 Km	193 THz to195 THz	31.8752 mW

Fig. 2 describes the eye diagram derived for present system using NRZ format at modulation frequency of 193.2 THz.This eye diagram is helpful in observing performance parameters like Q-Factor, BER etc.

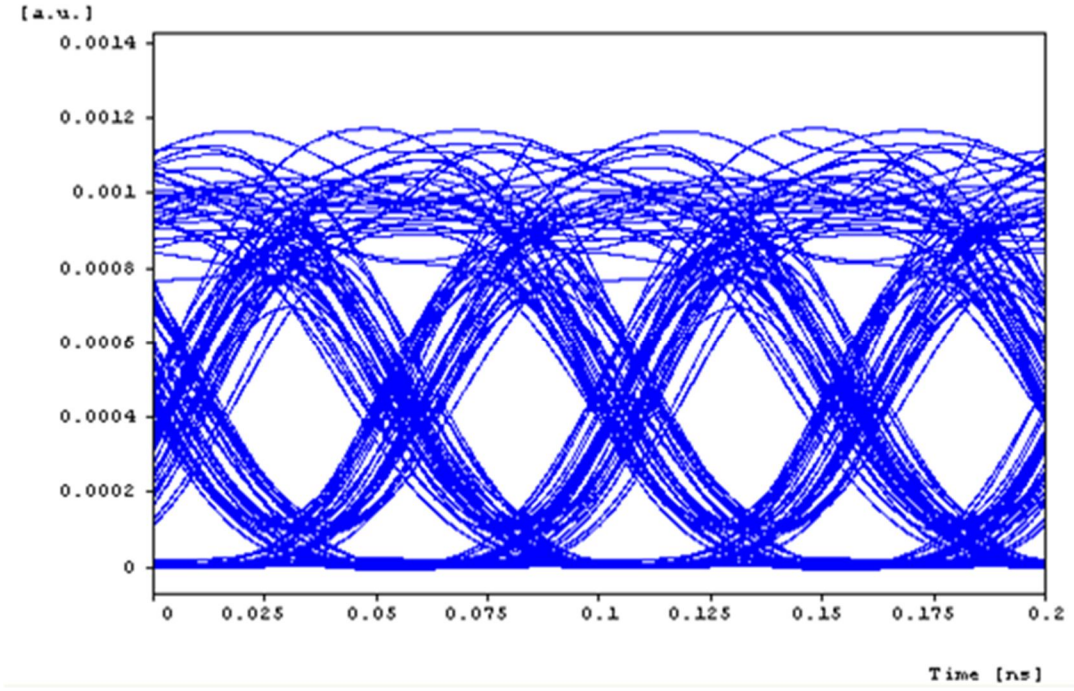


Fig. 2: Eye Diagram derived with NRZ Format at 193.2 THz Frequency

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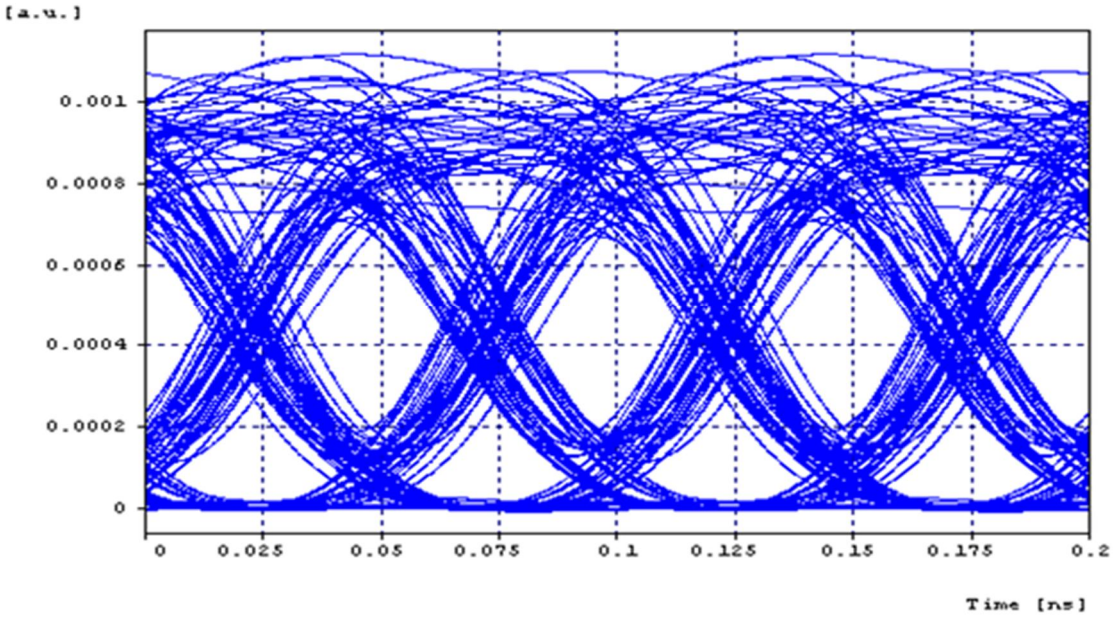


Fig. 3: Eye Diagram derived with NRZ Format at 193.8 THz Frequency

Fig. 3 describes the eye diagram derived for present system using NRZ format at modulation frequency of 193.8 THz. It is observed that improved system performance is obtainedat this frequency. Fig. 4shows the eye diagram derived for present system usingRZ format at modulation frequency of 193.2 THz.This eye diagram is helpful in observing performance parameterssuch as Q-Factor, BER etc. Fig. 5shows the eye diagram derived for present system using RZ format at modulation frequency of 193.8 THz. It is observed that improved system performance is obtainedat this frequency.

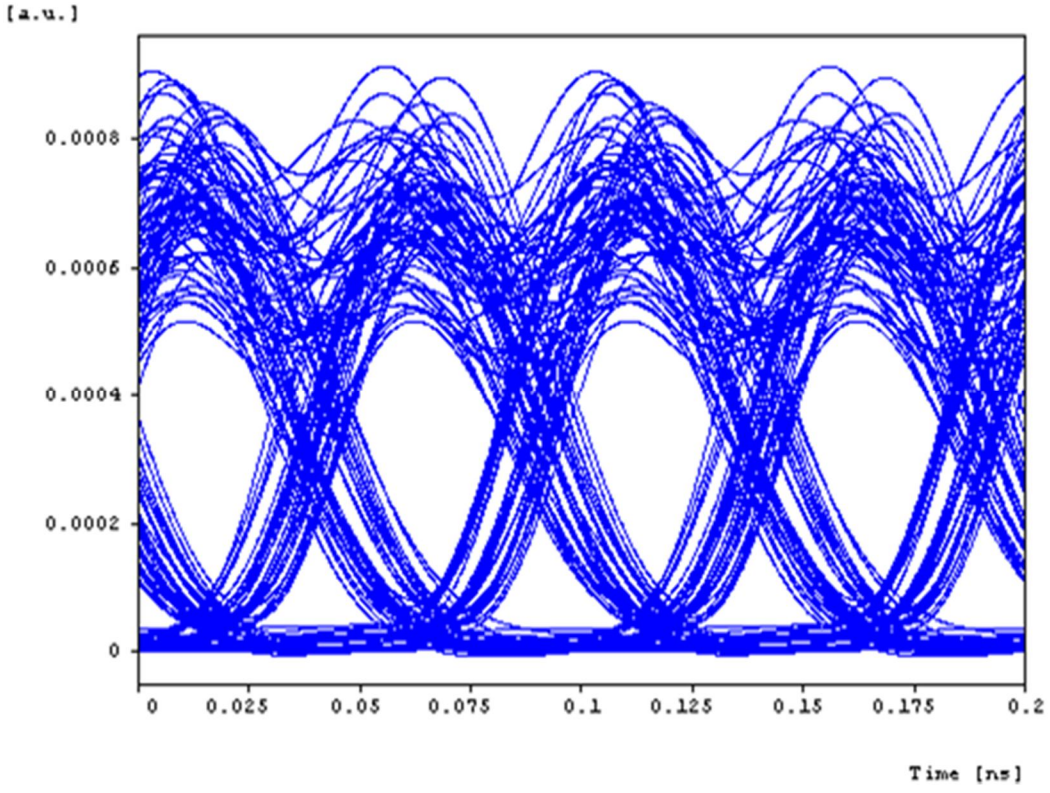


Fig. 4: Eye Diagram derived with RZ Format at 193.2 THz Frequency

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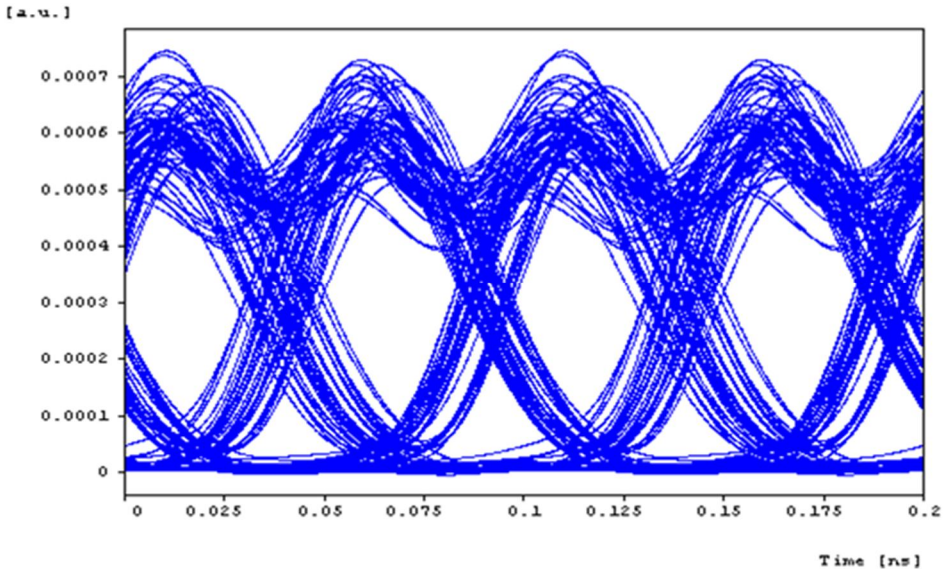


Fig. 5: Eye Diagram derived with RZ Format at 193.8 THz Frequency

The frequency is varied between 193 to 195 THz for both RZ and NRZ modulation formats. Different results like Q-Factor and BER are obtained and summarizes in table 2.

Table 2: RZ &NRZ Modulation Formats Comparison

Frequency [THz]	NRZ Format		RZ Format	
	Q-Value [dB]	BER	Q-Value [dB]	BER
193	13.7135	4.07E-22	14.8577	3.98E-25
193.2	14.2726	5.58E-23	15.3674	6.49E-27
193.4	14.8563	7.72E-24	15.9575	9.87E-27
193.6	14.8765	1.36E-25	16.1457	3.65E-28
193.8	14.9145	2.66E-25	16.2563	2.76E-29
194	14.6534	7.75E-23	15.3573	6.84E-27
194.2	14.2456	5.38E-22	15.0543	5.50E-25
194.4	13.8765	7.64E-21	14.7346	6.57E-24
194.6	13.3654	2.55E-20	14.389	8.35E-23
194.8	12.8635	3.49E-19	13.7654	9.93E-22
195	12.5568	7.49E-18	13.2673	3.76E-21

The two modulation formats (NRZ & RZ) are compared using parameters like BER and Q-Value. The Q-Value comparison is observed in Fig. 6.

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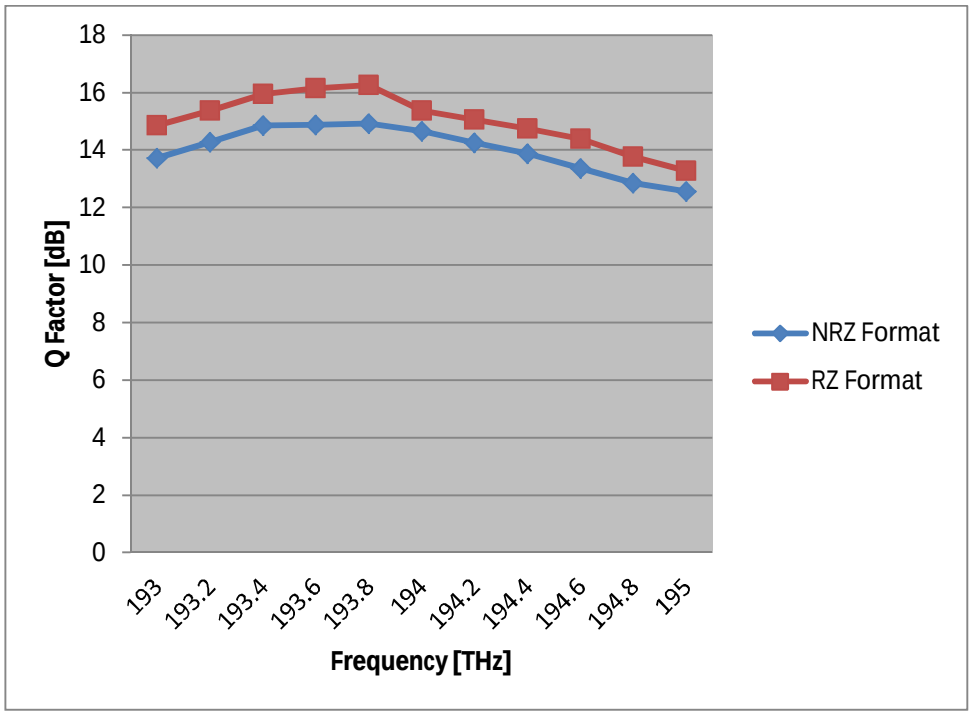


Fig. 6: Q-Factor comparison for NRZ & RZ Modulation Formats

It is observed that as the frequency is varied from 193 to 195 THz, the Q-Factor is increased for both formats up to 193.8 THz; afterwards Q-Factor again goes decreasing. Maximum Q-Factor is obtained at 193.8 THz frequency for both formats. However RZ format provides the improved Q-Factor than NRZ format at all frequencies. The BER comparison is observed in Fig. 7. It is observed that as the frequency is varied from 193 to 195 THz, the BER is decreased for both formats up to 193.8 THz; afterwards BER again goes increasing. Minimum BER is obtained at 193.8 THz frequency for both formats. However RZ format provides the lower BER values as compared to NRZ format at all frequencies.

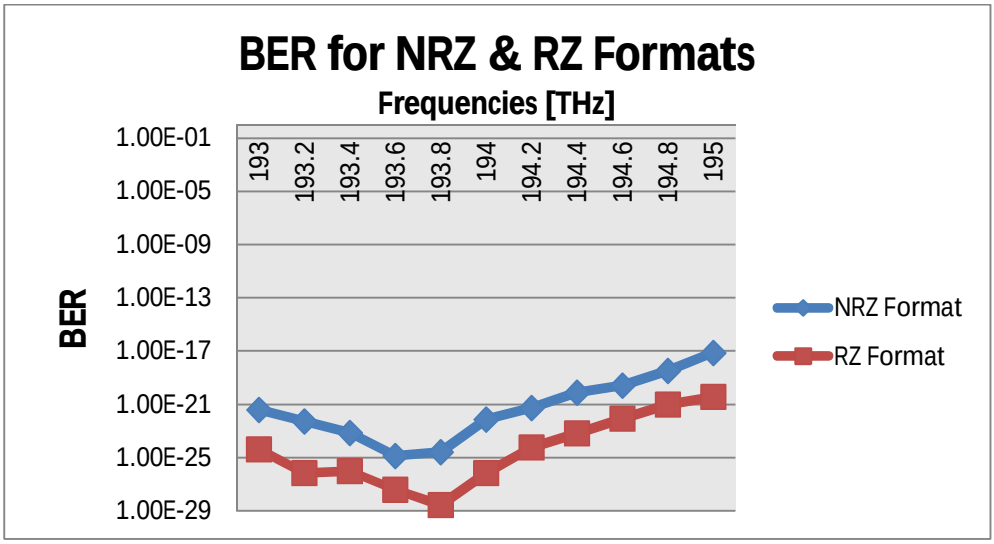


Fig. 7: BER comparison for NRZ & RZ Modulation Formats

IV. CONCLUSIONS

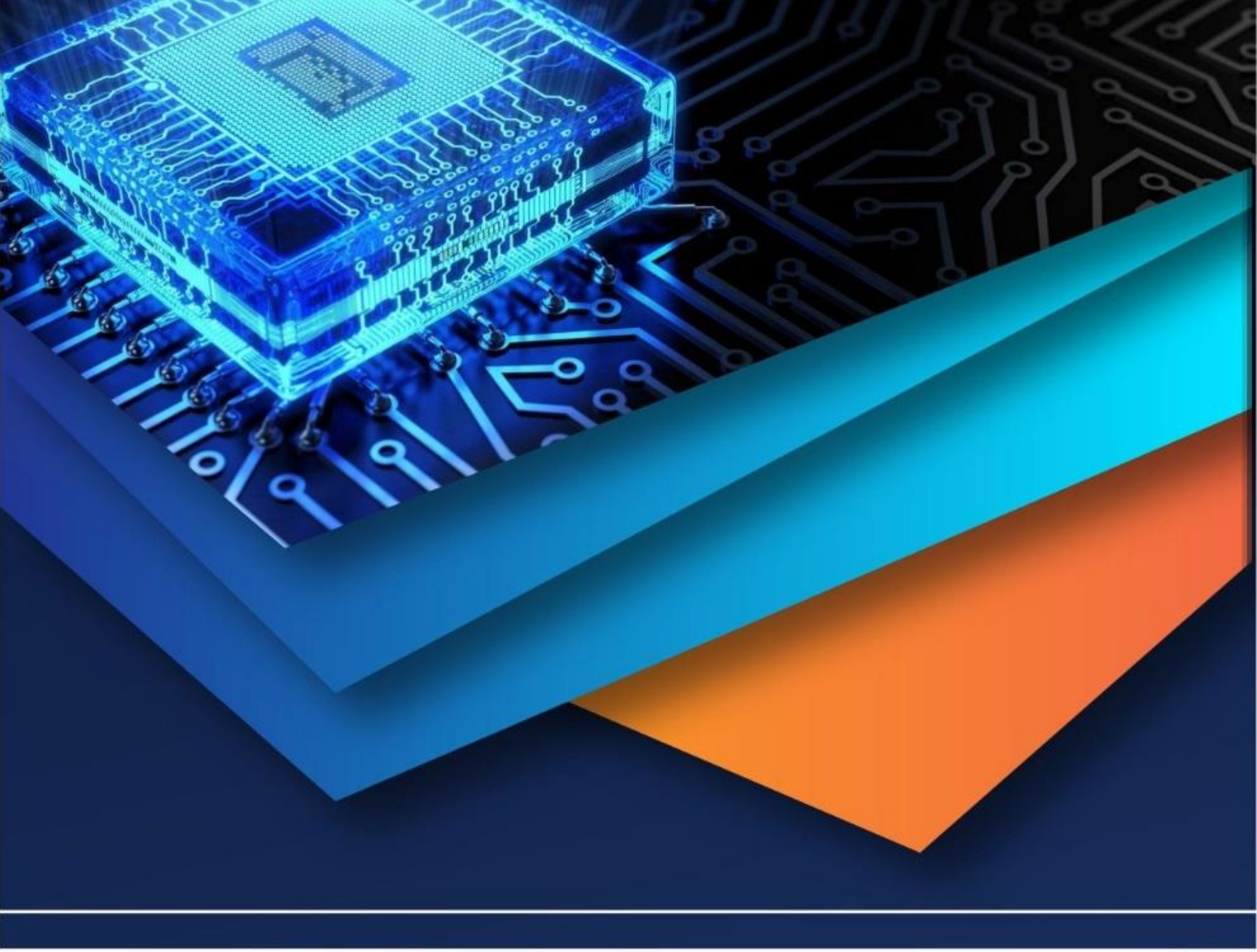
Performance analysis of 16channel WDM optical fiber system is performed with 20 Gb/s data rate and 200 GHz channel spacing using RZ & NRZ modulation formats over 80 Km transmission distance. The system performance is measured using eye diagrams in terms of Q factors & Bit Error Rate values to obtain the best transmission frequency between theoretical ranges of 193 to 195 THz. The RZ format offered high Q-Factor & low BER values as compared to NRZ format.

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