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A COMPARATIVE ANALYSIS FOR NRZ AND RZ TO THE BEST PERFORMANCE IN OPTISYSTEM PROGRAM TO CARY DATA OVER FIBER OPTICS

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Abstract
Data transmission has become an important issue in today's telecommunications world. In order to get the best results in sending and receiving data via optical cable, there are various ways to improve the performance of such systems. In this paper, the simulation program (optsystem) was used to design a communication system for data transmission over a fiber optic to compare the performances of the Return to the Zero (RZ) as well as Non Return to the Zero (NRZ) for different distances. The data was sent over distances ranging from 5 km to 50 km, with an increase of 5 km for each measurement. And recording the values of both Q. factor and (BER), as well as recording ayediagram figures for each case in order to compare to get the best performance for each distance used.
Keywords: Optisystem, NRZ and RZ, simulation applications, fiber optics, BER , Q. Factor.

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1. Introduction

The implementation of experimental instruction in optical communication systems poses challenges due to the high cost of equipment involved. The Optisystem is a software tool designed for the purpose of simulating optical communication systems, hence serving as a comprehensive platform for conducting simulations in this field [1].

Simulation tools have gained significant popularity and widespread adoption across diverse disciplines such as computer science, engineering, and medical science. These tools serve as valuable aids in the design and analysis of systems, allowing for thorough examination and evaluation prior to their actual implementation.

Like this applications offer a practical, cost-effective, and easily transportable solution for system design, enabling researchers to examine the operational framework of a system and extract information pertaining to its reactions or subsystems. Networking solutions associated with simulation have the potential to decrease both the financial expenditure and temporal requirements associated with utilizing tangible systems. This enables the opportunity to assess and authenticate network performance prior to actual implementation.

In the realm of fiber optic communication, simulation tools such as OptiSystem can be effectively employed to conduct comparative analyses of various modulation schemes, including RZ and NRZ [2]. Additionally, these tools facilitate the measurement of crucial metrics such as the Q-factor and bit error rate (BER). Simulation is a valuable tool employed by researchers to evaluate the performance of optical coherent systems and analyze the effects of channel impairments. In the domain of contemporary communication systems, fiber optics has emerged as a fundamental technology for sending data over extensive distances with remarkable velocity and dependability. The optimization of performance in optical communication systems becomes increasingly crucial as the demand for high-capacity data transfer continues to expand. This article explores a comparative examination of two prevalent modulation schemes, namely Return-to-Zero (RZ) and Non-Return-to-Zero (NRZ), utilizing the OptiSystem simulation program. The primary objective of this study is to assess the performance of various modulation schemes across varying lengths, specifically ranging from 5km to 50km with increments of 5km. This investigation aims to provide insights into the efficacy of these modulation schemes and identify any potential trade-offs that may arise in practical situations.

The basis of our analysis is rooted in the utilization of the OptiSystem application, a robust simulation tool that facilitates the precise modeling and analysis of optical communication networks for engineers and researchers. The utilization of OptiSystem enables the simulation of diverse modulation schemes and facilitates the examination of their influence on the efficacy of data transmission. This analysis takes into account crucial aspects including signal-to-noise ratio, bit error rate, and the highly sought-after Q-factor [3].

This article aims to conduct a comparative analysis of the performance of two modulation schemes, namely RZ and NRZ, in the context of data transfer over fiber optics. By conducting a methodical investigation of lengths spanning from short-haul to mid-haul scenarios, our objective is to elucidate the merits and drawbacks associated with each modulation approach. By comprehending the manner in which RZ (Return to Zero) and NRZ (Non-Return to Zero) techniques manage varying distances, significant insights can be derived to facilitate the development of optical communication systems that are both efficient and dependable.

The aim of this study is to enhance the overall comprehension of optical communication systems, thereby assisting researchers, engineers, and practitioners in making well-informed choices on the use of either RZ or NRZ modulation techniques for particular transmission distances. Additionally, our study emphasizes the need of utilizing simulation tools such as OptiSystem for the purpose of forecasting system behavior and enhancing performance prior to real-world deployment.

In the next sections of this article, the simulation results will be discussed and analyze these results in order to draw significant conclusions on the applicability of RZ and NRZ modulation techniques for data transfer across varied distances. The one of objectives of this study was to offer a more comprehensive framework for improving the effectiveness and dependability of optical communication systems during a period of accelerated data expansion.

1.2 literature review:

Paper byKaur and Malik conduct a comparative analysis of the NRZ and RZ modulation formats in the context of optical fiber transmission. The authors employ OptiSystem software as a tool for their investigation. The transmission of optical signals at varying distances is achieved by the utilization of a continuous wave laser and a PIN photodetector. The performance of this transmission system is assessed by evaluating the Q factor and the bit error rate (BER)[4]. In another scholarly publication authored by Ali and joung won, a comparative analysis is conducted between non-return-to-zero (NRZ) and return-to-zero (RZ) modulation techniques. The study delves into the impact of chirp frequency and power on the quality factor (Q factor) and bit error rate (BER). The authors present quantitative findings pertaining to various data rates and transmission distances [5].

1. practical part

Simulation circuit design:-

The simulation circuit was designed by dividing it into three main parts, which are the transmitting circuit, the carrier medium, and the data receiving circuit. In addition to connecting optical devices to measure some parameters, such as Q-factor, Bit Error Rate, and aye Diagram. The figure (1) below shows the parts of the circuit

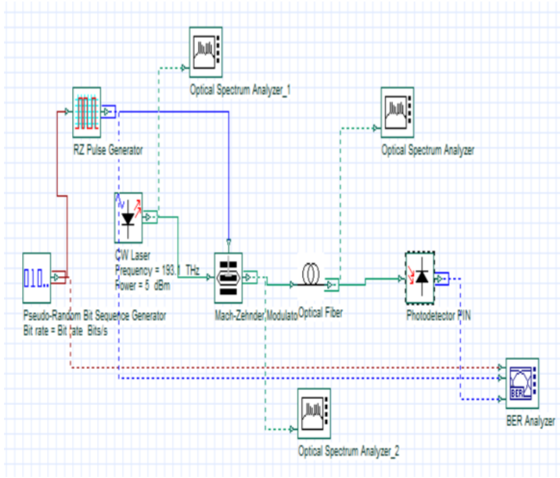
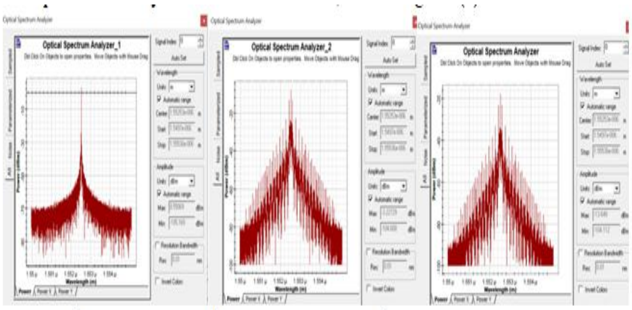


Fig. (1) Optisystem scheme used

The optical measurement devices used in this simulation was :

1- BER analyzer :- this device provide us by the figure of aye diagram , Q. Factor and BER values[6].
2- Optical spectrum analyzer[7] :- This device take the shape of fig. for wavelengths vs power for every test in the measurement, like the figures (2) below



A B C

Fig. (2) Optical spectrum analyzer diagrams for 3 cases

Where the figureA represents the data power after leaving the transmission circuit, while the figure B represents the data power after it is transmitted and before it passes through the optical cable and is exposed to dispersion, while the figure C represents the data power after it passes through the optical cable

The simulated communication circuit is designed by dividing it into three main parts, which are -:the transmitting circuit, the data transmission medium, and the receiving item.

2.1 The transmitpart :-

The transmitting circuit contains of four main parts:-

1- CW laser[8]:

CW laser or continues wave laser which is the majorsource of light in which the transmitted data is embedded and has characteristics as shown in the figure(3) below:

CW Laser Properties

Label: CW Laser Cost$: 0.00

Main | Polarization | Simulation | Noise | Random numbers

Disp	Name	Value	Units	Mode
☑	Frequency	193.1	THz	Normal
☑	Power	5	dBm	Normal
☐	Linewidth	10	MHz	Normal
☐	Initial phase	0	deg	Normal

Fig.(3) CW Laser Properties

2- Mach- Zenhdar Modulator [9]

Is an interferometric structure made from a material with strong electro-optic effect. The properties of this items can be clarify in fig(4).

Mach-Zehnder Modulator Properties

Label: Mach-Zehnder Modulator Cost$: 0.00

Main | Simulation

Disp	Name	Value	Units	Mode
☐	Extinction ratio	30	dB	Normal
☐	Negative signal chirp	☐		Normal
☐	Symmetry factor	-1		Normal

Fig. (4) Mach- Zenhdar Modulator properties

3- Pseudo-Random Bit Sequence Generator[10] :- PRBSG is particularly useful in communication and computing systems and the properties of it is explain in fig(5).

Pseudo-Random Bit Sequence Generator Properties

Label: Pseudo-Random Bit Sequence Generator Cost$: 0.00

Main | Simulation | Random numbers

Disp	Name	Value	Units	Mode
☑	Bit rate	Bit rate	Bits/s	Script
☐	Operation mode	Order		Normal
☐	Order	log(Sequence length)/log(		Script
☐	Mark probability	0.5		Normal
☐	Number of leading zeros	(Time window * 3 / 100) *		Script
☐	Number of trailing zeros	(Time window * 3 / 100) *		Script

Fig. (5) PRBSG Properties

4- NRZ and RZ

The is a main part used in this simulation and the properties is explain in figs(6).

NRZ Pulse Generator Properties

Label: NRZ Pulse Generator Cost$: 0.00

Main | Simulation

Disp	Name	Value	Units	Mode
☐	Rectangle shape	Exponential		Normal
☐	Amplitude	1	a.u.	Normal
☐	Bias	0	a.u.	Normal
☐	Position	0	bit	Normal
☐	Rise time	0.05	bit	Normal
☐	Fall time	0.05	bit	Normal

RZ Pulse Generator Properties

Label: RZ Pulse Generator Cost$: 0.00

Main | Simulation

Disp	Name	Value	Units	Mode
☐	Rectangle shape	Exponential		Normal
☐	Amplitude	1	a.u.	Normal
☐	Bias	0	a.u.	Normal
☐	Duty cycle	0.5	bit	Normal
☐	Position	0	bit	Normal
☐	Rise time	0.05	bit	Normal
☐	Fall time	0.05	bit	Normal

Fig. (6) A NRZ properties (B) RZ properties

2.2 Data carrier medium :-

This part consists of an fiber optical cable[11] that carrying data between the transmitting circuit and the receiving circuit. This carrier medium has properties shown in the following fig.(7)

Optical Fiber Properties

Label: Optical Fiber Cost$: 0.00

Main | Disp... | PMD | Nonl... | Num... | Gr... | Simu... | Noise | Rand...

Disp	Name	Value	Units	Mode
☐	User defined reference w	☑		Normal
☐	Reference wavelength	1550	nm	Normal
☐	Length	50	km	Normal
☐	Attenuation effect	☑		Normal
☐	Attenuation data type	Constant		Normal
☐	Attenuation	0.2	dB/km	Normal
☐	Attenuation vs. wavelengt	Attenuation.dat		Normal

Fig(7) fiber optic properties

2.3 Receiving part

This part consists of a main item for receiving data, which is a photodiode[12]. It receives the transmitted data embedded by the laser. The propreties for this part is clarify by the fig(8).

Photodetector PIN Properties

Label: Photodetector PIN Cost$: 0.00

Main | Downsampling | Noise | Random numbers

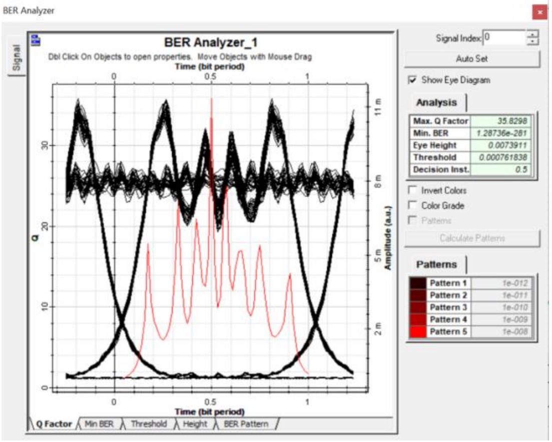
Disp	Name	Value	Units	Mode
☐	Responsivity	1	A/W	Normal
☐	Dark current	10	nA	Normal

Fig. (8)Photodiode properties

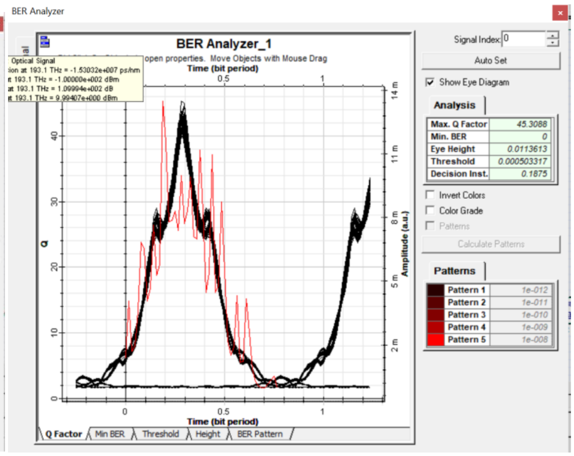
Table (1) Q. Factors and BER for RZ and NRZ variable distance

Distance	Q. F. for RZ	Q. F. for NRZ	BER (RZ)	BER (NRZ)
5	45.3	35.8	0	1.88 ề-281
10	34.4	13.43	4.8 ề-280	1.1 ề-41
15	21.49	13.40	6.8 ề -103	2.5 ề-41
20	19	7.5	5.4 ề -81	1.97 ề-14
25	9.36	8.45	2.88 ề -21	1.3 ề-17
30	6.3	8.31	1,18 ề-10	3.49 ề-17
35	6.76	5.25	4.3 ề-12	5.9 ề-8
40	10.9	5.14	4.1 ề-28	1.12 ề-7
45	4.2	4.12	8.5 ề-6	1.5 ề-5
50	2.6	3.6	2.95 ề-3	1.3 ề-4

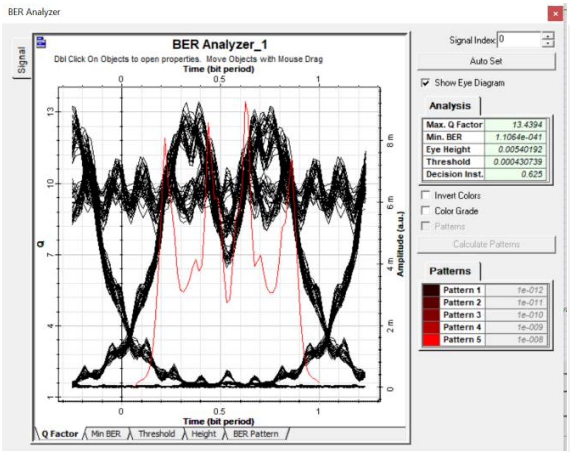
Aye Diagramsand BER for variable distances from 5Km to 50Km increasing 5 Km in every test can be shown in figs. (9)



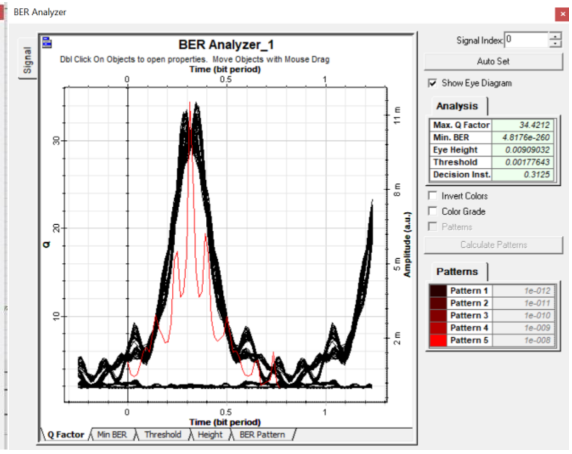
(a)5KM NRZ



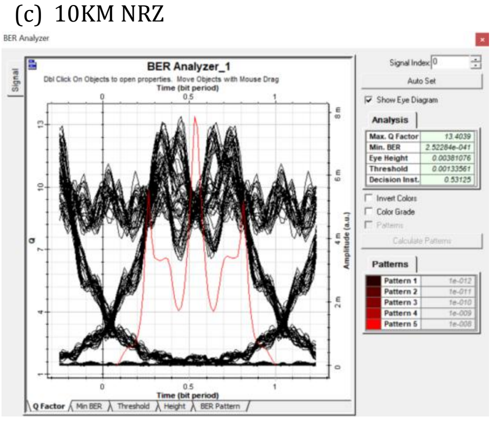
(b) 5KM RZ



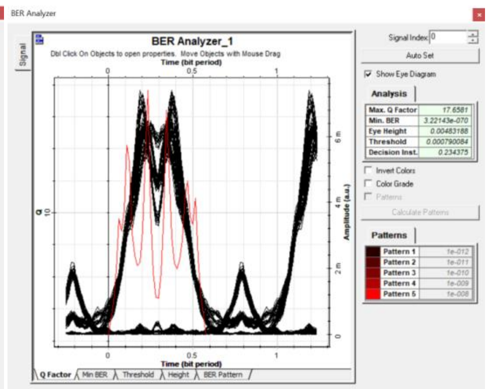
(c) 10KM NRZ



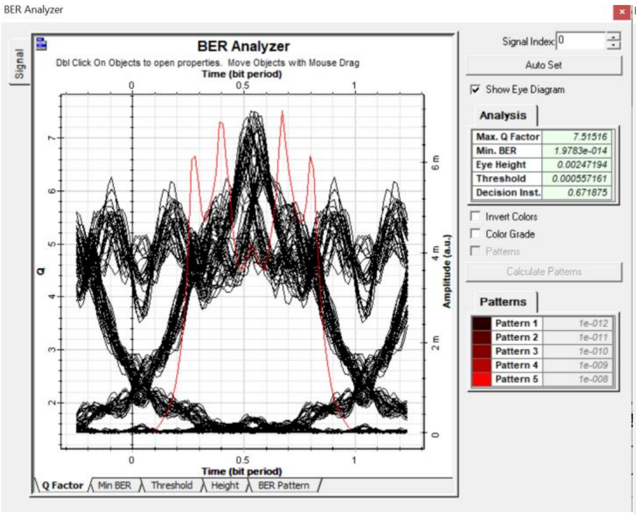
(d) 10KM RZ



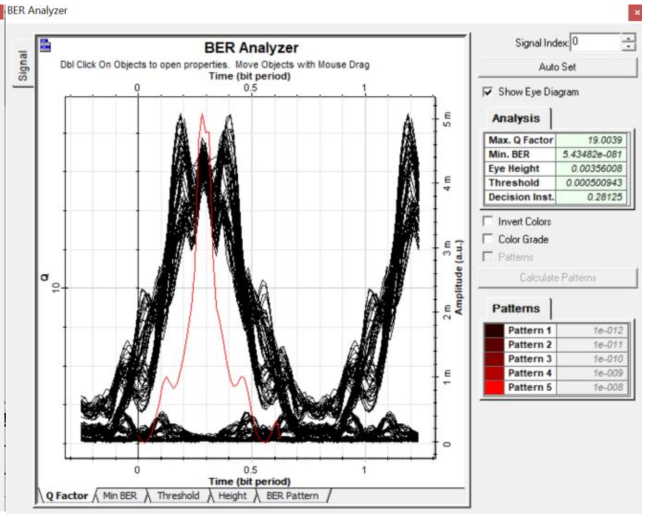
(e) 15KM NRZ



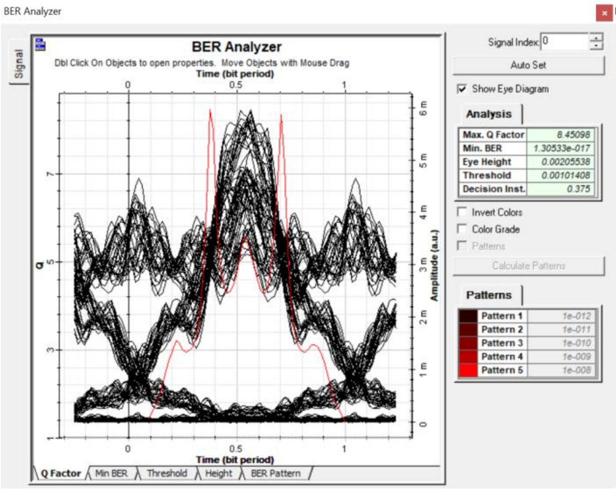
(f) 15KM RZ



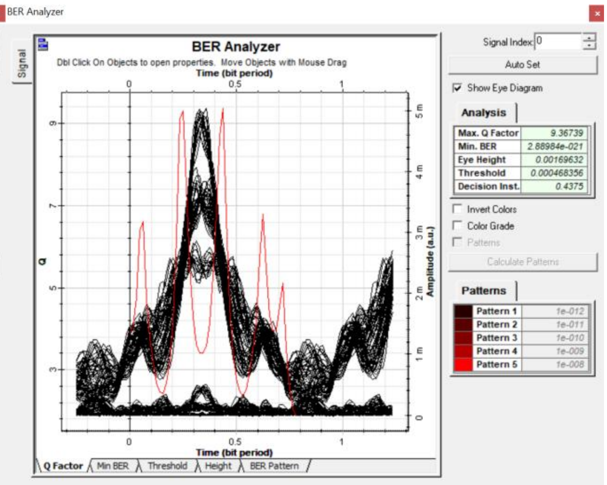
(g) 20KM NRZ



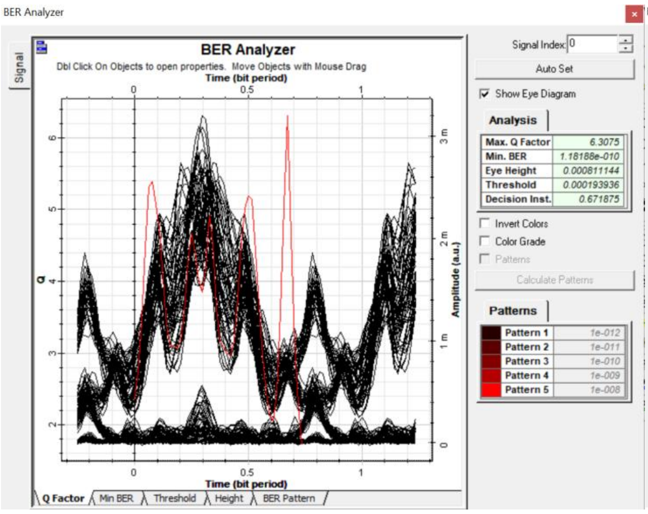
(h) 20KM NRZ



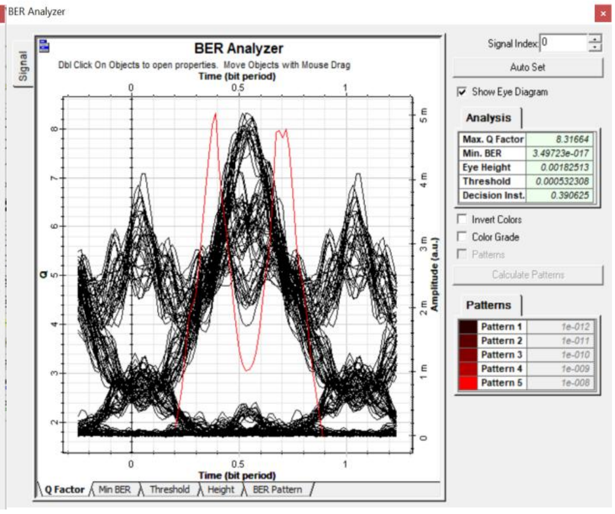
(i) 25KM NRZ



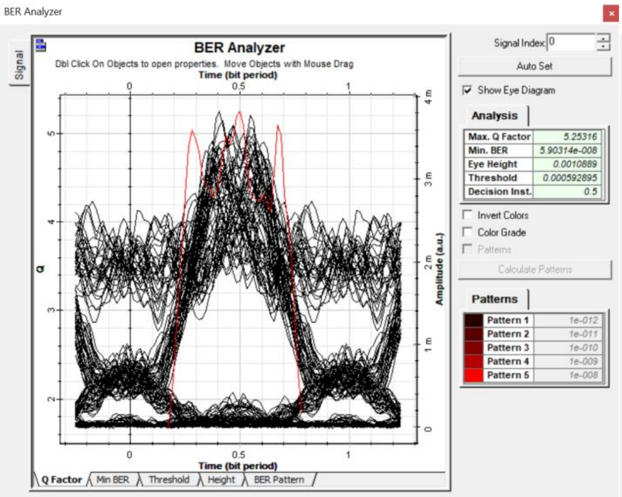
(j) 25KM RZ



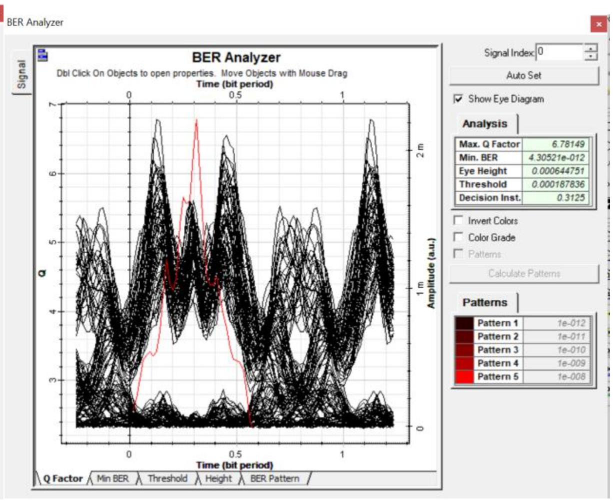
(k) 30KM NRZ



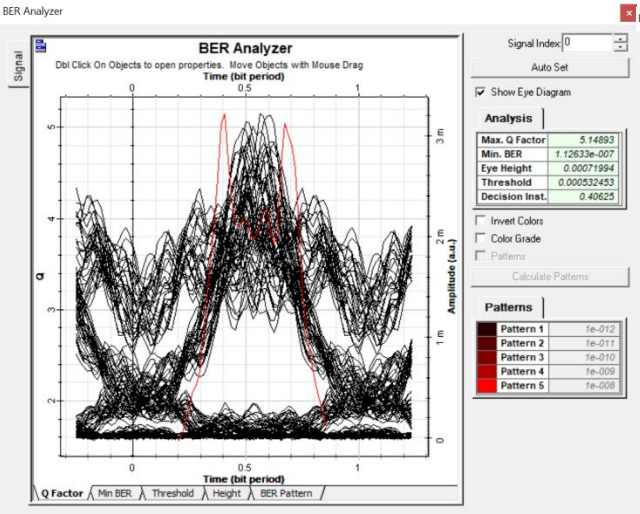
(L) 30KM RZ



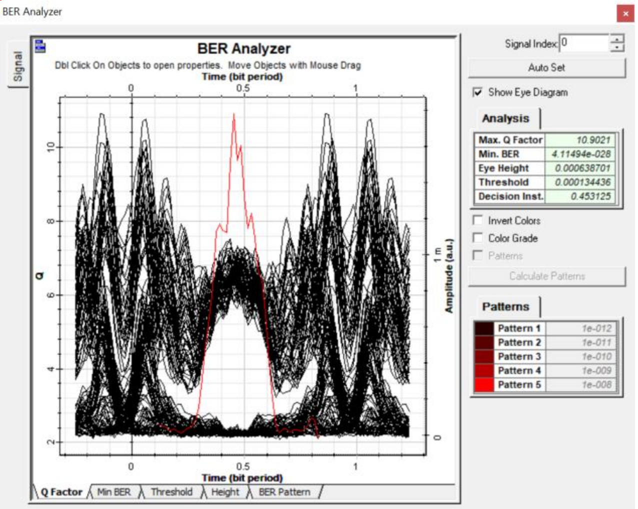
(m) 35KM NRZ



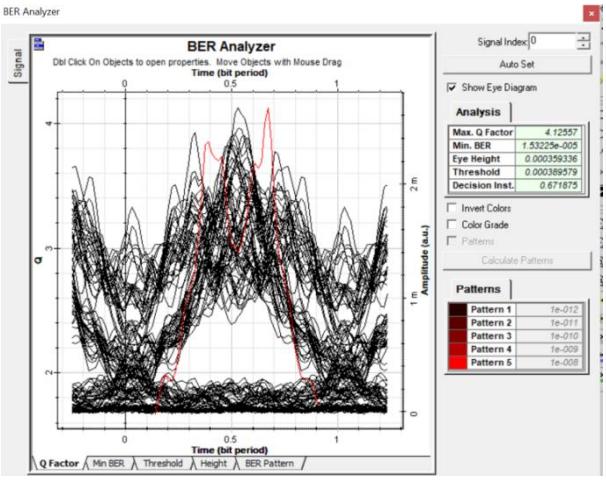
(n) 35KMRZ



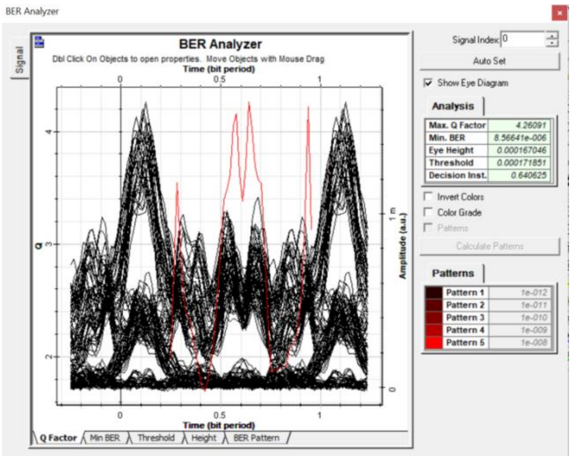
(r) 40KM NRZ



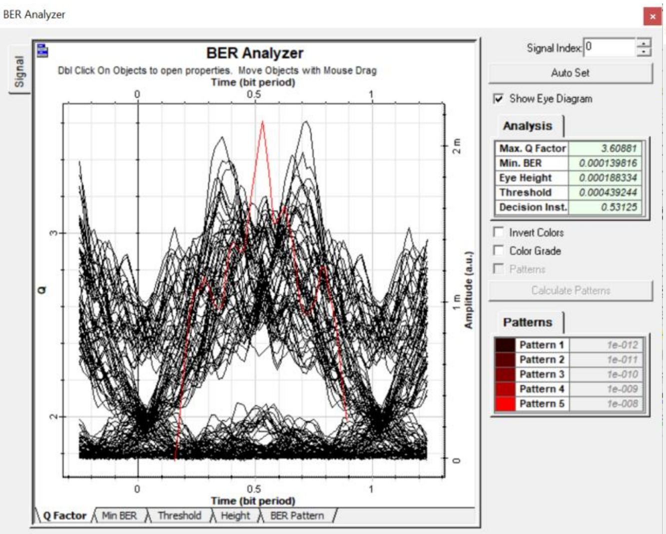
(s) 40KM RZ



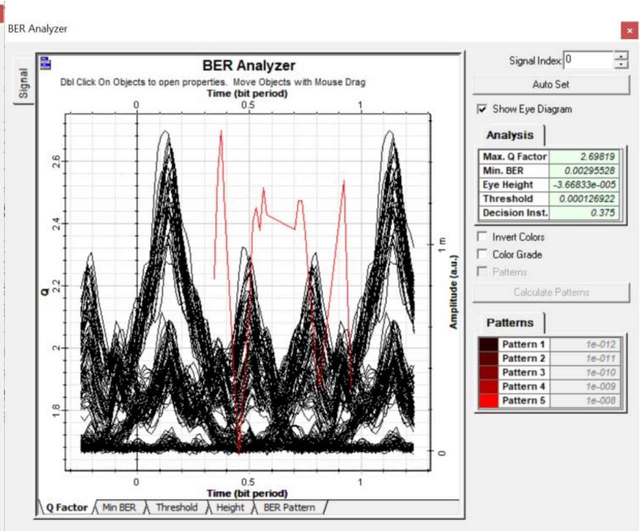
(q) 45KM NRZ



(w)45KMRZ



(z) 50KM NRZ



(y) 50KM RZ

2. Conclusion

When analysisthe results of the Q Factor values, a number of observations can be made:

1. Fiber optic communication systems can suffer from dispersion, where different optical frequencies travel at different speeds in the fiber, causing pulse spreading. Dispersion compensation techniques can be used to mitigate this effect. It's possible that at 30 km, some form of dispersion compensation is coming into play, which temporarily improves the Q factor.
2. Fiber nonlinearities can impact the quality of the signal as distance increases. At certain distances, nonlinear effects might combine in such a way that they temporarily enhance the signal quality.
3. 3. At diversedistances, interactions, signreflections, and interference might play a role. In some cases, these interactions can increasethe signquality if they accordconstructively at exactdistances.
4. 4. The specific featuresof the optical fiber used (e.g., dispersion, ,attenuation,properties) might lead to strangebehavior at certain distances.
5. 5. Noise can also impact sign quality.

There for it's possible that at 30 km(see fig. (9-L)), the noise levels in the simulation setup are reduced, leading to an increase in the Q. factor. Also, from observing the value of the Q.Factoralso BER for each of NRZ and RZ,(see fig. (9-s)), note that the performance of the system by transferring data at a distance of 40 km is the best possible in the case of RZbut at a distance of 30 km, it is preferable to use NRZ, because the value of Q-Factor and BER is better than its counterpart for the same distance.This behavior may be due to the reasons for the points mentioned above.

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Informed Consent

Not Applicable

Ethical Statement

Not Applicable

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