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Original scientific paper

Effects of Fibre Bragg Gratings and Channel Number Variation on System Performance in Free Space Optical Communication Systems

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Abstract: The FSO system uses free space to transmit high data rate data over long distances through light and has been developed as a technology that can be realised with high bandwidth and data rate as well as low BER. FSO systems have recently been preferred over fibre optic cabling and radio frequency communication, especially in urban data transmission, in emergency situations where fast network installation is required, and in rural or remote areas where fibre optic infrastructure is difficult to install. Q factor and BER values are among the main determinants in positioning FSO systems as a reliable, efficient and high performance communication solution. Reducing the BER and increasing the Q factor are of great importance for FSO systems to increase the communication quality and perform better in different environmental conditions. In this paper, we present a different approach to improve the communication quality by decreasing the BER and increasing the Q factor by integrating an FBG sensor, which is reported to have a significant effect on noise reduction in fibre optic communication systems, into the FSO link. In order to evaluate the system performance based on this approach, the communication link, which we designed as single-channel and 4-channel, was tested with and without FBG sensor using ASK, DPSK, QPSK, 4-QAM and 8-QAM modulations. According to the measurements, it has been determined that increasing the number of channels and the use of FBG reduces the BER value and improves the line quality by increasing the Q-factor value. Especially in the 4-QAM and 8-QAM modulation scenario, which is designed as a single channel, it is found that communication cannot be achieved without the integration of FBG sensors, while a quality communication can be achieved after the integration of FBG sensors into the system. In this study, it is shown that the use of FBG sensors in the FSO communication link improves the system performance under interference effects. In our study, the changes in line quality for the systems are presented in detail with eye diagrams, tables and graphs.

Keywords: ber; bit error rate; fibre bragg grating; free space optics; fso; Q-factor

1 INTRODUCTION

In modern telecommunication systems, wireless communication technologies are critical for providing high speed and reliable communication. Digitalisation and technological advances are challenging the capacity of wireless communication networks, which leads to various problems, especially in traditional radio frequency (RF) based systems. Free Space Optical (FSO) stands out as an alternative solution in this context. FSO offers a high speed and secure broadband connection by transmitting signals in free space without the need for fibre optic cables [1, 2].

While the laser-based nature of FSO provides significant advantages in wireless communication for a wide range of applications such as data, voice, text and video, its disadvantages are that it is affected by various parameters such as laser frequency, power, transmission line length, receiver filter type, modulation type and atmospheric conditions. Performance improvement methods and techniques on FSO systems are analysed and their contributions to the literature are evaluated. In the study by S. Das and M. Chakraborty (2016), ASK and PPM modulation based FSO system design was carried out under variable weather conditions. It was found that an FSO system using PPM modulation scheme outperforms the system using ASK modulation technique in terms of maximum Q-factor and minimum Bit Error Rate (BER), Pin Photo-diode works better for PPM while Avalanche Photo-diode works better for ASK [3]. Arockiyadoss, M. A. et al. (2024) investigated the integration of FSO with Fibre Bragg Grating (FBG) sensors in self-healing ring architectures, aiming to improve the reliability and signal-to-noise ratio in temperature sensing in sensor systems. It has been emphasised that the use of intensity wavelength division multiplexing (IWDM) is an important factor to manage the complexity of increasing the multiplexing number of FBG sensors [4]. Smriti Sharma et al. (2023) analysed the performance of an FSO system based on Dual Polarisation Quadrature Phase Shift Keying (DP-QPSK) in relation to the effects of various weather conditions. Fog, rain, snow and atmospheric turbulence are among the weather factors considered. Based on the simulation results, it is found that DP-QPSK based FSO systems provide very high bit rate performance and perform well in different weather conditions due to their digital compatible receivers [5]. N. S. Sadzali et al. (2021), On-Off Keying Non-Return to Zero (OOKNRZ), Binary Phase Shift Keying (BPSK) to reduce the turbulence effect and improve FSO link performances, He investigated the FSO performance under weak turbulence using Optisystem software based on various modulation schemes such as Quadrature Phase Shift Keying (QPSK) and Eight-Quadrature Amplitude Modulation (8-QAM) and found that the 8-QAM modulation scheme gives the best performance, followed by QPSK, BPSK and OOK-NRZ [6]. In the study by S.K. Evran and N. Ö. Ünverdi (2023), the efficient communication range of the proposed free space optical communication system under different weather conditions was analysed and internal variables such as optical power and external parameters such as weather conditions were evaluated. The performance of the system is analysed according to the maximum quality factor and the received optical power. It is observed that the quality value decreases with increasing distance in the system and the quality of the received signal increases with increasing transmission power. Weather conditions were found to be an important factor in communication. It was determined that the free space optical communication system was most adversely affected by hazy weather conditions [7]. In the study by I. Basudewa et al. (2020), a comparison of Pulse Position Modulation (PPM), Pulse Amplitude Modulation (PAM), and On-Off Keying (OOK) in FSO communication was conducted. A light source with a wavelength of 1550 nm was used, and simulations were performed at various distances, measuring the Signal-to-Noise Ratio (SNR) and Bit Error Rate (BER).

The researchers adopted a quantitative approach using MATLAB simulations and performed correlational studies to compare parameters such as BER, SNR, distance, and visibility. The results revealed that PPM is the most effective modulation technique compared to the others [8]. In the study by M. Sharma et al. (2016), the performance of High Altitude Platform (HAP)-based optical wireless communication systems was examined. The effects of atmospheric attenuation, turbulence, and signalling errors on system performance were evaluated. In this context, the average Bit Error Rate (BER) and channel capacity were calculated, and the impact of multi-path architecture on communication was analyzed. The calculations showed that the proposed architecture provided high bandwidth, low error rates, and reliable connections. Additionally, it was concluded that by using alternative inclined links, the system's resilience was enhanced, and its dependence on atmospheric conditions was reduced [9]. In the study by H. Nouri and M. Uysal (2018), a system based on adaptive MIMO-FSO systems was proposed. This system is capable of selecting the optimal transmission mode based on channel conditions. The aim of the study was to maximize the outage capacity while ensuring the specified target outage probability. To achieve this, the outage capacities of diversity, multiplexing, and hybrid operation modes were calculated, and a Lookup Table (LUT) was created. The received SNR value was compared with the thresholds in this LUT to determine the optimal transmission mode. The results showed that the proposed system offers higher performance compared to diversity and multiplexing methods alone, provides stable transmission over a wide SNR range, and enhances capacity while maintaining the outage probability at the specified level [10].

In this study, in order to compare the performances of ASK, DPSK, QPSK, 4-QAM and 8-QAM modulations, which are frequently used in the fields of communication and communication, in Free Space Optical systems, which are increasingly used in optical communication, and to examine the effect of the number of channels on performance, 1-channel and 4-channel systems were designed under attenuation and disturbance effects and the performances of these designed systems are examined. In addition, the systems designed in this study are examined separately with and without FBGs and the effect of using FBGs, which are reported to reduce noise for fibre optic communication systems, on the performance of FSO systems is investigated.

Our goal is to demonstrate how these techniques offer solutions to the challenges faced by FSO and how they can contribute to the future of wireless communications.

2 FSO SYSTEM DESIGN AND SIMULATION

FSO system generally consists of transmitter, channel and receiver, like all communication systems. In the simulation programme used in this study, modulation types such as ASK, QPSK, DPSK and QAM are modulated automatically by means of generators used in signal generation. These generators produce signals with a specific modulation technique and automatically adjust the required parameters, eliminating the need for users to build complex modulation circuits. Thus, the signals can be used directly to analyse the performance of the system, saving both time and reducing the margin of error.

The block diagram of the designed FSO systems is shown in Fig.1.

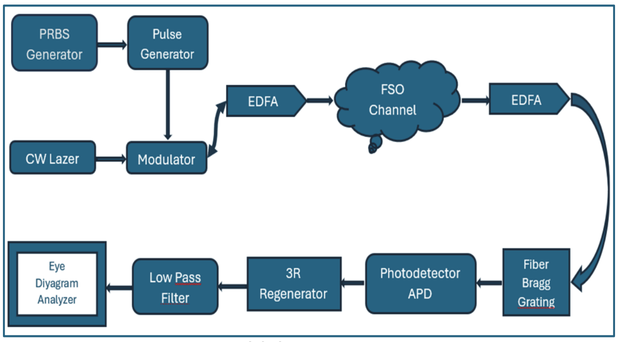

Figure1 FSO System Block Diagram

In the systems designed with ASK, QPSK, DPSK, 4-QAM and 8-QAM modulation within the scope of the study, the Pulse Generator element used in the transmitter section generates the modulated signal, while the M-ary Pulse Generator generates multiple bits in a certain time period, which provides timing in data transmission. CW Laser is a high frequency light source and is used as a carrier wave in modulation. Mach-Zehnder Modulator carries data by modulating the incoming laser light and plays a critical role in optical communication. The EDFA (Erbium-Doped Fibre Amplifier), which is used on the transmitter side in the designs, plays an important role in compensating for losses over long distances by amplifying the signal to be sent. FSO Channel is the channel through which laser light passes for free space optical communication.

At the receiver side, the EDFA is an amplifier that is used to amplify the incoming signal to avoid high losses, which is one of the disadvantages of the FSO system. The APD photodetector converts the optical signal at the receiver into an electrical signal. The low-pass Bessel filter is a type of signal processing filter whose main task is to pass signals below a certain frequency and suppress high frequency components. The 3R regenerator is used to ensure the repetition of the original bit sequence and the modulated electrical signal; the incoming data is connected to the Eye Diagram Analyzer component to analyse the *Q* factor and BER values of the eye diagram image of the installed system [11-13].

These elements form an effective optical communication system by providing high data transmission rate and reliability.

In order to examine the effects of using FBGs in the designed FSO system, the performances of the systems with and without FBGs were compared. FBGs reflect a narrow band of incident light while transmitting all the remaining wavelengths. In other words, FBGs are optical fibres that act as a filter for a specific wavelength [14].

This property enables FBGs to be used in a wide range of applications. Used in areas such as sensors, fibre lasers, fibre optic communication systems and optical filtering, these components play an important role in providing control of light at specific wavelengths. The working principle and structure of FBG sensors are shown in Fig. 2.

When a light beam enters the fibre, Bragg diffraction occurs in the grating with a periodic spatial phase distribution. The incident light is scattered as a reflection spectrum. The following equations are used for FBGs [16].

The central wavelength KB of the reflected spectrum is given by Eq. (1).

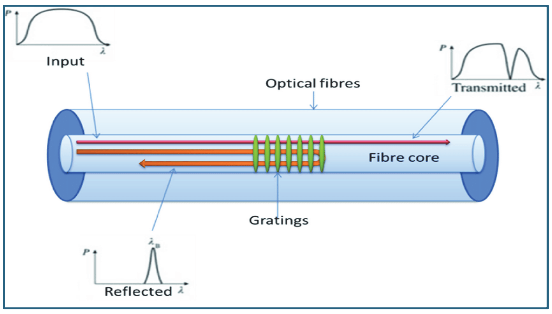

Figure 2 FBG structure [15]

$$K_B = 2n_{eff}\Lambda \tag{1}$$

where n_{eff} is the effective refractive index and Λ is the refractive index change period (grid period).

Eq. (2) is obtained by differentiating both sides of Eq. (1).

$$d\kappa_B = 2\Lambda \times dn_{eff} + 2n_{eff} \times d\Lambda \tag{2}$$

Dividing both sides of Eq. (2) by the centre wavelength KB gives the following result.

$$\frac{d\kappa B}{\kappa B} = \frac{dneff}{neff} + \frac{d\Lambda}{\Lambda} \tag{3}$$

The first term on the right hand side of Eq. (3) can be transformed as follows.

$$\frac{dneff}{neff} = -\frac{neff\,2}{2}[U_{12} - v(U_{11} + U_{12})]\varepsilon = (1 - U)\varepsilon \tag{4}$$

Here U relates only to the properties of the fibre and ε is the stress of the structure. Eq. (4) can be expressed as a function of strain and centre wavelength.

Free Space Optical (FSO) systems are subject to signal degradation due to atmospheric conditions and other losses. This results in high BER and adversely affects communication performance [17, 18]. To overcome these challenges, increasing the number of channels, such as FBG integration, plays an important role in terms of system performance. Increasing the number of channels improves spectrum efficiency in wireless communications, resulting in high data rates and high quality of service, while at the same time exploiting spatial diversity, which improves system reliability, and by receiving multiple independent copies of the same signal at the receiver, it increases the resilience of FSO systems to atmospheric attenuation and optimises performance [19].

Another important advantage of increasing the number of channels in FSO systems is flexibility. The needs of different users may vary according to the application context. For example, in distance education applications, if students and teachers need different data streams, these needs can be met by using multiple channels. In this way, the system can respond quickly to different user demands.

In conclusion, increasing the number of channels in FSO systems provides more effective and efficient solutions in various fields by increasing both data transmission capacity and communication reliability. Especially in areas such as high-speed internet connections, military communications, security systems and distance education, increasing the number of channels optimises system performance and plays an important role in meeting users' expectations. This allows FSO systems to have a wide range of applications and increases the overall effectiveness of the system [20, 21].

In this study, in order to investigate the use of FBG sensors in FSO systems with ASK, QPSK, DPSK, 4-QAM and 8-QAM modulations and the effect of channel number change, designs were made under the parameters and disturbance effects in Tab. 1, and the designs and eye diagram outputs of all modulations were presented.

Table1 Simulation Environment Parameters

Parameters	Value	Unit
Transmission Speed	10	Gbps
CW Lazer Frequency Power	 193,1 10	 THz dBm
FSO Distance Slimming Transmitter Aperture Diameter Receiver Aperture Diameter Beam Aberration Transmitter Losses Additional Losses	 2,5 9,34 2,5 20 1 1 1	 km dB/km cm cm mrad dB dB
EDFA Length	10	m
FBG Frequency Length	 193,1 1	 THz mm
Photodetector Profit Responsiveness	 3 1	 - A/W

2.1 Amplitude Shift Keying (ASK)

Amplitude Shift Keying (ASK) is one of the basic modulation techniques used in digital communications and works by varying the amplitude of the carrier signal for data transmission.

In this method, digital data is represented by fixed amplitude levels, with variations between amplitude levels corresponding to different levels in the amplitude of the carrier signal. For example, in binary ASK (Binary ASK or BASK), the presence of the carrier signal is represented by a '1' bit and its absence by a '0' bit. The main advantage of ASK is its ease of implementation and simple hardware requirements. Amplitude changes are easy to detect and therefore ASK is a suitable modulation method for low-cost systems. However, changes in signal amplitude are highly sensitive to disturbances such as interference and environmental noise. This can easily cause the signal to be distorted and thus cause errors in data transmission [22-24]. Fig. 3 shows the simulation circuit with 4 FSO channels with ASK modulation. The following figures show the eye diagrams of 1-channel and 4-channel FSO systems with ASK modulation with and without FBG.

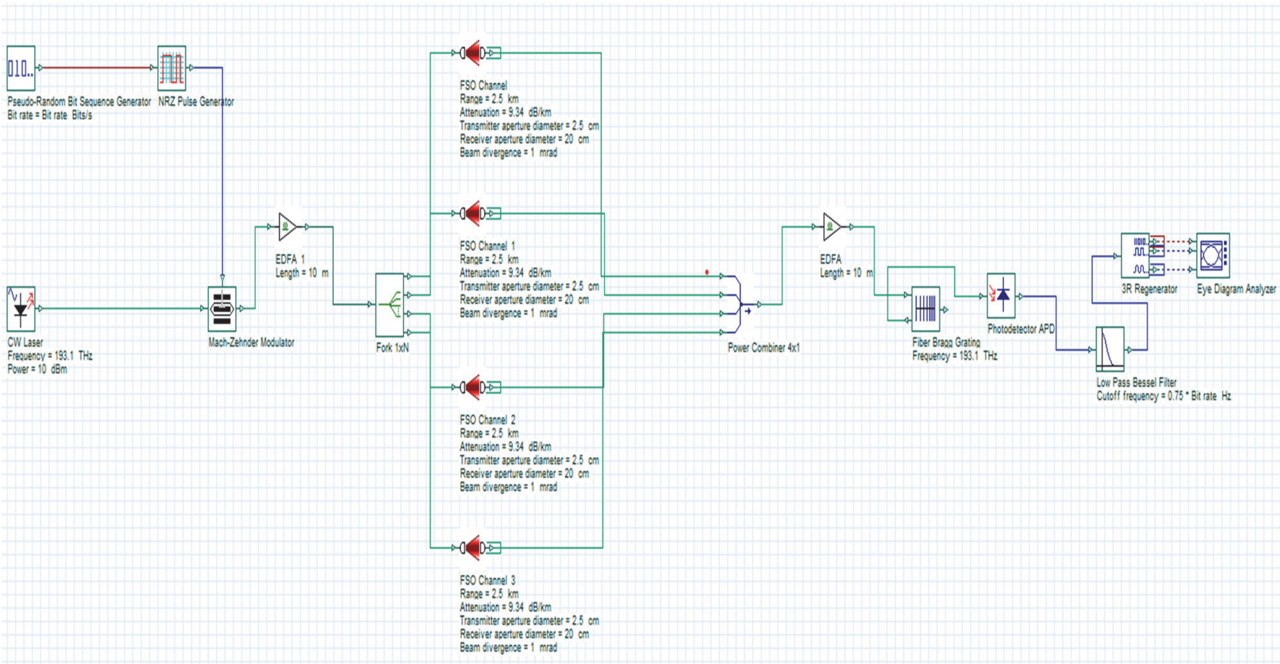

Figure 3 Simulation circuit with 4 FSO channels with ASK modulatio

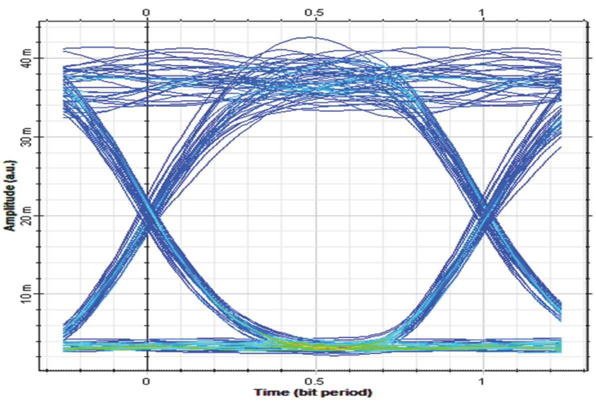

Figure 4 Eye diagram of 1 channel without FBGFSO system with ASK modulation

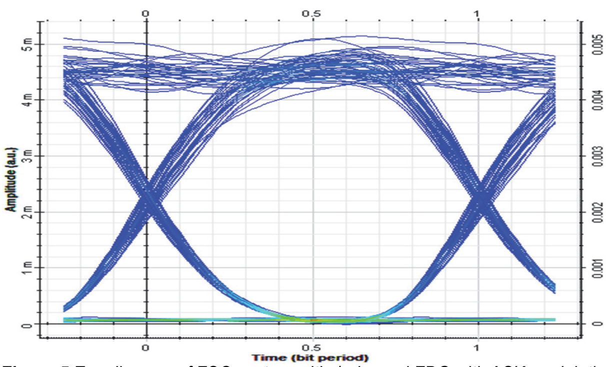

Figure 5 Eye diagram of FSO system with 1 channel FBG with ASK modulation

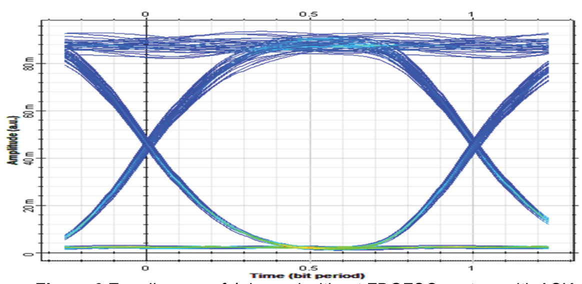

Figure 6 Eye diagram of 4channel without FBGFSO system with ASK modulation

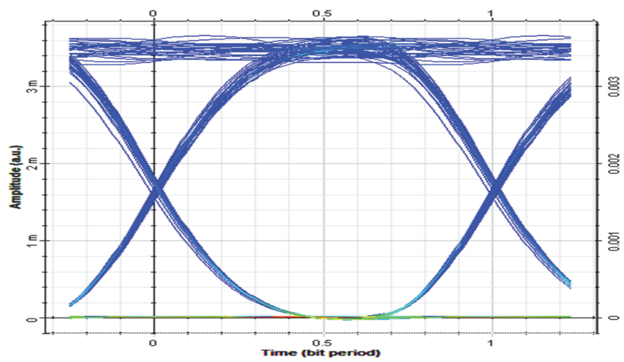

Figure 7 Eye diagram of FSO system with 4channel FBG with ASK modulation

2.2 Differential Phase Shift Keying (DPSK)

In Differential Phase Shift Keying (DPSK), the phase of the modulated signal is shifted relative to the previous signal element. No reference signal is used here. The phase of the signal follows the high or low state of the previous element. This DPSK technique does not require a reference oscillator. The fact that DPSK does not require a reference signal makes this method simpler and less costly, while the phase shifts are made according to the previous signal, making the signal processing process easier.

In systems where high data rates are required, such as 5G networks, these features of DPSK play an important role in providing more efficient and energy-efficient communication [25-27].

Fig. 8 shows the simulation circuit with 4 FSO channels with DPSK modulation. The following figures show the eye diagrams of 1-channel and 4-channel FSO systems with PSK modulation with and without FBG.

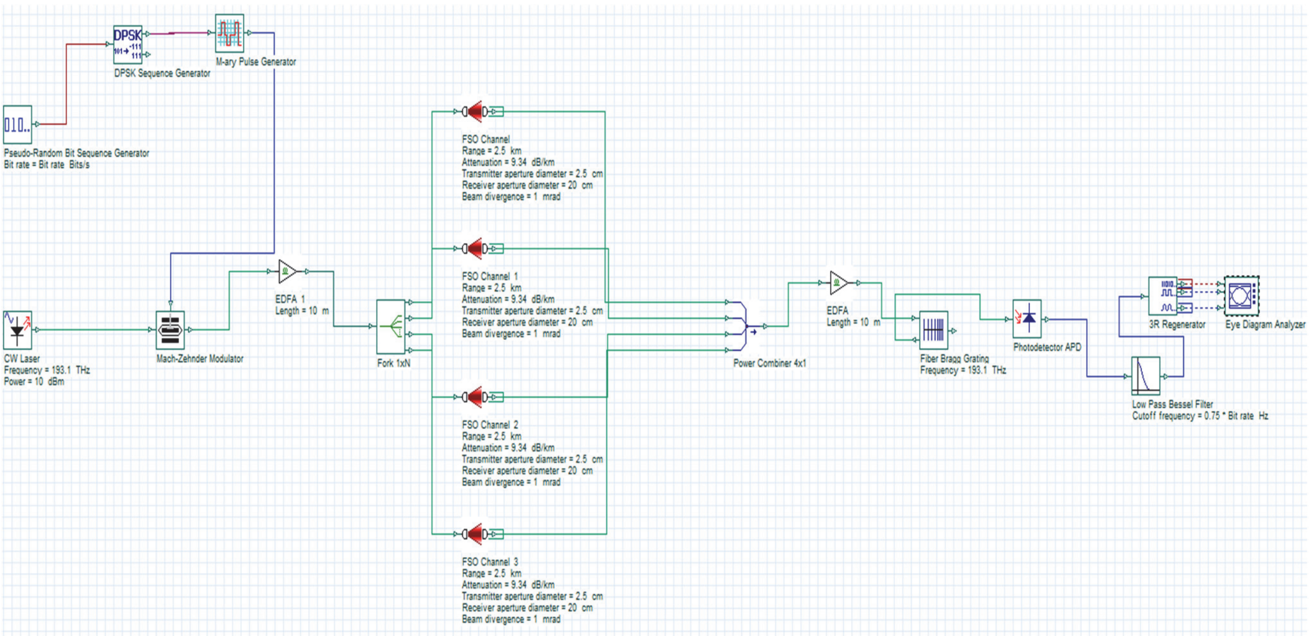

Figure 8 Simulation circuit with 4 FSO channels with DPSK modulation

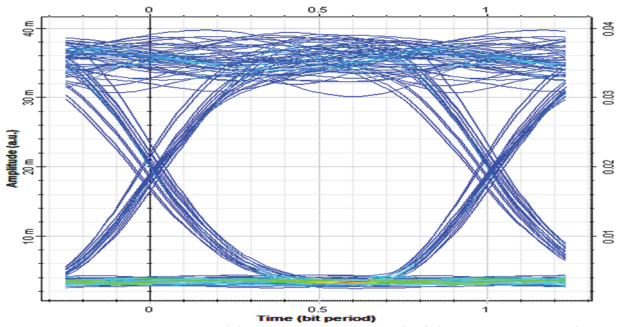

Figure 9 Eye diagram of 1 channel without FBGFSO system with DPSK modulation

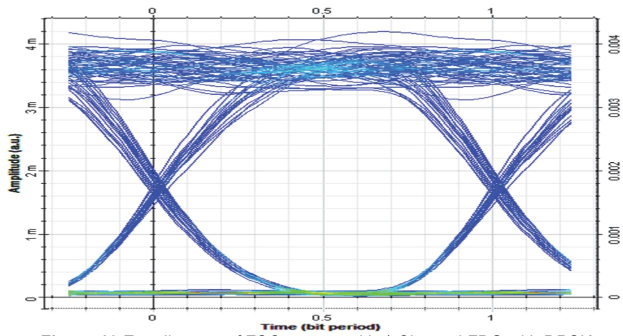

Figure 10 Eye diagram of FSO system with 1 Channel FBG with DPSK modulation

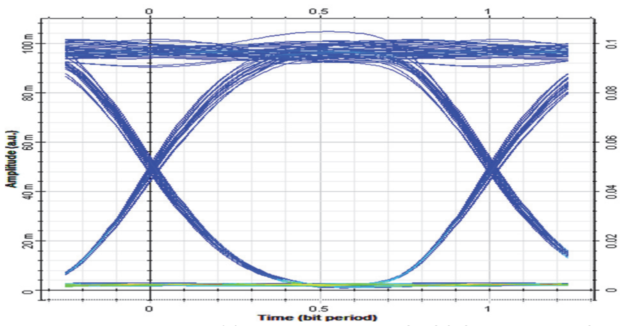

Figure 11 Eye diagram of 4 channels without FBG FSO System with DPSK modulation

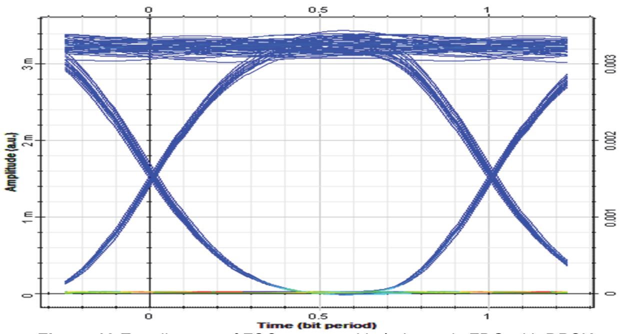

Figure 12 Eye diagram of FSO system with 4 channels FBG with DPSK modulation

2.3 Quadrature Phase Shift Keying (QPSK)

Quadrature Phase Shift Keying (QPSK) is a variation of the Two Phase Shift Keying (BPSK) method and sends two bits of digital information simultaneously using the Dual Sideband Printed Carrier (DSBSC) modulation scheme. The bits are converted into bit pairs, halving the data bit rate and this creates space for other users. The QPSK Modulator generates single BPSK (PSKI) and double BPSK (PSKQ) signals using a bit splitter, two multipliers and an addition circuit.

QPSK also plays an important role in 5G technologies. This modulation technique provides higher efficiency in data transmission and can transmit more information with less energy. Thanks to its greater data carrying capacity, QPSK enables high-speed data transmission in 5G networks, while at the same time improving the overall performance of the system. These features make QPSK especially ideal for applications that require intensive data transmission [28-30]. Fig. 13 shows the simulation circuit with 4 FSO channels with QPSK modulation. The following figures show the eye diagrams of 1-channel and 4-channel FSO systems with PSK modulation with and without FBG.

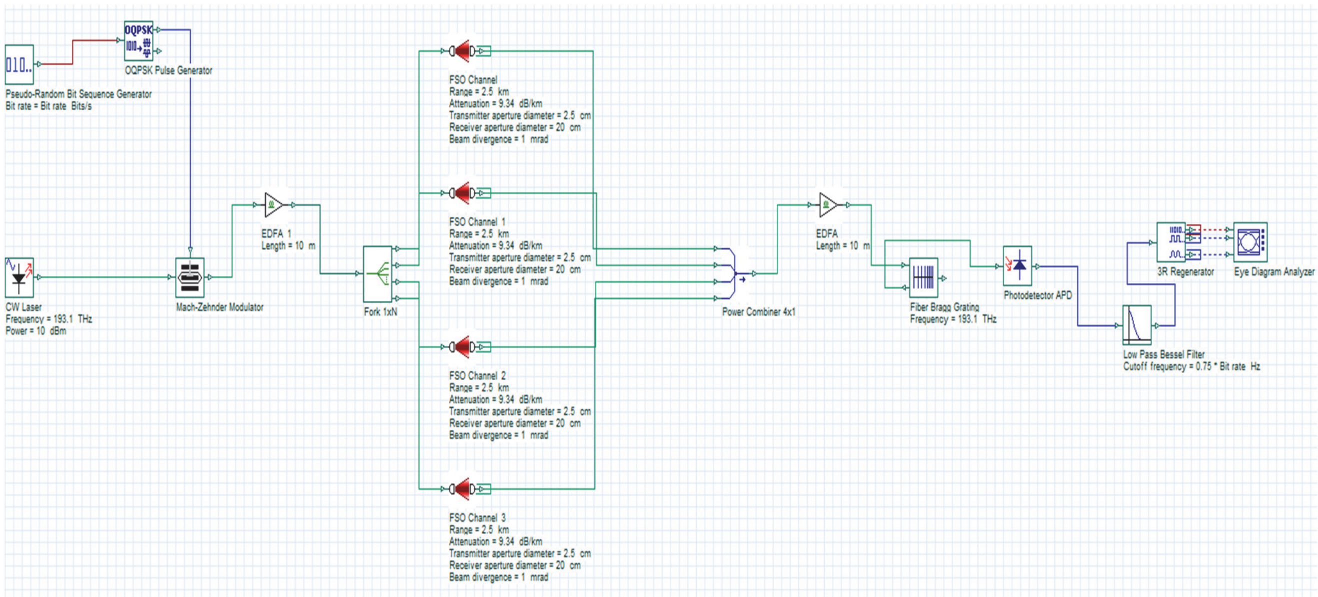

Figure 13 Simulation circuit with 4 FSO channels with QPSK modulation

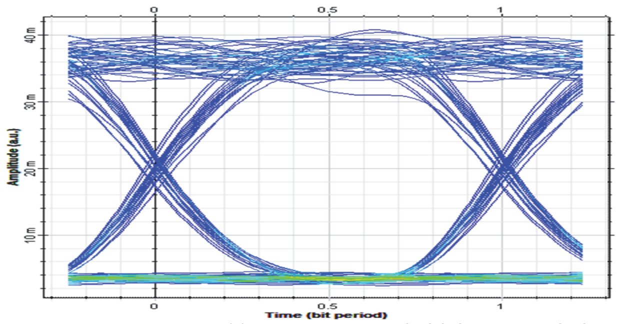

Figure 14 Eye diagram of 1 channel without FBGFSO System with QPSK modulation

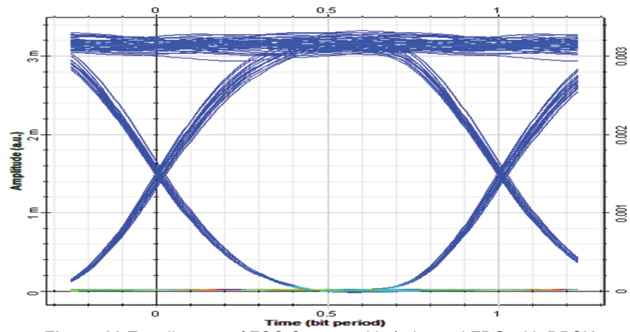

Figure 16 Eye diagram of FSO System with 4 channel FBG with DPSK modulation

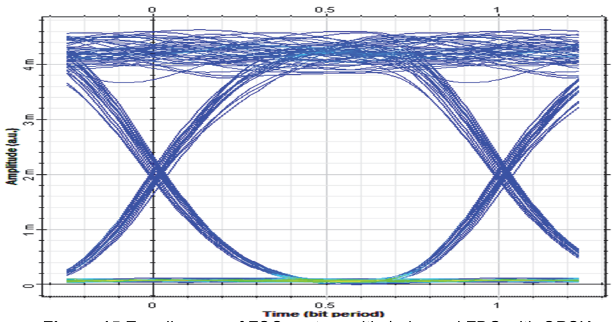

Figure 15 Eye diagram of FSO system with 1 channel FBG with QPSK modulation

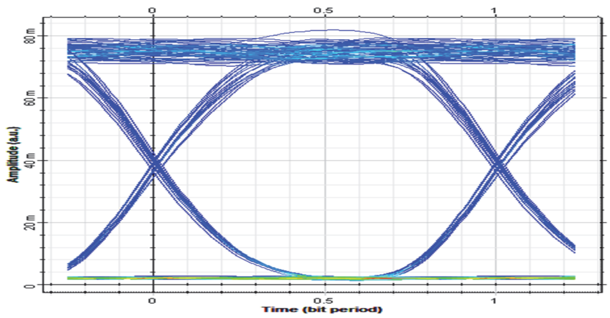

Figure 16 Eye diagram of 4 channels without FBGFSO System with QPSK modulation

2.4 Quadrature Amplitude Modulation (QAM)

QAM is a method that modulates both the amplitude and phase of the carrier signal and is widely used to improve data transmission efficiency. In this study, a FSO system with 4-QAM and 8-QAM modulation is designed. These modulations are generally used in applications that require lower data rates and more robust links. In weak signal conditions or long distance transmissions, these modulations can provide more secure and consistent links than modulations with higher data rates. It provides higher spectrum efficiency compared to modulations with higher data rates (16-QAM, 64-QAM, etc.), while at the same time being less sensitive to noise and signal degradation [31-33]. This provides a great advantage especially in FSO systems with various external influences. In the simulation circuit, the only difference between the 4-QAM and 8-QAM modulated FSO system is the change in the number of bits in the parameter settings of the QAM Sequence Generator element.

Fig. 18 shows the simulation circuit with 4 FSO channels with 8-QAM modulation. The following figures show the eye diagrams of 1-channel and 4-channel FSO systems with 4-QAM and 8-QAM modulation with and without FBG.

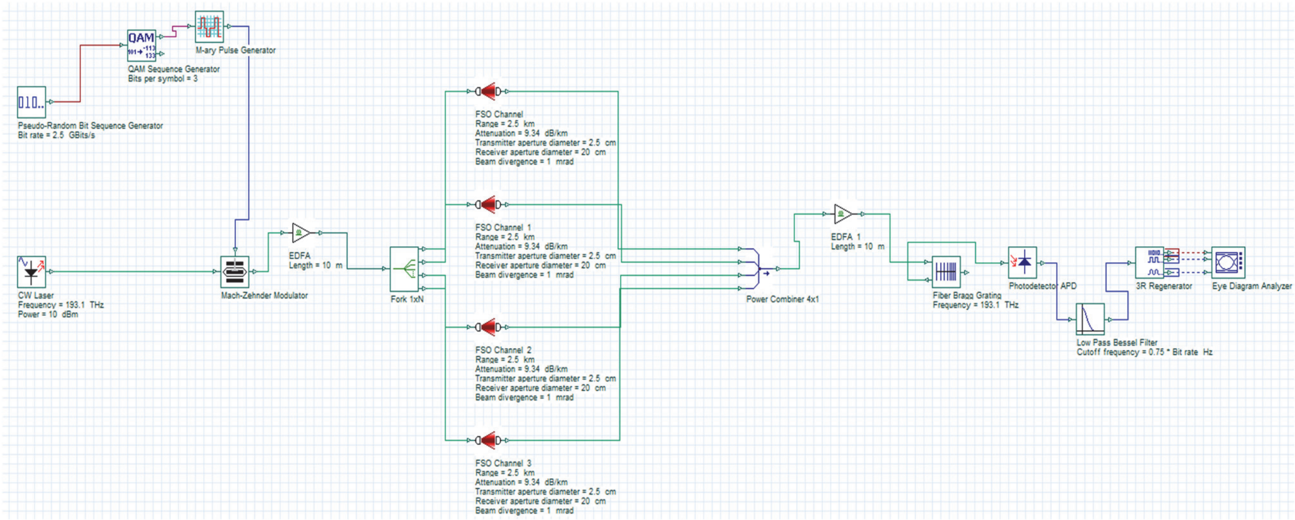

Figure 18 Simulation circuit with 4 FSO channels with 8-QAM modulation

The Q Factor value of the 1-channel FBG-free FSO system with 8-QAM and 4-QAM modulation was measured as 0 and the BER value was measured as 1. Therefore, the eye diagram could not be created. After the integration of FBG into the system, communication was achieved and the eye diagram of the system is presented in Fig. 19 and Fig. 22.

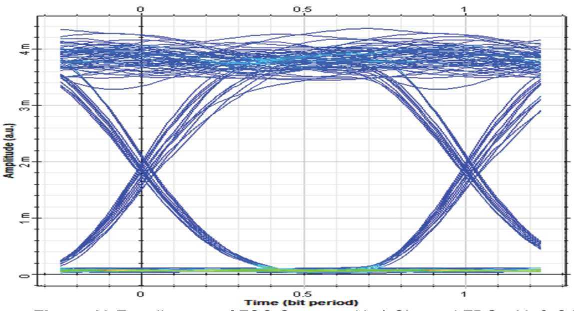

Figure 19 Eye diagram of FSO System with 1 Channel FBG with 8-QAM modulation

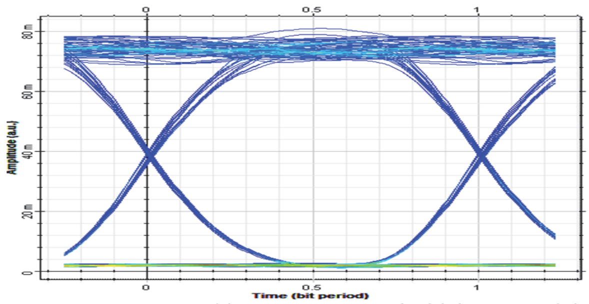

Figure 20 Eye diagram of 4 channels without FBG FSO System with 8-QAM modulation

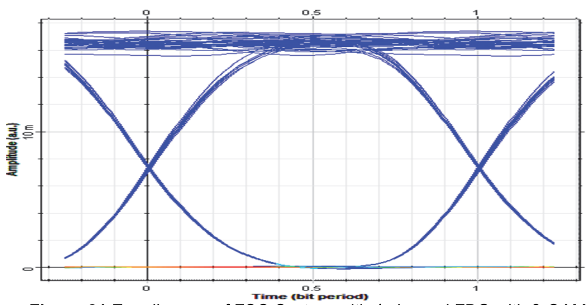

Figure 21 Eye diagram of FSO System with 4 channel FBG with 8-QAM modulation

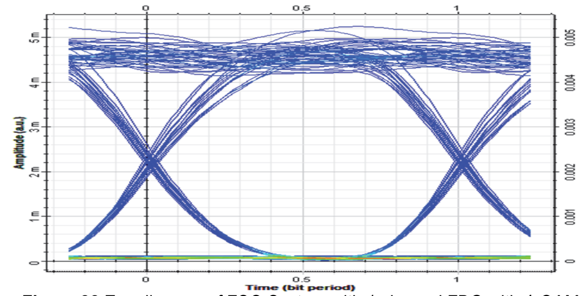

Figure 22 Eye diagram of FSO System with 1 channel FBG with 4-QAM modulation

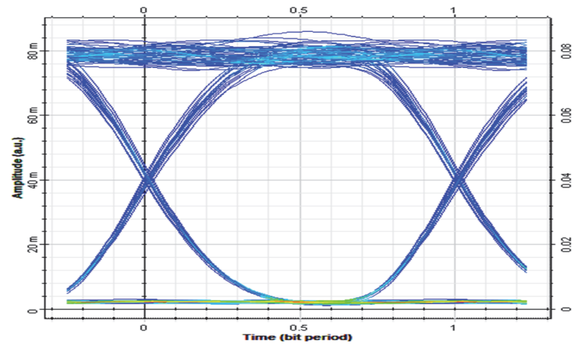

Figure 23 Eye diagram of 4 channels without FBGFSO System with 4-QAM modulation

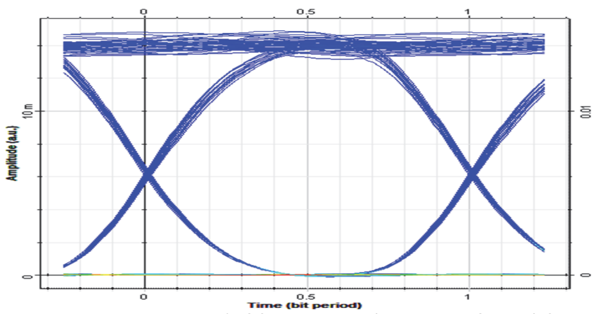

Figure 22 Eye diagram of FSO system with 4 channel FBG with 4-QAM modulation

When the eye diagrams of FSO systems with ASK, DPSK, QPSK, 8-QAM and 4-QAM modulation simulated in this study are analysed, it is seen that the use of FBG and increasing the number of channels increase the quality of the communication system. Q-Factor and BER are two important parameters used to evaluate signal quality and system performance in digital communication systems. Q-factor is a metric that expresses signal quality. It usually indicates the accuracy or robustness of digital signals against errors and measures the signal strength of the system against noise. BER is the ratio of the number of erroneous bits in the communication system to the total number of bits transmitted. It shows how many of the bits transmitted by the system are transmitted correctly and how many are received incorrectly. The Q Factor and BER values of the systems are presented in Tab. 2 in order to examine the communication quality of the systems in question and to make a more understandable performance comparison.

Table 2 Result values of simulation circuits

Modulation Type	Number of Channels	FBG Usage	Q/BER	Value	Number of Channels	FBG Usage	Q/BER	Value
ASK	1 Channel	without FBG	Q Factor	15,1763	4 Channel	without FBG	Q Factor	37,4826
			BER	2,04e−052			BER	6,33e−308
		with FBG	Q Factor	23,9318		with FBG	Q Factor	47,453
			BER	4,71e−127			BER	0
DPSK	1 Channel	without FBG	Q Factor	15,3547	4 Channel	without FBG	Q Factor	35,7385
			BER	1,29e−053			BER	3,20e−280
		with FBG	Q Factor	21,1382		with FBG	Q Factor	40,381
			BER	1,42e−099			BER	0
QPSK	1 Channel	without FBG	Q Factor	16,2319	4 Channel	without FBG	Q Factor	31,5406
			BER	1,20e−059			BER	9,63e−219
		with FBG	Q Factor	23,6261		with FBG	Q Factor	41,7695
			BER	7,24e−124			BER	0
8-QAM	1 Channel	without FBG	Q Factor	0	4 Channel	without FBG	Q Factor	30,802
			BER	1			BER	1,01e−208
		with FBG	Q Factor	20,9074		with FBG	Q Factor	45,1011
			BER	1,72e−097			BER	0
4-QAM	1 Channel	without FBG	Q Factor	0	4 Channel	without FBG	Q Factor	31,7553
			BER	1			BER	1,03e−221
		with FBG	Q Factor	21,944		with FBG	Q Factor	41,3171
			BER	3,07e−107			BER	0

When Tab. 2 is analysed, it is seen that after the addition of FBG to 1-channel ASK, DPSK and QPSK modulated FSO systems, Q factor values increased by 57.69%, 37.66% and 45.55%, respectively. In 1-channel 8-QAM and 4-QAM modulated systems without FBG, the Q factor value is 0 and the BER value is 1.

Thus, it was observed that before the use of FBG, communication could not be achieved, but after the use of FBG, Q factor and BER values showed that a quality communication was achieved.

In 4-channel FSO systems with ASK, DPSK, QPSK, 8-QAM and 4-QAM modulation without FBG, Q factor values increased by 26.6%, 12.99%, 32.43%, 46.42% and 30.11%, respectively.

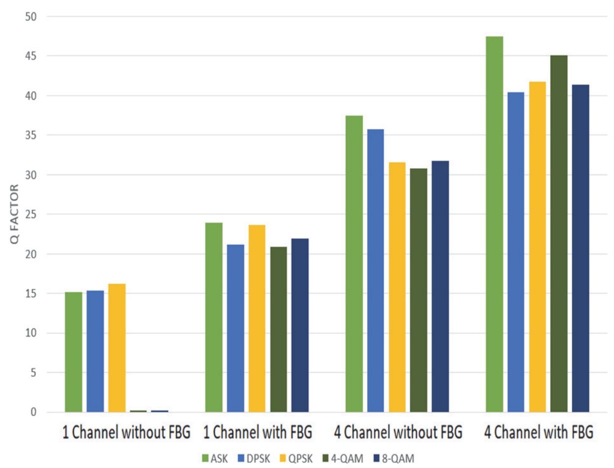

Figure 25 Q Factor values of designed FSO systems

Considering all the systems investigated in this study, it was observed that Q-factor values increased and BER values decreased when FBG was used. This situation shows us that the use of FBG in FSO system improves the line quality. In addition, increasing the number of channels from single channel to 4 channels increased the Q-factor values and decreased the BER values, thus causing significant positive changes in the system performance. The modulation type that provides the best communication from single channel FBG systems is QPSK modulation, while the best communication is provided with 8-QAM modulation system for 4 channel FBG systems.

The Q Factor values of each system are shown in Fig. 25 to compare the analysis more clearly.

When Fig. 25 is analysed, it is seen that increasing the number of channels and the use of FBG has a significant positive effect on the system performance. Especially in the scenario with 4-QAM and 8-QAM modulation designed as 1 channel, it was found that the BER value of the system was measured as 1 before the FBG integration and thus communication could not be provided, while a quality communication was provided after the FBG integration, indicating that the use of FBG can play a vital role especially in scenarios under such interference effects.

In this study, the EDFA was designed as a fixed 10 mt since the focus was on the effect of the change in the number of channels and the use of FBG on the performance. However, it is known that the EDFA length is also an important parameter in such communication systems. It was considered that it would be useful to briefly mention the effect of EDFA length on the system, and when we set the EDFA value at 2.5 mt and 5 mt values in the system design, the quality factor values of the systems were measured as shown in the table below.

When we analyse the table, it is seen that the EDFA length is a critical parameter that directly affects the performance of the system. It is found that the Q-factor generally decreases as the EDFA length increases due to the generation of more amplification noise (ASE) in the system. It is understood that the effect of EDFA length varies depending on the modulation type, therefore, the precise determination of EDFA length optimisation for each design is of great importance in terms of system performance.

Table 3 Q factor values of systems with different EDFA lengths

Mod. Type	Number of Channels	FBG Usage	Q Factor EDFA 2.5 m	QFactor EDFA 5 m	Q Factor EDFA 10 m
ASK	1 Channel	without FBG	17,3458	16,0961	15,1763
		with FBG	20,7236	25,1157	23,9318
	4 Channel	without FBG	40,0705	39,2861	37,4826
		with FBG	41,2162	49,2259	47,453
DPSK	1 Channel	without FBG	16,8765	16,2125	15,3547
		with FBG	17,3537	22,0994	21,1382
	4 Channel	without FBG	37,848	37,4284	35,7385
		with FBG	36,5632	41,9336	40,381
QPSK	1 Channel	without FBG	17,8457	17,2523	16,2319
		with FBG	18,5321	24,5847	23,6261
	4 Channel	without FBG	33,9163	32,9779	31,5406
		with FBG	39,3209	43,3972	41,7695
8-QAM	1 Channel	without FBG	0	0	0
		with FBG	18,0483	21,9556	20,9074
	4 Channel	without FBG	33,04	32,1954	30,802
		with FBG	47,7492	46,8770	45,1011
4-QAM	1 Channel	without FBG	0	0	0
		with FBG	19,013	23,0673	21,944
	4 Channel	without FBG	34,0766	33,2728	31,7553
		with FBG	42,8447	42,7339	41,3171

3 CONCLUSION AND DISCUSSION

In this study, systems using different modulation techniques are simulated within the scope of performance analysis of FSO systems, which are increasing their importance day by day in the fields of communication and communication, and the effect of the use of Fibre Bragg Gratings and the number of channels on system performance is examined in order to increase data quality and prevent losses.

According to the designed system, it is observed that the use of FBG in the FSO system increases the Q factor by decreasing the BER value, thus improving the communication quality by positively affecting the line quality.

With this study, a new one has been added to the rare studies in which FBG is blended with FSO. It is shown through analysis and graphics that FBG is an important component that increases line quality. The analysis also shows that increasing the number of channels increases the Q factor values and decreases the BER values, thus leading to positive results in system performance.

It is also shown that the EDFA length is a critical parameter that directly affects the performance of the system. The precise determination of the EDFA length optimisation for each system is of great importance in terms of system performance, and as the EDFA length increases, the use of FBG becomes more critical and improves the performance of the system.

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