Indonesian Journal of Electrical Engineering and Computer Science
Vol. 27, No. 1, July 2022, pp. 336~346
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v27.i1.pp336-346

Enhancement of single-mode optical fiber quality factor-bit error rate by using uniform fiber Bragg grating

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Article Info

Article history:

Received Mar 16, 2022
Revised May 12, 2022
Accepted May 26, 2022

Keywords:

Analyzer of eye diagrams
Bit error rate
Fiber Bragg grating
Quality factor
Single-mode fiber

ABSTRACT

The properties of optical fibers transmission systems based on Bragg gratings and uniform fibers, which are discussed in detail in this paper. Two-fiber optic communication channels Bragg gratings are used, along with Optisystem software for simulations. It is widely used in a variety of optical communication systems, such as, dispersion compensators, band filters, amplifiers and in-fiber sensors or fiber grating lasers, because of its versatility. In this design, the distance has been changed from 10 km up to 100 km, as well as the input power from 2 dBm to 16 dBm, and the calculation of both the bit error rate (BER) and quality (Q) factor at the receiver could be studied by modelling the model of a communication system and employing the system's most suited settings, such as fiber cable length (km) and input power (dBm).

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1. INTRODUCTION

The optical signal is transported without distortion from the transmitter to the receiver using the communication channel. It is common practice to use optical fibers as the communication channel for light wave communication systems because the light can be transmitted in fibers with low loss of power. Fiber loss influences the spacing of repeaters in a long-haul light wave system, therefore it's a significant design factor. Fiber dispersion, which causes pulse broadening inside the optical fiber, is another important design consideration [1]-[7]. A fiber is described as a periodic change in the refractive index along the core of an optical fiber, grating Bragg. It's fundamental in optical communication systems, particularly for building optical amplifiers and filters. Ultraviolet radiation is used to expose the fiber's core, the refractive index can be modulated. As a result, the index of refraction of the core changes. Photosensitivity is a crucial feature of optical fibers. Hill and Meltz [8] found it in 1978 at the Canadian communication center. It makes it possible to make fiber Bragg grating (FBG) in the core of the fiber. Photosensitivity refers to the ability of a core to modify its index of refraction when exposed to ultraviolet (UV) light. The photosensitivity of the optical system is influenced by a number of elements, including fiber core composition, source of irradiation, and fiber history prior to irradiation. Hydrogen loading can improve the photosensitivity of fiber [9]. The very first fiber grating was known as a "self-induced grating." This only works at the UV wavelength, which is used for writing. The core's refractive index is permanently altered. Because photosensitive silica fibers doped with germanium are utilized in the production of FBG, implying that light alters the core's refractive index. The quantity of change is determined by the exposure's intensity and duration. Fiber Bragg gratings (FBG) play a key role in fiber communication and fiber sensing [10]. Compensation for dispersion, amplifiers, laser stabilization, wavelength division multiplexing (WDM), optical code division multiple access (CDMA), fiber grating lasers, wavelength converters, and selective mirrors, are just a few of the applications for FBG in optical communication systems [11]. Low losses into the fiber, low maintenance, stability, spectrum flexibility, simple structure, and low insertion loss are just a few of the features of FBGs [12]. The most enticing aspect of fiber Bragg grating is the spectral properties of it. There are several designs, fiber grating reflection and transmission spectra can be designed and optimized for a variety of applications by carefully selecting parameters such as chirp, length, index modulation amplitude, period, and function of apodization [13]-[17]. Fiber Bragg gratings, wireless and wire technologies are widely used in optical telecommunications networks for the technique of dense wavelength division multiplexing (DWDM), dispersion compensation, the gain flattening of the erbium amplifier, the stabilization of the laser, the slope of dispersion, and optical CDMA [18]-[28].

2. MODEL DESCRIPTION

Optical FBG are utilized because they are a low-cost filter that is easy to select the suitable wavelength for various applications while also improving quality [29]. Filtration, low of loss, reflection, and high efficiency are some of the processes performed by FBG. The FBG compensates for color (chromatic) dispersion in the system of optical transmission. The reflected light will be produced at any little periodic refraction shift, and this a little amount of reflected light will eventually transform into a huge light that reflects with a specific wavelength. When the grating period is nearly half the wavelength of the incoming light, the wavelength is called Bragg. The light that remains will be transparent (with the exception of Bragg illumination). The first-order Bragg condition is as shown in (1).

$$\lambda\_B = 2n\_(eff)\Lambda \quad (1)$$

Where n_ (eff) is the effective refractive index of the Bragg is grating, λ_B is the wavelength of light that will be reflected off the Bragg grating in free space, and Λ is the grating period depicted in Figure 1.

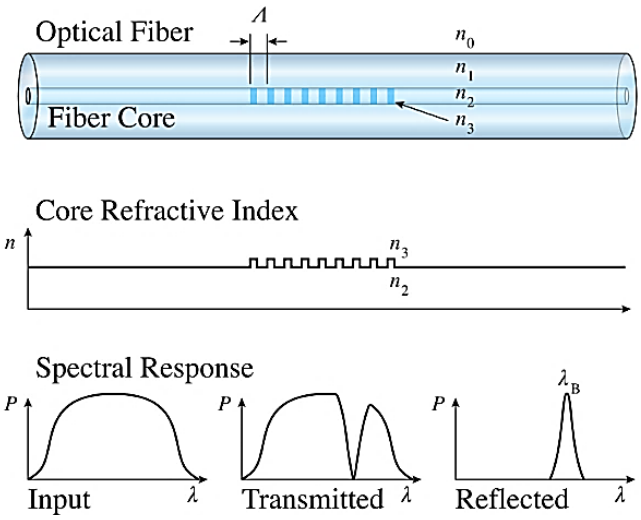


Figure 1. Principle of operation of FBG [29]

The transmission systems with minimum bit error rate (BER) and maximum quality (Q) factor are examined in this paper. The initiating system uses an optical fiber Coarse wavelength division multiplexing (CWDM) with uniform FBG circuit composed of a four-channel, the first channel is an optical fiber with FBG, the second channel is an optical fiber with uniform FBG, the third channel is the FBG with an optical fiber CWDM, and the last channel is an uniform FBG with an optical fiber CWDM as shown below in Figure 2. From 10 to 100 kilometers away, the system transmits data with an input power of (2-16) dBm. Eye diagram analyzers, which are employed in the process of evaluating performance, are shown to begin shaping the spectrum. These images were created with an application called Optisystem Version 15.

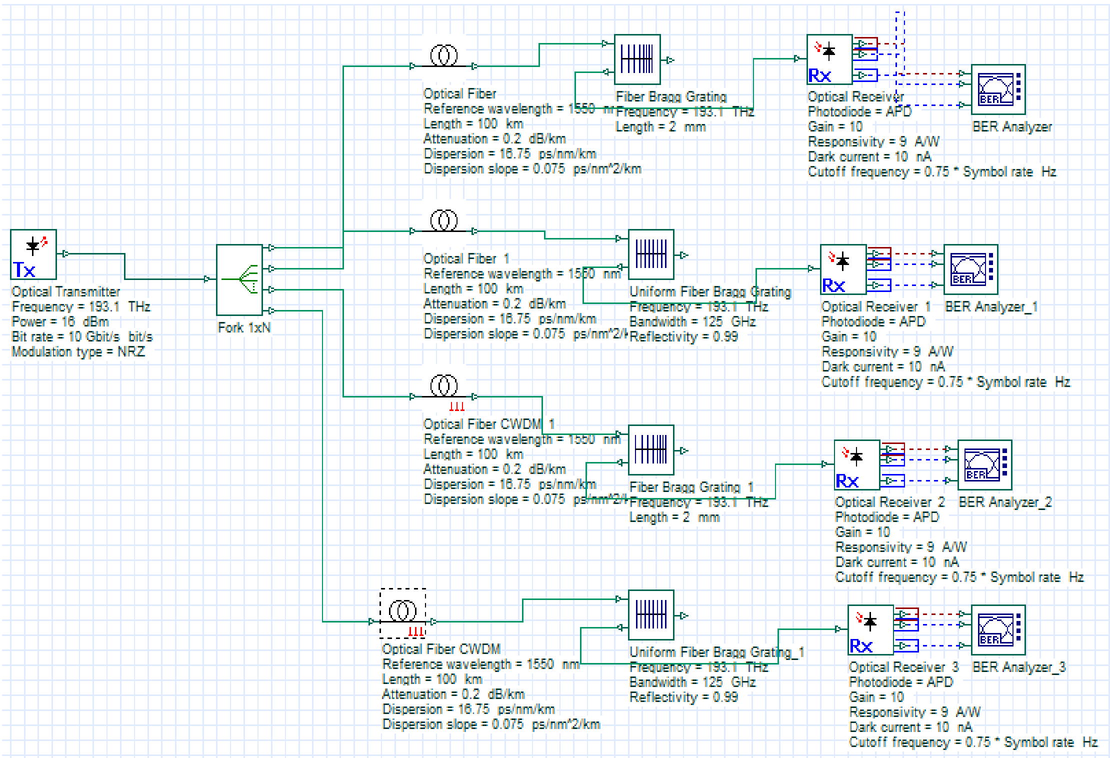


Figure 2. The opti system software was used to create a simulated optical fiber channel system model

3. A PROPOSED DESIGN SIMULATION

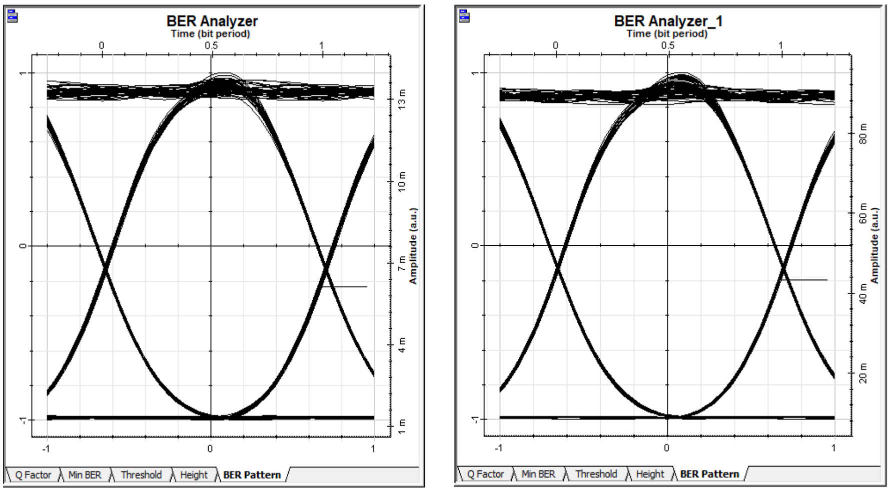
Optical transmitter at 193.1 THZ with a bit rate of 10 Gb/s generates power of 16 dBm, which is shown in Figure 1. Non-return-to-zero (NRZ) is the modulation type [27]. To distribute power to the four branches, the pulses are fired into the 1xN. With an effective index of 1.45 and a length of 2 millimeters, With FBG, the first 100-kilometer single-mode optical fiber has a dispersion of 16.75 ps $nm^{-1}km^{-1}$ and an attenuation of 0. 2 dB Km^{-1}.The second 100-kilometer branch the bandwidth of a single-mode fiber with a uniform FBG is 125 GHz, and the reflectivity is 0.99; the differential group delay for a CWDM optical fiber of the third and fourth channels is 0.2 75 ps nm^{-1}, and the slope of dispersion is 0.075 ps $nm^{-2}km^{-1}$. With a cutoff frequency of 0.75 Hz and a gain of 10, all of these optical channels are using optical receivers. Using an eye diagram to analyze all parameters, such as the minimum bit error rate and the maximum Q factor, is the final step.

4. RESULTS AND DISCUSSION.

On an oscilloscope, the eye diagram illustrates a digital data stream sampled at a predetermined rate. This visual data can be used to assess the quality of digital transmissions, is created using a time domain signal and overlapping traces. BER and Q are computed from this data. It is clear from the eye diagram that BER performance is very high. For optical fiber lengths of 10 to 100 kilometers, the maximum Q. Factor and minimum BER are shown in Figures 3 through 19. Reading eye diagrams are shown in Figures 3 through 10, data1 was received via a FBG with single-mode optical fiber, while data2 was received over a uniform FBG with a single-mode optical fiber.

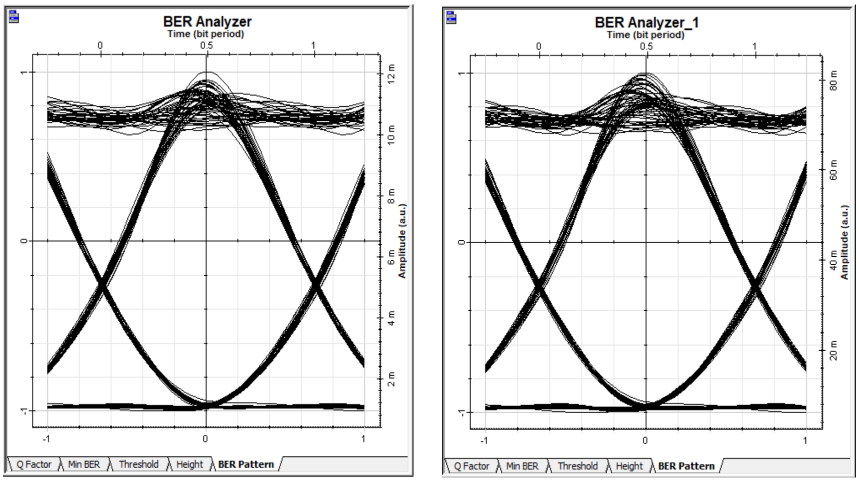
The output readings can be achieved by altering the input power as well as the fiber length when using FBG and uniform FBG. Tables 1 and 2 illustrate the parameters of the simulation and results for the maximum Q. Factor and minimum bit error rate, respectively. The Figures 11 to 18 demonstrate reading eye diagrams for data 1 and 2 collected from optical fiber CWDM with FBG and optical fiber CWDM with uniform FBG.

Effect of optical fiber CWDM type bit error rate (BER) and quality factor (Q) in optical fiber distance and input power for use of FBG and uniform FBG. Tables 3 and 4 list the simulation parameters. The program Origin 2021 was used to draw the relationship that shows the change in the length of the optical fiber with the maximum quality factor from Table 1 to Table 4 as shown in the Figure 19.



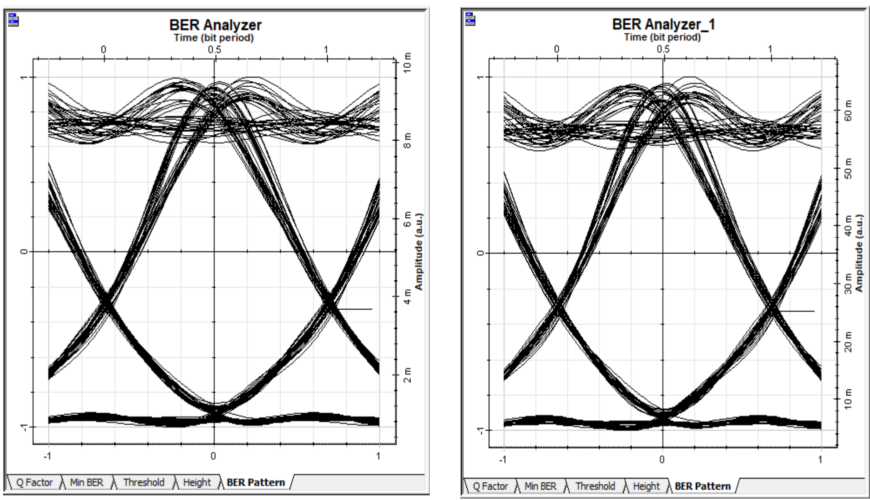
(a) (b)

Figure 3. 10 km of optical fiber with a 2 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



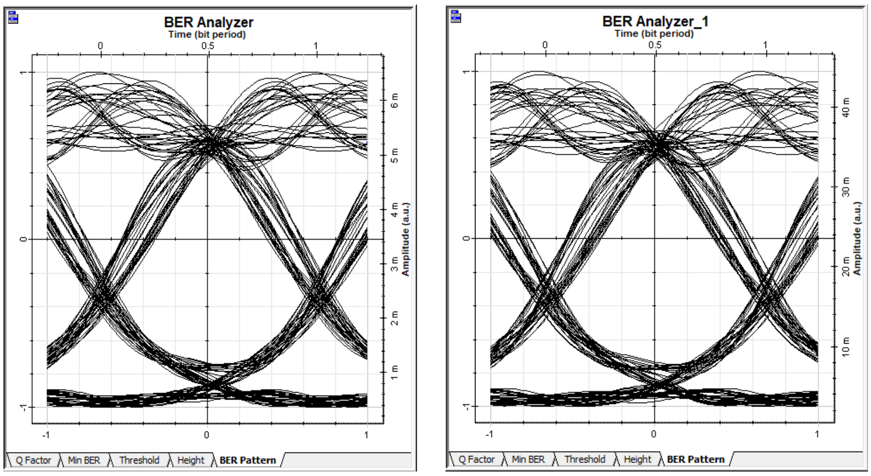
(a) (b)

Figure 4. 25 km of optical fiber with a 4 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



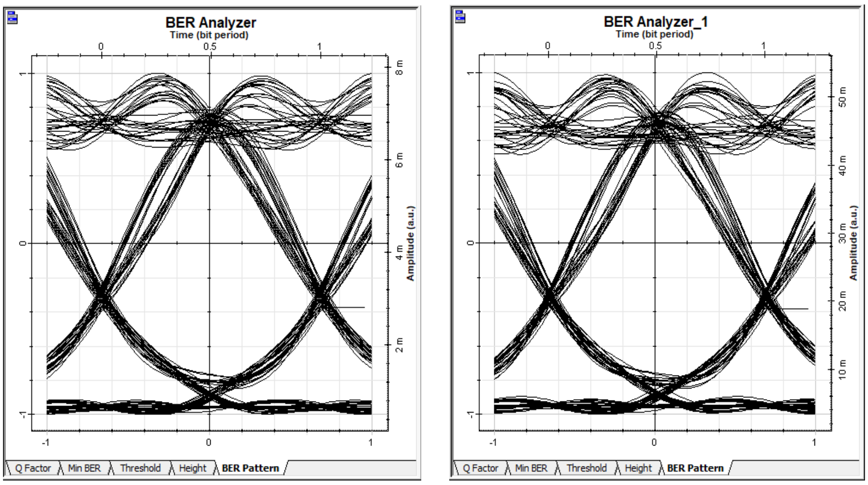
(a) (b)

Figure 5. 40 km of optical fiber with a 6 dBm input power Eye diagram using (a) FBG and (b) a uniform FBG



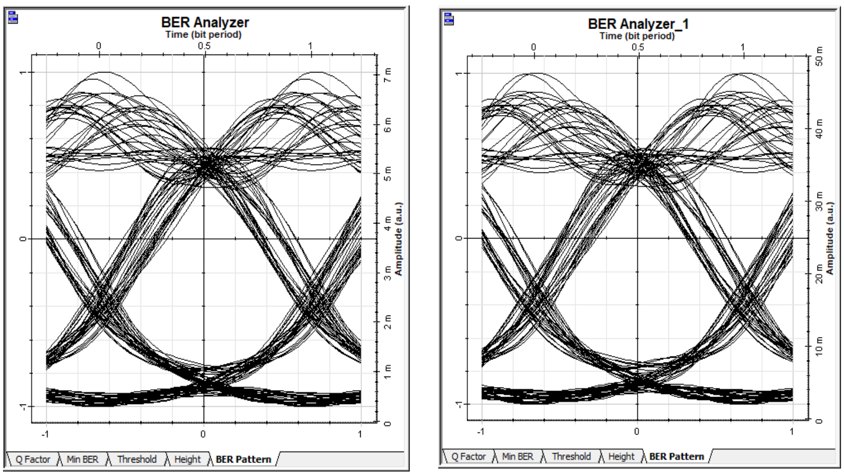
(a) (b)

Figure 6. 55 km of optical fiber with an 8 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



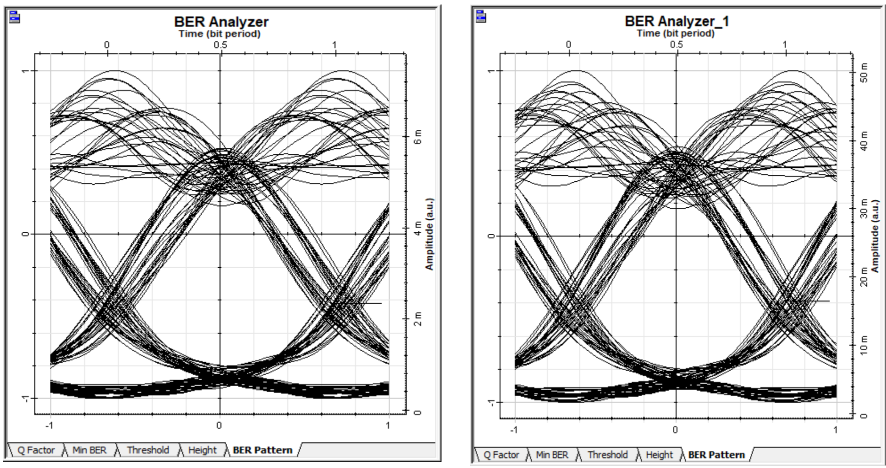
(a) (b)

Figure 7. 70 km of optical fiber with a 10 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



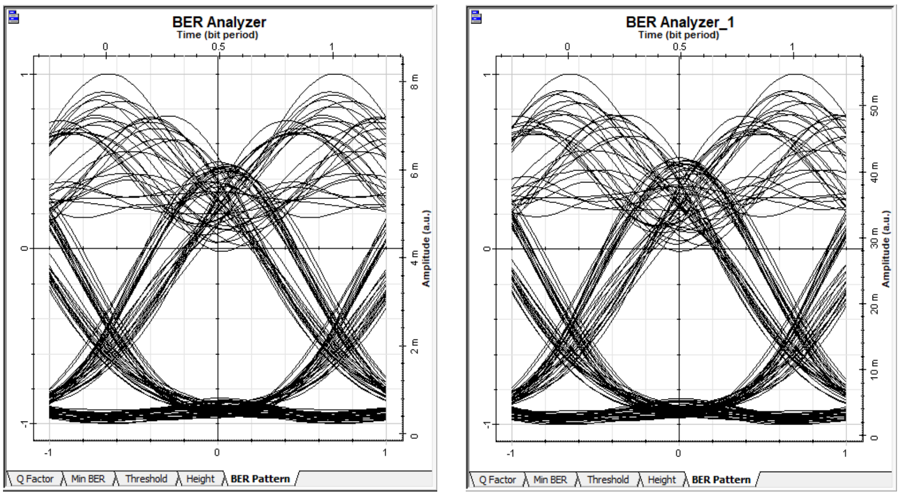
(a) (b)

Figure 8. 80 km of optical fiber with a 12 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



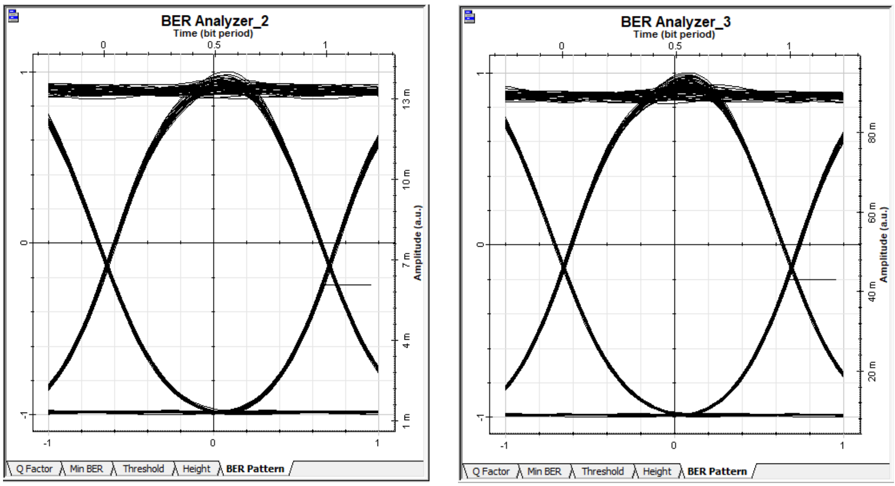
(a) (b)

Figure 9. 90 km of optical fiber with a 14 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



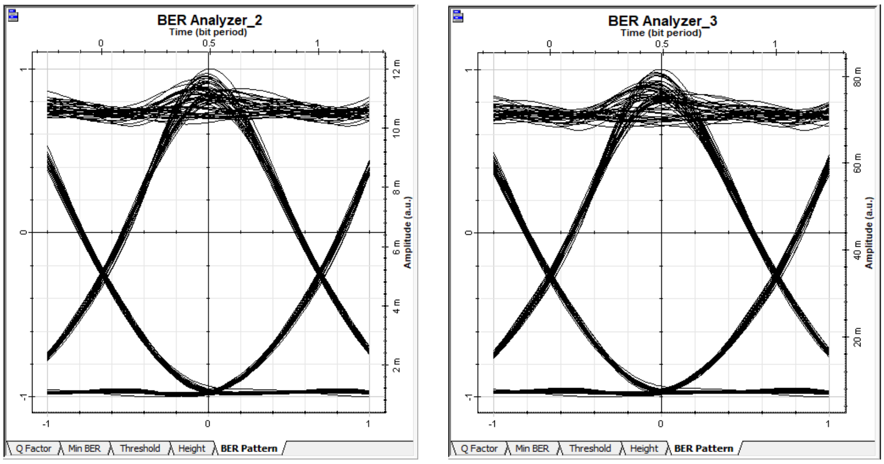
(a) (b)

Figure 10. 100 km of optical fiber with a 16 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



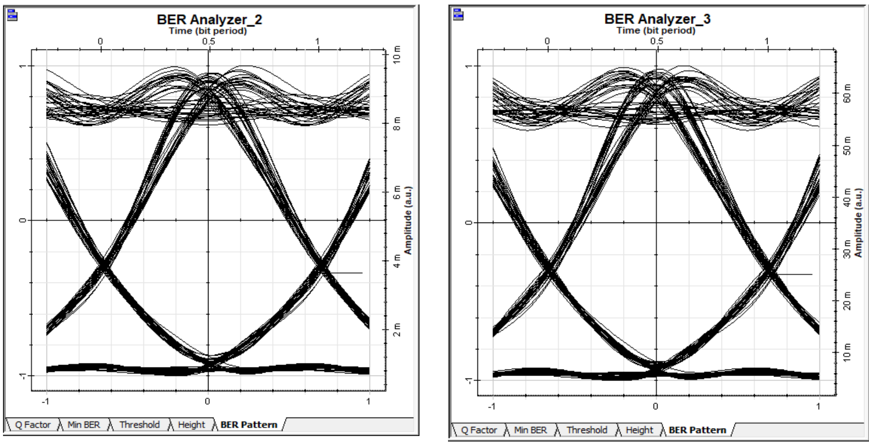
(a) (b)

Figure 11. 10 km of CWDM optical fiber with a 2 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



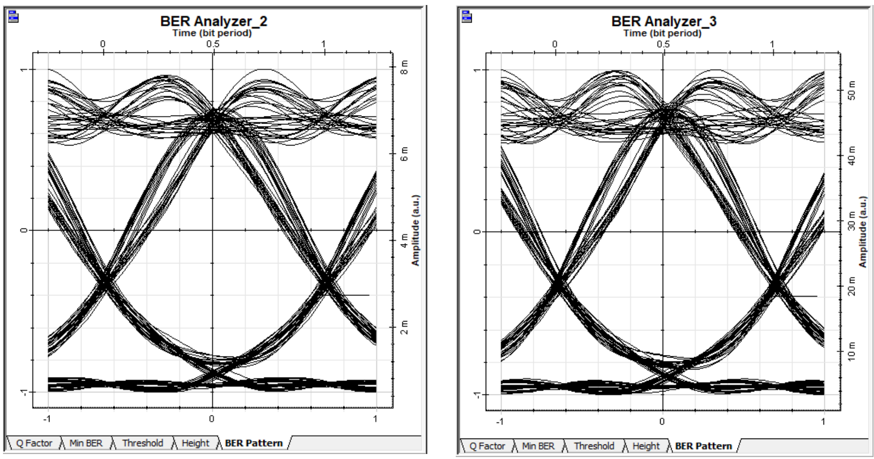
(a) (b)

Figure 12. 25 km of CWDM optical fiber with a 4 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



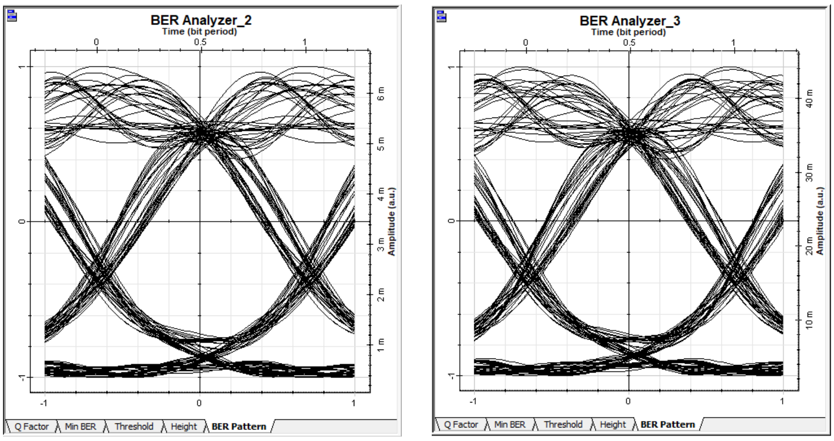
(a) (b)

Figure 13. 40 km of CWDM optical fiber with a 6 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



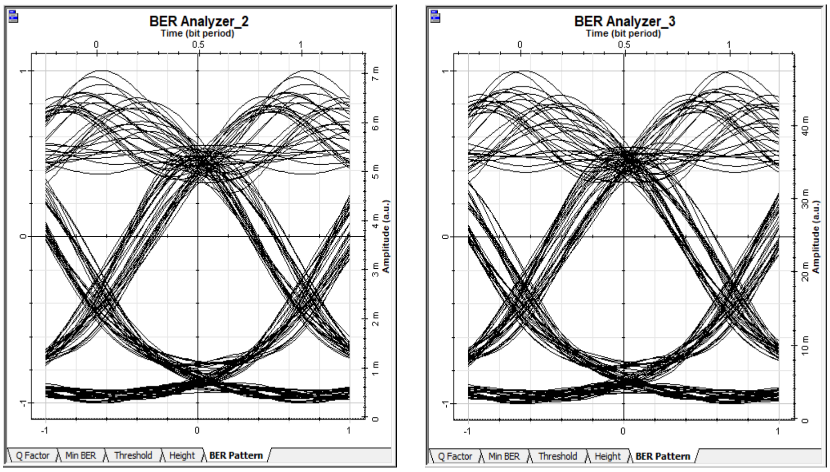
(a) (b)

Figure 14. 55 km of CWDM optical fiber with an 8 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



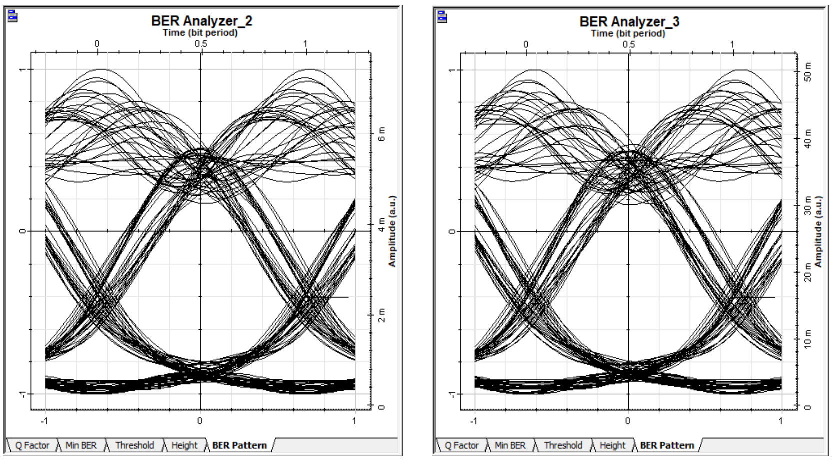
(a) (b)

Figure 15. 70 km of CWDM optical fiber with a 10 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



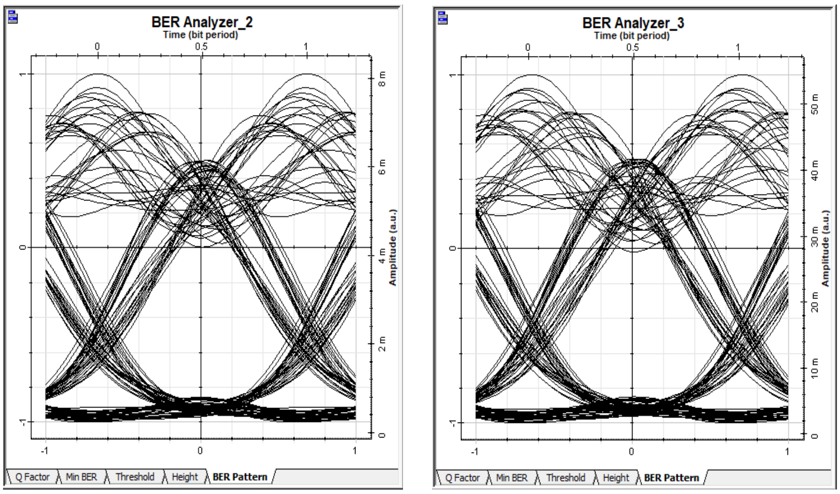
(a) (b)

Figure 16. 80 km of CWDM optical fiber with a 12 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



(a) (b)

Figure 17. 90 km of CWDM optical fiber with a 14 dBm input power eye diagram using (a) FBG and (b) a uniform FBG



(a) (b)

Figure 18. 100 km of CWDM optical fiber with a 16 dBm input power eye diagram using (a) FBG and (b) a uniform FBG

This research looks at how to construct and run a transmission system with a low bit error rate (BER) and a high Q factor. To improve the max quality factor and the BER, fiber Bragg grating (FBG) can be used in conjunction with this optical fiber transmission system architecture. Show that when comparing single- mode fiber with FBG findings, the Max Q factor is (47.981) and bit error rate is (0), whereas with uniform FBG, the bit error rate is (0) and the Max Q Factor is (55.9905).

A set of Tables 3 and 4 The maximum Q factor with FBG is (47.1122) and BER is (0) for optical fiber CWDM, while with uniform FBG it is (55.9905) and BER is (0) for all results above for 10km fiber length and 2dBm input power. Figure 19 demonstrates that as the distance grows, the maximum quality factor falls. We find that the results obtained are much better [30], which used the length of the optical fiber up to 50 km with the input power up to 10 dBm. The BER rises as the distance increases, while the quality factor falls. To account for the quality factor, the fiber Bragg grating used in the simulation model has a pattern of uniform grating. According to this study, the Q-factor diminishes as distance rises.

Table 1. Q factor and BER affect input power and fiber length when using FBG

Input power (dB)	Length of Fiber (km)	Max Q-factor Min BER
2	10	47.9810
4	25	20.2198 2.85082 e^{-091}
6	40	15.601 2.93899e^{-055}
8	55	15.7246 5.12297e^{-056}
10	70	14.0924 2.09951e^{-045}
12	80	13.1689 6.60993e^{-040}
14	90	11.0123 1.46317e^{-028}
16	100	7.72857 4.27059e^{-015}

Table 2. Q factor and BER affect input power and fiber length when using uniform FBG

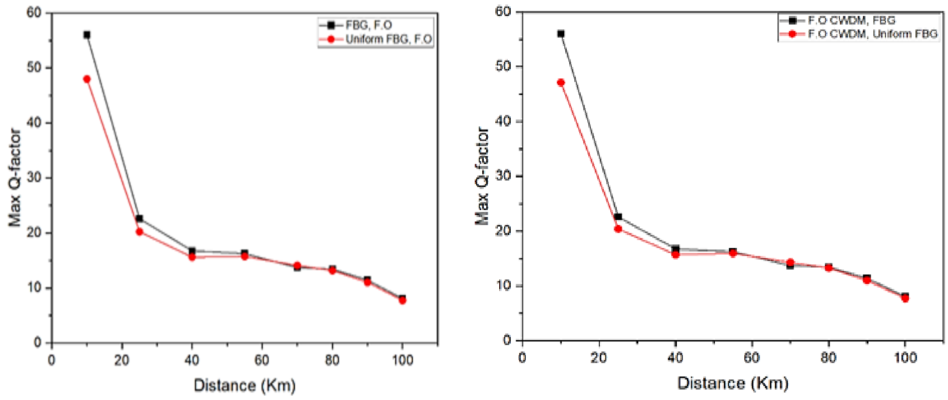
Input power (dB)	Length of fiber (km)	Max Q-factor Min BER
2	10	55.9905 0
4	25	22.5848 2.27461 e^{-113}
6	40	16.7568 2.18179e^{-063}
8	55	16.2415 1.2749e^{-059}
10	70	13.7008 4.96308e^{-043}
12	80	13.4056 2.79454e^{-041}
14	90	11.4459 1.10658e^{-030}
16	100	8.04225 3.49185e^{-016}

Table 3. The influence of the bit error rate (BER) and quality factor (Q) on the distance and input power of CWDM fibers with FBG

Input power (dB)	Length of Fiber (km)	Max Q-factor Min BER
2	10	47.9810
4	25	20.2198 2.85082 e^{-091}
6	40	15.601 2.93899e^{-055}
8	55	15.7246 5.12297e^{-056}
10	70	14.0924 2.09951e^{-045}
12	80	13.1689 6.60993e^{-040}
14	90	11.0123 1.46317e^{-028}
16	100	7.72857 4.27059e^{-015}

Table 4. The influence of the bit error rate (BER) and quality factor (Q) on the distance and input power of CWDM fibers with uniform FBG

Input power (dB)	Length of Fiber (km)	Max Q-factor Min BER
2	10	55.9905
4	25	22.5848 2.5089 e^{-112}
6	40	16.7568 4.70285e^{-063}
8	55	16.2415 1.32234e^{-063}
10	70	13.7008 1.40994e^{-044}
12	80	13.4056 1.07543e^{-038}
14	90	11.4459 1.14216e^{-028}
16	100	8.04225 1.60078e^{-016}



(a) (b)

Figure 19. Fiber length in kilometers versus the maximum Q factor (a) uniform FBG and (b) CWDM fibers with uniform FBG

5. CONCLUSION

Various optical communication transmission systems with different input powers and fiber lengths are examined in this paper. These findings can be used to optimize the performance of the fiber optic system's channels by applying a uniform FBG. According to the above results, the quality factor and bite error rate improved when using optical fiber with a uniform FBG channel. In optical fiber CWDM uniform FBG channels, a better factor of quality (Q) and a lower bit error rate (BER) improve optical system performance. When compared to optical fiber CWDM combined with uniform FBG, single mode fiber provides the best quality factor and the lowest BER. By watching the results, we find that there is a very clear improvement in the results when the uniform FBG was used, as well as when it was compared with the previous publications.

REFERENCES

[1] G. P. Agrawal, *Fiber-Optic Communications Systems*, 5th edition. John Wiley & Sons, 2021.

[2] N. Mohd Razali, P. N. S. Said Ja'afar, and S. Ambran, "Performance evaluation of a single mode optical fiber tip sensor for glucose detection," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 19, no. 3, p. 1407, Sep. 2020, doi: 10.11591/ijeecs.v19.i3.pp1407-1414.

[3] K. K. K. Annamdas and V. G. M. Annamdas, "Review on developments in fiber optical sensors and applications," in *Fiber Optic Sensors and Applications VII*, Apr. 2010, vol. 7677, p. 76770R, doi: 10.1117/12.849799.

[4] M. M. A. Eid, "Optical fiber sensors: Review of technology and applications*," Indonesian Journal of Electrical Engineering and Computer Science*, vol. 25, no. 2, pp. 1038–1046, Feb. 2022, doi: 10.11591/ijeecs.v25.i2.pp1038-1046.

[5] M. M. A. Eid, A. S. Seliem, A. N. Zaki Rashed, A. E. N. A. Mohammed, M. Y. Ali, and S. S. Abaza, "High modulated soliton power propagation interaction with optical fiber and optical wireless communication channels," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 21, no. 3, pp. 1575–1583, Mar. 2021, doi: 10.11591/ijeecs.v21.i3.pp1575-1583.

[6] I. S. Amiri, F. Mohammed Aref Mahmoud Houssien, A. N. Z. Rashed, and A. E. N. A. Mohammed, "optical networks performance optimization based on hybrid configurations of optical fiber amplifiers and optical receivers," *Journal of Optical Communications*, Jul. 2019, doi: 10.1515/joc-2019-0153.

[7] K. Kalantar-Zadeh, *Sensors: An introductory course*, vol. 9781461450528. Boston, MA: Springer US, 2013, doi: 10.1007/978-1-4614-5052-8.

[8] K. O. Hill and G. Meltz, "Fiber Bragg grating technology fundamentals and overview," *Journal of Lightwave Technology*, vol. 15, no. 8, pp. 1263–1276, 1997, doi: 10.1109/50.618320.

[9] R. Kashyap, "Fabrication of Bragg Gratings," in *Fiber Bragg Gratings*, Elsevier, 2010, pp. 53–118, doi: 10.1016/B978-0-12-372579-0.00003-X.

[10] A. H. Ali, S. A. Kadhim, K. A. Kazr, and A. T. Lateef, "Simulation and performance analysis of a fiber communication system based on FBG as dispersion compensator," *International Journal of New Technology and Research (IJNTR)*, vol. 4, no. 9, pp. 62–66, 2018, [Online]. Available: www.ijntr.org.

[11] M. M. A. Eid, A. S. Seliem, A. N. Zaki Rashed, A. E. N. A. Mohammed, M. Y. Ali, and S. S. Abaza, "High sensitivity sapphire FBG temperature sensors for the signal processing of data communications technology," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 21, no. 3, pp. 1567–1574, Mar. 2021, doi: 10.11591/ijeecs.v21.i3.pp1567-1574.

[12] P. Ferdinand *et al*., "Optical fibre Bragg grating sensors for structure monitoring within th nuclear power plants," in *Optical Fibre Sensing and Systems in Nuclear Environments*, Dec. 1994, vol. 2425, pp. 11–20, doi: 10.1117/12.198636.

[13] H. Zeng, R. Yan, L. Xu, and S. Gui, "Application study on fiber Bragg grating sensors in damage monitoring of sandwich composite joints," *Journal of Sandwich Structures and Materials*, vol. 22, no. 5, pp. 1542–1563, Jun. 2020, doi: 10.1177/1099636218789621.

[14] A. M. Hammadi, E. M. Abbas, and A. H. Ali, "New efficient model for improving quality factor and minimum bit error rate in optical fiber communication using CFBG," *International Journal of Microwave and Optical Technology*, vol. 17, no. 1, pp. 100–106, 2022.

[15] A. H. Ali *et al*., "Human body high resolution and accurate temperature FBG sensor," *IOP Conference Series: Earth and Environmental Science*, vol. 779, no. 1, p. 012029, Jun. 2021, doi: 10.1088/1755-1315/779/1/012029.

[16] O. G. Morozov, "Fiber bragg grating-based sensors and systems," *Sensors*, vol. 21, no. 24, p. 8225, Dec. 2021, doi: 10.3390/s21248225.

[17] A. H. Ali, S. Mutashar, and A. M. Hammadi, "Dispersion compensation of optical systems utilizing fiber Bragg grating at 15 Gbits/s," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 22, no. 1, pp. 369–378, Apr. 2021, doi: 10.11591/ijeecs.v22.i1.pp369-378.

[18] S. A. Al-Gailani, M. R. B. Arshad, O. M. Kharraz, and R. Q. Shaddad, "Performance evaluation of 6-Gbps hybrid dwdm/multibeam free-space optical network in an unusual haze," in *Lecture Notes in Electrical Engineering*, vol. 547, 2019, pp. 373–380.

[19] A. Amphawan, A. Ghazi, and A. Al-Dawoodi, "Free-space optics mode-wavelength division multiplexing system using LG modes based on decision feedback equalization," *EPJ Web of Conferences*, vol. 162, p. 01009, Nov. 2017, doi: 10.1051/epjconf/201716201009.

[20] H. Maraha, K. A. Ameen, O. A. Mahmood, and A. Al-Dawoodi, "DWDM over FSO under the effect of different atmospheric attenuations," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 18, no. 2, pp. 1089–1095, May 2020, doi: 10.11591/ijeecs.v18.i2.pp1089-1095.

[21] International Telecommunication Union, G. 694.1: Spectral grids for WDM applications: DWDM frequency grid, 2002. [Online]. Available: https://www.itu.int/rec/T-REC-G.694.1-200206-S/en.

[22] A. M. Alatwi, A. N. Zaki Rashed, and E. M. El-Gammal, "Wavelength division multiplexing techniques based on multi transceiver in low earth orbit intersatellite systems," *Journal of Optical Communications*, Jun. 2020, doi: 10.1515/joc-2019-0171.

[23] S. Sivaranjani, A. Sampathkumar, A. N. Z. Rashed, T. V. P. Sundararajan, and I. S. Amiri, "Performance evaluation of bidirectional wavelength division multiple access broadband optical passive elastic networks operation efficiency," *Journal of Optical Communications*, Oct. 2019, doi: 10.1515/joc-2019-0175.

[24] I. S. Amiri, A. N. Z. Rashed, and P. Yupapin, "Pump Laser automatic signal control for erbium-doped fiber amplifier gain, noise figure, and output spectral power," *Journal of Optical Communications*, vol. 0, no. 0, Dec. 2019, doi: 10.1515/joc-2019-0203.

[25] I. M. El-Dokany, A. E. A. Mohamed, A. N. Z. Rashed, and S. El-Tahan, "Optical Preamplifier and inline amplifiers comparison based raman-EDFA hybrid amplifiers in 40 × 10 Gb/s DWDM system," *Menoufia Journal of Electronic Engineering Research*, vol. 25, no. 2, pp. 147–160, Jul. 2016, doi: 10.21608/mjeer.2016.64093.

[26] K. Prabu, S. Charanya, M. Jain, and D. Guha, "BER analysis of SS-WDM based FSO system for Vellore weather conditions," *Optics Communications*, vol. 403, pp. 73–80, Nov. 2017, doi: 10.1016/j.optcom.2017.07.012.

[27] M. M. Kareem, S. A. S. Lafta, H. F. Hashim, R. K. Al-Azzawi, and A. H. Ali, "Analyzing the BER and optical fiber length performances in OFDM RoF links," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 23, no. 3, pp. 1501–1509, Sep. 2021, doi: 10.11591/ijeecs.v23.i3.pp1501-1509.

[28] M. H. Ali, A. H. Ali, S. M. Abdulsatar, M. A. Saleh, A. K. Abass, and T. F. Al-Mashhadani, "Pump power optimization for hybrid fiber amplifier utilizing second order stimulated Raman scattering," *Optical and Quantum Electronics*, vol. 52, no. 6, p. 274, Jun. 2020, doi: 10.1007/s11082-020-02400-x.

[29] B. Peeters, F. L. M. Dos Santos, A. Pereira, and F. Araujo, "On the use of optical fiber Bragg grating (FBG) sensor technology for strain modal analysis," in *AIP Conference Proceedings*, 2014, vol. 1600, pp. 39–49, doi: 10.1063/1.4879567.

[30] A. Mahdi, H. Amal, I. Mahmood, and Z. A. Jwad, "Quality factor compensation of single mode optical fiber by using uniform fiber bragg grating," *Journal of Babylon University/Engineering Sciences*, vol. 22, no. 2, pp. 435–443, 2014.

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