SSN 2277-3061

Comparison of dispersion compensation with Fiber Braggs Grating at Transmitter and Receiver end of a single channel optical communication system

Er. Abhishek Sharma, Er. Sukhbir Singh, Er. Rajeev Thakur, Er. Bhubneshwar Sharma
M. Tech student (ECE), Eternal University, H.P (India)
sharma.abhishek174@gmail.com
Assistant Professor (ECE), Eternal University, H.P (India)
sukh_ece@yahoo.co.in
Lecturer (ECE),Eternal University, H.P (India)
thakur.rajeev.1984@gmail.com
Assistant Professor (ECE), Eternal University, H.P (India)
bhubnesh86@gmail.com

ABSTRACT

Optical fibers are used to transmit the light signal in optical communication system. When the light pulses propagates down the fiber, the pulses spreading takes place, and this phenomenon is called Pulse Dispersion. Dispersion is the main factor which affects the performance of fiber in optical fiber communication system. Dispersion can be compensated by many ways. Dispersion compensation by FBG (fiber bragg grating) is studied in this paper. Dispersion compensation by FBG along EDFA plays a very important role in dispersion compensation. When FBG is used after EDFA at transmitter side (before fiber)in single channel optical communication system then it gives better performance (less BER) as compare to when FBG used after EDFA at receiver end (after fiber). In this paper performance of system is investigated by using FBG after EDFA at both transmitter side (before the fiber) and receiver side (after the fiber). For 50km BER reduces from 1.28559e-111 (FBG after EDFA at receiver side) to 9.57499e-201 (FBG after EDFA at transmitter side).

Indexing terms/Keywords

Dispersion, Dispersion compensation, Fiber Bragg Grating (FBG), Optical communication.

Council for Innovative Research

Peer Review Research Publishing System

Journal: INTERNATIONAL JOURNAL OF COMPUTERS & TECHNOLOGY

Vol 8, No 2

editor@cirworld.com
www.cirworld.com, member.cirworld.com

1.INTRODUCTION

Optical fiber is used in fiber-optic communication to transmit data in form of light pulses with higher rates over long distances as compare to other form of communication. Dispersion is the main factor which affects the performance of fiber in optical fiber communication. Dispersion compensating fiber (DCF) is a standard solution for dispersion compensation in long hall transmission system. But DCF are bulky [1] and by using these fibers nonlinear affects [2], cost of optical system [2], and insertion losses increases [4].

FBGs in optical communication system uses as gain flatteners [4], highly selective filters for channel selection in dense WDM systems [5],filters[6], and dispersion compensator [7].FBGs has many advantages as compare to DCF. FBGs have low insertion loss, small size and negligible nonlinearity [8-9].

Placement of components in optical communication system plays a very important role in dispersion reduction. Thus performance of system is checked by changing the position of FBG along with EDFA (using FBG after EDFA) at transmitter end (before fiber) and receiver end (after the fiber).

In the third section of this paper the performance (Minimum BER) of two systems (FBG before EDFA (at transmitter end before the fiber) and FBG before EDFA (at receiver end after the fiber) in the optical transmission system) is investigated by plotting the graph between input power and BER. In fourth section performance is investigated by plotting the graph between FBG length and BER for two systems.

2. SYSTEM DESCRIPTION

The diagrams of optical transmission system are shown in Fig. 1and Fig. 2.

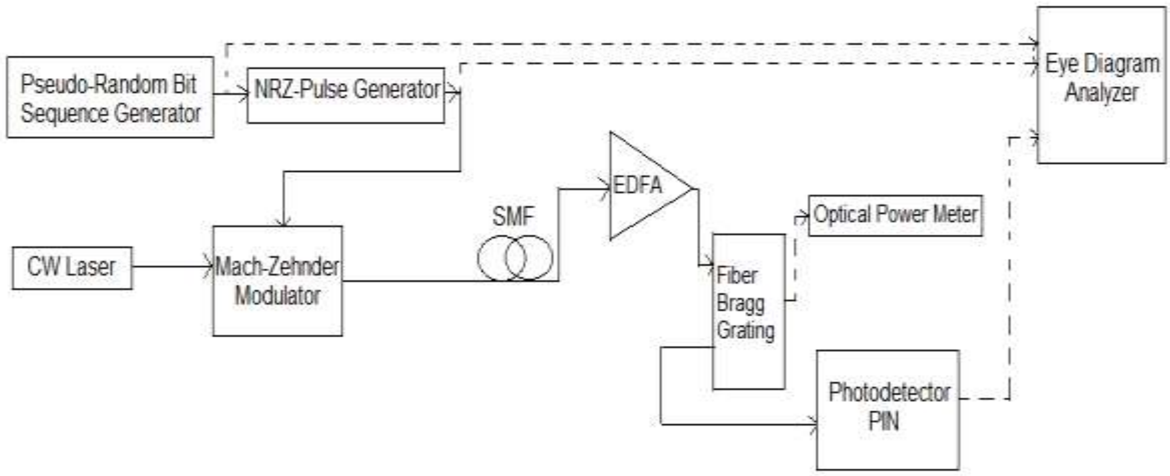

Fig 1: FBG after EDFA (at receiver end after the fiber) in the optical transmission system.

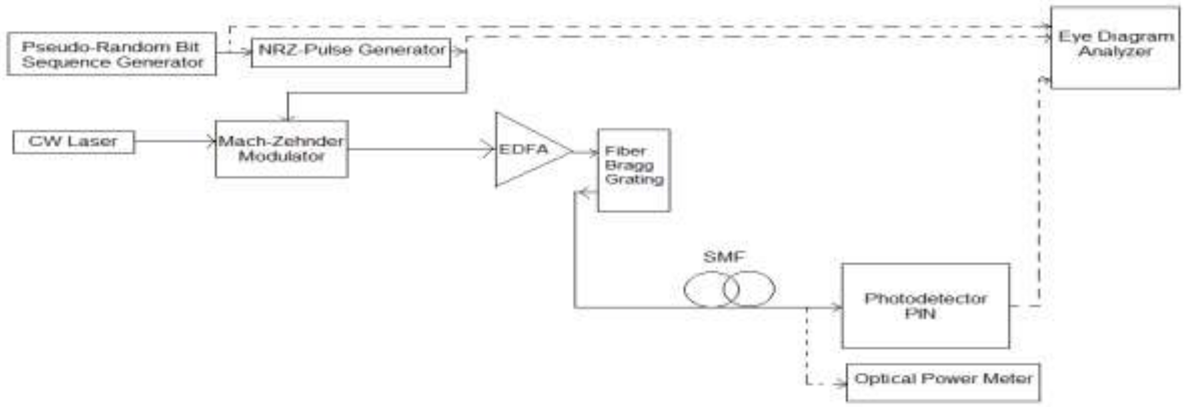

Fig 2: FBG after EDFA (at transmitter end before the fiber) in the optical transmission system.

The function of Pseudo-random bit sequence generator (generating 10 Gbps) is to scramble data signal in terms of bit rates [10]. NRZ-pulse Generator produces the electrical data signal for modulation process [11]. Continuous Wave (CW) laser is operating at frequency 193.1 THz is applied to the system and it is modulated externally with non-return-zero (NRZ) pseudorandom binary sequence in a Mach–Zehnder modulator (Mach-Zehnder has extinction ratio of 30 dB). Signal flows through single mode optical fiber. FBG is used to compensate the chromatic dispersion of optical fiber (working principle-the longer wavelengths are transmitted through the last part of grating and short wavelengths are reflected by the first part of grating, due to this results longer wavelength have to travel a longer distance, so they are delayed and allowing the shorter wavelength to catch up, and dispersion gets reduced).The function of erbium-doped fiber amplifier (EDFA) is to compensate the losses in optical transmission system. Function of photodector is detection of light (photon) at the receiver. It directly converts light into current. Optical power meter is used is used for checking the received signal power level. Eye Diagram Analyzer is used for checking the minimum bit error rate.

3. COMPARISON ON THE BASIS OF INPUT POWER VERSES BER

This section describes comparison between transmitted power with BER at different values of distances (10, 20, 30, 40, 50 Km). For 10km distance, power is varied from -10dBm to 10dBm and FBG length is also varied from 2mm to 14mm. Then minimum BER is observed and is plotted against transmitted power. The same process is repeated for other distances (20, 30, 40, 50 km).

The results shows that system achieves a low BER for a particular power, then afterward it increases. Graph between input power and BER for dispersion compensation with FBG after EDFA at transmitter end is shown in Fig. 3.

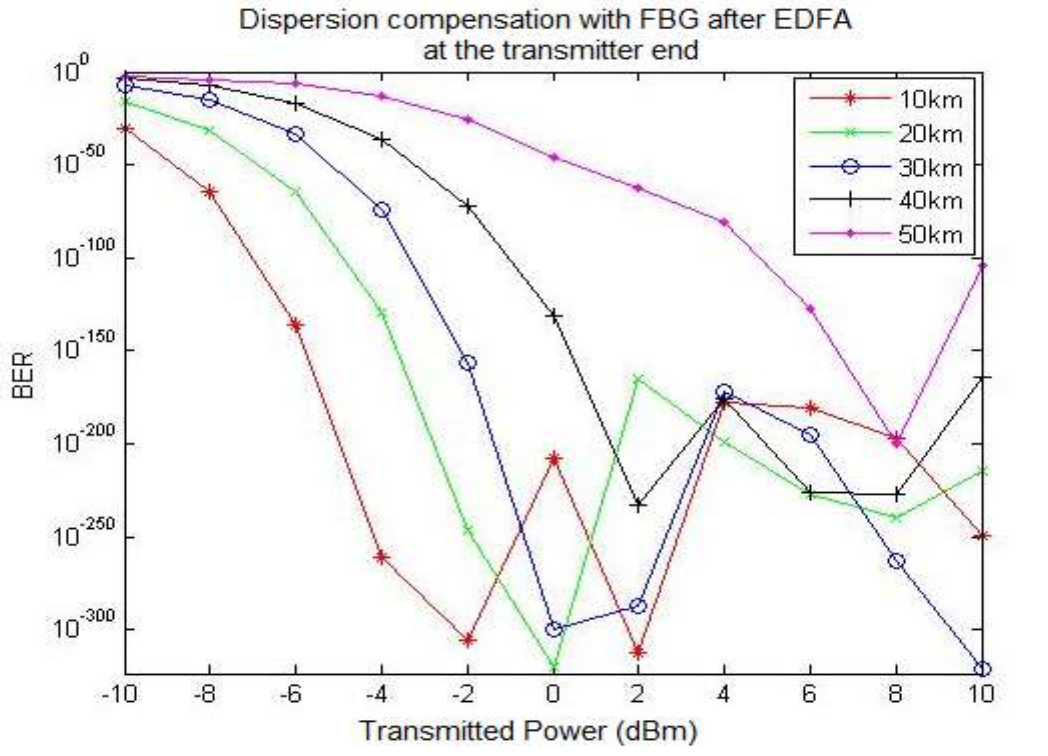

Fig 3: Graph between input power and BER for dispersion compensation with FBG after EDFA at transmitter end.

For 10km minimum BER of 2.52095e-313 is observed at 2dBm input power. For 20 km minimum BER of 3.02516e-320 is observed at 0dBm input power. For 30km minimum BER of 1.00295e-321 is observed at 10dBm input power. For 40km minimum BER of 2.09258e-233 is observed at 2dBm. For 50km minimum BER of 9.57499e-201 is observed at 8dBm.

Graph between input power and BER fordispersion compensation with FBG after EDFA at receiver end is shown in Fig. 4.

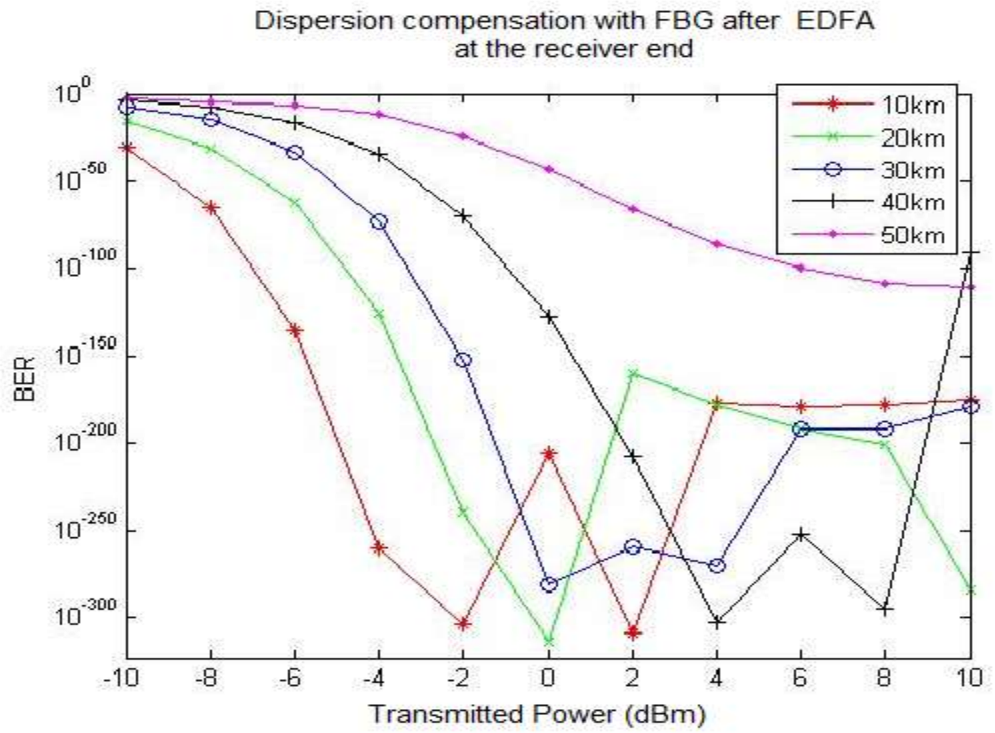

Fig 4: Graph between input power and BER for dispersion compensation with FBG after EDFA at receiver end.

For 10km minimum BER of 8.454e-310 is observed at 2dBm input power. For 20 km minimum BER of 1.73339e-314 is observed at 0dBm input power. For 30km minimum BER of 2.31627e-282 is observed at 0dBm input power. For 40km minimum BER of 5.59002e-304 is observed at 4dBm. For 50km minimum BER of 1.28559e-111 is observed at 10dBm.

Comparison of graphs in Fig. 5 and Fig.6 on the basis of minimum BER for particular distance is shown in table 1.

Table 1.Comparison of graphs on the basis of minimum BER for particular distance.

Distance (km)	Transmitted Input power (dBm) level for Dispersion compensation with FBG after EDFA at transmitter end	Minimum BER for Dispersion compensation with FBG after EDFA at transmitter end	Transmitted Input power (dBm) level for Dispersion compensation with FBG after EDFA at receiver end	Minimum BER for Dispersion compensation with FBG after EDFA at receiver end
10km	2dBm	2.52095e-313	2dBm	8.454e-310
20km	0dBm	3.02516e-320	0dBm	1.73339e-314
30km	10dBm	1.00295e-321	0dBm	2.31627e-282
40km	2dBm	2.09258e-233	4dBm	5.59002e-304
50km	8dBm	9.57499e-201	10dBm	1.28559e-111

After comparing the results (BER values) for the two configurations (using FBG after EDFA at transmitter end and FBG after EDFA at receiver end), it can be concluded that the optical system using FBG after EDFA at the transmitter end has a better performance (less BER) except for 40 km. Thus the placement of FBG after EDFA (by using FBG after EDFA) in optical transmission system plays an important role to reduce the BER of optical system.

3.1 Comparison of eye diagram

Comparison of eye diagram for 30km using dispersion compensation with FBG after EDFA at transmitter end and using dispersion compensation with FBG after EDFA at receiver end is shown in figures below. Fig 5.1 (Eye diagram using dispersion compensation with FBG after EDFA at transmitter end system) and Fig 5.2 (Eye diagram using dispersion compensation with FBG after EDFA at receiver end system) for 10 km.

1) For 30 km

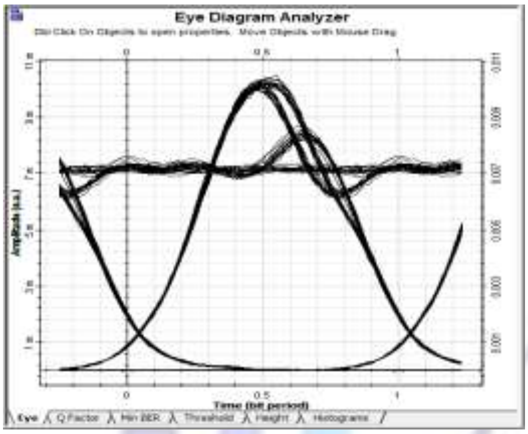

Fig 5.1: Eye diagram using dispersion compensation withFBG after EDFA at transmitter end system.

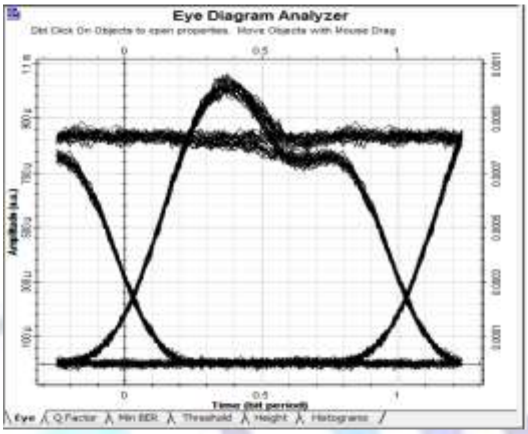

Fig 5.2: Eye diagram using dispersion compensation withFBG after EDFA at receiver end system.

From comparison it can be seen that signal on Eye diagram using dispersion compensation with FBG after EDFA at transmitter end system is much clear (with Eye Height 0.00660574) than eye diagram using dispersion compensation with FBG after EDFA at transmitter end system (with Eye Height 0.000755223).

3.2Comparison of Q-factor

Comparison of Q-factor of system using dispersion compensation with FBG after EDFA at the transmitter end and system using dispersion compensation with FBG after EDFA at the at receiver end is shown in Table 2 below.

Table 2.Comparison of Q-factor.

Distance (km)	Q-factor when dispersion compensation with FBG after EDFA at transmitter end	Q-factor when dispersion compensation with FBG and EDFA at receiver end
10km	37.8183	37.6031
20km	38.2377	37.8897
30km	38.3283	35.887
40km	32.5971	37.2443
50km	30.2026	22.416

From the comparison of Q-factor it is observed that system using FBG after EDFA at the transmitter gives a better performance for all distances (10, 20, 30, 50km), except for 40km.

4. COMPARISON ON THE BASIS OF FBG LENGTH AND BER

In this section performance is described by the comparison between FBG length with BER at different values of distances (10, 20, 30, 40, 50 km). The performance is investigated by varying the Input power of optical system is from -10 to 10 dBm and BER is observed by using BER analyser. Then resulting minimum BER (observed (available) at different input power level) obtained from BER analyser is plotted against FBG length.

From the graph in Fig. 6 and Fig. 7 it can seen that system achieves a low BER for a particular FBG length, and then afterward it increases. FBG length plays an important role in decreasing the BER. The results show that system achieves a low BER for a particular FBG length, and then afterward it increases.

Graph between FBG length and BER for dispersion compensation with FBG after EDFA at transmitter end is shown in Fig. 6.

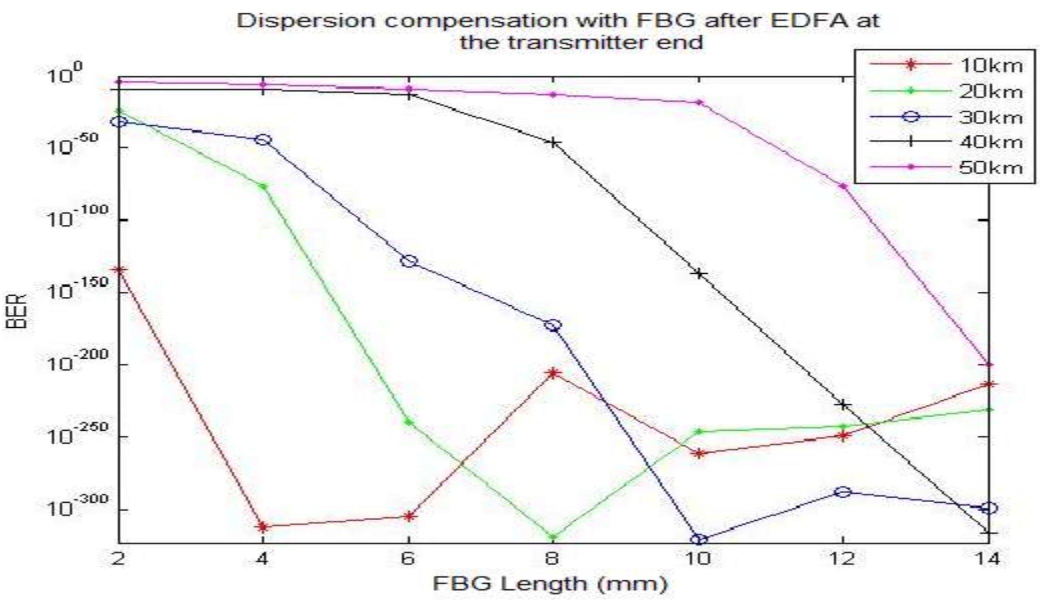

Fig 6: Graph between FBG length and BER for dispersion compensation with FBG after EDFA at transmitter end.

Graph between FBG length and BER for dispersion compensation with FBG after EDFA at receiver end is shown in Fig. 7.

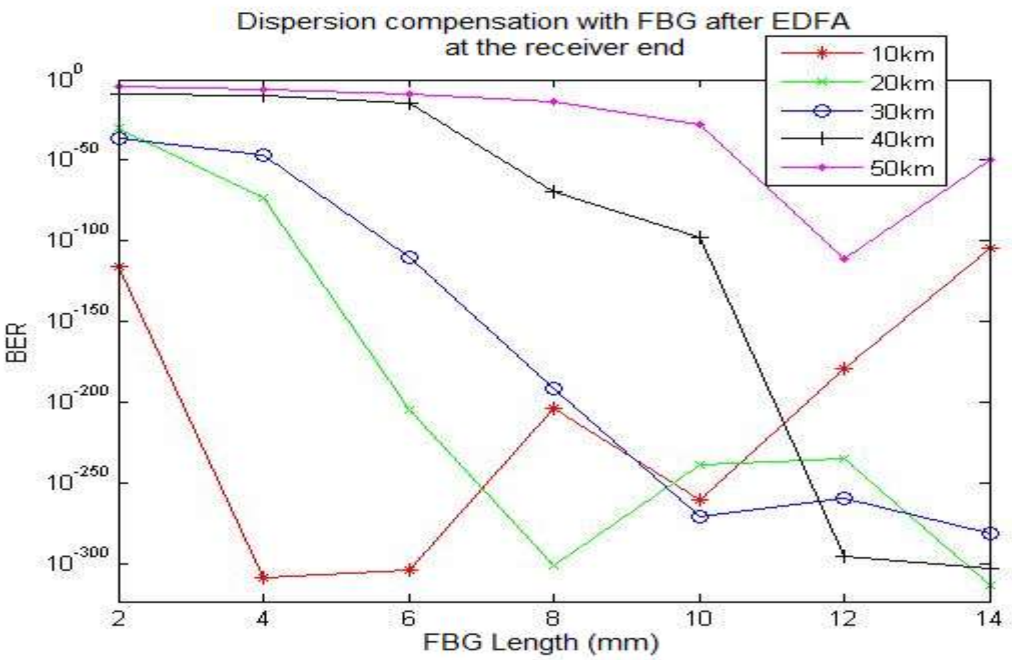

Fig 7: Graph between FBG length and BER for dispersion compensation with FBG after EDFA at receiver end.

Comparison of graphs in Fig. 5, Fig. 6 on the basis of minimum BER for particular distance is shown in Table 3.

Table 3.Comparison of on the basis of minimum BER for particular distance.

Distance (km)	Optimum FBG Length (mm) for Dispersion compensation with FBG after EDFA at transmitter end	Minimum BER for Dispersion compensation with FBG after EDFA at transmitter end	Optimum FBG Length (mm) for Dispersion compensation with FBG after EDFA at receiver end	Minimum BER for Dispersion compensation with FBG after EDFA at receiver end
10km	4mm	2.52095e-313	4mm	8.454e-310

20km	8mm	3.02516e-320	14mm	1.73339e-314
30km	10mm	1.00295e-321	14mm	2.31627e-282
40km	14mm	1.18248e-316	14mm	5.59002e-304
50km	14mm	9.57499e-201	12mm	1.28559e-111

From the table, it is clear that the optical system using FBG after EDFA at the transmitter end achieves less BER as compare to optical system using FBG after EDFA at the receiver end. Thus the placement of FBG after EDFA along with proper selection of FBG length in optical transmission system plays an important role to reduce the BER of optical system.

If we use FBG before EDFA then at the output with increase in input power BER increases (because of fiber loses and ASE noise produced by EDFA during the amplification of signal). And if FBG used after EDFA then FBG supresses the ASE noise (produced by EDFA during amplification of signal) and this results less BER at the reception of signal. Therefore it is better to use FBG after the EDFA to reduce EDFA in single channel optical communication system.

5. CONCLUSION

The positioning of the FBG along with EDFA at transmitter end (before fiber) end and receiver end (after fiber) plays an important role in improvement of the optical systems performance. When FBG is used at transmitter side after the EDFA for dispersion compensation, it gives better performance (minimum BER) as compare to when used for compensation at receiver side (after fiber). For 10km BER reduces from 8.454e-310 to 2.52095e-313 with input power 2dB, for 20km BER reduces from 1.73339e-314 to 3.02516e-320 with input power 0dB, for 30km BER reduces from 2.31627e-282 to 1.00295e-321 with input power 10 dB, for 50 km bit error reduces from 1.28559e-111 to 9.57499e-201. Only for 40km BER increases from 5.59002e-304 to 2.09258e-233. The optimum FBG lengths (to get minimum BER) are 4, 8, 10, 14, 14mm for 10, 20, 30, 40, 50km respectively.

REFERENCES

[1] D. van den Borne, V. Veljanovski, E.Gottwald, G. D. Khoe1 and H. de Waardt, “Fiber Bragg Gratings for In-Line DispersionCompensation in Cost-effective 10.7-Gbit/s Long-Haul Transmission”, Processing Symposium IEEE/LEOS Benelux Chapter, Eindhoven, 2006.

[2] G.P. Agrawal , “Fiber-Optic Communication Systems”, Third edition Wiley-India edition, 2002.

[3] S.O. Mohammadi, SaeedMozaffari and M. Mahdi Shahidi, “Simulation of a transmission system to compensate dispersion in an optical fiber by chirp gratings”,International Journal of the Physical Sciences, Vol. 6, No. 32, pp. 7354-7360, 2 December, 2011.

[4] A. M. Vengsarkar, J. R. Pedrazzani, J. B. Judkins, and P. J. Lemaire,“Long-period fiber-grating-based gain equalizers”,Opt. Lett., vol. 21, No. 5, pp. 336-338, 1996.

[5] Kersey A.D., Davis M.A., Patrick H.J., Leblanc M., Koo K.P., Askins C.G., Putnam M.A. and Friebele,“Fiber grating sensors”, E.J. Journal of LightwaveTechnology, Vol. 15, No. 8, pp. 1442-1463, 1978.

[6] G. Meltz, W. W. Morey, and W. H. Glenn, “Formation of Bragg gratings in optical fibers by a transverse holographicmethod”, Opt. Lett., vol.14, No. 15, pp. 823-825,1989.

[7] F. Ouellette, “Dispersion cancellation using linearly chirped Bragg grating filters in optical waveguides”, Opt. Lett., vol. 12, No. 10, pp. 847-849, 1987.

[8] K.O. Hill and G. Meltz, “Fiber Bragg Grating technology fundamentals and overview”, J. Lightwave Technol., vol.15, No.8, pp. 1263-1276, 1997.

[9] H. S. Fews, et. al, “Experimental Comparison of Fibre And Grating-Based Dispersion Compensation Schemes for 40 channel10Gb/s DWDM systems”, paper Th3.2.5,ECOC 2006.

[10] MohamadHasrulAriffin Bin MohdBadri, “A Cost Effective Broadband ASE Light Source Based FTTH”, thesis, page 20-26.

[11] M.A. Othman, M.M. Ismail, H.A. Sulaiman, M.H. Misran, M.A. Meor Said, Y.A. Rahim, A.N. Che Pee, M.R. Motsidi, “An Analysis of 10 Gbits/s Optical Transmission System using Fiber Bragg Grating (FBG)”, IOSR Journal of Engineering (IOSRJEN), Volume 2, No. 7, pp. 55-61, July 2012.

Author' biography with Photo

Er. Abhishek Sharma was born in 1989. He received his Bachelor's Degree in applied

Electronics and Communication Engineering from Sri Sai College Of Engineering &Technology Badhani (Pathankot) in 2011 under PTU Jalandhar**.**He is pursuing his Master's degree in Electronics and communication department from Eternal University, H.P,India. He is doing his M.Tech thesis under the guidance ofEr. Sukhbir Singh. His area of interest are field of Optical Communications, Digital Signal Processing and Wireless Networks.

Er. Sukhbir Singh was born in 1985. He did his Bachelor's degree in Electronics and Communication from Guru Nanak Dev Engineering College, Ludhiana in 2008. He then did his Masters in same stream from Punjabi University, Patiala in 2012. During his Master's thesis, he worked on improving receiver sensitivity in low cost optical links usingsemiconductor optical amplifiers. Currently, he is working as Assistant Professor in Electronics Engineering department at Eternal University, H.P, India. He has published many research papers ininternational journals and conferences and attended workshops. His research area of interest includes the fields of Optical communications, Signal processing, etc. At present he is guiding students for their master's thesis.

Er. Rajeev Thakur was born in 1984. He received his Bachelor's Degree in Electronics

and Communication Engineering from Institute of Engineering and Technology Baddi(Himachal Pradesh) in 2008 under HPU Shimla. He is pursuing his Master's degree inElectronics and communication department from Eternal University, H.P, India. He is doing his M.Tech thesis under the guidance of Er. SukhbirSingh. His area of interest arefield of Optical Communications, Digital Signal Processing, Wireless Networks and Embedded Systems.

Er. Bhubneshwar Sharma was born in 1986. He received Bachelor's Degree inElectronics and Communication Engineering from Jammu University in 2007 and received Master's degree in Electronics and Communication Department from Punjab in 2009. He is currently working as Assistant Professor in the Department of Electronics and Communication Engineering in Eternal University, Himachal Pradesh, India. He is pursuing Ph.D. He has published research papers in International Journals andpresented his work at conferences. He pursues a broad range of research interests that include Digital signal processing, neural networks, Wireless sensor networks. His comprehensive academic background coupled with an Excellent Knowledge and versatile experiences vibrate him with confidence.