UGC Approved Journal
IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2017

Compensation of Dispersion in Optical Communication Systems using DCF and FBG Methods

P.V.N.D.K. Kishore[1], K. Lakshmi Bhavani[2]

M.Tech Student, Department of Electronics and Communication Engineering, ANUCET, Archrya Nagarjuna University, Guntur, Andhra Pradesh, India[1]

Assistant Professor, Department of Electronics and Communication Engineering, ANUCET, Archrya Nagarjuna University, Guntur, Andhra Pradesh, India [2]

Abstract: Dispersion is a property of optical fiber, which causes spreading of light within the core of the optical fiber due to propagation delay spread of different spectral components of the transmitted signal which leads to pulse broadening of transmitted signal. Since the optical fibers will transfer the information at very high speeds, due to pulse broadening the Bit error rate (BER) is high and quality of the received signal at the receiver is very poor. In order to receive the signal with better quality that means with low Bit error rates (BER) we need to compensate the Dispersion property of the optical fibers. In this paper, Dispersion Compensation Fiber (DCF), Fiber Bragg Grating (FBG) methods are used to compensate the dispersion in optical fibers. Pre, post and symmetric compensation techniques are the three different techniques in DCF method of dispersion compensation, all and these techniques are analyzed by using Dispersion Compensation Fiber (DCF) and normal Single Mode Fiber (SMF).

Keywords: Dispersion, Dispersion Compensation, Dispersion Compensation Fiber (DCF), Fiber Bragg Grating (FBG).

I. INTRODUCTION

Now a day's communication plays the major role in the human life, communication means process of exchanging the information between the two or more things which are may be a transmitter or receiver or a transceiver. In order to transfer the information we need a media between the transmitter and receiver that may be a guided or unguided media. Depend on our requirement and convince we will choose the guided media or unguided media for our communication.

In present days we need high speed as well as more secured communication systems, in such systems we need to use communication media which will provides both high speed and secured communication. The optical fiber is guided media which provides the high speed and secured communication between transmitter and receiver. In optical fibers the high speed and secured communication is achieved by transferring the information in the form of light. The optical fiber has two layers namely core and cladding, the core is the inner layer and cladding is the outer layer, the refractive index of core is must be far greater than that of the refractive index of the cladding for traveling the light with in core by the principle of Total Internal Reflection (TIR). The optical fibers are classified into step index and graded index fibers depending on the change of the refractive index from core to cladding, if there is step change from refractive index of core to cladding then that type is called step index optical fiber and if there is gradual change from refractive index of core to cladding then that type is called graded index optical fiber. Another classification of optical fiber is single-mode and multi-mode depends on the how many signals it can carry. If the fiber carries only single signal it is called as single-mode fiber and if the fiber carries multiple signals it is called as multi-mode fiber.

In Optical communication systems optical fiber is used as communication channel between the transmitter and receiver, in these systems the BER at the receiver is directly proportional to the losses in the optical fiber link used between transmitter and receiver. There are many types of losses in the optical fibers those are attenuation loss, dispersion loss, bending loss, scattering loss, absorption loss. Out of these the dispersion loss of optical fiber is very important consideration in optical communication system for designing the efficient optical communication system.

The dispersion is the property of the optical fiber which causes the broadening of pulse while travelling through the optical fiber with in the core. The dispersion may sometimes call as chromatic dispersion. There are mainly three types dispersion losses in optical fibers those are Model dispersion, material dispersion and wave guide dispersion. If dispersion of the optical fiber is more causes loss in the received signal is more and BER at the receiver is also more and efficiency of the optical communication system is less, If dispersion of the optical fiber is less causes loss in the received signal is less and BER at the receiver is also more and efficiency of the optical communication system is more.

Copyright to IJIREEICE

UGC Approved Journal
IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2017

Hence in order to get lower BER at the receiver we need to compensate the dispersion of the optical fiber. In this paper the BER of the optical system is improved by compensating the dispersion of the optical fiber. Dispersion Compensation Fiber (DCF) and Fiber Bragg Grating (FBG) methods are used for compensating the dispersion.

In DCF method a Fiber with negative dispersion namely Dispersion Compensation Fiber (DCF) is connected along with the desired fiber. Depending on the placement of DCF and original Single Mode Fiber(SMF) there are three methods, those are pre, post and symmetric methods. In FBG method dispersion is compensated by connecting Fiber Bragg Gratings along with the desired optical fibers. A Fiber Bragg Grating is a type of distributed Bragg reflector, constructed by short segments of optical fiber, reflects the particular wave length of the signal and transmits all other as shown in bellow.

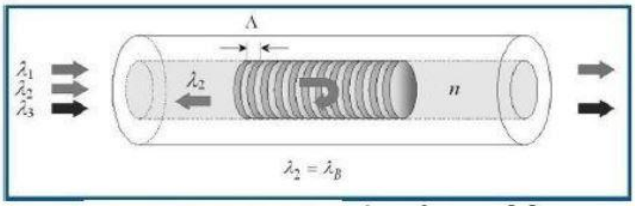

Fig 1: Reflection of wavelengths in FBG

II. SIMULATION SETUP

The simulation setup for the pre, post and symmetric compensation methods are shown bellow

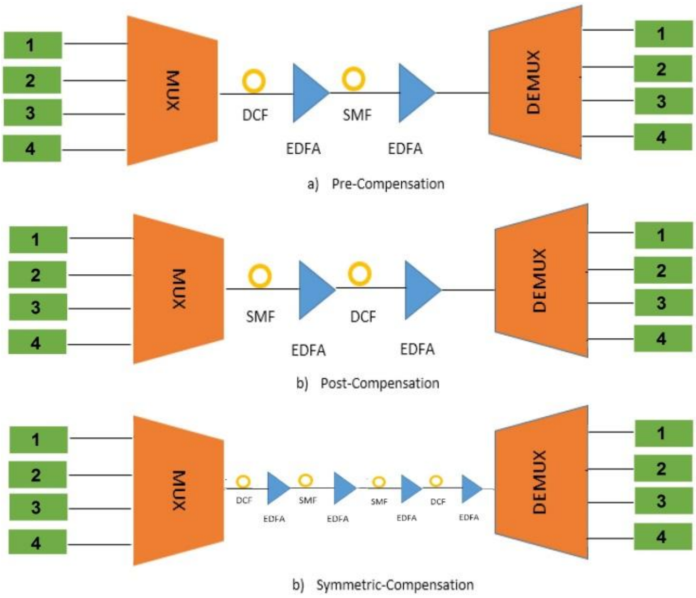

Fig 2: Block diagram of simulation setup for Pre, Post and Symmetric compensation

In Pre compensation method the Dispersion Compensation Fiber (DCF) which has negative dispersion is placed before (pre) to the original Single Mode Fiber (SMF), In Post compensation method the Dispersion Compensation Fiber (DCF) is placed after (post) to the original Single Mode Fiber (SMF) and Symmetric compensation scheme the both pre and post compensation methods are used.

The length and dispersion factors of DCF and SMF are taken from the fallowing equation to minimize the effect of the dispersion

$$L_2 = -\left(\frac{D_1}{D_2}\right) * L_1$$

Here L_1 is the length of the SMF, L_2 is the length of the DCF, D_1 is dispersion factor of SMF and D_2 is the dispersion factor of DCF.

Copyright to IJIREEICE
DOI 10.17148/IJIREEICE.2017.5705

UGC Approved Journal
IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2017

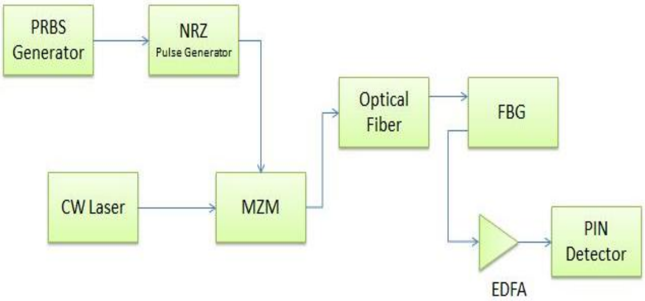

Fig 3: Block Diagram of simulation setup for FBG method.

The simulation setup for FBG method of compensating the dispersion was shown above and here the PRBS generator means Psudo-Random Bit Sequence Generator which generates the bit sequence randomly with our given bit rate, NRZ pulse generator will generates the Non Return to Zero electrical signal for the generated bit sequence and MZM means Mach-Zehnder modulator at which the both CW laser output and NRZ pulses are modulated together and generates optical signal according to the generated bit sequence, this optical signal is given to the optical fiber and then given to the FBG which will reflects the desired wave length and transfers all other, the reflected signal will be amplified by EDFA amplifier and the after it is converted back to the electrical signal by the PIN detector.

III.SIMULATION RESULTS

All the proposed circuits of the pre, post, symmetric and FBG methods of compensation are designed and simulated by using OptiSystem 7.0 software, simulation results of BER and Quality factors for different lengths of DCF and SMF are given bellow, the gain of optical amplifier DCF is taken as 4dB gain of optical amplifier at SMF is taken as 16dB.

Table 1: Pre compensation simulation results

S.No	DCF		SMF		Without pre compensation		With pre compensation	
	Length	Dispersion factor	Length	Dispersion factor	Quality factor	BER	Quality factor	BER
1	8	-80	80	8	69.61	0	72.64	0
2	16	-80	160	8	53.73	0	60.67	0
3	24	-80	240	8	32.25	$1.8*10^{-228}$	58.62	0
4	32	-80	320	8	18.29	$4.12*10^{-75}$	58.30	0
5	40	-80	400	8	9.78	$6.53*10^{-23}$	52.14	0
6	48	-80	480	8	5.74	$4.58*10^{-9}$	45.65	0
7	56	-80	560	8	3.38	$3.60*10^{-4}$	40.29	0
8	64	-80	640	8	2.10	$1.77*10^{-2}$	38.13	$1.28*10^{-318}$
9	72	-80	720	8	0	1	37.97	$5.92*10^{-316}$
10	80	-80	800	8	0	1	40.305	0

Table 2: Post compensation simulation results

S. No	DCF		SMF		Without post compensation		With post compensation	
	Length	Dispersion factor	Length	Dispersion Factor	Quality factor	BER	Quality factor	BER
1	8	-80	80	8	69.61	0	67.13	0
2	16	-80	160	8	53.73	0	54.57	0
3	24	-80	240	8	32.25	$1.8*10^{-228}$	49.82	0
4	32	-80	320	8	18.29	$4.12*10^{-75}$	49.54	0
5	40	-80	400	8	9.78	$6.53*10^{-23}$	47.81	0
6	48	-80	480	8	5.74	$4.58*10^{-9}$	41.64	0
7	56	-80	560	8	3.38	$3.60*10^{-4}$	36.72	$1.4*10^{-295}$
8	64	-80	640	8	2.10	$1.77*10^{-2}$	37.88	$1.70*10^{-314}$
9	72	-80	720	8	0	1	33.82	$3.53*10^{-251}$
10	80	-80	800	8	0	1	31.77	$5.79*10^{-222}$

UGC Approved Journal
IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2017

Table 3: Symmetric compensation simulation results

S. No	DCF		SMF		Without symmetric compensation		With symmetric compensation	
	Length	Dispersion factor	Length	Dispersion factor	Quality factor	BER	Quality factor	BER
1	8	-80	80	8	69.61	0	98.30	0
2	16	-80	160	8	53.73	0	83.59	0
3	24	-80	240	8	32.25	$1.8*10^{-228}$	73.61	0
4	32	-80	320	8	18.29	$4.12*10^{-75}$	77.01	0
5	40	-80	400	8	9.78	$6.53*10^{-23}$	72.09	0
6	48	-80	480	8	5.74	$4.58*10^{-9}$	64.12	0
7	56	-80	560	8	3.38	$3.60*10^{-4}$	62.43	0
8	64	-80	640	8	2.10	$1.77*10^{-2}$	56.49	0
9	72	-80	720	8	0	1	57.98	0
10	80	-80	800	8	0	1	47.24	0

The above tables shows the simulation results with and without pre, post and symmetric compensation, from these results the designed circuits of pre, post and symmetric compensation will improves the quality factor and BER by compensating the dispersion, among these three methods the symmetric compensation technique will gives better results than pre and post compensation techniques.

The simulation results of the FBG method dispersion compensation at various input power levels are given below; all the values are taken at FBG length of 10mm, fiber length of 20Km with dispersion factor of 10ps/nm/km.

Table 4: Simulation results of FBG

S. No	Input Power	Quality factor without FBG	Quality factor with FBG		
			Uniform apodization	Gaussian appodization	Tanh appodization
1	-15dB	6.10	7.07	6.18	7.39
2	-10dB	7.97	10.275	11.61	13.39
3	-5dB	9.14	13.587	21.17	22.41
4	0dB	9.70	16.15	37.37	32.82
5	5dB	10.19	17.77	62.03	48.22
6	10dB	11.55	20.13	99.01	67.10
7	15dB	17.43	30.015	159.17	81.08

In FBG method depending on the apodization structure of FBG we have three types those are Uniform, Gaussian, Tanh, the quality factors obtained in all these three cases are given above, and in all the three cases the quality factor is better than the quality factor without FBG. Hence the quality factor and BER are improved by compensating the Dispersion.

IV. CONCLUSION

The proposed setup was designed and simulated in Opti System 7.0, the simulation results shows that the Quality factor and BER of the optical communication system was improved by compensating the dispersion using both DCF and FBG methods are performed and obtained results are better than the values obtained without compensation.

REFERENCES

[1] Rajneesh Randhawa, J.S.Sohal, R.S. Kaler, “Pre-, Post and Hybrid Dispersion Mapping Techniques for CSRZ Optical Networks with Nonlinearities”, Optik 121(2010) 1274–1279, 0030-4026/$-seefrontmatterr 2009 Published by Elsevier GmbH. doi:10.1016/j.ijleo.2009.01.032.
[2] A. S. Karar, et al., “Electronic Pre-Compensation for a 10.7-Gb/s System Employing a Directly Modulated Laser”, Journal of light wave technology, vol. 29, no. 13, 2011.
[3] K. Khairi, et al., “Investigation on the Performance of Pre and Post Compensation Using Multi Channel CFBG Dispersion Compensators”, IEEE International RF and Microwave Conference (RFM 2011), 12th - 14th December 2011.
[4] R.I. Killey, P.M. Watts, M. Glick, and P. Bayvel, “Electronic dispersion Compensation by signal pre-distortion,” Optical Networks Group, Department of Electronic and electrical Engineering, University College London, Torrington Place, 2006.

UGC Approved Journal

IJIREEICE

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

ISO 3297:2007 Certified

Vol. 5, Issue 7, July 2017

[5] S.O Mohammadi, Saeed Mozaffari and M. Mahdi Shahidi. "stimulation of transmission system to compensate dispersion in an optical fiber chirped gratings". International Journal of the Physical Sciences Vol. 6(32), pp. 7354 - 7360, 2 December, 2011.
[6] Ravi prakash shukla, Mukesh kumar, A.K. Jaiswal, Rohini Saxena. "Performance Analysis of Dispersion in Optical Communication link Using Different Dispersion Compensation Fiber (DCF)models." ISSN: 2277-3878, Volume-1, Issue-2, June 2012.
[7] Sandeep Singh, Vaibhav Bhushan Tyagi,"Performance Analysis of WDM Link Using Different DCF Techniques", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 2, Issue 8, August 2012.

BIOGRAPHIES

P.V.N.D.K.KISHORE obtained B.Tech from Vignan's LARA institute of Technology and Sciences, Vadlamudi in 2014, pursuing M.Tech in Communication and Signal processing under the department of Electronics and Communication Engineering in University College of Engineering and Technology, Acharya Nagarjuna University, Guntur, India. His research interests are Communication systems and communication networks.

K. LAKSHMI BHAVANI obtained B.Tech degree in Electronics and communication engineering from JNTU .She received her M.Tech degree from JNTUH. She is doing her Ph.D in Acharya Nagarjuna University Guntur. She is currently working as Assistant Professor, Department of ECE in University College of Engineering and Technology, Acharya Nagarjuna University, Guntur, India.