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Simulation Comparison of Different Dispersion Compensation Techniques in Single Channel Optical fibre Using Optisystem

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ABSTRACT: Advancement in Fibre Optical Technology has updated the communication sector in terms of large capacity of information transmission (video, audio, and data), high quality and cost effectiveness. The combination of photons and glass fibres provides a tremendous transmission capability improvement compared to transmission lines through electrons and copper wires. However in the C band of the optical region ranging from 1530nm-1565nm, attenuation is low but chromatic dispersion and Polarization mode dispersion puts data rate limitation in single channel network. Therefore various dispersion compensation techniques namely FBG (Fibre Bragg Grating), DCF (Dispersion compensating Fibre) and OPC (Optical Phase Conjuction) with Electroabsorption modulator and Mach-Zehnder modulator are used to compensate the dispersion so that efficient data can be transmitted through the communication medium which is typically single mode optical fibre. In this study, the performance of different dispersion compensation techniques has been studied through software OptiSystem Version 7 from Optiwave. Eye Height, BER (Bit Error Rate) and Quality Factor (QF) have been observed to analyze the performance of these different compensation techniques to mitigate dispersion with varying bit rate from 10 Gbps to 20 Gbps and distance from 100km to 200km respectively.

KEYWORDS: Optical Fibre, Dispersion, Dispersion Compensation Techniques, Single Channel etc.

I.INTRODUCTION

Transmitting the maximum number of data bits per second over the fibre without distortion and least errors is the main objective in communication system. However, at high data rate inter-symbol interference due to dispersion causes the signal distortion, which needs to be accordingly compensated in cost effective manner. Dispersion is simply the widening of pulse duration as it travels through a fibre. As the optical pulse propagates, it gets substantially broadened to interfere with the neighbouring pulses on the optical fibre communication system, leading to Inter-Symbol Interference (ISI). Dispersion is not considered as big challenge when the bit rate was at or below 2.5 Gbps but when the distance extends to few hundred kilometers and bandwidth rose then dispersion effects the communication and needs to overcome.In long haul transmission system of over 10 Gbps speed, dispersion is major problem therefore one of the best things to speed up the optical communication networks would be to alter existing optical cables with advance cables. Hence current network has to compensate the positive dispersion of the existing single mode fibre at 1550 nm wavelength so as to make it acceptable for long distance broadband communication. Optical fibre capacity get restricted due to intensity-dependent Kerr nonlinearity limit and optical fibre channel non linear nature .So, all these limitation leads to implement different techniques to enhance the actual transmission capacity of wireless networks and optical terrestrial by implementing various compensation technique such as Fibre Bragg Grating, Uniform Fibre Bragg Grating, Ideal dispersion Compensating FBG, Optical Phase Conjuction and Dispersion Compensating Fibre.

II.DISPERSION COMPENSATION

The phenomenon in which the phase velocity or alternatively group velocity of a wave depends on its frequency is termed as dispersion. In single mode optical fibre the major dispersion is Chromatic Dispersion (CD) .Different modes

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travel with different group velocities due to the material and waveguide properties of the fibre in dispersion. Due to this all the modes reach at different times which results in "pulse broadening". Pulse broadening depends upon distance as well as dispersion parameter. The units of dispersion parameter are ps/nm/km which varies according to fibre. Chromatic Dispersion is the combination of material dispersion and waveguide dispersion.
The classification of different types of dispersion is shown in fig.1.

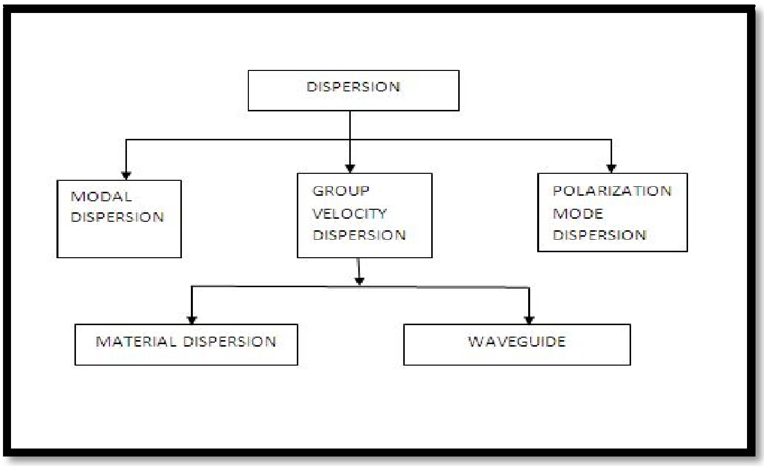

Fig . 1 : Classification of different types of dispersion.

The motive of dispersion compensation is to reduce the dispersion so that transmission distance can be extended in systems operating at higher bit rate. In this paper, Dispersion Compensating Fibre Technology with diffferent modulator is used in order to reduce the dispersion caused in the system.

III.VARIOUS DISPERSION COMPENSATION TECHNIQUES

In order to increase the efficiency of the network, dispersion and other nonlinear effects should be supressed therefore, several dispersion compensation technologies were proposed as discussed below.

3.1Fibre Bragg Grating

FBG is based on the principle of Fresnel reflection, where light travelling between media having different refractive indices may refract or reflect at the interface. At a particular length the refractive index will alternate also small amount of light is reflected during refraction.These reflected light signals combine to one large reflection at a particular wavelength in which the grating period is approximately half the input lights wavelength. This is Bragg condition on the wavelength at which reflection occurs is called Bragg wavelength.The Bragg wavelength ($\lambda\beta=2\bar{n}$) varies along the grating length, therefore the frequency component is reflected on where the Bragg condition is satisfied. The grating dispersion D_g

$$D_g = \frac{2\bar{n}}{C(\Delta\lambda)}$$

Where $\bar{n}$ average mode index and C is is the velocity of light. It acts as a dispersion compensator in transmission optical system which is used to compensate chromatic dispersion. Therefore the ultimate expected effect is compression in incident pulse and thus suitable to compensate chromatic dispersion in a communication link .When a light pulse propagates down an optical fibre, it is dispersed, that is the width of the pulse broadens because the longer wavelength light lags the shorter wavelength light. Consequently, at sufficiently high data rates and fibre lengths, the pulses in a data stream will begin to overlap. In this way, fibre dispersion limits the maximum data that can be transmitted through a fibre. The longer wavelengths dispersed light pulse lagging the shorter wavelengths is incident on a chirped Fibre Bragg Grating. However, near the front of the grating the longer wavelength light is reflected whereas

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the shorter wavelengths are delayed relative to the longer wavelengths. The chirped grating can be designed so that all wavelengths in the light pulse exit the reflector at the same time and the dispersion in the optical pulse is equalized.

3.2 Optical phase Conjucation

OPC function is to compensate chromatic dispersion and Kerr effect.The ability to compensate for Self Phase modulation through OPC was numerically calculated.Due to this ,phase distortions before conjugation that occur through Self Phase Modulation are undone by Self Phase Modulation induced phase distortions after conjugation.The prior realizations of OPC were based on stimulated Brillion scattering. Optical phase conjugation is caused with the help of device called Optical Phase Conjugator. It is used to reverse the phase propagation direction and phase of beam of light, the reversed beam is called conjugated beam. In WDM Optical system new techniques and components are being deployed to counter Four Wave Mixing effects. Methodically, it is the complex conjugate of the input power signal. In order to suppress FWM effects the optical phase conjugation is the best alternative. The Optical phase conjugator (OPC) should satisfy several requisite such as it must be transparent to signal bit-rate and modulation format, it must show a large available conjugation bandwidth, it must produce a conjugated signal with a suitable optical intensity, it must be polarization independent, and should not introduce any distortion of the signal during the OPC neither in terms of chirp nor of reduction of the optical signal to noise ratio (OSNR).

3.3 Dispersion Compensating Fibre (DCF)

The components of DCF are not easily affected by temperature and bandwidth, because DCF is more stable because they have higher negative dispersion coefficient and therefore can be connected to the transmission fibre having the positive dispersion coefficient. Therefore the overall dispersion of the link is zero.In Pre Compensation DCF is placed before the Standard Single Mode Fibre to compensate the positive dispersion of the standard fibre whereas in post Compensation DCF is placed after Standard Single Mode Fibre to compensate the positive dispersion and In Symmetrical compensation DCF is placed before as well as after Standard Single Mode Fibre (SSMF) to achieve the dispersion compensation.

Fig 2: Block diagram of Pre-compensation.

IV.PROPOSED SIMULATION MODEL

The designed system consists of block of Pseudo-Random Bit Sequence Generator (PRBS) having binary signal, sends the bit sequence to the NRZ Pulse generator.The NRZ pulse generator convert the bits into pulses and produces electrical output. The electrical output of the NRZ pulse generator is fed to the Electroabsorption Modulator. The continous wave laser emit light pulse on frequency 193.1 THz.The optical signal is then fed to Erbium doped Fibre amplifier which amplifies the light signal so it travel a long distance. In the Electroabsorption Modulator, here both the electrical and optical signal got mix and optical signal launched into optical fibre and FBG compensate the dispersion futher reduces the noise. At the receiver side, the Photo intrinsic diode(PIN) converts the optical signal into electrical signal.Low Pass Bessel Filter filters the electrical signal.The 3R regenerator consists of electrical signal as reference signal ,and binary signal and output as electrical signal also perform function of reamplification ,reshaping and retiming of data pulse .

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Table 1: Simulation parameters For Fibre Bragg Grating (FBG)

Parameters	**Values**
Frequency(THz)	193.1
Power (dBm)	0
Line Width (MHz)	10
Initial Phase (deg)	0
SMF Reference waveleng(nm)	1550
Bit Rate (Gbps)	10 -20
Length (Km)	100 -200
Attenuation (dB/Km)	0.25
Dispersion (ps/nm/Km)	5
Dispersion Slope (ps/nm/Km)	0.08
Differential Group Delay (ps/Km)	3
Apodization Function FBG	Tanh
Tanh Parameter	0.5
Chirp Function	Linear
Chirp Value	0.0001
Moduator	Electroabsorption
Photodetector	PIN

In uniform FBG the bandwith taken is 125 GHz .In the optical Phase conjuction and the symmetrical dispersion compensation technique the Avalanche photo diode is used.Moreover, in case of Optical Phase conjuction and pre, post and symmetrical DCF the highly non linear fibre with 0.5 km length and dispersion slope of 0.05 is considered.

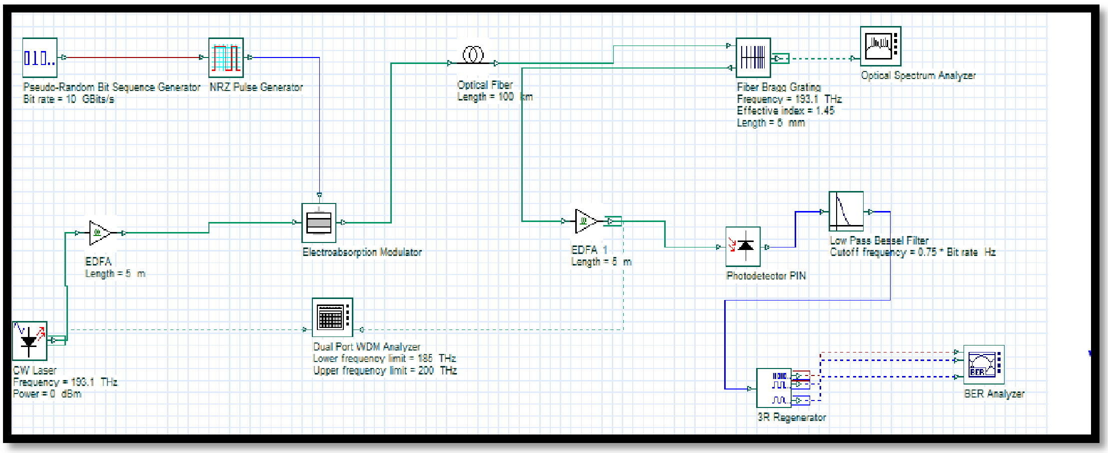

Fig. 3: FBG dispersion compensation technique with Electroabsorption modulator

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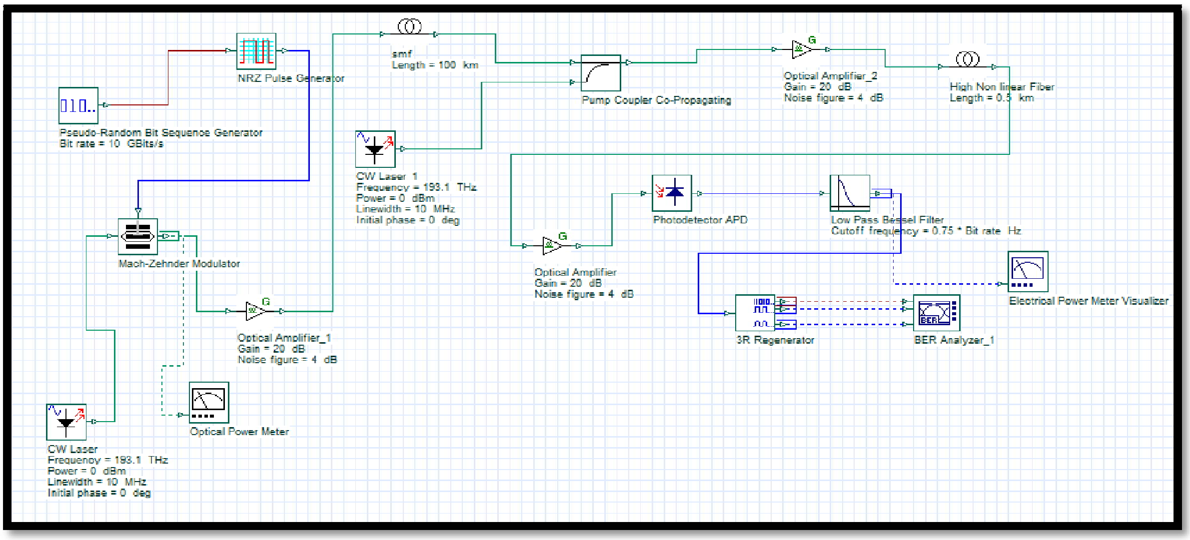

Fig. 4: Optical Phase Conjuction dispersion compensation technique with Electroabsorption modulator

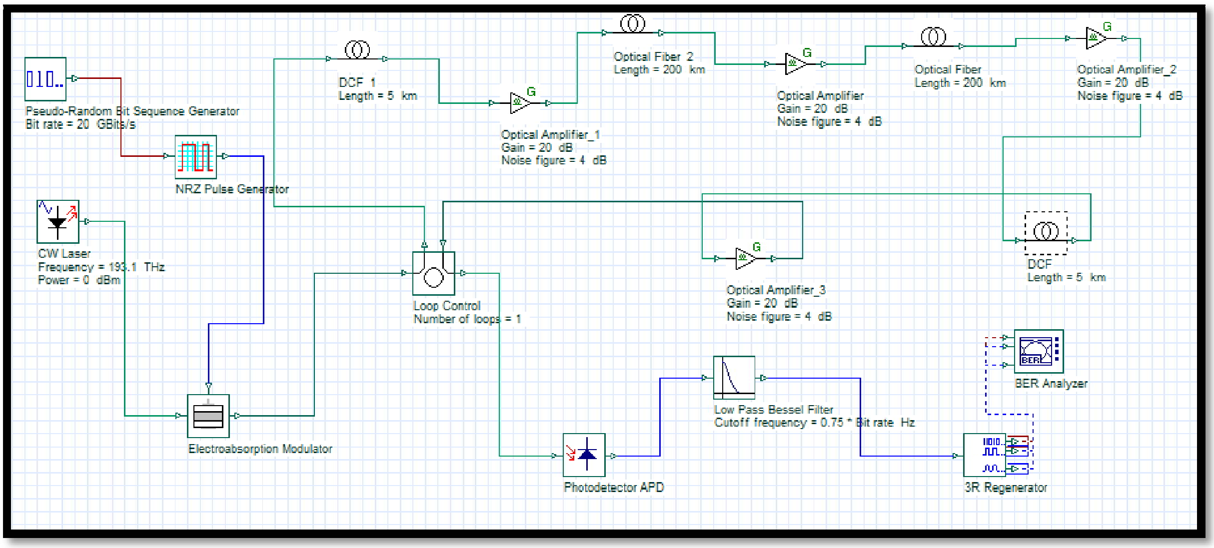

Fig. 5: Symmetrical dispersion compensation technique with Electroabsorption modulator

V. RESULT AND DISCUSSION

The performance of various dispersion compensation techniques is evaluated by varying the length of the fibre from 100 to 200 Km , bit rate from 10 to 20 Gbps and by using Electroabsorption and Machzehnder modulator .In some techniques Electroabsorption gives better result such as Fibre Bragg Grating, Uniform Fibre Bragg Grating etc. When Optical Phase Conjuction is used with Avalanche photo diode MachZehnder Modulator gives better result.These modulator also give better result in Ideal dispersion compensating Fibre Bragg Grating .The results are concluded on the basis of Q factor, Min. BER and Eye Height.

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Table 2: Comparison of different dispersion compensation technique

Technique	Modulator	Fibre Length (Km)	Bit rate (Gbps)	Quality Factor (Q)	Bit Error Rate (BER)	Eye Height
Fibre Bragg Grating	Electroabsorption	100	10	38.9659	0	0.0795915
			20	4.7905	7.37101	0.0257063
		150	10	15.1806	1.74381	0.015215
			20	3.1954	0.00067650	0.000971374
		200	10	4.50815	3.00915	0.000426209
			20	2.54031	0.0050172	-0.000184051
Uniform FBG	Electroabsorption	100	10	22.863	3.98519	0.0818
			20	2.6828	0.00339676	-0.00966454
		150	10	8.49285	6.72468	0.019405
			20	2.79775	0.00235836	-0.00170955
		200	10	5.51234	1.49635	0.000957247
			20	2.57791	0.00432416	0.000274147
	Mach-Zehnder	100	10	16.3015	4.22612	0.0828101
			20	3.00285	0.00123582	8.57339
		150	10	8.84657	3.52709	0.0203925
			20	3.28503	0.00046107	0.00211887
		200	10	6.28568	1.4955	0.00103512
			20	0	1	0
Ideal dispersion compensating fibre	Electroabsorption	100	10	10.1912	1.04185	0.0576585
			20	2.9986	0.00133677	-2.67905
		150	10	32.1024	1.73492	0.0228242
			20	3.0193	0.001262	0.000111771
		200	10	6.13974	3.62924	0.000976515
			20	4.66065	1.50206	0.000583376
	Mach-Zehnder	100	10	11.1085	5.4489	0.0663379
			20	2.09883	0.0178804	-0.0261483
		150	10	35.7336	4.43324	0.0244897
			20	3.21083	0.00065848	0.00124352
		200	10	6.56293	2.27497	0.00108662
			20	4.44239	4.25069	0.00054171
Optical phase conjuction	Mach-Zehnder	100	10	4.45681	2.87487	5.4538
			20	3.5556	0.00018822	2.13616
		150	10	5.00505	2.09904	2.63165
			20	1.83246	0.0306518	-2.52467
		200	10	4.10655	1.87253	0.368221
			20	0	1	0

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Technique	Modulator	Fibre Length (Km)	Bit rate (Gbps)	Quality Factor (Q)	Bit Error Rate (BER)	Eye Height
Pre DCF	Electroabsorption	100	10	19.0807	1.70088	0.201869
			20	2.58358	0.004315	-0.00372272
		150	10	12.2453	8.73214	0.00108851
			20	2.29977	0.008986	-0.00038273
		200	10	5.76947	3.76124	4.29424
			20	2.31686	0.00825	-2.04567
Post DCF	Electroabsorption	100	10	20.0159	1.7225	0.0204646
			20	6.02136	8.61228	0.00989347
		150	10	2.61989	0.004292	-0.000200912
			20	0	1	0
		200	10	0	1	0
			20	0	1	0
Symmetrical DCF	Electroabsorption	200	10	10.0716	3.51244	1.3711
			20	2.5281	0.004746	-0.327246
		300	10	2.64035	0.003921	-.000777516
			20	3.20127	0.000394	0.000598704
		400	10	0	1	0
			20	0	1	0

From table 2 it is clear that in Fibre Bragg Grating at 100 km, 10Gbps the Q factor found is 38.9659 and BER is 0.In uniform Fibre Bragg Grating with electroabsorption modulator at 100km, 10Gbps Q factor is 22.863 and BER is 3.98519. In ideal dispersion compensating FBG with electroabsorption modulator with Mach-Zehnder modulator at 150km, 10Gbps the Q factor found is 35.7336 and BER is 4.43324. In Optical phase conjuction with Mach-Zehnder modulator at 150km at 10Gbps the Q factor found is 5.00505 and BER found is 2.09904. In post Dispersion Compensation Fibre at 10 Gbps having 100km length the Q factor is 20.0159 and BER is 1.7225. In uniform Fibre Bragg grating at 200km, 20Gbps the BER is 0. In Post DCF at 150 km, 20Gbps Q factor found is 0.At 200 km at 10Gbps and 20Gbps the results found are 0.

VI.CONCLUSION

From the results it is concluded that FBG, Uniform Fibre Bragg Grating technique and Dispersion Compensating Fibre techniques with Electro absorption gives better results than Mach-Zehnder. Dispersion Compensating Fibre techniques contains three type namely Pre dispersion compensating fibre (Pre DCF), Post Dispersion Compensating Fibre (Post DCF) and Symmetrical Compensating Fibre and among them Symmetrical DCF is best when implemented with Electroabsorption. Optical Phase Conjuction technique shows less dispersion when Machzender Modulator is used with Avalanche Photo diode instead of Photo Intrinsic diode.However, as the length and Bit rate 20Gbps increases Mach-Zehnder gives better results.In, Ideal dispersion Compensating FBG at 150km and 20Gbps Mach-Zehnder is best.

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REFERENCES

[1] Parul Singh and Rekha Chahar,"Performance analysis of dispersion compensation in optical fibre using DCF" The International Journal of Engineering and Sciences, Vol.3, no.8 , pp. 18-22, 2014.

[2] Prachi Sharma et al, "A Review of the Development in the Field of Fibre Optic Communication Systems", International Journal of Emerging Technology and Advanced Engineering, Vol. 3, no. 5, pp. 113-119, 2013

[3] Nidhiya Shan and Asha A S, "Simulation and analysis of Optical WDM System Using FBG as Dispersion Compensator ," International Journal of Engineering Research and General Science, Vol. 3,no. 2, pp. 1073-1080 , 2015.

[4] Kaushal Kumar, A.K.Jaiswal, Mukesh Kumar and Nilesh Agrawal, "Performance analysis of dispersion compensation using Fibre Bragg Grating (FBG) in optical communication", International journal of current engineering and technology, Vol.4, no.3, pp.1527-1531, 2014.

[5] B.Prasad, B.Mallick and A.K.Parida," Fibre Bragg Grating as a dispersion compensator in an optical transmission system using optisystem software", International Research Journal of Engineering and Technology (IRJET) Vol. 2 , no.6 , pp. 9-14,2014.

[6] S. O. Mohammadi, Saeed Mozzaffari and M. Mahdi Shahidi, "Simulation of a transmission system to compensate dispersion in an optical fibre by chirp gratings." International Journal of the Physical Sciences, Vol. 6(32), pp. 7354 - 7360, December, 2011.

[7] K. O. Hill, F. Bilodeau, B. Malo, T. Kitagawa, S. Th´eriault, C. Johnson, J. Albert, and K. Takiguchi, "Aperiodic in-fibre Bragg gratings for optical fibre dispersion compensation," in Conf. Optic. Fibre Commun., OFC'94, San Jose, CA,1994.

[8] J. Harish D.Dilip Kumar and G. Aarthi, "Designing a Chromatic dispersion compensator performance comparison between NRZ and RZ", International Journal of Combined Research & Development (IJCRD*)* Vol 4,no. 5,pp. 838 -843 ,2015.

[9] Aashima Bhardwaj and Gaurav Soni,"Performance analysis of 20Gbps optical transmission system using Fibre Bragg Grating *International Journal of Scientific and Research Publications.* Vol. 5, no 1, pp 1-4 , 2015 .

[10] R K Sethi, Aditya Goel "Performance Analysis of Optical Communication System using OFDM by Employing QPSK Modulation", International Journal on Recent and Innovation Trends in Computing and Communication
(IJRITCC), vol 3, issue 1, pp.226-237 , 2015.

[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 Fibre Bragg Grating (FBG) ," www.iosrjen.org , ISSN: 2250- 3021 Volume 2, Issue 7(July 2012), PP 55-61 . .