PERFORMANCE COMPARISON OF VARIOUS DISPERSION-COMPENSATION TECHNIQUES WITH PROPOSED HYBRID MODEL FOR DISPERSION COMPENSATION AT 100GBPS OVER 120KM SINGLE MODE FIBER

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ABSTRACT

This paper includes the comparison of DCF, IDCFBG and UFBG dispersion compensation technique with the hybrid model. The experimentally proved results of Dispersion Compensating fibers, Fiber Bragg grating and uniform fiber Bragg grating has been examined, and it is depicted that post configurations of all the three dispersion compensation schemes provided outstanding results for transmission at 120Km at 100Gbps over single mode fiber. Evaluation of all these schemes is then done by comparing with the hybrid model, to examine the optimum approach for dispersion compensation. Evaluation of performance is explored by using simulation models and graphs. The immense outcomes show that Hybrid model has marvelous outcomes for compensation of dispersion at a higher bit rate of 100Gbps over 120Km transmitting distance in comparison with existing techniques of DCF, IDCFBG and UFBG.

KEYWORDS: Opti system 7.0, Uniform Fiber Bragg grating (UFBG); Dispersion Compensating Fiber (DCF); Chromatic Dispersion (CD); Q-Factor; Bit Error Rate (BER)

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I. INTRODUCTION

With the invention of laser in 1960, optical communication system developed quickly. These days, correct and fast trade of data has been an important requirement for individuals. Thus, the promotion of optical fiber is needed to transport the signals at longer distances with higher data rates and high capacity. With bringing it into rehearse, we found that the information carrying capacity of a system in optical fiber communication are affected by the losses in fiber, dispersion, polarization impacts, nonlinear impacts and distinct factors. The fundamental variables have dispersion and losses in the fiber. In this manner, how to lessen these two negative factors and wind up noticeably are critical issues in optical fiber communication systems. In the present days, with the development of EDFA (erbium doped fiber amplifiers), fiber loss is no longer the primary constraining component. At that point, dispersion has moved toward becoming the main consideration.

Dispersion in fiber yields mutilation of the communicating signal and corresponding dropping of the quality of signal, thereby, limiting the channel capacity. In this way, how to successfully regulate the dispersion is the highlighting concept in fiber optics [1, 2, 3].

II. METHODS OF CHROMATIC DISPERSION COMPENSATION

- **Dispersion Compensating Fibers:** With the change in the structure of the optical fiber, a fiber can be outlined with negative dispersion value. This fiber is known as dispersion compensating fiber (DCF). When it is utilized together with ordinary fiber, the two would scratch off each other out. Through very much outlined core diameter of fiber and distributed refractive index, coefficients of negative dispersion having distinct sizes can be obtained. These are composed in view of fundamental mode and higher mode [4, 5,6].
- **Fiber Bragg Grating:** It is another chromatic dispersion compensation technique used to mitigate the effects of the dispersion in long distance high capacity systems. It works on the principle of passing a particular wavelength through it, and reflecting all other wavelengths. Basically, two types of fiber Bragg gratings are most commonly used- chirped fiber Bragg grating and uniform fiber Bragg grating [7, 8, 9].

The work in this paper completely focuses on the reparation of dispersion by comparing the existing techniques with the proposed Hybrid model. Hence, to determine the results, the whole paper is divided into five sections. Section-III contains the simulation models for all the methods, while Section-IV includes the results and discussions of the simulation models. Section-V carries the conclusion of the paper.

III. SIMULATION MODELS

By using Optisystem 7.0, Simulations setups for dispersion compensation using DCF, IDCFBG, UFBG and Hybrid model are shown in this paper.

- **Simulation Models for DCF:** Simulation parameters of single mode fiber are displayed in Table-1, whereas, DCF simulating parameters are described in Table-2. Simulation setup of pre, post and symmetrical configuration is also shown in Figure 1, 2 and 3, respectively.

Table 1: SMF Simulation Parameters

Sr. No	Parameter	Value
1	Bit Rate(Gbps)	100
2	Power(dBm)	1-10
3	Extinction Ratio(dB)	30
4	Gain(dB)	20
5	Bandwidth(THz)	1
6	Sample Rate(THz)	6.4
7	Frequency(THz)	193.1
8	Noise(dB)	2

Table 2: Dispersion Compensating Fiber Parameters

Sr. No	Parameter	Value
1	Length of Fiber(Km)	120
2	Differential slope (ps/nm ² /km)	0.21
3	Length of DCF(km)	24
4	Attenuation(db/km)	0.3
5	Reference wavelength(nm)	1550
6	Dispersion(ps/nm/km)	-80

By placing the DCF at different locations, pre, post and symmetrical configuration can be obtained. The experimental verification of three configuration of DCF can be extracted by observing the graphs shown in Figure 4, 5,

6 and 7, respectively. The outcomes drawn from graphs show the post configuration to be superior, then pre and symmetrical. Initially, at input power of 1dBm, the highest Q-Factor observed is 6.83 with BER of $1.04 E^{-12}$ in post scheme.

Figure 1: Pre Compensation Configuration of DCF

Figure 2: Post Compensation Configuration of DCF

Figure 3: Symmetrical Compensation Configuration of DCF

As the input power increase, it causes a significant increase in Q-Factor with corresponding lowering of BER. Hence, at 10dBm maximum value of Q-Factor of 9.2 with least BER of $1.69 E^{-20}$ is observed with post configuration only.

Figure 4: Q-Factor Change with Input Power

Figure 5: BER Change with Input Power

Figure 6: Eye Height Change with Input Power

Figure 7: Received Power Change with Input Power

- **Simulation Models for IDCFBG:** Another compensation method of IDCFBG is also executed in three configurations of pre, post and symmetrical. Simulation model for analysis is drawn in Figure 8,9 and 10 along with the parameters for its simulations in Table- 3.

Table 3: Parameters of IDCFBG

Sr. No	Parameter	Value
1	Length of Fiber(Km)	120
2	Differential group delay(ps/km)	3
3	Attenuation(db/km)	0.2
4	Dispersion(ps/nm/km)	17
5	Differential slope (ps/nm ² /km)	0.008

Figure 8: Pre Compensation Scheme of IDCFBG

Figure 9: Post Compensation Scheme of IDCFBG

Figure 10: Symmetrical Compensation Scheme of IDCFBG

After the analysis of graphs shown in Figure 11, 12, 13 and 14 for Q-Factor, BER, eye height and threshold, respectively, the information is extracted that post scheme is achieving the highest Q-Factor of 10.2168 and least bit error rate of $8.32 E^{-25}$. This maximal output is yielded at input power level of 10dBm.

By examining the graphs, it is clear that with the growth of input power level, Q-Factor grows constantly and become maximal at 10dBm, while bit error rate graph shows a significant decay from 1 to 10dBm power level. Thus, fulfill the requirements of transmission with lesser impact of dispersion in fiber optics.

Figure 11: Q-Factor Change with Input Power

Figure 12: Change in BER with Input Power

Figure 13: Eye Height Change with Input Power

Figure 14: Received Power Change with Input Power

- **Simulation Models for UFBG:** UFBG is also a distinct technique for mitigating the impact of chromatic dispersion in present day optical fiber communication system. Same analysis of UFBG is provided at 100Gbps rate for 120Km by configuring it in pre, post and mix scheme. For determining the outcomes of UFBG, its simulation parameters and simulation setup is shown in Table-4 and Figure 15, 16 and 17, respectively.

Table 4: Parameters of Uniform FBG

Sr. No	Parameter	Value
1	Length of Fiber	120 Km
2	Sample Rate	500 GHz
3	Reflectivity	0.99
4	Noise Threshold	-100 dB

Figure 15: Pre Compensation of UFBG Model

Figure 16: Post Compensation of UFBG Model

Figure 17: Mix Compensation of UFBG Model

Analytical outcomes of three configurations are shown in Figure 18, 19, 20 and 21 describing the corresponding values of Q-Factor, BER, eye height and received power. All these results are iterated at various input powers from 1-10dBm. When these graphs are evaluated, it is observed that Q-Factor in post configurations grows linearly with the extension in the power level at input. Similarly, there is significant decay in the bit error rate of post configuration as the input power increases. Thus, getting the esteem value of Q-Factor equals to 27.54 and least value of BER equals to $1.95 E^{-16}$.

Figure 18: Plot of Q-Factor Vs Power

Figure 19: Plot of BER Vs Power

Figure 20: Plot of Eye Height Vs Power

Figure 21: Plot of Received Power Vs Power

- **Simulation Setup for Hybrid Model:** A Hybrid approach is introduced to provide compensation of chromatic dispersion for transmission of signal over 120Km of distance at 100Gbps rate. Block diagram of this approach is

shown in Figure 22. It consists of UFBG along with EDC. Simulation modal of this proposed modal is described in Figure 23 along with its simulation parameters in tabular form in Table- 5.

Figure 22: Hybrid Model Block Diagram

Table 5: Simulation Parameters for Hybrid Model

Components	Parameters	Value/Units
Uniform FBG	Frequency	193.1 THz
	Noise Threshold	-100dB
	Bandwidth	1 THz
EDC	Bit Rate	100Gbps
	Step Size	0.3
	Maximum Amplitude	1
	Minimum Amplitude	0
	Length	120 Km
SMF	Dispersion	0.01ps/nm/km
	Attenuation	0.2dB/Km

Figure 23: Simulation Model for Proposed Hybrid Model

Hybrid approach for the mitigation of dispersion is analyzed for Q-Factor, bit error rate, received power and eye height in Figure 24, 25, 26 and 27, respectively. Graphical analysis is done to get the outcomes at input launch power of 1-10dBm. From Graphs, it can be seen that as the input power level increases, the corresponding value of Q-Factor also grows linearly. In case of bit error rate, this value of BER decreases with the significant increase in input power, thereby, meeting the requirement of least BER and higher Q-Factor.

Figure 24: Plot of Q-Factor Vs Power

Figure 25: Plot of BER Vs Power

Figure 26: Plot of Received Power Vs Power

Figure 27: Plot of Eye Height Vs Power

IV. RESULTS AND DISCUSSIONS

In order to determine the best compensation technique for chromatic dispersion, three existing method of compensation that are DCF, IDCFBG and UFBG are compared with the proposed Hybrid model. This paper compares the values of Q-Factor, bit error rate and other relating outcomes of three techniques with Hybrid approach. Figure 28, 29, 30 and 31 are showing the comparison of DCF, IDCFBG, UFBG with proposed Hybrid model in terms of Q-Factor, BER, received power and eye height.

Figure 28: Comparison of Q-Factor

Figure 29: Comparison of BER

Figure 30: Comparison of Received Power

Figure 31: Comparison of Eye Height

As it can be seen from the graph shown in Figure 28, the corresponding values of quality factor tends to rise in all compensation techniques, but quality factor in Hybrid model reaches at maximum value of 37.12 at 10dBm power when compared with DCF, IDCFBG and UFBG. Similar analysis is done in case of BER. It is found that Hybrid model wins the title of least bit error of $4.84 E^{-302}$ in comparison with other methods. Thus, the combined effect of all the factors of all the techniques is described in tabular form in Table- 6. Hence, the final outcome analysis shows the Hybrid model to be the best in order to compensate chromatic dispersion.

Table 6: Comparison Table of Optimum Existing Chromatic Dispersion Compensation Methods with Hybrid Model

Compensation	Iterations	Q-Factor	BER	Received Power (dBm)	Eye Height
DCF(Post compensation)	1	6.8305	1.04E-12	-42.5	0.000186
	2	7.46805	3.91E-14	-40.647	0.00025
	3	8.11492	2.40E-16	-38.74	0.0003316
	4	8.80386	6.56E-19	-36.8	0.0004352
	5	9.33	5.20E-21	-34.85	0.0005621
	6	9.8	5.31E-23	-32.88	0.000722
	7	10.11	2.42E-24	-30.9	0.000917
	8	10.14	1.73E-24	-28.92	0.00115
	9	9.84	3.46E-23	-26.93	0.00142
	10	9.2	1.69E-20	-24.954	0.00173
IDCFBG(Post compensation)	1	6.2989	1.48209E-10	-39.957	0.0002255
	2	6.81376	4.7295E-12	-37.969	0.000303981
	3	7.31658	1.27011E-13	-35.978	0.0004038
	4	7.87031	1.7688E-15	-33.983	0.0005343
	5	8.37922	2.66181E-17	-31.988	0.0006996
	6	8.94922	1.7833E-19	-29.98	0.0009152
	7	9.43164	2.00538E-21	-27.99	0.00118621
	8	9.86961	2.17948E-23	-25.99	0.00152983
	9	10.1927	1.06085E-24	-23.99	0.00196169
	10	10.2168	8.31665E-25	-21.99	0.002486
C	1	10.5753	1.56102E-26	-39.619	0.00036
	2	11.913	4.0412E-33	-37.63	0.0004752
	3	13.369	3.5465E-41	-35.637	0.0006205
	4	14.9508	5.967E-51	-33.642	0.0008056
	5	16.663	9.121E-63	-31.645	0.00104

Table 6: Contd.,					
	6	18.512	6.1148E-77	-29.64	0.00133935
	7	20.5079	6.6143E-94	-27.649	0.001718
	8	22.6786	2.5457E-114	-25.649	0.002197
	9	25.028	1.0408E-138	-23.647	0.002805
	10	27.54	1.95E-167	-21.646	0.00357
Hybrid Model	1	14.48	7.75E-48	26.494	0.78
	2	16.69	7.40E-63	26.488	0.81
	3	18.84	1.56E-79	26.481	0.83
	4	21.01	2.58E-98	26.472	0.85
	5	23.22	1.33E-119	26.463	0.87
	6	25.51	6.30E-144	26.457	0.88
	7	27.96	2.40E-172	26.45	0.89
	8	30.64	1.52E-206	26.444	0.9
	9	33.66	8.45E-249	26.438	0.91
	10	37.12	4.84E-302	26.434	0.92

V. CONCLUSIONS

This paper introduces a new technique for the compensation of chromatic dispersion at a higher bit rate of 100Gbps over a SMF of 120Km. The approach known as Hybrid approach provides a significant growth in the Q-Factor of the signal when compared with other existing methods, which is the desired factor for high capacity long distance transmission optical communication system. In the same way, it provides a least BER, thereby, making its performance to be superior at higher bit rates. This paper concluded the use of Hybrid approach, introduced first time in this paper to limit the impact of dispersion in fiber optics.

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