Investigation of Dispersion Compensation Methods for the Data Rates of 2.5 and 10 Gbps Using Standard and Dispersion Compensated Fibers

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Abstract: We have investigated pre-, post-, and symmetry dispersion compensation methods for the data rates of 2.5 and 10 Gbps using standard and dispersion compensated fibers using optisystem. The performance characteristics like bit error rate (BER), eye diagrams, Q factor of the received signal is studied by different system configurations. The results of three compensation methods have been compared and it is found that the symmetrical compensation method is superior to pre and post compensation methods.

Index Terms - Dispersion Compensation, EDFA, DCF

I. INTROCDUCTION

Due to the dependence of speed of information carrying signal on the refractive index of the fiber which depends on the wavelength of the signal carrying information, different signals having different wavelengths reach the output of the fiber at different times as in case of multimode fiber [1]. Even in a single mode fiber the information carrying signal does not consist of a single wavelength rather a continuous group of wavelengths called the spectral width of transmitting source. These wavelengths experience deferent refractive index and hence travel with different velocities and reach output of the fiber at different time causing the pulse spreading [2-4]. Now if the data rate of the information signal is increased, the pulse at the output may overlap with each other. These causes inter symbolic interference (ISI). Due to inter symbolic interference we cannot increase the data rate of the fiber optic communication link. Thus in order to achieve high data rates, dispersion compensation is the most important requirement in fiber optic communication link [5-6].

II. LAYOUT AND PARAMETER SETTINGS

A transmitter is a core equipment of the fiber optic transmitter consisting of laser, electrical pulse generator and the optical modulator. The channel is composed of single mode fiber. An optical receiver is composed of PIN Photo detector, Bessel low pass filter and BER analyzer. Dispersion parameter D is given in ps/nm/km for different fiber used. It is also a function of wavelength. Typical value of D is about 16 ps/nm/km in the 1.55 μm wavelength for a standard single mode fiber (SMF). Fig.1. is the layout of the simulation for symmetric dispersion compensation technique. The layout of pre- and post- dispersion compensation techniques are not shown here.

For externally modulated sources, transmission distance limited by chromatic dispersion is-

$$L < \frac{2\pi c}{16|D|\lambda^2 B_T^2} \qquad (1)$$

Where L is length of fiber in km, c is speed of light (m/s), λ is wavelength in meter, B_T is Bit rate in Gbps [7]. Fiber length used satisfies the condition as indicated by equation -1.

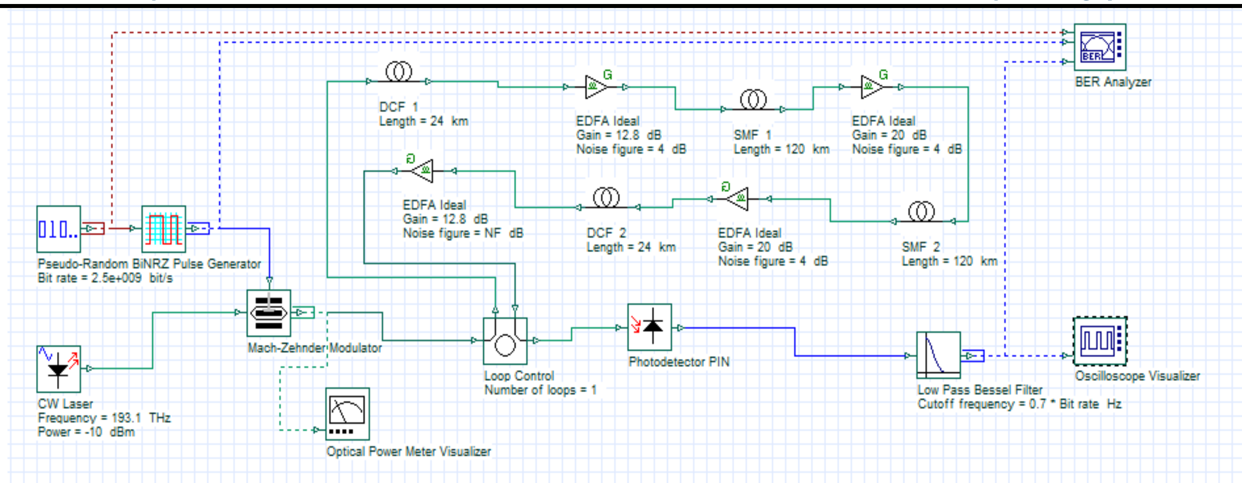

Fig.1. Simulation Layout- Symmetrical- Disperssion Compensation

Dispersion compensating fiber (DCF) is used before transmission fiber and amplifier combination in pre-dispersion compensation technique. In post-dispersion compensation technique DCF is placed after the transmission fiber and amplifier combination and in case of symmetric-compensation technique two DCFs are used, one before and another after the transmission fiber and the amplifier combination.

Optical amplifiers are used after each fiber to compensate for the propagation loss. The dispersion parameter of SMF 16ps/nm/km. Total accumulated dispersion is 16x120=1920ps/nm for 120 km length. This much dispersion can be compensated by using a 24 km long DCF with 80 ps/nm/km dispersion. Total transmission distance is used is 240 km for each cases. SMF attenuation 0.2 dB/km and DCF attenuation 0.6dB/km.

III. RESULTS AND DISCUSSION

The performance of the system for 2.5 and for 10 Gbps data rate is evaluated on the basis of BER and Q factor.

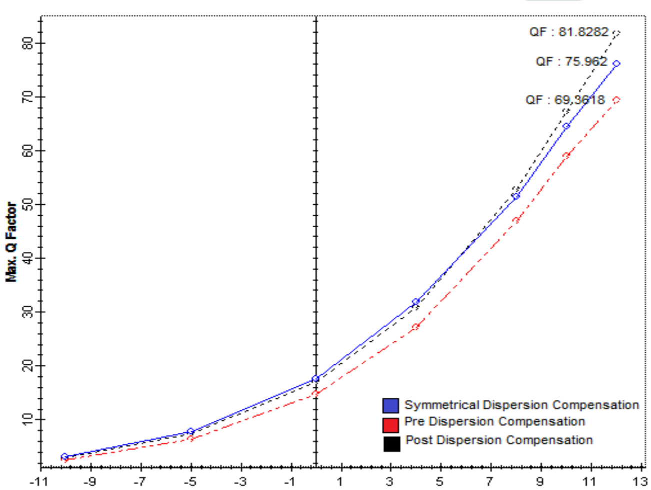

Fig. 2. Q factor vs signal power plot at 2.5 Gbps

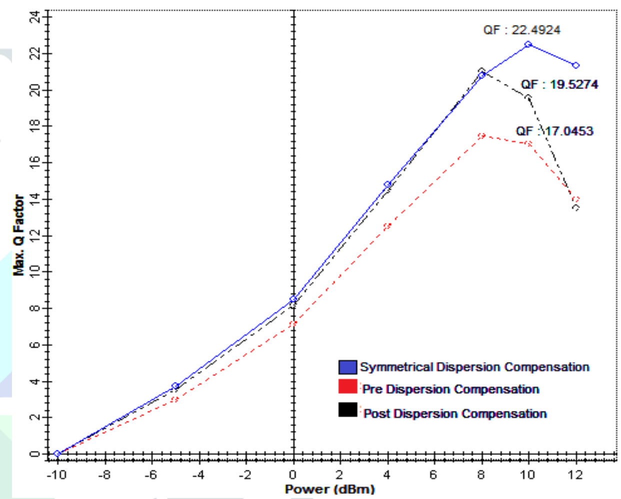

Fig. 3. Q factor vs signal power plot at 10 Gbps

The performance of the system is evaluated using the parameters, BER and Q factor with pre, post and symmetry compensation technique using DCF for 2.5 and 10 Gbps data rate. A receiver is said to be more sensitive if it achieves the same performance with less optical power on it. Fig. 2 and Fig. 3, show Q factor of received signal versus transmitted signal power for these schemes at 2.5 Gbps and 10 Gbps data rate respectively. When Q factor improves BER also improves. As evident from Fig. 2, with the increase of signal power post compensation scheme gives better performance compared to pre- and symmetric compensation schemes.

Increase of data rate from 2.5 to 10 Gbps, Q factor decreases with the increase of the signal power and an abrupt decrease of Q factor is occurred for post compensation scheme, which is depicted in Fig. 3. It also shows that the symmetry compensation scheme is the best one compared to the post and pre compensation cases. At 2.5 Gbps, the dispersion compensation scheme is much better at 10 dBm than what is at -5 dBm. It has also a better eye diagram shape and larger Q factor. But dispersion compensation scheme is better at 8 dBm than at -5 dBm when data rate is enhanced to 10 Gbps.
Fig. 5 to Fig., 7. show the Eye diagrams of symmetric-, post- and pre- compensation techniques for input power levels of -5

dBm and 10 dBm at data rate 10 Gbps. Fig. 8 shows the Eye diagram for three schemes at input power level of 12 dBm and data rate of 2.5 Gbps. Performance parameters values are summarized in Table 1 and Table 2 for the data rate of 10 Gbps and 2.5 Gbps respectively.

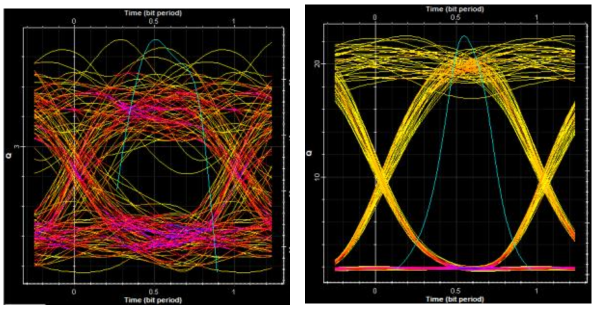

Fig. 5. Eye diagram Symm.DC scheme at 10 Gbps for -5 & 10 dBm laser power

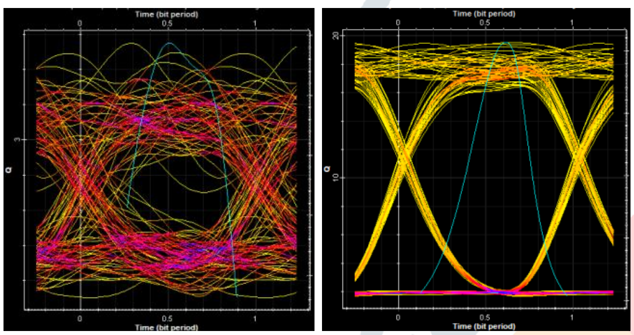

Fig. 6. Eye diagram Post .DC scheme at 10 Gbps for -5 & 10 dBm laser power

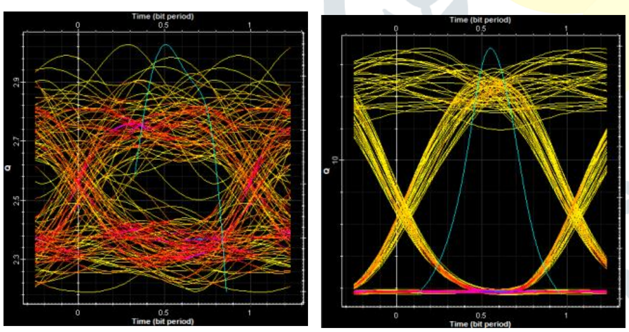

Fig. 7. Eye diagram Pre DC scheme at 10 Gbps for -5 & 10 dBm laser power

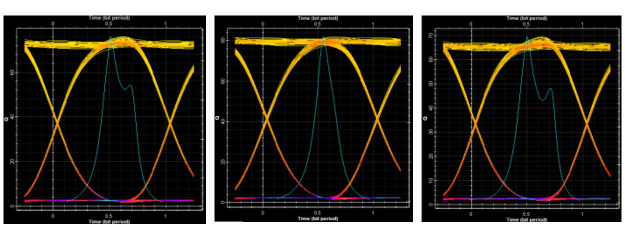

Fig. 8. Eye diagram Pre, Post & Symmetrical Dispersion Compensation schemes at 2.5 Gbps for 12dBm power

Table 1. Dispersion Compensation at 10Gbps system

10Gbps						
Compensation Schemes	Q Factor for input power level			Eye Height for input power level		
	10 dBm	**4 dBm**	**-5dBm**	**10 dBm**	**4 dBm**	**-5dBm**
Symmetrical	22.49	14.79	3.72	0.000672892	0.000151104	4.45E-06
Pre	17.05	12.51	3.03	0.000651984	0.000144797	2.07E-07
Post	19.53	14.48	3.54	0.000604506	0.000146852	3.56E-06

Table 2. Dispersion Compensation at 2.5Gbps system

2.5Gbps						
Compensation	Q Factor for input power level			Eye Height for input power level		
Schemes	**10 dBm**	**4 dBm**	**-5dBm**	**10 dBm**	**4 dBm**	**-5dBm**
Symmetrical	64.52	31.93	7.75	0.000724576	0.000172875	1.48E-05
Pre	58.92	27.25	6.36	0.000722059	0.000169969	1.27E-05
Post	67.20	30.82	7.43	0.00072294	0.000172035	1.44E-05

It can be shown that as the length of fibers are increased, the eye opening reduces. The eye opening for the post compensation method is better than the pre compensation method. For pre compensation method, the deterioration is so large that further increase in length is not feasible. From the analysis it can be concluded that the best performance is obtained by using symmetrical dispersion compensation for high data rate and low input signal power compared to other two schemes.

CONCLUSION

In this work, three compensation techniques using dispersion compensation fiber is analyzed. Performance parameters such as Q-factor, Min BER, eye Height etc. are evaluated for these three dispersion compensation schemes. Based on the analysis it is observed that performance of the symmetry dispersion compensation is much better than the other two methods. Eye diagram shows better value of threshold and eye height which alternatively results in reduced and improved synchronization in optical fiber communication networks. The symmetrical compensation has the best performance followed by post- and pre-compensation. In high data rate (40 Gbps) long-haul transmission systems, dispersion compensation is one of the most important areas which may be considered for future study.

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