SIMULATION AND PERFORMANCE ANALYSIS OF DISPERSION COMPENSATION USING DCF IN PRE, POST AND SYMMETRICAL ARRANGEMENT FOR 40GBPS DWDM NETWORK

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Abstract - *Nowadays communication plays a very important role in our day to day life. The most feasible and efficient method for data transmission and reception is through the optical fiber. Even though there are many merits of communication through optical fiber like higher data rate low loss etc but still some bottlenecks are present which limits the performance of a optical communication link. Through this article we are trying to grab your attention towards one of the major cause of loss of information i,e Dispersion, its type, Dispersion compensation techniques, Dispersion Compensating Fiber(DCF), and a comparison between pre, post and symmetrical dispersion compensation technique in a 8 channel WDM network. We have used Optisystem 14.0 simulator to compare these three compensating techniques on the basis of BER , Q factor, eye diagram by keeping bit rate constant i.e., 40Gbps and by varying distance.*

Key Words: Optical fiber, Dispersion , DCF, BER, Q-factor, eye height, optisystem 14.0,

1. INTRODUCTION

Everywhere on this planet hair-thin optical fibers carry vast quantities of information from place to place. There are many desirable properties of optical fibers for carrying this information. They have enormous information-carrying capacity, are low cost, and possess immunity from the many disturbances that can afflict electrical wires and wireless communication links. Optical fibers have played a key role in making possible the extraordinary growth in world-wide communications that has occurred in the last 25 years, and are vital in enabling the proliferating use of the Internet.

Fiber optics communication is preferred because of low cost, high transmission speed, less maintenance required and etc. but problems like attenuation, dispersion, non-linear effects which leads to decrease in performance of the optical fiber. Attenuation and dispersion limit the performance of optical fiber as data transmission channel. Attenuation, associated with losses of various kinds, limits the magnitude of optical power transmitted. Dispersion, which is responsible for temporal spread of optical pulses, limits the rate at which such data-carrying pulses may be transmitted.

Due to the rising population the number of users is increasing day by day. To fulfill the requirement of this rising population the system has to be more efficient. The efficiency can be increased by the help of WDM (Wavelength Division Multiplexing). In this technology the number of wavelength are combined onto the same fiber which increases the capacity of the fiber network dramatically. WDM network is also affected by dispersion, attenuation non linear effects. Amplifiers are used to amplify the transmitted signal and to reduce the loss.

The optical fiber communication system consists of 3 sections and they are transmitter section, medium and the receiver section. The medium mainly contains optical fiber and optical amplifier. The light signal travels in the optical fiber, while passing through the fiber it faces dispersion. Dispersion keeps on increasing along the length of the optical fiber. In this paper we have discussed about dispersion and dispersion management using DCF.

2. DISPERSION

The broadening of light signal while transmission along the optical fiber is called as dispersion. The dispersion effect spread the output pulse in time domain and change its shape. It limits the bandwidth or the information carrying capacity of a fiber.

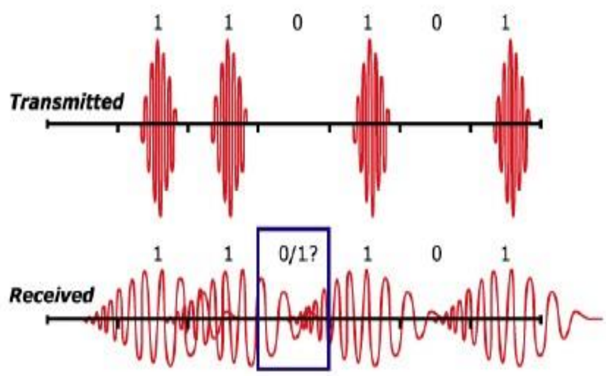


Fig. a-Dispersion

Generally, there are three types of dispersion:

1. Modal Dispersion
2. Chromatic Dispersion
3. Polarization mode Dispersion

Modal dispersion is of 2 types i.e., intra-modal dispersion and inter-modal dispersion.

Inter-modal dispersion: It occur in multimode fiber, where the incoming light signal has different modes of propagation. Each wave hence will reach at different time at the exit and will cause dispersion

Intra-modal dispersion: It can be defined as in single mode optical fiber different colour of light travel at different speed in different material in various waveguide structure. Hence light will exit at different time for each colour, hence causing dispersion. It is further divided into 2 types i.e., material dispersion and waveguide dispersion.

- Material dispersion depends on the wavelength of the fiber material refractive index whereas waveguide dispersion depends on the fiber geometry and refractive index profile.
- Chromatic dispersion can be defined as the spreading of light pulse as it travels through a optical fiber when light pulses launched close together spreads and result in loss of information.

Polarization mode dispersion occurs due to the presence of both orthogonally and vertically polarized component of the fundamental fiber mode in the signal.

3. DISPERSION COMPENSATING TECHNIQUE:-

There are several techniques to reduce dispersion. They are –

1. Dispersion compensating fiber (DCF)
2. Fiber Bragg Grating (FBG)
3. Optical filters
4. Optical phase conjugation technique

3.1 DISPERSION COMPENSATING FIBERS (DCFs):-

The idea of Dispersion compensating fiber was proposed in 1980s. It is a suitable way to compensate dispersion because the components of DCF are more stable, as it does not easily get affected by temperature, wide bandwidth and etc. Dispersion compensating fibers have a high negative dispersion coefficient and can be used to compensate the positive dispersion coefficient of optical fiber. This technique is used in long-haul WDM communication system.

The length of DCF can be calculated by:

$$D_{SMF} \times L_{SMF} = -D_{DCF} \times L_{DCF}$$

There are 3 compensation schemes to compensate dispersion-

Pre-compensation
Post-compensation
Symmetrical-compensation

PRE-COMPENSATION SCHEME:

In Pre compensation scheme, DCF is present before the standard optical fiber (SMF) to compensate the positive dispersion of the standard fiber.

POST-COMPENSATION SCHEME:

In Post compensation scheme, DCF is placed after standard optical fiber (SMF) to compensate the positive dispersion of the standard fiber.

SYMMETRIC-COMPENSATION SCHEME:

In Symmetrical compensation scheme, both the schemes are used ie., DCF is placed before as well as after Standard optical fiber to compensate the positive dispersion of the standard fiber.

4. SIMULATION SETUP

Here for designing 8 channel WDM, we have used optisystem 14.0 software .It is an efficient and reliable software which can be used to calculate the performance of the simulation setup.

The setup has 3 sections, they are transmitter section, medium for transmission and receiver section.

The transmitter section consists of pseudo random bit sequence generator, NRZ pulse generator, CW laser and Mach-Zehnder modulator. The pseudo random bit sequence generator has a bit rate of 8□□□□□□Gbps for generation of pulses. NRZ pulse generator is used for line coding. CW laser having power=0dbm is used and frequency at each channel vary from 193.1 to 193.8 Thz followed by Mach-Zehnder modulator. Then the transmitted signal is passed through a MUX having 8x1 channel and after getting multiplexed the signal is passed through a transmitting medium.

The medium consists of DCF, optical fiber, amplifiers (EDFA having a length of 5m) to amplify the signal and also to overcome the attenuation whenever required. After passing the signal through the medium it is again passed through the WDM DEMUX where demultiplexing takes place.

The last section is the receiver section which consists of optical receiver and BER analyzer. By the help of BER analyzer we can get the graph of the whole setup.

4.1. Simulation parameters:-

SL NO.	PARAMETERS	VALUES
1	Bit Rate	40Gbps
2	Sequence Length	128 bits
3	Power	0dbm
4	Samples per bit	64

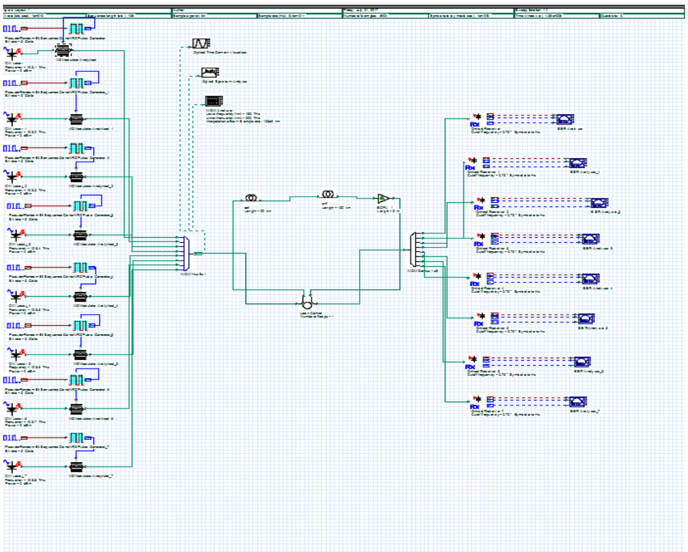


Fig. b : Optisystem 14.0 simulation setup(PRE)

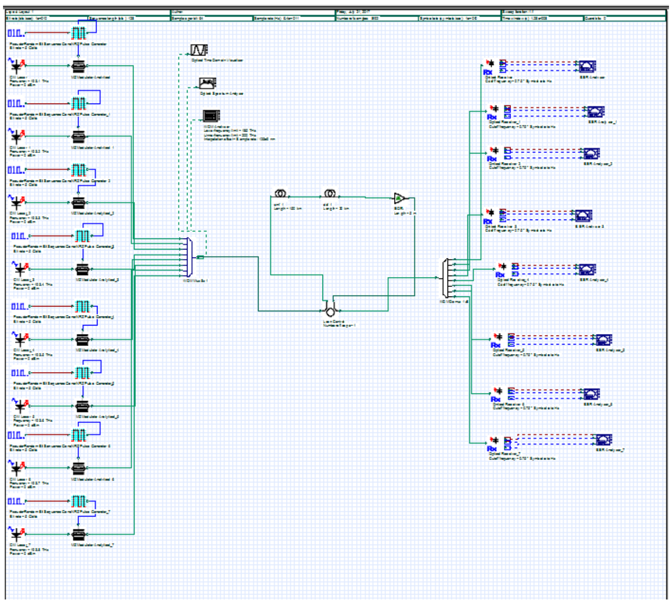


Fig. c : Optisystem 14.0 simulation setup(POST)

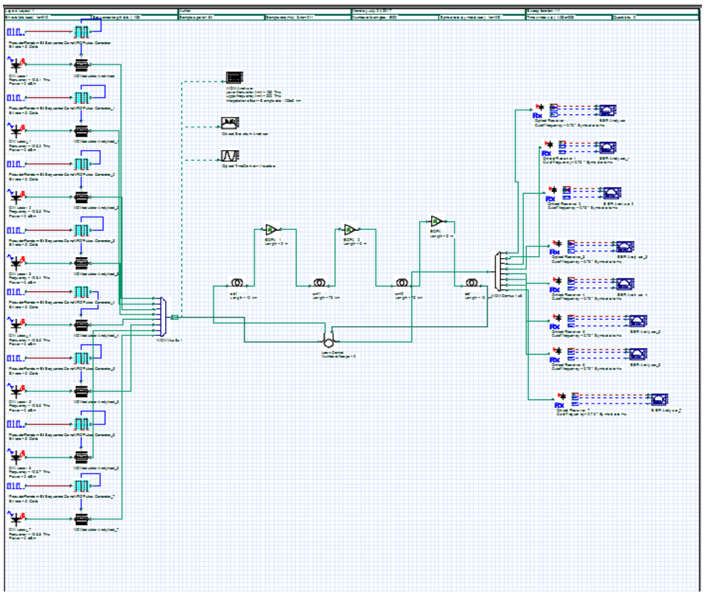


Fig.d:Optisystem14.0 simulation setup(SYMMETRICAL)

In pre-compensation technique when we transmitted signal to 150(20+130)km and at 40 Gbps we found that the Q-factor at channel 1 is 7.003 and at channel 8 is 7.31 . So here the transmitted signal can easily be recovered at the receiver end. But when we transmitted signal to 160(20+140)km at the same 40 Gbps we found that at channel 1 is 6.69 and at channel 8 is 6.67 which is little less than the standard value of Q factor. Hence the original transmitted signal may not be recovered at the receiving end.

LENGTH (DCF+SMF) (km)	Q-FACTOR		EER		EYE HEIGHT		THRESHOLD	
	CH-1	CH-8	CH-1	CH-8	CH-1	CH-8	CH-1	CH-8
20+130 - 150	7.003	7.31	8.896e-013	8.51665e-014	0.0014320	0.00186958	0.00037948	0.00049081
20+140 - 160	6.69	6.77	8.3008e-013	2.2731e-011	0.0009450	0.0011794	0.000259	0.00033827

TABLE 1. FOR PRE-COMPENSATION TECHNIQUE

In post-compensation technique when the signal is transmitted to a distance of 160(20+140)km at 40 Gbps it was found that the Q-factor is 7.29 at channel 1 and at channel 8 the Q-factor is 7.1. But when the signal is transmitted to a distance 170(20+150)km it was found that the Q-factor at channel 1 is 6.69 and at channel 8 is

5.9254 which is again quite less as compared to the standard value of Q Factor. so at the receiver end the transmitted signal mayn't be easily recovered.

LENGTH (DCF +SMF)km)	Q-FACTOR		BER		EYE HEIGHT		THRESHOLD	
	CH-1	CH-8	CH-1	CH-8	CH-1	CH-8	CH-1	CH-8
20+130-150	7.29	7.1	1.10648e-013	1.0521e-013	0.0010101 5	0.010256	0.0002481 8	0.0032106
20+140-160	6.69	5.9254	4.2885e-010	9.10077e-010	0.0001647	0.000731	0.0001647	0.0001919 9

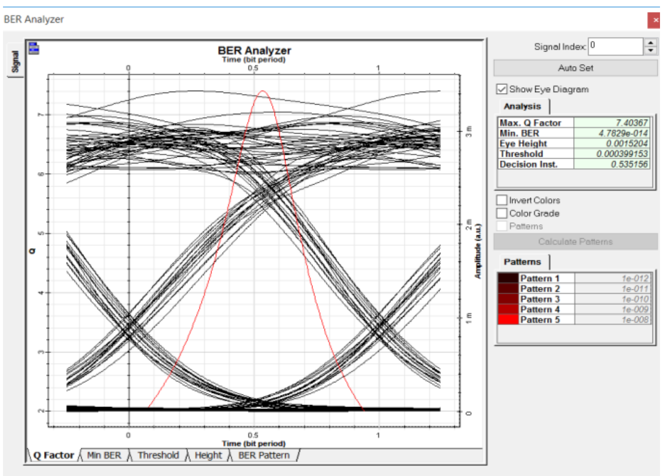
TABLE 2. FOR POST-COMPENSATION TECHNIQUE:

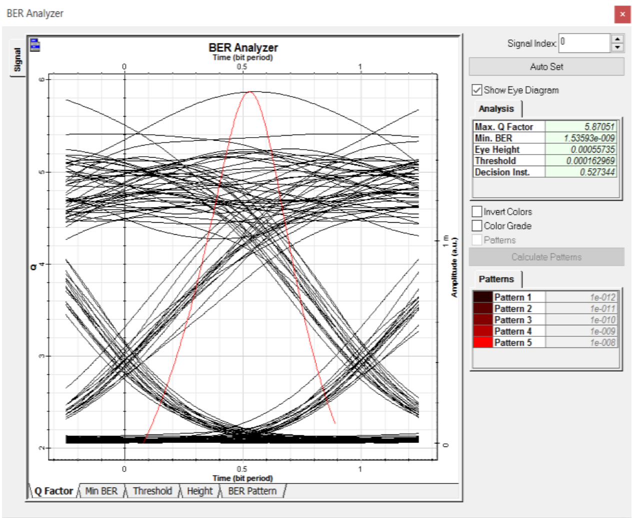
In symmetrical compensation scheme we transmitted the signal to 170(20+150)km at 40 Gbps and we found that the Q-factor is 8.33 at channel 1 and 8.328 at channel 8.

LENGTH (DCF +SMF)(in km)	Q-FACTOR		BER		EYE HEIGHT		THRESHOLD	
	CH-1	CH-8	CH-1	CH-8	CH-1	CH-8	CH-1	CH-8
20+130-150	8.33	8.328	3.10895e-017	2.5664e-017	0.0005748	0.000573271	0.0013944	0.000128284

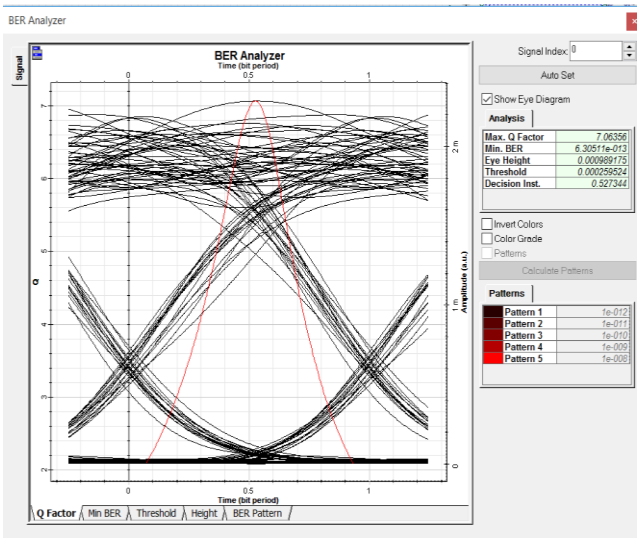
TABLE 3. FOR SYMMETRIC-COMPENSATION TECHNIQUE:

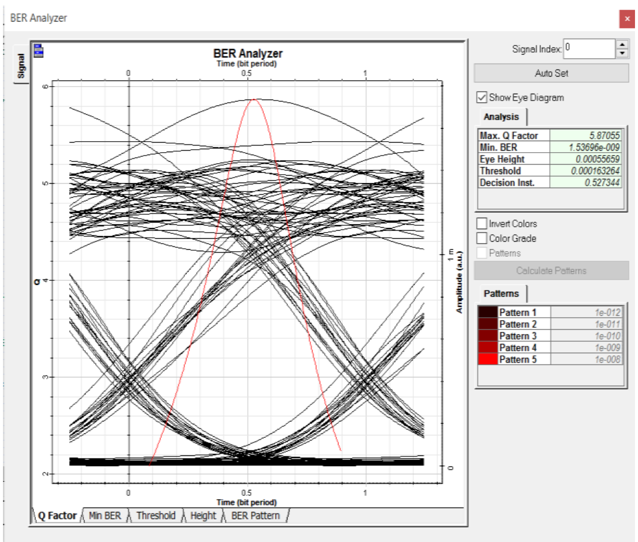
EYE DIAGRAM PRECOMPENSATION SCHEME :



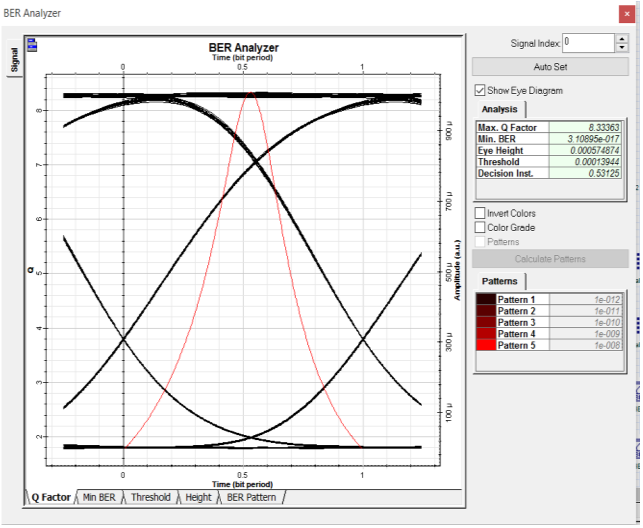


EYE DIAGRAM POST COMPENSATION SCHEME :





EYE DIAGRAM SYMMETRIC- COMPENSATION SCHEME:



5. CONCLUSIONS

In this paper we have analyzed 8 channel WDM system at 40Gbps for different types dispersion compensation scheme using pre , post and symmetrical DCF . For a system to work efficiently the Q-factor must lie above 7dB and the eye opening should be wider . From the above observations we found that by the help pre-compensation scheme we can transmit up to 150km. In case of post-compensation a transmission up to a distance of 160km was achieved. In symmetrical compensation scheme when the signal is transmitted to a distance of 170km a Q-factor of 8.333 was achieved which is far better than the Q Factor of pre & Post compensation set up. It can be observed that symmetrical compensation gives a better performance than pre and post DCF technique. The performance of this setup can be further enhanced by considering different modulation formats and varying the input power.

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