# Analysis on Dispersion Compensation with DCF based on Optisystem-A Review

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**Abstract:** The most commonly used dispersion compensation fiber (DCF) technology is studied. Three schemes (Pre-compensation.post-compensation, mix-compensation of Dispersion Compensation methods for 40 Gb/s non-return to Zero link using standard and dispersion compensated fiber through FBG compensator to optimize high data rate optical transmission. Objectives is to increase the quality factor ,fiber length and better eye opening in eye diagram using different modulations techniques. The simulation results are validate by analyzing the Q-factor and Bit error Rate(BER) in the numericalsimulator. A fiber brag grating (FBG) is one of the most important and applicable component in an optical communication system. The use of chirped FBG has been studied as a dispersion compensator in an optical communication system. The simulation Results are validated by analyzing the Q-factor .According to test ,when Q=6,the BER is about 10-9; when Q=7,the BER is about 10-12.Input power is taken as 9-10 db,Thecorresponding BER is better. It is observed that the symmetrical-compensation scheme performs better than pre-,post –compensation schemes for 8x40 Gb/s wdm system.

**Keywords:**Dispersion compensation ,Fiber brag grating,EDFA,BER,DCF,wavelength division multiplexing

## 1. Introduction

The schemes (pre-compensation, post compensation ,mix compensation)of dispersion compensation with DCF is proposed. The demand for transmission Capacity and bandwidth becoming more and more challenging to the carriers and service suppliers, under the situation, with its huge bandwidth and excellent transmission performance, optical fiber is becoming the most favorable delivering media and laying more and more important role in information industry[1]. A FBG is a type of distributed bragg reflector constructed in a small segment of optical fiber that reflects particular wavelength of light and transmits all others.Loss and dispersion are the major factor that affect fiber –optical communication being the high- capacity devolps.The EDFA is the gigantic change happened in the fiber –optical communication system; the loss is no longer the major factor to restrict the dispersion value in that wave band is very big, about 15-20ps/(nm.km-1)[2,3].

## 2. Fiber optic dispersion on optical Transmissions

It is easy to see that the dispersion become the major factors that restrict long distance fiber-optical transfers. Dispersion is defined as because of the different frequency or mode of light pulse in fiber transmits at different rates, so that these frequency components or models receive the fiber terminals at different time[4]. It can Cause intolerable amounts of distortions that ultimately lead to errors. In single mode fiber performance is primarily limited by chromatic dispersion which occurs because the index of the glass varies slightly depending on the wavelength of the light, and light from real optical transmitters necessarily has non zero spectral width. Polarization mode dispersion another source of limitation occurs because although the single mode- fiber can sustain only one transverse mode, it can carry this mode with two different polarization, and slight imperfections, or distortions in a fiber can alter the propagation velocities for the two polarizations. This phenomenon is called birefringence. Modebirefringence $B_m$ is defined as the follow:

$$B_m = \frac{\beta x - \beta y}{k0} = n_x - n_y (1)$$

Where nx and ny in Eq.(1) are the effective refractive of the two orthogonal polarizations. For a given Bm, its fast axis and slow axis components will be formed the phase difference after the light waves transmission L Km[5]

$$\varphi = k_0 B_{mL} \frac{2\pi}{\lambda}(N_x - N_y) = (\beta_x - \beta_y)L \ (2)$$

If the Bm in Eq.(2)is a constant ,through the light waves in transmission process the phase difference between its fast axis and slow axis will periodicity repetition .the length that it leads to a phase difference of $2\pi$ or power periodic exchange is called polarization beat length[5]

$$L_B = \frac{2\pi}{\beta_x - \beta_y} = \frac{\lambda}{\beta m} (3)$$

If the incident light has two polarization components, due to refractive difference between the fast axis and slow axis,the transmit rate of two polarization components will be different. Degree of pulse broadening can be expressed by different group delay$\Delta\tau$.The influence of dispersion on system performance is also reflected in the optical fiber nonlinear effects. Dispersion Increased the Pulse shape distortion caused by the self- phase modulation dispersion (SPM); the other hand, dispersion in WDM system can also increase the cross-phase modulation (XPM), four-wave mixing and other nonlinear effects.[5]

To improve overall system performance and reduced as much as possible the transmission performance influenced by the dispersion, several dispersion compensation were proposed. The ones that appear to hold immediate promise for dispersion fiber brag grating (FBG), and high-order mode (HOM) fiber.

A FBG is a type of Distributed Bragg reflector constructed in a small segment of an optical fiber that reflects particular wavelengths of light and transits all other. This is achieved by producing a producing a periodic variation in the refractive index of the fiber core. Transmitted light in an FBG core which satisfies the brag conditions is resonated by grating structure and reflected. A FBG can therefore be used as an optical fiber to block certain wavelengths [6,7]. Thereflected wavelength changes with the gating period, broadening the reflected spectrum. The most important inclination of chirp FBG than other recommended types are small internal loses and cost efficiency.

## 3. FBG operation principle

Subsequent gratings selectively reflect transmitted light in fiber in fiber according to brag wavelength which is given as follow.[6,7]

$$\forall_B = 2n\forall (4)$$

Here n and $\forall$ in Eq.(4) are the refractive index of core and grating periods in fiber, respectively a uniform grating can be expressed as sinusoidal modulation of fiber core refractive index.

$$n(Z) = n_{core} + \delta n[1 + \cos\left(\frac{2z\pi}{\forall} + \varphi(z)\right)] (5)$$

$n_{core}$ in Eq.(5) is the refractive index when it is not radiated and $\delta n$ is amplitude if induce refractive index variations.[6,7]

**Table 1.**FBG parameters [6,7]

| Parameters | Values |
|---|---|
| Frequency (THz) | 193.1 |
| Effective refractive index | 1.45 |
| Length of Grating(mm) | 6 |
| Apodiazation Function | Tanh |
| Tanh parameters | 4 |
| Chirp function | Linear |

| | |
|---|---|
| Linear parameters | 0.0001 |

**Table 2**. Fiber parameters [6,7]

| Parameters | Values |
|---|---|
| Bit rate | 40 Gbps |
| Sequence length | 64 |
| Samples per bit | 256 |
| Central frequency of first channel | 192.3 THz |
| Channel spacing | 200 GHz |
| Capacity | 8x40 gbps |

In 2011,Luis M,Rui [6,7],in order to increase the information carrying capacity of an optical fiber communication system, wavelength division multiplexing (WDM) is one of the most efficient techniques used in optical communication system. [6,7]The transmission in WDM optical networks is affected by attenuation, chromaticdispersion, polarization mode dispersion and the fiber non –linear effects at high bit rate and power level. so optical amplifiers like Er-doped fiber amplifiers (EDFAs) are mostely used in optical fiber communication networks. Thedispersion compensated fiber can be connected in three configuration pre,post and symmetrical. We investigate the WDM system at 40 Gbps using DCF over 120 km of optical fiber and 24 km of DCF.

## 4.Dispersion compensating fibers (DCFs)

In 2014,Gurinder singh,Ameta and sukbir singh[8] proposed three different Dispersion compensation schemes depending upon the positions of DCF:
i.Pre –compensation
ii post-compensation
iii symmetrical-compensation
In pre-compensation scheme, the DCF is placed before the standard single mode fiber (SSMF) to compensate the positive dispersion in SSMF.
In post-compensation, the DCF is placed after the SSMF to compensate the positive dispersion in SSMF.
In symmetrical-compensation, both the schemes(pre-,post-compensation)are used i.e. DCF is placed before as well as after the SSMF toachieve the dispersion[8]

### 4.1. Transmitter Section:

The Transmitter section consists of data source, which produces a pseudo random sequence of bits at 40Gbps.NRZ pulse generator converts the binary data into electrical pulses that modulates the laser signal through the Mach-Zender (M-Z) modulator.[9,10]

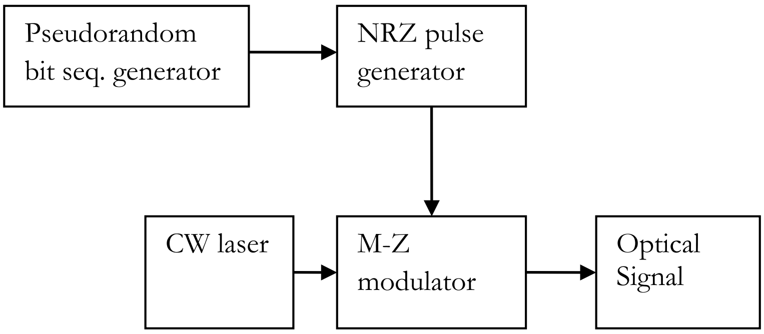


**Fig. 1.**Transmitter section [9,10]

### 4.2. ReceiverSection*:*

The1:8 demultiplexer is used to splits the signals to 8 different channels. The output of the demultiplexer is given to PIN photo detector and the passes through low pass electrical Bessel filter and 3R regenerator.[9,10]

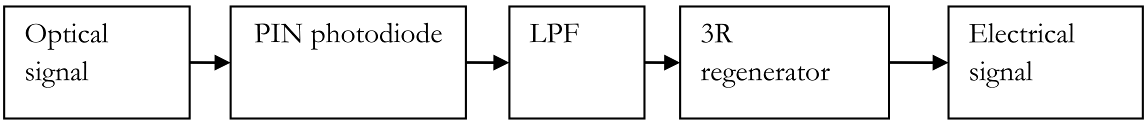


**Fig. 2.**Receiver section [9-11]

**Table 3**.Simulation parameters [12]

| Parameters | value |
|---|---|
| Bit rate | 40 Gbps |
| Sequence length | 64 |
| Sample per bit | 256 |
| Central frequency of first channel | 192.3Thz |
| Channel spacing | 200 GHz |
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**Table 4.** Fiber parameters [12]

| Parameters | SMF | DCF |
|---|---|---|
| Length(Km) | 120 | 24 |
| Attenuation(db/km) | 0.2 | 0.6 |
| Dispersion (ps/nm/km) | 17 | -8.0 |
| Differential slope (ps/$nm^2/km$) | 0.08 | 0.3 |
| Differential group delay(ps/km) | 0.5 | 0.5 |

**Table 5**.Three dispersion compensation scheme at different frequencies [12]

| | pre compensation | post compensations | Symmetrical compensation |
|---|---|---|---|
| Q-factor(db) | 8.78627 | 9.08408 | 9.87489 |
| BER | 4.32497e-019 | 3.91871e-020 | 2.33614e-023 |
| Eye height | 0.00418286 | 0.00400196 | 0.00410305 |

Table 5(a) At 192.3THz

| | | | |
|---|---|---|---|
| Q-factor(db) | 7.68547 | 10.0952 | 9.50989 |
| BER | 4.55109e-015 | 2.01069e-024 | 7.513e-022 |
| Eye height | 0.00461699 | 0.00515891 | 0.00494292 |

Table 5(b)At 192.5Thz

| | | | |
|---|---|---|---|
| Q-factor(db) | 7.13798 | 9.69011 | 11.6514 |
| BER | 2.72476e-013 | 1.16402e-022 | 6.62201e-029 |
| EYE height | 0.00420787 | 0.00515493 | 0.00589319 |

Table 5(c)At 193.7Thz

## 5. Conclusion

It is observed that the compensation schemes reduced the dispersion appropriately but among post compensation scheme reduced the accumulator fiber chromatic dispersion to the maximum possible extend. moderate lesser value of fiber Bragg grating dispersion and bigger value of laser average power is favorable to the performance of the transmission system. It can be understoodthat pulse was broadened and its power is increased as a result of increase in the chirp parameter which is the best volume. Wehave analyze the 8 channel WDM system at 40 Gbps for different dispersion compensation schemes using DCF.we observed that the symmetrical-compensation scheme performs better than the pre and post-compensations schemes.

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