ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 1, Issue 6, June 2012

# Optimization of DCF Length with Minimum BER using SMF

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***Abstract- In this report the analysis of optimum DCF Length for minimum bit error rate (BER) in SMF is done. With the aid of optsim simulation tool a DCF is employed with the proper variation in length to overcome the non linearity to get the minimum BER. Better performance was shown when the combination of SMF Length 90Km and DCF Length 12Km was chosen. At this particular value the minimum BER was obtained and maximum Q value was seen and Eye opening also helps to evaluate the system performance.***

*Index terms-* **DCF, BER, Q value, WDM, GVD and SMF.**

## I. INTRODUCTION

As the optical fiber transmission systems evolved to longer distances and higher bit rates, the linear effect of fibers, which is the attenuation and dispersion, becomes the important limiting factor. As for WDM (Wavelength Division Multiplexed) systems that transmit multiple wavelengths simultaneously even at higher bit rates and distances, the nonlinear effects in the fiber begin to present a serious limitation. The success of high bit rate long haul point-to-point optical transmission networks depends upon how best the linear and nonlinear effects are managed. These nonlinear effects can be managed through proper system design. By increasing information spectral efficiency, which can be done by increasing the channel bit rate, decreasing channel spacing or the combination of the both, the effect of fiber non linearity come to play even more decisive role. Fundamental investigations have been demonstrated that in optical communication system operating at 10 GB/s and above the use DCF is fundamental requirement for obtaining long transmission lengths without using of periodic regeneration of the signal [1]. Numerical and experimental studies gave first ideas about the design of appropriate passive dispersion management scheme for upgrading the existing SMF communication systems [2-4].High speed transmission over SMF at 1.55 µm suffers severely from nonlinearity and dispersion .The use of dispersion compensating fiber DCF has emerged the most practical techniques to compensate the chromatic dispersion in long haul optically amplified standard fiber transmission system. In this paper it is seen how the performance of WDM communication system has been evaluated in presence of non linear effect. The DCF compensating technique for SMF10Gb/s transmission system 0ver 120 km with minimum BER in SMF has been investigated.

## II. THEORETICAL CONSIDERATIONS

Fiber transmission is more challenging at higher bit rate than at 10Gbit/s. At high bit rate dispersion induces broadening of short pulses propagating in the fiber causes cross talk between adjacent time slots leading to errors when the communication distance increases beyond the dispersion length of the fiber. Excessive spreading will cause the bits to overflow their intended time slot and overlap adjacent bits. The receiver may then have difficulty in identifying the correct bits and interpret them, increasing the bit error rate. Actually at very high bit rate transmission fiber non linearity's is a critical factor that limits the transmission quality over the optical links. In a dispersion compensated link consisting of standard SMF and DCF is used, the input pulse first broaden due to propagation through SMF after propagating through such a fiber for a certain length $L_1$, we allow the pulse to propagate through wavelengths will now travel faster than the shorter wavelengths and the pulse will tend to reshape itself into its original form. This is the basic principle behind dispersion compensation in SMF is shown.

$$D_t = D_m + D_w = -\frac{2\pi c}{\lambda_0^2}\frac{d^2\beta}{d\omega^2}$$

**Thus' $d^2\beta/d\omega^2 < 0$ implies operation at $\lambda_0 > \lambda_z$ ($\lambda_z$ is the zero dispersion wavelength)**

During the propagation of a pulse through the fiber, the group velocity dispersion (GVD) changes the frequency across the pulse referred to as frequency chirp. The chirp depends on the sign of the dispersion parameter. If the dispersion coefficient parameter of the fiber is negative, the frequency increases across the pulse from the leading to the trailing edge that is referred to as the positive frequency chirp. On the other hand, the frequency chirp is negative, i.e., the frequency decreases across the pulse from the leading to the trailing edge if the dispersion coefficient parameter is positive. Therefore, the rate of pulse broadening in the fiber with negative dispersion coefficient parameter compared to that expected from the GVD alone. However, the broadening rate decreases during propagation in the fiber with positive dispersion coefficient parameter, as the two chirp contributions cancel each other [5]. In the dispersion management technique, consider the situation in which each optical pulse propagates through two fiber segments, the second of which is DCF. The condition for perfect dispersion compensation is [5-7].

$$D1L1+D2L2 = 0 \quad (1)$$

i.e., its length should be chosen to satisfy

$$L2 = -(D1/D2)\, L1 \quad (2)$$

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Where D1 and D2 are the fiber dispersions of SMF and DCF respectively, for practical reasons, L2 should be as small as possible. This is possible only if the DCF has a large negative value of D2.

## III. SIMULATION SET UP AND DESCRIPTION

In this Rsoft OptSim simulation software is used for this work which gives the environment almost the exact physical realization of a system. The simulation setup is shown in the Fig.1. This system consist of three major sections i.e., transmitter, fiber section and receiver section.

### *A. Transmitter section*

The transmitter consists of a pseudo random bit sequence generator (PRBS), which generate bit sequences at the rate of 10 GB/s. This bit sequence is fed to the non-return-to zero (NRZ) coder that produces an electrical NRZ coded signal. The pulses are then modulated with continuous wave (CW) laser radiation of wave length 1550 nm to obtain optical pulses. The modulator used here is the Mach-Zehnder modulator. It has two inputs, one for the laser diode and the other for the data from the channels. It converts the electrical signal into optical signal form.

**Table1. Length according to Q Value**

| SMF Length in Km(L1) | DCF Length in Km (L2) | Q value(db) | BER |
|---|---|---|---|
| 120 | 0 | 6.020600 | 0.0227501 |
| 110 | 4 | 9.609026 | 0.0010898 |
| 100 | 8 | 15.048067 | 1.16942e-005 |
| 90 | 12 | 22.585528 | 4.97521e-040 |
| 80 | 16 | 6.020600 | 0.0227501 |
| 70 | 20 | 6.020600 | 0.0227501 |

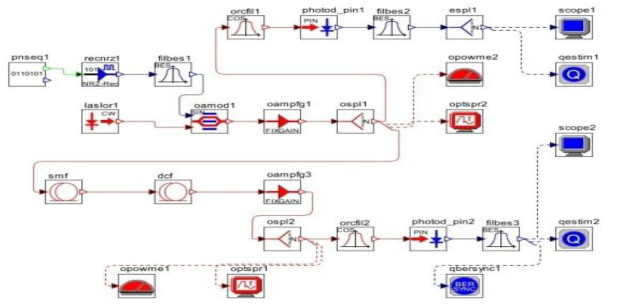


**Fig .1 Simulation setup**

### *B. Fiber section*

The optical signal is fed into the fiber. The 120 km fiber span consists of two segments, SMF of length L1 km and DCF of length L2 km. L1 and L2 are kept variables. The fiber parameters are adjusted according to the simulation environment and given in Table.1

### *C. Receiver section*

At the output of the optical filter, a photodiode converts the optical signal into an electrical signal. An electrical low pass Bessel filter follows the photodiode. This has a cut-off frequency determined by the type of the waveform used for modulation. Finally at the output OptSim provides a visualization tool called Scope. It is an optical or electrical oscilloscope with numerous data processing options, eye display and BER estimation

**Table 2.Fiber parameters**

| Parameter | SMF | DCF |
|---|---|---|
| Fiber length (km) | 120 70(L1) | 0-20(L2) |
| Fiber dispersion D (Ps/nm/km) | 17 | −95 |
| Effective core area Aeff (μm2) | 80 | 12.0 |
| Dispersion slope (Ps/nm2/km) | 0.08 | −0.1 |
| Nonlinear refractive index N2 (×10-20) | 2.5 | 2.5 |
| Attenuation α (dB/km) | 0.25 | 0.62 |
| PMD coefficient Ps/ √km | 0.5 | 0.1 |

## IV. RESULTS AND DISCUSSION

The performance of WDM optical transmission system was in terms of BER, Q value and eye diagrams. In this work transmission link composed of SMF of length L1 and DCF L2 at input power 1dbm is employed to determine the effects. In order to optimize the DCF length for minimum BER in SMF we monitor the eye diagrams and Q value with varied SMF and DCF lengths. Fig 4 show the eye diagram of the compensation scheme with SMF length L1 varied from 0 to 20 km .The wide eye opening for L1=90 and L2 =12 km indicates the better performance at this combination. Table 2 Variation of Q value and BER with SMF-DCF length is given in the given fig 2 and 3 shows miminum bit error rate (BER) and maximum Q value with SMF –DCF Length.The minimum BER is 4.97521e-040 and maximum Q value is 22.525528 at DCF (L1 12) at given SMF( L2 90) Figure 4(a) shows Eye Diagram for given DCF length L2 (12) for given length in between SMFL 1(90).The Eye opening is 0.0448734 and Eye closing is 0.665888

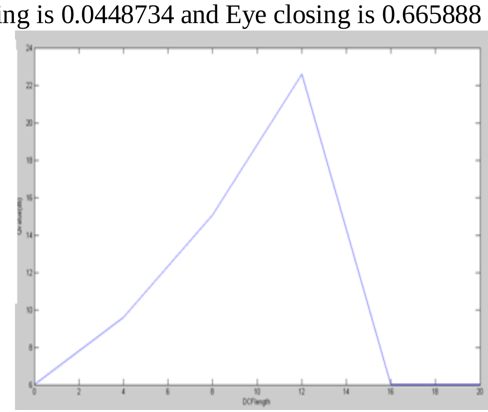

**Fig: 2 Q value Vs DCF length**

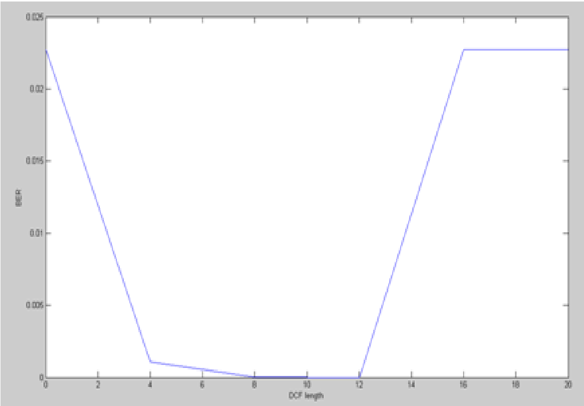

**Fig 3: BER Vs DCF length**

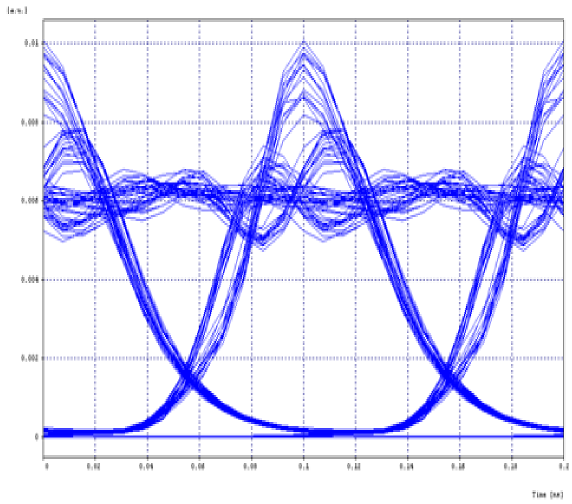

**Fig 4: Eye Diagram**

## V. CONCLUSION

In this report after comparing all the results and characteristics of system we have analyze that with proper usage of the DCF length between (0-20km) and SMF (0 -120km) lengths has been taken and it has concluded that SMF of length L1 90Km and DCF Length L2 12Km depicts the better BER and Q value which satisfies the dispersion management condition given by equation (1) and (2) and shows the maximum performance. The BER, Q value and Eye diagram technique have been evolved as good means for evaluating system performance in the present work.

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