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Chromatic Dispersion Compensation and Comparative Analysis of the Performance of RZ and NRZ Modulation Formats for the Long Haul Communication

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ABSTRACT

Optical Fiber communication technology is constantly growing because of the growth of demand that are high data and bandwidth. In long haul communication losses severely degrade the signal [2,6]. There are various types of losses in optical communication such as, linear losses and non linear losses [1,7]. Here we work on the linear losses such as attenuation, dispersion etc [4,8,9]. we design a simulation model for long haul communication and simulate the model for the results in the form of quality factor (Q Factor) and bit error rate (BER) on the different modulation formats such as RZ (return to zero) and NRZ (not return to zero). The key system parameters are modulation format, duty cycle, input power, amplifier span length and the range of the FBG bandwidth. The optimal parameter shows that the simulated model improves the transmission performance.

Index Terms:— *Attenuation, Dispersion, Long haul, RZ and NRZ modulation format, Duty cycle, Span length, Q Factor, Bit Error Rate (BER).*

I. INTRODUCTION

In long haul communication the optical signal travels longer distance (near about 2500 Km) in such transmission the signal get degrade due to the effect of attenuation and dispersion. The effect of attenuation is minimized by using the EDFA (erbium dopped fiber amplifier) but the effect of dispersion severely degrades the signal. There are two methods available for the dispersion management. First is the DCF and second one is FBG. DCF is the old method in which we use dispersion compensating fiber for dispersion management but now a days the second method FBG (fiber Bragg gratings) are very effective method for dispersion management because of their low loss, compact and polarization insensitive[9].

This paper describe the modeling of optical system based on single mode fiber (SMF) and dispersion compensation based on fiber bragg gratting (FBG) [1]. In this system we simulate the model for different parameters such as duty cycle, input power, amplifier span length, and the range of FBG bandwidth. We examine these parameters using modulation formats like RZ and NRZ. The model is simulated and the results are analyzed on the basis of Q factor and the bit error rate (BER).

II. Losses in Optical Communication

There are many types of losses are present in optical fiber communication such as attenuation, dispersion, absorption losses, scattering losses but here we work on the attenuation and dispersion losses.

III. Attenuation

Signal attenuation in an optical fiber is defined as the decrease in light power during light propagation along an optical fiber. It is also known as fiber loss or signal loss in an optical fiber. It results in a reduction of power of light wave as it travels down the optical fiber, It determines the maximum repeater less separation between the transmitter and the receiver.

IV. Dispersion

Dispersion: "Spreading of optical pulses as they travel down the fiber" is known as dispersion. It is the time distortion of an optical signal that results from many discrete wavelength components travelling at different rates [4,8]. The dispersion leads to the degradation of the signal quality at the output end. It spreads the output pulse in the time domain and changes its shape so that it may merge into the succeeding or previous pulses. In a fiber three distinct types of dispersions are observed

(i) Inter modal dispersion.

(ii) Intra modal dispersion.

(iii) Polarization mode dispersion.

In this paper we work on the chromatic dispersion also known as intramodel dispersion which occurs in long haul communication in single mode fiber.

V. Intramodel or Chromatic Dispersion

It is a pulse spreading that occurs within single mode fiber. It is also known as chromatic dispersion. It is caused by the dependence of the optical properties on wavelength. It limits both the bandwidth and the distance that information can be transmitted. Chromatic dispersion consists of two mechanisms:

(a) Material Dispersion

(b) Wave guide Dispersion

(a) Material Dispersion: It is the pulse spreading due to dispersive properties of the material. Material dispersion is caused by the wavelength dependence of the silica's refractive index. Information carrying light pulse contains different wavelengths because a light source radiates light of a spectral width. So, the components of the pulse with different wavelengths will travel within the fiber at different velocities and will arrive at the fiber end at different times, causing the spread of the pulse.

(b) Waveguide Dispersion: Waveguide dispersion is most significant in single mode fibers. An information carrying light pulse after entering in a single mode fiber is distributed between the core and cladding. Its major portion travels within the core, the rest within the cladding. Both portions propagate at different velocities. Since core and cladding have different refractive indexes, he pulse will spread because light is confined within the structure having different refractive indexes.

VI. Experimental Set-Up

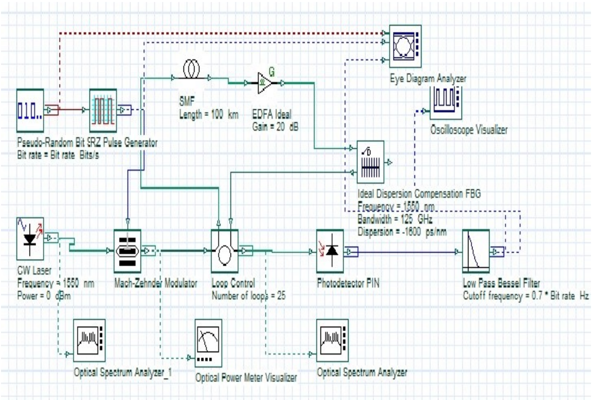

Figure 1: proposed Simulation Model

Figure 1 shows the conceptual scheme of an experimental setup for a single mode fiber using FBG as a dispersion compensator. For the modulation of the input signal RZ/NRZ modulation schemes are employed. After passing the signal from the fiber the amplification is done by the EDFA. Received signals are very much dispersed so the signal is allowed to enter into the FBG which behaves as a compensator of the dispersed signal. And allowed to circulate into the loop for the higher distance passage. APD photo detector is use for converting the optical signal into the electrical signal.BER analyser is proposed at the final stage after passing through the Bessel filter. The complete simulation set of the proposed model is demonstrated below with the tabulated value of used parameters:

Table 1 Parameters used in proposed simulation mode at 1550 nm

PARAMETRES	VALUE
Dispersion parameter of SMF (ps / nm/ km)	16.75
Dispersion slope of SMF (ps / nm^2/ km)	0.075
Attenuation coefficient of SMF (dB/ km)	0.2
Effective core area of SMF (μm^2)	50
Nonlinear index-coefficient of SMF (nm^2 /W)	2.6×10^{-20}
Bit rate (Gbit/s)	10
Total distance of transmission (km)	2500

VII. Results and Discussion

The setup shown in the modulation is simulated with the help of the two different modulation coding technique so called RZ / NRZ technique. Different parameters are described in the table. The input power of the CW laser which is used as a source is set to -2, 0 and +2 distinct values.

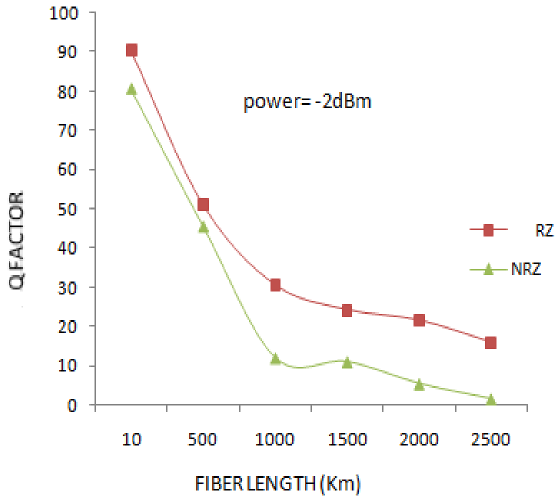

Figure 2: q factor v/s fiber length (power= -2dBm)

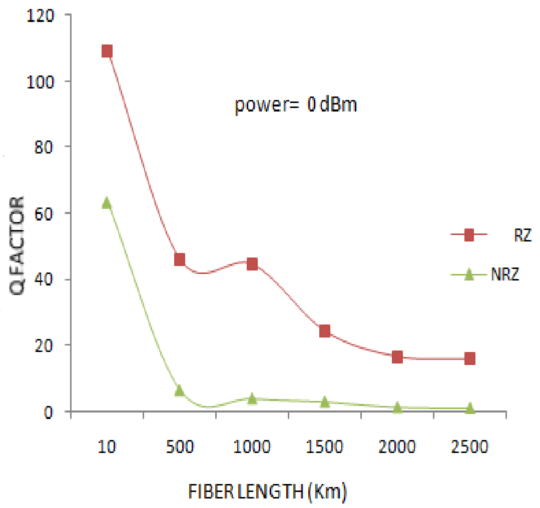

Figure 3: q factor v/s fiber length (power=0dBm)

The minimum distance between the practical use of the two repeater is increased with the use of the FBG in the channel whose band width is fixed to 100GHz. By default the duty cycle of the of RZ modulation coding is set to 0.5. The performance of the system for the distinct modulation format is shown below:

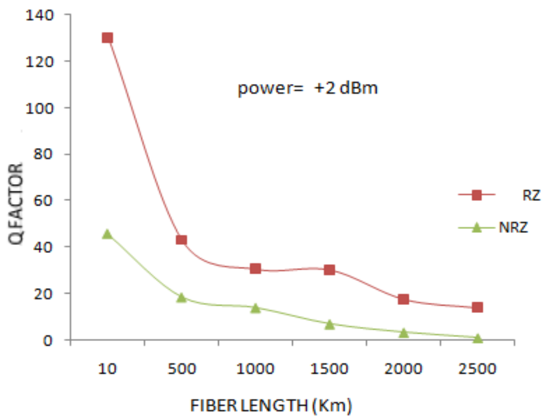

Figure 4: q factor v/s fiber length (power= 2dBm)

From all these figure(1, 2, 3) it is quite clear that the performance of the RZ modulation coding is better than that of the NRZ coding even at the different input power and the transmission distance, and also its quite clear that there is a large gap between the two technique. It is only two most significant property of the RZ technique that is the smaller inter-symbol interference and higher nonlinear tolerance than the signal modulated by NRZ.

VIII. Optimization of the FBG Bandwidth

FBG are suitable optical devices not only for wavelength selection elements of fiber lasers but also acts as a dispersion compensator. So particular reflection bandwidth is allowed to the FBG. The deep study of this band width is needed as in this bandwidth only the dispersion compensation takes place. The range of the FBG must be determined. Figure. 5 shows the experimental results that when the FBG bandwidth is from 30GHz to 50GHz, the system performs well. The reading at the different frequency ranging from the 20 to 130 GHz is taken from the experimental model. As the FBG is showing its excellent response to the 30, 40 GHz frequency range. Narrow FBG bandwidth could not reflect the signal effectively. That is to say the FBG bandwidth should be large enough to reflect the whole optical signal. But in practical engineering, the narrower bandwidth of FBG results in the easier production and lower costs. The systematic relation between the quality factor and the FBG bandwidth is shown in the diagram given below:

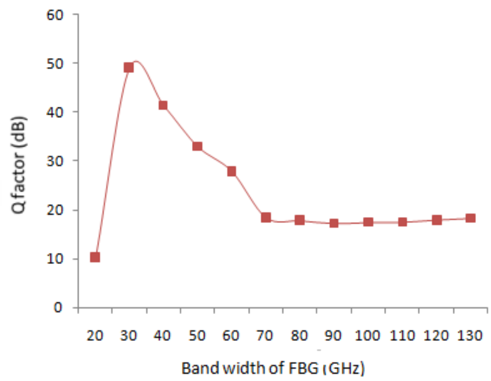

Figure 5: q factor v/s Bandwidth (GHz).

Comparison Between Original and Proposed System

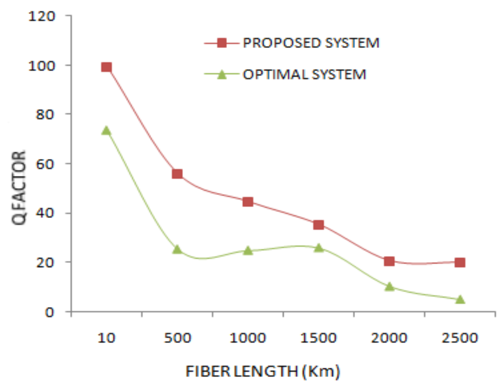

Figure 6: Performance of two different systems.

AS the figure 6 clearly demonstrates that the performance of the system improves very much with the increase in the length of the optical fiber. The obtained Q factor of the both of the system are plotted in the graph so that the clear difference them are notified.

IX. Conclusion

We have used the FBG in our proposed model although other dispersion compensation devices are also available. We have used device for the long haul communication compensation purpose. From the experimental analysis at the different input power it is clear that the RZ modulation coding technique is the best suited technique for our model. The frequency ranging from 30 to 50 the Q factor is almost 50 which are considered to be the best among the several values.

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