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# A Study over the Effect of NRZ and RZ Modulator; Optical Fiber and Fiber Bragg Grating on a 16 Channel Soliton Transmission System

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**ABSTRACT:** High capacity and speed in dada transmission in optical communications make its use more widespread by the day. Since soliton waves are not affected by the dispersion of the channel and can continue traveling with almost same speed, they are very interesting in the field of optical communication. A 16 channel soliton transmission has been simulated using OptSim software. The effect of using non-return to zero and return to zero modulators in the transmitter has been considered. Step index fiber and Fiber Bragg Grating are used in different simulations. The power in the transmitter is set to 25 mw and the starting wavelength is considered to be 1459 nm. The space between channels is 0.7 nm.

**KEY WORDS:** Soliton, Optical Communication, WDM.

## I. INTRODUCTION

The use of optical communications because of its special features is getting wider day by day. Fast data transfer with high security is achieved using optical fibers made of glass or plastic. They can transmit light from one end to another without significant attenuation or loss. Thus in optical communication the attenuation and losses problems of the channel are solved up to a considerable extent. Using a special type of wave which also has certain properties against nonlinear effects of the channel the quality of communication is even better.

Solitons in optical fibers are the result of a very special balance between the fiber dispersion chirps induced characterized by Group Velocity Dispersion coefficient $\beta_2$ and nonlinearity of fiber characterized by SPM (self-phase modulation) coefficient $\gamma$. The analytical solution of soliton propagation in optical fiber as a nonlinear Schrodinger equation can be derived as [1]:

$$A(z,t) = N\sqrt{P_0}Sech(t/T_0)\exp\left(j\frac{\Pi}{4}\frac{Z}{Z_0}\right) \quad (1)$$

Where $P_0$ is soliton peak power, $T_0$ is pulse width, $Z_0$ is soliton period which is defined as:

$$Z_0 = \frac{\Pi}{2}\frac{T_0^2}{|\beta_2|} \quad (2)$$

And N is the order of soliton which depends on the balance between nonlinearity and dispersion and is defined as:

$$N^2 = \gamma P_0 \frac{T_0^2}{|\beta_2|} \quad (3)$$

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Almost all studies and works done in the field of soliton are mathematical and for one channel data transmission.

In this work we have simulated the soliton transmission using 2 different kinds of modulation (NRZ and RZ) in the transmitter as well as 2 different types of fibers (simple step index fiber and Fiber Bragg Grating).

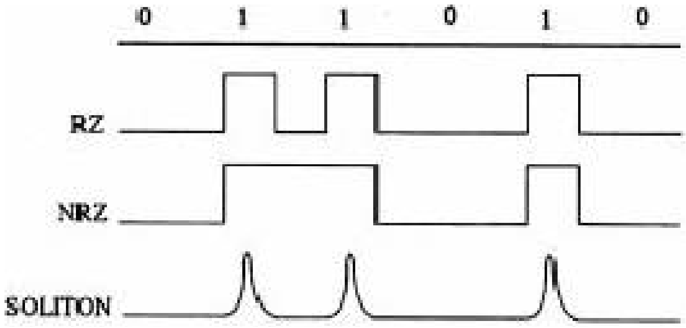
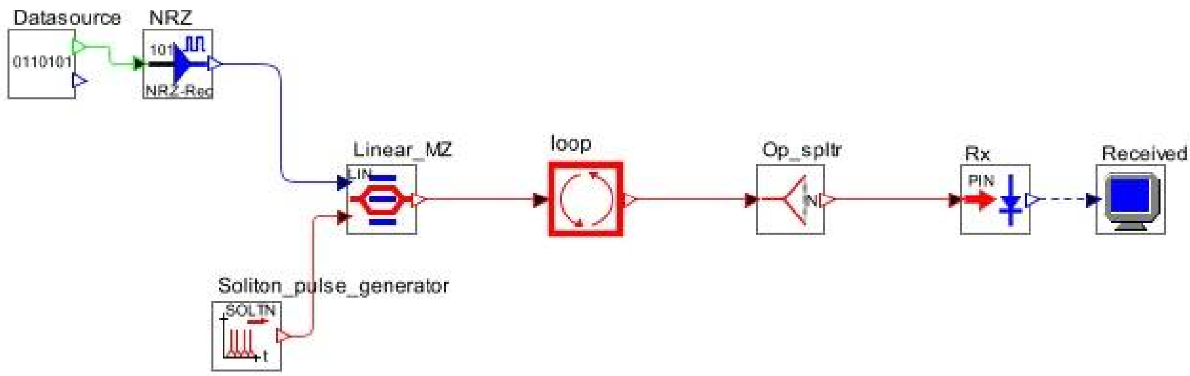
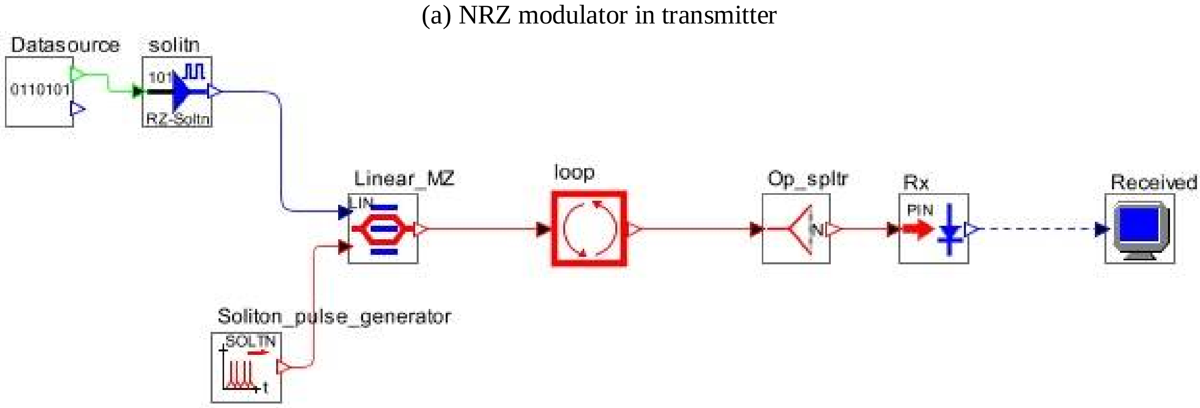



Figure 1: Various modulation formats for information transfer in fibers [1]

First we have started the simulation with one channel transmission and increased the number of channels to 16 using WDM. For all channels we have used 2 different modulators and fibers. The block diagram of the circuit is as in Figure 2.




(a) NRZ modulator in transmitter




(b) Soliton RZ modulator in transmitter

Fig 2: Soliton transmission using (a) NRZ modulator (b) Soliton RZ modulator

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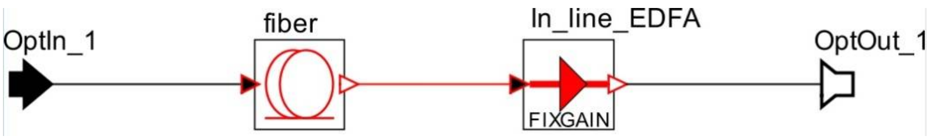
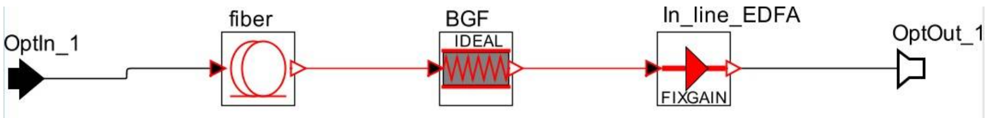
Where loop is Optical link composed of the iteration 20 times of the same span: 50 km of fiber (loss of 0.2 dB/km and Dispersion of 1.568 ps/nm/km) In-line fixed gain EDFA as in Fig.3.




(a) Step Index Fiber or simply optical fiber




(b) Fiber Bragg Grating

Fig 3: two different optical transmission line used in the simulation

## II. SIMULATION RESULTS

In this section we show the results of 16 channel transmission for different modulators and channel media. We have started with length of 200 km and for each run 50 km is added. Table 1 shows the results of the Q Factor in dB.

Table1. The results of Q Factor with changes in length of transmission

| | 200 km | 250 km | 300 km | 350 km | 400 km | 450 km | 500 km | 550 km | 600 km |
|---|---|---|---|---|---|---|---|---|---|
| **NRZ_SF** | 19.34 | 16.57 | 12 | 11 | 11 | 11 | 10 | 10 | 9 |
| **NRZ_FBG** | 22.26 | 21.1 | 17.17 | 15.26 | 14 | 13 | 12 | 11 | 9 |
| **RZ_SF** | 18.13 | 16.86 | 15.9 | 14 | 12 | 10 | 9 | 8 | 8 |
| **RZ_FBG** | 24.25 | 23.79 | 22.8 | 22.87 | 21.46 | 18.01 | 18.11 | 17.53 | 14.38 |

As it is shown in table1, the result of Q factor by using non-return-to-zero modulator in the transmitter and step index fiber in channel degrades suddenly from 19 dB for 200 km to 16 dB for 250 km which means increasing the length by 50 kilometers reduces the quality of the signal for 3dB. Comparing step index fiber and Fiber Bragg Grating while keeping the same modulator in the transmitter increases the quality of signal in the first run for 200 km from 19 dB to 22 dB also by increasing the length the Q factor is decreasing gradually so far as after 150km it reaches 15 dB.

Changing the modulator in the transmitter and repeating with step index fiber and Fiber Bragg Grating also gives interesting results. Using RZ modulator increases the Q factor in both channels and increasing the length has less effect on slope of changes in Q factor. Even after 550 km of travelling the data at the receiver has acceptable quality of BER equal to 7.59e-14.

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Figures 4-7 show eye diagram of 16 channel transmission for wavelength=1459 nm with NRZ, RZ, FBG and step index fiber for different lengths of transmission selectively.

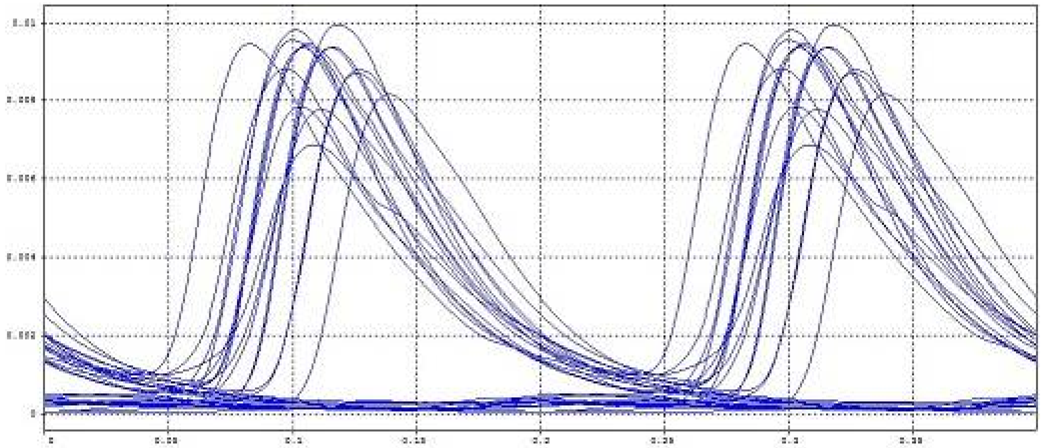

Fig 4: NRZ modulator with FBG of length 350 km, Q factor: 15.26 dB and bit error rate of (BER): 4.66e-9

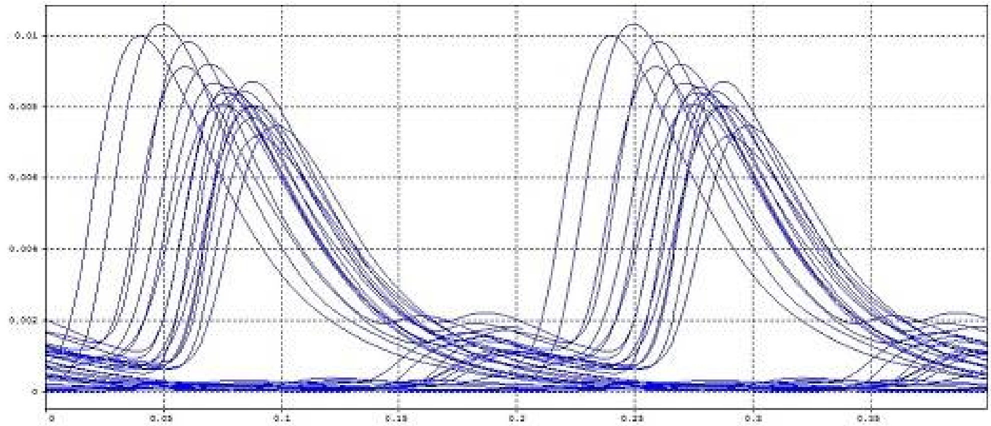

Fig 5: NRZ modulator with Step Index Fiber of length 250 km, Q factor: 16.56 dB and bit error rate of (BER):7.47e-12.

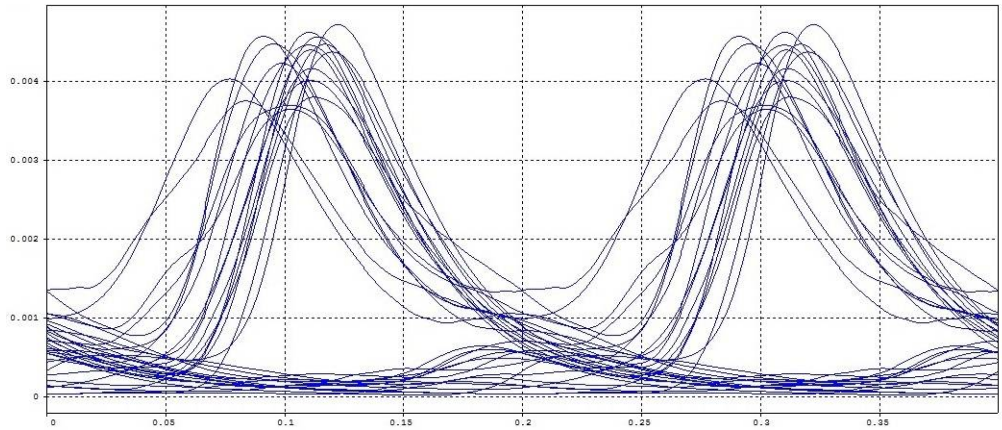

Fig 6: RZ modulator with FBG of length 550 km, Q factor: 17.54 dB and bit error rate of (BER): 7.6e-14.

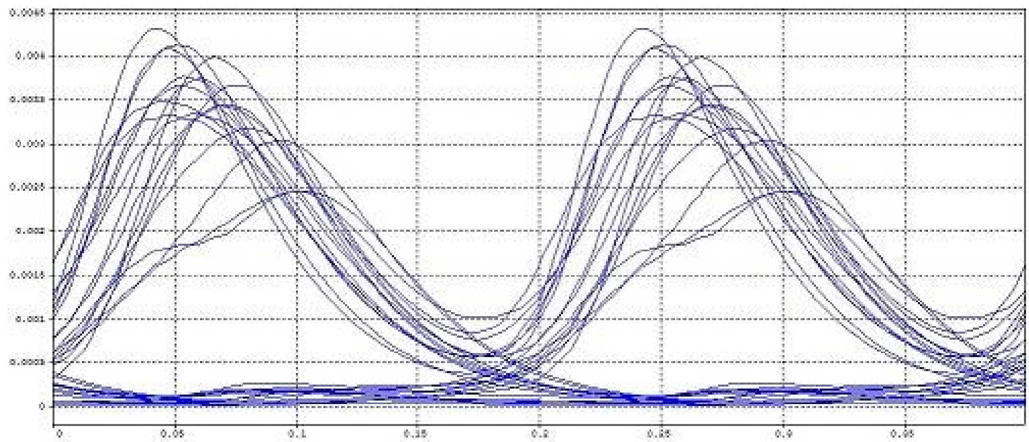

Fig 7: RZ modulator with Step Index Fiber length 300 km, Q factor: 15.9 dB and bit error rate of (BER): 6.54e-10.

All the results for the number of channels from 1 to 16 shows the same pattern which is as follows:

1. **NRZ modulator**

Using Fiber Bragg Grating increases the quality of the signal by 3 dB for 200 km. The signal is not reliable using step index fiber when the length is increased. However up to 350 km the FBG gives acceptable result with Q factor: 15 dB.

2. **RZ modulator**

A change in transmitter using RZ modulator, again the quality of signal is improved by 5 dB for 200 km using Fiber Bragg Grating. Increasing the length, using step index fiber, after 300 km the signal is almost lost but up to 600 km the FBG gives acceptable result with Q factor: 14 dB.

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**3. Step Index Fiber**

While using step index fiber in the medium part there is not any significant difference between using RZ or NRZ in the transmitter.

**4. Fiber Bragg Grating**

By using FBG the quality of signal increases when RZ modulator is used in the transmitter. As mentioned in table 1. By increasing the length the effect of RZ modulator is noticeable as for 350 km there is 7 dB improvements in signal quality as compared to the transmitter with NRZ modulator.

## III. CONCLUSION

Soliton based optical fiber communication systems are convenient choices for long distance communication because of their very high information carrying capacity. Soliton pulses are not affected (by dispersion) after long distance communication. By checking the results out of the simulation for getting more reliable results in soliton transmission the better options are using soliton RZ modulator as well as Fiber Bragg Grating as the medium of transmission. Using NRZ modulator and Step Index Fiber allows the signal to reach with an acceptable quality only up to 250 km however by using Fiber Bragg Grating as medium and RZ modulator the signal reaches up to 550 km and still there is 1 dB improvement in signal quality.

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