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BER & Quality Factor Optimization for Single Mode Optical Fiber Using Uniform & Non-Uniform FBG

Samarjit Biswas[1], Ashutosh Darmal[2], G. Aarthi[3]

[1]School of Electronics Engineering, VIT University, Vellore, Tamil Nadu 632014, India

***Abstract:** This work basically deals with properties of Optical system using fiber optics and Bragg gratings carried out via Optisystem software. The versatile nature of fiber grating gives it a wide spread application such as fiber sensors, grating lasers and amplifiers, filters (band pass), dispersion compensators etc. The main aim is to optimize the BER and Quality Factor of the receiver by varying the parameters such as coding techniques (RZ and NRZ) and grating distance.*

Keywords: BER, Quality Factor and Eye Diagram Analyzer, FBG-FIBER BRAGG

1. Introduction

The propagation of optical signal is carried through the optical fiber cable of the communication system. The optical fiber cable is preferred as it has minimal loss and ensures almost a distortion less transmission. Fiber loss (FSL) is another important parameter which impacts the repeater spacing along the entire length of the Cable i.e. tried to keep as high as possible [1] [2]. Dispersion which leads to pulse broadening again hampers the performance of the communication system. The fiber grating compatible with DWDM (dense wavelength division multiplexing) is used in most of the industries. The grating serves multiple functionality such as filters, dispersion compensator, laser stabilization, gain flattening etc. For normal fiber grating by properly choosing the length, modulation amplitude index, reflectivity we can considerably improve the performance of the system [3]. The paper reports for the system with minimum BER and maximum quality factor. WDM (wavelength division multiplexing) is multiplexing

Technique by which multiple wavelengths of light, share a single optical fiber. Wavelength division multiplexing is essentially frequency division multiplexing (FDM) at the optical level. Much as multiple electrical frequencies can coexist on an electrified copper circuit in support of multiple, simultaneous conversations in a FDM transmission system, multiple wavelengths can coexist on a single fiber of the appropriate type in a WDM system [4].

CWDM systems have channels at wavelengths spaced 20nanometers (nm) apart, compared with 0.4 nm spacing for DWDM. This allows the use of low-cost, uncoiled lasers for CWDM. In a typical CWDM system, laser emissions occur on eight channels at eight defined wavelengths: 1610 nm, 1590 nm, 1570 nm, 1550 nm, 1530 nm, 1510 nm, 1490 nm, and 1470 nm. But up to 18 different channels are allowed, with wavelengths ranging down to 1270 nm [5].

The energy from the lasers in a CWDM system is spread out over a larger range of wavelengths than is the energy from the lasers in a DWDM system. The tolerance (extent of wavelength imprecision or variability) in a CWDM laser is up to ± 3 nm, whereas in a DWDM laser the tolerance is much tighter. Because of the use of lasers with lower precision, a CWDM system is less expensive and consumes less power than a DWDM system. However, the maximum realizable distance between nodes is smaller with CWDM [5].

A fiber Bragg grating (FBG) reflects particular wavelengths of light and transmits all others. It is a type of distributed Bragg-Reflector constructed in a short segment of optical fiber. This is achieved by creating a periodic variation in the refractive index of the fiber core, which generates a wavelength-specific dielectric mirror; therefore it can be used as an inline optical filter to block certain wavelengths, or as a wavelength-specific reflector [6].

2. Circuit Design and Simulation Model

The circuit basically consists of four propagation path i.e. optical fiber with FBG and uniform FBG then optical fiber CWDM with FBG and uniform FBG. The fiber length is kept constant at 10 KM and the input power of 0 dbm is used for analysis. The optical transmitter at 193.1 THz is used to produce the input signal as per NRZ and RZ coding type. A 1X4 distributor is used to distribute the input signal on the four branches. The cable attenuation is kept at 02 db/km and dispersion 16.75 ps/nm-km. The index of FBG is kept constant at 1.45.The reflectivity is kept 0.99.The cut off frequency for the optical receiver is kept at 0.75 Hz and the gain at 3 db. The spectrum analysis is carried out through Eye diagram analyzer and OPTISYTSTEM 7 software is used for this simulation.

The given below Image is a schematic capture of the simulation circuit

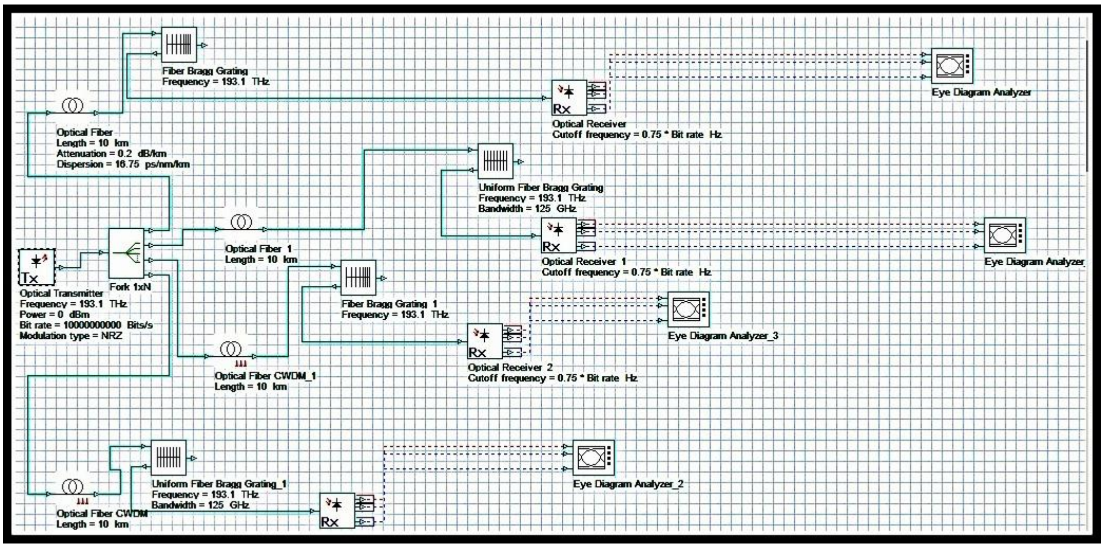

Image: Schematic capture of the simulation circuit

3. Simulation Figures

Basically an **Eye pattern**, also known as an **Eye diagram**, is an oscilloscope display in which a digital data signal from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep. It is an experimental tool use to evaluate the combined effects of channel noise and intersymbol interference on the performance of a baseband pulse-transmission system .It gives us the BER and Quality Factor.

Eye Diagram is useful in measuring additive noise, distortion and jitter. Eye opening (height, peak to peak) gives measurement of additive noise in the signal. Eye overshoot/undershoot gives a measurement of Peak distortion due to interruptions in the signal path. Eye width gives a measurement of jitter effects. Eye closure gives a measurement of intersymbol interference and additive noise.

From Figure 1 to Figure. 4 shows the Eye Diagram for optical fiber length 10km for normal fiber at input power of 0 dbm NRZ input type for different FBG width of non-uniform FBG.

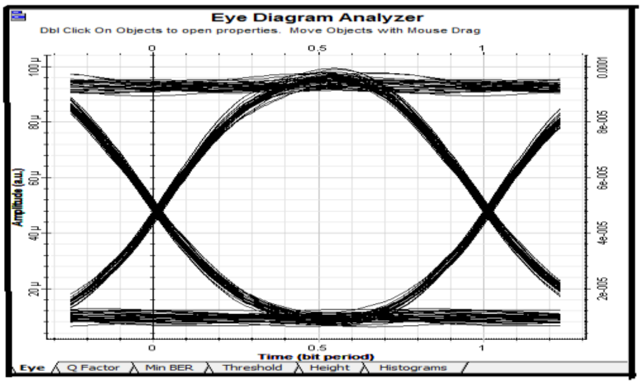

Figure 1: Eye diagram for FBG width 2mm

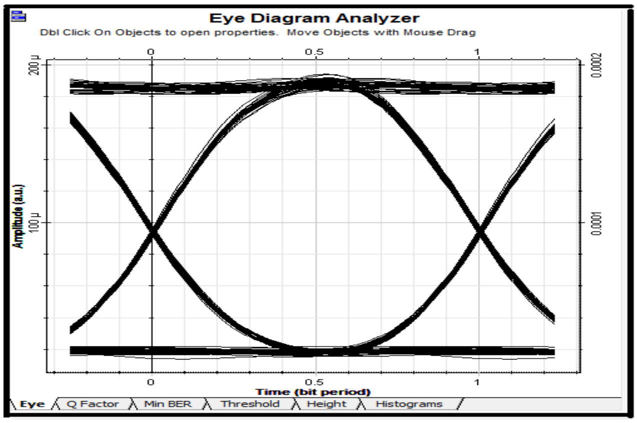

Figure 2: Eye diagram for FBG width 3mm

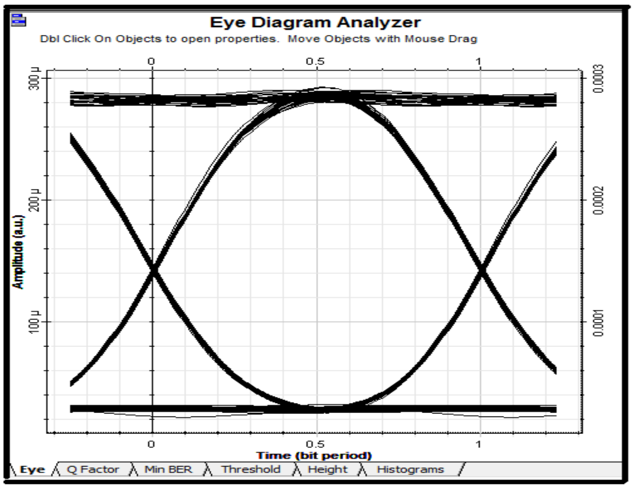

Figure 3: Eye diagram for FBG width 4mm

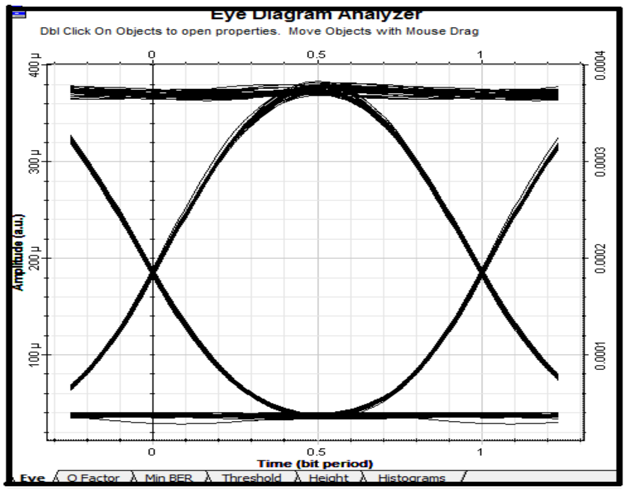

Figure 4: Eye diagram for FBG width 5mm

Figure 5 to Figure 8 shows the Eye diagram for optical fiber length 10km for CWDM fiber at input power of 0 dbm NRZ input type for different FBG width of non- uniform FBG.

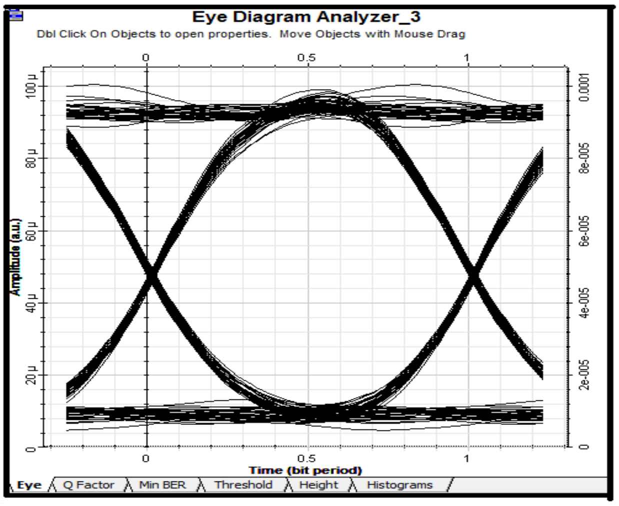

Figure 5: Eye diagram for FBG width 2mm for CWDM fiber

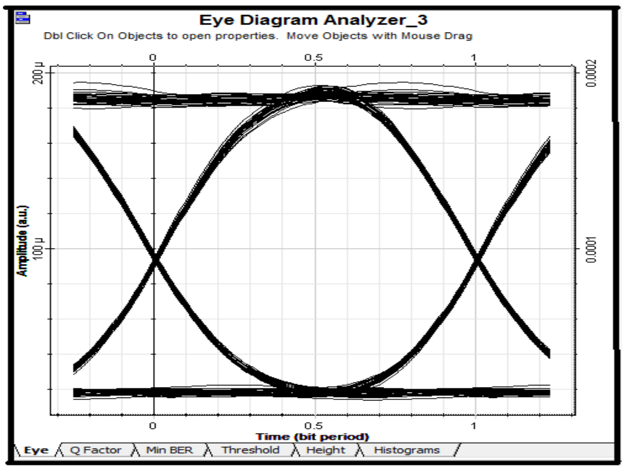

Figure 6: Eye diagram for FBG width 3mm for CWDM fiber

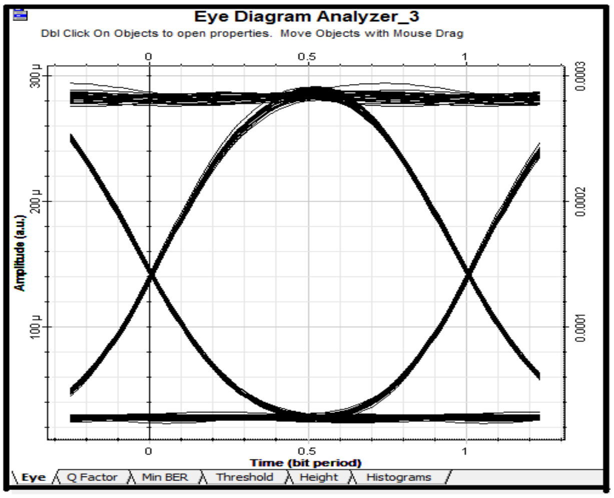

Figure 7: Eye diagram for FBG width 4mm for CWDM fiber

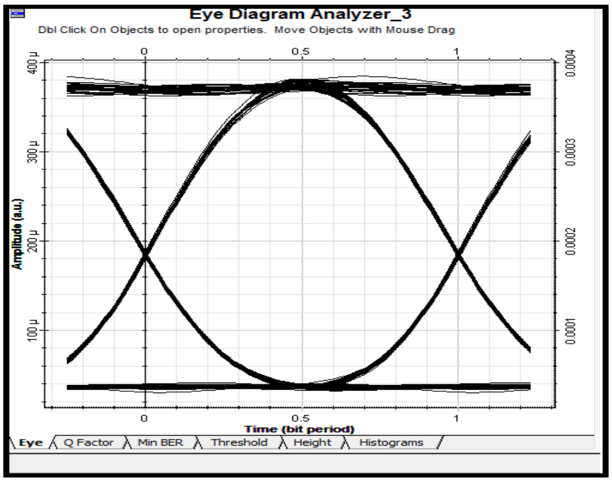

Figure 8: Eye diagram for FBG width 5mm for CWDM fiber

Figure 9 to Figure. 12 shows the Eye diagram for optical fiber length 10km for normal fiber at input power of 0 dbm RZ input type for different FBG width of non- uniform FBG.

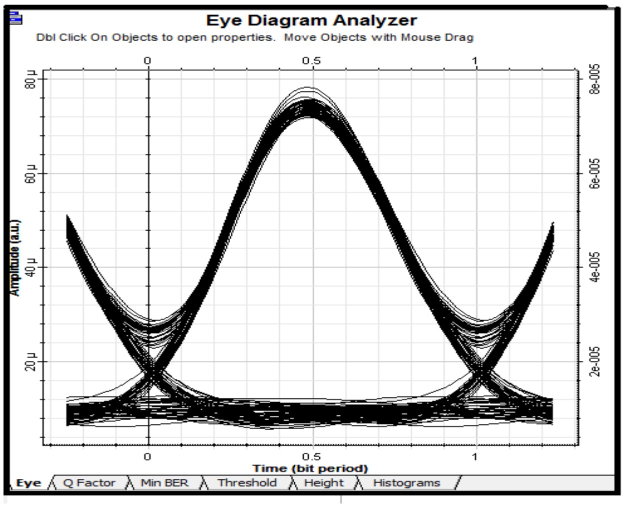

Figure 9: Eye diagram for FBG width 2mm for Normal fiber

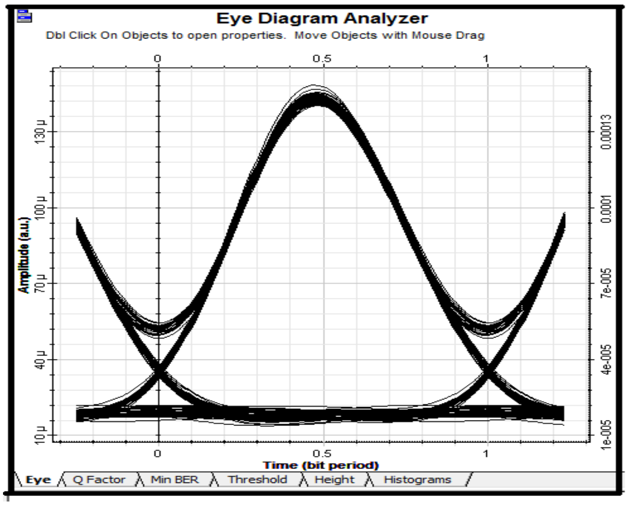

Figure 10: Eye diagram for FBG width 3mm for Normal fiber

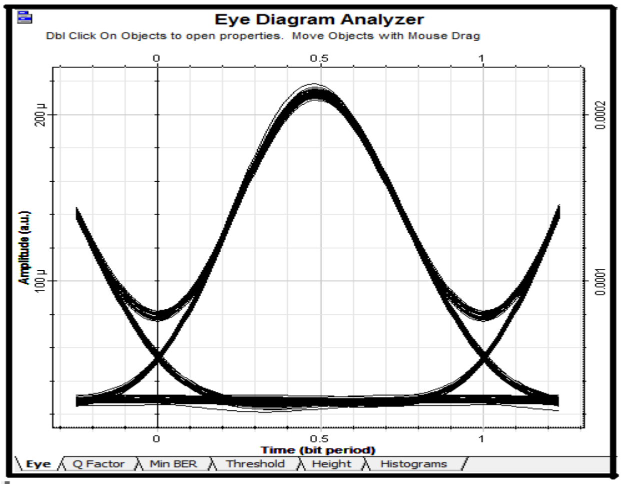

Figure 11: Eye diagram for FBG width 4mm for Normal fiber

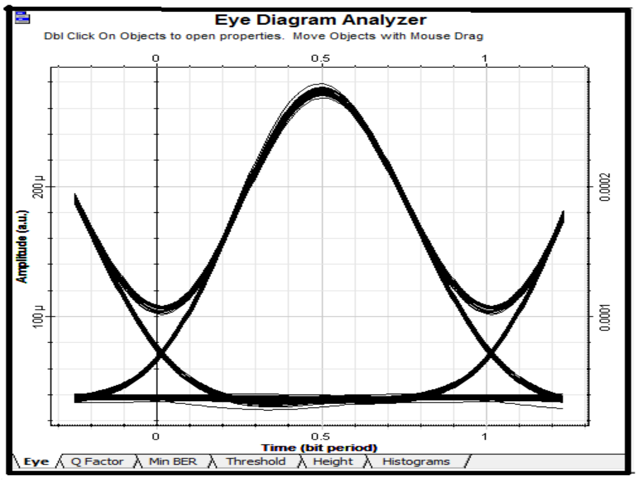

Figure 12: Eye diagram for FBG width 5mm for Normal fiber

Figure 13 to Figure. 16 shows the Eye diagram for optical fiber length 10km for CWDM fiber at input power of 0 dbm RZ input type for different FBG width of non- uniform FBG.

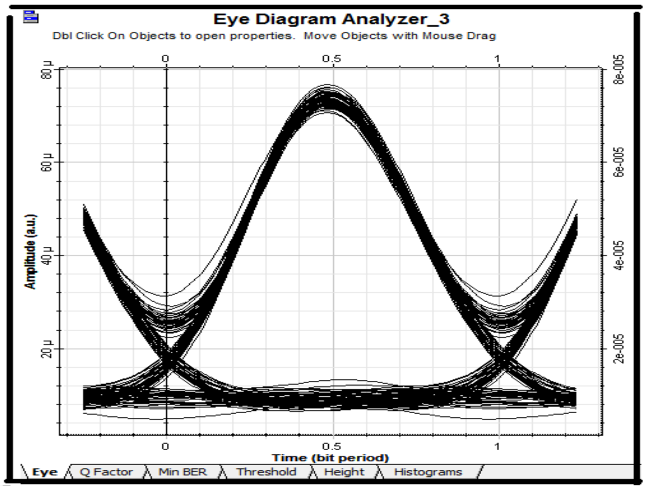

Figure 13: Eye diagram for FBG width 2mm for CWDM fiber

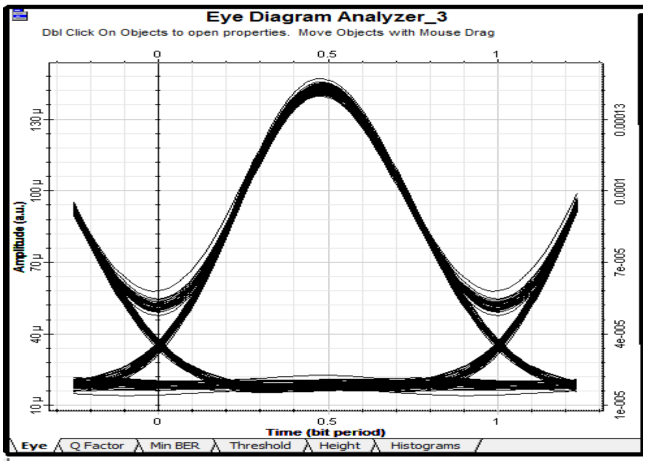

Figure 14: Eye diagram for FBG width 3mm for CWDM fiber

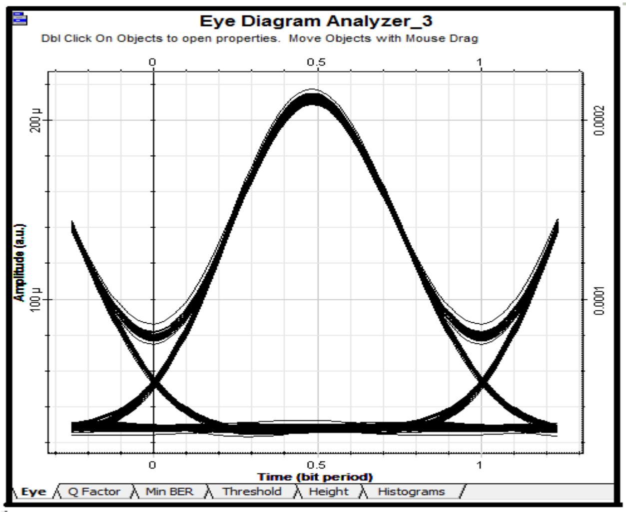

Figure 15: Eye diagram for FBG width 4mm for CWDM fiber

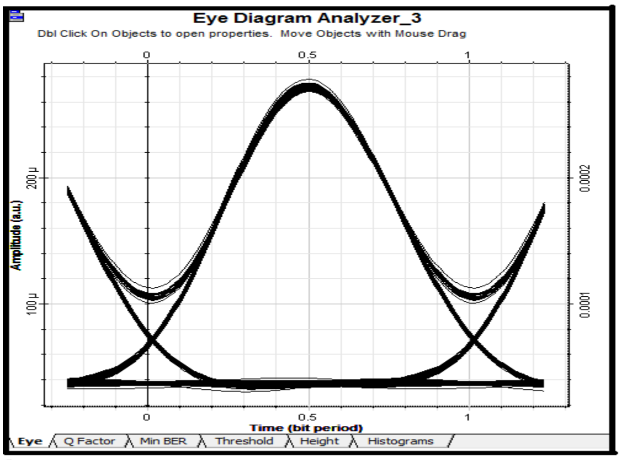

Figure 16: Eye diagram for FBG width 5mm for CWDM fiber

Figure 17 to Figure.18 shows the Eye diagram for optical fiber length 10km for normal fiber at input power of 0 dbm NRZ and RZ input type for uniform FBG.

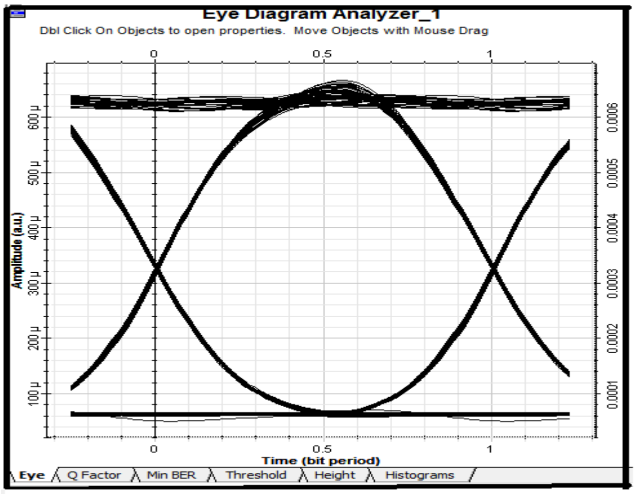

Figure 17: Eye diagram for Uniform FBG for Normal fiber with NRZ input type

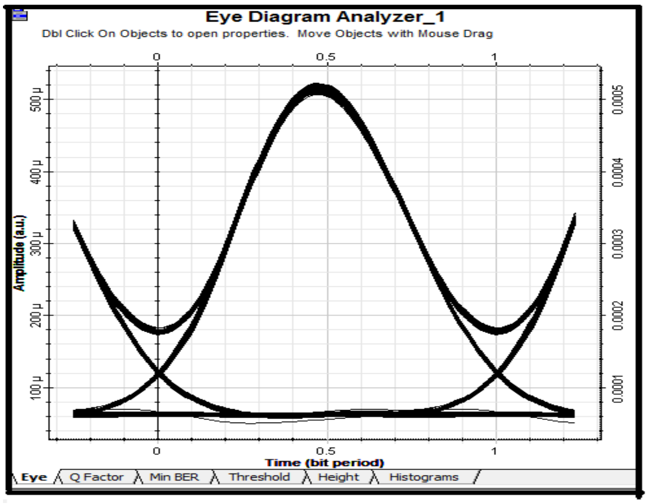

Figure 18: Eye diagram for Uniform FBG for Normal fiber with RZ input type

Figure 19 to Figure 20 shows the Eye diagram for optical fiber length 10km for CWDM fiber at input power of 0 dbm NRZ and RZ input type for uniform FBG.

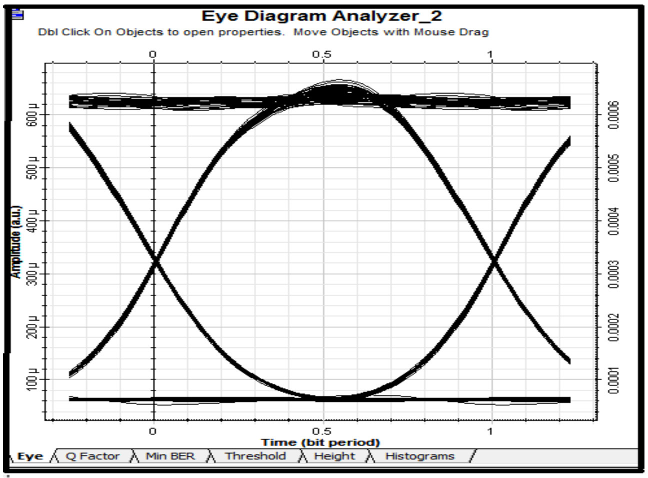

Figure 19: Eye diagram for Uniform FBG for CWDM fiber with NRZ input type

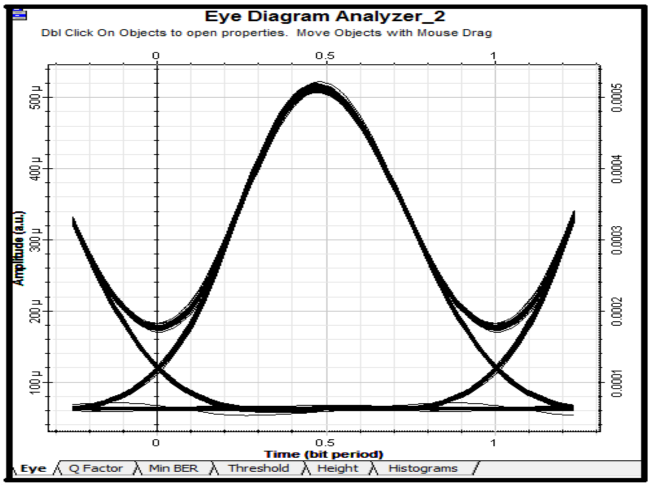

Figure 20: Eye diagram for Uniform FBG for CWDM fiber with RZ input type

Tables

Table 1: Effect of Width of FBG on BER and Q Factor for normal fiber at 0 dbm NRZ input type

Input type	*Width of fiber grating*	*Quality Factor*	*Bit error rate(BER)*
NRZ	2mm	30.1313	9.30E-200
NRZ	3mm	52.009	0
NRZ	4mm	66.8738	0
NRZ	5mm	73.9901	0

Table 2: Effect of Width of FBG on BER and Q Factor for CWDM fiber at 0 dbm NRZ input type

Input type	*Width of fiber grating*	*Quality Factor*	*Bit error rate(BER)*
NRZ	2mm	30.1501	5.35E-200
NRZ	3mm	48.9826	0
NRZ	4mm	63.2745	0
NRZ	5mm	70.418	0

Table 3: Effect of Width of FBG on BER and Q Factor for normal fiber at 0 dbm RZ input type

Input type	*Width of fiber grating*	*Quality Factor*	*Bit error rate(BER)*
RZ	2mm	25.833	1.89E-147
RZ	3mm	45.1895	0
RZ	4mm	61.5913	0
RZ	5mm	74.9101	0

Table 4: Effect of Width of FBG on BER and Q Factor for CWDM fiber at 0 dbm RZ input type

Input type	*Width of fiber grating*	*Quality Factor*	*Bit error rate(BER)*
RZ	2mm	25.8358	1.76E-147
RZ	3mm	44.0561	0
RZ	4mm	60.8621	0
RZ	5mm	75.5112	0

Table 5: Effect of input type on BER and Q Factor for normal and CWDM fiber at 0 dbm for Uniform FBG

Input type	*Type of fiber*	*Quality Factor*	*Bit error rate(BER)*
NRZ	Normal	30.1313	9.30E-200
RZ	Normal	82.3496	0
NRZ	CWDM	49.1367	0
RZ	CWDM	87.5082	0

4. Discussion

In Table 1 as the width of fiber grating is increasing from 2mm to 5mm the Quality Factor is improving from 30.1313 to 73.9901 and BER is reducing from 9.30307e-200 to zero. In Table 2 as the width of fiber grating is increasing from 2mm to 5mm the Quality Factor is improving from 30.1501 to 70.418 and BER is reducing from 5.34578e-200 to zero. In Table 3 as the width of fiber grating is increasing from 2mm to 5mm the Quality Factor is improving from 25.833 to 74.9101 and BER is reducing from 1.88651e-147 to zero. In Table 4 as the width of fiber grating is increasing from 2mm to 5mm the Quality Factor from 25.8358 to 75.5112 and BER reducing from 1.75571e-147 to zero. In Table 5 as input type change from NRZ to RZ Quality Factor improves from 30.1313 to 82.3496 and BER reduced to zero for normal fiber and for CWDM Quality Factor increases from 49.1367 to 87.5082 and BER is zero for both input type.

5. Conclusion

In this paper, the design and implementation of transmission system for various input type with various width of FBG has been studied. These results are important for improving system performance. As we are increasing the width of the non-uniform fiber grating the Quality Factor of the normal and CWDM fiber is improving and BER reduced to zero. As we are changing input type from NRZ to RZ the Quality Factor is improving and BER reduce to zero.

References

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