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Research Article

Performance Analysis of dispersion compensation using Fiber Bragg Grating (FBG) in Optical Communication

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Abstract

This paper discussed on a simulation of optical transmission system in optical fiber. The optical fiber is always used in telecommunication system because of its characteristics which include small size or dimension, low loss and low interferences from outside environment. There are various types of optical fiber, the Fiber Bragg Grating (FBG) is commonly chosen as important components to compensate the dispersion in optical communication system. FBG is very simple, has low cost filter for wavelength selection and low insertion loss, it has also customized reflection spectrum and wide bandwidth. We have analyzed the dispersion compensation using Fiber Bragg Grating at different fiber lengths. The simulated transmission system have been analyzed on the basic of different parameters by using OptiSystem simulator, By simulating a model of communication system and using the most suitable settings of the system which include input power (dBm), fiber cable length (km), FBG Length (mm) and attenuation coefficient (dB/km) at cable section, four different parameters will be investigated which are output power (dbm), noise figure (dB), and gain (dB) Q-Factor (db) at receiver. We will see the help of eye diagrams in subsequent graph. All the results are analyzed using OPTISYSTEM simulation at 10 Giga bits per second (Gb/s) transmission systems.

Keywords*: Optical Transmission System, Fiber Bragg Grating (FBG), dispersion compensation, Optisystem simulator, parameters.*

Introduction

Fiber optic communication is a method of transmitting information from one place to another by sending light through an optical fiber. The light forms an electromagnetic carrier wave that is modulated to carry information. The process of communicating using fiber optics involves the following basic steps: Creating the optical signal using a transmitter, relaying the signal along the fiber, ensuring that the signal does not become too distorted or weak, and receiving the optical signal and converting it into an electrical signal. The use of erbium doped fiber amplifiers (EDFA) in optical communication systems has made chromatic dispersion the most significant limitation for the transmission performance since EDFAs compensate for the transmission losses. The chromatic dispersion in optical fiber is a phenomenon caused by the wavelength dependence of its group refractive index. In optical fiber, the wavelength dependence of the fiber group refractive index causes a temporal broadening of the pulses as they are propagating. Fiber Bragg Grating (FBG) is commonly chosen as important components to compensate the dispersion in optical communication system. Because the low cost of filter for wavelength selection and low insertion loss, it has also customized reflection spectrum and wide bandwidth. The simulation of transmission system will be analyzed based on different parameters by using OptiSystem simulator .By simulating a model of optical communication system.

In this study, the simulation of the optical transmission system in input power (dBm), fiber cable length (km) and attenuation coefficient (dB/km) at cable section has been discussed by analyzed the effect of the components in data receiver by using different parameters setting. The value of parameters has been investigated such as output power (dbm), noise figure (dB), and gain (dB) Q-Factor (db) at receiver. All the results are analyzed using OPTISYSTEM 12 simulation at 10 Giga bits per second (Gb/s) transmission systems.

A. Fiber Bragg Grating

A fiber Bragg grating is a piece of optical fiber with periodic variation of the index of refraction along the fiber axis. Such a phase grating acts as a band rejection filter reflecting wavelengths that satisfy the ragg condition and transmitting the others. Fiber Bragg gratings act like tiny mirrors in a fiber that reflect specific wavelengths due to periodic changes in the index of the fiber core.

Fiber Bragg gratings couple light from a forward propagating guided mode into a backward or counter propagating guided mode at the Bragg wavelength (λB).

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This is the wavelength for the Bragg reflection, which is the phenomenon by which a single large reflection can result from coherent addition of many small reflections from weakly reflecting mirrors spaced a multiple of half of the wavelength apart. The equation relating the grating periodicity and the Bragg wavelength depends on the effective refractive index of the transmitting medium, neff, and is given by

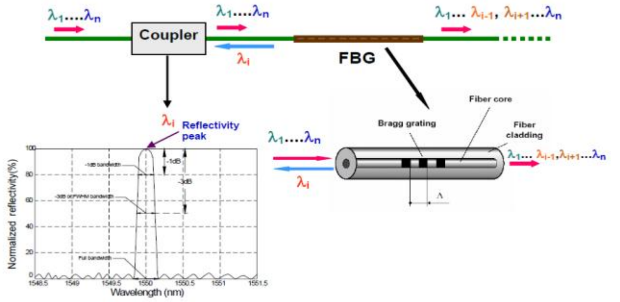


Figure 1: Fiber Bragg Gratings.

$2\ B\ eff\ \lambda = n\ \Lambda$

Where

λB= Bragg wavelength;

Λ = Grating period;

neff = Effective refractive index of the transmitting medium.

Figure1. also shows the application of a FBG as a filter. Light waves at several different wavelengths are traveling through the optical fiber and entering into the FBG. One of the wavelengths (λB) is reflected back by the FBG which comes back to the coupler. The coupler separates the Bragg wavelength from the incoming wavelengths and the reflection spectra of this reflected wavelength can be seen on an optical spectrum analyzer.

B. Optisystem simulator

Optisystem is an innovative optical communication system simulation package for the design, testing and optimization of virtually any type of optical link in the physical layer of the broad spectrum of optical networks, from long-haul systems to local area networks (LANs) and metropolitan area networks (MANs). A system level simulator is based on the realistic modeling of fiber optic communication systems,

2. Description of components and consideration

NRZ pulse generator has an advantage on controlling bandwidth. This is due to the characteristic of the generator that the returning signals to zero between bits. Pseudo-random bit sequence generator is used to scramble data signal in terms of bit rates. Mach Zender Modulator (MZ) has two inputs (optical signal and electrical signal) and one output (optical). Then the input signal is modulated with semiconductor laser that is represented by Continuous Wave (CW) laser Frequency 193.1 THz through Mach- Zehnder modulator. Continues laser diode (CW) to generate optical signals supplies input signal with 1550 nm wavelength and input power of 5dBm which is externally modulated at 10 Gbits/s. with a non-return-zero (NRZ) pseudorandom binary sequence in a Mach-Zehnder modulator with 30 dB of extinction ratio. The optical fiber used is single mode fiber because has higher data rate and long distance transmission. The fiber Bragg grating is used as the dispersion compensator. The FBG length 5 mm Photodetector (PIN) Diode Positive Intrinsic Negative to translate the optical signal into an electrical signal. The initial settings for the design are shown in Figure2. order to operate as the optical transmission system: Input power 5Db, Reference wavelength 1550nm, fiber length 15km, Attenuation coefficient of cable 0.2dB/km.

Table 1 Simulation Parameters

C\W Input power	5dBm
C\W Laser Frequency	193.1 THz
Reference wavelength	1550nm
Mach-Zehnder modulator with of extinction ratio	30 dB
Fiber length:	15km
Attenuation coefficient at cable section:	0.2dB/km
EDFA Length:	5m
FBG Length :	5mm

2.1Simulation of a transmission system

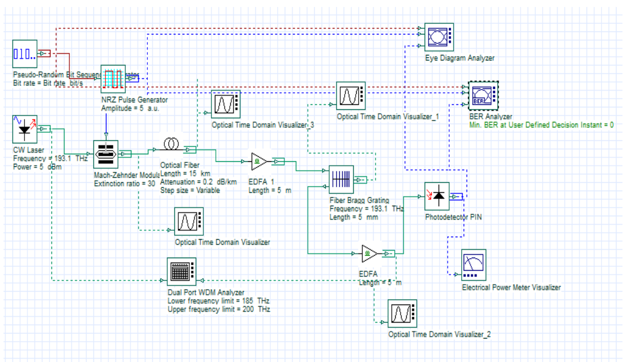


Figure 2.The designed model of simulated system with Optisystem software

2.2 Simulation of a transmission system to compensate dispersion

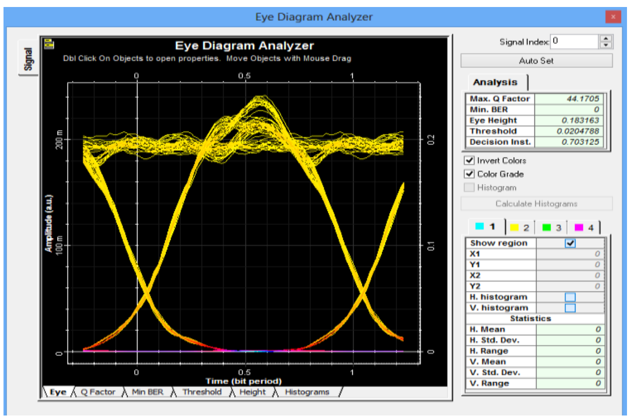


Figure 3 Eye diagrams Simulation of a transmission system of analyzed

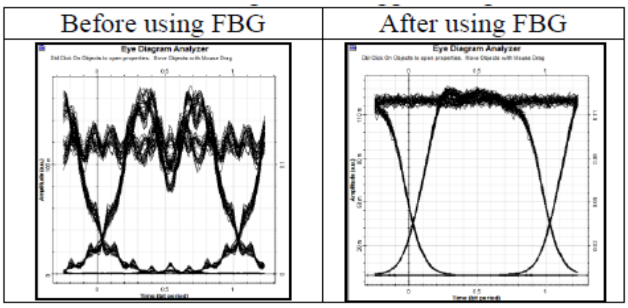


Figure 4 Before using FBG and after sing FBG

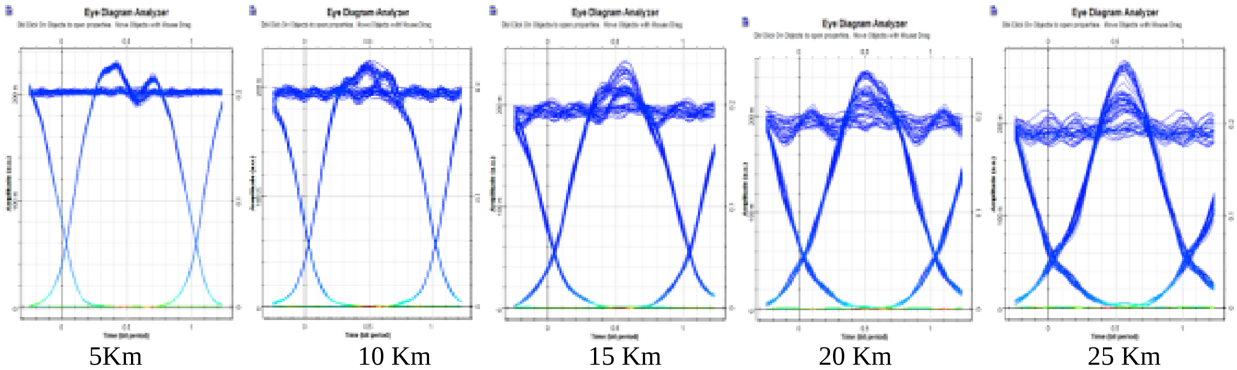


Figure 5 Eye diagrams are analyzed by using different values of OFC length

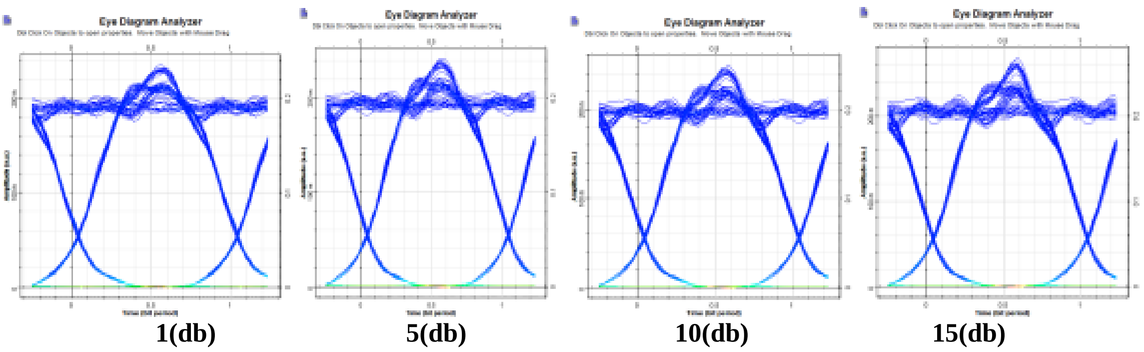


Figure 6 Eye diagrams are analyzed by using different values of input power

The Simulation design of optical transmission system is shown in Figure 2 where the parameter taken are input power 5db , Reference wavelength 1550nm fiber length 15km, Attenuation coefficient at cable 0.2dbm as also indicate in Table1

3. Results and Discussions

The simulation and optimization of the design is done by Optisystem 12 simulation software. The eye diagrams and results of output power, Signal power (dBm) at receiver, noise power by using different values of input power (dBm), attenuation coefficient (dB/km), and variable length of FBG (mm). The related graphs are also plotted

3.1 The differences of the eye diagram for the design with and without using Fiber Bragg Grating

Table 2: The output readings are tabulated by varying the OFC Length (km)

OFC lengt	Gain(db)	Noise Figure(db)	Output Power (dbm)	Q Factor(db)
5	14.445685	7.2409036	12.246	82.5466
10	14.429858	8.0812304	12.205	50.2712
15	14.404664	8.9688593	12.161	44.1705
20	14.38935	9.867433	12.131	28.9934
25	14.373075	10.788574	12.108	22.3704

Table 3: The output readings are tabulated by varying the input power

Input Power(dbm)	Gain (db)	Noise Figure db)	Output Power (dbm)	Q Factor (db)
1	18.334936	8.6869573	12.022	44.4777
5	14.404664	8.9688693	12.161	44.1705
10	9.4921333	9.9256251	12.338	42.6371
15	4.6586163	11.882006	12.686	32.7836

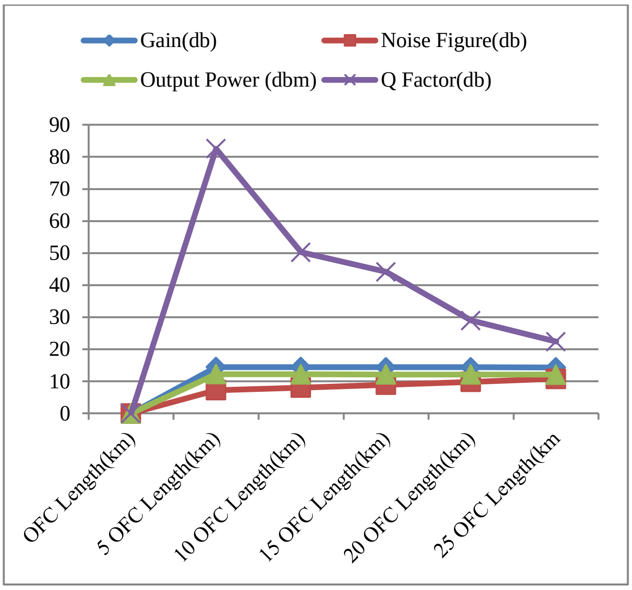


Figure 7 Graph of Signal/noise/output power figure versus OFC length

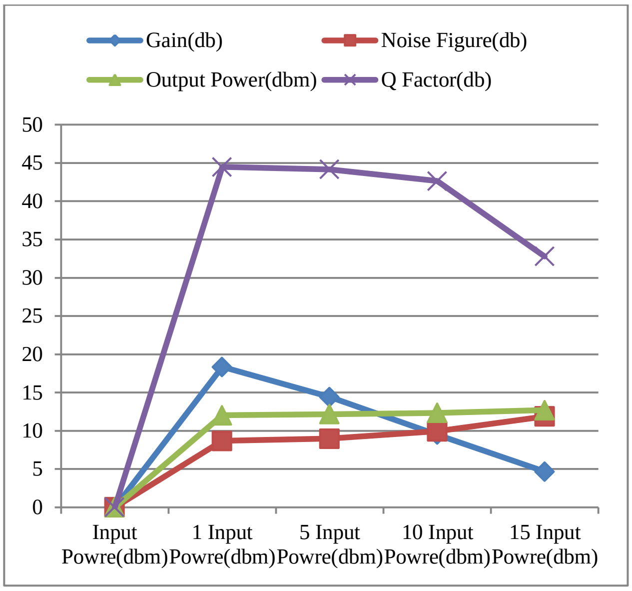
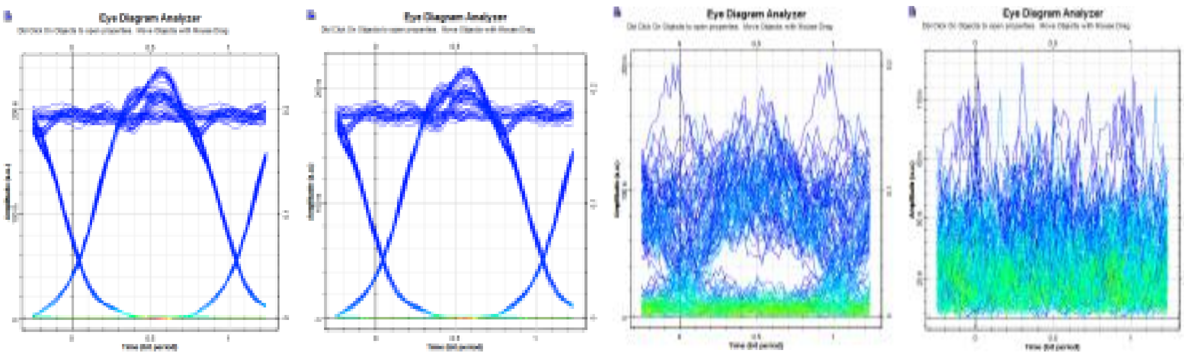


Figure 8 Graph of Signal/noise/output power figure versus Input power



0.2(db\km) 1(db\km) 3(db\km) 5(db\km)

Figure 9 Eye diagrams are analyzed by using different values Attenuation Coefficient (db\km)

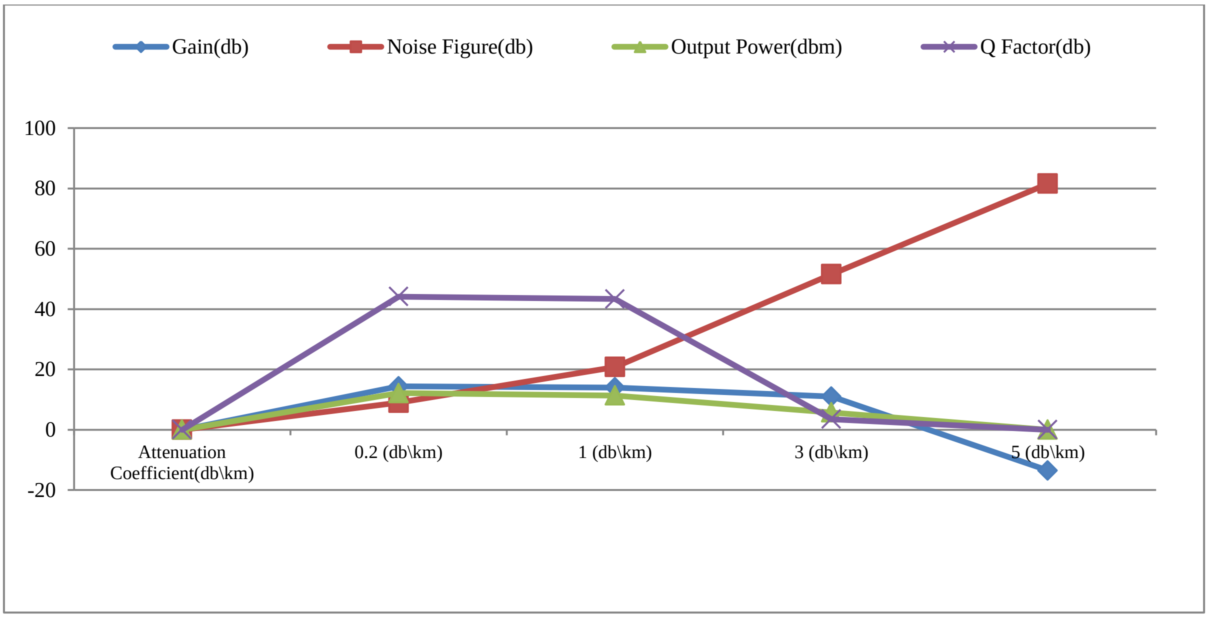
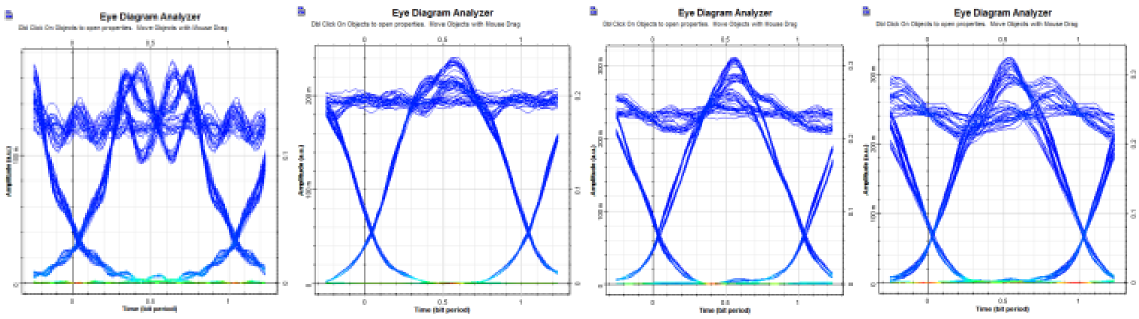


Figure 10 Graph of Signal/noise/output power figure versus Attenuation Coefficient (db\km)



1mm 5mm 10mm 15mm

Figure 11 Eye diagrams are analyzed by using different values of fiber bragg grating.

Table 4: The output readings are obtained by varying the attenuation coefficient at cable section

Attenuation Coefficient (db\km)	Gain(db)	Noise Figure (db)	Output Power (dbm)	Q Factor (db)
0.2 (db\km)	14.404664	8.96886	12.161	44.1705
1 (db\km)	14.003229	20.7865	11.359	43.3395
3 (db\km)	11.002245	51.5824	5.738	3.49102
5 (db\km)	-13.48586	81.5870	0.032	0

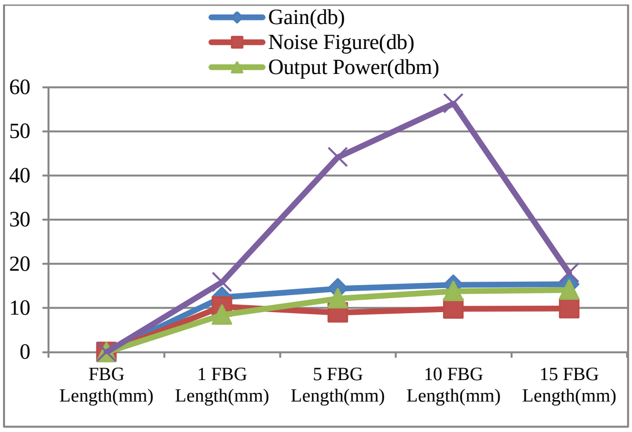


Figure 12 Graph of Signal/noise/output power figure versus length of FBG.

Conclusion

We have analyzed the dispersion compensation using Fiber Bragg Grating at different fiber lengths, The simulated transmission system have been analyzed on the basic of different parameters. By simulating a model of communication system and using the most suitable settings of the system which include input power (dBm), fiber cable length (km), FBG Length (mm) and attenuation coefficient (dB/km) at cable section, four different parameters will be investigated which are output power (dbm), noise figure (dB), gain (dB) and Q-Factor(db) at receiver. We will see the help of eye diagrams in subsequent graph. All the results are analyzed using OPTISYSTEM simulation at 10 Giga bits per second (Gb/s) transmission systems.

From the simulation result, it can conclude That, input power (dBm), fiber cable length (km),and attenuation coefficient (dB/km) at cable section are directly proportional to the noise figure. The noise figure is a measure of how much noise the amplifier adds to the signal. While the output power (dbm), gain (dB) and Q-Factor (db) are getting decreased with the increasing optical length (dBm), and Attenuation Coefficient (db\km). The input power (dBm) is increased and output power (dbm), is increased, gain (dB) and Q-Factor (db) are decreased the other hand FBG Length (db) is increased and output power (dbm), noise figure (dB),gain (dB), and Q-Factor(db) are nonlinear due to the usage of EDFA and the gain has been compressed.

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