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Analysis of Optical System to Compensate Dispersion by using Fiber Bragg Grating

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Abstract: To achieve the best performance of communication system dispersion needs to be compensated. For data transmission (light signal) in optical communication, optical fibers are used. In this paper the optical system is demonstrated which is designed in optisystem software to compensate dispersion and to transmit the signal to long length without using Fiber Bragg grating. Here we are doing comparison of two system first one is without using FBG and the other one is with FBG and then evaluate the result on the basis of bit error rate.
Index Terms— Optical communication, dispersion compensation.

I. INTRODUCTION

Because of dependence of group Index to wavelength chromatic dispersion takes place in optical fiber it creates a extension of time on pulses [1]. Electromagnetic carrier wave is modulated to carry information. In the 1970s first developed, fiber-optic communication systems have transform the telecommunications industry and have played a important role in the advent of the Information Age. Chromatic dispersion and polar mode dispersion occurs in single mode fiber (SMF). In optical system dispersion can be compensated by also using erbium doped fiber amplifier (EDFA) [2]. The frequency increases along the pulse when the dispersion coefficient parameter of the fiber is negative [3]. Chromatic dispersion is wavelength dependent and is ruling the single mode fiber [4]. The basic function of optical fiber is to transport a signal from one location to other location through communication equipment for ex. Computer, video device or telephone with high reliability and accuracy. The main constituents of an optical fiber communication link are information sources, optical transmitter, optical connectors, cabled optical fibers, optical amplifiers, passive or active optical devices and optical receivers. In optical fiber communication the phase velocity or group velocity of a wave depends on the frequency it is called dispersion. In optical

fiber due to dependence of group index to wavelength chromatic dispersion occurred. Optisystem is very useful tool or software for optical communication system. The experiment can be done very easily through it. Here we are using user defined bit sequence generator through which the desirable input can be given or information can be transmitted and can be easily vary with respect to need. The design of an optimum optical transmitter is crucial, in that it has to be capable of generating pulses with adequate temporal and spectral purity for desirable operation in high-speed optical communication systems. Optical fibers are employed for information transmission by light wave system from Fiber optic communication system. The first step in the design of an optical communication system is to convert electrical signal into an optical bit stream. The output of an optical source for ex. a semiconductor laser is modulated by applying the electrical signal either to an external modulator or directly to the optical source. The modulation format of the resulting optical bit stream have two choices. These are known as the return-to-zero (RZ) and non return-to-zero (NRZ) formats. In the RZ format, each optical pulse representing bit 1 is shorter than the bit slot, and its amplitude returns to zero before the bit duration is over. In the NRZ format, the optical pulse remains on throughout the bit slot and its amplitude does not drop to zero between two or more successive 1 bits. As a result, depending on the bit pattern, pulse width varies whereas it remains the same in the case of RZ format. In optical communication the use of RZ format help the design of high-capacity light wave systems. The optical carrier frequencies are 200 THz, whereas the microwave carrier frequencies are 1 GHz. It increases the information capacity of optical communication systems by a factor of up to 10,000, because of high carrier frequencies used for light wave systems. Here we are comparing two systems the first system does not contain any dispersion compensator and in the other one Fiber Bragg grating used. The fabrication of grating has done at a British Telecom Laboratories [5]. FBG is a type of common single mode fiber that is like a grating. The Bragg conditions satisfied propagated light, in a FBG core is resonated by grating structure and reflected. The gratings distances specify the reflected wavelength, so that, from transmission spectra reflected light is removed in Bragg wavelength. The most important feature of FBGs is that it reflects particular wavelength of light and transmits all others through the device without any attenuation. A fiber Bragg is one of the most simple and less expensive filters for wavelength selection. This filter has many applications through which the quality can be improved and the costs can be diminished in optical networks.

II. THEORY

A. Dispersion

In single mode fiber chromatic dispersion occurs due to the inherent property of silica fiber in which the refractive index varies with wavelength. Therefore, at slightly different speeds within the fiber different wavelength channels will travel. Because of this spreading of the transmission pulse takes place as it travels through the fiber. Chromatic dispersion in optical fiber is created because of the dependence of group index to

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wavelength. Some data are missing due to spreading of pulses. It should be minimized so that original data can be attained. Dispersion compensation is the process of designing the fiber and compensating element in the transmission path minimize the total dispersion. In other sentence dispersion compensation can be referred as the control of overall chromatic dispersion of the system [2].

B. Fiber Bragg Grating

In 1978 Fiber Bragg grating was firstly established by Ken Hill. Using a visible laser along the fiber core, the gratings were manufactured. Figure 1 shows the principle of FBG. In optical fiber, through Fiber Bragg grating selected wavelength of light reflected and all other were transmitted. FBGs were firstly percept as a result of strong argon ion laser radiation to a fiber with germanium dope. Afterwards, there so many methods were employed in order to map grating in optical fiber in which comprehensive types of pulsed and continuous lasers were used in visible and ultraviolet region (Raman, 1999; Othonos and Kyriacos, 1999; Marcuse, 1994). As a result according to Bragg wavelength, gratings selectively reflect the propagated light in fiber which is given as follow:

$$\lambda B = 2n\Lambda \quad (1)$$

In the equation (1), n and Λ are refractive index of core and grating period in fiber, respectively [1].
The principle of operation of Fiber Bragg Grating is shown in figure 1.

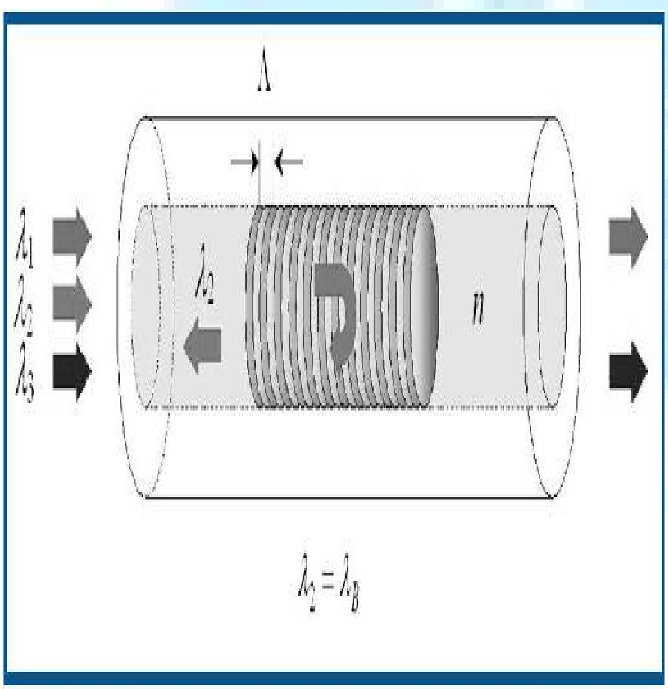

Figure 1: Principle operation of FBG

C. System design and simulation

In the figure 2, the transmission system contains user defined bit sequence generator of 10 Gbps, CW laser with 193.1 frequency, RZ pulse generator, dispersion slope of 0.075 ps/nm^2/km AM modulator, attenuation index 0.2, effective refractive index is 1.45, apodization function is tanh and its value is 5 here, chirp parameter is linear, optical time domain analyzer, optical power meter and eye diagram analyzer. In this model employed EDFA has the gain amount of 6dB, independent of wavelength and ignorable noise which is only used to compensate dispersion and nonlinear effects of transmission system. A compensator is introduced to give a dispersion index equal with opposite sign. Firstly we are giving user defined input 10 Gbps through user defined bit sequence generator to RZ pulse generator. Through CW laser, in the varying period's information is carried. Am modulator is used to superimposing the low frequency signal on a carrier signal of high frequency. Single mode fiber amplifies optical signal directly. To calculate the result we are using eye diagram analyzer through which signal to noise ratio can be observe and then bit error rate will be find. In the system without using FBG length of fiber is increasing and through the comparison of bit error rate, we can analyze the compensation in the dispersion. In the first graph there is a comparison of length of fiber and bit error rate. It is known that the bit error rate should be less than10^{-6}. After sweeping the length from 10 to 100 km we find that the signal can be reached at 60 km only without or less dispersion. All the parameters used in the model the dispersion effect given is 16.75 ps/km/nm. Now after that we included FBG in the system we can increase the value of single mode fiber from 60 to 70 km fixed it so the length of channel will be increased as compared to without FBG system and after that, sweeps the length of FBG from 1 to 20 mm at 16mm the dispersion is less with 70 km so also fixed the value of FBG length. Sweeping in the value of chirp parameter done after that we get a value 0.00007 after that bit error is increasing from the basic value. The values through which calculation has been done, evaluated by electrical power meter and eye diagram analyzer.

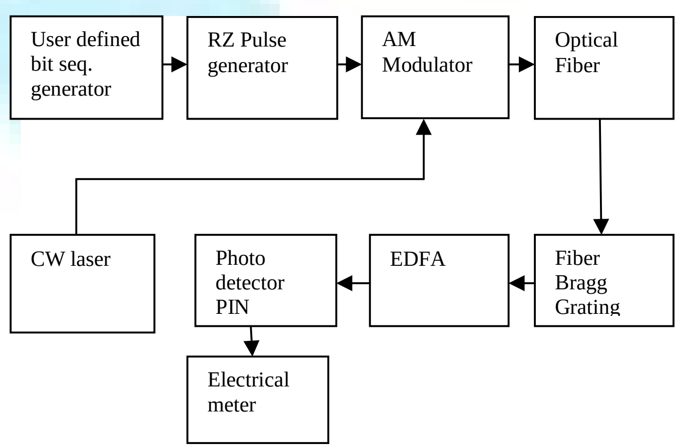

Figure 2: Block Diagram of the Optical transmission system

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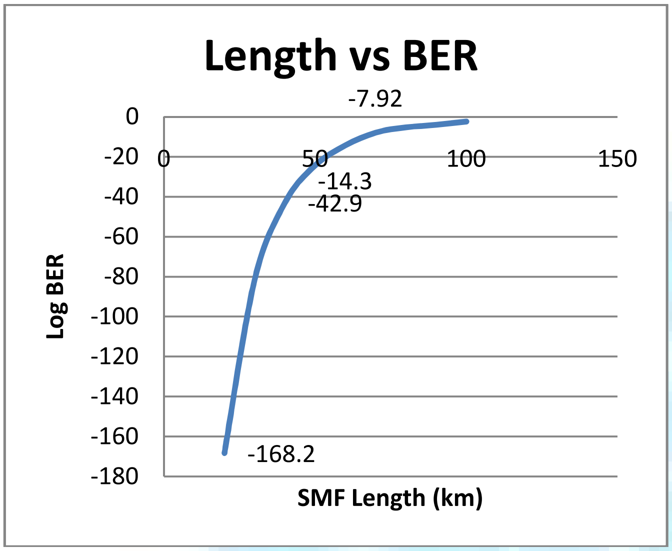
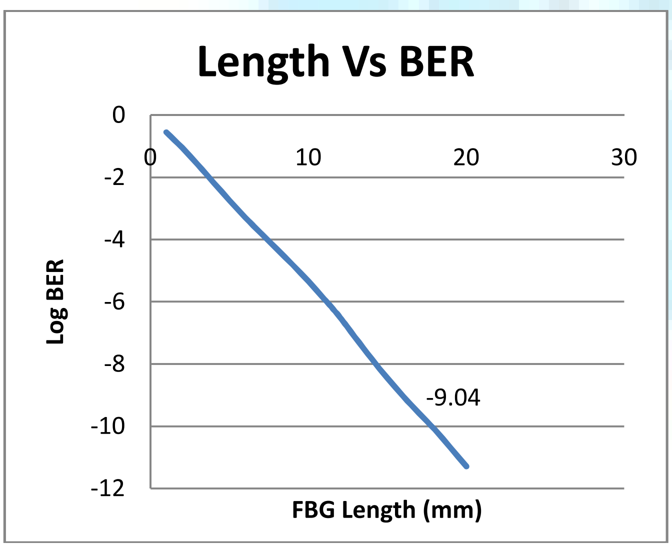
Through the electrical power meter the calculation of signal to noise ratio has been done. By using it the Q factor will be gained and the bit error rate determined. Bit error rate should be less because it is one of the main reasons of signal degradation.

III. RESULTS AND DISCUSSIONS



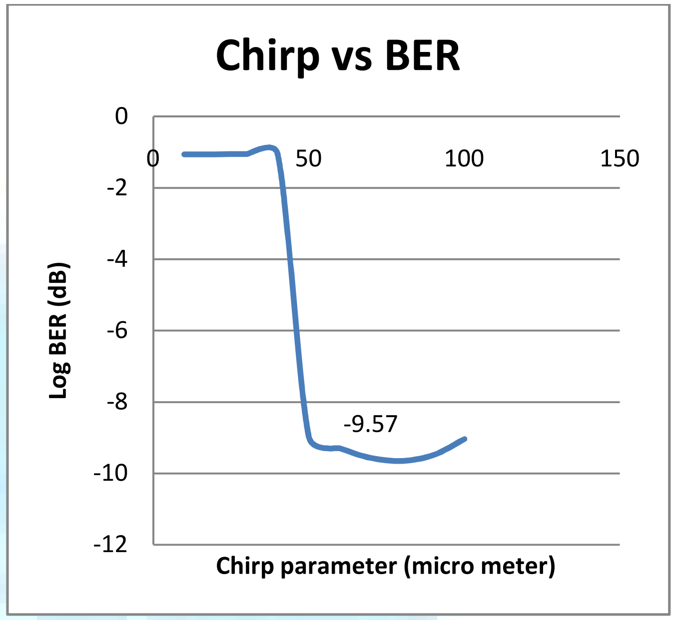
Graph 1: Length of SMF v/s BER without FBG

Here representation of two systems has been done, first one is a optical transmission system without using FBG and other one is with FBG. Graph 1 shows that after the simulation of the system the value of bit error rate is -14.3 dB at 60 km and after that dispersion occurs because the value increases to -7.92 dB.



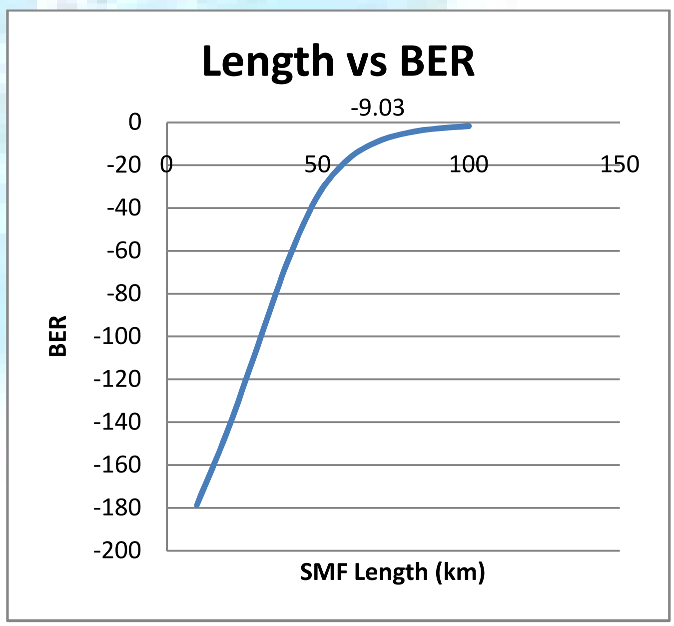
Graph 2: Length of FBG v/s BER

To increase the channel length of the system we are using Fiber Bragg Grating. Length of fiber changes from 60 to 70 km and apply sweep in the length of FBG from 1mm to 20 mm so at 16mm the value of bit error is -9.04 dB which will be fixed.



Graph 3: Chirp parameter v/s BER

After fixing the length of FBG to 16mm chirp parameter varies from 10 to 100mm, -9.57 dB occurs at 70mm which will be fixed.



Graph 4: Length of SMF v/s BER

After fixing all the values as 16mm of FBG length, 0.00007 of chirp parameter at 70 km -9.03 dB resulted. So by using FBG in the system channel length increases to 70 km.

IV. Conclusion

In this paper, in information transmission communication system is simulated. To get better result chromatic dispersion should be compensated in optical fiber. We increase the length of fiber to transmit the signal to long length with less dispersion. The length we gained is 60 km in the system without using FBG and 70 km after using FBG, which is better for the system than the other. The optisystem software is used to design this optical transmission system to compensate dispersion and to increase the length of fiber. Our aim is to survive a signal to long length without or less dispersion. By simulating we reached to a result of 60 km of length of the fiber (single mode fiber) by simulating a system without using FBG. After connecting FBG into the system the length increases from 60 to 70 km. more length can be increased through this system for future purpose.

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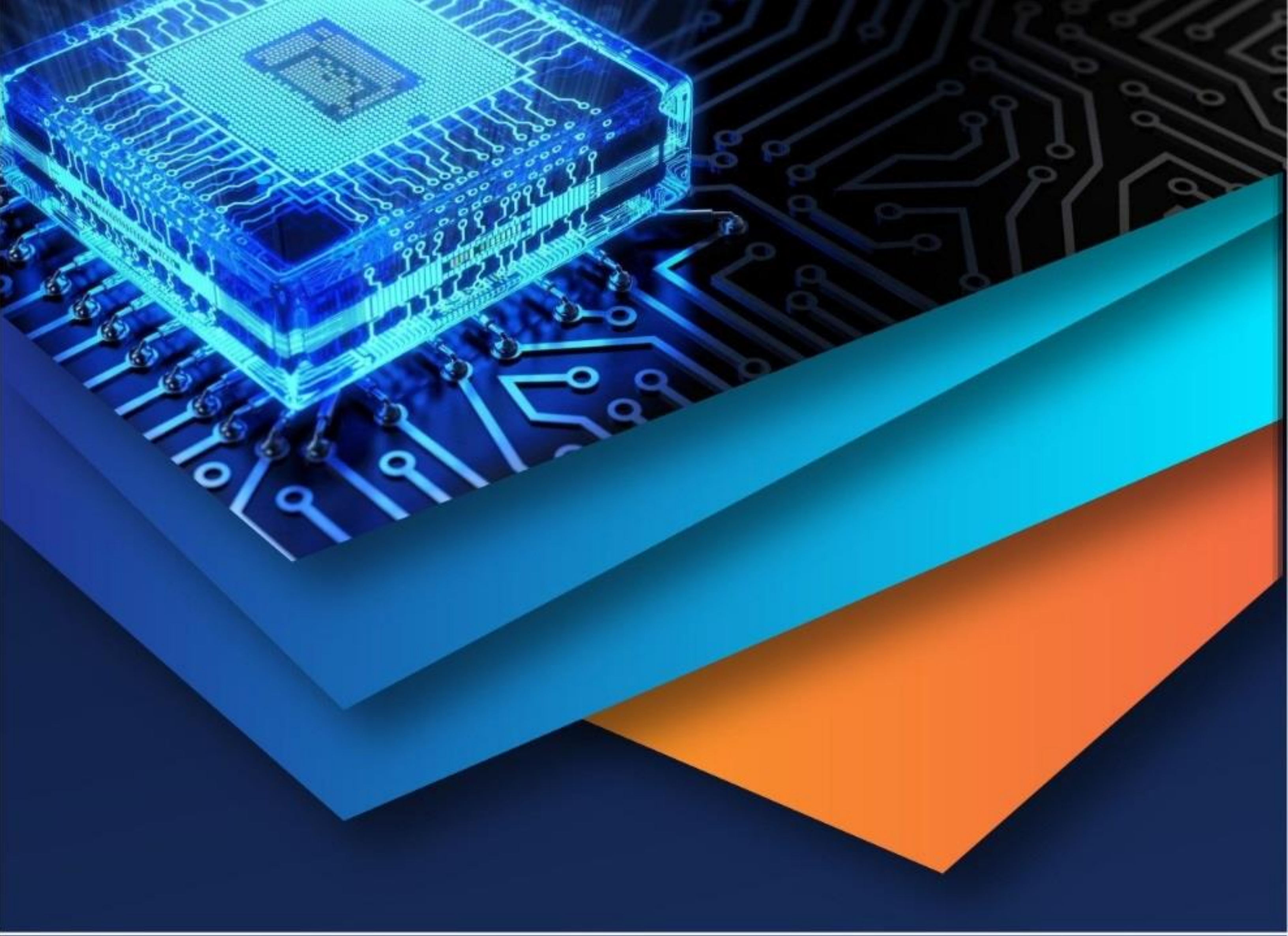

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