Reduction of dispersion using FBG in fiber optic communication

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Abstract – *Fiber optic transmissions are facing many difficulties that limited its ability for long distances. One of these difficulties is the degradation that occurs when an optical signal passes through the optical fiber. The causes of degradation are power attenuation, dispersion and nonlinear effects. Degradation in the system has to be minimized to support long haul transmission distance with high capacity. The effect of the degradation is studied and analyzed based on the BER and Eye Diagram obtained at the speed of 10 Gbps. The losses on the transmitted signals are eliminated by an optical amplifier. The results also show that Chromatic dispersion is the most significant effect of degradation phenomenon. Commonly used important component to compensate the dispersion in optical communication system is Fiber Bragg Grating. Reflection and filtering are the main functions of Fiber Bragg Grating. FBG has low cost filter for wavelength selection and low insertion loss and wide bandwidth. The simulation of transmission system will be analysed based on different parameters by using OptiSystem 7.0 simulator.*

*Key Words***:** *Fiber Bragg Grating, Degradation, Eye Diagram, Chromatic dispersion, Long Haul transmission*

1. INTRODUCTION

By using fiber optic communication the information or data transmitted from one place to another through an optical fiber. It is similar to an optical wire made it as the most acceptable for the communication channel. Three basic elements of optical communication are fiber media, input light sources and detector as the output. In optical communication the signal degradation is the most important phenomenon. Signal degradation includes power attenuation, pulse broadening, and fiber non-linearities. Power attenuation is the loss of power introduced by the fiber. The dispersion is also called as spreading of pulses as they travel through the fiber, it degrades the system performance by broadening of optical pulses as they propagate inside the optical fiber. If their parameter depends on the intensity an optical effect is called as nonlinear, these effects depend on the transmission length and there are two main nonlinear categories Stimulated light Scattering and Nonlinear Phase Modulation. The key component of optical communication system is FBG and they are used as dispersion compensator, filters and flatteners gain. FBG is very attractive components because as well as being passive,

linear and compact, retain strong dispersion in both reflection and transmission. The maximum compression ratio is achieved by using Fiber Bragg Grating. The overall losses non-linear effects and costs of optical transmission system are increased by using DCF. FBG helps to decreasing the system cost and also have lower insertion loss. In fiber optic communication Wave Division Multiplexing is a technology which multiplexes many number of optical signals on a single optical fiber by using different of light sources to carry different signals. OADM is a device used in WDM system for multiplexing and routing different channels of light into or out of a single mode fiber [9]. Programmable version of OADM is called as ROADM.*For simulation the most suitable settings of the system should be used which include input power (dBm), fiber cable length (km) and attenuation coefficient (dB/km).*

2 DISPERSION COMPENSATION

The dispersion or pulse broadening has to be compensated as it may produce Inter symbol interference and increase the Bit error rate. There are various mechanisms for compensating the dispersion.

2.1 Fiber Bragg Grating (FBG):

Fiber Bragg grating constructed in a short segment of optical fiber is a distributed Bragg reflector it will reflect the particular wavelength and the remaining wavelength will be transmitted as shown in Fig. 2.1. The refractive index of the fiber core is achieved by producing a periodic variations, it creates a wavelength-specific dielectric mirror. Chirped Fiber Bragg Grating is one of most important components for chromatic dispersion compensation. Fiber Bragg Grating is commonly used and low cost filter for wavelength selection. Fiber Bragg Grating has a several applications to improve the standard and reduce the costs in optical networks[1]. The operation of FBG is reflection and filtering techniques and they have a high efficiency and low losses. Chromatic dispersion can be reduced with the help of Fiber Bragg Grating. To compensate chromatic dispersion in a communication system, the final expected effect is compressed in incident pulse. Fiber Bragg Grating act as a single mode it will expose the core to the periodic pattern of intense UV light. The exposure will increase the refractive index so that refractive index is permanently increased. So that exposure pattern will produce fixed index modulation called as a grating. Due to the changes in

the periodic refraction, a small reflected light rays will be produced. Then, the small reflected light rays will be combined into a large reflected light rays. When the grating period is approximately half the input light wavelength which is called Bragg's wavelength. The other light (except the Bragg's light) will be able to see. The longer wavelength light move slowly than the shorter wavelength light because of pulse broadening. Because of high data rates and fiber lengths, the pulses in a data stream will tends to be overlap. Like that, fiber dispersion limits the higher data that can be transmitted through a fiber optic cable.
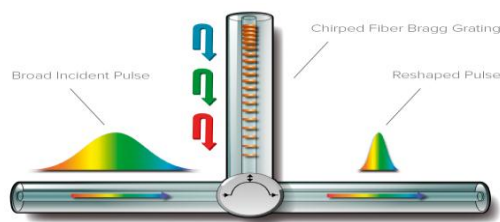

Fig 2.1: Dispersion compensation mechanism

The use of Fiber Bragg Grating shown in Figure 2.1 is to compensate the chromatic dispersion in an optical fiber communication. The transit times of different wavelengths in a pulse regulate the grating serves as a particular optical delay line. So that they are approximately equal. The faster wave lengths are travel at a longer distance and the shorter wave lengths are travel at a shorter distance [3].
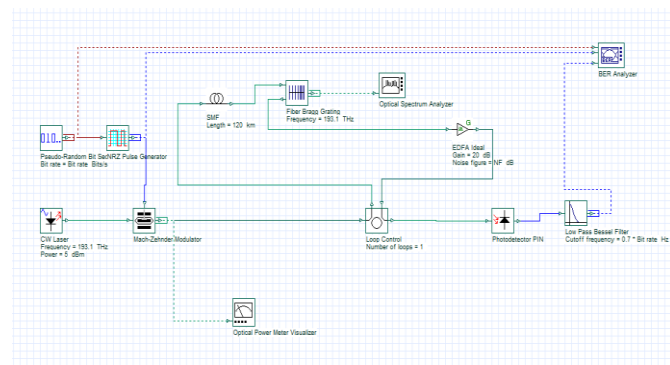

Fig 2: Dispersion compensation using FBG

3 Dispersion Compensation Fiber (DCF):

In recent years there has been a lot of work on dispersion-compensating fibers (DCFs), which are being used extensively for enhancing the installed 1310 nm optimized optical fiber links for operation at 1550 nm. The first step will be designing and simulation of the pre, post and symmetric dispersion compensation. This will be done by using OptiSystem software version 7.0. First we completely study about the software will be done. The

OptiSystem software is user friendly to work, flexible, and fast and the OptiSystem components library consists many components that can be measured from design of real devices. The parameters such as bit rate, fiber length, sensitivity and dispersion parameters will be varied to achieve best BER by using model design in OptiSystem software. By using the OptiSystem software the Comparison analysis of systems will be done. The BER analyser is used to analyse the BER and eye diagrams. We will discuss three dispersion compensation techniques in this research paper to compensate fiber dispersion, there are pre-, post-, and symmetrical compensation. In this simulations, NRZ modulation formats are used and receiver sensitivity for 2.5 Gbps is -28 dBm and for 10 Gbps -25 dBm.

3.1 . Pre DCF

The layout involving the pre DCF is shown in Fig. 3.1 and the BER for various transmitted optical power is shown in Table 3.1.
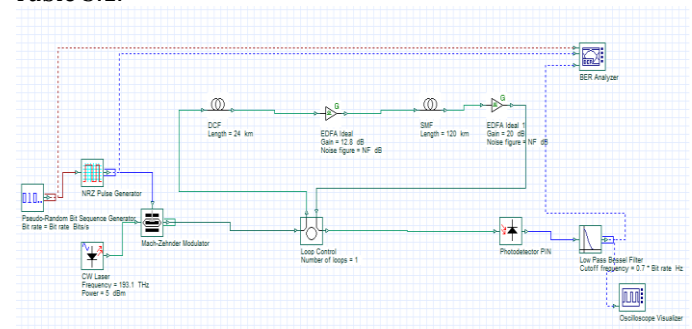

Fig 3.1: Pre DCF

The layout for Post DCF is shown in fig. 3.2. The layout for Symmetrical DCF is shown in fig. 3.3.
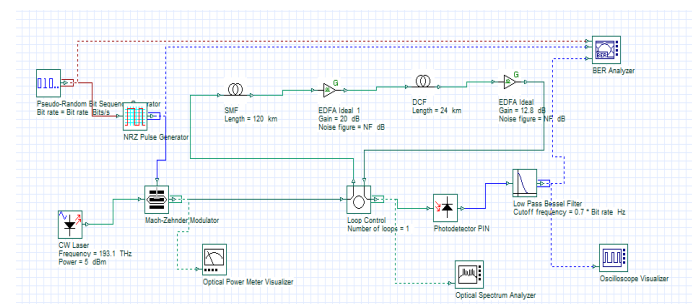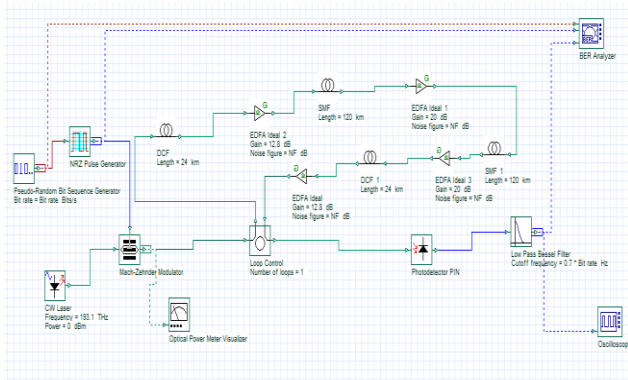

Fig 3.2: Post DCF

Fig 3.3: Symmetrical DCF

Table 3.1 :Observation of BER for various Transmitted power

Power (dBm)	DCF			FBG
	pre	Post	symmetrical	
0	1.149×10^{-10}	8.189×10^{-11}	2.3250^{-15}	1.09×10^{-24}
1	7.804×10^{-11}	5.564×10^{-11}	3.368×10^{-17}	7.11×10^{-26}
2	5.579×10^{-11}	3.581×10^{-11}	5.239×10^{-19}	6.22×10^{-27}
3	3.75×10^{-11}	2.216×10^{-11}	1.029×10^{-20}	6.36×10^{-28}
4	2.589×10^{-11}	1.245×10^{-11}	2.843×10^{-22}	6.66×10^{-29}
5	1.581×10^{-11}	6.239×10^{-12}	1.58470^{-23}	5.8410^{-30}

4. OPTICAL ADD-DROP MULTIPLEXING

Optical add-drop multiplexer (OADM) is a device used in WDM systems for various techniques as multiplexing and routing the different channels of light into or out of an optical network. Add and drop device has the capacity to add one or more new wavelength channels to an existing multi wavelength WDM signal. And it is used to drop one or more channels, passing those signals to another network path. An OADM has a various specification, one of the important specific type is an optical cross connects. An OADM consists of an optical multiplexer and an optical demultiplexer and reconfiguration is present in between the multiplexer and demultiplexer and a set of ports are present for adding

and dropping signals. The OADM can be realized by several ways.

The OADM layout with 4 channels is shown in Fig. 4.1. The evaluation of BER in different channels for various power levels is shown in Table 4.1.
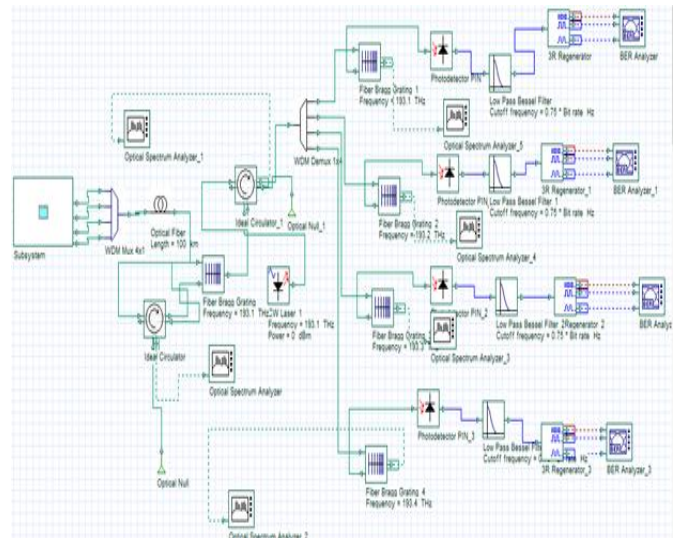

Fig 4.1: OADM with 4-channels

Table 4.1 Observation: BER in different channels

POWER (dBm)	BER			
	Channel 1	Channel 2	Channel 3	Channel 4
0	0.000474	0.00036	4.668×10^{-5}	4.082×10^{-5}
1	1.642×10^{-5}	8.665×10^{-6}	4.893×10^{-7}	3.318×10^{-7}
2	8.640×10^{-8}	7.460×10^{-8}	7.172×10^{-10}	1.675×10^{-10}
3	2.735×10^{-11}	1.958×10^{-11}	8.740×10^{-15}	1.013×10^{-15}
4	8.925×10^{-17}	1.076×10^{-16}	2.363×10^{-22}	6.961×10^{-24}

3. CONCLUSIONS

We have analyzed the dispersion compensation using Fiber Bragg Grating (FBG) and DCF at different transmission power. The transmission systems have been analyzed on the basic of different parameters. By simulating a communication system and using the acceptable settings of the system which include input power (dBm), fiber length (km), grating Length (mm) and

dispersion parameters. We design a OADM system to improve the efficiency of WDM system. All the results are analyzed by using OPTISYSTEM 7.0 software. From the result we found FBG is the best dispersion compensator compared to DCF.

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