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Fiber Bragg Grating as a Dispersion Compensator in an Optical Transmission System Using Optisystem Software

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Abstract—Optical fiber is one of the most important communications media in communication system. Due to its versatile advantages and negligible transmission loss it is used in high speed data transmission. Although optical fiber communication has a lot of advantages, dispersion is the main performance limiting factor. There are various types of optical fiber compensators, but 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 designed & analyzed based on different parameters by using OptiSystem simulator. A model of communication system is designed by suitable settings of the system

Keywords—*fiber optics, fiber bragg grating (FBG), optical fiber dispersion, dispersion*

I. Introduction

Fiber optics is a medium for carrying information from one point to another in the form of light. Unlike, the copper form of transmission, fiber optics is not electrical in nature. A basic fiber optic system consists of a transmitting device that converts an electrical signal into a light signal, an optical fiber cable that carries the light, and a receiver that accepts the light signal and converts it back into an electrical signal .Fiber Bragg gratings (FBGs) have been widely applied in optical Sensors and optical communications due to the promising Performances with electro-magnetic immunity, compactness, Remote sensing, ease of fabrication and wavelength selectivity. Fiber Bragg Gratings (FBG) is added for the design of Optical Transmission System. Fiber Bragg gratings have many applications in fiber optical telecommunication systems such as dispersion compensation, gain flattering for EFDAs, Raman amplifiers add/drop multiplexers and in fiber grating sensors and pulse shaping in fiber lasers. Combining, controlling and routing light are three main uses of FBGs in the optical communications .

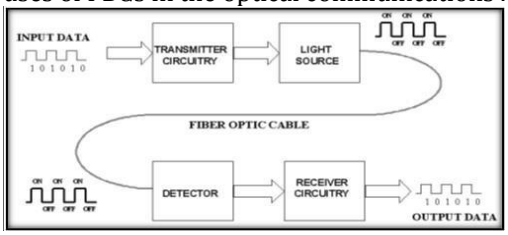

Fig 1. Basic fiber optic communication system

They are also stimulating growth in fiber optic applications outside of telecommunications, such as nonlinear frequency conversion, spectroscopy, and remote sensing.

Optisystem is an innovative optical communication system simulation package that designs tests and optimizes virtually any type of optical link in the physical layer of a broad spectrum of optical networks, from analog video broadcasting systems to intercontinental backbones. It is a system level simulator based on the realistic modelling of fiber-optic communication systems. It possesses a powerful new simulation environment and a truly hierarchical definition of components and systems. Its capabilities can be extended easily with the addition of user components, and can be seamlessly interfaced to a wide range of tools.

In this study, the simulation of the optical transmission system in optical fiber has been discussed by analysing the effect of the components in data receiver by using different parameters setting. The value of parameters has been investigated such as Signal power (dBm), Noise power (dBm), output power (Watt).

II.DESCRIPTION OF COMPONENTS

A. Fiber Bragg Grating

The Fiber Bragg Grating (FBG) is a fiber optic passive component exhibiting basic functional attributes of reflection and filtering.FBG's are relatively simple to manufacture, small in dimension, low cost and exhibit good immunity changing ambient conditions and EM radiation. FBG's have replaced bulk optic mirrors & beam splitters in equipment which increases system stability and portability. A fiber Bragg grating is region of periodic refractive index perturbation inscribed in the core of an optical fiber such that it diffracts the propagating optical signal at specific wavelengths.

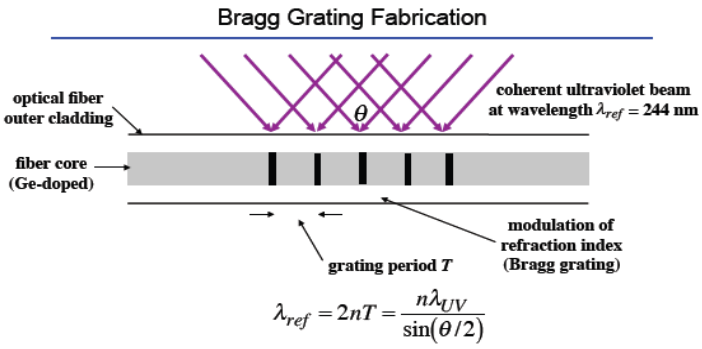

Fig 2: Fibre Bragg Grating

The system is operated with the basic optical communication which consists of a transmitter, transmission link and a receiver. The system transmits information using optical carrier wave from transmitter to receiver via optical fiber.

B. Pseudo–Random Bit to generate sequence random bits (0 OR 1)

Generates a Pseudo Random Binary Sequence (PRBS) according to different operation modes. The bit sequence is designed to approximate the characteristics of random data.

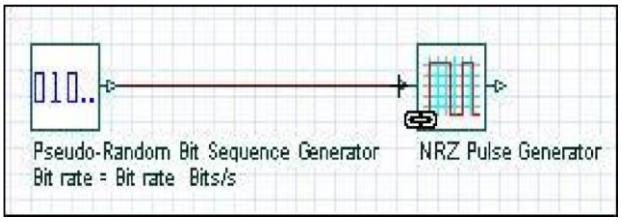

Fig 3. PRBS connected with NRZ

Pseudo Random Bit Sequence (PRBS) is used to scramble data signal in terms of bit rates. Pseudo-random bit sequence generator is used to scramble data signal in terms of bit rate.

C. NRZ Pulse Generator

Optical information signals get modulated with optical source signal and make two types of pulse RZ and NRZ. 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 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. 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.

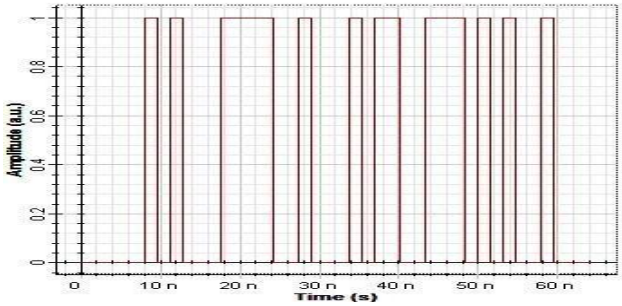

Fig 4 NRZ

D. MACH-ZEHNDER Modulator

Optical modulators are used for electrically controlling the output amplitude or the phase of the light wave passing through the device. To reduce the device size and the driving voltage, waveguide-based modulators are used for communication applications.

E. Optical Fiber

An optical fiber (or optical fiber) is a flexible, transparent fiber made of extruded glass (silica) or plastic, slightly thicker than a human hair. It can function as a waveguide, or "light pipe",[1] to transmit light between the two ends

of the fiber. The field of applied science and engineering concerned with the design and application of optical fibers is known as fiber optics. Optical fibers typically include a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fiber to act as a waveguide. Fibers that support many propagation paths or transverse modes are called multi-mode fibers (MMF), Optical fiber can be used as a medium for telecommunication and computer networking because it is flexible and can be bundled as cables. It is especially advantageous for long-distance communications, because light propagates through the fiber with little attenuation compared to electrical cables. This allows long distances to be spanned with few repeaters.

F. Fiber Amplifier (EDFA)

Erbium-doped fibre amplifiers (EDFAs) have received great attention due to their characteristics of high gains, bandwidths, low noises and high efficiencies. Optical amplification is required to overcome the fiber loss and also to amplify the signal before receive by Photo detector PIN at the receiver part.

G. Continues LASER Diode(CW)

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 to zero (NRZ) pseudorandom binary sequence in a Mach-Zehnder modulator with 30 dB of extinction ratio.

H. Optical Spectrum Analyzer

Optical Spectrum Analyzer (OSA), to monitoring output signals after each component. Optical spectrum analysis is the measurement of optical power as a function of wavelength.

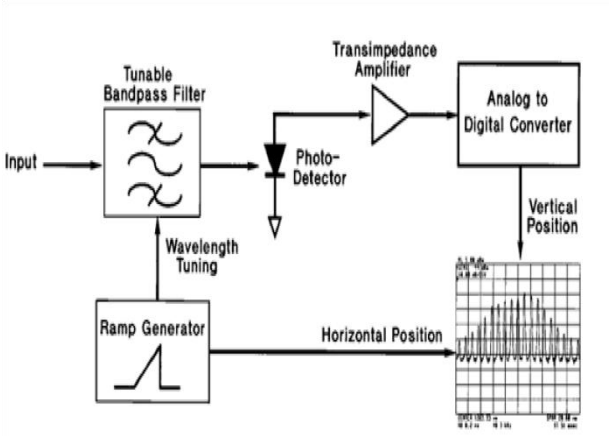

FIG 5 OSA GRAPH

III.SCHEMATIC DIAGRAM

This schematic diagram showing a brief idea about how the communication network will be arranged in optisystem software. Mach Zehnder Modulator to modulate the information pulse with the CW laser source output. Then they transmit over the fiber, the optical fiber we have taken is single mode because it has less distortion occur. The simulation is taken by putting the FBG in the path of optical fiber and without using FBG , FBG is so chosen which has step size of 6 mm. the following parameters are so select for simulation.

TABLE 1: SIMULATION PARAMETERS

C/W INPUT POWER	18dBm
C/W LASER FREQ	193.1THz
REFERENCE WAVELENGTH	1550nm
FIBER LENGTH	15km
ATTENUATION	0.2db/km
EDFA LENGTH	5km

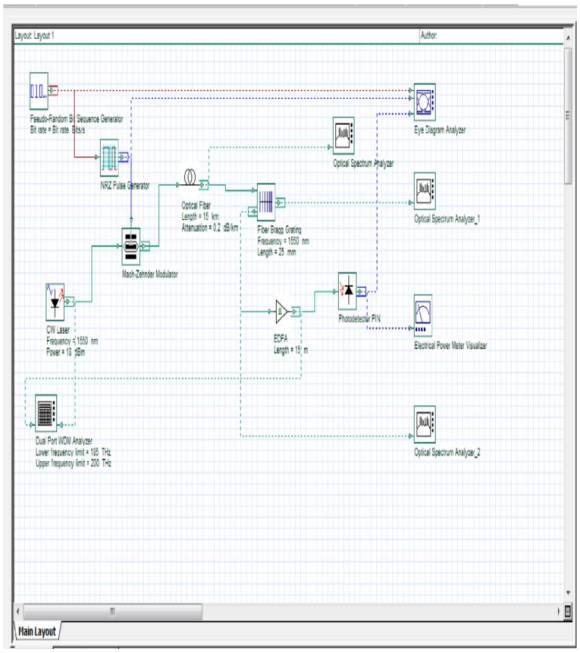

FIG 6 SCHEMATIC DIAGRAM

IV. RESULTS AND ANALYSIS

The simulation and optimization of the design is done by Optisystem 7.0 simulation software. The eye diagrams and results of output power, Signal power (dBm) at receiver, noise power are tabulated by using different values of input power (dBm), attenuation coefficient (dB/km), and variable length of FBG (mm). The related graphs are also plotted as shown in figures 7.1 & 7.2

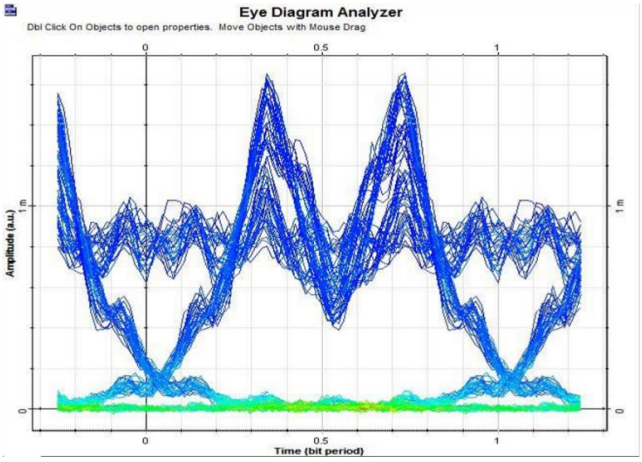

Fig 7.1 Before using FBG

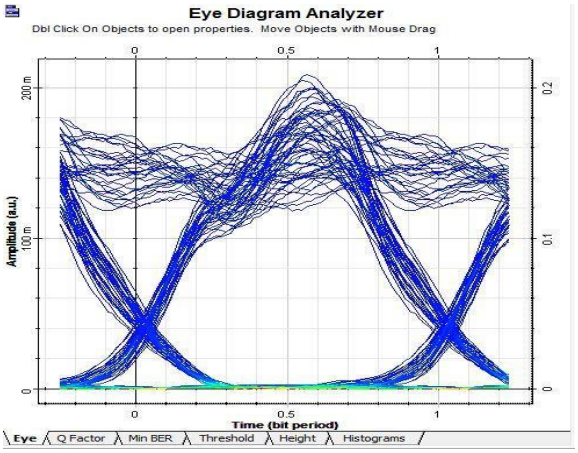

Fig7.2 After using FBG

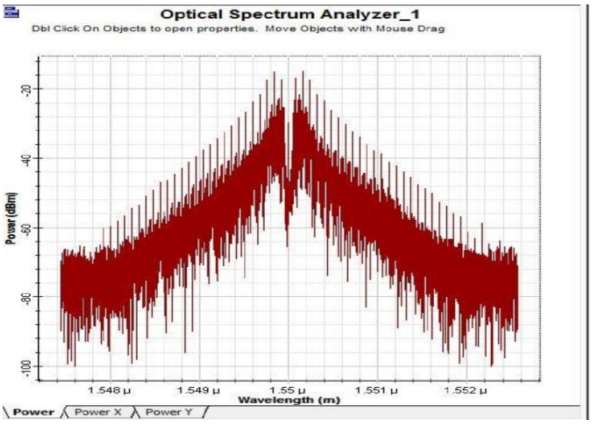

Fig7.3 Before using FBG

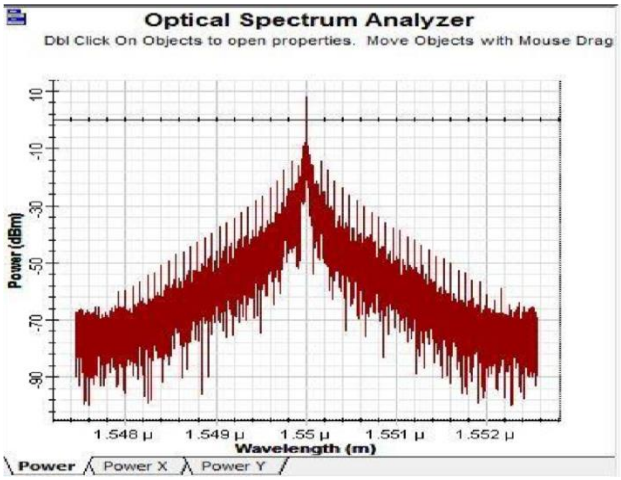

Fig 7.4 After using FBG

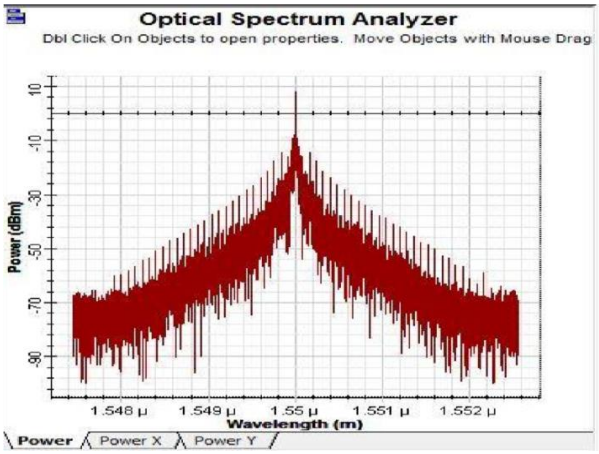

fig 7.5 Reflected from FBG

The above diagram shows the different values with respect to different fiber bragg grating, thus which some parameters like signal power, noise power and output power varies.it will give a briefly idea about quality factor and channel bandwidth accordingly. All the results are tabled accordingly the eye diagrams are showing the sharpness with improve quality factor.

IV. CONCLUSIONS

From the design and simulation of optical transmission system, the system will transmit information using optical carrier wave from transmitter to receiver via optical fiber, the transmission system block diagram Figure1 has been designed which consists of laser light as the source, modulator, single mode optical fibre as the channel, fiber Bragg grating (FBG) as the dispersion compensator, optical amplifier and the photo detector as the light detector. The optical transmission system has been modelled by using Optisystem7.0 simulator as shown in Figure 5 in order to investigate different parameters of the system. From the simulation result, it can conclude that the fiber Bragg grating length and the input power are directly proportional to the signal power. While the noise is getting lower with the increasing length, on the other hand, the output power is decreased although the attenuation coefficient increased.

V.FUTURE SCOPE

This project leaves a lot of ideas about the advancements which can be implemented in future days with further development in the optical fiber. Also, we can say that the FBG process is not 100% automated but yes, it can be possible in the future with the help of instrumentation engineers like us. Hence, we can say that it's not an end to the software field but a start and it will definitely reach much higher levels in the future, which are unpredictable in the present.

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Prof. Bibhu Prasad has completed his bachelor in Electronics& communication engg. And Master in Electronics & Instrumentation engg . Presently he is working as Assistant Professor in Department of Applied Electronics & Instrumentation in GIET, Gunupur, Odisha , India. His interest field of research is signal Processing, Application of optical fiber for Losses Control. Presently he is perusing his Ph.D at Sambalpur University., odisha.

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