International Journal of Soft Computing and Engineering (IJSCE)
ISSN: 2231-2307, Volume-6 Issue-4, September 2016

Implementation of FBG Mechanism for the Removal of Optical Signal Spreading

Mohammed AbdALLA Adam Elmaleeh, Fadalalla Suleiman Mahmoud Gamer

Abstract— ***Single mode fiber has been used in long haul communications systems to increase the transmission capacity and to meet the increasing of demand for the communication services. Therefore, any type of the signal degradation effects should be strappingly minimized. The performance of a digital communication system is measured by probability of error per bit, which is referred to as the bit error rate (BER). Error occurs as a result of noise in the received signal, or due to pulse spreading into neighboring bits which result in symbol interference. In this paper the optical signal degradation effects were studied. Initially the optical signal Eye diagram for an optical fiber of different lengths before applying compensation mechanism were obtained using OPTsys simulation tool. The data rate of 20 - 40 Gbps is introduced to the system and examined using specified fiber lengths parameters. It is observed that the received signals were significantly degrade due to the signal degradation effects. Fiber Bragg Grating is implemented as spreading lessens mechanism and the optical amplifier (EDFA) is used to compensate the reduction of signal power when propagates through the fiber strand. The results obtained showed that the width of the pulse spreading significantly reduced from 0.43ps to 0.18ps, with BER of $8.825x10^{-10}$, Quality factor = 9.7 and total possible distance is found to be of 25 k.***

Indexed Terms— ***Digital communication, FBG, BER, Optical Signal, Optical amplifier Bearings, Fast Fourier transform.***

I. INTRODUCTION

A. Laser Diodes

Laser diodes are complex semiconductor devices that convert an electrical current into light. The conversion process is fairly efficient since it generates slight heat compared to incandescent lights.

These diodes have the advantages of high power (ten of W), high speeds (many of Gb/s), narrow spectral line width (tens of MHz) and ease of coupling into single mode fiber. However they are sensitive to temperature variations. Multimode laser diodes suffer from partition noise, which is a random distribution of the laser power among the modes.

When subjected to chromatic dispersion in the fiber, this lead to random intensity fluctuations and reshaping of the transmitted pulse, laser diodes also suffer from frequency chirping which is a change of the laser frequency as the optical power is modulated [1].

There are four different types of laser diodes these are: distributed feedback laser (DFB), Vertical external cavity surface emitting laser (VECSEL), Fabry Pert cavity laser diodes and the distributed Bragg reflector (DBR).

Generally laser didoes are used for high speed long distance communications single – mode which must contain only a single longitudinal mode and a single transverse mode. Consequently, the spectral width of the emission is very narrow, with very small numerical aperture (NA). Figure1 represents a Laser diode as an optical source.

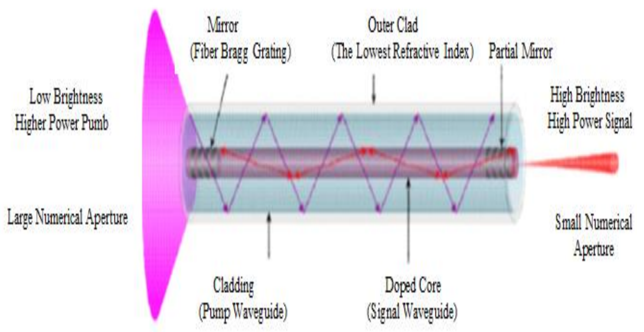

Figure1: Laser diode as Optical Cource

B. Light Source for Optical Fibers

Optical beams are generated by light sources to carry the information in an optical fiber system. The two most common sources of light are the Light Emitting Diode (LED) and Light Amplification by stimulated Emission of Radiation (Laser). Both diodes work on the principle of electro-luminance; a phenomenon of the emission of optical radiation by converting the electrical energy into light [1].

Laser light sources are significantly more expensive compared to LEDs. They produce a light with high power and low dispersion. Usually Laser can be precisely controlled and were used with a single mode cable. However, LEDs light sources produce more dispersed light sources (many modes of light) which were used with multimode cable.

The rudimentary requirements for the light sources used in optical communication systems depend on the nature of the intended application such as long – haul communication and local area network. The principle features are [1]:

- **Power**: The source power must be sufficient so that, after transmission through the fiber, the received signal is detectable with the required accuracy.
- **Speed**: The source power must be modulated at the rate desired for imparting.
- **Light width**: The source must have an arrow spectral line width so that the effect of chromatic dispersion in the fiber is minimized.

C. Optical Fibers

An optical fiber is a cylindrical dielectric waveguide made of low-loss materials, usually fused silica glass of light chemical purity. An optical fiber is made up of a core, cladding and buffer coating where the core carries light pulses, the cladding reflects light pulses back into the core

Revised Version Manuscript Received on August 25, 2016.

Mohammed AbdALLA Adam Elmaleeh, Faculty of Engineering, Alneelain University, Khartoum, Sudan.

Fadalalla Suleiman Mahmoud Gamer, Faculty of Engineering, Alneelain University, Khartoum, Sudan.

and the buffer coating is used to prevent core and Item LED Semiconductor Laser Data rate Low High Fiber type Multimode or Single mode Distance Short Long Temperature sensitivity Minor Substantial Cost Low cost Expensive cladding from being damaged. The basic view of an optical fiber is shown in the Figure2. It operates at optical frequencies, with three different waves length bands: 850nm, 1310nm and 1550nm. The light travels in the fiber in the form of modes; each represents a wave with a distinct spatial distribution, polarization propagation constant, group velocity, and attenuation coefficient. There are three modes of optical fibers with significant differences in their characteristics. These are Multi-mode step index fibers, Multi-mode graded index fibers and, single mode fiber [2-3].

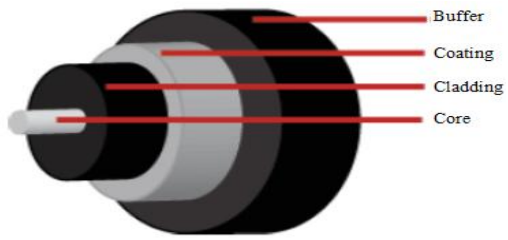

Figure2: Basic view of an Optical Fiber

The number of guided modes M is governed by the normalized frequency V; an important parameter connected with the cut off condition. V is can be obtained by the formula shown in equation1

$$V=\frac{2\pi a}{\lambda}\sqrt{n_1^2-n_2^2} \qquad (1)$$

Where: V: Normalized frequency (dimensionless number that determined how many modes a fiber can support), a: the radius of the core and λ: the wave length.

In the fiber With V >> 1 there are large number of modes, $M = V^2/2$, since the mode travels with different group velocities, this results in pulse spreading (Inter symbol interference), which increase linearly with the fiber length an effect called dispersion. The disadvantage of multi-mode fibers is that they suffer from intermodal dispersion. This restricts the distance that the pulse can be usually sent over multimode fiber.

D. Multi-mode Fibers

Fibers that carry more than one mode are called multimode fibers. In a multimode fiber, the core diameter is much bigger than the wave length of the transmitted light. A number of modes can be simultaneously transmitted. The number of modes that can be transmitted along the fiber increases with the core diameter. The problem with multimode cable is that some of the modes are longer than others. In this case a pulse of light will be 'spread out "due to the modal dispersion, this causes an effect referred to as" inter symbol interference ' which restricts the distance that the pulse can be usefully send over multimode fiber [2-3].

There are two types of multimode fibers: step-index multimode fiber and graded-index multimode fiber (shown in Figure3).

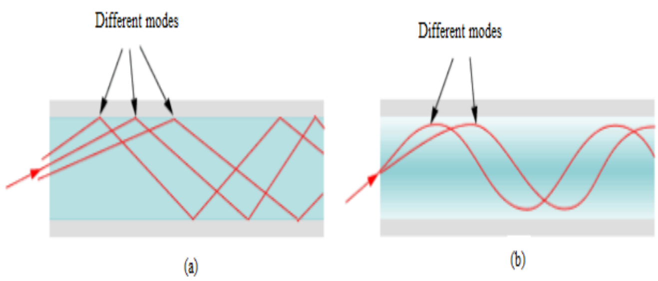

Figure3: Light Transmission in Multi mode fibers (a) Step index. (b) Gradded index

In Multi- mode step – Index fiber there is an abrupt change in the refractive index at the core cladding boundary due to the variable path length, the light entering the fiber takes a variable length time to reach the detectors. These results in pulse – broadening or dispersion, this limits the maximum distance and the rate at which the data (light pulse) can be practically transmitted. The output pulse reduces the amplitude as well as increases the width, the greater the fiber length, the worse this effect. The number of modes in a step index fiber is given by [4, 5]:

$$M \approx \frac{1}{2}\frac{(2\pi a)^2}{\lambda^2}(n_1^2-n_2^2)=\frac{V^2}{2} \qquad (2)$$

Where: λ: Is the operating wave length, n1 and n2 are refractive index for core and cladding respectively. The core diameter is 50– 200 μm.

Graded index fibers have intermediate bandwidth and capacity. It is less expensive method of overcoming transit time desperation. This fiber has a property of gradually changing refractive index (increasing from outside of the fiber core to it is center). It is a type of optical fiber whose refractive index is a function of the radial distance from the fiber's axis. The light waves with large angles of incident travel more paths – lengths than those with smaller angles, but it is know that the decrease of refractive index allow a higher velocity of light energy propagation. Thus, all waves will reach a given point along the fiber, at virtually the same time. As a result, the transit time dispersion is greatly reduced the variation of refractive index of the core of the graded index fiber with radius, measured from the center of the core is given by:

$$V = n_1\left[\sqrt{1-2\Delta\left(\frac{r^a}{a^a}\right)}\ \right] \quad for\ 0 \le r \le a \qquad (3)$$

$$V = n_1\sqrt{(1-2\Delta)} \cong n_1(1-\Delta) = n2 \quad for\ \ r \ge a \ (4)$$

Where: n1: Is refractive index at the Centre of core, α: Is index profile and Δ: (n1 – n2) / n1.

In the graded index fiber, the number of modes is expressed by the formula given below:

$$M = \frac{1}{2}\frac{(2\pi a)^2}{\lambda^2}(n_1^2 - n_2^2) = \frac{V^2}{4} \qquad (5)$$

Where: λ: Is the operating wave length, a: Is the core radius, n1 and n2 are refractive index for core and cladding respectively. The core diameter is about 50 - 100μm.

E. Single –Mode Fiber

When the fiber core is so small that only light ray at 0° incident angle can stably pass through the length of fiber without much loss, this kind of fiber is called single mode fiber. The basic requirement for single mode fiber is that the core must be small enough to restrict transmission to a single mode. This lowest-order mode can propagate in all fibers with smaller cores (as long as light can physically enter the fiber). The most common type of single mode fiber has a core diameter of 8 to 10 µm and is designed for use in the near infrared (the most common are 1310nm and 1550nm). The mode structure depends on the wavelength of the light used, so that this fiber actually supports a small number of additional modes at visible wavelengths. Multi-mode fiber, by comparison, is manufactured with core diameters as small as 50um and as large as hundreds of microns. Figure4 shows the fiber structure of a single mode fiber, which carries only one mode of propagation, and having small differences between the core and the cladding with V = 2.4. In practical the design of single - mode fiber, the core - cladding index differences varies between 0.2 and 1.0 percept [4-6].

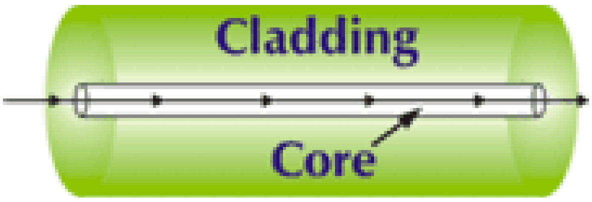

Figure4: Structure of a Single Mode Fiber [4]

F. Conditions for Single Mode Transmission

To calculate the number of modes N_m in a step-index fiber, N_m can be simplified as:

$$N_m = \frac{1}{2}\frac{(\pi d)^2}{\lambda^2}(n_f^2 - n_c^2) \qquad (6)$$

Where: d: is core diameter of the fiber, λ : is the operating wavelength, nf : is refractive index of the fiber core, nc : is refractive index of the cladding.

Reducing the core diameter sufficiently can limit transmission to a single mode. The following formula defines the maximum core diameter, D, which limits transmission to a single mode at a particular wavelength, λ**:**

$$d \le \frac{2.4\lambda}{\pi}\sqrt{n_f^2 - n_c^2} \qquad (7)$$

If the core is any larger, the fiber can carry two modes.

G. Dispersion of the common types of single-mode fibers

There are three basic classes of single mode fiber that are used in modern telecommunication systems. The oldest type and still the most widely deployed is the Non-Dispersion-Shifted Fiber (NDSF or Non-DSF). NDSF was the first successful single-mode fiber. Most of the existing fiber base in the U.S. in the late 1990's was NDSF fiber. NDSF was used in early systems because the fiber was optimized for operation at 1310 nm, the wavelength of choice at that time Later, 1550 nm systems were introduced. NDSF was thought to be ill-suited for use at 1550 nm because it had high dispersion at that wavelength, limiting the maximum data transmission rate and distance. To address this shortcoming, Dispersion-Shifted Fiber (DSF) was introduced [5, 6].

DSF was optimized for operation at 1550 nm years later it would be discovered that while DSF worked very well with a single wavelength at 1550 nm, it exhibited serious 18 nonlinearities when multiple, closely-spaced wavelengths in the 1550 nm band were transmitted, as in DWDM systems. Recently, to address the problem of nonlinearities, a new class of DSF fibers has been introduced. These are called non-zero dispersion-shifted fiber (NZ-DSF). These NZ-DSF fibers are available in both positive and negative dispersion varieties. They are the now the fibers of choice where new fiber must be deployed. Figure 5 shows the dispersion of the common types of single-mode fibers [7].

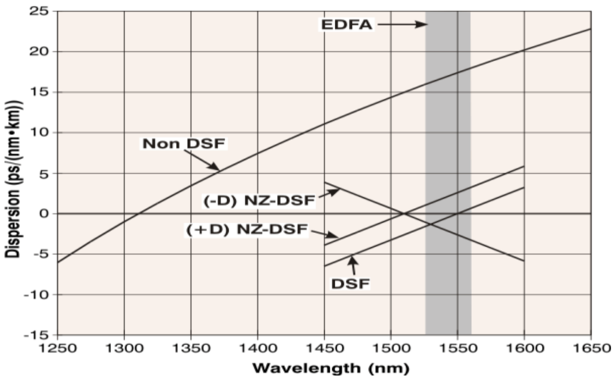

Figure5: Dispersion of Common Types of Single-Mode Fiber [5]

H. Dispersion types

Dispersion is the broadening of light pulses as it propagates through the fiber. It increases with the length of the fiber. Excessive dispersion causes over-lapping of adjacent pulses or inters symbol interference. So dispersion has a negative effect on the bandwidth of a fiber. The higher the dispersion, the lower will be the bandwidth of the system. Dispersion also decreases the peak optical power of the pulse and therefore increases the effective attenuation of a fiber. Dispersion may be classified into two categories depending on the cause. These are Intermodal dispersion and Intermodal dispersion (chromatic dispersion).

Modal dispersions are dominant in multimode fibers where the optical rays propagate in different modes, this type of dispersion is absent in single – mode fiber, simply because the energy of injected pulse is transported by a single mode [7].

Single mode fiber doesn't have modal dispersion, modal noise, and other effects that come with multimode transmission; single mode fiber can carry signals at much

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

higher speeds than multimode fibers. They are standard choice for high data rates or long distance span (longer than a couple of kilometres) telecommunications which use laser diode based fiber optic transmission equipment. Since single mode fiber's core is so much smaller than a multimode fiber's core, coupling light into single mode fiber requires much tighter tolerances than coupling light into the larger cores of multimode fiber. However, those tighter tolerances have proved achievable.

Single mode fiber components and equipment are also more expensive than their multimode counterparts, so multimode fibers are widely used in systems where connections must be made inexpensively and transmission distances and speeds are modest.

I. Four Wave Mixing (FWM)

FWM occurs when two or more signals propagate in the same direction in the same fiber .These signals mix to produce new signals at wave lengths. A signal at frequency w1 , mixes with a signal at frequency w2 to produce two new signals , one at frequency 2w1-w2 , and other at 2w2-w1.The effect can also occurs between three and more signals, FWM increases as channel spacing is increased ,as the signal power increases ,the FWM effect increase exponentially , and it causes crosstalk between four waves of different wave lengths travelling simultaneously in the same fiber since the wave may exchange energy. Two optical waves at frequency w1 and w2 mix to generate two third – order sidebands. The number of generated mixing products M is given by the following expression [6-8].

$$M = \frac{N^2}{2}\,(N-1) \qquad (8)$$

Where: N: is wavelength launches into a fiber

The efficiency of four wave mixing depends on fiber dispersion and the simulated random scattering(SRS), Stimulated Brillouin Scattering (SBS), and FWM result, in gain or losses in wave length channel that are dependent on the optical signal intensity. These nonlinear processes provide gains to some channels while depleting power from others. There by .producing crosstalk between the wave length channels. Both Self-Phase Modulation (SPM) and cross phase modulation (XPM) effect only the phase of signals, which causes chirping in digital pulse. When any of these nonlinear effects contribute to signal impairment, an addition amount of power will be needed at the receiver to maintain the same BER.

Generally, modelling the nonlinear processes is quite complicated since it depends on the transmission length (L), the cross-sectional are of the fiber (A), and the optical power level in the fiber (Pin). In practice, the power is assumed constant over a certain fiber length, which is less than or equal to the actual fiber length. The effective length (L_{eff}) which takes into account power absorption along the length of the fiber is given by:

$$L_{eff} = \frac{(1 - e^{-\propto L})}{\propto} \qquad (9)$$

Where: Leff: is effective length, and it is the sum of the effective lengths of the individual span between optical amplifiers

$$L_{eff} = (1 - e^{-\propto L} L_A)/\propto L$$

Where: L: Is the span length between amplifiers, LA: Is the total amplified link.

J. Chromatic dispersion

Dispersion is a phenomenon that occurs in all types of optical fiber. After attenuation, dispersion is considered as the next limiting factor that determines how much and how far the information can be transmitted on a given fiber. There are two main dispersion phenomena that need to be taken into account in single mode fibers link: chromatic dispersion and polarization mode dispersion (PMD). This paper focuses on chromatic dispersion.

Chromatic dispersion is due to an inherent property of silica fiber. The speed of a light wave is dependent on the refractive index, η, of the medium within which it is propagating. In silica fiber, as well as many other materials, η varies with wavelength. Therefore, different wavelength channels will travel at slightly different speeds within the fiber. Because each wavelength components of the fiber travels at slightly different speeds. This results in a spreading of the transmission pulse as it travels through the fiber [7].

Dispersion compensation is an important issue for fiber-optic links, i.e., in the context of optical fiber communications. Here, strong dispersive broadening of modulated signals can occur in cases with high data rates. Without dispersion compensation, each symbol would be broadened so much that it would strongly overlap with a number of neighboured symbols significant inter-symbol interference can strongly distort the detected signal. Therefore, it is essential to minimize the dispersion before detecting the signal. The key parameters of minimizes include: dispersion, bandwidth and insertion losses [6-7].

There are two known methods of performing dispersion compensation: fiber Bragg grating (FBG) technology and dispersion-compensating fiber (DCF). The newer FBG technology offers cost savings, lower insertion loss, and lower latency than the older, traditionally used DCF. Chromatic dispersion compensation using highly efficient reflective FBGs is significantly different from DCF compensation. It proves to have, as described later, some obvious benefits with regard to addressing both the technical as well as the cost-related issues of current and future dispersion compensation. Both solutions offer similar performance and cost. There are some differences that can have an impact.

K. Fiber Bragg Grating (FBG)

FBG is linearly chirped, i.e. the period of the grating varies linearly with position. This makes the grating to reflect different wavelengths at different points along its length and therefore introducing the different delay.

In standard fiber, Chromatic dispersion introduces large delay for lower frequency (high wavelength) components of a pulse. Chirped FBG introduces larger delay for the higher frequency components, thus compensating for the dispersion effects (i.e. compensating the pulse),a short strand of modified fiber that changes the index of refraction and minimizing intersymbol interference (ISI).

In a simple fiber Bragg grating, the refractive index of the fiber core vary periodically along the length of the fiber, as shown Figure6 , the refractive index of the fiber core is modulated with a period of λ.

When a light with a broad spectrum is launched into one end of fiber containing a fiber Bragg grating, the part of the light with wavelength matching the Bragg grating wavelength will be reflected back to the input end, with the rest of the light passing through to the other end.

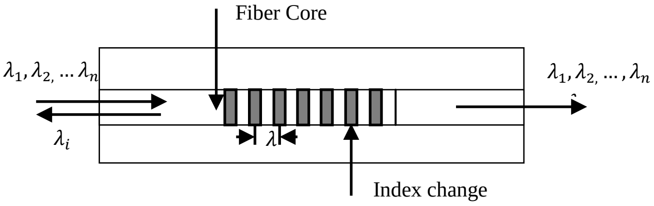

Figure6. Schematic Diagram of Fiber Bragg grating

L. *Optical fiber transmission*

Optical fiber transmission uses wavelengths that are in the near-infrared portion of the spectrum, just above the visible, and thus undetectable to the unaided eye. Typical optical transmission wavelengths are 850 nm, 1310 nm, and 1550 nm. Both lasers and LEDs are used to transmit light through optical fiber. Lasers are usually used for 1310- or 1550-nm single-mode applications. LEDs are used for 850- or 1300-nm multimode applications.

There are ranges of wavelengths at which the fiber operates best. Each range is known as an operating window. Each window is centered on the typical operational wavelength, as shown in Table 1.

Table1. Fiber Optic Transmission Windows [3, 8]

	Window (nm)	Operation Wave Length (nm)
1	800 - 900	850
2	1250 - 1350	1310
3	1500 - 1600	1550

II. DESIGN AND IMPLEMENTATION

This paper discusses the transmission link mechanism of an optical fiber. The block diagram of the proposed Transmission link mechanism of an optical fiber is shown in Figure7 consists of many parts:

A. *Optical Transmitter*

Fiber optic transmitters are devices that include an LED or Laser source, and signal conditioning electronics, the main function of an optical transmitter is to convert the electrical signal into optical signal and to launch the optical signal into the optical fiber.

The most popular wave-lengths of operation for optical transmitters are 850, 1310 or 1550 nanometres. The optical transmitter consists of the following components:

B. *Optical source*

LEDs and Laser diodes are used as optical sources. The input electrical signal modulates the intensity of light from the optical source. The optical carrier can be modulated internally or externally using an electro-optic modulator. Continuous wave laser output is given by:

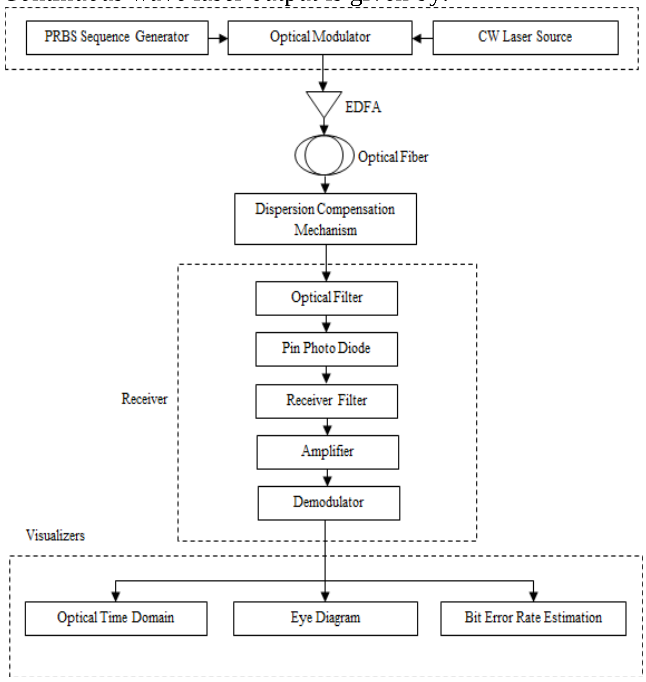

Figure7. Transmission link mechanism of an optical fiber.

C. *Optical source*

LEDs and Laser diodes are used as optical sources. The input electrical signal modulates the intensity of light from the optical source. The optical carrier can be modulated internally or externally using an electro-optic modulator. Continuous wave laser output is given by:

$$P_{out}(t) = P_{in}(t)d(t) \qquad (10)$$

Where d(t) is the power transfer function.

D. *Pseudorandom Binary Sequence (PRBS)*

It used to generate data signal, this type of signal generate ones and zeros at a uniform rate but in a random manner. PRBS comprises sequence of 2N different N- bit long combinations, this combinations are randomly selected .The PRBS length is of the 2N – 1 , where N is an integer. This choice assure that the pattern-repetition rate is not harmonically related to the data rate ,typical value of N are ,7,10,15,20,23 and 31 after this limit has been reached.

E. *Optical modulator*

Is a device which is used to modulate a beam of light. Electro-optic modulators are widely used as external modulators which modulate the light by changing its refractive index through given input electrical signal.

F. *Optical Coupler*

The function of a coupler is to couple the optical signal to optical fiber cable. The coupler is a micro lens that focuses the optical signal onto the entrance plane of an optical fiber with maximum efficiency. The launched power is an important design parameter, as indicates

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

how much fiber loss can be tolerated. It is often expressed in units of db with 1 mw as the reference level.

G. Optical Fiber

The most commonly used optical fiber in the communication systems is a single-mode-fiber where only one electrical field mode is propagating for systems requiring transmission over distances of many kilometres, or where two or more fiber optic cables must be joined together, an optical splice is commonly used. The Important fiber parameters are its loss, dispersion, dispersion slope and nonlinearities.

The mathematical model for the fiber transmission can be derived by considering an electrical field inside the fiber. This must obey the wave-equation of the form:

$$V^2E + \varepsilon(w)K_o^2E = 0 \quad (11)$$

Where ***E*** is the electrical field, ε(ω) is the permittivity of the fiber material and $\boldsymbol{K_0}$,is a wave number of free-space.

H. Demodulator

The demodulator demodulates the received electrical signal back to original information. The design of demodulator depends on the modulation format used by light wave system. The design of an optical receiver depends largely on the modulation format used by the transmitter, a digital receiver whose components can be arranged into three groups named: - Front end (photo diode, amplifier) - Linear channel (amplifier, low pass filter) and Data-recovery (decision circuit).

An important parameter for any receiver is the receiver sensitivity. It is usually defined as the minimum average optical power required realizing a BER of 10 −9. Receiver sensitivity depends on the SNR, which in turn depends on various noise sources that corrupt the signal received. Even for a perfect receiver, some noise is introduced quantum noise (photo detection), shot noise (particle nature of electron), thermal noise (internal inside receiver), and intersymbol interference (Chromatic dispersion).

I. Receiver Noise

Optical receiver convert incident optical Pin into electric current through photodiode, the relation:

$$I_p = RP_{in} \quad (12)$$

Where: Ip : Is average photocurrent, Pin : Is average optical power incident on photo detector, R: Is the photodiode responsivity.

Two fundamental noise mechanisms are: Shot noise and Thermal noise. These two noises are lead to fluctuation in the current even when the incident optical signal has a constant power.

J. Visualizes

Are used to display, measure and processing optical and electrical signal by taped a small quantity of the transmitted signal at any point along optical communication system such as signal time domain visualization eye diagram evolution, and bit error rate estimation .Most numerical modes investigate a short bit stream in order to avoid excessive computational time, with a few bits it essential to make some assumption about the noise distribution. A bit error estimation assuming a Gaussian noise distribution on both the one and zero levels.

K. Eye Diagram

To evaluate the system performance, the eye diagram is a simple method for digital transmission system. The performance of the systems depends on the amount of intersymbol interference (ISI) and noise .ISI can be occurred when the signal passes through the dispersive system .In optical interconnect system, dispersion is associated with the fiber, coupler, the transmitter circuitry, and the receiver circuitry. ISI is that the pulses corresponding to any one bit Smear into adjacent bits and overlaps. So, if ISI is large enough, this trigger a false detection in the adjacent time slot. As a result, an the ISI becomes more pronounced .When observing data transmitted by optical driver on the oscilloscope, there is a visual method that is often used to qualitatively measure the properties of the vertical input and the sampling clock is applied to the external trigger, a wave form looking like a human eye is obtained.

This is called an eye –diagram due to its similarity of shape to a human eye: An eye diagram is easily generated using an Oscilloscope that is triggered by the symbol – timing clock and keeping the curve trace for certain duration of time. The eye diagram is a composite of multiple pulses captured with a series of triggered based on data-clock pulse fed separately into the scope. The scope overlays the multiple pulses to form the eye diagram, so the eye diagram is a useful tool for visualizing the performance communication systems. The maximized eye diagram of the received pulses is shown below. The eye diagram shown in Figure8 is wide open .this shows that the digital '1' and '0' levels of the received bids are easy to distinguished, and implying a very good quality received signal.

The eye pattern can be viewed while making adjustments to the system. This allowed for the immediate observation of the effects of filter, circuit, or antenna adjustment.

The eye diagram shown in the Figure9 indicates that the received pulses are severally distorted compared to the previous one [3. 8].

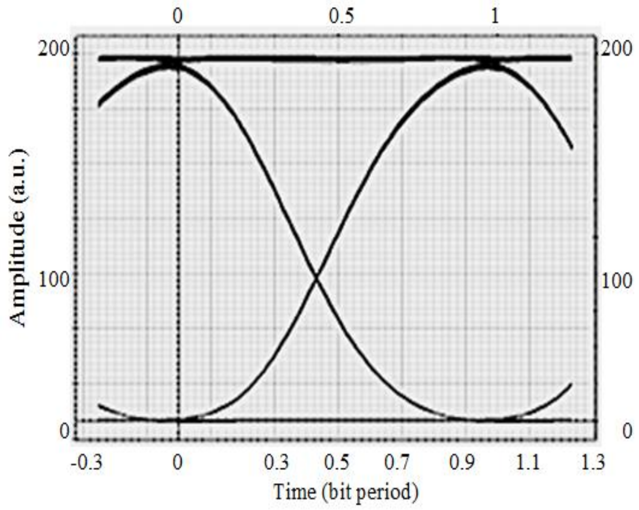

Figure8. Eye diagram analyzer shows clear digital '1' and '0' levels of the received bits.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

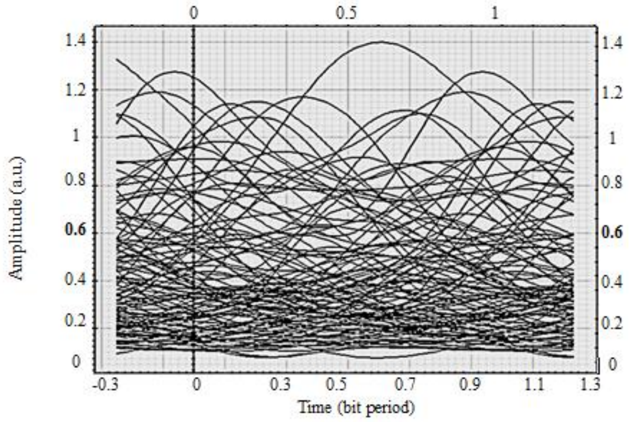

Figure9: Eye diagram analyzer shows sternly distorted received signals

L. BER Estimation

BER estimation is more objectives measure of the performance of bits detected incorrectly (i.e. bit errors) over a certain time interval, divided by the total number of bits transmitted during the same interval .BER works by making certain statistical assumption about the distribution of the digital '1' levels of the pulses in the received signal. In practical fiber-optic systems BER, should be below 10^{-9} for system without FEC.

III. RESULTS AND DISCUSSIONS

In optical communication systems signal power losses such as attenuation, chromatic dispersion non-linear effects occur during transmission processing: these losses significantly degrade the system performance. This paper intends to study the effect of introducing compensation mechanism.to minimize these losses.

The launch power from the transmitter is set to 0dBm.Then the BER is detected with BRE estimation device while the received signal is observed by the Eye Diagram. The input signal from the transmitter propagates through the single mode fiber. The simulation was conducted to the channel operating at 10Gbps and 40Gbps to observe the dispersion effects and the signal degradation at different transmission lengths using variable parameters. The fiber link is considered to operate at the parameters values shown in Table2.

It is observed that the received signal significantly degrades. The 40Gbps data rate gives only 5 km of the transmission distance. It indicates that the dispersion compensation has to be employed even for such short distance. This is because the high data rate has more weight at this stage causing dispersion phenomena.

The channel with the data rate of 40Gbps is found 6 times more sensitive to dispersion when compared to the channel with the data rate of 10 Gbps. It is clear that the increase of data rate decreases the transmission distance.

The aim of this comparison is to determine the maximum transmission length to be obtained without and with the implementation of compensation tool. Figrures10 shows a sample of the received optical signal Eye diagram for 5 km fiber length before applying compensation mechanism. Conversely, Figures18 and Figure12 represent the results obtained using FBG as spreading lessens mechanism. The width of the pulse spreading reduced from 0.43ps to 0.18ps, with BER of 8.825×10^{-10}, Quality factor = 9.7 and total possible distance of 25 km.

Table 2: Parameter values selected for the simulation

Parameter Name	Parameter Value
Bit rate (B)	10 Gbps,40Gbps
Transmission distance (L)	50 Km, 90 Km, 130 Km
Wave length (λ)	1550 nm
Fiber attenuation coefficient (α)	0.2 dB
Dispersion coefficient (D λ)	16 s/m
Sample rate	32, 64
Optical laser power	(P) 1mw
Laser line width	(Δλ) 10 MHz
Dispersion slope (S λ)	ps/(nm2.Km)
Responsivity of APD photodiode (R)	77A/w
Effective area (Aeff)	80μm2
Dark current (id) PIN	10 nm
Dark current (id) APD	15 nm

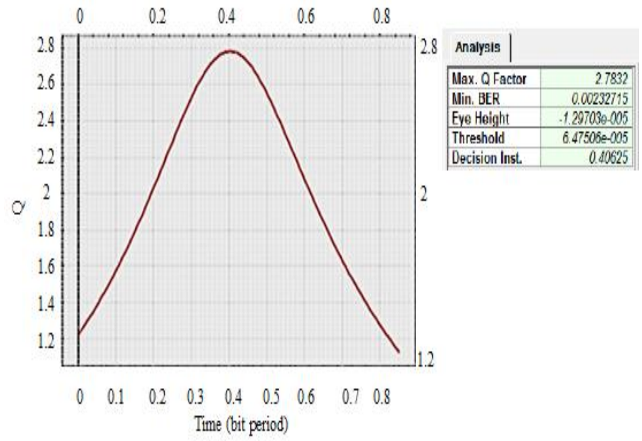

Figure10. Optical Signal Eye Diagram for 5km Fiber length before compensation.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

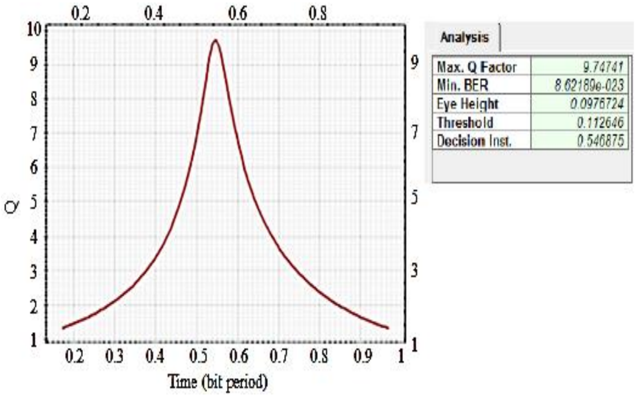

Figure11. Received Optical Single for 5km Fiber Length after spreading reduction.

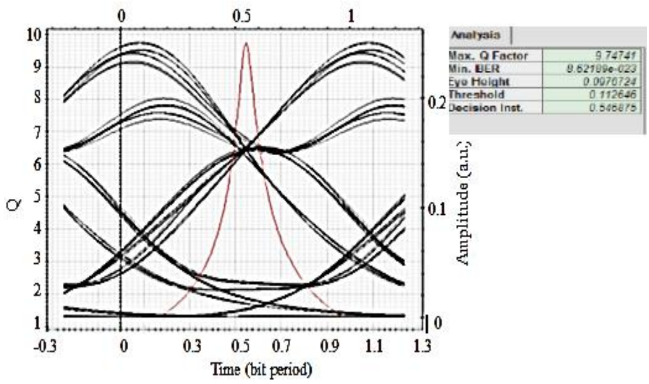

Figure12. Received Optical Signal of Fiber length 5 km after using FBG

Table3 shows two types of speed in optical fiber and their parameters. It clear that 10Gbps has a good performance with the receiver and RZ pulse generator .While PIN receiver and NRZ pulse generator are more suitable for the high data rate (40Gbps).The length of the FBG is very important parameter for reducing the dispersion effect, it increases with the increase of the data rate. For 10Gbps the length is adjusted to 3mm and for 40Gbps is set to 6mm.

Table3. Optical fiber selected speed parameter values

Item	10 Gbps	40 Gbps
MGOF bandwidth	20 GHz	30 GHz
Amplifier Gain	30 dB	10 dB
Amplifier Noise Figure	4 dB	6 dB
Fiber Bragg Grating length	3 mm	6 mm
Pulse generator	NRZ	RZ
Photo detector	APD	PIN

From the two stages results it could conclude that the BER is limited by two factors: the noise and dispersion at the lower speed level and both dispersion phenomena and nonlinear effect at high speed. The PMD is considered as important issue as data rates on long distance links increases to 10 Gbps and 40 Gbps. Unfortunately, there are no reliable compensation schemes for PMD, the only possible solution is to upgraded the test links for PMD using any standard test method.

PMD is generally tested for fibers during manufacture or when being cabled. In the field, it is common to test PMD on newly installed fibers which are intended for operation at high speeds; generally above 2.5 Gbps. Nonlinear effects can be minimized by reducing its influence using incidence optical power.

IV. CONCLUSION

In this study the optical signal degradation effects were studied. Initially the optical signal Eye diagram for an optical fiber of different lengths before applying compensation mechanism were obtained using OPTsys simulation tool. The data rate of 20 - 40 Gbps is introduced to the system and examined using specified fiber lengths parameters. It is observed that the received signals were significantly degrade due dispersion effects.

The link performance is limited by the fiber attenuation and dispersion. In fiber attenuation the received signal is weakened and may not be discernible from noise. Optical amplifiers are used to elevate the diminished optical power, so that the received power remains above the senility for longer time.

Fiber Bragg Grating technology is used to reduce the dispersion effects (Chromatic Dispersion, Polarization Mode Dispersion, and nonlinear effects.) at higher bit rates, while optical amplifier such as EDFA can compensate the reduce of signal power when it propagates through the fiber strand. It is very obvious, increasing of signal power cannot effect chromatic dispersion, which depend mainly depend on the of bit rate. While the nonlinear effects proportional to the power intensity.

REFERENCES

1. Subir Kumar Sarkar." Optical Fiber and Fiber Optic Communications System", Second edition, S. Chand, 2009.
2. Suleiman Al kurtas,"Introduction to the Communication System", first edition, Al Obeican, 2010
3. Harry. R. Duffon, "Understanding Optical Communications", first edition, International business machines Corporation, 1998.
4. International Journal of Mobile Network Communications & Telematics. (IJMNCT) Vol.2, No.3, June 2012
5. Vijay K. GARG," Wireless Communications and Networking ", second edition, Morgan Kanfman, 2010.
6. David R. Goff," Single Mode Fiber Types". Olson Technology, 2010
7. Cisco.In-Public Information "Chromatic Dispersion in a Single-Mode Fiber"com/en/us/prod/…White paper Pdf, 2008.
8. Mario F.S.Fereir, "Nonlinear effect in Optical Fiber", First Edition, John Wiley. 2011..