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Designing a Power-Efficient FSO System by Analysing the Q Factor using the FBG Technique in G-PON

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Abstract: FSO systems is attaining high populous and recommendation for the last few years with various advantages such as lower spectrum, low bit error rates, low-cost etc. In system, 10 Gbps data and transmitted over distances of 1 km FSO link by using fiber bragg grating technique. The result is reported in term of the Quality factors, BER and eye diagrams. This simulated system had been observed based up on different parameters using Optisystem 20.
Keywords: Free space optics (FSO), Optical Network (ON), Line Of Sight (LOS) Gigabit Passive Optical Network (GPON), Optical Signal (OS)

I. INTRODUCTION

Fibre communication refers to the manner of transmission of information from one area to some other via sending light waves through the optic fibre. light refers to an electromagnetic carrier wave and the modulation of which is made for holding statistics and various other information.

Technique of communicating the use of fibre optics comprises of the following primary steps: creation of the optic sign with a transmitter, transmission of signal through the fibre, making sure that signal does not end up being distorted and weaker in strength, and receipt of the OS followed by changing it into an electrical signal Bandwidth.

Unfastened space optical transmission (FSO) generation which makes the use of lasers for offering optical bandwidth connections or it's miles a method that propagates the mild in unfastened area like vacuum, air or something similar that wirelessly transmits information.

FSO communication is taken into consideration as an opportunity to relay line of sight verbal exchange system.

There has been an installation of Fiber to home system from point-point and point-2-multipoint time multiplexing ON structure. Displayed in figure A the general PON that delivers the 3 concentrated services to other guest similar like the university, home and other user's home from the centre office.

The focal office having the maximum furthest reaches of 1550.1 nm up to the lower furthest reaches of 1300.1 nm can be seen at the far end of collector. The Full Service Access leads to the creation of passive optical network i.e. PON, which is essentially characterized by the ITUT and IEEE. The most noteworthy pace of transformation with respect to FTTH utilizing the passive optical network that is in Asia.

The 2 significant principles for the PONs to have arisen is the E-PON and the G-PON. Optic access lines are used in a bi-directional point-2-multipoint networks structure in a G-PON system to connect a carrier's CO & customer locations. G-PON is among the most relevant framework in overall that is generally introduced in Fiber-2-Home organizations. Gigabit Aloof Optical Organization is characterized in ITU-T suggestion series G.984.1 to G.984.4. G.984 standard series showcases general qualities of G-PON (G.984.1) as well as actual layer (G.984.2) transmission layer detail (G.984.3) and ONU the board and control determination (G.984.4). G-PON can move Ethernet, yet ATM and TDM (counting PSTN, ISDN, E1 and E3) traffic by utilizing G-PON embodying work. While there are a few different methods for bringing optical fibers to different homes, as the G-PON is regarded as the most relevant for longer ranges of deployments.

G-PON depends on the TDM method, wherein the down frequency is utilized for advancement of data transmission whereas other downstream is utilized for the simple video administrations

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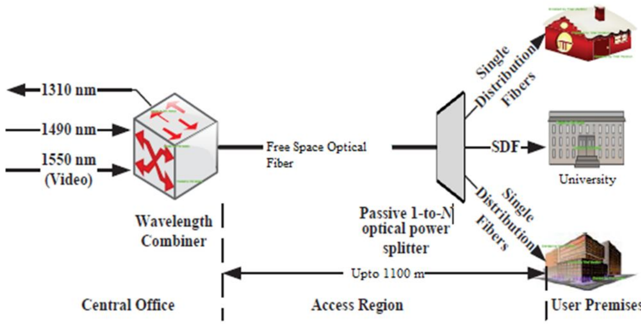

Figure A: Gigabit PON

A. FBG Technique

FBG is an acronym for Fiber Bragg Grating. Bragg procedure can be defined as a strategy wherein a center of the SMF fiber radiates an example on the occasional type of the extreme UV light which is to be made by the parallel uncover. Upon being exposed, it results in the rise of the fiber's core’s refractive index, resulting in "grating" pattern. A limited quantity of light is reflected which changes with each intermittent refraction. When the grating period is approx. 1/2 of the wavelength of the input light, a single layer of large reflection can coherently combine all reflected light signals. Such condition is known to be Bragg condition, and the wavelengths where reflection occur is described as the Bragg wavelength. Because these Bragg wavelengths are essentially pellucid in nature in comparison to the wavelength of light. The light that travels via the grating, experiences less variations in a signal and only a microscopic amt of attenuation.

$$\lambda refl = 2n\Lambda$$

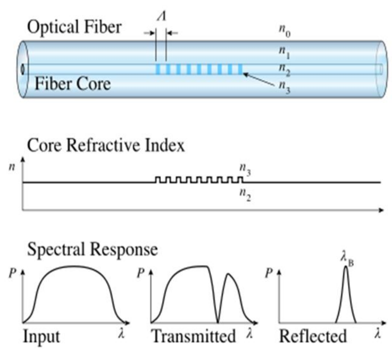

Figure B: FBG

B. Optisystem Software

Optisystem software will be used for investigation and analysis of different curves for spontaneous transmission with respect to intensity of light(db.) and wavelength(nm). There are different theoretical investigations also which take place showing different variations of curves with different parameters such as Normalized total carrier density, intensity transmission(db.), Q factor.

II. SYSTEM DIPICTION

Figure showing the proposed 10 Gb/s FSO transmitted framework. Optisystem is used to model the proposed system. This demonstrates how the FSO System's for much larger range to fulfill the preconditions of the high speed communication to withstand the effects of weather with regard to the FSO link for gigabit passive optical network (G-PON). The system's efficiency is determined by comparing the system's link distance to acceptable Q factor values.

III. SIMULATED SETUP

The motive of such a setup is putting an efficient ONC for wider range of communication for fulfilling the requirements and objectives of the premises’ current demands is by thoroughly understanding the objective of gigabit PON using the help of “OPTISYSTEM 20” software.

A. Simulation of the Transmission System

In the transmission, steps are divided into four major parts pseudo random bit sequence generator, NRZ pulse generator, the CW Laser, Mach-Zehnder modulator and an optical amplifier. The PRB sequence generator is basically used as a message signal that is to be transmitted through the free space onto the receiver end. This sequence generator produces values in the form of 0's and 1's which are produced randomly. This message signal is then modulated in the Mach-Zehnder modulator with the carrier signal. The CW laser is used in this simulation as the carrier signal with the frequency of 1550nm output. The output of the modulator is then passed through the optical amplifier having 20 db gain and 4 db noise figure. The amplifier increases the strength of the modulated signal so the signal that passes through the free space have the capacity to reach the destination with less distortion and noise because the line of sight comm. do not use any particular system to carrier the signal.

B. Reciever System

On the contrary, the exact opposite procedure is stipulated at the receiver end. The modulated and amplified optical signal is detected using the PIN photodiode. The photodiode is a pn junction diode which absorbs the light energy for producing electric current. At the receiver's end, the optical signal that is received is measured in comparison to the transmitted signal. The optical receiver consists of 2 optical amplifiers to increase the strength of the distorted signal, an optical attenuator, FBG system, Bessels Filter, a PIN photo diode, an optical regenerator and an eye diagram visualizer. The Bessel's filter is a form of analog linear filter having a maximally flat group delay which helps in the preservation of the filtered signal's wave shape in the pass band. An optical regenerator, which is an optical repeater is a part of the sub par component of the FSO system that reinforces the optical signal. It identifies optic signals, followed by renovating them into electrical signals. The BER analyzer is used for testing the qualities of the signal by providing the quality factor, Bit Error Rate and SNR of the signal received through the FSO channel.

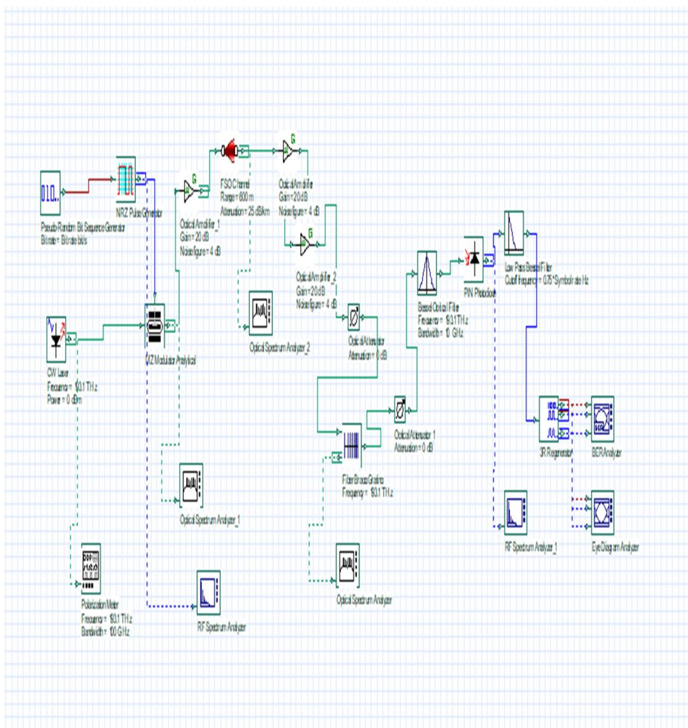

Figure C: Simulation Setup of G-PON

C. Signal to Noise Ration

Noise in the wireless system is required to be divided into 2 unique parts i.e. shot and thermal noise. The formula stimulated for the SNR in FSO system is enumerated below

$$SNR_{FSO} = \frac{S}{N}$$

Where S refers to the input signal in the receiver where λ = 1550 nm, B denotes bandwidth (Hz) while N denotes noise which can be caused due to the atmospheric turbulences, temperature and much more.

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D. Q Factor

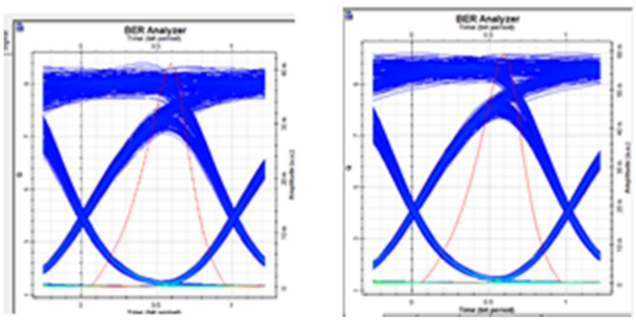
The Quality Factor can be best understood as a measure of the noisiness of a pulse for individual purposes. The eye pattern will generally lead to the inducement of a report showcasing the Q Factor number. The Quality Factor provides information about the minimal SNR which is used for gaining a particular pattern in the BER analyzer for the so provided signal. The measurement of the Optical SNR is done in db. The greater is the bit rate, the greater value the Optical SNR. Q Factor is a key parameter that ascertain the performance of a communication channel. Q Factor showcases the optical SNR for numerous binary or digital OC along with facilitating the system performance analysis where the Q Factor is calculated

$$Q = \frac{|\mu 1 - \mu 0|}{\sigma 1 - \sigma 0}$$

Where $\mu_{1,0}$ are the mean values of each part of the eye, and $\sigma_{1,0}$ are the S.D., or RMS noise, that are present on each of the eye diagram.

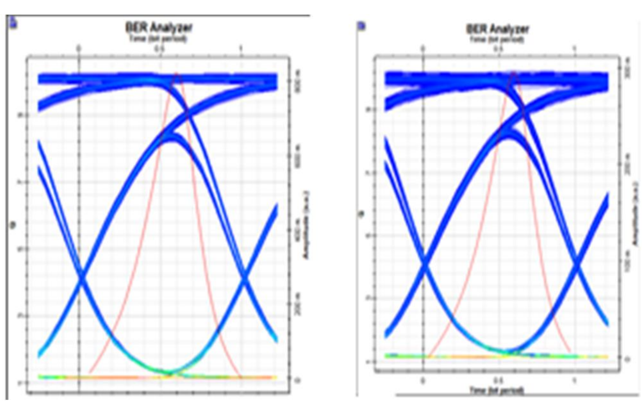
IV. RESULT AND DISCUSSION

This whole simulation was designed, simulated and performed in optisystem 20. A FSO transmission is considered as the medium for simulation. Herein the transmitter and the end of the receiver should be in the LOS medium. This simulation is stipulated, designed and performed for short-range communication operations, the collection of the results was made under the normal conditions. Considering the data to be transmitted at 10 Gbps, we receive a better eye diagram and quality factor. The process of the performance in respect of the structure transmits and receives data constellations using eye diagram. The Quadrature Modulator, FSO Optical system, RF Spectrum, Photodetector PIN RF Spectrum, from the simulation is displayed in figure A. In figure C the Block diagram of free space optic transmitter /receiver system is explained.



(a) (b)

Figure D: Eye Diagram of BER Analyzer for (a) 950 m and (b) 900 m



(c) (d)

Figure E: Eye Diagram of BER Analyzer for (c) 600 m and (d) 700 m

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Table 1: Values of Q factor at different Optical lengths in FSO system

FSO Length(m)	Max Q Factor	Min BER	Height	Threshold	Decision Inst.
600	10.3862	9.53881	0.434753	0.0748527	0.59375
700	10.3969	1.17859e-25	0.181487	0.0312299	0.59375
800	10.1404	1.23126e-24	0.0782477	0.0137445	0.59375
900	10.1482	1.14828e-24	0.0350737	0.00615485	0.59375
950	9.77882	4.58902e-23	0.0232544	0.00407842	0.59375

The optimum rate of BER should be less than that of 10^{-12} for distortion and noise figure in free space. The simulation of G-PON has provided with better results according to the BER for the purpose of delivering/transmitting the optimized signal with the PON. The connection of the polarization meter is connected next to Mach- Zehnder modulation at the transmitted area and polarized up to frequency range of 200THz. Due to the variations in the lengths of FSO, changes in the Q-factor are seen differently, for various lengths i.e. L=600m Q-factor is 10.3862 which is the max Q-factor that can be achieved in this simulated network in comparison to the other lengths i.e. L=700m Q-factor is 10.3969 and L=800 the Q-factor is 10.1404 whereas for L= 950 m it is 9.77882. Main motive is establishing an effective error free network by deploying FBG in the communication unit for fulfilling the vital requirements.

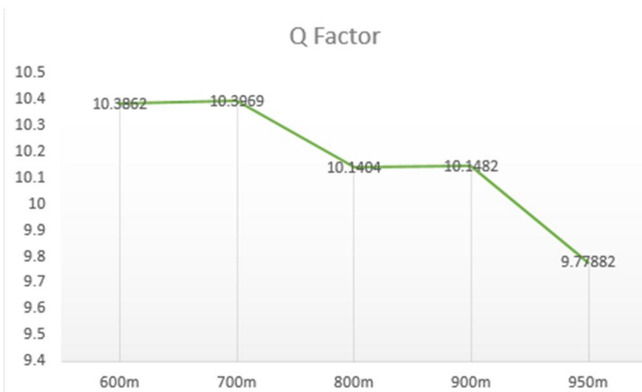

Figure F: Max Q-factor at Different Distances of G-PON

V. CONCLUSION

The Quality Factor is essential for High speed data rate transmission in G-PON for the efficient usage of the FSO fiber communication. The important agenda of this simulation is to maximize the Efficiency by varying different lengths between the free space around the transmitter and receiver. In this research the lengths of the FSO is to be varied in the ranges from 600m to 950 m which in fact results to max Q-factor of upto10.3862 at 600m in comparison with different lengths of the FSO system and the polarization values is 200 THz (193.1 THz).

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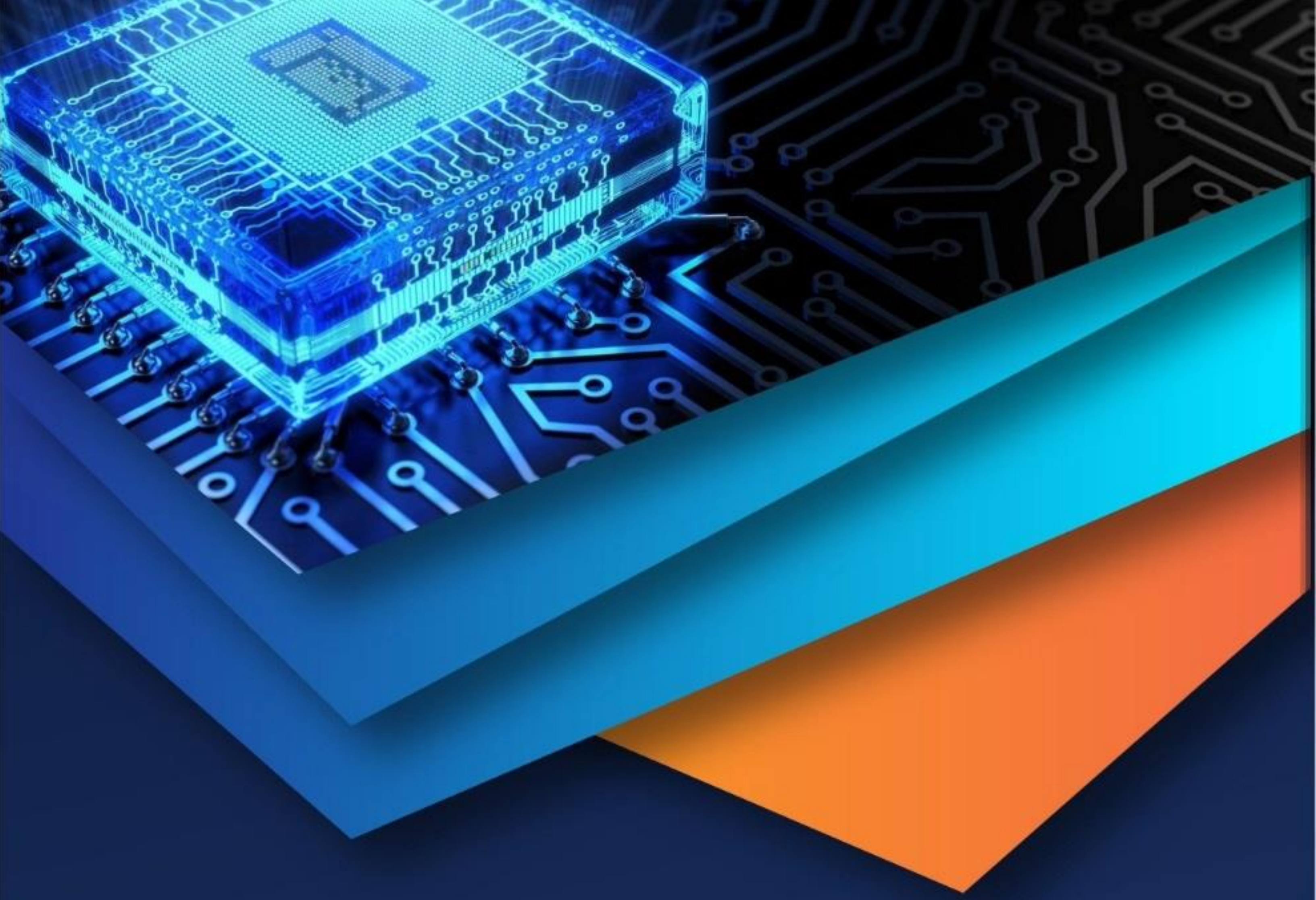

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