Simulation of 4×3 Gbits/sec WDM System based on Optical Amplifiers at 130km Transmission Distance

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Abstract

The focus of this paper is to analyze the performance of 4-Channel WDM System. The performance is analysed in terms of BER,Q-factor, eye height . Two configurations of WDM systems are used. The first one is without using EDFA and second configuration is using EDFA. For long distance transmission, EDFA plays a significant role in optical communication systems. This 4×3 Gbits/sec WDM System consist of 4 input channel transmitter, one multiplexer, one demultiplexer, and EDFA as a booster and pre-amplifier. In this paper, we have analysed the effect of fibre distance on 4-channel WDM System using EDFA and without EDFA in terms of bit error rate and quality factor. The analysis is done using OptiSystem 7.0 simulator. The analysis of simulation results shows that with the increase in distance the quality factor decreases and bit error rate increases.

Keywords: *EDFA, WDM, Bit error rate (BER), Q-factor, and Eye height.*

I. INTRODUCTION

These days, due to very high capacity demand for data transmission the optical fibre communication technology has very vast growth. For long distance transmission through optical fibre light signal gets attenuated and to recover from this type of attenuation we need an optical amplifier. There are number of optical amplifiers, EDFA is used mostly because of its high gain and low noise feature. Because the Doping material used for EDFA is erbium, so it is called as Erbium Doped Fiber Amplifiers. EDFAs are more reliable for long distance transmission using single or multi-wavelength sources because of their wide bandwidth and optimum Bit Error Rate (BER). Wavelength Division Multiplexing (WDM) Networks is also used for multi-channel Amplification without crosstalk. The WDM networks employing EDFA which is used for cost effective solution for increased demand of network capacity. EDFA enhances the quality of the output signal. This is basically used to remove the problems like attenuation, distortion and Rayleigh scattering .EDFA has two bands named as L-Band and C-Band, [1] which are very commonly used these days. Here C- band uses wavelength range 1530-1565 nm and L-band uses wavelength range 1565-1625.

A. *WDM Technology*

In optical communication, wavelength division multiplexing (WDM) is a technology which carries a number of optical carrier signals on a single fibre by using different wavelengths of Laser light. WDM is similar to frequency-division multiplexing (FDM). But instead of taking place at radio frequencies (RF), WDM is done in the IR portion of the electromagnetic (EM) spectrum. "Figure.1" is showing a basic the WDM technology. In this scheme, high carrier bandwidth is utilized to a greater extent to transmit multiple optical signals through a single optical fibre. [2]

Each channel is allocated a different wavelength. Then these are multiplexed by multiplexer onto a single fibre.

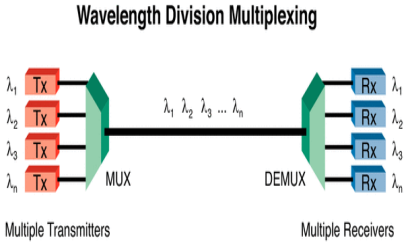

Figure 1: WDM System

At receiver, different wavelengths are demultiplexer by using the demultiplexer and are separated to different receiver channels.

B. *Basic Principle of EDFA*

EDFA is Erbium doped fibre amplifier or an optical amplifier that uses a doped optical fibre as a gain medium to amplify an optical signal. The signal which is to be amplified and a pump laser are multiplexed into the doped fibre, and then the signal is amplified through Interaction with the doping ions .EDFA is the most often used optical amplifier due to low loss optical window of silica based fibre. The EDFA also have large gain bandwidth. [4]

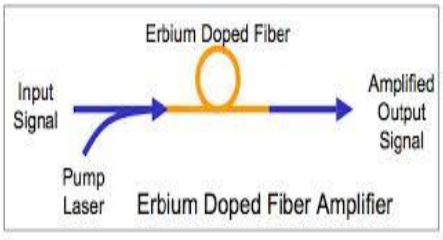

Figure.2: Diagram of EDFA

"Figure.2" is showing the diagram of EDFA.The basic principle of the EDFA is Stimulated Emission. When erbium is stimulated with some suitable wavelength (980nm or 1480nm pump source) light energy, the erbium ions are excited to some high energy state. After some time these ions come back to ground state, and giving up their energy in the form of light. If during decay process some light energy already present within the fibre then this process of decay is stimulated and hence, the name is stimulated emission.

II. CONFIGURATION OF WDM SYSTEM WITH AND WITHOUT USING EDFA

The simulated models of 4-Channel WDM Systems with and without using EDFA have been proposed. Bit Rate used for each channel was 3 Gbits/sec.The Optical fibre of length 130km was used in this system. The input power used is 5dBmThe applied methodology is based on using the Optical Amplifier in WDM Systems for enhancing the quality of the output signal. Both the configurations were modelled, simulated and tabulated the parameter values in "Table1". The parameter values were analyzed graphically to find out optimized values.
The two simulated configurations are as follows:
• WDM System without using EDFA
• WDM System using EDFA.

Table1. Simulation Parameters

WDM transmitter Frequency	193.1 THz
Frequency spacing	100 GHz
Input Power	5 dBm
Modulation Type	NRZ
Fiber length	130 km
Attenuation coefficient at cable section	0.2 db/km
EDFA Gain	3 db
Reference wavelength	1550 nm
Dispersion	18 ps/nm/km
Dispersion slope	0.075 ps/nm^2/km

A. *WDM System without using EDFA*

"Figure.3" is showing the configuration of WDM system without using an EDFA. On the transmitter side it consist of four transmitter channels with bit rate 3Gbits/sec[5] and laser line width of 10MHz, 4-channel WDM multiplexer, optical fibre of length 130 km. The receiver side of the configuration consists of one demultiplexer, PIN photodiode, and an electrical filter and 3R generator. This configuration suffers from losses and attenuation as there is no optical amplifier used. The proposed model for WDM System integrated with and without EDFA was simulated using OptiSystem Software. In this model I have analyzed the performance of WDM system in terms of BER, Q-factor, and eye height. "Figure.4" is showing the Eye diagram, as this configuration suffers from attenuation and dispersion losses so to overcome this problem there is need to use optical amplifier.

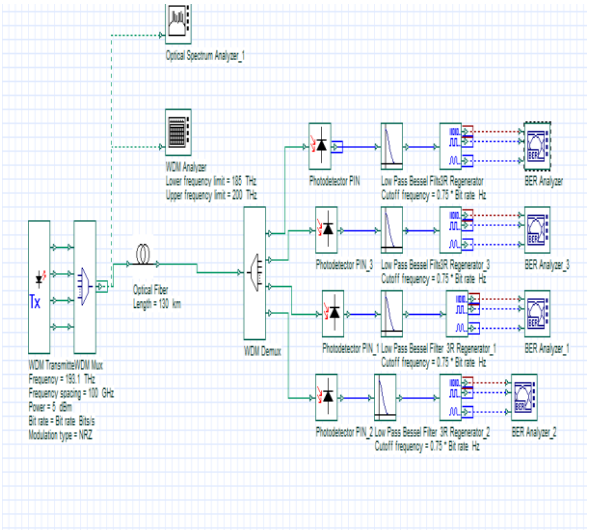

Figure.3: Simulated Model of WDM System without Using EDFA

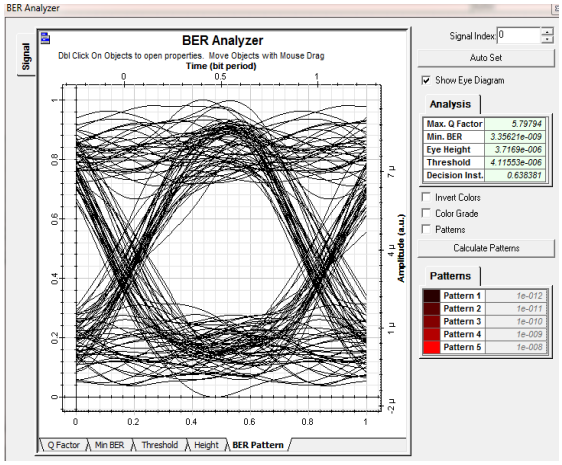

Figure.4: Eye Diagram for Simulated Model of WDM System Without using EDFA

B. WDM System using EDFA

"Figure.5" is showing the simulated model of WDM System using EDFA as a booster and pre-amplifier. The transmitter side consists of four channels with bit rate 3Gbits/sec and laser line width of 10.The WDM multiplexer is used to convert a number of optical carrier signals on a single fibre. In this model I have analyzing the output of all cannels. The receiver consists of one WDM demultiplexer, one PIN photo detector electrical filter and 3R generator.. Fig. 6 is showing the eye diagram the eye diagram shows that using EDFA the bit error rate is 3Gbits/sec .The Q-factor is 11.381, BER is 2.6002e-030 and the eye height is 1.15498e-005.The losses, dispersion and noise is less we use EDFA in WDM system and in other words response of system is good when we use the EDFA amplifier for 130 km distance.

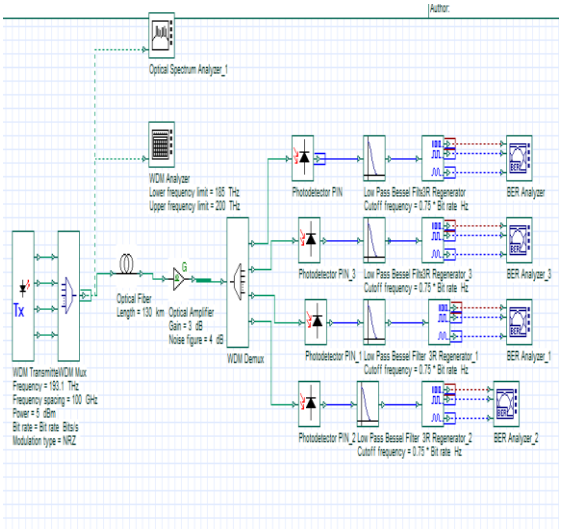

Figure.5: Simulated Model of WDM System Using EDFA

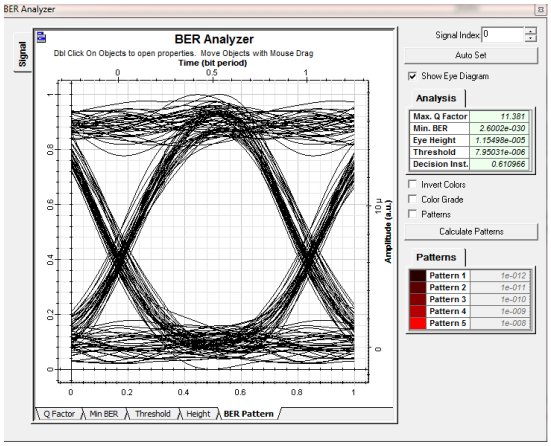

Figure.6: Eye Diagram for Simulated Model of WDM System Using EDFA

III. RESULTS AND DISCUSSION

The simulation and optimization of the design is done by OptiSystem 7.0 simulation software. For both configurations various parameters like, BER, eye height and Q-Factor are tabulated into "Table 2" for fibre length 130 (km), ,input power 5 (dBm), bit rate 3Gbis/sec and both the configurations are compared .

Table2: Results of Comparison of Different Parameters for WDM Configuration with and without EDFA.

S. No	Parameter	WDM Configuration without using EDFA	WDM Configuration using EDFA
1.	Q-Factor	5.79794	11.381
2.	BER	3.35621e-009	2.6002e-030
3.	Eye Height	3.7169e-006	1.15498e-005
4.	Threshold	4.11553e-006	4.11553e-006

Following points we have summarized from the results obtained first point is the Q-factor of the WDM system without using EDFA is 5.79794 and using EDFA the Q-factor is 11.381which shows using EDFA the Q-factor is better. The BER without using EDFA is 3.35621e-009 and using EDFA is 2.6002e-030 which is best result. The eye height without using EDFA is 3.7169e-006 and using EDFA is 1.15498e-005.The Threshold for the WDM system without using EDFA is 4.11553e-006 and for the WDM system using EDFA is 4.11553e-006.

IV. CONCLUSION

The wdm system is simulated in this paper with and without using EDFA in OptiSystem software. The various results were analyzed and compared also.WDM is one of the very useful technologies for optical networks. WDM multiplexes number of optical signals onto a single fibre by using different wavelength. Based on results obtained and

the result analysis, It can be concluded that the WDM System integrated with EDFA gives the optimized Q-Factor and BER and using EDFA long distance communication is possible. In Future, the WDM System integrated with High performance EDFA, and the other advanced optical technologies, as well as the market demand of more Bandwidth at lower costs have made an optical networking an attractive solution for advanced networks.

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