Improved BER and Output Power of Multistage WDM-PON Architecture for Long Distance Using EDFA

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Abstract— In this paper the analysis of Wavelength Division Multiplexing PON (WDM) network is done incorporating Erbium Doped Fiber Amplifier (EDFA) using Optisystem software. The goal of this paper is to analyse the EDFA and make the best performance for a wavelength division multiplexing network. The optical amplifier behaviour is studied for different parameters and their results are optimized for better performance. In WDM networks optical fibers are used and they suffer from heavy loss due to attenuation and dispersion. So in order to reduce these attenuation losses optical amplifiers are used. As the length of the amplifier and pumping power is increased, the Bit Error Rate reduces.

Keywords— WDM, EDFA, Optisystem, attenuation, optical amplifier, pumping power, BER, optical fiber.

I. INTRODUCTION

Fiber optics has become the key to telecommunications and data networking and is a preferred transmission medium for larger bit rate and larger distance transmission [1]. In WDM networks optical fibers are employed to transmit information in form of light pulse between the transmitter and the receiver. WDM systems have the potential to transmit multiple signals simultaneously. But the light signals degrade in intensity when they travel a long distance inside the fiber. So it is required to amplify all the light signals simultaneously after a certain interval of light propagation to regain the original signal. Optical amplifiers are generally used to amplify the light pulses. The commonly used amplifier is Erbium Doped Fiber Amplifier (EDFA).WDM optical networks are the revolution in data transmission because of low loss, high speed, better bandwidth and high capacity. Optical amplifiers are the backbone of optical network as they amplify the signal which occurs due to the fiber losses and many other reasons [2]. EDFA is the optical amplifier which is the most used amplifier because of their high gain and low pump power. So EDFA behaviour in a WDM network needs to be studied.

II. WAVELENGTH DIVISION MULTIPLEXING

In Wavelength Division Multiplexing (WDM) light signals of different wavelengths are transmitted through the same fiber [3]. The signal from the transmitter travels through the fiber and the different wavelengths are separated by a demultiplexer at the receiving end and the signals reach the receivers. Fig.1 is a schematic of WDM systems.

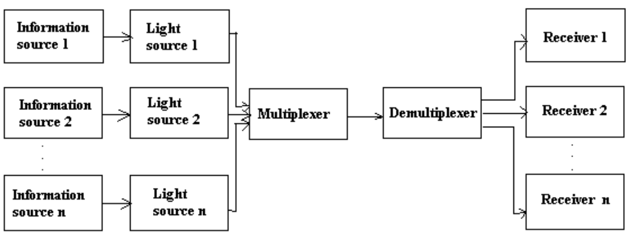

Fig.1 The schematic map of WDM system

WDM is used in Access networks. An Access Network (or the last mile network) is that part of a network which connects the Central Office (CO) and the Subscriber. WDM Passive Optical Network (PON) is a point to point access Network which uses Arrayed Waveguide Grating (AWG) instead of the passive splitter used in EPON and a dedicated wavelength is assigned to each of the ONUs. Fig. 2 shows a WDM PON.

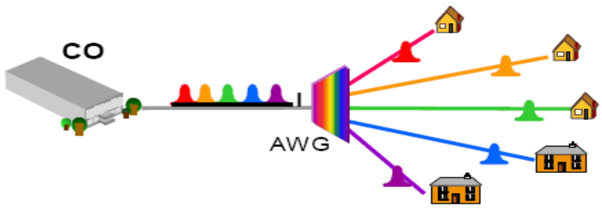

Fig.2 WDM PON

There are a number of advantages when WDM PON is employed

- ONUs can function with different bit rates.
- Each ONU can operate with its full bit rate.
- ONUs need not share Bandwidth.
- Power splitting losses are not present.
- Use of different wavelength improves privacy and reduces security problems.
- Periodic routing pattern of AWG makes WDM scalable.

A number of architectures [6]-[10] are proposed using WDM PON for the Next Generation Networks.

This paper analyses the benefits of using a EDFA in a WDM PON architecture. Section III deals with Implementation and simulation of a WDM system in PON without and with EDFA incorporated. Section IV presents the results and the analysis and section V concludes the paper.

III.IMPLEMENTATION AND SIMULATION

In this section we design and simulate the basic WDM PON and then analyze the advantages of EDFA incorporated into the basic schema.

A. Simulation of wavelength division multiplexing PON

The scenario explained in section II are simulated using Optisystem simulation software as shown in Fig.3. Different wavelengths from four lasers are multiplexed together using WDM Multiplexer and then coupled into the optical fiber. At the ONUs, a demultiplexer is used which separates the combined signal in the fiber and is represented by optical spectrum analyser. Fig.4 shows the frequency spectrum for the WDM multiplexer output. The output at the end of fiber is shown in Fig.5 with a reduced power output. After de multiplexing, the frequency spectrum of each channel is shown from Fig.6 to Fig.9 consisting of frequencies 193.1THz, 193.4THz, 193.7THz and 194.0 THz.

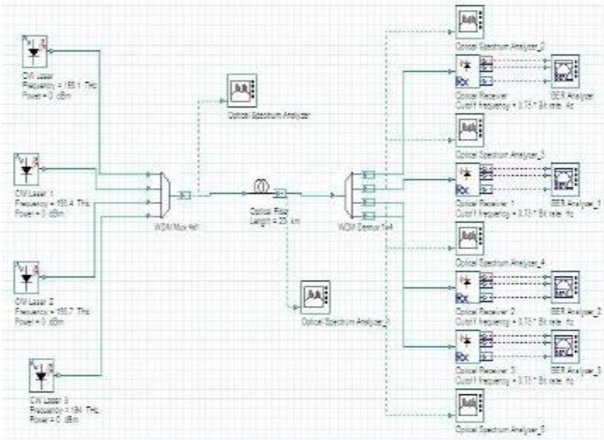

Fig.3. Optisystem WDM system diagram

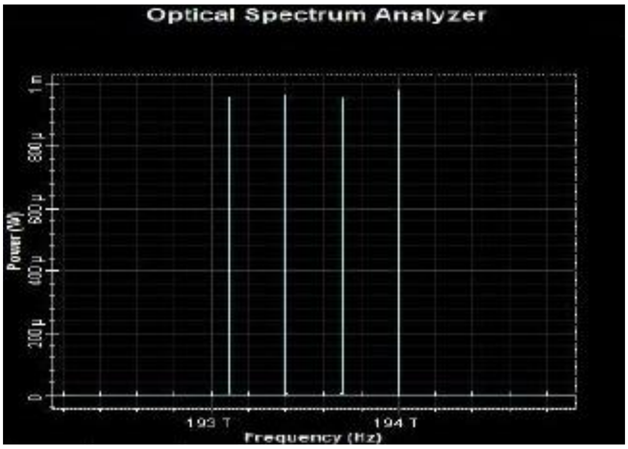

Fig. 4.Multiplexer output

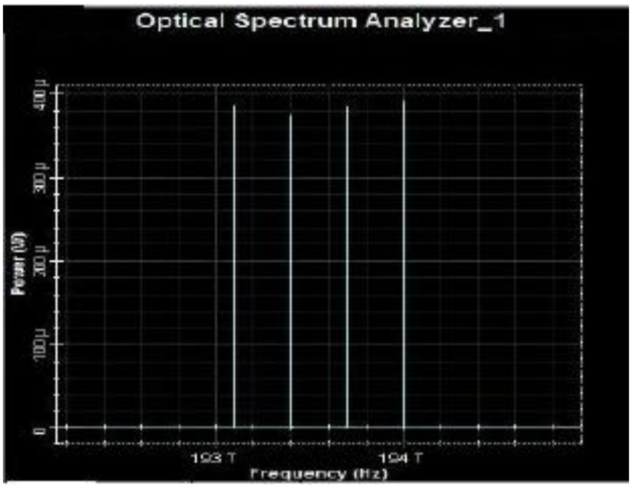

Fig.5.Output at the end of fiber

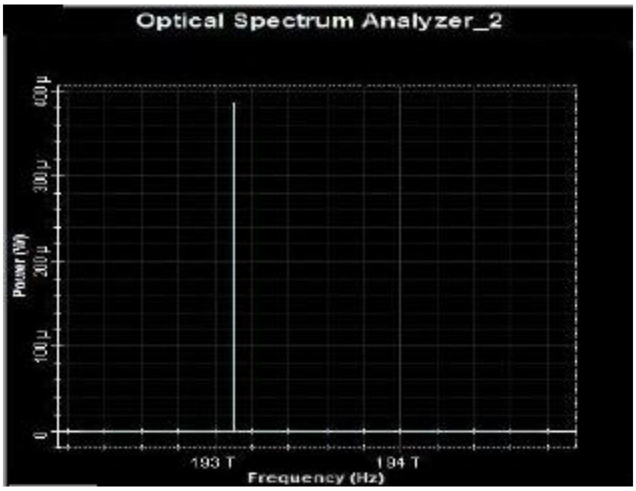

Fig. 6. Channel spectrum of receiver 1

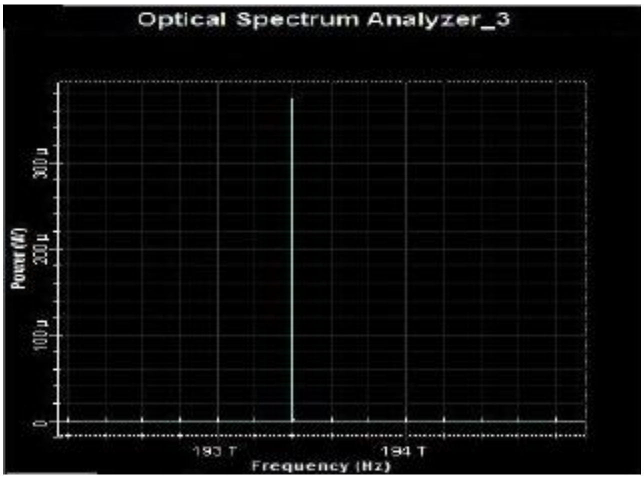

Fig.7. Channel spectrum of receiver 2

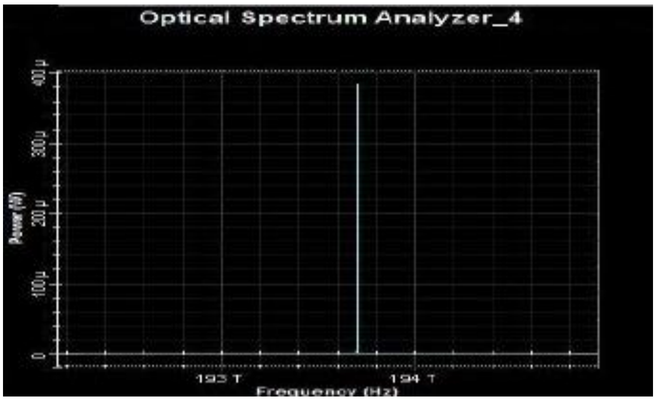

Fig.8. Channel spectrum of receiver 3

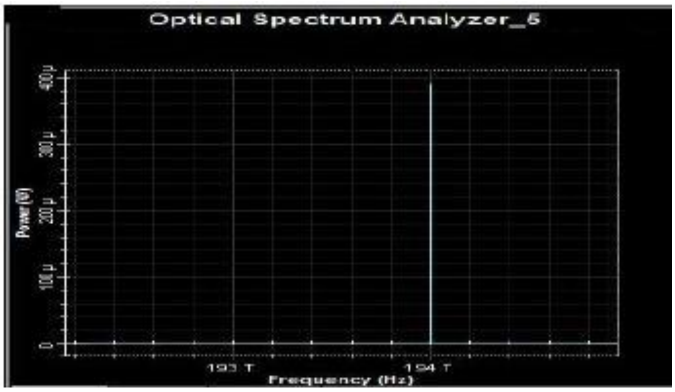

Fig.9. Channel spectrum of receiver 4

This simulation is conducted to implement the basic functions of WDM. It is seen that by properly adjusting the parameters of each device like length of optical fiber and input power, we can obtain better Q Factor.

B. *Simulation of optical fiber amplification experiment*

EDFA (Erbium doped Fiber Amplifier) consists of length of Erbium doped fiber that uses Laser diode as pump. It combines WDM multiplexer output and pump wavelength together, so that they can propagate simultaneously in the fiber. The signal and pump can both propagate in the same direction or they can propagate in the opposite direction to each other inside the EDFA. In earlier days we used electrical amplifiers which convert electrical to optical and vice versa, which was complex. After invention of EDFA, we are amplifying the optical signals directly [4]. Fig.10 shows the WDMPON system with EDFA, which is simulated using Optisystem. The wavelength of the signal light and pump light used here are 1550nm and 980 nm respectively. The signal spectrums of the optical before and after amplified are shown in Fig.11 and Fig.12 respectively. From these figures, we can see that the intensity of the signal is significant enlarged. Moreover, optical signal spectrum before and after amplified has similar shape. This means this system has achieved the purpose of optical amplification.

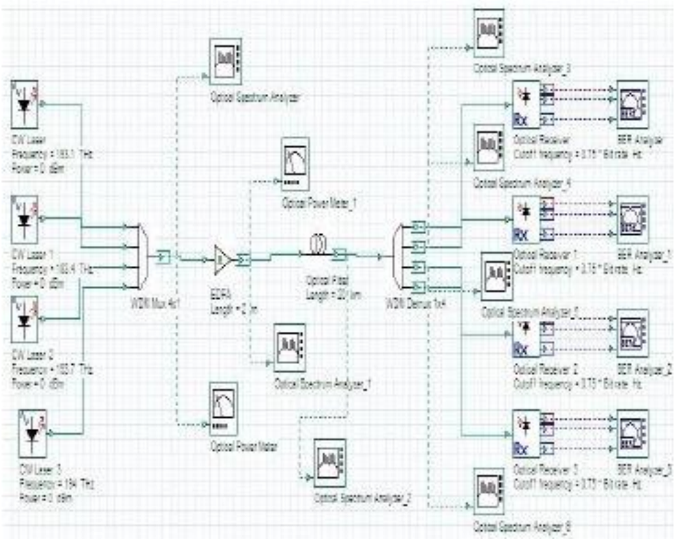

Fig.10. WDM PON optical amplification system

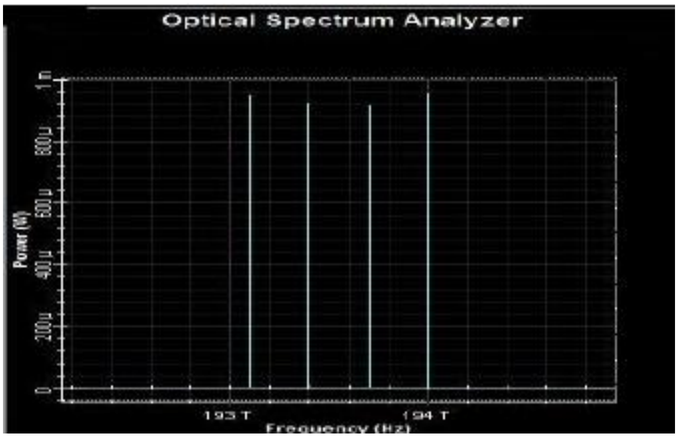

Fig.11. Signal spectrum before amplified

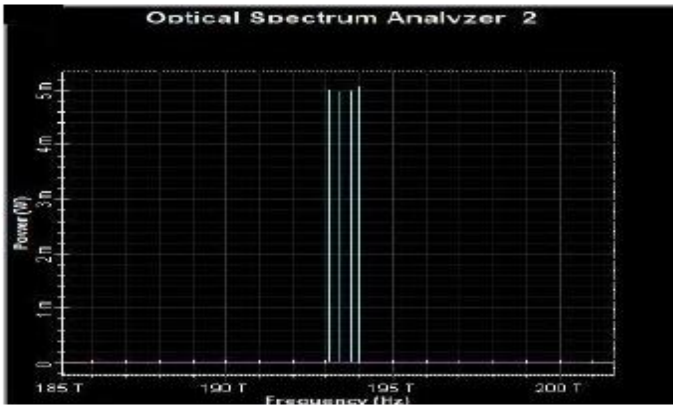

Fig.12. Signal spectrum after amplified

The length of the EDFA is varied between 2 and 22m. The pump power is varied for different values are 120mW, 150mW, 200mW, 250mW respectively and the output power is measured for a constant input power of the signal. To measure the optimum length, the reference pump power is set to 120mW and the output optical power is tabulated for different input power levels as shown in Table 1. 6m length of fiber is chosen as an optimum length for this system as at 6m the output power gave the maximum value .Therefore, the gain is measured at 6m length with different pump power as shown in the result above. The increasing of pump power will increase the output power at each meter of the length shown in Fig.13 and keeps the output power approximately constant.

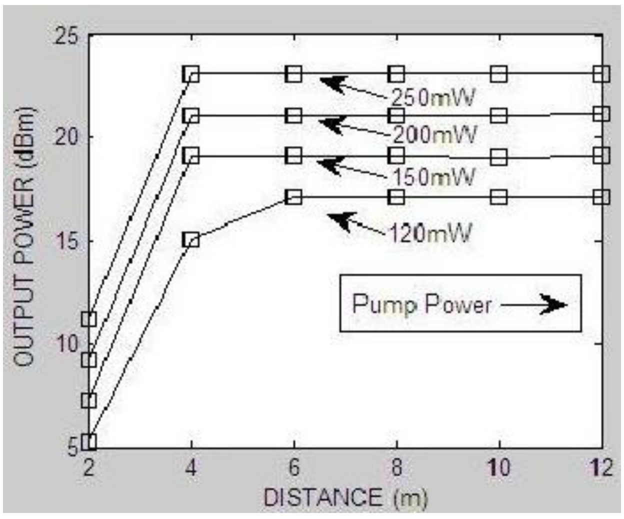

Fig.13. Length versus output power relation

TABLE 1: TRANSMITTED AND RECEIVED POWER LEVELS FOR DIFFERENT LENGTH OF EDFA AMPLIFIER

	Input power (e-3 W)	*Output power (e-3 W)*	*Output power (dBm)*
2	3.992	3.238	5.103
4	3.992	39.640	15.981
6	3.992	57.919	17.623
8	3.992	61.714	17.904
10	3.992	61.672	17.900
12	3.992	60.747	17.835

IV. RESULTS AND ANALYSIS

Estimating the bit error rate (BER) of an optical communication system, currently BER estimation tool required expensive measurement equipment such as serial data analyzer and BER Tester. Besides cost, all this has limited BER estimation based on standard format and is not suitable for custom analysis because of time constraint to use equipment even during offline estimation The BER (bit error rate) of the WDM system can be measured by changing the specifications of network like distance of fiber, number of users, power level etc. As the number of users increases the BER also increase as shown in below Fig.14. Fig.15 shows that by increasing the length of the fiber, the BER also increases.

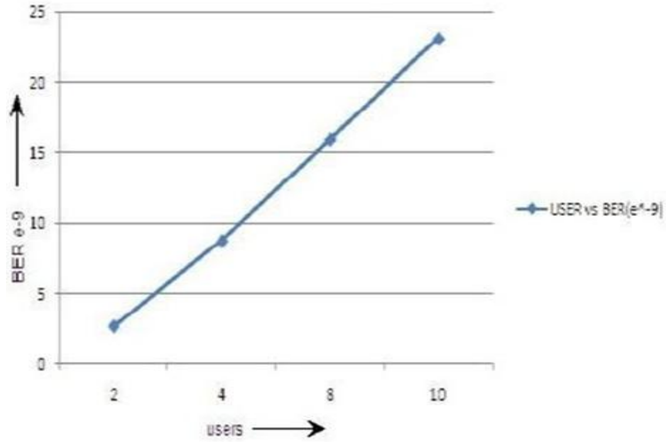

Fig.14. Number of users versus BER

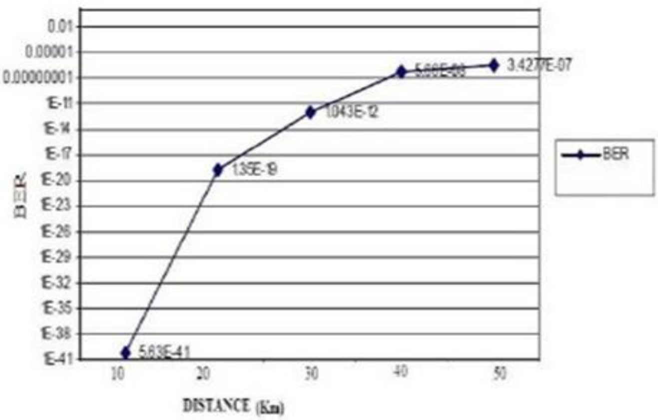

Fig.15. Distance versus BER

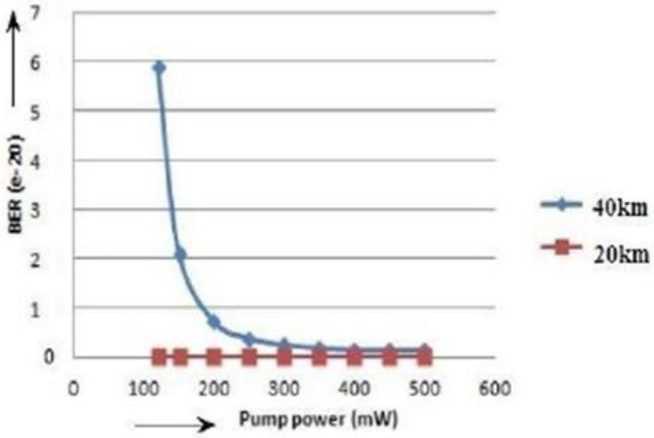

Fig.16. Pump power versus BER

Fig.16 shows clearly the decrease of the BER for lengths of 40 Km and 20 Km EDFA, when the pump power is increasing.

V.CONCLUSION

In WDM optical networks, attenuation is controlled by choosing appropriate pump power and length of EDFA in meters. As we increase the optical fiber distance in kilometres, the pumping power also have to be increased so that desirable bit error rate can be obtained. Suitable EDFAs with different pumping techniques can be deployed to compensate for the attenuation loss.

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