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# Role of EDFA in WDM Networks

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***Abstract* - Wavelength-division multiplexing (WDM) is a technology through which multiple optical channels can be transmitted simultaneously at different wavelengths on a single optical fiber. Optical network using WDM is widely used in present telecommunication infrastructures. It will play an important role in future generation networks. Today's Internet provides a large number of variety of services with different requirements which are fulfills by this technology. Wavelength division multiplexing (WDM) techniques combined with erbium-doped fiber amplifier (EDFA) increases the capacity of light wave transmission, provides high capacity and improves flexibility of optical network technology. The scope of this paper is to study the WDM system with and without using EDFA. EDFA plays an important and valuable role in optical communication systems. This paper also describes an effective comparison between non EDFA system and an EDFA based WDM system.**

***Keywords: WDM, EDFA Amplifiers, Optical Communication,***

## I. INTRODUCTION

In recent years, communication demands are increased due to introduction of various new communication techniques [1]. Today's internet service requires large bandwidth so EDFA's are used with WDM technology to achieve huge bandwidth and to deliver good quality of services to users without increasing the cost [2]. Also when optical signal has transmitted at long distances it is necessary to use an optical amplifier because signals are attenuated over long distances. EDFA is preferred due to low noise insertion and high gain. EDFA's are very much reliable for long distance transmission using single and multi-wavelength sources because of their wide bandwidth and optimum Bit Error Rate (BER) [3].It can provide amplification of multichannel without crosstalk and provide cost effective networks[4][5]. In the ordinary EDFA the optimum Gain efficiency is always accompanied by a compromise in noise figure to a value well above the quantum limit [6].

## II. WDM TECHNOLOGY

In optical communication, wavelength division multiplexing (WDM) is a technology which carries a number of optical carrier signals on a single fiber by using different wavelengths of laser light. It starts bidirectional communication. In comparison of unidirectional transmission with bidirectional transmission on a single fiber some advantages are pointed out like it reducing the number of fiber link, the number of passive components like splitters and WDM multiplexers etc. WDM networks splits their huge bandwidth into small bandwidth optical channels. It uses number of multiplexers at transmitters and de-multiplexers at receiver side. It allows multiple data stream to be transferred along a same fiber at the same time. The major component of the transmitter is an optical source which includes light emitting diodes (LED) or semiconductor laser diode (LD).Laser sources are superior in terms of high efficiency, compact size, good reliability, narrow spectrum and small emissive area compatible with fiber core dimensions etc.

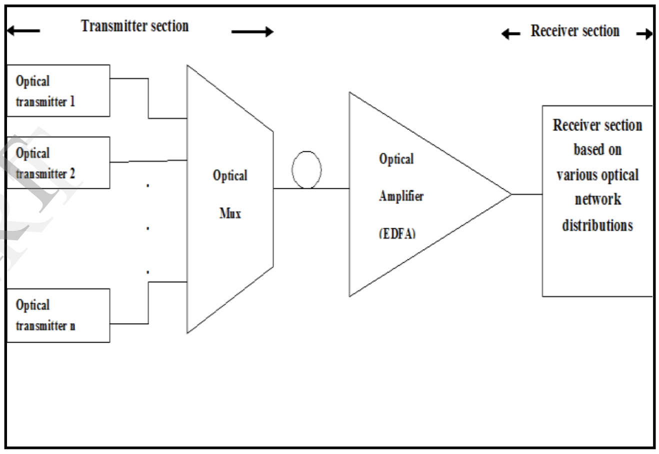


Fig.1 A WDM system

In fig.1 at transmitter side each channels allocated a different wavelength are multiplexed through multiplexer onto a single fibre At destination, reverse process has done means different wavelengths are demultiplexed by demultiplexer and are distributed to different receiver channels saparately. WDM Technology provides many benefits like Capacity Upgrade, Transparency , Wavelength Reuse, Scalability, Reliability etc.

Types of WDM Networks:

- CDWM (Coarse Wavelength Division Multiplexing)
- DWDM (Dense Wavelength Division Multiplexing)

Table 1

| Parameter | CDWM | DWDM |
|---|---|---|
| Channel Spacing | Large,1.6nm-25nm | Small,1.6nm or less |
| No. of base bands used | S(1480-1520 nm)C(1521- 1560 nm),L(1561-1620 nm) | C(1521-1560 nm),L(1561-1620 nm ) |
| Cost per Channel | Low | High |
| No of Channels Delivered | 17-18 most | hundreds of channel possible |
| Best application | Short haul, Metro | Long Haul |

Difference between both type of WDM network

Table 1 shows the specifications of CWDM and DWDM with the use of different parameters like channel spacing, no. of base bands used, cost per channels, no. of channels delivered and application

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## III. EDFA'S PRINCIPLE

EDFA is a mostly used fibre amplifier because the range of its amplification window is overlap with the transmission window which is called third transmission window of silica based optical fiber.

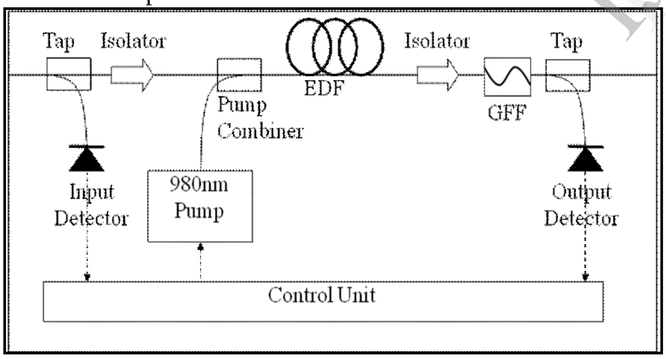


Fig. 2: Diagram of a typical single stage EDFA, showing the three basic components (EDF, pump and WDM combiner)

The basic principle of EDFA is Stimulated Emission. The Diagram of single stage EDFA as shown in fig. 2.The pump energy may either by 980nm pump energy,1480 nm pump energy, or a combination of both. Mostly 980nm has used. A relatively high powered light beam from pump source is combined with the input signal by power combiner. The input signal and the excited light signal must be at different wavelengths. The combined signal propagates through the section of fiber in which erbium ions is presented in the core. This high-powered light beam makes the transmission of the erbium ions from lower energy state to their higher-energy state. When the photons of different wavelength from the pump light collide with the excited erbium atoms, the erbium atoms releases some of their energy to the signal and return back to their ground-energy state. The erbium releases its energy in the form of additional photons. These photons are exactly in the same phase and same direction as the signal being amplified . So the signal is amplified only in a travelling direction. The two main parameters which have a direct impact on the performance of EDFA are Gain and Noise figure.

## VI. RELATED WORK

In the late 80's Erbium Doped Fiber Amplifiers (EDFA) have been a target of several improvements. The paper [1] discussed the research on EDFA applications in WDM communication system. The author concluded that the reduction in gain and ASE noise of EDFA can be achieve with the increase in input signal power. The paper [2] proposed a highly reliable approach to EDFA gain and output power control and a power monitoring scheme for fault detection in WDM Networks. These techniques are used for implementing a power stabilized control channel, the EDFA gain and output power are controlled by monitoring it. This paper [6] discussed the designing of broadband EDFA using dual forward pumping for next generation optical networks. The combination of WDM System with EDFA gives the optimized Q-Factor and Output Peak power according to paper[7].The paper [8] discussed the dependencies of various performance evaluating parameters i.e. Min.BER, Max. Q-Factor, Eye Opening, Dispersion and OSNR on various system parameters i.e. Fiber length, Operating Channel Frequencies, Adjacent channel spacing and EDFA gain were evaluated . This paper [9] represents a composite EDFA configuration. In which an optical isolator is incorporated and an highly efficient amplifier configurations whose total gain is high is investigated. The paper [10] discussed that as the amplification window of EDFA concide with the transmission window which is called third transmission window of silica based optical fiber, that's why it is the mostly used fiber amplifier.



## V. CONFIGURATIONS

Two basic configuration of WDM system have been proposed.

- WDM system without EDFA
- WDM system with EDFA

*Wdm System Without EDFA*

Fig. 3. is showing the configuration of WDM system without using an EDFA .At the transmitter end no. of channels are combined in a optical combiner. These combine multiple channels are transmitted over single fibre. Then splitters are used to split the signal into two parts, one is passes through the optical spectrum analyzer for signal's analysis .And other is passes through the photo detector to convert the optical signal into electrical. Then filter and electrical scope is used to observe the

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characteristics of signals. In this configuration signals at long distance get attenuated. This problem can be overcome by using EDFA amplifier.

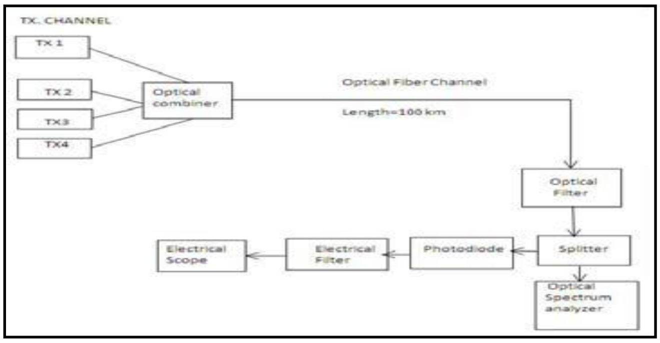


Fig. 3: WDM System Without Using EDFA

*WDM system with EDFA*

Fig.4 showing the configuration of WDM system by using EDFA. This configuration is almost same as WDM system without EDFA except some additional component are used .

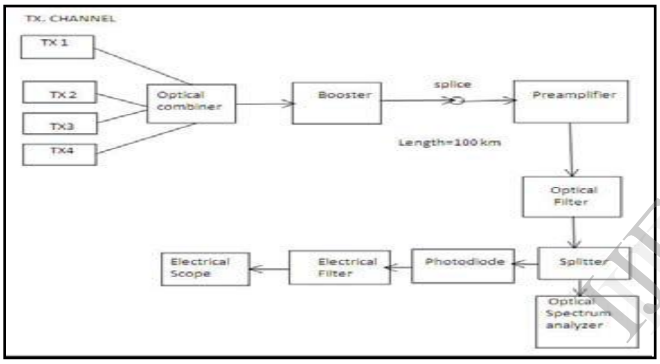


Fig. 4: WDM System Using EDFA

These components are EDFA which are used as a booster and preamplifier, one splice and another additional component is optical filter as shown in fig.4. As optical amplifier is used in this configuration it doesn't suffer from losses and attenuation. Through this, it is possible to build broadband WDM EDFA's which provide flat gain over a large dynamic gain range, low noise, high saturation output power and stable operation with excellent transient suppression. These features are provided in small modules and with power consumption of just a few Watts. This combination provides good reliable performance and relatively low cost, which allows EDFAs to address most application and functions in modern optical networks.

## VI. SIMULATION

The proposed model of WDM system integrated with EDFA are simulated on optisystem 7.0 software. Fig 5 shows the simulated model of WDM system with using EDFA.

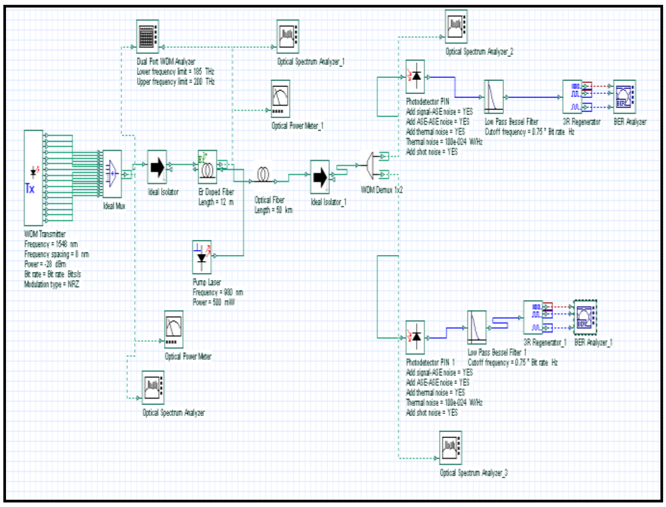

Fig.5 Schematic Design of EDFA-WDM System

In above fig. WDM transmitter is used with 16 output channels , ideal multiplexer to multiplex these 16 channels. The input power of transmitter is -26 dbm. Two isolators is used. The purpose of these isolators are to avoid amplified spontaneous emissions and prevent signals to propagating in a backward direction. The pump power with 980 nm is used to excite erbium ion to higher level.



## VII. RESULTS AND ANALYSIS

The reference pump power of 150mw is used to find out the optimal length. Table 2 is obtained by varying length of fiber and keeping pump power constant at 150mw.

Table 2

| Length (m) | Input power (e-6) W | Output power (e-3) W | dBm |
|---|---|---|---|
| 2 | 21.959 | 3.389 | 5..301 |
| 4 | 21.959 | 48.372 | 16.846 |
| 6 | 21.959 | 73.111 | 18.640 |
| 8 | 21.959 | 78.973 | 18.975 |
| 10 | 21.959 | 79.434 | 19.000 |
| 12 | 21.959 | 78.682 | 18.959 |
| 14 | 21.959 | 77.632 | 18.900 |
| 16 | 21.959 | 76.583 | 18.841 |
| 18 | 21.959 | 75.647 | 18.788 |
| 20 | 21.959 | 74.915 | 18746 |
| 22 | 21.959 | 74.394 | 18.715 |

The optimal length of fiber is 10m for this system because maximum output power is obtained at reference power. Now by taking optimal length 10m constant and varying pump power obtained table 3.

Table 3

| Pump Power( mw) | Gain (dB) | Output power(E-3) |
|---|---|---|
| 200 | 35.982426 | 109.102<br>20.378 dbm |
| 250 | 37.081489 | 138.767<br>21.422 dbm |
| 300 | 37.951303 | 168.366<br>22.263 dbm |
| 350 | 38.673055 | 198.021<br>22.967 dbm |
| 400 | 39.285025 | 227.463<br>23.569 dbm |
| 450 | 39.819687 | 256.961<br>24.099 dbm |
| 500 | 40.293054 | 286.421<br>24.570 dbm |

As shown in table 3 gain and output power are continuously increasing With the increasing pump power.

## VIII. CONCLUSION

WDM system with and without EDFA have been studied and proposed. According to this paper Optical network with WDM is widely used in present telecommunication infrastructures. It will play a significant role in future generation networks. Wavelength division multiplexing (WDM) techniques combined with erbium-doped fiber amplifier (EDFA) provides high light wave transmission with high capacity and also provides flexible optical network technology .It can be concluded that the WDM System integrated with EDFA gives the optimized Q-Factor and Output Peak power, provide flat gain over a large dynamic gain range, low noise, high saturation output power, and stable operation with excellent transient suppression. In Future, the WDM System integrated with High performance EDFA, and 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.



## REFERENCE:

[1] Brobrovs.V et al,"EDFA Application Research in WDM Communication Systems", ELEKTRONIKA IR ELEKTROTECHNIKA , Vol. 19, No. 2, 2013.

[2] M.N. Zervas, R.L. Laming and D. N. Payne," Efficient EDFA incorporating an optical isolator", In IEEE journal of quantum electronics, March 1995, vol 31, no.3 UK.

[3] G. Jyoti et al,"Analysis of Augmented Gain EDFA Systems using Single and Multi-wavelength Sources",International Journal of Computer Applications, Vol. 47,No. 4, June 2012.

[4] Semmalar S., Poonkuzhali, Devi.P,"Optimized Gain EDFA of different lengths with an influence of pump power", IEEE Paper, 2011.

[5] Semmalar S., Gujral Jyoti,"EDFA with Optimized Gain using Tri-Counter Directional Pumping", International Journal of Applied Engineering Research, Vol. 6, No. 5, April 2011.

[6] A. Goel and R. S. Mishra, "Design of broadband EDFA for next generation optical network", International journal of Neural networks and applications, jan-june 2010, pp. 9-13

[7] J. Gujral, M. Singh, "Performance and Analysis of 4 channel WDM system with and without EDFA" Indo Global College of Engineering, Abhipur, Mohali, Punjab, India IJECT Vol. 4, Issue Spl - 3, April - June 2013

[8] A. A. Bhatt, A. Basnotra, N. Sharma, " Design and Performance Optimization of 8-Channel WDM System" International Journal of Advanced Research in Computer Science and Software Engineering Volume 3, Issue 4, April 2013

[9] J.H. Jang, J.H. Jung, K.K.Lee, "Implementation of Automatic gain controlled bidirectional EDFA in WDM Networks" , IEEE CLEO/Pacific Rain 1999.

[10] Chaugule Sachin et al,"WDM and Optical Amplifier",2nd International Conference on Mechanical and Electronics Engineering (ICMEE 2010) IEEE Paper 2010