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# Investigation of Performance Analysis of EDFA Amplifier Using Different Pump Wavelengths and Powers

Ramandeep Kaur, Parkirti, Rajandeep Singh

## ABSTRACT

In this paper, an investigation of the performance characteristics of EDFA using different pump power and pump wavelengths of 980 nm and 1480 nm for two different systems is presented in order to reduce the noise figure and enhance the gain. Pump powers are compared and analyzed on basis of Bit Error Rate. Performance of EDFA is calculated by gain curves, noise figure and BER values in WDM PON architecture.

**Keywords-** Passive optical networks (PON's), Wavelength division multiplexing (WDM), Bit error rate (BER), Noise figure.

## 1.INTRODUCTION

PON technology is widely used by many internet service providers[1]. PONs are cost efficient because of absence of active components[2]. WDM PON network results in increased bandwidth and coverage as WDM multiplexes number of different channels into one channel[3]. To compensate the loss provided by propagation of signal, optical amplifier is used in this architecture. Optical amplification can be achieved either by use of semiconductor optical amplifier or by using fiber amplifier. The EDFA is used widely because its emission coincides with the 1.55 μm window[4] in conventional SMF[5].

In this paper, Performance of EDFA is analyzed using different parameters. Firstly, performance of EDFA is evaluated on basis of pump power and BER and then, performance is evaluated on basis of pump wavelength of 980 nm and 1480 nm. When pumping the EDFA using a wavelength of 980 nm. Then, amplifier corresponds to three level system and at 1480 nm, amplifier corresponds to quasi three level system. Both pumping schemes can be described in terms of two level populations[6].

The rate equations for populations of two level system is given by-

$$\frac{dN2}{dt} = W12\,n1 - W21\,n2 - A21\,n2 \quad [7]$$

$$n\,t = n\,1 + n\,2 \quad [7]$$

where W12 and W21 denotes the rates for stimulated transitions. n t represents the ion density of erbium ions. n1 and n2 represents fractional density of lower and upper excited levels respectively.

Optical noise generated in EDFA can be represented in term of noise figure. Optical noise figure is a measure of how much noise the amplifier adds to the signal when signal enters into it[8]. Mathematically, Noise figure can be represented in terms of Signal to noise ratio(SNR) by-

$$NF = \frac{SNR\,(in)}{SNR\,(out)} \quad [9]$$

Where SNR(in) represents signal to noise ratio before light enters the amplifier and SNR(out) represents signal to noise ratio after amplification. If the signal is much stronger than the noise, the noise figure can be written as [9].

$$NF = \left(1 + \frac{2P_{ASE}}{\hbar\upsilon\Delta\upsilon_{sp}}\right)\frac{1}{G} \quad [9]$$

Where $P_{ASE}$ represents amplified spontaneous emission (ASE) noise power, ħ is Planck's constant, ν is the frequency of the light and $\Delta\upsilon_{sp}$ is the bandwidth of

the noise (i.e. the bandwidth of the EDFA).
This chapter is organized as follows: section 2 describes the simulation setup. Results and discussions are explained in section 3 and at the end section 4 summarizes the work.

## 2. SIMULATION SETUP

The performance analysis of EDFA is realized using different parameters. The block diagram for the network is shown in figure 1. At transmitter eight channels with a channel spacing of 100GHz are multiplexed into fiber span of 115 km using 8×1 WDM multiplexer. NRZ modulation is used because NRZ data modulation format is most suitable format for passive optical network(PON)[10].The fiber span of 115 km consists of 100km of single mode fiber(SMF) and 15km of dispersion compensation fiber and an Erbium Doped Fiber Amplifier(EDFA). This amplified signal is demultiplexed at the Remote Node(RN) into eight transmitted wavelengths and each wavelength is splitted using 1X8 splitter. This splitted signal passes through a 5km SMF before reaching the optical network unit (ONU). The parametric values of the setup are written in table no. 1.

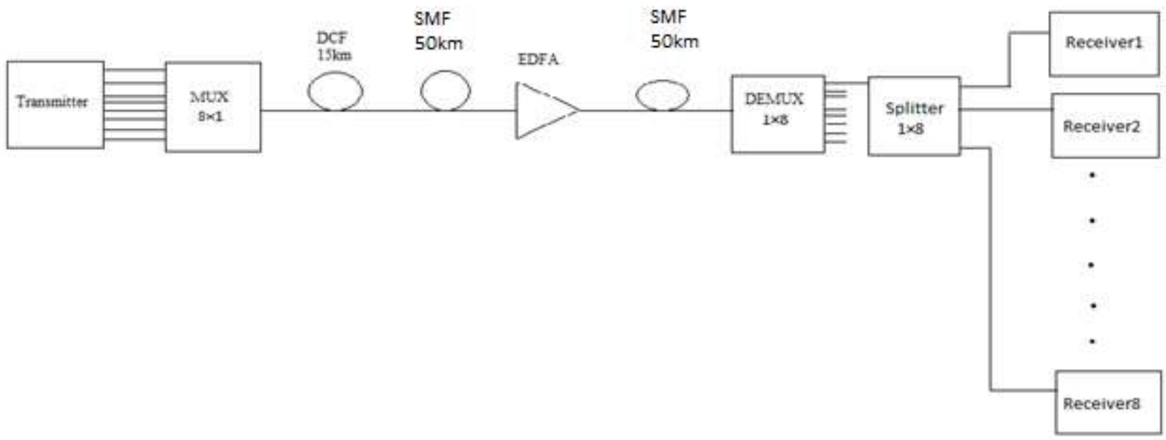


**Figure 1: Block Diagram of Simulation Setup**

At transmitter, a signal is generated with help of external laser source. A pseudo random bit sequence generated by PRBSG is passed to Non-return-to-zero (NRZ) generator and sent to Mach-Zehnder modulator where a laser source is connected.

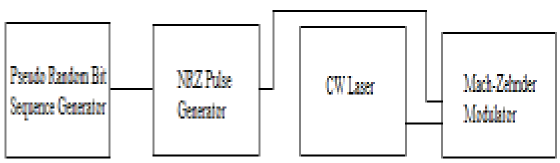


**Figure 2: Block Diagram of Transmitter**

At Receiver, each ONU section consists of a PIN photodetector, a low pass filter, filter regenerator and a analyzer as shown in figure 3. PIN photodiode converts the received optical signal to electrical signal[11] and low pass filter reduces the noise of signal by filtering it and analyzer analyses the signal.

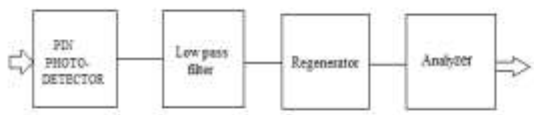


**Figure 3: Block Diagram of Receiver**

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**Table no. 1 Parameteric values of system setup**

| Parameters | Values |
|---|---|
| EDFA Length | 2.2 m |
| Pump Power | 100 mw |
| Pump wavelength | 1480 nm |
| Fiber length | 115 km |
| Pumping Technique | Bidirectional Pumping |
| Number Of Channels | 8 |
| Frequency Spacing | 100 GHz |

## 3. RESULTS AND DISCUSSION

In WDM PON, performance of EDFA is evaluated using different parameters. A plot between Bit Error Rate (BER) and Pump Power is drawn. which shows that BER values increases with increase in pump power values but after some values BER values start decreasing.

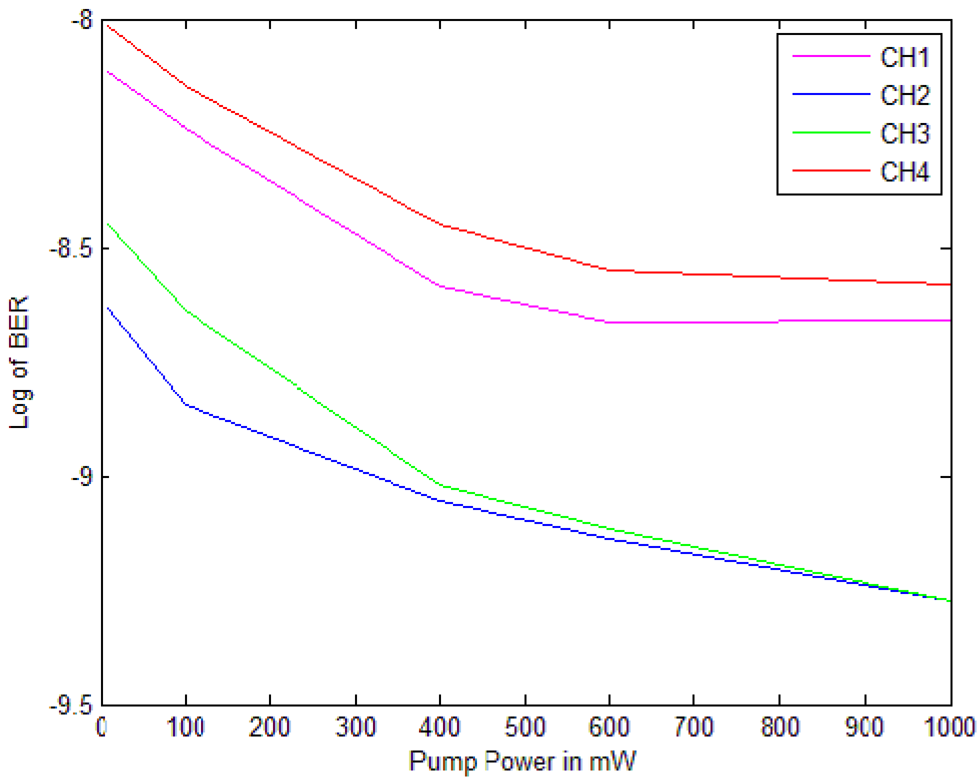


**Figure 4: pump power versus BER**

The different behaviors caused by pump wavelength (980 versus 1480 nm) is shown. Gain and noise figure values of EDFA at 980 nm pump wavelength and 1480 nm pump wavelength are calculated. Gain is more at 1480 nm pump wavelength as compared to 980nm.

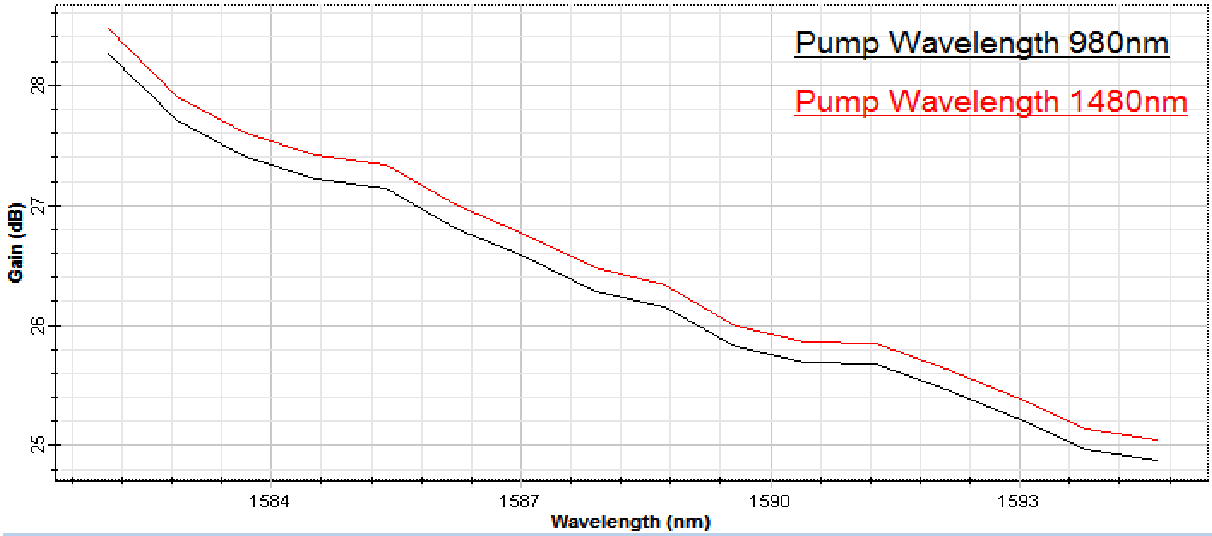


**Figure 5 :Gain curve for pump wavelengths**

Whereas noise figure is found to be less in case of 980 nm pump wavelength.

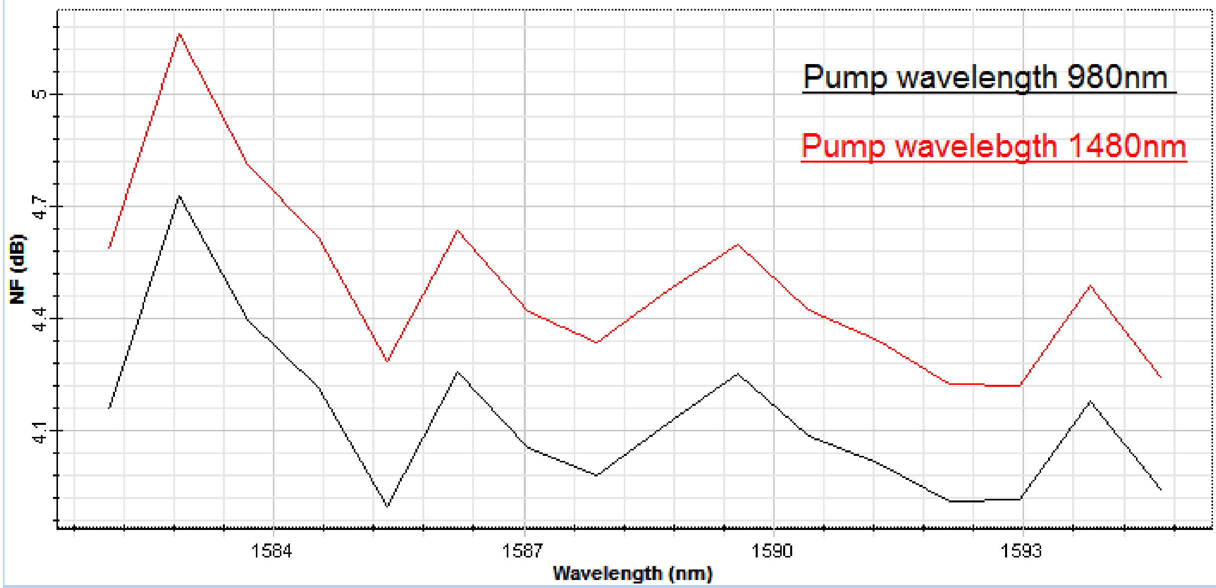


**Figure 6 :Noise Figure curve for pump wavelengths**

## 4. CONCLUSION

In this work, the investigation of performance characteristics of EDFA is done on basis of pump power and pump wavelength. Firstly, the differences in the responses of the EDFAs pump powers are compared and analyzed on basis of Bit Error Rate. Secondly, the performance of EDFA is investigated at two different pump wavelengths of 980 nm and 1480 nm in order to enhance the gain and reduce the noise figure and using bi-directional pumping. Gain flatness of 28.26 dB from 1582 nm to 1594 nm band has been observed with 3-4 dB of noise figure. At 980nm, gain and noise figure values both are less as compared to those at 1480 nm.

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**Parkirti, M.tech Student, ECE, Punjabi university, Patiala, Punjab.**

**Er. Ramandeep Kaur, Assistant Professor, ECE, Punjabi university, Patiala, Punjab.**

**Er. Rajandeep Singh, Assistant Professor, ECE, GNDU regional campus, Sultanpur Lodhi, India**.