

# Simulation of Gain flattening 32 channels EDFA-DWDM Optical System

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**Abstract**—The gain flatness of EDFA plays a very critical role in DWDM system applications in all optical network design. The main purpose of this paper is to achieve gain flatness for 32 channels in order to equalize amplitude gain of DWDM system. This system is simulated using Opti system software to achieve gain flatness of EDFA through variation of EDFA pump power and input power of system. The gains are flattened within  $41 \pm 0.9$  dB from Wavelength range 1546 to 1560 nm having noise figure less than 8dB, Optimized EDFA fiber length of 6.245 m and frequency spacing between channels is 0.4 nm simultaneously amplified in a EDFA of single stage. The working model consists of WDM transmitter, MUX, Pump laser, dual port WDM analyzer and EDFA as key components

**Keywords**—EDFA( $Er^{+3}$  doped fiber amplifier), DWDM(Dense wavelength division multiplexing), Pump power, Input power, NF(Noise figure)

## I. INTRODUCTION

As now a days, to facilitate high speed network services we require large amount of bandwidth, so EDFA are used extensively in WDM-DWDM technology which increases the capacity of optical network with high speed without affecting any cost. EDFA is an optical amplifier which uses generally  $Er^{+3}$  doped optical fiber as a gain medium to amplify an optical signal with multiplexed pump laser and signal is amplified through interaction of doping ions. The main characteristic of it is that its operating wavelength is  $1.55\mu m$  as we know that this wavelength related to third window of optical communication which shows lowest attenuation comparatively to another optical communication Transmitting window. The technical characteristics of EDFA include Efficient pumping, Low noise, High Gain, Low distortion and minimal inter channel crosstalk High output power (this is not gain but amount of possible output power) and most importantly it amplifies the data channels with high data rates in optical domain and in operating range of optical fibers. The gain of optical system depends on the wavelength which can effect system's performance and due to unequal gain spectrum of optical amplifiers, this can unbalance the powers in the transmitted WDM channels so by

equalizing gain of amplifier we can achieve error free detection of signals transmitted through optical link.

There are several methods through which optical flat spectral gain can be designed such as by altering the pump power, by controlling fiber length, by variation of input power and by properly choosing optical notch filter characteristics. In this paper, the gain flatness of EDFA is achieved by variation of pump power and input power for a fixed fiber length of 10 km and average output power of more than 7dBm.

## II. METHOD

Figure 1 shows the block diagram of EDFA-DWDM System design which includes WDM transmitter, MUX, Pump laser, dual port WDM analyzer, EDFA as key components in the wavelength region of 1546-1560 nm having single pumping power using wavelengths between 980-1480 nm. This model has been computed, simulated and analyzed with varying parameters of gain and noise figure. The gain flatness and system stability of 980 nm pump laser wavelength has been obtained maximum compared to 1480 nm wavelength.

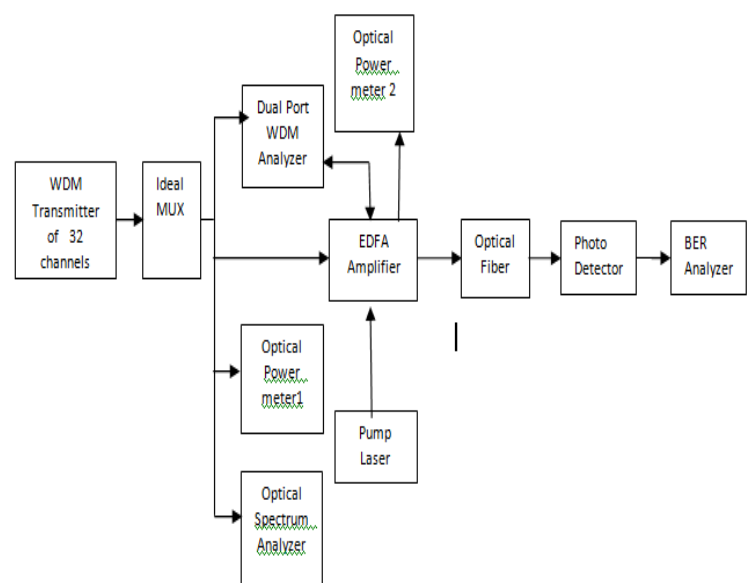


Fig.1: Block diagram of EDFA-DWDM system design with single pumping source

**III. BACKGROUND**

EDFA are always a prime choice to use them as optical amplifiers because of their capability to amplify signal in optical domain without converting into electrical signal. By using EDFA, the transmission distance and capacity of optical system increases and their characteristic is to provide flat gain over a range of frequencies.

In this context Paper [1] proposed a model that provides flat gain of around 27dB for 16 channel WDM system maintaining frequency spacing between channels to 0.8 nm by using Gain flattening filter(GFF).

In Paper [2] gains are flattened to around 24dB for 16 channel WDM system maintaining frequency spacing between channels to 0.8 nm by studying variation of Fiber length and pump power.

In paper [3], the system is simulated to achieve gain flatness of 16 channel EDFA-WDM through optimized fiber length and pump power .The gains are flattened between 24±0.3dB from 1546 to 1558 nm band of wavelength and noise figure less than 6dB obtained.

Paper [4] describes the simulation models of EDFA Gain of different Pump powers. Here, EDFA length of 10m and pump power of 220mW gives the gain of 40.17dB , pump power of 620mW gives the gain of 44.3dB and pump power of 1000mW gives the gain of 46 dB.

Paper [5] proposed a simulation model that provides EDFA-WDM flattened gain to around 38dB and noise figure<9dB for 16 channels by variation of fiber length and pump power.

**IV. RESULTS AND DISCUSSIONS**

The pump power is different to be in range 100 mW and 510 mW, by varying the wavelength of each channels in ranging between 1545-1560 nm, the corresponding gains and noise figure data obtained from dual port WDM analyzer(both are in dB) are plotted in figure 2 and figure 3 respectively.

Figure 2 shows that the EDFA gain increases as pump power increases. The average gain values for different pump powers are shown in Table 1. As we can see that the highest flattened gain which is around 41 dB is achieved for a pump power of 510mW with an optimized fiber length of 6.245 m and most importantly the frequency spacing between channels is reduced to 0.424 nm which is a quite effective step in order to save bandwidth.

Figure 3 shows the variation of noise figure for different pump powers. Here it is visualized that for low pump power noise figure is high and chances of distortion in signal increases. Table 1 shows the average values of noise figure for different pump power values.

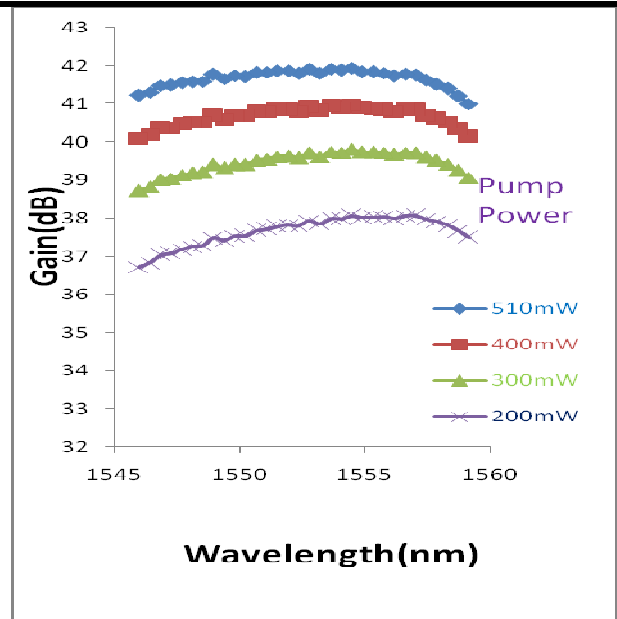


Fig.2: Variation of Gain along the wavelength for different pump powers at a constant input power

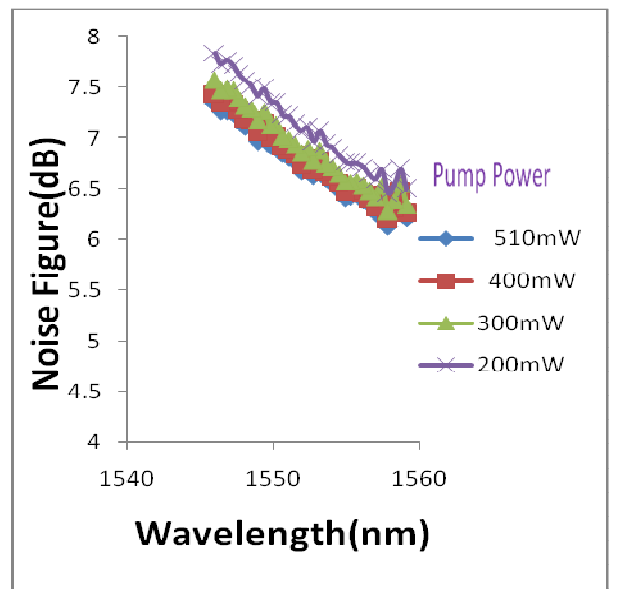


Fig.3: Variation of Noise figure along the wavelength for different pump powers at constant input power

Table 1. Average gain and noise figure values for different pump powers

Pump Power	200 mW	300 mW	400 mW	510 mW
Avg Gain(dB)	37.657	39.448	40.666	41.665
Avg NF(dB)	7.093	6.886	6.783	6.714

Figure 4 shows the variation of Gain for different input powers. Here it is visualized that for low input power gain

is low and on increasing input power the amount of gain flatness increases considerably.

Table 2: EDFA-DWDM Parameters

Parameters	Values(Units)
Number of Channels	32
WDM transmitter frequency	1546 nm
WDM transmitter freq. spacing	0.4 nm
WDM Bandwidth	10GHz
Modulation type	NRZ
EDFA optimized length	6.245 m
EDFA core radius	2.2 $\mu$ m
Er <sup>+3</sup> ion density	1.425e+025 m <sup>-3</sup>
Numerical aperture	0.24

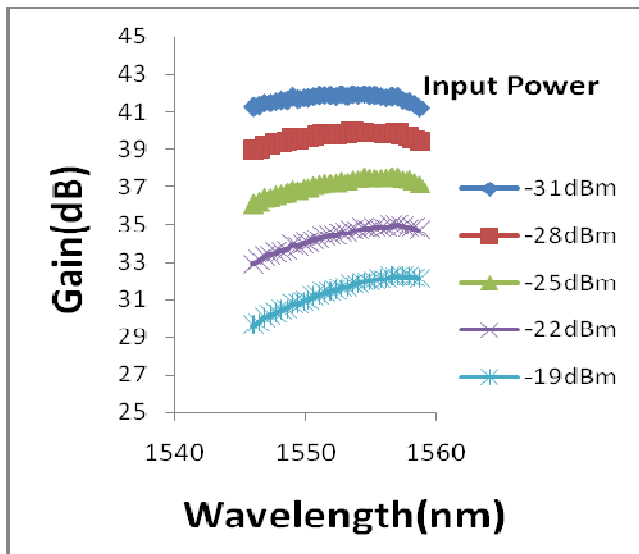


Fig. 4: Variation of Gain along the wavelength for different input powers at a constant pump power

Figure 5 shows the variation of noise figure for different input powers. Here it is visualized that for low input power noise figure is high and on increasing input power the amount of noise figure increases considerably.

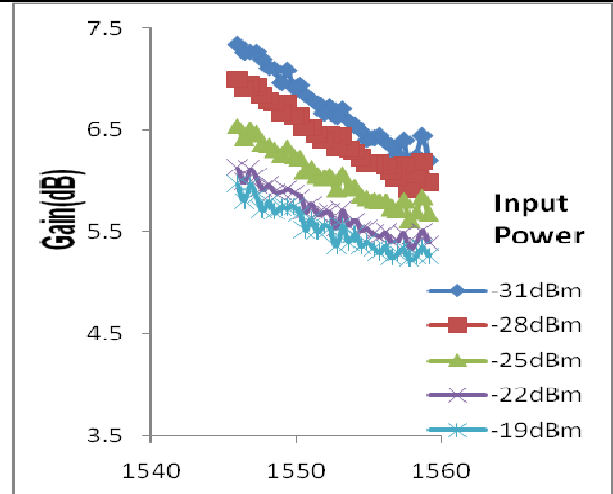


Fig. 5: Variation of Noise figure along the wavelength for different input powers at constant pump power

## V. CONCLUSION

In this paper, flattened gain EDFA-DWDM system designed for 32 channels in wavelength range from 1546-1560 nm. and it is observed that population inversion of Er<sup>+3</sup> ions can be controlled by properly choosing the injected pump power of CW laser and doping of Er<sup>+3</sup> to EDFA. It is found that the optimized Er<sup>+3</sup>doped fiber length is 6.245 m whereas the optimum pump power is 510mW to flat the gain within 41 $\pm$ 0.9dB for 0.424 nm frequency spacing between transmitting channels. The output power at EDFA 7.9188 dB and an average noise figure is 6.714686dB. It is also found that this system also provides maximum EDFA gain at lowest attenuation wavelength of optical fiber i.e 1.55 $\mu$ m.

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