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Gain Flatness and Bit Error Rate Improvements for an EDFA in WDM System

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Abstract: The Gain flatness of EDFA (Eridium Dopedd Fiber Amplifier) plays a important role for WDM optical application. The purpose of this paper is to improve the gain uneveness for each channel in order to equalize the amplitude in a Wavelength Division Multiplexing (WDM) system .By using low pass Chebshev filter, tunning numerical aperature, fiber length and pump power we can improve the gain faltness. The gain are flattened within 33.5795dB-33.9714dB from 1546nm-1558nm band of wavelength with noise figure(NF) < 7dB, output power 18 dB, Bit Error Rate (BER) < 10^{-22} & Quality factor is 14.78. By theses above parameters we achieved the gain flatness is 0.3dBThe design is simulated using Optisystem 12 software.

Keywords: BER, EDFA, fiber length, gain flatness, punp power, WDM system.

1. Introduction

WDM is a technology which multiplexes multiple optical carrier signals on a single optical by using different wavelengths. In C and L band region ,by multiplexing a stream of wavelength channel can simultaneously amplify the desired power level where the amplification of particular channel is dependent on the signal wavelength .In place of doing equalize the power of each individual WDM signal a uniform gain for the WDM signals cab be achieved by flattening the gain spectrum of EDFA[1].

EDFA (Eridium doped fiber amplifier)with advantages of high gain, low noise and large bandwidth and disadvantage of uneven gain is an important component in WDM. This uneveness characteristics will degrade the system performance and reduce effective transmission bandwidth,so we need to reduce this uneveness in EDFA.EDFA is actually a fiber where the core of silica fiber is doped with eridium ions(Er^{+3}) and can be efficiently pumped with a laser at a wavelength of 980 nm or 1480 nm.It is not necessary that in WDM system EDFA amplify the wavelength of channels equally,so we need to equalize gain spectrum in order to achieve uniform output power.

There are various method of gain flattening in EDFA such as by controlling fiber length, pump power and proper selection of filter's characteristics.In this paper the gain flatness of EDFA is achieved by controlling the fiber length and pump power for a input power of -26 dBm and our desired ouptput power more than 15 dBm with quality factor in the range of 10-15[2].

2. System Design

The Optisystem 12 software is used to design the EDFA in WDM system.The system contains of 16 input signals,ideal multiplexer,pump laser,eridium doped fiber,demultiplexer, 3R generator,photodiode and low pass chebyshev filter as shown in figure 1.

The input of the system is 16 equalized wavelength multiplexed signals in the wavelength region 1546nm-1558nm with 0.8 channel spacing. The pump power 980nm is used to excite the doped atom to a higher energy level. The power of each channel is -26dBm [2].Our desired gain is about to 33dB and outpit power is more than 15dbm 2gain flatness is less than 0.5dBm.To get optimized result fiber length, pump power parameter are selected. The Dual Port WDM Analyzer
measures gain and flatness, whereas the Optical Power Meter measures the output power[6].

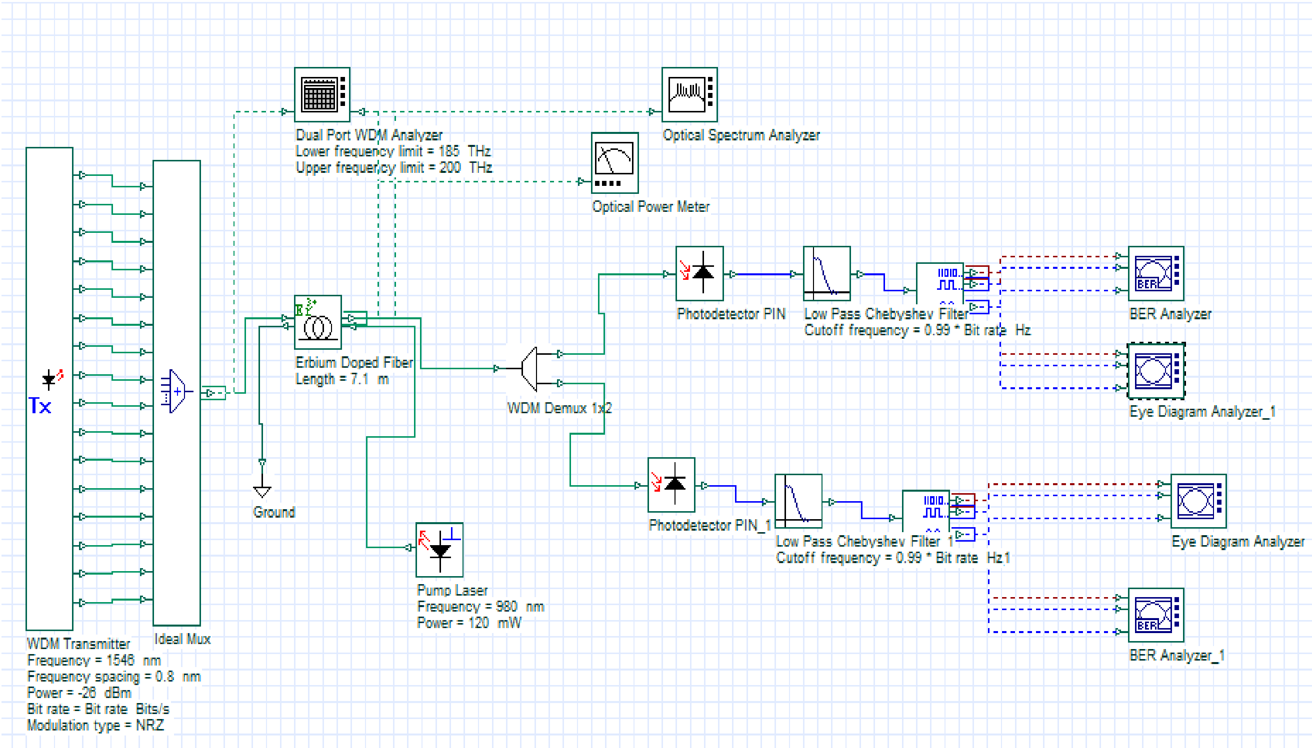
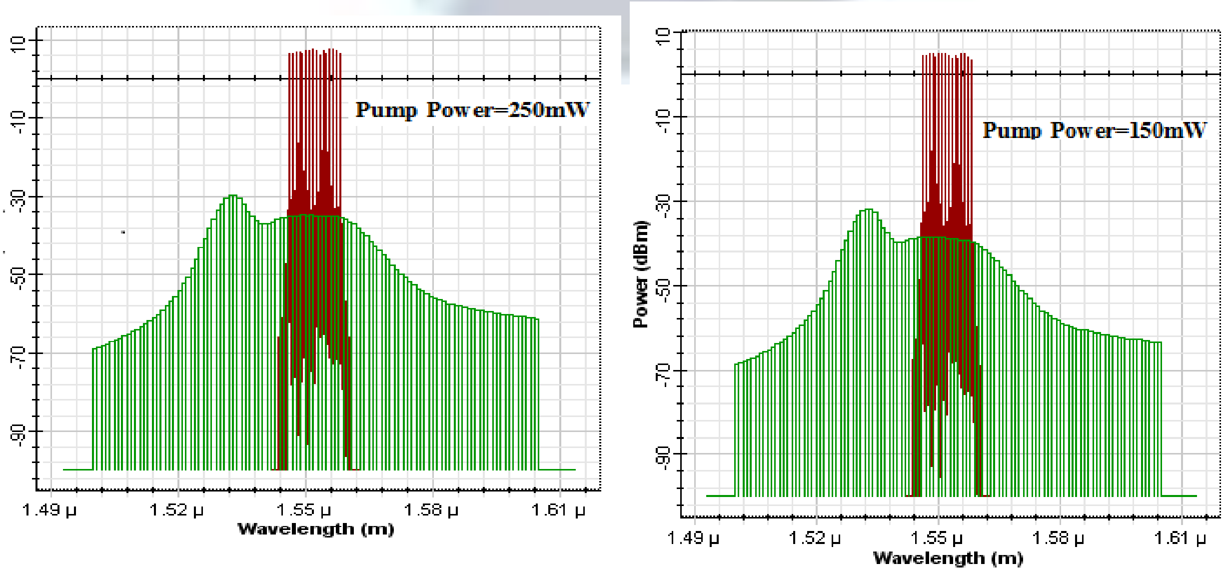


Figure 1: Design of the system in OptiSystem software

3. Simulation and Result

By our simulation it is observed by varying the pump power for diffrernt fiber length at a constant input power -26dBm. As the pump power increase,the output power is also increase it is shown in figure 2 that the output power is increased initially for a given power pump,than it gets decreased in stable order and almost gets saturated up to length of is improved. For pump power 100mW has the gain high 33.72dB with low noise figure 4.846dB but in this case the gain is not equalized for all channel because gain flatness is 2.0035dB .For the pump power 250mW has the higher gain 37.6682dB and gain flatness is also less 1.32dB but in this case the noise figure is vey high 8.5600dB.For the fiber length 5m and pump power 150mW we get the gain 34.66 and noise figure 4.80 but the gain flatness is very high that is 2.2dB and this gain flatness is not good for EDFA-WDM system.This analysis shows that the pump power 100mW and 250mW do not offer better performance for the the system because there is not equalized gain for all channels. The optimizd value is measured for 120mW pump power and fiber length 7.1m.We get the gain flatness 0.38 and noise figure is 6.8dB.



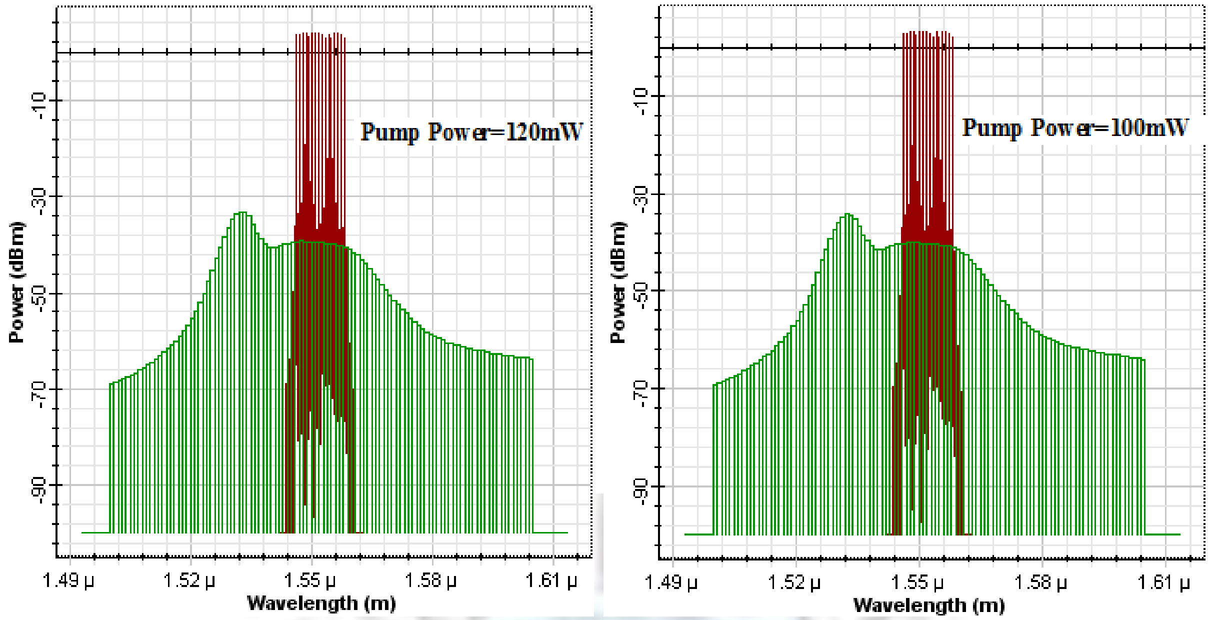


Figure 2. Output power (red) and Noise power (green)

4. Analysis of Bit Error Rate (BER)

A bit error rate is defined as the rate at which errors occur in a transmission system. This can be directly translated into the number of errors that occur in a string of a stated number of bits. The fiber length, pump power ,ripple factor of filter, ,numerical aperature affects the BER performance of the system[5]. In this paper we have used 2nd order low pass chebyshev filter having ripple factor 0.5dB.The BER is found to be in the range of 10^{-21}.For fiber length7.1m, pump power 120mW ,numerical aperature 0.24 and BER 1.686×10^{-21} having quality factor 14.7808.The graph of quality factor shown in figure 3.

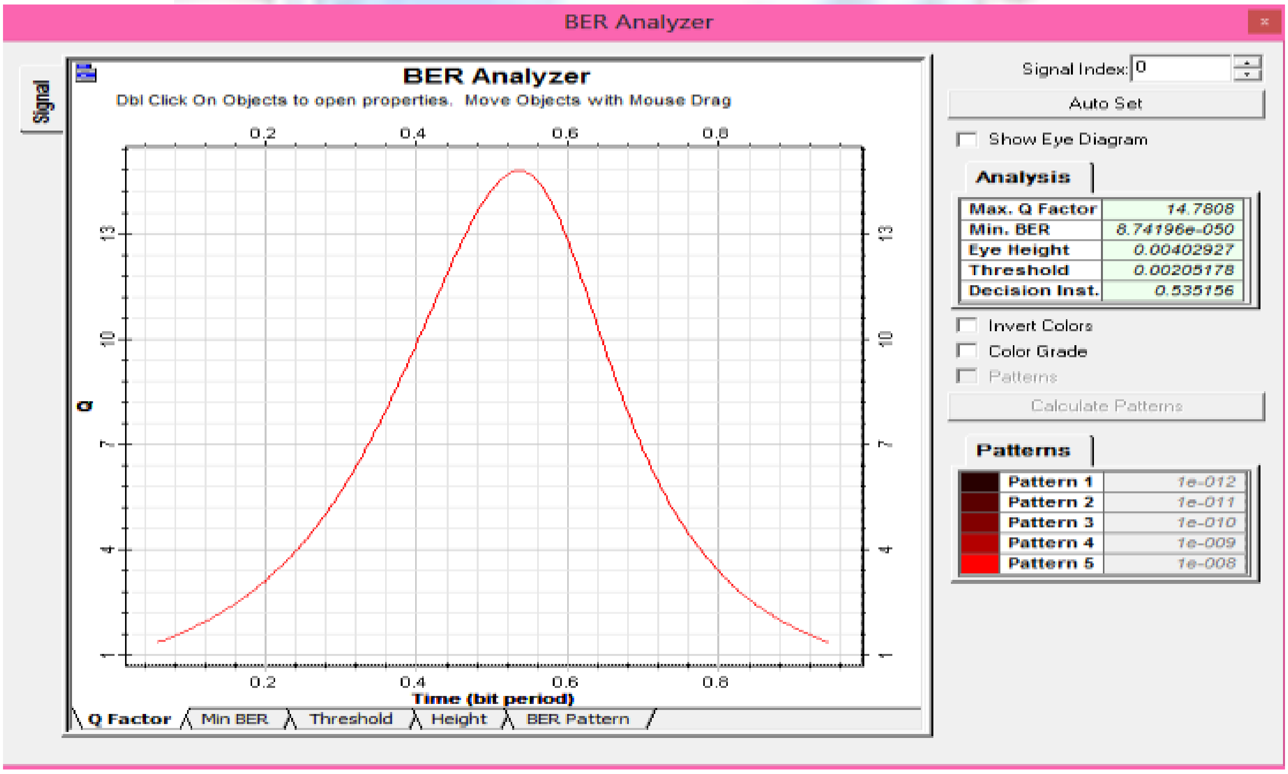


Figure 3: Graph for quality factor

The improved BER performance of system is shown in figure 4.

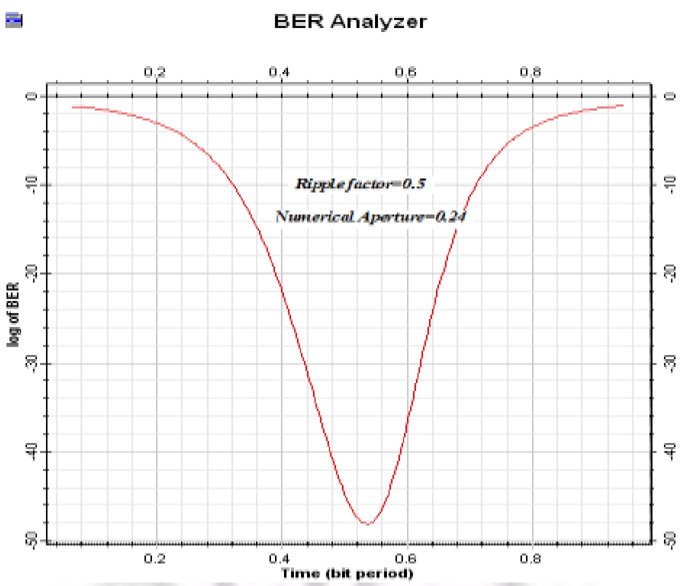


Figure 4: Graph of Min BER

By using eye diagram analyzer we can see that the eye pattern for channel 1 gives a big eye opening which mean that the intersymbol interfernce is low and avearge BER is 10^{-22} for channel 1 .Width of opening represents the time over which sampling for detection is performed. It is shown in figure 5.

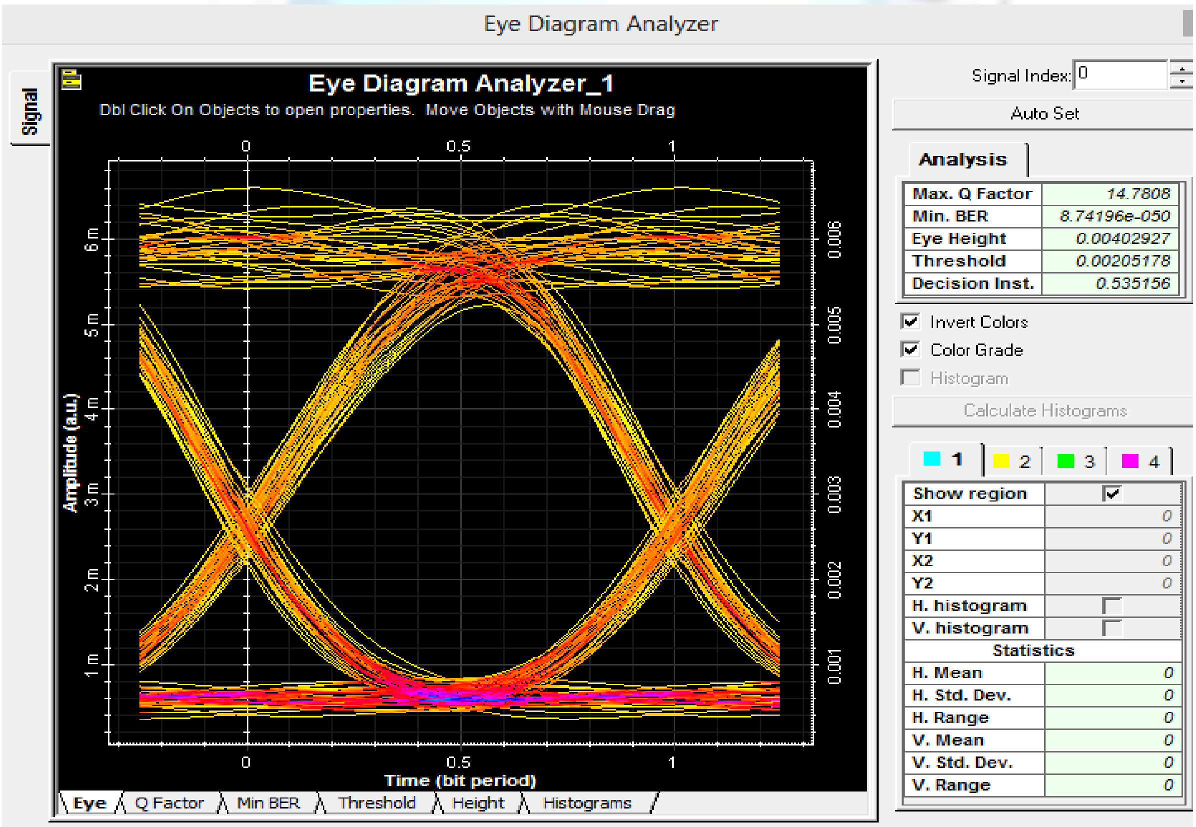


Figure 5. Eye pattern of the system

In this paper we used chebyshev filter having ripple factor 0.5dB. The graph of BER vs Numerical Aperture at ripple factor 0.5dB is shown in figure 6.

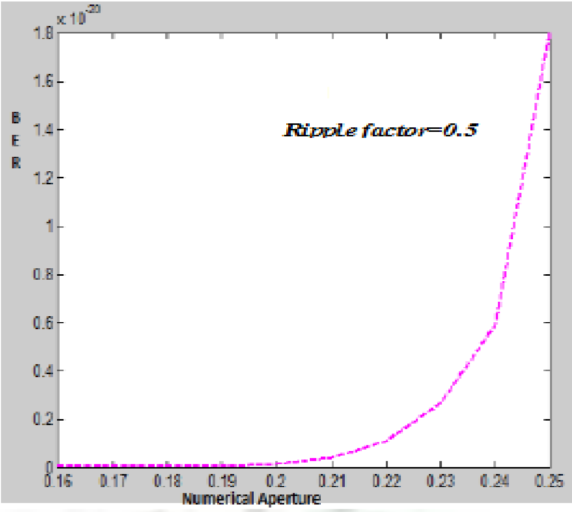


Figure 6: BER vs Numerical Aperture at different ripple factor=0.5

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Conclusion

The gain flatness is improved by optimize the pump power to EDFA and fiber length. By simulation we concluded that the optimize fiber length is 7.1m and pump power is 120mw.The WDM system has a good bit error rate in the range of 10^{-21}.The system for 16 channel amplification was designed for gain of 33.5795dB-33.9714dB from 1546nm-1558nm having gain flatness is 0.39dB with noise figure(NF) < 7dB and the quality factor is 14.7808.

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