Optimization Of Gain And Bit Error Rate Of An Erbium Doped Fiber Amplifier For Wdm System

Saikat Saha [1] , Pratham Majumder [1] , Myneni Soundarya [2]

[1,2]SENSE DEPT , VIT UNIVERSITY , INDIA

Abstract

The Gain flattened EDFA plays a major role for modern WDM optical application. Use of a Low Pass Cosine Roll Off Filter and tuning numerical aperture and fiber length for a specific pump power optimizes the gain flattening. The design is simulated using OPTISYSTEM software. The gains are flattened within 29.61dB-30.401dB from 1546nm-1558nm band of wavelength with noise figure (NF) < 5.5dB and bit error rate (BER) <$10^{-36}$for 16 channel simultaneous amplification in a single stage EDFA.

1. Introduction

The ER^{3+} doped optical fiber amplifier (EDFA) has recently drawn very considerable attention in the field of optical fiber communication. EDFA uses a doped optical fiber as a gain medium to amplify an optical signal which is to be amplified and a pump laser are multiplexed into the doped fiber, and the signal is amplified through interaction with the doping ions [1]. The gain spectrum of EDFA exhibits sharp peak around 1.53μm, a valley around 1.54μm. EDFA is widely used optical amplifier for low loss optical window of silica based fiber [2].

In WDM system by multiplexing a stream of wavelength channel particularly in C and L band region can simultaneously amplify the desired power level where the amplification of particular channel is dependent on the signal wavelength [3]. Instead of equalizing the power of each individual WDM signal a uniform gain for the WDM signals can be achieved by flattening the gain spectrum of the EDFA [4].

2. System Design

The software OptiSystem is used to design the EDFA in the WDM system. The system contains 16 input channels, ideal multiplexer, a pump laser, erbium doped fiber, demultiplexer, photo detector PIN, low pass cosine roll off filter, 3R regenerator as shown in figure 1.

The input of the design is 16 equalized wavelength multiplexed signal in the wavelength region 1546nm-1558nm with 0.8nm channel spacing. The power of each channel is -23dBm. The pumping is 980nm is used to excite the doped atom to a higher energy level causing population inversion. The desired gain is close to 30dB and output power of more than 10dBm and gains flatness less than 0.5dBm. The fiber length, numerical aperture, pump power are selected as parameter to get optimized result.

3. Result and Discussion

It is observed that the optimum value of fiber length is between 4m to 6m due to minimum losses. The pump is bound between 80mW and 200mW while the fiber length is bound between 2m and 6m. Output power is measured by varying pump power for different fiber length at a constant input power of -23dBm as shown in figure2. Output power increases as the pump power increases with a constant positive slope.For a given pump power, the output power increases initially then its gets deceased in a stable order, and almost gets saturated up to the length is optimized. It is also observed from the graph that the optimum value of the fiber length is in between 4 to 6 m with minimum losses.

The optical gain and noise figure (NF) for multichannel amplification were measured for different pump power at a constant fiber length of 5m, since the optimum fiber length is in between 4m to 6m because at this range the flattening of the gain having maximum difference among the individual channels for a specific input pump power. As seen from the figure the gain of the system increases first and after that uniformly saturates for the different wavelengths and NF decreases shown in figure3.

The pump power of 80mW has very low gain 28.388dB but high noise figure of 5.035dB. Whereas the pump power of 200mW shows high gain 33.76dB but it has low noise figure of 4.15dB. This shows the pump power of 80mW and 200mW does not offer good performance of the system because it does not offer equalized for all channels, both of this case gain flatness yields are 0.45db and 0.92db. The values is worst for pump power of 120mW having gain flatness of 1.164db. Optimized calculation is being measured for 100mW pump power having gain flatness of 0.3749db.

Figure4 shows gain and noise figure (NF) variation of multichannel amplification for constant pump power and for different fiber length. As the pump power of 100mw is optimized in the previous section so this power has been made constant for the later experiment. By varying the length of the fiber ranging from 3m to 6m the gain and NF is observed. This comparison follows the same phenomena, as the length of the fiber is increased the gain is obtained

whereas NF also gets increased as well. But the optimized value of the length is obtained for most equalized channel is 5.75m having noise figure of 0.2134dB.

Figure5 shows the results obtained from optical spectrum analyzer in the OptiSystem software. It displayed a clear view about the gain flatness obtained for different pump power (80mW, 100mW, 120mW, 150mW). The better outcomes results for -23dBm NRZ modulated signal having power 100mW while the power of 150mW represents the worst case causing an unequalized gain.

Figure6shows comparative study about bit error rate (BER) measurement of the system. This shows for the previous optimized case that is fiber length 5.75m, pump power of 100mW, the numerical aperture of the fiber and roll off factor of the filter dominates the BER performance of the whole system. For a 2^{nd} order low pass filter having roll off factor of 0.1 performs well than a roll off factor of 0.2. Low numerical aperture signifies less no of optical signal can pass through the fiber causing a significant level of BER at the output. The usual BER is found to be in the range of 10^{-25}. The optimized design parameters are fiber length 5.75m,pump power 100mW, numerical aperture 0.16, roll off factor 0.1 and BER of $2.43x10^{-36}$.The final optimized BER performance of the whole system is shown in figure7.

The performance of the system is analyzed using eye pattern for the channel 1 gives a big eye opening which means that the inter symbol interference (ISI)is low. The width of the opening indicates the time over which sampling for the detection is performed. The optimum sampling time corresponding to the maximum eye opening yields the greatest protection against noise. This system shows an average BER of 10^{-30} for channel1.Figure8 shows the eye diagram pattern of 16 WDM channels of optimized BER of 10^{-36}.

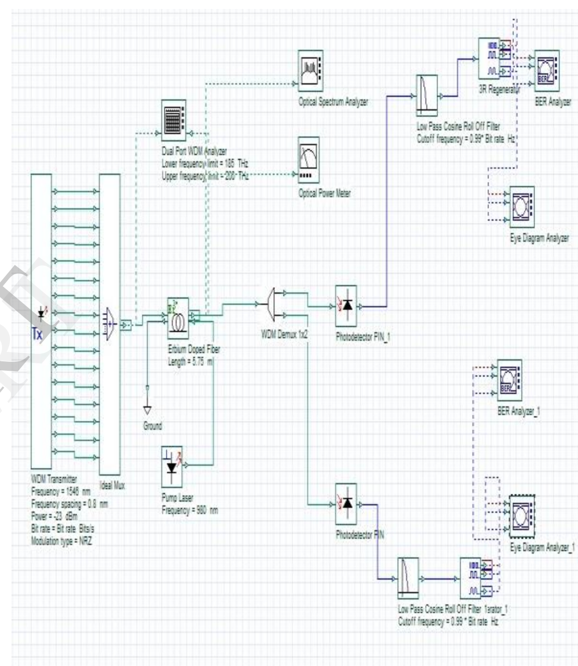

Figure 1.Design of the system in OptiSystem software.

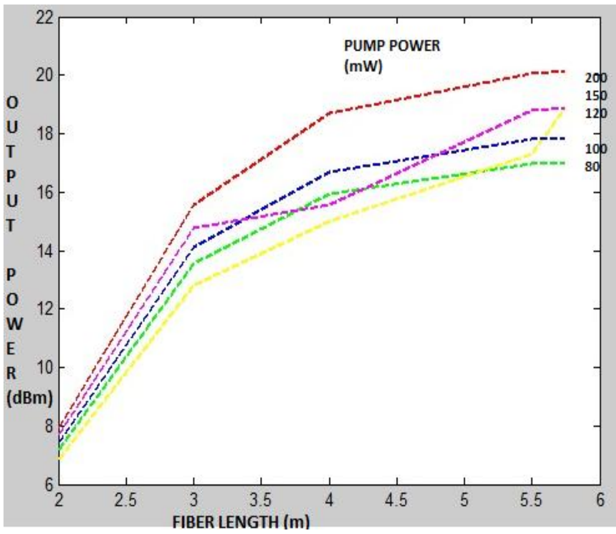

Figure 2. Output power Vs Fiber Length .

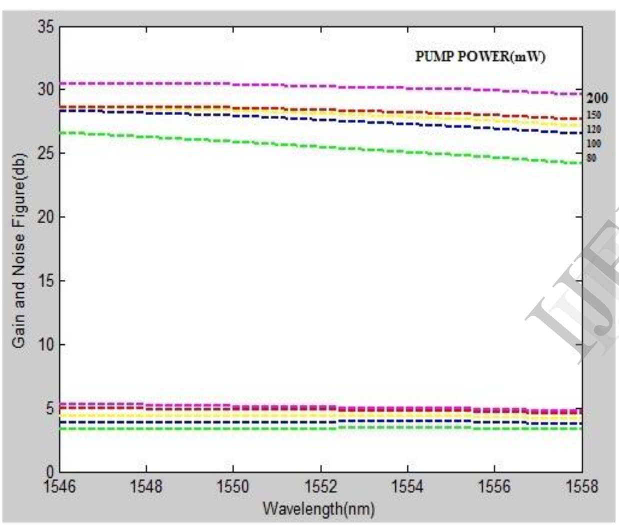

Figure 3. Gain and Noise Figure Vs Wavelength for constant fiber length.

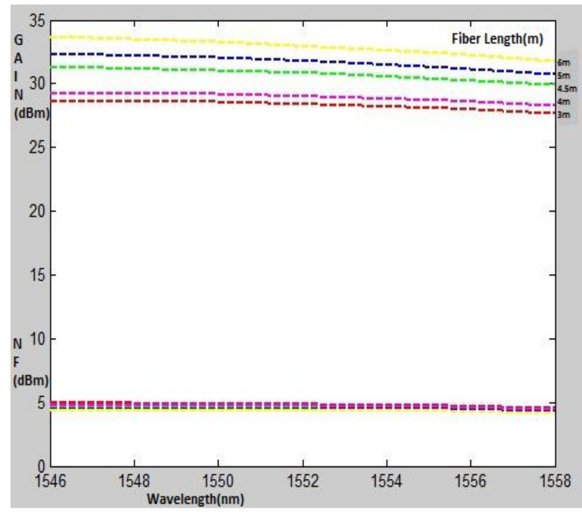

Figure 4. Gain and Noise Figure Vs Wavelength for constant Pump Power

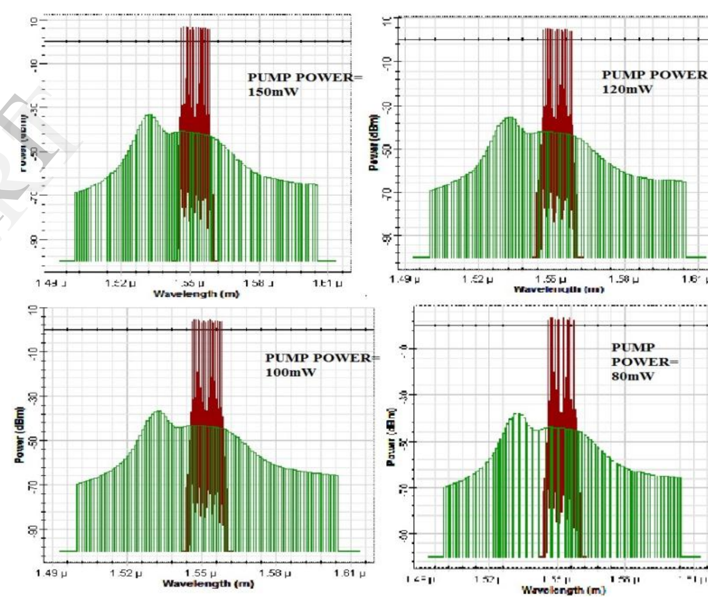

Figure 5.Output power(red) and Noise power (green)

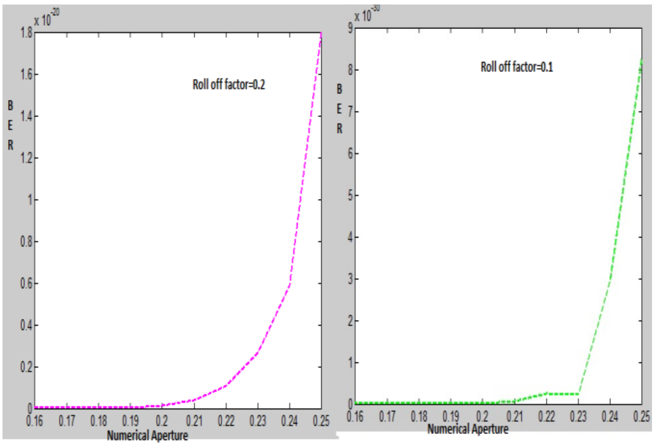

Figure 6.BER vs Numerical Aperture at different roll off factor.

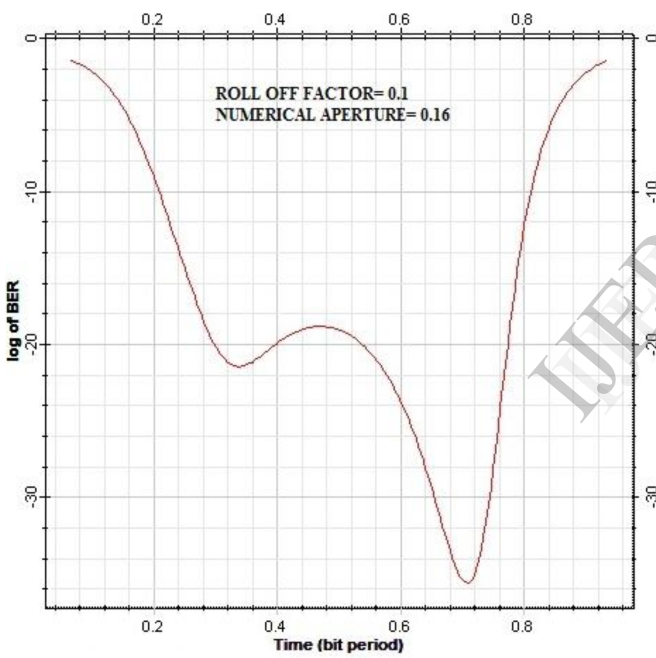

Figure 7. Optimized BER

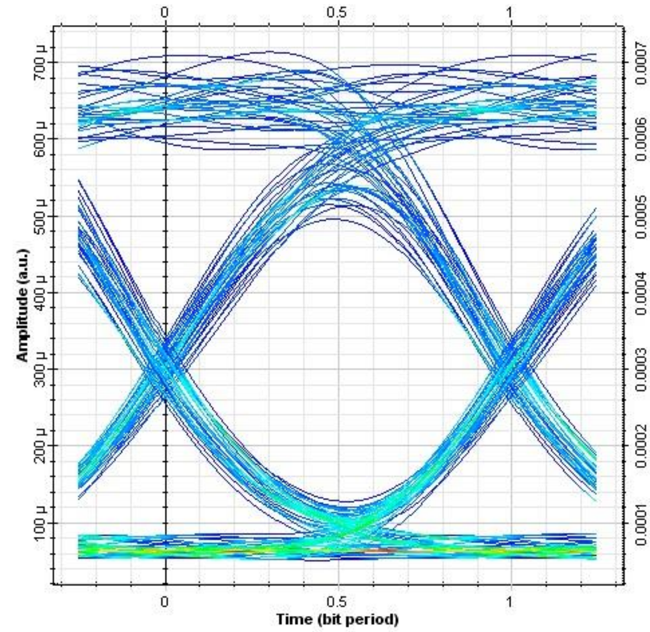

Figure 8.Eye pattern of the system.

4. Conclusion

The population inversion can be controlled by optimizing fiber length and injected pump power to EDFA. The optimum fiber length is 5.75 meter and pump power is 100mW. The system for 16 channel amplification was designed for gain of 29.61dB-30.401dB from 1546nm-1558nm band of wavelength with noise figure (NF) <5.5dB . The WDM system has a good Bit Error Rate in the range of 10^{-36}.

5 . Reference

[1] Modeling ,simulation and gain flattening improvement for an erbium doped fiber amplifier,Barisaltiner,N.Ozlem unverdi,IEEE,2009

[2] S.F.Su,etal,"Flattering of erbium doped fiber amplifier gain spectrum using an Acusto-optic tunable filter.

[3]S Yoshida,S.kuwano,KIwashita,Electron letter,1995

[4] M.Tachibana,et.al,"Erbium Doped Fiber amplifier with flattened gain spectrum",IEEE photon ,Tech Letter 3,118,1991

Authors Profile

Saikat Saha received the B.TECH degree in Electronics & Communication engineering from WestBengal University of Technnology, India in 2012. Currently he is persuing the M.TECH degree in Communication Engineering from Vellore Institute of Technology. His area of interest covers Microwave, Optical Communication and Signal Processing.

Pratham Majumder received the B.TECH degree in Electronics & Communication engineering from WestBengal University of Technnology, India in 2012. Currently he is persuing the M.TECH degree in Communication Engineering from Vellore Institute of Technology. His area of interest covers OFDM,Optical Communication and Signal Processing.

Myneni Soundarya received the B.TECH degree in Electronics & Communication engineering from JNTU, India in 2012. Currently she is persuing the M.TECH degree in Communication Engineering from Vellore Institute of Technology. Her area of interest covers Optical Communication and Signal Processing.