Performance Analysis of Optical Link using EDFA

Bhumika A. Patel[1] Prof. Ankit Patel[2]
[1,2]Department of Electronics & Communication Engineering
[1,2]Shankersinh Vaghela Bapu Institute of Technology, Vasan, Gandhinagar, Gujarat

Abstract— Analysis of DWDM system using EDFA in C band. Optimum results of gain, output power, BER and Q-factor are obtained proper choosing of input power, pump power, EDF length and concentration of erbium ions. Transmit 320Gb/s data rate for 70km of fiber length. Pumping methods are discussed at 1440nm and 980nm. Results were obtained using optisystemv13 software.

Key words: DWDM, EDFA, PIN Photodiode

I. INTRODUCTION

The original optical fiber links that were installed in 1980 consisted of simple point to point connections. The basic use of Wavelength Division Multiplexing is to upgrade the capacity of installed point to point transmission links. Dense Wavelength division multiplexer (DWDM) is the key feature of modern optical communication system [3]. This technology use to divide and combine different wavelength channels to increase the capacity of the existing optical network, each carrying an optical data signal. Isolation between the different wavelength channels holds good as long as the total optical power of all the channels in the optical fiber is sufficiently low to avoid nonlinear effect such as stimulated Birllouin Scattering and four wave mixing process from degrading the performance of the link. These devices are mainly used to split and combine of different wavelength, or to tap optical signals [3]. In optical fiber communication, signals are dispersive when travelling from one medium to other medium. In this present paper, we have studied and simulated the performance of 32 channel DWDM systems using EDFA for 70km fiber lengths has been done. EDFA has a narrow high gain peak at 1532 nm and a broad peak with a lower gain centered at 1550nm. Different DWDM signals are amplified by different amounts.

II. PROPOSED BLOCK DIAGRAM OF EDFA

The heart of EDFA is the erbium doped fiber (EDF), which is silica fiber doped with erbium. EDFA is work in between 1500nm to 1600nm wavelength range. The system is consist of three sections are transmitter section, channel section and receiver section shown in fig.1. Signals are attenuated after travelling certain distance. This signal can be amplified and regenerate using EDFA. There are three pumping techniques are used. These techniques are forward pumping, backward pumping and bidirectional pumping technique. Two pumping source are 980nm and 1440nm. In 980nm, erbium ions are continuously moved from upper to lower level through intermediate stage. In 1440nm, ions are only move in between intermediate stage to lower stage. Isolator is used to remove reflected signal.

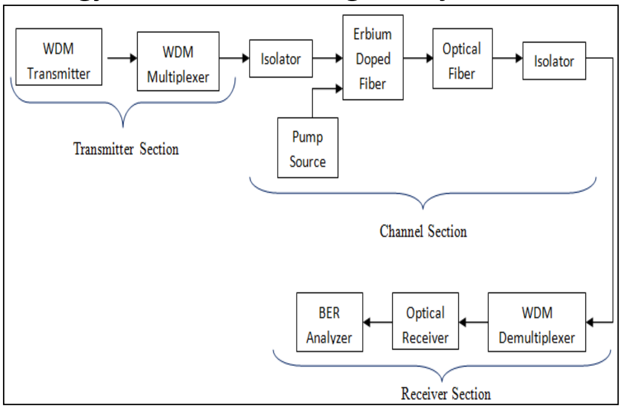

Fig. 1: Block Diagram of Erbium Doped Fiber Amplifier

III. WORKING PRINCIPLE OF EDFA

Erbium ions (Er3+) are having the optical fluorescent properties that are suitable for the optical amplification. There are two wavelength C-Band (1530nm-1560nm) and L-Band (1560nm-1600nm). EDFA can amplify a wide wavelength range (1500nm-1600nm) simultaneously [12]. Three energy levels E1, E2, E3 are the ground, intermediate and upper state levels respectively as shown in fig.2. The population density is N1>N2>N3 in equilibrium state, when no pump signal is used. When pump or signal is present the population density of ions are change. Population density of upper level is greater than the lower level, called as population inversion. With 980nm pumping wavelength the Er3+ ions in the ground state (E1) are excited to the upper state (E3). But excited state is not stable so, ions are not stay for more time and decay back to the intermediate state and then fall back to the ground state after 10ms and emits photon. This is called spontaneous emission.

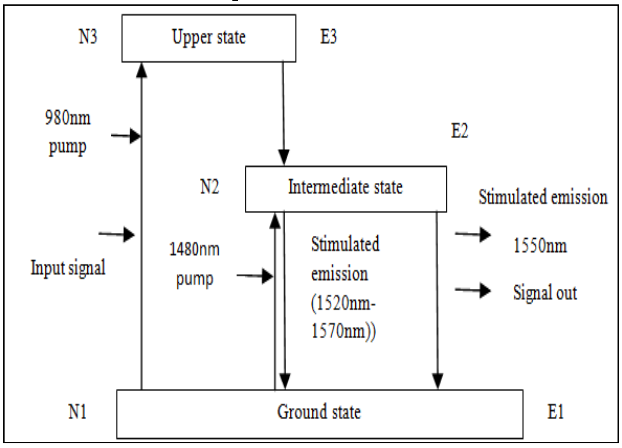

Fig. 2: Three Level Energy Diagram of EDFA

But photons generated in this spontaneous process are treated as noise as the photons are non-polarized and incoherent through time and space. But when the ions or photons that are in the metastable state incident with light photons of suitable wavelength, they fall back to the ground state emitting photons having same phase, frequency and polarization and travel in the same direction as the photons of the incident wave. This is called stimulated emission [12].

IV. SYSTEM SETUP

We simulate a 32 channel DWDM system in the range of 1527-1552 nm. System configuration is shown in Fig.3. Modulation used is NRZ. The 32 multiplexed channels are normally simulated in the range of 1527-nm to 1552-nm, which is however sometimes changed to analyze the system performance for varying wavelength. Frequency spacing between various channels is set normally to 0.8-nm, having wavelength range of 25-nm. Power of each channel is -25dBm, which is however varied to analyze the effect of varying input power on Gain and Noise of the active fiber. The optical isolator is also used to achieve stable amplifier operation, which functions to block the reflected light into the amplifier. Pumping at 980nm is used to excite the doped atoms to a higher energy level. Results are obtained on BER Analyzer. Low Pass Bessel Filter used limits the noise power.

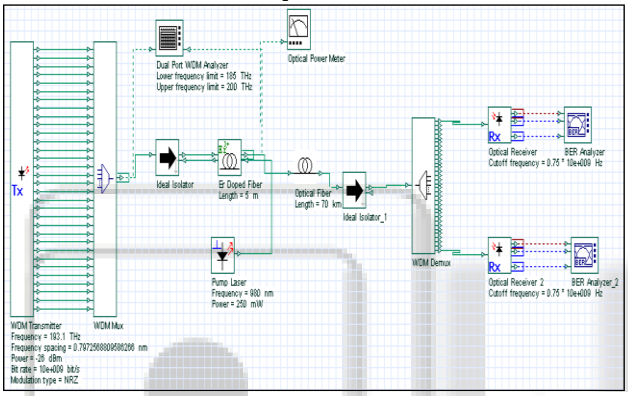

Fig. 3: System Layout

V. RESULTS

At pump power of 250mW, Gain obtained is in the range of 34±4dB for 5m length over the wavelength range from 1527 to 1552. Fig. 4 shows variation of Gain with varying input power of a channel. As Input Power varies from 10dBm to -50dBm, Gain varies from 5.1644 to 36.02111dB. In Fig. 5 the pump power is varied to measure the output power for the different fiber length at a constant input power of -25dBm. With increase in pump power, output power increases linearly.

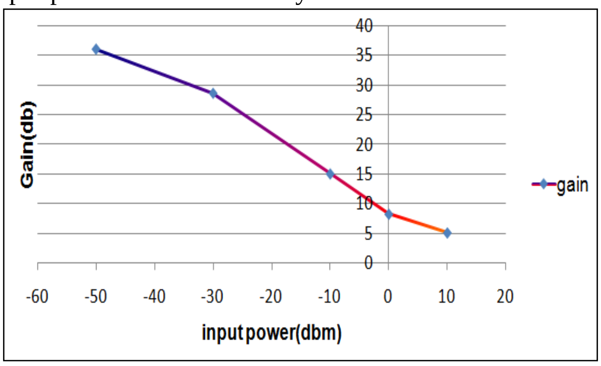

Fig. 4 : Variation In Gain With Change In Input Power

Fig.6 shows gain increase with increase in concentration of erbium ions from 100ppm for various pump power. Q-factor is varied with input power. At 70km of fiber length Q-factor is increase with increase in input power. Fig.7 shows length of fiber increase than performance is going to be decrease.

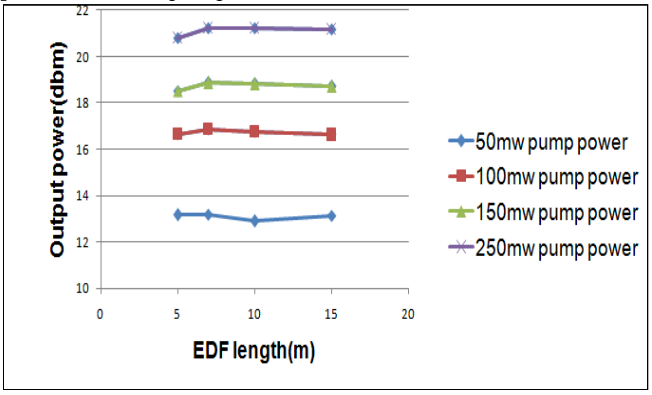

Fig. 5 : Variation of Output Power with Change In EDFA Length At Constant Pump Power

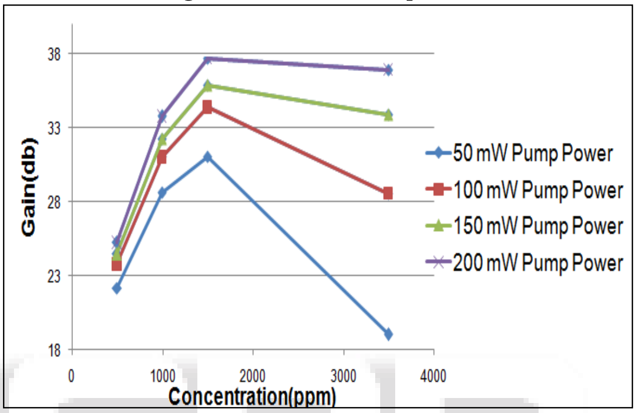

Fig. 6 : Variation of Gain with Change In Concentration Of Erbium Ions At Constant Pump Power

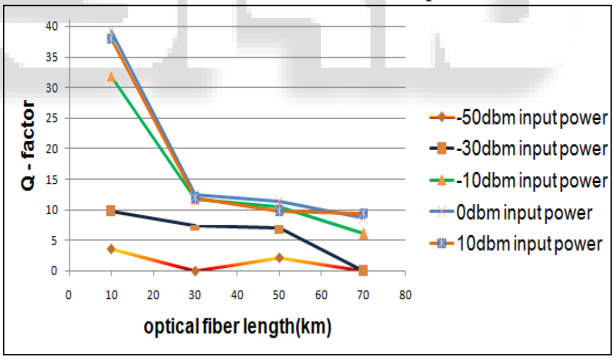

Fig. 7 : Variation of Q-Factor With Change In Optical Fiber Length At Different Input Power

In fig.8 best Performance of BER of 10^{-20}, Q-factor of 9.02413 and eye diagram is obtain at -26dBm input power for 70km of fiber length.

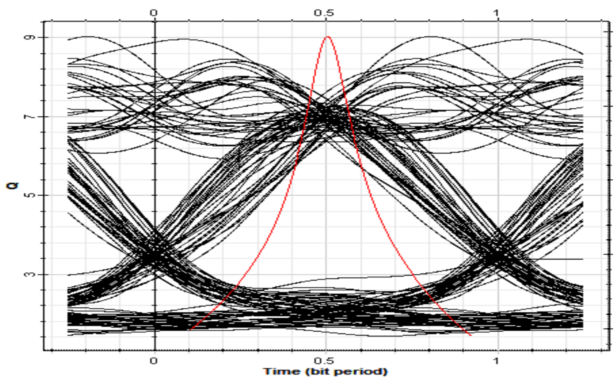

Fig. 8: BER Analyzer For 70km Optical Fiber Length

VI. CONCLUSION

In this paper, design and simulate DWDM system for 320 Gbps data rate at 70km of fiber length. The system for 32-channel amplification was analyzed with 34±4db gain flatness from 1527 nm to 1552 nm bandwidth. The output power of 21.255dBm for a fiber length of 5m and 250mw pump power were obtain from the simulation. Varying concentration of erbium ions changed the gain and the best performance is obtained for a concentration of 1000ppm-wt and pump power of 250mw at which Q-factor of 9.02413 and BER of 10^{-20}. The optimal values of gain were obtained for a value of -25 dBm. All the value was taken at 70 km fiber length and wavelength 980 nm. So, this amplification technique is providing better performance of optical link.

REFERENCES

[1] Mishal Single, Preeti, Sanjiv Kumar “Comparative analysis of erbium doped fiber amplifier (EDFA) based 64 channel wavelength division multiplexing (WDM) systems for different pumping techniques”, International Journal of Scientific & Engineering Research, Volume 5, Issue 6, June-2014.
[2] Mubashir Ul Zaman, Shahid Iqbal a nd Isha “Performance analysis of EDFA amplifier for DWDM system” IEEE, March 2014.
[3] Priyanka Sharma, Arun Kumar and V.K.Sharma “Performance analysis of high speed optical network based on Dense Wavelength Division Multiplexing (DWDM)”, IEEE, February 2014.
[4] W. forysiak, D.S. govan, i.mcclean, b.k.nayar, O.A. Olubodun and N.J. Doran “Analysis of extended range variable gain hybrid Raman-EDFAs in system using Nyquist-WDM 100/200G PM-QPSK/16-QAM” IEEE, 2014.
[5] Usman J Sindhi, Rohit B Patel, Kinjal A Mehta and Vivekananda Mishra “Performance analysis of 32-channel WDM system using erbium doped fiber amplifier” international journal of electrical and electronics engineering and telecommunication(IJEETC), April 2013.
[6] Simranjit Singh and R.S.Kaler “Flat gain L-band Raman-EDFA hybrid optical amplifier for DWDM system” IEEE, 2013.
[7] Sameksha Bhasker, M.L.Sharma and Ramanddep Kaur “Performance comparison different hybrid amplifier for different numbers of channels”, International Journal of Advanced Computer Science and Applications (IJACSA), 2012.
[8] Mir Muhammad lodro and Muhammad ali joyo “32-channel DWDM system design and simulation by using erbium doped fiber amplifier (EDFA) with Dispersion Compensation fiber (DCF) and Raman amplifiers”, International Conference on Information and Computer Networks (ICICN), 2012.
[9] Matheus O. L. Beninca, Maria J. Pontes and Marcelo E. V. Segatto “Design of a wideband hybrid EDFA with a fiber Raman amplifier”, IEEE, 2011.
[10] Cristian Rivera, Ricardo Olivares, Maria Thereza M. Rocco Giraldi, Andres P. Lopez Barbero, Maria Jose Pontes, Marcelo E. V. Segatto, Maria Aparecida G. Martinez, Joao Crisostomo Weyl Costa “Numerical Simulation and Experimental results of a hybrid EDFA-Raman amplifier”, IEEE 2009.
[11] N Sindhu and P. K. Shafeena “Gain flattening in Erbium Doped FiberAmplifier Based Optical Communication – A Review”, International Journal of Emerging Trends in Electrical and Electronics (IJETEE), Vol. 1, Issue. 2, March-2013.
[12] Sushanta Kumar Swain Report on “Analysis of WDM network based on EDFA pumping and dispersion compensation using Optisystem”, National Institute of Technology, Rourkela, 2012.

