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Performance Evaluation of Hybrid Optical Amplifier in Different Bands for DWDM System

Kuldeep Kaur[#1], Gurpreet Bharti[*2]

[#1]*M Tech Student, E.C.E. Department, YCOE, Talwandi Sabo, Punjabi University, Patiala.*

[*2]*Assistant Professor, E.C.E. Department, YCOE, Talwandi Sabo, Punjabi University, Patiala.*

Abstract*— In this paper 180 channels DWDM system at 10Gbps has been investigated with RAMAN EYCDFA hybrid amplifier at different channel spacing for different bands i.e. C band, L band and C+L band and the performance has been evaluated. It is observed that RAMAN EYCDFA hybrid amplifier in C+L band gives better performance in terms of gain flatness and noise figure than C band and L band without using any gain flattening technique.

Keywords*— Dense wavelength division multiplexing (DWDM), erbium ytterbium co doped fiber amplifier (EYCDFA), Raman amplifier, hybrid optical amplifier, gain flatness.

I. INTRODUCTION

A powerful aspect of an optical fiber communication link is that many different wavelengths carrying independent signal channels can be sent along a single fiber simultaneously. In particular, telecommunication service providers are using this feature in the low-loss 1300-to-1600-nm spectral region of optical fibers. [1] There has been a strong demand in high capacity signal transmission systems and networks in recent. To increase data transmission capacities, several methods are proposed by adding more channels in the wavelength division multiplexing (WDM) system, so that spectral efficiency needs to be upgraded. To overcome these problems, the DWDM systems have been demonstrated using several types of wideband optical amplifiers. [2] Dense Wavelength-division-multiplexing (DWDM), a key technology, comes into picture to enable the very high-capacity photonic networks required by our communication thirsty society and is well known for its dramatic increase in transmission capacity and flexibility in optical networking [3]. In literature various gain flattening techniques have been used to reduce the gain variation over the bandwidth. Dr.Soni Changlani et al. [4] presented the optimization of the gain of 8 DWDM channel over entire conventional band i.e. C band. The gain flattening is done with the help of the Gain Flattening Filter (GFFs) as well as DCF. Numerical simulation result shows that both techniques can minimize unevenness of gain in all the prescribed WDM channels. An efficient gain-flattened L-band optical amplifier was demonstrated using a hybrid configuration with a distributed Raman amplifier (DRA) and an erbium-doped fiber amplifier (EDFA) for 160×10-Gb/s dense wavelength division multiplexed system at 25 GHz interval.[5] Optical amplifier basically amplifies input signal coming to it directly without converting it to an electrical signal, with the use of pumping. There are many amplifiers which are used for amplification of signals. Every amplifier has its own characteristics. In this paper we used Raman fiber amplifier and Erbium Ytterbium co doped fiber amplifier. We have investigated the hybrid scheme of these amplifiers in C band, L band and C+L band.

It was realized that due to fiber imperfections and also the non-linear gain provided by different amplifiers, the gain is not flat over the working frequency range of a DWDM optical communication system. Gain flattening can be a significant area of research for DWDM optical communication system. Recent optical communication systems are working in C and L band and thus, the present work should be focused on the gain flattening in both C and L bands. Gain flattening can be achieved by using individual amplifiers like Raman amplifier, EYCDFA etc., but individually these amplifiers will not be able to provide a flat gain over larger bandwidth, a hybrid amplifier which can be a combination of Raman amplifier and EYCDFA can be used to obtain a flat gain over larger bandwidth and to transmit signal at larger distance.

This paper consists of four sections. After the introduction, Section II represents the experimental setup and description of its components. In Section III, simulation results have been reported and Section IV summarizes the conclusion about the performance of the system.

II. EXPERIMENTAL SETUP

An optical transmission link consists of three stages i.e. transmitter, optical amplifier and receiver as shown in Fig.1.Each Transmitter section consists of the data source, electrical driver and laser source and amplitude modulator. Data source generates a pseudorandom binary sequence of data stream. Electrical driver here generates data format of the type NRZ rectangular. Laser block shows simplified continuous wave `Lorentzian (CW) laser. The output from the driver and laser source is passed to the optical amplitude modulator. The pulses are modulated using MZ modulator at 10Gbps data rate. The amplitude modulator is a sine square Mach-Zehnder modulator with an excess loss of 3 dB. Single receiver is composed of optical fabry perot filter. Bidirectional fiber is used for Raman interaction. Dispersion Compensation

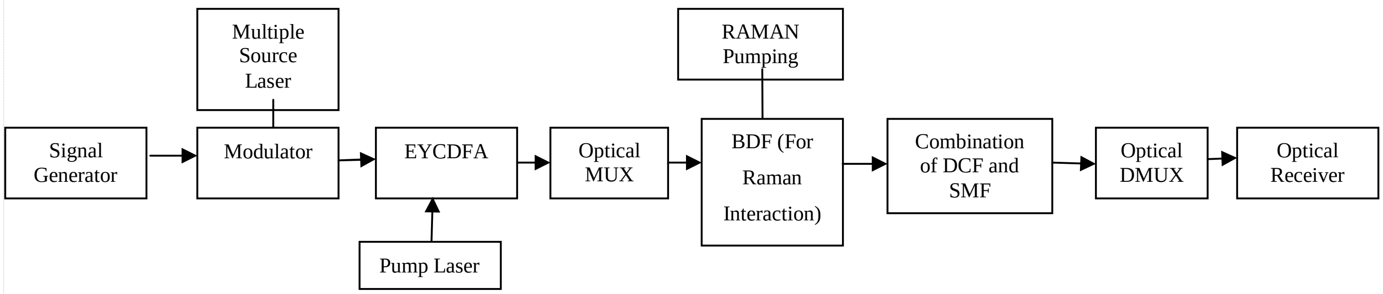

Fig. 1 Block diagram of simulation setup

Fibers DCFs and Single Mode Fibers SMFs are used to propagate the signal. Optical demultiplexers are used for demultiplexing of signals at the output. Optical receiver is used at the output. In this setup, 180 channel DWDM system is implemented with Raman EYCDFA hybrid amplifier in different bands. Different channel spacing is used for different bands. Signal is transmitted over 650km distance in DWDM system. Table 1 shows parameters of different bands used in simulation.

TABLE I

PARAMETERS OF DIFFERENT BANDS

Parameters	**Bands**		
	C Band	**L Band**	**C+L Band**
Range(nm)	1530-1565	1565-1625	1530-1625
Channel Spacing(nm)	0.19	0.33	0.52

III. RESULTS

Sections III-A, III-B and III-C present results for C band, L band and C+L band respectively. After the implementation of 180 channel DWDM system, we obtained the results for gain flattening in C band, L band and C+L band.

A. C-Band

C-Band covers 1530nm to 1565nm wavelength in optical spectrum. Fig. 1 shows that in C-Band, gain is increasing firstly from 1530nm to 1535nm and then it starts decreasing for 1535nm to 1545nm due to fiber non linearities and imperfections. After 1545nm, gain starts increasing till 1555nm. Gain is totally flat for 1553nm to 1565nm. Gain is flat for only 12nm range of wavelength. Fig. 2 shows that the noise figure of the system goes decreasing as wavelength increases. So, it gives an efficient system performance. It varies from 47dB to 8dB. At 1565dB, it approaches to 8dB, which is larger than NF value of C+L band.

B. L-Band

L-Band covers 1565nm to 1625nm wavelength in optical spectrum. Fig. 3 shows that gain of Raman Eycdfa hybrid amplifiers changes with wavelength. Gain gradually increases as wavelength increases till 1580nm.

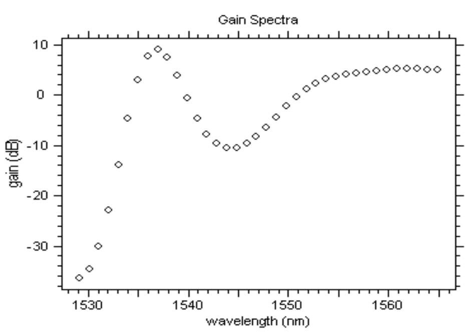

Fig.1 Flattening of gain in Raman Eycdfa in C band

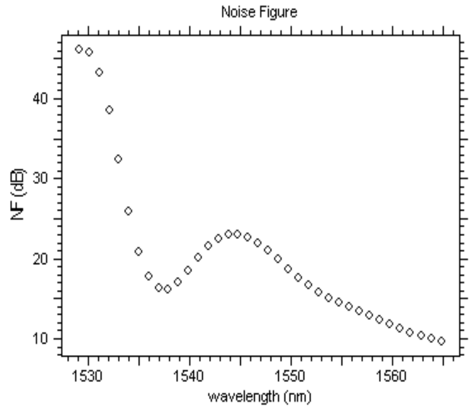

Fig.2 Variation of noise figure along the fiber in Raman Eycdfa in C band

At 1580nm -1590nm wavelength, gain remains unchanged i.e. flat. Gain is flat in the range of 10nm. After that gain increases till 1610nm.Then gain slightly decreases till 1625nm.Fig. 4 shows that the noise value of the system goes decreasing as wavelength increases. So, it gives an efficient system performance. It varies from 21dB to 0dB. At 1625dB, it approaches to 0dB, which is desired in every optical system. Thus, in L-Band gain is flat in 10nm range of wavelength.

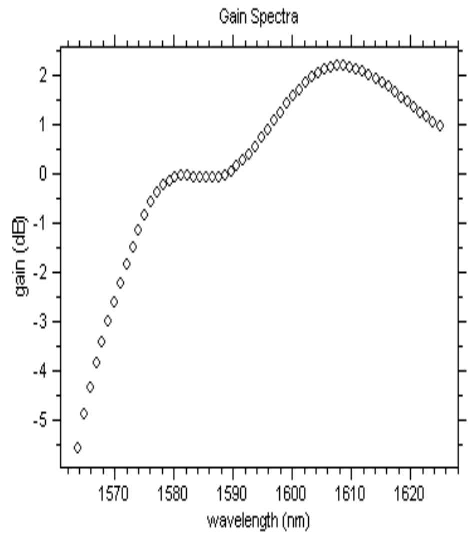

Fig. 3 Flattening of gain in Raman Eycdfa in L band

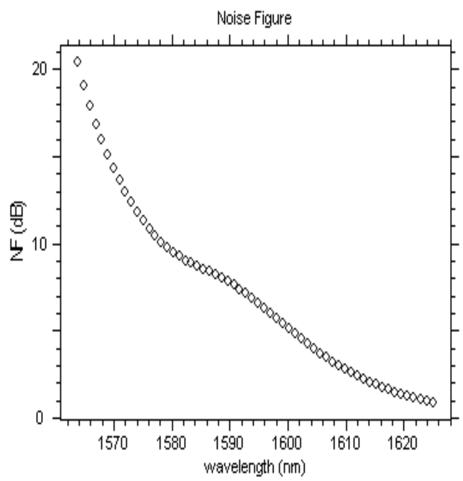

Fig. 4 Variation of noise figure along the fiber in Raman Eycdfa in L band

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C. C+L Band

C+L Band covers 1530nm to 1625nm wavelength in optical spectrum. Fig. 5 shows that gain is increasing firstly from 1530nm to 1540nm and then it starts decreasing for 1540nm to1545nm due to fiber non linearities and imperfections. After 1545nm, gain starts increasing till 1560nm. Gain is totally flat for 1565nm to 1625nm, which is main advantage of the proposed work. Gain is flat for 60nm range. Fig. 6 shows that the noise value of the system goes decreasing as wavelength increases. So, it gives an efficient system performance. It varies from 70dB to 0dB. At 1625dB, it approaches to 0dB, which is desired in every optical system.

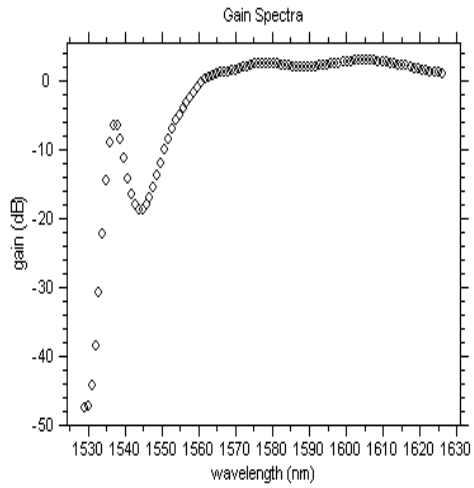

Fig.5 Flattening of gain in Raman Eycdfa in C+L band

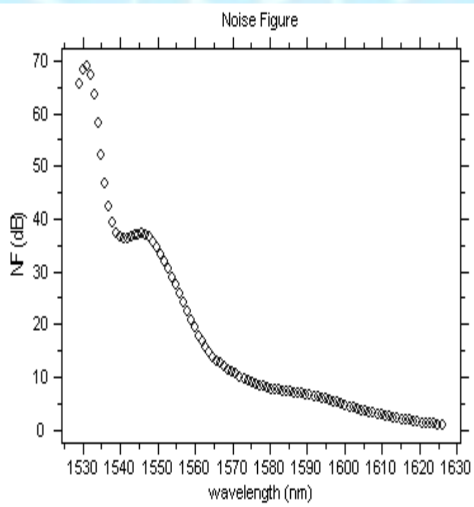

Fig .6 Variation of noise figure along the fiber in Raman Eycdfa in C+L band

In the proposed hybrid amplifier, gain and noise figure of DWDM system has been investigated in C band, L band and C+L band at different channel spacing for different band. Table II represents range of gain flattening in different bands.

TABLE II

RANGE OF FLATTENING OF GAIN IN DIFFERENT BANDS

Range of flattening of gain in different bands		
C Band	**L Band**	**C+L Band**
1553nm-1565nm (12nm)	1580nm-1590nm (10nm)	1565nm-1625nm (60nm)

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IV. CONCLUSIONS

In proposed work, we have implemented Raman Eycdfa hybrid scheme for C band, L band and C+L band. From simulation results, it has been concluded that RAMAN EYCDFA hybrid amplifier gives better results in C+L band than other bands i.e. C band, L band. In C+L Band, gain is flat in the range of 60nm, which is quite efficient value and value of noise figure is 0db at 1625nm wavelength. In proposed work gain has been flattened without using any gain flattening technique, which is a cost effective solution.

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