Analysis Of Residual Pumped Fiber Raman Amplifier In High Capacity DWDM Systems

Er. Manbir Singh, Dr. Beant Kaur, Er. Gautam Kaushal

Abstract: With the expeditions high speed requirements for internet applications, high capacity optical systems are need of the day. Optical amplifier such as Fiber Raman amplifier is widely deployed because it can serve any optical band with different pump wavelengths. In this work, a Residual Pumped Fiber Raman Amplifier in High Capacity Dense Wavelength Division Multiplexed Systems is investigated. Analysis has been done by incorporating different pump powers, channel spacings in terms of Gain. A wavelength window of 96 nm is covered starting from 1470 nm to 1566 nm at 0.8 nm spacing.

Index Terms: Multiple pumps, Fiber Raman amplifier (FRA), DWDM, optical amplifier, Gain ,Noise Figure, Wavelength window

1. INTRODUCTION

WITH the rapid increase in the internet enabled services such as online gaming, video conferencing, and high definition TV, pressure on the optical communication system is growing day by day [1]. Optical communication systems have great advantages such as wide bandwidth, no EMI, high security and high speed [2]. Transmission in optical fiber communication brings two major effects such as signal degradation (attenuation), and pulse broadening (dispersion) [3]. In order to reduce dispersion, there are dispersion compensation and fiber bragg gratings. However, attenuation effects can be lowered by using repeaters in the link [4]. Optical to electrical conversions are required in repeaters and this makes repeaters costly to use [5]. Repeaters are replaced by optical amplifiers because they can directly amplify the weak signals [6]. Optical amplifiers are erbium doped fiber amplifier, semiconductor optical amplifier, Raman amplifier, thulium doped fiber amplifiers and hybrid amplifiers. With the increase in pressure of increased internet activities on conventional band 1530 nm-1560 nm, amplifiers are required which can cover other bands also [7]. Semiconductor optical amplifier has high noise figure, coupling losses and it is polarization sensitive. EDFA amplifiers are prominent in C band only and these amplifiers have issues of amplified spontaneous emission (ASE) noise, large size and gain saturation [8] [9]. On contrary, Raman amplifier has the benefits to perform in any wavelength band depending upon pumps wavelengths. In literature, Raman amplifiers are analyzed in different studies [10] [11]. It is perceived that Raman amplifiers are proposed with at large cannel spacings, demonstrated less gain, high noise and required multiple pumps. For getting the advantages of Raman amplifiers, techniques are required to lower the number of pumps in the system. Therefore, in this proposed work, a Residual Pumped Fiber Raman Amplifier in High Capacity Dense Wavelength Division Multiplexed Systems is investigated.

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2 RESEARCH GAPS

Due to the increase in the internet applications, high capacity systems are required. Wavelength division multiplexing is premier to enhance the capacity of the system. Optical amplifiers are key components to enhance the performance of the optical communication systems. Erbium doped fiber amplifiers are incorporated in the conventional band and long band. But Gain variation in both band is uneven and therefore impact the performance of system. Raman amplifiers with the use of high pump powers and different wavelengths can operate in C and L band both. However, pumping in the Raman amplifiers is very crucial parameter. Optimal power and pump wavelength is required in Raman amplifier.

3 PROBLEM FORMULATION

Dense wavelength division multiplexing provide high capacity and with the large increase in the channels, gain variation is a prominent issues. Therefore, enhanced gain flatness in optical amplifiers is good area of research. Reported work has used three optical pumps in Raman amplifier which provide Gain over 88.8 nm window >16 dB. However multiple pumps increase cost of the system. Therefore residual pumping is great to be analyzed in this system. Gain at 0.8 nm channel spacing is reported 35 dB in reported work, this can be increased further by reducing noise as well as by employing optimal parameters of Raman fiber.

4 OBJECTIVES

To propose residual pumped Raman amplifier over wide wavelength window for high Gain and low noise figure.
Comparison of proposed work with reported work in terms of Gain and noise figure large wavelength array.

5 SYSTEM SETUP

Optiwave Optisystem software tool is selected to design and analyze the Fiber Raman amplifier based wavelength division multiplexed system. Figure 1 represents the block diagram of proposed WDM-FRA system with residual pumping. Here, incorporation of residual pumping is done to eliminate requirements of multiple pumps. WDM channels starting from 1470 nm to 1566 nm are considered for 0.8 nm system where input power of each channel is fixed to -20 dBm. Data speed of 10 Gbps is modulated over each channel with the help of non return to zero modulation and intensity modulator (MZM).

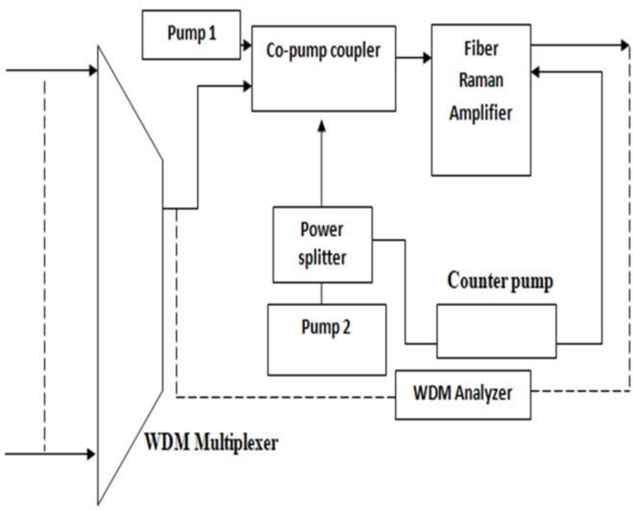

Fig 1 *Block diagram of residually pumped FRA in high capacity WDM systems*

TABLE 1 *SYSTEM SPECIFICATIONS*

Parameters	Values
Data Rate	10 Gbps
Amplifier	Fiber Raman Amplifier
Length	10 km
Attenuation	0.2 dB/km
Effective Area	72 µm2
Input Power	-20 dBm
Wavelength window	1470 nm to 1566 nm
Modulation	NRZ
Pumping	Residual Pumping
Total Pumps	2
Channel Spacing	0.2 nm, 0.4 nm, 0.8 nm
Pump Wavelength P1 and P2	1390 nm, 1410 nm

Data speed of 10 Gbps is modulated over each channel with the help of non return to zero modulation and intensity modulator (MZM). Multiplexer of 1 x 120 is deployed to accumulate all the channels and combined signal is fed to Fiber Raman amplifier. Fiber Raman amplifier with two pumps is proposed in this work and one of them is residual pump which sends power in co as well as counter direction. Pump 1 has wavelength 1390 nm and a residual pump at 1410 nm combined with it from co pumping direction. In counter pumping direction, only 1410 nm acts in FRA. System specifications of the system are given in Table 1. After amplification from the Fiber Raman amplifier, Gain is calculated from the WDM analyzer.

6 RESULTS AND DISCUSSIONS

An ultra high capacity system is proposed in this work using Fiber Raman amplifier employing residual pumping. Simulation analysis is carried out to check different parameters in terms of Gain such as by varying

1. Pump wavelength difference
2. To find optimized power of pumps
3. Comparison of different channel spacings in WDM

6.1 Effect of different pump wavelengths difference

First and foremost, different pump wavelengths are investigated by choosing diverse values of pump 1 and pump 2. Channel spacing 0.8 nm and system is analyzed to find optimal pump wavelength of two pumps. Wavelength of pump is 1390 nm and pump power is 1500 mW. After selecting the values of pump 1, wavelength of second pump is varied.

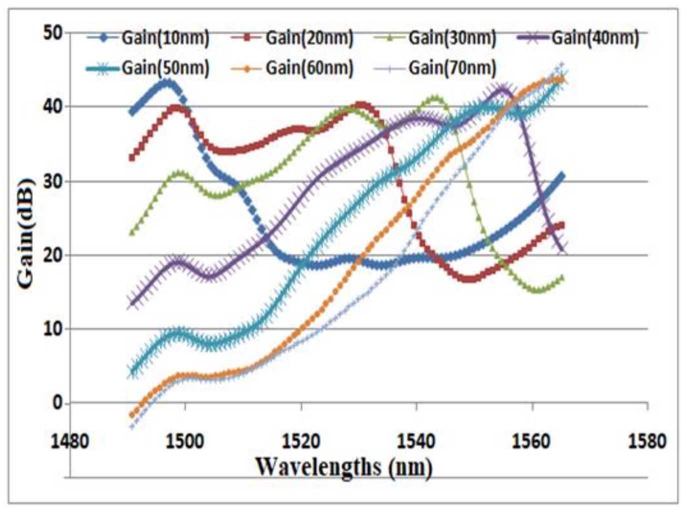

Fig 2 *Effects of pump wavelengths on RFA system*

Pump 2 is started from 1400 nm and then wavelength gaps of 10 nm are placed. Results revealed that with the increase in the pump wavelength differences, Gain increased in 50 nm, 60 nm and 70 nm. However Gain fluctuations are very high between lowest and maximum amplified signal wavelength. High Gain, good flatness is observed in case of 20 nm wavelength difference of pumps as shown in Figure 2. Highest Gain in this configuration is 44 dB and lowest is 18 dBm in wavelength band of 96 nm and it is noteworthy that maximum noise in the system is 5.12 dB only.

6.2 Effect of Variation of Pump1 power when P2 Fixed at 2000 mW

After selecting the optimal level of wavelengths of both the pumps i.e. 1390 nm and 1410 nm, now work is done to select the optimal power level of pump 1. In order to accomplish the this task, power of pump 2 is fixed at 2000 mW and power of pump 1 is varied from 100 mW to 2000 mW. Figure 3 represents the performance of the amplifier at fixed pump 2 power and varied pump 1 powers. It is perceived that the increase in the pump 1 power, show more Gain and optimal power is 2000 mW. Maximum Gain of 43 dB is observed with NF 5.12 dB at 2000 mW P1 power.

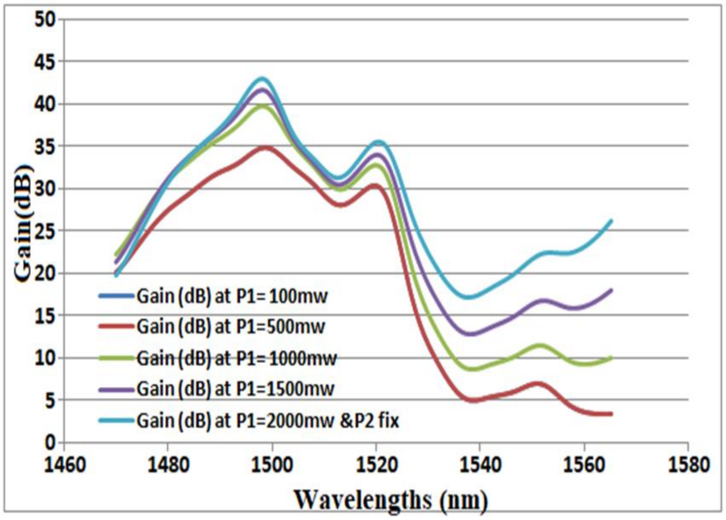

Fig 3 *Effect of P1 power on FRA when P2 is fixed at 2000 mW*

6.3 Effect of Variation of Pump2 power when P1 Fixed at 2000 mW

Further investigations have been carried out by fixing P1 to 2000 mW and by varying powers of P2 from 100 mW to 2000 mW in residual pumped FRA. Wavelengths of both the pumps i.e. 1390 nm and 1410 nm, now work is done to select the optimal power level of pump 2. In order to accomplish this task, power of pump 1 is fixed at 2000 mW and power of pump 2 is varied from 100 mW to 2000 mW. Figure 4 represents the performance of the amplifier at fixed pump 1 power and varied pump 2 powers. It is perceived that the increase in the pump 2 power, show more Gain and optimal power is 2000 mW. It is observed that with the increase in the power level of P2, Gain of the system increase and maximum Gain are observed at P1=1500 mW and P2=2000 mW but noise figure at 1500 mW is less. Therefore, optimal power selected for P1 is 1500 mW.

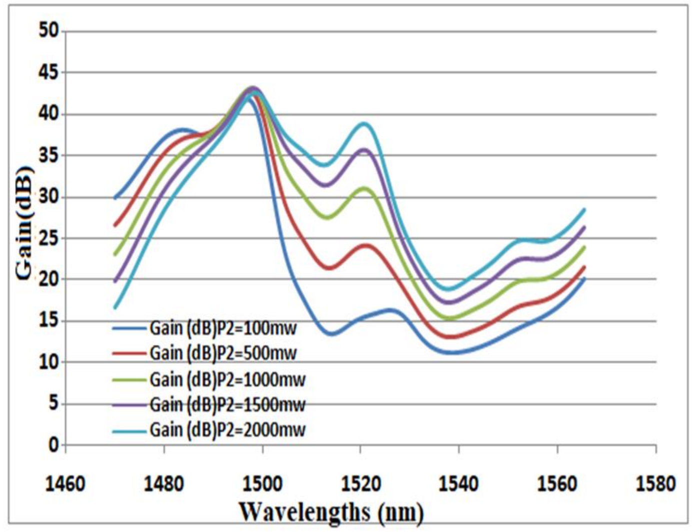

Fig 4 Effect of Variation of Pump2 power when P1 Fixed at 2000 mW

6.4 Effect of Channel Spacing on the FRA Performance

In order to check the performance of the proposed RFA at different channel spacings of wavelengths division multiplexing channels. Results are shown in Figure 5 and varied channel spacings are shown at 0.8 nm, 0.4 nm and 0.2 nm. It is observed that due less interference in 0.8 nm system, maximum Gain is observed of 44 dB with noise figure 5.12 dB. However in case of 0.4 nm channel spacing, interference increased therefore Gain also distributed and less is observed (24 dB). Least Gain (16 dB) is observed in the 0.2 nm channel spacing, due to severe interference and large number of channels.

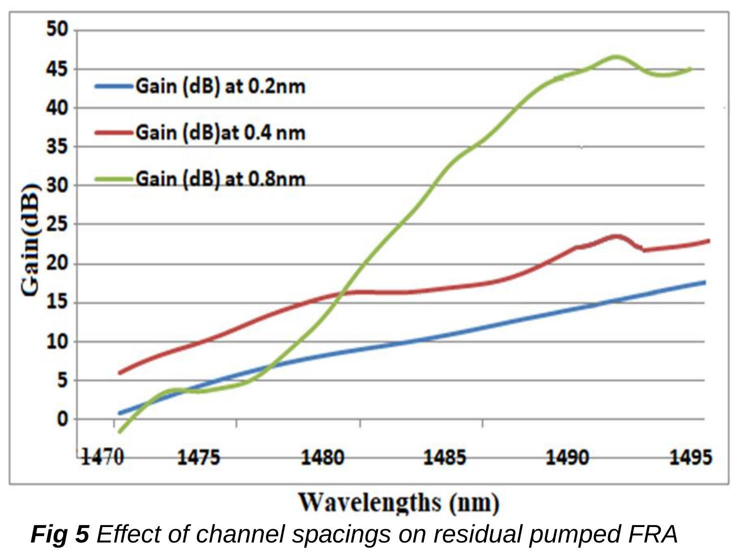

Fig 5 *Effect of channel spacings on residual pumped FRA system*

7 CONCLUSION

In this paper, a residual pump cost effective Fiber Raman amplifier in wavelength division multiplexed system is proposed. Two pumps are employed in this work to serve 96 nm wavelength array and optimal values are selected for FRA like pump power and pump wavelength on its gain spectra. Different channel spacings among WDM channels are fixed such as 0.8 nm, 0.4 nm and 0.2 nm and it is observed that due to less interference in 0.8 nm system, maximum Gain is observed of 44 dB with noise figure 5.12 dB. However, 0.2 nm system shows least results in terms of Gain (16 dB). Pump wavelength are investigated further and optimal power is selected for systems a 1390 nm and 1410 nm with power P1 (2000 mW) and P2 (1500 mW) respectively.

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