



DESIGN AND ANALYSIS OF ERBIUM DOPED FIBER AMPLIFIER FOR OPTICAL FIBER COMMUNICATION

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Abstract: Flat-gain and wideband amplification of Erbium Doped Fiber Amplifier (EDFA) was demonstrated using a dual stage amplifier technique. The performance of dual stage EDF amplifiers was investigated at high input signal power (0 dBm) and low input signal power (-30 dBm) and then it is compared with single stage EDF amplifier by varying input signal power and length of gain medium. Compared to high input signal power both stages of amplifiers showed better performance at low input signal power (-30 dBm). Dual stage amplifier showed better amplification in comparison with single stage amplifier. The dual stage amplifier gave the highest gain from the gain medium length of 1 m and 10 m for EDF 1 and EDF 2, respectively, with the fixed pump power of 100 mW and the fixed gain medium length of 1.5 m for EDF 1 and 15 m for EDF 2 gave highest gain with the highest pump power of 700 mW. Through the dual stage amplifier technique, flat-gain and wideband amplification were significantly achieved.

Index Terms: Dual stage amplifier, EDFA, Flat-gain, Gain amplification

I INTRODUCTION

In telecommunication systems, signal transmission with high speed data rate over long distances are important but signal performances is inevitably decrease due to high attenuation, fiber losses and dispersion which occur during the transmission process. Gain plays an important role in amplifier system. During signal transmission, improvement in gain amplification performances helps to overcome the losses by using optical amplifier. Gain plays an important role in amplifier system. Optical fiber amplifiers like Erbium Doped Fiber Amplifier (EDFA) which allowed to overcome the signal losses during transmission.

It possess the properties that can reduce data loss, that is noise figure and high gain. These two factors governs the performance of transmission of signal, aside from system configuration and total pump power channeled to the system. Various configurations such as single pass, double pass, triple pass, quadruple pass are needed to enhance the performance of EDFA in terms of gain amplification. Many researchers have been carried out with EDFA to attain flat-gain and wideband amplification performance namely gain-clamping, double pass, hybrid amplifier and many more. In this paper, gain amplification performance for obtaining flat-gain and wideband amplification using dual stage Erbium Doped Fiber amplifier technique is proposed. The gain amplification performance of dual stage EDFA is compared with single stage EDFA in terms of varying the length of gain medium, pump power and input signal power and the amplification performance is characterized in Conventional band (C-band) wavelength region and Long band (L-band) wavelength region and simulated via Optisystem software.

II EXPERIMENTAL SETUP

Here single and dual stage EDFAs are investigated using an optisystem software. Optisystem software that enables users to plan, test and simulate optical links in the transmission layer of modern optical networks. Based on the amplification performance the results are analyzed by varying the length of gain medium, pump power and input signal power. For the amplification performance two types of input signal power is used which are high and low input signal with values of 0 dB and -30 dB, respectively.

Fig.1 and Fig. 2 shows the design configuration of single stage Erbium Doped Fiber Amplifier and simulation diagram for single stage EDFA using optisystem. It consists of Continuous Wave (CW) laser, Pump laser, Pump coupler co-propagator, Dual Port WDM Analyzer(DPWDMA), Optical Spectrum Analyzer(OSA), Optical null.

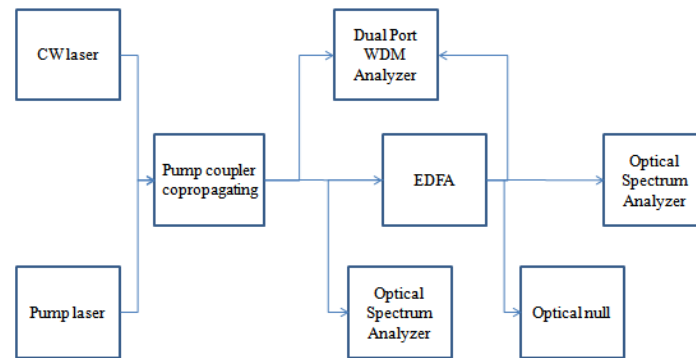


Fig.1 Configuration of Single stage Erbium Doped Fiber amplifier

The Continuous Wave laser is also known as TLS (Tunable Laser Source) which generates a continuous wave optical signal. A Pump laser is used as an optical amplifier pump. The pump lasers transfer its energy or provide energy from an external source into the gain medium. The absorbed energy will produce excited states which cause population inversion that leads to amplification. A pump coupler combines the CW laser and the pump laser. It is able to control the attenuation of the signal and the pump independently. The output of EDFA is characterized and showed on OSA and DPWDMA. This process is considered as Single stage of EDFA. The Amplified signal from single stage of EDFA and additional pump power is combined by pump coupler and passes to Erbium doped fiber where the amplification takes place and output is visualized in OSA and DPWDMA.

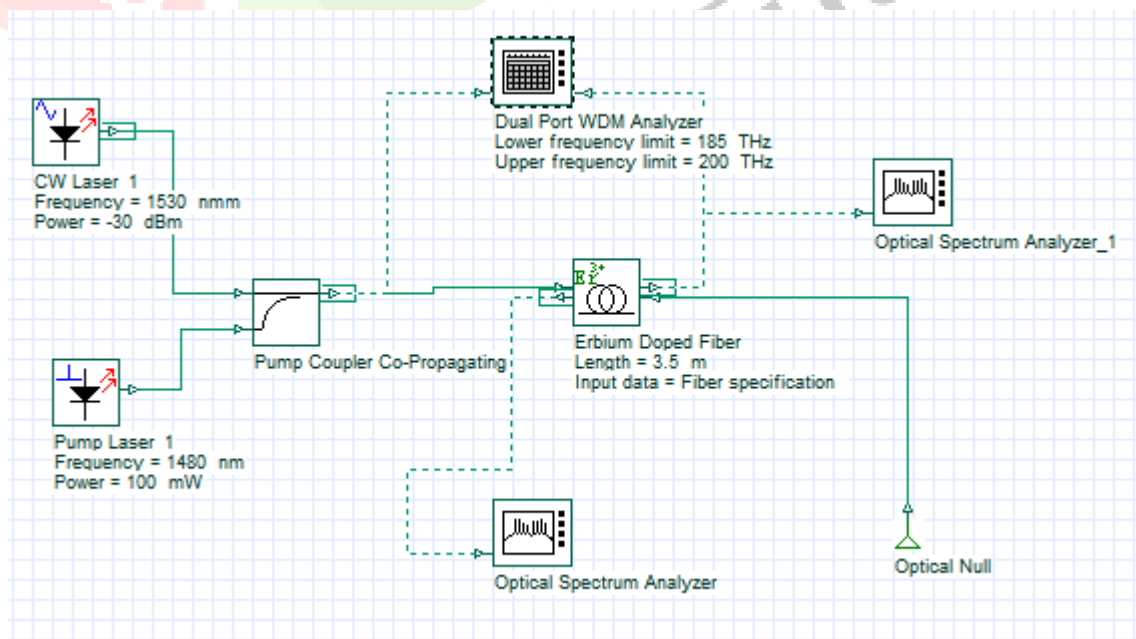


Fig.2 Simulation diagram for single stage EDFA by using optisystem

Fig.3 shows the design configuration of dual stage Erbium Doped Amplifier which is similar to Single stage Erbium Doped Amplifier with the additional 1480 nm laser pump, gain medium and pump coupler which results in another amplifying stage, dual stage EDFA

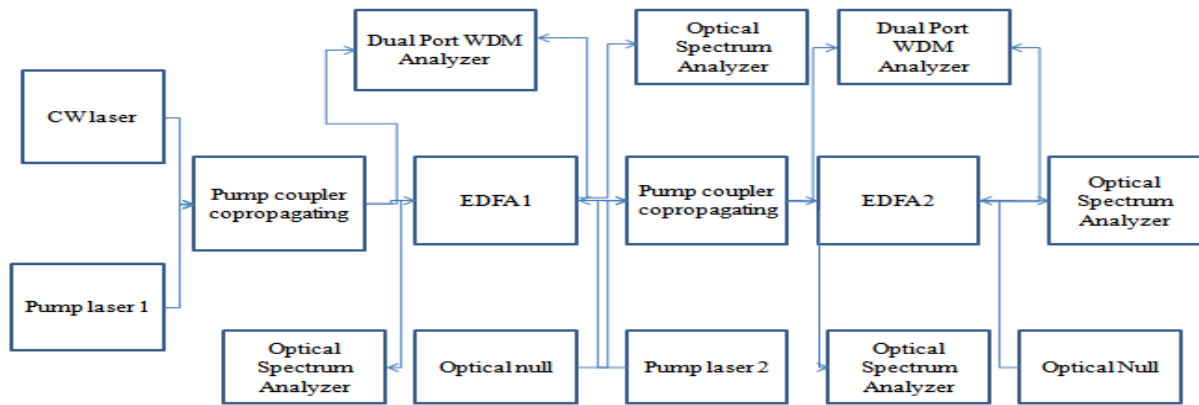


Fig.3 Configuration of Dual stage Erbium Doped amplifier

Fig.4 shows the simulation of the dual stage EDFA by using optisystem software. This configuration is similar to single stage EDFA with additional amplifying stage which consists of pump laser, pump coupler, EDF gain medium, additional OSA and Dual port WDM analyzer are needed for the characterization of gain amplification.

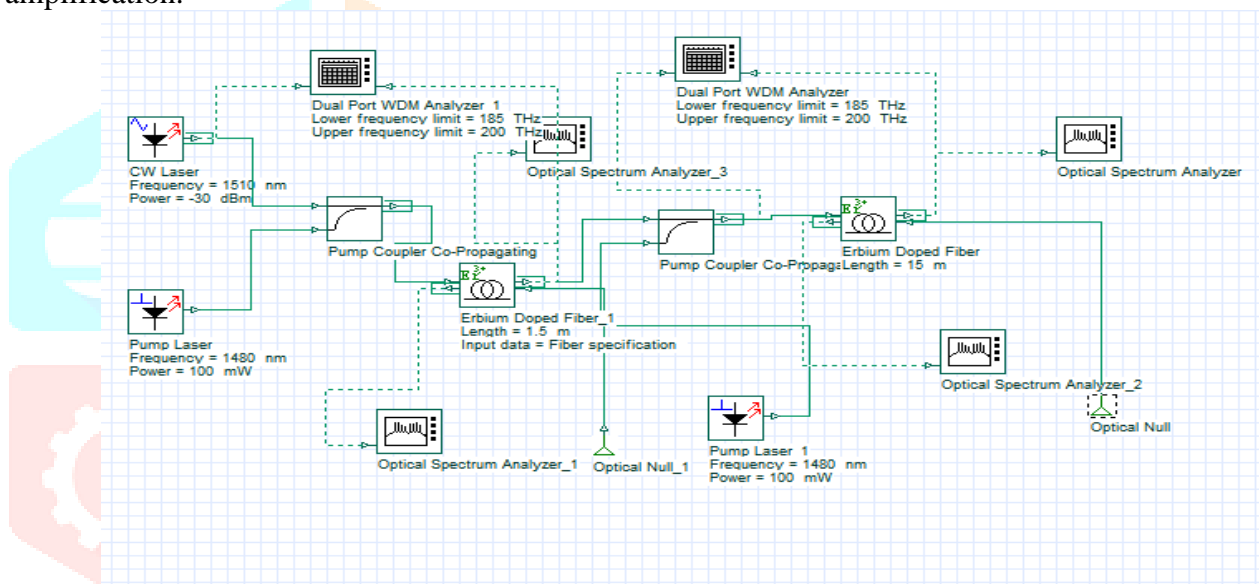


Fig.4 Simulation diagram for Dual stage EDFA by using optisystem

III RESULTS AND DISCUSSION

In this section, gain amplification performance for both single and dual stage EDFA were analyzed by varying the length of gain medium, input signal power and pump power. Table I and II shows the parameter used in single stage amplifier and Dual stage amplifier. Fig. 5(a) and Fig.5(b) show the gain performance for the single stage amplifier with high input signal power (0 dBm) and low input signal power (-30 dBm) using different length of gain medium. The pump power was fixed at 100 mW with varying the length at 0.5m, 1 m, 1.5m, 2m. The performance of gain was characterized in the Conventional band (C-band) and Long band (L-band). Changing the length of gain medium is to find an optimal length of medium can give the highest gain performance. For both input signal powers the longest gain medium length of 2 m gave the highest gain performance followed by 1.5 m, 1 m, 0.5 m. From the results simple conclusion drawn here is that the longer the length of gain medium, higher its gain performance, due to effective population inversion occurred with longer gain medium for both input signal powers. For 0 dBm and -30 dBm highest gain is only at C-band wavelength region (1530 nm-1560 nm) that is 12 dBm and 15 dBm and its started to decrease in L-band wavelength region (1565 nm-1610 nm) because of inefficient population inversion

I. Parameters used in single stage EDFA

Input signal power	0 dBm and -30 dBm
Pump power	100 mW
Length of gain medium	0.5 m, 1 m, 1.5 m, 2 m, 2.5 m, 3 m

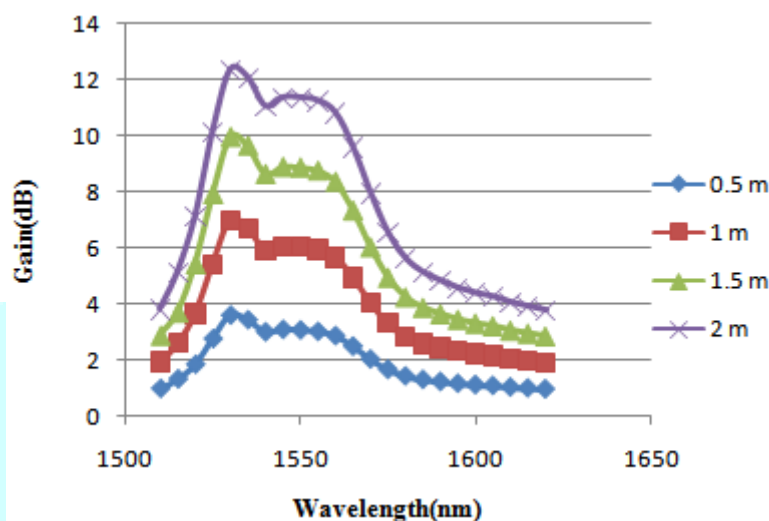


Fig.5(a) Variation of EDF length for single pump at 0 dBm

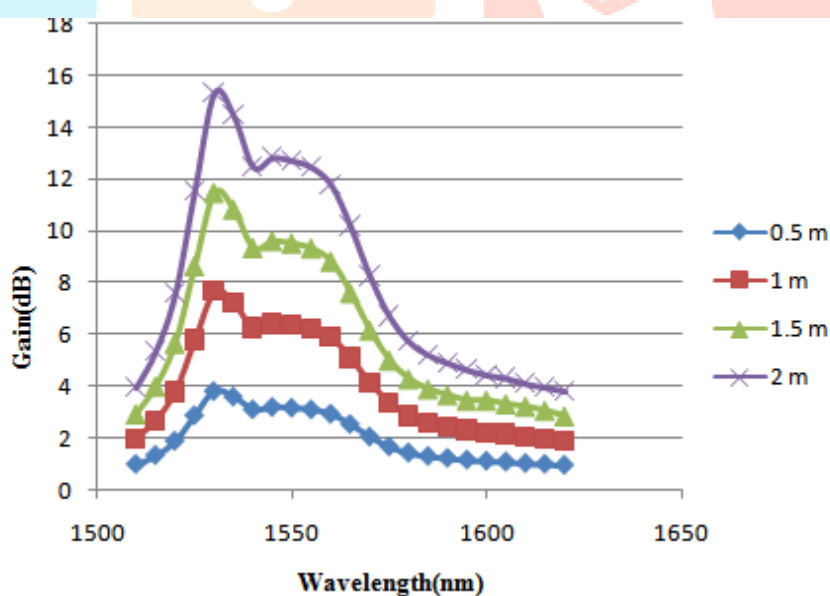


Fig.5(b) Variation of EDF length for single pump at -30 dBm

Fig.6 (a) and Fig.6(b) shows the performance of gain for dual stage amplifier which is investigated under high and low input signals of 0 dBm and -30dBm which is characterized in C-band wavelength region and L-band wavelength region for different length of gain medium. The length of gain medium is varied from 0.5 m, 1 m, 1.5 m, 2 m, 2.5 m, 3 m, 3.5 m for EDF 1 and 5 m, 10 m, 15 m, 20 m, 25 m, 30 m, 35 m for EDF 2. The pump power is fixed at 100 mW. The objective being that dual stage is meant to increase the gain amplification performance at L-band wavelength region to achieve flat-gain and wideband amplification. Here the length of gain medium (EDF 2) should be ten times longer than that of EDF 1 to avoid full absorption at the L-band region that will lead to no gain amplification. The obtained result is high gain at 0 dBm and -30dBm in C-band is 18 dB and 41dB at the length of 1 m for EDF 1 and 10 m for EDF 2. At 0 dBm gain attains flatness in L-band at the length of 1.5 m for EDF 1 and 15 m for EDF 2

with high gain at L-band is 17.9 dB. Thus the length of 1 m for EDF1 and 1.5m for EDF 2 are indeed the best results for gain amplification with most flat gain and wideband amplification.

II. Parameters used in dual stage EDFA

Input signal power	0 dBm and -30 dBm
Pump power	100 mw
Varying length of EDF1 and EDF2	0.5 m and 5 m, 1 m and 10 m, 5 m and 15 m, 2 m and 20 m, 2.5 m and 25 m, 3 m and 30 m, 3.5 m and 35 m.

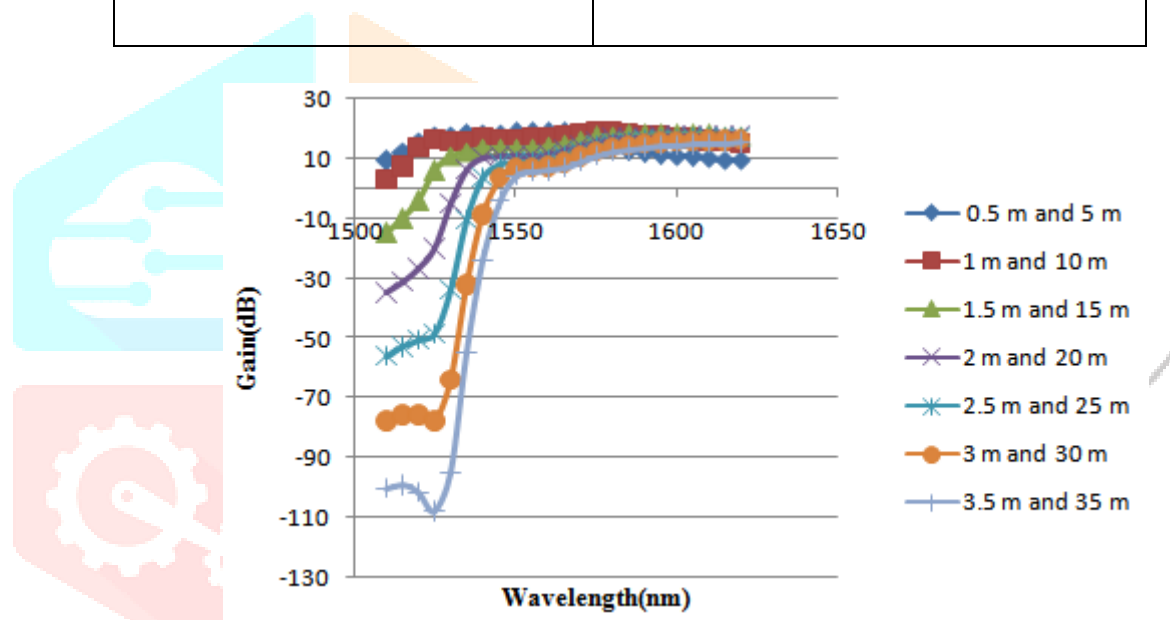


Fig.6(a) Variation of EDF length for dual pump at 0 dBm

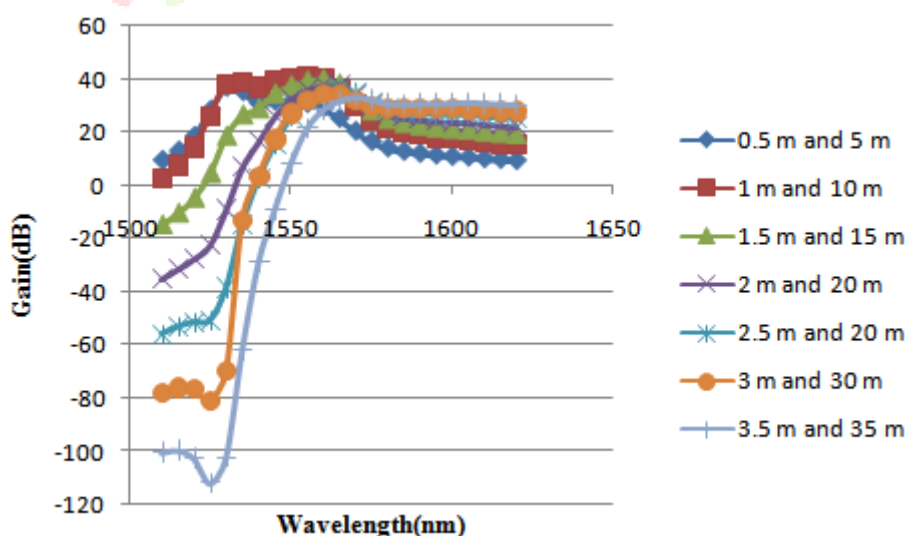


Fig. 6(b) Variation of EDF length for dual pump at -30 dBm

Fig. 7(a) and Fig.7(b) shows the performance of gain for dual stage amplifier which is investigated under high and low input signals of 0 dBm and -30dBm which is characterized in C-band wavelength region and L-band wavelength region for different pump powers. Pump power is varied from 100 mW-700 mW while the gain medium is fixed at the length of 1.5 m for EDF 1 and 15 m for EDF 2. At 0 dBm gain is highest at the pump power of 700 mW that is 22.2 dB followed by the pump power 600 mW, 500 mW, 400 mW, 300 mW, 200 mW and 100 mW and at -30 dBm gain is highest at the pump power of 700 mW that is 48.2 dB followed by the pump power 600 mW, 500 mW, 400 mW, 300 mW, 200 mW and 100 mW which is in C-Band of 1560 nm. For L-Band gain is high compared to single stage amplifier for both high and low input signal power.

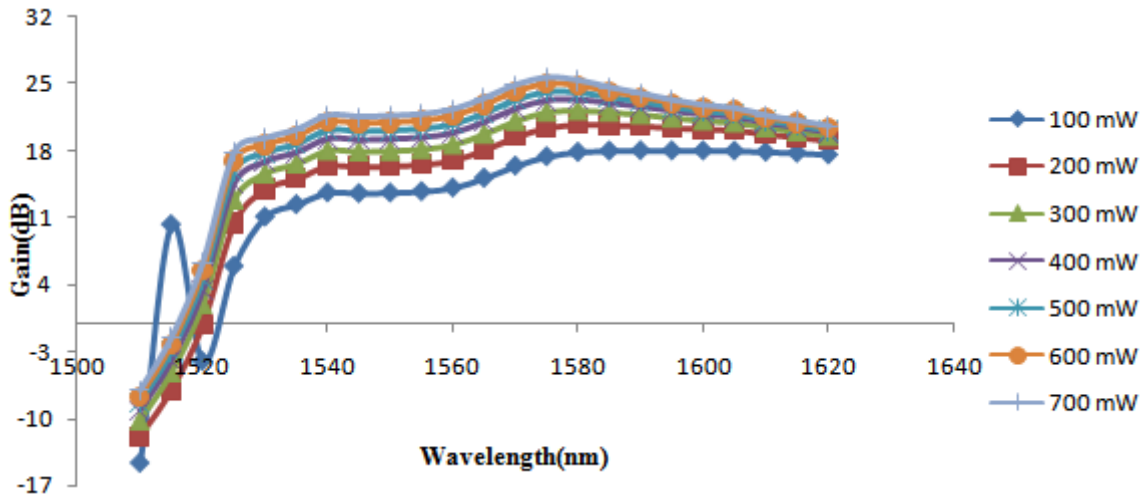


Fig. 7(a) Variation of pump power for dual pump at 0 dBm

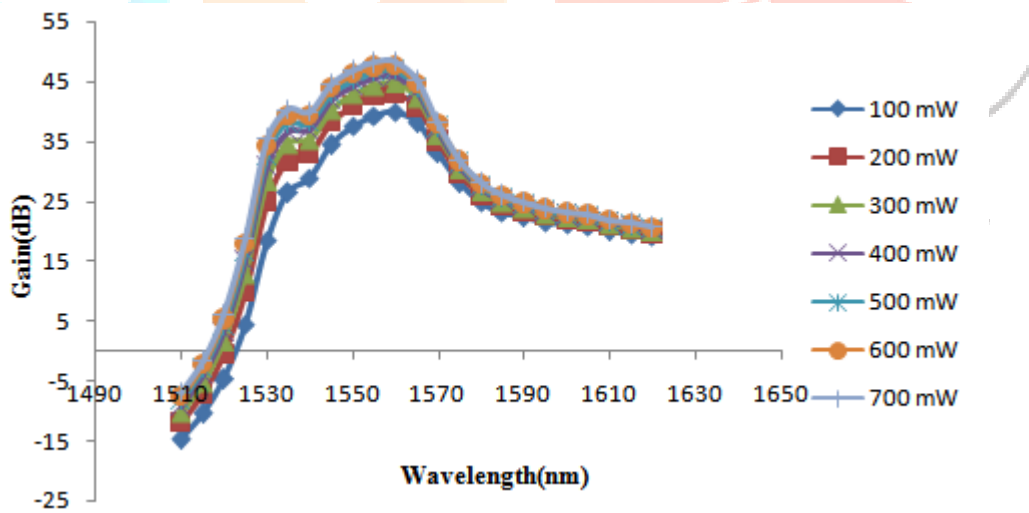


Fig. 7(b) Variation of pump power for dual pump at -30 dBm

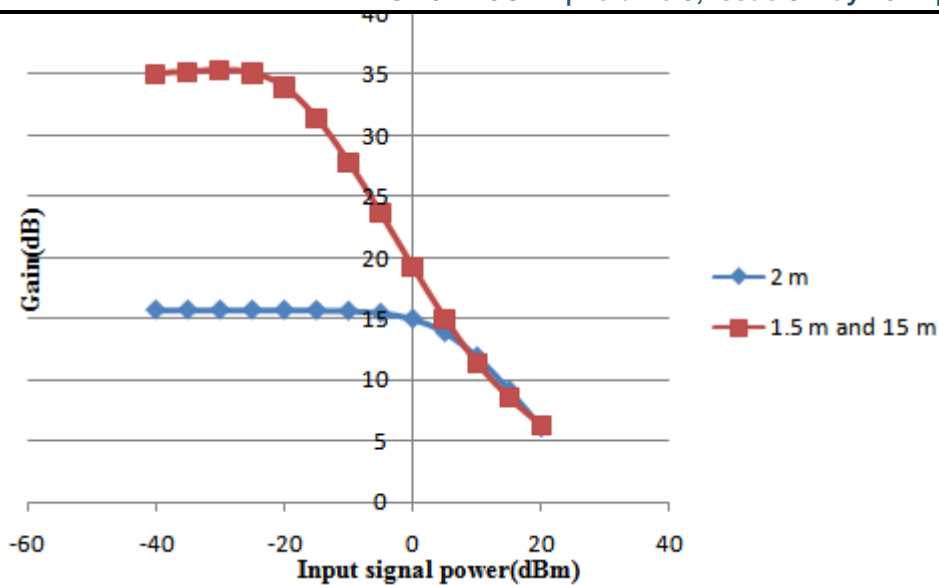


Fig.8 Gain comparison between single and Dual stage EDFA by varying the input signal power

Fig.8 shows the gain comparison between single and dual stage amplifiers with varying input signal power from -40 dBm to 20 dBm. The obtained result is, the input signal power for dual stage amplifier gives high gain performance than single stage amplifier but the gain is decrease when the input signal is increased. Through the gain is lower for single stage amplifier the gain seems to be flat from -40 dBm to 0 dBm.

IV CONCLUSION

The different physical parameters of Erbium Doped Fiber Amplifier on the conventional band wavelength and long band wavelength have been analyzed in single and dual stage EDFA. From this gain performance of dual stage amplifier delivers better performance from the aspects of flat gain and wideband amplification compared to single stage amplifier by varying variables such as length of gain medium and input signal power Here, flat -gain is achieved without using any gain flattening filter. The gain is highest when the length of gain medium is 2m for single stage amplifier and 1 m for EDF 1 and 10 m for EDF 2 for dual stage amplifier. Highest pump power of 700 mW gives the best gain amplification for dual stage amplifier. Thus gain performance is strongly dependent on the length of gain medium, pump power and input signal power.

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