Study of Pumping Methods In Erbium Doped Fiber Amplifier (EDFA)

Hasanuzzaman[1]
Department of Electronics and Communication Engineering, Aliah University, Newtown, Kolkata, West Bengal

Mijanur Rahim[2]
Department of Electronics and Communication Engineering, Aliah University, Newtown, Kolkata, West Bengal

Mafikul Islam[3]
Department of Electronics and Communication Engineering, Aliah University, Newtown, Kolkata, West Bengal

Md Asraful Sekh[4]
Department of Electronics and Communication Engineering, Aliah University, Newtown, Kolkata, West Bengal

***Abstract*—Erbium Doped Fiber Amplifier (EDFA) is an optical amplifier that uses a doped optical fiber as a gain medium to amplify an optical signal. A single EDFA is used for simultaneously amplifying many data channels at different wavelengths within the gain region. The signal which is to be amplified and pump power is multiplexed into the doped fiber and the signal is amplified because of the interaction with the doping ions. In this paper various EDFA pumping schemes are studied and analyzed. The analysis is made for high pump power 200mW to 600mW. Standard Erbium Doped Fiber of length 16.2m is used. Input signal power is set at -34dBm at 1550nm. Output power calculated is in the range of 15 to 25dBm, while the noise figure varied between 4.37 to 7.24 dBm. Among the different pumping method it is found that bi-directional pumping method shows best results.**

Keywords—EDFA, Pump Power

I. INTRODUCTION

Erbium doped fiber amplifier (EDFA) is one of the key component in optical communication system. It has been used in long haul and wavelength division multiplexed (WDM) fiber optic communications since 1990s. The performance of such system utilising EDFA largely depends on how the latter one performs in terms of gain and noise. The EDFA performance largely depends on pumping mechanism. Three pumping techniques namely co-directional pumping, counter-directional pumping, and bidirectional pumping are useful in EDFA [1-4].

Co-directional pumping- In co-directional pumping, both input signal and pump signal travel in the same direction inside the optical fiber. A combiner i.e., wavelength division multiplexer is used to combine both input signal and pump signal. The pump signal transfers its energy to input signal with the help of the amplifier action and the information carrying signal gets amplified at the output of the fiber. Isolators are also used to ensure that signal travel only in forward direction and are not reflected backward.

Counter-directional pumping- In counter pumping scheme, the input signal and the pump signal travel in opposite direction inside the optical fiber. In backward pumping, the direction of the signal is insignificant. The information carrying signal gets amplified while travelling in opposite direction.

Bi-directional pumping- In bidirectional pumping, the input signal travels in the forward direction. But in bidirectional pumping, two pump laser are used which travel in both forward and backward direction inside the fiber along with the input signal.

II. INVESTIGATION ON PUMPING METHODS

The layouts for analysing three different pumping mechanisms are shown in Figure. 1(a), 1(b) and 1(c) respectively. The layouts mainly consist of CW laser source for input signal at 1550 nm, pump laser source at 980 and 1480 nm, erbium doped fiber amplifier, dual port WDM analyser, optical spectrum analyzer and optical power meter. Table 1 shows the used parameters for different system components. High amplifier gains in the range 39-46 dB can be obtained by sweeping the pump power from 200 mW to 600 mW. The signal input power considered is -34 dBm at 1550 nm wavelength. Output power calculated in this project is in the range 15 to 25 dBm, while the noise figure varied between 4.37 to 7.24 dBm. Different signal input power or signal wavelength as well as fiber parameters can also be simulated to obtained new results and can be compared.

Table 1. System parameters for EDFA pumping study

Components	Parameters	Values
CW laser	Input power	-34 dBm
	Wavelength	1550 nm
Pump lasers	Pump powers	200, 300, 400, 500 and 600 mW
	Wavelengths	980 nm, 1480 nm
EDFA	Length	16.2 m
	Er ion density	$10*10^{24}$ m^{-3}
	Er metastable time	10 ms
	Core radius	1.3 μm
	NA	0.27

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 08, August - 2017

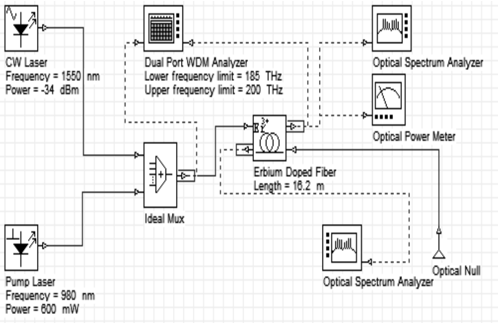

Figure. 1(a). Layout in co-propagating scheme

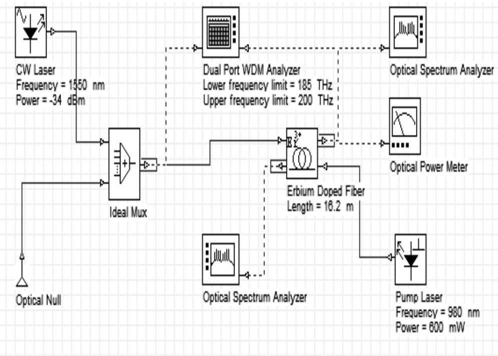

Figure. 1(b). Layout in counter-propagating scheme

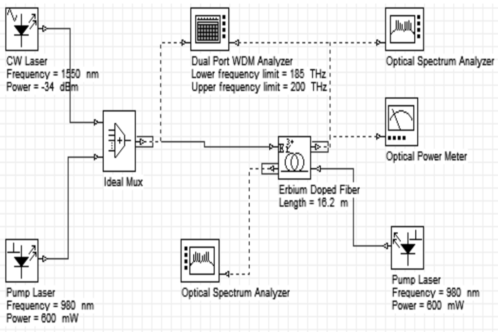

Figure. 1(c). Layout in bi-directional pumping scheme

III. RESULTS AND DISCUSSIONS

Figure. 2(a) and Figure. 2(b) respectively show the gain and noise figure (NF) variation with pumping powers for co-propagating pumping at 980 nm. As seen from these figures that the both gains and NF are slowly increasing with increase in pump powers. The gain of the amplifier varies between 39.62 to 43.18 dB and the NF varies between 4.37 to 4.39 dB. The output signal levels are low and vary between 14.85 to 19.99 dB. Table 2. shows the results.

To compare the co-propagating pumping at 1480 nm, the pump wavelength in Figure. 2(a) has been set to 1480 nm and other parameters are remained unchanged. Figure. 3(a) and Figure. 3(b) respectively show the gain and noise figure (NF) variation with pumping powers for co-propagating pumping at 1480 nm.

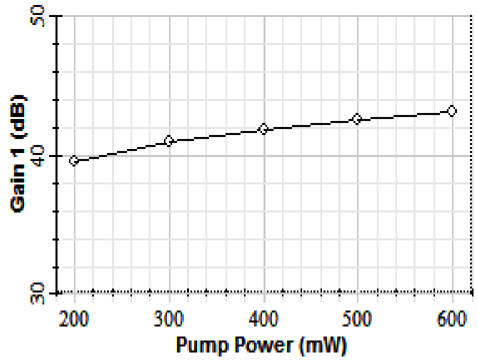

Figure. 2(a). Gain for Co-propagating pumping @980 nm

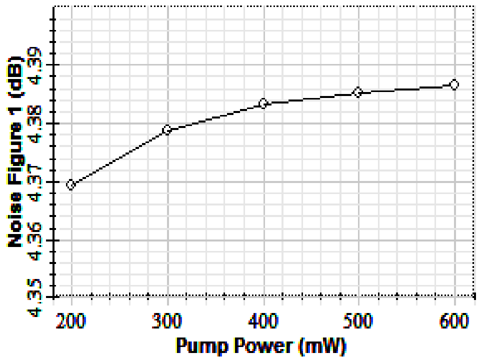

Figure. 2(b). Noise Figure variation for Co-propagating pumping @980 nm

Table 2. Gain, noise figure and output power for co-propagating pumping @980 nm

Pump Powers (mw)	Gains (dB)	Noise Figures (dB)	Output Powers (dB)
200	39.62	4.37	14.85
300	40.97	4.38	16.76
400	41.90	4.38	18.10
500	42.61	4.39	19.14
600	43.18	4.39	19.99

As seen from these figures that the gains is slowly increasing with increase in pump powers but NF is slowly decreasing. The gain of the amplifier varies between 40.55 to 43.01 dB and the NF varies between 4.81 to 4.62 dB. The output signal level however, enhances with the values 21.61 to 26.92 dB. Table 3. shows the results. Figure. 4(a) and Figure. 4(b) respectively show the gain and noise figure (NF) variation with pumping powers for counter-propagating pumping at 980 nm. As seen from these figures that the gain is quite high and it increases from 39.74 to 43.26 dB whereas NF is slowly decreasing from 7.24 to 6.94 dB. The output signal level however, varies between 19.76 to 24.54 dB. Table 4. shows the results.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 08, August - 2017

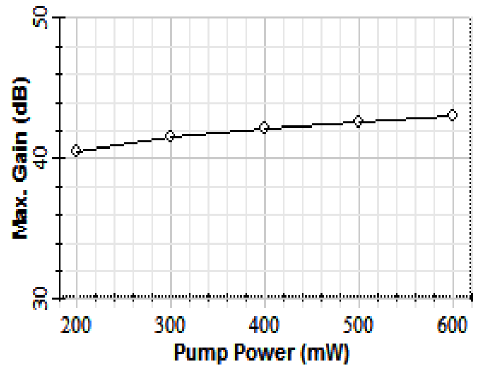

Fig.ure. 3(a). Gain for Co-propagating pumping @1480 nm

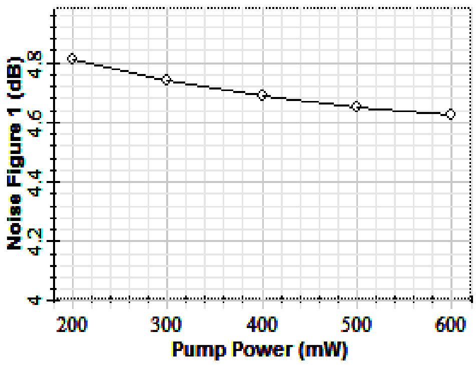

Fig.ure. 3(b). Noise Figure variation for Co-propagating pumping @1480 nm

Table 3. Gain, noise figure and output power for Co-propagating gains and noise parameters @1480 nm

Pump Power (mw)	Gains (dB)	Noise (dB)	Output Power (dB)
200	40.55	4.81	21.61
300	41.53	4.74	23.58
400	42.18	4.69	24.97
500	42.65	4.65	26.05
600	43.01	4.62	26.92

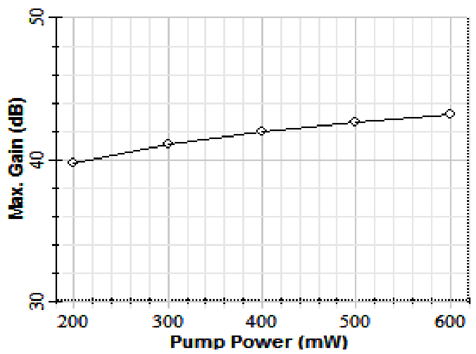

Figure. 4(a). Gain for Counter-propagating pumping @980 nm

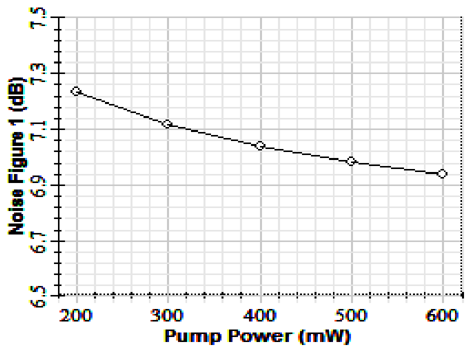

Figure. 4(b). Noise Figure variation for Counter-propagating pumping @980 nm

Table 4. Gain, noise figure and output power for Counting-propagating pumping @980 nm

Pump Power (mw)	Gains (dB)	Noise (dB)	Output Power (dB)
200	39.74	7.24	19.76
300	41.07	7.12	21.55
400	41.99	7.04	22.80
500	42.69	6.98	23.76
600	43.26	6.94	24.54

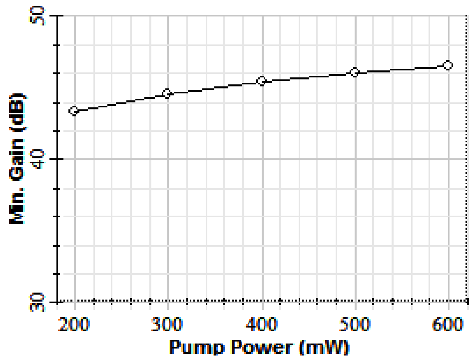

Fig.ure.. 5(a). Gain for Bi-directional pumping @1480 nm

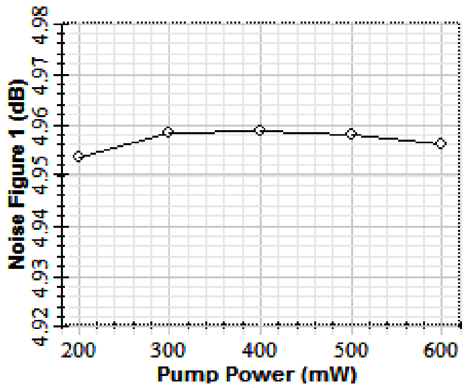

Fig.ure.. 5(b). Noise Figure variation for Bi-directional pumping @1480 nm

Figure. 5(a) and Figure. 5(b) respectively show the gain and noise figure (NF) variation with pumping powers for bi-propagating pumping at 980 nm. As seen from these figures that the gain is slowly increasing and NF almost constant with increase in pump powers. The gain of the amplifier is quite high and it varies between 43.21 to 46.55 dB and the NF varies only between 4.95 to 4.96 dB. The output signal level varies between 21.06 to 25.87 dB. Table 5. shows the results.

Table 5. Gain, noise figure and output power for Bi-directional pumping @980 nm

Pump Power (mw)	Gains (dB)	Noise (dB)	Output Power (dB)
200	43.41	4.95	21.06
300	44.58	4.96	22.84
400	45.40	4.96	24.10
500	46.04	4.96	25.08
600	46.55	4.96	25.87

IV. CONCLUSION

From the above results, it can be seen that the best performance is obtained by bi-directional pumping scheme as it gives the maximum value of output power for each case and in the case of co-propagating pumping at 980 the output power level is low and the NF is also increasing. However, co-propagating pumping at 1480 nm shows good results with moderate power and better noise performance.

The performance comparison between co-directional, counter and bi-directional pumping schemes in terms of system parameters like BER and Q-factor is in progress and to be communicated in future.

V. REFERENCES

[1] R. Vijaya and R. Deepa, ‘Influence of bidirectional pumping in high-power EDFA on single-channel, Multichannel and pulsed signal amplification’, Elsevier, pp. 20-26 (2008).

[2] F. Vasile and P. Schiopu, ‘The EDFA Performance with gain versus pump power’, IEEE Semiconductor Conference, vol. 1, (2004).

[3] R. F. Souza, S. Milo, M.B.C. Silva, E. Conforti and C. Bordonalli, ‘An EDFA Theoretical Analysis Considering Different Configuration and Pumping Wavelengths’, IEEE Microwave and Optoelectronics Conference, vol. 1, pp. 105-110 (2003).

[4] A.C. Cokrak and A. Altuncu, “Gain and Noise Figure Performance of Erbium Doped Fiber Amplifiers”, Journal of Electrical & Electronics Engineering, vol. 4, pp. 1111-1122 (2004).