Gain and Noise Figure Characteristic of EDFA by Four Stage Method

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ABSTRACT
Fiber loss is a fundamental limitation in realizing long haul point-to-point fiber optical communication links and optical networks. One of the advanced technologies achieved in recent years is the advent of erbium doped fiber amplifiers (EDFAs) that has enabled the optical signals in an optical fiber to be amplified directly in high bit rate systems beyond Terabits. In this paper, an EDFA simulation program has been written in opt system to characterize Gain, Noise Figure and optical signal to noise ratio (OSNR). The four stage enhancement circuit has been designed and simulation studies for different types of pump power. Further, for the EDFA with comparatively better gain and noise figure spectrum, the pump powers are varied and a comparison of gain and noise figure with respect to wavelength is carried out.

Keywords
Erbium Doped Fiber Amplifier (EDFA), Gain, Noise Figure, Optical Signal to Noise Ratio (OSNR)

1. INTRODUCTION
Communication is the process of transmitting and sharing of data or information or news from certain location to destination. In previous time People uses certain types of music instruments such as drums, Pigeon post, Hydraulic semaphores etc. to convey the information. But due to invent of science, communication can became a easy task as compare to previous era. It may also be described that communication is to sharing of idea between one people to another.

Nowadays we can't imagine the world without communication. The use of fiber optic communication emerges due to its low weight, high bandwidth, easy to maintain, low cost etc. Because of its wide variety of advantages fiber optic communication system has wide range of applications also. The fiber optic communication systems are used in telephones, internet services, cable television, closed circuit television, military applications etc. Although the communication system suffers from fiber loss, attenuation, dispersion, etc [1], [2] Optical amplifiers are used to overcome these limitations occurs in fiber optic communication systems. The optical amplifiers were developed in 1980s and commercially available in 1990s. The most significant types of optical amplifiers are Raman amplifier [3], semiconductor laser amplifier, Brillouin amplifiers and rare-earth doped fiber amplifiers. EDFA (Erbium doped fiber amplifier) is a special class of optical amplifier widely used today. EDFA has several parameters such as pump wavelength, pump power, signal wavelength, signal power, Erion density, Er-doping radius, Fiber length, Gain, Noise figure etc. Out of them the overall performance of fiber optic communication is mainly depends on the gain-noise figure values. The gainnoise figure are highly depends on the parameters like pump power, fiber length, Er-ion concentration etc. Here the low powered input signal along with high powered pump signal is fed to erbium doped fiber through an optical coupler. The pump energy is transferred to the signal by the process of stimulated emission. The pump can be used at either 980nm or 1480nm. The signal wavelength shows better gain in the range of 1530-1560nm.The pump power always greater than 10mw to obtain good gain-noise figure values. The EDFA acts like an optical repeater. It amplifies the optical signal itself without ever changing it to electricity. For long haul point-to-point fiber optic communication without significant loss of power EDFA has become the best choice. We can achieve an optical gain upto 30db, it means 1000 photons out per photon in. There should an optimum value of these parameters for better performance. The amplified optical signals are given to demodulators for optical to electrical conversion.

2. EDFA DESIGN
The simulation model in optisystem is shows in figure 1. Here the information signal and the pump signal are passed into the EDFA with sufficient Er-ion density through the coupler. The information signal is at 1552nm and pump signal is at 2nm. Pump power is selected at 100mw. Then simulate the output for different values of pump power. One more parameter that is strongly depends on the gain also considered, terms the fiber length. Then vary these parameters in a combined manner so that better gain, noise figure is obtained.

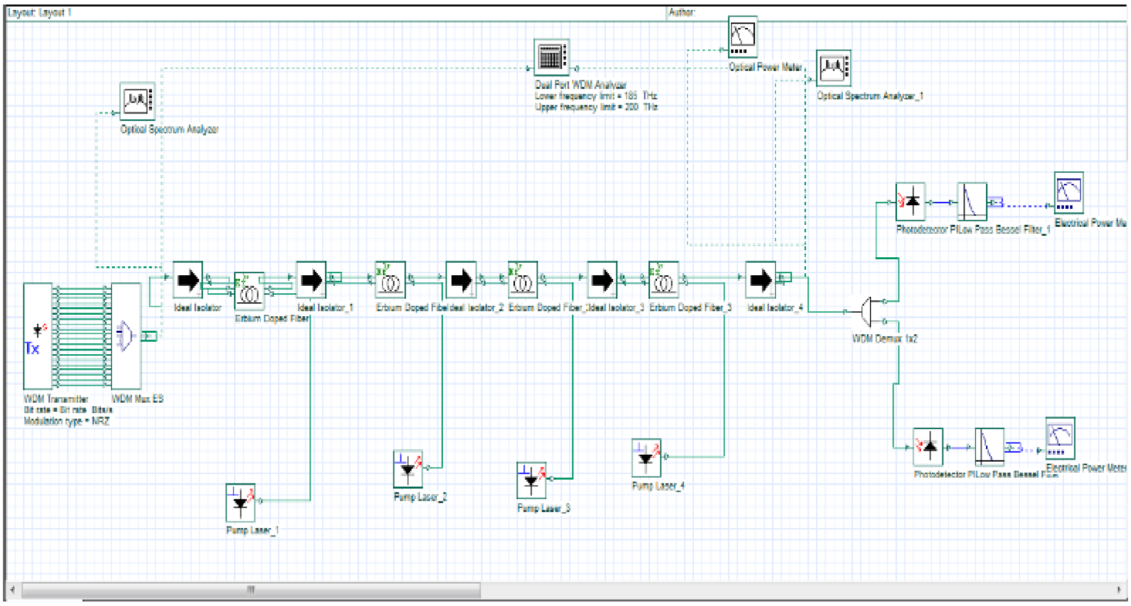

Figure 1: Four Stage EDFA Circuitry

3. RESULTS AND DISCUSSION

The dynamic response of the amplifier is obtained when switching from the red sub band channels to the blue sub band channel.

Table I: Gain Spectrum for different pump powers

Wavelength	Gain dbm			
nm	0.2w pump power	0.25w pump power	0.5w pump power	0.75w pump power
1552	28.96	31.02	37.03	40.28
1554	32.4	34.39	40.19	43.32
1556	35.53	37.45	43.03	46.05
1558	38.44	40.28	45.64	48.53
1560	40.8	42.54	47.59	50.32
1562	42.69	44.31	49.02	51.56
1564	44	45.48	49.79	52.12
1566	44.86	46.21	50.12	52.23
1568	45.31	46.53	50.06	51.97
1570	45.35	46.44	49.6	51.31
1572	45.35	46.33	49.19	50.73
1574	45.21	46.09	48.68	50.07
1576	44.94	45.74	48.08	49.34
1578	44.83	45.57	47.72	48.89
1580	44.74	45.43	47.43	48.51
1582	44.856	45.5	47.4	48.42
1584	44.852	45.46	47.25	48.21
1586	45.1	45.7	47.42	48.35
1588	45.16	45.72	47.37	48.25
1590	45.28	45.82	47.41	48.26

Since the goal is to assess the pump wavelength dependency, the gain of the probe channel remains unchanged during the number of values. This is achieved by adjusting the pump power at different pump wavelengths to obtain the reference gain of the probe channel.

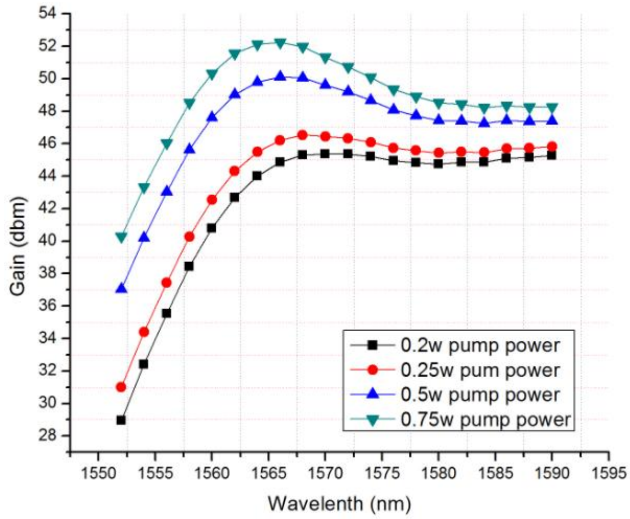

Figure 2: Gain Spectrum for different pump powers

Initially, a four-stage EDFA circuitry is designed by connecting four EDFAs in cascade in Opti system software. The Gain and Noise Figure for each and every Fiber circuitry is plotted and compared.

The four values of pump power that has been used are 0.2 W, 0.25 W, 0.5 W and 0.75W are shows in table 1-3 respectively. The Gain Spectrum, Noise Spectrum and the output signal to noise ratio have been found out for each of the respective pump powers.

Table II: Noise Figure Spectrum for different pump powers

Wavelength	Noise Figure (dbm)			
nm	0.2w pump power	0.25w pump power	0.5w pump power	0.75w pump power
1552	43.88	42.61	39.41	37.97
1554	42.27	41.24	38.63	37.42
1556	41.1	40.25	38.06	37.02
1558	40.16	39.25	37.57	36.65
1560	39.49	38.88	37.25	36.43
1562	38.9	38.37	36.92	36.17
1564	38.43	37.97	36.68	36.01
1566	37.96	37.55	36.39	35.79
1568	37.58	37.21	36.17	35.62
1570	37.29	36.97	36.04	35.55
1572	36.95	36.66	35.81	35.36
1574	36.69	36.43	35.66	35.25
1576	36.48	36.25	35.56	35.19
1578	36.27	36.05	35.42	35.08
1580	36.08	35.89	35.31	35
1582	35.86	35.68	35.14	34.85
1584	35.76	35.6	35.1	34.83
1586	35.6	35.44	34.98	34.72
1588	35.45	35.5	34.87	34.63
1590	35.32	35.18	34.77	34.55

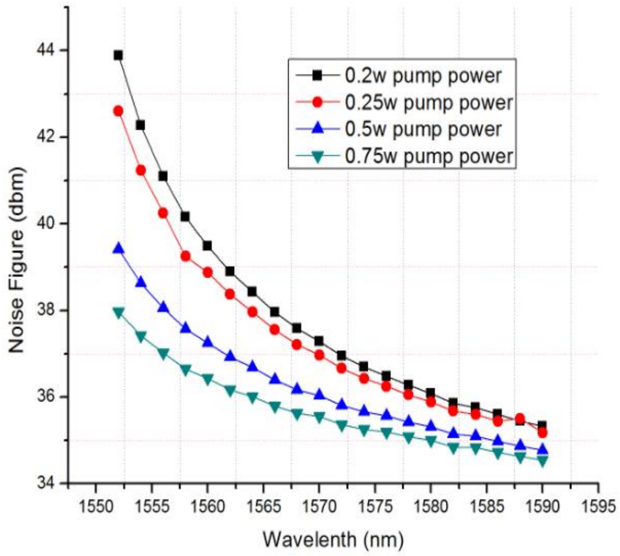

Figure 3: Noise Figure Spectrum for different pump powers

After comparing the Gain and Noise figure for pump powers 0.2W, 0.25W, 0.5 and 0.75W it has been found that, for pump power 0.75W the best simulation results are obtained.

Table III: Optical SNR Spectrum for different pump powers

Wavelength	OSNR (dbm)			
nm	0.2w pump power	0.25w pump power	0.5w pump power	0.75w pump power
1552	74.44	75.67	78.77	80.18
1554	75.91	76.91	79.46	80.65
1556	77.1	77.93	80.07	81.1
1558	77.94	78.63	80.49	81.4
1560	78.67	79.26	80.88	81.69
1562	78.25	79.77	81.21	81.95
1564	79.72	80.17	81.45	82.12
1566	80.12	80.52	81.67	82.28
1568	80.52	80.88	81.91	82.46
1570	80.86	81.18	82.11	82.6
1572	81.15	81.43	82.27	82.72
1574	81.42	81.68	82.44	82.75
1576	81.7	81.93	82.61	82.98
1578	81.72	82.13	82.75	83.09
1580	82.06	82.26	82.83	83.14
1582	82.28	82.46	83	83.29
1584	82.4	82.56	83.05	83.31
1586	82.62	82.77	83.23	83.48
1588	82.78	82.92	83.34	83.57
1590	82.86	83	83.39	83.61

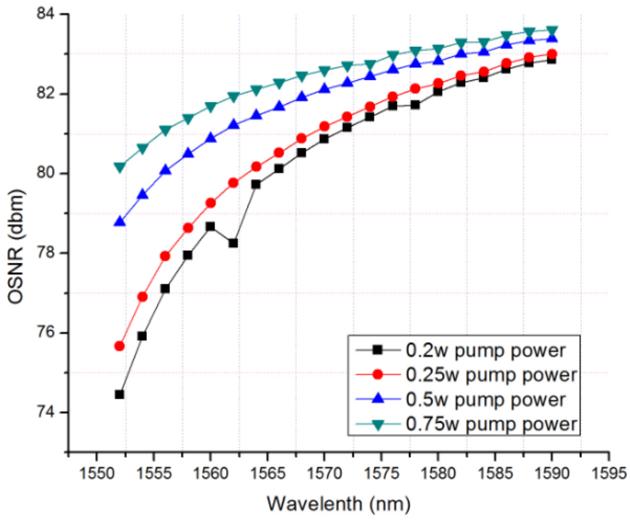

Figure 4: Noise Figure Spectrum for different pump powers

4. CONCLUSION

From the Optisystem, it is concluded that M-5 fiber is the most suitable fiber for the four-stage implementation of EDFA. The pump power was varied. Different Pump Powers like 0.2W, 0.25W, 0.5W and 0.75W were used. Analyzing the gain, optical signal to noise ratio and noise figure spectrum for the EDFA under different pump powers, it was concluded that the pump power of 0.75 W gives better results.

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