Original Article

Diminution of ASE Noise in Erbium Doped Fiber Amplifiers with Fabry Perot CW Laser Source in Single Pumping Technique

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ABSTRACT

The scope of this paper is to decrease the ASE Noise in the simulation model of EDFA with little amount of FPCWL source power using single pumping method. . The simulation model consists of FPCWL source with wavelength (1550nm), pumping CW Laser source (with wavelength 980nm) and Filter. The resulting model accurately represents EDFA Gain and optimized output signal power and reduces the ASE noise when input signal power decreases from 0.1mw to 0.01mw. Simulation results shows that by choosing careful fiber length 20m and pump power 1mw in single pumping gives ASE noise 0.005mw at signal input 0.1mw and 0.0042mw at signal input of 0.01mw.

Keywords: ASE noise power, Output signal power, EDFA, FPCWL (Fabry Perot Continuous Wave Laser), Optical fiber communications, Single pumping, Wavelength and WDM.

INTRODUCTION

As the demand of high speed internet services is increasing, an answer to long distance communication system with high bit rate transmission is optical communication systems which uses optical fiber acts as amplifier after doping an erbium ions into the fiber material and can be used as a medium for telecommunication and networking instead of using complex circuitry in regenerators. EDFA's are mostly used as preamplifiers with multi channel amplification without cross talk and also multi gigabit transmission rates by low bit errors[1].

Basic principle of EDFA

Amplification in an Erbium-doped fiber amplifier occurs through the mechanism of stimulated emission. Pumping signal 980nm is incident to the erbium ions in semiconductor fiber material excited and gives the downward transition produces the emission called the stimulated emission gives the signal amplification in 1550nm, EDFA used C and L Band wavelength range limits.

Signal power in an EDFA

The output signal power is calculated as,

$$Pout = Pin \times G \quad (1)$$

Where G is the EDFA (Amplifier) power gain and Pin is the input signal power. The most important feature of the EDFA is gain as it determines the amplification of individual channels when a WDM signal is amplified[5].

The amplified output signal power is measured from the output line is taken after the filter in the block diagram of Fig 1. And the input signal power is fixed as 0.001mw.

Two such bands are in use today. One is the C-band (Conventional band) which occupies the spectrum from 1530 nm to 1560 nm and the second is L-band (Long wavelength band) which occupies the spectrum ranging from 1560 nm to 1610 nm. Most EDFA work in the C-band. Noise is the second most important characteristic of an optical amplifier.

ASE noise

The principal source of noise in EDFAs shown in Fig. 1 is Amplified Spontaneous Emission (ASE), which has a spectrum approximately the same as the gain spectrum of the amplifier.

Optical noise of an amplifier is inherently due to a random spontaneous emission amplified in a fiber medium. ASE spectrum is quite broad. Total ASE power over the gain bandwidth is:

$$P_{sp} = n_{sp}(G-1)h\nu(\Delta\nu) \quad (2)$$

Where G being the amplifier gain and,

$$n_{sp} = \frac{N_2}{N_2 - N_1} \quad (3)$$

The n_{sp} denotes inversion factor. The carrier density is N_1, and N_2 is its value at transparency.

Fabry Perot CW laser

This block models a Fabry Perot CW laser with multiple longitudinal modes. The user specifies a center wavelength (wavelength), the total output power (total Power), the total spontaneous output power (spontaneous Power), the total number of side modes (num Side modes), and the spacing in Hz between adjacent modes (mode Spacing). Based on these settings, the power in each mode is calculated as

$$\frac{Po}{1+\left(\frac{Po}{Pspo}-1\right).(m/M)^2} \quad (4)$$

Where *Po* is the power in the central mode, *Pspo* is the spontaneous power in each mode (assumed to be the same for all modes, and thus equal to the total spontaneous power divided by the total number of modes), *m* is the mode number in the range [-*M*, +*M*], and the total number of modes is 2*M*+1. *Po* is calculated such that the total power over all modes is equal to the total output power specified.

This paper is organized into six sections. In section II Literature Review of this work, while section III presents the methodology and the proposed work. Section IV demonstrates the model Simulation details. Section V presents the results and discussions. Finally, the paper is concluded in section VI.

Literature review

This paper[11] developed an analytic model for gain modulation in EDFAs. The paper[14] proposed a average power analysis technique similar to that used for semiconductor optical amplifiers. In this paper[13] analyzed gain versus pump power for EDFA. This paper[15] allows network designers to determine the tolerances by which the signal power levels may deviate from their pre designed average values. This paper[17] Multi wavelength EDFA, ASE noise is investigated by connecting connectors and splice techniques. This paper[18] ASE broadband light source and EDFA gives the emission spectrum and ASE noise increases with pump power.

METHODOLOGY

In this work, the small signal laser source gives less ASE noise and an analysis of amplified forward signal output power, Gain, noise figure and ASE noise from the simulation model of EDFA connected with single pumping of 980nm with EDFA Length 20m using the variation of signal source FPCWL have been simulated with optical combiner blocks and a high Performance approach is presented that has not been used in this manner before such design. EDFA employed in such systems have been shown to incur system impairment.

Applied methodology

The applied methodology is based on single pumping approach. Each block in the architecture was added in the model, and the output data has taken from the graph and tabulated the parameters (Forward output signal power, Gain, noise figure and ASE noise) values.

Proposed work

The Proposed work uses FPCWL with various values of input sources given to EDFA follows the model given in simulation model reduced the ASE noise.

The simulation model consists of the input single source 1550nm, external modulator, and optical combiner, non linear fiber of length 20m, continuous wave laser of wavelength 980nm and whose output is given to the optical filter.

In the single pumping with EDFA gives maximum gain and reduced noise and has been compared with different input sources. Filter here is to remove the unwanted wavelengths.

Model simulation

Simulation model formed by the combination of PRBS Pattern Generator, Electrical Signal Generator, optical combiner, non linear fiber, EDFA (Erbium doped Fiber Amplifier) and optical filter.

PRBS Pattern Generator: Produces a maximal length pseudo-random binary sequence and Electrical Signal Generator converts an input binary signal into an output electrical signal. The output signal may be specified as either voltage or current. The user parameters are used to configure the electrical signal output.

The simulation model, PRBS input given to electrical generator, the output voltage is connected to external modulator and VCSBL laser and external modulator modulates the two input signals with FPCWL variable input power the output is given to the optical combiner, it combines VCSBL output and modulated signal and the combined optical signal given to the non linear fiber and Physical EDFA with the Pumping CW source of wavelength 980nm of power 1mw.

EDFA amplifies the power and sends to non linear fiber and then to the optical filter shown in Fig. 2.

The parameters Output forward signal power, noise figure, Gain and ASE noise has been measured using multiplot block with pump power 1mw and EDFA Length 20m from the simulation model and that has been tabulated and analyzed.

RESULTS AND DISCUSSIONS

The output of EDFA has been taken as Gain and ASE noise are shown in Fig. 3 and Fig. 4 with the FPCWL source power of 0.1mw.

The output of EDFA has been taken from the simulation model as Gain and ASE noise are shown in Fig. 5 and Fig. 6 with the FPCWL source power of 0.01mw

From the simulation results, the values are taken and analyzed and tabulated and plotted the bar graph for the various values of the input FPCWL signal power is 0.01mw and 0.1mw. Simulation results indicated that the ASE noise decreases when FPCWL power increases from 0.1mw to 0.01mw shown in table 1.

Table 2 shows the simulated values and are tabulated, ASE noise compared with single wavelength FPCWL sources (1550nm) using single backward pumping technique EDFAs length=20m.

Fig. 7 and 8 shows the Bar Chart performance analysis of EDFA with different signal FPCWL sources.

CONCLUSION AND FUTURE ASPECTS

In summarize, we have simulated the EDFA using FPCWL source of less power reduced the ASE noise using single pumping scheme of 980nm. Thus, we have shown that the proposed model of an EDFA utilizing single pumping technique was successfully simulated with various parameters. The results have been compared with the conventional EDFA with two different FPCWL source values.

The proposed model is suitable for optical communication with higher bandwidth rate with reduced ASE noise. This is applicable in telecommunication.

In future work, the model can be modified and enhanced further by Gain flattening filters (GFF) based on advanced fiber Bragg gratings (FBG) allow amplifier manufacturers to improve gain flatness. Advanced FBGs can be used to replace other GFF technologies in current-generation amplifier designs as a simple means to improve gain ripple. Similarly, new amplifier designs can take advantage of this technology to help and push the performance of next-generation amplifiers to new heights.

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Table 1. Results: EDFA parameters FPCWL signal power 0.1mw and 0.01mw fiber length 20m and pump power =1mw in 1550nm

Parameters	Pump power = 0.1mw EDFA length= 20m		
	FPCWL 0.1mw	FPCWL 0.001mw	Remarks
Gain (DB)	-110	-111	Decreases
Noise Figure(DB)	118	118	Maintained
ASE noise (Forward & Backward)	0.005mw	0.0042mw	ASE noise decreases
	0.0025mw	0.0025mw	ASE noise maintained

Table 2. Results: EDFA parameters pump power from 100mw and 200mw and 0.01mw input FPCWL source and length 20m

Parameters	Fabry perot Laser Source = 0.01mw (1550nm), pump power & EDFA length= 20m		
	pump power 100mw	Pump power 200mw	Remarks
Gain (DB)	21.5	24	increases
Noise Figure(DB)	13.8	15	Increases
ASE noise (Forward & Backward)	50mw	100mw	ASE noise increases
	10mw	20mw	ASE noise increases

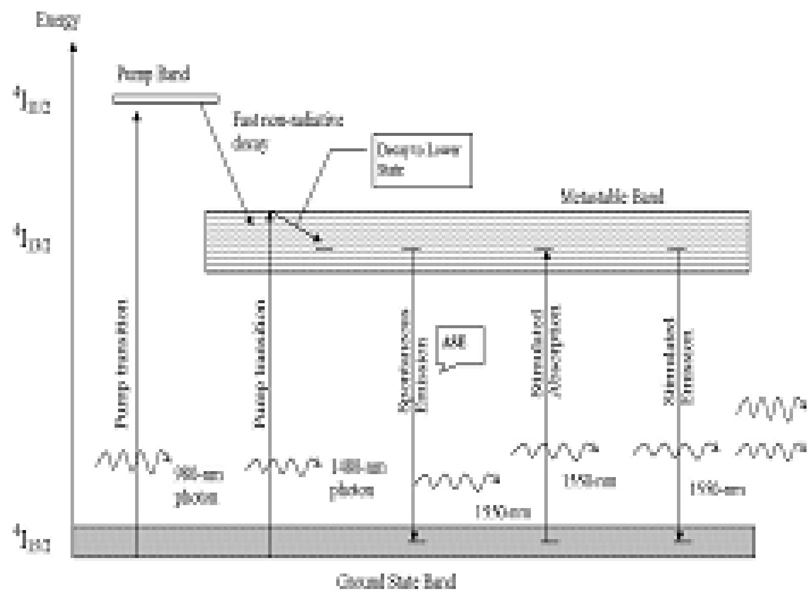

Figure 1. ASE noise in EDFA energy band diagram

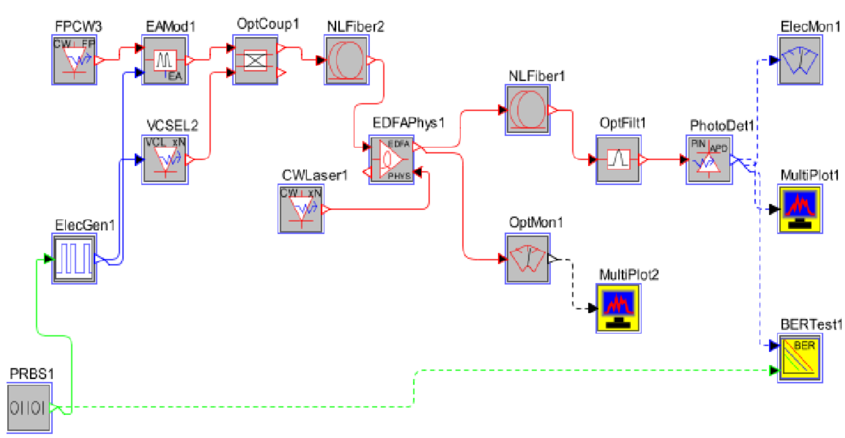

Figure 2. Simulated model of EDFA with FPCWL source using single Pumping scheme

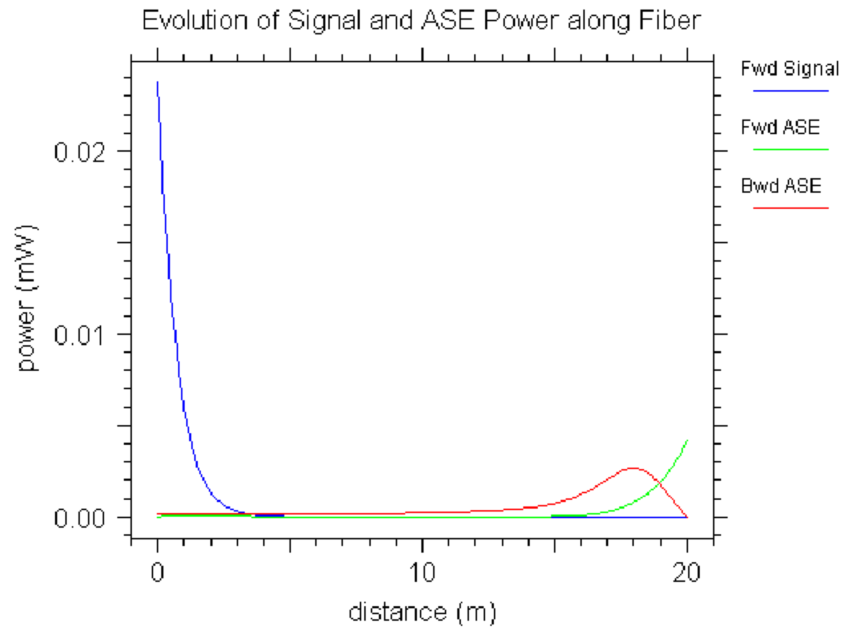

Figure 3. ASE Noise characteristics of single pumping EDFA of length 20m and pump power 1mw and FPCWL source = 0.1mw

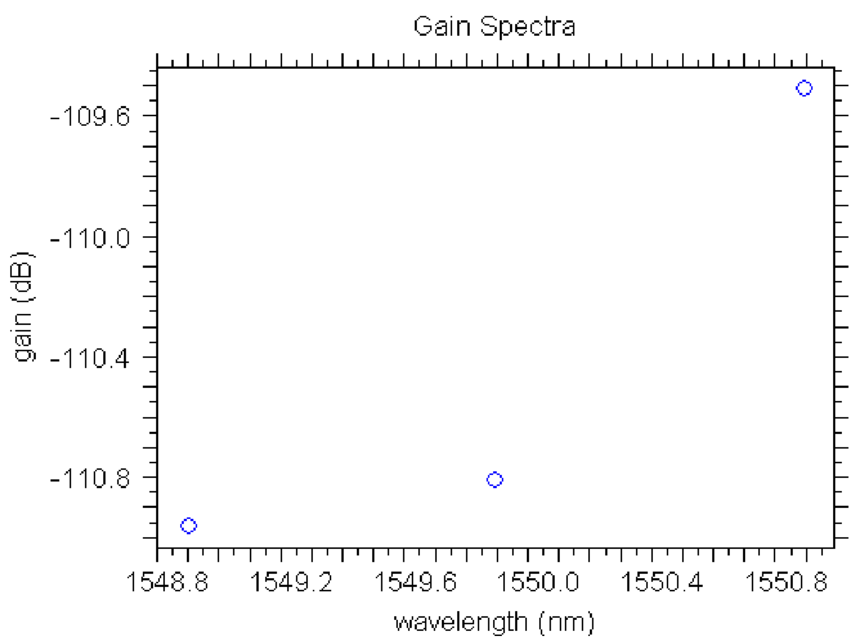

Figure 4. Gain spectrum output of EDFA with FPCWL source power 0.1mw

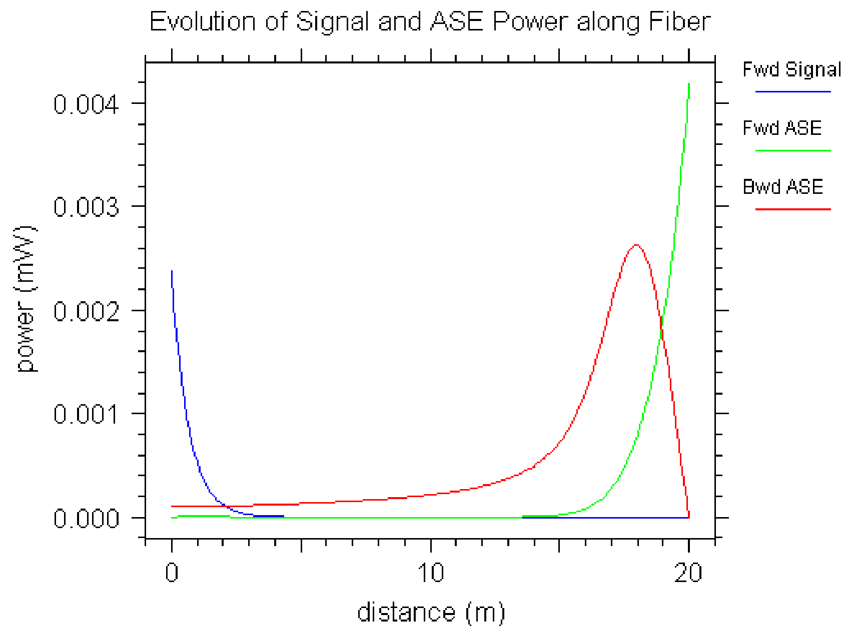

Figure 5. ASE Noise characteristics of single pumping EDFA of length 20m and pump power 1mw and FPCWL source = 0.01mw

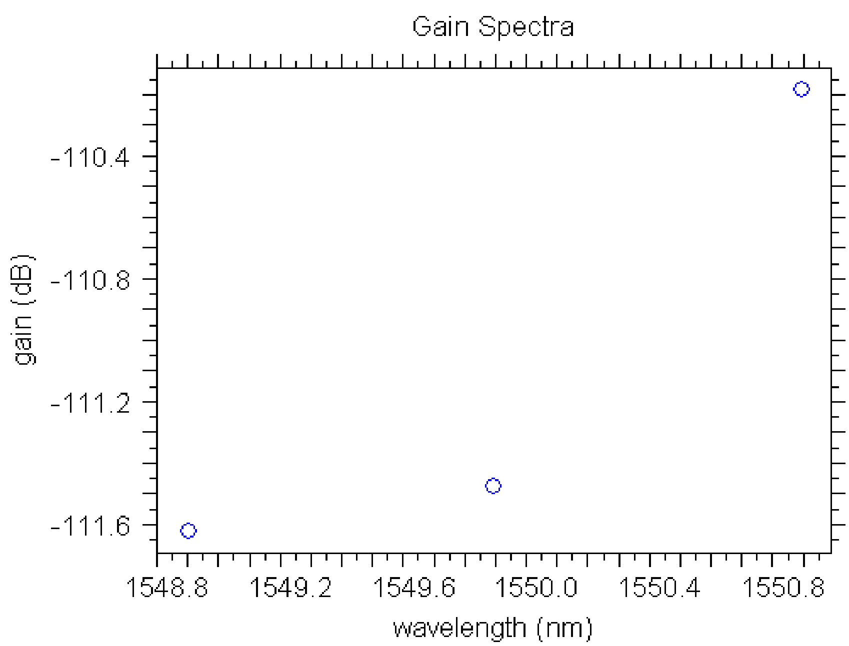

Figure 6. Gain spectrum of EDFA of FPCWL source power = 0.01mw

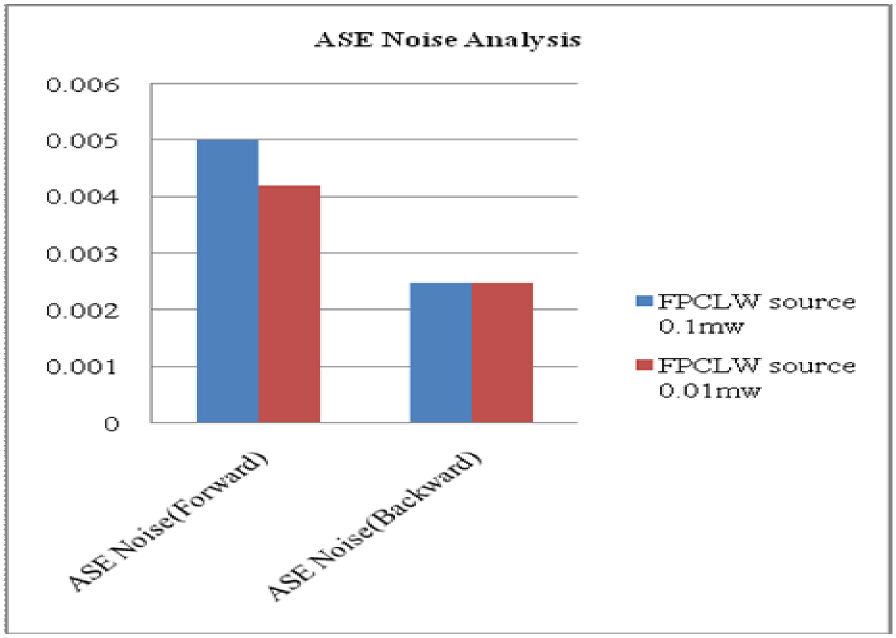

Figure 7. Plotted the ASE noise in single pumping analyzed with different single FPCWL source of 1550nm

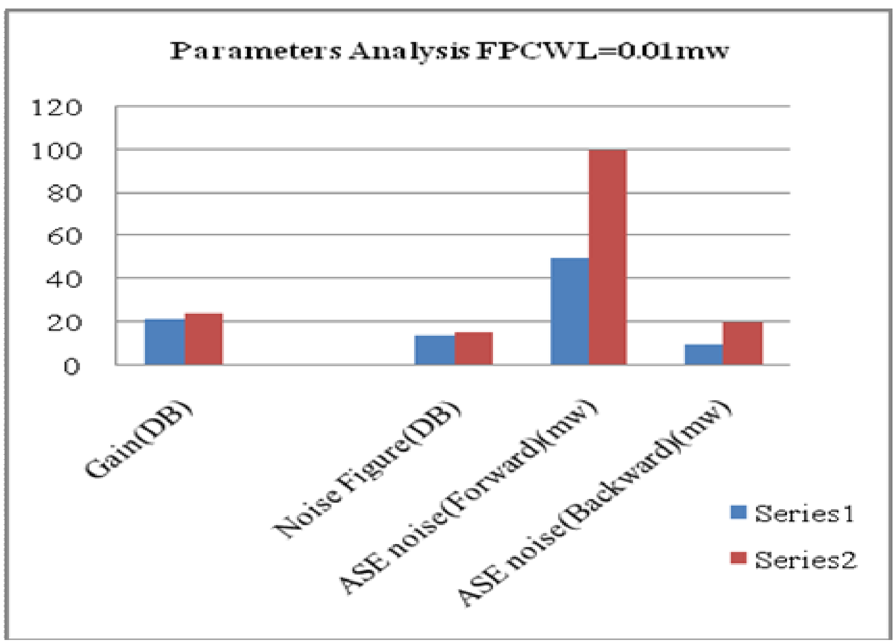

Figure 8. Plotted the EDFA Parameters with the constant input signal power = 0.01mw