Gain Stabilization and Analysis of Various Configurations of Hybrid Optical Amplifiers

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Abstract: *The Hybrid optical amplifiers are the key components for increasing the flexibility and capacity of long haul optical fiber communication systems. The Hybrid optical amplifiers find a wide range of applications in today's scenario and are successful in achieving flat gain which is very important in order to have long distant communication.*

Index Terms: *Erbium doped fiber amplifier (EDFA), Raman amplifier, Ytterbium doped fiber amplifier (YDFA), Fiber optic communication.*

1. Introduction

With the advancement in fiber optic communication, great need arises to send more and more data over optical fibers. With the increased data carrying capacity of fiber optic communication system it becomes more and more popular. The fiber optic communication system used a light carrier with the highest frequency range i.e. in the range of Terahertz among all the practical signals this is the reason due to which it have the highest information carrying capacity. Wavelength division multiplexing (WDM) systems allow transmission of number of wavelengths simultaneously and in current scenario, the WDM technology finds a wide range of applications in fiber optic communication not only this, use of WDM technology along with hybrid optical amplifiers such as EDFA and RFA provides a number of advantages such as increased data carrying capacity, long distant communication becomes flexible and easier.

The WDM technology is growing fast because it can handle many optical signals simultaneously thus it is smooth and the expansion of capacity is easily manageable [1]. Due to continuous growth in optical fiber communication technology the need of hybrid amplifiers increased the reason being the hybrid amplifiers enhances the gain-bandwidth and also reduces the distortions which arises in optical fiber. Semiconductor optical amplifiers (SOAs) can replace EDFAs but they produce a great amount of amplified spontaneous emission (ASE) noise and other signal

impairment [2]. Compared to SOA and EDFA, distributed Raman amplifier (DRA) provide broad amplification spectrum, producing very little signal distortions, even noise figure (NF) values can be obtained [3]. Increase in data rate, brings back the Raman amplifiers in optical networks due to several merits of Raman amplifiers such as flat gain, larger bandwidth and there is possibility of employing a Raman amplifier in an already installed fiber [1], [4]. Raman amplifiers had a number of merits but on the other side its implementation in real scenario is a big challenge because selection of designing parameters such as number of pumps, pump wavelength, achievement of flat gain is very difficult.

2. Gain

Gain can be defined as ratio of output power to input power. It is given as:

$$\text{Gain} = \frac{P_{out}}{P_{in}} \quad (1)$$

And in decibels it can be represented as:

$$\text{Gain(db)} = \frac{10\log_{10}P_{out}}{P_{in}} (2)$$

3. Noise figure

The performance of ahybrid optical amplifier can be evaluated in terms of noise figure denoted by NF. It is a dimensionless quantity and can be defined as that how much an amplifier changes its input signal to noise ratio (SNR) to output signal to noise ratio (SNR) given as:

$$NF = \frac{SNR_{in}}{SNR_{out}} \quad (3)$$

where, SNR_{in} and SNR_{out} are input and output signal to noise ra
NF can also be defined as a figure of merit used to evaluate the noise performance of the optical amplifier.

4. Results

In proposed work the comparison is made between YDFA optical amplifier and EDFA optical amplifier in terms of gain (dB) and noise figure (dB). The tool used for simulation is MATLAB R2010a; it is a very flexible and powerful tool which can easily handle complex mathematical computations. The blue coloured line reveals the output of YDFA whereas the red dashed line reveals the EDFA output in terms of gain

and noise figure. From figure 1 it is clear that the output gain characteristics of YDFA is much better than EDFA. The output gain of YDFA is around 35dB whereas the output gain of EDFA is around 26dB, thus the gain of YDFA amplifier is much higher than EDFA gain. But the value of noise figure of EDFA is lesser than YDFA (the characteristic of YDFA is almost linear).

Next the comparison between various amplifiers i.e., EDFA, Hybrid EDFA and Raman, Hybrid EDFA and YDFA optical amplifiers in terms of gain at different wavelengths is as shown in figure 2. The blue coloured line represents EDFA, the green coloured line represents hybrid EDFA and Raman optical amplifier whereas the red coloured line represents hybrid EDFA and YDFA optical amplifier. It is clear from the graph that a EDFA-only optical amplifier has lowest gain and the hybrid EDFA and YDFA optical amplifier has highest gain while hybrid EDFA and Raman optical amplifier lies in between of other two amplifiers. At 1500nm wavelength the gain for EDFA optical amplifier, EDFA and Raman hybrid optical amplifier and EDFA and YDFA hybrid optical amplifier is around 14dB, 16dB and 17.5dB respectively.

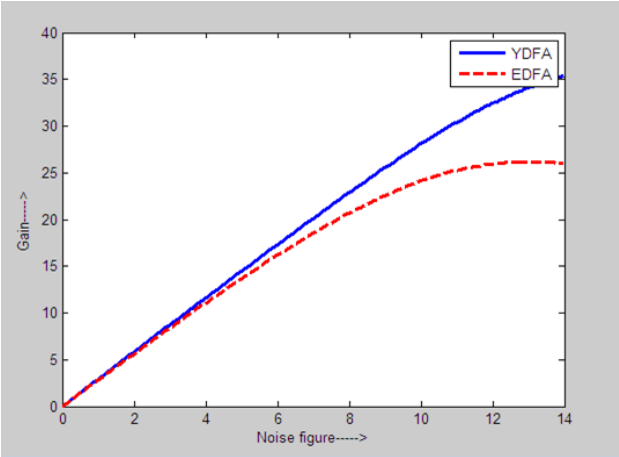

Fig.1 Comparison between YDFA and EDFA in terms of gain and noise figure

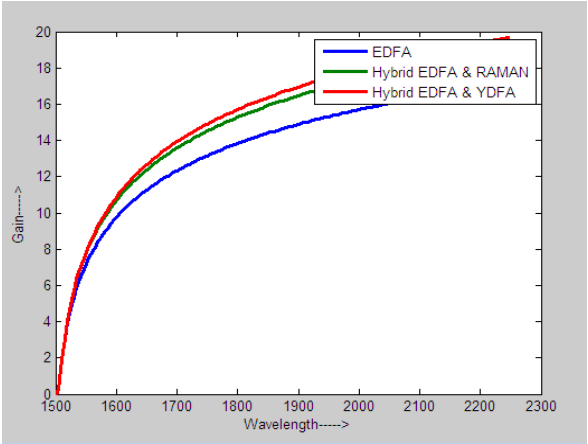

Fig. 2 Comparison between EDFA, Hybrid EDFA and Raman, Hybrid EDFA and YDFA in terms of gain at 1500nm wavelength

5. Conclusion

The comparison between EDFA and YDFA optical amplifiers is made in terms of gain and noise figure which concludes YDFA has more gain and more noise figure than EDFA. The characteristics of YDFA optical amplifier are nearly linear. From the comparison of optical amplifiers EDFA alone, hybrid optical amplifier EDFA/Raman and, hybrid optical amplifier EDFA/YDFA in terms of gain it can be concludedthat optical amplifier EDFA alone has lesser gain than other two hybrid optical amplifiers and hybrid optical amplifier EDFA/YDFA has maximum gain at same wavelength i.e. 1500nm while the gain of EDFA/Raman hybrid optical amplifier lies in between of other two amplifiers.

6. References

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