Analysis of Hybrid Optical Amplifiers for Dense Wavelength Division multiplexing

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ABSTRACT

This manuscript proposes the different models of hybrid optical amplifiers at different channel spacing and different transmission distance of an optical fiber. The proposed amplifiers are investigated for 4 channels DWDM system and the results are further compared in terms of Q- Factor and transmission distance. The setups of the different schemes of the hybrid optical amplifiers such as Raman-EDFA, Raman-EDFA-Raman, Raman-SOA, and EDFA-EDFA are studied and analyzed. The available Dense Wavelength Division Multiplex (DWDM) transmission system has been operated at the frequency spacing of 25 GHz, 50 GHz and 100 GHz and at different transmission distance ranging from 60 Km to 160 Km. It has been found that Raman-EDFA hybrid amplifier shows better results as compare to Raman-EDFA-Raman, Raman-SOA, and EDFA-EDFA hybrid amplifiers.

Keywords: hybrid amplifiers, DWDM, Raman-EDFA, Raman-EDFA-Raman, Raman-SOA, and EDFA-EDFA

1. INTRODUCTION

If we gather a light to previous work's the invention of EDFA takes the substitution for the ongoing research on the Hybrid Optical Amplifiers. In literature there were various combinations on the Hybrid Optical Amplifiers which are used to achieve the large bandwidth and gain flatness. These proposed amplifiers are investigated for the Wavelength Division Multiplexing system at 100 GHz [1]. There are various combinations of the amplifiers which are used in these processes or configurations such as Raman Amplifier, EDFA (Erbium Doped Fiber Amplifier), SOA (Semiconductor Optical Amplifier) and EYDWA (Erbium-Ytterbium Doped Fiber Amplifier) etc. [2-6]. Raman amplifier has attracted the huge attention because this amplifier is basically used for long-haul systems and high-capacity optical communication systems. This is the reason behind, that any wavelength within the transparency window of an optical fiber can be adjusted by using the pump wavelength or it should be easily amplified by changing the pump wavelength. If we talk about the Raman the purpose behind the attraction of Raman Amplifier is that it provides the large gain bandwidth which is typically in tens of nanometers (nm) and thus actually more than enough to amplify data channels with highest data rates without introducing any effects of gain narrowing [7, 8].

EDFA'S actually plays an important key role as the power boosters, optical repeaters and pre-amplifier in long distance optical fiber communication system. This proves and results in the formation of improved power and BER in DWDM systems [9-10]. Kim et al. [11] investigated the different optical amplifier for less number of channels with large channel spacing using Eye Pattern, BER (Bit Error Rate) and Q-Factor. Simranjit Singh et al. [12] presented a HOA (Hybrid Optical Amplifier) model using two stages DRA-EDFA dense wavelength division multiplexing system to minimize the gain variation without using any gain flattening techniques. It was observed that Raman-EDFA provides least bit error rate and high output power. This manuscript proposes the different models of hybrid optical amplifiers at different channel spacing and different transmission distance of an optical fiber. The proposed amplifiers are investigated for 4 channels DWDM system and the results are further compared in terms of Q- Factor, Transmission and Bit Error Rate.

2 SIMULATION SETUP

The proposed system has been simulated in Opt system 7.0 software. The setups of the different schemes of the hybrid optical amplifiers such as Raman-EDFA, Raman-EDFA-Raman, Raman-SOA, and EDFA-EDFA are studied and analyzed. The available DWDM transmission is operated in the frequency spacing of 25 GHz, 50 GHz and 100 GHz and at different transmission distance. Simulation setup of Hybrid Optical Amplifier Raman-EDFA at 25 GHz frequency spacing with varying transmission distance is shown below in the figure 1.

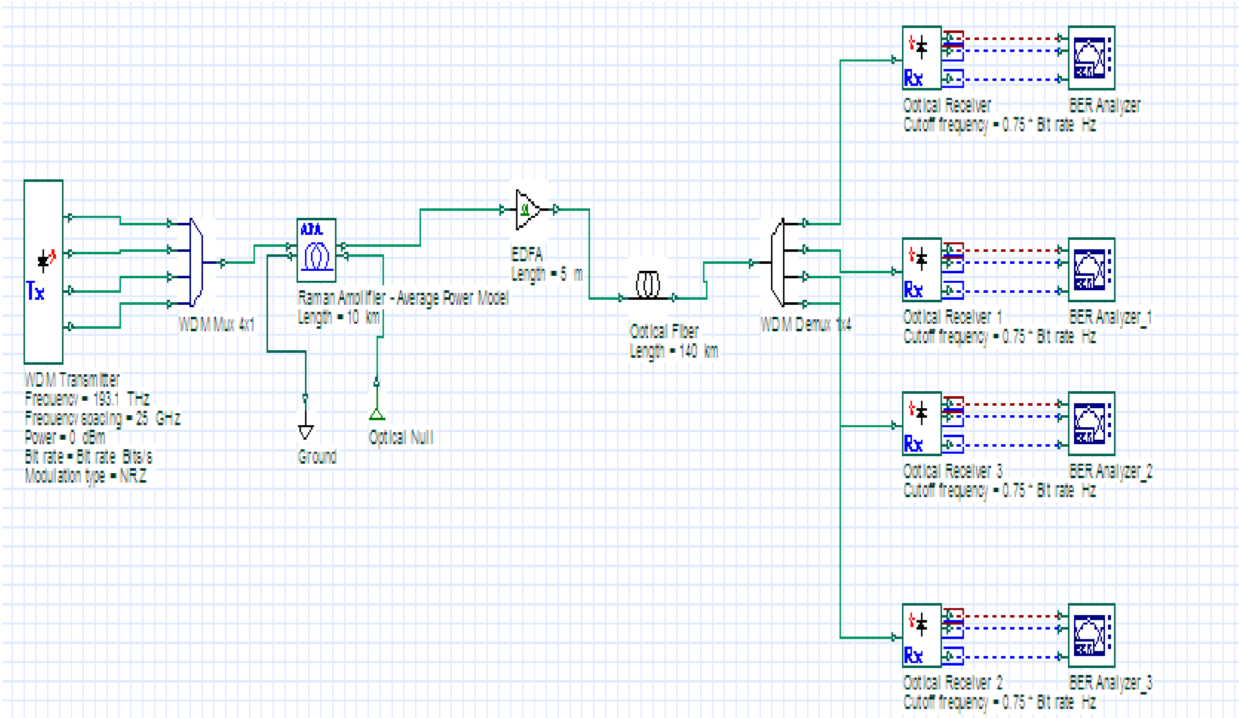

Figure 1: Simulation setup of Hybrid Optical Amplifier Raman-EDFA at 25GHz

Simulation setup of Hybrid Optical Amplifier EDFA-EDFA at 25 GHz frequency spacing with varying transmission distance is shown below in the figure 2.

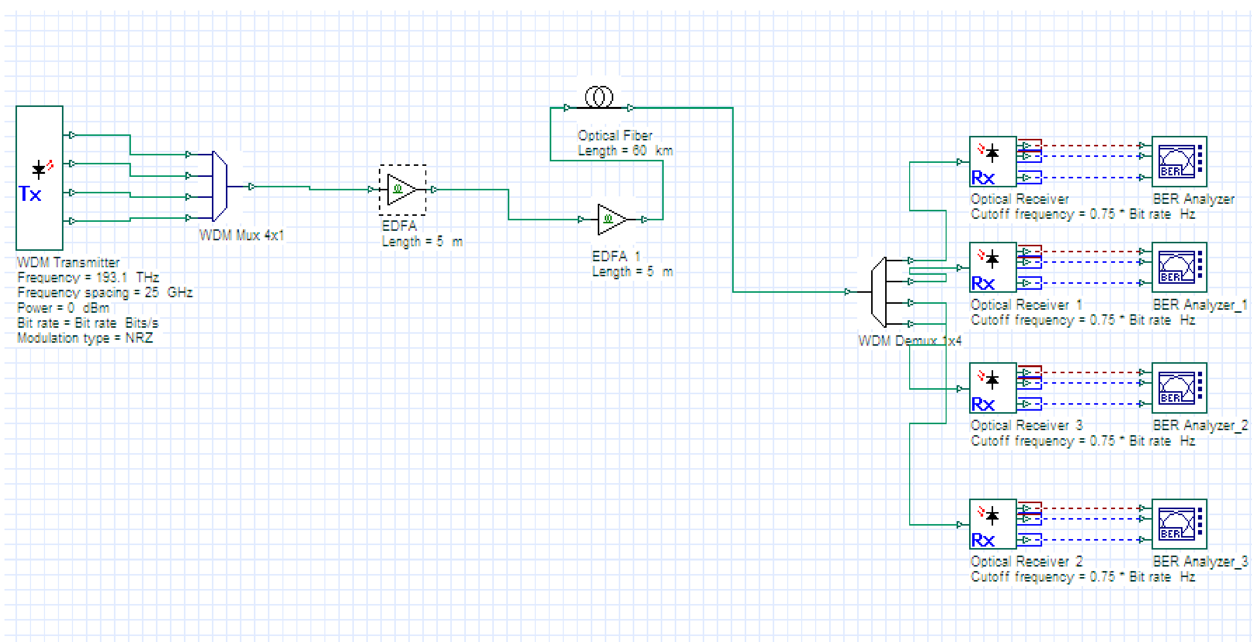

Figure 2: Simulation setup of Hybrid Optical Amplifier EDFA-EDFA at 25GHz

Simulation setup of Hybrid Optical Amplifier Raman-EDFA-Raman at 25 GHz frequency spacing with varying transmission distance is shown below in the figure 3.

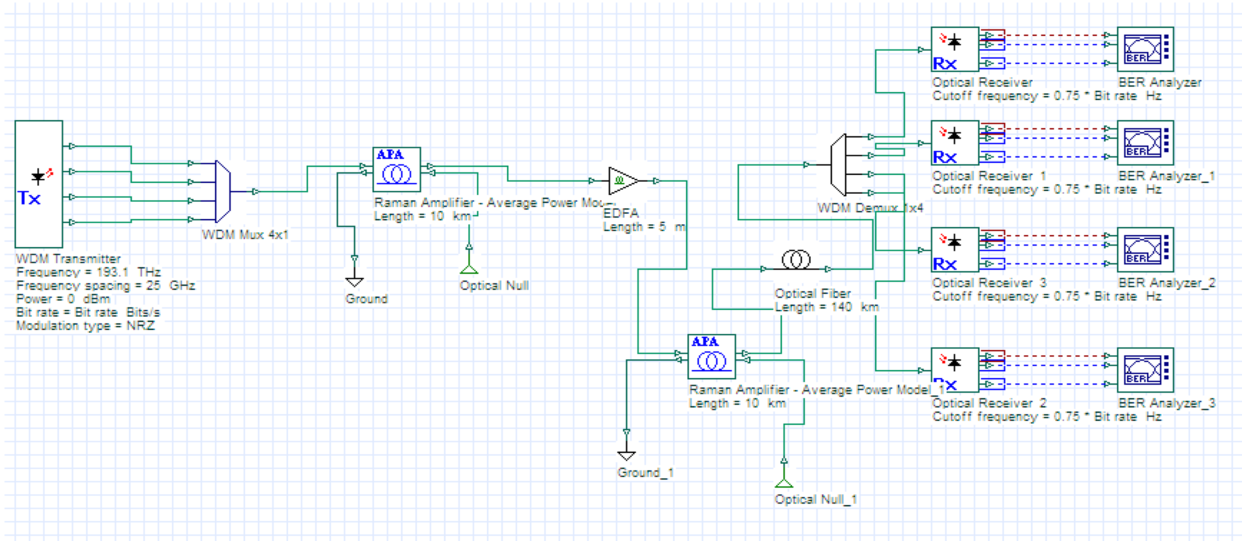

Figure 3: Simulation setup of Hybrid Optical Amplifier Raman-EDFA-Raman at 25GHz

Simulation setup of Hybrid Optical Amplifier Raman-SOA at 25 GHz frequency spacing with varying transmission distance is shown below in the figure 4.

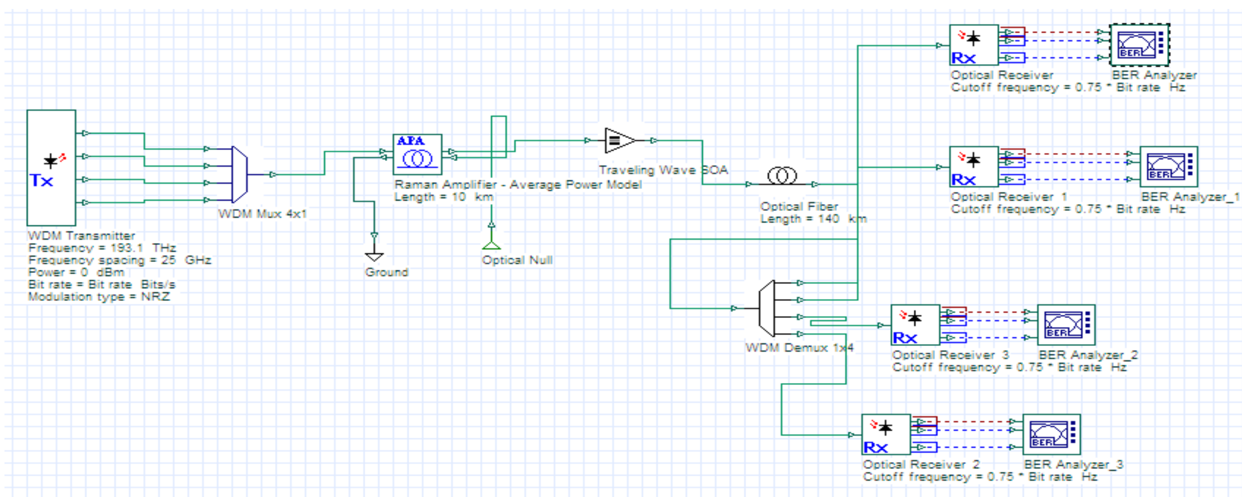

Figure 4: Simulation setup of hybrid amplifier Raman-SOA

In all the different combinations of hybrid optical amplifiers such as Raman-EDFA, Raman-EDFA-Raman, EDFA-EDFA and Raman-SOA, we have kept the frequency spacing of 25GHz with 4 channels by varying the transmission distance of the optical fiber from 60 Km to 160 Km. The various parameters for Raman, EDFA and SOA amplifiers have been given in the table 1, 2 and 3 respectively.

Table 1: DWDM Parameters for Raman Amplifier

Parameters	Value
Raman Loss	0.2dB/Km
Attenuation	0.2dB/Km
Power	500 Mw
Reference Frequency	1550 nm
Operating Temperature	300 K

Table 2: DWDM Parameters for EDFA Amplifier

Output power	32 mW
Gain	Flat
Noise Figure	3 dB

Table 3: DWDM Parameters for SOA Amplifier

Bias current	100 mA
Amplifier length	300
Input/output insertion loss	3 dB

3. RESULTS AND DISCUSSIONS

In this article, all the hybrid optical amplifiers are placed in the system with reduced channel spacing, the different quality factor after each amplifier stage are recorded at the first channel of the DWDM system.

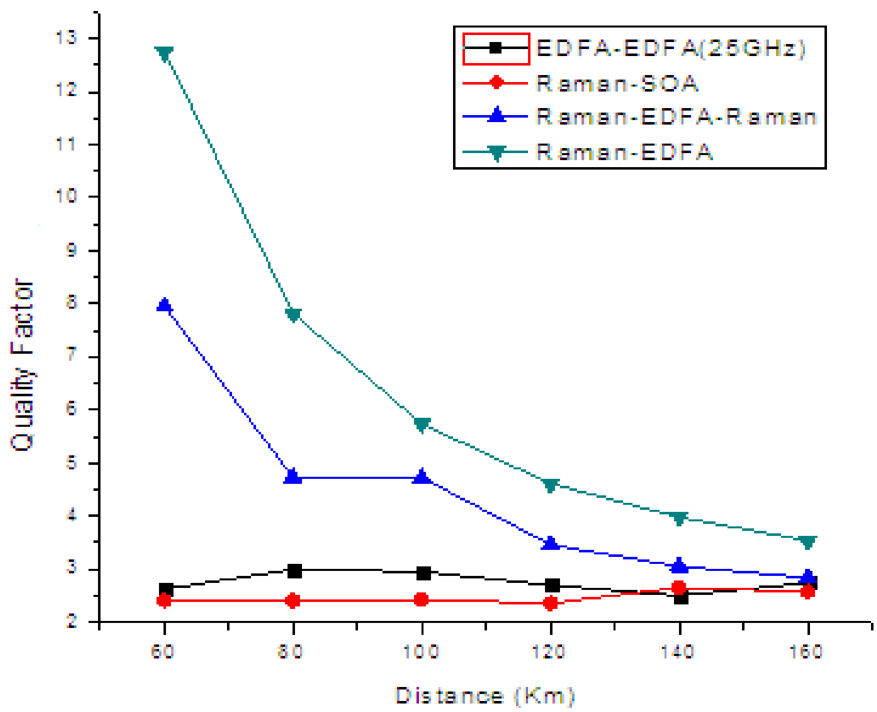

Figure 5: Quality Factor versus Distance for DWDM System at 25GHz

The above figure 5 shows the Quality Factor at various distances for EDFA-EDFA, Raman-SOA, Raman-EDFA-Raman and Raman-EDFA hybrid amplifiers after each hybrid optical amplifier at 25 GHz of channel spacing. This shows that as the channel spacing decreases the quality of the signal decreases. The quality factor varies for different hybrid optical amplifiers such as for Raman-EDFA is 3.53 dB to 12.74, for Raman-EDFA-Raman is 2.83 to 7.94, for Raman-SOA is 2.60 to 2.40 and for EDFA-EDFA is 2.73 to 2.62.

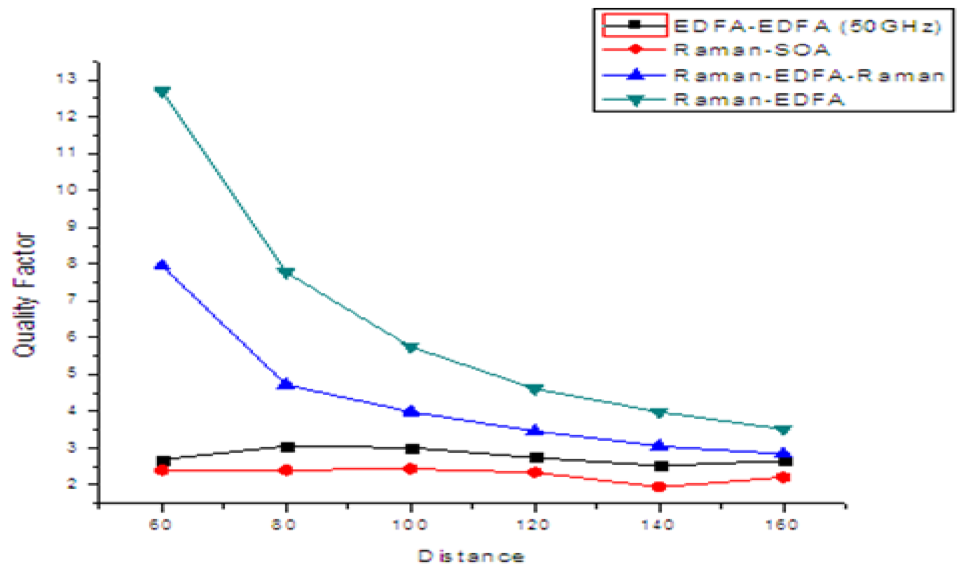

Figure 6: Quality Factor versus Distance for DWDM System at 50GHz

The above figure 6 shows the Quality Factor at various distances for EDFA-EDFA, Raman-SOA, Raman-EDFA-Raman and Raman-EDFA hybrid amplifiers after each hybrid optical amplifier at 50 GHz of channel spacing. The variation in the quality factor with respect to the transmission distance of an optical fiber of various hybrid optical amplifiers at channel spacing of 50 GHz for Raman-EDFA is 12.69 to 3.52, for Raman-EDFA-Raman is 7.94 to 2.83, for Raman-SOA is 2.40 to 2.20 and for EDFA-EDFA is 2.68 to 2.64.

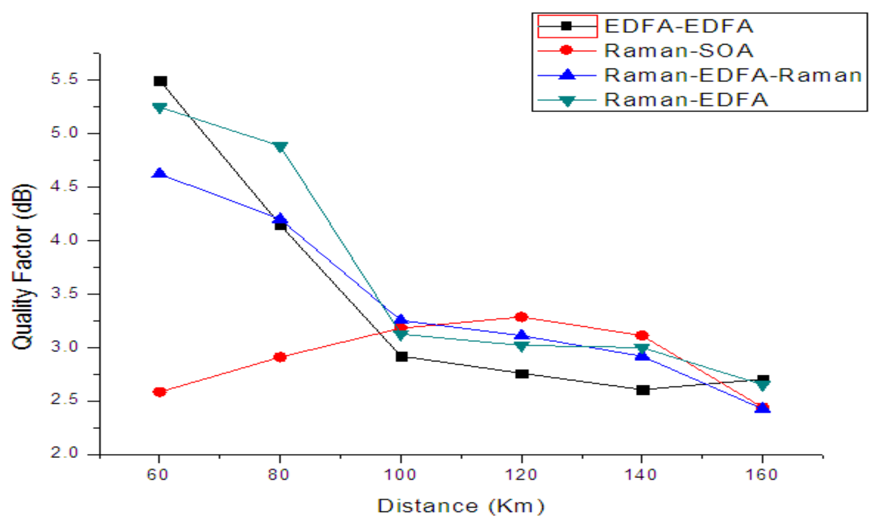

Figure 7: Quality Factor versus Distance for DWDM System at 100GHz

The figure 7 shows the Quality Factor at various distances for EDFA-EDFA, Raman-SOA, Raman-EDFA-Raman and Raman-EDFA hybrid amplifiers after each hybrid optical amplifier at 100 GHz of channel spacing. The variation in the quality factor for different hybrid optical amplifiers for different combinations such as for Raman-EDFA is 12.6961 to 2.65, for Raman-EDFA-Raman is 4.62 to 2.42, for Raman-SOA is 2.58 to 3.91 and for EDFA-EDFA is 5.49 to 2.70.

CONCLUSION

In this manuscript, the different models of hybrid optical amplifiers at different channel spacing and different transmission distance of an optical fiber has been investigated. The proposed amplifiers are investigated for 4 channels DWDM system and the results are further compared in terms of Q- Factor and transmission distance. The setups of the different schemes of the hybrid optical amplifiers such as Raman-EDFA, Raman-EDFA-Raman, Raman-SOA, and EDFA-EDFA are studied and analyzed. The available Dense Wavelength Division Multiplex (DWDM) transmission system has been operated at the frequency spacing of 25 GHz, 50 GHz and 100 GHz and at different transmission distance ranging from 60 Km to 160 Km. It has been found that Raman-EDFA hybrid amplifier shows better results as compare to Raman-EDFA-Raman, Raman-SOA, and EDFA-EDFA hybrid amplifiers.

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