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Performance Analysis of Hybrid Optical Amplifiers in 120 x 10 Gbps WDM Optical Network with Channel Spacing of 50 GHz

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Abstract-- **We investigated the performance of RAMAN--EDFA, RAMAN-SOA, EDFA-SOA hybrid Amplifiers in 120 channel WDM systems with each channel having data rate 10 Gbps at reduced channel spacing of 50 GHz. The performance has been compared on the basis of different fiber length at dispersion equal to 2 ps/nm/km in terms of Q- factor, BER and Eye opening. The results showed that RAMAN – EDFA provides the highest Q-factor, lowest BER and maximum eye opening up to distance of 100 km as compared to RAMAN-SOA and EDFA-SOA hybrid amplifiers. RAMAN – EDFA is the best alternative to RAMAN-SOA and EDFA-SOA in high capacity WDM system with reduced channel spacing.**

Keywords-- **Optical Amplifier, EDFA, SOA, RAMAN, WDM**

I. Introduction

Hybrid optical amplifiers are key devices to satisfy increasing need of transmission capacity for optical systems. Now days, the internet services requires large bandwidth which can be accomplished by wideband amplification of hybrid optical amplifiers. The distributed Raman amplifier can provide amplification at any wavelength by proper choice of pump signal wavelength through stimulated Raman scattering. The Erbium doped fiber amplifier (EDFA) amplifies signal wavelengths in 1550nm window while Semiconductor optical amplifier provides amplification both in 1310nm and 1550 nm optical window. Hybrid optical amplifiers consist of different configuration of semiconductor optical amplifier, EDFA and Raman amplifier.

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They can provide amplification in S+C+L band and thus increases transmission capacity of optical network. Flat gain bandwidth of 90.5 nm has been achieved for distance up to 50km using Raman-EDFA hybrid amplifier [1]. The placement of optical amplifier in pre, post and symmetric power compensation method has been studied [2]. The gain improvement by double passing signal in EDFA using a circulator has been investigated [3].The effect of amplified spontaneous noise on signal quality has been studied using different modulation formats [4]. The optimized gain is obtained in EDFA by using different simulation models with single pumping scheme [5].Wideband erbium doped fiber amplifier has been proposed using erbium doped zirconia fiber as gain medium [6].The performance of optical amplifiers in DWDM system has been studied at channel spacing of 100 GHz [7-10]. We extend the study by analyzing performance of hybrid amplifiers at reduced channel spacing to 50 GHz and with high capacity optical network. In our paper, we investigated performance of RAMAN-EDFA, SOA-RAMAN and SOA-EDFA hybrid amplifier configurations in 120 x 10 Gbps DWDM system at dispersion of 2 ps/nm/km at reduced channel spacing of 50 GHz.

II. Simulation Setup

In our study, 120 users transmitted their data at 10 Gb/s speed with channel spacing of 50 GHz. Each input signal is modulated in NRZ format. On transmitter side we design a transmitter compound component using 120 transmitters. This transmitter compound component consists of the data source, electrical driver, laser source and external Mach-Zehnder modulator in each transmitter section. The CW laser sources generate the 120 laser beams at 191.8 THz to 197.9 THz with 50 GHz channel spacing. The signals from data source and laser are fed to the external Mach- Zehnder modulator where the input signals from data source is modulated through a carrier (optical signal from the laser source). The optical signal is then multiplexed and sent over optical fiber .The communication link has hybrid optical amplifiers as inline amplifiers .The optical fiber length is varied from 80 km to 200 km in simulation models. The simulation set up is repeated for measuring the signal strength by using different amplifiers i.e. EDFA-SOA, RAMAN–EDFA, RAMAN-SOA using optisystem 7.0 simulation software. The performance of hybrid optical amplifiers is analyzed in terms of, Q-factor, BER (Bit Error Rate) and eye opening of eye diagram at receiver.

III. Results and Discussion

The multiplexed signal of data rate 1.2 Tbps is transmitted over single mode fiber having dispersion of 2 ps/nm/km and attenuation 0.2 dB/km. The biased current of SOA is taken as 100mA and Raman fiber length is 10km.The maximum small signal gain of EDFA is chosen to be 32 dB and noise figure. The signal is analyzed at distance of 80,100,120,140,150,160, 180,200 Km by BER analyzer. Fig.1. shows Q-Factor as function of transmission distance for different hybrid amplifiers. We found that by increasing the transmission distance from 80 to 200 km, Q factor is decreasing. High value of Q-factor means high value of quality of transmission. The variation in Q-factor at dispersion D=2 ps/nm/km is 28.12 dB to 4 dB for RAMAN-EDFA, 25.9dB to 7.3 dB for EDFA-SOA and 7.52 dB to 8.59 dB for RAMAN-SOA. We found that at distance of 100km RAMAN-EDFA provides highest Q-factor of 29.3 dB.

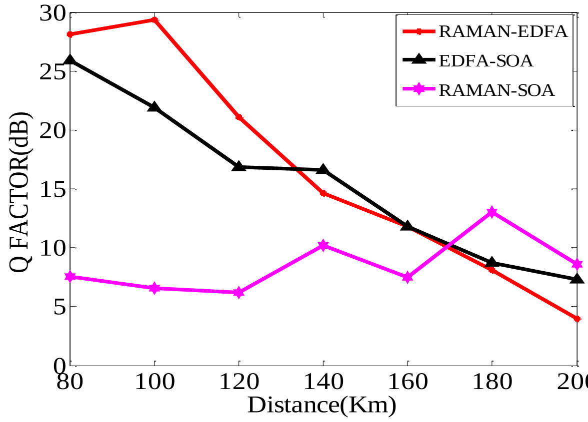

Fig. 1. Q Factor as function of distance for different hybrid configurations at D=2 ps/nm/km

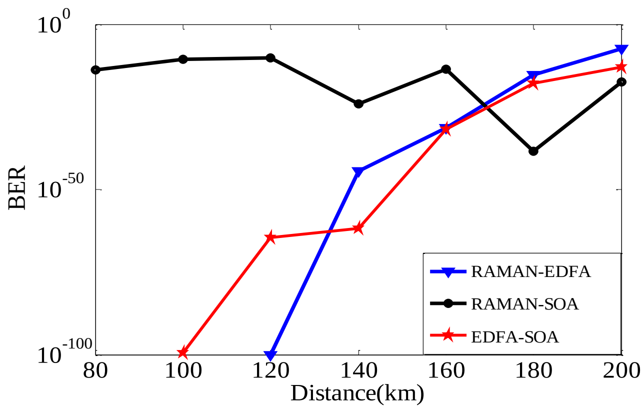

Fig. 2. BER as function of distance for different hybrid configurations at D=2 ps/nm/km

Fig.2. shows bit error rate variation of different hybrid amplifiers as function of transmission distance. The BER decreases as quality of transmission grows. We found minimum BER value is obtained from RAMAN-EDFA up to 130 km transmission distance and RAMAN-SOA provide minimum BER at distances exceeding 130km.

Fig.3. shows the variation of eye opening of eye diagram at the receiver of our system. .Large eye opening means less BER and good quality of communication. It is observed that by increasing the transmission distance from 80 to 200 km, eye opening is decreasing. The variation in eye opening from different optical amplifiers at dispersion D=2 ps/nm/km is 0.2 to 2×10-4 for RAMAN-EDFA, 0.07 to $4.4\text{x}10^{-4}$ for EDFA-SOA, 8.7×10-4 to1.9×10^{-4} for RAMAN-SOA. We found that RAMAN-EDFA provides the larger eye opening as compared to RAMAN-SOA and EDFA-SOA.

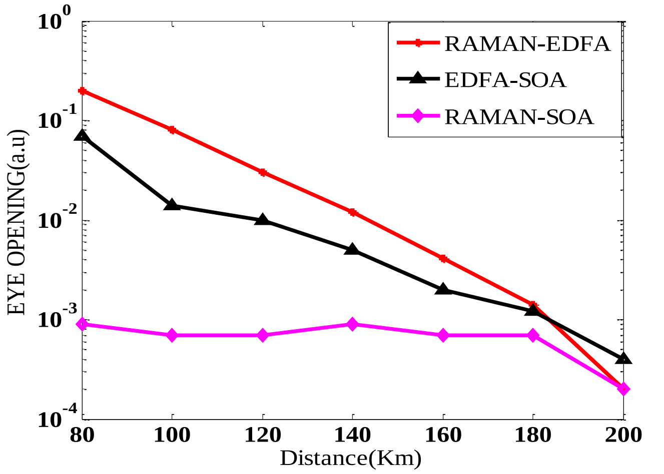

Fig. 3. Eye opening as function of distance for different hybrid configurations at D=2 ps/nm/km

The eye diagram of RAMAN –EDFA amplifier at distance of 100 km is shown in Fig.4.

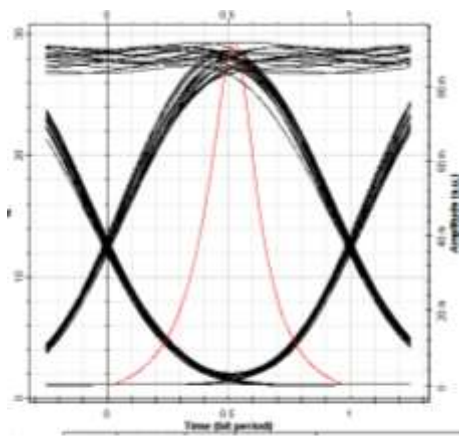

Fig.4. Eye Diagram of RAMAN-EDFA at distance of 100 km at D=2 ps/nm/km

Fig.5. shows the eye diagram of RAMAN – SOA amplifier and Fig .6 Shows eye diagram of EDFA – SOA. We found that EDFA –SOA has better eye diagram than RAMAN –SOA but it has less eye opening as compared to RAMAN-EDFA.

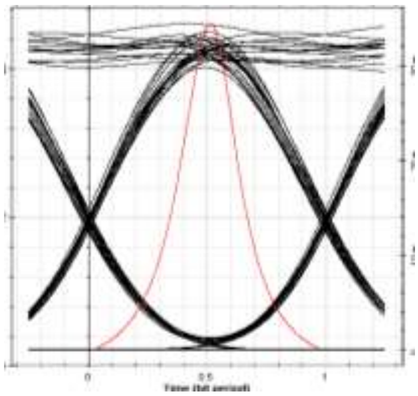

Fig.5. Eye Diagram of EDFA-SOA at distance of 100 km at D=2 ps/nm/km

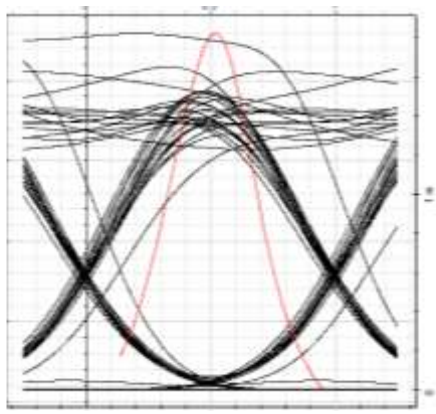

Fig. 6. Eye Diagram of RAMAN-SOA at distance of 100 km at D=2 ps/nm/km

IV. Conclusion

The performance of optical amplifiers was evaluated using the eye patterns, BER measurement, eye opening and Q factor. The simulation results show that RAMAN-EDFA performed better than EDFA-SOA, RAMAN-SOA optical amplifier up to distance of 120km. RAMAN-EDFA provides high Q-factor of 21.1 dB and minimum BER of $3.5x10^{-95}$ and eye opening of 0.1 a.u at distance of 100 km with dispersion of 2ps/nm/km in optical fiber. Above 120 km distance, EDFA-SOA performs better than RAMAN-EDFA and RAMAN-SOA amplifier. At distance of 180 km RAMAN-SOA gives better Q factor and BER than RAMAN-SOA and RAMAN-EDFA amplifier. The Q factor and eye opening are decreasing very rapidly after distance greater than 180 km. we place optical amplifier at distance of 80-100 km in optical network. This model provides RAMAN-EDFA is best alternative to EDFA-SOA and RAMAN-SOA at distance of 100 km in multiplexed system of 120 x 10 Gbps with channel spacing of 50 GHz.

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