



Performance analysis of different Hybrid optical amplifier due to varying Transmission distance at 10 Gbps

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Abstract: We have investigated the performance comparison of different hybrid optical amplifiers (RAMAN-EDFA, RAMAN-SOA, SOA-EDFA, EDFA-RAMANEDFA). The proposed configuration consists of 16 and 32 channels at speed of 10 Gbps. We have realized the different hybrid amplifiers and their parameters like quality factor, Min log of BER, Max eye opening and output power at different number of channels. The different combinations can provide a better result and better feasibility for long distance transmission.

Keywords: RAMAN-EDFA; RAMAN-SOA; SOA-EDFA; EDFA- RAMAN-EDFA; QUALITY FACTOR; BER; EYE OPENING; OUTPUT POWER

I. Introduction

In the fiber optic communication, there is degradation in transmission signal with the increase in distance [1]. To compensate signal degradation optoelectronic regenerators were used before the advent of optical amplifier. In optoelectronic regenerators, the optical signal is first converted into electric current and then regenerated by using a transmitter. But such regenerators become quite complex and expensive for wavelength division multiplexing systems. This reduces the reliability of networks as regenerator in an active device. Therefore, up gradation of multichannel WDM network [2] will require optical amplifier. To remove loss limitations and to amplify the signal, the optical amplifiers are used which directly amplify the transmitter optical signal without conversion to electric forms as in-line amplifiers. So, there is a demand to investigate the unrepeated all optical transmission and ultra fast broadband transmission over long distances. In order to achieve these objectives *i.e.* broadband and repeater less transmission of an optical communication system [3], it is of utmost importance to optimize the hybrid optical amplifier and then placement in optical networks.

Hidenori Taga *et al.* [4], discussed that until the optical amplifiers were developed, only the short distance (up to a few tens km) WDM system was in focus, because the optical repeaters for the WDM transmission were considered to be not practical. The advent of the optical amplifiers made it possible to construct the long distance. There are two types of OAs which are used in communication system; semiconductor optical amplifiers (SOAs) and doped fiber amplifiers (DFAs). The SOAs are basically semiconductor lasers which operate below lasing threshold.

The first fiber amplifiers were pumped by flash lamps and operated in a pulsed mode. In the mid- 1980s, the group led by D.N. Payne [5] at the University of Southampton, developed a technology of rare earth ions deposition in single-mode silica fibers and the first EDFA was reported in 1987. They are observed that Gains of up to 28 dB have been attained in the important wavelength region of 1.54 micrometre.

Desurvire E *et al.* [6] demonstrates the potential of erbium-doped fiber amplifiers for application in wavelength-division multiplexed communication systems. It has low insertion loss, low crosstalk, high gain, polarization insensitive and low noise figure. An EDFA has a comparatively wide wavelength range of amplification making it useful as transmission amplifier in wavelength division multiplexing systems.

Jowan Masum-Thomas *et al.* [7] designed a hybrid amplifier for short wavelength amplification. It is reported by cascading a Thulium doped fluoride fiber with a discrete Raman amplifier. Gain >20 dB for a bandwidth 1445 - 1520 nm (75 nm) was achieved and also Gain >30 dB and noise figures of between 7-8 dB were achieved for 50 nm bandwidth. They have achieved a flat gain without the usage of any gain flattening techniques due to the symmetric gain spectra of both amplifiers.

Ju Han Lee *et al.* [8] demonstrated the hybrid optical amplifier in which DCF based Raman amplifier is used which is cascaded with EDFA. They show experimental performance comparison of three types of single-pump highly efficient dispersion-compensating Raman/erbium-doped fiber amplifier (EDFA) hybrid amplifiers with respect to gain, noise figure (NF), and stimulated Brillouin scattering (SBS)- induced penalty: Raman/EDFA hybrid amplifiers recycling residual Raman pump in a cascaded erbium-doped fiber located either after (Type I) or prior to (Type II) a dispersion-compensating fiber, and a Raman assisted EDFA (Type III). To get higher OSNR Tuan Nguyen Van *et al.* [9] proposed three calculating models of Terrestrial cascaded EDFAs Fiber optical communication links using Hybrid amplifier.

The results from M. M. J. Martini *et al.* [10] demonstrated that the Raman/EDFA hybrid amplifier under recycling residual Raman pump, allied with the properly chosen of the pump wavelengths and powers, enables the construction of broadband amplifiers with enhanced power conversion efficiency and high and flat gains. It is

reported that best configuration considering two pump lasers is obtained with wavelengths 1425 nm and 1468.4 nm and powers of 296.3 mW and 61.3 mW, respectively.

We pursue and extend the same work in which we compared the performances of different hybrid amplifiers on various number of channels of 16 & 32.

II. Simulation Setup

In this work 16 and 32 channels are transmitted at 10 GB/s data rate with 0.1 THz channel spacing. We have used NRZ format and the launched signal after multiplexing into DS-anomalous fiber of different transmission distance. A transmitter compound component (T) is built up using 16, 32 transmitters. The signals from data source and laser are fed to the external Mach-Zehnder modulator ($\sin^2_MZ$ for all configurations), where the input signals from data source is modulated through a carrier (optical signal from the laser source). The simulation setup using RAMAN-EDFA as a compound component at different transmission distance is shown in Figure 1.

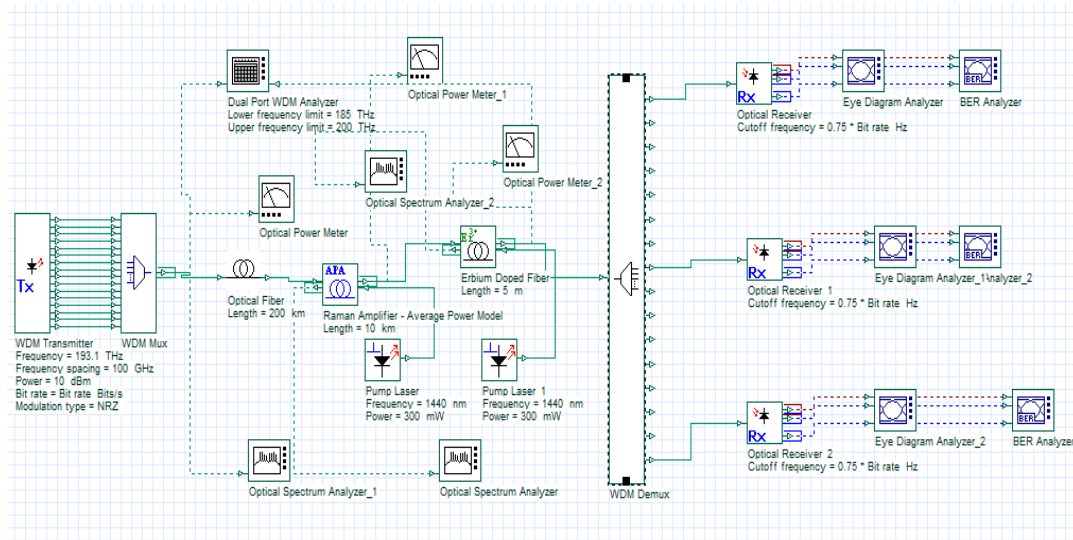


Figure 1 shows simulation diagram using Raman-EDFA amplifier of 16 channel system

This optical signal is transmitted and measured over different distance for 40, 80, 120, 160 and 200 Km (R) at 16.75 ps/nm/km dispersion. The modulated signal is converted into original signal with the help of PIN photodiode and filters. A compound receiver (R1) is used to detect all sixteen signals and converts these into electrical form. Different types of optical amplifiers are also applied at the receiver side. The set up is repeated for measuring the signal strength by using different hybrid amplifiers i.e. RAMAN-EDFA/ RAMAN-SOA/ EDFA-RAMAN-EDFA/ EDFA-SOA. For all the cases maximum Q-factor, output power, EYE opening factor and minimum BER have been evaluated.

For DS Anomalous fiber the reference frequency is 1550 nm and attenuation is 0.2dB/km. In this work the various parameter of EDFA are length 5 metre, numerical aperture 0.24. The various parameters for SOA are biased current is 100 mA, Amplifier length is 300×10^{-6} m, confinement factor is 0.35, insertion loss is 3 dB and output insertion is 3 dB. The various parameters for RAMAN are Raman fiber length is 10 km, operating temperature is 300 K, pump wavelength is 1480 nm and pump power is 300 mW.

III. Results and Discussions

The different hybrid amplifiers (RAMAN-EDFA, RAMAN-SOA, EDFA-RAMAN-EDFA and SOA-EDFA) have been compared for 16 X 10 and 32 X 10Gbps WDM system in the term of received maximum Q Factor (dB), minimum eye opening factor (dB), minimum BER and maximum output power (dBm). To analyze the system, the results of the first channel have been taken.

Fig 2 shows the variation of output power with respect to length of optical fiber with dispersion of 16.75 ps/nm/km. The highest output power is provided by EDFA-RAMAN-EDFA (26.78 dBm). Output power decreases as the length increases due to fiber attenuation & no of channels in the fiber. RAMAN-SOA provides the lowest value of output power among all the hybrid amplifiers.

The variation in output power for RAMAN-EDFA, RAMAN-SOA, EDFA-RAMAN-EDFA & SOA-EDFA are 24.88 to 17.98 dbm, 23.12 to 13.56 dBm, 26.78 to 24.74 dBm & 25.06 to 23.86 dBm respectively.

Fig 3 shows the variation of Q factor with length of 16 channel system. Maximum Q factor is provided by RAMAN-EDFA 4.82 dB which is same almost for entire range and start decreases after 120 km its worst value

at 200 km is 3.86 dB. RAMAN-EDFA & EDFA-RAMAN-EDFA have comparably same Q factor over distance range between 10-110 km & in last at 200 km EDFA-RAMAN-EDFA has highest value of 4.16 dB.

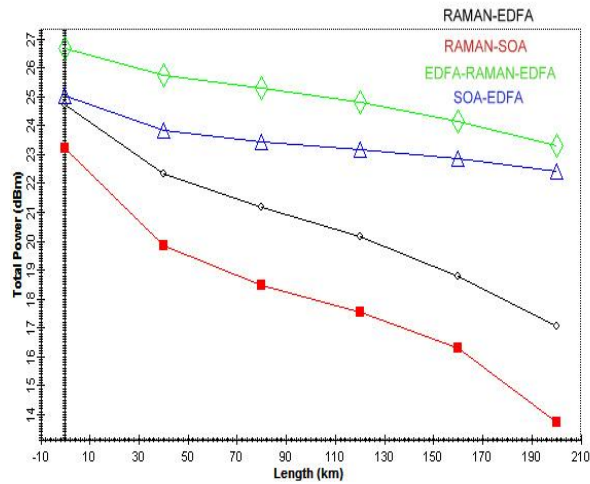


Fig 2: Variation of output power for 16 channel system

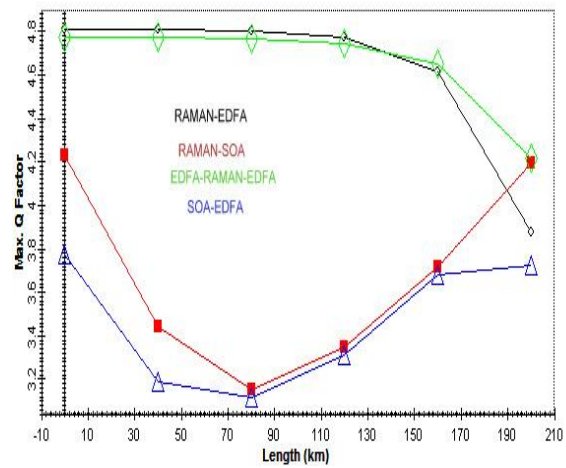


Fig 3: Variation of Q-Factor for 16 channel system

Fig 4 shows the variation of max eye opening factor with respect to length of optical fiber. Large eye opening means less BER & good communication. It is clearly visible in the graph that RAMAN-EDFA & EDFA-RAMAN-EDFA has best eye opening value. At a distance of 100 km values of eye opening for different hybrid amplifiers are 0.788(RAMAN-EDFA), 0.696(RAMAN-SOA), 0.790(EDFA-RAMAN-EDFA) & 0.694(SOA-EDFA) respectively.

The variation in Max eye opening Factor for RAMAN-EDFA, RAMAN-SOA, EDFA-RAMAN-EDFA & SOA-EDFA are 0.789 to 0.738, 0.764 to 0.762, 0.791 to 0.761 & 0.735 to 0.732 respectively.

Fig 5 shows the variation of Min log of BER with length of optical fiber. BER values increases as the distance increases. The acceptable Bit Error rate for the optical transmission is 1×10^{-10} . More BER means there is more distortion in the detected signal. The graph clearly shows that both RAMAN-EDFA & EDFA-RAMAN-EDFA have least value of Min log of BER i.e. -6.21.

The variation in Min log of BER for RAMAN-EDFA, RAMAN-SOA, EDFA-RAMAN-EDFA & SOA-EDFA are -6.21 to -4.23, -5.28 to -5.46, -6.21 to -5.42 & -4.69 to -4.73 respectively.

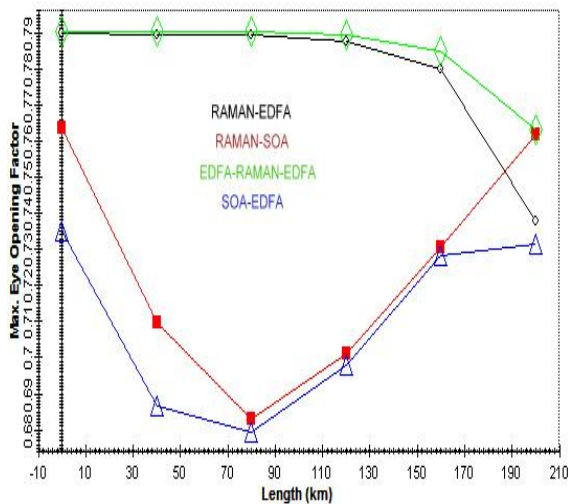


Fig 4: Variation of Eye opening Factor for 16 channel system

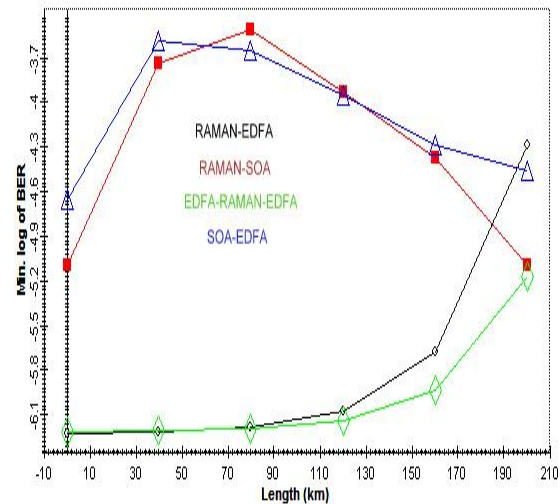


Fig 5: Variation of MIN log of BER for 16 channel system

Fig 6 shows the variation of output power with respect to length of optical fiber with dispersion of 16.75 ps/nm/km for 32 channel system. The highest output power is provided by EDFA-RAMAN-EDFA (26.83 dBm). RAMAN-SOA provides the lowest value of output power among all the hybrid amplifiers.

The variation in output power for RAMAN-EDFA, RAMAN-SOA, EDFA-RAMAN-EDFA & SOA-EDFA are 26.12 to 18.21 dbm, 25.38 to 15.56 dBm, 26.83 to 24.17 dBm & 26.08 to 22.94 dBm respectively.

Fig 7 shows the variation of Q factor with length of 32 channel system. Maximum Q factor is provided by RAMAN-EDFA 4.81 dB which increases in small amount for entire range and start decreases after 135 km its worst value at 200 km is 4.45 dB.

Both RAMAN-SOA & SOA-EDFA have comparably same value of Q- factor(4.16 dB) at length of 162 km. The variation in Q- Factor for RAMAN-EDFA, RAMAN-SOA, EDFA-RAMAN-EDFA & SOA-EDFA are 4.81 to 4.45 dB, 4.29 to 4.53 dB, 4.79 to 4.44 dB & 3.97 to 4.23 dB.

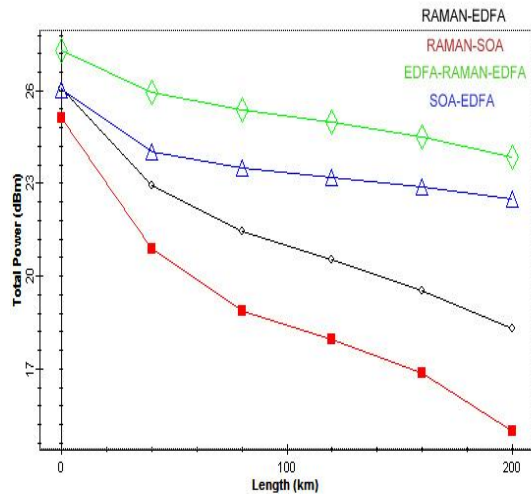


Fig 6: Variation of output power for 32 channel system

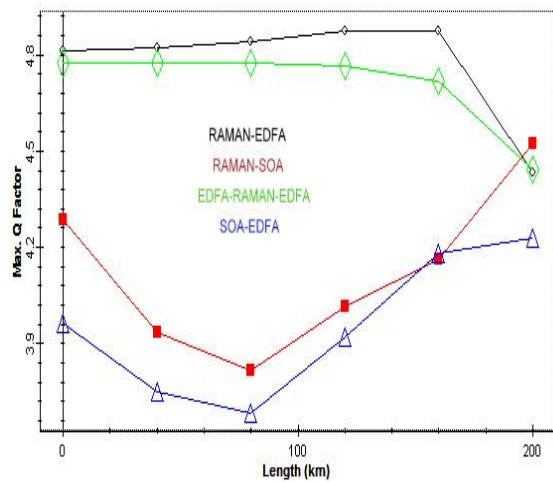


Fig 7: Variation of Q- Factor for 32 channel system

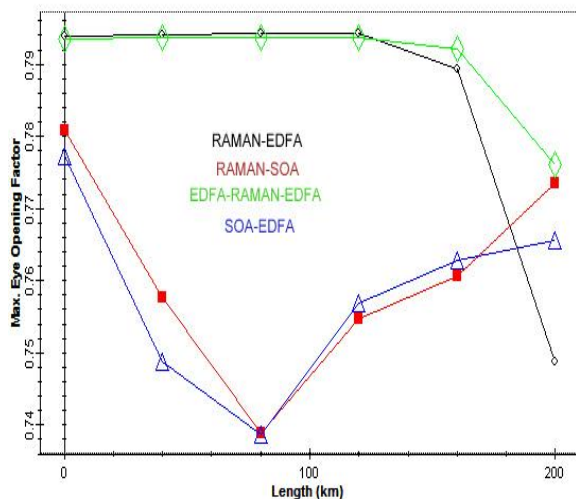


Fig 8: Variation of Eye opening Factor for 32 channel system

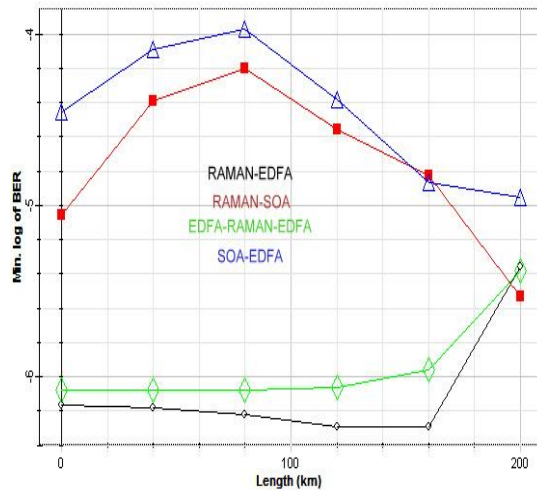


Fig 9: Variation of MIN log of BER for 32 channel system

Fig 8 shows the variation of max eye opening factor with respect to length of optical fiber. Large eye opening means less BER & good communication. Its clearly visible in the graph that RAMAN-EDFA has best max eye opening value. At a distance of 160 km values of eye opening for different hybrid amplifiers are 0.794(RAMAN-EDFA), 0.791(RAMAN-SOA), 0.759(EDFA-RAMAN-EDFA) & 0.762(SOA-EDFA) respectively.

The variation in Max eye opening Factor for RAMAN-EDFA, RAMAN-SOA, EDFA-RAMAN-EDFA & SOA-EDFA are 0.795 to 0.748, 0.782 to 0.775, 0.794 to 0.776 & 0.778 to 0.762 respectively.

Fig 9 shows the variation of Min log of BER with length of optical fiber. BER values increases as the distance increases. The acceptable Bit Error rate for the optical transmission is 1×10^{-10} . More BER means there is more distortion in the detected signal. The graph clearly shows that RAMAN-EDFA have least value of BER at the distance of 165 km(-6.24) and in worst case at 200 km its value is -5.54.

The variation in Min log of BER for RAMAN-EDFA, RAMAN-SOA, EDFA-RAMAN-EDFA & SOA-EDFA are -6.24 to -5.54, -5.08 to -5.64, -6.15 to -5.55 & -4.46 to -4.88 respectively.

IV. Conclusion

In this research paper the performance of different combination of optical amplifier i.e. hybrid optical amplifier for 16 x10 & 32 X 10 Gbps WDM system has been examined. These comparisons have been done by varying transmission distance in between 10 to 200 km with a dispersion of 16.75 ps/nm/km. The performance was evaluated on the basis of parameter like output power, Q- factor, Min log of BER & eye opening factor. Now it is observed that EDFA-RAMAN-EDFA provides better results for output power. In 16 channel system both RAMAN-EDFA & EDFA-RAMAN-EDFA have same value for Q-factor & BER for short distance but for long distance EDFA-RAMAN-EDFA has highest value among all. But as the no channel increases i.e. in 32 channel system RAMAN-EDFA shows best performance in terms of Output power, BER & Q-factor.

V. References

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