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Transmission Performance 64 × 10 Gb/s WDM system based on optical hybrid amplifiers Using RZ- Soliton modulation format at different transmission distance

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ABSTRACT: - *In this paper we study the DWDM 10 Gbps systems at 64 channels have been investigated with different hybrid configuration of EDFA, RAMAN and SOA amplifiers and the performance has been compared on the basis of transmission distance and dispersion with nonlinearities. Here the investigation focused on RZ-Soliton data format. The amplifiers EDFA and SOA, RAMAN have been investigated with different configuration and with hybrid optical amplifiers like SOA-EDFA-RAMAN. It is observed that hybrid optical amplifier SOA-EDFA-RAMAN provides the highest output power (7.66 dBm and 7.90 dBm) and least bit error rate (*1.099×10^{-39} *and* 0.999×10^{-40}*) at presence and absence of nonlinearities for dispersion 2 ps/nm/km at 200 km. We also observe Q-factor, BER and Average Eye Opening at different distance. This Hybrid amplifier provides better results in the term of BER and output power, but it shows non-uniform gain spectrum.*

I. INTRODUCTION

With the development of reliable commercial optical amplifiers in the early 1990s the high capacity and low cost per- bit of wavelength-division multiplexed (WDM) transmission systems were soon realized. The introduction of the erbium-doped fiber amplifier (EDFA) revolutionized optical communications by simultaneously amplifying a multiplicity of WDM channels. Optical amplifiers have several advantages over regenerators. Optical amplifiers can be more easily upgraded to a higher bit rate. In an optical communication system, as the optical signals from the transmitter propagate through optical fiber are attenuated by it and losses are added by other optical components, such as multiplexers and couplers which causes the signal to become too weak to be detected. Before this the signal strength has to be regenerated [1]. There are versatile amplifiers have been demonstrated in the lab, such as semiconductor optical amplifiers (SOA), EDFA and Raman amplifiers, these technologies have not gained wide commercial acceptance due to their inability to compete with the low cost and high performance of EDFAs. High spectral efficiency in DWDM system can be achieved with an attractive bit rate of 10Gbps [2]. 100GHz and 50GHz frequency spacing in DWDM systems are used for implementing metro and local area network systems, due to cost advantages [3]. But the dispersion and nonlinearity must be managed to achieve transmission over an appreciable distance. Dispersion management, utilizing specialized fiber of opposite direction values, is a key technique that keeps the total accumulated dispersion low while suppressing the nonlinear effects. The combination of an erbium-doped fiber amplifier (EDFA) and a fiber Raman amplifier (FRA or RA) is called a hybrid

amplifier (HA), the RAMAN-EDFA and SOA-EDFA-RAMAN. Hybrid amplifier provides high power gain. Raman amplifier is better because it provides distributed amplification within the fiber. Distributed amplification uses the transmission fiber as the gain medium by multiplexing a pump wavelength and signal wavelength. It increases the length of spans between the amplifiers and regeneration sites. So this provides amplification over wider and different regions [4]. HYBRID Raman/erbium-doped fiber amplifiers (HFAs) are an advance technology for future. Hybrid Raman/erbium doped fiber amplifiers are designed to maximize the long-haul transmission distance [5].

Manoj Kumar et.al[6] investigation on optical soliton transmission link with in-line SOA at 1.3 mm has been carried out to show that soliton pulses when propagated with a $\beta_2 = -0.5ps^2/k.$ indicate the pattern effect for soliton propagation best suited for transmission upto the distance of 400 km.

Singh et al. [7] concluded that the post-power compensation method shows good performance in terms of bit error rate, eye closure penalty and received power as compared to pre- and symmetrical power compensation methods. The bit error rate and eye closure penalty increases with increase in the signal input power.

S.Singh et al.[8] investigated the 16×10, 32×10 and 64×10Gbps WDM lightwave system using optical amplifiers with and without non-linarites and concluded that when the dispersion is 2 ps/nm/km then SOA provide better results but as we increase the number of channels it degraded the performance because gain saturation problem arises. If we increase the dispersion and number of channels then EDFA provides better results than SOA.

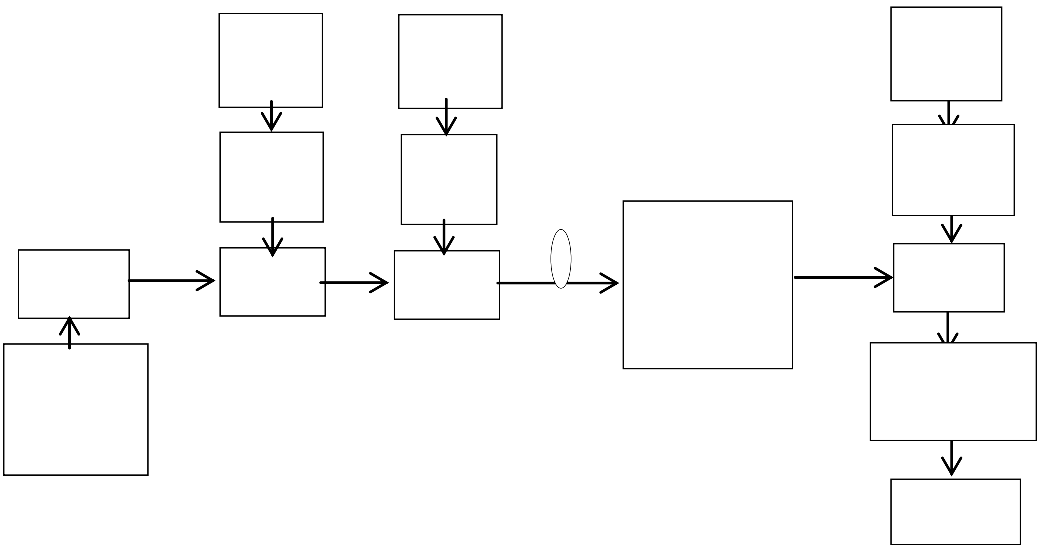

Fig. 1: Simulation Setup

II. SIMULATION SETUP

In this figure 1 Shown above 64 channels are transmitted at 10Gb/s speed of data. Input signals are pre-amplified by a booster and these signals are transmitted over optical fiber of different transmission distances. The figure shows the Compound component composed of different configuration of hybrid optical amplifier at different distance and dispersion. This transmitter compound component consists of the data source, electrical driver(RZ-Soliton format), laser source and external Mach-Zehnder modulator (sin^2_MZ for all configurations),in each transmitter section. The data source is generating signal of 10 Gb/s with pseudo random sequence. The electrical driver converts the logical input signal into an electrical signal. The CW laser sources generate the 64 laser beams at 188.28 THz to 194.72 THz with 100 GHz channel spacing. These beams have random laser phase and ideal laser noise bandwidth. 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 output signal is transmitted over different distance for 40 80 120 160 200 240 km for 64 channel at 2 ps/nm/km dispersion. Optical power meter and optical spectrum analyser with splitter are used for calculating signal power and spectrum. Receiver is used to receive 64 output signals different levels. Optical signals are amplified using hybrid amplifier. The signal power is measured by power meter and optical probe. The modulated signal is converted into original signal with the help of PIN photodiode and filters. A compound receiver is used to detect all signals and converts these into electrical form is the variable length of 40 80 120 160 200 240 km for 64 channels for long hual transmission of optical fiber using hybrid Optical amplifiers. For all type of hybrid amplifier we have evaluated maximum Q factor, output power, minimum BER and Eye opening.

For DS Anomalous fiber the reference frequency is 193.414 THz and attenuation is 0.2 dB/km .In this paper we have used fixed out-put power configuration EDFA and its output power is 15 dBm, gain shape is flat and noise figure is 4.5 dB. The various parameters for SOA are biased current is 100 mA, Amplifier length is 3×10^{-6m}, confinement factor is 0.35, insertion loss is 3 dB and output insertion loss 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

Performance of different hybrid amplifiers configuration is compared at different distance and dispersion. The optical signal is connected to different optical amplifier through a splitter. In order to observe the performance of different hybrid amplifiers, the output power vs. transmission distance graphs are shown in the presence of nonlinearities. These graphs show that as we increase the transmission distance from 40 to 240 km, the output power decreases simultaneously. The variation in output power due to presence of nonlinearities from different optical amplifiers at 200km is 31.38 to 1.298 dBm for EDFA-EDFA, 11.49 to -7.709 dBm for RAMAN-SOA, 22.82 to -7.45 dBm for RAMAN-EDFA, 18.90 to 5.85 dBm for EDFA-SOA,22.60 to -8.06 dBm for EDFA-RAMAN, 27.00 to 7.66 dBm for SOA-RAMAN-EDFA and 17.84 to 5.32 dBm for RAMAN-

EDFA-SOA. The variation in output power due to absence of nonlinearities from different optical amplifiers at 200km is 22.84 to -7.48 dBm for EDFA-EDFA, 11.41 to -7.705 dBm for RAMAN-SOA, 22.84 to -7.48 dBm for RAMAN-EDFA, 18.90 to 5.85 dBm for EDFA-SOA, 22.61 to -8.20 dBm for EDFA-RAMAN, 27.32 to 7.90 dBm for SOA-RAMAN-EDFA and 17.85 to 5.31 dBm for RAMAN-EDFA-SOA respectively. If we have not considered the nonlinearities, better output power is provided but little variation in power in all cases. But in the SOA_RAMAN_EDFA hybrid amplifier at 40km power

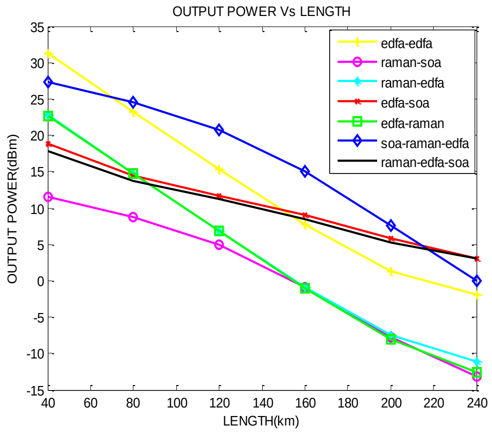

Fig 1: Output Power vs. Distance for in the presence of nonlinearities

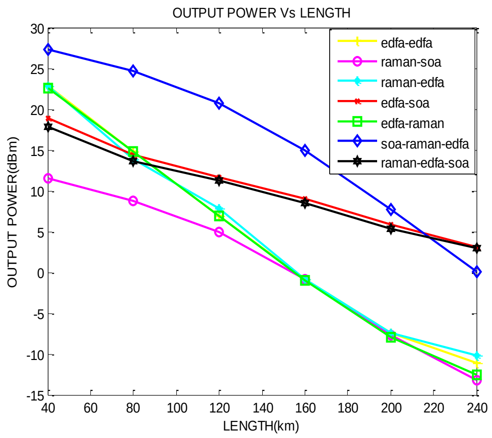

Fig 2: Output Power vs. Distance for in the absence of nonlinearities

is 27.84 dBm and also for the worst case (at 200 km) it becomes 7.90 dBm as compare to other amplifiers as shown in Fig.2.

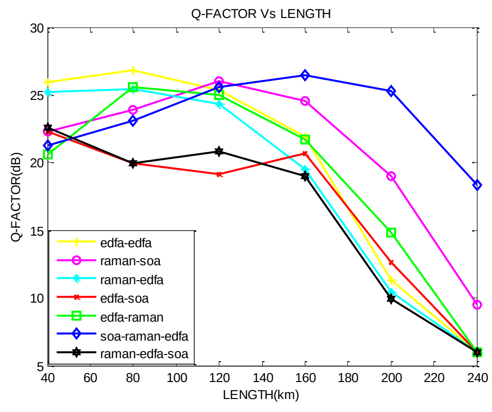

Fig 3: Q-fector vs. Length in the absence of nonlinearities.

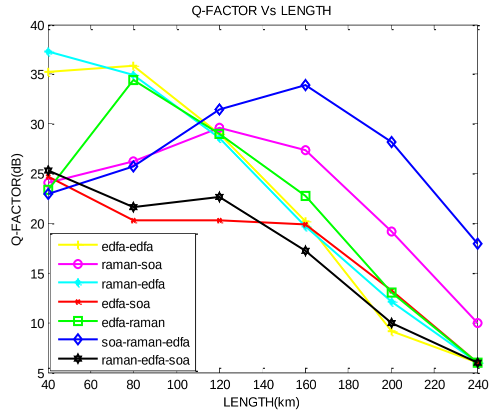

Fig 4: Q-fector vs. Length in the absence of nonlinearities.

Fig. 3 Q-factor as a function of length is ploted in the presence of nonlinearities. Up to 160 km SOA_RAMAN_EDFA has increased Q-factor and then start decreasing but all other hybrid amplifiers has continually decrement in Q-factor. SOA_RAMAN_EDFA amplifier provides best Q-factor among all for distance 160 km onwards and also for the worst case (at 200 km) it becomes 25.29 dB. The variation in Q-factor for other hybrid optical amplifiers at 200 km is 25.93 to 11.35 dB for EDFA-EDFA, 22.33 to 18.96 dB for RAMAN-SOA, 25.32 to 10.46 dB for RAMAN-EDFA, 22.303 to 12.67 dB for EDFA-SOA, 25.60 to 14.83 dB for EDFA-RAMAN and 22.60 to 9.98 dB for RAMAN-EDFA-SOA.

If we are not considered the nonlinearities, up to 160 km SOA_RAMAN_EDFA provides higher and better value of Q- factor among all and at 200 km all the amplifiers have comparable Q-factor as shown in Fig. 4. The variation in Q-factor for other hybrid optical amplifiers at 200km is 35.28 to 9.13 dB for EDFA-EDFA, 24.11 to 19.13 dB for RAMAN-SOA, 37.32 to 12.07 dB for RAMAN-EDFA, 24.66 to 13.25 dB for EDFA-SOA, 24.66 to 13.02 dB for EDFA-RAMAN, 25.32 to 9.98 dB for RAMAN-EDFA-SOA respectively.

Fig. 5 shows the graphical representation of BER as a function of Length in the presence of nonlinearities. The value of BER Up to 80 km SOA-RAMAN-EDFA has decreased and then it constant up to 200 km and then start increased again. All the amplifiers have variable BER of the order of 10^{-20} to 10^{-40} in range between 40km to 160 km. SOA-RAMAN –EDFA has least BER among all the amplifiers at 200km(0.999×10^{-40}). The variation in BER for other hybrid optical amplifiers is 0.999×10^{-40} to 0.218×10^{-03} for EDFA-EDFA, 0.138×10^{-37} to $0.108 \times 10 -^{17}$ for RAMAN-SOA, 0.999×10^{-40} to 0.227×10^{-03} for RAMAN-EDFA, 0.379×10^{-38} to 0.227×10^{-05} for EDFA-SOA, 0.337×10^{-26} to 0.227×10^{-07} for EDFA-RAMAN, 0.999×10^{-40} to 0.227×10^{-03} for RAMAN-EDFA-SOA at 200km respectively.

Fig. 6 shows if we have not considered the nonlinearities, all the amplifiers have comparable least value of BER and

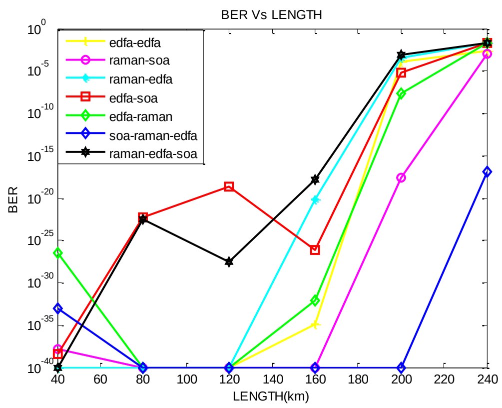

Fig 5: BER vs Length in the presence of nonlinearities

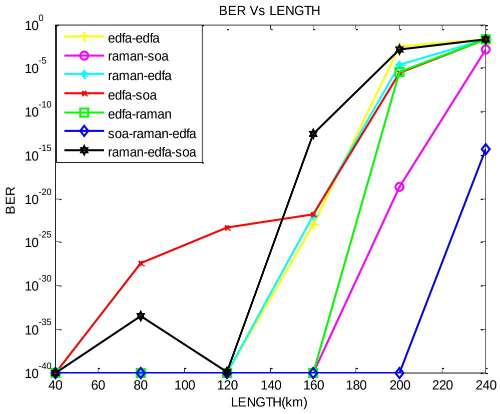

Fig. 6. BER vs Length in the absence of nonlinearities

at 200 km SOA-RAMAN-EDFA has least BER among all amplifiers. The variation in BER for other hybrid optical amplifiers is 0.999×10^{-40} to 0.278×10^{-02} for EDFA-EDFA, 0.999×10^{-40} to 0.235×10^{-18} for RAMAN-SOA, 0.999×10^{-40} to 0.217×10^{-04} for RAMAN-EDFA, 0.999×10^{-40} to 0.2826×10^{-05} for EDFA-SOA, 0.999×10^{-40} to 0.371×10^{-05} for EDFA-RAMAN, 0.999×10^{-40} to 0.141×10^{-02} for RAMAN-EDFA-SOA at 200km respectively.

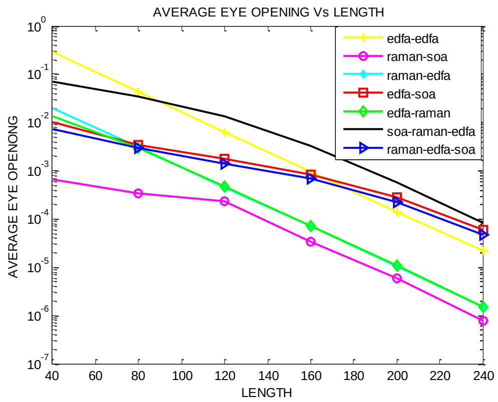

Fig. 7: Average eye opening Presence of Nonlinearities

The eye opening from different hybrid amplifiers verses transmission distance in presence and absence of nonlinearities is shown in Figs. 9 and 8. Large eye opening means less BER and good communication. It is observed that by increasing the transmission distance from 80 to 240 km, eye opening is also decreasing.

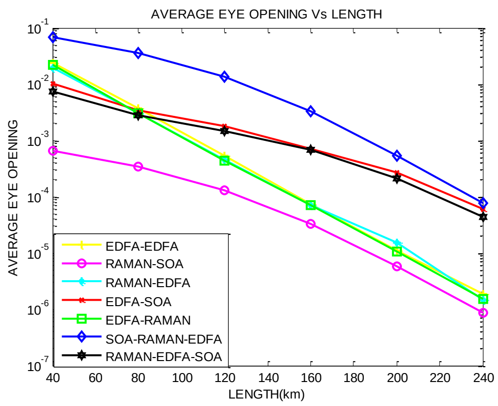

Fig. 8 Average eye opening absence of Nonlinearities

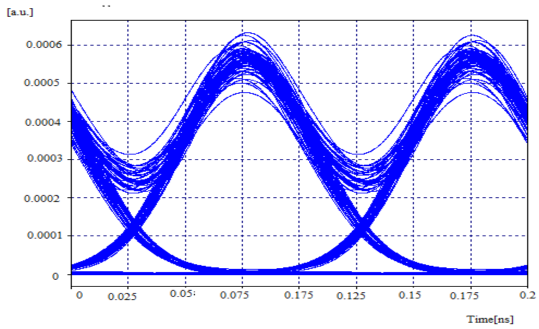

Fig. 9 Eye Opening Presence of Nonlinearities at 200km

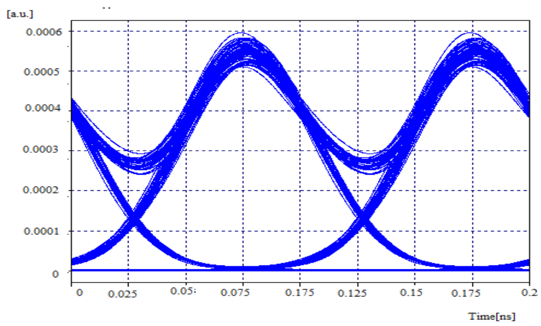

Fig. 10: Eye Opening absence of Nonlinearities at 200km

The eye diagrams of signal after SOA-RAMAN-EDFA at 200 km distance with presence of nonlinearities and absence of nonlinearities Fig. 11. The eye opening for dispersion 2 ps/nm/km 1.099×10^{-39} at presence of nonlinearities and 0.999×10^{-40} absence of nonlinearities respectively this is better than other amplifier.

IV. CONCLUSION

The 64 channel WDM systems at 10 Gb/s have been investigated for the various hybrid optical amplifiers and the performance has been compared on the basis of transmission distance at presence of nonlinearities and absence of nonlinearities. The performance of optical amplifiers was evaluated using the power level, eye patterns, BER measurement, eye opening and Q factor. It is observed that maximum output power (7.66 and 7.90 dBm), average eye opening (0.558×10^{-03} and 0.533×10^{-03}), maximum Q factor (25.29 and 33.86 dB) and least BER ($1.099 \times 10^{-39}$and 0.999×10^{-40}) at 200 km transmission distance for presence and absence of nonlinearities respectively is obtained from SOA-RAMAN-EDFA as compare to other configuration. In conclusion, this model has demonstrated that SOA-RAMAN-EDFA is a promising alternative to EDFA-EDFA, RAMAN-SOA, RAMAN-EDFA, EDFA-SOA, EDFA-RAMAN and RAMAN-EDFA-SOA in optical transmission.

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