Performance Analysis of 32 × 10 Gbps WDM System Based on Hybrid Amplifier at Different Transmission Length and Dispersion

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Abstract. A design for a hybrid optical amplifier is presented in this paper. The performance of DWDM system consisting of hybrid amplifier RAMAN + EDFA for NRZ and RZ data format is investigated. It has been observed that RZ format provides highest quality factor 38.5 dB and OSNR 26.6 dB for 32 channels. We further investigated that the hybrid amplifier provides least Bit error rate $8.9e^{-52}$ and $1.02e^{-92}$ for dispersion 2 ps/nm/km and 16 ps/ns/km respectively. It is observed that the Quality factor is for RZ format is 29.5 dB at 8 ps/nm/km and for NRZ format is 24.1 dB at 6 ps/nm/km.

Keywords: Dense Wavelength Division Multiplexing (DWDM)
Single Mode Fiber (SMF) · Non Return to Zero (NRZ) · Return to Zero (RZ)

1 Introduction

To increase the transmission capacity of optical fiber system, a DWDM system is designed. In order to compensate fiber loss for the optical fiber communication system, a multipump Raman amplifier was designed along with EDFA.

Martini et al. [1] have simulated the performance analysis of multipump Raman amplifier with EDFA for WDM system. The gain variation was compensated within the c band. Kelar [2] observed least BER (10^{-40} and 9.0810^{-18}) at 100 km for dispersion 2 ps/nm/km and 4 ps/nm/km respectively.

In this paper we have extended the work reported [2] by using hybrid amplifier. Singth and Kelar [3] investigated RZ provide good quality factor and acceptable bit error rate. A flat gain has been presented in S band (1460–1490 nm).

Liang et al. has examined and compared various types of EDFA-EDFA hybrid amplifiers. The design of H-WDM EDFA was to keep the output power among digital channels at ≤ 0.2 dB while providing output power of ≥ 60 mW and low noise figure of ≤ 4 Db [4]. A 20 channel S band Raman amplifier is analyzed. A novel high gain wide band hybrid amplifier has been reported [5]. Singh et al. optimized the gain flattening filter and reduce the gain ripple across the frequency range from 190 to 197.9 THz [6]. The multiparameter optimization of Raman amplifier has already

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reported [6]. The Gain variation of <4.5 dB has been obtained for L band Raman-EDFA hybrid optical amplifier for DWDM system [7]. Singh compared multi terabits DWDM system at different modulation formats such as NRZ, RZ and DPSK, it is found that RZ format is better than all other types of data format [8]. Kelar et al. optimized the hybrid amplifier using different parameters such as Gain and NF. The system achieves 70 km distance at dispersion 16 ps/nm/km [9].

2 Simulation Setup

In this model, 32 channels are transmitted with 100 GHz, channel spacing t 10 Gbps speed in both RZ and NRZ modulation format. Each input signal is amplified by booster. The DWDM system is design with C band ranging from (1530–1554.8 nm) at 100 GHz channel spacing. The experimental setup of EDFA-RAMAN at different transmission distance is shown in Fig. 1.

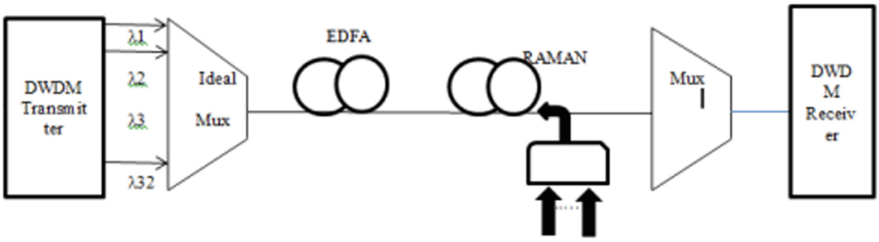

Fig. 1. Simulation setup of Hybrid amplifier in DWDM system

The optical signal is transmitted and measured at different distance for 10 km to 100 km at 2 ps/nm/km to 16 ps/nm/km. Optical power meter and spectrum analyzers are used to measure Q factor and BER. Various parameters are obtained at fixed RAMAN fiber length 20 km, operating temperature is 300 k, pump wavelengths are 211.9 THz, 210.1 THz and 203.5 THz and pump powers are 244.1 mW, 269.9 mW and 60.1 mW respectively (Table 1).

Table 1. General simulation parameters

	Parameters	Value
1	Input signal power	−10 dBm
2	Data rate	10 Gbps
3	Bandwidth	1530–1554.8
4	Band utilized	24.8 nm
5	Modulation format	NRZ and RZ
6	Channel spacing	0.8 nm

3 Result and Discussion

The performance of hybrid amplifier with NRZ and RZ format is compared at different transmission length and dispersion. The system is analyzed at constant input power at −10 dBm. Figure 2 shows that the maximum quality factor is obtained for RZ format is 38.5 Db at 20 km distance of single mode fiber whereas for NRZ is 20.4 Db (Table 2).

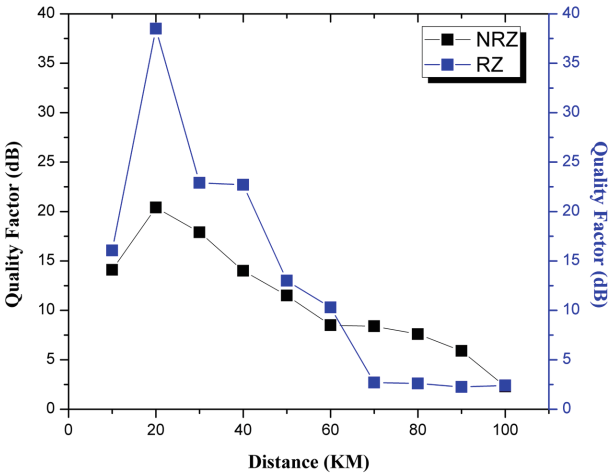

Fig. 2. Quality factor vs Distance of SMF for NRZ format and RZ format

Table 2. Simulation parameters of SMF and EDFA

Sl.no	Parameters	Value (SMF)	Parameters	Value (EDFA)
1	Length	10–100 km	Length	5 m
2	Dispersion	16.75 ps/nm/km	Core radius	2.2 μm
3	Reference wavelength	1555 nm	Er doping radius	2.2 μm
4	Effective area	80 μm^2	Er ion density	1000 ppm-wt
5	Attenuation	0.2 dB/km	Loss at 1550 nm	0.1 dB/m

It is observed that, as the transmission distance increases the quality factor decreases and OSNR also decreases as shown in Fig. 3. From Fig. 4, it is found that the dispersion of single mode fiber is varied from 2 to 16 ps/nm/km and we observed that the Quality factor is for RZ format is 29.5 dB at 8 ps/nm/km and for NRZ is 24.1 dB at 6 ps/nm/km (Table 3).

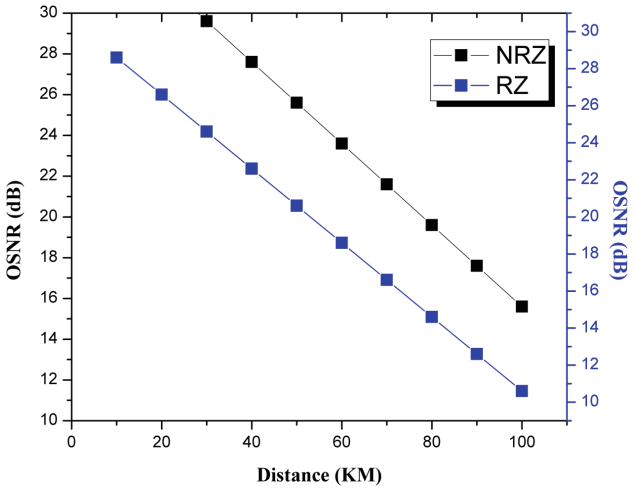

Fig. 3. OSNR vs Distance of SMF for NRZ format and RZ format

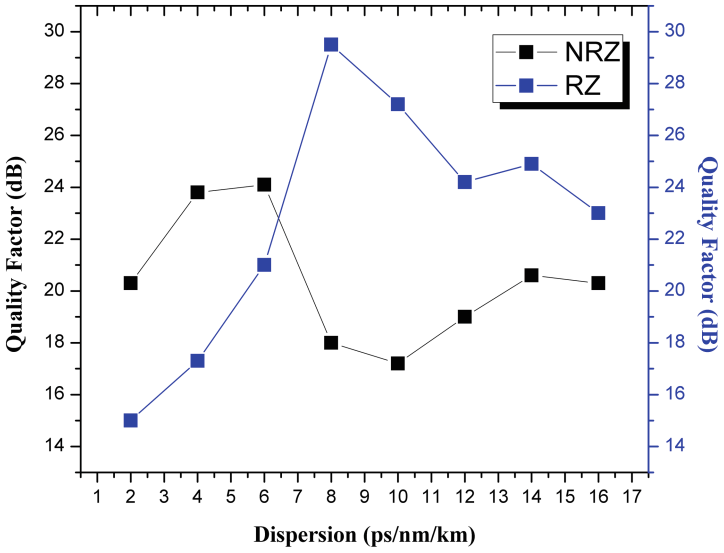

Fig. 4. Quality factor vs Dispersion of SMF for RZ format and NRZ format

Table 3. Simulation parameters of multi pump Raman amplifier.

Pump signal power	Pump signal wavelength	Parameters	Value (Raman amplifier)
		Length	20 km
244.1 mW	1414.5 nm	Dispersion	16.75 ps/nm/km
269.9 mW	1426.5 nm	Effective area	72 μm^2
60.1 mW	1472.5 nm	Attenuation	0.2 dB/km

4 Conclusion

This paper proposed a method for searching least bit error rate and good quality factor for 32 channel 10 Gbps DWDM system. As the transmission distance increases the quality factor and OSNR decreases. The maximum quality factor is obtained 38.5 dB and BER 0 for RZ modulation format at −10 dBm input power. Comparing for both RZ and NRZ data format for hybrid amplifier the RZ format provide better performance than NRZ data format.

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