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Performance Analysis of 100 Channels DWDM System Using Raman-EDFA Hybrid Optical Amplifier With SOA Booster

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ABSTRACT: We investigated the performance of Raman-EDFA hybrid optical amplifier using SOA booster for 100 channels DWDM transmission system with each channel having data rate of 10 Gbps at reduced channel spacing of 0.2 nm. The performance of the system has been compared for different signal input power on the basis of transmission distance in terms of output power, Q-factor, eye opening and bit error rate. It is observed that Raman-EDFA hybrid optical amplifier with SOA booster provides high value of Quality-factor, low bit error rate and maximum value of output power and eye opening for -20 dBm signal input power up to transmission distance of 200 km as compared to -10 dBm and 0 dBm signal input power.

KEYWORDS: DWDM, RAMAN, EDFA, SOA, Output power, Q-factor, Eye Opening, BER.

I. INTRODUCTION

Fiber optic communication system plays a vital role in transmitting the information faster from one position to another [1]. Fiber optics can definitely transfer more data over longer distances as fiber provides more bandwidth and extremely reliable data transmission than copper [2]. To satisfy the bandwidth requirement, Wavelength Division Multiplexing (WDM) technology is a very attractive solution for simultaneous transmission of different optical wavelengths through same optical fiber [3]. Dense Wavelength Division Multiplexing (DWDM) is the multiplexing technique of WDM used to increase the data transmission capacity over existing fiber networks by increasing the number of channels [4].

In modern long-haul fiber optic communication systems, the transmission distance is limited by fiber loss and dispersion. To overcome this limitation, optical amplifiers have become an essential component in long-haul fiber optic systems which eradicate the need of costly repeaters [5]. They can be placed after a certain intervals to acquire accurate information with minimum Bit Error Rate (BER) and good quality of signal without degradation of signal at destination. There are certain advantages and disadvantages of using individual amplifier in span of transmission distance. To overwhelm the drawback of individual optical amplifier, hybrid optical amplifier can be used by combining the benefits of different optical amplifier [6].

II. RELATED WORK

To provide better performance, a semiconductor optical amplifier (SOA), and an erbium doped fiber amplifier (EDFA), both can be used in combination with a distributed Raman amplifier (DRA). The results obtained that EDFA-DRA combination will produce less distortions of the amplified signal than SOA-DRA hybrid amplifier [7].

A concept of the dispersion-compensating Raman/EDFA hybrid amplifier recycling residual Raman pump has been demonstrated for increase of overall power conversion efficiency. As compared to the performance of the Raman amplifier only, the significant enhancement of both signal gain and effective gain bandwidth by 15 dB (small signal gain) and 20 nm respectively has been achieved by Raman-EDFA hybrid amplifier [8].

The comparative performance of hybrid optical amplifiers Raman-EDFA, Raman-SOA and EDFA-SOA for 32 × 10 Gbps with 0.8 nm channel spacing DWDM system has been evaluated. It is observed that the RAMAN-EDFA hybrid optical amplifier provides the highest output power (14.025 dBm), maximum average eye opening (0.0065) and minimum bit error rate ($1.96e^{-10}$) at 224 Km transmission distance than other hybrid optical amplifiers [9].

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The performance of hybrid optical amplifier for 16 and 32 channels WDM system has been examined at bit rate of 10 Gbps. Raman-EDFA and EDFA-Raman-EDFA hybrid optical amplifier have been compared by varying transmission distance in between 10 to 200 km with a dispersion of 16.75 ps/nm/km. It is observed that Raman-EDFA shows best performance in terms of Output power, BER & Q-factor than EDFA-Raman-EDFA [10].

Raman-EDFA hybrid optical amplifier has been investigated for 64 channel DWDM system at 10 Gbps and 0.8 nm channel spacing interval. The performance was calculated for different bit rate and input signal power. It is observed that at the bit rate of 15 Gbps, the worst results are obtained and Raman-EDFA hybrid optical amplifier provides acceptable quality factor (15.57 dB) and BER (1.04 e^{-09}) up to 135 km transmission distance for -20 dBm signal input power without any dispersion compensation methods [11].

The performance of Raman-EDFA, Raman-SOA and EDFA-SOA hybrid amplifiers for 120 channels WDM systems having data rate 10 Gbps at reduced channel spacing of 50 GHz has been investigated. 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 [12].

This paper is divided into four sections for 100 channels DWDM transmission system. The Simulation setup with detailed parameters has been discussed in section II. Section III discussed the optimized result for different transmission distance after the simulation while the conclusion has been proposed in section IV.

III. SIMULATION SETUP

The block diagram of 100 channels DWDM transmission system using Raman-EDFA hybrid optical amplifier with SOA booster amplifier at data rate of 10 Gbps and channel spacing of 0.2 nm interval is shown in Fig. 1. A transmitter consists of the data source, NRZ electrical driver, CW Laser source that generates the light signal at input power of -20 dBm and external modulator.

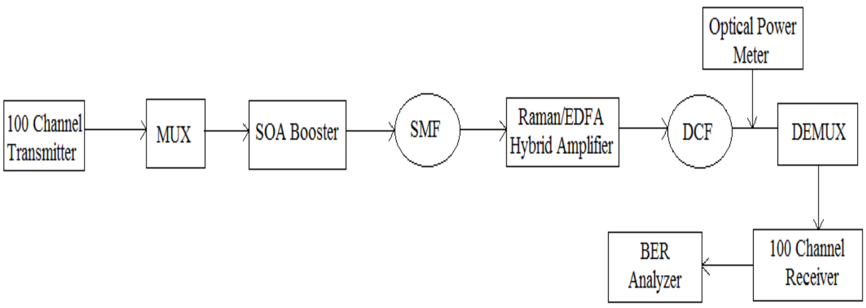

Fig.1. Block Diagram of Simulation Setup

SOA booster amplifier is used as preamplifier to boost all optical signals after combining with the help of multiplexer. These signals are transmitted through optical fiber and measured over different distance. After that signals can amplify with the help of Raman-EDFA hybrid optical amplifier. To obtain all the different optical signals, demultiplexer is used. The modulated signal is converted into original signals with the help of Photo detector PIN and filters. Receiver is used to detect all signals and convert these into electrical form. Output Power is obtained from Optical Power Meter. The values of BER, Quality factor and an average opening of eye can be analyzed from BER Analyzer.

The operational parameters of different components are listed below. The dispersion and attenuation of Single Mode Fiber (SMF) for transmission distance of 200 km is set with 33.5 ps/nm/km and 0.2 dB/km. To compensate the dispersion of SMF of 200 km distance, Dispersion Compensation Fiber (DCF) is set with the parameters of 33.5km length, -200 ps/nm/km dispersion and 0.1 dB/km attenuation. The parameters for SOA are: injection current of 0.05A, length of 300µm and optical confinement factor of 0.02. The parameters for Raman are: amplifier length of 5km, pump wavelength of 980nm and pump power of 100mW. The length of EDFA is 5m.

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IV. SIMULATION RESULTS

To analyze the performance of the system various parameters are examined at first channel. The performance of hybrid optical amplifier Raman-EDFA using SOA booster amplifier are evaluated for 100 channels DWDM transmission system with each channel having data rate of 10 Gbps and 0.2 nm channel spacing in the terms of received output power, Q-factor, eye opening and minimum BER at different transmission distance by varying the signal input power. The transmission distance is taken up to 300 km in steps of 50 km.

Fig. 2 shows the graphical representation of output power as a function of transmission distance for different signal input power. It is observed that by increasing the transmission distance, output power is decreasing. The output power remains constant from 60-180 km for all signal input power.

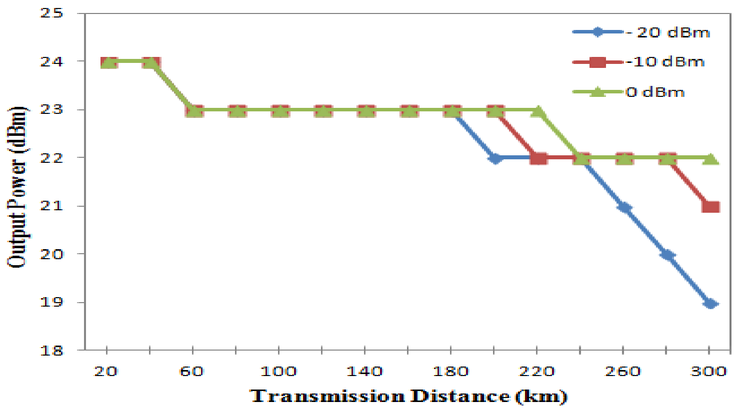

Fig.2. Output Power vs. Transmission distance

The variation in output power for different signal input power up to transmission distance of 300 km are 24 to 19 dBm for -20 dBm, 24 to 21dBm for -10 dBm and 24 to 22 dBm for 0 dBm signal input power.

Fig. 3 shows the graphical representation of Quality-Factor as a function of transmission distance for different signal input power. The quality of the received signal remains steady up to transmission distance of 200 km. After that it rapidly starts decreasing. High value of Q-factor means high quality of the signal at the receiver.

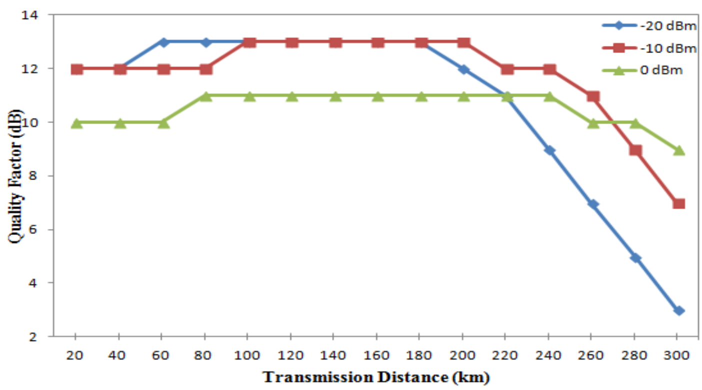

Fig.3. Quality-Factor vs. Transmission Distance

The variation in Quality-Factor for different signal input power up to transmission distance of 300 km are 12 to 3 dB for -20 dBm, 12 to 7dB for -10 dBm and 10 to 9 dB for 0 dBm signal input power. The highest value of Q-factor of 13 dB is provided by -20 dBm and -10 dBm signal input power up to transmission distance of 200 km.

Fig. 4 shows the graphical representation of eye opening as a function of transmission distance for different signal input power. Large eye opening means less BER and high quality of transmission of the signal. Eye opening gradually increases by increasing the transmission distance for all signal input powers. For -20 dBm signal input power, the value

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of eye opening decreases speedily after 220 km and for -10 dBm and 0 dBm it starts decreasing after 260 km and 300 km respectively.

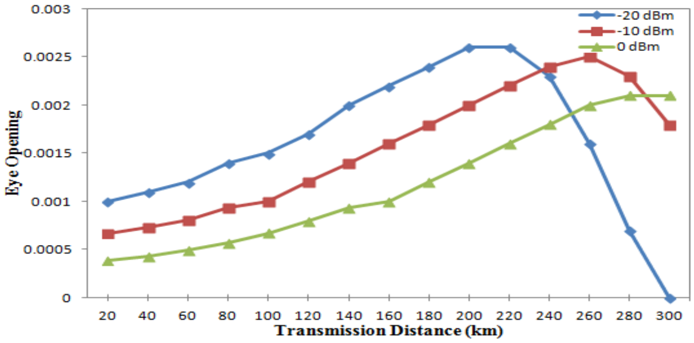

Fig.4. Eye Opening vs. Transmission Distance

The variation in eye opening for different signal input power up to transmission distance of 300 km are 0.001 to 10^{-005} for -20 dBm, 0.0006 to 0.0018 for -10 dBm and 0.0003 to 0.0021 for 0 dBm signal input power. It is observed that at 220 km, signal input power of -20 dBm has maximum eye opening of 0.0026.

Fig. 5 shows the graphical representation of log of BER as a function of transmission distance for different signal input power. At 140 km, the better BER (10^{-43}) is provided by the signal input power of -20 dBm and for 300 km it becomes zero. The signal input power of 0 dBm and -10 dBm also provides the acceptable BER.

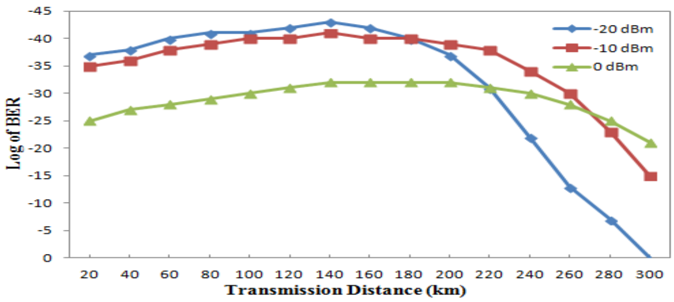

Fig.5. Log of BER vs. Transmission Distance

The variation in log of BER for different signal input power up to transmission distance of 300 km are -37 to 0 for -20 dBm, -35 to -15 for -10 dBm and -25 to -21 for 0 dBm signal input power.

The eye diagram of signal after Raman-EDFA hybrid optical amplifier with SOA booster amplifier at 200 km transmission distance is shown in Fig. 6.

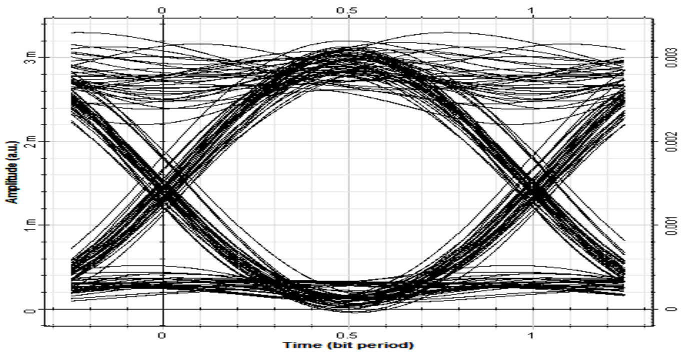

Fig.6. Eye Diagram of Raman-EDFA with SOA booster at 200 km

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V. CONCLUSION

DWDM system for 100 channels with bit rate of 10 Gbps and 0.2 nm channel interval has been investigated with the help of Raman-EDFA hybrid optical amplifier along with SOA booster. The performance is calculated for different input signal power and has been analyzed in terms of output power, Q-factor, eye opening and BER. It is observed that the hybrid optical amplifier Raman-EDFA using SOA booster provides acceptable output power (23 dBm), Q-factor (13 dB), eye opening (0.0026) and BER (10^{-43}) for -20 dBm signal input power up to 200 km transmission distance. It is also shown that these parameters have acceptable values for -10 dBm signal input power also. The worst results are obtained at the signal input power of 0 dBm as compared to -20 dBm and -10 dBm signal input power.

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BIOGRAPHY

Kirandeep Kaur is pursuing Mtech in Computer Science and Engineering from RIMT-Institute of Engineering & Technology and done Btech from RIMT-MAEC. Her research area is optical fiber amplifiers.

Dr. Harsh Sadawarti is working as a senior professor cum director. He has done PhD in CSE from PTU, Mtech from Thapar University and Btech from Nagpur University. He has over 40 international publications in reputed journals and conferences. He has more than 20 years of academic experience. His research area is parallel processing, network and image processing.