Investigation of SOA Amplifier Performance of 40 * 10 GB/s DWDM System with 50 GHz Channel Spacing

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Abstract

*In this study, transmission performance of Semiconductor Optical Amplifier (SOA) in 40*10Gb/s Dense Wavelength Division Multiplexing (DWDM) at channel spacing of 50 GHz is investigated. The measured values of (Q factor, BER, output power) are evaluated by varying the distance of optical fiber of acceptable value (25-300) Km at (-20) dBm minimum input power. The best result is achieved for the system data rate transmission of (400) Gb/s, with the maximum Q factor of (22.21) dB for lower input power (-20) dBm at (50) Km transmission distance. Also, the maximum fiber length of up to (250) km corresponding to less than (10E-12) BER is achieved.*

***Keywords**: DWDM, SOA, Q Factor, Channel spacing, Bit Error Rate (BER)*

1. Introduction

Dense Wavelength Division Multiplexing (DWDM) is a vital optical technology to exchange the data rate between the transmitter and receiver systems. This technology has witnessed a massive growth to satisfy the increase of capacities over comprehensive properties as a fiber communication network [1,2]. So, worldwide bandwidth optical fiber can definitely exchange more data rate over large distance as a link to give more flexible and reliable transmission than copper.

Semiconductor optical amplifiers (SOAs) are classified into fiber and semiconductor amplifiers. In the costumer or framework applications, the SOA has had tendency as a functional component in the extension optical system network [3,4,5]. However, the SOAs are excellent components to give large potential for high gain, reasonable cost and wide frequency range, which consume low power and simple integrity with other optical amplifiers [6,7].

On the other hand, the SOA works without important interval channel crosstalk in slight case of saturated gain regions. Therefore, there are networks that support up to (200) different frequency channels. Each effectively channel that transmitted (10) Gb/s having format is investigated and utilized a single mode fiber with SOA amplifier. However, several different positions such as pre-amplifier and poster-amplifier of SOA in the optical link are observed at high performance of different compensation methods [8,9,10]. When the input power signal was increased, the observed effect of power level of compensation methods can be compared in terms of BER, Q-factor and output power. previous research investigated the performance of DWDM at different speeds and distances. For example, [14] studied and demonstrated the 32*10Gb/s DWDM system at the transmission distance up to 260 Km of 50GHz channel spacing. likewise, [7] studied the WDM system at 10Gb/s data rate for the transmission distance up to 72Km to the (SMF) single mode fiber as the optical link. This study investigates the performance of SOA in 40*10Gb/s DWDM) at channel spacing of 50 GHz by optimizing the parameters of SOA amplifier to support the high capacity of DWDM system at the same channel spacing. This paper is organized into four sections including the introduction. Section 2 presents the simulation scheme setup. Section 3 demonstrates the results and discussion. Finally, the conclusion is introduced in section 4.

2. Simulation Scheme Setup

This section introduces the design setup of DWDM communication system that utilizes the (SOA) amplifier. The design of the optical transition system includes transmitter, SOA amplifier with optical fiber and optical receiver as illustrated in Figure 1.

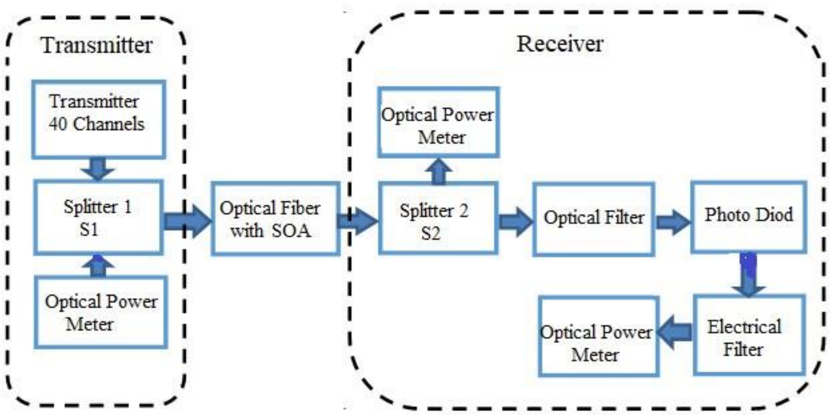

Figure1: The schematic System Design

The transmitter is composed of forty channels connected to (10) Gb/s data rate with 50 GHz channel spacing, each of them working at different frequencies i.e., (193.1-196.05) THz. Each transmitter part is composed of data source and a virtual random binary sequence for data rate (10) Gb /s. The rectangular pulse train formatted as a non- return to zero (NRZ) is given using input signal obtained by the data source. The continuous wave (CW) of the leaser source is utilized to transform the data from electrical signal to optical carrier wave.

Mach –Zehnder modulator modulates two pulses including the output of signal and (CW) laser source signal 3db to demonstrate the excess of the amplitude MZ modulator. The modulator passes the optical signal across the (SOA) amplifier, which is operated as a poster. The (SOA) amplifier parameters are optimized to be utilized in the simulation as shown in Table 1. In addition, the fiber link uses a reference frequency of (194.05) THz and an attenuation value of (0.2) dB/ km. Both devices are utilized to measure the power meter, which is connected to the first branch of splitter (s1) and the optical probe, which is connected to the second branch of splitter (s2) to measure the optical (dBm) and spectrum at various values.

Table 1: SOA Parameters Optimized Values

Name	Optimum value	Units
Injection current	0.14	Ampere [A]
Length	0.0008	m
Width	3e−006	m
Height	8e−008	m
Initial carrier density	1e+024	m−3
Differential gain	3.5e−020	m2

The optical signal is received by a PIN diode photodetector and a band bass filter at (60) GHz bandwidth with spacing frequency (50) GHz that used to detect the optical signal and convert to electric signal. Finally, at the receiver side, the operating properties of the PIN diode that has a dark current Id (10) nA are set where the quantum efficiency and responsively parameters are set to (0.78) and (0.7) A/W to achieve a high performance in term of the response values.

3. Results and Discussion

In this study, the results of data rate transmission are achieved in terms of SOA optimization parameters in optical telecommunication network. The high performance for (400) Gb/s data rate DWDM system is obtained with (50) GHz channel interval in terms of input power change. Figure (2) shows the relation between Q factor and Fiber length at different values of input power.

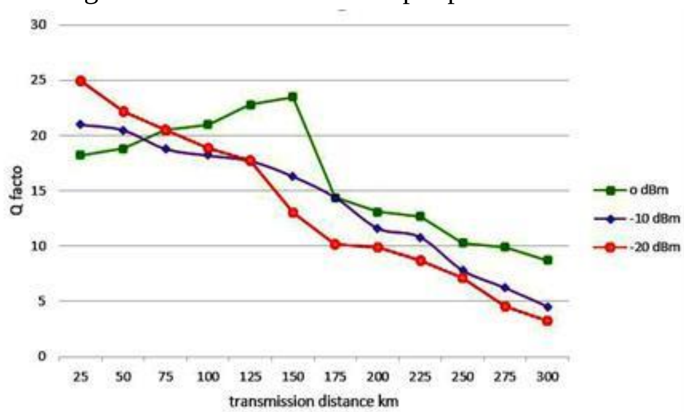

Figure 2: Q Factor vs. Fiber length

It is observed from Figure 2 that the quality factor of the received signal decreases by increasing the transmission distance due to the fiber losses that affect the nonlinearities. The Q factor value (10-25) dB is a satisfying value when the signal input power was (-20) dBm at a fiber length longer than 170 km.

Figure (3) explains the relationship between BER VS Fiber Length for different input powers as graphical representation.

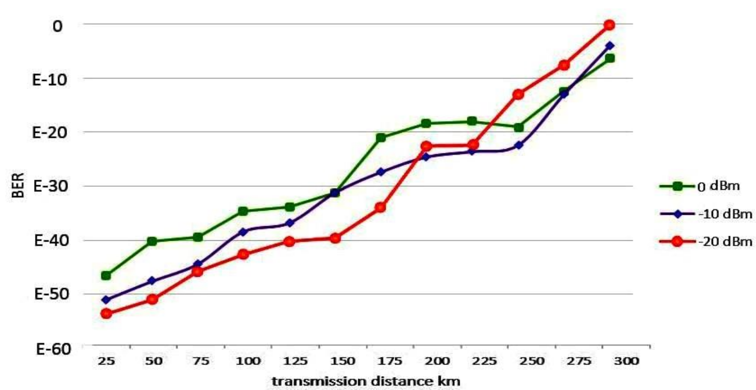

Figure 3: BER vs. Fiber Length

Figure 3 illustrates that the lowest BER is less than (1*10E-35) when the fiber length is less than 100 km at (0) dBm input signal power. The satisfying value of BER is (1.02*10E-12), which is obtained at more than 250 km. Moreover, when the input power decreased, the BER with transmission distance increases at the same transmission distance mentioned above. At minimum input power equals to -20dBm, the transmission distance exceeds 250 km. The results of the optical communication system are successfully done with lower BER.

Figure (4) describes the clear eye diagram for three different values of the input power (0, -10, -20). For (0) dBm input power, the measured value of Q. factor is 9.08 dB and BER is 1.4E-14 with the fiber length up to 290Km. When the input power is (-10) dBm, the measured value of Q. factor is 11.32 dB and BER is 5.6E-23 achieved with fiber length up to 215Km. At input power (-20) dBm, the values (10.02 dB, 5.6E17) are measured of Q. factor and BER respectively with fiber length up to 175 Km.

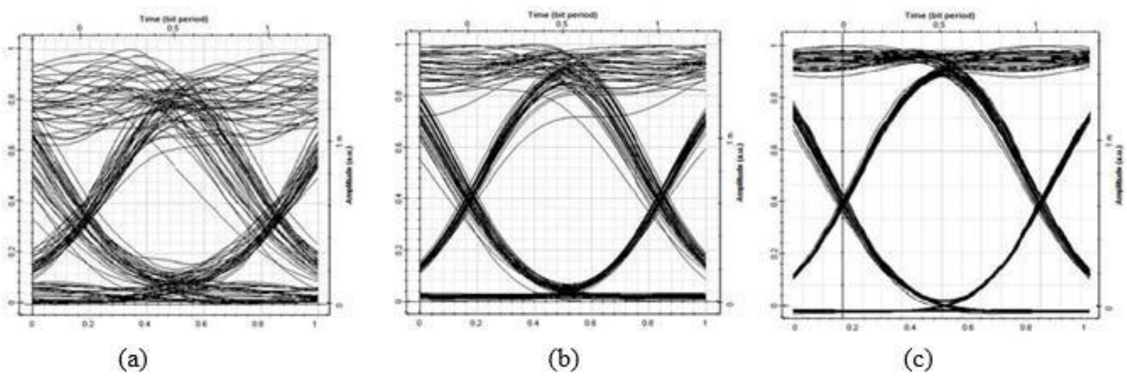

Figure 4: Eye Diagrams for Different Input Power Values (a) 0 dBm, (b) -10dBm, (c) -20 dBm

The optimum eye opening shows that the received signal is degraded due to signal propagation across the fiber link. However, the performance of the optical system and the quality of the signal is almost equal that of the SOA amplifier with diverge fiber length.

Figure (5): illustrates the relationship between the input and output of the signal power for different fiber length.

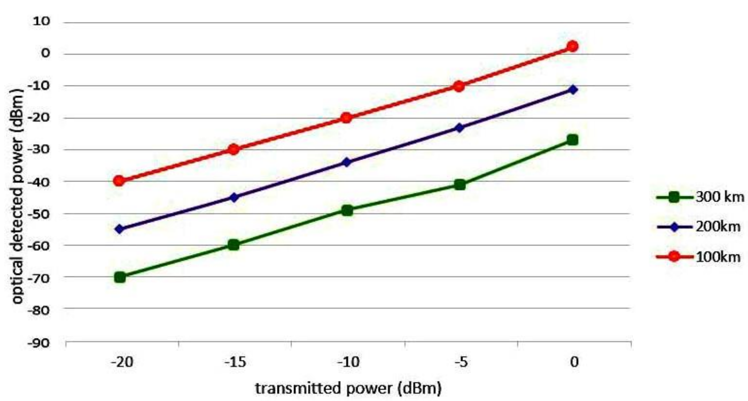

Figure 5:Received power vs. transmitted power

With fiber length (100) km, when the input power is (0) dBm, the obtained output power is (3.9) dBm as shown in Figure 5. At fiber length more than 300 km, the value of the output power decreases to -28 dBm due to the noise power on the SOA.

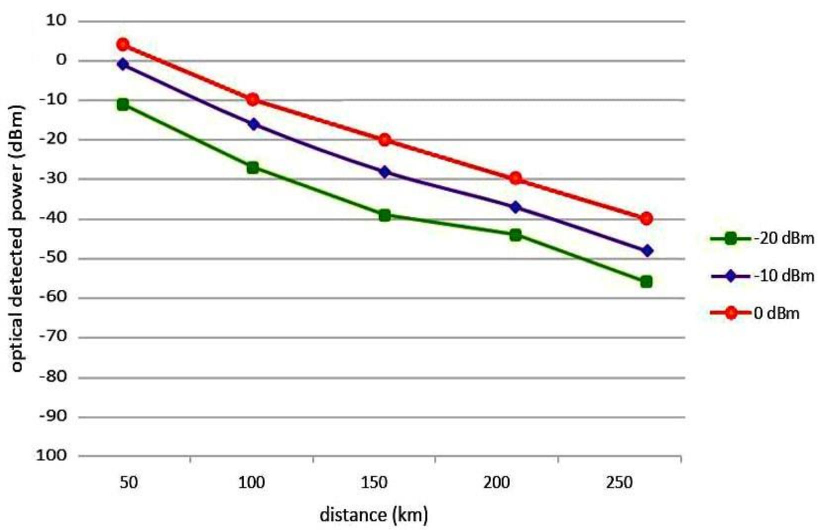

Figure 6: Received Power vs. Distance

Figure (6) illustrates the relationship between the fiber length vs the optical received power at various input power. When the input power equals (0) dBm, the length of fiber is more than 239 km, and the obtained output power is (-36. 9) dBm. At low input power (-20) dBm, it is observed that the output power value is (-28.7) dBm, which supports the fiber length of (135) km.

4. Conclusion

DWDM system is successfully designed and simulated in this study. All the results are recorded and compared in terms of (BER, Q factor, output signal power) for different fiber lengths and input powers due to optimized SOA parameters. As a result, when the signal of input power is decreased, the quality of received signal almost decreases. Then, the maximum fiber length is investigated at low input power and high performance of transmitted signal is attained.

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