Performance Analysis of an Optical System with Mach-Zehnder Interferometer and Semiconductor Optical Amplifier

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1. Abstract

This paper presents the study of the performance of an optical system composed of a Mach-Zehnder interferometer, semiconductor optical amplifier and Bragg grating fiber. The system was simulated in OptiSystem software from OptiWave Corporation and analyzed in terms of bit error rate (BER) and Q factor for different bit sequences and input powers.

2. Introdution

Optical telecommunications systems play a key role in transmitting data at high speeds and over long distances. The Semiconductor Optical Amplifier (SOA) is an essential component in these systems, providing signal amplification and data processing. However, SOA is subject to non-linear effects such as cross-phase blending (XPM) and cross-gain modulation (XGM), which can compromise system performance [1]. In addition, the presence of a Bragg Grating in SOA can significantly influence its behavior, affecting the generation and amplification of optical signals [2].

Recent research has explored combining semiconductor optical amplifiers (SOA) with optical interferometers to create all-optical logic gates [3,4]. In [3], for example, the use of a Michelson interferometer with SOA and Fiber Bragg Grating (FBG) to implement an optical NOR logic gate at 10 Gb/s is investigated, aiming at high-speed processing and analysis of non-linear effects. In turn, in [4] fully optical "AND" logic gate schemes with three inputs are simulated and experimentally studied, in which the proposed gate exploits the non-linearities of the semiconductor optical amplifier Mach-Zehnder interferometer (SOA-MZI).

In this work, we present and analyze the performance of an optical communication system that implements the Mach-Zehnder interferometer (MZI) and a semiconductor optical amplifier (SOA) and Fiber Bragg Grating (FBG).

3. Materials and Methods

The system proposed in this work was simulated using the OptiSystem software and the Q-Factor and Bit Error Rate (BER) for the simulated system were analyzed.

A. Design of optical communication system with Mach-Zehnder interferometer

The optical communication system analyzed in this study is presented in Figure 1. The transmitter operates with two input signals, A and B, generated by the Bit Sequence Generator, with the Optical Gaussian Pulse Generator at frequencies of 1550 and 1550.1 nm, respectively, with input powers of 0.35 mW. Each signal is combined with a CW Laser pump at frequencies of 1330 and 1330.1 nm, with powers ranging from 0 dBm to 10 dBm, through 2x1 WDM multiplexers.

The combined signals enter the Mach-Zehnder interferometer, connected to the 1x2 Power Splitter, with an IIR optical filter at a frequency of 1550 nm between them, where the outputs have FBGs with frequencies equal to 1550 nm. The output signals from the FBGs are coupled back to the Co-Propagating Pump Coupler and passed through the Traveling Wave SOA, as shown in Fig.2. In the receiver, an optical IIR filter at 1550 nm is used to reject interference and noise, before being converted from optical to electrical form by the Optical Receiver, with a cutoff frequency of 0.55 times the Bit Rate in Hz, for a Gaussian Pulse Generator. The output signal is viewed through the Oscilloscope Visualizer and analyzed with the Eye Diagram Analyzed.

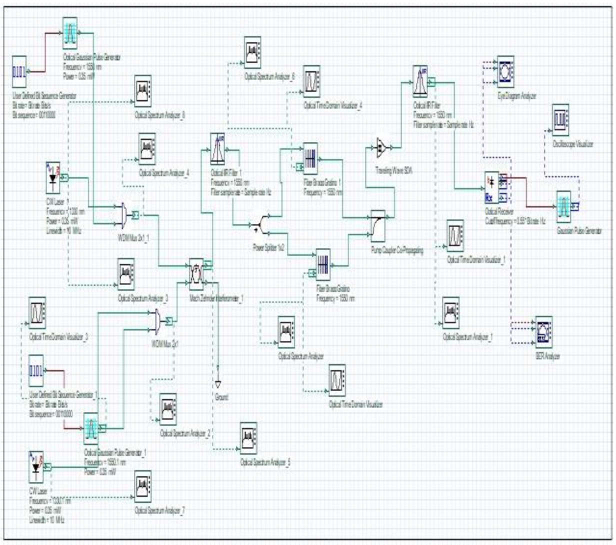

Fig.1. *Overview of the proposed system.*

Table I. *Simulation Results*

Number of Bit	***Input Power***					
	0 dBm		***5 dBm***		***10 dBm***	
	Q-Factor	***BER***	***Q-Factor***	***BER***	***Q-Factor***	***BER***
4	6.00791	9.290×10^{-10}	6.00797	9.286×10^{-10}	6.00818	9.274×10^{-10}
8	11.989	1.940×10^{-33}	11.9893	1.939×10^{-33}	11.9894	1.938×10^{-33}
16	3.57904	0.000168248	3.57906	0.000168233	3.57914	0.000168184

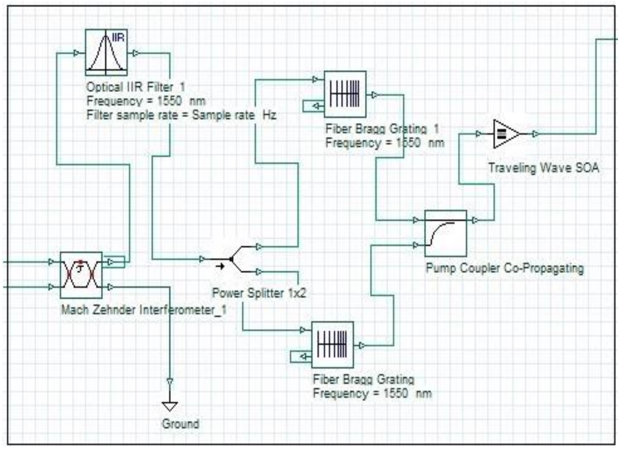

Fig.2. *Mach-Zehnder interferometer combined with SOA and Fiber Bragg Grating (FBG).*

4. Results and Analysis of the Simulations

Table 1 shows the Q Factor and minimum BER for different bit inputs and power of CW Lasers pumps from 0 to 10 dBm. Evaluation of the above results reveals a marked change in the Q-Factor and BER values in response to the variation in the bit sequence transmitted through the proposed communication system. In contrast, the change in power of CW Lasers is practically imperceptible.

Furthermore, it is noted that the most favorable results for the analyzed performance parameters were observed in an eight-bit sequence and an input power of 10 dBm. Figures 3 and 4 show the results obtained using the Oscilloscope Visualizer and the EyeDiagram Analyzer for the 8-bit sequence with an input power of 10 dBm, as they presented the best results among the simulations.

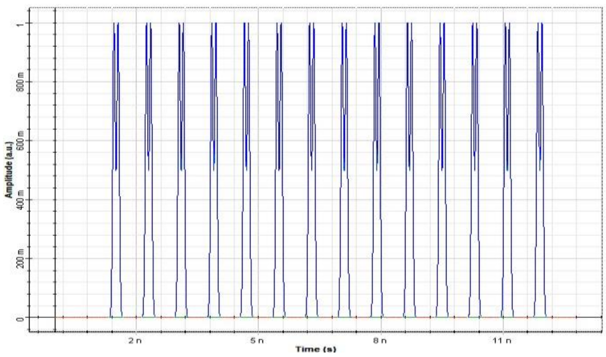

Fig.3 *Output signal viewed on the oscilloscope.*

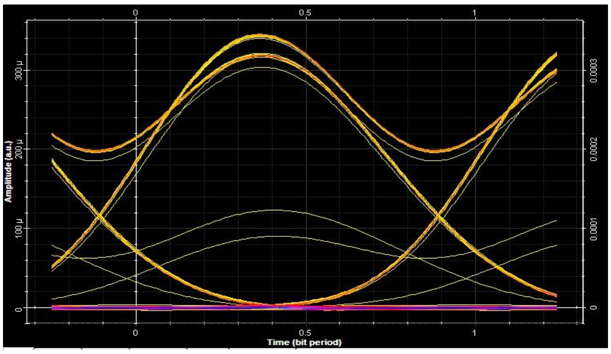

Fig.4 *Eye diagram for an 8-bit sequence and 10 dBm input power.*

4. Conclusions

In this work, we present a system for optical communication that combines the Mach-Zehnder interferometer (MZI), the semiconductor optical amplifier (SOA) and Bragg grating fibers (FBG). The system was simulated and studied using the OptiSystem software. Furthermore, the Q-Factor and bit error rate (BER) were analyzed for different bit sequences (4,8 and 16) and input power (0, 5 and 10 dBm). The results obtained showed a significant variation for the parameters analyzed for the variation of the bit sequence, presenting the best values for an 8-bit sequence with an input power of 10 dBm.

Acknowledgments

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