RESEARCH ARTICLE OPEN ACCESS

Performance of Optical Encoder and Optical Multiplexer Using Mach-Zehnder Switching

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ABSTRACT
It is an established fact that the bit rate of optical networks is slowed down by the optical to electrical to optical (OEO) conversion, here a simple all optic logic device is composed by the use of a Semiconductor Optical Amplifier and an optical coupler, this configuration is known as a Mach-Zehnder Interferometer. This device is used for generating an optical multiplexer as well as an optical encoder. The simulation of encoder and multiplexer is done at a rate of 10 Gb/s.

I. INRODUCTION

Extensive study has been conducted on the overall performance of various de-multiplexing switches. Investigations revealed that among all the switches Symmetric Mach-Zehnder (SMZ) was found to be most suitable because of the compact size, thermal stability and low power consumption [5]. The main advantage of Symmetric Mach-Zehnder over the Tera-Hertz Optical Asymmetric demux is that SMZ can be easily integrated on a single photonic chip. In digital optical computing optical interconnecting systems are the primitives that constitute various optical algorithms and architectures. High speed all optic logic gates are the key elements in the next generation optical networks and computing systems to perform optical signal processing functions [6]. In the last few years, several approaches have been proposed to realize various logic gates using either high non linear fibres or SOA's [7, 8]. Most SOA based logic gates have been performing by the use of cross gain modulation [7] and cross phase modulation[8],which inevitably limits the operating speed of such devices due to intrinsic slow carrier recovery time of SOA. Although the operating speed can be increased to 40 Gb/s or higher with the use of high-power continuous wave holding beam or different interferometric structures, complexity and cost of the device are increased. The request for high speed all optical signal processing has been posed by current and near future optical networks in an effort to release he network nodes from undesired latencies, speed limitations that are imposed by O-E-O conversion stages and to match the processing speed as well as the transmission speed. SOA based interferometric optical gates have appeared as the main stream photonic signal processing units, exploiting the fast response to high speed operation and taking advantage of hybrid and the monolithic integration techniques for operating compact switching elements. To end this, single element high speed all optical logic gates have been demonstrated as integrated devices in a number of laboratories across the world and have been developed as commercial product primarily for the conversion of wavelength and for the regeneration of the wavelength. Interferometric devices have drawn greater interest in all optical signal processing for the high speed photonic activity.

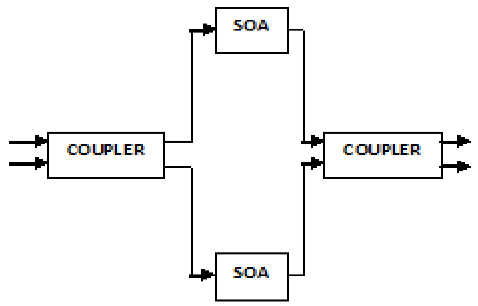

Fig 1. MZ Interferometer Switch

II. Working Of a Multiplexer:

A multiplexer is a device that is used for the operation of multiplexing, it selects one of many analog or digital input signals and gives output on a single line. It has select bits to select the input that has to be sent to the ouput.

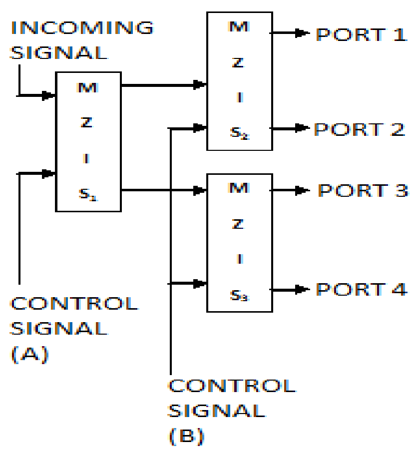

Fig 2. Block Diagram of a Multiplexer

CASE 1: When A = 0 and B = 0, the CW light beam that comes from constant CWLS is incident on switch S_1, here control signal A is absent so the light emerges through the lower channel and falls on switch S_3, here the control signal B is also absent so the light finally comes out through the lower channel of S_3 and reaches Output Port 4, no light is present at other output ports.

CASE 2: When A = 0 and B = 1, the CW light beam that comes from constant CWLS is incident on switch S_1, here the control signal A is absent so the light emerges through the lower channel and falls on switch S_3, here control signal B is present so the incoming CW signal finally comes out through the upper channel of S_3 and reaches the Output Port 3, no light is present at other output ports.

CASE 3: When A = 1 and B = 0, the CW light beam that comes from constant CWLS is incident on switch S_1, here control signal B is absent so the light finally comes out through the lower channel of S_2 and reaches Output Port 2, no light is present a other output ports.

CASE 4: When A = 1 and B = 1, the CW light beam that comes from constant CWLS is incident on switch S_1, here control signal A is present so the light emerges through the upper channel and falls on switch S_2, here control signal B is also present so the light finally comes through the upper channel of S_2 and reaches the Output Port 1, no light is present at other output ports.

III. Experimental Setup

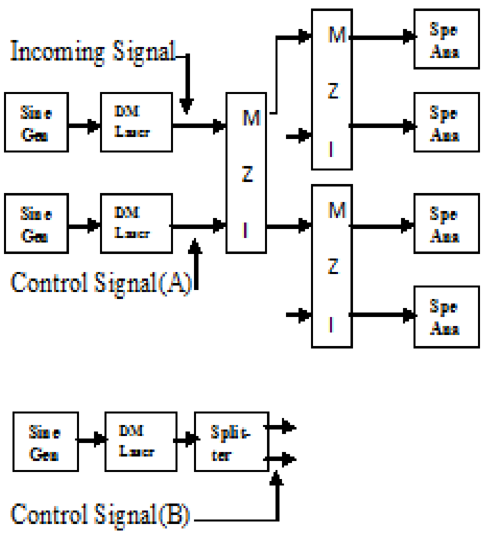

Fig 3. Block diagram of Mux for A=1 and B=0

The above figure represents the schematic diagram of an all-optical logic multiplexer composed of MZI switches. It consists of two sine wave generators having a frequency of 10 GHz which acts as a signal generator followed by a Direct Modulated Laser , laser converts the electrical signal into light signal and the output of both the lasers is fed to the optical coupler which has two ports, named as the cross port and the bar port. Now each arm of the coupler is fed to the semiconductor optical amplifier and finally goes to the second optical coupler. An optical coupler followed by an SOA is known as a Mach-Zehnder switch and different outputs of optical coupler are fed to the spectrum analyser. Signal generator generates 10 GHz signal in sinusoidal form which is fed to the direct mode laser. Direct mode laser block shows simplified continuous wave laser. Optical couplers are referred to as opto-couplers, these are devices which are used to direct light from a source to a receiver. It is a passive device. These semiconductor optical amplifiers have their gain medium in the form of semiconductors, i.e. the semiconductors provide the gain medium. It is of small size and electrically pumped, the SOA has higher noise, lower gain and moderate polarization reliance and high non linearity with fast transient time.

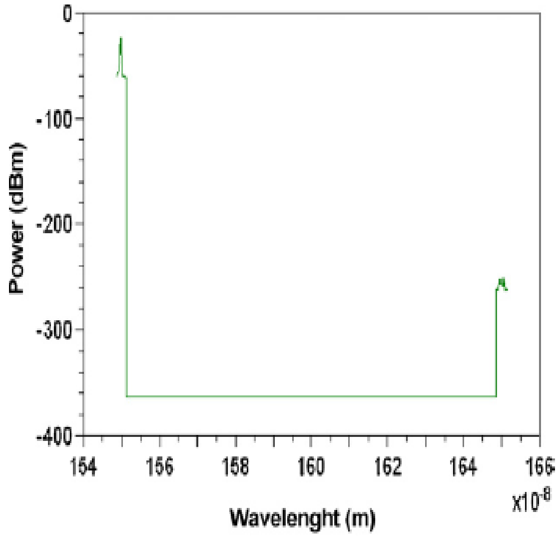

Fig 4. Wavelength Spectrum of Mux for A=1, B=0

The previous figure (fig 4) shows the wavelength spectrum of the required logic at output port 1. As the spectrum has both the input signal and the control signal having different wavelength so we are using the control signal of 1550 nm while the incoming signal is taken as 1650 nm so that it has maximum amplitude at the wavelength of the control signal.

IV. Experimental Setup and Working of Encoder

Case 1: When we have taken A=1, B=0, EN=1

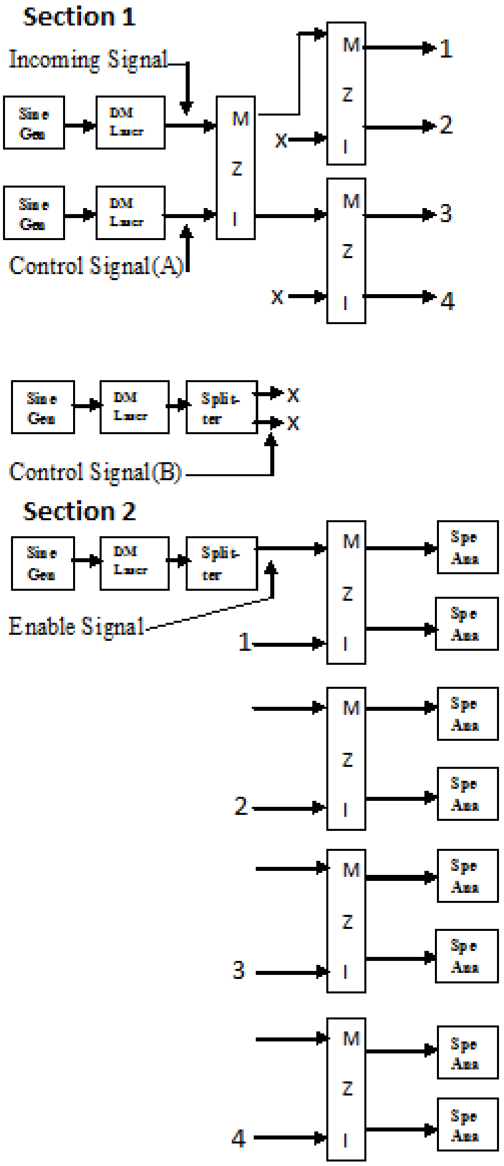

Fig 5. Block diagram of Encoder for A=1,B=0,EN=1

In this block diagram of an encoder there are three sine wave generators which are used to generate sinusoidal pulses which are directly fed to the direct modulated laser, which is working at a different wavelength for a particular signal, as this encoder has three input signals and an enable signal which is fed directly to the input arm of the coupler of the MZI switch by beam splitter and provides the required logic. This block diagram consists of two parts named as Section 1 and Section 2. The arrows labelled as 1,2,3,4 are just to make the point clear that these will be connected to the same numbered arrows in section 2 to obtain the required logic. In Section 2 there are arrows which are not numbered at all it is to show that that the Enable signal is not given o these ports. The control signal B is shown as x but it is also not connected to the input port as the case that we have taken has considered B as 0.

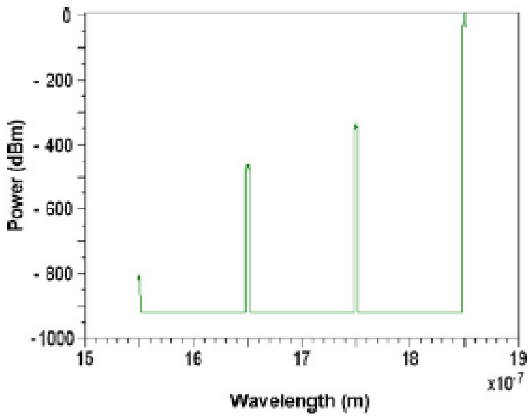

Fig 6. Wavelength Spectrum of Encoder for A=1, B=0, EN=1

Case 2: When A = 1, B = 1, EN =1 In the block diagram of the encoder for this case there are two sinusoidal generators of 10 GHz each of which is followed by the direct modulated laser which converts the electrical signal into an optical signal or light signal and the output of the laser is directly fed into the input arms of the coupler which passes the signal on the bar port depending on the control signal.

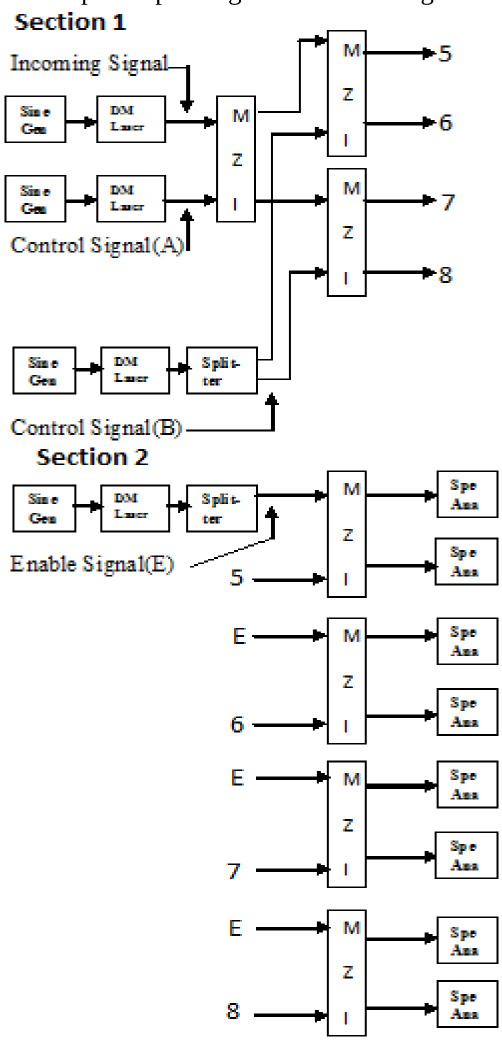

Fig 7. Wavelength Spectrum of Encoder for A=1, B=1, EN=1

Here the control signal is inserted into the circuit at the third level of the MZI switch as i consists of two semiconductor optical amplifiers at both the ports of the optical couplers at the input and the same thing is followed at the output switch. So here in this circuit control signal is applied to all the inputs of the encoder but according to the principle of the MZI switch the input is received at the bar port of the coupler when the control signal is present so as we have applied two continuous signals at the input of both the lasers so at first stage output is received at the bar port of the coupler. The switches work in the similar manner as explained before. By making use of the pattern of switching we can obtain the required logic of that of an encoder.

In fig 7 which shows the block diagram of the encoder for the case A=1, B=1, EN=1 there are two sections namely Section 1 and Section 2, the arrows labelled as 5,6,7,8 in he first section represent the output ports of the first section. In the second section i.e. section 2 we have arrows labelled as 5,6,7,8 and E. This E represents the enable signal which is given as input to all the MZI's as this is case where we have taken EN as '1'. The arrows labelled as 5,6,7,8 show that they will be connected to the same numbered arrow i.e. 5 will be connected to 5 and so on.

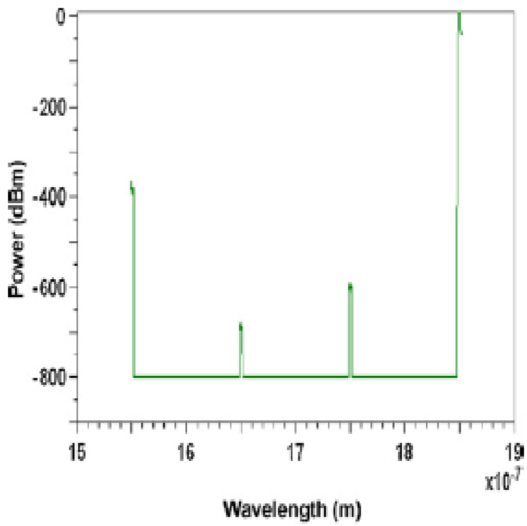

Fig 8. Wavelength Spectrum of Encoder for A=1, B=1, EN=1

The previous figure i.e. fig 8 shows the wavelength spectrum of the encoder.

V. Conclusion

All optical logic based Multiplexer and Encoder using Mach-Zehnder interferometer has been simulated. As different logic functions can be realized by simply adjusting two components i.e. multiplexer and encoder. This simulation method has the potential to operate above 40 Gb/s.

VI. Acknowledgement

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