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Scheme of developing an optical Encoder using switching and frequency conversion properties of semiconductor optical amplifiers

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Abstract-— **Present day's communication technology demands high data processing speed, potential band width with enormous data handling capacities, and this can be achieved with light wave technology in all optical domains. In this article the authors have proposed a method of developing an optical encoder circuit that has been working based on the nonlinear polarization switching action and frequency conversion properties of semiconductor optical amplifiers. For secure and error free performance frequency encoded data have been exploited.**

Index Terms - Semiconductor optical amplifiers, Cross polarization gain, optical encoder, optical multiplexer, demultiplexer.

I. INTRODUCTION

In digital data based communication technology, encoding and decoding of data is very much necessary for secure communication. In digital system, a set of ten switches, one for each numeral between '0' and '9' is one of the most commonly used devices. When a particular switch corresponding to a decimal number (0 to 9) is pressed, the BCD code corresponding to that number is generated. This is the function of an Encoder.

In optical domain this circuit can also be designed and so far various attempts have been made in this field [1-3]. Here the authors propose a method of designing an optical encoder using the frequency conversion and polarization switching action of semiconductor optical amplifier (SOA) with the help of frequency encoded data. For this purpose the optical beam of frequency 'ν0' is encoded as binary '0' state, and the optical beam of frequency 'ν1' is encoded as '1' state. To implement optical encoder polarization switching character of SOA, frequency conversion property of SOA using cross polarization modulation gain of the probe beam [4] have been exploited.

II.WORKING PRINCIPLE

The basic building block of our proposed scheme is polarisation switch (PSW).Here the polarisation switching action of SOA has been utilised [5]. The PSW is made up of a tensile strained bulk SOA, a polarization controller (PC), an attenuator, and a polarization beam splitter (PBS). A beam having low intensity, called probe beam, and another beam having high intensity, called pump beam are injected into the SOA as shown in Fig.1. Polarisation beam splitter (PBS) splits the amplified probe beam into a horizontal and a vertical component. The probe beam is applied to the SOA through an attenuator and a polarization controller, PC. The power of the probe beam is attenuated by the attenuator in such a way that it reduces the effect of self-polarisation modulation of SOA. The state of polarisation of the input probe beam is controlled by the polarisation controller. When the pump beam is absent, at port-1 of the PSW an amplified output probe beam is developed. With the application of pump beam, gain of the SOA becomes saturated, and total power is developed at port-2.Thus PSW acts as an optical switch where by the application of pump beam output can be switched from port-1 to port-2.

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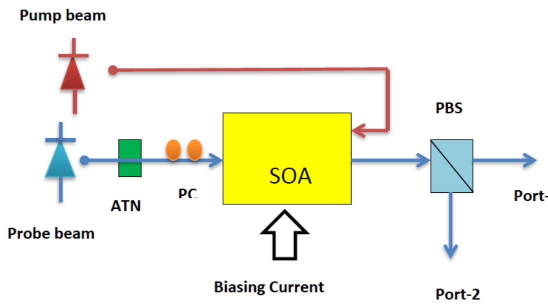

Fig.1 Polarisation switching action of SOA

III.OPERATION OF THE PROPOSED SCHEME

Optical circuit of the 'Encoder 'is shown in Fig.2.The encoder circuit comprises four polarisation switches PSW0 ,PSW1, PSW2 and PSW3; four multiplexers (MUX) M0,M1,M2 and M3; and ten switches(0 to 9). All the outputs A3, A2, A1 and A0 are taken from the port-1 of the respective PSWs, whereas port-2 are kept open.

Case 1: When switch '9' is pressed In this case the input signal of frequency ν1 after passing through the MUX M3 divided into two equal parts out of which one part reaches the output port-1 of reaches PSW3 directly and gives the output beam of frequency ν1 as MSB at A3, and port-2 of PSW3. Similarly the input beam of frequency ν1 after passing through M0 serves as the pump beam of PSW0. In the presence of pump beam of sufficient intensity in PSW0, the probe beam of frequency ν0 is switched to port-2, giving the output A0 the optical beam of frequency ν1. Here PSW2 and PSW1 does not receive any pump beam, and consequently the probe beam of frequency ν0 will appear at A2 and A1 via port-1 of the PSW2 and PSW1 respectively. Therefore output frequency encoded BCD corresponding to decimal number is 9 is ν1 ν0 ν0 ν1.

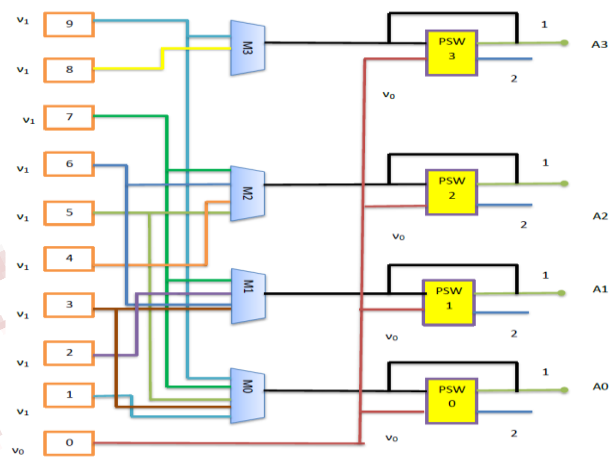

Fig.2. Schematic diagram of optical Encoder circuit

Case 2 : When the decimal number is '8'

In this case the input signal of frequency ν1 after passing through M3 divided into two equal parts out of which one part reaches the output port A3, and the remaining part serves as pump beam of PSW3. In the presence of the pump beam of sufficient intensity in PSW3, the probe beam of frequency ν0 is switched to port -2 giving the output A3 as ν1 and all others PSW (PSW2,PSW1,PSW0) receive no pump beam and consequently give optical beam of frequency ν0 in port-1 of PSW0, PSW1 and PSW2, respectively. Therefore output frequency encoded BCD data corresponding to decimal number is 8 is
ν1 ν0 ν0 ν0.

Case 3 : When switch '7' is pressed

In this case the input signal with frequency ν1 is divided into three equal parts and passes through M2, M1 and M0 respectively .After passing through the respective MUX s all the signals are divided into two parts, out of which one part directly reaches the output ports A2, A1 and A0, and the remaining parts serve as pump beam for PSW2,PSW1 and PSW0 respectively. In the presence of pump beam of sufficient intensity in PSW2, PSW1 and PSW0, the probe beam of frequency ν0 is switched to port-2, giving the output A2,A1 and A0 as ν1.Here PSW3 does not receive any pump power and consequently probe beam of frequency ν0 will appear at output A3 via its port-1. Therefore output frequency encoded BCD data corresponding to decimal number is 7 is
ν1 ν0 ν0 ν1 .

In the similar way we can get the frequency encoded BCD data output for rest of input decimal numbers(6 to 0).

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In Fig.3 the variation output power at port-1 and port-2 with imput pump beam power is shown.

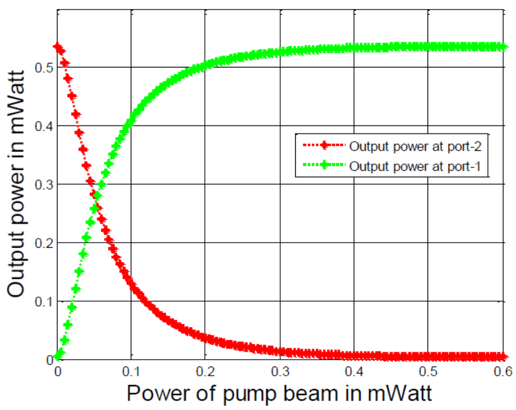
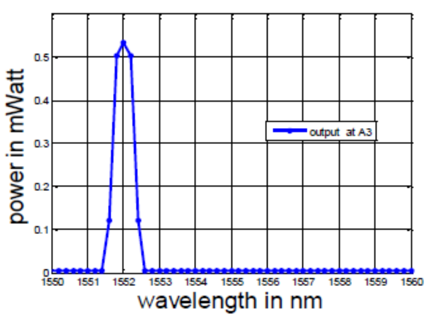
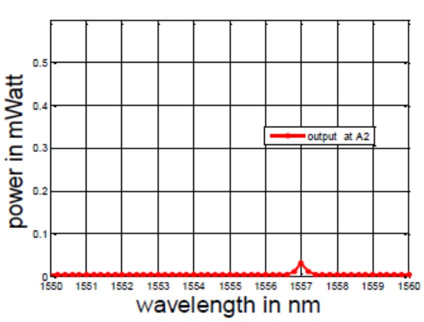
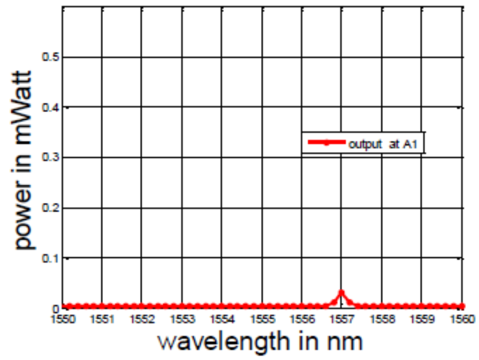


Fig.3. Output power at port -1 and port-2 with input pump power.

The simulated output power spectra for the optical Encoder for decimal number '9' is shown in Fig.4 . The power at the outputs is represented by Gaussian pulse."0"is represented by an optical beam with wavelength 1557 nm (corresponding to a frequency of 1.9255×1014 Hz ,i.e., ν0.) and "1" is represented by an optical beam with wavelength 1552 nm(corresponding to a frequency of 1.9317×1014 Hz ,i.e., ν1).







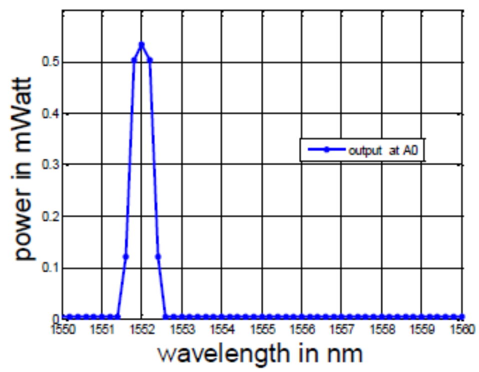


Fig.4. Simulations results for decimal number'9'

Table 1. Presentation of decimal numbers in terms of BCD and frequency encoded bits.

Decimal Number	**BCD**	**Frequency Encoded Bits**
9	1001	$\nu_1\ \nu_0\ \nu_0\ \nu_1$
8	1000	$\nu_1\ \nu_0\ \nu_0\ \nu_0$
7	0111	$\nu_0\ \nu_1\ \nu_1\ \nu_1$
6	0110	$\nu_0\ \nu_1\ \nu_1\ \nu_0$
5	0101	$\nu_0\ \nu_1\ \nu_0\ \nu_1$
4	0100	$\nu_0\ \nu_1\ \nu_0\ \nu_0$
3	0011	$\nu_0\ \nu_0\ \nu_1\ \nu_1$
2	0010	$\nu_0\ \nu_0\ \nu_1\ \nu_0$
1	0001	$\nu_0\ \nu_0\ \nu_0\ \nu_1$
0	0000	$\nu_0\ \nu_0\ \nu_0\ \nu_0$

IV.CONCLUSION

A switching speed of 10 Gb/s can be easily achievable in PSW by proper biasing. To switch the probe beam from port-2 to port-1,minimum power of the pump beam of

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PSW should be 0.4 mW, probe beam should have power 0.03 mW.[6] Here the encoded frequencies [ν0 (1557 nm), ν1(1552 nm)] are chosen from in C –band as in this region gain of the PSW becomes frequency independent .In the proposed Encoder circuit some of the input beams are spitted into two or three parts .so their powers should be properly adjusted to get the pump beam of sufficient power. In this scheme the losses of optical signals due to the presence of MUXs/DEMUXs are not taken into consideration. Time delay problem due to passing of signals through optical fibres of different lengths, can be overcome by using optical fibre of same lengths. Transmission time should be less than the switching time of PSW. This scheme is very much suitable in use of optical data processing network.

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