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A Method of Maintaining the Intensity Level of a Polarization Encoded Light Signal

Debajyoti Samanta* and Sourangshu Mukhopadhyay**

* Department of Physics, The University of Burdwan, Golapbag, Burdwan,
West Bengal, India-713104.
email: *d_samanta06@yahoo.co.in.
**sourangshu2004@yahoo.com.

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ABSTRACT

Optical signal has a strong role in parallelism. That is why, a strong effort to implement data processors with optics as information carrying signal instead of electronic signal is being supported in almost every corner of the world. In an optical system a logic state can be represented in different ways e.g. with the intensity level or with the polarization angle of the light signal. In long distance communication of optical signal the intensity of the signal may be reduced due to various reasons. Then the logic processor which operates on the basis of the intensity level encoding of the signal fails to work properly in the detecting side. In that situation we need to find out an alternative approach to maintain the intensity level of the light signal. In this communication the authors propose a new method to continue the intensity level of the light signal keeping the polarization of the beam unaltered.

***Key words:** Nonliner material, polarized light, constant laser source.*

1. Introduction

Optics has already established itself as a successful candidate in logic and data processing. The advantages of optical system are widely known. Due to inherent parallelism very high speed processing and operations can be achieved with optical system. Many optical data processors are proposed in last few decades[1-4]. Sometimes it is also necessary to encode or to decode the optical signal with its polarization. Again the intensity of a light signal may be reduced due to loss at the time of propagation. Again those optical systems to work properly, the intensity of the light beam is to be maintained at a fixed level. Here in this communication the authors propose an alternative method to maintain the intensity level of a polarized encoded light beam.

2. Use of Some Non-linear Material as Optical Switch

Some isotropic nonlinear materials (NLM), where the second order nonlinearity is strong enough, can be successfully used to implement many all-optical logic and arithmetic operations[5–7]. The refractive index of some of those isotropic nonlinear materials (NLM) is given by

$$n = n_0 + n_2 I \tag{1}$$

Here ‘I’ is the intensity of light passing through the NLM, ‘n_0' is a constant linear refractive index term and ‘cn_2’ is the nonlinear correction term. For carbon disulfide (CS_2) $n_0 = 1.63, n_2 = 514\times10^{-20} m^2/W$. Again for fused $SiO_2 n_o$=1.458, $n_2 = 2.7\times10^{-20} m^2/W$. Optical AND and Ex-OR logic gates can be successfully implemented using such nonlinear materials. Let two input channels A and B are combined together and the combined signal is incident (shown in fig.l) at the interface of linear (LM) and nonlinear materials (NLM). Y_1 and Y_2 are the two output channels, one of which carries the refracted light from NLM at a time. Here the presence of light is assumed as the ‘logic 1’ (high) state and the absence of light represents the 'logic 0' (low) state. When both A=B=0, no light is seen at the output channels Y_1 and Y_2. If any one input is at high state i.e. gets light of a prefixed intensity, then Y_1=0 and Y_2=1. Again if A=B=1, the refractive index of the NLM increases as the intensity of light passing through NLM is doubled. Then the output channel Y_1 receives light while no light is obtained at Y_2. Thus if the output is taken from Y_1 end we get the result of AND logic operation and if the output is taken from the channel Y_2 the Ex-OR logic operation is obtained [as Y_1 gets light (1) only when both A and B carries light (1) and Y_2 gets light (1) if only any one of A and B gets light (1)]. Taking the above values of n_0 and n_2 (the non-linear correction term) for CS_2 and using the intensity of radiation $I = 2\times10^{18}$ W/m^2 and considering the angle of incidence as 45° we can find the value of θ_2 as 3.404°. Here 92 is the output angle of refraction in the nonlinear material. The above value of θ_2 is obtained using the Snell's law. Now if the intensity of the light passing through NLM is made doubled the value of θ_2 goes to 1.826°. That is a change of the angle of refraction will be obtained which is $\Delta\theta_2 = 1.578^0$. [For $n = n_0 + n_2 I = 11.91$, $\theta_2 = \sin^{-1}(\sin 45^0/11.91) = 3.404^0$ and for $n = 22.19, \theta_2 = 1.826^0$]

3. Implementation of the Scheme with the use of Nonlinear Material

In the proposed scheme let the light beam of intensity ‘I’ is coming from the point 'A' (shown in fig.2). The light beam may be polarized either in the plane of the paper (β) or perpendicular to the plane of paper (•). The light beam is splitted into two beams at the point 'B' by a beam splitter and made incident on two polarizers 'P_1' and 'P_2'. 'P_1' can pass only light having ‘(β)’ polarization and only the ‘•’ polarized light beam can pass through ‘P_2'. The each of two beams coming from 'B' is assumed to have an intensity level '1/2'. Now, in the first case, if the light beam coming from 'A' is polarized in the plane of paper (J) then polarizer 'P_1' allows the light beam to pass through it and 'P_2' blocks the light beam. Therefore light of intensity '1/2' arrives at the point ‘C’ This beam is now combined with the light beam of intensity '31/2' (polarized as 'β') coming from a constant laser source (CLS) as shown in the figure. This combined light beam is incident at the point ‘O_1’ at the linear material (LM) and nonlinear material (NLM) boundary. As the intensity of the incident beam is '21' it is refracted to the channel 'E' having the less angle of refraction then that of 'F' channel. On the other hand no light passes through 'P_2' in this case. So at the point 'D' only the light from another CLS prevails. The light beam from this CLS has intensity level '31/2' [and is polarized perpendicular to the plane of paper (•)]. Therefore the light beam, after incidence at the point 'O_2' at the second LM and NLM boundary, is refracted to the channel 'H'. Naturally no light is obtained at the channel 'G'. Thus at the point ‘S’ only the light beam from the channel 'E' is received. This will result at the output 'Y' light of intensity '21' with 'β' polarization.

In the second case, the light coming from 'A' is assumed to have intensity ‘I’ and polarized perpendicular to the plane of paper (•). Similar to the first case, this light beam is splitted into two beams'with each of intensity level '1/2' at the point 'B'. The first component cannot pass through the polarizer 'P_1' (as it can pass only 'β' polarized beam). So the light beam incident at 'O_1' is of intensity '31/2' (due to CLS only) and refracted through the NLM to the channel ‘F’. Thus it contributes no light at the point ‘S’ On the other hand the second component of the light beam from the point ‘B’ passes through the polarizer P_2' and reaches at the point ‘D’. This beam is now combined with the light beam (of intensity '31/2' and '•' polarized) coming from the second CLS. Thus the combined light beam incident at the point ‘O_2’ has the intensity level ‘2I’ and refracted through the NLM to the channel 'G’ This beam only arrives at the point 'S' now. Thus the output 'Y' gives a light beam of intensity '21' with '•' polarization.

4. Conclusion

Thus using the above scheme the intensity of a polarized encoded light beam can be maintained or raised at a required level. The strength of the CLS guides whether the signal intensity level would be kept same or increased. So the intensity as well as the polarization of a light signal both can be maintained simultaneously by the proper application of the method. This scheme will be very useful in logic processors where a prefixed intensity level of a signal with proper polarization is required for an operation. This scheme can support the strengthening of the intensity level of a signal whatever its state of polarization is ('β' or '•').

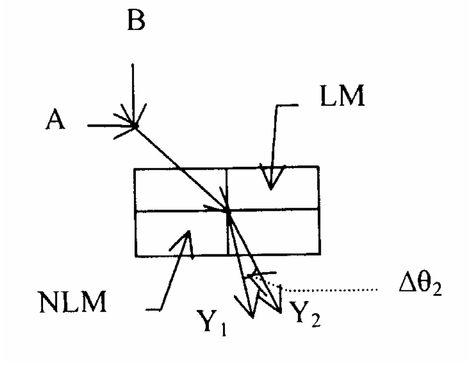

Fig. 1 : An optical AND and Ex-OR logic gate using nonlinear material

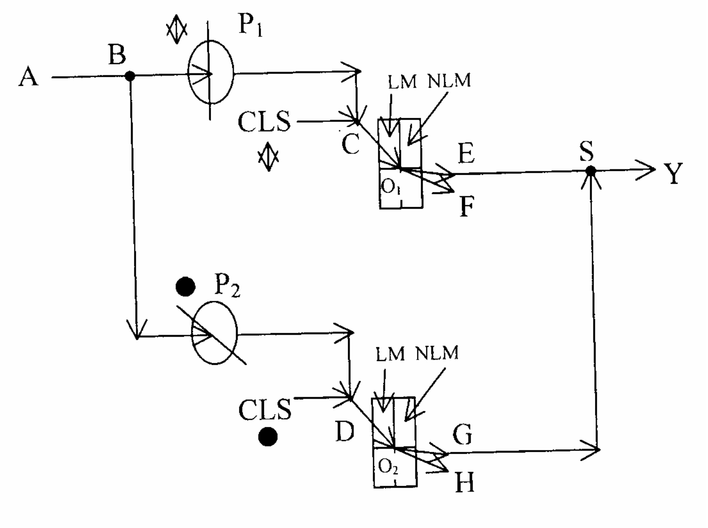

Fig. 2 : A scheme for maintaining the intensity level of a polarized light.

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