A new method of binary addition scheme with massive use of non-linear material based system

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The limitations in electronics in arithmetic, algebraic & logic processing are well known. Very high speed performance (above GHz) are not expected at all in conventional electronic mechanism. To achieve high speed performance we may think on the introduction of optics instead of electronics for information processing and computing. Non-linear optical material is a successful candidate in this regard to play a major role in the optically controlled switching systems and therefore in all-optical parallel computation these materials can show a very good potential aspect. In this paper, we have proposed a new method of an optical half adder as well as full adder circuit for binary addition using non-linear and linear optical materials.

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Electronic circuits are not so successful in very high speed (above GHz) communication systems[1−5]. For better performance, one can introduce optics in place of electronics. Non-linear material has been established as a successful candidate in optical switching devices[6−8]. The equation of refractive index for some type of non-linear materials can be written as $n = n_0 + n_i \cdot I$, where n_0 and n_i are the refractive indices and I is the intensity of the light beam. According to the above equation, the direction of the output beam will change if we change the intensity of the light beam passing through it. In the present paper, we propose a method of using of non-linear optical materials to construct optical half adder and full adder system in such a way that the output will obey the truth table of half adder and full adder. This proposed all optical circuit developed with such non-linear optical material is able to perform addition operation.

Figure 1 shows a process of using optical non-linear material to perform 1 bit binary addition optically. Here the non-linear material (NLM) and linear material (LM) combination block works as a half adder. A_0 and B_0 are two binary optical input signals. The refracted output signal will pass through either OP or OQ channel. Light in OP channel indicates the SUM. Similarly light in OQ channel indicates the presence of CARRY bit of the result of one bit addition.

First, we like to add two binary numbers 1 and 1. So, $A_0 = 1$ and $B_0 = 1$. The output will follow the channel OQ, i.e. we get light at the CARRY terminal and no light at SUM terminal, which means SUM=0 and CARRY=1. The output result is 10. This represents $1 + 1 = 10$.

Let us think the addition operation between 1 and 0. Here $A_0 = 1$ and $B_0 = 0$. The output will go through the channel OP, and no light will go through OQ channel. This indicates SUM=1 and CARRY=0. Here the obtained output result is 01 of $(1 + 0)$.

Similarly consider the addition between 0 and 1. Here $A_0 = 0$ and $B_0 = 1$. The output channel will be the same i.e. along OP channel. This gives SUM=1 and CARRY=0. The output result is 01 $(0 + 1)$.

Finally, let us see the addition between 0 and 0. Here $A_0 = 0$ and $B_0 = 0$. Due to absence of input signals, there will be no output signal, which means SUM=0 and CARRY=0. The corresponding output result is 00.

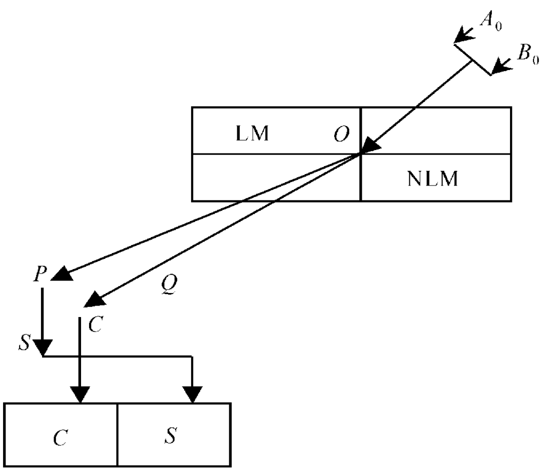

Fig. 1. An optical half adder using the combination of linear and non-linear optical material.

The principle of the operation is that when both the inputs (each having almost same intensity) present the refractive index of the NLM becomes more higher (according to the character of some specific non-linear materials) than at the situation when any one of A_0 and B_0 is present. In the first case the light passes through OQ and in the later case it passes through OP.

We now discuss a general binary addition scheme capable for addition between two multibit data. The system is shown in the Fig. 2. Tree architectures A and B are used to convert a decimal value into its respective binary value[9−10]. B_1B_0 and A_1A_0 are two multibit binary inputs (obtained from decimal inputs) which we want to add. One full adder system and one half adder system are placed for binary addition. For half adder system, A_0 and B_0 are the two inputs.The output will follow either OP_1 or OQ_1 channel. The light in channel OQ_1 indicates the CARRY.

For full adder, the inputs are A_1, B_1 and C (CARRY

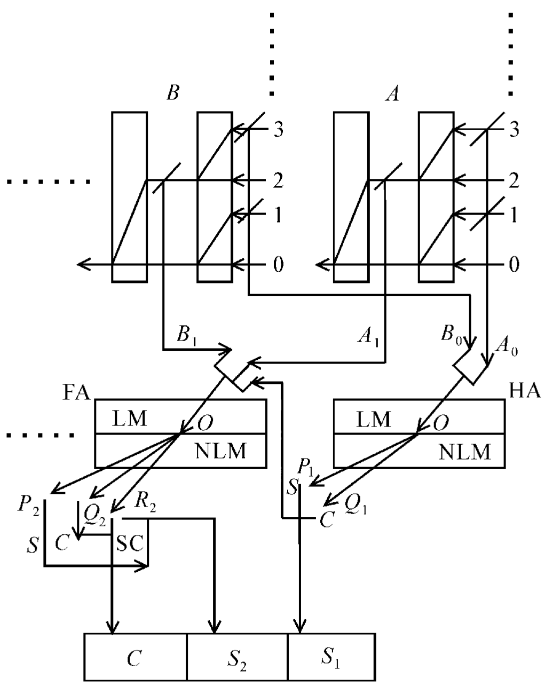

Fig. 2. Binary addition scheme using the combinations of linear and non-linear optical materials.

from previous half adder). Light may pass through the output channel marked by OP_2 or OQ_2 or OR_2. OP_2 represents the SUM. OQ_2 indicates the CARRY and OR_2 channel indicates both SUM and CARRY are present.

The output result is CS_2S_1. This is the binary output value.

Let us take an example for adding 2 and 3. We take $A = 2$ and $B = 3$. The binary equivalent of $A = 2$ is $A_1A_0 = 10$ and the binary equivalent of $B = 3$ is $B_1B_0 = 11$.

The inputs in the half adder are $A_0 = 0$ and $B_0 = 1$. The output will follow OP_1 channel, i.e. SUM=1 and CARRY=0, which means $S_1 = 1$. The inputs of the full adder are $A_1 = 1$, $B_1 = 1$, $C = 0$ (from half adder carry output). The output will follow OQ_2 channel. i.e. SUM=0 and CARRY=1 which means SUM=0=S_2, CARRY=1.

The final result will be $CS_2S_1 = 101$ which comes from the addition of 10(2) and 11(3).

For addition of two different strings of binary data (number) we require more expanded trees for conversion of decimal number (having greater value than that of 3) to its respective binary counter part. For such case we require also additional full adders. The dots in the Fig. 2 are representing such expansions. HA and FA are the abbreviations of half adder and full adder respectively.This blocks marked by FA & HA in Fig. 2, are same as that of Fig. 1 comprising linear and non-linear material.

Here in this circuit we used the inherent parallelism and advantages of optical signal as information carrier. The speed of operation is more or less real time that is very very faster operation than electronic system is obtained here. The major limitation here is the availability of suitable non-linear material and to activate it suitable laser radiation is also required.

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