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ALL OPTICAL FREQUENCY ENCODING METHOD FOR CONVERTING A DECIMAL NUMBER TO ITS EQUIVALENT BINARY NUMBER USING TREE ARCHIRECTURE

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Abstract: In any kind of computing and data processing system he use of binary numbers are found very much suitable and reliable. On the other hand several natural representations have been realized by decimal numbers. So conversion of a decimal number to its binary equivalent and vise-versa are of great importance in the field of both computation and communication technology. There lie several established methods for dealing such conversion process. Again optical tree architecture is one of the most promising systems for realizing the optical conversion of any decimal number to its equivalent binary. Here in this communication the authors propose a new method for optical conversion of a decimal number to its binary equivalent using optical tree architecture and frequency encoding principle.

1. INTRODUCTION

Optics has a strong and very potential role in information and data processing because of its inherent parallelism. It can exhibit several advantages over electronic in superfast computation and data processing. In last few decades, several all optical data processors were proposed based on the Boolean logic. Those optical systems and optical logic devices based on optical switches are found very much useful than electronic one in connection to enhanced operational speed and many other aspects. There lie several types of optical switches. Semiconductor optical amplifier (SOA) is one of them which can be used as a potential high speed optical switch. Again it is well established that like electronic computation, in optical computation also the conversion from decimal number to binary number or vise-versa is very much important as data represented in binary are found most suitable for computation and the natural numbers are mostly dealt in decimal. Here in this communication the authors propose a new concept to implement all-optical conversion from decimal to binary with optical tree architecture using the frequency encoding principle[1-2]. The advantages of frequency encoding are that as the frequency is a fundamental character of any signal, so it remains unchanged in reflection, refraction, absorption etc. during transportation of signal. The high reflecting and frequency diverting properties of optical ADD-DROP multiplexer (ADM) and high wavelength conversion property of reflected RSOA are exploited here to implement the above conversion [3-4].

2. FREQUENCY ENCODED PRINCIPLE AND TREE ARCHITECTURE

Frequency is a fundamental character of light. In optical computing and data processing the most important point is the very high speed operation. Generally the presences of optical signal at input/output end are encoded as '1'and absence of optical signal as '0'. In case of long distance communication intensity of optical signal may significantly change, it may dropdown below the respective reference level because of absorption and many other reasons. This problem can be solved by using frequency of light in coding procedure. One can encode and decode two different states of information by two different frequencies [5-6]. Here if '1' state is represented by a specific frequency ν_2 then '0' state can be represented by another frequency ν_1. These frequencies are remaining unaltered during the reflection, refraction, absorption etc when data is transmitted for long distance communication. Here in this proposal we encode and decode the state of information '0' by a beam of wavelength λ_1 (which is corresponding to ν_1) and state of information '1' by another wavelength λ_2 (which is corresponding to ν_2).

For optical conversion from a decimal to binary number and its vise-versa are very important. Several types of conversion methods are well-known in computation process. Optical tree architecture is one of them. It is also an established optical technique. No switches are required here for converting a decimal digit to its binary counter-part. Some beam

splitters (BS) and mirrors (M) are used in proper positions of the tree to execute this conversion. Some optical channels are used here to get the desired output. Light beams are splited by the BS's and reflected by the M's and go through the optical channels. In fig.1 the tree architecture is shown. Here any decimal digit (position-wise represented) is converted to its respective binary counter-part. For example if the decimal value (which is supposed to be converted) is 5, then one have to apply light to the input channel of the tree marked by 5. At that time one can receive the output 101 which is binary equivalent of decimal 5, i.e. light will come at X_2 and X_0 but no light will come at X_1.

2.1 SWITCHING OPERATION OF SEMICONDUCTOR OPTICAL AMPLIFIER (SOA)

Semiconductor optical amplifier (SOA) is an optoelectronic device which can amplify an input signal. Many functional applications of SOA are based on its nonlinearity. SOAs can be used as different types of optical switches which are based on four wave mixing, wavelength conversion, Add/drop multiplexing (ADM) etc. Here in this communication the authors use the Add/Drop multiplexing and wavelength conversion characters of SOA. In Add/Drop multiplexing the selection of proper frequency from a band of frequencies are done by not disturbing others. The wavelength conversion property of SOA can be is used for the conversion of the selected frequency or wavelength to another desired one. A mixer of frequencies of pulse or continuous signal (ν_0 to ν_9) falls on the ADM which is tuned at any particular frequency by the application of the proper bias current. The ADM then passes all the frequencies not allowing that particular frequency to pass through it. One can receive that particular frequency of light at output by the use of an optical circulator. This is shown in figure-2. The reflecting semiconductor optical amplifier (RSOA) on the other hand is a wavelength converter [7-8]. In this switch a particular frequency of week light signal is given as a probe beam and another signal of another frequency is given as a pump beam to the input channels of RSOA. If only those two specific light signals are present in the input channels then one can get the power of the pump beam delivered to the week probe beam at output, i.e. the probe beam is amplified by a power factor. The scheme is shown in figure-3. Using the ADM a specific frequency is selected and using RSOA the selected frequency is amplified [9-12].

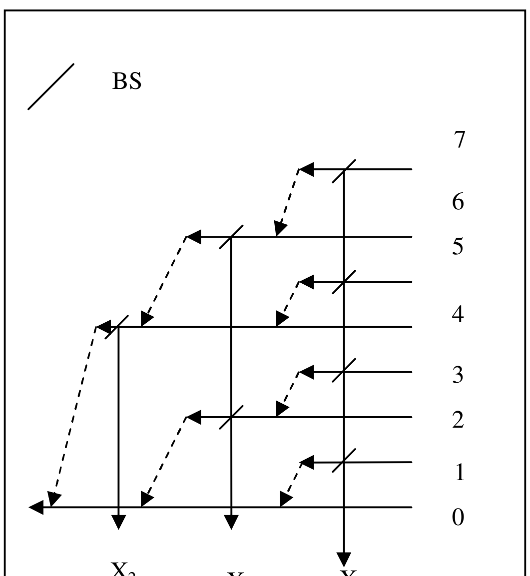
3. OPTICAL IMPLIMENTATION OF DECIMAL TO BINARY CONVERSION

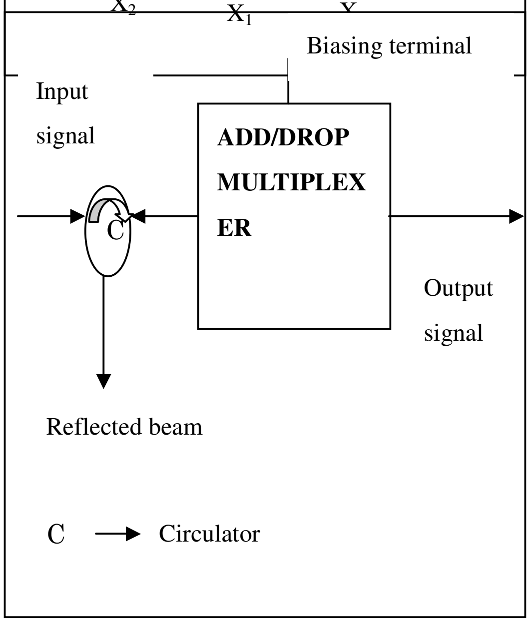
METHOD

Here the proposed conversion scheme is given in figure -3, ν_0 to ν_9 the ten frequencies are taken for representing 10 decimal digits. A light beam having a frequency ν_i (where i lies from 0 to 9) falls on the ADM_1 (the 1^{st} add drop multiplexer) where this ADM_1 is tuned for reflecting the light of frequency ν_1 by the application of proper bias current to it. So, only ν_1 frequency of light will not pass through the 1^{st} SOA whether all other will easily pass through it. The ν_1 frequency will come out from the ADM_1 by the optical circulator (C). Similarly nine other ADMs are used in series which are tuned for different other frequencies (ν_2 to ν_9) respectively. So, those selected frequencies of light will come from 10 different channels of the 10 SOA blocks in the series of ADM's. Now using some optical beam splitters BS's and mirrors M's one can convert a decimal number to an appropriate binary number follow the principle of conversion by tree architecture. For this conversion one can use now the frequency encoding principle. Here the light frequency is used to code signal bit. If it is to convert the decimal number 5 one should use the ν_5 light frequency at initial input. As for example-101 is the equivalent binary number of the decimal number 5, so first the ν_5 light frequency is selected and applied as initial input for conversion. It passes through the ADM_1, ADM_2, ADM_3, and ADM_4 but can not pass through ADM_5 as it is tuned for the frequency ν_5. So ν_5 can not pass through the ADM_5 and the ν_5 frequency is received from the respective circulator. Then passing through the properly oriented BS's and M's one can get the binary output from the respective channels. These outputs are $A_3A_2A_1A_0$. In the particular case one can get ν_5 signal at A_2 and A_0 and no light at A_3 and A_1 which indicates 0101. Now these outputs $A_3A_2A_1A_0$ treated as inputs of the wavelength converter switches (the RSOA's). Here these outputs are used as pump beams and another constant ν_1 frequency light beam is given as probe beam to all the wavelength converters. For different input frequencies ν_0 to ν_9 (representing different decimal inputs) the $A_3A_2A_1A_0$ are converted in such a way that the bits (A_3 or A_2 or A_1 or A_0) takes a particular frequency when it is 1 and it takes no light when it is 0. For example when the decimal input 7 is applied for conversion, it indicates ν_7 frequency is applied. Therefore $A_3A_2A_1A_0$ is 0111 which is binary equivalent of 7. So here A_3 represent 0 by consuming no light in the channel whereas $A_2A_1A_0$ takes the light of frequency ν_7 to represent 1. Now for conversion of decimal 6, ν_6 is applied as decimal input. The binary equivalent of 6 is 0110. To represent it the A_2 and A_1 takes light of ν_6 frequency to represent 1 and no light to represent 0. Therefore for different conversions for different decimal inputs the bits are represented by different frequencies. To get rid of this problem, the outputs of A_3, A_2, A_1 and A_0 are passed through four different RSOA's for conversion of light frequencies to a specific frequency ν_1 to represent 1. So a decimal number is to be converted, the bits of the converted binary number are represented by frequency ν_1, by the use of RSOA. Thus the final outputs are $B_3B_2B_1B_0$, which comes after the operations from RSOA's. Therefore one can get ν_1 frequency of light to represent a binary bit 1 and no light to represent the binary bit 0. In the same way for application of all the decimal inputs the 1 bits of the converted binary number is represented the ν_1 frequency of light and 0 bits by no signal. The whole conversion method is shown in fig.4.

4. FIGURES

FIGURE-1: Optical tree architecture

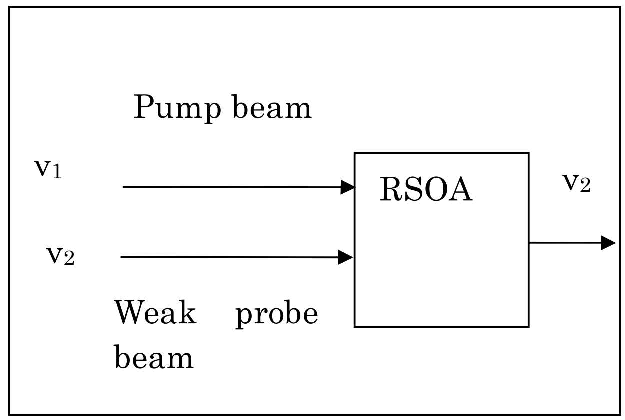


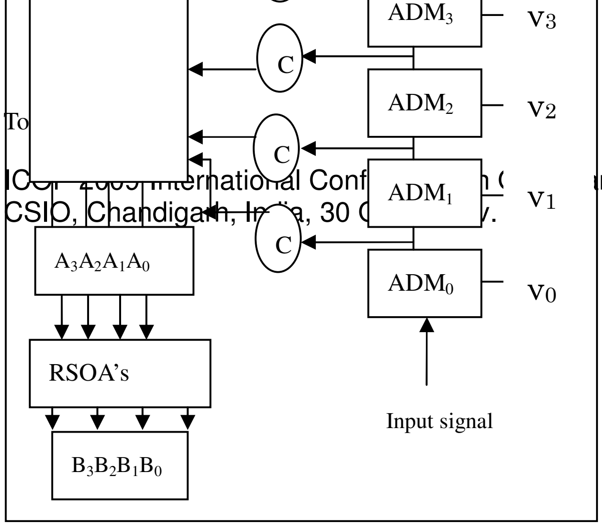


FUGURE-2: Add/Drop multiplexer

FIGURE-3: Wavelength conversion by RSOA

FIGURE-4: Frequency encoded conversion method





5. CONCLUSION

The whole operation system is all-optical one and extends a very high speed operation (far above GHz limit).This method can be extended also for converting a decimal number of higher values (greater than 9) by enlarging the tree architecture. The potential advantage of the method over any other electronic and optical one is the frequency depending input and output encoding. For that reason the coded information (1 or 0) in a signal remain unchanged in reflection, refraction, transmission, absorption etc. For the same converters based on the intensity based encoding/decoding of decimal numbers, the most disadvantageous point is the fluctuation of intensity of light during transition which may alter the reference level of bit value. Again due to the fluctuation of the light intensity the direction of the output may be changed in case of implementation of the conversion by Kerr type nonlinear materials switch based optical switch with intensity based encoding, decoding mechanism. So in the case of nonlinear material based optical switches it always requires constant intensity light source. Whereas in frequency based encoding/decoding system this disadvantage is removed. Here the coded frequency remains unaltered in all the above conditions. Therefore, this proposed system does not only give a high speed operation, but also offers a trouble free and noise free conversion.

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