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ARTICLE

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THEORETICAL DESIGN OF HYPERSECANT SOLITON BASED DEMUX

CHINMOY MUKHERJEE[1*] AND ABHIJIT SINHA[2]

For the design of a communication circuit, we need to propose a high speed and low dispersion model. But we can design de MUX circuit using soliton-based logic gates. A deMUX is a design where single channel can be connected with multi-channel. We analyses the deMUX using solition pulse as a signal and the control line as a trigger pulse. The input pulse is a hypersecant pulse like $f(z,t) = E_0 \sec(h\sigma T)e^{-imz}$ *. This pulse superposed with trigger pulse under different phase condition.*

Introduction

Soliton overview: The word Soliton was learn in Science vocabulary in 1964 mainly through the work of M Kruskal and N Zabusky[1]. Optical Soliton already established its strong candidature in optical fiber-based communication system. Use of optical Soliton is a well-established phenomenon in digital communication because of Soliton pulses remains almost unaltered their shape and potential after propagating long distance. Now a day's communication system also demands very fast and high security communication. Question of security in communication can be managed easily by the nonlinear optical phenomenon. In this regard we consider the interesting fact of soliton superposition.

Design of Logic Gate Based DeMUX: We can design a deMux using basic logic gates, where there was single input and multiple output. Output as selected by the control line. The truth table and the fig corresponding to deMUX as shown in figure. The input line I always on mode and the output will be selected by the selection line S_0 and S_1. The output will be on according to selection line[2]. We propose a demux design using soliton pulse propagate through a fiber. Soliton pulse is a non dispersive pulse, which can propagate long distance without the shape change[3].

Theory

Consider the hyper secant soliton pulse (HOSP) as a signal we can analyses from non- linear Schrodinger equation

$$i(\partial f / \partial Z + 1/v_g \partial f / \partial t) = \Gamma(f^2) f - \gamma / 2 \frac{\partial^2 f}{\partial t^2} \qquad (1)$$

Where $f(z, t)$ represents the pulse envelop function,

$$\gamma = \left(\frac{d^2 k}{dw^2}\right)_{w=w_0} ; \quad v_g = \frac{1}{\left(\frac{d\beta}{dw}\right)_{w=w_0}} ; \quad \Gamma = \frac{1}{2} w_0 \varepsilon_0 n_0 n_2 , \beta$$

is the propagation constant.

n_0 is the refractive index of fiber. n_2 non-linearity correction of refractive index.

$\Gamma\left(f^2\right) f$ is the non-linearity, term and $\frac{\gamma}{2}\frac{\delta^2 f}{\delta t^2}$ is the dispersive term.

1 Department of physics, Government General Degree College, Dantan II. Medinipur, West Bengal, India, Sahanapally, Kenduadihi, Bankura, 722102
e-mail: ichinmoy82@gmail.com,

2 Department of Physics, Bankura Christian College, Bankura, West Bengal, India
e-mail: sinhaabhijit74@rediffmail.com

The solution of this equation

$$Fi(z,t) = E_0 sech\sigma T e^{(-imz)} \tag{2}$$

Equation (2) is the HOSP form for signal propagation. Suppose we consider a signal and two control line as the input of demux, they superposed with each other and each interaction followed by a phase[4]. Every phase measured by a phase selector, so as the input selected[5].

The HOSP with arbitrary amplitude and phase

$$Fi(z,t) = E_{0i} sec\, h\sigma_i T_i e^{-im_i z} \tag{3}$$

We consider three HOSP superposed together and the resultant pulse as[3]

And $F_3(z,t) = \left(E_{01} \sec h\sigma_1 T_1 e^{-im_1 z} + E_{02} \sec h\sigma_2 T_2 e^{-im_2 z} + E_{03} \sec h\sigma_3 T_3 e^{-im_3 z}\right)$

E_{01} be the signal and E_{02} , E_{03} are the control line.

The intensity of resultant HOSP after superposition

$$I = F_3(z,t) \times F_3^*(z,t)$$

$$\begin{aligned} I = &\left(E_{01}^2 \sec^2 h\sigma_1 T_1 + E_{02}^2 \sec^2 h\sigma_2 T_2 + E_{03}^2 \sec^2 h\sigma_3 T_3\right) + \\ &2E_{01}E_{02} \sec h\sigma_1 T_1 \sec h\sigma_2 T_2 \{\cos m_1 z \cos m_2 z + \\ &\sin m_1 z \sin m_2 z\} + 2E_{02}E_{03} \sec h\sigma_2 T_2 \sec h\sigma_3 T_3 \\ &\{\cos m_2 z \cos m_3 z + \sin m_2 z \sin m_3 z\} + 2E_{01}E_{03} \sec \\ &h\sigma_1 T_1 \sec h\sigma_3 T_3 \{\cos m_1 z \cos m_3 z + \sin m_1 z \sin m_3 z\} \end{aligned}$$

The regarding phase angle

$$\phi_1 = (m_2 - m_1) z$$

$$\phi_3 = (m_1 - m_3) z$$

$$\phi_1 = \phi_2 - \phi_3$$

$$= (m_2 - m_3) z - (m_1 - m_3) z$$

The resultant pulse intensity is the following

and $\phi_2 = (m_2 - m_3) z$

$$I = \begin{pmatrix} E_{01}^2 \sec^2 h\sigma_1 T_1 + E_{02}^2 \sec^2 h\sigma_2 T_2 + E_{03}^2 \sec^2 h\sigma_3 T_3 + \\ 2E_{01}E_{02} \sec h\sigma_1 T_1 \sec h\sigma_2 T_2 \cos\phi_1 \\ +2E_{01}E_{03} \sec h\sigma_1 T_1 \sec h\sigma_3 T_3 \cos\phi_3 \\ +2E_{02}E_{03} \sec h\sigma_2 T_2 \sec h\sigma_3 T_3 \cos\phi_2 \end{pmatrix} \tag{5}$$

Analyze the HOSP Logical Operation for the Different Output Selection: 1.With a condition followed that trigger pulse E_{03}=0 that is a low signal

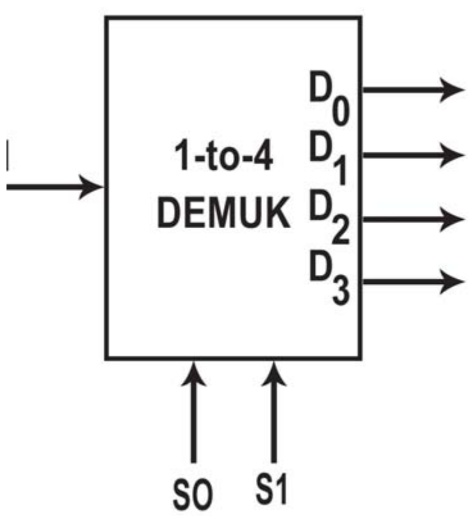
When A = 1, high and B = 0 and consider trigger pulse phase with any arbitrary phase.

Consider the input pulses, E_{01}= A, E_{02} = B and E_{03} = C then $I = E_{01}^2$ that is input selected as D_0 in fig 1.

2. A = High (1), B = High (1) with E_{02} = E_{01} = E_0

$$I = E_0^2 (sec^2 h\sigma_2 T_2 + sec^2 \sigma h_3 T_3 + 2 sech\sigma_2 T_2 sech\sigma_3 T_3 cos\phi_2) \tag{6}$$

As, $\phi_2 = 0$.



I	Select		O/P			
	SO	S1	D_0	D_1	D_2	D_3
1	0	0	1	0	0	0
1	0	1	0	1	0	0
1	1	0	0	0	1	0
1	1	1	0	0	0	1

Fig. 1 : Block diagram of deMUX and truth table.

$$I = E_0^2\left(\sec h\sigma_2 T_2 + \sec h\sigma_3 T_3\right)^2 \quad (7)$$

I = High as Consideration, D_2 as selected.

3. Consider A = High and B = Low, $E_{01} = E_{03} = E_0$ and $\phi_3 = 2\pi$.

$$I = E_0^2\left(\sec\sec h\sigma_1 T_1 + \sec\sec h\sigma_3 T_3\right)^2 \quad (8)$$

I = High state, output D_2 selected, and

4. We consider the trigger pulse E_{03} = 0, A = High and B = High, $\phi_1 = 0$

$$I = E_0^2(sech\sigma_1 T_1 + sech\sigma_2 T_2)^2 \quad (9)$$

I = High state, D_3 output selected.

So, every output be selected as required. The input A is always high and every phase condition selected by the input phase. The relevant fig. 1 describe the block diagram and truth table of the 1:4 deMUX.

Conclusion

Design of deMUX using HOSP is essentially very important and interesting analyse of modern communication. It is high speed and dispersion less communication. No delay time like the digital deMUX. Easy to design, just like a superposition of pulses. So, the new concept may design by practical view also by photonic crystal using this theoretical model. ❐

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