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# Solitons for Switching Technologies

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**Abstract—***Soliton refers to highly stable localized solutions of certain nonlinear partial differential equations describing physical phenomenon. Soliton concept was first discovered on hydrodynamics in the 19th century and then entered into other branches in physics.An optical soliton in a short high amplitude optical pulse that does not spread as it propagates. It propagates through a nonlinear optical medium without any changes in its shape and velocity.Solitons in nonlinear optical fiber have important applications in communication, optical computing, optical switching etc.*

## 1. INTRODUCTION

### 1.1 Discovery of Solitons

The existence of optical solitons in lossless fiber was theoretically demonstrated first by Hasegawa and Tappert in 1973 in the form of dark and bright solitons in anomalous (normal dispersion regime).As defined by Akria Hasegawa in [1] the solitons in the fiber is made by deriving the equation of complex light wave envelope E(z,t) by retaining the lowest order of the group dispersion and the nonlinearity which is cubic for glass fibers and originates from kerr nonlinearity. The index of refraction in kerr medium is defined by $n = n_0(w) + n_2(w) \left| E \right|^2$

Where $\eta_2$ is kerr coefficient [1].When complex light wave passes through a nonlinear medium the modes are defined by the nonlinear Schrodinger (NLS) equation. Complex wave envelope equation becomes inhomogeneous in the nonlinear medium because of the variations in dispersion and fiber losses. DBF Distributed Feedback lasers can be used as a source for soliton generation.[1].Soliton is then guided through erbium doped fiber amplifiers (EDFA) system [1].

## 2. SWITCHING AND OPTICAL SIGNAL PROCESSING

Optical signal processing requires nonlinear materials where one light beam is controlled by another. The SOA Semiconductor optical amplifier does all optical signal processing work. The conventional electrical signals are more difficult o route and transmit at the speed of 40 GB/s or above. To meet these ever increasing demands of data communications for future optical networks high speed digital processing is required and photonics signals at the physical layer are attractive to perform various computational functionalities such as packet buffering, bit length conversion, header processing, switching, reshaping and overcoming all the speed electronics limitations. All optical digital processing seems to be one of the most promising technologies to bring increased capacity, flexibility and scalability to the next generation systems in the optical domain.[2]

## 3. ROLE OF PHOTONICS

The dream of photonics is to have a completely optical technology in which electrons the traditional information carriers are replaced by photons for devices based on switching and logic. To overcome the electronics bottlenecks and fully exploit the advantages of fibers its necessary to move towards network where the transmitted data will remain exclusively in the optical domain without optical electrical optical conversions[3] .

## 4. OPTICAL SOLITION FOR LOGIC GATES:

Logic gates are primarily implemented using diodes or transistors acting as electronic switches. But can also be constructed using electromagnetic relay, fluidic logic, pneumatic logic, optics, molecules, or ever mechanical elements. Solitons are used to make Optical logic gates that are applied to label swapping architectures and optical packet time to live processors. These logic gates have high throughputs, low power consumptions and high band efficiency compared to conventional electrical routers.

Optical solitons have been concentrated for their potential applications in photonics, optical wave guiding, optical communications and optical interconnects.

## 5. REVIEW ON DESIGNING A SWITCH

### 5.1 Optical Solition and Panda ring

Using a Panda ring resonator we can tune, amplify and control the data signals. The stability is generated and achieved when the system is controlled by the Gaussian pulse via control port.

By using dark and bright soliton conversion control within the Panda ring, the obtained output signal can be attenuated and used to perform the single photon switching, which is used for security code applications. These dark and bright soliton can be used for random binary applications. These can be used with add/drop optical multiplexers.

The technique is phase modulation technique which is based on spatial soliton switching properties. The modulator device accepts as input two stream of amplitude modulated pulses whose phase values depends on the different input combinations ,coding property and input streams and increasing the transmission capacity of the optical channel that carries this information.

The driving force behind this evolution is the use of interferometeric configuration that employ a semiconductor optical amplifier (SOA) as the nonlinear element in combination with cross phase modulation to achieve switching by means of light. Examples are TOAD switch /terahertz optical asymmetric demultiplexer, SOA based Mach Zehnder interferometer and ultrafast nonlinear interferometer(UNI) [3].There modules have been widely exploited as discrete entities to execute various bitwise processing speed and power consumption.[3].

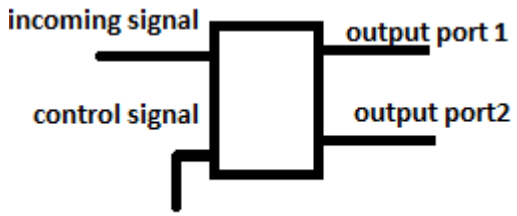


**Fig. 1: Shcematic diagram of TOAD based optical switch**

TOAD based optical switch uses soliton technology which perform terabytes per second(T bytes/s) demultiplexing.

Dilip Kumar and Arunva Bhatacharya has proposed Binary coded Decimal adder with this technology in [3] using TOAD. To maintain appropriate power level Erbium Doped Fiber amplifier can be used.

It has been proposed by Yuji Miyoshi ,Kensuke Ikeda etal. in [4] an ultrafast all optical logic gate .A number of research groups have investigated all optical switching in fibers. Islam etal [5] implemented an imbalanced nonlinear optical loop mirror where the amount of light transmitted by the loop was a function of the input pulse energy. Switching in this case was based on self-phase modulation (SPM). Blow etal [6] also used a loop mirror configuration, except that two wavelength were used and switching was based on cross phase modulation (XPM). Jay E. Sharping, Marco Fiorentino, Prem Kumar etal. have reports on experimental setup of all optical switch, which operates on the basis of XPM in MF Microstructure Fibers. It required shorter fiber length, lower switching powers and allows switching of weaker pulses. These experiments showed the feasibility of using nonlinear optics in Micro structured Fibers to perform essentially functions in high speed all optical processing. Using WDM system as linear and soliton approach is attracting interest in high speed switching networks[7].Two dimensional discrete cavity solitons has been studied for the gate design and switching technologies[9].

## 6. CONCLUSION

For communication a channel is needed and optical fiber is one such channel among many others. Optical fiber communication has many advantages over conventional communication systems like higher bandwidth, immunity to external disturbance etc, it has certain problems as well. The dispersion phenomenon is one such problem for high bit rate and long haul optical communication systems. An easy solution for this problem is optical soliton pulses that preserve their shape over long distances. Soliton based optical communication systems can be used over distances of several thousands of kilometers with huge information carrying capacity [13].

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