Volume 5, Issue 1, January 2018 ISSN: 2348-8565 (Online)
International Journal of Modern Engineering and Research Technology
Website: http://www.ijmert.org Email: editor.ijmert@gmail.com

Soliton Transmission in Optical Fiber Communication System

Pragati Patharia
Assistant Professor
Guru Ghasidas Vishwavidyalaya
Central University,
Bilaspur (C.G.) India
Email: pathariapragati@gmail.com

ABSTRACT

Soliton transmission is a new hope of data transmission. Main aim of this paper is to introduce the basic concept of soliton transmission propagation model in optical fiber. It is the pattern of short optical pulse in optical fiber. This short optical pulse is known as Soliton. It is very effective and attractive type of transmission because shape of pulse does not changes during the process. So in long distance transmission, signal can be transmitted effectively without any kind of distortion such as dispersion. Basic principle of soliton transmission is based on Non Linear Schrodinger Equation.

Keywords:— *Soliton, Dispersion, Non linear Schrodinger Equation (NLSE).*

I. INTRODUCTION

Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber. The light wave is basically a electromagnetic wave which acts as a carrier that is modulated according to information signal. Fiber-optic communication systems gives enormous potential channel bandwidth which is the biggest advantage of it. Because of its advantages over copper wire system, it replaced the whole copper wire system in core networks. In basic building block of optical fiber communication system have following steps electric source, light source, optical fiber, optical detector, electric destination.

II. BASIC OPTICAL FIBER COMMUNICATION SYSTEM

The input electrical signal modulates the intensity of light from the optical source. Electro optic modulator is used for modulation. It modulates the intensity of light according to message signal. Electric pulses modulate the intensity of the light of the laser diode or LED and therefore they convert into optical pulses. In the receiver section, the photo detector (photo diode) which can be avalanche photodiode (APD) or PIN diode converts the light pulses into electrical pulses. A decoder converts the electrical pulses into original electric signal. Main components of the basic optical fiber communication are as follow:

- Electric Transmitter
- Optical Source
- Optical fiber cable
- Optical detector
- Electric Receiver

III. Structure of Fiber

A typical glass fiber consists of core which is surrounded by a cladding and both are made of glass Silicondioxide. Refractive index of core is kept higher than the refractive index of cladding. Propagation of light follows the principle of total internal reflection. The overall diameter of the fiber is about 125 to 200 micro meter. Cladding gives mechanical strength and safety to the fiber from scratches, and also guides the light in to the core. Based on the refractive index profile, there are two types of fibers :

Step index fiber

In the step index fiber, the refractive index of the core is uniformly distributed from the centre of core. The light rays propagate through the core of fiber in the form of meridional rays. Meridional rays follows the zigzag path in core which results from the multiple total internal reflections at core cladding boundary.

Graded index fiber

In the graded index fiber, the refractive index profile is in parabolic shape. So the maximum value of refractive index is at the centre of the core and it gradually decreases from it. The shape of light rays is in form of skew rays or helical rays which do not cross the fiber axis at any time.

Based on the number of modes supported by the fiber, there are 2 types of fibers, multimode and single mode. In single mode fiber, only one mode (ray) is confined with the fiber whereas in multimode fiber, several modes are associated with the fibers.

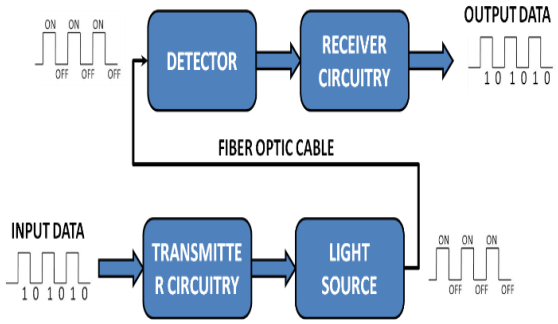

Figure 1: Basic Optical Fiber Communication system

IV. Advantages of Optical Fiber Communication

Wider bandwidth

The channel bandwidth is directly proportional to the carrier frequency of the transmitted signals. The optical carrier frequency is in range of Tera Hz while the radio wave frequency is in range of MHz and the microwave frequency is in range of GHz. Thus the optical fiber gives higher transmission bandwidth than the conventional communication systems and the data rate is also so high. Further the wavelength division multiplexing and dense wavelength division multiplexing techniques can more increase the channel capacity.

Low transmission loss

In optical fiber communication system there is the transmission loss of 0.02 dB/ km, which is very low in comparison to other conventional system. By using erbium doped silica fibers over a short length in the transmission path at selective points; optical amplification can be done. Because the amplification is done in the optical domain itself, so the distortion is almost negligible.

As a waveguide

Optical fiber is made from silica which is a perfect electrical insulator. Therefore they do not response any electromagnetic disturbance. Optical fiber is also suitable in explosive environments because it is not affected by any interference resulting from power cables, railway power lines and radio waves. There is no cross talk among so many fibers in a cable because of no optical interference between them.

Signal security

The transmitted signal is totally confined within the core of the fibers so it does not radiate the signal. So the transmitted signal cannot be tapped from a fiber in an easy way. Therefore optical fiber communication system gives 100% signal security.

Small size and weight

Fiber optic cables are designed with small radii so they are flexible, compact and light in weight. The fiber cables can be installed easily because it can be bent or twisted without any damage. So the optical fiber cables have more advantages over copper cables in terms of storage, handling, installation and transportation, maintaining comparable strength and durability.

V. DISPERSION PHENOMENON

Dispersion is a type of distortion in optical fiber communication system. Because of the dispersion there is result of pulse broadening, which affects the data rate. Dispersion is basically wavelength dependent phenomenon. It is based on the fact that the velocity of the electromagnetic wave depends on the wavelength. This degradation in signal is occurred because the different spectral components have different frequencies propagate with different velocities.

Types of dispersion

- Intermodal dispersion
- Material dispersion
- Waveguide dispersion
- Intra modal dispersion
- Polarization dispersion

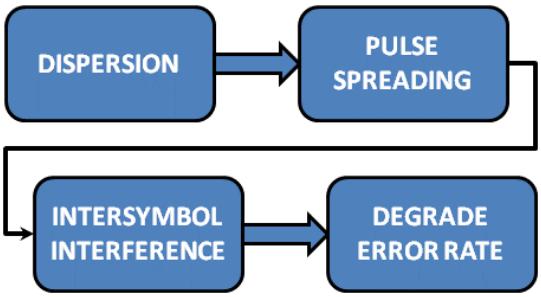

Figure 2: Block diagram of effect of dispersion

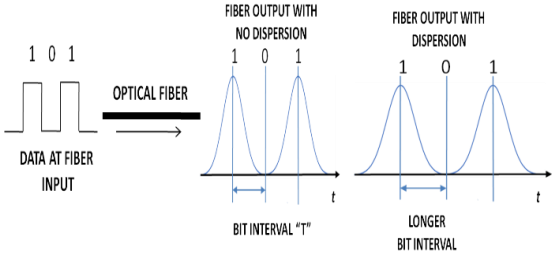

Figure 3: Block diagram of effect of dispersion on wave shape of pulses

Dispersion affects the bit rate of data transmission.

Dispersion affects the bit rate and performance of long distance communication. It limits the performance of the system. Solution of dispersion is optical solitons–pulses that preserve their shape over long distances. So the system based on optical soliton can be used over long distances with greater efficiency.

Optical amplifiers can be used for enhancing the performance. If optical amplifiers are combined with WDM in soliton based communication, Tera bits per second data transmission can be achieved.

VI. Soliton Based Transmission

Soliton waves are the special kinds of waves that can propagate over long distances without changing their shape and these are unaffected by collisions with each other. Description of some line coding schemes are as follows:

- RZ (Return to Zero) line coding when digit 1 represents the one pulse.
- NRZ (Not Return to Zero) line coding when 2 or more pulses are connected with sequences of 1
- Duo-binary line coding if the one pulse is allowed to have two type of pulses with opposite phases.
- In Soliton format one soliton represents 1 digit.

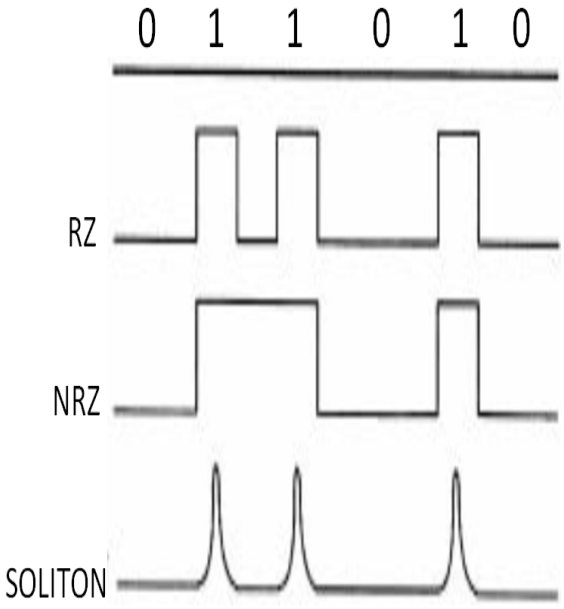

Figure 4: Various modulation schemes for transferring the information in fibers

VII. Information Transmission

When individual pulses are well separated then solution of Non Linear Schrodinger equation can be applied. This can be achieved by keeping soliton width a small fraction of the bit slot.

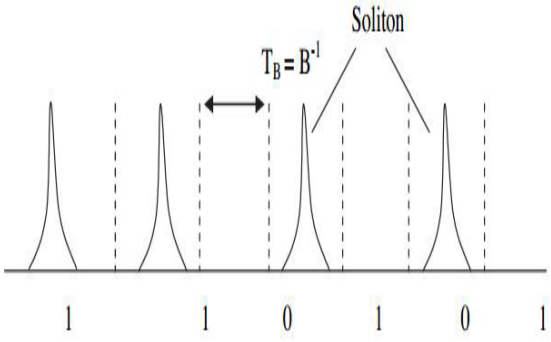

Figure 5: Transmission of soliton pulses

The bit rate B and the width of the bit slot TB can be related as :

$$B=\frac{1}{T_B}=\frac{1}{2S_0T_0} \quad \text{..... (1)}$$

Where 2S0=TB/T0 is the normalized separation between two neighbouring solitons.

VIII. Soliton in Optical Fiber

By this example it is the demonstration of the propagation of soliton pulse in optical fiber. Balance between the chirps induced by GVD (Group Velocity Dispersion) coefficient β2and fiber nonlinearity characterized by SPM (self-phase modulation) coefficient γ is the result of existence of soliton.

$$A(z,t) = N\sqrt{p_0}\,Sech\,(t/T_0)\exp\left(j\frac{\Pi}{4}\frac{Z}{Z_0}\right) \quad (2)$$

$$Z_0 = \frac{\Pi}{2}\frac{T_0^2}{|\beta_2|} \quad \text{.....(3)}$$

$$N^2 = \gamma P_0 \frac{T_0^2}{|\beta_2|} \quad \text{..... (4)}$$

XI. Simulation and Results

Opt Sim software is used for simulation. Given values are $n^2=2.69e^{-21}$ m^2/W, $A_{eff}=61$ um^2, and $\lambda=1550$ nm - $\gamma=1.75e^{-31}/m/W$. $Z_0=$ 26.525 km is the fiber length. Initial pulse has been taken a sech shape. FWHM pulse width has been taken 32 ps, corresponding to T0=18.5 ps. For fundamental soliton input power is 32.5 mW. Wave shapes figures shows soliton pulse evolution (in time and frequency domains) in fiber along one soliton period for N=1. By comparing input and output figures we can say that soliton pulse shapes are exactly same after travelling the distance 26.525 Km.

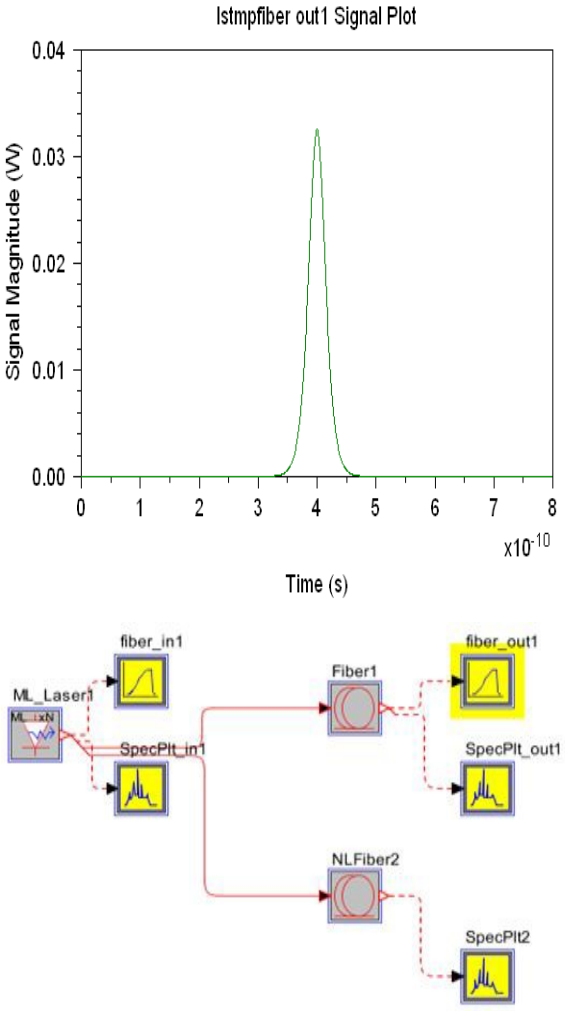

Figure 6: Setup diagram for soliton, N=1

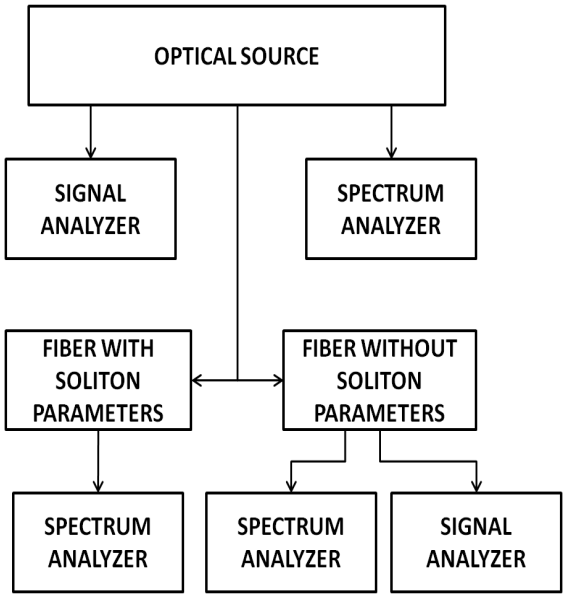

Figure 7: Block diagram of setup for soliton, N=1

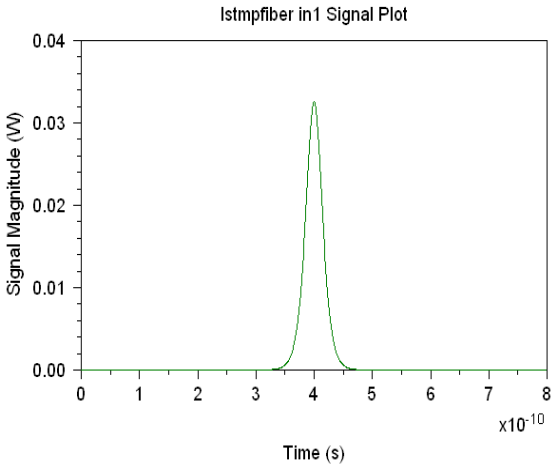

Figure 8: Input signal in time domain (N=1)

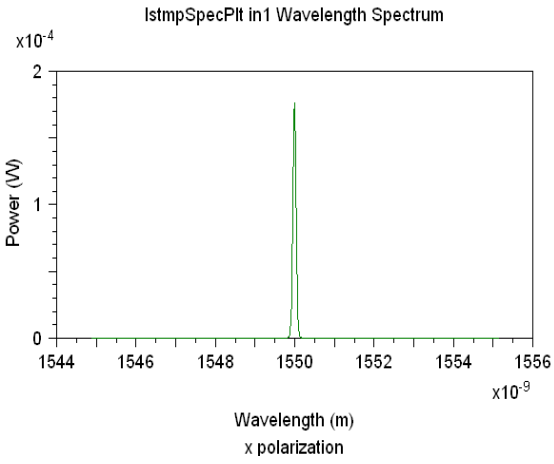

Figure 9: Input signal in frequency domain (N=1)

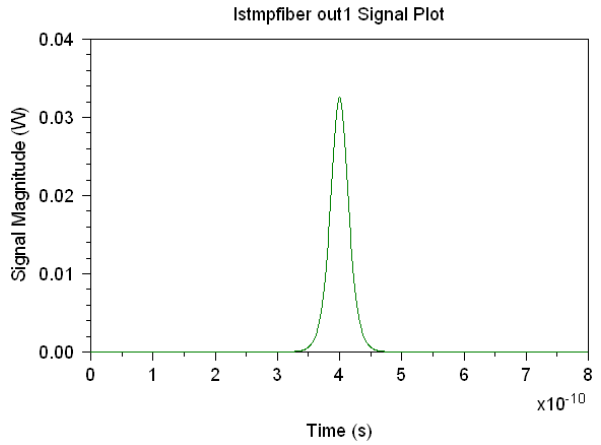

Figure 10: Output signal in time domain N= (1)

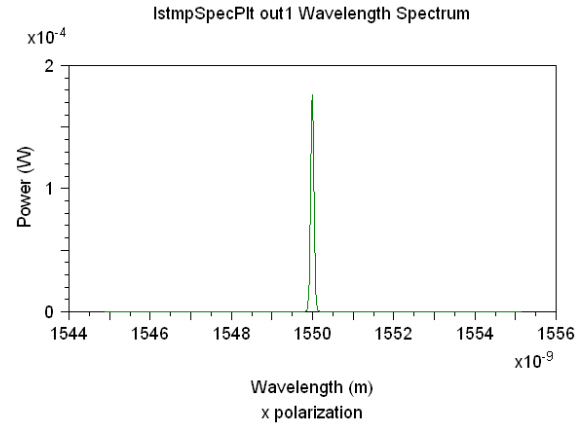

Figure 11: output signal in frequency domain (N=1)

CONCLUSION

For long distance communication, Soliton optical communication is more efficient because it provides high data rate without changing its repeater less transmission. Soliton pulses do not respond dispersion. By result of simulation software for fundamental soliton, it can be said that soliton pulses shape have same shape after travelling 26.525Km distances.

REFERENCES:

[1] Gerd Keiser, Optical Fiber Communications, 4thedition, Tata McGraw-Hill, 2008.

[2] http://hank.uoregon.edu

[3] R. Gangwar, S. P. Singh, and N. Singh, "Soliton based optical communication", Progress in Electromagnetics Research, PIER 74, 157–166,2007.

[4] Akira Hasegawa, "Soliton-based ultra -high speed optical communications", Vol. 57, Nos 5 & 6-Journal of Physics Nov. & Dec. 2001.

[5] R. Ganapathy, K. Porsezian, A. Hasegawa, Life Fellow, IEEE, and V. N. Serkin, "Soliton Interaction Under Soliton Dispersion Management", IEEE journal of quantum electronics, Vol. 44, NO. 4, April 2008.

[6] Yang Jing Wen and Xiang Lin Yang, Senior Member, IEEE, "Quasi-Transform-Limited Pulse Transmission in Dispersion Managed Soliton System", IEEE photonics technology letters, Vol. 11, NO. 4, April 1999.

ABOUT AUTHORS

Mrs. Pragati Patharia received the B.E. degree in Electronics & Telecommunications from Jabalpur Engineering College, Jabalpur, (India) and M. Tech Degrees in Opto Electronics from SGSITS, Indore, (India) in 2005 and 2009, respectively.

She has been teaching various subjects like Digital Electronics, Basic Electronics, Microprocessor, Analog & Digital Communication, and Optical Fiber Communication in different Institutes from 2009.

Her Research interest is an application of Soliton Communication system in a data network.