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412 – 420

Study of WDM Add and Drop in Soliton Effects in Free Space Optics

Muthana. Y. Aldouri[1], louay F.Hasan[2], Maki Mahdi[3]

Al-Nisour University College/Department of Computer Technical Engineering/Baghdad-Iraq.

E-mail: muthserv@yahoo.com[1], lfhalbaghdady@gmail.com[2], dr.maki.eng@nuc.edu.iq

Mob: +9647715227636

Abstract: Researchers discussed soliton waves system and its effects on optical communications many times. In this paper a new designed system depend on the generation of the Gaussian optical pulse generator, used to see the effect of soliton waves how can used to send data transmit, the WDM add and WDM drop, is used, Free Space Optics (FSO) is an excellent supplement to conventional radio links and fiber optics. It is a broad band wireless solution for the “Last Mile” connectivity gap throughout metropolitan network. A very stable system which is designed by optisys software simulation. In this paper the design using free space optics FSO as the media channel. The maximum distance used in this project this can transfer data to more than 350 Km, in addition a very stable system.

Keynote:*, FSO, WDM add, WDM drop, optical Gaussian pulse generator, APD photodiode,*

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I. INTRODUCTION:

A soliton is a self-reinforcing solitary wave packet that maintains its shape while it propagates at a constant velocity. Solitons are caused by a cancellation of nonlinear and dispersive effects in the medium. (The term "dispersive effects" refers to a property of certain systems where the speed of the waves varies according to frequency.) Solitons are the solutions of a widespread class of weakly nonlinear dispersive partial differential equations describing physical systems.

A single, consensus definition of a soliton is difficult to find. Ascribe three properties to solitons:

1. They are of permanent form;
2. They are localized within a region;
3. They can interact with other solitons, and emerge from the collision unchanged, except for a phase shift.

More formal definitions exist, but they require substantial mathematics. Moreover, some scientists use the term *soliton* for phenomena that do not quite have these three properties (for instance, the 'light bullets' of nonlinear optics are often called solitons despite losing energy during interaction).

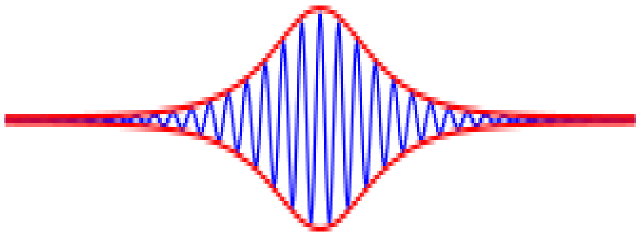

Fig 1. Hyperbolic secant (sech) envelope soliton for water waves

A hyperbolic secant (sech) envelope soliton for water waves. The blue line is the carrier signal, while the red line is the envelope soliton.

1-1 Solitons in fiber optics:

Much experimentation has been done using solitons in fiber optics applications. Solitons in a fiber optic system are described by the Manakov equations. Solitons' inherent stability makes long-distance transmission possible without the use of repeaters, and could potentially double transmission capacity as well.

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412 – 420

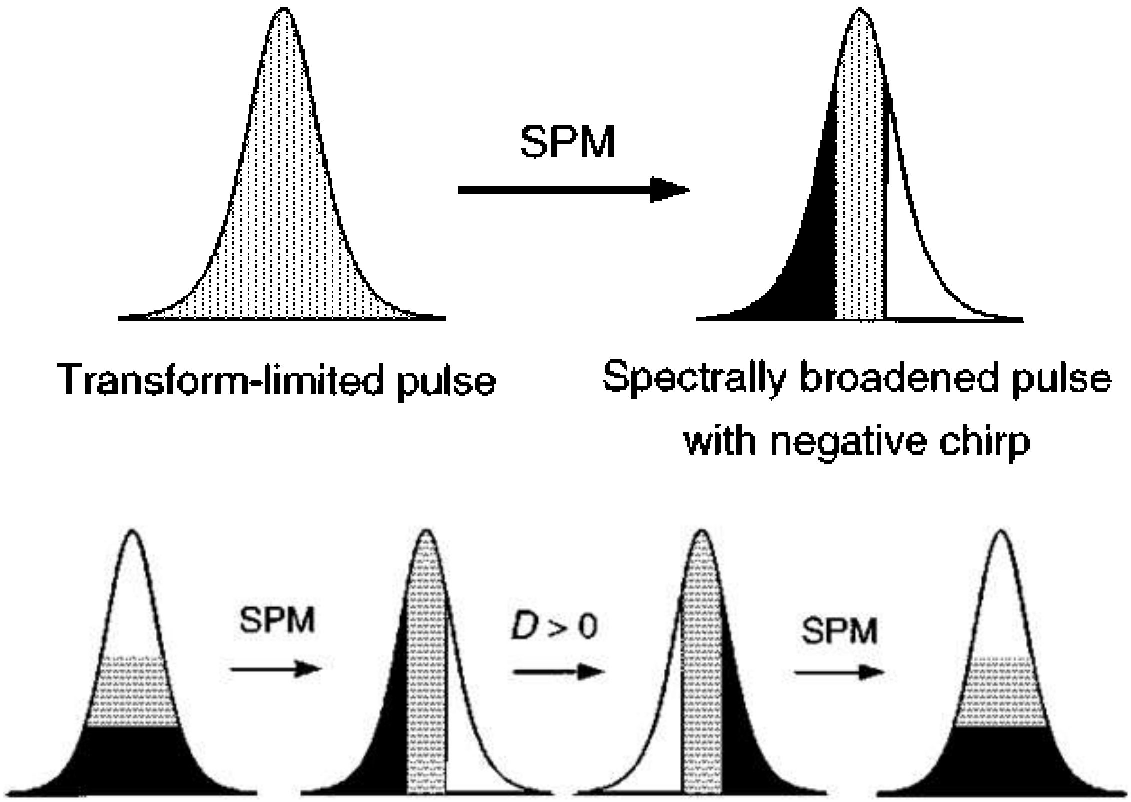

Fig 2. Soliton shape

1-2 Optical Pulses in the Time Domain;

In the time domain, a pulse has an optical power *P* (energy per unit time) that is appreciable only within some short time interval and is close to zero at all other times. The pulse duration τ_p is often defined as a full width at half maximum (FWHM), that is, the width of the time interval within which the power is at least half the peak power. The pulse shape (power versus time) often has a relatively simple form, described for example with a Gaussian function or a sech^{2}function, although complicated pulse shapes can occur, for example, as a result of nonlinear and dispersive distortions, when a pulse propagates through some medium.

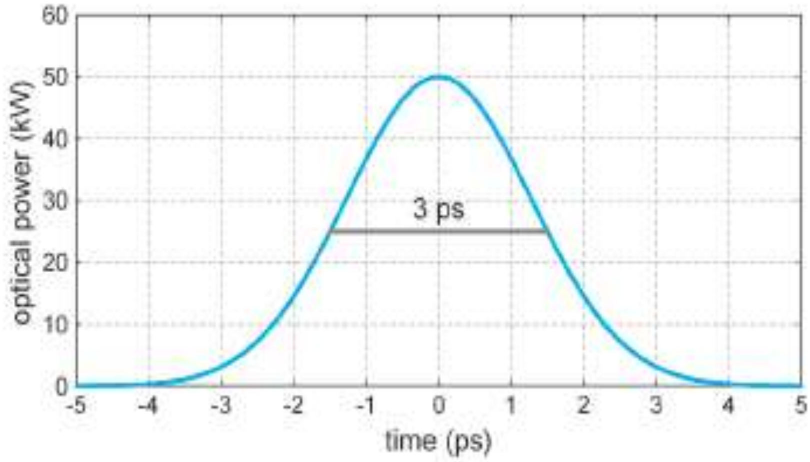

Fig 3. Gaussian optical pulse generator pulse

The figure above shows the power versus time for a Gaussian-shaped pulse with 50-kW peak power and FWHM duration of 3 ps. Short laser pulses, as generated for example with Q-switched lasers, often have durations in the regime of nanoseconds, while ultra short pulses from mode locked lasers last only for picoseconds or femto seconds.

ISSN: 2454-4248
412 – 420

Pulse durations down to a few tens of picoseconds can be measured with fast electronics, while purely optical techniques are required for measuring shorter durations.

The pulse energy E_p is the optical power integrated over time. When the pulse shape is known, the peak power P_p can be calculated from energy and duration according to

$$P_p = f_s \frac{E_p}{\tau_p}, \quad (1)$$

Where fs is a numerical factor depending on the pulse shape. For example, this factor is ≈0.94 for Gaussian-shaped pulses or ≈0.88 for $sech^2$-shaped pulses. In the literature, peak powers are often roughly estimated with the assumption that fs is approximately 1.

A pulse is more precisely characterized by its electric field strength $E(t)$, taken at a fixed position, for example, on the beam axis. The field strength is often represented as

$$E(t) = \mathrm{Re}\left[A(t)\exp(i\omega_0 t)\right], \quad (2)$$

Where $\omega 0 = 2\pi v_0$ is the central optical angular frequency, and $A(t)$ is a field envelope function, which often exhibits a comparatively slow variation. The optical phase φ is the sum of $\omega 0t$ and the complex phase of $A(t)$. The envelope function can thus describe both the variation of optical power (or intensity) and a temporal variation of the optical phase.

The temporal derivative of φ, divided by 2π, is the instantaneous frequency [1].

1-3 Nonlinear Effect as Self-Phase Modulation (SPM):

In a Kerr effect medium such as fiber optics, high intensity of light causes a phase delay having the similar temporal shape with the intensity. This nonlinear phenomenon occurs for a beam is called self phase modulation (SPM) which is generated by its intensity. This effect refers to nonlinear changes of the refractive index given by

$$\Delta n = n^2 I \quad (3)$$

Where, $n2$ is the nonlinear index and the optical intensity is shown by I. Therefore,

This phase shift is a temporal dependence effect, whereas the transverse dependence

leads to the effect of self-focusing.

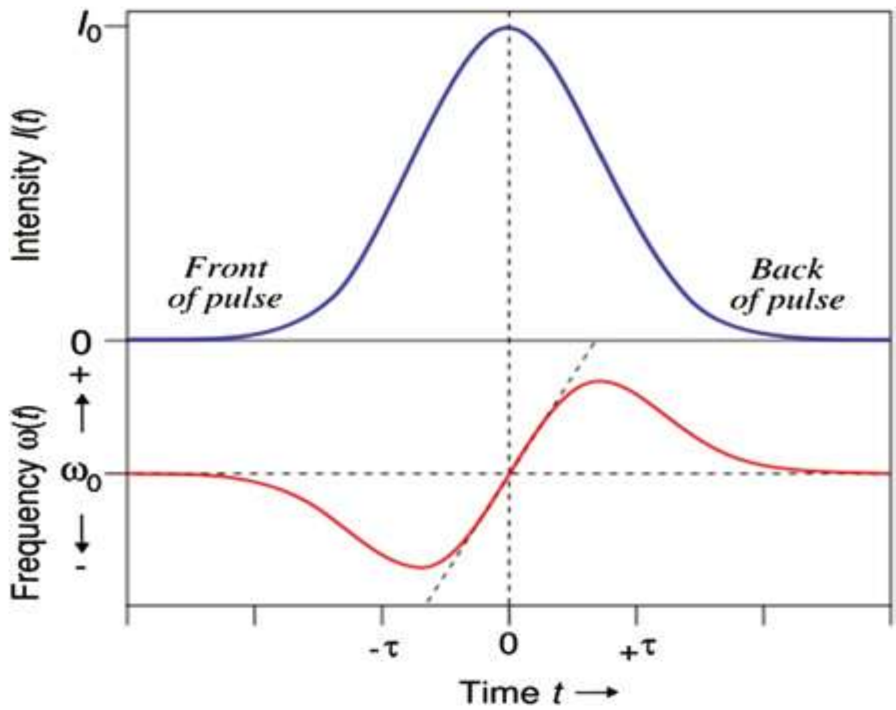

Fig. 4. Spectral broadening of a pulse due to SPM [7]

Unlike the way that SPM affects the phase of the propagating pulse such phase changes in semiconductor lasers do not follow the temporal intensity profile. Therefore, this effect is declared for the pulse of picoseconds to a few nanoseconds. SPM is very efficient in mode-locked femto second lasers with the Kerr nonlinearity effect medium. In materials with negligible or zero dispersion effects, the nonlinear phase shift is unstable, thus soliton pulse mode is employed which is a result of balancing SPM and dispersion [4, 5].

The intensity of a Gaussian ultra short pulse at a time (t) can be expressed by

$$I(t) = I_O \, EXP(-t^2/\tau^2) \quad (4)$$

Where $I0$ and τ are the peak intensity and pulse duration. In a Kerr type medium,
The refractive index is given by

$$n(I) = n_o + n_2 I \qquad (5)$$

Where, $n0$ and $n2$ are the linear and nonlinear refractive indices.

An optical pulse is a flash of light. Lasers and related devices have been found to have an amazing potential for generating light pulses with very special properties:

- There is a wide range of techniques for generating pulses with durations of nanoseconds, picoseconds, or even femto seconds with lasers. Such short durations make light pulses very interesting for many applications, such as telecommunications or ultra precise measurements of various kinds.

1-5: Free Space Optics (FSO):

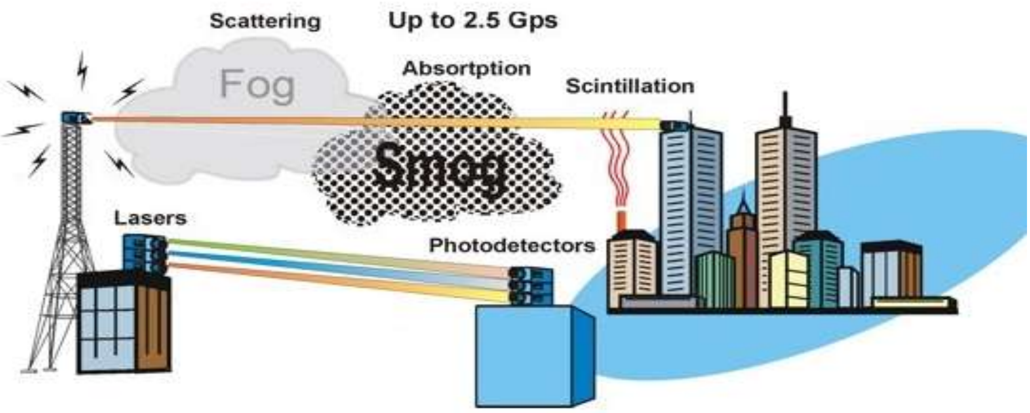

Fig.5. Free Space Optics - FSO Diagram

Free space optical communication systems use an optical carrier signal to transfer information through the air (free space) between two or more optical receivers or transceivers.

Figure .5. Show free space optical (FSO) transmission. This diagram shows that free space optical transmission systems lose some of their energy from signal scattering, absorption and scintillation. Optical signal scattering occurs when light signals are redirected as they pass through water particles. Optical signal absorption occurs as some optical energy is converted to heat as it strikes particles (such as smog). Scintillation occurs when heated (such as from smokestacks) air cause a bending of the optical beam. This example shows that it is possible to transmit multiple light wave signals on different straightforward method was used in optical communication in order to convert from electrical to optical binary information. Electrical bit “1” was associated with a higher optical while bit “O” was associated to a lower optical intensity [6].

Today, many people need high data rates for connecting to the internet or for other access-services. Therefore free space optics (FSO) is a well suited technology. The high bandwidth of the backbone (fiber network) is also available for the end user.

II. SIMULATION SETUP:

The simulation has been carried out by using opt system software version 7.

In this occupation we used optical sech pulse generator as a source to transmit data over 300 km length through one loop control and a traveling wave SOA (0.15 A injection current). The systems build as figure 7. This figure shows the system design of soliton wave effect in optical fiber.

ISSN: 2454-4248
412 – 420

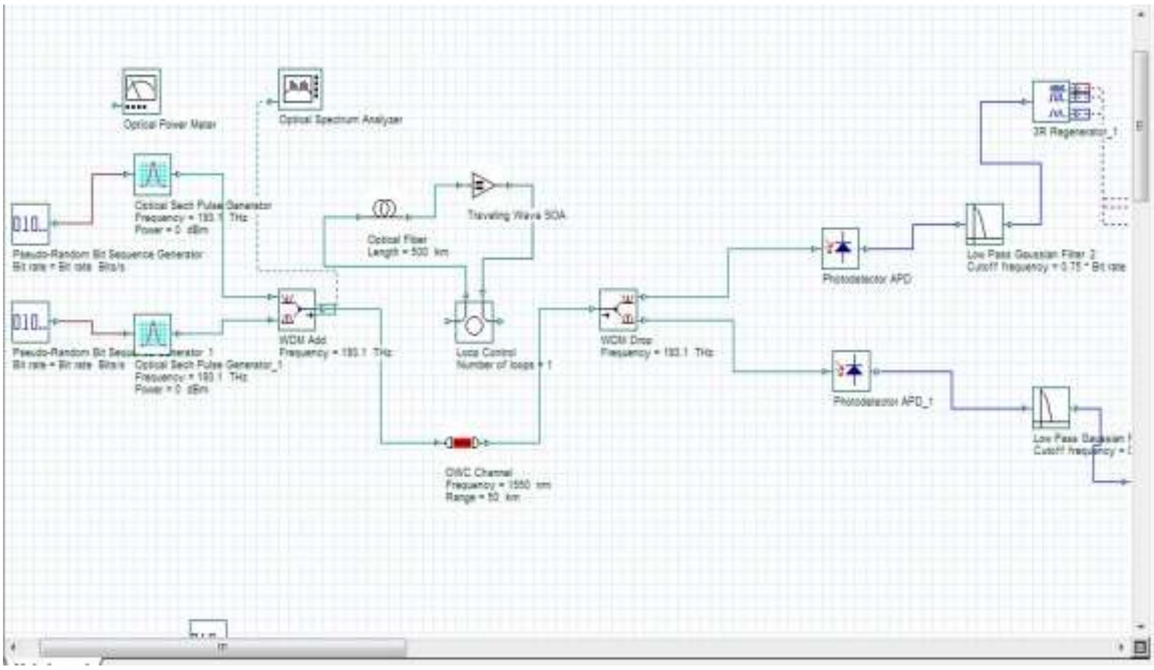

Fig 6 .Soliton system using FSO project layout

For this system the parameters was setting as;

- Multiplexing channel from the transmitter is 1556nm, 1550nm, for the two users.
- FSO channel is setting at 1556nm.
- Demultiplexing channel at the receiver is 1556, 1550, for the two users.
- Coupling coefficient = o.5.

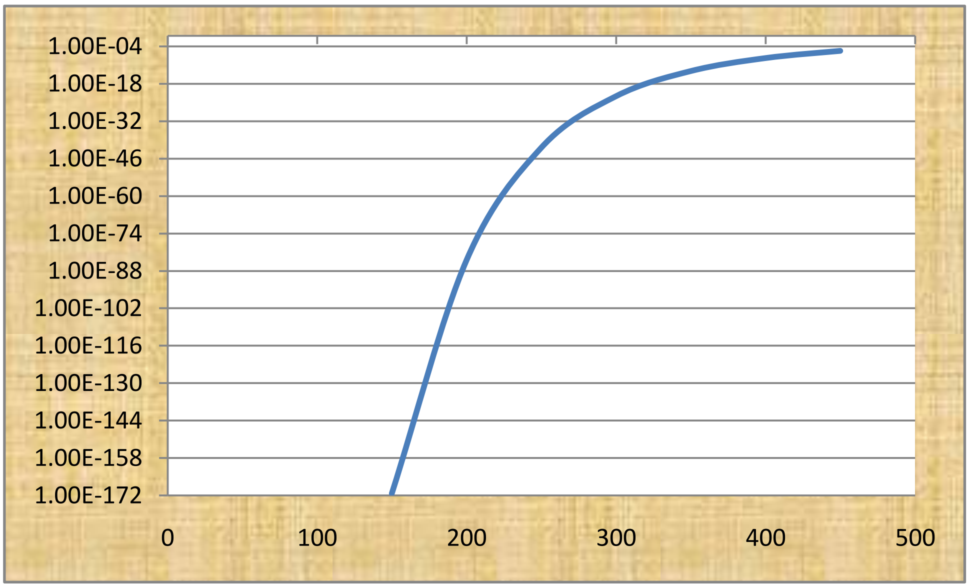

Fig. 7 .Relation between fiber lengths VS Bit Error Rate

From figure above show the fiber length started from minimum distance equal to 100 Km and the BER value recording to the value of $6.1x10^{-318}$.while at the maximum distance 450Km, the value of BER recording to the value of $2.5x10^{-6}$. This results taking in the free space channel FSO.

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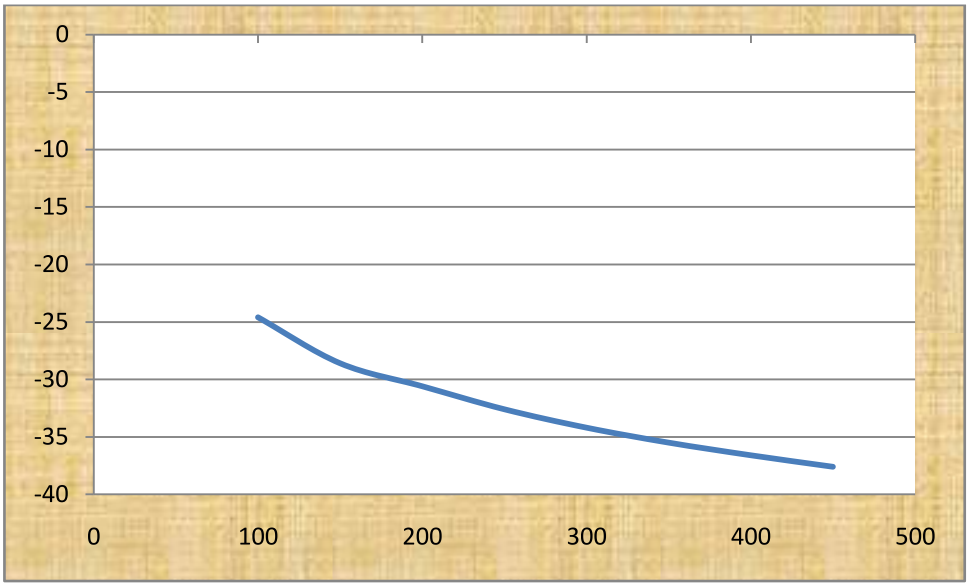

Fig 8. Relation between fiber length and output power when input power is constant at - 5.7 dBm

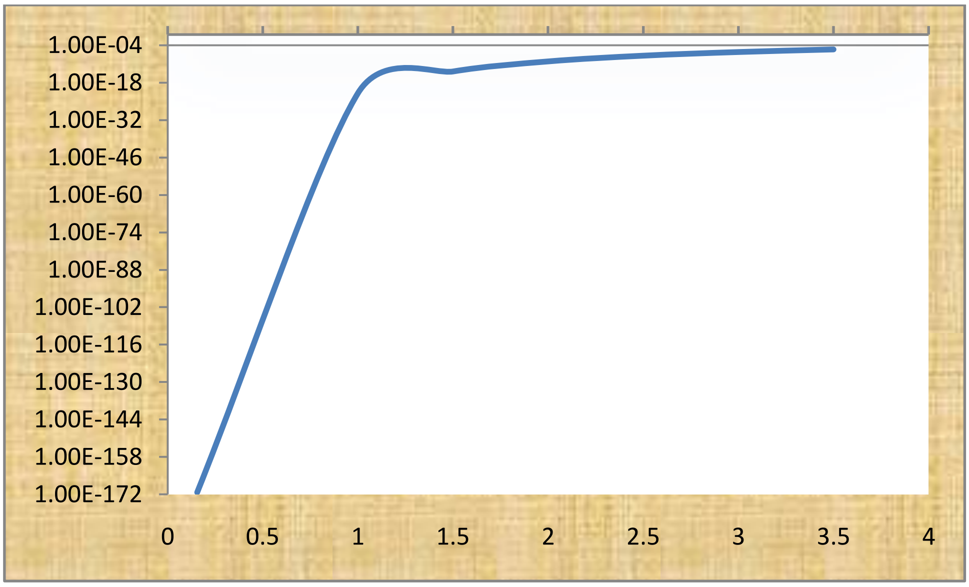

Fig9 .Relation of Bit Rate and BER

At constant distance equal to 150Km, then recording the relation of multi Data Bit Rates to the Bit Error Rates.

 ISSN: 2454-4248
412 – 420

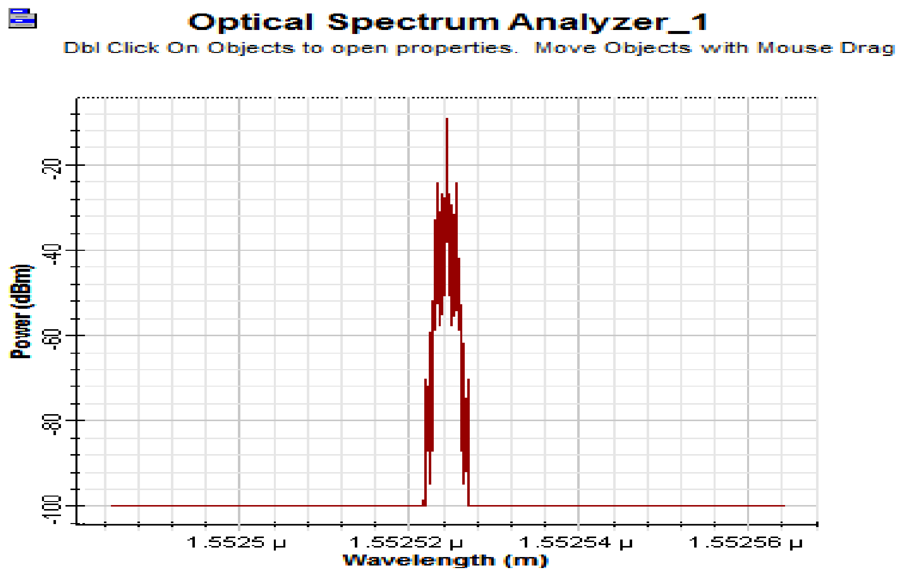

Fig 10. Input signal screened by optical spectrum analyzer

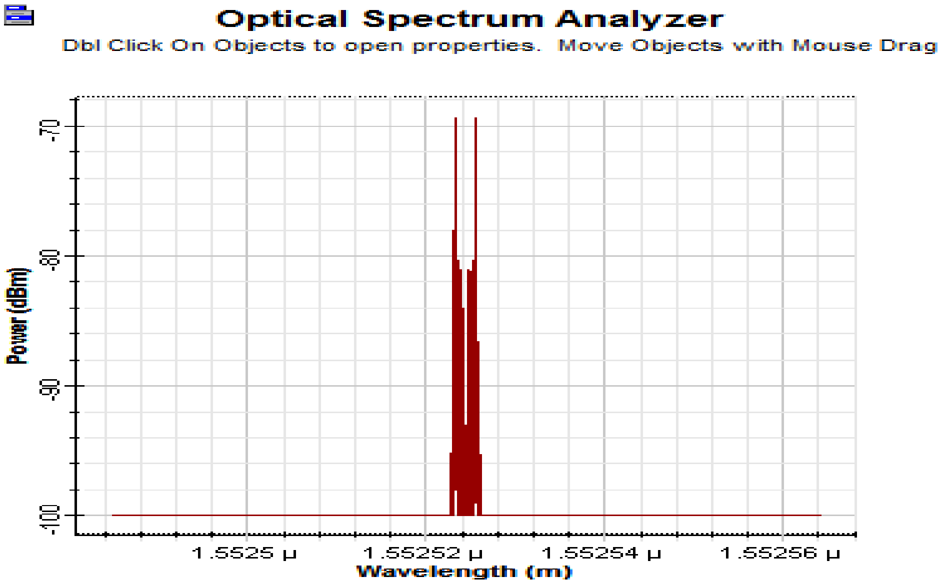

Fig 11. Output signal of the two users

 ISSN: 2454-4248
412 – 420

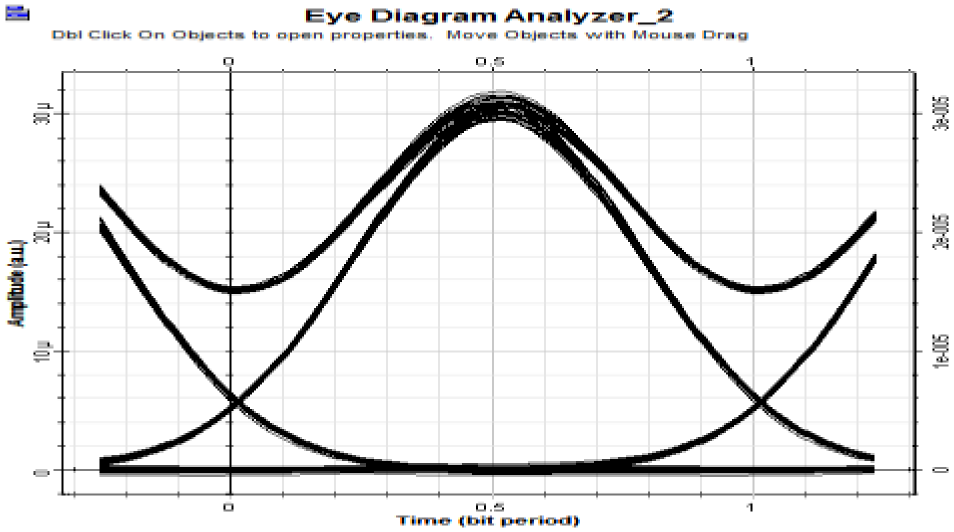

Fig.12. Minimum distance of transmitter 100Km

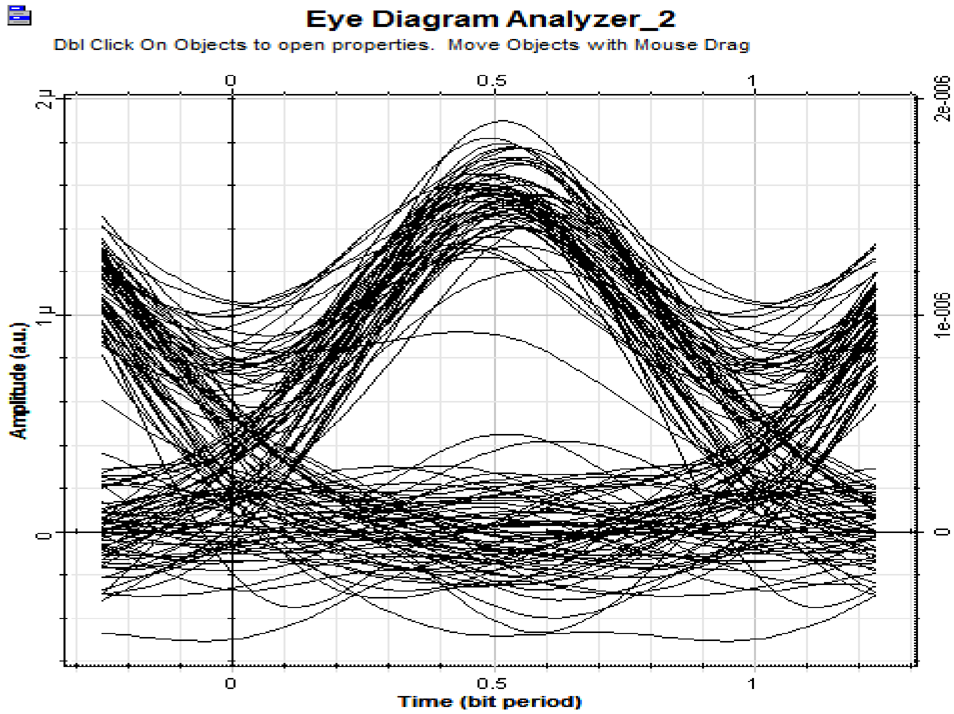

Fig 13: maximum transmitter distance 450Km

The eye diagram analyzer is a very good observation device to illustrate the output results of the designed system. From this diagram it seems clearly that at minimum distance 100Km, the BER recording the value of $5.1x10^{-194}$ and at maximum distance 350 Km, the value of BER is $7.1x10^{-5}$.this results is at 1GHz Data Rate. This is a very good results can be achieved by this system. Parameter relative with bit error ratio or quality of the communication system.

III. CONCLUSION:

In this paper, we have discussed that to transfer data (voice, sound and data) through two buildings, we can use a modified leaser with high data rate up to 5 Gbps using soliton system in free space with the use of Gaussian optical pulse generators. This will be reducing the width of the signal to more than 3ps increasing the data rate to be transferred. From the results optioned at 350 Km distance using free space optics (FSO) to transfer data to the receiver's.

Finally, we can see that we can use the sech optical pulse generator which is equal to the square root of Gaussian. Application based on FSO has a great potential to become one of the optical communication suitable system for OCDMA implemented in FTTH application. And by using the FSO the OCDMA network will be expanding directly.

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