Characterization and Application of Solitons in a High Nonlinearity Optical Link with Dense Wavelength Division Multiplexing (DWDM) and Ultra-Dense Wavelength Division Multiplexing (UDWDM) Technics

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The constantly growing needs in terms of speed and bandwidth, especially all services using data has become greedy. Today optical fiber is the medium of choice for many advantages over others channels. although the optical fiber has taken the label of transmission channels, we won't be able to do without its nonlinear character and dispersions, which are part of the major problems during

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optical transmission. In this article, we are presenting the use of optical solitons in the fiber optic link, with a particular way; we have considered two kind of links, the underground one and the overhead one, in the first link, we have applied optical soliton in order to just take into account the optical Kerr effect. And for the overhead link, we can transmit for short distance by using the return to zero modulation's format and the use of optical Erbium Doped Fiber Amplifiers (EDFA). The solitons which are the impulses, capable of propagating in the nonlinear optical fiber and dispersive without any distortion; to justify our hypothesis, we compare a dense wavelength division multiplexing (DWDM) without soliton and the dense wavelength division multiplexing with solitons; we notice that, the link with soliton is better than the first because the pulse keeps its shape from the source up to the destination, its eye diagram is opened which means there is no much noises. After the simulations in Matlab and optisystem software, we went to Congo telecom, to do our test with the optical time-domain reflectometer (OTDR), for both installations. From that study while transmitting over 100km it is better to use optical solitons with the high speed.

1. INTRODUCTION

The advent of new technologies, especially with the arrival of 5G, the need in terms of bandwidth, bitrate and the good quality of data at the destination, require a reliable transmission system. Since their first deployments, optical telecommunications networks have continued to meet growing bandwidth and capacity requirements, thanks to the wide bandwidth of optical fibers (a few tens of THz) which make it possible to support high speeds. The implementation of very high speed internet access and Fiber to the home (FTTH) technology makes it possible to solve capacity problems and guarantee the speed. Beyond the real satisfaction of optical fiber, we cannot do without nonlinearity, distortion and dispersion during the transmission [1]. These problems always noticed by the engineers in the field; although a few attempts of solutions have been proposed by [2], but this is far from satisfying the users. To extend our thinking, the same perspective, we call to witness three research works of literature, especially that of, Yufengsong and Dinguan Tang [3], who focus on the presentation of a detailed overview of the experimentally verified optical solitons in fiber lasers, including bright solitons, dark solitons, vector solitons, dissipative solitons, dispersion-managed solitons, polarization domain wall solitons, and so on. An outlook for the development on the solitons in fiber lasers is also provided and discussed. And also the work ManjeetBagri, SureshKumar [4], which is focus on a detailed study of Solitons transmission system, including their types, applications, e ects, and updated research work and research gaps. Findings: The 4th, generation fiber optic communication system utilizes visual amplification to decrease the demand for repeaters and WDM to increase the information power Similarly, 5th the phase of Optical Fiber Communication is now expending the distances range which the wavelength division multiplexing system will control. The traditional wave length frame called the Cring covers the distance range1.53 to 1.57um and dry material has the low loss window promising extension of rangeto1.30 to 1. 65um.Additional development includes the idea of visual solitons pulses that maintain their body by counteracting the results of distribution with nonlinear e ects of this material by applying pulses of specific shape. Application: This will motivate the researchers to undertake research work in the field of Solitons communication to achieve improved design characteristics, reducing number of repeaters, cost and higher data rate transmissions. And finally the work of Houria Triki1 and Vladimir I. Kruglov2[5] which aims the consideration of the ultrashort light pulse propagation through an inhomogeneous monomode optical fiber exhibiting higher-order dispersive e ects. There results show that the contribution of all orders of dispersion is an important feature to form this kind of self-similar dipole pulse shape. The dynamic behaviours of the self-similar dipole solitons in a periodic distributed amplification system are analysed. The significance of the obtained self-similar pulses is also discussed. Beyond of [2,3,5,4]. we can say, it was solved partially, because their presences are constantly still noticed, especially when we go over the modern transmission technics. One of the solutions proposed was the use of optical amplifiers and also the use of optical solitons [6].

In this article we deal with the comparative study, between the underground and overhead fiber

optic links by using the DWDM and UDWDM. In the first link, we will use optical soliton, and the second one, EDFA optical amplifiers with the return to zero (RZ) modulation's format.it will therefore be a question of evaluating the bit error rate, while varying the bit rate, then examining the opening of the eye diagram and also seeing the variation in the amplitude of emissions on reception for both types of links.

2. SOME IMPORTANT NON-LINEAR EFFECTS THAT INFLUENCE THE PROPAGATION OF A SIGNAL IN THE OPTICAL FIBER

We briefly describe below the non-linear effects that can occur in optical fibers, namely: The Kerr effect, the Raman effect and the Brillouin effect

2.1 The Optical Kerr Effect

The nonlinear polarization induced in the optical fiber by the propagation of a strong optical field, is responsible for an intensity dependence of the value of the refractive index. This dependence of the refractive index on intensity is known as the optical Kerr effect [7,8,9].

We can say that, the non-linear effects undergone by the optical signal during its propagation come mainly from the Kerr effect. This effect consists of a variation of the refractive index of the material as a function of the intensity of the optical signal [7]. We can express this refractive index Kerr by the relation [10,11,12]. The optical Kerr effect or the intensity dependence of the refractive index is the most important effect in optical fiber. This effect is at the origin of other nonlinear effects [3,10,7], such as self-phase modulation, cross-phase modulation, four-wave mixing, modulation instability and again the existence of soliton impulses.

2.2 The Brillouin Effect

Stimulated Brillouin Scattering (SBS) is the result of a parametric coupling between an optical wave and an acoustic wave when the optical power exceeds a certain threshold, called PsB. It manifests itself by the generation of optical waves shifted in frequency from the incident wave by an amount determined by the propagation medium. In optical fibers, stimulated Brillouin scattering takes place only in the direction opposite to that of the incident wave [7].

2.3 Raman Effect

Stimulated Raman Scattering (or SRS) is a coupled three-wave process in which the pump wave generates a frequency-shifted wave and a vibrational excitation wave in the medium. This phenomenon appears when the optical power exceeds a certain threshold. Stimulated Raman scattering takes place in both directions of fiber propagation.

The frequency shifts ∆uR by Raman scattering is much greater than in the case of Brillouin scattering. In silica, it is about 13 THz [7,13]. One technique to reduce this non-linear effect is to use fibers with high local chromatic dispersion. The phase matching between the channels is therefore minimized. Chromatic dispersion compensation can be used periodically to reduce the accumulation of chromatic dispersion [7].

Among these three nonlinear effects, we will first focus on the optical kerr effect, for the optical link with soliton, assuming that there is no loss, which is the underground one, and then the Raman effect for the optical link without soliton, therefore the one which is considered as the aerial link/

3. ANALYTICAL STUDY OF THE SOLITON IN THE SINGLE-MODE OPTICAL FIBER: RESOLUTION OF NONLINEAR SCHRÖDINGER EQUATION

The nonlinear Schrödinger equation (NLSE) appears in various physical contexts to describe the propagation of waves in a nonlinear medium. It is of particular importance in the description of nonlinear effects in optical fibers, where it governs the propagation dynamics of laser pulses in an optical fiber characterized by low non-linearity and high dispersion. It is written in the following form [14,15]:

$$\frac{\partial A(z,t)}{\partial t} + \beta_1 \frac{\partial A(z,t)}{\partial t} - i \frac{1}{2} \beta_2 \frac{\partial^2 A(z,t)}{\partial t^2} = i \gamma |A(z,t)|^2 A(z,t) - \frac{\alpha}{2} A(z,t) \qquad (1)$$

where $A(z,t)$ is the slowly varying envelope connected to the optical pulse described by the optical pulse $E(z,t)$ as:

$$E(z,t) = A(z,t)\exp[i(\omega_0 t - \beta_0 z)] \qquad (2)$$

γ defines as follows $\gamma = \frac{2\pi \bar{n}_2}{\lambda A_{eff}}$, is the nonlinear coefficient,

α: is the attenuation coefficient, β_2: is the second order dispersion.

We present here the analytical resolution of the nonlinear Schrödinger equation of soliton propagation in an optical fiber. We remind that the soliton is a constant envelope light pulse which propagates without deforming in an optical fiber. It is the particular stable solution of the nonlinear Schrödinger equation. This stability of the soliton comes from the balance between chromatic dispersion (linear effect) and the Kerr effect, more exactly, the self-phase modulation (non-linear effect). We can benefit from the nonlinear effect by compensating for the linear effect ensuring the stability of the signal during its propagation.

The nonlinear equation (1) can be simplified, if we neglect the Raman and Brillouin effects and the higher orders of chromatic dispersion (for long pulses, T0> 5 ps), the generalized nonlinear Schrödinger's equation (3) takes the following simple form [10,16]:

$$\frac{\partial A(z,t)}{\partial z} + \frac{\alpha}{2} A(z,t) - \frac{j}{2} sng(\beta_2) \frac{\partial^2 A(z,t)}{\partial T} = \gamma \mid A(z,t) \mid^2 A(z,t) \tag{3}$$

This equation can be normalized using three variables of small dimensions, , $U = \frac{A}{\sqrt{P_0}}$,

$$\xi = \frac{Z}{L_D} , \tau = \frac{T}{T_0}$$

A parameter can be defined $u = NU = A(\gamma L_D)^{1/2}$, where P_0 is the maximum intensity of the peak power of the envelope A (z,) which varies slowly, , T_0, is a temporal characteristic value of the initial pulse which is often defined as half of the maximum pulse width (the 3 dB pulse). $L_D = \frac{T_0^2}{|\beta_2|}$ Equivalently, we define the nonlinear length which characterizes the optical Kerr effect [9], $L_{NL} = \frac{1}{\gamma P_0}$, The two lengths characterize the distance at which an impulse must propagate to show the respective effect. Physically, L_D is the propagation length at which a Gaussian pulse expands by a factor of $\sqrt{2}$ due to the dispersion of group velocities (GVD) N is the order of the soliton, it determines the stability of the soliton [17]. By neglecting the losses, we can write.

$$\frac{\partial U}{\partial \xi} - jsgn(\beta_2)\frac{1}{2}\frac{\partial^2}{\partial \tau^2} + jN^2|U|^2U = 0 \tag{4}$$

where

$N = \frac{L_D}{L_{NL}} = \frac{\gamma P_0 T_0}{\beta_2}$ This expression reflects the order of the soliton, in this calculation, we first consider the simplest case, that of N = 1 which reflects the fundamental order of the soliton Since we have defined $u = NU$ => $U = \frac{u}{N}$, And we know that for an abnormal dispersion,

$$\beta_2 < 0 , sign(\beta_2) = -1$$
$$\frac{\partial u}{\partial \xi} + j\frac{1}{2}\frac{\partial^2 u}{\partial \tau} + j |u|^2 u = 0 \tag{5}$$

Suppose that

$$u(\xi,\tau) = \psi(\tau)e^{j\phi(\xi,\tau)}$$

Where $\phi(\xi,\tau) = -K\xi + \delta\tau$, and $K\xi$ is the phase constant and δτ is the frequency shift

if $\delta = 0 \rightarrow \phi(\xi,\tau) = -K\xi$ we can easily write

$$\begin{cases} \frac{d^2u}{d\xi^2} = -\psi kje^{-k\xi} \\ \frac{d^2u}{d\tau^2} = \frac{d^2\psi}{d\tau^2}e^{-k\xi} \end{cases} \tag{6}$$

By replacing (6) in (5)

$$-\psi kje^{-k\xi} + j\frac{1}{2}\frac{d^2\psi}{d\tau^2}e^{-k\xi} + \psi.\psi^2.e^{j\phi(\xi,\tau)} = 0$$

$$-\psi k + \frac{1}{2}\frac{d^2\psi}{d\tau^2} + \psi^3. = 0$$

$$\frac{1}{2}\frac{d^2\psi}{d\tau^2} = \psi k - \psi^3$$

$$\frac{d^2\psi}{d\tau^2} = 2\psi(k - \psi) \tag{7}$$

Multiply (7) member to member by the integral $\int 2\frac{d\psi}{d\tau}d\tau$

$$\int 2\frac{d\psi}{d\tau}\cdot\frac{d^2\psi}{d\tau^2}d\tau = \int 2\psi(K - \psi)2\frac{d\psi}{d\tau} ; \tag{8}$$

Let's pose $J = \int 2\frac{d\psi}{d\tau}\cdot\frac{d^2\psi}{d\tau^2}d\tau$

Let's do the computation of J using integration by part $V = \frac{d\psi}{d\tau} \implies dV = \frac{d^2\psi}{d\tau^2}d\tau$

$$W_p = 2\frac{d\psi}{d\tau} \implies dW_p = 2\frac{d^2\psi}{d\tau^2}d\tau$$

$$J = [VW_p] - \int W_p \, dV$$

$$J = 2\frac{d\psi}{d\tau}\frac{d\psi}{d\tau} - \int 2\frac{d\psi}{d\tau}\frac{d^2\psi}{d\tau^2}\,d\tau$$

In this expression the second term represents the integral J, so we can easily write:

$$J = 2\frac{d\psi}{d\tau}\frac{d\psi}{d\tau} - J \Rightarrow 2J = 2\frac{d\psi}{d\tau}\frac{d\psi}{d\tau}$$

Finally

$$J = \frac{d^2\psi}{d\tau^2} \tag{9}$$

Replace (9) in the expression of (8)

$$\left(\frac{d\psi}{d\tau}\right)^2 = \int 2\psi\,(K - \psi)2\frac{d\psi}{d\tau}\,d\tau$$

$$\left(\frac{d\psi}{d\tau}\right)^2 = 2k\psi^2 - \psi^4 + C \tag{12}$$

With c, a constant to be determined with respect to the boundary conditions For $\psi = 0$; $\frac{d\psi}{d\tau} = 0$, $\tau \rightarrow \infty$ this implies that C = 0

And when we apply the normalization conditions $\psi = 1\ to\ \tau = 0$ and therefore to the level of the maximum of the shape of the pulse, we have $\frac{d\psi}{d\tau} = 0$, under these conditions, equation (10) becomes:

$2k\psi^2 - \psi^4 = 0$, by setting $k = \frac{1}{2}$

$$= 2\frac{dV}{d\tau}\cdot\frac{dV}{d\tau} - 2\int\frac{d^2V}{\partial\tau^2}\cdot\frac{dV}{d\tau}\,d\tau$$

$$= 2(\frac{dV}{d\tau})^2 - I$$

$$I + I = 2(\frac{dV}{d\tau})^2$$

$$2I = 2(\frac{dV}{d\tau})^2$$

$$\Rightarrow I = (\frac{dV}{d\tau})^2 \quad (11)$$

By replacing (11) in (10),

$$\left(\frac{dV}{d\tau}\right)^2 = \int 4V(K - V^2)\,dV$$

$= 2KV^2 - V^4 + C$, where c is an arbitrary constant

By applying the boundary conditions, we get $V = 0$, $\frac{dV}{d\tau} = 0$ $\Rightarrow C = 0$

If we normalize, we get $V = 1$ and $\tau = 0$, $\frac{dV}{d\tau} = 0$ at the level of the soliton peak, this allows us to obtain $K = \frac{1}{2}$, finally

$$(\frac{dV}{d\tau})^2 = V^2 - V^4 \ , \frac{dV}{d\tau} = \pm V\sqrt{1 - V^2}$$

By integrating member to member

$$\int\frac{dV}{V\sqrt{1-V^2}} = \int d\tau \Rightarrow Sech^{-1}(V) = \pm\tau\ ,$$

$$V = Sech(\pm\tau)$$

Since the function $\sec h(x)$ is an even function, the solution can simply be written

$$u(\xi,\tau) = Sech(\tau)e^{-j\frac{\xi}{2}} \tag{12}$$

The hyperbolic secant function is therefore the analytical solution of the nonlinear Schrödinger equation in the case where the order of the soliton is equal to 1, this also corresponds to the bright soliton, which is used in optical communication, and it means that dispersion and non-linearity are not taken into account [18].

4. NUMERICAL AND EXPERIMENTAL PROPAGATION

4.1 A Single Point to Point Optical Link

In this part, it is a question of making a comparative study, of a connection without soliton and a connection with soliton, to confirm the veracity of our results, we carried out a study within the company Congo Telecom, where we carried out measurements for underground links and overhead links, during this study, we took two links of the same length, the simulation parameters of which are in the following table, this study allowed us to assess the quality of the signal in terms of losses, bit rate and quality factor. We first carried out a simulation on Matlab and on optisystem and carried out the practical measurements for the confirmation of the results.

These results are obtained for a small single link of 10km, this first approach, just allowed us to find the results of the literature, by comparing the soliton-shaped pulse profile at the output of the modulator (Fig. 1a) and the profile pulse after 10km (Fig. 1b), we notice that after 10km the amplitude of the pulse has not changed shape, which justifies the performance of the soliton in

optical transmission. To justify this, we have therefore considered more complex links, in particular DWDM, UDWDM and the DWDM and UDWDM coupling. For our study, we applied the solitons only to subterranean bonds since, we just considered the optical Kerr effect. So that for air links with high temperatures from 37 ° to 45 °, there is indeed an interaction between the solar radiation on the coating of the optical cladding, which physically influences the core and the optical wave which is propagates in the heart and therefore at these temperatures, we notice the appearance of the Raman and Brillouin effect. To fully understand this, we took two types of bonds, a bond without soliton and a bond with soliton to justify the performance of the soliton.

4.2 Simulation and Results of DWDM and UDWDM Systems

The analysis of the diagrams of Fig 2a and 2b represents the synoptic of DWDM with soliton, which is at the center of our simulations. These two links consist respectively of a bit sequence generator which allows the configuration of the bit rate used a RZ modulation format, which makes it possible to encode the information, of a laser diode(CW laser), which has the task of converting the electrical signal into an optical signal, a Mach Zehnder modulator which allows the information to be adapted to the transmission channel, a DWDM multiplexer with a spacing of 0.8 according to the IUT standard, a loop control which allows to set number of times the signal propagates in the components, that are connected between the loop control input and output ports, an optical fiber of 100km, where the signal will propagate, an amplifier (EDFA) for a link without soliton, a PIN photodiode, which will convert the optical signal into an electrical signal

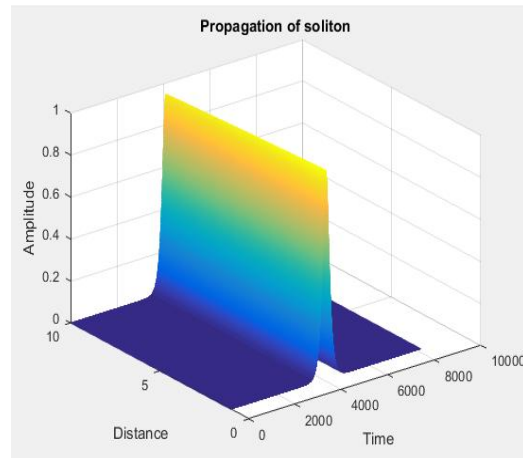, and an optical power spectrum analyzer and that of the eye diagram.

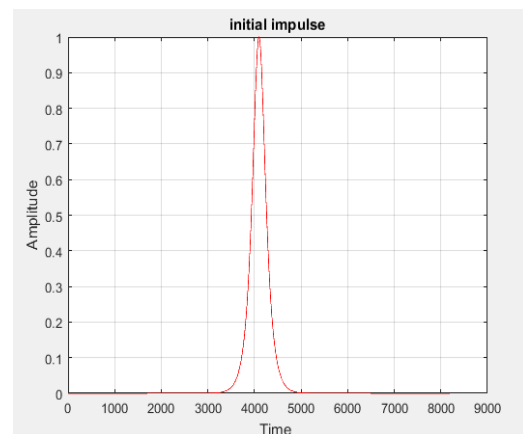**Fig. 1. Evolution of a bright soliton in 3D**

Fig.1(a). Evolution of the initial Bright soliton in 2D

Table1. Point-to-point link parameters used for simulations

| Input parameters	Values and units
Speed	[10Gbps-100Gbps]
Frequency or wavelength	1550nm
Optical fiber length	100km
Source width	0.15bit
Electric filter at the outlet	20GHz, low pass filter,4th order
EDFA optical amplifier	1
Input power	0dBm
ITU-TG652 optical fiber parameters	
Dispersion parameters D(ps/nm.km)	17
Attenuatioν $\alpha(dB/Km)$	0.2
The effective area (μ_m^2)	70
Dispersion slope S(Ps/nm.Km)	0.075
DGD parameter ($Ps/\sqrt{Km}$)	0.1
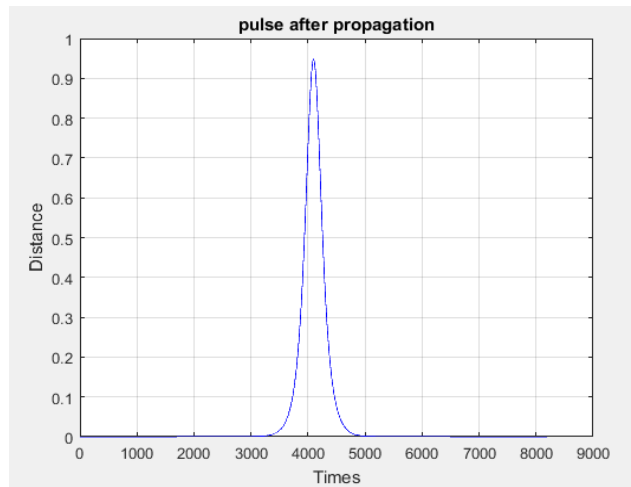
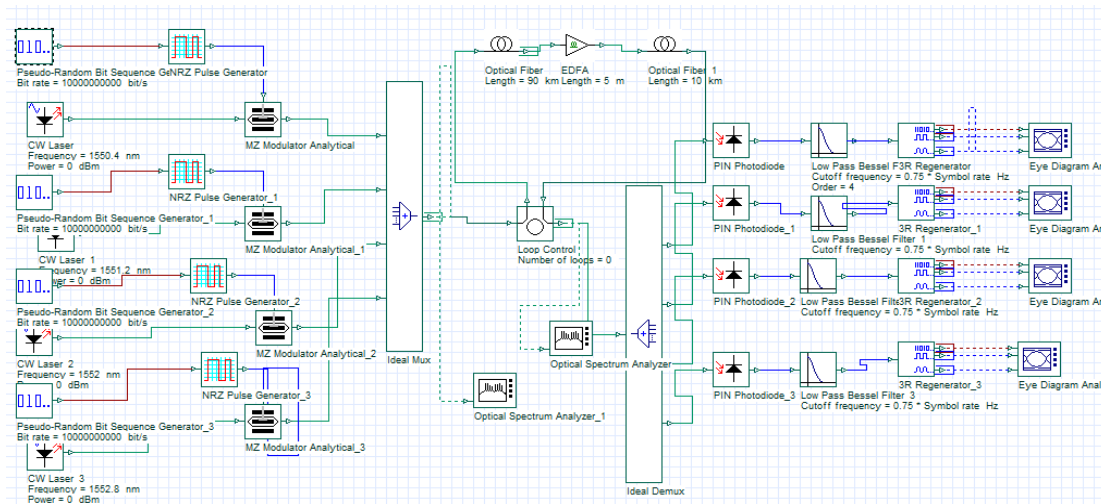**Fig. 1(b) . Evolution of the bright soliton after travelling the fiber link**

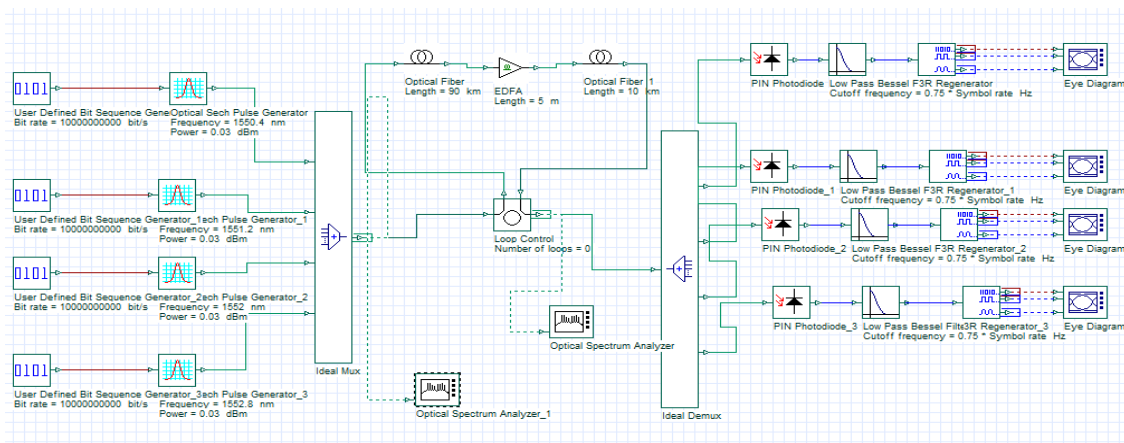**Fig. 2a. Block diagram of a DWDM connection without soliton**

Fig. 2b. Block diagram of a DWDM link with soliton

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**Table 2. DWDM and UDWDM parameters used for simulations**

Parameters	Values	Units
Bit Rate	10	Gbps
Power	0	dBm
Pulse width	13,11	Ps
Dispersion	1.176	Ps/nm/km
Wavelength	1550	nm
Length	100	Km
Attenuation	0.2	dB/Km
Beta2	-20	Ps^2/km
Effective Area	60	$\square_\square^2$
n_2	$2.6e^{-20}$	m^2/w

4.3 Results of DWDM Connection without Soliton

These graphs of Fig 3a and 3b represent the variation of the power according to the wavelength, what we notice is that at the output of the multiplexer the peaks of the input signals are different according to the height, while we have transmitted a power of 0dBm at 10Gbps and even after 80km, although we have used the RZ modulation format and an EDFA amplifier. We also notice a very high noise level between -100dBm and -60dBm. Then we notice in the following figure that the opening of the diagram of the eye is less extended, and therefore the bit error rate is very high, even exceeding the order of 10^{-9} established by ITU .

performance of the soliton in modern telecommunications, because it allows us to avoid losses and noise does not exist, the optical Kerr effect and the dispersion compensate for each other. It is clear that in the eye diagrams, the opening of each eye is extended, as shown in the figure below.

We can notice that, when the source impulses are soliton, the eye diagrams for the fours wave length are widely opened, this is to say that there is no noise or distortion during the transmission. As result of that there is no doubt for the performance of solitons in fiber optics communication, especially while using DWDM or UDWDM, which are the common technologies in the fiber optic transmission area.
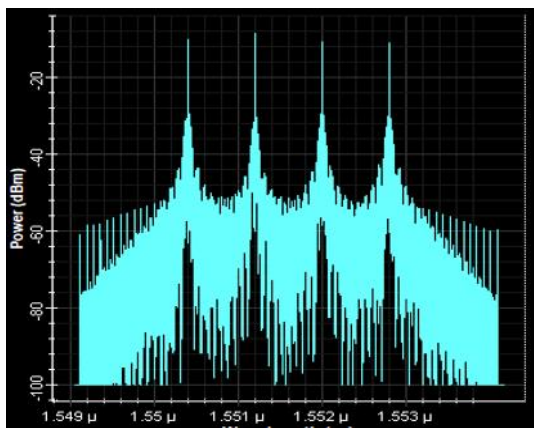
Fig.3a. Pulse output without solitons of the multiplexer
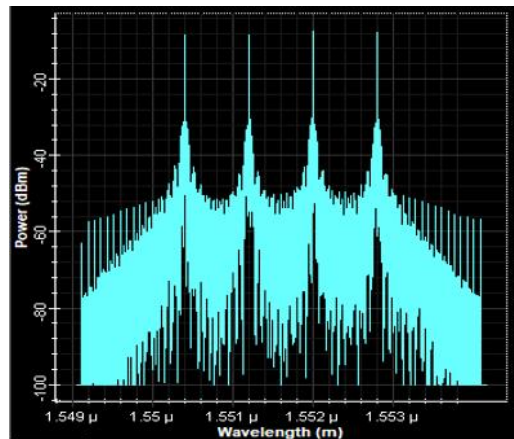
Fig. 3b. Pulses after 100Km of the fiber

4.4 DWDM link Results with Soliton

Unlike the link without soliton, here we notice that, at the output of the multiplexer and at the last terminal of each subscriber, the pulses have retained their shapes, this indeed shows the

5. DISCUSSION

The concept of soliton remains very useful within the framework of the communication by optical fiber at long distance, the studies started in the literature [3], are not sufficient to express the performance of the soliton, so well that [3] did

right a description of this theme, with regard to the study presented by [15], which consisted of taking into account the propagation of light pulses, ultra short through an inhomogeneous single-mode optical fiber, higher order dispersive effects, this result, which we do not contradict, but which we can qualify as a general knowledge, on the theoretical level, although he mentioned the invariant character of the soliton. As part of the technological progress of science and the world of industry, we went into a somewhat more concrete environment, first doing the detailed resolution of the nonlinear Schrödinger equation by considering that the whole bond losses are negligible; this resolution is educated in a pedagogical framework for future researchers and students who will write their end-of-study projects. Then we were endeavored to go to the deepening, by comparing a bond without soliton and a bond with soliton, that by the means of the Canadian software optisystem, during this study, we noted that, on the diagram of the Fig 3a, 3b of a link without soliton, the noise level is very high; and also with diagrams of the eye of Fig. 4 months extended, in terms of opening, which reflects the presence of noise; whereas for a link with the soliton of Figs. 5a and 5b, the pulses keep their shapes from the source to the destination; in terms of the eye diagram, it should be noted that in the presence of the soliton the eye diagram is very extensive, which justifies the absence of noise, to illustrate this, the diagram in Fig. 6 confirmed it perfectly good.

What [4] used is not in contradiction with us, because his study focused on WDM but today DWDM or UDWM has taken the label of optical multiplexers, so that with WDM, one does not reach enormous data rates and also the problem of crosstalk, it is therefore adequate to use DWDM or UDWDM with soliton for long distance transmissions with an underground cable and DWDM without soliton in aerial transition, but using the format RZ modulation.
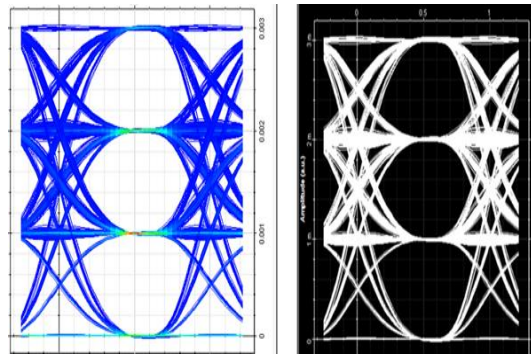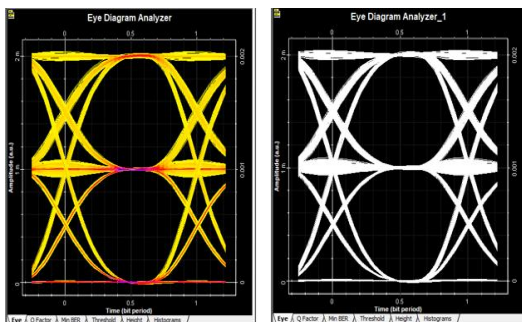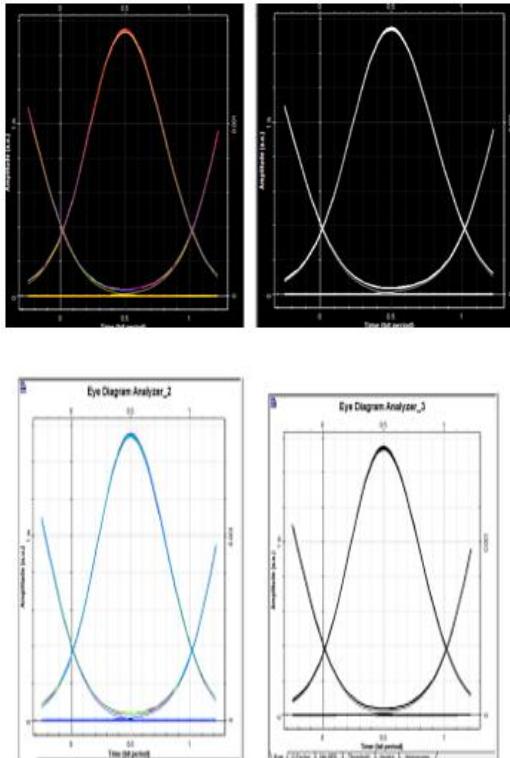

Fig. 4. Eye Diagram dedicated to the four communication channels without soliton
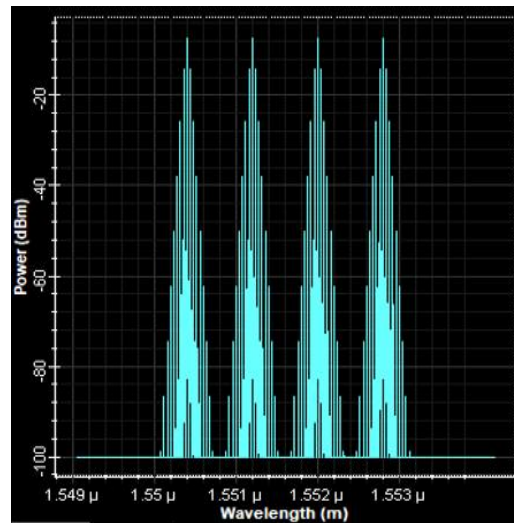
Fig. 5a. Soliton pulses output from the multiplexer
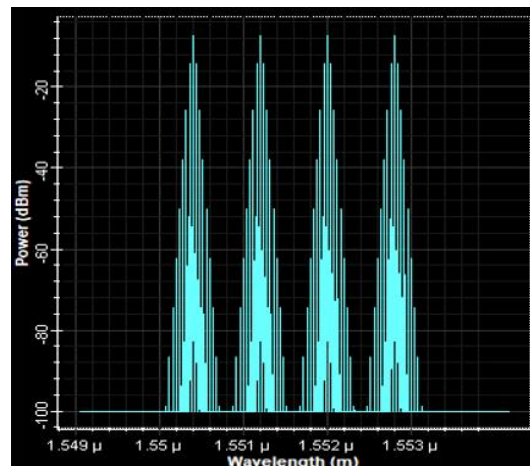
Fig. 5b. soliton pulses after 100Km from the fiber

Fig. 6. eye Diagram dedicated to the four communication channels with soliton

6. CONCLUSION AND FUTURE WORK

In view of all that proceeds, it should be remembered that solitons are the solution to the problems of nonlinearity and dispersion in the optical fiber, it has been shown that the propagation of the pulses in a nonlinear and dispersive fiber is done in an invariant fashion. Due to the stable nature of the optical soliton during propagation along a very long distance lossless optical fiber, it can be used as an information carrier. In this article, we have limited ourselves to making the presentation and the performance of the soliton in a DWDM optical link which are part of the multiplexing techniques currently used in modern telecommunications and a comparative study allowed us to confirm the hypothesis on the performance of the soliton, by taking a link without soliton, which is assumed to the overhead link, generate a lot of noise at the receiver point, even when we use EDFA amplifiers, but with the high speed or bitrate and the huge amount of power, the noise still; whereas, the link with soliton and without loss, kept the pulse shape during the transmission from the source up to destination. The concept of the soliton is currently being researched to form the backbone of tomorrow's global telecommunications networks. We would like to point out that on the practical level of the measurements that we carried out at Congo Telecom company, this was only possible for long-distance underground links, physically speaking, on the Kerr effect is take into account. In the overhead links with the fiber bending, the high temperature, especially in some Africans counties, this affect the fiber optics jacket, which in return influence negatively the fiber optic core by occurring some others nonlinear effects. So what we should keep at the back of our mind, when we deal with long distance transmission, like in a WAN it is better to use optical solitons in the underground fiber optic installation and in a MAN, we can use the overhead optical installation without soliton but with EDFA amplifier and RZ modulation's format. In the future, it will be better to deal with the hybrid link by combining DWDM and UDWDM in order to increase the speed of transmission, and the transmission capacity.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Agrawal Govind P. Nonlinearfibre optics. 5th ed. UK: Academic press;2013.
2. Fedor Mitschke, Christoph Mahnke, Alexander Hause. Soliton Content of Fiber-Optic Light Pulses;2017.
3. Yufeng Song, Dingyuan Tang. Recent progress of study on optical solitons in fiber lasers;2019
4. Manjeet Bagri, Suresh Kumar. Solitons transmission system: Adynamic shift in optical fiber communication; 2020.
5. Houria Triki, Vladimir I. Kruglov. Propagation of dipole solitons in inhomogeneous highly dispersive optical fiber media;2019.

6. Bakodah HO, Banaja MA.Numerical Solution of Dispersive Optical Solitons with Schrödinger-Hirota Equation by Improved Adomian Decomposition Method;2019.

7. S PHILIPPE, ''la fibre optique technologie et applications''

8. Christodoulides DN, Joseph RI. Slow Bragg solitons in nonlinear periodic structures. Phys. Rev. Lett. 1989;62(15):1746.

9. Chen YF, Beckwitt K, Wise F, Aitken BG, Sanghera JS, Aggarwal ID. Measurement of fifth- and seventh-order nonlinearities of glasses. J. Opt. Soc. Am. B 2006;23:347-352.

10. Eggleton B.J, Slusher RE, de Sterke CM, Krug PA, Sipe JE. Bragg grating solitons. Phys. Rev. Lett. 1996;76:1627-30.

11. Yosia Y, Shum Ping. Double optical bistability and its application in nonlinear chalcogenide-fiber Bragg gratings. Physica B. 2007;394:293-296.

12. Ming Wang and Guo-Liang He. Soliton solutions and collisions for the multicomponent gross–pitaevskii equation in spinor bose–einstein condensates; 2020.

13. Christoph Mahnke, Alexander Hause, and Fedor Mitschke. On the Creation of Solitons in Amplifying Optical Fibers " Institutf¨urPhysik,Universit¨atRostock,18059Rostock,Germany;2018.

14. Goving P. agrazal. Nonlinear Fiber optics. Academic press, san Diego, USA, 4th edition;2006.

15. Taverner D, Broderick NGR, Richardson DJ, Laming RI, Ibsen M. Nonlinear selfswitching and multiple gap soliton formation in a fiber Bragg grating", Opt. Lett. 1998;23:32830.

16. Thomas Schneder.Nonlinear Optics in Telecommunications.springer, Berlin;2004.

17. Shevgaonkar R.K. Advanced optical communications course NPTEL.

18. Nair S Sreedevi, Vipal Prem. Solitons: A Promising Technology in Optical Communication. International J of Science and Research. 2014;03(01).