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Soliton Transmission in DWDM Network

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Abstract- *The main challenge facing high bit rates optical communication systems is their tolerance to linear and nonlinear fiber impairments. In this paper an optical soliton is a way to mitigation the effect of dispersion in optical fiber, by balance between the Group-Velocity Dispersion (GVD) and Self-Phase Modulation (SPM).*

Comparison between CW Laser source with (33%RZ-DPSK) modulation formats and soliton source system in (1×40 Gb/s) Single channel show that the soliton source has the better performance than the CW Laser, where the soliton source has Q factor of (49. 73) dB, while the CW Laser has Q factor of (40.73) dB, when the input power is (5.41) dBm.

On other hand the soliton source has BER (-30. 136) dB while CW Laser has BER (-19.29) dB at SNR (4.61836) dB.

Comparison between the CW Laser source with (33%RZ-DPSK) modulation formats and soliton source system in (32 × 40 Gb/s) multi channel show that the soliton source has the better performance than the CW Laser ,where the soliton source has Q factor of (15.62), while the CW Laser has Q factor of (14.63),when the input power is (6.02) dBm .

On other hand the soliton source has BER (-5.03) dB, while CW Laser has BER (-4.14) dB at SNR (6.27) dB.

Index Terms- Optical soliton solution, Mitigation of linear and nonlinear channel impairment, dispersion-managed Solitons.

I. Introduction

Optical signals will be distorted while propagating through an optical fiber, due to fiber loss, dispersion and nonlinearity [1]. With the introduction of wavelength division multiplexing (WDM) to increase fiber capacity, it became clear that not only dispersion, but fiber nonlinearity as well, could significantly degrade signal quality [2]. The transmission impairments induced by non- ideal physical layer components can be classified into two categories: linear and nonlinear [3]. Linear impairments, in particular chromatic dispersion (CD) and polarization-mode dispersion (PMD) resulting from fiber transmission are now routinely mitigated by digital signal processing (DSP) in coherent receivers [4]. Nonlinear impairments include self phase modulation (SPM), cross phase modulation (XPM) and four-wave mixing (FWM) [5]. The development of telecommunications presents a wide field for applications of recent achievements of nonlinear physics. May be the most impressive is the use of soliton effects in optical fiber [6].To achieve a lossless soliton, the group velocity dispersion (GVD) parameter is required to be constant along the fiber length. But it is difficult to achieve a constant GVD parameter, so dispersion compensated fiber is used for increasing the efficiency of the soliton fiber link. These kinds of solitons are called dispersion-managed Solitons [7].

In this paper optical soliton used to mitigation channel impairment, where the soliton system performance improves with increasing transmission distance because the effects of nonlinearity (self-phase modulation) appears to be balanced with effects of linearity (group velocity dispersion).

System design

Design of single channel and multi-channel (DWDM) system using different types of optical source (CW Laser and Optical Soliton) at the 40 Gb/s bit.

1) For single channel

i. Using Optical Soliton

Simulation of single channel transmission system that uses soliton source pulse at bit rate 40 Gb/s is illustrate in figure(1).

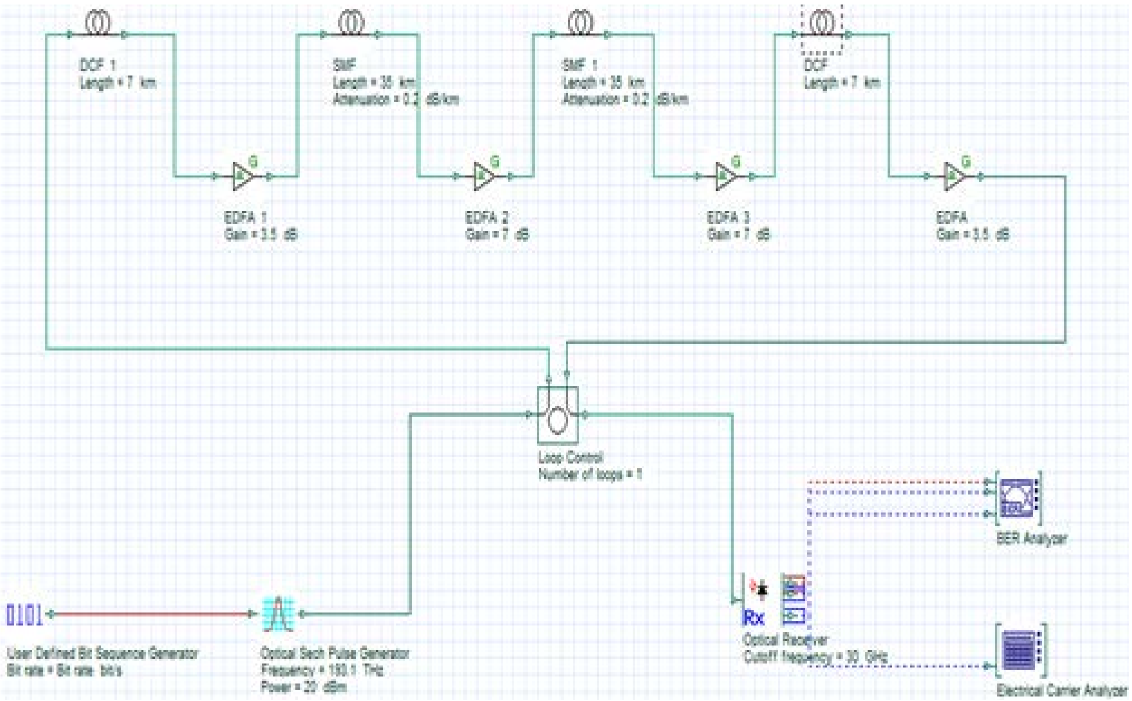


Figure (1): The simulated of single channel system with soliton source.

ii. Using CW Laser source

Simulation of single channel transmission system that uses CW Laser source at bit rate 40 Gb/s is illustrate in figure(2).

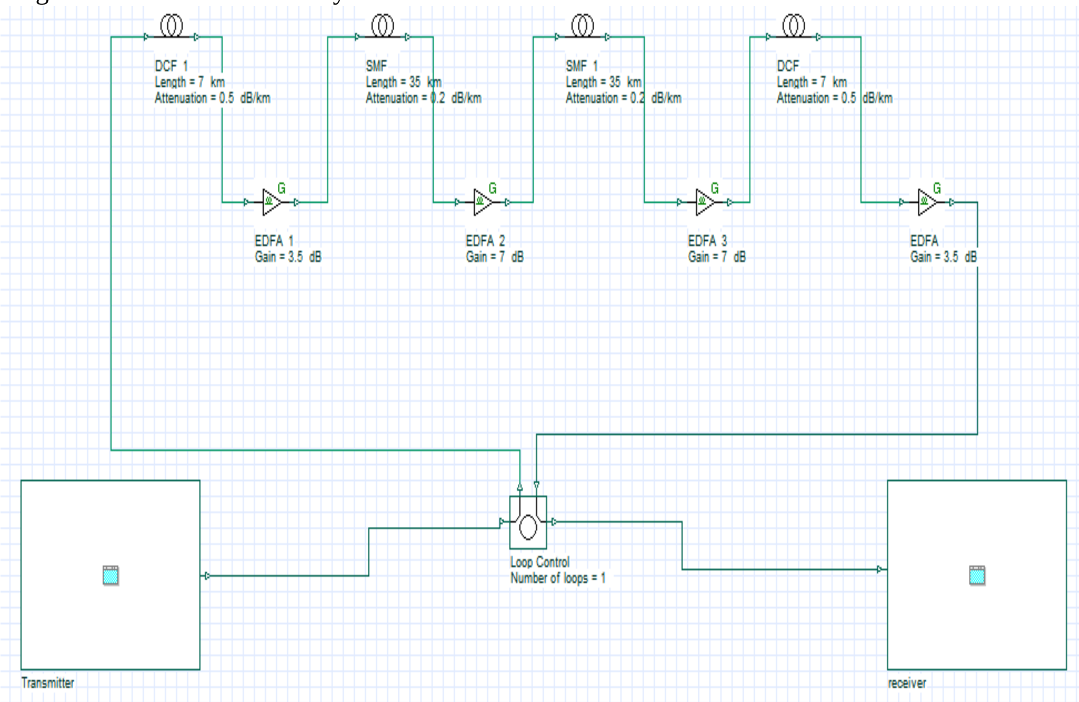
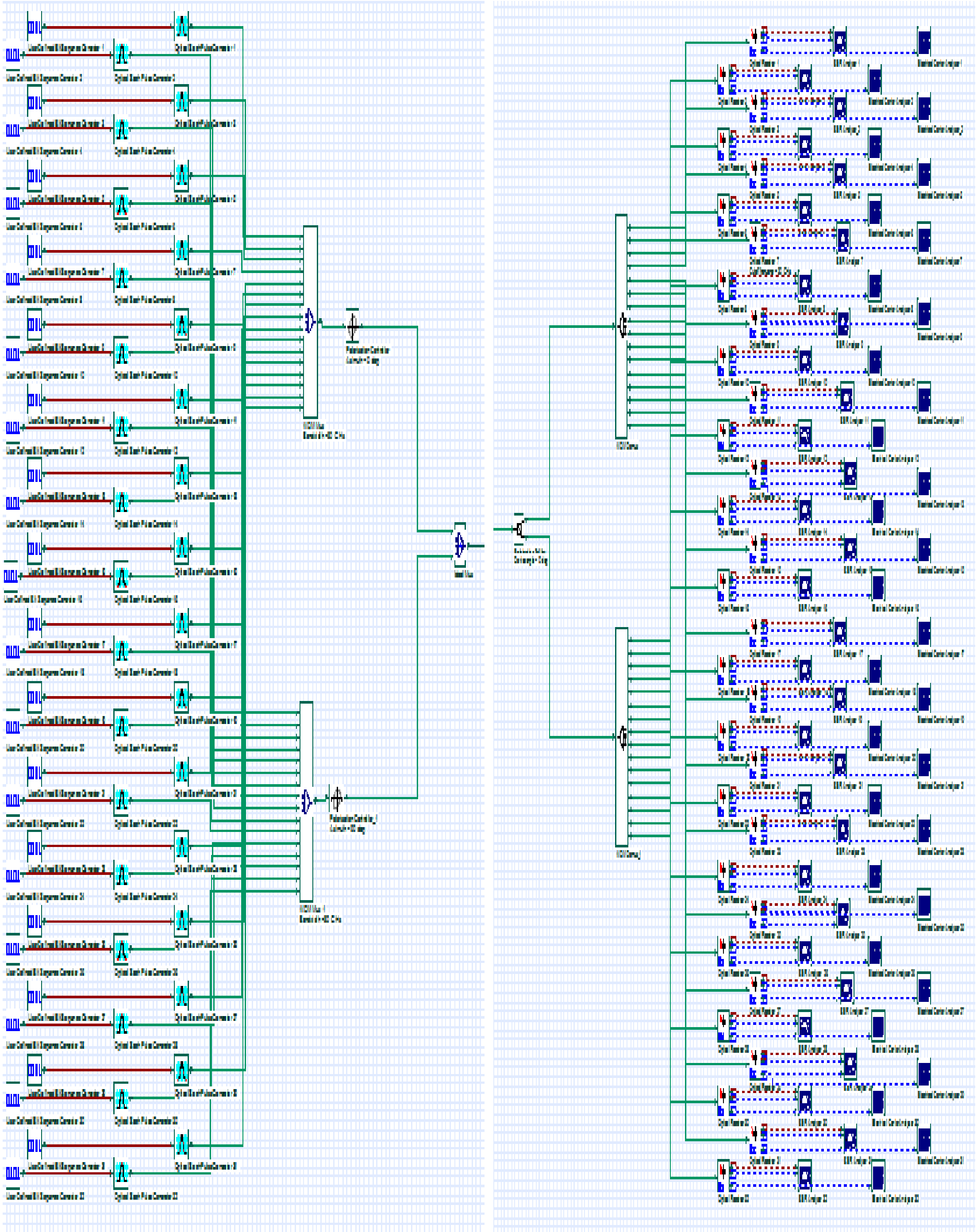


Figure (2): The simulated of single channel system with CW Laser source.

2) For multi-channel

i. Using Optical Soliton

Simulation of (32 × 40 Gb/s) multi-channel DWDM system at 50GHz channel spacing that uses soliton source pulse is illustrated in figure(3).



(a):Structure of the transmitter **(b):Structure of the receiver**

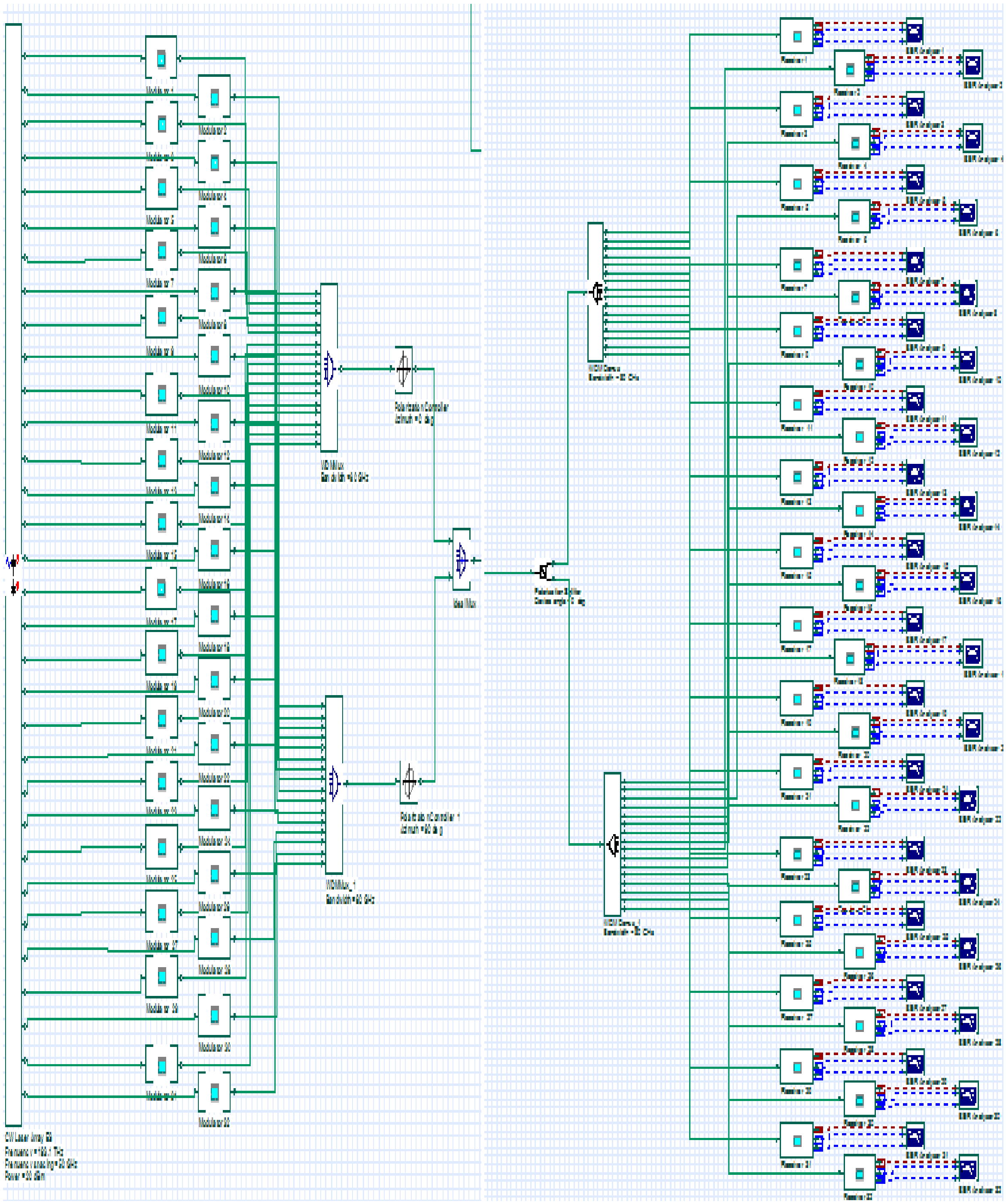
Figure (3): The receiver and transmitter sides of the simulated DWDM system layout by using soliton source.

Table (1): Parameters of the system.

Parameter	**Value**
Reference bit rate	40 Gb/s
Number of channels	32 channels
Frequency spacing	50 GHz
Center frequency	193.1 THz
Span length	70 km
Source linewidth	0.15 bit
Optical filter in mux. and demux.	80 GHz, Bessel filter, 4rd order
Electrical filter in reciever.	30 GHz, Low pass filter, 4rd order
NF of EDFA (dB)	4
ITU-T G.652 Fiber parameters	
α (dB/km)	0.2
Dispersion parameter D (ps/(nm.km))	17
Dispersion slope S (ps/(km.nm^2))	0.075
Effective area (μm^2)	80
DGD parameter (ps/$\sqrt{km}$)	0.1
DCF parameters	
α (dB/km)	0.5
Dispersion parameter D (ps/(nm.km))	-85
Dispersion slope S (ps/(km.nm^2))	-0.3
Effective area (μm^2)	30
DGD parameter (ps/$\sqrt{km}$)	0.1

ii. Using CW Laser sourc

Simulation of (32 × 40 Gb/s) multi-channel DWDM system at 50GHz channel spacing that uses CW Laser source is illustrated in figure(4).



(a)Structure of the transmitter (b) Structure of the receiver

Figure (4): The receiver and transmitter sides of the simulated DWDM system layout by using CW Laser source.

Table (2): Parameters of the system.

Parameter	**Value**
Reference bit rate	40 Gb/s
Number of channels	32 channels
Frequency spacing	50 GHz

Center frequency	193.1 THz
Span length	70 km
Source linewidth	1 MHz
Optical filter in mux. and demux.	80 GHz, Bessel filter, 4^{rd} order
Electrical filter in reciever.	30 GHz, Low pass filter, 4^{rd} order
NF of EDFA (dB)	4
ITU-T G.652 Fiber parameters	
α (dB/km)	0.2
Dispersion parameter D (ps/(nm.km))	17
Dispersion slope S (ps/(km.nm^2))	0.075
Effective area (μm^2)	80
DGD parameter (ps/$\sqrt{km}$)	0.1
DCF parameters	
α (dB/km)	0.5
Dispersion parameter D (ps/(nm.km))	-85
Dispersion slope S (ps/(km.nm^2))	-0.3
Effective area (μm^2)	30
DGD parameter (ps/$\sqrt{km}$)	0.1

II. Stimulation Result and Discussion

The relationship between Q-factor and power input in the single channel system (1 × 40 Gb/s) for CW Laser source with (33%RZ-DPSK) modulation formats and the soliton source are illustrate in figure (5).

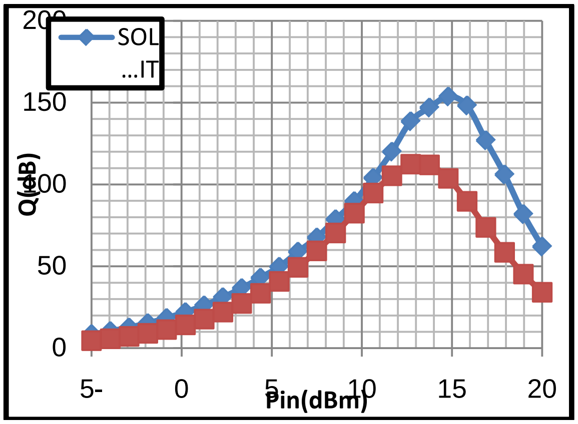


Figure (5): Q-Factor versus input power at 40 Gb/s single channel for soliton source system (W=0.15 bit) and CW Laser source.

The performance of BER related with the SNR in the single channel system (1 × 40 Gb/s) for the CW Laser source and soliton source with symmetric dispersion compensation are illustrate in figure (6)

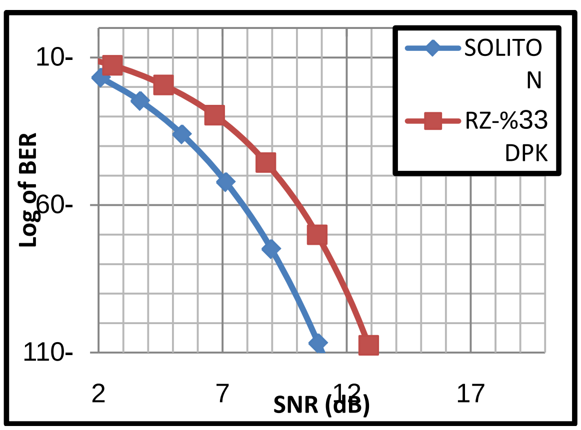
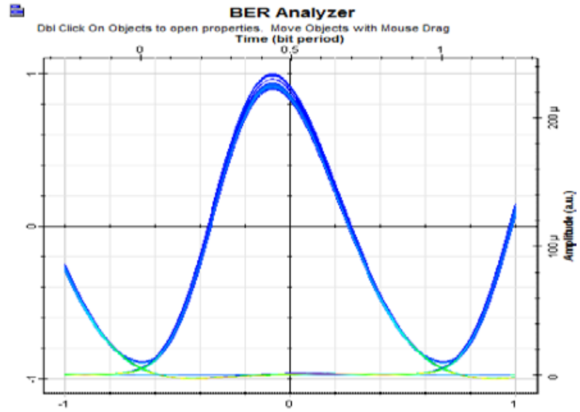
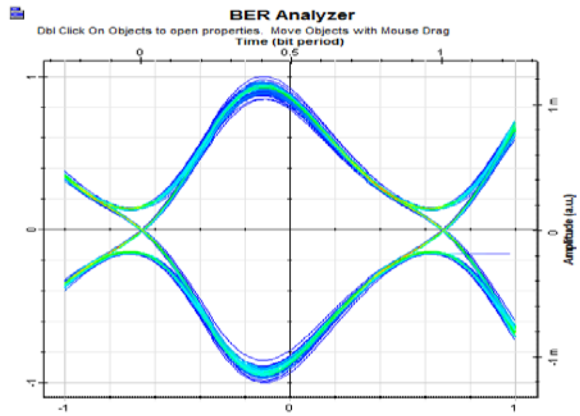


Figure (6): BER versus SNR for 40 Gb/s single channel with soliton source system (W=0.15) bit and CW Laser source.

The eye diagrams of CW Laser source with (33%RZ-DPSK) modulation formats and soliton source in (1 × 40 Gb/s) single channel system with symmetric dispersion compensation are illustrated in figure (7).



(a) soliton source system(W=0.15bit).



(b) CW Laser source system.

Figure (7): The eye diagrams at 40 Gb/s single channel for soliton source system (W=0.15) bits and CW Laser source

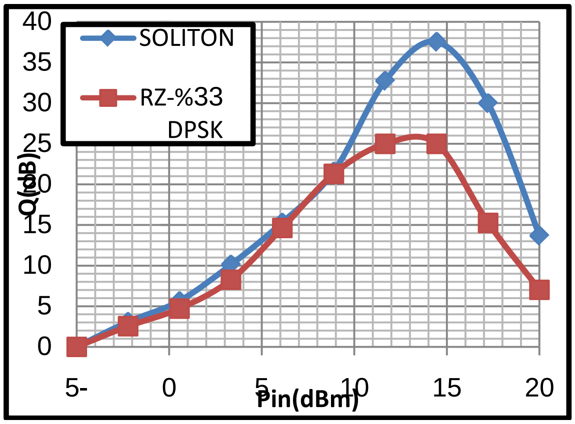
The simulation results illustrate that the performance of system with soliton source is better than the CW Laser source.

It can note clearly from figure (6) that the soliton system has Q.factor (49. 73691) while CW Laser source has Q.factor(40.7364)dB with distance 70 Km, of power input (5.41667) dBm.

From figure (7) shows that the soliton system has BER (-30. 136) dB while CW Laser source has BER (-19.29) dB at SNR (4.61836) dB with 70Km distance.

The relationship between Q-factor and power input in (32 × 40 Gb/s) multi-channel DWDM system for CW Laser source with

(33%RZ-DPSK) modulation formats and the soliton source (W=0.15 bit) are illustrate in figure (8).



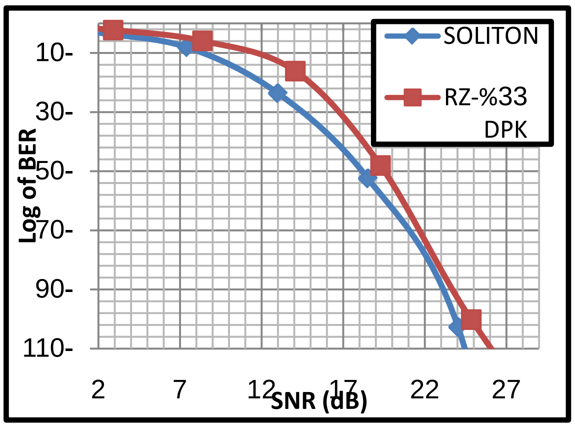
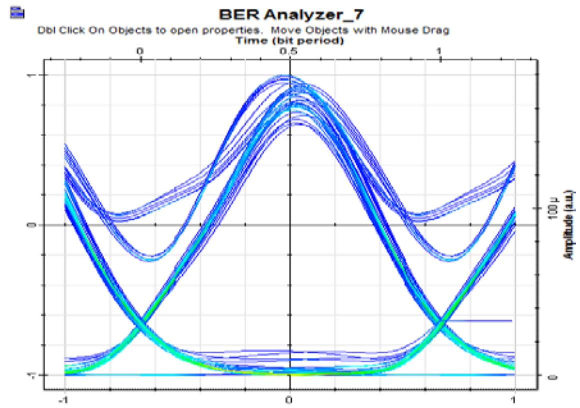


Figure (8): Q-Factor versus input power at (32 × 40 Gb/s) multi-channel for soliton source system (W=0.15 bit) and CW Laser source.

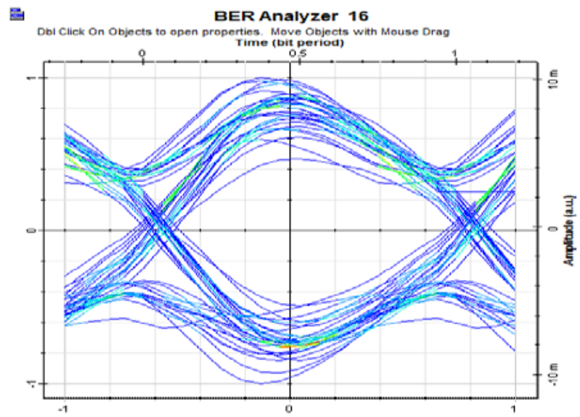
The performance of BER related with the SNR in (32 × 40 Gb/s) multi-channel DWDM system for the CW Laser source with (33%RZ-DPSK) modulation formats and soliton source (W=0.15bit) are illustrate in figure (9).

Figure (9): BER versus SNR for (32 × 40 GB/s) multi-channel for soliton source system (W=0.15 bit) and CW Laser source

The eye diagrams of CW Laser source with (33%RZ-DPSK) modulation formats and soliton source in (32 × 40 Gb/s) multi-channel DWDM system are illustrated in figure (10).



(a):soliton source system(W=0.15)



(b): CW Laser source system.

Figure (10): The eye diagrams for (32 × 40 Gb/s) multi-channel for soliton source system (W=0.15 bit) and CW Laser source.

It can note clearly from figure (8) that the performance of system with soliton source is better than the CW Laser source,where the soliton system has Q.factor (15.62) while CW Laser source has Q.factor(14.63)dB with distance 70 Km, of power input (6.02) dBm.

From figure (9) shows that the soliton system has BER (-5.03) dB while CW Laser source has BER (-4.14) dB at SNR (6.27) dB with 70Km distance

III. Conclusion

In this paper, design of (1 × 40 Gb/s) single channel and (32×40 Gb/s) multi-channel DWDM system using different types of optical source (CW Laser and Optical Soliton). The simulation results illustrate that the performance of system with soliton source is better than the CW Laser source with (33%RZ-DPSK) modulation formats.

The soliton system performance Improves with increasing transmission distance because the effects of nonlinearity (self-phase modulation) appears to be balanced with effects of linearity (group velocity dispersion).

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