Simulative analysis of dispersion managed solitons for Long-haul optical communication system

Bharti Gupta [a]
Department of ECE,
Sscet
Badhani, India

Simranjeet Kaur [b]
Prof Department of ECE
Sscet
Badhani, India

Kamaljit Singh Bhatia [c]
Prof Department of ECE
SGGSW University
Fatehgarh Sahib, India

Abstract

The purpose of this Paper is to demonstrate the dispersion-managed soliton regime in a fiber link with the loss and periodical amplification upto 36000 Km . Ideal lossless and loss-managed solitons require GVD parameter β_2 to stay constant along the fiber length. Modern WDM light wave systems employ dispersion management to compensate for cumulative dispersion and to suppress FWM penalties. It was demonstrated that solitons can even form when β_2 varies along the fiber length but their properties are quite different.

Keywords :soliton, dispersion compe-nsation, amplifiers.

Introduction

The dispersion management (DM) technique for short pulse propagation in optical fibers has become a subject of great interest for telecommunication applications [1-3]. In any realistic optical network it will not be possible to compensate for all the dispersion in each element, so that there will remain some residual dispersion. The field of telecommunications has undergone a substantial evolution in the last couple of decades due to the impressive progress in the development of optical fibers, optical amplifiers as well as transmitters and receivers.[4] Furthermore the amplitude of the signal is bounded from below to keep a reasonable signal to noise ratio, so that the nonlinearity should be also taken into account.[5] It was shown that the pulse propagation in such conditions was described by the nonlinear Schrodinger equation with a distance-varying dispersion coefficient [3]. As a result the concept of DM soliton in dispersion compensated lines was proposed. It combines the advantages of the traditional fundamental soliton of the nonlinear Schrodinger equation, and the dispersion-managed signal transmission. Both computational and experimental investigations have shown the existence and the stability of this new type of optical solitary wave. However the theoretical understanding of the DM soliton is still far from being complete .Furthermore it is well known that the nonlinear Schrödinger wave

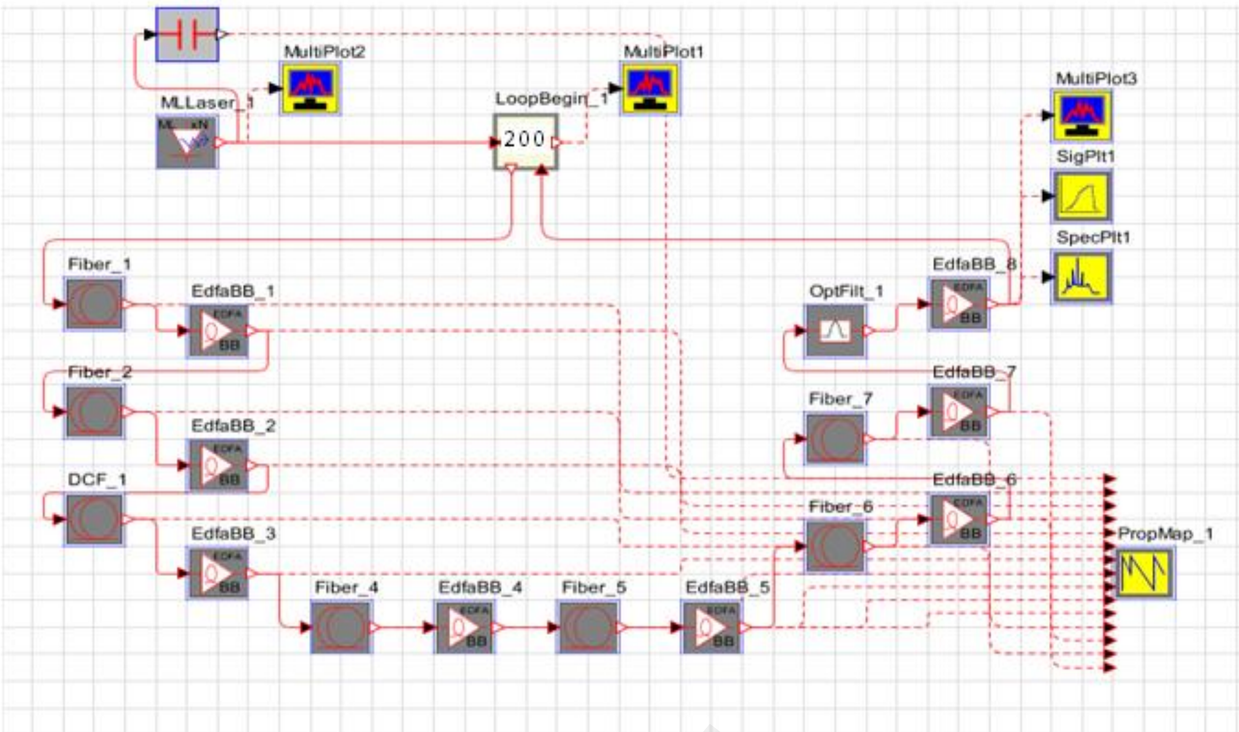

Figure 1 dispersion management system 36000 Km

equation does not completely describe the pulse propagation in realistic fiber transmission links. In addition to the periodic dispersion management and nonlinearity, random fluctuations of dispersion may occur [6, 7]. Indeed recent measurements by a recto meter yield the significance of dispersion randomness [8,9]. These terms have been shown to involve dramatic effects on the modulation instability of stationary waves because of a stochastic parametric resonance phenomenon [10]. In this paper we shall analyze the stability of the DM soliton with respect to random fluctuations of the dispersion.[11]

Dispersion management strategy, involves altering the local dispersion between a large positive and a large negative GVD such that the average GVD is small. DM strategy gives rise to several very striking improvements over conventional soliton transmission systems [12]. This technique is also a very promising way to increase the transmission capacity of soliton-based communication lines. DM solitons have several advantages over standard solitons in fibers with constant dispersion, when we use them as information carrier for long distance transmission. This variation is maintained periodically and the average dispersion over a period could be positive, negative or even zero. [13]

A circulating loop which consists of eight regular fiber spans, one dispersion compensating fiber (DCF) span, optical filter and EDFA is used for implementing the system. [14]The system transmits the data up to 36000 km. It is shown that the pulse spectrum is broadening due to the high order soliton effect and third- order dispersion near the zero dispersion wavelength, the spectrum begin to be shaped by optical filter installed at the end of the loop which removes the unwanted spectral peak that gets created on the left hand side of the spectrum., dispersion mapping and optical spectrum are used for the performance analysis. Rsoft OptSim is used for the simulation.

We came to our results with the help of Simulative analysis of integrated DWDM and MIMO-OFDM system with OADM was done recently for optical-OFDM system and Monitoring and Compensation of Optical Telecommunication Channels [17-22]

SIMULATION SETUP

The simulation for transmission of Dispersion managed solitons as shown in Fig.1 was performed using OptSim 5.2 by RSoft a simulation based tool for designing advanced optical communication systems.

The Mode locked laser is used for input pulse generation for multiple soliton partly because of the complexity in systematically varying the linear dispersion. The ultra short optical pulses propagating in solid-state mode locked lasers are also dispersion managed.

The simulation setup consist the Six fiber span 30 KM each ,one dispersion compensating fiber span (DCF) span has length 0.5 km and dispersion –72 ps/km/nm and, i.e. total dispersion is –36 ps/nm. is also shown in the simulation layout. Amplification is provided periodic interval by EDFAs. The total length of the one loop is 180 KM. Pulse has to travel total 200 loops or 36,000km with certain amplification within the path and with various dispersion management techniques. pulses.[15] Multiple patter is selected for laser used. The laser produced sechperbolic (sech) pulses with 7ps pulse width. These pulses are used because these are made to propagating in recirculating loop so as increase the transmission distance. Dispersion management is to simulate the compensate for cumulative dispersion and suppress the FWM penalties. The pulse peak power corresponds to N=1 soliton and is set to 11.56 mW. A number of signal and spectrum analyzers are attached to output from laser, fiber, and amplifiers blocks. Property Map block tapped to outputs of elements in the loop will record pulse dispersion, width, and optical power along the fiber length.

To experimentally characterize the propagation dynamics of DM solitons, a medium amenable to systematic changes in the linear dispersion is required. Such characterization has proven difficult

For six spans total accumulated dispersion is 36 ps/nm. DCF has dispersion –72 ps/km/nm and length 0.5 km, i.e. total dispersion is –36 ps/nm and fully compensates the cumulative dispersion in the loop to zero. The optical filter is placed at the end of the loop and has a width of 2.7 nm.

Conclusion and suggestion

Figure 2 shows the dispersion map of fiber link. In the every loop the dispersion is reduced approximately near to zero with the dispersion compensated fiber .The DCF is inserted non symmetrical second out of eight fiber span, so the dispersion is small but non zero equal to -5ps/nm**.**

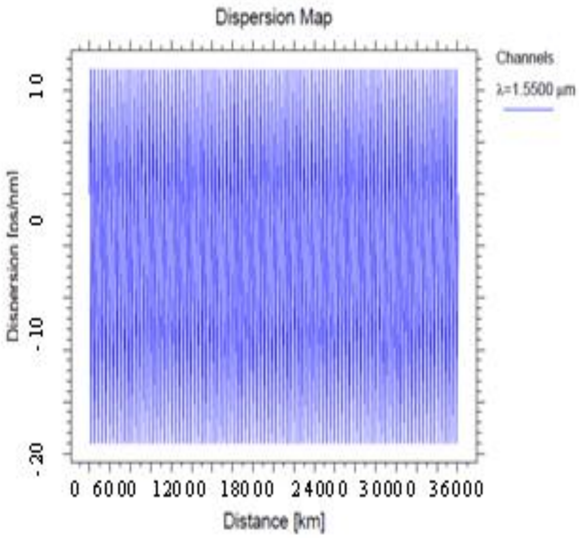

Figure2. Dispersion evolution along the fiber length

Non zero local dispersion improves to reduced the FWM panalties.Figure 3 shows the four wave harmonics mixing. A pulse of 7 ps is initial value and oscillating with amplitude up to 30 ps with the 3000 km and after the pulse width decreases 3 ps .after 6000 km it converges to steady state with pulse width changing between 10 to 13 ps with each loop.

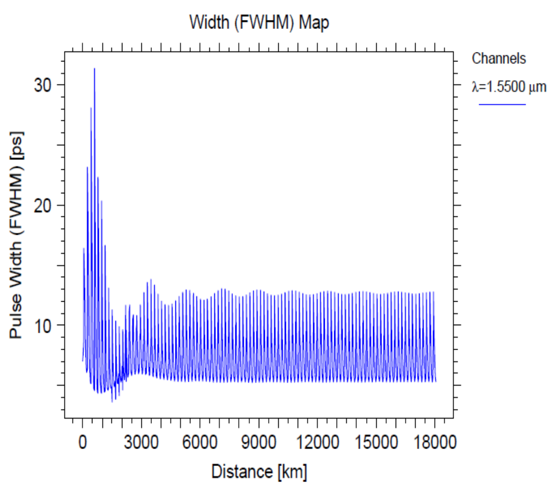

Figure3 shows the optical spectrum variation of the input and output pulse after travelling 36000Km.

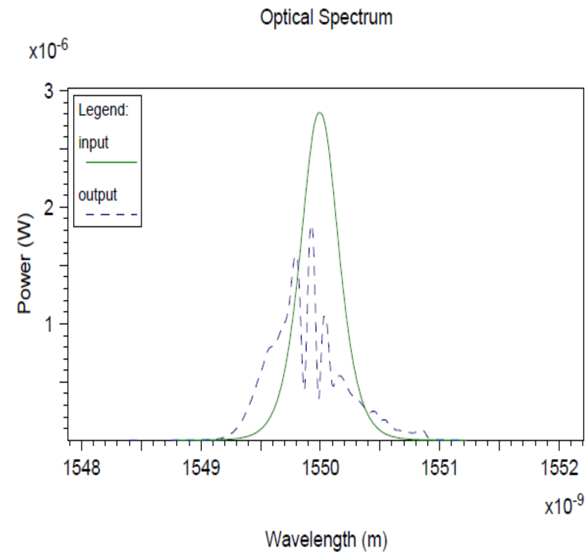

Figure4 input and output (after 36000 KM) optical spectra

Figure 5 shows the variation of the pulse amplitude of input and output after travelling 36000Km.

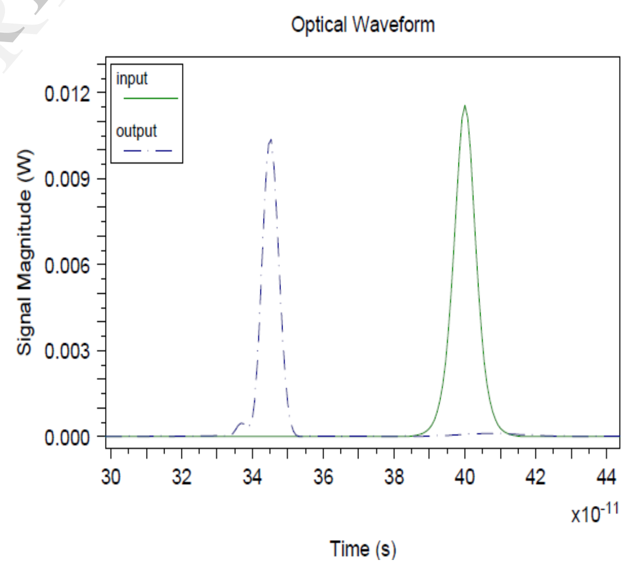

Figure5 . Input and output (after36,000 km) pulse

Figure6 shows the 3D view of the output signal at receiver. There is a very little distortion over 1000 km transmission. That demonstrates the robustness of path averaged soliton pulse. The amplitude of the 3D view which shows error-free communication.

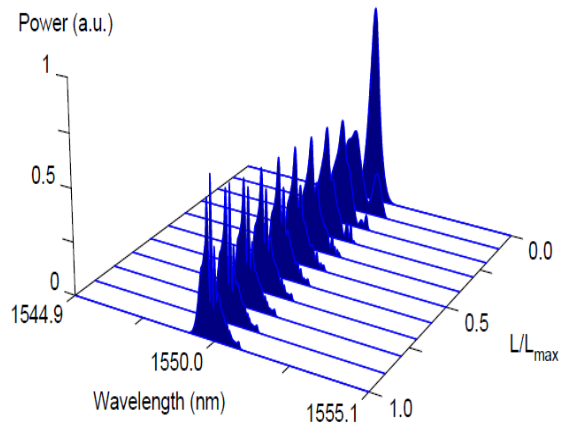

Figure6 Dispersion-managed soliton evolution in time (top plot) and frequency domain (bottom plot) along the fiber length

CONCLUSION

This paper gives the design, implementation and performance analysis of a dispersion managed soliton link. The soliton transmission is very attractive as a potential method for realizing high-speed, long distance communication. The performance analysis includes 3D diagram, dispersion mapping and optical spectrum analysis. Analysis shows that by using dispersion compensated fiber and periodic amplification with EDFA, soliton based data transmission with least error is possible.

References

[1] M. Suzuki, I. Morita, N. Edagawa, S. Yamamoto, H. Taga, and S. Akiba, Electron. Lett. 31 1995.

[2] N. Smith, F. M. Knox, N. J. Doran, K. J. Blow, and I. Bennion, Electron. Lett. 32 (1996) 54.

[3] I. Gabitov and S. K.Turitsyn, Opt. Lett. 21 (1996) 327; JETP Lett. 63 (1996) 862.

[4] Anjan Biswas, "Asymtotic Analysis for Dispersion Managed optical solitons", International Mathematical Forum, 1, 2006, no. 3, 103-137

[5] Sergei K. Turitsyn, Dispersion-Managed Solitons and Optimization of the Dispersion Management, Optical Fiber Technology 4, 384, 1998.

[6] S. K. Turitsyn, T. Schafer, K. H. Spatschek, and V. K. Mezentzev, Opt. Commun. 163 (1999) 122.

[7] Y. Kodama, A. Maruta, and A. Hasegawa, Quantum Opt. 6 (1994) 463.

[8] S. Wabnitz, Y. Kodama, and A. B. Aceves, Opt. Fiber Techn. 1 (1995) 187

[9] L. F. Mollenauer, P. V. Mamyshev, and M. J. Neubelt, Opt. Lett. 21 (1996) 1724.

[10] J. Grip and L. F. Mollenauer, Opt. Lett. 23 (1998) 1603.

[11] F. Kh. Abdullaev, S. A. Darmanyan, A. Kobyakov, and F. Lederer, Phys. Lett. A 220 (1996) 213.

[12] M. Mishra and S. Konar, "High Bit rate Dense Dispersion Managed Optical communication systems with distributed amplification", Progress In Electromagnetics Research, PIER 78, 301–320, 2008

[13] http://photonicssociety.org/newslett[ers/feb99/solit.htm

[14] M. Mishra and S. Konar, "High Bit rate Dense Dispersion Managed Optical communication systems with distributed amplification", Progress In Electromagnetics Research, PIER 78, 301–320, 2008

[15] Masataka Nakazawa, Hirokazu Kubota, Kazunori Suzuki, Eiichi Yamada, and Akio Sahara, "Recent progress in soliton transmission technology", Chaos, Volume 10, issue 3, American Institute of Physics 2000

[16] Qudsia Quraishi, Steven T. Cundiff, Boaz Ilan,Mark J. Ablowitz," Dynamics of Nonlinear and Dispersion Managed Solitons", National Institute

of Standards and Technology, June 2005

[17] Kamaljit Singh Bhatia, R. S. Kaler, T. S. Kamal and Rajneesh Kaler, "Monitoring and Compensation of Optical Telecommunication Channels by using Optical Add Drop Multiplexers for Optical OFDM System" Copyright © 2012 De Gruyter. DOI 10.1515/joc-2012-0001

[18] E K. Singh Bhatia,T.S. Kamal, R.S. Kaler, "Peak-to-average power ratio reduction using coded signal in optical-orthogonal frequency division multiplexing systems" IET Optoelectronic., *Elsevier Science. (2012)*, Vol. 6, Iss. 5, pp. 250–254, doi: 10.1049/iet-opt.2011.0089, Impact Factor-1.201 Available online at www.ieeexplore.ieee.org.

[19]Kamaljit Singh Bhatia, R.S. Kaler, T.S. Kamal, "DESIGN AND SIMULATION OF OPTICAL-OFDM SYSTEMS" Journal of Russian Laser Research, Springer Science+ Business Media (2012), Volume 33, Number 5, pp. 202-208, September, 2012, Impact Factor-0.7, Available online at www.springerlink.com

[20] K.S. Bhatia, T.S. Kamal, R.S. Kaler, "An adaptive compensation scheme-based coded direct detection optical–orthogonal frequency division multiplex (OFDM) system" Computers and Electrical Engineering 38, Elsevier *Science*(2012) 1573–1578, http://dx.doi.org/10.1016/j.compeleceng. 2012.06.007, Impact Factor-0.7, Available online at www.sciencedirect.com

[21]Kamaljit Singh Bhatia, R.S. Kaler, T.S. Kamal, Rajneesh Randhawa, "Simulative analysis of integrated DWDM and MIMO-OFDM system with OADM" Optik 124, *Elsevier Science* (2013) 117– 121, doi:10.1016/j.ijleo.2011.11.081, Impact Factor-0.5,Available online at www.sciencedirect.com

[22] Kamaljit Singh Bhatia, T.S. Kamal, "Modeling and simulative performance analysis of OADM for hybrid multiplexed Optical-OFDM system" In Press Optik,*Elsevier Science,* Volume 124, Issue 14, July 2013, Pages 1907–1911

.