1.6 Tbps High Speed Long Reach DWDM System by incorporating Modified Duobinary Modulation Scheme

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Abstract

This work is focused to investigate the duobinary modulation scheme in high speed DWDM systems. In this work, 40 channels having capacity 40 Gbps each are multiplexed with channel spacing of 50 GHz to realize 1.6 Tbps as total transmission over optical span of 1800 Km by incorporating pre and post dispersion compensation techniques. The non linear effects are limiting factors in narrow channel spaced system and in order to reduce their effects duo binary format is used and attenuation in the fiber is minimized by EDFA. Moreover, the role of laser line-width is also investigated to minimize the non linearity and Four wave mixing effect.

Keywords: DWDM, Laser Line-width, Duo binary Modulation scheme, Pre and Post compensation techniques.

1. Introduction

High speed dense wavelength division multiplexing (DWDM) systems are become very popular to the researchers as it offers multiple transmissions of channels over the same transmission medium. The last decade has seen enormous growth in the field of 40 Gbps optical transmission systems. Moreover, 40 Gbps systems provide high spectral efficiency of DWDM transmission systems (T.Hoshida et al 2002; A.Hodzik et al 2002). One of the key advantages of DWDM systems is its ability to cope with the current technologies such as SONET, ATM, SDH, Ethernet etc. The role of dispersion and nonlinearities produced in the optical fiber should be managed for the transmission systems in which data rate is higher than 10 Gbps. The post and pre compensation techniques are often employed to compensate the dispersion in optical fibers. It is well known fact that the positive dispersion effect in single mode fiber (SMF) can be overcome by negative dispersion of dispersion compensated fiber (DCF) in the optical transmission link(M. Forzati et al 2002; K.S.Cheng et al 2002). With the aid of pre compensation and post compensation, the effect of four wave mixing can also be minimized. The DWDM and pre and post compensation techniques can be employed to increase the efficiency and capacity of optical transmission systems (Ramandeep Kaur et al 2014). Non Return to Zero (NRZ) and Return to Zero (RZ) are the most often modulation formats for optical transmission systems. The NRZ format offers narrow optical spectrum as compared to RZ format where as in some cases for long haul communication RZ format is proved as better performance as compared to NRZ formats(G.Bosco et al 2002). However, both RZ and NRZ formats are not suitable for DWDM systems due to presence of non linear effects and FWM. For conventional SMF, the advanced modulation formats such as Duobinary modulation performs well as compared to the NRZ and RZ(K.S.Cheng et al 2002). In an experiment(Shao et al 2014), 10 X 10 Gbps of data are transported over optical fiber having span of 106 km by employing RZ-DQPSK-DWDM scheme. In another simulation work, 40 Gbps of data is transmitted over optical fiber having span of 500 Km to 2000 Km by employing DWDM scheme(Anu Sheetal et al 2010). Moreover, the effect of various modulation schemes such as carrier-suppressed return-to-zero (CSRZ), duobinary return-to-zero (DRZ) and modified duobinary return-to-zero (MDRZ) modulation formats are also investigated in the presence of Kerr effect. In another work (Yin, Xin et al 2014), 40 Gbps data is transported over optical fiber and performance is evaluated in terms of optical signal to noise ratio (SNR). In 2014, the authors has reported 1.28 Tbps data transmission over optical fiber having span of 200 km(Bijayananda et al,2013). In that simulative work, pre compensation, post compensation and symmetrical dispersion compensation techniques are investigated. In this work, 1.6 Tbps of data is transported over 1800 Km optical fiber by adopting duobinary modulation format and DWDM scheme. For the aid of dispersion compensation, DCF and Erbium doped Fiber amplifier is used in the transmission link. The remainder of paper is stated as: Section II describes the simulation set up, Section III depicts the Result and Section where as conclusion is presented in Section IV.

2. System Description

The schematic diagram of proposed high speed DWDM based optical transmission system is shown in Fig 1. The
proposed model is simulated by using OptiSystem™ software. In this work, 40 channels with channel spacing of 50 GHz are multiplexed and transported over optical link. Each of the channels is capable of generating 40 Gbps data. The 40 Gbps data is encoded by using modified Duobinary encoder which is further optical modulated by using Mach Zender modulator (MRZ) derived by Continuous wave (CW) laser having power of 0 dBm

The output of MZM is fed to multiplexer which combines the output of all channels to realize the total transmission of 1.6 Tbps data and transported over optical link. The optical spectrum measured after multiplexer and 50 Km SMF is shown in Fig 2.

It has been shown from Fig 2 (a) & (b) that after transmission over 50 Km SMF, the optical power is reduced and non linear effects are more significant. The optical link is comprised of SMF having length of 50 Km, EDF with gain of 10 dB, DCF having length of 10 Km and dispersion of -85 ps/nm/km and again EDF having gain of 5 dB. In the transmission channel, the positive dispersion of 17 ps/nm/km of 50 Km fiber is compensated by using DCF of 10 Km with dispersion of -85 ps/nm/km. The total number of loops for the transmission link is considered to 30 so that 60 Km x 30 to realize total length of 1800 Km. The output of loop control is fed to the demultiplexer which splits the optical signal into 40 channels. The optical signal is received by optical Gaussian filter having cut off frequency synchronized with the optical wavelength of each channel at the transmission channel. The output of Gaussian filter is fed to PIN photo diode. The eye diagram is used to measure the output signal at PIN Photo diode.

3. Results and Discussions

In this section, the results from the simulation are presented and discussed. The performance of proposed system is evaluated in terms of SNR, total received power and eye diagrams. Fig. 3 depicts the SNR received for channel 1 and channel 40 with respect to line width which also plays significant role in minimizing the non linearity’s of optical fiber. The SNR for channel 1 is computed as 25.41 dB, 22.43 dB and 29.11 dB at laser line-width of 2 MHz, 6 MHz and 10 MHz as shown in Fig 3. (a), which states that SNR is degraded for channel 1 when the line width is changed from 2 MHz to 6 MHz but after 6 MHz, an improvement is noticed in SNR at 10 MHz, whereas for channel 40, there is no significant changes in SNR is noticed when laser line-width is changed from 2 MHz to 10 MHz. Similarly, the total power received at photo-detector is shown in Fig 3. (b) which clearly states that the received power for channel 1 and channel 40 is noticed high at laser line width of 6 MHz.

Fig. 3: Measured Result for Proposed 40 x 40 DWDM System (a) SNR v/s Laser Line-width (b) Total Power v/s Laser Line-width

Fig 4 depicts the eye diagram for channel at different line-width of input continuous line-width.

Fig 4 Eye Diagrams of Channel 1 (a) at 2 MHz Laser Line-width (b) at 4 MHz Laser Line-width (c) at 6 MHz Laser Line-width (d) at 8 MHz Laser Line-width (e) at 10MHz Laser Line-width

Fig 4 Eye Diagrams of Channel 2 (a) at 2 MHz Laser Line-width (b) at 4 MHz Laser Line-width (c) at 6 MHz Laser Line-width (d) at 8 MHz Laser Line-width (e) at 10MHz Laser Line-width

Similarly, Fig 5 depicts the eye diagrams of channel 2 at different laser line-width. The received eye diagrams clearly states that all the channels are successfully
transmitted over optical transmission link having span of 1800 Km.

**Fig. 3 (a)** Measured Result for Proposed 40 x 40 DWDM System - SNR v/s Laser Line-width

**Fig. 3 (b)** Measured Result for Proposed 40 x 40 DWDM System - Total Power v/s Laser Line-width

**Eye Diagram**

**Fig. 4 (a)** Eye Diagrams of Channel 1 - at 2 MHz Laser Line-width

**Eye Diagram**

**Fig. 4 (b)** Eye Diagrams of Channel 1 - at 4 MHz Laser Line-width

**Eye Diagram**

**Fig. 4 (c)** Eye Diagrams of Channel 1 - at 6 MHz Laser Line-width

**Eye Diagram**

**Fig. 4 (d)** Eye Diagrams of Channel 1 - at 8 MHz Laser Line-width
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**Fig. 4 (e)** Eye Diagrams of Channel 1 - at 10 MHz Laser Line-width

**Fig. 5 (a)** Eye Diagrams of Channel 2 - at 2 MHz Laser Line-width

**Fig. 5 (b)** Eye Diagrams of Channel 2 - at 4 MHz Laser Line-width

**Fig. 5 (c)** Eye Diagrams of Channel 2 - at 6 MHz Laser Line-width

**Fig. 5 (d)** Eye Diagrams of Channel 2 - at 8 MHz Laser Line-width

**Fig. 5 (e)** Eye Diagrams of Channel 2 - at 10 MHz Laser Line-width
Conclusions

In this section, the results from the simulation are presented and discussed. The performance of proposed system is evaluated in terms of SNR, total received power and eye diagrams. Fig. 3 depicts the SNR received for channel 1 and channel 40 with respect to line width which also plays significant role in minimizing the non linearity’s of optical fiber. The SNR for channel 1 is computed as 25.41 dB, 22.43 dB and 29.11 dB at laser line-width of 2 MHz, 6 MHz and 10 MHz as shown in Fig 3. (a), which states that SNR is degraded for channel 1 when the line width is changed from 2 MHz to 6 MHz but after 6 MHz, an improvement is noticed in SNR at 10 MHz, whereas for channel 40, there is no significant changes in SNR is noticed when laser line-width is changed from 2 MHz to 10 MHz. Similarly, the total power received at photo-detector is shown in Fig 3. (b) which clearly states that the received power for channel 1 and channel 40 is noticed high at laser line width of 6 MHz.

In this work, Duobinary scheme is proposed as modulation scheme for transmission of 40 channels with 40 Gbps data rate each over 50 Km SMF and 10 Km DCF having loop of 30 to realize the total transmission of 1.6 Tbps over 1800 Km by using DWDM scheme. The channel spacing between all the channels is set to narrow frequency of 50 GHz. The role of laser line-width is also investigated as it plays important role to minimize the nonlinearity and four wave mixing. The performance of proposed 40 X 40 high speed system is evaluated in terms of SNR, total received power and eye diagrams which clearly states that all the channels are transmitted up to long optical span of 1800 Km with acceptable SNR and BER.

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