ISSN 2229-5518

NRZ versus RZ in 136 x 10 Gbps DWDM Systems

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Abstract— we investigated the 136 × 10 Gbps DWDM system with the interval of 100 GHz for NRZ and RZ modulation formats and further compare the performances of these formats in the term of Quality factor and eye closure, BER. The obtained results reported that NRZ DWDM system will provide better results with acceptable Quality factor (>15 dB) and BER (<10-9).

Index Terms— BER, DWDM systems, Eye closure, NRZ, Optical spectrum, Quality factor, RZ.

1 Introduction

THE current efforts of research and development are aiming at investigating the DWDM systems with various modulation formats for increasing the total capacity of medium and long haul optical transmission systems [1], [2]. At the same time, deregulation of telecommunication markets and global success of the internet has driven the demand for higher and higher system capacity. Aihan Yin et al. [5] discussed the principals of RZ, NRZ and CSRZ. NRZ has an electrical output signal, which can assume one of the two electrical levels depending on the transmitted bit. When a "1" is fed into the driver, the output signal is at the low level during the entire bit time. When a "0" is fed into the driver, the output signal is at the high level during the entire bit time. RZ has an output signal that can assume two electrical levels. When a "1" is transmitted, the output signal is at the high level for a time equal to the product of the duty cycle by the bit time. Then it goes down to the low level for the remaining time. When a "0" is transmitted, the output is constant at the low level for the entire bit time. Switching between the two levels is instantaneous with resulting square edges.
Toshiya Matsuda et al. [8] compared nonreturn-to-zero (NRZ) and return-to-zero (RZ) signal formats for single-channel long-distance transmission in an in-line amplifier system with dispersion management providing average zero dispersion and local nonzero dispersion at an interval equal to the in-line amplifier spacing. It was reported that with linear amplified spontaneous emission (ASE) accumulation, signal waveform distortion due to the combined effect of higher order group-velocity dispersion (GVD) and self-phase modulation (SPM) dominates the performance.
M. I. Hayee et al. [9] compared nonreturn-to-zero (NRZ) with return-to-zero (RZ) modulation format for wavelength-division multiplexed systems operating at data rates up to 40 GB/s. It was reported that in 10–40-Gb/s dispersion-managed systems single-mode fiber alternating with dispersion compensating fiber.
G. Bosko et al. [10] investigated the ultra dense wavelength-division multiplexing (UDWDM) scenario at 40 GB/s using nonreturn-to-zero (NRZ), return-to-zero (RZ), and carrier-suppressed return-to-zero (CSRZ) modulation formats. It is reported that NRZ modulation does not benefit from the introduction of a transmission optical filter, while it takes advantage of the orthogonal polarization launch of adjacent channels. In this paper, we pursue the same target, but in the context 136 channels DWDM system and compare modulation formats such as NRZ, RZ. Each channel has 10 Gbps data speed.

2 Simulation Setup

Simulation setup for 136 DWDM channels for NRZ and RZ modulation formats is shown in figure1.

As shown in figure 136 signals from CW laser sources, modulated by both modulation formats individually, are transmitted over a medium hall link i.e. 50 to 100 Km. The laser power is set to 0 dBm because at higher power the wavelengths tend to overlap each other causing more dominance of non-linear effects like XPM and FWM [1]. The 136 channels (1492.3-1612.7 nm) are spaced at 100 GHz. The input signal spectrum occupies a bandwidth of 120.4 nm. At the receiver section, the performance of one of the 136 channels (first channel) is evaluated using the optical spectra, eye diagram, and BER and Q value measurement.

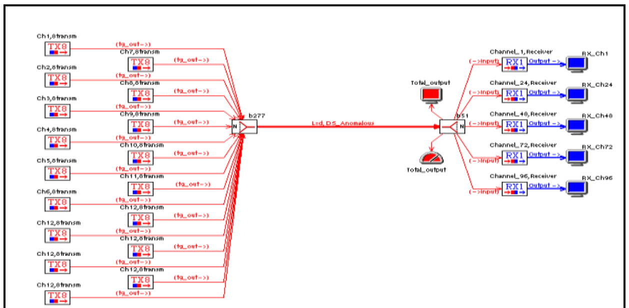

Fig. 1. Simulation setup of 136 channel DWDM system

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3 Results and Discussions

Both (NRZ and RZ) modulation formats have been compared for 136 X 10 Gbps DWDM systems in the term of received maximum Q value (dB) and minimum eye closure and BER. To analyze the system, the results of the first channel have been taken

3.1 Quality Factor

The figure 2 shows the graphical representation of Q value as a function of transmission distance. Q value can be seen for NRZ and RZ modulation formats that as the line is vary from 50 Km to 300 Km then the Q-factor is decreased due to the fiber non-linearties. This graph shows that RZ format has better Q value for transmission distances from 50 to 250 Km because NRZ suffers from the non-linearties and after that the effect of dispersion is increased due to shorter pulse width and RZ suffers from more dispersion. For the worst case (at 300 Km) Q Factor with NRZ modulation format is 20 dB and with RZ format, its value is 15.7 dB. So the better Q value is provided by the NRZ data format at 300 Km.

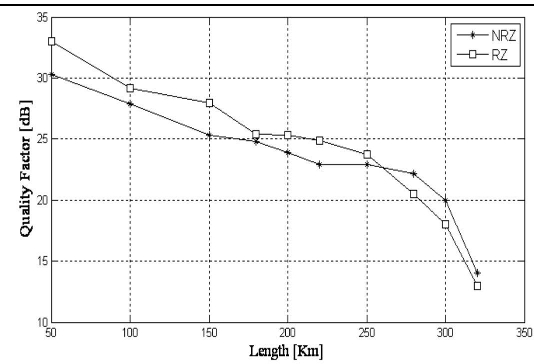

Fig. 2. Q-Factor versus distance for 136 channels DWDM system.

3.2 Eye Closure Penality

Figure 3 indicates that RZ provides the less eye closure penalty in worst case (at 300 Km) and its value is 0.78 dB. But its value is 1.3 dB for NRZ format. Means as we increase the transmission distance, the eye closure penalty goes on increasing. As the eye closure penalty goes on increase, the quality goes on decreasing.

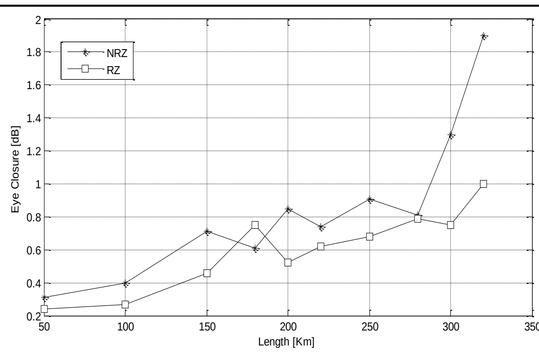

Fig. 3. Eye closure versus distance for 136 channels DWDM system.

3.3 Bit Error rate

Figure 4 indicates that NRZ provides the better BER in worst case (at 300 Km) and its value is 10-25 dB. But its value is 10-18 dB for RZ format. So NRZ format has far better BER than RZ format.

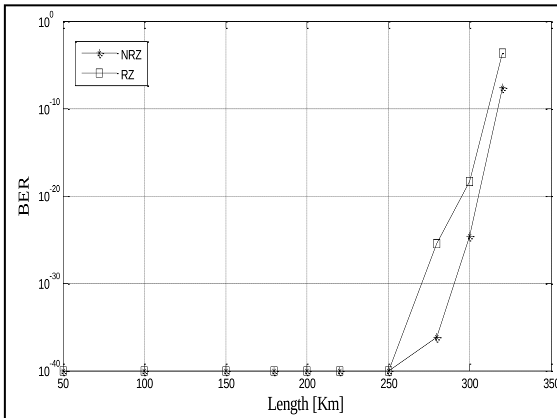

Fig. 4. BER versus distance for 136 channels DWDM system.

From the previous results it is observed that the NRZ has better Q factor and BER than RZ format. Then we further find the maximum covered single span distance using NRZ format. From Fig. 2-4 it can see that using this setup we can able to send the data over 300 Km with acceptable Quality factor (20 dB), BER (10-25) and eye closure (1.3 dB).

3.4 Eye Closure and Optical Spectrum for NRZ

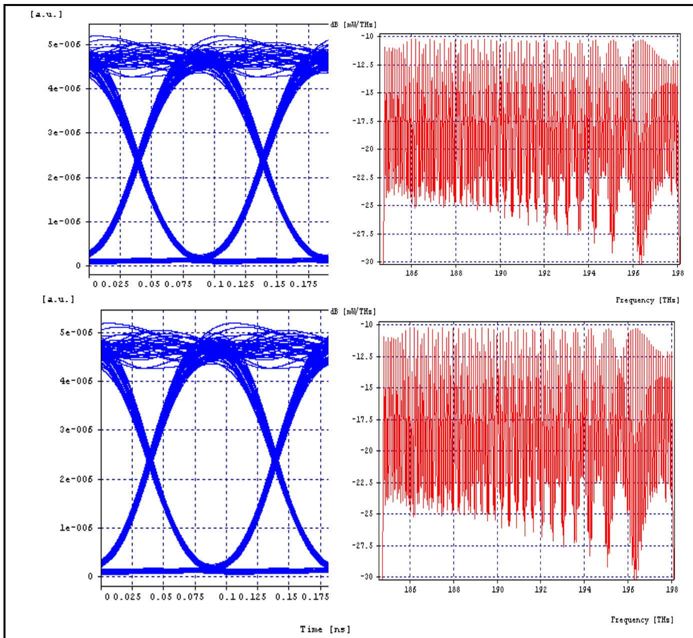

Fig. 5. Eye diagrams and Optical spectrums for 136 channels DWDM systems using NRZ modulation formats at (a)

3.5 Eye Closure and Optical Spectrum for RZ

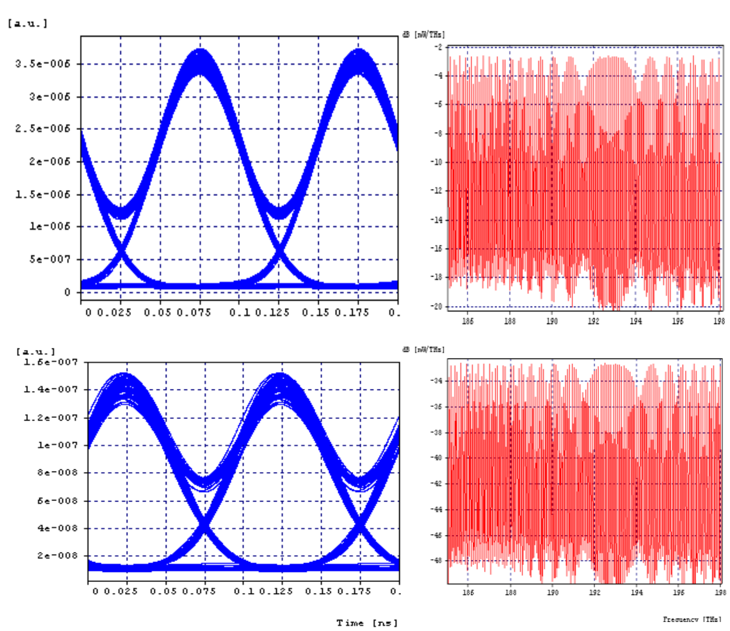

Fig. 6. Eye diagrams and Optical spectrums for 136 channels DWDM systems using RZ modulation formats at (a) 100 (b) 200 KM

4 Conclusion

In this paper, we investigated the 136 × 10 Gbps DWDM system for NRZ and RZ modulation format and further compare the performances of these formats in the term of Quality factor, BER and eye closure. It is observed that non-return to zero provide better results than RZ which provide better Quality factor (20 dB) and BER 10 -25 .But RZ has better Eye closure (0.78 dB) at 300 Km.But in general,RZ format is used for fewer channels being limited by dispersion Further, we covered 300 Km of single span distance using this system with NRZ modulation format.

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