Carrier Suppressed Return-to-Zero (CSRZ) and Modified Duobinary Return- to-Zero (MDRZ) Advance Optical Modulation Formats Analysis for Long Haul Rural Coverage

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Abstract

The rapid increase in the usage of data communication and data consuming devices demands higher data rate and reliable communication. In order to meet these demands new technologies are required which will be able to provide optimal quality of service and higher data rates. Next-Generation optical networks promise fast and flexible connectivity to resolve above challenging demands and can provide enough capacity for the next few years but the increase in data rate and transmission distance causes increase in dispersion. It occurs when different frequencies or mode of light in optical fiber are received by the terminals at different time and it increases, with an increase in fiber length. This is the major cause for breaking down quality of signal in optical fiber. Different modulation techniques are used to reduce the effect of dispersion, and improve the performance of the optical system. In this work, Performance of Carrier Suppressed Return-to-Zero (CSRZ) & Modified Duobinary Return-to-Zero (MDRZ) Advance Optical Modulation Formats are investigated in terms of Eye Height, Bit Error Rate (BER) and Quality Factor at 2Gbps for two different lengths of fiber in Optisystem. It found that MDRZ gives dispersion less transmission and less BER for long distance transmission.

Key words: Carrier Suppressed Return-to-Zero (CSRZ); Modified Duobinary Return-to-Zero (MDRZ); Quality Factor (Q-Factor); Bit Error Rate (BER); Eye diagram

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INTRODUCTION

The explosive increase in data traffic and the rapid development of global communication from past few decades result in more bandwidth demands. In order to face these challenges, service providers are working hard to develop new telecommunication networks. As bandwidth demand for multimedia applications is continuously increasing customers require higher bandwidth and data rate, with fewest numbers of channel errors. A variety of broadband technologies are emerging to meet those challenging demands (Dionisio et al., 2014). Next-Generation (NG) optical networks promise fast and flexible connectivity to fulfill the bandwidth requirement of end users and at the same time raise many technical challenges in order to ensure a flexible and reliable transmission, and most importantly to bring down the cost. These technical problems bring research opportunities and require innovations in devices, network architecture and transmission techniques (Kocher et al., 2013).

As the distance increases, beside the increase in the system cost, the optical system performance degrades as well. With the increase in transmission distance both the upstream and the downstream transmissions face a large amount of dispersion. Dispersion is the major factor that degrades the quality of signal in optical communication. Dispersion occurs when different frequencies or mode of light in optical fiber are received by the terminals at different time. The dispersion and BER (Bit Error Rate) increases in optical communication with the increase in distance (Patel et al., 2014; Seraji and Ahvati, 2014). The increase in data rate and transmission distance also causes a rapid increase in BER (Patel et al., 2014).

In order to further improve the overall capacity of the system, the number of channels per fiber also needs to be increased which can be accomplished by the use of efficient modulation scheme such as Non-Return-to-Zero (NRZ) and Return-to-Zero (RZ). But the linear and non-linear impairments, dispersion and Bit Error Rate (BER) become worse in such modulation schemes (HURA et al., 2013). An Advance Optical Modulation format is required to minimize the degrading effects that exist due to impairments in the fiber. Narrow optical spectrum in advance optical modulation format is able to tolerate distortion induced by Chromatic Dispersion(CD) and Polarization Mode Dispersion (PMD) and increase spectral efficiency (Winzer et al., 2006). Hence, in order to realize optical networks with high spectral efficiencies that can provide huge capacity, these advanced modulation schemes are crucial. Better optical modulation format increases the system performance by reducing the dispersion and BER and provides reliable communication (Albeladi et al., 2013). In (Irfan et al., 2015), the performance of GPON system at 2Gbps with NRZ modulation format is analyzed, while (Kumar et al., 2014) investigated the GPON system with and without square root module at bit rate of 2.5Gbps for 60km transmission distance. The (Srinath et al., 2014) analyzed the performance of 2Gbps and 2.5 Gbps GPON system using NRZ modulation respectively.

The optical spectrum of different modulation formats for GPON system for single data rate is evaluated in (Li et al., 2014). In (Simmons, 2014) the GPON system at 2Gbps with NRZ modulation format is investigated, while in (Rawshan and Park, 2013) authors analyzed the RZ and NRZ modulation formats in Passive Optical Network (PON) and GPON system respectively by changing the length of the fiber. Kocher et al, in 2013 reported the Gigabit Ethernet Passive Optical Network (GEPON) system at 2Gbps at 20 km using NRZ modulation format.

The RZ and NRZ modulation formats in PON and GPON system by changing the length of the fiber is analyzed in (Kaur et al., 2013). In this analysis the authors achieved better results at 2Gbps with NRZ and if the data rate is further increased BER increases sharply. Kaur et al., 2013 estimated the performance of Time Division Multiplexing-Passive Optical Network (TDM-PON) system in terms of Quality Factor (Q-factor) and BER. Authors analyzed the two modulation formats RZ and NRZ by changing the length of fiber and input power at a constant bit rate of 622Mbps. It is analyzed that the RZ is better than NRZ and TDM-PON system gives the optimum performance at power 20dBm. The repeater less transmission up to the distance of 130 km is observed.

Previous works focused on the performance of the optical modulation formats for single fiber length or constant data rate and most of the work considered the NRZ and RZ modulation formats.

As in (Irfan et al., 2015; Srinath et al., 2014; Simmons, 2014; Kocher et al., 2013) both data rate and length of the fiber are kept constant while in (Li et al., 2014; Kaur et al., 2013; Kaur et al., 2013) the length of the fiber is changed while keeping the data rate constant. Most of the previous work restricted to NRZ and RZ modulation formats.

To the best of author's knowledge no one analyzed the anti-dispersive performance and BER in CSRZ and MDRZ at the same time for different fiber lengths. Most analysis is done at 2Gbps with NRZ or RZ modulation formats.

Most of authors considered a small fiber length because as the transmission distance increases dispersion also increases. Kocher et al., 2013 and Kumar et al., 2014, authors used 20 km and 60km fiber length with NRZ modulation format respectively. Therefore, in this paper, we analyze the performance of CSRZ and MDRZ modulation formats for two different lengths of fiber at 2Gbps. Large transmission distances (240km & 255km) are considered to make the system reliable for long haul rural coverage. Performance in terms of eye diagram, Q-factor and BER is investigated and results are drawn. Q factor measurement is the new quality evaluation parameter. System Q-factor adopts the concept of Signal to Noise ratio in a digital signal and is an evaluation method that assumes a normal noise distribution.

System design and description

Performance of Advance Optical Modulation Formats (CSRZ & MDRZ) are investigated, using different length of fiber (240 & 255km) at 2Gbps. Analysis in terms of Eye pattern, Q-factor & Bit Error Rate (BER) is performed in Optisystem.

Figure.1 & Figure.2 show the block diagram of CSRZ & MDRZ advance optical modulation formats.

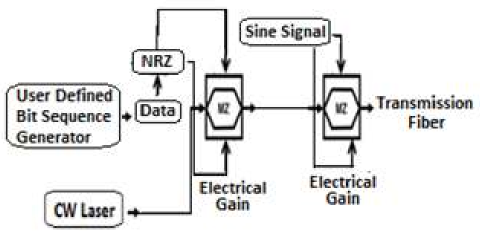

Figure 1: Block Diagram of CSRZ

CSRZ modulation format consists of two Mach-Zehnder modulator, first modulator generates chirp free RZ optical signal and second modulator prove pi shift between adjacent bits.

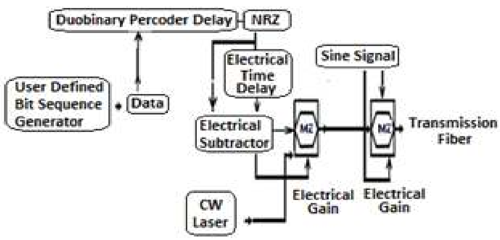

Figure 2: Block Diagram of MDRZ

The MDRZ signal is produced first by creating NRZ Duobinary signal with the help of delay and subtracts circuit. This NRZ Duobinary signal drives the first Mach-Zehnder Modulator (MZM). First MZM cascaded with second MZM, which then driven by sinusoidal electrical signal. At the receiver side photo detector is used for the detection of MD signals.

RESULTS AND DISCUSSION

Simulation for both CSRZ & MDRZ is carried out in Optisystem for two different lengths of fiber at 2Gbps. Table 1 shows the simulation results for BER and Q values using CSRZ format at 240km and 255km length of fiber.

Table I: Result Table for CSRZ at 2Gbps

Modulation Format	Fiber Length	Min BER	Q Factor
CSRZ	240 km	Zero	70.6943
	255 km	4.66307e-028	10.9192

Performance in terms of eye diagram for CSRZ is carried out for two lengths at 2Gbps.
Figure 3 shows the eye diagram at 240km length of fiber and Figure.4 shows the eye diagram at 255km length of fiber using CSRZ.

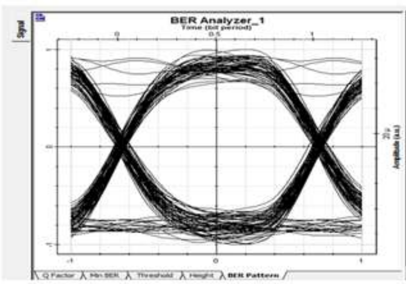

Figure 3: Eye Diagram of CSRZ at 2Gbps with a fiber length of 240km**.**

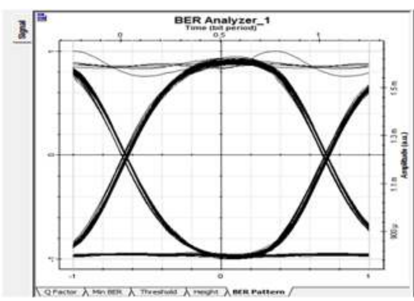

Figure 4: Eye Diagram of CSRZ at 2Gbps with a fiber length of 255km.

Figure 3 shows an open eye pattern, which indicates less errors and jitters. Figure.4 indicates that at 255km, Q-factor decreases from 43.9458 to 10.9192. Table 2 shows the simulation results for BER and Q values using MDRZ format at 240km and 255km length of fiber.

Table 2: Result Table for MDRZ at 2Gbps

Modulation Format	Fiber Length	Min BER	Q Factor
MDRZ	240 km	Zero	188.276
	255 km	1.73202e-068	17.4494

Similarly to CSRZ, performance in terms of eye diagram for MDRZ is carried out for two lengths at 2Gbps.
Figure 5 shows the eye diagram at 240km length of fiber and Fig.6 shows the eye diagram at 255km length of fiber using MDRZ.

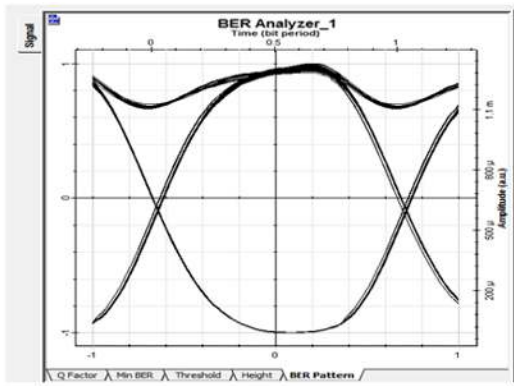

Figure 5: Eye Diagram of MDRZ at 2Gbps with a fiber length of 240km**.**

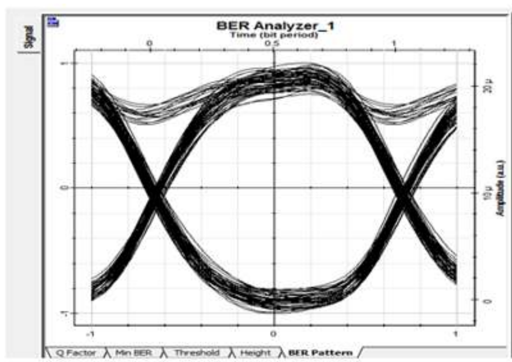

Figure 6: Eye Diagram of MDRZ at 2Gbps with a fiber length of 255km.

Figure 5 shows no distortion and signal loss at data rate of 2Gbps. Q-factor is highest i.e. 188.276 and BER is low. Considering Figure 6 eye pattern has minimum number of zero's and ones and transmission quality is also great.

If we plot a graph using fiber length vs Q- factor we will come to know that with increase in length of fiber in CSRZ and MDRZ, the Q-factor decreases more rapidly in CSRZ as compared to MDRZ at data rate 2Gbps.

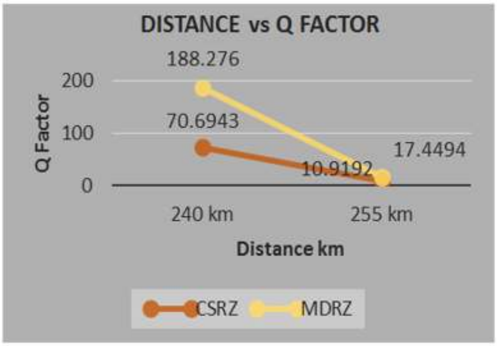

Figure 7: Q values as a function of fiber Length at 2 Gbps for CSRZ & MDRZ

From the graph in Figure 7 it is clear that as the transmission distance increases the system performance decreases. At 240km CSRZ has low quality value than MDRZ, and as we move from 240 to 255km, MDRZ shows optimum performance as compared to CSRZ.

CONCLUSION

The performance of CSRZ and MDRZ optical modulation formats is investigated in in terms of eye diagram, Q- factor and BER. These modulation formats are compared and evaluated for 240km and 255km fiber length at 2Gbps. MDRZ gives high Q-value than CSRZ. The eye opening and eye height of MDRZ shows maximum eye opening at longer distance. Number of zero's and one's in eye diagram of MDRZ are minimum than CSRZ at distance of 255km. CSRZ show dispersion at large transmission distance than MDRZ. MDRZ has better Q-value at maximum transmission distance thus for long haul rural coverage MDRZ modulation format is the best choice.

REFERENCES

- Dionisio R, Teixeira AL and Nogueira R. (2014). Advanced optical modulation and format conversion. In Second International Conference on Applications of Optics and Photonics. International Society for Optics and Photonics, pp. 92861–92861
- Kocher D, Kaler R and Randhawa R. (2013). Simulation of fiber to the home triple play services at 2gbit/s using GE-PON architecture for 56 onuses. Optik-International Journal for Light and Electron Optics. 124(21):5007–5010
- Patel V, Patel R, Mehtaetal K. (2014). Comparative analysis of single span high speed 40Gbps long haul optical link using di erent modulation formats in the presence of kerr nonlinearity, in Students' Technology Symposium (TechSym), IEEE. IEEE, pp. 132–13
- Seraji FE and Ahvati J. (2014). Design of dispersion compensating fibers with high negative dispersion and low bending loss: A comparative analysis. International Journal of Optics and Applications 4(2):40–45
- HURA BK. (2013). Performance evaluation and analysis of EPON for radio over fiber optical networks. Ph.D. dissertation, National Institute of Technology Hamirpur
- Winzer FT, Peter J and Rene-Jean Essiambre. (2006). Advanced optical modulation formats. Proceedings of the IEEE. 94(5):952-985
- Albeladi, Ahmed MF and Bakry AH. (2013). Performance evaluation of 40Gb/s directly-modulated optical fiber communication systems, in Electronics, Communications and Photonics Conference (SIECPC), 2013 Saudi International. IEEE, pp. 1–6
- Irfan M, Qureshi MS and Zafar S. (2015). Evaluation of advanced modulation formats using triple-play services in GPON based FTTH, in Cloud Computing (ICCC), International Conference on. IEEE, pp. 1–6
- Kumar N. (2014). Improved performance analysis of gigabit passive optical networks. Optik-International Journal for Light and Electron Optics 125(7):1837–1840
- Srinath S. (2014). Performance Analysis of 2.5 Gbps GPON. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering 1(3): 10148-10155

- Li L, Yan-Tao C, Ji-Jun Z, Zhi-Rui L and Wan-Li C. (2014). Research on the modulation performance in gpon system. TELKOMNIKA Indonesian Journal of Electrical Engineering 12(10):7304–7310

- Rawshan F and Park Y. (2013). Architecture of multi-OLT PON systems and its bandwidth allocation algorithms. Photonic Network Communications 25(2):95–104

- Kaur ML, Singh and Sheetal A. Comparison of RZ and NRZ data formats for co-existing GPON and XG-PON system," in Advanced Nanomaterials and Emerging Engineering Technologies (ICANMEET), 2013 International Conference on. IEEE, pp. 666–669.

- N. Kaur, M. Sarangal et al., (2013). E ects of using RZ and NRZ modulation formats for TDM PON system on transmission characteristics for downstream signals. International Journal of Computer Applications Technology and Research 2(6):645

- Simmons JM. (2014). Optical network design and planning. Optical Network Elements, Springer, 25-87