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Simulation and Performance Comparison of Dual arm Mach Zehnder Modulator and Single arm Mach Zehnder Modulator in Duobinary Transmission System

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Abstract: ***Duobinary signal is a three level signal which has higher dispersion tolerance and better bandwidth efficiency than conventional binary signal formats. Optical duobinary signal can be generated by using either a dual arm Mach Zehnder Modulator (dual arm MZM) or a single arm Mach Zehnder Modulator (single arm MZM). This paper deals with the simulation and performance comparison of duobinary transmission systems with dual arm MZM and single arm MZM using OptSim software.***

Keywords: duobinary, dual arm Mach Zehnder Modulator (dual arm MZM, single arm Mach Zender Modulator (single arm MZM).

1. Introduction

In recent years, the demand for faster communication due to the explosive growth in internet activities has lead to the better usage of channel bandwidth. Thus, Optical fiber communication technology which has higher bandwidth than copper cable is preferred to transmit higher data rates at longer distances. At higher data rates, chromatic dispersion in optical fiber causes waveform distortion and becomes a limiting factor in the Standard Single Mode Fiber (SSMF).

Correlative coding, also known as Partial Response Signaling (PRS), can enhance the chromatic dispersion tolerance of a SSMF. Duobinary coding, which was first introduced by A Lender in 1960s , is a type of PRS . It is a three level signal with spectral width one half that of the binary.

Duobinary data can be obtained from binary data by adding the binary bits to a one bit delayed version of itself . Duobinary transmitter section has both optical and electrical part. Electrical section of duobinary transmitter consists of data source, electrical generator and duobinary encoder. Duobinary encoder produces three level electrical signal. It can be either a delay and add circuit or a duobinary filter (5 pole Bessel Thomson low pass filter). Duobinary filter is better than delay and add circuit for generating duobinary signal. The optical section of duobinary transmitter consists of a laser diode and Mach Zehnder Modulator (MZM). MZMs can be of two types - dual arm MZM and single arm MZM. A continuous wave or pulsed light wave generated by a laser diode is modulated by an external MZM and is transmitted through fiber. At the receiver, the square law detector neglects the phase of a received pulse. Therefore the received data sequence is absolute value of transmitted sequence [1].

2. System Design

Duobinary transmission systems based on dual arm MZM is shown in Figure 1. In this setup, the data source feeds two drivers, one directly and other through NOT gate, that generates the NRZ signal. These two signals are then passed to the electrical filters of Bessel type. The Bessel filters have 5 poles and a bandwidth of 0.25* bit rate. It acts as duobinary encoder that produces a three level signal. Here, dual arm MZM which is driven in push-pull fashion is used as the modulator. Push-pull means that each arm of MZM are driven by opposite voltages to avoid chirping of the output signal. MZM splits an incoming light signal into two waveguide branches. The two branches experience different optical delays, depending on the voltage applied to each arm, and then recombine constructively or destructively. Thus three level optical signal is produced. This signal is amplified and then transmitted through SSMF. Finally it is detected and filtered by using a PIN photo diode and Bessel low pass filter respectively.

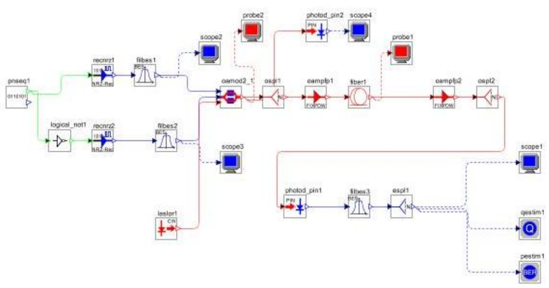


Figure 1: Duobinary transmission system based on dual arm MZM

Duobinary transmission system based on single arm MZM is shown in Figure 2.

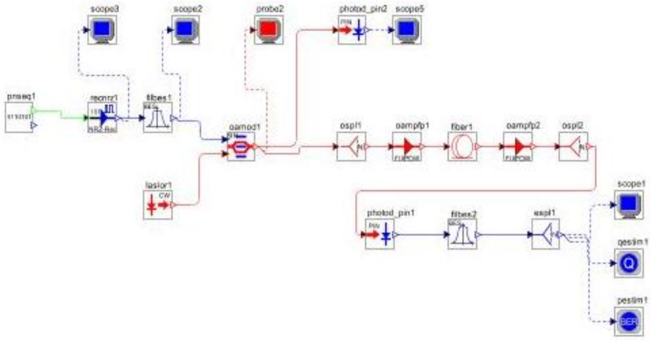


Figure 2:.Duobinary transmission system based on single arm MZM.

Here, the Pseudo Random Bit sequence generated by the data source is encoded by using NRZ electrical generator. Three level electrical signal is produced by passing this signal through a Bessel Thomson low pass filter. It is then modulated by using a single arm MZM with $\sin^2$ electrical shaped input-output characteristics to produce three level optical signal. This transfer function is typical for a Mach-Zehnder external modulator based on the electro-optic effects in the Lithium Niobate (LiNbO3) devices. Transmitting channel and the detector are same as that of dual arm MZM based system.

Compared to dual arm MZM, the transmitter section based on single arm MZM is less complex and also it avoids symmetric requirements [2,3].

3. Results and Discussions

3.1 Variation of Q Factor with Distance for Various Bit rates

Figure 3 and Figure 4 shows the variation of Q factor with distance for dual arm MZM and single arm MZM at bit rates 10, 20 and 30 Gbps respectively.

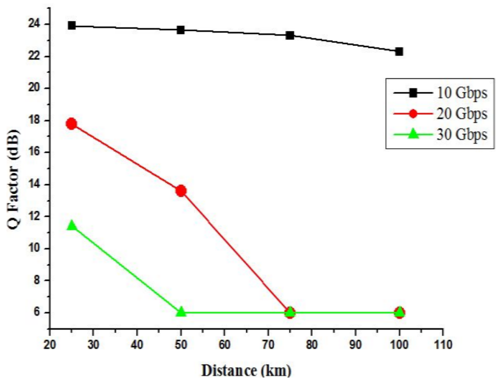


Figure 3:.Variation of Q Factor with distance for dual arm MZM

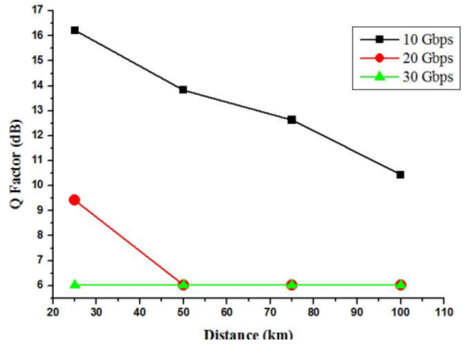


Figure 4: Variation of Q Factor with distance for single arm MZM

Dual arm MZM based duobinary transmission system provide better Q Factor than single arm MZM based transmission system. At lower bit rates single arm MZM based system can be used since it provide considerable value of Q Factor and low circuit complexity. But at higher bit rates and longer distances, dual arm MZM is better.

3.2 Variation of BER with Distance for Various Bit rates

Variation of BER with distance for dual arm MZM and single arm MZM at bit rates 10, 20 and 30 Gbps are shown in Figure 5 and Figure 6 respectively.

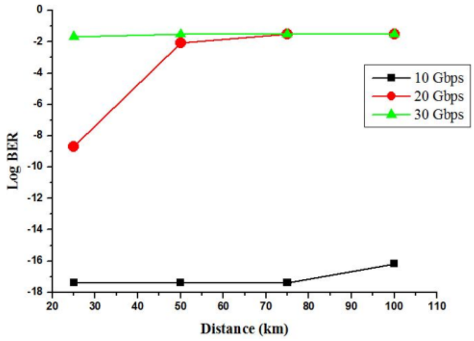


Figure 5: Variation of Log BER with distance for dual arm MZM

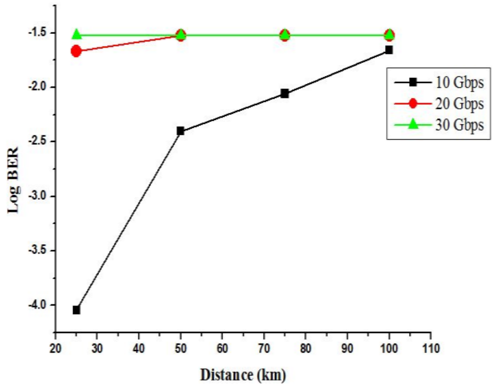


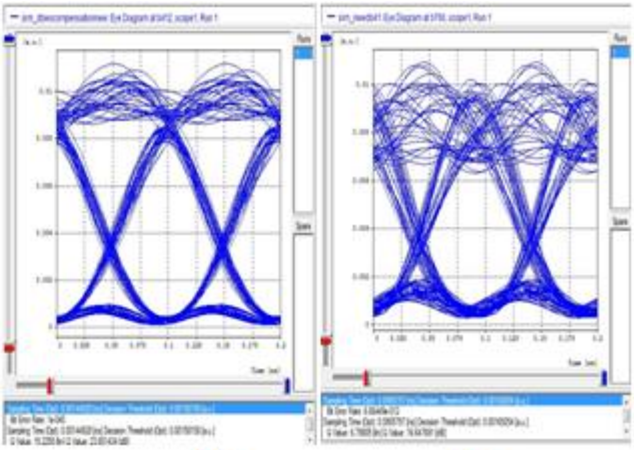
Figure 6: Variation of Log BER with distance for single arm MZM

In duobinary transmission system, dual arm MZM provides low BER values compared to single arm MZM. Also from the graphs it is clear that, as the distance increases Q Factor decreases and BER increases.

3.3 Eye Diagram Analysis

3.3.1 At 10 Gbps for 25 km

Figure 7 (a) and (b) shows the eye diagrams of duobinary transmission systems using dual arm MZM and single arm MZM respectively at 10 Gbps for 25 km.

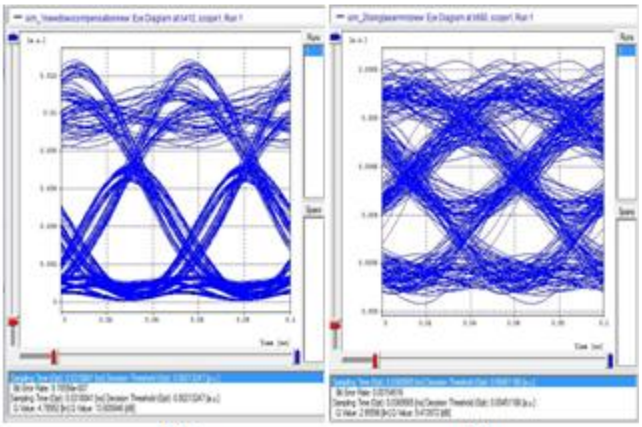


(a) (b)

Figure 7: Eye diagrams of duobinary transmission systems based on (a) dual arm MZM (b) single arm MZM at 10 Gbps

3.3.2 At 20 Gbps for 25 km

Eye diagram of duobinary transmission systems using dual arm MZM and single arm MZM at 20 Gbps for 25 km are shown in Figure 8 (a) and (b) respectively.

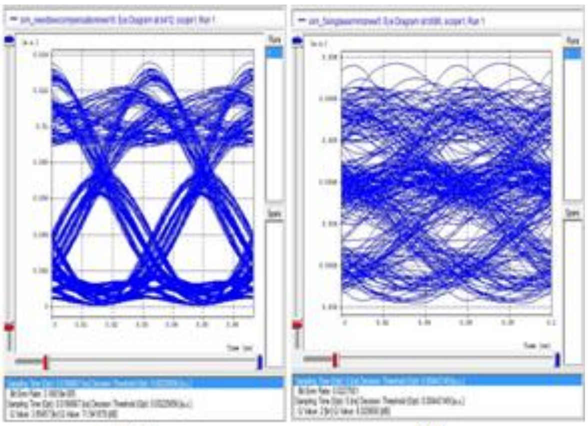


(a) (b)

Figure 8: Eye diagrams of duobinary transmission systems based on (a) dual arm MZM (b) single arm MZM at 20 Gbps

3.3.3 At 30 Gbps for 25 km

Figure 9 (a) and (b) shows the eye diagrams of duobinary transmission systems using dual arm MZM and single arm MZM respectively at 30 Gbps for 25 km.



(a) (b)

Figure 9: Eye diagrams of duobinary transmission systems based on (a) dual arm MZM (b) single arm MZM at 30 Gbps

From the above eye diagrams it is clear that the eye openings of duobinary transmission systems based on dual arm MZM is higher than that of single arm MZM based transmission systems.

4. Conclusion

Optical duobinary signal can be generated by using either a dual arm MZM or a single arm MZM. From the analysis ,it is observed that the transmission setup based on single arm MZM is less complex and it avoids all symmetry requirements. But it is suitable only for low bit rates. At high bit rates and for long distances, dual arm MZM is preferred due to its high Q Factor, low BER and large eye openings.

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