DATA FORMAT CONVERSIONS USING SINGLE SOA AT 10 GB/S

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Abstract: *This paper described the simulation demonstration of an all optical data format conversion scheme between nonreturn to zero (NRZ) to return to zero (RZ) that employs a Mach-Zehnder (MZ) Interferometer For the first time, I have proposed MZ-Interferometer using a single SOA for data format conversion from NRZ to RZ.*

Keywords: *Data Formats, Mach-Zehnder Interferometer (MZI), NRZ, RZ.*

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I. INTRODUCTION

Future all optical networks are likely to employ both wavelength-division multiplexing (WDM) and optical-time-division multiplexing (OTDM) techniques. Optical TDM (OTDM), a scheme that can increase the bit rate of a single optical carrier to values above 1Tb/s. A key feature of WDM is that the discrete wavelengths from an orthogonal set of carriers that can be separated, routed, and switched without interfering with each other. Transmultiplexing or interconversion [1] between wavelength-division multiplexing (WDM) and optical-time-division multiplexing (OTDM) may become an important operation for future optical networks [2]. All wavelength-division multiplexed (WDM) and optical-time-division multiplexed (OTDM) networks are required to support a variety of data formats. The extensively used two data formats in these networks are nonreturn-to-zero (NRZ) and return-to-zero (RZ). NRZ is preferred in WDM networks for its ease of implementation, relatively high spectral efficiency and timing-jitter tolerance. Although RZ format requires twice the NRZ transmission bandwidth, it is quite useful in applications including passive time-division multiplexing and demultiplexing due to its tolerance to fiber nonlinearities in spite of dispersion-induced effects. There will be a need for all-optical data format conversion between WDM and OTDM signals [3]. It has been stated that fully functional WDM networks should have the capability of all-optical format conversion between RZ and NRZ format [4]. Therefore data format conversions are likely to be used for all future al optical networks in order to add the flexibility to the optical networks. Especially, all the optical data format converters between NRZ and RZ is an essential function in interfacing metro/access and optical core networks [5]. Figure 1 shows an optical network that includes both metro network and core network. Access/Metro networks transport data to (and from) individual users. An access network is that part of a communications system which connects subscribers to their immediate service provider. In the access/metro networks the transmission distance is only from few meters to few hundred kilometers. Therefore the preferred data format for the access/metro networks is low cost NRZ. Whereas a core network (or network core) is the central part of a telecom network that provides various services to customers who are connected by the access network as shown in figure 1. Therefore in the core network the data rate is very much high so we can transmit a very high speed OTDM signals such as 40Gb/s to 120Gb/s. So the preferred data format is RZ. From the access nodes to the all-optical transport layers, the OTDM system with the RZ data format has been suggested to increase the total transmission capacity over 40 Gb/s by using the bit-interleaving technique. For this high-speed OTDM transmission, the RZ format is preferred due to its robustness to the nonlinear effect in spite of the dispersion-induced effect.

Therefore, format conversion between NRZ and RZ data formats is an essential function in linking and interfacing the ultrafast OTDM networks and the low-speed access networks. Therefore we required a data format conversion that converts the NRZ signals in access/metro networks to RZ signals in core networks and vice-versa. Up to now, no data format converter between NRZ and RZ has been demonstrated using single SOA. In this paper I experimentally demonstrated 10Gb/s data format conversion between NRZ and RZ using physical Mach-Zehnder Interferometer with various delays in the interferometer and which is compared with physical MZ-Interferometer based on single SOA.

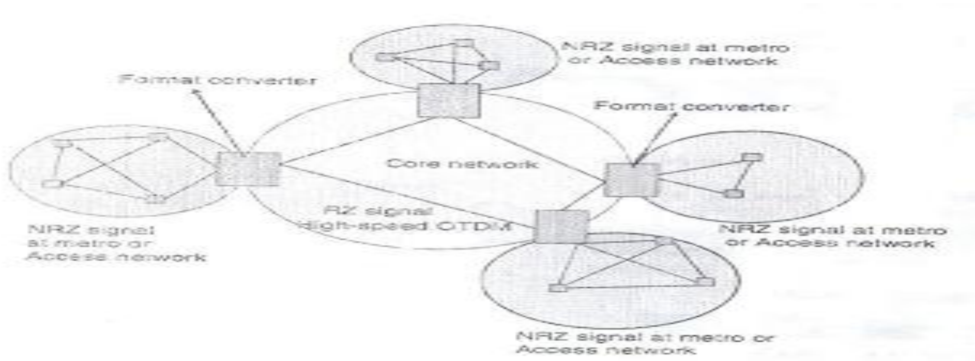


Figure 1: Data Format Converters at the interface between access/metro network and core network

II. DATA FORMAT CONVERSION USING MZ-INTERFEROMETER

Figure 2 shows the principle of data format conversion from NRZ-RZ based on Mach-Zehnder (MZ) Interferometer. We can see that consecutive ones in the symbol sequence alternate between two phase levels to provide the converted RZ signal. The input signal directly goes to the output coupler without any delay whereas the signal in the lower arm is delayed and combined with the un-delayed signal to provide the RZ signal. In principle, any duty cycle of RZ signal can be generated by choosing the proper delay between two arms using Mach-Zehnder (MZ) Interferometer, however the pulse width or duty cycle is limited by the rise and fall time of the data [6].

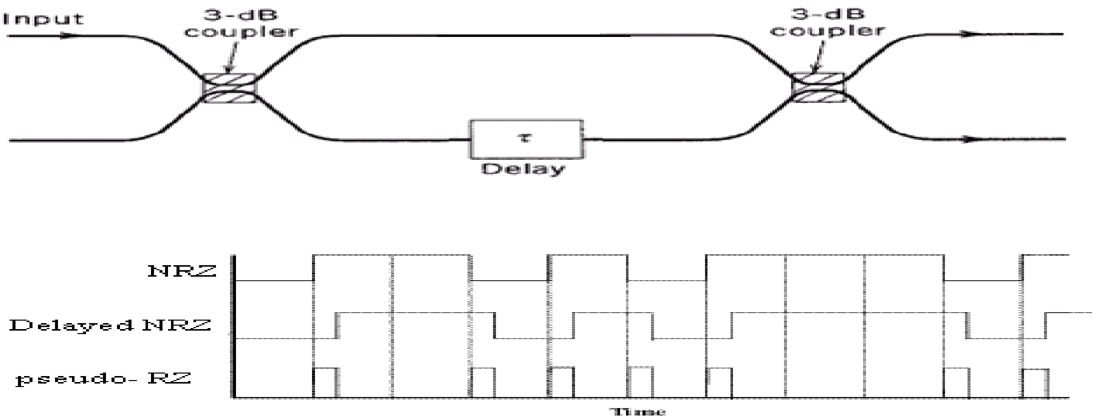


Figure 2: The Principle of Data Format Conversion Using MZ-Interferometer

Figure 3 shows the experimental set up for the data format conversion from NRZ-RZ. A continuous wave (CW) laser wavelength is 1558.2nm. A binary 10Gb/s NRZ electrical source is placed at the input. The generated 10Gb/s NRZ is modulated using MZ modulator before it is applied to the Mach-Zehnder (MZ) Interferometer. The input power set in the CW laser is -3dBm. Then I use a MZ interferometer to realize the data format conversion. The time delays set between the two arms in the MZ Interferometer are 3,5,10,15,20,25,30,35,40,45,50,55 and 60psec.

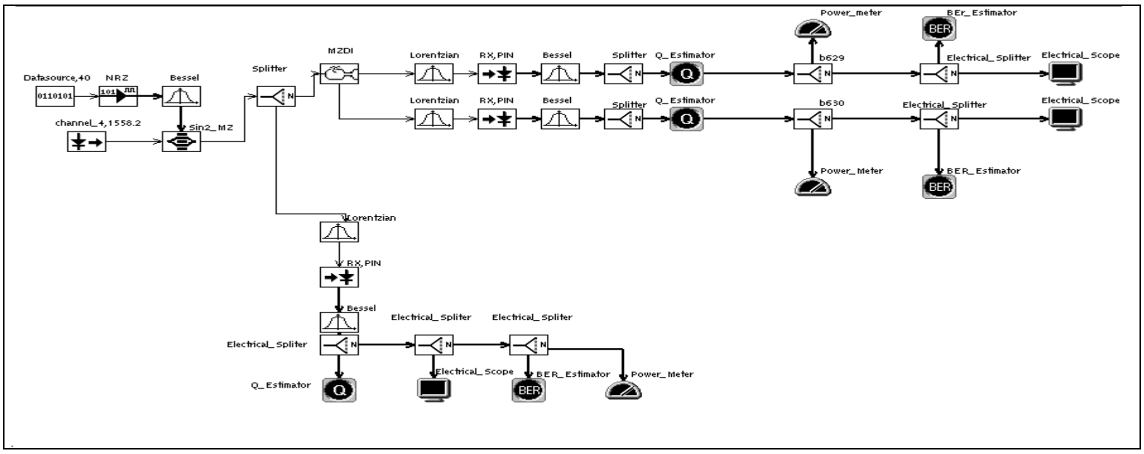
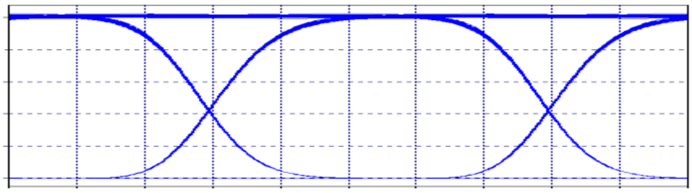


Figure 3: Experimental Setup

Figure 4 the eye diagrams of input and output signals at various time delays between two arms of the MZ-Interferometer are shown in figure 4. The eye diagrams are observed with 10 Gb/s oscilloscope. As shown in figure 4, the smaller the time delay between the two arms of the MZ-Interferometer, the smaller the duty cycle and the wider spectrum. Because for the 10 Gb/s the rise time and the fall time of the signal are 50 psec, the shortest pulse width of the optical signal is approximately 50 psec. Therefore, as the time delay between the two arms is greater than 50 psec the duty cycle of the converted RZ signal is improved [6].



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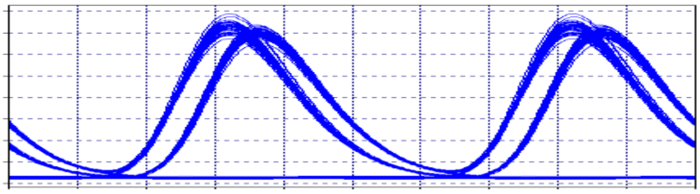

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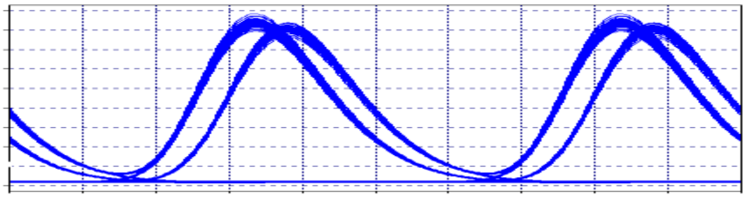

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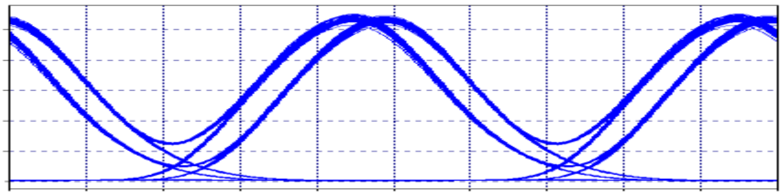


(d)

Figure 4: Measured Eye Diagram at Input and Output Signals at 10Gb/s (a) Input Signal (b) 20psec (c) 25psec (d) 60psec

III. DATA FORMAT CONVERSION USING MZ-INTERFEROMETER

In this section, ideal MZ-Interferometer is designed by using a single SOA at 10 Gb/s for NRZ to RZ data format conversion. The MZ-Interferometer is an ideal component which provides the delayed in the output signals according to the time delay in the lower arm of the interferometer as described in previous sections. In this section, the MZ-Interferometer is physically implemented using a single SOA to provide the same outputs as obtained with MZ-Interferometer.

The proposed model of this converter is shown in figure 5. For the conversion from NRZ-RZ, the local RZ pulse train is applied to the input port whereas the NRZ data signal which is to be converted is applied to the control port as shown in figure 5 [7]. The parameter of the SOA is so adjusted so that it would be able to generate some delay (phase shift) in the lower arm of the interferometer.

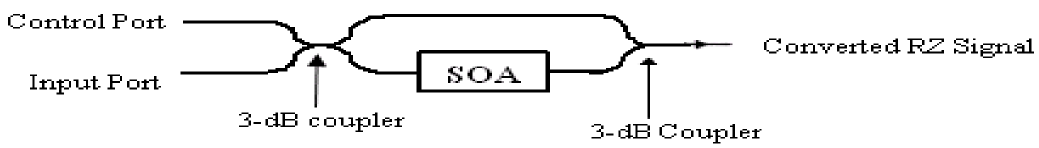
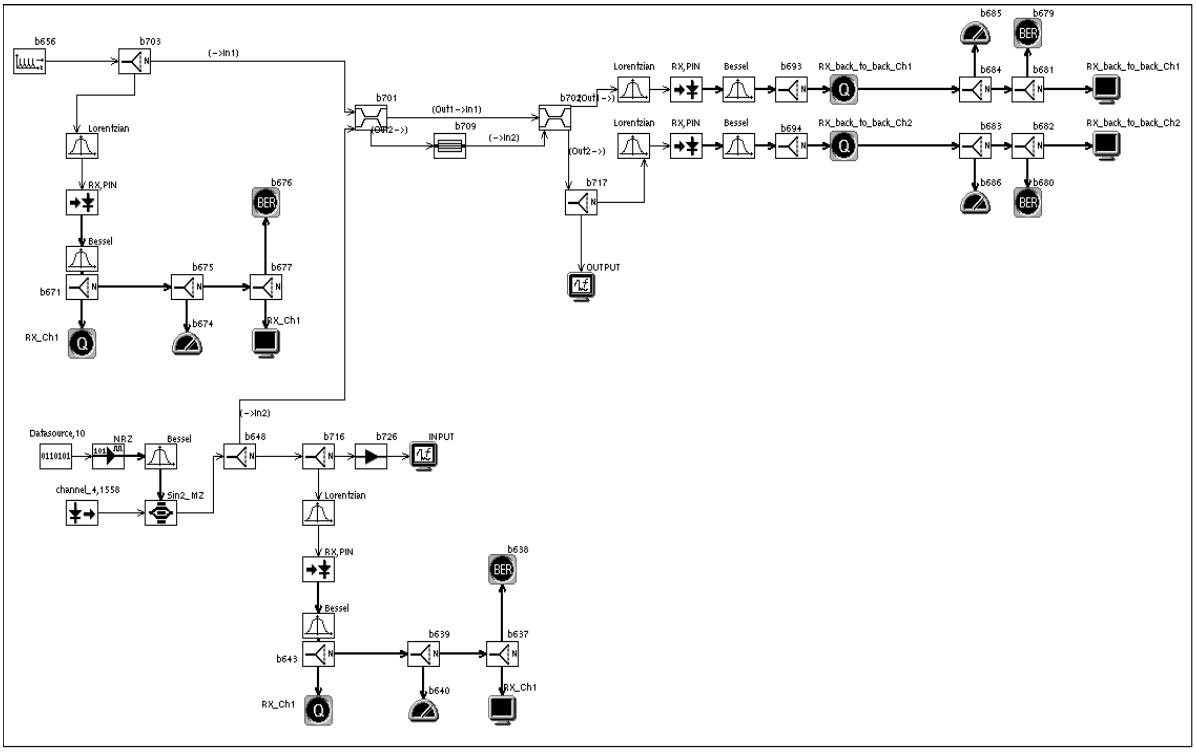


Figure 5: Single SOA Based MZ-Interferometer for NRZ to RZ Conversion

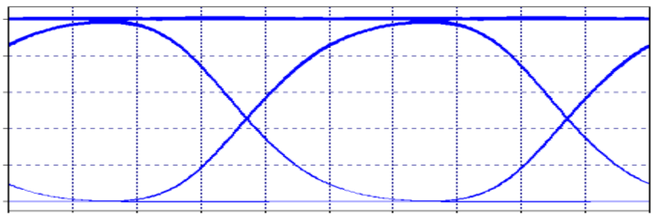
The simulation setup for single SOA based NRZ –RZ data format converter at 10 Gb/s is shown in the figure 6. A continuous wave (CW) Lorentzian Laser wavelength is 1555 nm. Which has a FWHM (Full Width Half Maximum) of 1 MHz and power of -3 dBm. A binary 10 Gb/s NRZ (Non-Return-to Zero) electrical signal is generated by data source at the input with pseudo-random sequence degree of 10. The generated electrical signal is then applied to the Bessel low pass filter (Number of poles are 2 and -3dB bandwidth of 20 GHZ).The filtered electrical pulses from the data source are modulated with the laser using Mach-Zehnder (MZ) Modulator which has Sin^2 electrical shaped Input-Output P-V characteristic (-3dB bandwidth of 20 GHZ). The clock RZ pulses are generated by the pulse generator. The wavelength of the RZ clock is 1558 nm. The RZ clock is raised cosine with round off of 0.5. The RZ clock and NRZ input signal are applied to the 3-dB coupler where at the output of the coupler, the signal in the upper arm is directly applied to the output coupler. Whereas signal in the lower arm is pass through a SOA.



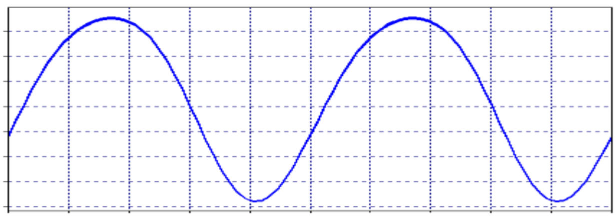
Unit: SOA-1-10

Figure 6: Simulation Setup for Single SOA based Data Format Converter at 10 Gb/s

The eye diagrams of input signal NRZ, clock signal RZ and output signal are shown in figure 7, when the wavelength of the input NRZ signal is 1555 nm. As shown in figure 7, the NRZ signal is converted in the RZ signal.



(a)



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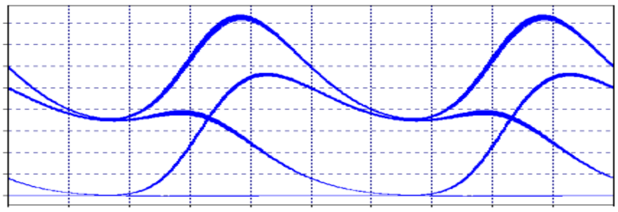

(c)

Figure 7: Eye diagrams at 10 Gb/s (a) input signal NRZ and (b) clock signal (c) converted output RZ signal

IV. CONCLUSION

I have proposed a 10Gb/s data format conversion between NRZ and RZ signals and successfully demonstrated for the first time using single SOA as MZ-Interferometer. The converted RZ signal using physical MZ-Interferometer with single SOA has improved quality of the converted signal as compared to the ideal MZ-Interferometer. Also, due to the SOA as delay element the signal after passing through the SOA is amplified. Hence the received power is more than the ideal MZ-Interferometer. Therefore, the designed physical interferometer using single SOA based NRZ-RZ data format converter at 10 Gb/s has provided the best results as compared to the MZ-Interferometer at 10 Gb/s.

V. REFERENCES

[1] J. P. R. Lacey, M. V. Chan, R. S. Tucker, A. J. Lowery, and M. A. Summerfield, "All-optical WDM to TDM transmultiplexer," *Electron. Lett.*, vol. 30, pp. 1612–1613, 1994.

[2] Sang-Gyu Park, L. H. Spiekman, M. Eiselt, andJ. M. Wiesenfeld," Chirp Consequences of All-Optical RZ to NRZ Conversion Using Cross-Phase Modulation in an Active Semiconductor Photonic Integrated Circuit," IEEE Photonics Lett., vol. 12, No. 3,pp. 233-235, 2000.

[3] D. Norte, E. Park, and A. E. Willner, "All-optical TDM-to-WDM data format conversion in a dynamically reconfigurable WDM network," *IEEE Photon. Technol. Lett.*, vol. 7, no. 8, pp. 920–922, Aug. 1995.

[4] D. Norte and A. E. Willner, "Experimental demonstrations of all-optical conversion between RZ and NRZ data formats incorporating noninverting wavelength shifting leading to format transparency," *IEEE Photon. Technol. Lett.*, vol. 8, no. 5, pp. 712–714, May 1996.

[5] Jianjun Yu, Gee Kung Chang, John Barry, Yikai Su, " 40 Gb/s signal format from NRZ to RZ using a Mach-Zehnder delay interferometer," *optics communication science direct*, vol. 248 (2005), pp. 419-422.

[6] Jianjun Yu," Generation of Modified Duobinary RZ Signals by Using One Single Dual-Arm LiNbO3 Modulator," *IEEE Photon Technology letters*, vol. 15,no. 10, Oct. 2003.

[7] L. Xu, V. Baby, I. Glesk, and P. R. Prucnal, "All-optical data format conversion between RZ and NRZ based on aMach–Zehnder interferometric wavelength converter," *IEEE Photon. Technol. Lett.*, vol. 15, no. 2, pp. 308–310, Feb. 2003.