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All-Optical NRZ-to-PRZ Converter Based on Cascaded Long-Period Fiber Gratings

Sie-Wook Jeon[1], Tae-Young Kim[1], Masanori Hanawa[2], Youngjoo Chung[1], Chang-Soo Park[1]
[1]Department of Information and Communications, Gwangju Institute of Science and Technology, 1 Oryong-dong, Buk-Gu, Gwangju, 500-712, Republic of Korea,
[2]University of Yamanashi, 4-3-11 Takeda, Kofu, Yamanashi 400-8511, Japan,
Tel/Fax: +82-62-970-2218, E-mail: csp@gist.ac.kr

ABSTRACT

We propose an all-optical NRZ-to-PRZ converter based on the cascaded long-period fiber gratings to enhance the clock component for clock signal extraction. By using the proposed converter, clock-to-modulation component ratio was improved about 48 dB.

I. INTRODUCTION

In fiber-optic systems, the clock extraction is essential for jitter reduction of the electrically converted signal. In conventional fiber-optic systems, the non return-to-zero (NRZ) data format has been used to decrease the bandwidth occupied by the modulation signal, however, this has a difficulty in extracting clock components because the clock-to-modulation component ratio (CMR) of the NRZ signal is quite low. Thereby, this NRZ signal has been converted to the pseudo-return-to-zero (PRZ) signal, which can give a better CMR due to its RZ-like pattern.

All optical NRZ-to-PRZ conversion, in this respect, has been attractive to the high speed optical communication over 40-Gb/s. Among the previous methods [1-3], the method based on π-phase shifted fiber Bragg grating (π-PSFBG) [3] is most likely in terms that it can be implemented more compactly and insensitive to the environmental perturbation. Only drawback comes from the noise caused by the multiple reflections between two gratings as a reward of low insertion loss.

In this paper, we propose a novel all-optical NRZ-to-PRZ converter based on the cascaded long period fiber gratings (LPGs), which can be implemented as a transmitted form and, as a result, free from multiple reflections. Also, this method is more useful for very high speed modulation because it basically uses precise time delay due to the index difference between the core and cladding modes and is insensitive to the environmental perturbation because the coupled mode to the cladding undergoes the same perturbation with the core mode along the fiber [4].

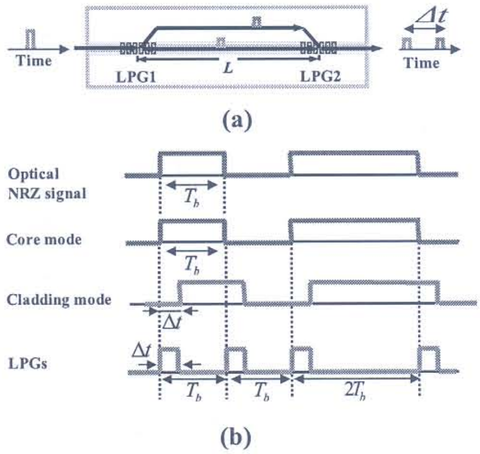

Fig.1. (a) Schematic diagram of all optical NRZ-to-PRZ converter based CLPG and (b) Principle of NRZ-to-PRZ conversion. Δt :pulse width of PRZ, T_b :bit period of NRZ

II. PRINCIPLE

The schematic diagram of the proposed NRZ-to-PRZ converter is depicted in Fig. 1. The converter consists of two cascaded LPGs apart from each other with the fiber length corresponding to the time delay required. This could be relatively long and, instead, it has an advantage of spatial margin to accurately implement very small time delay. When the NRZ signal propagating along the core mode meets the first LPG (LPG1), then the signal is split into two: one for core mode and the other for cladding mode undergoing different propagation velocities from the index difference. At the second LPG (LPG2), they are combined and again split into two, core and cladding modes, acting as an optical delay interferometer with the precise time delay [4]. This time delay is given by the difference between the arrival times at LPG2 due to the different refractive indices of the core and cladding modes. Furthermore, if one of the two NRZ signals propagating between the two LPGs is controlled to have π phase difference to the other, then the output after LPG2 will show a PRZ pattern due to interference. The time delay, which decides the pulse width of the PRZ signal, is given by

$$\Delta t = \frac{L}{c} \Delta m_{eff} ,$$

where Δm_{eff} is the differential effective group index (DEGI) between two modes and L is the center to center separation between the gratings. The time delay should be less than one bit period [4].

III. EXPERIMENT AND RESULTS

The experimental setup is shown in Fig. 2. The output of the tunable laser source was modulated with a 10-Gb/s pseudo random binary sequence of length of 2^{31}-1 using a LiNbO3 modulator. LPG2 was spliced to LPG1 to have a separation of 2-m between the gratings, corresponding to 50-ps time delay which was chosen considering the bit rate and the rising and falling time of the NRZ signal. Then, the modulated NRZ signal was sent to the cascaded LPGs for NRZ-to-PRZ conversion. After LPG2, the PRZ signal was detected by a photodetector (PD) and measured by an electrical spectrum analyzer and a sampling scope.

The inset of Fig. 2 shows the interference fringe of the cascaded LPGs. The fringe spacing was measured about 0.16 nm appropriate for the time delay of 50-ps. Fig. 3 (a) and (b) show the waveforms of the NRZ signal and the PRZ signal extracted at the leading and trailing edges of the NRZ signal. The insets of Fig. 3 (a) and (b) show the corresponding eye diagrams. The RF spectra of the NRZ and PRZ signals are shown in Fig. 3 (c) and (d). The NRZ signal showed a low CMR of -10 dB. On the other hand, the PRZ signal extracted from the proposed method had a large CMR of 38 dB, showing an enhancement of about 48 dB.

IV. CONCLUSION

We have proposed an all-optical NRZ-to-PRZ converter based on the cascaded long-period fiber gratings to extract clock components from the NRZ signal. Its performance was experimentally demonstrated for 10-Gb/s NRZ system. The clock component was drastically enhanced about 48 dB in CMR using the proposed converter with 50-ps delay.

ACKNOWLEDGEMENT

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REFERENCES

[1] H. J. Lee, et al., Elec. Lett, 35, pp. 989–990 (1999).
[2] H. K. Lee, et al., Elec. Lett, 34, pp.478-480 (1998).
[3] M. Hanawa, et al., OECC 05, pp.820-821 (2005).
[4] T. J. Eom, et al., JLT, 23, pp.597-608 (2005).

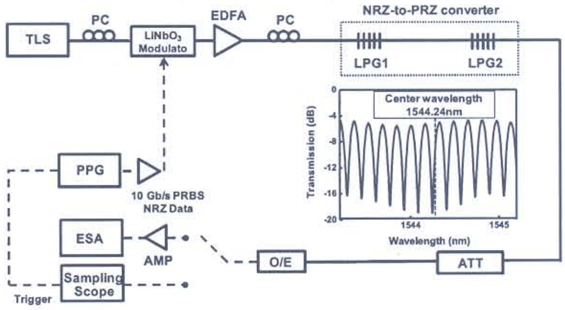

Fig. 2. Measured optical spectrum and experiment setup. TLS: tunable laser source, PC: polarization controller, EDFA: erbium-doped fiber amplifier, PPG: pulse pattern generator, ESA: electrical spectrum analyzer, O/E: optical receiver, AMP: low noise electrical amplifier.

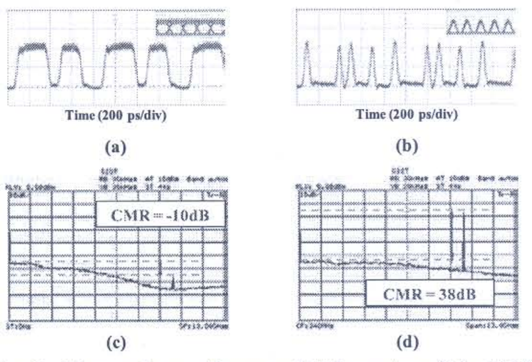

Fig. 3. Measured waveforms and RF spectra of the NRZ and PRZ signals: (a) and (b) Waveforms for '11101100' pattern, (c) and (d) RF spectra for the NRZ and PRZ signals, respectively