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IMPROVEMENT OF A PHASE MARGIN IN OPTICAL RZ RECEIVER USING KERR NONLINEARITY IN NORMAL DISPERSION FIBERS : EXPERIMENTAL VERIFICATION

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Abstract: We propose a new technique to improve a phase margin in an optical RZ receiver using Kerr nonlinearity in normal dispersion fibers. Experiment was made to show the effectiveness of the proposed method.

Introduction

In optical fiber communication systems using RZ pulse format, detected amplitude of each RZ signal decreases when detection time differs from the pulse peak. Thus, displacement of pulse position at receiver caused by timing jitter causes the bit error. An electrical Bessel-Thompson low-pass filter is normally employed after direct detection, which expands the pulse width and therefore reduces the influence of the displacement of pulse position/1/. This technique seems suitable, but there exists trade-off between the cut off frequency of the filter and the intersymbol interference. In this paper, we propose a new technique to reduce the influence of timing jitter without increasing the intersymbol interference by utilizing Kerr nonlinearity in normal dispersion fibers. We experimentally show the effectiveness of the proposed method by adopting it to 10 Gbit/s sliding frequency soliton transmission.

Principle of phase margin improvement

It is well known that when an optical pulse propagates along normal dispersion fibers with Kerr effect, its temporal waveform changes to a rectangular-like profile with steep leading and trailing edges as shown in Figure 1/2,3/. By utilizing this property, the phase margin at the optical RZ receiver can be expanded.

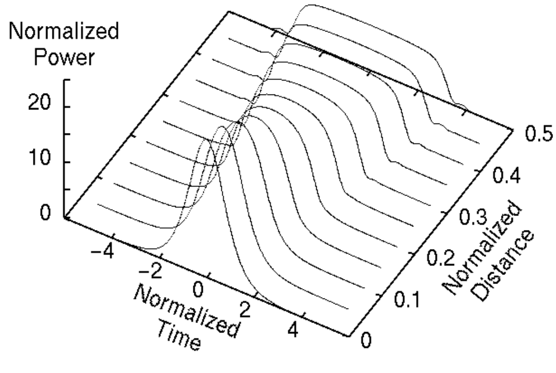

Figure 1: Pulse shapes propagating along normal dispersion fiber with Kerr nonlinearity.

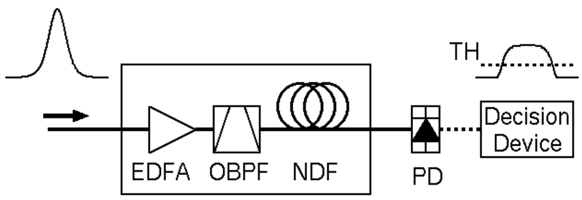

Figure 2: Schematic diagram of the setup for phase margin improvement.

Figure 2 shows the schematic diagram of the setup. The system is constructed by an erbium-doped fiber amplifier (EDFA), an optical bandpass filter (OBPF) which removes the amplified spontaneous emission (ASE) noise, and normal dispersion fiber (NDF). When this technique is used in a soliton transmission system, Gordon-Haus timing jitter accumulated in transmission fiber with anomalous dispersion can also be decreased/4/. This technique, however, requires wider frequency bandwidth for detection compared to typical optical RZ receivers because the pulse spectrum also spreads out. This brings the decrease of signal to noise ratio in the detected electrical signals. Therefore, the proposed method may be effective in a jitter-limited transmission system.

Experiment

We carried out 10 Gbit/s soliton transmission experiment in a sliding frequency recirculating loop to verify the effectiveness of the proposed method. The setup for the loop transmission is described in Reference /5/ in detail.

Figure 3 shows the eye diagrams of the transmitted pulses over 16,000 km detected (a) without Bessel-Thompson filter, (b) with a Bessel Thompson filter with 7.5 GHz bandwidth,

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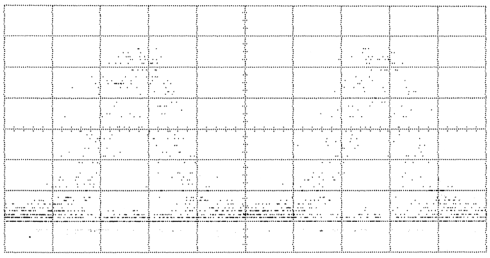
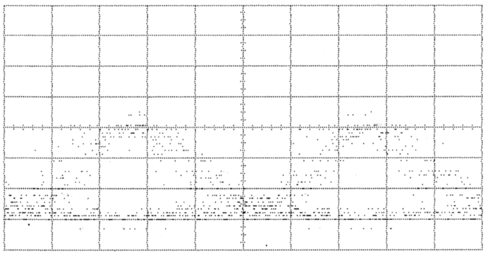
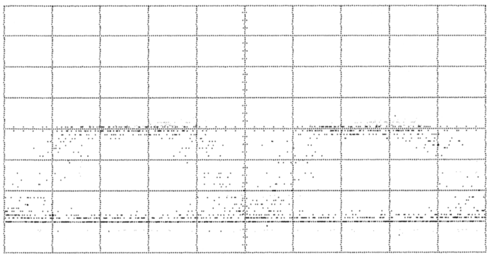


(a) Without Bessel-Thompson filter



(b) With 7.5GHz Bessel-Thompson filter



(c) With the proposed method

Figure 3: Eye diagrams of the transmitted 10 Gbit/s soliton in a sliding frequency recirculating loop over 16,000 km (20 ps/div).

and (c) with the proposed method, respectively. We kept the average optical power to the photodiode equal for each case. We can see in Figure 3(b) that the pulse is broadened by the Bessel-Thompson filter as in normal optical RZ receivers. In Figure 3 (c), we used 20-km NDF with the group velocity dispersion of -3 ps/nm/km. The averaged launched power to the NDF was 18.8 dBm. By utilizing nonlinearity in the NDF, the waveform of the pulses is changed to rectangular-like as seen in Figure 3 (c). The eye opening detected with the proposed method is wider than that detected with the Bessel-Thompson filter.

Next, we measured threshold voltage and detection time of bit error rate (BER) detector where BER is below 10^{-7}. The electrical bandwidth of the BER detection scheme was 15 GHz. Figure 4 shows the result. The phase margin detected with the proposed method is wider than the others. In addition, the margin of threshold voltage is also improved.

Conclusion

We proposed a new technique to improve the phase margin in optical RZ receiver using Kerr nonlinearity in normal dispersion fibers. By utilizing the proposed method to 10 Gbit/s sliding frequency soliton transmission, we confirmed

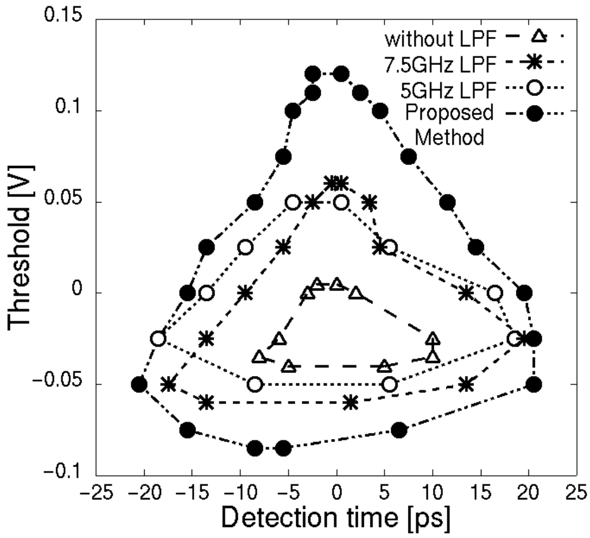


Figure 4: Measured threshold and detection time of BER detector where BER is below 10^{-7}.

the effectiveness of the proposed method to improve the receiver characteristics.

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