Prior-based Line-coding for WDM RZ Systems

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Abstract: We propose a block line-coding scheme that uses prior information about the distortion mechanism for reducing timing jitter in WDM return-to-zero (RZ) systems, and we demonstrate its effectiveness using simulations.

OCIS codes: (060.2330) Fiber optics communications; (060.4510) Optical communications

Collision-induced timing jitter due to interchannel cross-phase modulation is one of the major impairments limiting the performance of WDM RZ systems [1]. In this paper, we introduce a prior-based line code (PBLC) that allows us to mitigate the timing jitter in WDM RZ systems by using prior information on the dependence of the collision-induced timing shift of a pulse on the particular pattern of bits in the adjacent channels. Simulation results verify the effectiveness of this PBLC.

Collision-induced timing jitter is a bit-pattern-dependent phenomenon, meaning that the timing shifts of pulses in a given channel depend on the bit patterns in the neighboring channels [3]–[5]. The basic idea of our code is to reduce the occurrence of patterns that increase the timing jitter by inserting redundant bits. We choose a target pulse in the center channel (Ch. 2) and compute its timing shift [4] after interaction with one pulse located initially in i-th bit of the adjacent channel (Ch. 1), which is denoted by G_{1i} and shown in Fig. 1. The timing shift contribution of a single

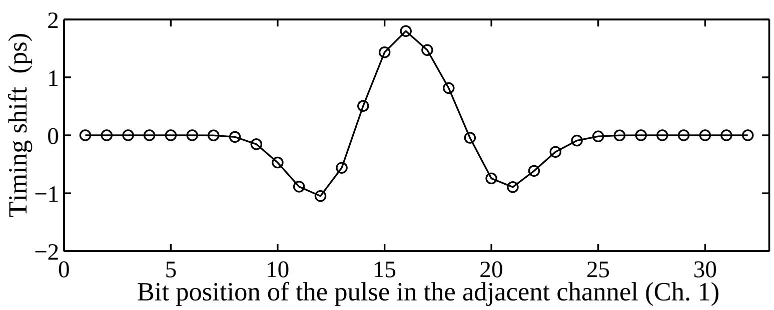

Figure 1. Timing shift G_{1i} of the target pulse in the center channel (Ch. 2) induced by interaction with a pulse in bit position i in one of the adjacent channels (Ch. 1). The target pulse is at bit 16. The propagation distance of the WDM RZ system is 5000 km, the amplifier spacing 50 km, the channel spacing 35GHz and bit rate 10GB/s.

codeword is measured by the summation of the G_{1i} values for the marks. Since we focused on the nonlinear penalty, we did not consider noise, and only the adjacent channels are considered since their contribution is the largest [5].

We use an (n,k) block code with 2^k distinct codewords of length n. We remove $2^n - 2^k$ codewords that lead to large timing shifts and keep the remaining 2^k as PBLC codewords. Note that besides removing the codewords whose timing shift contribution is large, we also have to avoid the occurrence of “undesirable” codewords that arise by concatenating two “desirable” codewords.

We construct a (14,12) PBLC using the timing shift function given in Fig. 1. In order to compensate for redundancy, we increase the bit rate for the PBLC-encoded signal and keep the average power the same. For the two outer channels, we generate random bit sequences and compute the timing shift for each bit of the center channel by summing over bits from each of the adjacent channels. We fit a Gaussian curve to the histogram of the timing shift and use a signal receiving window of width T_r to approximate the bit error rate (BER) [2]. If the timing shift exceeds $T_r/2$, we count an error. In Fig. 2, we show the distributions of the timing shifts for the cases when we use the (14,12) PBLC, and when no coding is used. The reduction of the standard deviation of the timing shift that we reach by using PBLC is more than 20%, while the improvement in the BER is more than one order of magnitude.

In conclusion, PBLC can effectively decrease timing-jitter-induced bit errors, and it can be practically concatenated as an inner code with other forward error correction (FEC) codes, such as a Reed-Solomon (RS) code [2].

References

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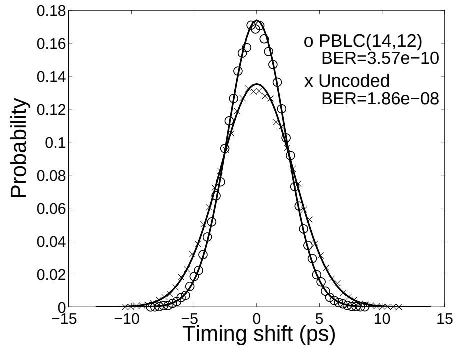

Figure 2. The timing shift distributions and BER of uncoded and (14,12) PBLC encoded data sequences. Symbols represent histograms, and solid lines the Gaussian fits. The bit rate is 11.67 Gb/s for the PBLC-encoded signal and 10 Gb/s for the uncoded signal, and T_r is chosen as 24 ps and 20.6 ps, respectively. Three WDM channels are used and 50,000 bits are sent in each channel.

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