Novel Intersymbol Interference Reduction Technique by Bit Synchronized π/2 Phase Shift

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1. Introduction:

Current systems working with return-to-zero (RZ) signal transmission have problems with symbol interference of neighboring bits. Bit synchronized π phase shift has been proposed to reduce intersymbol interference (ISI) [1]. On the other hand, compared to π phase shift, $\pi/2$ phase shift can greatly reduce any interference between neighboring bits. In this paper, bit synchronized $\pi/2$ phase shift is proposed and numerically demonstrated to greatly reduce ISI, and to extend the transmission length.

2. System Description:

To simulate the transmission behavior, a transmission system at 40 Gbit/s with a duty cycle of 0.5 is investigated with 60-km long spans consisting of a single mode fiber (SMF), EDFA, gaussian filter, dispersion compensating fiber (DCF), EDFA and gaussian filter in succession [2]. Fiber properties are shown in Table 1. To show the effect of ISI alone, ASE noise is not included.

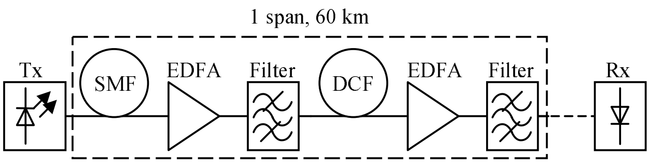

Fig. 1 Block diagram of system configuration.

Table 1: System parameters

System Parameters	SMF	DCF
Fiber length L / km	50	10
Dispersion D / (ps/km/nm)	16	-80
Disp. Slope dD/dλ / (ps/km/nm^2)	0.08	0.08
Loss α / (dB/km)	0.2	0.5
Nonlinear coefficient γ / (1/W/km)	1.31	5.24
Gain G of following EDFA / dB	10.1	5.1
Filter bandwidth of the filters / nm	0.85	0.85

3. Simulation and Results:

In order to examine ISI, transmission of the bit sequences (101) and (111) is simulated: For these two bit sequences, we compare the interference of the pulses at the central bit for RZ-modulation, π, and $\pi/2$ phase shift:

Figs. 2a) – 2c) show the simulation results of a (101) bit sequence transmission over 600 km. As shown in Figs. 2a) and 2b) for RZ-modulation and π phase shift, the phases of the two outer bits are equal, and their amplitudes at the central bit add up linearly. In $\pi/2$ phase shift, the phases of the two outer bits differ by π, and so the amplitudes reduce as shown in Fig. 2c). As long as pulse broadening is mainly caused by dispersion, the amplitudes at the central bit are almost the same and cancel nearly totally at this point.

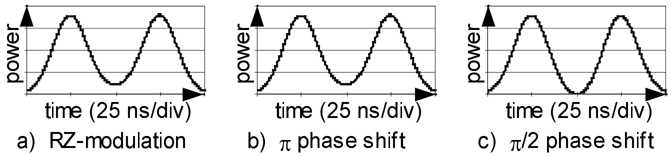

Fig. 2 Bit sequence of (101) after 600 km transmission.

Figs. 3a) – 3c) show the simulation results of the (111) bit sequence transmission. As shown in Fig. 3a), the outer bits increase the central bit height, if their phases are both equal (RZ-modulation). All pulses merge into one big pulse with a very high amplitude. As shown in Fig. 3b), in π phase shift, the outer pulses reduce together the amplitude of the central pulse. As shown in Fig. 3c), with a $\pi/2$ phase shift, the amplitudes of neighboring bits add up like two perpendicular vectors. As long as the amplitudes of the disturbing bits at the position of the central bit are small, the amplitude of the central bit does not change much. For example: Even if the amplitude of the interfering bit at the position of the central bit is half of the actual bit height, this bit changes its amplitude only by a factor of 1.12.

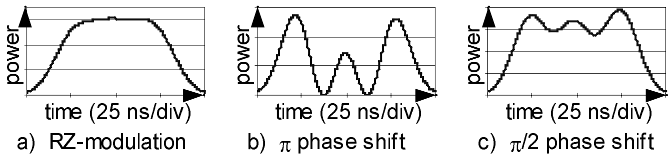

Fig. 3 Bit sequence of (111) after 600 km transmission.

Figs. 4a) – 4c) show the eye diagrams of 32 bit transmission over 600 km for RZ-modulation, π, and $\pi/2$ phase shifting. These results show that $\pi/2$ phase shift leads to a much wider opening in the eye diagram.

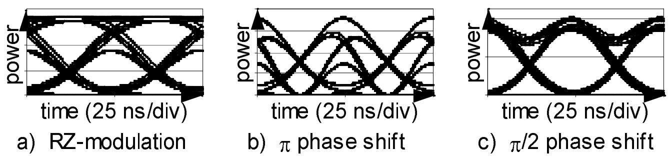

Fig. 4 Eye diagram after 600 km transmission.

4. Conclusion:

ISI can be reduced dramatically by shifting the carrier phases of each following bit by $\pi/2$.

Reference:

[1] D. Penninckx, et al. , IEEE Photonics Technol. Lett. pp. 259 – 261, vol. 9, no. 2, 1997.
[2] D. Breuer, et al. , IEEE Photonics Technol. Lett. pp. 398 – 400, vol. 9, no. 3, 1997.