High-speed, multichannel, variable dispersion compensation link for suppression of nonlinear distortion

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Multichannel information transmission, high transmission rate in a separate channel, and high-order coding formats improve fiber communication lines. The signal distortion's main factors are amplifier noise and nonlinear effects accompanying signal propagation through the communication line. This paper considers a combination of methods for suppressing nonlinear distortions in a communication line with zero average dispersion: the large chirping of the input pulses and variable dispersion compensation. We show that the simultaneous use of these methods significantly improves the signal quality in multichannel information transmission.

We performed a numerical calculation of signal propagation in the framework of nonlinear coupled Schrödinger equations [1] for three channels. The communication line consists of 10 sections of the type

SMF(100 км) + EDFA + $DC(i)$.

Here SMF is a standard single-mode fiber, EDFA is an erbium amplifier that fully compensated for the signal attenuation in the fiber section, $DC(i)$, the i-th compensator. We assume that the compensation is based on Bragg grating's low loss and neglect the polarization dispersion. Let us denote by d_i the amount of chromatic dispersion that the $DC(i)$ device compensates. The d_i values form an arithmetic progression with a step Δd. The sum of d_i is -17000 ps/nm, i.e. fully compensates for the 10 SMF spans' accumulated dispersion. Thus, in contrast to work [2], this design does not require a post-compensation of accumulated chromatic dispersion. The modulation format is 8QAM. Here, we use two amplitude values (0.043 $W^{1/2}$ and 0.086 $W^{1/2}$) and four-phase values for each amplitude. The information is encoded with Gaussian pulses of the form $a_n(\tau) = B_n \exp[-(\tau^2 - iC\tau^2)/2T_0^2]$, where B_n is the amplitude of the bit with number n, C is the chirp parameter, T_0 = 6 ps is the pulse width, the bit-length is 25 ps. The channels are spaced by interval 100 GHz.

Below are the constellation diagrams for the central channel at the receiver after processing to separate the channels and reduce the amplifiers' noise. Fig. 1 shows a graph for Δd = 0 and zero initial chirp. Fig. 2 shows a graph for Δd = 288.89 ps / nm of zero chirp C = 0. Fig. 3 shows a graph for Δd = 222.22 ps/nm and C = 5. We see that in the last case the symbols are most distinguishable; the achieved bit error rate is 6.8×10^{-3}.

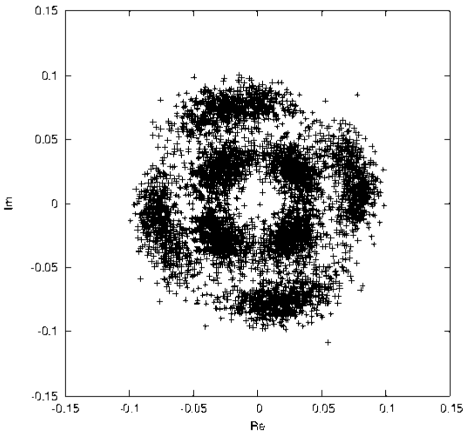

Fig. 1

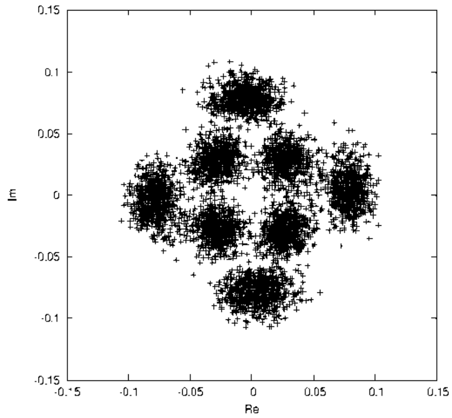

Fig. 2

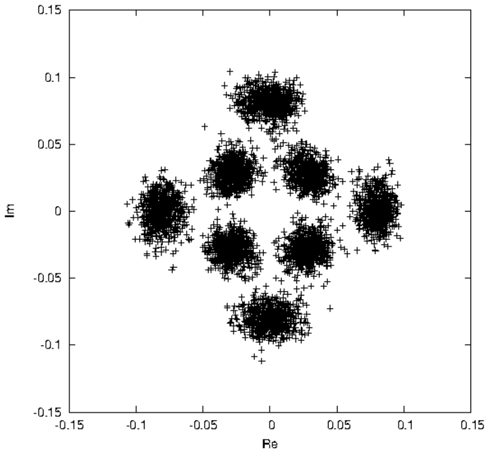

Fig. 3

Because of the strong chirp, the channels overlap the frequency domain. However, the amplitudes of Fourier components remain small, and then the interchannel interference is linear. The chirp, along with the variable dispersion compensation, also reduces the intersymbol interference in each channel.

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References

[1] G. P. Agrawal, *Nonlinear fiber optics*, Amsterdam, Elsevier, 2007
[2] E. G. Shapiro, D. A. Shapiro, *Quant. Electr.*, **50**(2) 184–186 (2020).