Continuous dual-polarization signal processing using windowed Nonlinear Fourier Transform

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***Abstract*—We present a new way to handle dual-polarization signal processing in fiber-optic networks. It combines chromatic dispersion compensation (CDC) with sliding window techniques to make processing signals more precise and effective. The nonlinear Fourier transform (NFT) is a key tool used here to manage chromatic dispersion and the Kerr effect, which are crucial for transmitting signals over long distances.**

***Index Terms*—nonlinear Fourier transform, nonlinear Schrodinger equation, Manakov equation, signal processing**

Nonlinear Fourier transform (NFT) is a powerful mathematical tool used to analyze and process signals transmitted over fiber-optic networks. A significant advantage of NFT is its ability to compute signal propagation over long distances through a three-step process: forward NFT, nonlinear spectrum evolution, and inverse NFT [1]. NFT is beneficial as it enhances the performance of optical communication systems. However, using NFT is challenging because it requires a lot of computing resources and specific hardware or software, making the systems more complicated and costlier. Despite these challenges, NFT is a promising area of research that could significantly improve how we process and transmit signals in the future. One major problem of applying NFT for Manakov equation (ME) to telecommunication systems is dealing with continuous signals. Traditional methods for signal division aren't effective enough. Our new approach combines CDC and sliding window techniques for better processing of continuous dual-polarization signals (NFT-CDC). By correcting chromatic dispersion, we reduce issues like overlapping and distortion, improving NFT's effectiveness. This method enhances accuracy, solves continuous signal processing problems, and boosts the overall performance of telecommunications systems.

Following a similar approach used for optical signal processing using neural networks [3], we propose a new method for stream processing of continuous telecommunication signals using NFT. This approach can be represented as the following sequence of steps: (a) compensation of the dispersion of the entire propagated signal without additional correction, (b) dividing the signal into many intersecting windows, in the middle of which there is a part of the signal that is reconstructed in one step, and the tails on the sides are used to take into account the influence of dispersion, (c) dispersion decompensation for a separate windowed signal, (d) processing this sub-signal in the window using NFT, (e) collecting the complete signal. To restore the entire signal, a window of size T_w symbols is used, which in one step of the algorithm restores T_{proc} symbols and then shifts along the signal by the same number of symbols.

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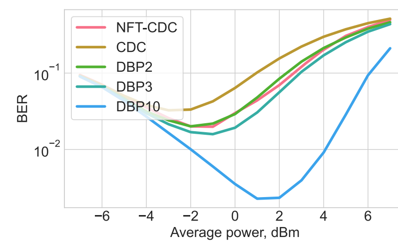

Fig. 1. The dependence of BER versus the average signal power per polarization P_0. The total window size $T_w = 2048$, with a processed symbol count $T_{proc} = 205$ and a dispersion broadening scale factor $R_d = 1.1$. The noise power equals to 4.5 dBm.

We used the methodology presented in [3], which introduced a novel dual-polarization transmission system with lower complexity. This scheme uses an independent processing (based on NLSE) for each polarization component, which is a departure from the more complicated scheme based on ME. It was shown that, despite the channel model and processing mismatch, this simplified processing could even improve performance compared to full vector processing for specific system parameter regimes where noise effects on the nonlinear spectrum predominate. Consequently, we used NFT to process each polarization independently for NLSE and discovered that this approach was successful in producing a high performance level.

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