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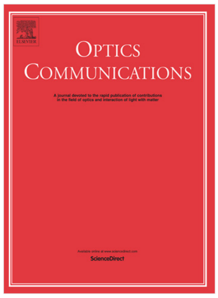

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Influence of Physical Dimensions on Efficiency of Phase-Conjugated Twin Waves Technique in Coherent Optical Communication Systems

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Abstract

The potential of phase-conjugated twin waves (PCTWs) technique has increased interests in optical communication systems due to its ability to mitigate the fiber nonlinearity. In this paper, the influence of the multiplexing dimensions of twin waves on the effectiveness of PCTWs technique is analytically modeled and numerically investigated. Moreover, the analytical models that characterize the phase noise suppression in both spatial and frequency domains are developed. In the spatial dimensions (SD), the 20 Gsymbol/s quadrature phase shift keying (QPSK) signal and its phase-conjugated copy are spatially multiplexed though two identical optical fiber channels, while in frequency dimensions (FD); these waves are multiplexed and sent through the same fiber channel. At receiver, the signals are coherently superimposed to cancel the nonlinear phase noise and enhance the signal to noise ratio (SNR). The results show that the mitigation efficiency of the PCTWs technique is governed by the physical dimensions of propagation. The PCTWs technique in SD system can achieve better performance than that in FD system. The achievable transmission distance is extended by 77.8 % for SD system and 44.5% for FD system at bit error rate (BER) of 10^{-5}.

Key words: Coherent optical communication, Fiber nonlinearity, Nonlinear phase noise, Phase-conjugated twin waves.

1. Introduction

Optical fiber communications have played the most important role for transforming the information around world without degrading system performance [1-4]. Due to the rapid growth of information capacities in the last few decades, the demand of transmission techniques that can maintain the optical signal to noise ratio (OSNR) and enhance the overall system efficiency have been increased effectively [4, 5]. However, the performances of these systems are degraded by fiber nonlinearity. The first consequence of the Kerr effect is SPM, where the optical field experiences a nonlinear phase delay that results from its own intensity. On the other hand, XPM refers to the nonlinear phase shift of an optical field induced by another field with different wavelength.

Several nonlinearity compensation techniques have been proposed in combination with coherent detection systems to overcome Kerr nonlinearity[6]. Some of them deal with the received signal in electrical domain, such as digital-back-propagation (DBP), Volterra and machine learning. The DBP has been considered as an efficient nonlinearity compensation method in which the distorted signal can be inverted at the receiver digitally [7, 8]. However, as the number of spans is increased; the complexity of the digital processing substantially increases [9]. To overcome the computational complexity, inverse Volterra series transfer function (IVSTF) has been reported for partially inverting the dynamic nonlinear distortion induced by fiber nonlinearity[10, 11]. Various machine learning algorithms have been also utilized to mitigate nonlinear fiber impairments[12]. One of the most popular