Optoelectronic signal processing for chromatic dispersion mitigation in direct detection systems

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ABSTRACT

An optical pre-processing structure is used to reduce the burden of digital equalizers and increase transmission reach for a direct detected system impaired by chromatic dispersion. The optical pre-processing consists of the optical signal being sliced into narrow frequency sub-band by an optical filter. Two distinct filters are numerically investigated: an arbitrary waveguide grating (AWG) filter and a series of cascaded Mach-Zehnder delay interferometers (MZDI). Each signal's spectral slice is detected by a photodetector and used as input for the digital equalizer. Two options are also considered for equalization: a feedforward neural network (NN) equalizer and a recurrent neural network with reservoir computing (RC). The results are analyzed in simulation in terms of signal-to-noise penalty at the KP4 forward error correction threshold. The penalty is calculated with respect to a back-to-back transmission without equalization. A 32 GBd on-off transmission shows 0 dB penalty at ≈25 km transmission reach with optoelectronic processing with FNN and at ≈40 km with RC.

Keywords: Reservoir computing, signal equalization, chromatic dispersion mitigation, short-reach transmission, direct-detection.

1. INTRODUCTION

The ever increasing demand for data rates driven by the huge amount of new technologies that communicate with each other is challenging a sustainable growth for inter- and intra-datacenter communication. Transmission rate and reach need to be increased with a low-complexity solution. Direct detection systems are being considered given their low complexity, but losing the phase signal information makes chromatic dispersion compensation a major obstacle to increasing transmission reach. To overcome this challenge, solutions in the optical domain [1-2], digital/electronic domain [3-11] and joint optoelectronic approaches [12-20] are being considered. In our previous work, we showed that an optical pre-processing stage can be used to reduce the burden of the digital equalizer and, therefore, increasing the transmission reach at the expense of optical power loss [19, 20].

In this talk, we review our previous efforts on investigating methods to decrease the receiver complexity for a direct detection system, by sharing it between the optical and electrical domains. Additionally, we compare our previous results with an optoelectronic approach using a nonlinear digital equalizer based on reservoir computing (RC) [12-18; 21-22]. This machine learning method has the advantage of having the power of dynamic nonlinear systems with a simplified training stage. The results are numerically validated for a 32-GBd on-off keying transmission in a directly detected scenario considering an optical pre-amplifier.

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