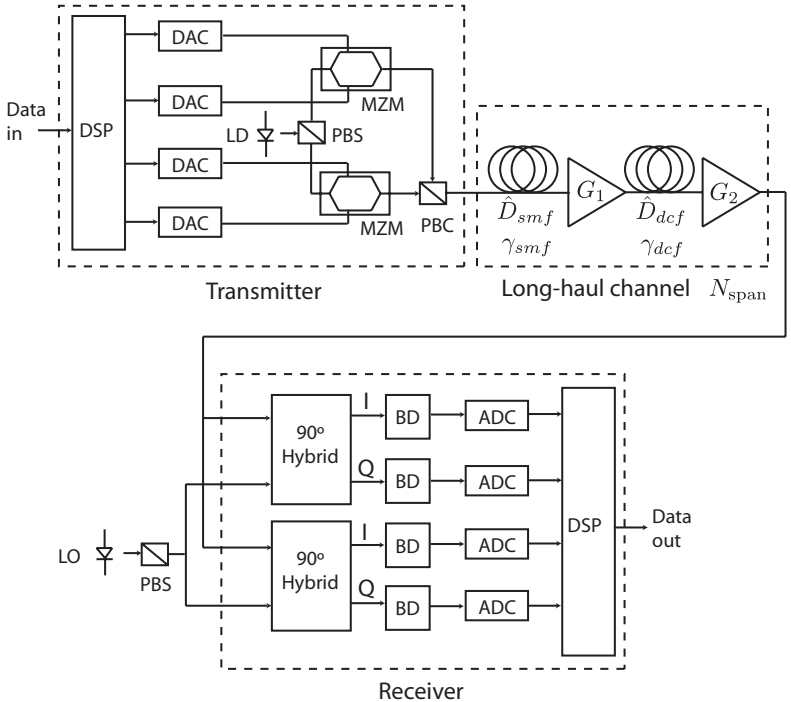
Compensation of fibre impairments in coherent optical systems

- PhD started in October 2006 and finished in July 2010. Total of 8 publications including 4 international conferences and 3 top-impact factor journal papers.
- This work studied digital signal processing algorithms for long-haul optical transmission systems, using coherent detection, contributing to improve the capacity and efficiency of future optical transport networks.
- Research topics: Compensation of chromatic dispersion, polarization-mode-dispersion, carrier phase estimation, optimized parallel implementation of algorithms, digital back-propagation for both single carrier and OFDM systems for simultaneous compensation of linear and nonlinear impairments.
- Coherent detection was used because it allows for high spectrally efficient modulations, and the recovery of the full field information in each polarization. This enables the digital compensation of transmission impairments.
- Study of carrier phase estimation based on reduced computational complexity approaches. Proposal of new methods for a parallel implementation of a carrier phase estimator in feedback with an equalizer.
- Assessment of digital back-propagation algorithm using both single carrier and OFDM approaches targeting the study of nonlinear tolerance for dispersion unmanaged transmission.
  - Study of different back-propagation implementations in terms of performance/computational complexity for multi-band OFDM signals.
  - Extension of back-propagation equations to polarization multiplexed signals, for both single channel and wavelength division multiplexed scenarios.



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Supervisors:
Prof. Henrique Salgado
Prof. Izzat Darwazeh

Abstract

Optical fiber backbone networks are increasingly demanding new ways of supporting the continuous growth in worldwide data traffic. In this context, a study on digital signal processing (DSP) techniques enabling the improvement of currently installed optical fiber systems, in terms of throughput and distance reach, becomes relevant. Coherent systems are seen today as a means of enabling the usage of complex modulation formats, increasing the spectral efficiency of transmission, and employment of advanced DSP functions that subsequently allow for the mitigation of impairments stemming from both the system optical sources (phase noise) as well as the transmission channel (noise, chromatic dispersion, polarization mode dispersion and nonlinearity). This work discusses the main digital signal processing functions inherent to a coherent optical receiver, where the main focus is directed to the topics of equalization, carrier recovery and nonlinearity mitigation.

Different equalizer functions are investigated, and their performance is assessed in terms of integration with carrier phase estimation algorithms. Although the speed of digital electronics is continuously increasing, it is still approximately one order of magnitude behind the speed of optical circuits and therefore it is relevant to study the issues associated with a parallel implementation of the discussed algorithms, in order to determine the restrictions and strategies that allow for an effective practical implementation. The joint mitigation of both dispersion and nonlinear effects is critical in systems employing arbitrary dispersion maps. In this context, the back-propagation algorithm provides a means of partially solving this problem in the digital domain, allowing for an improvement of system performance. This work studies the performance and computational complexity requirements of different implementations of the back-propagation algorithm, as well as on optimum design options regarding the dispersion map characteristics, considering Polarization multiplexed quadrature phase shift keying (PM-QPSK) and coherent optical orthogonal frequency division multiplexing (CO-OFDM) modulation formats (including multi-band OFDM), which are seen today as the main candidates for future optical networks. New simplified compensation schemes are proposed in this context.