

The continuous increase of the worldwide data traffic demands new concepts for data transmission in the optical fiber-based backbone networks. One promising way to increase the capacity of the existing fiber infrastructure is to use multilevel modulation formats in combination with polarization-multiplexing and coherent detection. Though elaborate transmitters and receivers are required to transmit multiple bits per symbol, but this also enables a very efficient utilization of the available bandwidth. The development of coherent optical receivers thereby profits from advancements in integrated circuit technologies that allow the digital realization of the required signal processing.

In this dissertation all necessary algorithms for the signal processing in a coherent digital receiver are presented. The main focus thereby lies on the algorithms for polarization control and carrier recovery. A digital polarization control is required to realize a polarization-multiplexed transmission system without optical polarization control. Both a non-data-aided and a decision-directed polarization control algorithm are presented. For the latter an extension is proposed to enable also the compensation of intersymbol interference.

The most time-critical task in coherent receivers for optical transmission systems is it to recover the carrier phase from the received symbols. Due to the large linewidth of the distributed feedback (DFB) lasers employed in commercial systems a high phase noise tolerance is required. Several algorithms have been proposed to solve this problem. This dissertation compares the different approaches at the example of the quadrature phase shift keying (QPSK) modulation format. Additionally a novel feed-forward carrier recovery for arbitrary quadrature amplitude modulation (QAM) constellations is proposed. Together with the other carrier recovery schemes it is analyzed for QPSK, but additionally also for higher-level square QAM.

Finally the results of the real-time implementation of a polarization-multiplexed synchronous optical QPSK transmission system are presented, which was developed in the framework of the synQPSK project funded by the European Commission. The algorithms implemented in the coherent receiver and their parameters are optimized based on the simulation results of this thesis. Both the single-polarization QPSK transmission system and the polarization-multiplexed QPSK transmission system presented in this dissertation are the worldwide first that were realized with a real-time coherent digital receiver and standard DFB lasers.