ABSTRACT

The deployment of optical networks has become inevitably paramount due to the phenomenal advancement in the communications industry and the associated extraordinary demand for high data throughput. Optical networks provide the needed solution and reliability especially in this era where bandwidth-hungry devices are in high demand. The current technical trend seeks to increase the optical networks capacity, flexibility and reconfigurability, in order to effectively support long haul data transportation. The orthogonal frequency division multiplexing (OFDM) technique has been proposed as a viable scheme that can be incorporated so as to greatly enhance the overall output of the existing optical transport networks. The OFDM technique has become a popular scheme in telecommunications due to its support for high data-rate transmission, robustness and spectral efficiency. The scheme is particularly of great interest and very attractive for use in optical transport system due to its tolerance to chromatic dispersion. However, with the introduction of the OFDM scheme comes the attendant challenges of carrier frequency offsets (CFO) and phase noise, which must be adequately addressed in order to ensure optimum performance of the coherent optical OFDM communication system.

This research work therefore, seeks to address the impact of phase noise and carrier frequency offset on a non-simplistic, complex and an all-encompassing optical OFDM system model which considers the influence of polarization mode dispersion, group velocity dispersions, attenuation and other polarization-dependent losses in the optical link. The effectiveness of the algorithms, utilized to combat phase noise and carrier frequency offset based on the simplistic optical OFDM models in the literature, is verified using the non-simplistic comprehensive system model. Also, a closed-form maximum likelihood (ML) method is developed and utilized for phase noise and CFO estimation. First, a closed-form ML estimator is derived and implemented for CFO estimation in coherent optical OFDM (CO-OFDM) system. Thereafter, this is then extended so that the phase noise and the CFO are jointly acquired using the derived closed-form ML method.

The closed-form derivations avoid the traditional exhaustive search associated with the traditional ML methods and ensure low complexity.

In a departure from the pilot-based methods mentioned above, the blind subspace-tracking algorithm is developed and implemented, as countermeasure to address the impact of phase noise in CO-OFDM systems. The subspace-tracking algorithm is based on the fast data projection method (FDPM). The FDPM is uniquely combined with a forward-backward linear predictor to ensure an efficient adaptive way of estimating the phase noise in the optical system. Also, a variable step-size is introduced, which deviates from the constant normalized step-size traditionally utilized for the subspace-based algorithms to ensure an enhanced overall system performance.

Furthermore, an efficient constant modulus method for CFO acquisition is introduced. The method is implemented using a cost function that ensures robustness against fiber impairments. The suitability and efficiency of the constant modulus approach in terms of the system complexity, cost-efficiency and overall performance is implemented and investigated while considering pertinent impairments along the optical fiber link. The method is adequately compared with other prominent methods in terms of system performance and complexity.

Thus, the impact of the CFO and the phase noise are adequately addressed in this research work. The performances of the various methods utilized are verified using computer simulations and documented in this thesis.