

This thesis presents several novel contributions in the field of Passive Optical Networks (PON). The first part is devoted to the ITU-T 50G-PON standard, with its first recommendation released in September 2021. Being the first PON generation to foresee digital signal processing (DSP) in the form of Rx equalization to counteract bandwidth limitations and chromatic dispersion effect. Compared to previous PON generations, which required expensive reference equipment for compliance testing, 50G-PON introduces the transmitter dispersion eye closure (TDEC) as the metric for transmitter compliance testing. This new strategy allows to avoid an expensive reference transmitter and evaluate by means of mathematical tools the maximum amount of noise that can be added to the transmitted signal, therefore predicting the maximum channel penalty that can be allowed in order for a reference receiver to work properly. In this work, the rationale behind this metric is explained, including the modifications needed in 50G-PON to account for noise enhancement due to the receiver equalizer and shot noise introduced by avalanche photodiodes. Through a set of simulations and experiments, an optimization of parameters affecting the final measurement is performed. Two strategies of EQ adaptations and their effect on TDEC is analyzed, followed by a comparison between real-time and sampling oscilloscopes. Last and most important, a series of experimental results shows that TDEC is able to predict receiver sensitivity penalties due to typical impairments present in PON networks, such as limited extinction ratio and chromatic dispersion, being able to work also in negative chromatic dispersion region, where the interaction with positive chirp from electro-optical devices produces an improvement in signal quality going through the fiber.

The second part of the Thesis delves into a novel approach to counteract signal degradation due to system bandwidth limitations and chromatic dispersion. By exploiting a combination of conventional binary detection and electrical duobinary detection, a novel scheme, named Enhanced Electrical Duobinary, is analyzed through simulation and experiments in multiple working conditions. The results show that this scheme can obtain better sensitivity compared to binary detection in the case of severely reduced system bandwidth, while keeping limited sensitivity penalty in case of large system bandwidth.

In the last part, this work studies potential directions for Passive Optical Networks. Under the assumption that the next generation of PON will still use IM/DD and that two-level modulation will not be able to guarantee adequate performance when doubling the bitrate to 100 Gbps, a real-time PAM-4 PON testbed was implemented and studied. Different transmitter and receiver schemes (i.e. with and without optical amplification at both ends) and their sensitivities and power budgets were analyzed, showing promising results both for PON and Point-to-Point links.