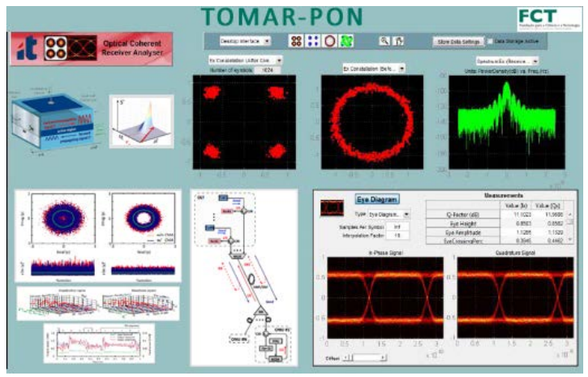
TOMAR-PON

Techniques of Modulation and Remodulation for PON

Main focus of TOMAR-PON research group was the study of crucial PON elements, such as optical line terminal (OLT) and optical network unit (ONU), in pursuing the optimum (re) modulation techniques towards high performance and low cost operation. Extensive research resulted in final demos outlining a clear path towards flexible and virtually unlimited solution: higher order modulation in coherent PON.



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Funding Agencies

FCT	**113,248€**
Start Date	01/09/2009
Ending Date	01/07/2013

Indicators

Journal Papers	9
Conference Papers	19
Concluded PhD Theses	5

Two Main Publications

Z. Vujicic , R. P. Dionísio, A. Shahpari, N. P. Pavlovic, A. Teixeira, **Efficient Dynamic Modeling of Reflective Semiconductor Optical Amplifier**, IEEE Journal of Selected Topics in Quantum Electronics, Vol. 19, No. 5, pp. NA, April, 2013

M. M. Krstić, J. V. Crnjanski, D. M. Gvozdić, **Injection Power and Detuning-Dependent Bistability in Fabry–Perot Laser Diodes**, IEEE Journal of Selected Topics in Quantum Electronics, Vol. 18, No. 2, pp. NA, April, 2012

PROJECT WEBPAGE URL

https://www.it.pt/Projects/Index/1721

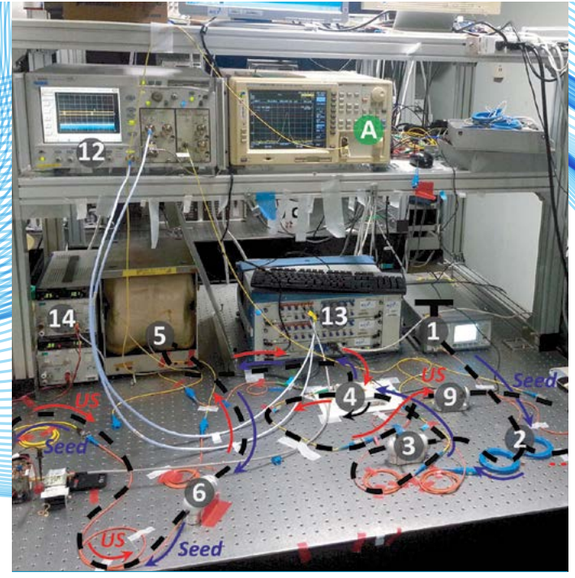

Fig. 1 Laboratory system assembly for remotely seeded reflective PON, based on upstream (US) signal generation by means of RSOA.

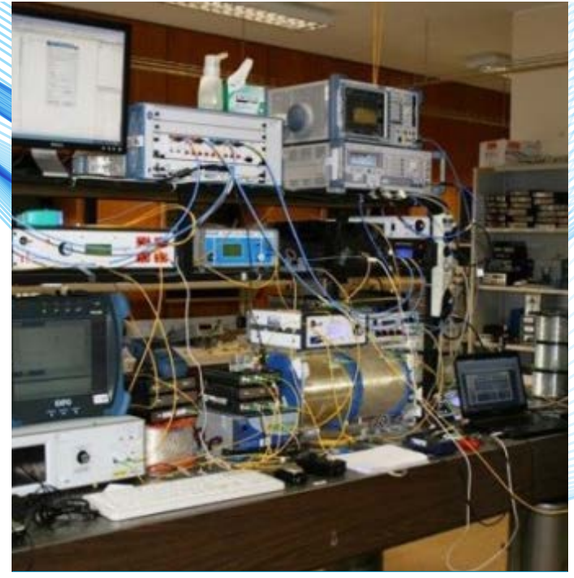

Fig. 2 Laboratory UDWDM and DWDM demo setup, with fiber and free space optics infrastructures

GENERAL MOTIVATION AND OBJECTIVES

Wavelength division multiplexing (WDM) passive optical networks (PONs) offer a potentially cost effective way of increasing the individual customer bandwidth through increased use of wavelength domain. An important target towards their commercialization involves the overall performance enhancement, through improvements of capacity and reach. Bidirectional transmission with extended reach and data rate, up to the Ethernet rates of 100Gb/s, is of paramount importance towards meeting the ever growing bandwidth demands.

CHALLENGE

Investigation of optimum (re)modulation techniques for WDM PON, as well as their robustness towards the most deleterious fiber nonlinearities, is of great importance for network capacity and reach. In particular, remodulation techniques within PON scenarios relying on low cost reflective semi-optical amplifier (RSOA) represent a crucial aspect of general efforts to further the cost reduction in PONs.

WORK DESCRIPTION AND ACHIEVEMENTS

One of the core aims of TOMAR-PON was the development of a numerical platform for PON link, based on both standard and reflective PON scenarios. To that end, a novel numerical model for RSOA component, based on computationally efficient estimation of spatial-temporal distribution of photons and carriers was proposed and integrated into the access link simulation platform. Moreover, as part of the transmission line impairment study, a detailed investigation of the main system-impairing nonlinearities for ultra-dense (UD) WDM systems was performed. This investigation included theoretical modeling of stimulated Brillouin effect (SBS), Brillouin-Rayleigh interaction, and the efficiency of Four Wave Mixing (FWM) process arising from the aforementioned interaction. Also, models for phase, polarization and pulse shaping were developed towards the optimization of UDWDM transmission. For the first time, PON link was modeled and characterized independently for the linear and nonlinear behavior of the WDM signals, using the Volterra series approach. In essence, extensive work was performed in modeling of UDWDM PON systems and experimental validation thereof, which thereafter served as the path towards TOMAR-PON solutions and resulted in a number of international conference and journal publications.

Several experiments had been performed with the aim of providing validation to the numerical part of the work, resulting in several international conference and journal publications. The system performance of proposed modulation formats was investigated, analyzing their robustness to main system impairments. Optimal transmission conditions (e.g. launch power, channel spacing) towards nonlinear impairment mitigation in UDWDM scenario were explored both experimentally and numerically. Particular focus was placed on reflection induced impairment, identified as most detrimental in reflective PON scenario based on RSOA. As a result, an extensive investigation of the most suited modulation formats was performed, enabling impairment mitigation towards the overall high speed system performance optimization. QPSK, 16QAM and OFDM modulation formats with improved generation schemes had been demonstrated. Several hybrid scenarios were also investigated and implemented in order to smoothen the progress towards future PONs. As a culmination of our efforts, for the first time ever, a full blown demo of 192 channels bi-directional PON was achieved in a single fiber and a record data rate efficiency was achieved 1.92 Tbit/s over 12.8 nm. Also, aligning the project objectives with ever strived for low cost scenario, particular care was taken to reduce the system complexity (sampling rates of the ADC's of less than 5 Gs/s) while maintaining modular bit rates compatible with the current 100GBE LR10.