

MÁSTER EN NUEVAS TECNOLOGÍAS ELECTRÓNICAS Y FOTÓNICAS

TRABAJO DE FIN DE MÁSTER - CURSO 2026-2027

PROPUESTA

Título:	<i>Compact and Cost-Effective Characterization of a Chirped-Pulse DAS Interrogator</i>
Título en inglés:	<i>Compact and Cost-Effective Characterization of a Chirped-Pulse DAS Interrogator</i>
Tutor/es:	<i>Saverio Pellegrini</i>
Correos-e:	<i>saverio.pellegrini@csic.es</i>
Lugar de realización:	Instituto de Óptica CSIC. Calle Serrano 144, Madrid

Resumen:

Distributed acoustic sensing (DAS) systems are attracting increasing interest for a wide range of applications, particularly in geophysics, including earthquake and tsunami monitoring. Their operating principle is similar to that of a traditional optical time-domain reflectometer (OTDR), which works analogously to a radar (or sonar): optical pulses are launched into the fiber, while the time of flight of the backscattered light is used to determine the corresponding position along the fiber. By suitably processing the backscattered trace, it is possible to detect, localize, and quantify changes in temperature or strain occurring along the fiber. Chirped-pulse DAS (CP-DAS) is nowadays a well-established technique, with increasing relevance in industrial and scientific applications. This project will explore the implementation of a compact CP-DAS interrogator, addressing the practical trade-offs imposed by both optical and electronic hardware. The goal is to experimentally assess solutions that reduce cost, complexity, and size while retaining performance comparable to that of conventional equipment.

Metodología:

1) Introduction to the technology

The student will be provided with the necessary material to understand the working principle of CP-DAS, as well as hands-on preliminary experiments to translate theory to practice.

2) Experiments

Introduction and explanation of the provided hardware, assisted by the TFM supervisor. Characterization of the experimental setup components' parameters and working points. Change of the transmitted pulse modulation to test the system's limitations and related performance. Test of different perturbations affecting the fiber (for example, vibrations at different frequencies and intensities) to analyze the system detection capabilities. We'll use laboratory grade instrumentations such as optical and electrical spectrum analyzers, analog waveform generators (AWGs), Mach-Zehnder modulators (intensity ones), erbium-doped fiber amplifiers (EDFAs) ...

3) Experimental data processing

The student is required to acquire and process the data coming from the experiments; the interpretation is discussed together with the TFM supervisor. The computed system parameters (such as signal-to-noise ratios, backscattered trace statistics, recovered perturbation distortion) will be related to the different experimental working conditions tested.

4) Expected outcomes

The student should gain good practical knowledge about CP-DAS, starting from theory. They are expected to learn the basics about how to work in a photonics laboratory (specifically, a sensing/optical fiber one), involving non trivial electrical and optical hardware. The final result of this work should be the full characterization of the experimental CP-DAS system, including all its parameters and sensing performance.

Conocimientos previos recomendados:

- **Basic optics concepts.** Especially, modulation of light pulses.
- **Basic operations with optical fiber components.** The student is not required to assemble/design the setup from scratch, which would instead be done by the TFM supervisor, but to understand it, work with it, and, at the end of the TFM, be able to reproduce it.
- **Digital signal processing.** Fundamental for generating and analyzing the signals in the experiments. Standard engineering DSP knowledge is enough (time-frequency domain operations, SNR computations...).
- **Good/Basic skills in programming.** Matlab and/or Python are preferred, as the main part of data processing will involve array/matrices operations.

Bibliografía:

Working principle of the CP-DAS:

J. Pastor-Graells, H. F. Martins, A. Garcia-Ruiz, S. Martin-Lopez, and M. Gonzalez-Herraez, "Single-shot distributed temperature and strain tracking using direct detection phase-sensitive OTDR with chirped pulses," *Opt. Express* 24, 13121-13133 (2016). <https://doi.org/10.1364/OE.24.013121>

R. Fernández-Ruiz, M.; Costa, L.; F. Martins, H. Distributed Acoustic Sensing Using Chirped-Pulse Phase-Sensitive OTDR Technology. *Sensors* **2019**, 19, 4368. <https://doi.org/10.3390/s19204368>

One interesting application of the CP-DAS:

Williams, E.F., Fernández-Ruiz, M.R., Magalhaes, R. *et al.* Distributed sensing of microseisms and teleseisms with submarine dark fibers. *Nat Commun* **10**, 5778 (2019). <https://doi.org/10.1038/s41467-019-13262-7>