Integrated Photonics for the Next Generation of Autonomous Vehicles using InP Technologies

# Deliverable D6.6 (D25)

Technical hands-on courses (TC) - TC1

Hands-on Jeppix training

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**Abstract**

In addition to the scientific-based training, DRIVE-In offers to all ESR specific short-term hand-on training which can provide the ESRs with skills in highly experienced organizations, receiving cutting-edge technological knowledge and skills. These hands-on training will be provided at the same time the ESRs are seconded to Partner Organizations providing the courses, i.e. CTAG and BP, and are aimed to explore knowledge in circuit simulation and packaging.

**Keywords:** Photonics, Physics, Solid-state physics, Robotics, Training, Automation

## Change Record

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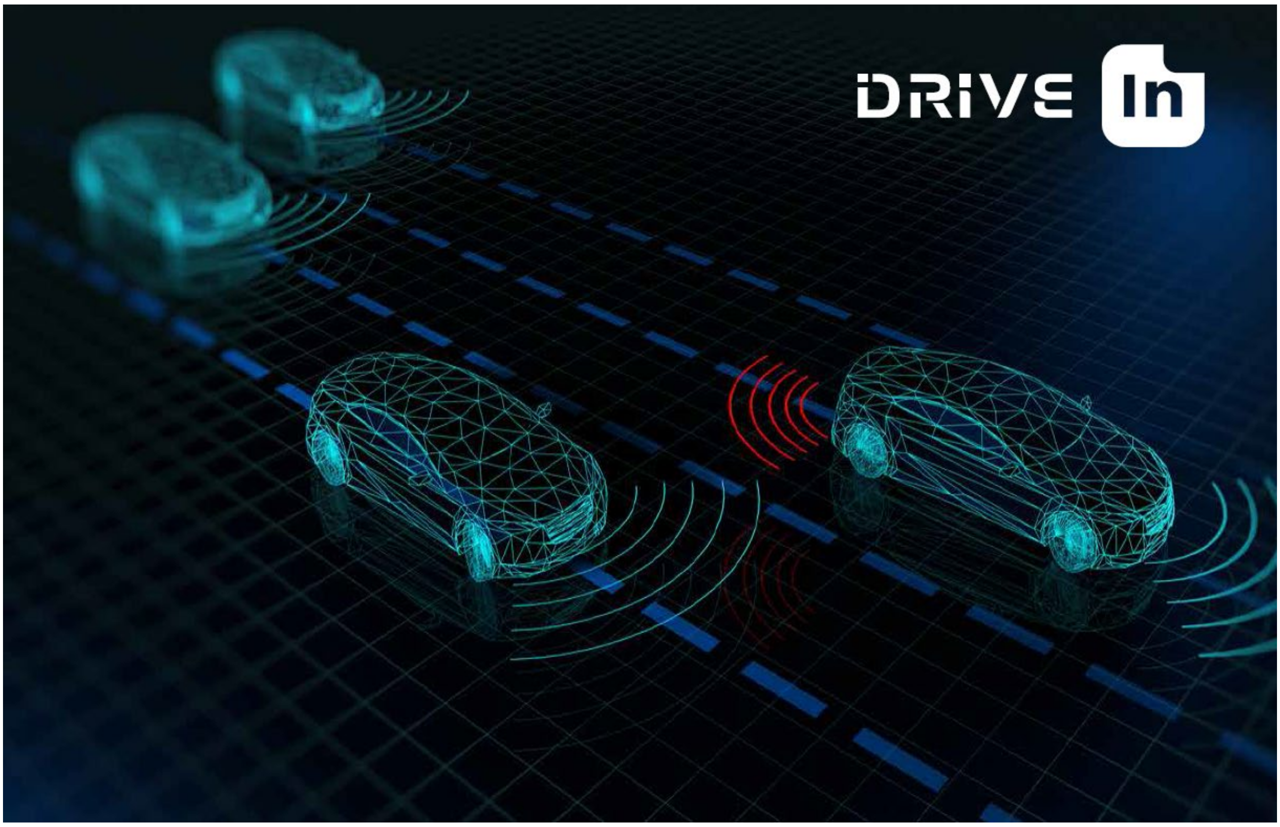
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# 1. INTRODUCTION

The aim of this report is to provide a brief overview of the **Technical Hands-on Course TC1-Hands on Jeppix training** organized in the framework of the project DRIVE-In. As a general introduction, the challenge for the DRIVE-In Training Network is to develop new fundamental skills on simulation, design, measurement automation, fabrication and validation, and organization in an integrated photonics foundry. These are intended to develop PDK specifically for LiDAR and FSO applications and new hybrid photonics and electronics modelling and simulation software for the next generation of ITSs and ADASs enabling integrated InP technologies. As collateral goals, the ESRs will contribute to the development of new test structures, advanced PIC designs and new optoelectronic hybrid software tools. To achieve this, DRIVE-In training strategy aims to combine scientific advanced training (Scientific Courses 1-5), technical hands-on courses (TC1-3), Winter School and regular EID meetings and networking events. Furthermore, all ESRs will be equipped with a range of transferable skills, as defined in the proposal.

The following specific training objectives (TOs) are defined to fulfill these goals:

- TO1: To enhance the attractiveness of a career in the front-line area of research in photonics’ software circuital and physical simulation, design and modelling tools and in the creation of building blocks, test structures and models for generic InP integration platforms. This will provide the opportunity for the ESRs to be involved in the creation of a new and major research area in hybrid photonics and electronics simulation and modelling, joining two major different technologies like microelectronics and integrated photonics; by applying consolidated knowledge coming from integrated circuits to develop integrated photonics-electronics software with enhanced performance.
- TO2: To provide future employers (both academic and industrial) with the next generation of researchers that: i) are skilled in a wide range of techniques and methods, stemming from software to design, fabrication and characterization of InP integrated circuits; ii) have direct experience of interaction across disciplines and sectors with different background in electronics/photonics towards the development of a completely new area of research, producing new devices suitable for, but not limited to, the next generation of ITSs and hereby ADASs.
- TO3: To produce researchers with excellent transferable skills and the ability to transform abstract and challenging ideas into influential and practical outcomes.
- TO4: To create an active, long-term network of young researchers whose personal contacts, support and expertise will help Europe shape the future of research in ITSs and ADASs for active/passive sensoring and optical communication devices; and to enhance/optimize the software simulation tools by integrating electronics in the optical

design process.

- TO5: To cascade expertise and spread good practice throughout Europe by personnel exchange and delivering European researchers able to – in the near and mid-term future – become leaders in the fields of integrated hybrid photonics and electronics software simulation and design, PIC designs, ADAS applications and automation in photonics industry.

The four ESRs **have been enrolled (07/10/2020) in the PhD program from the UVigo (Doc-TIC)**. Doc-TIC is the PhD Program promoted by the School of Telecommunications Engineering and atlanTTic. Its mission is to train the best professionals and researchers to generate quality research with international impact and to provide the industry with professionals with advanced knowledge to improve its competitiveness at global level. Doc-TIC involves the merging and expansion of the previous PhD Programmes in Signal Theory and Communications (TSC) and Telematics Engineering, both with Mention of Excellence awarded by the Spanish Ministry of Education. Each ESR will be required to accumulate at least 30 ECTS (European Credit Transfer and Accumulation System) credits, among the pool of scientific- and transferable skills-based courses at UVigo and TUe **to obtain their PhD title**.

Through the Doc-TIC PhD Programme the UVigo offers a number of **course modules in areas related to photonics (active and passive devices), quantum mechanics, solid-state physics**, all of which are given in English. Between them, **this group of Technical-based courses (TC) offered to each ESR, will allow them to obtain six ECTS, two per TC (30 lecturing hours and 10 hours of homework).**

## 1.1 TECHNICAL HANDS-ON COURSE TC1 – HANDS-ON JEPPIX TRAINING

In the following Table we describe the fundamentals of these technical training group of courses and corresponding skills to be acquired by the ESRs.

| Title | Hands-on JeppiX training (TC1) | Month: 13 | Duration: 2 Weeks |
|---|---|---|---|
| Lead | UVigo | | |
| **Contents**: To get an overview of the latest status of the integrated photonics eco-system for the three major photonics technologies: InP, silicon photonics and TriPleX (SiN). This overview will include the available design tools and the importance of considering test and packaging in an early stage. The unique combination of lectures and hands-on training will teach how to perform circuit simulations, including fabrication tolerances, how to use and develop a PDK and how to set-up libraries in a structured way. Several Software tools will be used for this purpose (Synopsys Optodesigner, VPI, Lumerical). | | | |
| **Skills for ESRs**: Get introduced to Integrated Photonics Design Flow Automation. Learn the use of photonic integrated circuit simulation tools. Obtain in-depth knowledge of integrated design from mask to photonic and process flow simulations. Exchange experiences and ideas with other participants. Learn different technologies for integrated devices, other software tools, cleanroom processing and testing mechanisms. | | | |
| Title | Hands-on VPI Photonics (TC2) | Month: 13 | Duration: 2 Weeks |
| Lead | VPIP | | |
| **Contents**: To learn a suite of robust circuit solvers for integrated photonics structures, using HHIF PDKs. It supports time and frequency domain solvers, and large number of complementary algorithms which allows it to solve a large variety of photonics and electronics problems which may be made of any material and of almost any geometry. VPI Photonics allows product modelling, design and optimization of heterogeneous PICs, linear electric circuits, and multisection optoelectronic devices and can show how the current co-simulation with electronic software (Keysight ADS) works and highlight the current limitations. Designed optoelectronic devices cover applications such as widely tuneable and mode-locked lasers, gain-clamped SOAs, electro-absorption modulators, wavelength converters and 2R/3R optical regenerators, etc. Designed PICs cover applications such as coherent transmitters and receivers for advanced modulation formats, optical interconnects, recirculating optical buffers and reconfigurable delay lines, multi-ring filters and arrayed waveguide gratings, and practically any other monolithically integrated or hybrid PICs based on silicon (Si), indium phosphide (InP) or gallium arsenide (GaAs) substrates. VPIPhotonics optical design and configuration products come with an extensive library of over 700 demonstration applications. | | | |
| **Skills for ESRs**: to learn how to model InP related devices, subsystems and circuits; how to optimize their performance, perform the layout and mask simulation, optimize structures according to specifications sweeping parameters and gain knowledge on programming and scripting aspects. Design topics include: Graphical User Interface features, Overview of signal models and simulation technique, Parameter sweeps and optimizations, Visualization and post-processing of simulation results, Scripted simulations and automated system design | | | |
| Title | Automotive ADAS devices and specifications (TC3) | Month: 14 | Duration: 1 Week |
| Lead | CTAG | | |
| **Contents**: A full course on ADASs. It will give an overview about sensor types, topologies, and system setups today. It will show later on examples based on camera sensors, radar sensors, lidar, free space optics communication systems inside and outside the car, types of Advanced Driver Assist Systems. It will introduce driver assist systems associated with the windshield and their related concerns. This module provides an overview of some of these systems and how they assist the driver. These include: Lane departure warning and lane keep assist systems; Collision mitigation systems; Pre-collision systems; Automatic high-beam assist systems; Night vision systems; Head-up displays; Automatic Windshield Wipers. | | | |
| **Skills for ESRs**: An introduction and overview towards ADASs, algorithms devices and electronics technologies to develop ADASs; specifications and guidelines to produce devices with enhanced performance; interdisciplinary knowledge in photonics and electronics applied to automotive disciplines. | | | |

## 1.2 SYLLABUS

The outline of this course is described below. TC1 has been held between 9-13 Nov 2020 in a virtual mode (16:00-19:00). This course should have been developed in a face-to-face mode. However and due to the current pandemia, the lecturer Dr. Katarzyna Lawniczuk couldn´t travel and the course was moved to an online version. However, this circumstance did not imply a considerable change in the contents or in the extension of the training. Since the training included in TC1 is fundamentally oriented to software and programming (circuit design, simulation and layout), this type of course is the most suitable to be taught online.
Topics covered in the course: PIC specifications, PIC technologies and design, cells and layer, interconnect, building block and PDK creation, GDS introduction and advanced manipulation, connection DRC, circuit level path-tracing and compact models.

**Technical Hands-on Course TC1: Jeppix Training (Dr. Katarzyna Lawniczuk)**

1. **Introduction**: PIC requirements and specifications depending on the specific application. Technology selection.
2. **PIC technologies (SOI, InP, SiN, glass).** PIC design constraints related to technology and across multiple packages. How the PIC specifications and technology selection influence the circuit design. How to carefully design your PIC to accommodate the circuit into the mask layout.

3. To learn to use **PIC design with Lumerical and Nazca Design in Python**:
    a. To **get started and directions** into the more advanted features of circuit integrity validation, GDS manipulation and PDK development.
    b. **The role of Nazca** in the PIC development chain and how an open source design tool with community and commercial support provide long term security, flexibility and innovation.
4. **Hands-on through an example: A PIC transceiver**. Design flow tool. Foundry and technology definition. Layout design and verification.  Mode solving. Data processing.

The **methodology** applied was based in:
Lectures: The professor introduces the main contents of each chapter to the students. These lectures did not cover all the contents of each subject. For that reason, the students had to review the supplementary notes provided in class. It is also expected that the students reviewed the concepts introduced in the classroom and expand on their contents using the guide of each chapter, together with the recommended bibliography, as a reference.
Laboratory: The lectures included some exercises in the lab involving different optical devices and optical communication systems.
Case studies: It consisted on activities that complement the master sessions and allow a better understanding of the theoretical concepts.