Course Description

Course name	**#063 - Advanced Optical Sensors: From Detectors to ASIC Integration with Edge AI and Functional Safety Considerations**
Duration	**4 days**
Format	**Public Classroom, Inhouse Event and Online**

Overview
Dr. Farzad Parsaie, founder of SAND Microsystems GmbH, Switzerland, is teaching this 4-day course on **Advanced Optical Sensors.**

Optical sensors are evolving toward intelligence, downsizing, and multi-functionality, with critical roles in functional safety applications like autonomous driving, industrial automation, and medical diagnostics. Artificial Intelligence (AI) enhancing optical sensor performance by improving data processing, signal-to-noise ratios, and handling dynamic scenarios, essential for high-fidelity measurements in these fields.

This course covers these advancements, from photodetector fundamentals to ASIC integration and interfacing, with a focus on Edge AI and Functional Safety.

Technical Focus
The course, "Advanced Optical Sensors: From Detectors to ASIC Integration with Edge AI and Functional Safety Considerations for Intelligent and Safety-Critical Applications," provides a comprehensive four-day exploration of modern optical sensor technologies. Participants will gain a thorough understanding of photodetectors, their underlying physical principles, and performance characteristics, ensuring a strong technical foundation. The course progresses to signal conditioning and ASIC integration, highlighting critical design challenges and best practices for low-noise and high-speed interfaces. The focus then shifts to the implementation of Edge AI for real-time data processing in intelligent systems and the incorporation of Functional Safety considerations to ensure reliability and robustness in safety-critical environments. The final day includes practical design and simulation activities, emphasizing hands-on skills and preparing participants to tackle challenges in advanced sensor applications. This course equips professionals with tools to develop intelligent, reliable, and safe optical sensor systems for applications like autonomous vehicles, industrial automation, and medical devices.

Course Content
This 4-day course provides a comprehensive overview of photodetectors, their materials, and processes, emphasizing their role in innovative applications such as LiDAR, optical communication, and industrial automation. Advanced topics include discrete and integrated techniques like Analog/RF Frontends, Discriminators, ADC/TDC, and ASIC process technologies (CMOS, BiCMOS). The course also addresses Edge AI for intelligent optical sensors and Functional Safety considerations for safety-critical systems, ensuring reliability and robustness.

Who Should Attend
This course covers the realization of optical sensors, including photodetectors, low-noise interface front-end electronics, digitization of signals, and their integration with Edge AI and Functional Safety. As optical sensors are crucial in multi-disciplinary products, this course is relevant for professionals seeking to optimize system performance holistically rather than focusing solely on single-discipline aspects.

It will be of interest to:

- Engineers, Physicists, Optics Experts, Scientists, Technical Staff, and Students
- System Architects, Project Managers, Technical Managers, and Functional Safety Managers involved in the design, implementation, and optimization of intelligent and safety-critical systems.
- Business Development Managers and Marketing Managers are involved in the specification, development, or commercialization of intelligent and safety-critical optoelectronic products aiming for rapid Time to Market.

This course provides critical insights for those working in cutting-edge applications such as LiDAR, autonomous systems, industrial automation, and medical devices.

Course Daily Schedule

Day 1: Fundamentals of Photodetectors
1. Introduction to Photodetectors
o Discrete vs. Integrated Photodetectors: Features, Applications, and Trends
o Overview of Photodetector Technologies (e.g., PIN Diodes, APDs, SPADs)
o Key Applications: From Conventional Sensing to Intelligent Systems

2. Physical Principles and Technologies
o Photoelectric Effect, Material Properties, and Device Physics
o Sensitivity to Wavelength and Light Power (UV, Visible, NIR, SWIR)

3. Performance Characteristics
o Noise Sources (Shot Noise, Dark Current, Thermal Noise)
o Speed and Bandwidth Limitations in Photodetectors

Day 2: Signal Conditioning and ASIC Integration
1. Low-Noise and High-Speed Interface Design
o Challenges in Photodetector Signal Interfacing
o Techniques for Low-Noise Amplification and Bandwidth Optimization

2. ASIC Integration and Interfacing
o Analog and Mixed-Signal ASIC Design Challenges
o Topologies for Analog-to-Digital (ADC) and Time-to-Digital Converters (TDC)
o Power and Noise Optimization in ASIC Design

3. Integration Challenges and Trends
o System-on-Chip (SoC) Considerations for Optical Sensors
o Advanced Packaging for Optical and ASIC Co-Integration

Day 3: Edge AI and Functional Safety Implementation
1. Edge AI for Intelligent Optical Sensors
o Implementing Edge AI to Enhance Optical Sensor Intelligence
o Real-Time Data Processing with Machine Learning Models for Sensor Applications
o Case Studies: Intelligent Optical Sensors in LIDAR, Environmental Monitoring, and Industrial Automation

2. Functional Safety Considerations for Safety-Critical Optical Sensors
o Overview of Functional Safety Standards (ISO 26262, IEC 61508)
o Hazard Analysis and Risk Assessment (HARA) and FMEDA
o Safety Mechanisms for Optical Sensors: Redundancy, Diagnostics, and Fault Tolerance
o Design for Robustness in Safety-Critical Systems

3. Integration of Edge AI and Functional Safety
o Designing Optical Sensors with Adaptive Intelligence and Deterministic Safety Requirements
o Applications: Autonomous Vehicles, Medical Imaging, and Industrial Safety
o Addressing Challenges When Combining AI Capabilities with Functional Safety Requirements

Day 4: Practical Design and Future Trends
1. Hands-On Design and Simulation
o Design of a Low-Noise Interface Circuit for Photodetectors
o Simulation of Signal Conditioning Circuits (using tools like LTspice, Cadence, or MATLAB)

2. Future Trends in Optical Sensors
o Integration with AI and Machine Learning for Real-Time Data Processing
o Edge Computing for Intelligent Sensor Systems

3. Interactive Discussion
o Real-World Challenges in AI and Functional Safety Implementation
o Open Q&A and Networking

Instructor Biography

Mr. Farzad Parsaie, founder of SAND Microsystems GmbH, Switzerland, is an experienced engineer and entrepreneur working for more than 25 years in the area of Semiconductors and Sensor research and development. In his work he focuses primarily on MEMS/Sensor and Photonic Products (such as Optical Sensors and LiDAR).

Dr. Parsaie previously worked at the Institute of Microelectronics from Technical University Berlin, Philips Semiconductors AG, NXP Semiconductors AG, ams AG and Elesta GmbH. He has been in charge of CMOS Analog/Mixed-Signal and RF Design, Optoelectronics, MEMS interfacing and industrial sensors from feasibility study and development to industrialization with strong focus on miniaturization through ASIC and (Co-)Packaging. As an expert in different areas he has worked with several leading semiconductor and product companies as customers and contributed to minimize their development risks and cost.

Dr. Parsaie has been a member of the Continuing Education Institute-Europe faculty since 2020.