



UNIVERSITÀ DI PISA  
**DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE**  
**Dottorato di Ricerca in Ingegneria dell'Informazione**

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Doctoral Course

**“Pivotal role of electronics in the next generation of sensor systems”**

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**Short Abstract:** In recent years, the role of sensor systems as key components of complex artificial apparatuses has been continuously gaining importance. The effectiveness of future devices, such as robots, autonomous vehicles and wearable medical systems, in improving the life of human beings critically depends on the availability of specialized sensor systems allowing the acquisition of precise information about the surrounding environment. In the last three decades, challenging requirements of size, cost and reliability drove the research towards the present generation of sensors, which leverage on the progress in micro-technologies. On the other hand, the lack of sensor systems with adequate performances is still limiting exciting application that could significantly contribute to the safety of humans in everyday life. For the success of present and future sensor systems, the crucial role of electronics is undisputable.

This course is meant to analyze the structure of a modern sensor systems, classifying the different components according to their specific function and proposing an original hierarchical overview based on modularity. Within this general view, the focus is placed on the intimate relationships between physical components, i.e. the transducers, and the electronic units, highlighting the challenging requirements that the former posed to the latter. By a in depth analysis of significant case studies, it will be shown how the function performed by the electronic circuits is essential for the transduction mechanism. Furthermore, the fundamental design approaches and technologies that allowed the integration of complex sensor systems on a single chip (System on a Chip) or in single packages (System in Package) will be discussed. Finally, the trend toward versatile universal sensor interfaces will be exposed, focusing on a research product being developed by the research group of the author of this course [1-4]. Theoretical lectures will be alternated with experimental demonstrations performed by means of purposely built development boards controlled with the Python language.

**Course Contents in brief:**

- Overview of sensor system: classification, characteristics & trend.
- Beyond the standards: design strategies for non-intrusive sensor systems with challenging constraints.
- Let's practice: experimental demonstrations of sensor systems by means of purposely built development boards

**Total # of hours of lecture:** 16 hours (4 credits)

## References:

- [1] Ria, A., Cicalini, M., Manfredini, G., Catania, A., Piotta, M., Bruschi, P. (2022). The SENSIPLUS: A Single-Chip Fully Programmable Sensor Interface. In: Saponara, S., De Gloria, A. (eds) Applications in Electronics Pervading Industry, Environment and Society. ApplePies 2021. Lecture Notes in Electrical Engineering, vol 866. Springer, Cham. [https://doi.org/10.1007/978-3-030-95498-7\\_36](https://doi.org/10.1007/978-3-030-95498-7_36)
- [2] Ria, A., Contardi, S., Piotta, M., Bruschi, P. A miniaturized ECG system based on a versatile single chip sensor interface. *To be published in "9th International Conference on Smart and Sustainable Technologies (SpliTech), 2024.*
- [3] A. Ria, M. Piotta, X. Muñoz-Berbel, P. Bruschi and M. Dei, "Low-Cost Sweating-Rate Sensor for Dehydration Monitoring in Sports," *2023 IEEE SENSORS*, Vienna, Austria, 2023, pp. 1-4, doi: 10.1109/SENSORS56945.2023.10325206.
- [4] Ria, A., Motroni, A., Gagliardi, F., Piotta, M., Bruschi, P. (2024). The SensiTag: An Innovative BAP RFID TAG for Environmental Multi-sensing. In: Bellotti, F., *et al.* Applications in Electronics Pervading Industry, Environment and Society. ApplePies 2023. Lecture Notes in Electrical Engineering, vol 1110. Springer, Cham. [https://doi.org/10.1007/978-3-031-48121-5\\_36](https://doi.org/10.1007/978-3-031-48121-5_36)
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## CV of the Teacher

Andrea Ria (Senior Member IEEE) received the bachelor's, master's degrees and the PhD in electronics engineering from the University of Pisa, Pisa, Italy, in 2014, 2016 and 2021, respectively. He is currently an Assistant Professor with the Department of Information Engineering of University of Pisa. In 2018, received the second prize of "Huawei Italy University Challenge". In 2024 he won the "Best Paper Award" during the 9th Splitech Conference. He is Vice Chair of IEEE SB of University of Pisa. His research activity is mainly focused on low-voltage and low-power mixed-signal integrated sensor interfaces.

Author of 47 papers including research articles and conference proceedings (H-index 9 and more than 200 citations) mainly in electronic integrated circuits and systems.

**Final Exam:** multiple choice questions [1hr]

## Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

Day1 – February 10, 2025 - 14:00 /18:00, Lecture #1, (3 h) + Exercitation (1 h)

Day2 – February 11, 2025 - 14:00 /18:00, Lecture #2, (3 h) + Exercitation (1 h)

Day3 – February 12, 2025 - 14:00 /18:00, Lecture #3, (3 h) + Exercitation (1 h)

Day4 – February 13, 2025 -14:00 /18:00, Lecture #4, (3 h) + Final Exam (1 h)

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