MEMS Design (10 ECTS)

Designing microelectromechanical systems (MEMS), also known as microsystems or micromachines, such as sensors, actuators and generators requires the ability to analyze and synthesize devices working in several physical domains. This course gives an introduction to modelling and design of MEMS devices based on multiphysics, i.e coupled electrical, magnetical, mechanical and thermal phenomena. The course divides into two parts; one giving the foundation for device analysis and one focusing on design case studies. The emphasis of the first part is on analysis of devices using a combination of analytical treatment, circuit simulation of lumped models and finite element analysis. The design case studies will be a selection of canonical MEMS devices and examples of recent advances in the field.

Topics of study (curriculum):

- Lumped model formulation in the electrical, mechanical and thermal domain
- Sensor and actuator principles
- Energy conserving transducers
- Dissipation and irreversible phenomena
- Analysis of system dynamics
- Lumped model simulation with circuit simulator
- Coupled domain modelling and simulation
- CAD tools
- Mechanical, electrical and thermal design
- Foundry process design rules
- MEMS-design case studies, for example: packaging, piezoresistive pressure sensor, projection displays, capacitive accelerometer, rate gyroscope, DNA amplification and gas sensor

Learning outcome

The course will enable the students to achieve the following learning outcome:

Knowledge

Upon successful completion of this course you will be able to describe the working principles of a range of MEMS devices and identify methods that can be used to analyse their performance.

Skills

Upon successful completion of this course you will be able to apply analytical and numerical methods to predict the behavior of a variety of MEMS sensors and actuators and evaluate their performance. You will be able to relate design parameters to performance in order to reach design goals.

General Competence

Upon successful completion of this course you will have knowledge and insight into MEMS design that can also be applied to other electromechanical systems. You will have hands-on experience with conducting a design under the constraints of a given process, as well as to report and discuss the results.

Sensor Interface (10 ECTS)

The main focus in this course would be on front-end analog circuits for MEMS sensors. The course begins with brief introduction on different sensors and their signals and will continue with discussions on areas such as smart MEMS interfaces, calibration techniques and error sources. During the course we will take a closer look at various properties of front-end circuits such as noise figure, impedance matching, band-width and gain. At the end a few case-studies from real-life will be given.

Content:

- Low noise, high gain amplifiers
- Low power design
- Filter design
- AD Converters
- High linearity amplifier
- Front-end design with AGC/TVG functions, practical solutions
- Front-end impedance matching
- Low- and high-bandwidth reception
- Front-end noise figure estimation
- High-voltage sensor driver
- High-speed interface
- Smart sensors
- ASIC design

Learning outcome

The course will enable the students to achieve the following learning outcome:

Knowledge

Upon completion of this course, the student should be able to:

- Verify different sensor front-end techniques
- Explain different interface circuits for MEMS sensors
- Design front-end and signal conditioning circuits for sensors

Skills

Students will be able to design, simulate and do calculations on electronic front-end circuits for MEMS (Micro Electro Mechanical Systems) sensors. Students will also learn how to search for the latest publications in the field.

General Competence

The students will be familiar with the use of microsensors and their applications in practical life. Students will be able to present their work in a scientific way by written report and oral presentation.