MICRO-617

Energy Autonomous Wireless Smart Systems

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Cursus	Sem.	Type
Electrical Engineering		Opt.
Microsystems and Microelectronics		Opt.

Language of teaching	English
Credits	3
Session	
Exam	Multiple
Workload	90h
Hours	**42**
Courses	42
Number of positions	**16**

Frequency

Every 2 years

Remark

Next time: Spring 2027

Summary

The course provides in depth knowledge on how to design an energy autonomous microsystem embedding sensors with wireless transmission of information. It covers the energy generation, power management, and data processing and transmission with an emphasis on low-power and energy efficient operation.

Content

The objective of the course is to get in depth knowledge and experience on how to design an energy-autonomous microsystem embedding sensors with the transmission of the information with a wireless link. All the segments of the microsystem will be covered: the energy sources, power conversion, local energy storage, power supply management, sensor operation modes, signal conditioning, processing and storage, communication link, with an emphasis on low-power and energy efficient operation. The main sources of power consumption, the limitations and properties of different technologies, and the key techniques for reducing power consumption and improving energy efficiency will be identified. Based on this understanding, the trade-offs and key issues involved in the selection and design of a suitable low power autonomous wireless link will be highlighted.
On the system side, we will cover the design aspects that often precede the actual design process, leading from the ideas and requirements to an initial system specification and block diagram. We illustrate how decisions made at this point can have a tremendous impact on the efficiency of the final design due to the significant degrees of freedom available at this early stage of the design process. In this regard, we will discuss the important tradeoffs that can be considered for example in terms of how a certain functionality is realized and which components are most appropriate for the task at hand. We will base our discussion on the different components described in more detail throughout the course and we will illustrate the available tradeoffs with corresponding case studies.
At the end of the course, the participants will have gained knowledge on the state of the art and research trends in the field of energy autonomous wireless systems. The participants will be able to select, among the various possible energy sources and communication links, the best ones in function of given specifications. They will then be able to select appropriate components and perform system-level design so as to obtain an autonomous wireless sensing system meeting applicative needs. They will have an understanding of the established technologies, commercially available, of those currently under development and of the research opportunities in the field.

Introduction to Energy Autonomous Wireless Systems (C. Dehollain/1h)
- Description of course organization and content
- Introduction to EAWS, building blocks, state of the art, applications, case studies

RF, Inductive and Acoustic Powering and Backscattering Wireless Communication (C. Dehollain/6h)
- Near field, far field and ultrasonic remote powering
- AC to DC converter (rectifier) and voltage regulator dedicated to magnetic, electro-magnetic and electro-acoustic

coupling
- Charge storage on a large load capacitor, on a super-capacitor and on a rechargeable battery
- Remote powering RFID smart systems and sensor nodes
- Backscattering data communication for telecoms and biomedical application
- Load modulation for telecoms and biomedical applications

Digital low power VLSI design (A. Burg/3h)
- Power consumption in VLSI systems
- Low-power IC design techniques and physical limitations (reliability)
- Technology selection

System level design: Case studies (A. Burg/3h)
- System-level design tradeoffs for low power: processing/storage/communications
- Component selection and integration
- Power management
- Case studies

Wireless communications (A. Burg/7h)
- Introduction: applications, characteristics, protocols and models;
- The wireless channel: propagation principles, link budget;
- Access and controls: coding, modulations, medium access controls, performance metrics;
- Existing wireless solutions: proprietary, standardized;
- Practical constraints with energy harvesting

Antennas for Energy Autonomous Wireless Smart Systems (A. Skrivervik/ 7h)
-Physical limitations
-Miniaturization techniques
-Fundamental issues with simulations and measurements

Ultra-low power and efficient electronics (F. Maloberti/7h)
- Converters for power sources and energy storage
- Electronics strategies for energy harvesters
- Electronics for sensors and low-power sensor usages
- Sensor selection criteria for low-power consumption
- Low-energy sensor data processing, storage and transmission strategies

Seminars
A. Skrivervik (3h)
A. Burg (4h)
F. Maloberti (1h)

Keywords

Autonomous, Electronics, Energy, Harvesting, Ultra Low-Power, Sensors, Communication

Learning Prerequisites

Required courses

Prior knowlege / basics in electronics and in microelectronics

Assessment methods

Report and oral presentation

Resources

Moodle Link

- https://go.epfl.ch/MICRO-617