Course guide
300266 - LOWPOW - Low-Power Systems with Energy Harvesting

Last modified: 06/06/2024

Unit in charge: Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.

Degree: MASTER'S DEGREE IN APPLIED TELECOMMUNICATIONS AND ENGINEERING MANAGEMENT (MASTEAM) (Syllabus 2015). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

Academic year: 2024 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: OSCAR LOPEZ LAPEÑA

Others: Primer quadrimestre:
OSCAR LOPEZ LAPEÑA - NMAS2
JOSE POLO CANTERO - NMAS2

PRIOR SKILLS

Ansy C programming, analysis and design of basic analog and digital electronic circuits using passive and active electronic components and basic knowledge on microcontrollers.

REQUIREMENTS

No further requirements.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Generical:
03 DIS. (ENG) Diseñar aplicaciones de alto valor añadido basadas en las Tecnologías de la Información y las Comunicaciones (TIC), aplicadas a cualquier ámbito de la sociedad.

Transversal:
02 SCS. SUSTAINABILITY AND SOCIAL COMMITMENT. Being aware of and understanding the complexity of social and economic phenomena that characterize the welfare society. Having the ability to relate welfare to globalization and sustainability. Being able to make a balanced use of techniques, technology, the economy and sustainability.
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

Basic:
CB6. Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context.
CB9. Students will be able to communicate their conclusions and the knowledge and ultimate reasons that support them to specialized and non-specialized audiences in a clear and unambiguous manner.
CB10. Students will acquire learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.

TEACHING METHODOLOGY

Lectures and laboratory hands-on work.

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course the student should be able to:
1. Program low-power Microcontrollers (MSP430) to implement a wireless sensor node.
2. Use power consumption monitoring tools during program debugging.
3. Identify the power consumption factors on a Microcontroller based system.
4. Understand power management strategies and propose design alternatives to reduce power consumption.
5. Understand the architecture of low-power energy harvesting systems.
6. Select energy transducers and secondary batteries to power autonomous systems.
7. Design power conditioner circuits for low-power energy harvesting systems.

STUDY LOAD

Type	Hours	Percentage
Self study	48,0	64.00
Hours large group	4,0	5.33
Hours medium group	23,0	30.67

Total learning time: 75 h

CONTENTS

Ultra-low-power embedded systems

Description:
Ultra-low-power microcontrollers: architecture, power consumption factors and operating modes. Programming basics, interrupts programming and software optimization.

Related activities:
Lectures, laboratory exercises and project

Full-or-part-time: 23h
Theory classes: 2h
Practical classes: 6h
Self study : 15h

Analog front and back ends

Description:
Analog-to-digital converters. Comparator and digital input ports. Timers/counters and capture/compare registers. Digital-to-analog converters. Output digital ports and PWM outputs.

Related activities:
Lectures, laboratory exercises and project

Full-or-part-time: 10h
Practical classes: 4h
Self study : 6h

Power management strategies

Description:
Analisys of energy consumption of CMOS circuits. Dynamic power management: break-even time and switching policies. Dynamic voltage and frequency scaling: supply voltage and frequency optimization.

Specific objectives:
Desc

Related activities:
Lectures, laboratory exercises and project

Full-or-part-time: 8h
Theory classes: 1h
Practical classes: 3h
Self study : 4h

Batteries and energy supervision

Description:
Characteristics of secondary batteries. Overcharge and undercharge protection circuits. State of charge and state of health monitoring

Related activities:
Lectures, laboratory exercises and project

Full-or-part-time: 6h
Theory classes: 0h 10m
Practical classes: 1h 50m
Self study : 4h

Energy harvesting and power conditioning

Description:
Low-power DC/DC switching power converters. Photovoltaic energy harvesting: irradiation analysis and system design. Alternative power sources: mechanical, thermal and RF energy harvesting

Related activities:
Lectures, laboratory exercises and project

Full-or-part-time: 28h
Theory classes: 3h
Practical classes: 6h
Self study : 19h

ACTIVITIES

Lectures

Description:
Oral presentation

Specific objectives:
Introduce a new subject

Material:
Commented slides and electronic books available from atenea

Delivery:
None

Full-or-part-time: 7h
Theory classes: 3h
Self study: 4h

Laboratory exercises

Description:
Programming exercises

Specific objectives:
Acquire practical experience on programming a ultra-low-power micrcontroller and low-power design techniques

Material:
Laboratory guide sheet, computer, basic electronic instruments, training boards and compilers.

Delivery:
None

Full-or-part-time: 29h
Theory classes: 9h
Self study: 20h

Low-power energy harvesting project

Description:
Conception, design and implementation of a low-power energy harvester

Specific objectives:
Apply new knowledge to a real design problem

Material:
Project guide sheet, computer, basic electronic instruments, training boards and compilers.

Full-or-part-time: 36h
Practical classes: 12h
Self study: 24h

Individual assessment (exams)

Description:
Exams

Full-or-part-time: 3h
Theory classes: 0h 30m
Practical classes: 2h 30m

GRADING SYSTEM

EXAMINATION RULES.

Programming exam (20 %), laboratory project (60 %) and final exam (20 %).

BIBLIOGRAPHY

Basic:
- Benini, Luca. Dynamic power management: design techniques and CAD tools. Boston: Kluwer, 1998. ISBN 079238086X.
- Jiménez, Manuel; Palomera, Rogelio; Couvertier, Isidoro. Introduction to Embedded Systems [Recurs electrònic]: using microcontrollers and the MSP430 [on line]. New York: Springer, 2014 [Consultation: 20/10/2022]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-1-4614-3143-5. ISBN 9781461431435.
- Luecke, Gerald. Analog and digital circuits for electronic control system applications: using the TI MSP430 microcontroller. Amsterdam: Elsevier/Newnes, 2005. ISBN 0750678100.
- Davies, J. H. MSP430 microcontroller basics. Oxford: Newnes, 2008. ISBN 9780750682763.

RESOURCES

Audiovisual material:
- Nom recurs. Resource

Other resources:
MSP430FR5969 LaunchPad Evaluation Kit
Photovoltaic panels illuminated by power LEDs
Low-power solar energy harvesting board