Course guide
240327 - 240IIT33 - Sensors and Communications

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.
Degree: MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Optional subject).
Academic year: 2023 ECTS Credits: 4.5 Languages: Catalan, Spanish

LECTURER
Coordinating lecturer: Calomarde Palomino, Antonio
Others:

PRIOR SKILLS
It is convenient to have passed the subject "Ampliació d'Electrònica"
C / C ++ language programming
Basic knowledge of microcontrollers

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMEI07. Ability to design electronic systems and industrial instrumentation.
CEETI2. (ENG) Modelar sistemes de comunicació i gestió de dades entre processos mitjançant protocols de comunicació i de forma segura. (Competència específica associada a l'especialitat en Tecnologies de la Informació per a la Industria).
CEETI5. (ENG) Disseñar sistemas de comunicación que enlacen sensores, controladores e actuadores (Competència específica associada a l'especialitat en Tecnologies de la Informació per a la Industria).

Generical:
CGMEI08. (ENG) Aplicar els coneixements adquirits y resoldre problemas en entorns nous o poc coneguts dintre de contextos més amplis i multidisciplinaris.

TEACHING METHODOLOGY
The course uses, approximately, the exposition/participation methodology in 25%, individual work in 50%, and group work in 25%. Cooperative work techniques and problem- and project-based learning techniques are also used. The realization of the lab sessions is a condition to pass the subject.

LEARNING OBJECTIVES OF THE SUBJECT
Understand, analyze and know how to apply the appropriate techniques for IoT in different industrial fields

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>20.3</td>
<td>18.03</td>
</tr>
<tr>
<td>Self study</td>
<td>72.0</td>
<td>63.94</td>
</tr>
<tr>
<td>Hours small group</td>
<td>20.3</td>
<td>18.03</td>
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</tbody>
</table>
### CONTENTS

#### Sensors and Their Characteristics

**Description:**  
Resolution of a Sensor  
Accuracy of a Sensor  
Gain Error, Offset and Offset Drift of a Sensor  
Linear and Nonlinear Characteristics of a Sensor  
Transient and Steady State Responses of a Sensor  
'Static' and 'Dynamic' Characteristics of a Sensor

**Full-or-part-time:** 12h  
Theory classes: 5h  
Self study: 7h

#### Analog Signal Conditioning in Instrumentation

**Description:**  
content english

**Full-or-part-time:** 12h  
Theory classes: 5h  
Self study: 7h

#### Noise and Coherent Interference in Measurements

**Description:**  
Descriptions of Random Noise in Circuits  
Propagation of Gaussian Noise through Linear Filters  
Broadband Noise Factor and Noise Figure of Amplifiers  
Spot Noise Factor and Figure

**Full-or-part-time:** 12h  
Theory classes: 5h  
Self study: 7h

#### Introduction to the Internet of Things

**Description:**  
The meaning of IoT  
A brief history of IoT  
Technologies that enable the IoT paradigm  
The technical challenges facing IoT ecosystems  
Opportunities and potential applications

**Full-or-part-time:** 1h 30m  
Theory classes: 0h 30m  
Self study: 1h
IoT System Architectures and Standards

**Description:**
Key considerations for IoT architectures
Cloud, fog, and edge paradigms
The role of gateways in IoT
IoT internetworking approaches
Standards that enable practical IoT deployment and interoperability

**Full-or-part-time:** 1h 30m
Theory classes: 0h 30m
Self study: 1h

Introduction to Embedded Systems

**Description:**
An overview of embedded systems
Examples of embedded systems
Features of embedded systems
Software for embedded systems
Embedded systems programming and debugging

**Related activities:**
C Introduction and integrated development environment

**Full-or-part-time:** 5h
Theory classes: 0h 30m
Laboratory classes: 1h 30m
Self study: 3h

Hardware Platforms for IoT

**Description:**
What is a hardware platform
Types of memory
Power saving techniques
Types of sensors
Analog-to-digital conversion

**Full-or-part-time:** 1h 30m
Theory classes: 0h 30m
Self study: 1h
The Arm Cortex-M4 Processor Architecture

Description:
What is the Arm architecture
Arm processor families
The ARM Cortex-R series
The Arm Cortex-M series

Related activities:
Digital I/O access on ST Nucleo-64 boards

Full-or-part-time: 5h
Theory classes: 1h
Laboratory classes: 2h
Self study: 2h

Introduction to Cortex-M4 Programming

Description:
Cortex-M4 Processor Overview
Cortex-M4 Block Diagram
Cortex-M4 Registers
Cortex-M4 Memory Map
ARM Cortex-M4 Processor Instruction Set

Full-or-part-time: 5h
Theory classes: 1h
Self study: 4h

MCU extensions

Description:
Digital inputs and outputs
Analog inputs and outputs
Timers and PWM
Serial communication
DMA

Full-or-part-time: 9h
Theory classes: 2h
Self study: 7h

Interrupts and Low Power Features

Description:
Exception and Interrupt Concepts
Core Interrupts
Using Port Module and External Interrupts
Timing Analysis
Program Design with Interrupts
Sharing Data Safely Between ISRs and Other Threads

Full-or-part-time: 3h
Theory classes: 1h
Self study: 2h
Real Time Operating Systems

**Description:**
Operating System Overview
What is an Operating System?
Functions, types, and services of Operating Systems

Real-Time Operating System (RTOS)
RTOS overview
RTOS task scheduling
Keil RTX RTOS

RTOS on Mbed Platform
Mbed RTOS API
Using Mbed RTOS API for your project
Threads, Mutex, and Semaphore

**Full-or-part-time:** 3h
Theory classes: 1h
Self study : 2h

IoT Connectivity

**Description:**
Introduction to Bluetooth
Bluetooth Low Energy (BLE)
BLE profiles
New features in Bluetooth 5
ZigBee
Wireless Local Area Networks (WLAN)
IEEE 802.11 based WLANs
IEEE 802.11 enhancements
Low-power Wide Area Networks (LPWAN)
LoRaWAN
Narrow-band IoT (NB-IoT)

**Related activities:**
Communication with bluetooth
Communication via Wifi
LoraWan

**Full-or-part-time:** 21h
Theory classes: 4h 30m
Laboratory classes: 4h 30m
Self study : 12h
The Cloud

Description:
What is the cloud?
Virtualization
Cloud interfacing protocols
Big data processing
Device management platform

Full-or-part-time: 7h
Theory classes: 1h
Self study : 6h

IoT Security

Description:
Importance of security in IoT
Threat modeling
Code signing
Encryption
Wireless security

Full-or-part-time: 11h 30m
Theory classes: 2h
Laboratory classes: 1h 30m
Self study : 8h

Current and Future trends of IoT

Description:
Current state of IoT landscape
Machine learning
Edge computing
Platform Security Architecture
Research topics

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

GRADING SYSTEM

The final grade for the course will be:
NF = max (0.60 * NE + 0.4 * NL; 0.6 * NEF + 0.4 * NL)
NF: Final note.
NE: Exercises, problems and/or tests.
NEF: Final exam grade
NL: lab. sessions.
BIBLIOGRAPHY

Basic: