Course guide
295127 - 295II011 - Data Acquisition and Instrumentation

Last modified: 07/09/2026

Unit in charge: Barcelona East School of Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.

Degree: MASTER'S DEGREE IN INTERDISCIPLINARY AND INNOVATIVE ENGINEERING (Syllabus 2019). (Compulsory subject).
ERASMUS MUNDUS MASTER IN SUSTAINABLE SYSTEMS ENGINEERING (EMSSE) (Syllabus 2024). (Optional subject).
MASTER'S DEGREE IN TECHNOLOGIES FOR DISTRIBUTED ENERGY SYSTEMS (Syllabus 2025). (Optional subject).

Academic year: 2026 **ECTS Credits:** 6.0 **Languages:** Spanish, English

LECTURER

Coordinating lecturer: HERMINIO MARTINEZ GARCIA

Others: Primer quadrimestre:
POL AINOZA SEGU - Grup: T12
ROBERT CALATAYUD CAMPS - Grup: T11, Grup: T12, Grup: T13
JOSE MARIA JOVE CASALS - Grup: T11

PRIOR SKILLS

A course on basic electronics or fundamental of electronics such as “Electronics Systems” (STI – 820017), taught at the EEBE.

REQUIREMENTS

A course on basic electronics or fundamental of electronics such as “Electronics Systems” (STI – 820017), taught at the EEBE.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMUEII-01. Apply sensing, instrumentation and data acquisition technologies for the characterization, monitoring and control of the state of a system, plant or process.

Generical:
CGMUEII-01. Participate in technological innovation projects in multidisciplinary problems, applying mathematical, analytical, scientific, instrumental, technological and management knowledge.

Transversal:
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.
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.

LEARNING RESULTS

Knowledges:
K2. Identify the structural and functional particularities and applicable regulations of decentralised electrical systems.
K3. Recognise and compare the electronic subsystems used in processing and managing electrical energy in distributed electrical systems.
K06. Design and implement systems and applications in the field of intelligent production systems.
K05. Design and implement acquisition, actuation and control systems that integrate electronic, electrical and mechanical technology.
K01. Design and implement modelling techniques to describe the behaviour of a system. Predict the stability of the system and apply control techniques in different scenarios.

Skills:
S2. Analyse the electronic subsystems required in a renewable energy plant and evaluate automation and control technologies for energy management of smart electrical grids and microgrids in a decentralised energy system.
S02. Educate well-trained and enthusiastic professionals with broad multidisciplinary knowledge of tools and technologies for sustainable systems engineering. Training takes place in an international and multicultural environment to stimulate global collaboration in addressing complex challenges in a wide range of application fields, such as logistics, transport, advanced production systems, energy systems management and health improvement.

Competences:
C4. Apply the knowledge acquired and appropriate methodologies to analysis and design in the field of decentralised electrical systems with renewable sources.
C03. Manage the acquisition, organisation, analysis and presentation of data and information in the field of complex systems engineering and critically assess the results obtained.
C05. Propose advanced scientific and technological solutions to complex industrial challenges in areas such as intelligent production, robotic systems, logistics, fault detection and predictive maintenance.
C02. Work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

TEACHING METHODOLOGY

- Master classes: 60%.
- Lab sessions: 30%.
- Conferences and workshops: 10%.

LEARNING OBJECTIVES OF THE SUBJECT

Following successful completion of the course, students should be able to:

1. Describe the elements in a measurement system and their function.
2. Describe sensor principles for electric and non-electric measurements.
3. Explain the principles of operation of the main types of sensors.
4. Utilize the merits of various types of sensors for a wide range of applications.
5. Understand the limitations in the performance of instrumentation systems.
6. Analyze the specifications of various types of sensors and understand the main characteristics of sensors.
7. Implement instrumentation systems.
8. Select appropriate sensors for a given application and design simple electronic sensor interface systems.
9. Select components for instrumentation systems.
10. Present possible coupling mechanisms between noise sources and the measurement circuit, and how the uncertainty in a measurement can be estimated and presented.

The course consists of a set of lectures to introduce sensors and advanced electronics systems in the framework of measurements, data acquisition systems and instrumentation technologies. As a consequence, some lab sessions and personal work supervised by faculty to develop a project. The course will be PBL oriented. In particular, the course will be PBL oriented in order to design, simulate and implement a data acquisition systems (DAS) devoted to sense a set of environment or meteorological variables.

STUDY LOAD

Type	Hours	Percentage
Self study	96,0	64.00
Hours large group	27,0	18.00
Hours small group	27,0	18.00

Total learning time: 150 h

CONTENTS

Input Signal Conditioning: Low Power Amplification and Analog Processing.

Description:
• General concepts and terminology in data acquisition systems (SAD).
- General structure of a measurement and control system.
• Review of signal amplification.
• Differential amplifier (DA) and instrumentation amplifiers (IA).
- CMRR (common mode rejection ratio) and PSRR (power supply rejection ratio) errors.
- Examples of application.
• Isolation amplifiers (AA).
- IMRR (isolation mode rejection ratio) errors.
- Examples of application.
• Static limitations in integrated amplifiers.
- Input offset voltage. Low offset voltage VFOAs.
- Offset currents and bias currents. Low bias current VFOAs.
- Compensation techniques for offset errors in VFOAs.
- Effect of the offset voltage, and bias and offset currents on the behavior of the circuit.
- Temperature effects on static limitations.
• Dynamic limitations.
- VFOA's open loop gain.
- VFOA's open and closed loop gain responses. Gain-bandwidth product.
- Input and output impedances.
- Transient response. Slew-rate limitations.
- Full power bandwidth (FPB).
- VFOA's frequency response on the behavior of a circuit.
- Temperature effects on dynamic limitations.
• Linearization circuits.
- The reason of linearization.
- Linearization based on logarithmic and exponential amplifiers.
- Linearization based on analog multipliers.
• Linear signal filtering.
- Design process based on first and second order RC active filtering cells.
• Analog switches and multiplexers.
- Application to the PGDA (programmable gain differential amplifier).
• Data registration and dataloggers.
- Data logging versus data acquisition.
- Communication protocols.
- Specifications
- Applications.
- Examples.

Specific objectives:
Study the analog front-end in data acquisition systems, especially their DC and AC errors in order to obtain optimal designs.

Related activities:
• Lectures on input signal conditioning.
• Laboratory sessions (Activity 1): Simulation of input signal conditioning circuits.
• Laboratory sessions (Activity 2): Static and dynamic limitations in integrated amplifiers.

Full-or-part-time: 31h
Theory classes: 7h
Laboratory classes: 4h
Self study : 20h

Capture of the Measurement Signal: Sensors.

Description:
• Classification of sensors.
- Linear and non-linear sensors.
• Analog and digital sensors.
• Modulator and generator sensors.
• Voltage divider for the acquisition of measurements.
• Wheatstone bridge for acquisition of measurements.
• Alternatives to the Wheatstone bridge: Pseudo-bridges.

Related activities:
• Lectures on sensing elements and devices.
• Laboratory sessions (Activity 3): Implementation of input signal conditioning stages for a particular sensing element.

Full-or-part-time: 17h
Theory classes: 4h
Laboratory classes: 2h
Self study : 11h

Output Signal Conditioning: Actuators and Final Control.

Description:
• Electronics associated with electromechanical actuators.
- Opto-isolation of input and output signals.
• Power amplifiers.
- Darlington stages and complementary-symmetry push–pull amplifiers.
- Operational power amplifiers.
- Commercial ICs for power amplifiers and low frequency amplifiers.
• Stages with thyristors (SCR) and TRIACs.
- Control of activation. Activation with DIACs.
• Industrial automatic controllers.
- Discontinuous and continuous controllers.
- Tuning of electronic controllers.
• Analog and digital implementation of electronic controllers.
- Discretization of analog signals and control laws.
- Analog controllers and their discretization.
- Digital implementation.
• Introduction to digital filters and digital signal processors (DSPs).

Specific objectives:
• Lectures on output signal conditioning.
• Laboratory sessions (Activity 4): Simulation of output signal conditioning circuits.
• Laboratory sessions (Activity 5): Implementation of an analog subsystem for a complete data acquisition system.

Full-or-part-time: 31h
Theory classes: 7h
Laboratory classes: 4h
Self study : 20h

Microcontroller-Based Systems.

Description:
• Microcontroller basics.
• Components of a microcontroller system.
• Communications.
• Programming the microcontroller.
• Interfacing sensors and actuators.

Specific objectives:
• Understand microcontroller principles and develop the necessary abilities to develop systems based on microcontrollers.

Related activities:
• Lectures on microcontroller systems.
• Laboratory session (Activity 6): Introduction to a microcontroller development platform.
• Laboratory session (Activities 7 and 8): Programming the microcontroller.

Full-or-part-time: 44h
Theory classes: 10h
Laboratory classes: 6h
Self study : 28h

Analog-to-Digital (ADC) and Digital-to-Analog (DAC) Conversion.

Description:
• Sampling.
• Sample & Hold.
• Quantization.
• Accuracy.
• Digital-to-Analog conversion.
• Nyquist ADC's.
• Sigma-Delta ADC.
• Digital-to-Analog conversion.

Specific objectives:
• Understand ADC and DAC principles and develop the necessary abilities to use them in a microcontroller system.

Related activities:
• Lectures on ADC and DAC conversion.
• Laboratory sessions (Activities 9 and 10): ADC conversion.

Full-or-part-time: 27h
Theory classes: 6h
Laboratory classes: 4h
Self study : 17h

GRADING SYSTEM

Any academic fraud, plagiarism or use or possession of unauthorised means in an assessment activity leads to a mark of zero (0) for the affected test or assignment. Furthermore, in accordance with the University's regulations, if disciplinary proceedings are initiated the subject is recorded as "Pending Assessment" until a decision is reached. These incidents are managed in accordance with the **Action Framework for Academic Integrity in Assessment at the UPC**.

- Midterm exams and/or activities: 20 %.
- Final exam: 40 %.
- Lab sessions and activities: 30 %.
- Guided activities: 10%.

Since it is a course with continuous (ongoing) assessment, there is not final re-assessment test.

EXAMINATION RULES.

It will be published during the first week of the course.

BIBLIOGRAPHY

Basic:
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- Chesmond, Colin J. Control system technology. London [etc.]: Edward Arnold, 1984. ISBN 0713135085.
- Chesmond, Colin J. Basic control system technology. London [etc.]: Edward Arnold, 1990. ISBN 034050143X.
- Gayakwad, Ramakant A.; Sokoloff, Leonard. Analog and digital control systems. Englewood Cliffs, NJ: Prentice-Hall, cop. 1988. ISBN 0130326739.
- Johnson, Curtis D. Process control instrumentation technology. 8th. Upper Saddle River: Prentice Hall, cop. 2006. ISBN 0131976699.
- Pallás Areny, Ramón; Webster, John G. Analog signal processing. New York [etc.]: John Wiley & Sons, 1999. ISBN 0471125288.

Complementary:
- Pérez García, Miguel Ángel. Instrumentación electrónica. Madrid: Paraninfo, cop. 2014. ISBN 9788428337021.
- Pallàs Areny, Ramón. Adquisición y distribución de señales. Barcelona: Marcombo Boixareu, DL 1993. ISBN 8426709184.
- Pallás Areny, Ramón. Sensores y acondicionadores de señal. 4ª ed. Barcelona: Marcombo Boixareu, cop. 2003. ISBN 8426713440.
- Pelgrom, Marcel. Analog-to-Digital Conversion [on line]. 3rd ed. Cham: Springer International Publishing, 2017 [Consultation: 06/05/2020]. Available on: http://dx.doi.org/10.1007/978-3-319-44971-5. ISBN 9783319449715.
- Zhu, Yifeng. Embedded systems with ARM cortex-M microcontrollers in assembly language and C. 3rd ed. Ballston Spa, NY: E-Man Press LLC, [2017]. ISBN 9780982692660.