Course guide
820030 - SCSB - Sensors and Signal Conditioners

Last modified: 14/06/2023

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

Degree: BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: LEXA DIGNA NESCOLARDE SELVA

Others: Primer quadrimestre:
GEORGINA COMPANY SE - Grup: M15
LEXA DIGNA NESCOLARDE SELVA - Grup: M11, Grup: M12, Grup: M13, Grup: M14, Grup: M15

PRIOR SKILLS

Having passed the "Electronic Systems" subject.

REQUIREMENTS

Per G* ENG BIOMÈDICA
PROCESSAMENT DE SENYALS BIOMÈDICS - Irequisit
SISTEMES ELECTRÒNICS - Prerequisit
Per DG BIO-ELECT IND AUT
PROCESSAMENT DE SENYALS BIOMÈDICS - Irequisit
SISTEMES ELECTRÒNICS - Prerequisit
Per DG ELECT IND AUT-BIO
PROCESSAMENT DE SENYALS BIOMÈDICS - Irequisit

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Identify, Understand and apply the principles of sensors, conditioners and biomedical signal acquisition systems.

Transversal:
2. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.

TEACHING METHODOLOGY

Lectures, cooperative work, autonomous learning, project based learning.

LEARNING OBJECTIVES OF THE SUBJECT

Understanding the principles of the sensors used in biomedical applications. Acquiring the ability to understand and use conditioning circuits and signal acquisition systems suitable for the usual biomedical signals.

STUDY LOAD

Type	Hours	Percentage
Hours small group	15,0	10.00
Self study	90,0	60.00
Hours large group	45,0	30.00

Total learning time: 150 h

CONTENTS

T1. Introduction to biomedical signal acquisition systems

Description:
1.1 Structure of the measurement and acquisition systems for biomedical signals. Types of Sensors. Sensor classification. Security considerations.
1.2 General input-output configuration. Interferences and internal disturbances. Compensation techniques.
1.3 Static characteristics of measurement systems: Accuracy, fidelity, sensitivity. Linearity, resolution. Systematic errors. Random errors.
1.4 Dynamic characteristics of measurement systems: Zero order measurement systems. First-order measurement systems. Second order measurement systems.
1.5 Input characteristic: impedance

Specific objectives:
1. The student, will be able to explain and identify the concepts related to all the static and dynamic characteristics of sensors, in general.
2. The student, will be able to explain the structure of a biomedical signal acquisition system and to identify and classify the different sensors that are used and their generic characteristics.

Related activities:
1. Resolution of exercises on sensor characteristics.
2. Laboratory practice on static characterization of sensors.

Full-or-part-time: 8h
Theory classes: 4h
Laboratory classes: 2h
Self study : 2h

T2. Sensor and signal conditioning

Description:
2.1 Resistive sensors. Signal conditioning circuits: resistance measurement. Voltage and current dividers. Wheastone Bridge: Measurements by comparison and by deflection. Instrumentation Amplifiers. Interferences.
2.2 Variable reactance and electromagnetic sensors. Signal conditioning circuits: AC bridges and amplifiers. Carrier amplifiers and consistent detection. Specific conditioning for capacitive sensors. A / D and D / A converters.
2.3 Generating sensors. Signal conditioning circuits: Amplifiers with low drifts. Electromagnetic amplifiers. Load amplifiers. Noise in amplifiers. Drifts and noise in resistors.
2.4 Other detection methods: Sensors based on semiconductor junctions. Sensors based on ultrasound. Sensors based on optical fibers. Biosensors

Specific objectives:
1. The student will be able to describe the principles of operation of the sensors used in equipment acquisition of biomedical signals, the electric model and its advantages and limitations.
2. The student will be able to analyze the conditioning circuitry associated with sensors, select the most appropriate and perform basic designs.

Related activities:
1. Resolution of problems related to different types of conditioning circuits.
2. Resolution of problems related to acquisition systems.
3. Laboratory related to measures of resistance bridge circuit and differential amplifier.
4. Laboratory related to conditioning circuit for a piezoelectric sensor.

Full-or-part-time: 30h
Theory classes: 9h
Laboratory classes: 2h
Self study : 19h

T3. Biomedical sensors

Description:
3.1 Fundamental concepts. Signal and noise in the measurements. Characteristics of measurement systems. Determination of absolute values. Measurement unit systems.
3.2 Pressure measurements. Pressure units and requirements for pressure measurements. Direct and indirect pressure measurements.
3.3 Flow measurements. Flow units and requirements for flow and range measurements. Measurements of blood flow in individual vessels. Tissue blood flow measurements. Respiratory gas flow measurements.
3.4 Measures of movement and force. Objective and units of measurement. Measurement methods.
3.5 Bioelectric and biomagnetic measures. Units and requirements for bioelectrical and biomagnetic measurements. Electrode theory. Surface electrode potential. Microelectrode. Biomagnetism.

Specific objectives:
1. The student will be able to identify the components of a data acquisition system for biomedical applications and their functions. In addition, set up, analyze and perform basic designs.

Related activities:
1. Resolution of problems related to different types of conditioning circuits.
2. Resolution of problems related to acquisition systems.
3. Practice of conditioning circuit for piezoelectric sensor.
4. Configuration of an acquisition system for the non-invasive measurement of blood pressure project.
5. Design and implementation of conditioning circuits for the non-invasive blood pressure measurement project.

Full-or-part-time: 88h 20m
Theory classes: 28h
Laboratory classes: 7h
Self study : 53h 20m

Project: Design of a measurement system for biomedical signals with Biopac system.

Description:
Design of system to measurement biomedical non-invasive signals, by means of sensors, conditioning circuits and system acquisition with Biopac system.

Specific objectives:
1. Develop skills for teamwork.
2. The student will be able to carry out the design and implementation of biomedical signal measurement and acquisition systems.

Related activities:
In combination with the subject "Biomedical Signal Processing", carrying out a project in which the students designed a system of non-invasive measurement of biomedical signals with Biopac:
1- Selection of sensors and design of the conditioning circuits.
2- Configuration and programming of the acquisition system.
3- Processing of signals and obtain of the biomedical parameters.

Full-or-part-time: 23h 40m
Theory classes: 4h
Laboratory classes: 4h
Self study : 15h 40m

ACTIVITIES

Proyect.S1- CONFIGURATION OF A SYSTEM ACQUISITION

Description:
Laboratory of configuring a system with biomedical signal acquisition Biopac.

Specific objectives:
1. The students will be able to explain the characteristics of an acquisition system and set their parameters for a given application.

Material:
Biopac system in the lab.

Delivery:
Report with the results and analysis of the measures.

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

Proyect.S2- MEASUREMENT SYSTEM FOR BLOOD PRESSURE AND ECG

Description:
Project of design of a measurement system noninvasive blood pressure and ECG based on the use of sensors, conditioning circuits and a procurement system, by the integrating of circuits obtained in previous practices and complementing it with the signal processing necessary to obtain estimators blood pressure.

Specific objectives:
1. Develop skills for teamwork.
2. The student must be able to integrate circuits into the design and add to the project the signal processing necessary to obtain the blood pressure estimators.

Material:
Circuits and acquisition system available in the laboratory.

Delivery:
Work plan and final report.

Full-or-part-time: 19h 40m
Laboratory classes: 4h
Self study: 15h 40m

Practice 1- PRESSURE SENSOR: CHARACTERIZATION, AMPLIFICATION AND ADJUSTMENT OF THE ANSWER

Description:
Laboratory which objective is a design and characterization of a conditioning circuit for a pressure sensor with resistive bridge configuration.

Specific objectives:
1. Be able to explain the coupling between sensors with differential output and differential amplifiers.
2. To design basic structures of differential amplifiers and to obtain their characteristics.

Material:
Kit available in the laboratory.

Delivery:
Previous calculations, report on the measures and analysis.

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

Practice 2- PIEZOELECTRIC SENSOR: CONDITIONING OF A PIEZOELECTRIC SENSOR AND CHARGE MODE AMPLIFIER

Description:
Laboratory which objective is the design of the conditioning circuit for a piezoelectric sensor. In addition the characteristics of sensor will be determined.

Specific objectives:
1. To be able to explain the load amplifier used (SLOA033A), to design its parameters and to determine its characteristics.

Material:
Kit available in the laboratory.

Delivery:
Previous calculations, measurements and report analysis.

Full-or-part-time: 6h
Laboratory classes: 4h
Self study: 2h

GRADING SYSTEM

Midcourse Control: 20%
Laboratory activities: 20%
Project: 20%
Final exam: 40%
* This subject has not re-evaluation.

EXAMINATION RULES.

Late delivery or non delivery of individual tasks (cooperative work and in the Project) will penalize the final grade.
The completion of the laboratory practices and the project is a necessary condition to pass the course.

BIBLIOGRAPHY

Basic:
- Togawa, Tatsuo; Tamura, Toshiyo; Öberg, P. Ake. Biomedical sensors and instruments [on line]. 2a ed. Boca Raton: CRC Press, cop. 2011 [Consultation: 11/06/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=729635. ISBN 9781420090789.
- Pallás Areny, Ramón. Sensores y acondicionadores de señal. 4ª ed. Barcelona [etc.]: Marcombo Boixareu, cop. 2003. ISBN 8426713440.
- Pallás Areny, Ramón; Casas, Òscar; Bragós Bardia, Ramon. Sensores y acondicionadores de señal : problemas resueltos. Barcelona: Marcombo, cop. 2008. ISBN 9788426714947.

Complementary:
- Pérez García, Miguel Ángel. Instrumentación electrónica. Madrid: Paraninfo, 2014. ISBN 9788428337021.
- Webster, John G. Medical instrumentation : application and design. 4th ed. Hoboken: Wiley, 2009. ISBN 9780471676003.