



## IDENTIFYING DATA

### Advanced electronic sensors

Subject	Advanced electronic sensors			
Code	V05G306V01409			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	Spanish Galician			
Department				
Coordinator				
Lecturers				
E-mail				
Web	<a href="http://moovi.uvigo.gal">http://moovi.uvigo.gal</a>			

**General description** The main purpose of this subject is to train students in order that they become well-qualified to understand the physical principles and current techniques employed in the most recent electronic sensors technology. Course outline:

- + Optical fiber sensors.
- + Microelectromechanical sensors (MEMS).
- + Image sensors.
- + Acoustic wave sensors.
- + Ionizing radiation detection.

The documentation of the course will be in English. It will be taught in Galician and Spanish. It will be assessed in Spanish.

## Training and Learning Results

Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C63	(CE63/OP6) The ability to design and use optoelectronic sensors, micromechanical sensors (MEMS) and acoustic wave sensors.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

## Expected results from this subject

Expected results from this subject	Training and Learning Results	
Knowledge of the modes of operation and applications of fiber optic sensors.	B3	C63
Knowledge of the modes of operation and applications of microelectromechanical sensors.	B3	C63
Knowledge of the modes of operation and applications of acoustic wave sensors.	B3	C63
Ability to select and work with next generation electronic sensors.	B4	C63
Ability to evaluate the measurement systems uncertainty.	B3	C63
Ability to work in groups and to develop communications skills in order to elaborate and present technical reports related to the subject.	B9	C63 D4

## Contents

## Topic

Unit 1: Physical principles of measurements	<ul style="list-style-type: none"><li>- Pyroelectricity y piezoelectricity</li><li>- Hall effect</li><li>- Acoustic waves</li></ul>
Unit 2: Optical components of sensors	<ul style="list-style-type: none"><li>- Mirrors</li><li>- Lenses</li><li>- Waveguides</li></ul>
Unit 3: Interface electronic systems for sensors	<ul style="list-style-type: none"><li>- Precision circuits</li><li>- Low noise techniques</li></ul>
Unit 4: Advanced electronics sensors	<ul style="list-style-type: none"><li>- Optic sensors</li><li>- Microelectromechanical sensors</li><li>- Acoustic wave sensors</li><li>- Image sensors (CCD and CMOS sensors)</li><li>- Ionizing radiation detection</li></ul>
Unit 5: Sensor fusion	<ul style="list-style-type: none"><li>- Inertial measurement unit</li><li>- Mahony, Madgwick and Kalman filter</li></ul>

Groups B: 7 Practices of laboratory with sensors preferably not previously used by the students.

Groups C: Practice or practical realized with sensors preferably not preferably no previously used by the students. Always that it was possible, will facilitate the material so that the students work of autonomous form out of the laboratory.

## Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	1	2
Lecturing	17	8	25
Mentored work	1	12	13
Mentored work	2	18	20
Laboratory practical	12	40	52
Studies excursion	2	0	2
Project based learning	7	29	36

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Methodologies

	Description
Introductory activities	Subject presentation. Presentation of laboratory sessions, instrumentation and software resources to be used. Individual task. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.
Lecturing	The lecturer will explain in the classroom the main contents of the subject. The students individually have to manage the proposed bibliography to carry out a self-study process in a way that leads to acquire the knowledge and the skills related to the subject. The lecturer will answer the students' questions in the classroom or at the office. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.
Mentored work	The students have to manage basic concepts to search and select information in order to get a deeper understanding in some specific fields related to the subject. The lecturer will propose in the classroom the topic of this individual task and monitor the student's work in personalized attention sessions. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.
Mentored work	The students have to manage basic concepts to search and select information in order to get a deeper understanding in some specific fields related to the subject. The lecturer will propose in the classroom the topic of this individual task and monitor the student's work in personalized attention sessions. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.
Laboratory practical	Small-group activities designed to apply the main concepts and definitions of the subject. The student will be asked to acquire the basic skills to manage the laboratory instrumentation, software tools and components in order to construct and test electronic circuits. The student has to develop and demonstrate autonomous learning and collaborative skills. He/she is supposed to be able to manage bibliography and recently acquired knowledge. Possible questions can be answered in the laboratory sessions or at the lecturer's office. Software to be used: National Instruments (NI) LabVIEW and NI Multisim, and Arduino IDE. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.

Studies excursion	Large-group activities designed to apply, contrast and observe the knowledge within a particular context in an outdoor space. The student will acquire more knowledge about a specific type of sensors through a guided visit to a site where these sensors are being used. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.
Project based learning	Project-based learning: students have to develop a group activity that goes on over a period of time and address a specific problem. They have to design, schedule and carry out a set of tasks to achieve a solution. The assessment will be based on the quality of the proposed solution, the depth of content understanding demonstrated and the final presentation. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.

### Personalized assistance

Methodologies	Description
Lecturing	The students can attend tutoring sessions (individually or in a group). The information can find published in the web page: <a href="https://moovi.uvigo.gal/user/profile.php?id=11301">https://moovi.uvigo.gal/user/profile.php?id=11301</a> . In these sessions the lecturer will answer the students questions and also give instructions to guide the studying and learning process.
Laboratory practical	The students can attend tutoring sessions (individually or in a group). The information can find published in the web page: <a href="https://moovi.uvigo.gal/user/profile.php?id=11301">https://moovi.uvigo.gal/user/profile.php?id=11301</a> . In these sessions the lecturer will help students understand the work to be developed in the laboratory (components, circuits, instrumentation and tools).
Mentored work	The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will help students to deal with the monitored work.
Project based learning	The students can attend tutoring sessions (individually or in a group). The information can find published in the web page: <a href="https://moovi.uvigo.gal/user/profile.php?id=11301">https://moovi.uvigo.gal/user/profile.php?id=11301</a> . The lecturers will be available to help students in order to deal with the contents of the subject, the practices as well as the monitored work.

### Assessment

Description	Qualification	Training and Learning Results
Mentored work It will evaluate the number and the suitability of the bibliographic sources and the contents selected to tackle to thematic assigned. The final mark of this first part of the work (NTT1: Note of the Mentored Work 1) will be comprised between 0 and 10 points. They will evaluate the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4).	15	B3 C63 D4 B4 B9
Mentored work It will evaluate the work taking into account the quality of the results obtained, of the presentation and analysis of the same, as well as of the final memory delivered. The final mark of this second part of the work (*NTT2: Note of the Mentored Work 2) will be comprised between 0 and 10 points. They will evaluate the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4).	35	B3 C63 D4 B4 B9
Laboratory practical The lecturers will check the level of compliance of the students with the goals related to the laboratory skills. They will consider the work of the students carried out before the practical session to prepare the proposed tasks, the attendance, and the quality of the work done. The mark for this part (FML: Final Mark of Laboratory) will be graded in a 10 points scale. In these practices, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be assessed.	30	B3 C63 D4 B4 B9
Project based learning The lecturers will consider the quality of the results obtained, their analysis, and the classroom presentation. Marks will be (GPM: Group Project Mark) assigned in a 10 points scale. In these tasks, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be evaluated.	20	B3 C63 D4 B4 B9

### Other comments on the Evaluation

#### 1. Continuous assessment

According to the guidelines of the degree and the agreements of the academic commission, a *continuous assessment learning scheme* will be offered to the students.

When the students go to the lectures regularly (less than 10% unjustified absence), or miss at most one B laboratory session, or miss at most one C group project session, **they will be assessed by continuous assessment**. An attendance register will be made at each session.

The subject comprises three different parts: theory (15% and 35 %), laboratory practical (30%) and group project (20%).

Once a task has been assessed, the students cannot do/repeat the task at a later date. The marks are valid only for the current academic course. The final grade for the students which have selected this option, may not be "no standing".

### **1.a Theory**

In the first weeks of the course each student will be asked to carry out a task individually with the help of the lecturer about a topic related to the subject. The work will be divided in two parts (15% and 35 %). In order to assess the first part, the lecturer will consider the quality of the sources of information and the contents selected. In order to assess the second part, the lecturer will consider the quality of the results obtained, their analysis, the final report, and the classroom presentation. The students will be informed of the deadline by the lecturer. Marks will be (TWM: Tutored Work Mark) assigned in a 10 points scale. If the students present their works after the deadline the WM will be 0.

The final mark of this part will be:

$$\text{FMT (Final Mark of Theory)} = \text{TWM (Tutored Work Mark)}$$

It is compulsory to get a score of  $\text{FMT} \geq 5$  and to have attended a lectures regularly (less than 10% unjustified absence) to pass this part by continuous assessment.

### **1.b Laboratory**

Six laboratory sessions and one outdoor study (if it possible to schedule this activity) are scheduled. Each practical session lasts approximately 120 minutes and the students will work in pairs.

The lecturers will assess the individual student work. They will consider the individual work carried out before the laboratory session to prepare the proposed tasks, the laboratory attendance, as well as the student work in the laboratory.

In the first session, the practice 1 will be performed. The mark of this session (P1M: Practice 1 Mark) will be assigned in a 10 points scale.

In the remaining sessions, a practical work related to process control modules available in laboratory will be carried out. In order to assess this work, the lecturer will consider the quality of the results obtained, their analysis, and the classroom presentation. The final mark of this part, (LWM: Laboratory Work Mark), will be graded in a 10 points scale.

The outdoor study will be also assessed in a 10 points scale (OSM: Outdoor Study Mark).

The final mark of this part is calculated as the weighted sum of the three individual marks:

$$\text{FML (Final Mark of Laboratory)} = 0.15 \cdot \text{P1M} + 0.75 \cdot \text{LWM} + 0.10 \cdot \text{OSM}$$

Attendance at these classes is compulsory to pass this part by continuous assessment. If the student miss more than one session without a valid documented reason (medical, bereavement or other) he/she will be assigned a grade of 0 for this part (FML=0).

### **1.c Group project**

The classroom workload will be carried out in the C group project sessions. In the first session lecturers will present the objectives and the schedule of the project. They also assign a specific project to each group. In this sessions the lecturer will monitor the group work and the individual student work.

In order to assess the project, the lecturer will consider the quality of the results obtained, their classroom presentation and analysis, and the quality of the final report. The students will be duly informed of the report deadline by the lecturer. The final mark of this part, (GPM: Group Project Mark), will be assessed in a 10 points scale.

In order to pass this part by continuous assessment, the student can not miss more than one project sessions and only if this absence is duly justified.

### **1.d Final mark of the subject**

In order to pass the subject by continuous assessment, students will be required:

- + to obtain  $\text{FMT} \geq 5$ , and
- + no more than one missed practical session, and
- + no more than one missed group project session.

The weighted *points* from all assessed parts are added together to calculate the final *mark(FM)*. The following weightings will be applied: 50% theory, 30% laboratory and 20% group project.

$$FM = 0.50 \cdot FMT + 0.30 \cdot FML + 0.20 \cdot GPM$$

A final mark higher than five points ( $FM \geq 5$ ) should be achieved in order to *pass the subject*.

However, when:

- +  $FMT < 5$ , or
- + more than one missed practical session, or
- + more than one missed group project session,

the final mark (FM) will be:

$$NF = \min\{ 4.9, 0.50 \cdot FMT + 0.30 \cdot FML + 0.20 \cdot GPM \}$$

## 2. Global assessment

If a student prefers a different educational policy he/she can take an exam on a scheduled *date*. The date will be specified in the academic calendar. This exam will comprise three parts (similar to the activities completed by the continuously assessed students):

- + an **exam** or a task monitored by a tutor (**tutored work**),
- + a **practical exam**,
- + a previously assigned **project**.

The tutored work and the project will be assigned following the procedure described in advance by the lecturer.

### 2.a Theory

#### 2.a.1 Theory Exam or Tutored Work

In order to pass the theory, the student will have to attend to an exam or a tutored work:

- + the exam with short or long answer questions. Marks will be (EM: Exam Mark) assigned in a 10 points scale.
- + to evaluate the tutored work the lecturer will consider the results, the presentation, the analysis and the quality of the final report. Marks will be (TWM: Tutored Work Mark) assigned in a 10 points scale.

#### 2.a.2 Theory Final Mark

The final mark of theory (FMT) will be:

$FMT = EM$  (Exam Mark) if the exam has been carried out.

$FMT = TWM$  (Tutored Work Mark) if the tutored work has been carried out.

### 2.b Laboratory

In order to pass the laboratory part, the student will have to attend to a practical exam. In this exam the student will be asked to deal with some of the electronic circuits developed in the practical sessions as well as some short answer questions related to these sessions. Marks will be (LEM: Laboratory Exam Mark) assigned in a 10 points scale.

The final mark of laboratory (FML) will be  $FML = LEM$  (Laboratory Exam Mark).

### 2.c Project

In order to assess the project, the lecturer will consider the quality of the results obtained, their analysis, and the classroom presentation. Marks will be (GPM: Group Project Mark) assigned in a 10 points scale.

### 2.d Final mark

In order to pass the subject, it is mandatory:

- +  $FMT \geq 5$ , and
- +  $FML \geq 5$ , and
- +  $GPM \geq 5$ .

The final mark will be the weighted average of the marks obtained by the student in the different parts. The final mark (FM) will apply a weight of 50% to the final theory mark (FMT), a 30% to the laboratory final mark (FML) and a 20 % to the group project mark (GPM).

$$FM = 0,50 \cdot FMT + 0,30 \cdot FML + 0,20 \cdot GPM$$

A final mark higher than five points ( $FM \geq 5$ ) should be achieved in order to *pass the subject*.

However, when:

+  $FMT < 5$ , or

+  $FML < 5$ , or

+  $GPM < 5$ ,

the final mark (FM) will be:

$$NF = \min\{ 4.9, 0.50 \cdot FMT + 0.30 \cdot FML + 0.20 \cdot GPM \}$$

### 3. Extraordinary opportunity and End-of-program exam

The assessment policy in these calls will follow the scheme described in the single assessment. Dates will be specified in the academic calendar. The lecturer will assign the tutored work and the project to the student. The student has to contact to the lecturer according to an established procedure. The procedure will be published in advance.

Marks obtained in the previous continuous or global assessment are kept if the student have got a pass in some parts. Moreover, students cannot take an exam, develop a project or a tutored work task if they have got a pass previously.

The final mark will be the weighted average of the marks obtained by the student as it has described in section 2.

### 4. Others

The subject will be taught in Galician and Spanish. It will be assessed in Spanish.

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#### Sources of information

##### Basic Bibliography

Pérez García, M.A., **Instrumentación Electrónica**, 1ª ed., Ediciones Paraninfo, S.A., 2014

Pallás Areny, R., **Sensores y Acondicionadores de Señal**, 4ª ed., Marcombo D.L., 2003

Norton, H.N., **Sensores y analizadores**, Gustavo Gili D.L., 1984

Fraile Mora, J., García Gutiérrez, P., y Fraile Ardanuy, J., **Instrumentación aplicada a la ingeniería**, 3ª ed., Editorial Garceta, 2013

Martín Fernández, A., **Instrumentación electrónica. Transductores y acondicionadores de señal y sistemas de adquisición de datos**, 2ª ed., Dpto. de publicaciones de la E.U.I.T.T. de Madrid,, 1990

##### Complementary Bibliography

Jacob Fraden, **Handbook of Modern Sensors, Physics, Design, and Applications**, 5ª, Springer,

del Río Fernández, J., Shariat-Panahi, S., Sarriá Gandul, S., y Lázaro, A.M., **LabVIEW: Programación para Sistemas de Instrumentación**, 1ª ed., Editorial Garceta, 2011

Paul Horowitz y Winfield Hill, **The Art of Electronics**, 3ª, Cambridge Press,, 2015

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#### Recommendations

#### Other comments

It recommends to have passed the following subjects:

+ Electronic Technology/V05G301V01206

+ Digital Electronics/V05G301V01203

+ Analogue Electronics/V05G301V01311

+ Data Acquisition Systems/V05G301V01314

+ Electronic Instrumentation and Sensors/V05G301V01316