

## COURSE PROGRAM<sup>1</sup>

**Academic Year: 2021/2022**

| Identification and characteristics of the course  |  |  |   |   |   |   |         |        |        |        |
|---|--|--|---|---|---|---|---------|--------|--------|--------|
| Code <sup>2</sup>   | 501097   | ECTS Credits   | 6   |   |   |   |         |        |        |        |
| Course name (English)   | Electronic technology  |  |   |   |   |   |         |        |        |        |
| Course name (Spanish)   | Tecnología electrónica   |  |   |   |   |   |         |        |        |        |
| Degree programs <sup>3</sup>  | Degrees in electronics and automation engineering and mechanical engineering (industrial branch) |  |   |   |   |   |         |        |        |        |
| Faculty/School <sup>4</sup>   | Industrial Engineering School  |  |   |   |   |   |         |        |        |        |
| Semester  | 5  | Type of course   | Compulsory  |   |   |   |         |        |        |        |
| Module  | Specific Technology of Industrial Electronics and Automation<br>Optional                         |  |   |   |   |   |         |        |        |        |
| Matter  | Electronics<br>Diversification in Industrial Electronics and Automation                          |  |   |   |   |   |         |        |        |        |
| Lecturer/s  |  |  |   |   |   |   |         |        |        |        |
| Name  | Office   | E-mail   | Web page  |   |   |   |         |        |        |        |
| Ausín Sánchez, José Luis  | D1.8   | <a href="mailto:jlausin@unex.es">jlausin@unex.es</a>   | <a href="http://campusvirtual.unex.es">http://campusvirtual.unex.es</a> |   |   |   |         |        |        |        |
| Carrillo Calleja, Juan Manuel   | D1.6   | <a href="mailto:jmcarcal@unex.es">jmcarcal@unex.es</a> | <a href="http://campusvirtual.unex.es">http://campusvirtual.unex.es</a> |   |   |   |         |        |        |        |
| Subject Area  | Electronic Technology  |  |   |   |   |   |         |        |        |        |
| Department  | Electrical, Electronic and Automatic Engineering   |  |   |   |   |   |         |        |        |        |
| Coordinating Lecturer <sup>5</sup><br>(If more than one)  | Ausín Sánchez, José Luis   |  |   |   |   |   |         |        |        |        |
| Competencies <sup>6</sup> (see table at <a href="http://bit.ly/competenciasGrados">http://bit.ly/competenciasGrados</a> ) |  |  |   |   |   |   |         |        |        |        |
| Basic Competences<br>Check<br>With an " X "   | General Competences<br>Check<br>With an " X "  | Transversal Competences<br>Check<br>With an " X "      | Specific Competences<br>Basic Formation<br>Check<br>With an " X "       | Specific Competences<br>Common to the Industrial Branch<br>Check<br>With an " X " | Specific Competences<br>Specific Technology<br>Check<br>With an " X " | Specific Competences<br>Specific Technology<br>Marked<br>with a " X " |         |        |        |        |
| CB1   | X  | CG1  | X   | CT1   | X   | CEFB1   | CECRI1  | CETE1  | CETE11 |        |
| CB2   | X  | CG2  | X   | CT2   | X   | CEFB2   | CECRI2  | CETE2  | CETE12 |        |
| CB3   | X  | CG3  | X   | CT3   | X   | CEFB3   | CECRI3  | CETE3  | CETE13 |        |
| CB4   | X  | CG4  | X   | CT4   | X   | CEFB4   | CECRI4  | CETE4  | CETE14 |        |
| CB5   | X  | CG5  | X   | CT5   | X   | CEFB5   | CECRI5  | CETE5  | CETE15 |        |
|   |  | CG6  | X   | CT6   | X   | CEFB6   | CECRI6  | CETE6  | X      | CETE16 |
|   |  | CG7  | X   | CT7   | X   |   | CECRI7  | CETE7  |        | CETE17 |
|   |  | CG8  | X   | CT8   | X   |   | CECRI8  | CETE8  |        | CETE18 |
|   |  | CG9  | X   | CT9   | X   |   | CECRI9  | CETE9  |        | CETE19 |
|   |  | CG10   | X   | CT10  | X   |   | CECRI10 | CETE10 |        | CETE20 |

<sup>1</sup> In case of joint programmes, inter-faculty programmes, double degrees, etc., please collect information from all degrees and all faculties involved in the same document.

<sup>2</sup> In case there is more than one code for a given subject, please include all.


<sup>3</sup> In case the subject is delivered in more than one degree, please include all (also double degrees).

<sup>4</sup> In case the subject is delivered in more than one faculty, please include all.

<sup>5</sup> In case the subject is delivered in more than one faculty, please include name of responsible lecturer at each one.


<sup>6</sup> Competencies must conform to those specified in the "Degree's Verified Memory".

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|  |   |         |       |
|--|---|---------|-------|
| CG11   | X | CECRI11 | CETFG |
| CG12   |   | CECRI12 |       |
| <b>Contents</b>  |   |         |       |
| <b>Course outline<sup>6</sup></b>  |   |         |       |
| Study of functional and constructive characteristics of passive and active electronic components, printed circuits, and introduction to the design of integrated circuits.   |   |         |       |
| <b>Course syllabus</b>   |   |         |       |
| Title of unit 0: <b>Course presentation and initial evaluation (1 hour)</b>  |   |         |       |
| Contents of unit 0:<br>Course presentation and previous knowledge (1 hour)   |   |         |       |
| Title of unit 1: <b>Semiconductor diodes (9 hours)</b>   |   |         |       |
| Contents of unit 1:<br>Theory (4 hours):<br>1.1. Semiconductor materials<br>1.2. The pn junction<br>1.3. The diode: operation and equivalent circuits<br>1.4. Diode Applications<br>1.5. Special purpose diodes<br>Problems (1 hour)<br>Electronic circuit simulation (2 hours):<br>O1. PSpice tutorial<br>Laboratory practices (2 hours):<br>L1. Diode characterization   |   |         |       |
| Title of unit 2: <b>Bipolar Junction Transistor (9 hours)</b>  |   |         |       |
| Contents of unit 2:<br>Theory (5 hours):<br>2.1. Device structure and physical operation<br>2.2. Current-voltage characteristics<br>2.3. DC operation and polarization<br>2.4. Small signal equivalent model<br>2.5. Internal capacities and high-frequency model<br>Problems (2 hours)<br>Laboratory practices (2 hours):<br>L2. BJT amplifier stage  |   |         |       |
| Title of unit 3: <b>MOS Field-Effect Transistor (11 hours)</b>   |   |         |       |
| Contents of unit 3:<br>Theory (5 hours):<br>3.1. Field-Effect Transistors (FETs)<br>3.2. MOSFET structure and physical operation<br>3.3. Current-voltage characteristics<br>3.4. DC operation and MOSFET polarization<br>3.5. Small Signal Equivalent Model<br>3.6. Internal capacitances and high-frequency model<br>Problems (2 hours)<br>Laboratory practices (4 hours):<br>L3. Characteristic parameters of MOS transistor<br>L4. MOSFET Amplifier Stage |   |         |       |
| Title of unit 4: <b>Power Semiconductor Devices (3 hours)</b>  |   |         |       |
| Contents of unit 4:  |   |         |       |

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|   |
|---|
| <p>Theory (2 hours):</p> <p>4.1. Power diodes</p> <p>4.2. Power transistors: BJT, MOSFET, IGBT</p> <p>4.3. Thyristors: diacs, triacs, IGCT, SCR, GTO</p> <p>Problems (1 hour)</p>   |
| <p>Title of unit 5: <b>Passive Devices (3 hours)</b></p> <p>Contents of unit 5:</p> <p>Theory (3 hours):</p> <p>5.1. Conductive materials. Resistances: construction technologies.</p> <p>5.2. Dielectric materials. Capacitors: construction technologies.</p> <p>5.3. Magnetic materials. Inductors: construction technologies.</p>   |
| <p>Title of unit 6: <b>Printed Circuit Board Technology (10.5 hours)</b></p> <p>Contents of unit 6:</p> <p>Seminar (2 hours):</p> <p>6.1. Introduction to printed circuit board</p> <p>6.2. Introduction to surface mount technology</p> <p>6.3. Basics of printed circuit board manufacturing</p> <p>6.4. Assembly technology on printed circuit boards</p> <p>6.5. EMI: design tips</p> <p>Electronic circuit simulation (2 hours):</p> <p>O2. Eagle tutorial</p> <p>Laboratory practices (6.5 hours):</p> <p>L5. PCB manufacturing</p> <p>L6. Tutored project based on the design of a printed circuit board</p> |
| <p>Title of unit 7: <b>Integrated Circuit Technologies (3 hours)</b></p> <p>Contents of unit 7:</p> <p>Theory (1 hour):</p> <p>7.1. Integrated circuits</p> <p>7.2. CMOS fabrication steps</p> <p>Seminar (2 hours):</p> <p>S2. Integrated devices: passive, diodes, and MOSFET transistors. Layout methodology</p>   |

| Educational activities <sup>7</sup>   |       |          |                      |      |     |     |                     |          |
|---------------------------------------|-------|----------|----------------------|------|-----|-----|---------------------|----------|
| Student workload in hours by lesson   |       | Lectures | Practical activities |      |     |     | Monitoring activity | Homework |
| Lesson                                | Total | L        | HI                   | LAB  | COM | SEM | SGT                 | PS       |
| 0                                     | 2     | 1        |                      |      |     |     |                     | 1        |
| 1                                     | 21.5  | 5        |                      | 2    | 2   |     | 0.5                 | 12       |
| 2                                     | 25.5  | 7        |                      | 2    |     |     | 0.5                 | 16       |
| 3                                     | 28.5  | 7        |                      | 4    |     |     | 0.5                 | 17       |
| 4                                     | 13.5  | 3        |                      |      |     |     | 0.5                 | 10       |
| 5                                     | 8     | 3        |                      |      |     |     |                     | 5        |
| 6                                     | 27    | 0        |                      | 6.5  | 2   | 2   | 0.5                 | 16       |
| 7                                     | 10.5  | 1        |                      |      |     | 2   | 0.5                 | 7        |
| <b>Assessment<sup>8</sup></b>         | 13.5  | 3        |                      |      |     |     |                     | 10.5     |
| <b>Final Assessm.</b>                 | 13.5  | 3        |                      |      |     |     |                     | 10.5     |
| <b>TOTAL</b>                          | 150   | 30       | 0                    | 14.5 | 4   | 4   | 3                   | 94.5     |
| L: Lectures (100 students)            |       |          |                      |      |     |     |                     |          |
| HI: Hospital internships (7 students) |       |          |                      |      |     |     |                     |          |

<sup>7</sup> The contents of this table must literally conform to the information of document 12c.

<sup>8</sup> Specify total number of hours devoted to assessment in the present subject.

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LAB: Laboratory or field practices (15 students)  
 COM: Computer room or language laboratory practices (30 students)  
 SEM: Problem classes or seminars or case studies (40 students)  
 SGT: Scheduled group tutorials (educational monitoring, ECTS type tutorials)  
 PS: Personal study, individual or group work and reading of bibliography

### Teaching Methodologies<sup>6</sup>

Among the teaching methodologies included in the formative program, in this course the following are used:

| Teaching methodology   | Used methodologies labelled as "X" |
|--|------------------------------------|
| 1. Explanation and discussion of theoretical contents.   | X                                  |
| 2. Resolution, analysis and discussion of support examples or previously proposed exercises.   | X                                  |
| 3. Exposition of related topics by students.   | X                                  |
| 4. Development of case studies or demonstrations at laboratory, computer room, etc.  | X                                  |
| 5. Resolution of specific doubts in small groups in order to identify potential problems in the teaching-learning process, and academic guidance for essays, case studies, practical works, demonstrations, etc. | X                                  |
| 6. Search for information prior to the development of the topics, or for complementary information once they are in progress.  | X                                  |
| 7. Preparation of essays, either individually or in groups.  | X                                  |
| 8. Study of each topic, which may consist of: content study, analysis of practical exercises or case studies, preparation for examinations, etc.   | X                                  |

Lessons and theoretical discussions, problems resolution and theoretical/practical cases will be carried out in the **lectures**.

**Seminars** will be held in the location assigned to this type of activity and the expected schedule will be included in the semester's agenda.

Assembly and test of electronic circuits, also supported by CAD activities, will be carried out in **labs and computer room activities**. Practical lessons have associated personal work of the student, both previous to the face-to-face sessions (prelab), so that students become familiar with the contents, as well as after each session, for the drawing and writing of conclusions from the obtained results.

The **advised project** consists of a face-to-face part in the lab and a personal part, in which the student will carry out a previous preparation, with the help of the appropriate bibliography, and will finish the project by writing a report with the most significant results obtained during the realization of the activity.

### Learning outcomes<sup>6</sup>

- Knowing the different devices and electronic components of general use in the industrial environment.
- Knowing the processes involved in the manufacture of integrated circuits individually, as well as their integration to obtain a certain active device.
- Becoming familiar with the use of CAD tools for circuit simulation, geometric edition of masks and design of printed circuit boards.
- Managing laboratory equipment for test and verification of circuits and manufacturing of printed circuit boards.

### Assessment systems<sup>6</sup>

**Assessment criteria:**

The course will be assessed according to the following criteria:

|                                |   |        |              |
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- CE1. Domain of theoretical contents.  
*Related to competences CB1, CB5, CG3, CT1, CETE6.*
- CE2. Knowledge of practical procedures.  
*Related to competences CB2, CB5, CG4, CT2, CETE6.*
- CE3. Ability to apply the knowledge acquired in the resolution of practical cases.  
*Related to competences CB3, CB5, CT4, CETE6.*
- CE4. Domain of CAD and lab tools related to the subject.  
*Related to competences CB5, CT5, CETE6.*
- CE5. Ability to communicate and transmit knowledge in an appropriate technical language, oral and written, within the field of the electronic technology.  
*Related to competences CB4, CB5, CT3, CT7, CETE6.*
- CE6. Acquisition of skills related to realization of a project based on a real case.  
*Related to competences CB2, CB5, CG1, CG2, CG4-CG11, CT6, CT8-CT10, CETE6.*

**Assessment activities:**

Among the assessment activities included in the formative program, in this course the following are used:

|   | Range fixed | Ordinary call | Extraordinary call | Global assessment |
|---|-------------|---------------|--------------------|-------------------|
| 1. Final exam and/or partial examinations.  | 0%–80%      | 60%           | 60%                | 80%               |
| 2. Practical activities in: classroom, lab, computers room, visits, etc   | 0%–50%      | 10%           | 10%                | 10%               |
| 3. Solution and submission of activities (cases, exercises, assignments, projects, etc.), individually and/or in groups | 0%–50%      | 15% + 15%     | 15% + 15%          | 10%               |
| 4. Active participation in the learning activities.   | 0%–10%      | 0%            | 0%                 |                   |
| 5. Attendance to the learning activities.   | 0%–10%      | 0%            | 0%                 |                   |

**Description of the assessment activities:**

The criteria indicated previously will be assessed by means of the following activities:


**AE1. WRITTEN TEST** (related to activity 1. in the table)

It will be held in the examinations period and the contents of seminars can also be evaluated. To pass the course, it will be necessary to obtain a grade of at least 4, being 60% its contribution to the final grade. This activity is RECOVERABLE in the extraordinary call, with the same weight of 60% of the final grade. In case the course is not passed in the ordinary call, the grade of this evaluation activity will only be maintained for the extraordinary call if it is equal to or greater than 5.

**AE2. LABS AND COMPUTER ROOM LESSONS** (related to activity 2. in the table)

Attendance at labs and computer room lessons is compulsory. Students who take advantage of practical sessions will have a passing grade. In addition, these students will submit a report with the results and conclusions of the labs L1 to L4 within the two weeks after being held, which may report up to 10% of the final grade. The unexcused absence in more than one lab and computer room lesson will entail the obligation of the student to face a practical exam, which must be passed in order to pass the course, without reporting any contribution to the final grade. This activity is considered NON-RECOVERABLE,

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that is, it cannot be carried out in the extraordinary call, even though the corresponding grade obtained in the ordinary call will be added in the extraordinary call. In this call, the student must pass a practical exam, although, as in the ordinary call, it will not have any contribution to the final grade.

**AE3. FOLLOW-UP TASKS** (related to activity 3. in the table)

The student will have to carry out different tasks throughout the course, being the contribution of this activity 15% of the final grade. These activities are classified as NON-RECOVERABLE. However, if the student has submitted them during the ordinary call, the grade obtained will be added, if applicable, to the final grade in the extraordinary call, with the same weight of 15% of the final grade.

**AE4. DEVELOPMENT OF AN ADVISED PROJECT** (related to activity 4. in the table)

The student will have to submit a memory where the project carried out is described. This report must deal with the development of an electronic technology project. Attendance at face-to-face project sessions is mandatory. It is compulsory to include the design of a printed circuit board (PCB) in the project to pass this part of the course, as all the contents related to PCBs are exclusively assessed through this activity. The project will have a weight of 15% in the student's final grade, being a RECOVERABLE assessment activity.

If the mark obtained in the exam (AE1) is lower than the minimum required to pass the course, the final grade will be 4.9 if it is equal to or greater than 5 and the final grade itself on the contrary.

The global assessment will take place the same day assigned to the final exam of each call. It will consist of the following parts:

- Written part: written test with theoretical/practical questions and/or problems, with a weight of 80% in the final grade.
- Practical part: assembly and explanation by the student of a lab, which computes with 10% in the final grade.
- Design part: test in which the student must demonstrate the handling of simulation and PCB edition tools used in the course, whose contribution to the final grade is 10%.

**Bibliography (basic and complementary)**

**Basic Bibliography:**

- B1. Microelectronic circuits (6<sup>th</sup> ed.), A.S. Sedra, K.C. Smith, Oxford Univ. Press, 2011.
- B2. Electronic devices (8<sup>th</sup> ed.), T.L. Floyd, Prentice Hall, 2008.

**Complementary Bibliography:**

- C1. Electronic devices and circuit theory (8<sup>th</sup> ed.), R.L. Boylestad, L. Nashelsky, Prentice Hall, 2002.  
Electronic version available in the Electronic Library of UEx.
- C2. Electronic principles (7<sup>th</sup> ed.), A. Malvino y D.J. Bates, McGraw-Hill, 2007.
- C3. Electronics (2<sup>nd</sup> ed.), A.R. Hambley, Prentice Hall, 2001.


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Electronic version available in the Electronic Library of UEx.

- C4. Electronic circuits: analysis, simulation, and design, N.R. Malik, Prentice Hall, 1996.
- C5. Electronic technology: materials and fabrication techniques, A. Bandera, J.A. Rodríguez, F.J. Sánchez, University of Málaga, 2002.

**Other resources and complementary educational materials**

- W1. Virtual Campus of the University of Extremadura: <http://campusvirtual.unex.es>.
- W2. Eagle docs and tutorials: <https://www.autodesk.com/products/eagle/overview>.
- W3. OrCAD resources and tutorials: <http://www.orcad.com/>
- W4. Electronic Engineers Community: <http://www.element14.com>.

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