Universidad Zaragoza

Academic Year/course: 2021/22

28919 - Electrical engineering and rural electrification

Syllabus Information

Academic Year: 2021/22
Subject: 28919 - Electrotecnia y electrificación rural
Faculty / School: 201 - Escuela Politécnica Superior
Degree: 583 - Degree in Rural and Agri-Food Engineering
ECTS: 6.0
Year: 2
Semester: First semester
Subject Type: Compulsory
Module:

1. General information

1.1. Aims of the course

This course and its expected outcomes meet the following approaches and goals:

Approaches:

- Describe the electromagnetic fundamentals that electrotechnical applications are based on.
- Define and interpret the quantities and units of measurement involved in a low-voltage installation.
- Use and characterize the switching, safety and power-system protection devices.
- Design and justify the calculations necessary to: (*a*) project low-voltage lines for electric-power distribution; (*b*) project indoor and outdoor lighting facilities; and (*c*) apply in an appropriate manner the switchgear maneuver, safety and protection elements; always in relation to the agriculture, agribusiness, green areas and sports facilities fields of study.
- Propose, design and solve low-voltage electrical projects for farms, food-processing industries, green areas and sports facilities.

Goals:

- Understand and be able to interpret the electromagnetic phenomena that low-voltage electrical installations are based on.
- Be able to evaluate the performance and justify the choice of the elements involved in a low-voltage electrical installation in the agricultural, agribusiness, green areas and sports facilities fields of study.
- Be able to draw up low-voltage electrical projects for farms, food-processing industries, green areas and sports facilities.

SDGs alignment:

Aforementioned goals are aligned with the following UN Sustainable Development Goals (SDGs), contributing to some extent to their achievement:

- *SDG 7*: Ensure access to affordable, reliable, sustainable and modern energy.
- *SDG 9*: Build resilient infrastructure, promote sustainable industrialization and foster innovation.

and, in particular, with the following targets:

- *Target 7.1*: By 2030, ensure universal access to affordable, reliable and modern energy services.
- *Target 7.2*: By 2030, increase substantially the share of renewable energy in the global energy mix.
- *Target 7.3*: By 2030, double the global rate of improvement in energy efficiency.
- *Target 7.A*: By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.
- *Target 9.4*: By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial

processes, with all countries taking action in accordance with their respective capabilities.

Likewise, they also respond to the objectives set by the European Union within the 2030 Climate & Energy Framework:

- At least 40% cuts in greenhouse gas emissions (from 1990 levels)
- At least 32% share for renewable energy
- At least 32.5% improvement in energy efficiency

and to the objectives of the Spanish National Integrated Energy and Climate Plan (PNIEC), which calls for a 30% improvement in the energy efficiency of farms in the period 2021-2030, as well as a tripling of renewable energy consumption in farms by 2030.

1.2. Context and importance of this course in the degree

Electric power is one of the main forms of energy used in the world today. The electrical systems are responsible for the energy supply for the vast majority of agribusiness and agricultural production processes, thus allowing to carry out tasks and processes which would be impossible to perform without them. Consequently, a graduate in Agri-food and Rural Engineering should master the concepts, principles and scientific laws concerning electric and electromagnetic fields underlying the physical phenomena covered in Electrical Engineering, together with their applications in an electrical project (which should define and characterize the elements involved in the electrical installations of farms, food-processing industries, green areas and sports facilities).

On the other hand, electric power production is not exempt from the use of non-renewable resources, so the design and justification of the facilities must be contextualized not only in the specific geographical area, but at a global scale.

This course provides practical significance to many of the physical fundamentals studied in the first year of the degree, serving at the same time as a basis for many other courses that, in one way or another, use electric power in their approaches and processes.

The in-depth knowledge of electrotechnical fundamentals and the basic types of electrical services allows the professional to select and design safe and sustainable installations in such a way that: (*i*) they are profitable, with tight budget and controlled running costs; (*ii*) they respect the natural environment through proper sizing, installation and operation; and (*iii*) they are beneficial to the society, promoting a profitable and safe use.

1.3. Recommendations to take this course

This subject is also offered in the *English Friendly* format.

Having pursued the *Mathematics I* (28900), *Mathematics II* (28905), *Physics I* (28901) and *Physics II* (28906) courses is strongly recommended. Attending class regularly is also advised so as to make the most of this course.

2. Learning goals

2.1. Competences

The students who pass this course will have developed the following competences:

Generic or transversal competences:

- **CG.2**. Apply their knowledge to their work or vocation in a professional manner and equip themselves with the skills that are typically demonstrated through the devise and defense of arguments and the solving of problems within their field of study.
- **CG.3**. Be able to gather and interpret relevant data (usually within their field of study) that would allow them to make judgments that include reflections on relevant social, scientific or ethical issues.
- **CG.5**. Develop the learning skills required to conduct further studies with a high degree of autonomy.

Specific skills:

- **CE.15****. Be able to know, understand and use the principles of Engineering in rural areas (In particular with regard to Electrical Engineering).
- **CE.24****. Be able to know, understand and use the principles of Engineering in farms and agribusinesses: electrification of farms and food processing industries.
- **CE.26****. Be able to know, understand and use the principles of Engineering related to green areas, sports facilities and fruit and vegetable farms: electrification.

Note: Those skills in which the ?**? superscript appears will only be partly acquired in this course. The acquired part is detailed in the verification report of the corresponding Degree.

2.2. Learning goals

The student, in order to pass this course, should be able to:

- Classify, analyze, calculate and design the use of direct current (DC) and alternating current (AC, both single-phase and polyphase) electric circuits in systems that meet the needs of farms and food-processing industries.

- Analyze, calculate and design electric power requirements and electric power distribution in farms, food-processing industries, green areas and sports facilities, prioritizing their energy efficiency (in line with targets 7.3 and 9.4).
- Design, calculate and define -from a technical, scientific and social point of view- the electrical connections, the transformation and the distribution of electric power in farms, food-processing industries, green areas and sports facilities, incorporating distributed energy resources (DER) into these facilities whenever feasible (in line with targets 7.1, 7.2, 7.A and 9.4).
- Identify, analyze and justify lighting systems to meet the needs of farms, food-processing industries, green areas and sports facilities.
- Identify, interpret, calculate, design and justify switching, measurement, power system protection and safety elements in low-voltage installations in farms, food processing industries, green areas and sports facilities.
- Study, choose and justify the design and calculations of low-voltage electrical installation projects in farms, food-processing industries, green areas and sports facilities.

2.3. Importance of learning goals

Electrical Engineering is important in the training of the Rural and Agri-Food Engineering degree-holders because throughout their career they will often deal with interventions related to electric power that they must understand and resolve. Thus, their knowledge in this subject should provide them with sufficient ability and self-confidence to address problems both in facilities and in occupational safety and health, both of themselves and of their staff, avoiding unnecessary accidents.

Rural Electrification adds to the Rural and Agri-Food Engineering degree-holders? training the basic knowledge to analyze, design and justify a sustainable low-voltage installation. This implies that the graduate should be aware of the importance of environmental impact mitigation through energy efficiency on the demand side and through the supply of energy from renewable sources (mainly solar photovoltaic and wind energy, the basics of which he/she will learn in this course), always taking into account the goals set by the EU in the 2030 Climate & Energy Framework and SDGs 7 and 9.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

The student must demonstrate that he/she has achieved the intended learning outcomes through the following evaluation activities:

The subject will be evaluated with a final exam. Its content will be adapted to the program of the course (theoretical, problem-solving and laboratory sessions) and it will be conducted at the end of the semester, on the date scheduled in the official Higher Technical School of Huesca calendar of exams for the exams period of the corresponding academic year.

Aforementioned final exam will consist of four blocks:

- *Block 1*: theoretical part, with multiple choice questions and theoretical and practical short questions. 45% of the final grade.
- *Block 2*: practical part, problems about applications and electrical installations (Part I). 40% of the final grade.
- *Block 3*: practical part, problems about applications and electrical installations (Part II). 5% of the final grade.
- *Block 4*: practical part, dedicated to the different software tools used in the laboratory sessions. 10% of the final grade.

Throughout the written exam students will be allowed to use a short equations compendium, prepared by themselves and with a maximum length of 2 pages (DIN-A4 size).

Blocks 3 and 4 may be passed during the semester (without prejudice to the right of the students to complete those blocks in the final exam, upon notification to the teacher in advance). To this end, the following complementary evaluation activities are proposed:

- *Block 3: Weekly problems assignments*. After certain units of the syllabus, the solving of some engineering problems will be proposed. These assignments will be handed in using the online-learning platform.
- *Block 4: Reports of laboratory sessions*. During laboratory sessions, the students will complete some exercises with the various software tools to demonstrate their proper usage. Writing reports will not be required for those students who attend these face-to-face laboratory sessions, provided that the teacher will revise the exercises in situ. Those students who do not attend the F2F sessions must solve the exercises autonomously and hand in a report.

Evaluation criteria

General criteria used in the assessment of the written test

Each of the blocks will be graded in a 0 to 10 points scale, taking into consideration the following general criteria:

Favorable rating	**Unfavorable rating**
Understanding the laws, theories and concepts	Errors in approaches and/or in the development of exercises and/or questions

The skillfulness in handling mathematical tools	Errors in calculations
Proper use of the magnitudes and units	Absence of explanations in the solving of problems
Clarity in the diagrams, figures and graphs	Misspellings
The correction of the approach and results, together with the tidiness, presentation and interpretation of the results	Disorder and poor presentation

Assessment of the weekly problems assignments

Each problems assignments will be graded in a 0 to 10 points scale. The final grade of all the assignments will be a weighted average, taking into account the number of problems per assignment and the level of difficulty of each problem. The numerical results, handed in through questionnaires available in online-learning platform, will be corrected admitting error tolerances vs. the results calculated by the teacher.

Assessment of the lab sessions reports

Each report of the laboratory sessions will be graded in a 0-to-10 scale. Once all lab sessions have been completed, the score will be the average of all the reports. The assessment of the reports of the laboratory sessions will depend on:

- Consistency and analysis of the results obtained in the different sections of each report.
- Rigor, clarity and appropriateness of the submitted reports.
- Active participation and interest demonstrated by the student during the development of the laboratory session.

Requirements to pass and to weight the various evaluation activities

The student will have achieved the intended learning outcomes if the following requirements are met:

- In the final exam, the score should be greater than or equal to 5 points out of 10, taking into consideration the following restrictions:
    - In the theoretical part (block 1), the obtained score must be greater than or equal to 3.50 points out of 10.
    - In the problems part (block 2 + block 3), the obtained score, considering the weighted average of the two blocks, has to be greater than or equal to 4.50 points out of 10.
    - In block 4 (software tools), the score must be greater than or equal to 5 points out of 10.

Although blocks 3 and 4 of the global final test may be passed during the semester by completing the complementary activities, obtaining a score lower than 5 points out of 10 in the weekly problems assignments or in the lab sessions reports makes it compulsory to complete the corresponding block in the final exam, which will be equivalent both in content and in weight on the final grade.

Please note that grades obtained in blocks 1 and 2 will not be saved from the first to the second examination period. The grades of blocks 3 and 4 may be saved (if the student wishes to) for successive exams, corresponding to academic years other than the one in which the grades were obtained.

Calculation of the final grade

As explained above, the final grade (FG) in a 0 to 10 points will be determined using the following equation:

FG = (0.45 × block 1 score) + (0.40 × block 2 score) + (0.05 × block 3 score) + (0.10 × block 4 score)

To pass (FG ? 5.0), it is compulsory that: [block 1 score ? 3.5] and [weighted average of block 2 and block 3 scores ? 4.5] and [block 4 score ? 5.0].

In the event that the above requirements are not met, the final grade will be obtained as follows:

- If FG ? 4.0, the final grade will be: fail (4.0)
- If FG < 4.0, the final grade will be: fail (FG)

Alignment with SDGs

In relation to 2030 Agenda, the acquisition by the students of the competences related to targets 7.1, 7.2 and 7.A will be evaluated in block 1 and block 4, through theoretical questions and the report of software lab session no. 5, respectively. The competences associated with goals 7.3, 7.A and 9.4 will be evaluated in block 2, in the problems related to three-phase electric power system installations and electrical grids, and in the software lab sessions no. 2 and no. 3. These evaluation activities approximately represent 35% of the overall grade of the course.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The course is divided into two types of activities that will be carried out throughout the semester: *lectures in the classroom* and *practice sessions in the laboratory*.

- In the *lectures* (one group), the teacher will develop the content of the lesson after an introduction and an outline of its approach and goals. At the end of the lecture, there will be a questions-and-answers section to, for example, re-explain or solve some aspects in which students may have doubts. This Q&A section may also be conducted, if the teacher deems it necessary, at any time during the master class.

- As regards the *laboratory sessions* (two groups), theoretical and practical problems concerning electrical installations in the agro-industrial sector will be proposed and solved, either by numerical calculations and/or by using specific software tools. In relation to the latter, the aim is that the students become familiar with free applications such as EcoStruxure Power Design - Ecodial, PrysmiTool and CableApp, AMIkit, DIALux Evo or RELUX, System Advisor Model (SAM), etc. The participation of students will be encouraged more intensively than in the sessions dedicated to the theoretical contents.

4.2. Learning tasks

The course includes the following learning tasks:

- *Lectures*: at the beginning of each session, the theoretical content that the teacher will cover in the class will be supplied through the online learning platform, together with supporting information to reinforce the understanding.
- *Problem-solving sessions and lab sessions*: a collection of exercises and problems with their solutions (with all the intermediate steps in some cases and only with the final result in others) will be provided through the online-learning platform. Some engineering problems will also be proposed (weekly problems assignments) to be solved not in the classroom, but by the students on their own, allowing to pass block 3 of the final exam during the semester. In the case of the lab sessions with software tools, links for their download (provided that they are all free programs), the session outlines, the software manuals and tutorials will be provided.
- *Office hours (tutorials)*. Meetings with the teacher, either in the teacher's office or virtually, either individually or in groups, for those students struggling with classes. To make the most of these office hours, previous work and having checked the recommended bibliography, both basic and supplementary, is strongly encouraged.
- *Non-contact activities*. Non-contact activities basically consist in reinforcing what has been explained in the classroom, solving proposed exercises or problems and drafting reports for the lab sessions (i.e., guided and individual self-study).

In relation to 2030 Agenda, several of the theoretical sessions and laboratory sessions with software tools are closely related to SDGs 7 and 9, as indicated in section 4.3 of this syllabus.

4.3. Syllabus

The course will address the following topics:

1. Electricity: general concepts.
2. Electrical resistance.
3. Electric power.
4. Thermoelectric effect.
5. Applications of the thermoelectric effect.
6. Serial, parallel and mixed DC circuits.
7. Solving of circuits with multiple meshes.
8. Electrochemical and photovoltaic generators [aligned with SDG 7].
9. Capacitors.
10. Magnetism and electromagnetism.
11. Interactions between the electric current and the magnetic field.
12. Alternating current.
13. RLC circuits (AC).
14. The solution of parallel and mixed AC circuits.
15. Three-phase power systems [aligned with SDG 9].
16. Lighting [aligned with SDG 9].
17. Transformers.
18. DC machines.
19. AC machines.
20. Basic electrical safety tips.
21. Low-voltage electrical installations: legislation; electrical symbols and units of measurement; the low-voltage electrical project; low-voltage overhead power lines; electrical connections; calculations in low-voltage electrical installations (degree of electrification and power, full load, circuits, wiring and brownouts, protection elements, dimensions of tubes and pipes, etc.) [aligned with SDG 9].
22. Electrical installations of interest in agribusiness: pumping stations, electrification in greenhouses, refrigeration,

electrical fences, etc. [aligned with SDG 9].

Please note that the contents of lesson 21 be addressed progressively and in a fractional manner as we progress in the course, covering them together with the contents from the rest of the syllabus to which their understanding is linked (e.g., calculations for conductors sizing (cross-sectional areas) will be covered be in the sessions associated with lessons 4 and 15; protective elements such as fuses and circuit breakers will be covered in lessons 4 and 20; etc.).

Practical contents

Apart from solving practical problems (oriented to an extension of the theoretical contents so that the student can understand and solve problems similar to those that they have to face in their career) by using numerical calculations, the following sessions aimed at training the students in different software tools will also be conducted:

- *Software session 1: calculation of conductor cross-sections*. Students will be trained in a computer program such as PrysmiTool and CableApp (Prysmian).
- *Software session 2: indoor electrical installations* [aligned with SDG 9]. Students will be trained in the use of a computer program for the calculation, design and assessment of indoor electrical systems, such as EcoStruxure Power Design - Ecodial (Schneider Electric).
- *Software session 3: lighting* [aligned with SDG 9]. The calculation tools aimed at lighting installations that will be discussed will be the flow and the point to point methods. To apply this latter method, due to the difficulty of its manual solving, a computer program such as DIALux Evo will be used. The design of both indoor and outdoor lighting installations will be covered.
- *Software session 4: electrical substations*. A computer tool, such as AMIkit (Ormazabal) will be used for the dimensioning of a electric power transformer.
- *Software session 5: distributed energy resources* [aligned with SDGs 7 and 9]. NREL's free System Advisor Model (SAM) software will be used to model a photovoltaic system and a wind energy system. In this session, students will also become familiar with free tools for the design of photovoltaic and wind energy installations such as PV-Sol or Calensof 4.0, DIAFEM, etc.

4.4. Course planning and calendar

Schedule

Activity type / Week		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Total (hours)**
Face-to-face activities	Theoretical sessions (1 group)	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	28
Face-to-face activities	Classroom problem-solving and laboratory sessions (two groups)	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	28
Face-to-face activities	Assessment																4
Non-contact activities	Autonomous work	3	5	5	5	6	6	6	6	8	8	8	8	4	8	4	90

The final exam will be conducted on the date appointed by the Higher Technical School of Huesca Board, according to the official examination schedule.

Throughout the semester, while we delve into the contents of the course, engineering problems specific to each topic will be posed and solved. The understanding of their approach and resolution can positively and decisively contribute to pass the course.

4.5. Bibliography and recommended resources

BB Alabern Morera, Xavier.. Electrotecnia : problemas / Xavier Alabern Morera, Jordi -Roger Riba Ruiz. [Libro electrónico]. Segunda edición. Barcelona : Universitat Politècnica de Catalunya, 2006

BB García Trasancos, José. Instalaciones eléctricas en media y baja tensión / José García Trasancos. 6ª ed. Madrid [etc.] : Paraninfo, D.L. 2011

BB Guía Técnica de Aplicación al REBT 2002 : actualizada a febrero de 2009. [Barcelona] : Cano Pina, Ediciones Ceysa, [2009]

BB Lagunas Marqués, Ángel. Nuevo reglamento electrotécnico de baja tensión : Teoría y cuestiones resueltas : basado en el nuevo RBT, Real Decreto 842/2002 de 2 de agosto de 2002 / Ángel Lagunas Marqués. 1ªed., 2ªreimp. Madrid : Paraninfo, 2003 (reimp. 2002)

BC ALABERN MORERA, X.; HUMET CODERCH, L. Electrotecnia: circuitos eléctricos en alterna. [s. l.], 2015.

BC ALABERN MORERA, X.; HUMET CODERCH, L. Electrotecnia: circuitos magnéticos y transformadores. [s. l.], 2015.

BC Alcalde San Miguel, Pablo. Electrotecnia / Pablo Alcalde S. Miguel. 7ª ed., 2ª reimp. Madrid [etc.] : Thomson, D.L. 2002

BC BAYOD RÚJULA, Á. A. Sistemas fotovoltaicos. 1ª ed. [s. l.]: Prensas Universitarias de Zaragoza, 2009. ISBN 9788492521944.

BC CANO PINA. REBT con tests y ejercicios de cálculo. [S. l.: s. n.]. ISBN 978-84-15884-29-3.

BC Carrasco Sánchez, Emilio. Guía técnica de interpretación del reglamento electrotécnico para baja tensión : Real Decreto 842-2002 : tests y problemas resueltos / Emilio Carrasco Sánchez ; colaboración, Alexis Pérez Rubio. 2a. ed. Madrid : Editorial Tebar, 2007

BC Castejón Oliva, Agustín. Tecnología eléctrica / Agustín Castejón Oliva, Germán Santamaría Herranz ; revisión técnica Antonio Plácido Montanero Molina. [1a. ed. en español, reimpr.]. Madrid [etc.] : McGraw-Hill, D.L. 2000

BC CATALÁN IZQUIERDO, S. Electrotecnia: circuitos eléctricos. [s. l.], 2014.

BC CATALÁN IZQUIERDO, S.; Electrotecnia: instalaciones eléctricas. [s. l.], 2014.

BC Charles K. Alexander, Matthew N. O. Sadiku (2012): Fundamentals of electric circuits. McGraw-Hill [english frienly]

BC González Martín, José Manuel. Manual de electricidad según el reglamento electrotécnico de baja tensión / José Manuel González Martín, Julián Becerril García. Burgos : Editorial Universidad de Burgos, [2016]

BC Guerrero Fernández, Alberto. Instalaciones eléctricas en las edificaciones / Alberto Guerrero Fernández. Madrid [etc.] : McGraw-Hill, D.L. 2000

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BC Martín Sánchez, Franco. Nuevo manual de instalaciones eléctricas / Franco Martín Sánchez. 2a. ed. Madrid : A. Madrid Vicente, 2003

BC Nilsson, James W. Electric circuits / James W. Nilsson, Susan A. Riedel. 7th ed., international ed. Upper Saddle River, N.J. : Pearson Prentice Hall, cop. 2005 [english friendly]

BC Zerriffi, Hisham (2011): Rural Electrification, Strategies for Distributed Generation. Springer [english friendly]

LISTADO DE URLs:

AllAboutCircuits.com / Lessons in Electric Circuits (free Electrical Engineering book), Vol. 1 [https://www.allaboutcircuits.com/textbook/direct-current/]

AllAboutCircuits.com / Lessons in Electric Circuits (free Electrical Engineering book), Vol. 2 [http://www.allaboutcircuits.com/textbook/alternating-current/]

The up-to-date recommended resources can be consulted in:
http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=28919

The bibliographical references for the ***English Friendly*** version of this course will be provided by the instructor.