Course guide
295324 - 295SE021 - Reliability, Life Cycle and Heat Dissipation

Last modified: 16/06/2025

Unit in charge: Barcelona East School of Engineering
Teaching unit: 709 - DEE - Department of Electrical Engineering.

Degree: MASTER'S DEGREE IN TECHNOLOGIES FOR DISTRIBUTED ENERGY SYSTEMS (Syllabus 2025). (Compulsory subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: Ramon Bargalló Perpiñà

Others: Ramon Bargalló Perpiñà
Robert Piqué López

PRIOR SKILLS

General knowledge to enroll in this master.

REQUIREMENTS

General knowledge to enroll in this master.

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.

Skills:
S1. Analyse, design and evaluate the reliability and life cycle of decentralised electrical systems based on renewable energy sources. Assess the reliability and life cycle of a distributed system for energy generation from renewable resources.
S3. Assess the impact and needs of new electricity consumption models and relate them to the change in energy model resulting from the decarbonisation of energy sources.

Competences:
C4. Apply the knowledge acquired and appropriate methodologies to analysis and design in the field of decentralised electrical systems with renewable sources.
C2. Identify and analyse problems that require making autonomous, informed and reasoned decisions in order to act with social responsibility following ethical values and principles.

TEACHING METHODOLOGY

AF.1.- Presentation of theoretical content.
AF.2.- Resolution of exercises, problems and cases.
AF.3.- Practical work sessions in the laboratory.
AF.4.- Discussion of problems or scientific articles.
AF.5.- Participation in seminars and conferences.
AF.6.- Carrying out individual and cooperative work.
AF.7. Sessions in computer or simulation laboratories

LEARNING OBJECTIVES OF THE SUBJECT

By taking the FCVGT subject, the student will acquire skills aimed at analyzing and determining the useful life and reliability of distributed energy systems, both as an isolated element and as part of a set that works in coordination with other energy systems, and with emphasis on distributed energy systems for processing electrical energy using renewable energies, paying special attention to the configurations of electric microgrids (smart microgrids).

They will also acquire knowledge and skills aimed at determining the thermal loads and temperature distribution in the elements that form part of a distributed electrical energy system and the effects that these temperatures produce on it, determining which solution is the most suitable to improve and optimize the effects of this thermal load.

STUDY LOAD

Type	Hours	Percentage
Hours small group	28,0	18.67
Self study	94,0	62.67
Hours large group	28,0	18.67

Total learning time: 150 h

CONTENTS

Raliability analysis of distributed energetic systems

Description:
1. Fundamentals of reliability in electrical systems. Failure rate (λ) and mean time between failures (MTBF). Customer-oriented indices: SAIDI (minutes of interruption/customer/year) and SAIFI (number of interruptions/customer/year) Cost of energy not supplied (EENS) and economic impact of interruptions. (2h)
2. Mathematical models. Reliability function. Analysis of series and parallel components. Models based on Markov chains. Reliability models for small and large systems. (4h)
3. Reliability analysis in distributed microgrids. Application examples. Consideration of different topologies. (4h)
4. Reliability and useful life of the subsystems of an electric vehicle. (2h)
5. Reliability aspects for the design of distributed energy systems. (2h)

Specific objectives:
The student will acquire skills aimed at analyzing and determining the useful life and reliability of distributed energy systems, both as an isolated element and as part of a set that works in coordination with other energy systems, and with emphasis on distributed energy systems for the processing of electrical energy using renewable energies, paying special attention to the configurations of electric microgrids (smart microgrids).
.

Related activities:
1. Calculation of reliability, service life and other reliability parameters for a simple system (static converter (2h)
2. Calculation of reliability of a microgrid with different working configurations. (4h)
3. Talk on determination of MTBF and FIT for an electronic board. (2 h).
.

Full-or-part-time: 44h
Theory classes: 14h
Practical classes: 8h
Self study : 22h

title english

Description:
1. Heat transfer in power electronic systems. (2 h)
2. Thermal properties of materials. (2 h)
3. Heat dissipation systems. (2 h)
4. Determination and validation of the heat dissipation system. (4 h)
5. Improvements in system cooling. Passive and active methods. (2 h)
6. Calculation tools and design of heat dissipation systems. (2 h)

Specific objectives:
The student will acquire knowledge and skills aimed at determining the thermal loads and temperature distribution in the elements that form part of a distributed electrical energy system and the effects that these temperatures produce on it, determining which solution is the most suitable to improve and optimize the effects of this thermal load.

Related activities:
1. Calculation and simulation of a heat sink. Use of software. (2h)
2. Measurement of temperature in a static converter subjected to different loads. Effects of forced ventilation. (2h)
3. Talk on heat dissipation in SMD components. (2h).

Full-or-part-time: 42h
Theory classes: 14h
Practical classes: 6h
Self study : 22h

title english

Description:
Resolution of a project in informal collaborative groups. As an initial idea, they will be within the following areas:
1. Reliability calculation of a microgrid. The student, based on general indications, must choose a configuration for a microgrid with no less than four elements (for example, battery, network, consumption and photovoltaic) and must perform an analysis of the reliability of the chosen configuration. If necessary, the original structure must be modified in order to guarantee the minimum reliability required.
2. Based on given specifications, the student must determine the methodology to be implemented to improve the thermal management of a device (it can be a specific element such as an inverter, or an entire system that manages a microgrid - it can be the previous microgrid).

Full-or-part-time: 25h
Theory classes: 2h
Guided activities: 8h
Self study : 15h

GRADING SYSTEM

Individual written exam grade (EE): 30%
Practice grade (PR): 30%
Proposed exercises grade (EP): 20%
Group work grade (TG): 20%
In summary, the final grade is given by: N_curs=0.3·EE+0.3·PR+0.2·EP+0.2·TG

Apart from the scheduled tests indicated above, additional unscheduled tests may be taken, within class hours and without prior notice, such as aspects of formative assessment (theory, exercises), problem solving, improvement of evaluation results, etc., which may increase the grades of these initially scheduled tests.
In accordance with academic regulations:
This subject is considered a continuous assessment and, therefore, does not have a "final" exam in the classic sense.
It is not subject to reassessment.
Carrying out the practical activities (laboratory work, writing reports and, where applicable, prior preparations for the practicals) is a necessary condition to pass the subject. If the practicals are not carried out, the grade for the subject will be, at most, a Fail 3.5.

EXAMINATION RULES.

You must bring, and if applicable show, a valid personal identifier (ID, passport or student card).
Online tests, if applicable, will be governed by the regulations that regulate them.
In accordance with section 3.1.3 of the Academic Regulations for Undergraduate and Master's Studies at the UPC, the completion of laboratory practices is mandatory in order to opt for the subject.
OTHER
[Plagiarism / Fraud] Irregular actions that may lead to a significant variation in the qualification of one or more students constitute a fraudulent performance of an assessment act. This action entails the descriptive qualification of failure and a numerical grade of 0 for the assessment act and the subject, without prejudice to the disciplinary process that may arise as a result of the acts carried out. (Academic Regulations for Undergraduate and Master's Studies at the UPC. (Section 3.1.2.)
[Code of Ethics of the UPC] (Agreement CG/2022/02/30 of the Governing Council, section 4.2) Students, ..., must make efficient and responsible use of all the resources that the University makes available to them, whether material or immaterial. Therefore, they must not only strive to achieve the highest level of knowledge, but must also have special consideration for the public nature of the resources that society invests in their training. They must maintain a participatory attitude in all training activities, must facilitate the work of the teaching staff and must actively participate in the teaching staff evaluation process. They must also value their personal effort in all actions, must prove their honesty and integrity in evaluation acts, and must promote these attitudes among their fellow students.

BIBLIOGRAPHY

Basic:
- Tuinema, Bart W.; Rueda Torres, J.L.; Stefanov, Alexandru I.; Gonzalez-Longatt, Francisco M.; van der Meijden, Mart A. M. M. Probabilistic Reliability analysis of power systems : A student's introduction [on line]. Cham: Springer International Publishing, 2020 [Consultation: 16/09/2025]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-030-43498-4. ISBN 3030434982.
- Reliability analysis of modern power systems. New Jersey: Wiley IEEE Press, 2024. ISBN 9781394226771.
- Lienhard, John H. A Heat transfer textbook [on line]. Cambridge: Phlogiston Press, 2004 [Consultation: 19/09/2025]. Available on: https://ahtt.mit.edu/.
- Williams, Barry W. Principles and elements of power electronics. Devices, Drivers, [on line]. 2006Available on: http://personal.strath.ac.uk/barry.williams/book.htm.
- Albarbar, Alhussein; Batunlu, Canras. Thermal analysis of power electronic devices used in renewable energy systems [on line]. Cham: Springer International Publishing, 2018 [Consultation: 19/09/2025]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-319-59828-4. ISBN 3319598287.
- Dhillon, B. S. Life cycle costing for engineers. Milton: CRC Press, 2009. ISBN 9781439816899.

Complementary:
- Haque, Ahteshamul. Reliability of power electronics converters for solar photovoltaic applications. London: Institution of Engineering and Technology, 2021. ISBN 9781839531170.
- Ellison, Gordon N. Thermal computations for electronics : conductive, radiative, and convective air cooling. Milton: CRC Press, 2020.

ISBN 9781000047462.
- Shabany, Younes. Heat transfer : thermal management of electronics. Boca Raton, FL: CRC Press, 2020. ISBN 9781439814680.
- Dorkel, Jean-Marie. Semi-conducteurs de puissance – problèmes thermiques (partie 1). Techniques de l'Ingénieur, D-3112V1, 2003.
- "Advanced cooling for power electronics". Integrated Power Electronics Systems (CIPS), 2012 7th International Conference on [on line]. Available on: https://ieeexplore.ieee.org/document/6170618.- Jamnia, Ali. Practical guide to the packaging of electronics : thermal and mechanical design and analysis. Boca Raton: Taylor & Francis,, 2016. ISBN 9781498753951.
- Billinton, Roy. Reliability evaluation of engineering systems : concepts and techniques. 2nd ed. New York, NY: Springer, 1992. ISBN 1489906851.
- Billinton, Roy; Allan, Ronald N. Reliability evaluation of power systems. 2nd ed. New York [etc.]: Plenum Press, 1996. ISBN 0306452596.
- Abramushkina, Ekaterina [et al.]. "A Thorough Review of Cooling Concepts and Thermal Management Techniques for Automotive WBG Inverters: Topology, Technology and Integration Level". Energies [on line]. Tomo 14, N.º 16, (2021) [Consultation: 19/09/2025]. Available on: https://www.proquest.com/docview/2565244697/CD7054B931694260PQ/1?accountid=15300&sourcetype=Scholarly%20Journals.- Jones-Jackson, Samantha [et al.]. "Jet Impingement Cooling in Power Electronics for Electrified Automotive Transportation: Current Status and Future Trends". IEEE transactions on power electronics. PP (99) : 1-1 Feb. 2021.
- IEEE Industry Applications Society. IEEE recommended practice for the design of reliable industrial and commercial power systems. [New York, N.Y.]: IEEE, 2007. ISBN 073815301X.
- Karki, Rajesh. Reliability modeling and analysis of smart power systems [on line]. New Delhi: Springer India, 2014 [Consultation: 19/09/2025]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-81-322-1798-5. ISBN 8132217985.

RESOURCES

Audiovisual material:
- Nom recurs. Resource