ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

53001543 - Three Phase Rectifiers And Inverters

DEGREE PROGRAMME

05BG - Master Universitario En Electronica Industrial

ACADEMIC YEAR & SEMESTER

2019/20 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	53001543 - Three Phase Rectifiers And Inverters
No of credits	3 ECTS
Type	Optional
Academic year ot the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	05BG - Master Universitario En Electronica Industrial
Centre	05 - Escuela Tecnica Superior de Ingenieros Industriales
Academic year	2019-20

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Pedro Alou Cervera (Subject coordinator)		pedro.alou@upm.es	Sin horario. Solicitar cita previa por correo electrónico

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Analog And Power Electronics

3.2. Other recommended learning outcomes

- Circuit Analysis

- Linear Control Theory

- Power Electronics

4. Skills and learning outcomes *

4.1. Skills to be learned

CB07 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio

CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo

CE01 - Comprender, diseñar y analizar sistemas y componentes electrónicos en el ámbito de la electrónica industrial. Modelización y caracterización de sistemas electrónicos complejos.

CE02 - Ser capaz de desarrollar un proyecto de diseño de un sistema electrónico, identificando sus principales retos, en ámbitos de aplicación tales como el aeroespacial, la automoción, la ingeniería médica, las energías renovables o las comunicaciones

CE03 - Optimizar la gestión energética de los sistemas electrónicos mediante la aplicación de técnicas avanzadas de diseño de circuitos y de métodos de control.

CE04 - Utilización de herramientas CAD para la simulación, modelado y diseño de circuitos electrónicos industriales con altas prestaciones y/o restricciones

CG01 - Haber adquirido conocimientos avanzados y demostrado, en un contexto de investigación científica y tecnológica o altamente especializado, una comprensión detallada y fundamentada de los aspectos teóricos y prácticos y de la metodología de trabajo en uno o más campos de estudio

CG05 - Saber transmitir de un modo claro y sin ambigüedades a un público especializado o no, resultados procedentes de la investigación científica y tecnológica o del ámbito de la innovación más avanzada, así como los fundamentos más relevantes sobre los que se sustentan

CT01 - Uso de la lengua inglesa

CT04 - Organización y planificación

CT07 - Trabajo en contextos internacionales

4.2. Learning outcomes

RA35 - Comprender el funcionamiento detallado de los inversores y rectificadores trifásicos

RA36 - Analizar el funcionamiento de las topologías fundamentales y las técnicas de modulación

RA38 - Saber simular inversores y rectificadores de potencia

RA37 - Diseñar lazos de control para inversores y rectificadores trifásicos.

RA39 - Implementación de los sistemas de control sobre tarjetas industriales de propósito general

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

The main objectives of this subject is that the students acquire knowledge on the theoretical and applied aspects in the field of three phase rectifiers and inverters .

The subject provides the student the mathematical tools needed model and control three phase rectifiers and inverters connected to the grid.

This subject also covers different modulation techniques that can be applied and shows their implementation.

There is a chapter focused on the main topologies of inverters both two-level and three-level, and unidirectional rectifiers.

In order to get a clear understanding on the impact of the design decisions on the efficiency and size of the converters, a chapter covers both the estimation of losses in semiconductor devices and the design of magnetic components.

5.2. Syllabus

1. Fundamentals
    1.1. DC/AC Half-Bridge Converter
    1.2. DC/AC Full-Bridge Converter
2. Space Vectors and Alpha/Beta Transformations
    2.1. Space-Vectors
    2.2. Alpha/Beta transformation
    2.3. DQ transformation
    2.4. PLL
3. Modulation Techniques
    3.1. Sinusoidal Modulation
    3.2. Zero sequency injection
    3.3. Space Vector Modulation

4. Topologies

   4.1. Two-Level and Three-Level Inverters

   4.2. Unidirectional Rectifiers

5. Component Selection

   5.1. Active Devices Losses and Thermal Modeling

   5.2. Inductor Design

   5.3. LCL Filter Design

   5.4. EMI filters

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Other face-to-face activities	Assessment activities
1	**T1 Introducción. HB Converter Analysis** Duration: 02:00			
2	**T1 Half-Bridge Distortion. Current Control** Duration: 00:00			
3		**HW1 Simulation of Half-Bridge Converter with control** Duration: 02:00		**HW1 Half-Bridge Simulation Example** Continuous assessment and final examination Duration: 02:00
4	**T2 Space Vectors and alpha eta transformation** Duration: 02:00			
5	**T2 DQ Transformation and PLLs** Duration: 02:00			
6		**HW2 Three-phase VSI simulation** Duration: 02:00		**HW2 Three-phase VSI simulation** Continuous assessment and final examination Duration: 02:00
7	**T3 Modulation Techniques** Duration: 02:00	**HW3 Zero Sequence Injection Simulation** Duration: 01:00		**HW3 Zero Sequence Injection Simulation** Continuous assessment and final examination Duration: 02:00
8	**T4 Topologies. Inverters** Duration: 01:30	**HW4 Three-Level VSI Simulation** Duration: 01:30		**HW4 Three-Level Inverter Simulation** Continuous assessment and final examination Duration: 02:00
9	**T4 Topologies. Rectifiers** Duration: 03:00			
10	**T5 Component Selection. Losses in Semiconductors. Thermal Models** Duration: 03:00			

11	**T5 Inductor Design.** Duration: 01:00	**HW 5 Inductor Design** Duration: 02:00		**HW5 Inductor Design** Continuous assessment and final examination Duration: 02:00
12	**T5 LCL Filters. EMI Filters** Duration: 02:00	**LCL Filter Design** Duration: 01:00		
13			**Final Project Review** Duration: 03:00	**Final Project Review** Continuous assessment and final examination Duration: 03:00
14				
15				
16				
17				**Final Exam** Continuous assessment and final examination Duration: 02:00

The independent study hours are training activities during which students should spend time on individual study or individual assignments.

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The subject schedule is based on a previous theorical planning of the subject plan and might go to through experience some unexpected changes along throughout the academic year.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
3	HW1 Half-Bridge Simulation Example		No Presential	02:00	6%	5 / 10	CB10 CT01 CT07 CG01 CE03 CE04 CB07 CE01 CE02
6	HW2 Three-phase VSI simulation		Face-to-face	02:00	6%	5 / 10	CB10 CT01 CT07 CG01 CG05 CE03 CE04 CB07 CE01 CE02
7	HW3 Zero Sequence Injection Simulation		Face-to-face	02:00	6%	5 / 10	
8	HW4 Three-Level Inverter Simulation		Face-to-face	02:00	6%	5 / 10	CB10 CT01 CT07 CG01 CG05 CE03 CE04 CB07 CE01 CE02
11	HW5 Inductor Design		Face-to-face	02:00	6%	5 / 10	CB10 CT01 CT07 CG01 CG05 CE03 CE04 CB07

							CE01 CE02
13	Final Project Review		Face-to-face	03:00	40%	5 / 10	CB10 CT01 CT04 CT07 CG01 CG05 CE03 CE04 CB07 CE01 CE02
17	Final Exam		Face-to-face	02:00	30%	5 / 10	CB10 CT01 CG01 CG05 CE03 CB07 CE01 CE02

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
3	HW1 Half-Bridge Simulation Example		No Presential	02:00	6%	5 / 10	CB10 CT01 CT07 CG01 CE03 CE04 CB07 CE01 CE02
6	HW2 Three-phase VSI simulation		Face-to-face	02:00	6%	5 / 10	CB10 CT01 CT07 CG01 CG05 CE03 CE04 CB07 CE01 CE02
7	HW3 Zero Sequence Injection Simulation		Face-to-face	02:00	6%	5 / 10	

8	HW4 Three-Level Inverter Simulation		Face-to-face	02:00	6%	5 / 10	CB10 CT01 CT07 CG01 CG05 CE03 CE04 CB07 CE01 CE02
11	HW5 Inductor Design		Face-to-face	02:00	6%	5 / 10	CB10 CT01 CT07 CG01 CG05 CE03 CE04 CB07 CE01 CE02
13	Final Project Review		Face-to-face	03:00	40%	5 / 10	CB10 CT01 CT04 CT07 CG01 CG05 CE03 CE04 CB07 CE01 CE02
17	Final Exam		Face-to-face	02:00	30%	5 / 10	CB10 CT01 CG01 CG05 CE03 CB07 CE01 CE02

7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

7.2. Assessment criteria

Along the course there will home work assignments that will start during the class and that they will have to be completed two weeks later

Homework delivered after the corresponding deadline will count 50%

There will be a final project to be done during the course about a complete design of a three phase rectifier or invereter including the control.

Weighting of the activities on the final grade:

Homework assignments 30%

Final Project 40%

Final Exam 30%

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Voltage-Sourced Converters in Power Systems: Modeling, Control and Applications	Bibliography	Voltage-Sourced Converters in Power Systems: Modeling, Control and Applications Amirnaser Yazdani, Reza Iravini
Slides	Bibliography	Slides with the main contents of the classes
Computers	Equipment	Computers for simulations
MATLAB/Simulink	Others	Software for desing and simulation of controllers
Grid Converters for PV and Wind Power Systems	Bibliography	Grid Converters for PV and Wind Power Systems Remus Teodorescu, Marco Liserre, Pedro Rodríguez