UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria		
ACADEMIC YEAR	2021/2022		
MASTER'S DEGREE (MSC)	ELECTRICAL ENGINEERING		
INTEGRATED COURSE	ELECTRIC CONVERTERS AND ACTIVATIONS WITH LABORATORY - INTEGRATED COURSE		
CODE	19306		
MODULES	Yes		
NUMBER OF MODULES	2		
SCIENTIFIC SECTOR(S)	ING-IND/32		
HEAD PROFESSOR(S)	MICELI ROSARIO	Professore Ordinario	Univ. di PALERMO
OTHER PROFESSOR(S)	DI TOMMASO ANTONINO OSCAR	Professore Associato	Univ. di PALERMO
	MICELI ROSARIO	Professore Ordinario	Univ. di PALERMO
CREDITS	15		
PROPAEDEUTICAL SUBJECTS			
MUTUALIZATION			
YEAR	2		
TERM (SEMESTER)	Annual		
ATTENDANCE	Not mandatory		
EVALUATION	Out of 30		

TEACHER OFFICE HOURS

DI TOMMASO ANTONINO OSCAR

Monday	15:00	16:00	Laboratorio "EDALab" (all'interno della sala macchine) - Edificio nr. 9, ex DEIM. E' gradito un contatto (telefono o e-mail) almeno un giorno prima.
Tuesday	15:00	16:00	Laboratorio "EDALab" (all'interno della sala macchine) - Edificio nr. 9, ex DEIM. E' gradito un contatto (telefono o e-mail) almeno un giorno prima.
Wednesday	15:00	16:00	Laboratorio "EDALab" (all'interno della sala macchine) - Edificio nr. 9, ex DEIM. E' gradito un contatto (telefono o e-mail) almeno un giorno prima.
Thursday	15:00	16:00	Laboratorio "EDALab" (all'interno della sala macchine) - Edificio nr. 9, ex DEIM. E' gradito un contatto (telefono o e-mail) almeno un giorno prima.
Friday	15:00	16:00	Laboratorio "EDALab" (all'interno della sala macchine) - Edificio nr. 9, ex DEIM. E' gradito un contatto (telefono o e-mail) almeno un giorno prima.

MICELI ROSARIO

Monday	12:00	13:00	ufficio personale
Tuesday	15:00	18:00	studio terzo piano
Friday	15:00	18:00	studio terzo piano

DOCENTE: Prof. ROSARIO MICELI

PREREQUISITES	The student, in addition to consolidated basic knowledge of mathematics, physics and electrical engineering, has to possess appropriate knowledge and ability to apply knowledge regarding the steady state operation of the rotating electrical machines, components and power electronic systems, different types of controllers, open and closed loop control techniques, transducers and measurement tecniques.
LEARNING OUTCOMES	Knowledge and understanding skills. At the end of the course the student, will acquire knowledge and methods to address and solve in an original way problems regarding the study and development of the main electrical drives and power electronic converters. In particular, the student will be able to analyze, through mathematical models, computer simulations and experimental verification, the behavior of suchsystems, both in steady state and dynamic operations. To achieve this goal, lectures, discussion of case studies, guided numerical and laboratory exercises are developed during the course. The verification of these objectives is foreseen within the oral test. Ability in applying knowledge and understandings The student will acquire ability to apply knowledge and understanding with methods of problem solving and design of electrical drives and power electronic converters through numerical simulations. To achieve this goal, lectures, classroom exercises and guided labs are conducted during the course, both guided and autonomous, discussion of case studies, use of specialized software, use of commercial catalogs. The verification of these objectives is foreseen within the oral test. Judgments Autonomy The student will be able to interpret properly and autonomously the issues ofelectric drives, making a judgments on their own proper operation and collecting the necessary and more appropriate technical and economic drive specifications, in order to satisfy customer's needs. In addition, the student wil lacquire analysis methodologies for the development and tuning of complex electrical systems, such as electric drives and power electronic converters, enabling him to deal with unstructured problems and deciding also in uncertain situations. To achieve this objective, in performing laboratory exercises the students are called to make their own choices. In particular, the course includes lectures, discussion of case studies, guided exercises in the classroom and in the laboratory, autonomous exercises, use of specialized software, development of a small project. The verification of these objectives is foreseen within the oral test, also through discussion of the project and the exercises carried out during the course presented by each student during the exam. Communication skills At the end of the course the student will be able to properly communicate with competence and language property, even in highly specialized contests, issues and problems regarding the study and the development of the main electrical drives and power converters offering solutions. This skill will be exercised by means of discussion on the laboratory assignments between students and the teacher. To achieve these objectives the course includes lectures, discussion of case studies. The verification of these objectives is foreseen within the oral test. Learning ability The student will be able to learn autonomously further contents about electric drives and power electronic converters. He will be able to delve into complex issues such as those related to the development of new and original control strategies. Such ability will be developed by proposing the student to broaden the knowledge gradually acquired through the autonomous use of theoretical sources of information, other than provided as teaching aids, such as texts, regulations, laws, websites, scientific papers, etc.. To achieve these objectives the course includes lectures and numerical applications. The achievement of these objectives will be verified during the oral test.
ASSESSMENT METHODS	The exam consist in a “first oral mandatory test” for the “Power converter and Drives” module and in a “second oral mandatory test” for the “Electrical Drive laboratory” module. The assessment of the whole exam is expressed in thirtieth and is obtained as the weighted averaging of the single module assessments with respect to the credits of the two modules. In the first learning evaluation oral test for the “Power converter and Drives” module, which will be placed in the calls after the conclusion of the lectures period in the semester, the student will have to argument on 3 questions, at least, concerning the issues of the module. The assessment of test is

	expressed in thirties. In the second learning evaluation oral test for the “electrical drives laboratory” module, which will be placed in the calls after the conclusion of the lectures period in the semester, the student will have to argument on 2 questions, at least, concerning the issues of the module and the report on the laboratory experiences gone during the course. The assessment of the test is expressed in thirtieth. The learning evaluation tests have the aim to assess the degree of knowledge and understanding on the lecture and assignments issues and the assessment of the application skills finalized to the analysis and the solution of concrete cases, assessment of self-orienting and evaluation, showing clarity in arguments and language property, competence in both knowledge re-elaboration and in finding multi-disciplinary connections, ability in starting further studies and facing professional activity autonomously. The passing mark (18/30) will be 'reached by the student who know and understand the arguments at least in general terms, and that show enough application skills in order to solve concrete cases and argument clarity as to enable transmission of his knowledge. Below this threshold, the examination results will be unsatisfactory. Evaluation can increase, up to a maximum of 30/30 “cum laude”, depending on the argumentative and expository ability (More 'than sufficient, fair, good, more than good, excellent) with which the examinees interacts with the examiner and the degree of knowledge and capacity of application (more' than sufficient, fair, good, more than good, excellent) of the discipline objects as verified during the exam.
TEACHING METHODS	The course includes the following teaching activities: lectures, class exercises, laboratory exercises. The above activities are organized such a way to facilitate the achievement of learning objectives and learning outcomes, reported in the appropriate frameworks of this form. In particular, the laboratory exercises are developed by each student mainly in the module "Electric Drives Laboratory", under the guidance of the teacher. During these exercises each student is guided: - to analyze, through mathematical models, computer simulations and experimental verification, the behavior of the main electrical drives and power electronic converters, both at steady-state and transient; - to acquire the ability to apply methodologies allowing analyze and solve typical problems of design, development and fine-tuning of the systems, even operating autonomous choices.

MODULE
ELECTRIC DRIVES LABORATORY

Prof. ANTONINO OSCAR DI TOMMASO

SUGGESTED BIBLIOGRAPHY

1) Presentazioni utilizzate dal docente in formato digitale;
2) Dispense del corso in formato digitale;
3) Leonhard W.: Control of Electrical Drives, Springer Verlag, 1996;
4) N. Mohan, T. Undeland, W. Robbins “Power Electronics” Ed. John Wiley and Sons, NY 1999.

AMBIT	50363-Ingegneria elettrica
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54

EDUCATIONAL OBJECTIVES OF THE MODULE

The module has a substantial applicative character and face the study of Electrical Drives and Converters actually employed on both industry applications and traction, privileging the main operative issues.
The learning objectives consist in giving to student adequate skill to:
- chose and assembly different components and structures of an Electrical Drive;
- planning and realizing verification and trial for Electrical Drives and Static power converters;
- apply properly strategy of problem solving through mathematical modeling, computer simulations and experimental testing concerning the study and the development of Electrical Drives and Power converters with particular reference to VSIs;
- simulate and implement on DSP and microcontrollers traditional and innovative control strategies for VSI and speed controlled electrical drives;
- realize a self-evaluation of his own tracks and patterns and on the applied study methods;
- gain a confident application of tools and methodologies learned within the course, in his future professional experiences.

SYLLABUS

Hrs	Frontal teaching
4	Introduction to the course, ideal model of a power transistor, dynamical model of a power inverter including DC Link equations.
8	Classical Space Vector modulation, implementation of Space Vector Modulation through the duty cycle and a low computation algorithm.
3	State space equations of a a.c. electrical machines.
4	Recalls on standard regulators, PI, PID, P, PD, tuning methods, model matching tuning rules.

Hrs	Workshops
7	Implementation of the induction motor model, scalar control implementation and simulations. PM synchronous motor model implementation. Tuning and simulation of regulators for Permanent Magnet Motor Drives. Tuning and simulation of regulators for Permanent Magnet Motor Drives.
6	Numerical Simulations (in the Simulink environment) of modulated VSI and DC and AC Drive control.
6	Use of the dSPACE and Arduino Due systems to implement sinusoidal PWM, Space Vector PWM.
16	Scalar Control and Field oriented control of AC Drives with induction motors and synchronous (PM) motors with dSPACE and Arduino Due systems.

MODULE
ELECTRIC CONVERTERS AND DRIVES

Prof. ROSARIO MICELI

SUGGESTED BIBLIOGRAPHY

1) Presentazioni utilizzate dal docente in formato digitale;
2) Dispense del corso in formato digitale;
3) Leonhard W.: Control of Electrical Drives, Springer Verlag, 1996; ISBN-13: 978-3-642-97648-3, e-TSBN-13: 978-3-642-97646-9, DOT: 10.1007/978-3-642-97646-9;
4) N. Mohan, T. Undeland, W. Robbins “Power Electronics” Ed. John Wiley and Sons, NY 1999. ISBN-13:978-88-203-3428-4.

AMBIT	50363-Ingegneria elettrica
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81

EDUCATIONAL OBJECTIVES OF THE MODULE

The module has essentially an applicative nature and deals with the study of the electric drives and associated power converters currently used both in industry and in traction, favoring, in particular, the issues associated with their operation. In particular, after an initial part concerning the modeling of rotating electrical machines, the space vectors and a classification of the electric drives based on the used motors, converter and control systems, the module regard the static characteristics of the loads, the mode of motor-load coupling, the equations of motion, the established conditions, the speed control, the operation in the four quadrants of the torque-speed plan, the open loop and closed control, the current and speed control and DC motors Drives and converter, AC drives and converter with both asynchronous and synchronous machines.
The educational objectives are to provide the following skills to students:
- Choose and assemble the various components of a commercial electrical drive;
- Test and manage DC and AC electrical drives.
- Address and resolve in an original way, through mathematical models and computer simulations, problems concerning the study and development of the main electrical drives and power electronic converters with particular reference to Voltage Source Inverters;
- simulate control strategies for speed regulation of electric drives.

SYLLABUS

Hrs	Frontal teaching
4	Course introduction. The primitive machine and its circuital model. Dynamic models of DC machines with different excitation types
6	Induction machine mathematical model: model in phase coordinates, models in stationary reference frames and in synchronously rotating reference frame.
4	Mathematical models of the synchronous motor
2	Block scheme of an electrical drive
4	Steady state and dynamical load characterization
11	Static converter for DC drives and DC Drives: AC/DC converter for DC drives, behavior of DC Drives with AC/DC converter, DC/DC converter for DC drives, behavior of DC Drives with DC/DC converter, block schemes for the control of DC Drives
12	Converters for AC drives: voltage regulators, structure and operation principle of DC/AC converters, Voltage Source Inverters, Generated Space Vectors, modulated inverter (analog synchronous and asynchronous PWM, PWM duty cycle, Digital PWM techniques). Current Source Converters, CRPWM inverter.
12	Induction motor drives: speed regulation, behavior of an inverter (VSI, CSI, CRVSI) fed induction motor, scalar control schemes, field oriented control and schemes.
10	Synchronous Motor Drives: speed regulation, scalar control schemes and principles of Field Oriented Control.

Hrs	Practice
16	Classroom assignments on DC and AC Drives. Use of Simulink for electrical drives simulations.