UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2021/2022
MASTER'S DEGREE (MSC)	CYBER-PHYSICAL SYSTEMS ENGINEERING FOR INDUSTRY
SUBJECT	INDUSTRIAL ELECTRICAL DRIVES
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50356-Ingegneria dell'automazione
CODE	21511
SCIENTIFIC SECTOR(S)	ING-IND/32
HEAD PROFESSOR(S)	MICELI ROSARIO Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**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 oral mandatory test. The assessment of the whole exam is expressed in thirtieth. In the learning evaluation oral test 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 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.
EDUCATIONAL OBJECTIVES	The Course has essentially an applicative nature and deals with the study of the electric drives and associated power converters currently used in industry, 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.
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, 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.
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.

SYLLABUS

Hrs	Frontal teaching
2	Course introduction. The primitive machine and its circuital model. Dynamic models of DC machines with different excitation types
3	Induction machine mathematical model: model in phase coordinates, models in stationary reference frames and in synchronously rotating reference frame.
3	Mathematical models of the synchronous motor
2	Block scheme of an electrical drive
4	Steady state and dynamical load characterization
2	Static converter for DC drives and DC Drives.
6	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.
8	Induction motor drives: speed regulation, behavior of an inverter (VSI, CSI, CRVSI) fed induction motor, scalar control schemes, field oriented control and schemes.
8	Synchronous Motor Drives: speed regulation, scalar control schemes and principles of Field Oriented Control.

Hrs	Practice
12	Classroom assignments on AC Drives. Use of Simulink for electrical drives simulations.

Hrs	Workshops
4	AC Drives laboratory