UNIVERSITÀ DI PAVIA

Anno Accademico 2020/2021

ELECTRICAL DRIVES FOR INDUSTRIAL APPLICATIONS

Enrollment year	2019/2020
Academic year	2020/2021
Regulations	DM270
Academic discipline	ING-IND/32 (POWER ELECTRONIC CONVERTERS, ELECTRICAL MACHINES AND DRIVES)
Department	DEPARTMENT OF ELECTRICAL,COMPUTER AND BIOMEDICAL ENGINEERING
Course	ELECTRICAL ENGINEERING
Curriculum	Sistemi elettrici
Year of study	2°
Period	1st semester (28/09/2020 - 22/01/2021)
ECTS	12
Lesson hours	116 lesson hours
Language	English
Activity type	ORAL TEST
Teacher	BASSI EZIO (titolare) - 12 ECTS
Prerequisites	Principles of electrical engineering and mechanics, analysis of periodic waveforms, vector diagrams, basic elements of electrical machines and power electronics.
Learning outcomes	The course reviews the basic concepts concerning functional characteristics, design and applications of electrical variable speed drives at steady state, with a few hints on their control and transient behavior. In the second part are addressed items concerning the dynamical behavior of electrical drives: various regulation schemes are introduced, principally with induction and brushless motors, with different solutions as to the controlled variables and the regulation algorithms.
Course contents	This course is attended by the 2nd year students of the Laurea

Magistrale degree in Ingegneria Elettrica-curriculum Sistemi Elettrici. Industrial Automation Engineering and Computer Engineering (Embedded Systems).

In the following are resumed the main topics of this course (the list is not in cronological order, but grouped according to the argument).

Dynamic Mechanical equation: reflected torque and inertias, torque/speed load and actuators curves, stability of an operating point, jerk, optimal transmission ratio, motor-load elastic coupling, constant torque/power operating regions.

Inverter-fed Induction machine
Dynamic model of the IM and instantaneous torque; different reference system and transformation matrices; vector representation of three-phase variables; Field Oriented Control: direct and indirect implementaion, reconstruction of flux and torque variables, field weakening operation.
Doubly Fed Induction Machine: rotor current limit and torque control.
Direct Torque Control: selection of the inverter configuration & modulation strategies; Direct Self Control: hexagonal stator flux path.

A.C. current control
Control of the currents of a three-phase system (i.e. motor) in different reference systems (abc, $\alpha\beta$, dq); PI regulators; Hysteresis regulators; predictive control; compensation of dq coupling terms.
Control of an Induction machine fed from Current Source Inverter.

Space Vector PWM and a.c. current control
Inverter configurations, voltage reference and basic principles of the method, limit voltage exagon and overmodulation, optimal sequence of inverter states, switching frequency and current ripple; effect of dead-times and common mode voltage.
Active Front-End Converter: block diagram and basic operation.
Open- and closed-loop control; current control on different reference frames with linear (PI) and hystereisi regulators, voltage saturation, decoupled current control.

Electrical Drives with dc machines fed from SCR rectifiers and choppers; voltage and current waveforms, continuous and discontinuous operation, transfer functions, steady-state and dynamic behavior.

Brushless Drives
Use of Permanent magnets, different types of rotor design and rotor saliency, elctromagnetic force induced on the stator windings (d.c. and a.c. BL), effect of saliency on torque; cogging; regulation schemes; steady-state operation and geometrical loci in the field-weakening region.

Teaching methods

Lectures (hours/year in lecture theatre): 62
Practical class (hours/year in lecture theatre): 48

	Practicals / Workshops /Seminars (hours/year in lecture theatre): 4
Reccomended or required readings	In the following a list of taxtbooks free downloadable and related to EDs is presented. Additional material (notes, books, links, technical papers, hanbooks and so on) will be given during lectures; please also refer to KIRO Portal. N. Mohan, T.M. Undeland, W.P. Robbins – Power Electronics: Converters, Applications and Design – John Wiley &Sons, 2003 Bimal K. BOSE – Power Electronics & Motor Drives – Elsevier, 2006 Austin HUGHES – Electric Motors and Drives – Elsevier, 2006 T.J.E. MILLER - Brushless Permanent-Magnet and Reluctance Motor Drives-Clarendon Press, 1989 P.C. SEN – Principles of Electric Machines and Power Electronics – Wiley, 2014 Piotr WACH – Dynamics and Control of Electrical Drives – Springer, 2011 Murphy, Turnbull. A.C. current control. Pergamon Press,1988 (NOT downloadable). W. Leonhard. Control of Electrical Drives. Springer Verlag, 2003.
Assessment methods	Oral exam during which the students can be required to solve a simple written exercise on the very basic contents of the course. A written report on specific topics could be required; the interest displayed during the lectures can contribute to the evaluation. Online exams (e.g. via Skype), or online written exams could also be considered.
Further information	
Sustainable development goals - Agenda 2030	$lbl_legenda_sviluppo_sostenibile