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|---|---|---------------------------------|--------------------------------|---------------------|
| Title<br><b>Azionamenti elettrici II</b><br><b>Electric Drives II</b> | Degree<br><b>Corso di Laurea Magistrale in Ingegneria</b><br><b>Elettronica (DM 270/04)</b> | Year<br><b>2</b>                | Teaching<br>Period<br><b>2</b> | Credits<br><b>6</b> |
| Teacher: <b>Roberto Petrella</b>                                      |   | Academic year: <b>2014/2015</b> |                                |                     |

**Objectives:**

The course gives specific skills on the design of AC motor drives. Dynamic behaviour of most important AC motor is analysed. Both conventional and advanced control techniques are applied to synchronous and asynchronous motor drives. A complete design example is carried out by a case study. Principles of EMC for electric drives are also illustrated.

**Acquired skills:**

- Understanding the terminology of technical literature;
- recognising motors and drives performances;
- knowing guidelines for EMC problems and measurements in electric drives;
- carrying out the design and implementation of an AC motor drive;
- knowing rules of thumb and pitfalls of a numerical implementation of control algorithms;
- use of electric drives in main industrial applications
- recent applications of ac control in renewable energy sources: photovoltaic and wind generation.

| <b>Lectures and exercises</b>                      |  | <b>hours</b> |
|--|--|--------------|
| <b>Topics</b>                                      | <b>Specific contents</b>   |              |
| AC electric drives                                 | Introduction to high-performance AC electric drives: classification and main features.   | 2            |
| Two- and three-level three-phase inverters         | Space vectors for the study of three-phase systems: definitions, coordinate transformations, modulators for two- and three-level three-phase inverters. influence and compensation of dead-times. Analysis of ripple current.                                  | 8            |
| Three-phase current control                        | Stationary and synchronous reference frames and control. Predictive and hysteresis control.  | 2            |
| Permanent magnet synchronous motor drives          | Structure of the drive. Dynamical model. Operating regions. Current control. Feed-forward and decoupling. Flux-weakening. Sensor-less control. Measurement and estimation of machine parameters. Applications.   | 6            |
| Interior permanent magnet synchronous motor drives | Structure of the drive. Dynamical model. Operating regions. Current control. Feed-forward and decoupling. Flux-weakening. Sensor-less control. Measurement and estimation of machine parameters. Applications.   | 8            |
| Synchronous reluctance motor drives                | Structure of the drive. Dynamical model. Operating regions. Current control. Feed-forward and decoupling. Flux-weakening. Sensor-less control. Applications.   | 4            |
| Induction motor drives                             | Equations and dynamical model. Direct and indirect field oriented control (FOC). Operating regions. Current control. Feed-forward and decoupling. Flux-weakening. Sensor-less control. Applications.   | 8            |
| Advanced drive control for ac machines             | Model Reference Control (MRAS). Direct Torque Control (DTC). Model Predictive Control (MPC).   | 6            |
| Electric drive design                              | Design of a (digital) controller for electric drives: timings, real-time constraint and fixed-point numerical representation. Simulation by means of Matlab/Simulink. Implementation by DSP microcontrollers. Analysis of actual motor and drives data sheets. | 6            |
| Sensors for electric drives                        | Current, voltage, position, speed and torque sensors. Principle of operation, classification, features and use.  | 2            |
| Renewable energy sources                           | Emergent applications in the field of renewable energy sources: photovoltaic and wind generation systems. Control schemes and features.  | 4            |
| EMC and acoustic noise in drives                   | European regulation 61800/3. Acoustic noise measurement - a case study.  | 2            |
| Microcontrollers and control systems               | DSP microcontrollers for power electronics and drives applications: block diagrams, peripherals, applications.   | 2            |
| <b>Total hours for lectures and exercises</b>      |  | <b>60</b>    |
| <b>for exercises only</b>                          |  | <b>6</b>     |

| Further educational activities                          | hours     |
|---|-----------|
| Labs (experimental demonstration of drives)             | 2         |
| Tutorials / Seminars                                    | 0         |
| Workshops   | 0         |
| Technical tours (possible technical tours in companies) | 4         |
|   | 0         |
| <b>Total hours for further educational activities</b>   | <b>6</b>  |
| <b>Total hours</b>                                      | <b>66</b> |

**Type of exam:** Written and oral

**References:**

- S. Bolognani, M. Zigliotto, Azionamenti Elettrici, Libr. Progetto, Padova, 1998
- L. Bonometti, Convertitori di potenza e servomotori brushless, UTET, ISBN 88-7933-207-4
- M.H. Rashid, Elettronica di potenza – Dispositivi e circuiti, Volume 1, 3a edizione, Pearson/Prentice Hall, ISBN 9-788871-923475
- J.M.D. Murphy, F.G. Turnbull, Power Electronic Control of AC Motors, Pergamon Press, ISBN 0-08-022683-3, 1988
- W. Leonhard, Control of Electrical Drives, Springer, ISBN 3-540-41820-2
- N. Mohan, T.M. Undeland, W.P. Robbins, Power electronics: converters, applications and design, John Wiley & Sons, ISBN 0-471-61342-8
- P. Vas, Vector control of AC machines, Oxford University Press, 1990
- G.R. Slemon, Electric machines and drives, Addison-Wesley, MA, ISBN 0-201-57885-9, 1992
- I. Boldea, S.A. Nasar, Electric Drives, CRC Press, 1998
- A.M Trzynadlowsky, Control of Induction Motors, Pergamon Press, ISBN 0127015108, Sept. 2000

Additional material or information on line <http://web.diegm.uniud.it/petrella>