UNIVERSIDAD PONTIFICIA
ICAI ICADE
COMILLAS
MADRID

ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA

DIE-GITI-432 Electric Drives

SEMESTER: Spring

CREDITS: 9 ECTS (6 hrs. per week: 4 Theory + 2 Lab, on average)

LANGUAGE: Spanish

DEGREES: GITI

Course overview

Speed control of induction motors using scalar V/f control is deeply analyzed. Dynamical models for induction machines (squirrel cage and wound rotors) and synchronous machines (rotor excited with and without damping windings, permanent magnets motors and reluctance motors) are derived using space vector theory. Vector control for all the former machines is studied.

Simulations of the scalar and vector control are made in the lab. In addition, two lab. experiences using commercial V/f equipment are also done.

Prerequisites

Basic knowledge of power system and circuits fundamentals.

Basic knowledge of power electronics.

Basic knowledge of electromagnetic fields.

Course contents

Theory:

1. **Introduction to the electric drives.** What are they? What are they used for?
2. **Modeling dynamical rotating systems.** Introduction. Dynamic equation. General analytical scheme. Gears and pulleys. Torsional resonance and electric analogy. Per unit system in mechanical systems. Load types.
3. **Speed scalar control of induction machines. loop and closed loop schemes. Slip compensation.** Introduction. Basic principles in induction machine. Steady-state model. Comparison between steady-state and dynamical models. Principles of constant flux control. Operation zones and limitations. Compensation of voltage droop at low speed. Soft start. Open
4. **Sinusoidal PWM.** PWM fundamentals. Triphasic PWM. Harmonics. Effects on the induction machine.

5. **Space vector theory.** Introduction. Space vector in triphasic systems. Reference systems. Park transform. Definition of flux, current and voltage space vectors. Equivalent circuits of general triphasic machines. General equation of torque production.
6. **Synchronous machine dynamical model.** Model without damping windings. Permanent magnet synchronous machine dynamical model. Reluctance synchronous machines dynamical model. General model with damping windings.
7. **Induction machine dynamical model.** Doubly fed model. Squirrel cage model. Equations.
8. **Vector control.** General structure. Principle of one degree of freedom. Vector control in induction machines: direct and indirect control. Vector control of permanent magnet machines. Vector control of reluctance machines.
9. **Vector control regulators design.** Current (intensity) models. Inverter modeling. Decoupling i/v regulator design. Speed/torque/position regulator design.
10. **Introduction to FACTS and wind energy control.** Typical control schemes in wind energy generation. FACTS principles. Active and reactive power control using a STATCOM.
11. **Control of DC and brushless machines.** Introduction. Principles of DC machines. Equivalent model. Speed control by voltage chopping. Principles of brushless machines. Control of brushless machines.

Laboratory:

There will be eight 2-hour sessions between the third and the last lecture week, including the lab exam.

P1. Introduction to Simulink and dynamic electric machines models: starting of induction motors.
P2. Induction motor machine steady-state model vs. dynamic model.
P3. V/f Control of induction motor. Simulation of the steady-state characteristics.
P4. V/f Control of induction motor. Commercial speed controller. Basic use.
P5. V/f Control of induction motor. Commercial speed controller: PWM and starting ramp.
P6. V/f Control of induction motor. Simulation of soft starting and breaking.
P7. V/f Control of induction motor. Simulation of PWM effects on torque and current.
P8. Transients in standard synchronous machines. *dq* reference system and park transformation.
P9. Transients in standard synchronous machines. Damping windings.
P10. Design of vector controllers for induction motors. Current loop.
P11. Design of vector controllers for induction motors. Speed loop.
Exam

Textbook

- Novotny D. W., Lipo T. A., *Vector control and dynamics of AC drives*, Oxford University Press, 1996.
- Krause P.C., Wasynczuk O., Sudhoff S. D., *Analysis of electric machinery*, IEEE Press, 1995

Grading

The following conditions must be accomplished to pass the course:

- A minimum overall grade of at least 5 over 10 in the 'theory' part.
- A minimum overall grade of at least 5 over 10 in the 'Laboratory' part. A minimum grade of 5 over 10 in the 'Laboratory' exam.

The overall grade is obtained as follows: 65% theory grade + 35% Lab. Grade.

- Theory: Final exam 70% + other exams 30% (typically there are 2 additional short exams).
- Laboratory: Final exam 50% + 50% performance during the lab sessions.