Aalto University
School of Electrical
Engineering

# Syllabus

## ELEC-E8405 Electric Drives (5 ECTS)

Marko Hinkkanen

Autumn 2022

# Course Description

**Course name:** ELEC-E8405 Electric Drives

**Credits:** 5 ECTS

**Periods:** I–II

**Time:** Every Wednesday 7.9. – 7.12.2022 at 8:15–12:00

**Physical location:** Auditorium T2 (Konemiehentie 2)

**Distance teaching platform:** Microsoft Teams

**Teacher in charge:** Prof. Marko Hinkkanen (marko.hinkkanen@aalto.fi)

**Prerequisites:** Circuit theory, basics of electrical power engineering, analog control

# Instructors

- Lectures
  - Marko Hinkkanen
- Exercises and assignments
  - Firdausa Ahmed
  - Rayane Mourouvin
  - Hannu Hartikainen
  - Lauri Tiitinen
  - Reza Hosseinzadeh

# Course Format and Preliminary Schedule

- 12 lectures (8:15–10:00)
- 6 problem-solving exercises (10:15–12:00)
- 4 instruction sessions for assignments (10:15–12:00)
- If you take both half-course exams, you can skip the full-course exam

| Date | Lecture 8:15 – 10:00 | Problem-solving exercise 10:15 – 12:00 | Classroom instruction for assignments 10:15 – 12:00 |
|---|---|---|---|
| 7.9.2022 | 1, 2 | | |
| 14.9.2022 | 3 | 1 | |
| 21.9.2022 | 4 | 2 | |
| 28.9.2022 | 5 | | 1a |
| 5.10.2022 | 6 | 3 | |
| 12.10.2022 | 7 | | 1b |
| 19.10.2022 | Half-course exam 1 at 9:00 – 12:00 | | |
| 26.10.2022 | 8 | 4 | |
| 2.11.2022 | 9 | | 2a |
| 9.11.2022 | 10 | 5 | |
| 16.11.2022 | 11 | | 2b |
| 23.11.2022 | 12 | 6 | |
| 30.11.2022 | Half-course exam 2 at 9:00 – 12:00 | | |
| 7.12.2022 | Full-course exam at 9:00 – 12:00 | | |

# Preliminary Lecture Plan

1. Syllabus, introduction
2. DC motor model
3. Mechanics
4. Losses and heat transfer
5. DC motor dynamics
6. DC-DC conversion, PWM
7. Cascade control of a DC motor drive
8. Elementary AC machines, 3-phase systems
9. Space-vector models
10. Field-oriented control of a PMSM drive
11. Other AC motor and converter types, future trends
12. Guest lecture

# Course Materials

Materials available at MyCourses

- Lecture slides (also some lecture notes)
- Exercise materials
- Assignments

Readings (selected pages)

- Electric Motors and Drives: Fundamentals, Types, and Applications by A. Hughes and B. Drury (2013) (online: http://app.knovel.com.libproxy.aalto.fi/hotlink/toc/id:kpEMDFTA01/electric-motors-drives/electric-motors-drives)
- Control of Voltage-Source Converters and Variable-Speed Drives by L. Harnefors, M. Hinkkanen, O. Wallmark, and A. G. Yepes (2015) (MyCourses)

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Additional recommended textbook (not course material): Electric Machines and Drives: A First Course by N. Mohan (2012)

# Grading: Assignments and Exams (100 Points in Total)

- Assignment 1: Selecting an All-Electric Vehicle Powertrain (10 points)
  - Instruction sessions: 28.9. and 12.10.2022 at 10:15–12:00
  - Deadline: 19.10.2022
- Assignment 2: Modelling and Simulation of a DC Motor Drive (20 points)
  - Instruction sessions: 2.11. and 16.11.2022 at 10:15–12:00
  - Deadline: 23.11.2022
- Two half-course exams...
  - Exam 1: 19.10.2022 at 9:00-12:00 (35 points)
  - Exam 2: 30.11.2022 at 9:00-12:00 (35 points)
- ...or one full-course exam: 7.12.2022 at 9:00-12:00 (70 points)

- Assignments are to be completed in groups of two (or alone)
- You are encouraged to discuss the assignments in general terms with others
- Copying solutions from other groups is not allowed!
- Matlab and Simulink software is needed to complete the assignments

# Grading: Available Points

| | Available points |
|---|---|
| Assignment 1 | 10 |
| Assignment 2 | 20 |
| Exams | 70 |
| Total | 100 |

- If you take half-course and full-course exams, the better result is considered
- At least one question in each exam will be very similar to an exercise problem
- Assignments will also prepare you for the exam

# Grading: Course Grade

| Grade | Total points |
|---|---|
| 1 | 50–59 |
| 2 | 60–69 |
| 3 | 70–79 |
| 4 | 80–89 |
| 5 | 90–100 |

# Estimated Student Workload

| | Contact (h) | Individual (h) | Total (h) |
|---|---|---|---|
| Lectures (à 2 h) | 24 | 24 | 48 |
| Exercises (à 2 h) | 12 | 12 | 24 |
| Assignments (2) | 8 | 24 | 32 |
| Preparing for the exams | | 24 | 24 |
| Taking the exams | | 6 | 6 |
| Total | 44 | 90 | 134 |

- Weekly individual working is necessary for learning!
- Reading assignments
- Reviewing lecture slides and exercises
- Completing assignments

# After the Course You Will Be Able to...

1. Select a motor and converter for periodic duty
2. Build the simulation model for a cascade-controlled DC motor drive
3. Tune the control system of the DC motor drive
4. Apply space vectors for modelling and analysis of three-phase systems
5. Draw and explain the block diagram of a vector-controlled PMSM drive system