KTH Electrical Engineering

EJ2221 Design of permanent magnet synchronous machines

Course description

7.5 ECTS credits, 1st period, autumn 2012

Objectives

The aim of the course is to understand how to make an electromagnetic and thermal design of permanent magnet synchronous machines from any given set of specifications. The knowledge is applied by designing a machine for an industrial application.

Aim

After the course, the student should be able to:

- list different existing topologies of permanent magnet machines.
- describe and compare distributed and concentrated windings.
- explain the principle of field-weakening for permanent magnet synchronous motors.
- choose the appropriate permanent magnet material for a given construction with regard to functionality, operating conditions, economical and environmental factors.
- explain and compare the properties of iron laminations and soft magnetic composites in relation to their use in electrical machines.
- enumerate different loss components in a machine and relate them to different existing models.
- develop a simple analytical model of the thermal behaviour of a machine taking into account the relevant losses for the application.
- explain all the tasks in the design procedure and apply them to a surface mounted permanent magnet motor with distributed windings using simplified analytical models.
- explain discrepancies between results from different analytical methods through knowledge about the various approximations they are based on.
- describe the concepts of finite element software tools and apply them in the analysis of permanent magnet synchronous machines.
- report and present orally the results of the design project that has been conducted for a chosen application.
- do a critical evaluation of the report and presentation of the specific studies conducted by the other students.

Pre-requisites and number of students

Electrical Machines and Drives (EJ2200), 7.5 ECTS credits, or equivalent.
The number of participants in the course is limited to 10 due to restricted computer resources and intensive project supervision. The results of EJ2200 (or equivalent) will be considered to select participants together with the attendance at the first three lectures (compulsory) will be considered to select the course participants among the pre-registered students.

Course examiner, head teacher and lecturer

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Course assistants

Andreas Krings, room 3316, tel 08-790 7757, project assistant and meetings
Stephan Meier, email: meier@kth.se, project meetings

Course material

Course folder "Design of Permanent Magnet Synchronous Machines", Juliette Soulard, KTH, 2012. Distributed (free of charge) to course participants on Tuesday 28th of August during course activity.

Course web page

Login to Bilda (Ping Pong) with your KTH account at http://bilda.kth.se

All the course documents will be available on the web page. The status reports, opposition reports and power point presentations have to be submitted via your log book in accordance to the course schedule.

Course language and structure

The language of the course is English for all activities.

Six lectures of 2 hours each deal with the common knowledge needed by designers of permanent magnet machines independently of the application. Two computer-assisted tutorials are also scheduled to introduce the web-based educational design tool EMETOR, and the finite-element software FLUX.

Due to the nature of the objectives (skills of a working engineer), most of the planned activities in the course are part of a project that is based on an industrial application.

The progress of the project is reported both orally and in written form on a weekly basis to provide training for the oral examination, final report and opposition.

Project work

The project is the core part of the course. Each student works on different tasks that can be linked to one or several applications defined in conjunction with

companies collaborating with the division of Electrical Energy Conversion in research projects.

Tasks are assigned by the teaching team and can be revised in conjunction with progress meetings. The set of tasks is the same for everybody but different sets of specifications are provided for each student and tasks can be dealt with at different times.

For each **progress meeting**, a short status report may be submitted (4 compulsary reports + 2 recommended) to be handed in by **Mondays at 8:00** (see also schedule for compulsory individual deadlines). The contents of the compulsory status reports are presented orally (12min maximum) on **Tuesdays,** beginning on week 37 (3 times according to individual schedule). It is expected that you actively participate in the discussion on how to solve the difficulties faced by all the students in the group. Your **participation** is only **compulsory for 3 of the 6 hours** of presentations (your group session) but you are welcome to participate to the other session if you wish to.

Opposition reports are to be handed in by **Tuesdays at 8:00** for the two weeks you do not hold a presentation (see also schedule for compulsory individual deadlines). In this way, you give advice on how to improve reporting skills and you learn how another student has solved a task.

Project hours are scheduled on Wednesdays, Thursdays, and Fridays. During these sessions, at least one of the teachers is available in the project room. We will do our best so that project support may also be provided during normal working hours (Mon-Fri 9-16) on request.

Requirements

To obtain 7.5 credits, you have to pass the following tasks:

- Oral examination, submission of final report and final opposition (3 ECTS credits)
- 4 status reports (3 ECTS credits)
- 3 presentations, 2 progress oppositions (1.5 ECTS credits).

A pdf-version of the **final report** (based on the contents of the weekly reports) has to be **submitted** no later than **Monday 15th of October at 8:00**. The **written opposition** on a designated final report has to be submitted at the latest by **Tuesday 16th of October at 8:00**.

The oral examination is scheduled on **Thursday 18th of October at 9-12:00 and 13-16:00**. It is basically a final project meeting with each student presenting for 12min the completed investigations, followed by around 15min of questions from the teaching team and possibly audience. It is a 3-hour examination where every student is present listening to the other 4 presentations of the session. *You attend the complete examination session (morning 9-12* ***or*** *afternoon 12-16) according to your presentation time.*

Grading

The grading is based on the directives from KTH for the evaluation of Master of Science projects. The process and presentation criteria are exactly the same as for the final degree project but the criteria have been adapted to the course

nature for the engineering-related and scientific content. The course criteria are described in Table 1 (last page).

In order to pass the course, all three criteria must be met with a grade of sufficient or better. For the “Engineering-related and scientific content”, grade sufficient may only be obtained if the three first tasks have been passed (correct answers) and at least one extra task has been dealt with.

Ideally, you work with one new task each week. However, higher grades are linked to the quality of the produced results, more than the number of tasks which have been looked at. The produced results basically include all the activities leading to credits due to the process criteria. However, the status reports, oppositions and presentations are considered as working material for the evaluation.

The grades A till E are obtained based on the sum of the points collected for each criterion.
A: 21-25 points, B: 16-20 points, C: 11-15 points, D: 6-10 points, E: 3-5 points

A grade Fx is obtained if maximum one of the criteria is insufficient. If the examiner estimates that the lacking skills can be acquired by working on a new project task, the assessment will be done on the complementary report. The examiner might also decide that a written examination is more suitable. In both cases, grade E is obtained if all the three criteria are now met.

According to these directives, the **respect of the deadlines** is considered in the grading.

Written reports

Within the course, you will write two types of scientific reports: the final report and at least four status reports.
The final report has no fixed size but a maximum of 50 pages is imposed (including appendix). The contents and format are expected to follow the praxis for the MSc final degree project reports produced at the laboratory. Many reports can be found in the publication database of the laboratory available on internet. Some of them will be used as reference in the course. Do check several of them to get inspiration.
Status reports have several aims: train and improve your ability to write a scientific report, communicate with the teaching team so that errors and misunderstandings can be detected and corrected, and provide you with a good base material for your final report. Make sure you implement the corrections in your status reports using the different feedbacks as soon as you get the comments. The quality of your base material for the final report is then higher.

Opposition

To widen your knowledge, you should be able to critically review another student’s work: this is called opposition. The results of the opposition are presented in a written form (opposition report of max. 2 pages). The review should clearly show that you have read the report and familiarized yourself with the content of the report. No special format is provided but the opposition report should at least contain the evaluation of the points listed in the document

"Guidelines for opposition". A completed opposition also includes assisting to the oral presentation of the report and give oral feedback on it. You can choose the report to oppose on among the three files submitted on the Monday morning of your opposition week by the students in your own group (1, 2 or 3). The final opposition will be done on a designated report, defined at the same time as the practical details of the oral examination will be organized.

Missed progress meetings

If you cannot attend one progress meeting, please contact in advance the head teacher by e-mail or telephone. In any case, the complete set of status reports, opposition reports and PowerPoint files to oral presentations has to be submitted in Bilda.

Work load

7.5 ECTS points = 4 weeks of full-time work = minimum of 160 hours
It is highly recommended and partly compulsory that you attend the course activities. They are planned to help you go through the course contents and organize your learning activities. These represent 66 hours (12 hours lecture, 44 scheduled hours of project including tutorials, 10 hours progress meetings). It means you are expected to **work a minimum of 94 hours on your own** or with other students *(*average of 13.5 hours a week during 7 weeks).

The same task may take double as much time for you as for your friends, depending on your and their abilities. Working together is encouraged as long as it is beneficial for every member of the team. When it is time to write reports though, this is a totally individual activity. Two plagiarism checks are planned. If your work load during the course does not seem to match the present description, please feel free to book time with the head teacher to help analyse why and find appropriate remedies.

Table 1: Grading criteria for EJ2221

The student should, for the respective criterion:

Criteria	Process [1]	Engineering-related and scientific content	Presentation [1]
Excellent	• Independently plan and carry out the project within pre-ordained time constraints, have good initiative and be open to supervision and criticism • Independently identify one's own need for new knowledge and assimilate it. • Show a good ability to adopt the perspective of another's work and formulate relevant and constructive criticism. **4-5 points**	• Show a very good ability to apply engineering-related and scientific skills[1] required to design permanent magnet synchronous machines. **11-15 points**	• Show a well disposed report, with clear accounts of the project and the results, clear analysis, and well founded argumentation, as well as good language usage, format and scientific accuracy. • Show a good ability to orally present with clear argumentation and analysis, and also a good ability to discuss the work. **4-5 points**
Good	• Plan and carry out the degree work within the pre-ordained time constraints, show initiative and be open to supervision and criticism. • Show the ability to assimilate new knowledge. • Show the ability to adopt the perspective of another's work and formulate relevant criticism. **2-3 points**	• Show a good ability to apply engineering-related and scientific skills[1] required to design permanent magnet synchronous machines. **6-10 points**	• Show a well disposed report with clear accounts of the project and the results, analysis and argumentation, as well ass good language usage and format. • Show a good ability to orally present and discuss the project. **2-3 points**
Sufficient	• Carry out the project work within the pre-ordained time constraints, show certain initiative and be open to supervision and criticism. • Show a sufficient ability to assimilate new knowledge. • Show the ability to adopt the perspective of another's work and formulate criticism. **1 point**	• Show a sufficient ability to apply engineering and scientific skills[1] required to design permanent magnet synchronous machines. **1-5 points**	• Show a written report with acceptable structure, format and language usage. • Show the ability to orally present the report. **1 point**
Insufficient	• Insufficient respect for agreements, severe lack of independence, or disregard for supervision. Lacks the ability or desire to assimilate new knowledge.	• Significant lack of engineering-related or scientific skills or lack of methodology required to design permanent magnet synchronous machines.	• Lacks important elements in the written report despite the request, or lack of the ability to orally present or discuss the project.

[1]For a non-exhaustive list of these skills, refer to course objectives stated in the course description.

[1] "Evaluation criteria for the degree project", English version of the appendix to KTH-Handbok 2, Flik 15.1.