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COURSE DESCRIPTION

EJ2440 ELECTRIC TRANSPORTATION

Period 4, spring 2017, 6 hp

Transportation of people and gods is fundamental for a modern society. Apart from trains, almost all transportation is driven by fossil fuel like diesel and petrol and is therefore a large source for green-house gas (GHG) emissions. Despite the fact that we cannot explain exactly the effects of the GHG emissions, there is a large consensus that in the long run we will have to move to renewable energy sources. Also the transport sector will have to do this and the enabling technology is likely to rely on electrical solutions. The rail-bound transportation is already to a large extent electrically driven but the road-bound still has a long way to go before it will be substantially less dependent on fossil fuel.

In order to increase flexibility and efficiency of road-bound vehicles, various electrical solutions can be adopted. Both the actual traction system and the sub-systems can benefit from being more or less converted into electrical variants.

This course aims at providing a fundamental understanding of the new technology that will be introduced in the future transportation sector.

Learning outcomes

Aim of the course is to give a broad insight into electrification of both rail and road bound transportation systems.
After completed course the student should be able to:

- describe fundamental system issues in electric transportation including e.g. tractive demands and power and energy consumption;
- calculate tractive effort, power, acceleration and velocity of rail and road vehicles;
- make estimations of voltages, currents and power of electrical drives for electric transportation;
- explain the most important electric drives for rail vehicles;
- describe generic hybrid topologies;
- explain how a hybrid vehicle works and describe its main components and their function;
- construct and apply models for electric and hybrid vehicles in order to analyse their performance;
- describe the operating principle for energy storage components, such as batteries and super capacitors, and calculate basic performance of them;
- describe the design of ac and dc power supplies for electric railway traction;
- calculate the power capacity for different railway power supply systems;
- describe the background to electromagnetic interference in electric traction.

Examiner

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Course responsible

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Course main content

Historical survey

General principles of electric traction and traction systems. Tractive and braking effort. Power requirements and energy consumption

Rail bound vehicles; electric drives, transformers and converters, control and mechanical transmission.

Power supply systems; AC and DC supplies, power capacity, overhead catenary systems, over voltages, line interferences. Electromagnetic compatibility (EMC).

Driving factors for environment friendly transportation

Propulsion and auxiliary systems for conventional light and heavy road vehicles

Propulsion and auxiliary systems for electric and hybrid vehicles

Batteries - energy storage for transportation

Development trends

Course structure

The course is based on lectures, computer exercises and 2 major assignments.

Course material

Östlund, S. *Electric Railway Traction*, KTH 2012.

Hybrid drive systems for vehicles, part 1 - System design and traction concepts, LTH 2006. (Available on Canvas)

Price: 150:-

An animation program for electrical machines and power electronics is available at:

http://webfiles.portal.chalmers.se/et/Files/elkraft/Engelsk/start/index.html

Animated engines are found at http://www.animatedengines.com/.

Computer access: The course requires access to Matlab/Simulink and hence a computer.

Assignments

There are 2 compulsory and graded assignments in the course.

1. The first assignment concerns the traction drive. It is handed out in the second week of period 4. This assignment is done on an individual basis. The assignment can give 1-5 points.

It is not required to submit a complete report for this assignment. Submit your solutions and some comments regarding how you have approached the problem.

2. The second assignment deals with the propulsion systems for hybrid vehicles. In this assignment the students work in pairs. Each student group shall submit a report that will be published in Canvas for opposition by other groups. All reports are submitted to *Urkund* for check of plagiarism. The reports of assignment 2 are discussed during seminars that take roughly 1 hour. The assignment can give 1-10 points.

The reports are limited in size: 12 pages / 4500 words / 22500 characters. This limit means that you should not use more than 12 pages (or 4500 words) to report *your own work*, out of which no more than 20-30% should be figures/tables. In principle there is no need to repeat things already covered in the textbook. Cover page, table of contents, references etc. are not included in the 12 pages. Names of students and group number should be placed on every page in the footer.

Division of students into groups and allocation of seminar time slots are done in the beginning of the course.

Last day for submission of assignment no. 1: *18th April*

Last day for submission of assignment no. 2: *6th May*

Registration for the groups for the second assignment is done via Canvas.

Evaluation of the second assignment

The grade on the second assignment is based on: How well is the problem described? How well has the group managed to find and describe the method they use to solve the problem? How successful has the group been in drawing conclusions from their own work?

Seminars

During the last week of period 4, several time slots will be offered and each student group has to select one of them. Each group has to prepare a 15 minutes presentation of their work and then be prepared to defend and discuss it. Prepare to do the presentation in English but if all participants at the seminar are fluent in Swedish, then Swedish may be used.

Computer and projector will be available.

Registration for the seminar is done via a Doodle link that will be sent out on YYYY-MM-DD.

Preparatory work for the seminars

Prepare for a seminar by reading the other group's report that will be presented during the seminar. A list of seminar groups will be available via Canvas.

Study the report so that you are able to participate in a technical discussion on it. Furthermore, study also the structure of the report, how well the work is described and how easy it is to understand the content.

It is compulsory for each student to individually write a ***single page summary***. A summary should cover:

- Comments on the analysis that the report presents
- Comments on the quality of the written report (outline, structure, readability, grammar etc.)

- Comments to the results given in the report

Submit summaries and presentations by e-mail to Mats Leksell at least 2 days before the seminar. Do not forget to write your own name and the names of the report's authors, on your summaries!

Examination

TEN1 (4 credits, A-F) Written examination

PRO1 (2 credits, P/F) 2 assignments

The examination consists of two assignments and one written exam. Both the assignments and the written exam contribute to the final grade of the course.

The written exam gives a maximum of 30 points, assignment no. 1 a maximum of 5 points and assignment no. 2 a maximum of 10 points. The total maximum of points is thus 45. At least 20 points is needed to pass the course. The following grade boundaries apply:

00-15 = F
16-19 = Fx
20-24 = E
25-29 = D
30-34 = C
35-39 = B
40-45 = A

KTH has a centralized administration of exams for students with any kind of handicap, who have the right to any individualized situation for examination. If you have any questions concerning this service, please contact: Towe Breidenstein, FUNKA. Brinellvägen 8, tow@kth.se, 08-7906178

Time schedule

N.B. There are 4 time slots allocated for the battery lessons, but only 2 will be used. The dates will be announced later.

The dates for the seminars are tentative. A detailed schedule will be decided in cooperation with the course participants.

Le1	20/3		SÖ	Running resistance, tractive effort, braking effort, adhesion *1*). Electrification of railways, 2.1 Traction mechanics*
Le2	24/3		OW	Why hybridisation, The ideal road-bound vehicle, Simulink. *Introduction, slide hand-out, HDS pp. 1-6*
Le3	27/3		OW	Non-ideal vehicle components, The conventional vehicle. *HDS pp. 7-35*
Le4	28/3		SÖ	Power electronics for propulsion *3.1 Basics of Power Electronics, 3.2 Voltage Source Converters*
Le5	29/3		SÖ	Traction motors, general aspects, induction machines, Induction motor drives, *4.1Mechanical Transmission, 4.2 AC Traction Motors,*

				Introduction to Assignment no. 1
Le6	29/3		OW	The series hybrid, The parallel hybrid *HDS pp. 35-49*
Le7	31/3		SÖ	Permanent Magnets Synchronous Motors and mechanical transmission, DC traction motors, *4.3 Control of induction motor drives, 4.4 DC traction motors, 4.5 PM traction motors*
CE1 grp a	31/3		OW/ SK	Computer exercise 1: Ideal and conventional vehicles.
CE1 grp b	3/4		OW/ SK	Computer exercise 1: Ideal and conventional vehicle.
Le8	4/4		SÖ	Traction transformers, Propulsion with Voltage Source Converters *5.1 Traction transformers, 5.2 Control of the Line side converter*
Le9	18/4		OW	Parallel hybrid, Alternative drive trains *HDS pp. 44-60* Last day for submission of Ass. 1 Introduction to Assignment no. 2
Le10	19/4		Tbd	Reservtid för batterier
CE2 grp a	20/4		OW/ SK	Computer exercise 2 and 3: Series and parallel hybrid, Ideal motion profile.
CE2 grp b	21/4		OW/ SK	Computer exercise 2 and 3: Series and parallel hybrid, Ideal motion profile.
Le11	24/4		OW	Auxiliary systems *HDS pp. 61-92*
Le12	26/4		SÖ	AC Railway power supplies, power capacity *10.1 AC Power supplies*
Le13	3/5		Tbd	Batteries
Le14	5/5		Tbd	Batteries
	6/5			Last day for submission of Ass. 2
Le15	9/5		Tbd	Batteries

Sem	16, 18/5		ML/ OW/ SK	Seminars. 90 minutes slots to sign-up for
Ex	30/5			Written examination

*) This number refers to the corresponding recorded video lecture.

HDS: Textbook *Hybrid Drive Systems for Vehicles*.