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COURSE DESCRIPTION

EJ2410 HYBRID VEHICLE DRIVES

Period 2, autumn 2016, 7,5 hp

There is an increasing demand today to produce environment friendly vehicles with high performance. This can to a large extent be accomplished by electrifying the systems on-board, including the propulsion of the vehicle. This means for example that systems traditionally mechanically driven from the combustion engine will now be supplied from the electrical system. This will increase the efficiency and simplify the physical distribution of loads in the vehicle.

If the propulsion of a vehicle combines the traditional combustion engine and an electrical machine, the vehicles are referred to as “hybrid vehicles”. The introduction of hybrid vehicles requires more knowledge on a system level, both in the design and operation of the vehicles. This course aims at providing a fundamental understanding of the new technology.

1. Learning outcomes

The aim of the course is to give a broad insight into alternative solutions for conversion of primary energy to transport activity for road vehicles. Different types of fuel (e.g. fossile and bio), different types of conversion methods, different topologies and auxiliary power systems are considered.
After completed course the student should be able to:

- explain how a hybrid vehicle works and describe its main components and their function.
- describe the different hybrid topologies with respect to their functional blocks and their characteristics,
- design and implement both simple and advanced models of the vehicles,
- analyse the performance of a hybrid vehicle,
- build efficiency models of important components,
- evaluate the environmental impact of road vehicles,
- calculate basic electrical and thermal properties for power electronic converters,
- describe the operating principle and properties for the most common types of electrical motors in hybrid technology,
- describe the operating principle for fuel cells and energy storage elements and calculate basic performance of them,
- describe the fuel alternatives for hybrid vehicles.
- solve, in a group, a given assignment and both in written form and orally present and discuss the result,
- discuss about future trends.

2. Course main content

Course main content
Vehicles of today – propulsion and auxiliary systems.
Driving factors for environment friendly vehicles.
Propulsion and auxiliary systems for hybrid vehicles.
Generic components.

System concepts and simulations.
Development trends.

3. Course structure

The course is based on lectures/tutorials, computer exercises and 2 major assignments. At the end there is one laboratory exercise and 2 seminars.

4. Course material

The course material is available via Bilda, www.bilda.kth.se. A printed version of the material will be available for 200:- from STEX / the department. Participants are expected to obtain additional information for the projects via other sources too.
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. It is assumed that you have access to suitable computer facilities. However, during the computer exercises you can of course use the computers offered in the room.

5. Assignments

There are 2 assignments in the course. During the first lecture, course participants are divided into groups of 2. Each student group shall submit a report that will be published in Bilda for opposition by other groups whereby an automatic check of plagiarism is done.
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 that are 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. On Bilda you can find guidelines for the report and a Word template.
Assignment 1: Simulation of a hybrid vehicle on system level. The systems are modelled by map tables and fuel consumption is a prime parameter to study.
Available 2016-11-10. Submit via Bilda no later than 2016-11-20. PLEASE, one (1) student per group makes ALL submissions.
Assignment 2: Study of the hybrid vehicles on a component level.
Available 2016-11-21. Submit via Bilda no later than 2016-12-04.
Registration for the groups is done during the lessons.

6. Seminars

During week 47 seminars will be held on assignment 1 and during week 49 on assignment 2.
The purpose of the seminars is to present, defend and discuss the student reports. Active participation in the discussions is expected from all participants.
Each group is expected to give a 15 minutes presentation of their own work. Prepare to do the presentation in English. If all seminar participants are fluent in Swedish, then Swedish may be used. Computer and projector will be available.
Registration for the seminars is done during the lessons.

Preparatory work for the seminars

You should prepare for a seminar by reading the other reports that will be presented during the respective seminar. A list of seminar groups will be available via Bilda.
Study the reports so that you are able to participate in a technical discussion on them. Furthermore, study also the structure of the reports, how well the work is described and how easy it is to understand the content.
It is compulsory for each student in the course to individually write a ***single page summary for each respective report***. That means that each student should in total submit 2 x 2 opposition reports. A summary should cover:

- A short introduction to the (technical) solution that the report presents
- An analysis of the quality of the written report (outline, structure, readability, grammar etc.)
- Comments to the results given in the report

Submit the summaries by e-mail to Mats Leksell at least 1 day before the seminar. Do not forget to write your own name and the names of the report's authors.

7. Laboratory exercise

There is one compulsory laboratory exercise on a PM motor drive.
Registration for the exercise is done during the lessons.
The exercise takes place in the *Electrical Machines Laboratory*, Teknikringen 35.

8. Requirements

TEN1 (4,5 credits, A-F) Written examination
PRO1 (3,0 credits, P/F) 2 assignment reports
In total 4 opposition reports for the seminars
Active participation in final seminars
1 laboratory exercise (compulsory preparatory work)
Course evaluation

Evaluation

The project work will be graded and the result will be weighted by 30% in the total grade for the course.
The grade on the project work 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?

As of autumn term 2013, KTH will have 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, 08-790 6178

9. Teachers

Mats Leksell, mats.leksell@ee.kth.se, 08-790 8135, Course responsible
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10. Study visit

CANCELLED 2016 due to lack of resources at Scania.
A study visit to Scania will hopefully be possible to arrange on Monday 14th November. The visit goes to the Hybrid development group at Scania Technical Centre, Södertälje.
SUGGESTED TRAVEL from KTH:
Underground 14 from Tekniska högskolan. Get off at T-centralen
Commuter train from Central station. Get off at Södertälje hamn
Bus from Södertälje hamn. Get off at Granpark
Walk 5 minutes to Scania Technical centre

11. Time schedule

Tr33 = Teknikringen 33, 2nd floor, Student room
Le: Lesson, CE: computer exercise, Lab: laboratory work, Stu: study visit

Le1	31 Oct	Why hybridisation, The ideal vehicle, Simulink

Le2	1 Nov	Non-ideal vehicle components, The conventional vehicle,
Le3	3 Nov	The series hybrid , The parallel hybrid
CE1 grp a	3 Nov	Comp. ex. 1. Group a.
CE1 grp b	4 Nov	Comp. ex. 1. Group b.
Le4	7 Nov	Parallel hybrid, Alternative drive trains
Le5	8 Nov	The fuel cell hybrid, Auxiliary systems
CE2 grp a	9 Nov	Comp. ex. 2. Group a.
CE2 grp b	9 Nov	Comp. ex. 2. Group b.
Le6	10 Nov	Auxiliary systems
Le7	10 Nov	Power electronics
CE3 grp a	11 Nov	Comp. ex. 3. Group a.
CE3 grp b	11 Nov	Comp. ex. 3 Group b.
Stu	14 Nov	Scania, study visit
Le8	15 Nov	Power electronics
Le9	17 Nov	Power electronics
CE4 grp a	21 Nov	Comp. ex. 4. Group a
Le10	21 Nov	El. machines and drives
Le11	22 Nov	El. machines and drives
Le12	24 Nov	El. machines and drives
CE4 grp b	24 Nov	Comp. ex. 4. Group b.
Sem	24-28 Nov	Seminars on assignment no. 1 One 2-hour session per group, schedule published on Social/Bilda.
Le13	29 Nov	Batteries
Le 14	1 Dec	Batteries

Le 15	6 Dec	Separate seminar by Scania
Le16	8 Dec	Fuel cells
Sem	8-14 Dec	Seminars on assignment no. 2 One 2-hour session per group, schedule published on Social/Bilda.
La	1-16 Dec	One 3-hour session per group, schedule published on Social/Bilda.
Exam	11 Jan 2016	Written examination

12. Outline of reading material

Course participants are assumed to have basic knowledge of electrical engineering. The document "System components – introduction to Electrical engineering" gives a rough idea of what is needed.

Lecture	Content	Reading
1	Why hybridisation, The ideal vehicle, Simulink	Introduction, slide hand-out HDS pp. 1-6
2	Non-ideal vehicle components, the conventional vehicle, case studies	HDS pp. 7-35
3	Alternative drive trains, the series hybrid, design aspects, modelling in Simulink	HDS pp. 35-42
4	Case study of the series hybrid, the parallel hybrid, introduction to the complex hybrid	HDS pp. 42-49
5	The complex hybrid, fuel cell hybrid, Auxiliary systems	HDS pp.49-64
6	Auxiliary systems	HDS pp. 64-85
7	Power electronic, switch-mode conversion, basic circuits and components	HDS pp. 84-91 (important from EE pp. 1-5, 12-22, 32-38) PE pp. 1-9 Numerical example.
8	Dc/dc-conversion, mainly step-down (buck)	PE p. 9-12 (no calculations on boost or ac/dc) Concentrate on the step-down converter when it comes to calculations. There is one numerical exercise for the lecture and one for training at home.
9	Ac/dc-conversion, cooling	PE p. 12-25 (overview) pp. 26-27 (main characteristics) pp. 33-41
10	Electrical machines	EMD pp. 1-10 CTH basic electromagnetic relations
11	Electrical machines	CTH the DC machine EMD pp. 10-18
12	AC machines	EMD pp. 19-44

	Electrical drives	
13,14	Energy storage	BAT and over-head slides
15	Fuel cells	FC

HDS	Hybrid drive systems for vehicles, part 1 - System design and traction concepts
PE	System components – Power electronics 2 papers “Vehicle electronics” and “Automotive electrical systems”
EE	Introduction to electrical engineering
EMD	System components – Electrical machines and drives
FC	Fuel cells – Green power
BAT	Excerpt from Handbook of batteries (3rd edition), Linden et al. Available as electronic resource at the library. Chapters 1, 2 (*not* 2.6), 3, 15 and 29 (sec. 5-9) ”In search of the perfect Battery”, The Economist, 6th March 2008. ”Batteries and electrochemical capacitors”, Interface, Spring 2006.
CTH	Machine animation, http://webfiles.portal.chalmers.se/et/Files/elkraft/Engelsk/start/index.html
LS	Lecture slides
CE1	The ideal and conventional vehicle
CE2	The series hybrid, ideal motion profile
CE3	The parallel hybrid
CE4	Power electronics – step-down dc/dc converter