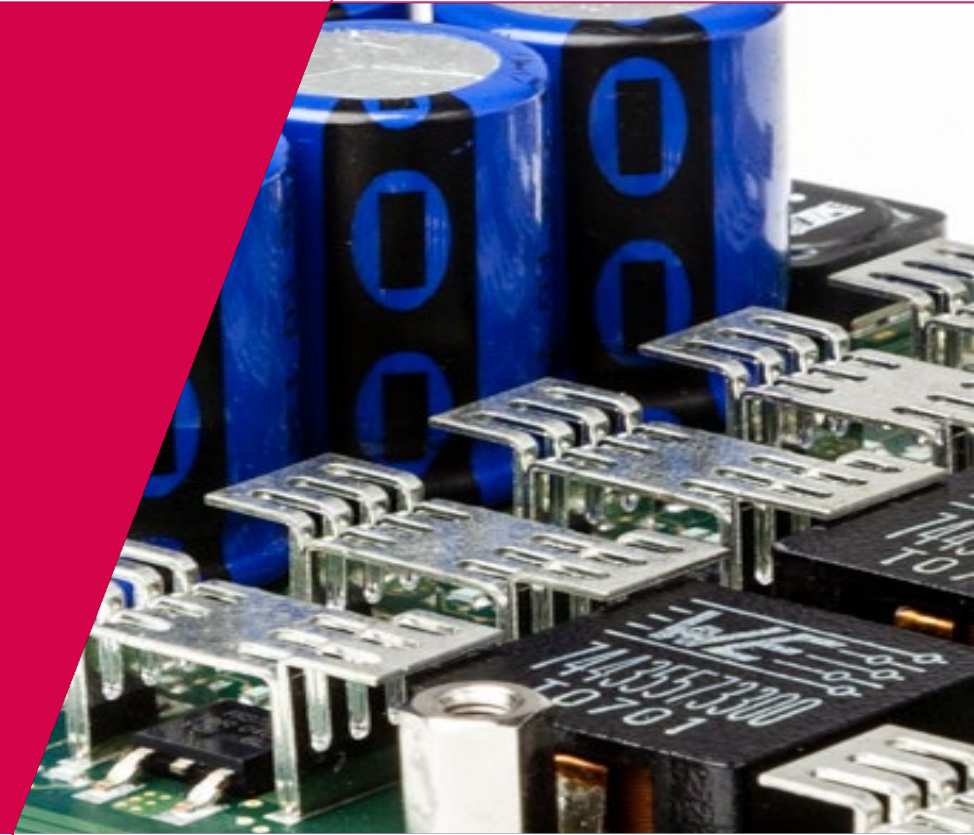


4AT060 Powertrains (ED) 5AT010 Electrical Components

Final words, Reflection

Dr. Esin Ilhan Caarls

Dr. Steven Wilkins



TU / **e**

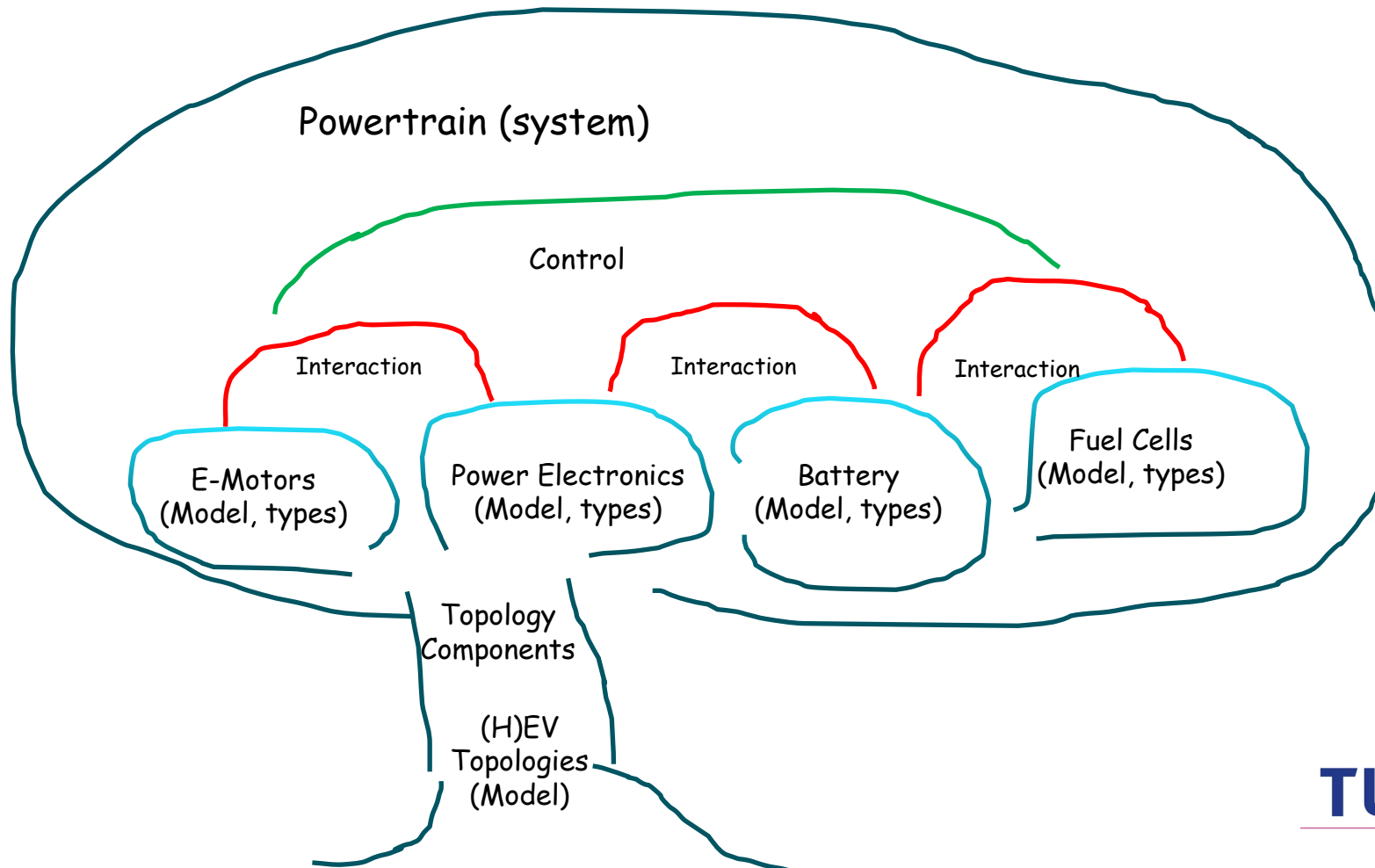
Technische Universiteit
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Where innovation starts

Content tree

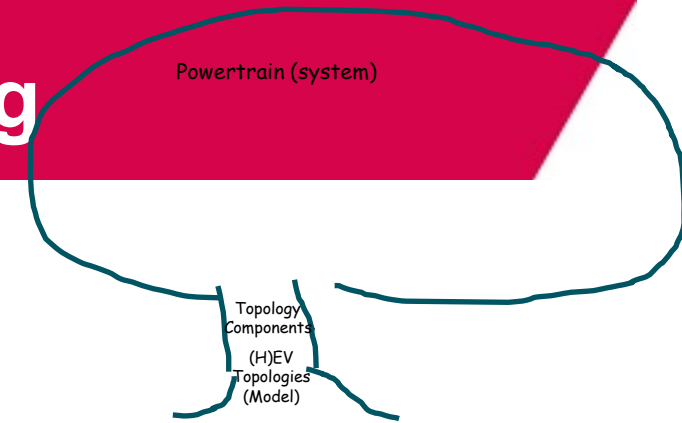
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	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8
Topics	Powertrain Topologies & Modeling	Electrical machines Power Electronics, Charging			Batteries	Powertrain Control	Fuel Cells	Reflection



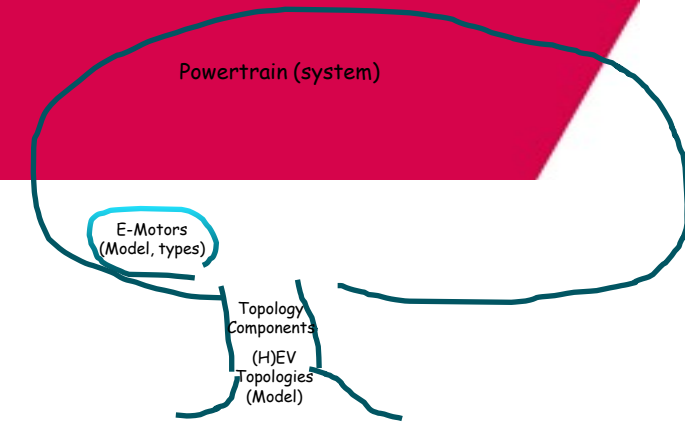
Week 1: Powertrain Topologies & Modeling

- **Market and Technology Trends**
- **General introduction to EVs**
- **Introduction to Powertrains**
- **Simulation and Modeling:**
 - Review on Steady-State
 - Basic Modelling Concepts
 - Simulation Approaches (Backward, forward)
 - Performance simulations
 - Drive Cycles



Week 2: Electrical Machines

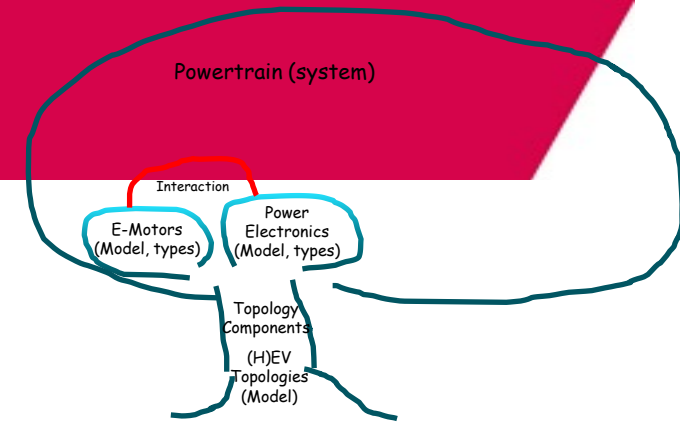
- **E-drives**
 - 4Q Operation
 - Control interactions
- **Electrical Machines**
 - Magnetism, torque production mechanism
 - Modeling of EMs, electrical circuit basics
 - PMSM
 - E-drive control aspects
 - Efficiency/Power loss maps (EM loss mechanism, effects on the E-drive performance)



Week 3: Power Electronics

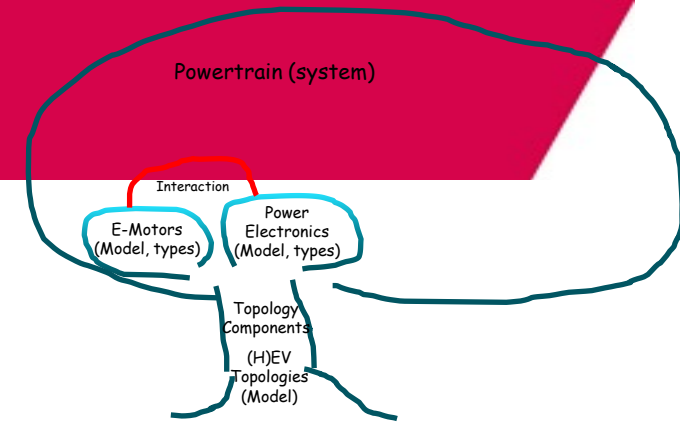
- **Power Electronics**

- Introduction to Power Conversion
- Passive-active elements
- DC-DC Converters (Examples, Types/topologies, operation)
- DC-AC Converters / Inverters (Examples, PWM control, 3-phase inverters)



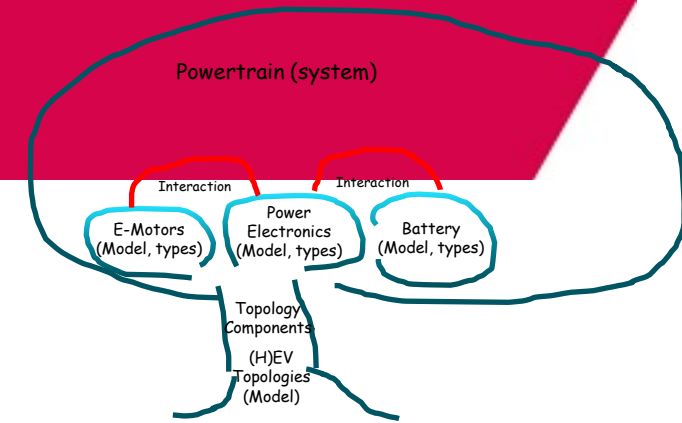
Week 4: Charging

- **Charging systems**
 - Charging infrastructure
 - AC vs DC charging
 - AC-DC Converters
 - Design and Thermal Aspects of E-drives and Sustainability
- **Guest lecture:**
 - Fundamentals of ML & AI with application to E-drives



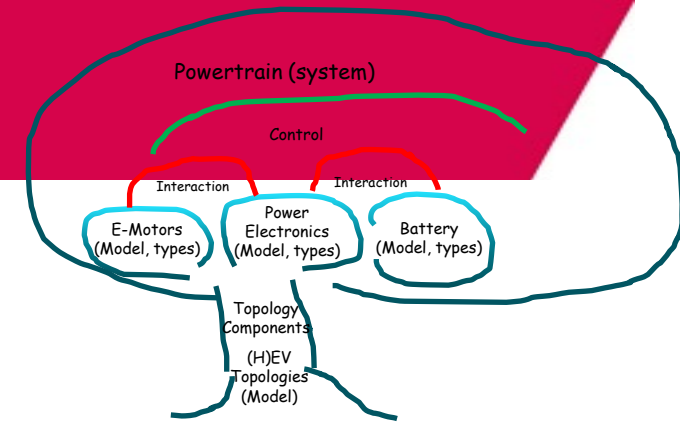
Week 5: Batteries

- **Battery Basics**
 - Chemistry
 - Terminology
 - Formats
 - Cooling
 - Battery Charging
 - Aging
 - Trends
- **Battery Modeling**
 - Circuit modelling
 - Open circuit modelling
 - Thermal modelling
- **Battery Systems**
 - Balancing



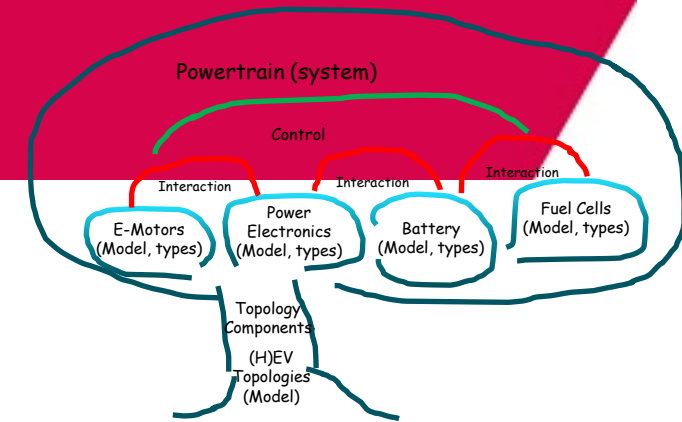
Week 6: Powertrain control

- **EV & HEV (Powertrain) Topologies**
 - Classification
 - Comparisons
 - Technical capabilities
 - Trends
- **Basic control**
 - Introduction and Overview
 - Rule-Based Control
 - Optimisation via control



Week 7: Fuel Cells

- **Fuel Cell Context**
 - Example Applications
 - Basics
 - Modeling
 - System
 - Hydrogen Storage
-
- **Auxiliaries**
 - Climate systems



Course goals

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Do you think you have achieved the targeted goal?, Positive, Neutral, No

01

Identify the **working principles** of the main electrical components as a global (H)EV powertrain systems engineer

02

Explain current and future **vehicle technologies** and the basic concepts for the component control

03

Describe the multi-physical **interactions** between powertrain components in (H)EVs

04

Make first **design estimations** of electrical components to analyze the vehicle performance (via Matlab/Simulink scripts)

L01-4 all positive, L01 more than L02, lowest L003

Your feedback helps us improve!

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Positive:

- Assignments:
 - helped with getting experience/competence with Matlab, Simulink, electrical engineering competences
 - had enough explanation and hints to students with less experience with Matlab and Simulink
 - group assignments helped for peer working
- Spectrum of diverse powertrain topics
- Support: MS Teams, Canvas, Instructions

Neutral:

- Overlapping topics with Automotive Bachelor
- Workload (ED-Interim Assignment moderate-high, Final Assignment OK)

Needs to be improved:

- More time/lecture hours dedicated for E-drives / E-machines

What is your experience on the changes from last year

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- No end-exam, assignment only based evaluation
- Group assignments
- Short mentimeter pulse check and questions at the begin of the lecture on the content?
- Guest lecture, topic, interesting?

Pls do not forget to complete the Course Evaluation Surveys!

- Support:** Pls open Canvas discussions, since this is the norm in most of the courses,
- Mention that we are not getting a proper notification when there are questions.
 - A larger room, not breathable, too hot.
 - Swap ED-CE part order. ED takes more mental power since students do not have EE background
 - 4 hours of lecture is very long, maybe 2nd half could be more implementation?
 - Try to integrate the lecture towards assignments more.
 - Give some time (maybe during lecture)
 - Workload (ED) is fine as it is now
 - Group assignments are good
 - Guest lecture is good, but timing is bad. Should not be at the same week as Assignment 1 deadline. Give more time for the lecture itself.
 - For Interim assignment ED, the lecture 2-3 very near to assignment deadline. Add Week 1 to the topics and preferably also extend the deadline by 1 week.

Applying what you have learned...

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Research reports in 4AT100

- Feel free to contact us while exploring powertrain topics in the 4AT100 course; example topics include:
 - Energy management of hybrid or electric trucks in operation for supermarkets
 - Using models to accelerate the charging of batteries
 - Optimizing component sizing for vehicles
 - Designing the next 'e-axle' for electric vehicles

Teaching Assistants

- Great experience and help us improve the course further next year

Internships

- TU/e-based internships, e.g. EPE, CS, CST, etc.
- Industry-based placements, TNO, BOSCH, but also VDL, DAF, Heliox, NXP, etc.

Graduation projects and beyond...

- Often based on internship
- Well-placed graduation project is sometimes a route towards your first job / important contribution towards your CV



Example partners in NL

Contact us and we may be able to help you find a project...