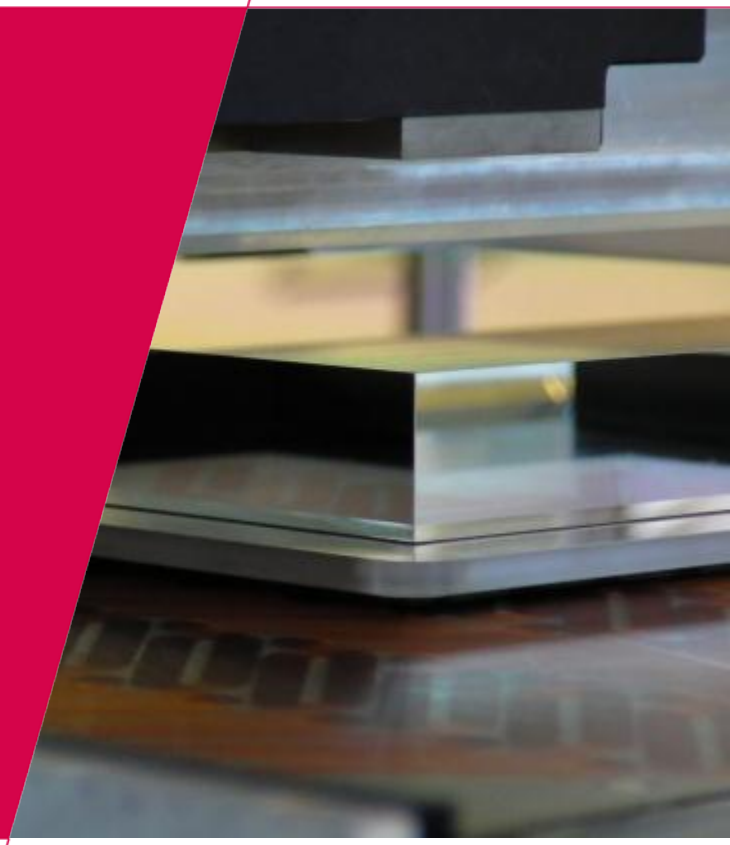
Electromechanics & Power Electronics (EPE)



Chair: prof. dr. Elena Lomonova
e.lomonova@tue.nl

Maurice Roes

Technische Universiteit
Eindhoven
University of Technology

Where innovation starts

Electromechanics and Power electronics

- **High-tech systems**
  - Linear and planar motors, magnetic levitation
  - Ultra-high precision power amplifiers
  - Field modeling, materials, parasitic effects
- **Health**
  - High-speed motors
  - Medical robotics
  - Power amplifiers for MRI and X-ray
- **Smart mobility and smart grids**
  - Distributed generation and net coupling
  - Storage and energy management
  - Active suspension
  - Drive trains for electric vehicles

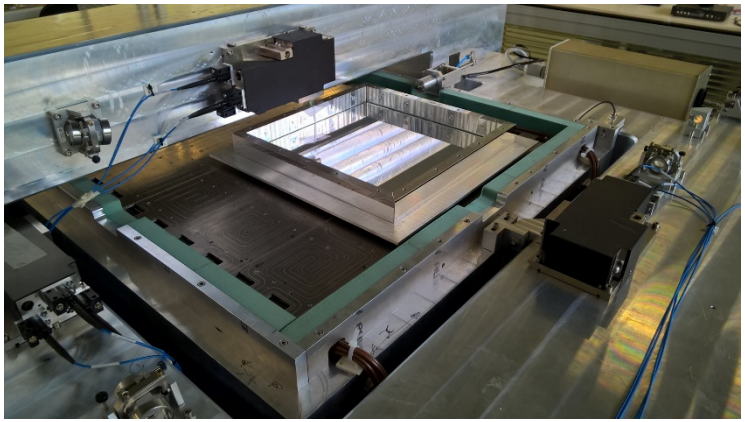
Electromechanics and Power Electronics

- **Big group with friendly atmosphere**
- **Fundamental and design oriented research**
- **Strong cooperation with industry**

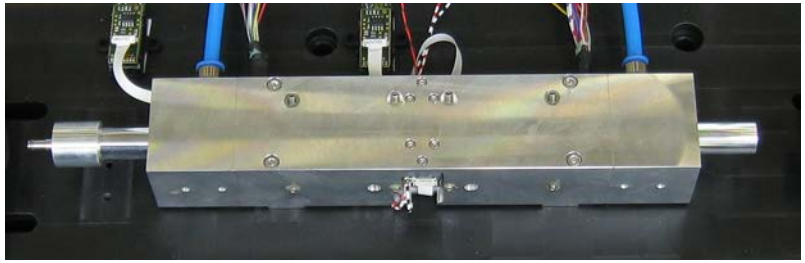
Facts and figures EPE	
Total personnel	53
Professors	1
Associate professors (full-time)	2
Lecturers (full-time)	4
Fellows from industry	10
PhD students	22
PDEng students	2

Actuators for high-tech mechatronics

- **Linear and planar actuators**
- **Improved models**
  - Force and torque distribution
  - Deformations
  - Transient phenomena (eddy currents, thermal)
- **Integration of degrees-of-freedom**



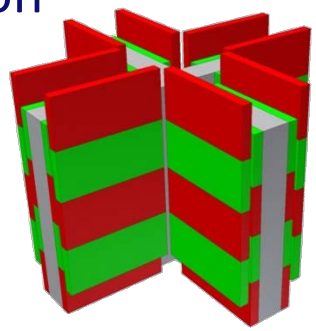
Magnetically levitated planar motor

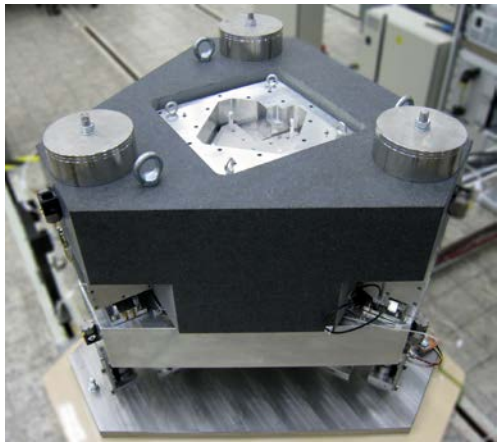


Integrated linear and rotary actuator for pick-and-place (150 m/s^2)

High precision: elimination of disturbances

- **Mechanical: vibration isolation**
  - PM based force vibration isolation for heavy loads (10 kN)
  - 700 kg gravity compensator
  - P = 0.3 - 6 W

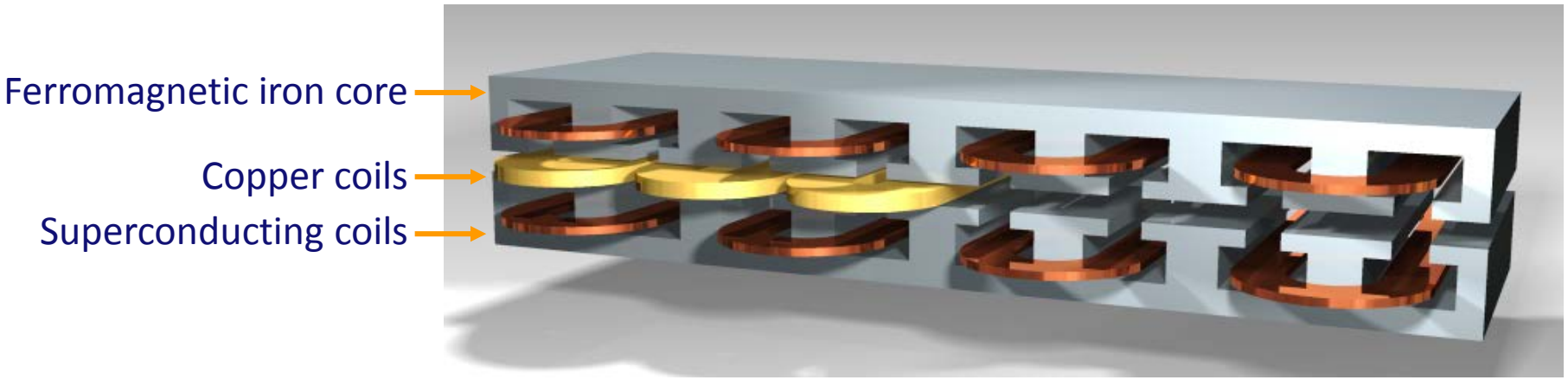




- **Electromagnetic:**
  - Cross-talk between long stroke and short stroke stages
  - Calculate cross-talk with magnetic shielding

Superconducting linear motor

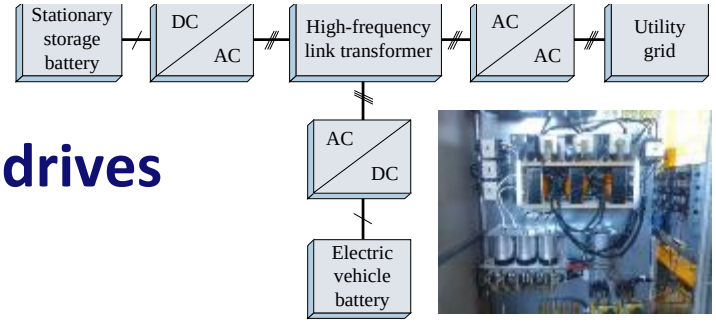
- **High-force density linear motor**



- **Superconducting coils achieve 4-5x current density of regular copper coils**
- **AC losses limit performance**
  - Result of highly non-linear behaviour of superconductor

Automotive systems

- **Drive-train systems**
- **Wide speed/torque range electrical drives**
- **Auxiliary automotive systems**
- **Power and battery management**



Fast charging converter (50kW demonstrator)

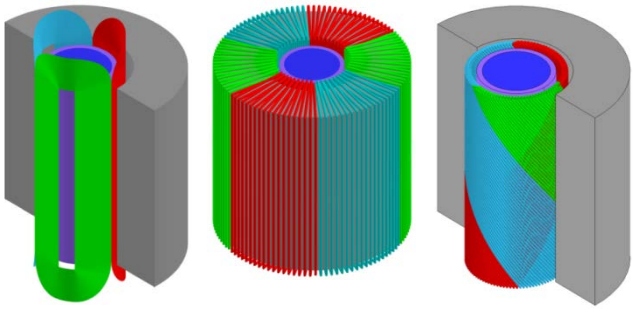
Active car suspension (tested on road)

In-wheel drive-train system

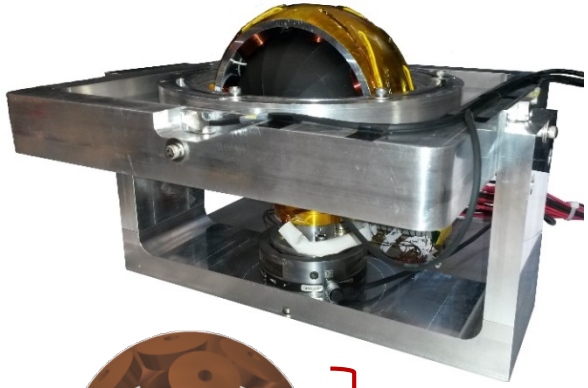
1-Phase bidirectional onboard charger with power density

Actuators for medical application

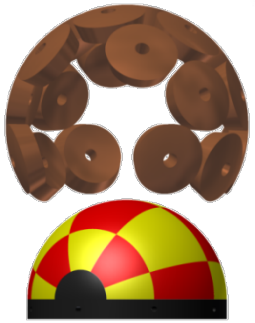
- **Medical robotics**
- **Limb rehabilitation**
- **Highly-dynamic drives**



90000 rpm turbo compressor for medical ventilator



Spherical shoulder joint for active arm support system

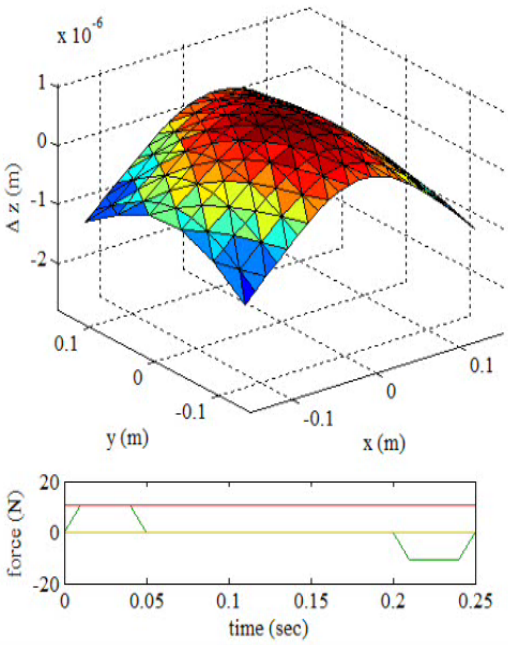


Spherical actuator

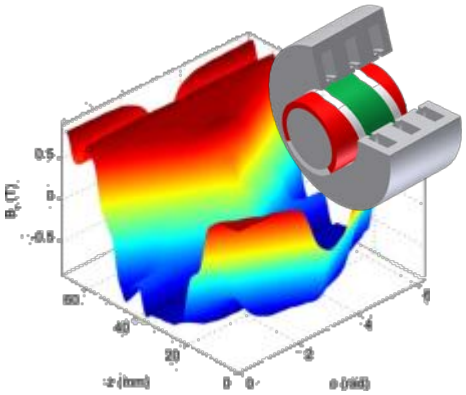
Gravity compensator

Electromagnetic analysis and design

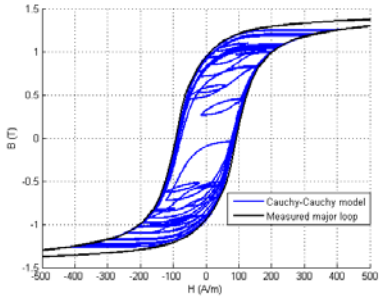
- **Ultrafast simulation and design tools**
- **Coupled models: magnetic, mechanic, thermal and electric**
- **Modeling of magnetic materials: hysteresis and magnetostriction**

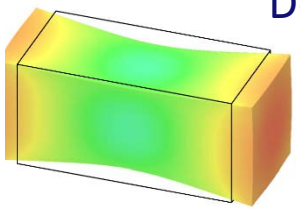


Deformation of planar motor during motion



Magnetic fields in 3D slotted structures

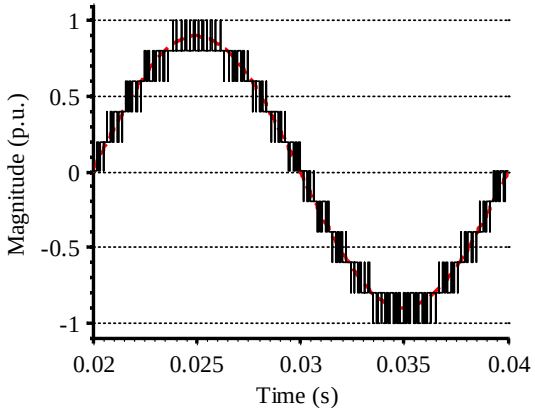


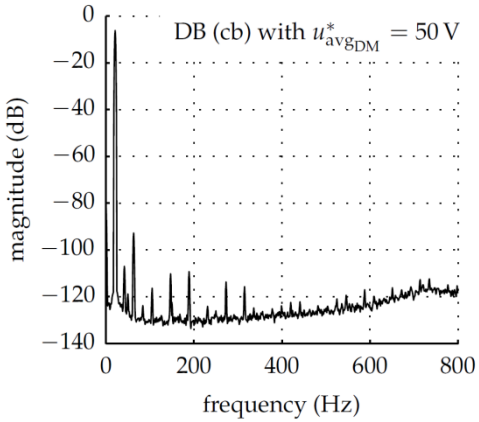


Material modeling and characterization

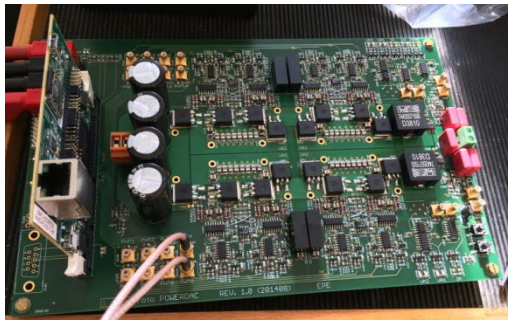
High precision & multilevel converters

- **Topologies for high-precision power amplifiers**
  - Elimination of zero-crossing distortion
  - Ultra-level converters:
    - Increased bandwidth and accuracy
    - Reduced size of passive components





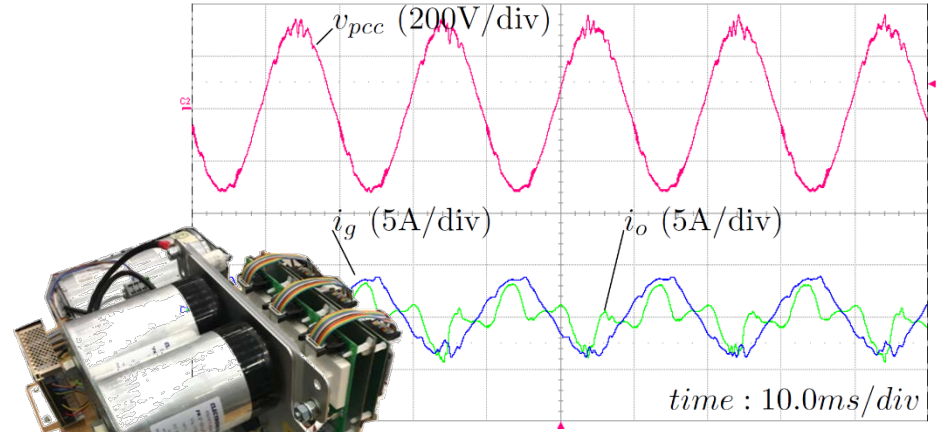
High precision switching amplifier with <-90dB zero crossing distortion



Power DAC for filterless high precision power conversion

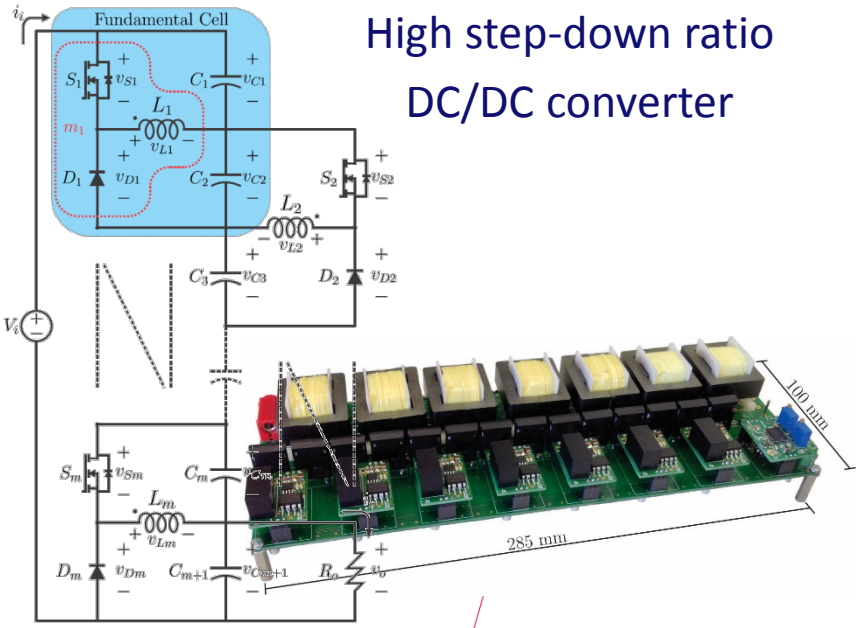
Grid applications

- **Local power quality enhancement**
  - Compensate for disturbance due to loads
  - Control of injected power and voltage harmonics
- **Auxiliary supply for high voltage applications with high step-down ratio (3kV to 24V)**



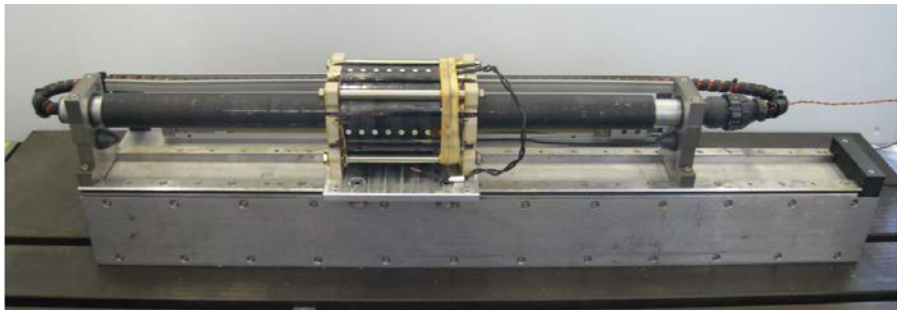
Local voltage quality enhancement

High step-down ratio DC/DC converter



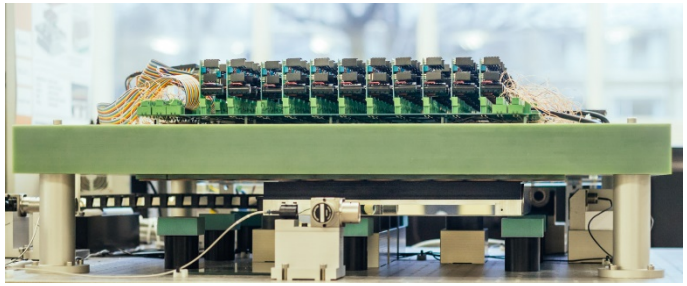
Wireless energy transfer

- Inductive charging
- Acoustic energy transfer
- Energy to moving objects
- Integrated energy transfer

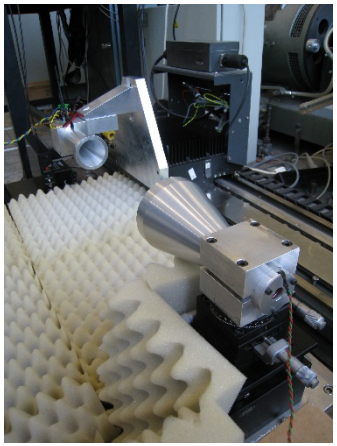


Wireless energy transfer integrated in tubular linear motor

Low-power domestic applications



Ceiling robot with integrated wireless energy transfer



Acoustic energy transfer

Supported student projects

World Solar challenge (STE),
1st place 2013 & 2015 in cruiser class

Robocup (TechUnited),
World champion 2012, 2014, 2016
EU 2016, Portugese open 2017

Formula student (URE)

InMotion

STORM

Road to EPE: Core courses

	Complex Analysis (2DME30)	Discrete Mathematics (2DME10)	Non-linear Optimization (2DME20)	Semiconductor physics and materials (5CCA0)	Fundamental aspects of random signals (5CRA0)	Classical and Modern Physics (5CHA0)	Numerical Methods for Electrical Engineers (5CPA0)	Modeling Dynamics (5CSA0)
CS	◆		◆		✓		✓	◆
ECO	◆			◆	◆	✓	✓	✓
PHI				◆	◆	✓		
EES	✓		✓	◆	◆	◆	✓	◆
EPE	✓		✓	✓	✓	✓	✓	✓
EM	◆		✓	◆		◆	◆	
ES		◆	✓	✓	✓		✓	✓
MsM				◆	◆	✓	◆	✓
SPS	✓		◆		◆		✓	✓

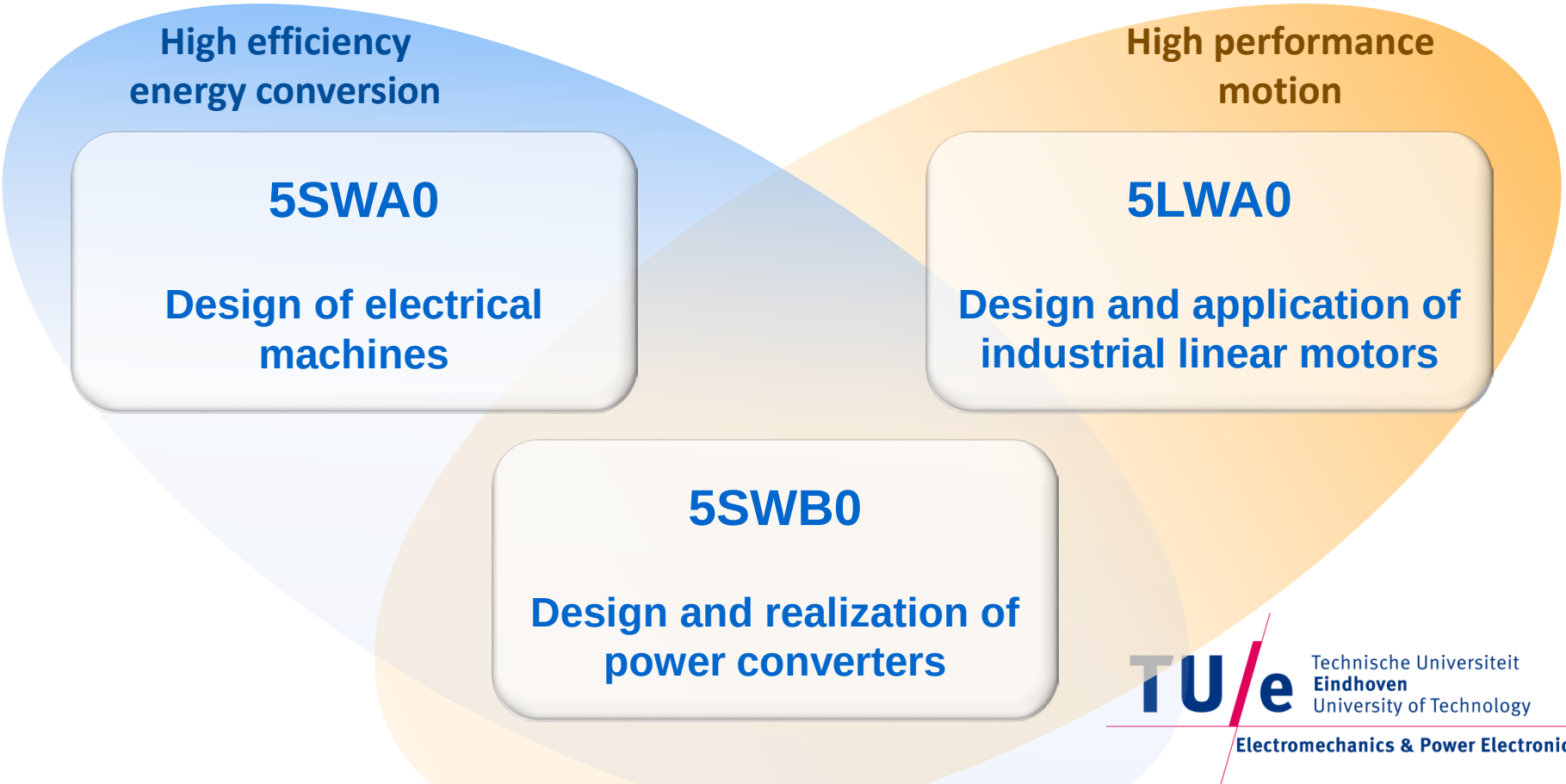
◆ = Important

✓ = Preferred

- **Free choice (3x)**
- **Discrete mathematics not advised**
- **Example of a useful set of courses:**
  - Complex analysis ***or*** Non-linear optimisation
  - Semiconductor physics ***or*** Modelling dynamics
  - Numerical methods for electrical engineers ***or*** Fundamental aspects of random signals

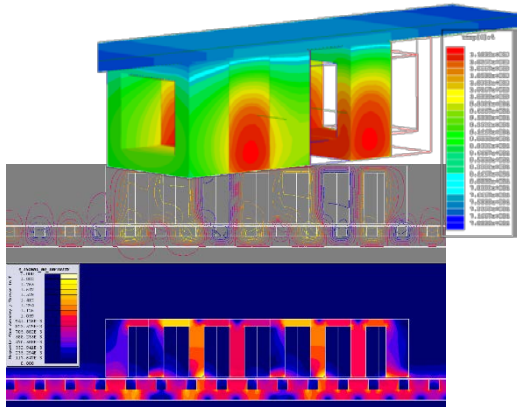
Road to EPE: Specialisation

- **Two EPE specialisation tracks:**
  - **EPE-1**: High efficiency energy conversion
  - **EPE-2:** High performance motion

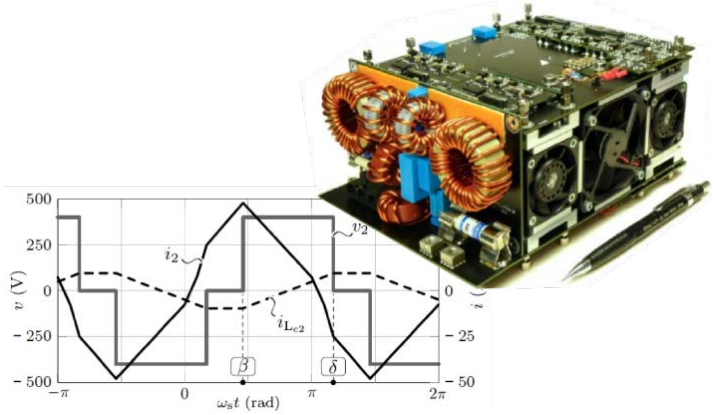


Road to EPE: Electives

- **Electromechanics:**
  - 5LWE0 Control of rotating field machines
  - 5LWF0 FEM for electromagnetic devices
  - 5LWC0 Advanced actuator design

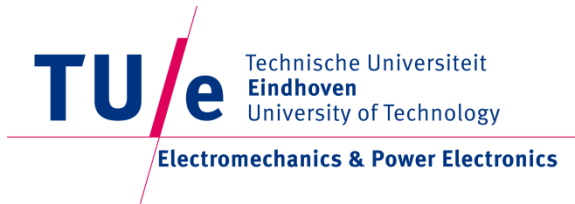


- **Power electronics**
  - 5LWD0 Low-power electronics
  - 5LWG0 Power Electronics for high-precision applications



Traineeships, graduation and job prospects

- **Many options:**
  - National / international
  - Industry / academia
- **Excellent job prospects**



Is this your graduation project?

Thank you

TU/e Technische Universiteit Eindhoven University of Technology

www.tue.nl/epe