Systems & Control @ EPE

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13 September 2022

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Welcome to the EPE group

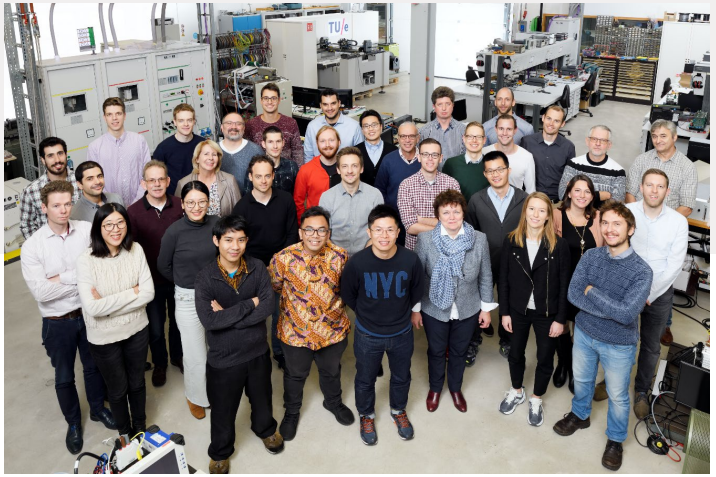
Enthusiastic team of ~55 people with a relaxed and informal atmosphere

Many (inter)national industrial partners

12 part-time fellows from industry

State-of-the-art laboratory

Very good job opportunities



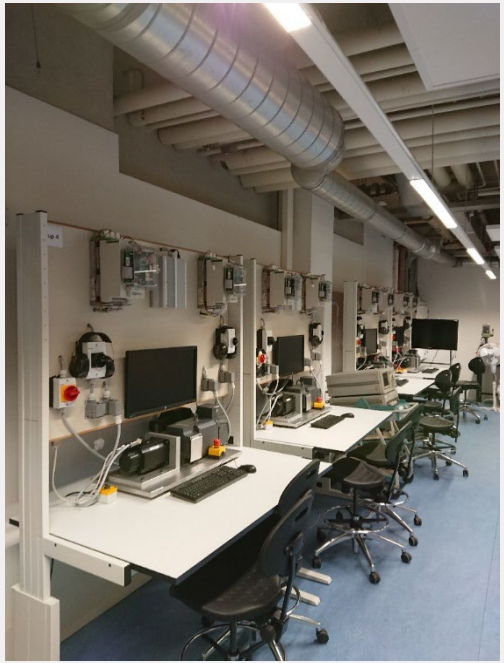
ASML PHILIPS PRODRIVE TECHNOLOGIES AME

Strukton Rail heliox TECNOTION THE LINEAR MOTOR COMPANY protonic holland TNO

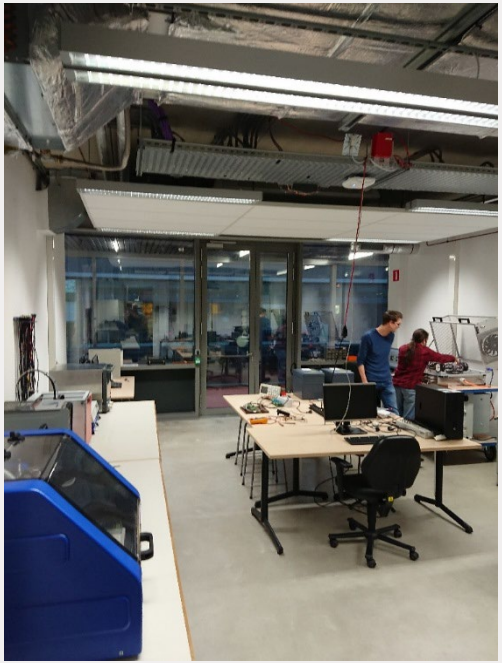
epe TU/e

680 m² state of the art research and education laboratories + new MV laboratory – 120 m² since June 2022

Research laboratory



Educational laboratory



Low power laboratory

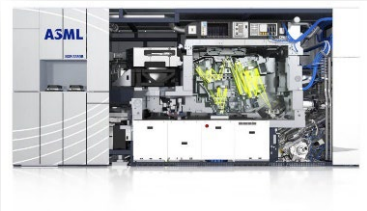
Electromechanics & Power Electronics group

EPE = "systems** and **technology** for **processing electric energy"

Interaction between electrical and mechanical energy (electromechanics)

Dynamic control of flow and shape of electric energy (power electronics)

High-tech systems



Robotics

Renewables & smart grids

Automotive & smart mobility

Healthcare

Electromechanics & Power Electronics - group

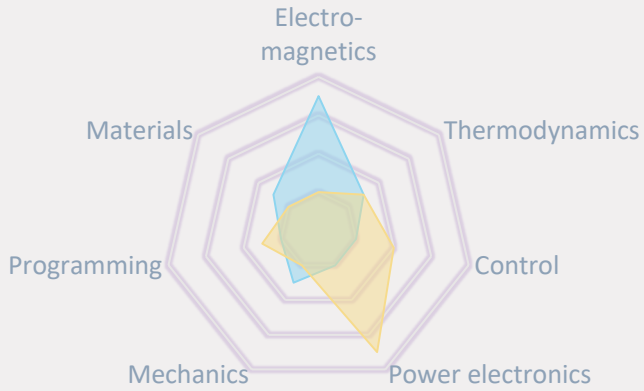
Our *scientific* mission:

Performing top-class scientific *research* with societal and industrial **relevance** in electromechanical and power electronic systems

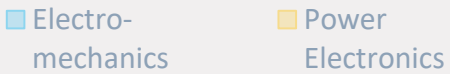
Our *educational* mission:

Educating **top-class** engineers in our discipline by providing them with a well-balanced skill-set to start or further their industrial or academic career

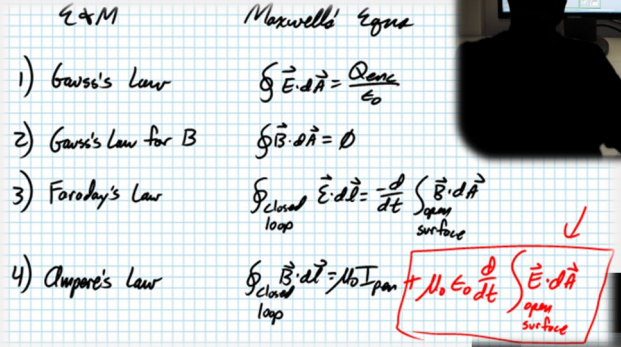
We strive for a system-level approach…



…where you can determine *your focus*!

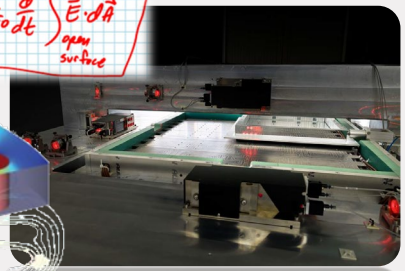


Our mission is reflected in our education



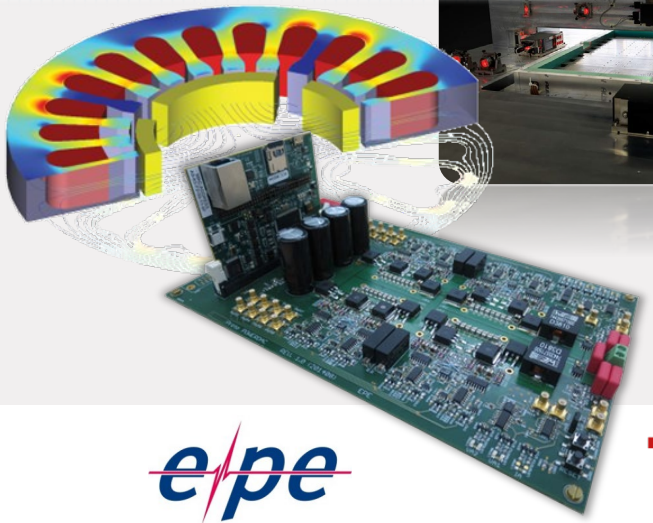
Master courses: Design oriented teaching

1. learn **fundamentals** & gain insight during lectures
2. apply knowledge with **design-oriented** assignments
3. be tested through design assignments representative of a **practical problem**

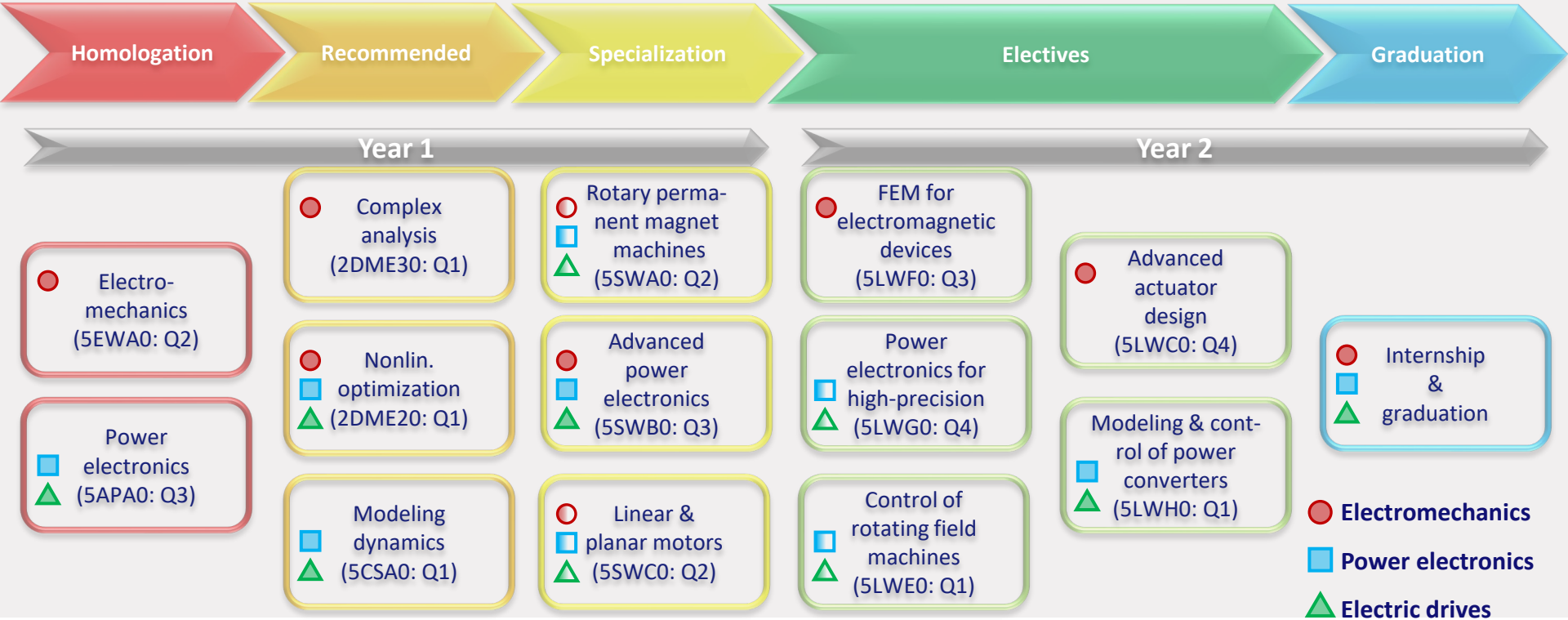


Graduation projects: Experience and Ownership

1. work on **tailored assignment**, with **individual freedom**
2. assume **responsibility**, well-supported by coaches in an **informal atmosphere**
3. experience both **industry and academic oriented** projects

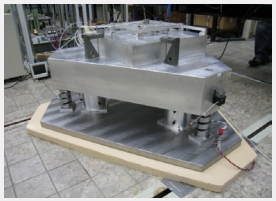


3 Tracks towards specialization: 7 courses

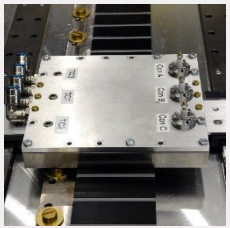


Research in high-precision motion stages

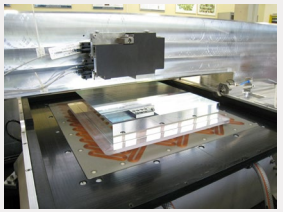
- Planar motors
  - Magnetic levitation and suspension
  - High accuracy, over-actuated
- Linear motors
  - Integration of wireless energy transfer
  - Higher forces: new cooling and insulation concepts
- Special machines
  - Vibration isolation
  - Multi-DOF actuators
  - Vacuum compatibility



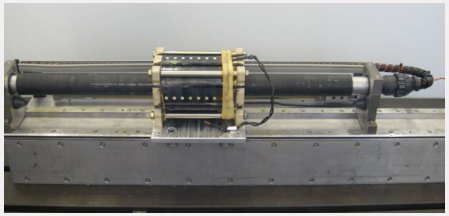
7kN isolation



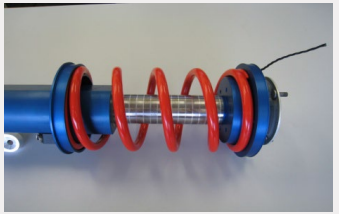
2kV, 60A_{rms}/mm^2 motor



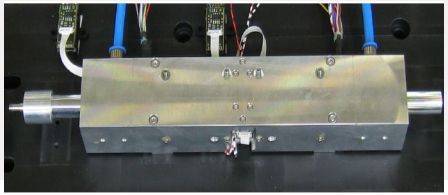
Concept planar motor



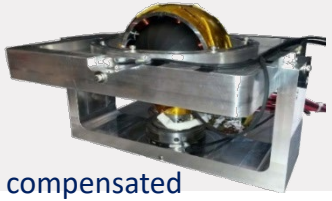
Wireless moving-coil motor



Active car damper



150m/s^2 pick-and-place



Gravity compensated spherical motor

PEL/e Research portfolio

Research areas:

High Performance Power Electronics

- **GaN**

Computational intelligence for Resilience

Control of Power Electronics

- **MPC**

Grid-connected & MV Power Electronics

Modular topologies & systems

WBG

Distributed control

- **SST and SiC in MV**

Magnetics for PE

PEL/e Research portfolio – High Performance Power Electronics

Applications…

High-def audio: Voltage amplifiers

(Medical) Robotics: Motor drives

Medical imaging: Gradient amplifiers, RF amplifiers

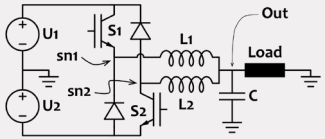
Semiconductor lithography: Motor drives, Voltage amplifiers

… and **solutions**

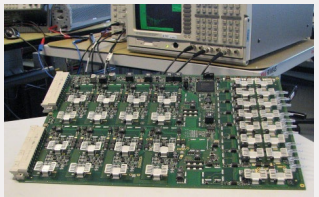
High accuracy topologies: Dead-time distortion elimination, Current ripple cancellation, Sub PPM sensing and control

High voltage motion amplifiers: Stacked bridges, PD reduction. Lifetime enhancement

High bandwidth motion control: Soft switching topologies, Wide band gap circuits, Advanced modulation and control

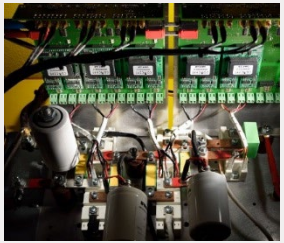


Dead-time-less amplifier

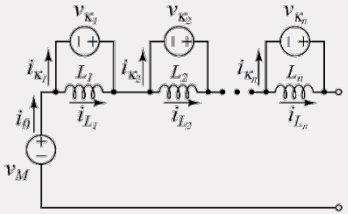


Current amplifier multiplexer

Asymmetric multilevel converter



Modulated-level converter



Ripple-less e-beam amplifier

Beyond SiC
– High Performance Power Electronics

The future is GaN

Technology for ultra-high efficiency and precision

Scaling up in power

- Current research on ~3kW modules, Next scaling to ~30kW converters

Expanding applications

- Integration to drivetrains

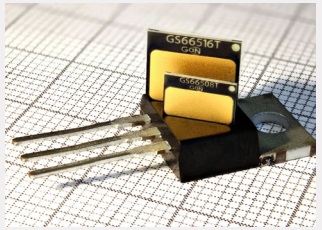
But there are issues

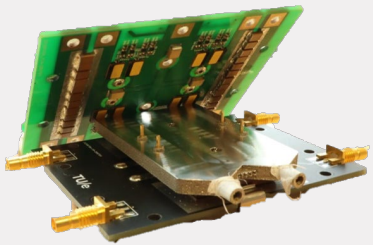
Cooling: extreme heat flux density due to very small surface

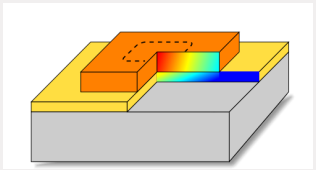
Magnetics: new materials and concepts under study

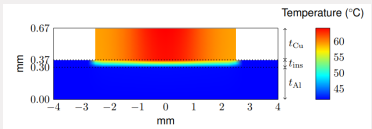
Control: **estimation and computation adjusted to ultra-high switching frequencies**

EMI: EMI filters behavior in MHz switching frequencies, voltage stresses on insulation and passives in drivetrains









PEL/e Research portfolio – Computational intelligence for Resilience

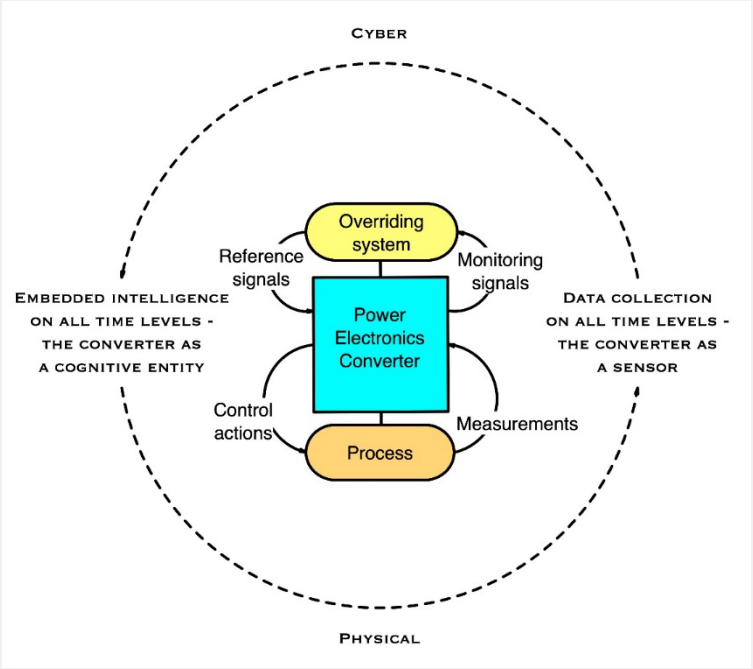
Efficiency

Flexibility

Productivity

2021

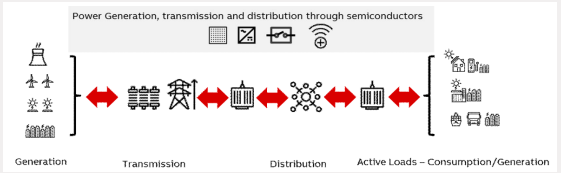
Components with computational and sensing capabilities operating isolated, majority of data generated confined within converter/device



2040

Bidirectional power flows, electronically controlled loads & sources, elements with variant roles. Energy processing device as cognitive entity: Awareness, Computation & Decision on all time levels

Availability



Versatile, adaptable control – an example

Induction motor: Power horse of industrial motion

~50% of global electric energy consumed by motors

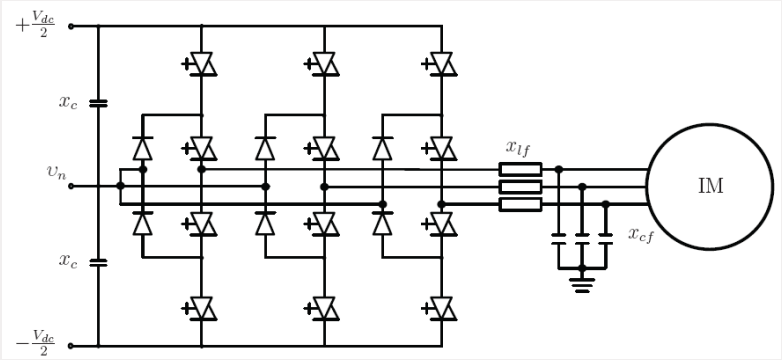
induction motors accounting for the largest share by far

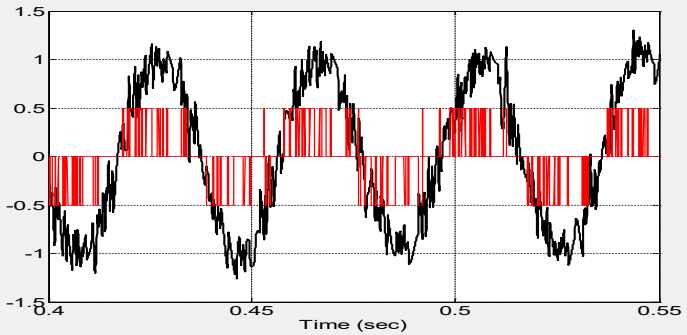
Variable Frequency Drives (VFDs) employing Power Electronics Converters

providing controlled, variable speed operation

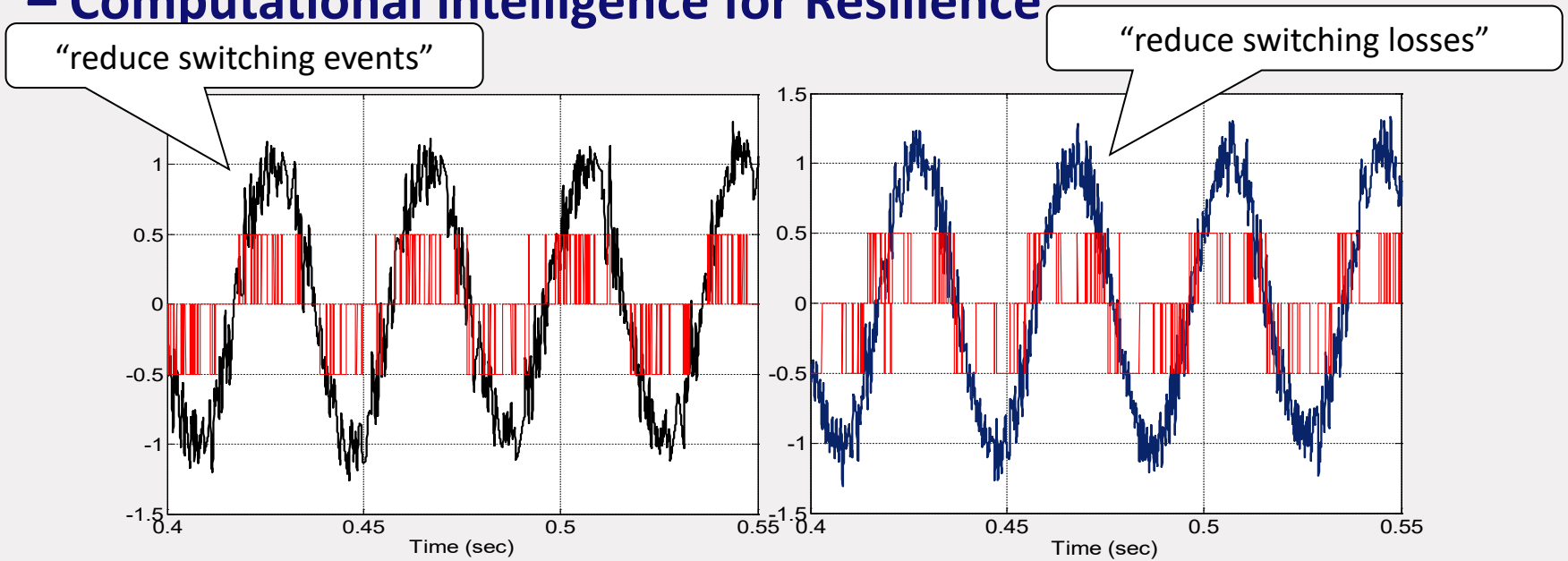
carrying significant energy saving potential improving motor efficiency

Reliable operation of VFDs key element in their acceptance and expansion in more industries





Model Predictive Control
– Computational intelligence for Resilience



Decision on the microsecond level enables **switching at lower currents**

Next steps

- Plan your master, and if considering EPE – request a follow-up meeting @EPE by mailing Ms. Tanja Swanink - *secretariaat-epe@tue.nl*