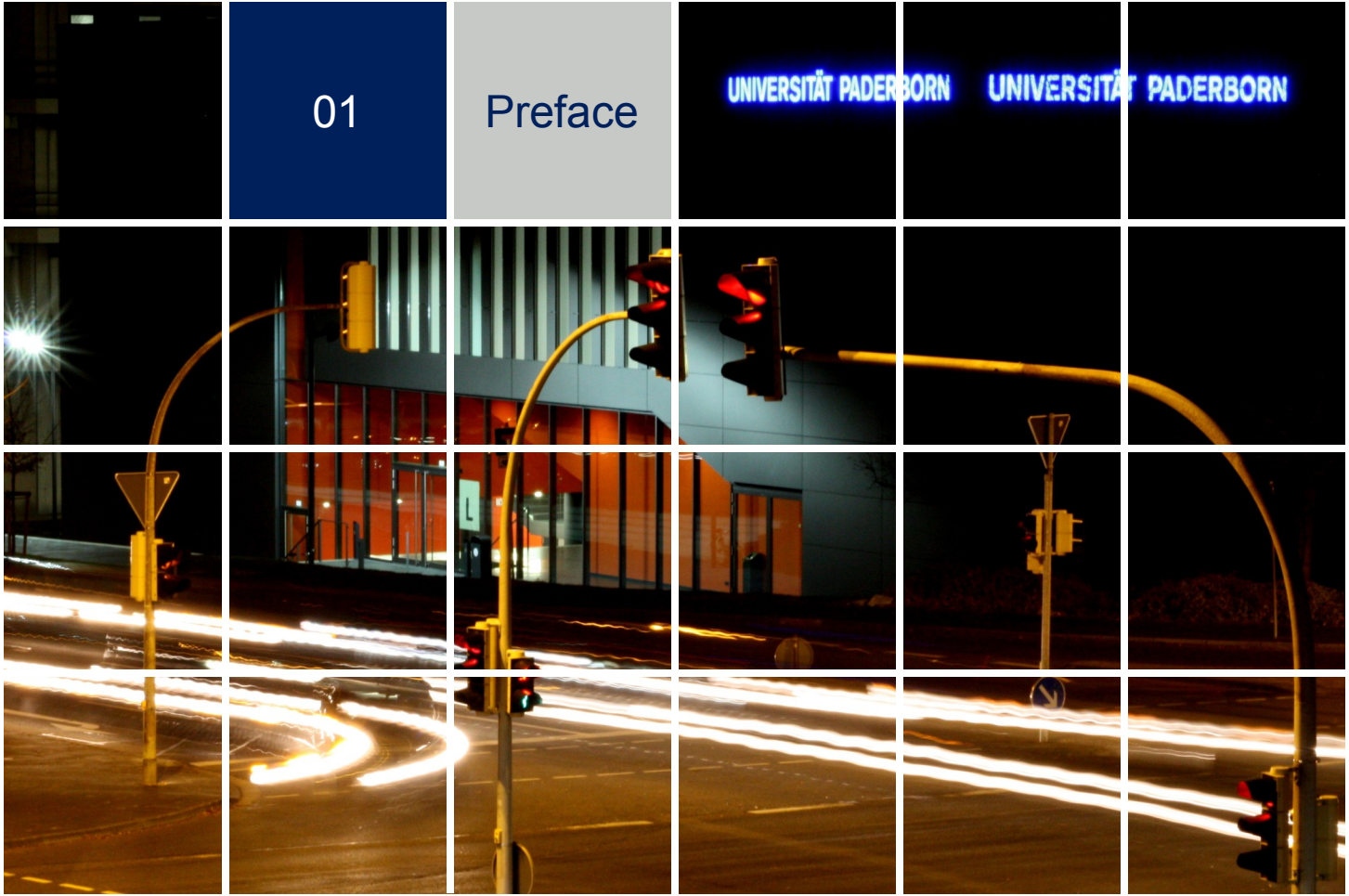
PADERBORN UNIVERSITY

*The University for the Information Society*

Power Electronics and Electrical Drives
Prof. Dr.-Ing. Joachim Böcker


01
Preface
UNIVERSITÄT PADERBORN
UNIVERSITÄT PADERBORN

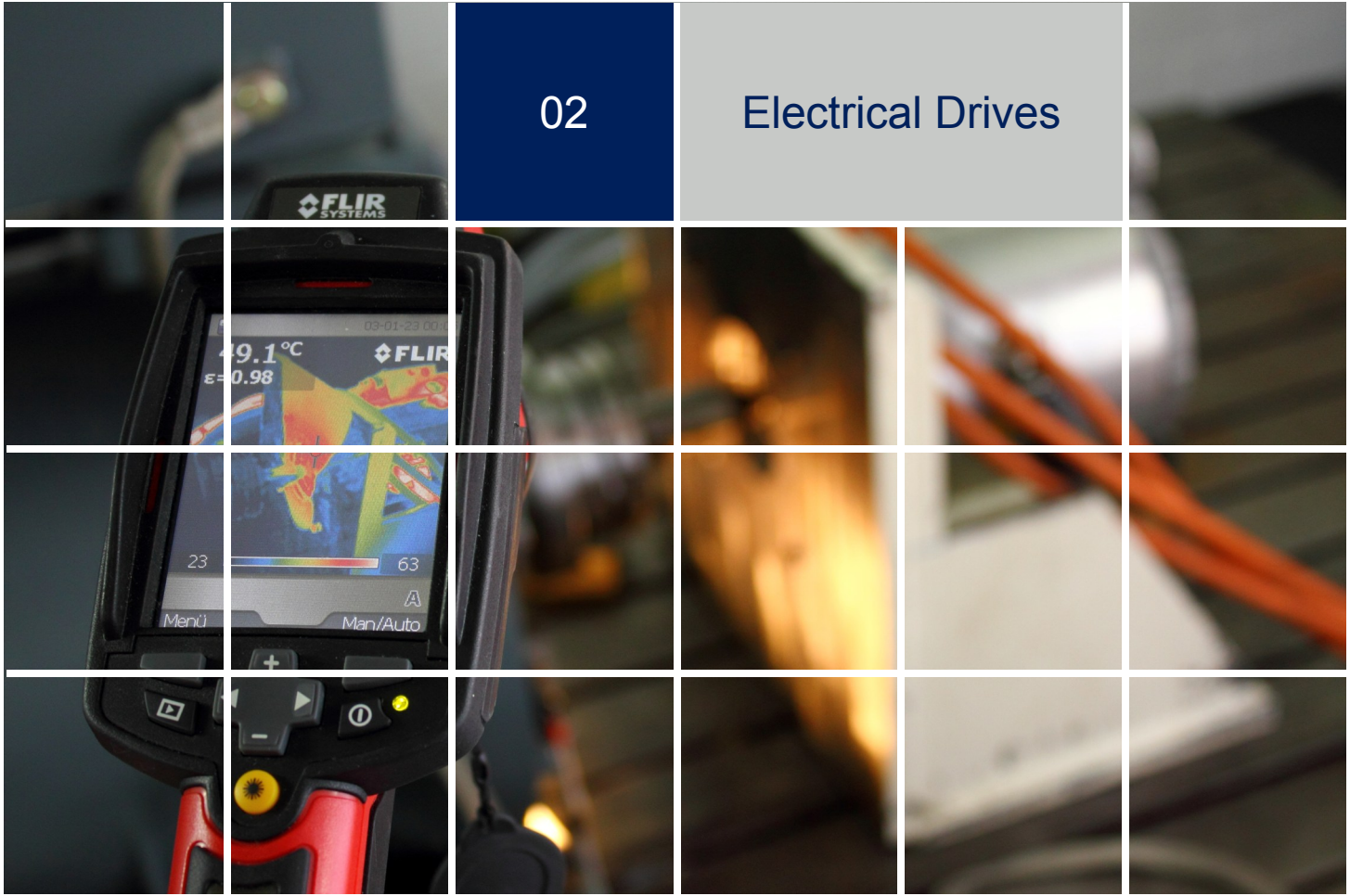
***Power electronics and electrical drives*** are counted among the key technologies of our modern industrial society. Propulsion and motion control by ***electrical drives*** are present in all areas of life. Often, this happens unnoticeably and automatically and is taken for granted by the users. Variable-speed drives are state of the art even for home appliances. More sophisticated drives can be found in elevators, robots, multi-axle machining centres, or as a very contemporary issue in electric vehicles. In total, 65% of the electric energy produced in Germany is used by electrical drives in the end.

The task of ***power electronics*** is the conversion of electrical energy between different voltage levels or frequencies. Thus, it is not only an essential part of controllable electrical drives, but is by now also a key component in the efficient generation, distribution and use of electrical energy. The grid-connection of renewable energy sources such as wind power or photovoltaics is not imaginable without power electronics. New impetus is given by IT systems like server farms, where electronic power supplies of highest efficiency and smallest size are demanded. It is estimated that in a few years up to 80% of the total electric energy will be converted by one or even several power electronic stages on their way between generation and use.

As the electrical power flow is now controllable by power electronics, ***energy management*** strategies how to distribute the power flow between various generators, consumers and storage systems for best economic energy utilisation are getting more and more important.

In these three areas, the department is broadly positioned. Our research is not only of theoretical nature but we are also in close cooperation with industrial partners to get the ideas running in practise.

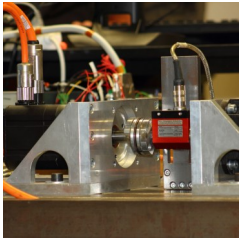
Paderborn, August 2016
Prof. Dr.-Ing. Joachim Böcker.




# 02 Electrical Drives

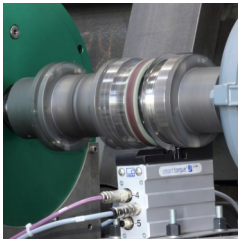
## Topics

- Control and observer concepts
- Electrical modelling and simulation (real-time-simulation and co-simulation)
- Thermal modelling and system identification



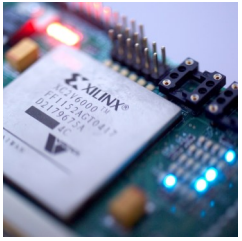
## Applications

- Electric and hybrid electric vehicles
- High-speed-drives
- Industry drives
- Wind power plants



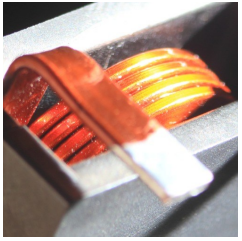
## Goals

- Improvement of system performance
- Optimal utilisation (energy and resources)
- Efficiency enhancement
- Improvement of modelling accuracy
- Observer-based error detection



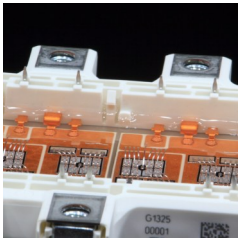

The technological progress demands a steady increase using electrical drive systems almost in all spheres of life. Tasks that were previously handled mechanically or pneumatically are increasingly handled using highly precise and efficient electrical drives. In addition, hybrid and full electric vehicles are grabbing the limelight which gave the development of electric drive components an additional boost in recent years. Thus, mastering the entire bandwidth of electrical drives, starting with microdrives of some mW up to giant conveyer drives in the MW-range, is one of the essential keys in our today's and future research work.

Power electronic systems are omnipresent. In electric welding supplies, chargers for electric and hybrid electric vehicles and high-voltage direct current power transmission, the conversion of electric energy is realised with power electronic converters. However, the major goals of most applications are similar: high efficiency, small size and low costs. The Department of Power Electronics has more than 30 years of experience in design, modelling and control of power converters regarding these divergent goals and application specific requirements.



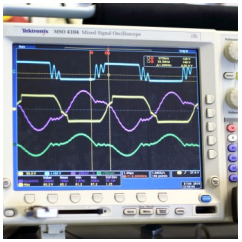
**Topics**

- Soft switching techniques and topologies
- Power semiconductors switching loss characterization (Si, SiC, GaN)
- Control concepts for PFC rectifiers and resonant converters
- Design optimization of magnetic components



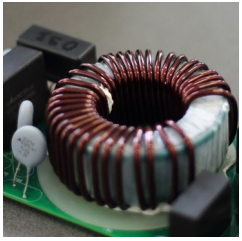
**Applications**

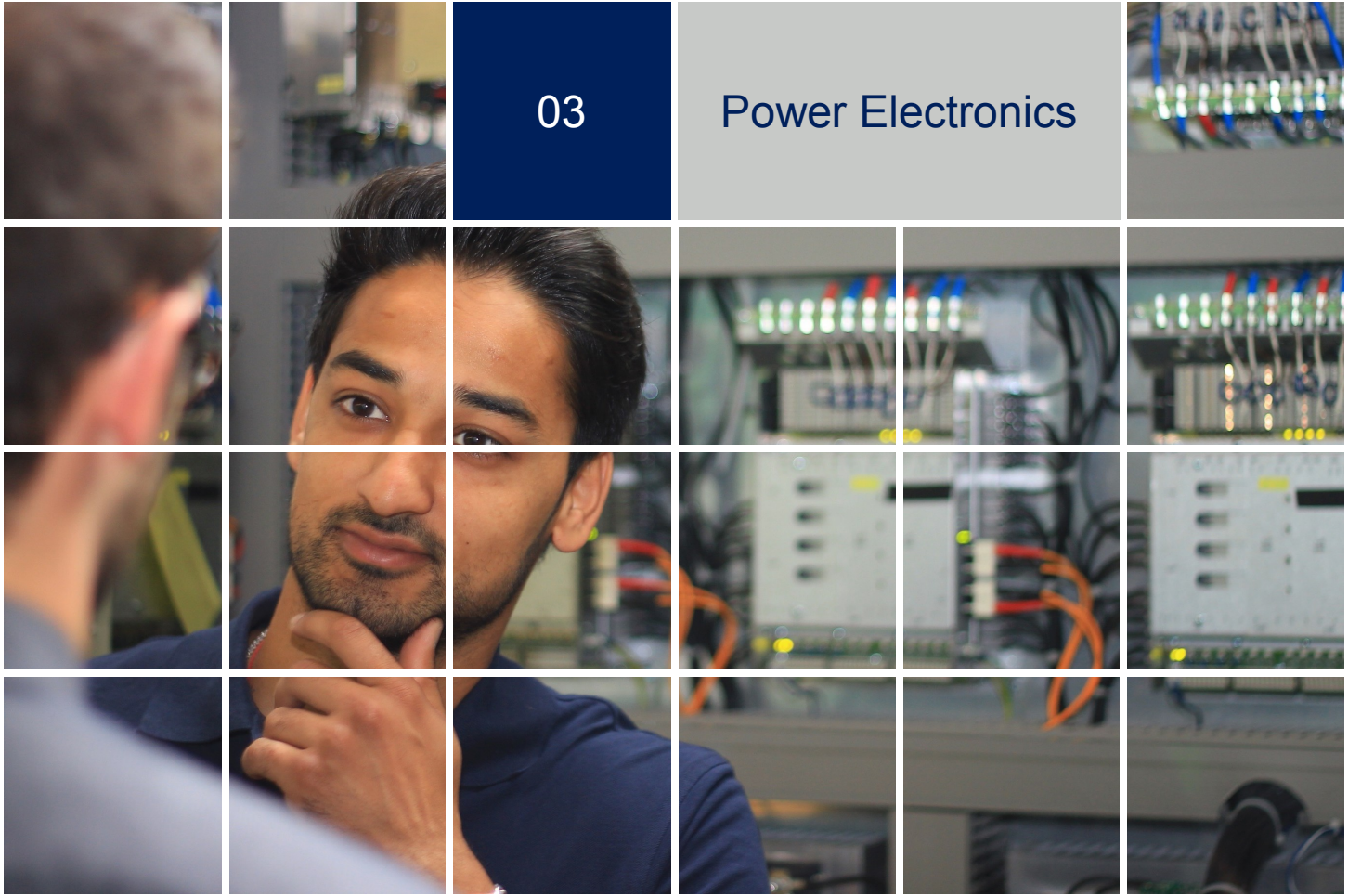
- Data centre power supplies
- Chargers for electric and hybrid vehicles
- Electric spot welding power supplies
- DC/DC converters in power distribution systems
- Piezo electric drives



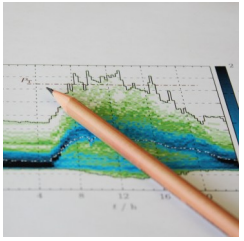
**Goals**

- Requirements-oriented conversion, control and distribution of energy
- Higher power density, less weight
- Improved efficiency and dynamics




03
Power Electronics

Systems as microgrids or hybrid electric vehicles offer degrees of freedom in terms of internal power splitting or temporally demand shifting. An intelligent energy management system utilises those degrees of freedom to achieve the most economic energy use. Main challenges typically are the solution of complex optimisation problems to obtain suitable control strategies and optimal dimensioned systems and components. We apply complex methods like model predictive control, artificial neural networks as well as detailed system modelling and analysis to maximise the improvement compared to rule based methods.

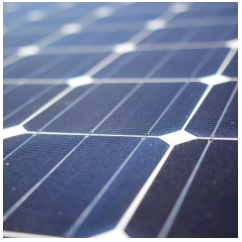


**Topics**

- Optimisation and model predictive control
- Prediction of power profiles
- Component and system modelling
- Analysis of measured power profiles
- Optimal component dimensioning

**Applications**

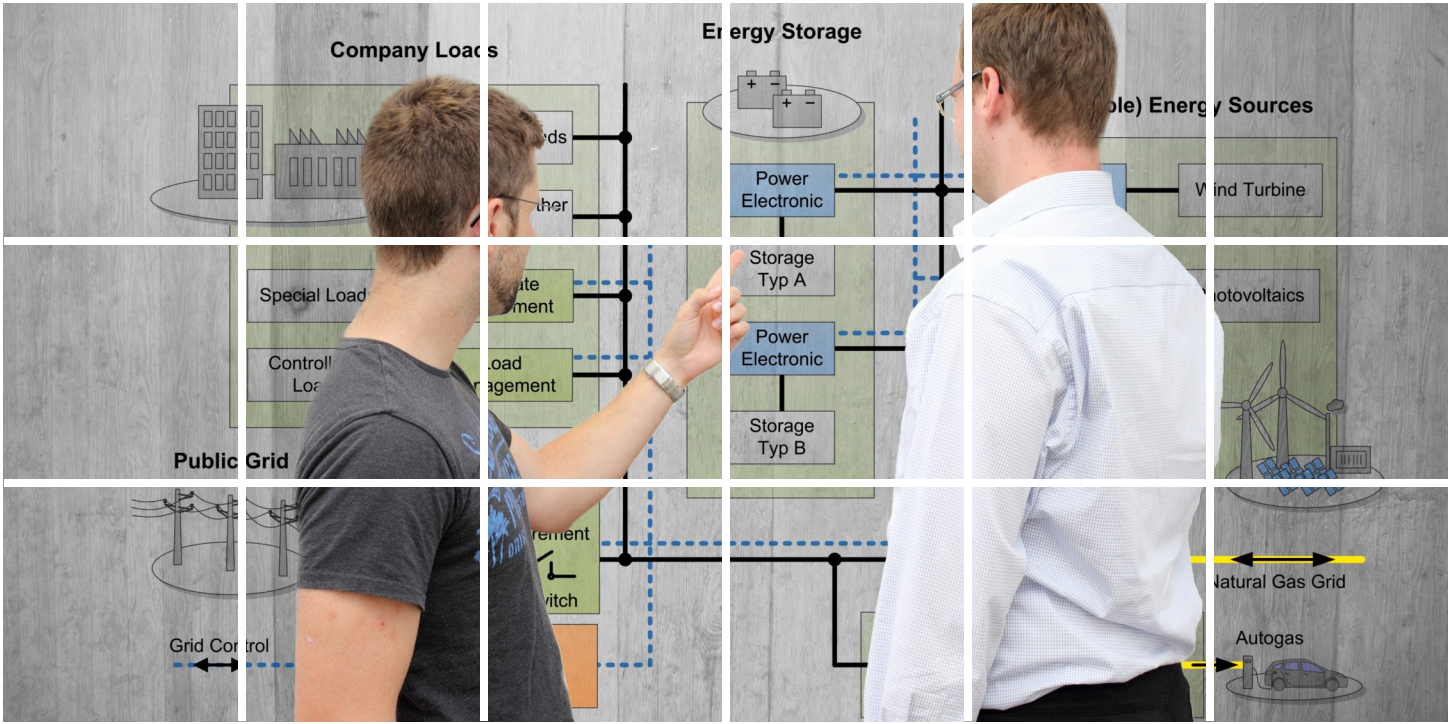
- Industrial microgrids
- Domestic applications (load optimisation)
- Hybrid energy storage systems
- Electric and hybrid electric vehicles



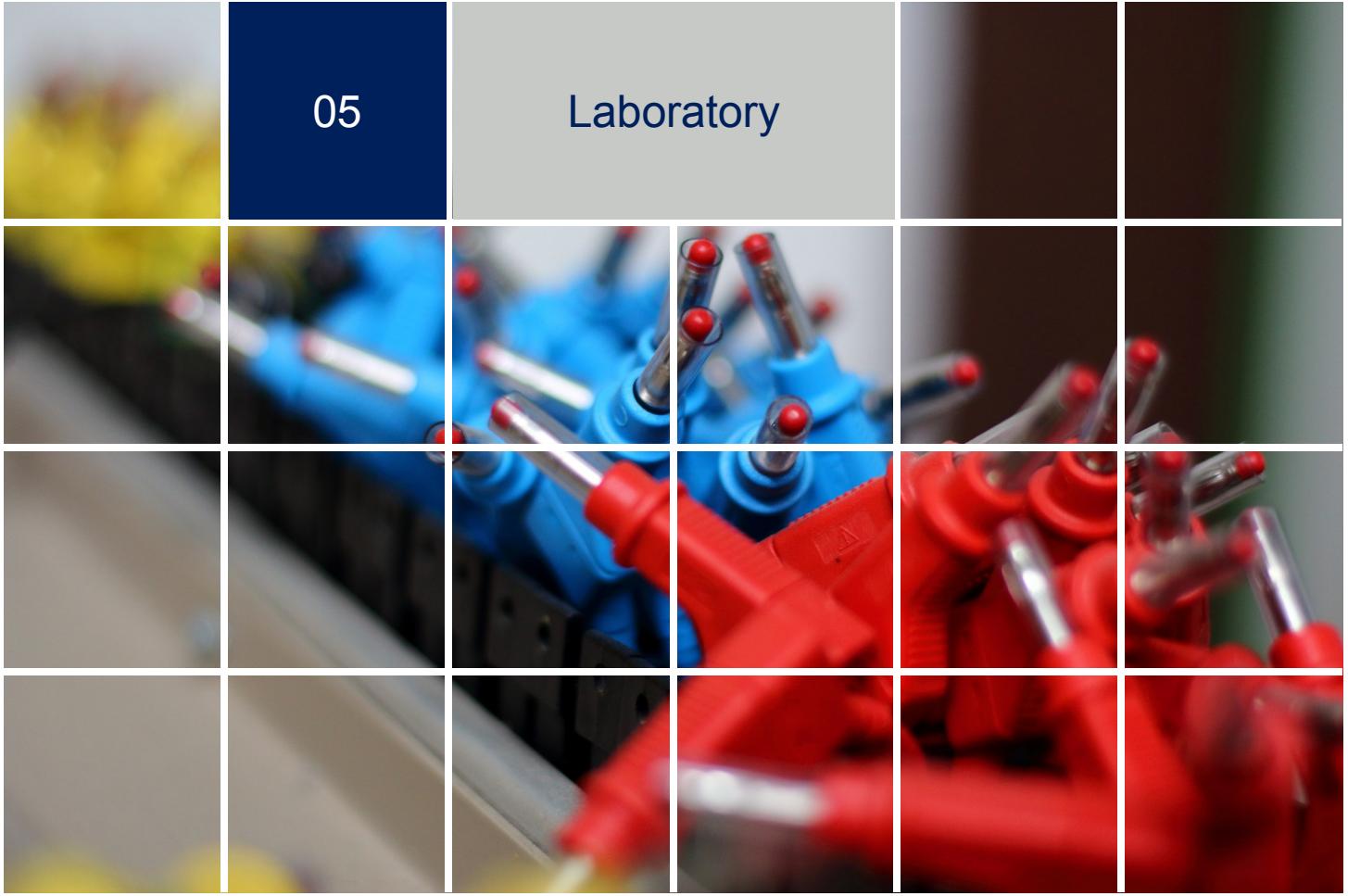
**Goals**

- Most economic use of energy
- Reduction of supply costs
- Increase of total system efficiency
- Economic optimisation without affecting system reliability

# 04 Energy Management



# 05 Laboratory

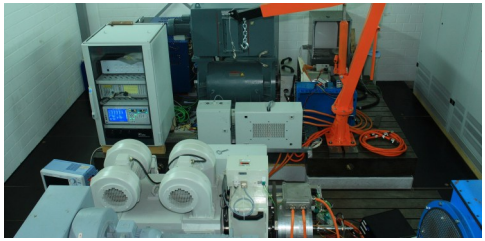
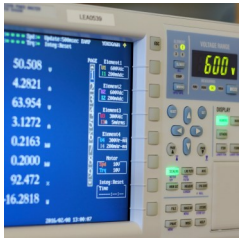
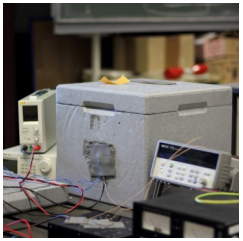


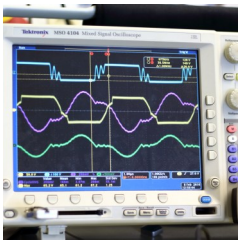
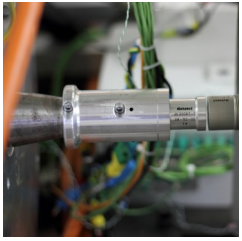
## Electric motor test beds

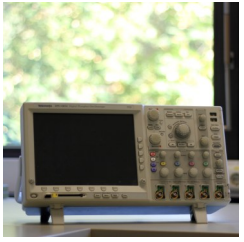
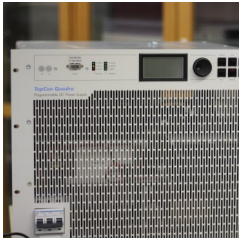
- Test cabin for automotive traction drives (up to 500 kVA)
- Liquid cooling and air conditioning units
- Rapid control prototyping hardware
- Precise efficiency measurement systems
- Various inverter and converter topologies
- Rotor telemetry system

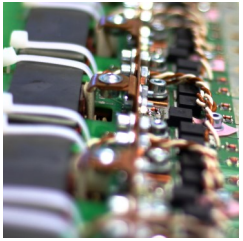
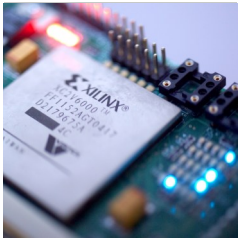
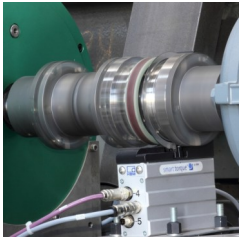
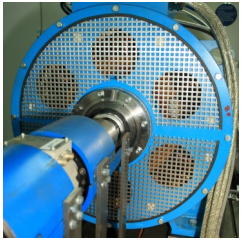
## Power electronic test beds

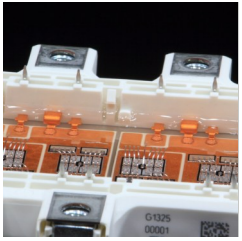
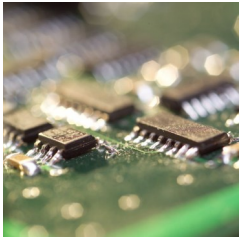
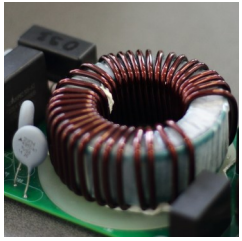
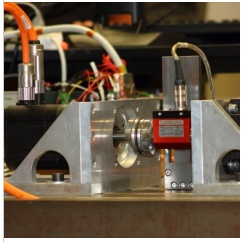
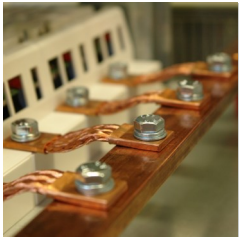
- High performance electric power analysers
- Programmable power supplies and sinks
- Impedance measurement systems
- High definition oscilloscopes
- Frequency response analyser
- Power semiconductor characterisation test beds
- Calorimetric power loss measurement


Paderborn University

Department of Power Electronics
and Electrical Drives (LEA)

Warburger Str. 100
33098 Paderborn
+49 5251 60-2210
sekretariat@lea.upb.de
http://wwwlea.upb.de
(List of all publications on website)