UNIVERSITY OF STUTTGART | FACULTY 5
ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY DEPARTMENT
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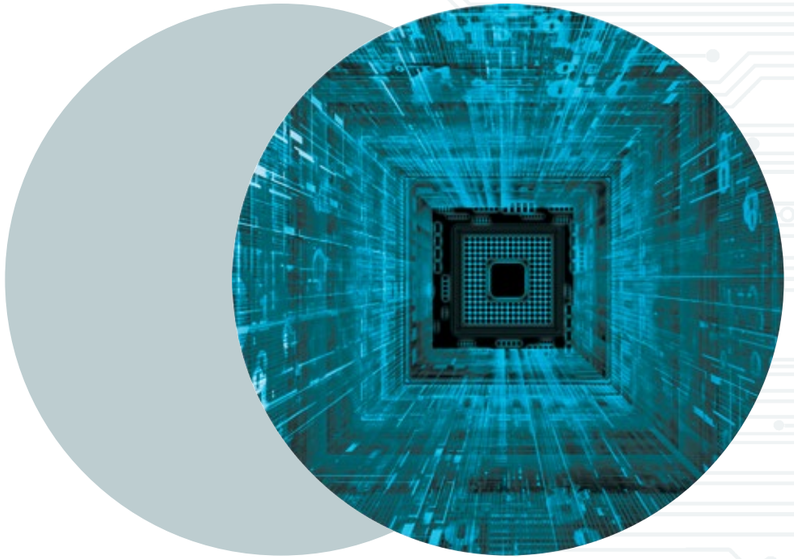
University of Stuttgart
Germany



ELECTRICAL ENGINEERING INFORMATION TECHNOLOGY

www.ei.uni-stuttgart.de

UNIVERSITY OF STUTTGART | FACULTY 5

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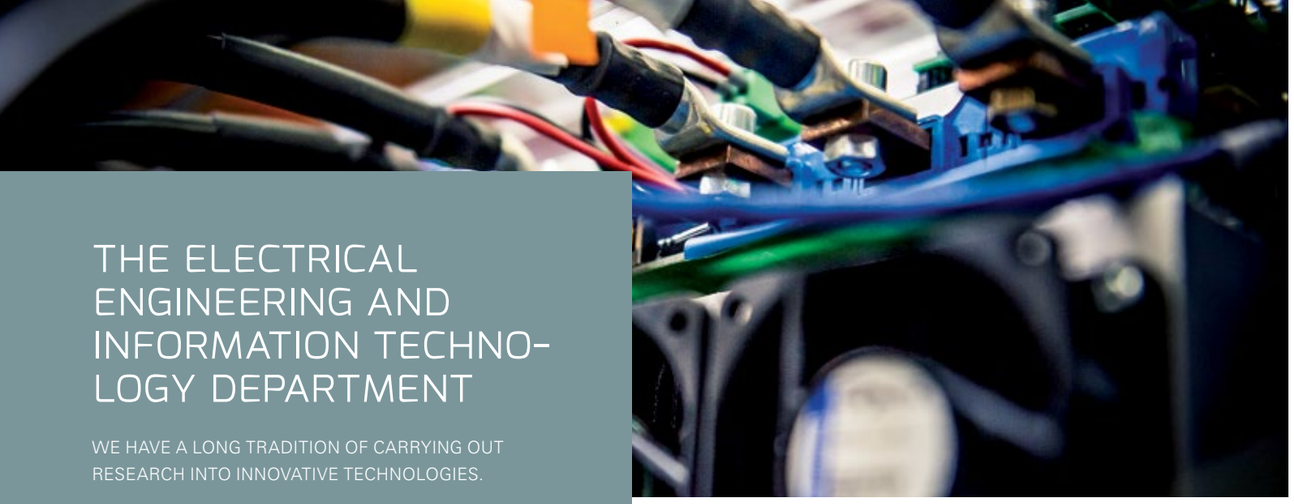


THE ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY DEPARTMENT

WE HAVE A LONG TRADITION OF CARRYING OUT RESEARCH INTO INNOVATIVE TECHNOLOGIES.

We deal with questions from all areas of life

The first professor of Electrical Engineering was appointed to the University as far back as 1882. He carried out research into topics that were highly innovative at the time. Nowadays, electrical engineering and information technology cover all areas of modern life, and our research is developing the technologies of tomorrow. We deal with questions from all areas of life: How can telecommunications become more reliable? Under what circumstances can things communicate with each other intelligently and in a targeted manner?
How can technology support elderly or chronically ill people in their everyday lives? How can we make driving a car more environmentally friendly? How can we integrate renewable energies in the power grid? What happens to solar modules that have been used up?

In teaching and research, we therefore cover a broad section of electrical engineering and information technology, with an emphasis on automation technology, information and communication technology, micro-, opto- and power electronics as well as electrical energy engineering. What all research topics have in common is that they are looked at from the aspects of security, reliability, energy efficiency, user friendliness and human-machine interaction. The department has modern large-scale equipment, such as high-voltage testing and measuring lines, several clean rooms and laser units.

Our aim is to carry out outstanding basic research and at the same time to be a reliable partner in the field of application-oriented research. Our success in obtaining external funding and establishing long-term research-oriented collaborations with industry testifies to the high quality and level of innovation of our research. For instance, for many years we have been successfully undertaking research with Robert Bosch GmbH and the Nokia Bell Laboratories.

Based on these traditions, we are focused on growth: New professorships on battery research, for example, complement our focus areas strategically. The number of students undertaking doctoral degrees is constantly increasing. New international partners, for example in China, allow our students to gather experience abroad. Last but not least, the number of our students are at a high level. This bears testimony to our approach to teaching: Our students are given a broad base from which they can specialize at a later stage. Early-stage independent learning is an elementary part of our program. On the master's programs in particular, there is an emphasis on dealing with specialized, highly current research topics.

Our motto is quality in everything we do. Our objectives are to be recognized worldwide as an authority in our disciplines and research focus areas and to be a sought-after place of education for high-performing students.

Our aim is to carry out outstanding basic research and at the same time to be a reliable partner in the field of application-oriented research.

INSTITUTES AND EXPERTS

OUR INSTITUTES COMPRISE HIGHLY SPECIALIZED
EXPERTS WITH INTERNATIONAL RESEARCH EXPERIENCE.

1 **Industrial Automation and Software Engineering (IAS)**
1.1 **Institute Head (IAS):** Prof. Dr.-Ing. Michael Weyrich
1.2 **Networked Automation Systems:** Jun.-Prof. Dr.-Ing. Andrey Morozov
2 **Electrical and Optical Communication Engineering (INT):** Prof. Dr.-Ing. Manfred Berroth
3 **Power Transmission and High Voltage Technology (IEH):**
3.1 **Institute Head:** Prof. Dr.-Ing. Stefan Tenbohlen
3.2 **Grid Integration of Renewable Energy Sources:** Prof. Dr.-Ing. Krzysztof Rudion
4 **Semiconductor Engineering (IHT):** Prof. Dr. habil. Jörg Schulze
5 **Radio Frequency Technology (IHF)**: Prof. Dr. sc. techn. Jan Hesselbarth
6 **Communication Networks and Computer Engineering (IKR):**
Prof. Dr.-Ing. Andreas Kirstädter
7 **Power Electronics and Electrical Drives (ILEA):** Prof. Dr.-Ing. Jörg Roth-Stielow
8 **Telecommunications (INÜ):** Prof. Dr.-Ing. Stephan ten Brink
9 **Photovoltaics (IPV):**
9.1 **Institute Head:** Prof. Dr. Michael Saliba
9.2 **Electrical Energy Storage Systems:** Prof. Dr.-Ing. Peter Birke
10 **Signal Processing and System Theory (ISS):** Prof. Dr.-Ing. Bin Yang
11 **Institute of Smart Sensors (IIS):** Prof. Dr. Jens Anders
12 **Nano and Microelectronic Systems (INES):** Prof. Dr.-Ing. Joachim Burghartz
13 **Electrical Energy Conversion (IEW):** Prof. Dr.-Ing. Nejila Parspour
14 **Large Area Microelectronics (IGM):** Prof. Dr.-Ing. Norbert Frühauf
15 **Robust Power Semiconductor Systems (ILH):** Prof. Dr.-Ing. Ingmar Kallfass

DEPARTMENT EQUIPMENT

FROM ANTENNA MEASURING ROOMS TO CENTRAL WORKSHOPS.

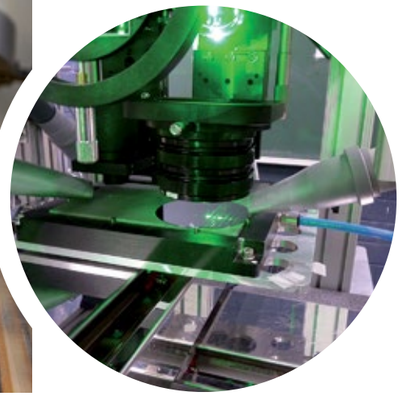
TOP-CLASS RESEARCH REQUIRES MODERN EQUIPMENT: OUR INSTITUTES HAVE ACCESS TO SEVERAL LARGE CLEAN ROOMS, ACOUSTIC LABORATORIES, AN ANTENNA MEASURING ROOM, HIGH-VOLTAGE LABORATORIES AND MACHINE HALLS.

The Institute for Large Area Microelectronics (IGM) has a clean room with zones of the clean room classes 10 and 100 (ISO 4 and 5) and a usable area of 480 m². It also has the additional infrastructure that is necessary for thin-film processes and large area electronics, with which substrate sizes of up to 16 inches can be handled. The Institute for Photovoltaics (IPV) also has a large clean room. All processes customary in wafer-based photovoltaics on 6-inch wafers can be simulated and optimized on industrial equipment. Entire solar modules can also be manufactured.

There is a third large clean room in the Institute for Semiconductor Engineering (IHT). The internally developed clean room technology line comprises among other things molecular beam epitaxy equipment and a 110 GHz network analyzer.

The Vaihingen location has a high-voltage testing and measuring device, including a 400 kV surge voltage generator for switching impulse 50/2,500 and lightning impulse 1.2/50 with cut-off spark gap (400 kV). The considerably larger high-voltage hall at the Nellingen location houses a surge voltage generator up to 2,000 kV, 100 kJ. A climate chamber and a pollution chamber round off the equipment.

An anechoic chamber was set up in the department for signal research purposes. Several machine halls allow research to be carried out on large projects, such as electric motors. A central modern workshop for all institutes allows for the efficient use of the equipment available.



RESEARCH AREAS

WE CAN DO BOTH: BASIC RESEARCH AND APPLICATION-ORIENTED RESEARCH.

AT THE UNIVERSITY OF STUTTGART, THE ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY DEPARTMENT HAS A LONG HISTORY OF ESTABLISHED AND TRADITIONALLY STRONG RESEARCH STRUCTURES.

We work mainly in the following domains of competence:

- Power electronics: We are specialists for power semiconductors, for their assembling and packaging technology as well as for circuit technology. We carry out research into procedures to make power electronics systems more reliable and more energy efficient.
- Nano-, opto- and quantum mechanics: We push the boundaries on what has been possible in the engineering sciences thus far in order to improve information processing, transmission and storage.
- Intelligent sensors in different areas of use, e.g. automation, communication, sensor signal processing, energy supply: The focus is on the issues of low-cost production as well as reducing size, on speed and on energy efficiency (including chips, high-resolution radar and antennae).
- Information technology for Industry 4.0: Creative and innovative solutions are developed in a majority of our institutes in relation to this topic. These include automation and software systems for dynamic cooperation, independent adjustment and system testing as well as for self-diagnosis; microsystem components for applications, e.g. detecting, processing and transmitting information in Industry 4.0 networks; integrated sensor signal processing and Big Data analysis.
- Electromobility: In this area of research, new variants of electrical drives are being developed, innovative infrastructure measures such as highly efficient wireless energy transfer and data transmission systems are being tested and work is being carried out on vehicle assistance systems in connection with the department's other research focus areas of sensor systems, sensor signal processing and technical IT.
- Renewable energy sources and energy efficiency: Research is being carried out into photovoltaics, from the manufacture of high-efficiency solar modules to feeding into the grid, including the related infrastructure, and disposal of solar cells. Other matters include electromagnetic compatibility (EMC) in energy engineering and electronic systems, life cycle management of transmission networks and concepts for smart grids. A new area involves research into batteries, accumulators etc. of the future.

RESEARCH FOCUS AREA

INFORMATION AND COMMUNICATION TECHNOLOGY

WE FACILITATE RELIABLE AND FAST NETWORKS.

MODERN COMMUNICATION SYSTEMS CONNECT PEOPLE ACROSS CONTINENTS, INTEGRATE MACHINES IN PRODUCTION LINES AND FORM THE BASIS FOR THE DIVERSE WORLD OF THE INTERNET.

These communication systems open up new possibilities for how we perceive the world and how we act within it. The days of the traditional landline telephone are over. Instead, highspeed mobile networks simplify the processes in our work lives, increase traffic safety and enrich our leisure time. Nowadays, we consider it absolutely normal to be online all the time.

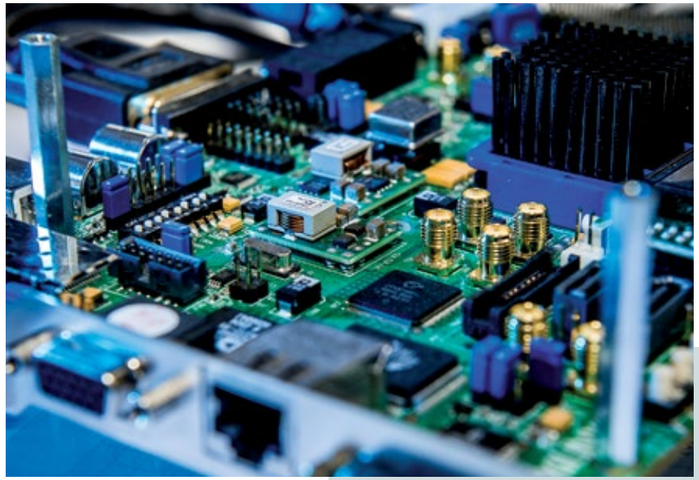
The focus area of information and communication technology focuses on the theory and the technical implementation of this new digital world. The variety of research topics ranges from the architecture of future high-speed networks and encoding of data packages to algorithms for machine learning, autonomous driving and medical signal processing as well as the design of radio antennae and highly integrated circuit designs (microchips).

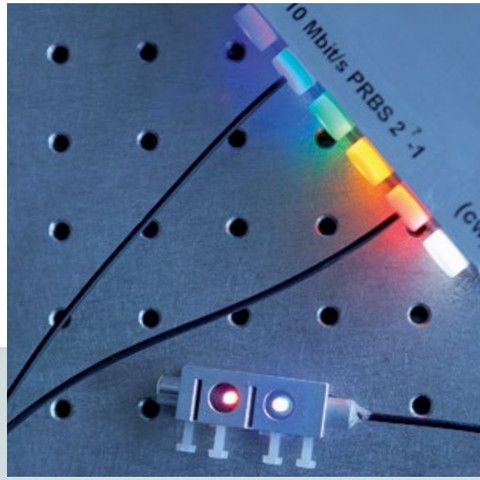
New approaches have arisen from an exciting mix of mathematical modeling of physical effects (for example the characterization of a transmission path) and algorithmic implementation in software on digital computers and/or custom-designed highly integrated components of analog and digital technology.

EXAMPLES OF RESEARCH TOPICS

- Sensor networks, networking for Industry 4.0 and examination of new semantics for information exchange architectures and protocols for high availability networks as a basis for time-critical services and applications, software-defined networks and new computer architectures
- Signal processing and machine learning with applications for example for language, images, radar, automotive, medical technology and smart grids
- Robust fault detection and correction, field bus systems for manufacturing environments, signal shaping for next-gene-ration mobile communication (“5G”, “WiFi”) and non-linear optics
- Extremely fast analog-digital / digital-analog converters, highly integrated circuit technology, silicon photonics and integration of electronics/photonics for communication technology
- Tapping of new frequency bands in the terahertz range for radio communication and radar sensors, smart office; mono-lithically integrated transmitter and receiver circuit systems
- Antenna systems or large bandwidths and high carrier frequencies, integration of antennae and transmitters/ receivers; new materials for high-frequency circuit technology

Not only are many of these topics analyzed in terms of their theoretical fundamentals and their performance evaluated via modeling and simulation, they are also verified by means of prototype structures in the lab, generally in close cooperation with partners from industry.





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Prof. Ingmar Kallfass,
ILH, Institute of Robust Power Semiconductor Systems
Prof. Jan Hesselbarth,
IHF, Institute of Radio Frequency Technology

RESEARCH FOCUS AREA

AUTOMATION

THE NEXT STAGE OF AUTOMATION FOR INDUSTRY AND EVERYDAY LIFE.

AUTOMATION TECHNOLOGY IS NOW AN INTRINSIC PART OF OUR EVERYDAY LIVES.

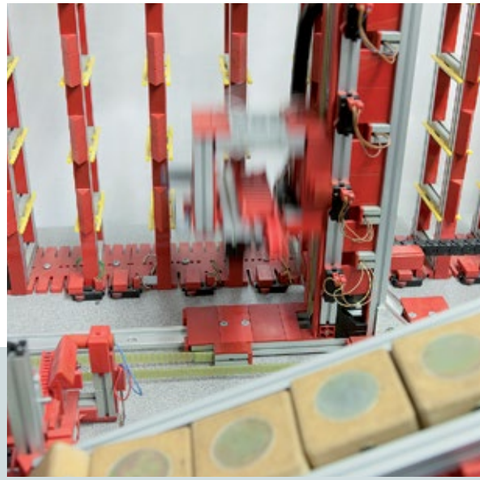
Just about everything and anything of modern life is the result of complex processes: from smart phones to cars and appliances at home and at work. Automation cuts across all levels to ensure sustainability and enhance quality of life and work. It plays an important role in accelerating and integrating manufacturing.

Terms like “Internet of Things and Services”, “Cyber physical systems” or Germany’s “Industrie 4.0”describe a new level of automation technology.

Automation technology of the future will consistently advance and develop new interconnected functionalities which perform process optimization and knowledge processing. In addition to the automation of simple and repetitive functions as of today, future automation systems will also increasingly perform cognitive tasks.

Research in the institutes range from theoretic research to the creation of base technologies and their application, involving the following topics:

- **Self-organization of automated real-time systems:** There is a need for new and innovative software systems which can reconfigure and test themselves automatically. In the future, automation systems will entail software that allows devices and their components to self-adjust during operation.
- **Automatically created automation systems** which aim towards the development of the systems for the entire life cycle. Decision support systems assist engineers in a variety of tasks, for example the orchestration of technical systems and help with their support and service.
- **New microsystem components for automation** will be needed to record, process and transmit information. Research is looking at microsystems with integrated sensors, signal processing, energy supply and wireless encrypted communication.
- **Communication and the industrial internet** help establishing an efficient machine to machine communication, creating new possibilities for automated production and human-machine cooperation. Our research relates to wireless communication, in particular the security, reliability and real-time ability of such communication.



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IKR, Institute of Communication Networks and Computer Engineering
Prof. Jörg Roth-Stielow,
ILEA, Institute for Power Electronics and Electrical Drives
Prof. Joachim Burghartz,
INES, Institute of Nano and Microelectronic Systems and
IMS CHIPS, Institute of Microelectronics Stuttgart

RESEARCH FOCUS AREA

MICRO-, OPTO- AND POWER ELECTRONICS

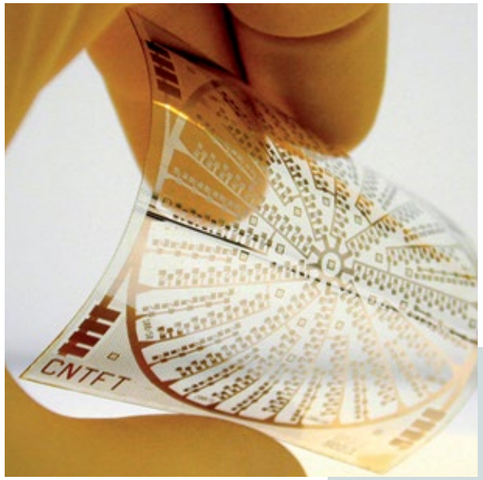
RESEARCH THAT PUSHES THE BOUNDARIES.

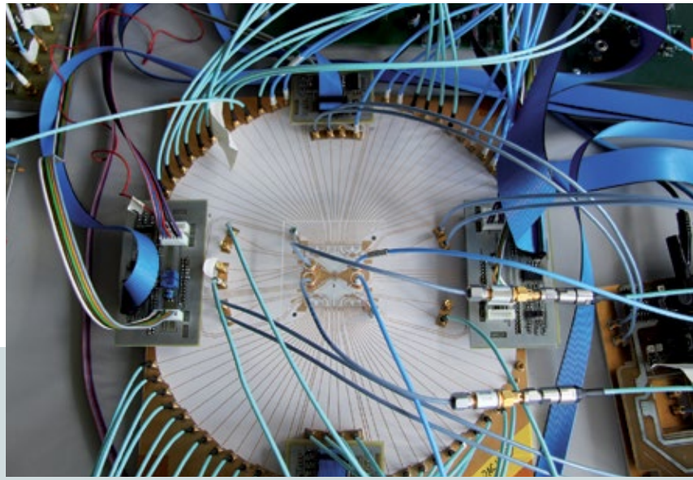
MICRO-, OPTO- AND POWER ELECTRONICS PROVIDE THE ESSENTIAL TECHNOLOGICAL BASIS FOR MODERN ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY.

Innovative solid-state lighting and highly integrated circuits for telecommunications, data processing and sensor systems to complex power electronics controllers and converters as well as large-area maximum-efficiency solar units or monitors, none of these would be possible without micro-, opto- and power electronics. Topics like the energy policy, mobility, intelligent systems, photonics and quantum technologies can only be successfully implemented with completely new types of technology, component and system concepts.

Research in the field of micro-, opto- and power electronics ranges from work geared to basic research in the field of process, component and circuit technology to the application in practice, and covers the following topics:

- **Flexible electronics:** Mechanically flexible electronic systems can be realized by using extremely thin chips or by using unconventional semiconductors on flexible substrates. This allows for more efficient heat transfer and low-parasitic assembly techniques for power semiconductors as well as innovative applications such as flexible displays, sensors and medical implants.
- **Quantum electronics:** The constant miniaturization of micro- and nanoelectronic elements in the sub-10 nm range is leading to the emergence of quantum mechanical effects that blanket or even destroy the traditional behavior of these components. The research objective of semiconductor-based quantum electronics is to exploit quantum mechanical effects and the spin degrees of freedom of electrons in a targeted manner and to functionalize these in new component concepts.
- **Unconventional semiconductor and process technologies:** Compound semiconductors (SiGeSn, GaAs, InP, GaN, SiC, InGaZnO) and organic semiconductors as well as new types of vacuum-free manufacturing processes (laser processes, printing) form the basis for realizing revolutionary component and circuit concepts for a large range of applications extending from information transfer with just a few pJ/bit to energy conversion in the Gigawatt range and high-efficiency solar cells and batteries.
- **Photonics:** The increasing density of integration in microelectronics makes it possible to accommodate ever smaller and more complex electronic and optical circuits on tiny surfaces. This integration of electrical and optical components to photonic circuits is opening up new possibilities in the field of data transmission, sensor systems and the usability of quantum effects.





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INES, Institute of Nano and Microelectronic Systems and
IMS CHIPS, Institute of Microelectronics Stuttgart
Prof. Michael Saliba,
IPV, Institute for Photovoltaics
Prof. Peter Birke,
IPV, Institute for Photovoltaics, Electrical Energy Storage Systems

RESEARCH FOCUS AREA

ELECTRICAL ENERGY ENGINEERING

SUSTAINABILITY RESEARCH: FROM ELECTRICITY SUPPLY TO THE ELECTRIC CAR.

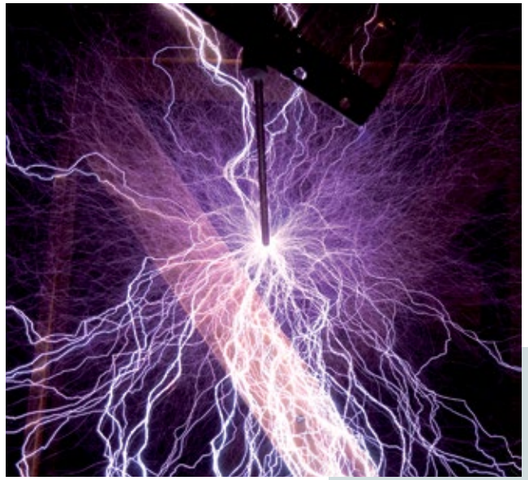
CONSIDERING THE ADVANCING CLIMATE CHANGE AND ITS IMPACTS, THE TRANSFORMATION OF THE ENERGY SUPPLY TO LOW-EMISSION CONCEPTS IS ONE OF THE CENTRAL TECHNICAL AND SOCIAL CHALLENGES.

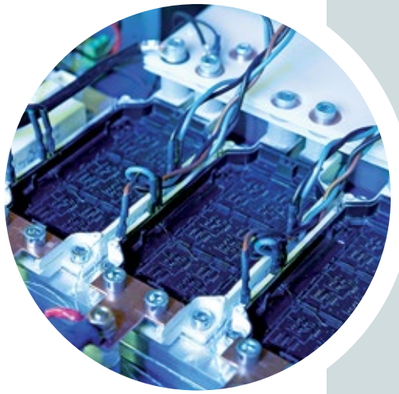
For example, the German government has set the objective of halving primary energy consumption by means of improved energy efficiency and increasing the share of renewables in the gross final energy consumption to 60 percent by 2050. This relates in particular to the area of electricity generation, which is to comprise 80 percent renewables in 2050, and requires an innovative, highly complex and intelligent power system to be developed that ensures an environmentally friendly, reliable and affordable energy supply. In this respect, electromobility is one of the decisive components of the turnaround in energy policy and offers a promising alternative for making the mobility of the future environmentally and resource friendly.

As a result, there are numerous socially highly relevant research topics in the field of photovoltaics, storage technologies, electromobility, power electronics and the integration of renewable energy sources in the existing energy supply network.

Research at the department ranges from work geared to basic research to the creation of base technologies and their application in practice. It involves the following topics:

- Energy-efficient electrical drives for electromobility and industrial automation
- Development of maximum-efficiency photovoltaic systems for electricity costs under 5 ct/kWh
- Development and optimization of insulation systems and diagnostic procedures for high-voltage operating equipment for electrical power networks
- Methods and approaches for planning and operating electrical grids with decentralized feed-in, smart grid, storage and controllable loads
- Voltage transformers with high power density based on modern power semiconductor technologies
- Inductive charging for electric vehicles and contactless energy supply for railway vehicles
- Development of innovative power electronic and electromechanical components for electric vehicles, wind energy plants and robot technology
- Development of modern battery management systems for controlling and integrating electrochemical energy stores as part of renewables





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IPV, Institute for Photovoltaics
Prof. Peter Birke,
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DEPARTMENT FACTS AND FIGURES

ON A GROWTH TRAJECTORY IN RESEARCH AND TEACHING.

APPROX. 1,400 STUDENTS IN

- **one bachelor's degree program:**
  B.Sc. Electrical Engineering and Information Technology
- **three German taught master's degree programs:**
  M.Sc. Electrical Engineering and Information Technology;
  M.Sc. Electromobility;
  M.Sc. Sustainable Electrical Power Supply
- **two English taught master's degree programs:**
  M.Sc. Electrical Engineering (EENG);
  M.Sc. INFOTECH (with the Computer Science department)

PARTICIPATION IN THE STUDY PROGRAMS

- B.Sc. Renewable Energies (with Faculty 4);
- M.Sc. and B.Sc. Mechatronics (with Faculty 7);
- M.Sc. Photonic Engineering (with Faculties 7 and 8);
- M.Sc. and B.Sc. Medical Technology (with Faculties 4 and 7 as well as the University of Tübingen);
- M.Sc. Autonomous Systems (with the Computer Science department and Faculties 4 and 7)

DOCTORAL STUDENTS AND PROFESSORSHIPS

- On average 19 doctoral students per year, on the increase
- Increase in professorships in recent years to 15 institutes and 18 professorships.

FOUR LOCATIONS

- Pfaffenwaldring 47 Campus Vaihingen (main location),
- Allmandring 3b Campus Vaihingen (IGM),
- Allmandring 30a Campus Vaihingen (INES with IMS Chips),
- Nellingen high-voltage hall

THE UNIVERSITY OF STUTTGART

WE ARE ONE OF THE LEADING NINE TECHNICAL UNIVERSITIES – WITH OUR OWN UNIQUE PROFILE.

Around 24,000 students in around 160 study programs; 10 faculties, 150 institutes, roughly 5,000 employees, including around 300 professors; in excess of EUR 180 million in external funding annually.

The University in Stuttgart was founded in 1829 and became a technical university in 1890. From its very beginnings, its special strength lay in the cooperation between technical and natural science as well as between the humanities and social science. Today the University of Stuttgart is one of the TU9, the nine leading technical universities in Germany. Its special profile, referred to as "the Stuttgart model", with the integration of engineering, natural sciences, humanities, social and economic sciences facilitates complex solutions to global challenges. The research activities of the university are focused on eight areas: modeling and simulation technologies, new materials, complex systems and communication, concepts of technology and technology evaluation, sustainable energy supply and the environment, mobility, integrated product design and production organization as well as the design and technology of sustainable living. The university has international visibility as a research university and houses the Simulation Technology Cluster of Excellence, the Graduate School of advanced Manufacturing Engineering, the ARENA2036 Research Campus as well as numerous Collaborative Research Centers and Research Training Groups.

Numerous outstanding institutions where highly specialized research is carried out or that support teaching and research operations are located at the university. These include for example the High-Performance Computing Center, the Visualization Research Center, the Automotive Simulation Center Stuttgart, an extremely high-performing wind canal, Europe's largest driving simulator, the Materials Testing Institute and the Aerospace Center Baden-Württemberg with the airborne observatory SOFIA.

The university is an important and attractive employer in the Stuttgart region. It is a campus university with two locations, in the city center and in Vaihingen, that are well connected by public transport and offer attractive recreation possibilities. It is certified as a family-friendly university since 2012.

The Electrical Engineering and Information Technology department is one of the oldest of the university. Back in 1882, Stuttgart Technical University, as it was known at the time, created the first Professorship of Electrical Engineering. We are still one of the university's largest departments today. Our research focus areas are reflected in the university's central strategic research focus areas. This allows us to form close cooperations within the university, in particular with the Engineering departments, for example in the area of electrical drives, automation, electromobility and energy engineering. There are also close links to the Physics department, particularly in relation to quantum technology.

Within the faculty, we work closely with the Computer Science department in several areas. This allows us to cover the entire range of information and communication technology: from micro-, opto- and power electronics, hardware and computer architectures to signal processing and complex information systems, machine learning and autonomous systems as well as automation technology.

STUTTGART AS A RESEARCH REGION

WE TAKE ADVANTAGE OF OPPORTUNITIES TO COLLABORATE WITH DYNAMIC PARTNERS.

Innovative Research Campus: ARENA2036

Baden-Württemberg ranks first in Europe in terms of its innovative power, and within Baden-Württemberg the Stuttgart region is top of the list.

The University of Stuttgart is located in the midst of a dynamic business region that is home to both large enterprise and highly specialized small and medium-sized businesses in the areas of automotive, IT, production and manufacturing technology and biosciences. Baden-Württemberg ranks first in Europe in terms of its innovative power, and within Baden-Württemberg the Stuttgart region is top of the list. The University of Stuttgart has built up research collaborations spanning several years with many of these research-intensive industries. These companies in turn are attractive employers for the university's graduates.

The region is also characterized by a high density of universities, universities of applied science and research organizations such as the Max Planck Society (Max Planck Institute for Solid State Research, Max Planck Institute for Intelligent Systems), the second-largest research center of the Fraunhofer-Gesellschaft in Germany with several institutes, the German Aerospace Center or the German Literature Archive in Marbach. Institutes of the university regularly work together with researchers from these organizations in joint projects. One new form of collaboration is the "ARENA2036" Research Campus, where different partners from science and industry join together under one roof to undertake research into innovative topics relating to automobile production and lightweight construction.

The institutes of the Electrical Engineering and Information Technology department regularly work together with various regional partners from research and industry. These include high-profile major employers in the region such as Daimler AG and Robert Bosch GmbH as well as numerous SMEs from research-intensive industries, for example the Trumpf group, SEW Eurodrive or Vector Informatik GmbH. Some of those projects have given rise to close cooperation at different levels, such as the SEW Eurodrive Study Award or research promotion by the Vector Foundation. Special mention should be made of the Robert Bosch Center for Power Electronics (rbz) in this regard, where institutes of the department research and teach together with Reutlingen University and Robert Bosch GmbH. This close cooperation also resulted in a cooperative doctoral program.

There are also long-term research collaborations in place in the field of information and communication technology with Alcatel Lucent, now Nokia. The annual "Nokia Lectures" on the topic of communication are a public expression of this close collaboration.

There is an intensive exchange in particular with the University of Ulm in the field of microelectronics and power semiconductors, with the University of Tübingen in medical technology and with Reutlingen University in power semiconductors and microelectronics.

One new form of collaboration is the "ARENA2036" Research Campus, where different partners from science and industry join together under one roof to undertake research into innovative topics relating to automobile production and lightweight construction.

LEGAL NOTICE

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