PROJECTS AT POWER ELECTRONICS LABORATORY

LAB ENGINEERING

Supervisor: Jonathan Braun
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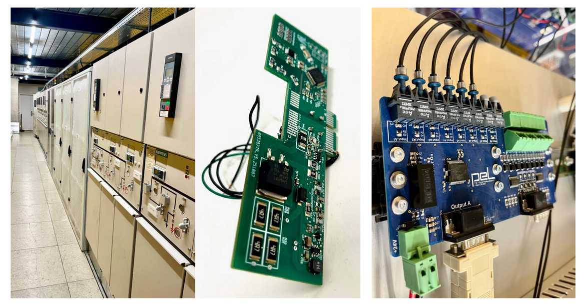
Keywords: #Electronics #Automation #Measurements #Embedded

Description: The research conducted at the Power Electronics Laboratory needs a strong engineering support. From advanced measurements techniques to miniaturized power supplies, the engineering projects are plenty and always challenging.
The lab also uses an intricate medium voltage infrastructure in order to support experiments up to 1 MW and 20 kV. This infrastructure needs adaptation and improvements from time to time and this also leads to some automation projects.
If you are interested in a very hands on project that leads to a direct use in the lab, please feel free to contact me.



The main topics that I can propose are related to the following fields:

- Electronics design.
- Automation.
- Embedded Systems.

SOLID-STATE TRANSFORMER (SST) FOR FUTURE DATA CENTERS

Supervisor: Zhenchao Li
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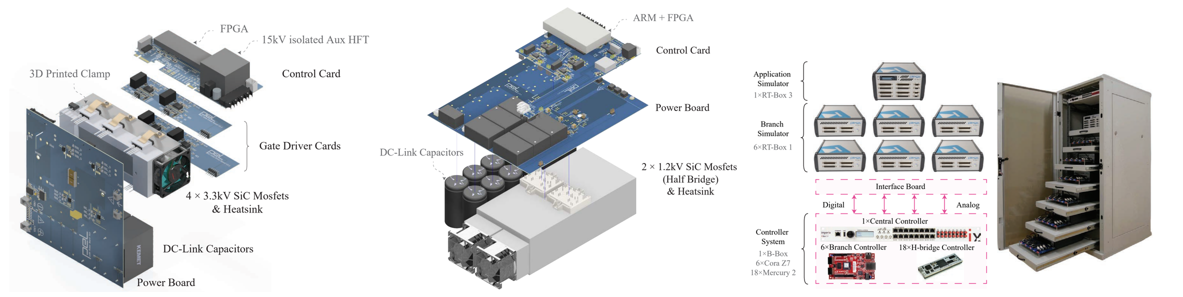
Keywords: #Data Center #Solid-State Transformer #Hardware

Description: This project investigates the application of Solid-State Transformer (**SST**) technology to future HVDC power distribution systems in **data centers**. Specifically, a 250 kW, 3.3 kV/800 V SST is being developed for **EPFL's next-generation data center**, utilizing a novel single-stage topology. This SST prototype will serve as a platform for exploring the capabilities of 3.3 kV **SiC MOSFETs** and advancing **medium-frequency transformer** (MFT) design. The project also encompasses the development of a **Real-Time Hardware-In-Loop** (RT-HIL) system, the coordination of **multi-controller architectures** (ARM + FPGA), and the implementation of advanced system-level and submodule-level **control algorithms**.



ISOLATED DC-DC CONVERTER FOR SERVER POWER SUPPLY

Supervisor: Celia Hermoso Díaz
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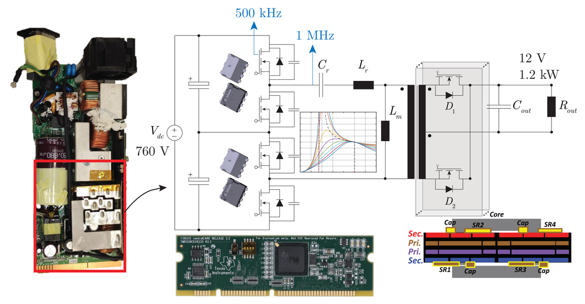
Keywords: #Data Center #Server #Magnetics #Efficiency

Description: The increasing demand for data-oriented technologies has led to a need for more efficient data centers. Due to their large electricity consumption and required reliability, data center servers are the most performance-driven, energy and cost-aware among all the power supplies for industrial applications.

In data center server power supplies, DC/DC converters must meet very strict requirements. They need to provide electrical isolation, achieve high efficiency, and must be very compact. Resonant converters meet these conditions and, the LLC topology in particular is widely used for this application. However, achieving high power density and high-efficiency designs is challenging.



To address these challenges, the current research covers:

- PCB design and optimization
- High power density strategies
- Integrated magnetics prototyping
- Synchronous rectification

GAN-BASED 6.78MHZ INDUCTIVE POWER TRANSFER SYSTEM

Supervisor: Israel Yepez Lopez
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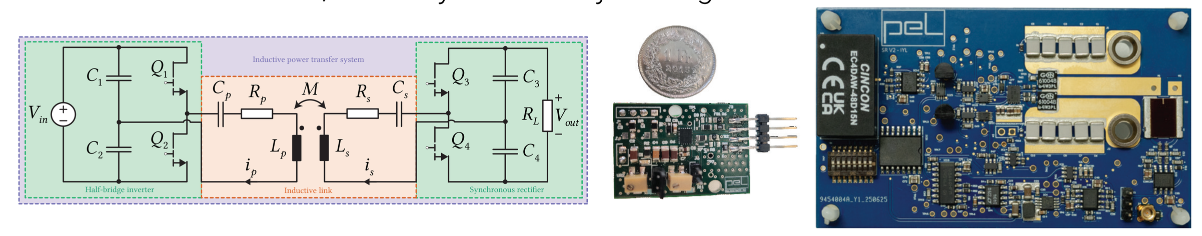
Keywords: #IPT #High-Frequency power electronics #GaN devices

Description: Medium voltage converters require the operation of auxiliary circuits such as gate drivers, sensors, conditioning stages, controllers, etc. All these subsystems are typically defined as a Power Electronics Building Block (PEBB) unit and need to be powered by an Auxiliary Power Supply (APS). This APS needs to provide high isolation, high efficiency and a high level of compactness. APS based on inductive power transfer (IPT) is an attractive way to overcome the insulation constraint due to the contactless nature of IPT, but efficiency and compactness must be ensured to the same extent. To solve this problem, this research project proposes to design and optimise, model and characterise, simulate and prototype high-frequency power electronics based on GaN devices for the IPT system. If this sounds like something you'd like to work on, please feel free to contact me, either by email or by visiting me in ELH117.



IPT COUPLING COILS WITH HIGH ISOLATION CAPABILITIES

Supervisor: Gaia Petrillo
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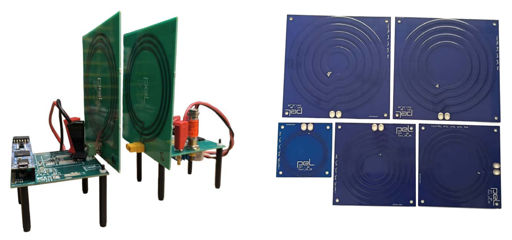
Keywords: #IPT #6.78MHz #coils #insulation #modeling #design

Description: The focus of this research activity is the optimization of coupling coils for inductive wireless power transfer (IPT). The coil design, including the geometry of the windings and the selection of the shielding material, has a significant impact on the losses, and therefore the efficiency and power transfer capabilities, of the entire system, as well as its influence on surrounding objects. Furthermore, this project requires ensuring insulation in the full medium voltage (MV) range, up to 36 kV, between the transmitter and receiver coils. Using air for this insulation has detrimental effects on coupling efficiency; therefore, it is necessary to explore solid insulation materials to identify an approach that can fulfill the insulation requirements while preserving power transfer efficiency.

Potential project topics include:

- Modeling coil parameters
- Definition of optimization routines
- Assessment of magnetic materials
- Assessment of dielectric materials
- Thermal analysis
- Design of test setups



DESIGN AND CONTROL OF SOLID-STATE TRANSFORMERS

Supervisor: Dr. Giacomo Andrioli
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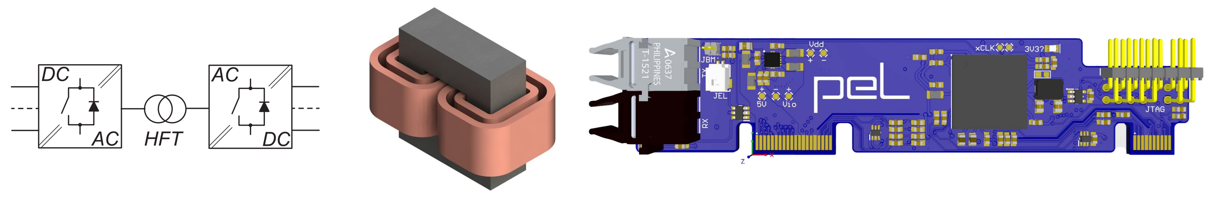
Keywords: #SolidStateTransformers #Design #Control #Test

Description: High-power electronic systems power up our world. **Solid-State Transformers** (SSTs), in particular, are employed where cutting-edge performance and smart functions are needed, from modern **data centers** to **industrial plants** and transportation.

For robustness, efficiency, and power density, a comprehensive approach is required:

- **Power converter design**: selection of converter topology and its modulation can be analyzed and optimized. PEL tests at full power, no excuses.
- **Magnetic components**: modeling, optimization, and electro-magnetic simulations improve their design. Then, we build it and test it. Hands-on approach.
- **Control**: the mathematical rules for the coordination of different elements, and their implementation on DSPs, FPGAs, and CPUs. Power is nothing without control.



DESIGN OPTIMIZATION OF HIGH POWER MAGNETIC DEVICES

Supervisor: Sophie-Linn Karlsson
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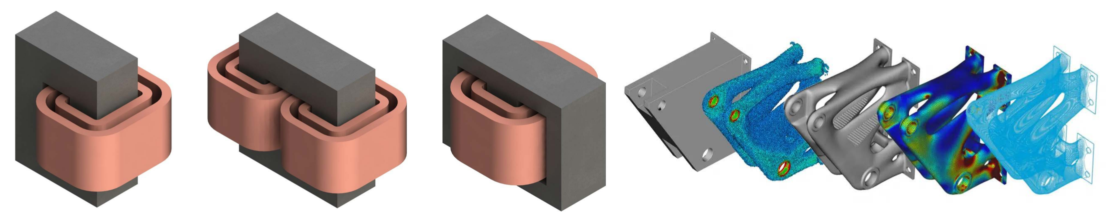
Keywords: #Converter #Design #Magnetics #Medium Voltage

Description: Emerging conversion solutions, such as Solid State Transformers, typically require large number of medium/high frequency transformers, providing galvanic isolation and voltage adaptation. Design optimization of these components is typically a multi-physics, multi-objective design problem, as electrical, magnetic, dielectric and thermal considerations must be all simultaneously considered. To achieve optimal designs, thorough modeling and simulations are required, supported by experimental characterization and prototyping.
Many student projects can be derived from the ongoing activities and we are looking for students passionate for electromagnetic modeling and simulations, as well as practical hardware design and laboratory work.



ELECTRONIC ON LOAD TAP CHANGER (E-OLTC)

Supervisor: Dr. Jiasheng Huang
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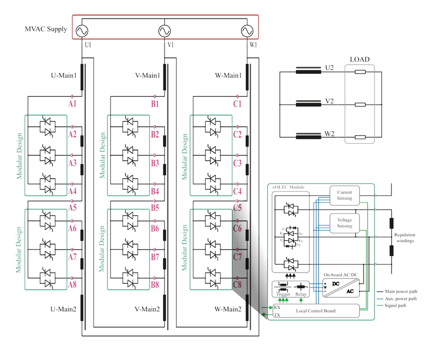
Keywords: #On load tap changer (OLTC) #voltage regulation

Description: Mechanical OLTCs are widely spread technology in distribution networks, providing necessary voltage regulation in case of varying conditions. However, they suffer from reliability issues due to the presence of moving parts that are prone to wear and tear over time. This mechanical stress can lead to frequent maintenance requirements, increasing operational costs and causing downtime. The switching process in mechanical OLTCs is slower, which can result in voltage fluctuations and reduced power quality.

This project will collaborate with Rauscher & Stoecklin AG to explore feasibility to develop solid-state based solution, benefiting from ever increasing performances of semiconductor devices.

Potential research topics include:

- Design of driver circuits for thyristors
- Design of winding and switch configurations
- Optimal tap-changing sequences for eOLTC
- Startup solutions for eOLTC
- Thermal analysis for eOLTC



MONOLITHIC HIGH-POWER DC-DC CONVERTER

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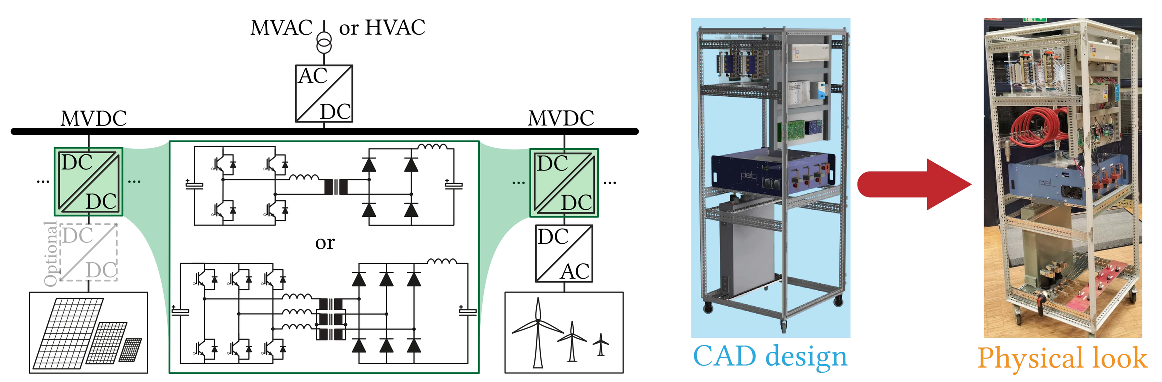
Keywords: #Modeling #Design Optimization #Hardware #MVDC #SST

Description: Connection of renewable energy sources to the MVDC collection grid requires an efficient, reliable and economically viable high power DC/DC converter. As an alternative to the widely studied modular converters, monolithic topologies present themselves as an attractive solution for this future application. The overall aim of the project is a holistic investigation of the monolithic high-power solid-state transformer concept spanning topology level analysis, conversion stage and device-level considerations, and including hardware design and implementation within a comprehensive optimization framework.



OPTIMIZING ENERGY STORAGE IN DATA CENTERS

Supervisor: Baihan Liu
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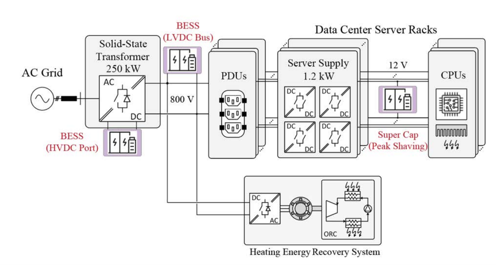
Keywords: #PEBB Design #Gate Driver #SiC MOSFET

Description: Data center power consumption is surging due to AI and cloud computing. The transient current of a single server jumps rapidly to hundreds of amperes within tens of microseconds. Such a fast load dynamic puts enormous pressure on the upstream power supply as well as the grid.

In order to reduce the pressure and improve the stability of the data center power supply. Energy storage systems are now becoming the key technology. By integrating energy storage systems, data centers can achieve: Mitigating transient load surges and improving bus stability; boosting the power density of servers and improving space utilization; reducing upstream power supply design redundancy and improving system efficiency; reducing peak demand and fast power supply on the grid side.

This project will focus on:

- Modeling, sizing, and control strategies development.
- Power converter design.
- Control algorithm implementation.
- Thermal modelling.



RESONANT CONVERSION-BASED SOLID-STATE TRANSFORMER

Supervisor: Amin Darvishzadeh
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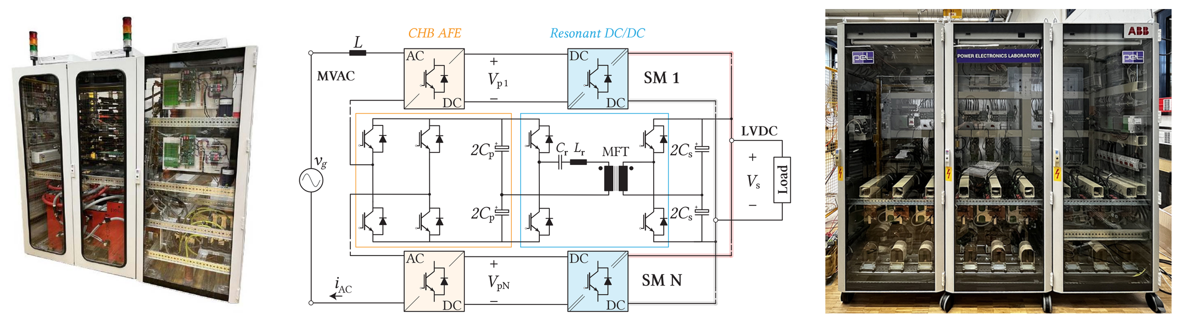
Keywords: #Direct Current Transformer #Solid-state Transformer

Description: The Solid-State Transformer (SST) is an intelligent and agile successor to traditional converter technologies, leveraging power electronics to deliver a lighter, more flexible power supply with advanced functions such as grid support—enabling applications such as ultra-fast EV charging, forming the backbone of future smart grids, and providing high-quality power to demanding loads such as data centers.
While SSTs promise revolutionary advancements, their widespread adoption still faces critical challenges—including scalability limits, control complexities, long-term reliability, and efficiency optimization—challenges that motivate my thesis, with a focus on resonant conversion-based modular AC/DC and monolithic DC/DC SST designs.



MMC CONTROL FOR MVDC APPLICATIONS

Supervisor: Max Dupont
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Keywords: #MMC #Control #MVDC

Description: The Modular Multilevel Converter (MMC) is a highly scalable converter structure particularly well suited for high voltage DC applications, and commercial examples are already in operation. Its characteristics also make it a good candidate for future MVDC power distribution networks. However, in such an environment, the converter would be exposed to a broader range of loads and perturbations than in the existing HVDC examples. This is why my research focuses on robust DC side control for MVDC applications. Activities range from commissioning and testing of a 10kV 250kVA dual MMC setup to control development assisted by real time hardware in the loop simulation before deployment on the physical setup.