PROJECTS AT POWER ELECTRONICS LABORATORY

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This poster presents the main activities of the members of the power electronics laboratory.
If you are looking or a semester of thesis project, feel free to contact the people working on the topics that excite you the most

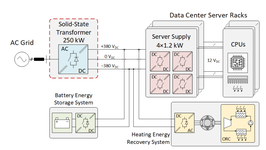
MVAC/LVDC CONVERTER FOR FUTURE DATA CENTERS

Supervisor: Zhenchao Li
ELH117
zhenchao.li@epfl.ch

Keywords: #Data Center #Solid-State Transformer #Hardware

Description: As AI applications proliferate, Data Centers are consuming increasing amounts of electrical power. Traditional AC power distribution architectures can no longer meet the demands for high efficiency and power density.

In this project, we explore a cutting-edge DC power distribution architecture for Data Centers, designed to integrate renewable energy sources seamlessly. To replace the bulky line-frequency transformers in MV/LV conversion, we employ a novel Solid-State Transformer (SST) with integrated high-frequency galvanic isolation. A 250kW prototype will be built for new EPFL Data Center.



To maximize system performance, the ongoing research topics include:

- Topology innovation.
- Hardware design and optimization.
- High power magnetic design.
- Control algorithm development.

ISOLATED DC-DC CONVERTER FOR DATA CENTER POWER SUPPLY

Supervisor: Celia Hermoso Díaz
ELH115
celia.hermosodiaz@epfl.ch

Keywords: #Data Center #Server #Magnetics #Efficiency

Description: In our perpetually connected society, data centers are the backbone of the digital world. To meet the ever-growing demand for data processing, optimizing the core of data center energy systems is crucial. By enhancing the efficiency of the DC-DC power supply stage, we are not just improving data center sustainability; we are also advancing the technology that powers our connected world.

Research focus:

- Innovation in energy conversion.
- Sustainable solutions for data centers.

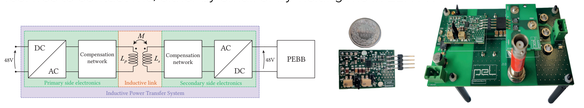
For those of you whose curiosity has been sparked by the brief description above and who have a strong desire to learn, please don't hesitate to get in touch with me. We can discuss potential projects and expected outcomes that match your expectations

GAN-BASED 6.78MHZ INDUCTIVE POWER TRANSFER SYSTEM

Supervisor: Israel Yepez Lopez
ELH117
israel.yepezlopez@epfl.ch

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.



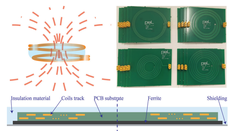
IPT COUPLING COILS WITH HIGH INSULATION CAPABILITIES

Supervisor: Gaia Petrillo
ELH117
gaia.petrillo@epfl.ch

Keywords: #IPT #6.78MHz #coils #insulation #modeling #design

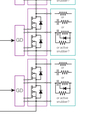
Description: Inductive Power Transfer (IPT) is a wireless power transfer technology that allows to convey power through magnetic coupling between coils generating a magnetic field, and without contact between transmitter and receiver. This research activity has the objective to develop this technology further and apply it in the MV (Medium Voltage) field where high insulation capability is required (up to 36kV), and therefore IPT contactless feature is especially advantageous. On the other side, efficiency is often one of the weaknesses of IPT. Optimal design of coupling coils can improve the link efficiency. To achieve this objective, different aspects need to be considered such as, winding structure, insulation material, magnetic and electric shielding, and thermal equilibrium.

You can expect to work on: the development of the Winding Optimization Design Tool, the characterization of different coupling coils, the integration of coils in IPT system, the comparison of different insulation materials, the insulation design and test, etc. Projects could also be tailored to your specific interests and skills.



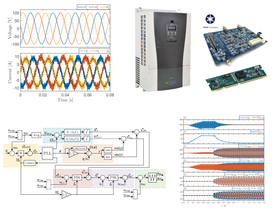
CONTROL IN POWER ELECTRONICS

Supervisor: Dr. Andrea Cervone
ELH109
andrea.cervone@epfl.ch



Keywords: #Control #Power #Electronics

Description: Power Electronics plays a key role in our world, allowing flexible and efficient use of energy. But power is nothing without control. Discover and explore new concept of control algorithms for power electronics. New ideas to improve efficiency, stability, robustness and dynamics can make the difference and allow to make the best use of power equipment.



The research activity is focused on the development of advanced control algorithms for power electronics converters, considering grid-tied applications, grid-emulation and electric drives. The activity combines theoretical studies, numerical simulations, Hardware-In-the-Loop (HIL) testing and experimental validation.

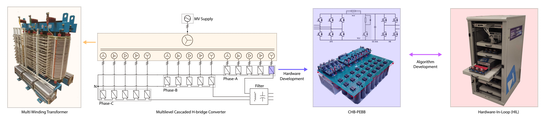
Potential projects can be defined based on your interests, and the results may be eligible for publications.

CASCADED HALF-BRIDGE CONVERTER FOR MV GRIDS

Supervisor: Jules Macé
ELH010
jules.mace@epfl.ch

Keywords: #Converter #Design #Hardware #PCB

Description: At the Power Electronics Laboratory, we are building a medium-voltage grid emulator built on the CHB converter topology. Grid emulators are converter-based systems that generate grid waveforms and are used for testing devices under any grid condition. For medium-voltage applications, simple converter topologies are not possible and multilevel topologies are widely adopted. The Cascaded Half-Bridge (CHB) topology is a multilevel converter topology based on multiple cells in series that demultiply the voltage ratings.
At the current stage of the project, we are developing the cell and the surrounding testing infrastructure and we are looking for students passionate about hardware design. Projects around test rig development, component evaluation and PCB design can be proposed based on your interests.



ELECTRONIC ON LOAD TAP CHANGER (E-OLTC)

Supervisor: Jiasheng Huang
ELH108
jiasheng.huang@epfl.ch

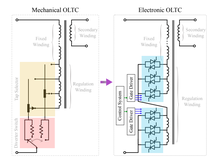
Keywords: #On load tap changer (OLTC) #voltage regulation

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 CONCEPTS FOR MV SOLID-STATE TRANSFORMERS

Supervisor: Stefan Subotic
ELH115
stefan.subotic@epfl.ch

Keywords: #Modelling #Design Optimization #MVDC #SST #MFT

Description: MVDC power collection/distribution and its enabling technologies, specifically, Solid-State Transformers (SSTs), are gaining increasing attention in recent times as an attractive solution for the future of the power system. Research on SSTs in academia has, so far, mainly focused on ISOP (input series output parallel) architectures with cell powers below 1 MW and frequencies in the range of 10–20 kHz. Next to the ISOP approach, there is a rising interest in monolithic, high-power MV SSTs, operating at frequencies in the lower range. The overall aim of the project is a holistic investigation of this alternative monolithic high-power SST concept.

The research scope of the project includes:

- Topology-level modelling
- Addressing inverter and rectifier design challenges
- Medium-frequency transformer (MFT) design considerations
- Modelling and analysis, simulations, experimental testing and optimization

HIGH VOLTAGE SIC PEBB

Supervisor: Rui Wang
ELH109
ru.wang@epfl.ch

Keywords: #PEBB Design #Gate Driver #SiC MOSFET

Description: The continuous development of power semiconductors allowed modern Silicon Carbide (SiC) MOSFETs to have higher voltage rating, temperature capability and frequency operation compared with traditional Si based counterpart.

Accordingly, the overall research objective is to develop and test a high-voltage Power Electronics Building Block (PEBB) for DC-AC conversion with equivalent switches represented by series-connected 3.3kV SiC MOSFETs. Along with it, gate drive apparatus has to be implemented in order to control the switches. The final PEBB has the potential to greatly contribute to future grid distribution systems.

Work in the characterization of the PEBB involves:

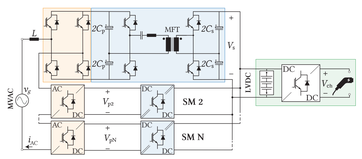
- Reliability and protection tests
- PCB design
- Implementation of control algorithm
- Thermal modelling

SOLID-STATE TRANSFORMER FOR HIGH-POWER EV CHARGING

Supervisor: Amin Darvishzadeh
ELH115
amin.darvishzadeh@epfl.ch

Keywords: #EV Charging #High-Power Electronics #SST

Description: Solid-state transformers (SSTs) have been recently raised as a promising power conversion technology, particularly in applications such as traction and the smart grid. Yet, considering the high functionality of SSTs, they can enable a multitude of compelling future concepts. In this thesis, the preoccupation is to address the increased demand for electric vehicle (EV) charging stations by proposing a three-stage high-power EV station based on an input-series output parallel (ISOP) SST.
The research platform is a 54 kVA ISOP SST constituting a 19-level cascaded h-bridge as the AC/DC stage, an isolated DC/DC stage based on LLC converters, and a battery energy storage-based DC/DC converter for fast charging.



MMC CONTROL FOR MVDC APPLICATIONS

Supervisor: Max Dupont
ELH108
max.dupont@epfl.ch

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.