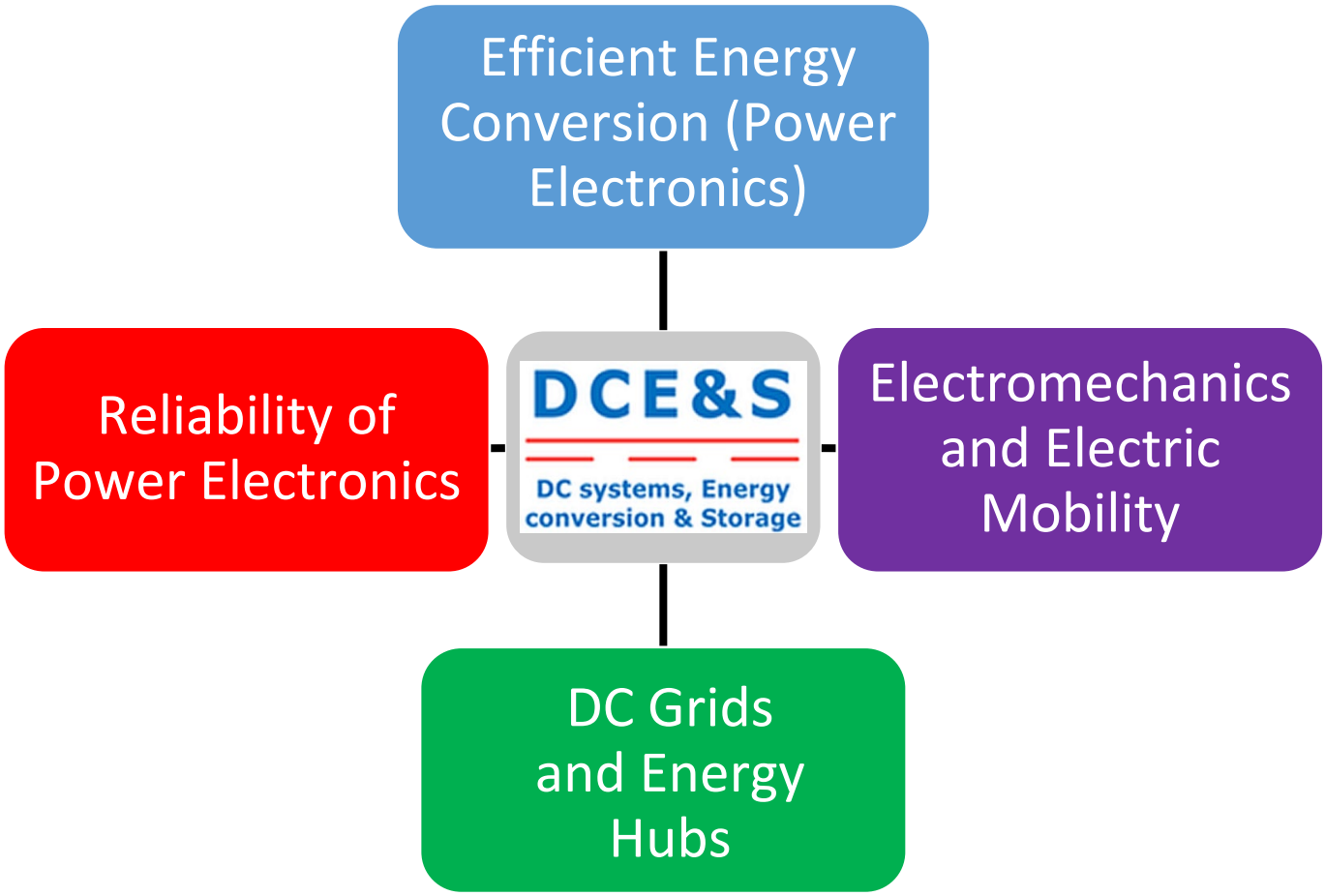
DC Systems, Energy conversion & Storage Matchmaking Event

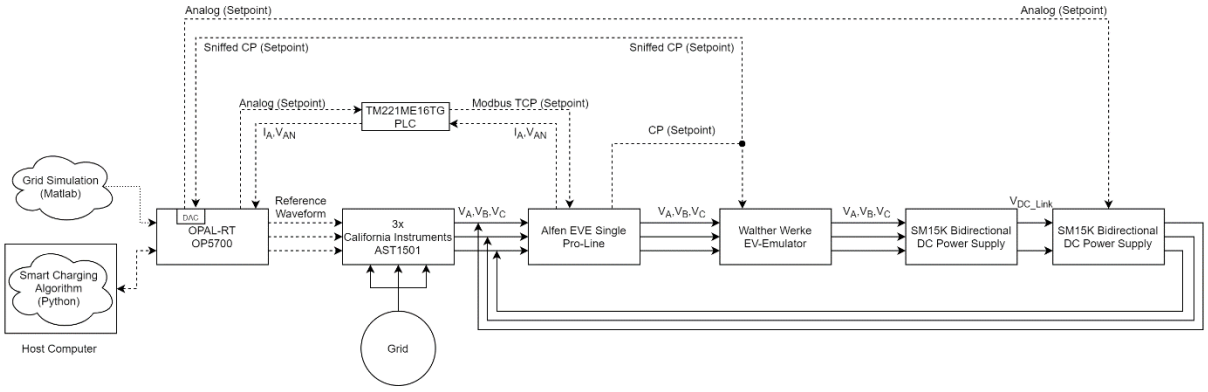
24th April 2024

12.30 - 14.00



BUILDING A HIL SETUP WITH V2G CAPABILITY

Type of project: MSc thesis



Scope:

The goal of this project is to build a Hardware In the Loop (HIL) setup in the laboratory, which is capable of emulating bidirectional charging of Electric Vehicles (EVs), and develop the necessary control algorithms.

Problem definition:

The increasing number of EVs will significantly impact the power grid because of the substantially increased electricity demand for charging the vehicles. On the other hand, with proper charging strategies and using vehicle-to-grid (V2G) technology, EVs can also offer services to the grid. The charging algorithms in the literature are usually only verified using simulations. A HIL setup can offer more insights and give a more accurate picture during testing.

Research Objectives:

- Build the V2G-capable HIL setup using the already available parts and integrating the new components (V2G charger, EV emulator)
- Modify or extend the control algorithms and communication between the components.
- Test the V2G charger alone and together with the EV emulator (the whole setup).

Methodology:

This project includes both hardware and software work. A base setup with only unidirectional charging (shown in the picture) is already available, but some components must be replaced. The bidirectional charger is already available, and a new EV emulator will be developed in a separate project. The integration of these components and the testing of the new setup will be the primary goal of this project. Optionally, the California Instruments grid emulator could also be replaced by a Cinergia grid emulator, as the latter offers higher power limits. Apart from the hardware changes, the control algorithm for the charger (running on the OPAL-RT unit), the grid simulation and communication between the components also need to be revised. If time allows, different bidirectional optimisation and charging algorithms could be tested.

Contact details:

- PhD student: István Bara, I.Bara@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, g.r.chandramouli@tudelft.nl

TU Delft

MULTI-OBJECTIVE OPTIMISATION FOR EV CHARGING STATIONS

Type of project: MSc thesis

Scope:

The first goal of this project is to develop a Multi-Criteria Decision Making (MCDM) algorithm suitable for an Electric Vehicle Charging Station (EVCS). The second objective is to compare unidirectional (V1G) and bidirectional (V2G) charging in different scenarios using the developed algorithm.

Problem definition:

The increasing number of EVs will significantly impact the power grid because of the substantially increased electricity demand for charging the vehicles. On the other hand, with proper charging strategies and using vehicle-to-grid (V2G) technology, EVs can also offer services to the grid. The different objectives often conflict, which makes multi-objective optimisation approaches (specifically a posteriori methods) have significant advantages compared to single-objective methods.

Research Objectives:

- Develop decision-making algorithm(s) based on 1 or 2 chosen method(s) from the literature.
- Test the algorithm together with the multi-objective optimisation and energy management system.
- Compare V1G and V2G charging in different scenarios using the whole EVCS model and control algorithms.

Methodology:

A multi-objective optimisation framework and Energy Management System (EMS) have been already developed (although they could be modified or extended). However, they require a separate decision-making algorithm to choose the most appropriate solution. After the selection, the Energy Management System (EMS) can execute the chosen schedule. Thus, the EVCS can operate independently (without a human decision-maker). The focus is on selecting the most suitable solution from the Pareto front using different external inputs (e.g. local grid conditions, renewable energy source forecasts) and operator preferences. The whole model will then be used to compare V1G and V2G charging in different scenarios.
The already existing parts of the algorithm are written in Julia. Other languages could also be used for the MCDM module, but compatibility must first be checked. Computer simulations will be used for the comparison.

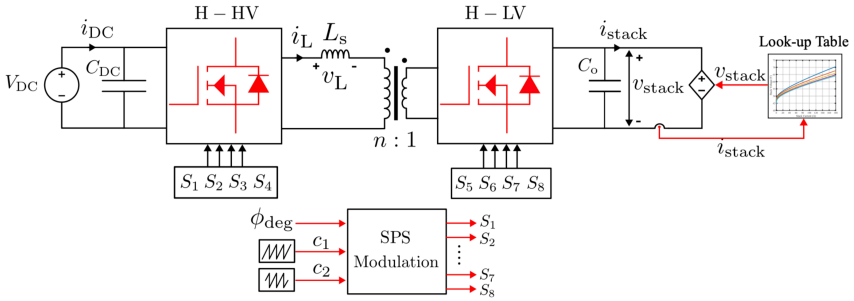
Contact details:

- PhD student: István Bara, I.Bara@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, g.r.chandramouli@tudelft.nl

TU Delft

ADVANCED CONTROLLER DESIGN OF DUAL ACTIVE BRIDGE CONVERTERS (DAB) FOR ELECTROLYSIS APPLICATIONS

Type of project: <MSc thesis>



Scope:

Electrolysis relies on precise low voltage and high current operation, mandating the isolation of high and low voltage components through isolated DC-DC converters. The Dual Active Bridge Converter stands out as an optimal choice for this purpose. However, it's crucial to note that the stack current during electrolysis exhibits noticeable ripple, potentially harming efficiency and hydrogen production. As hardware often limits switching frequency, improving the converter's control system design becomes a pivotal pathway for enhancement.

Problem Definition:

To develop a control method for minimising the stack current ripple in DAB converters for electrolysis.

Methodology:

The student begins with an in-depth exploration of the DAB converter. Subsequently, the student proceeds to conduct literature review, delving into the diverse spectrum of control techniques currently in use with DAB converters. The student then focuses on the development of control system design with the help of the given converter model and software based on the student's preference. To validate the effectiveness of this control technique, the PLECS RT-Box or OPAL-RT will be utilised, which provides a bridge between theoretical designs and real-world application.

Research Objectives:

- Conduct literature review of the various control techniques currently utilised for DAB converters.
- Identify the key requirements of the control system based on the application and initiate the control system design with the given converter model on your preferred software (MATLAB, PLECS, etc).
- Validate the control technique with a PLECS RT-Box or OPAL-RT and DAB converter prototype.

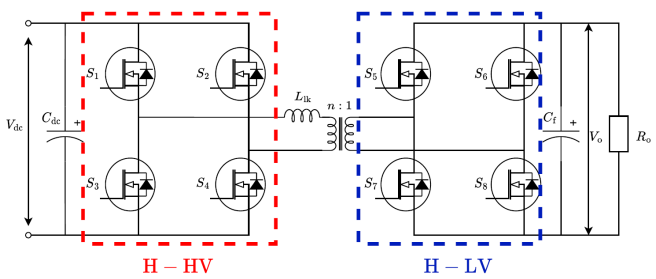
Contact details:

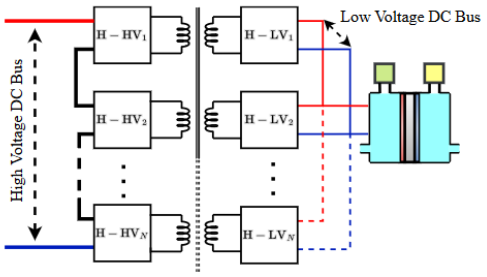
- PhD student: <Rohan Shailesh Deshmukh, R.S.DESHMUKH@TUDELFT.NL>
- Supervisor: <Dr. Hani Vahedi, H.VAHEDI@TUDELFT.NL>

TU Delft

SIZING AND DEVELOPMENT OF A MODULE FOR MODULAR DUAL ACTIVE BRIDGE CONVERTERS FOR HIGH POWER ELECTROLYSIS

Type of project: <MSc thesis>





Scope:

Electrolysis requires low voltage and high current. Modular Dual Active Bridge converters (M-DAB) can help to redistribute the high current required for electrolysis among several modules to enhance the conversion efficiency. Identifying the minimum module rating would provide insights regarding the possible modular configurations. A prototype of a DAB converter corresponding to the identified minimum module rating can be developed to assist in future studies such as conducting control system testing and validation with the help of power hardware in loop (PHIL).

Problem Definition:

Hardware design of a M-DAB converter module based on the identification of the optimum module sizing for high power electrolysis.

Methodology:

The student will focus on creating a strong foundation of DAB converter and the electrical behaviour of an electrolyser. This will be followed by conducting literature review of design of DAB and M-DAB converters and identification of factors that would influence the module rating for electrolysis. The student would analytically determine the minimum module rating of the converter for a given system power. Furthermore, based on the identified minimum module rating, the student would design a prototype using Altium Designer and run the setup in the lab.

Research Objectives:

- Hardware design of the DAB module including calculation of components rating, part selection, electronics and power electronics circuit design, schematic and PCB layout design.
- Implementing a standard switching and controller on the designed converter.
- Test and measurement of the designed converter at different switching frequency and power rating.

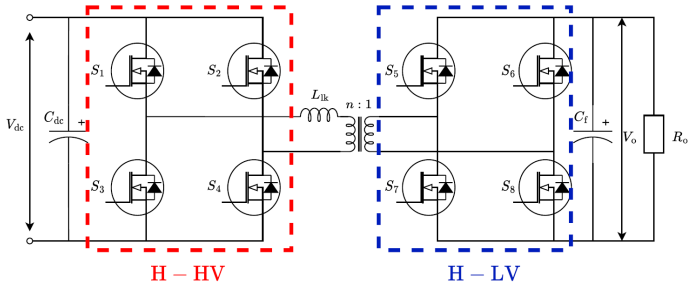
Contact details:

- PhD student: <Rohan Shailesh Deshmukh, R.S.DESHMUKH@TUDELFT.NL>
- Supervisor: <Dr. Hani Vahedi, H.VAHEDI@TUDELFT.NL>

TU Delft

DESIGN OF HIGH-FREQUENCY TRANSFORMER IN DUAL ACTIVE BRIDGE CONVERTER FOR HIGH-POWER ELECTROLYSIS SYSTEMS

Type of project: <MSc. thesis>



Scope:

Electrolysis requires low voltage and high current for optimal operation. ISO standards necessitate the implementation of galvanic isolation between the high voltage side and low voltage side of a power electronics converter for such an application. This requirement imposes several design constraints on the transformer design. Some of the issues include large turn ratio, leakage inductance, and selection of magnetics. Therefore, it is important to optimize the design of such a transformer that considers these issues from the electrolysis perspective.

Problem Definition:

Design a high-frequency (HF) transformer for a DAB utilized for electrolysis applications.

Methodology:

The student would start with the literature review of various high-power DAB prototype designs. The next step would be to study the behavior of the converter during electrolysis and identify the issues that might occur within the HF transformer. Furthermore, the student would investigate the impact of identified issues on the design of the transformer. Analytical calculations would be carried out based on the design requirements. Furthermore, FEM simulations need to be carried out. The student concludes the project by building a prototype and testing it out on a pre-made DAB module.

Research Objectives:

- Identify the issues that might occur within the high-frequency transformer. Furthermore, identify the requirements for the transformer to be designed.
- Perform parameter calculations, thermal consideration, magnetics selection and validate with FEM simulations on your preferred software (Ansys Maxwell, FEMM, etc).
- Develop prototype and validate simulation results.

Contact details:

- Ph.D. student: <Rohan Shailesh Deshmukh, R.S.DESHMUKH@TUDELFT.NL>
- Post-doc: <Dr. Gautam Rituraj, G.RITURAJ@TUDELFT.NL>
- Supervisor: <Dr. Hani Vahedi, H.VAHEDI@TUDELFT.NL>

LOW PROFILE POWER CONVERTER FOR CONTACTLESS E-BIKE CHARGING

Type of project: MSc thesis

Scope:

Power electronics hardware design for contactless e-bike charging

Problem definition:

This project aims at developing low profile power electronics to enable an even flatter contactless charging transmitter for e-bikes, based on the solution developed by Tiler (https://www.tilercharge.com/). The project will try to reduce the footprint, especially the thickness of the power electronics so that it will fit the flat charging coils. The project will start with reviewing existing designs to identify ways to reduce the component height. The system will be modelled to evaluate its electrical and thermal performance. Critical components will be selected to minimize the height without sacrificing the efficiency and reliability. A hardware prototype is expected to be delivered by the end of the project.

Methodology:

- Circuit simulation
- Multi-physical modelling
- Power electronics hardware design
- Experimental validation

Research Objectives:

- Design, implementation and validation of a low profile power converter

---

Contact details:

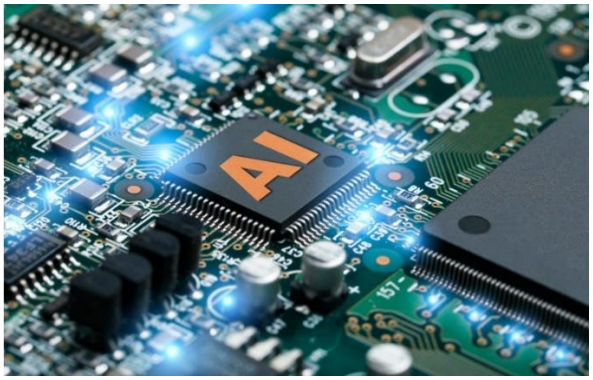
- Supervisor: Jianning Dong (J.Dong-4@tudelft.nl)

  Pavol Bauer (P.Bauer@tudelft.nl)

TU Delft

ARTIFICIAL INTELLIGENCE APPLICATION IN ELECTRIFICATION OF INDUSTRIAL PROCESSES

Type of project: Master Thesis



Scope:

Nowadays, artificial intelligence (AI) plays an important role in industry. It is an inseparable part of the smart electrification of the industrial processes. On the other side, power electronics is believed to be the heart of electrification. AI has applications in three phases of the power electronics life cycle: design, control, condition monitoring, and maintenance. In this project, a deep study of AI applications in power electronics towards electrification will be performed. The current state of the art and future challenges will be explored to make a roadmap for AI application in electrification. An example of condition monitoring of a power electronic converter using data analysis tools will be presented.

Problem definition:

Defining a roadmap for the application of AI in the electrification of industrial processes.

Methodology:

A literature review of AI in power electronics for electrification purposes will be done. Different techniques such as neural networks, fuzzy logic, data analysis, and condition monitoring will be studied to investigate their applications for power electronics systems. Condition monitoring of a power converter will be performed in MATLAB using the feedback data of a setup in the lab.

Research Objectives:

- Performing a literature review on AI applications and advantages for power electronics.
- Defining a roadmap of application of AI in electrification of industrial processes.
- Condition monitoring of a power converter with real-time feedback.

Contact details:

- Supervisor: Dr. Hani Vahedi, H.Vahedi@tudelft.nl
  Prof. Pavol Bauer, P.Bauer@tudelft.nl

TU Delft

HYDROGEN POWERED DATA CENTERS

Type of project: Master Thesis

Scope:

Data Centers should not experience any outages, even for a minute. The diesel generator has long been an imperfect but inescapable piece of the data center ecosystem. Already, some organizations are relying on batteries for longer load support – up to five minutes in some cases – and even designing their data centers with minimal generator capacity. In 2023, experts anticipate a preferred alternative will emerge – specifically hydrogen fuel cells. These fuel cells (FC) will function much like a generator at first, providing momentary load support and eventually hold promise for sustained or even continuous operation. Power electronics converters play a key role in data centers to deliver stable voltage and current to the loads at high efficiency and reliability.

Problem definition:

Reviewing the role of hydrogen as an energy storage solution for data centers. Designing a power electronics system configuration to meet the discovered challenges.

Methodology:

An extensive and comparative study will be done to extract the pros and cons of using hydrogen and FC for data centers. Theoretical studies and modeling will be done to find the best configuration and voltage/current rating of hydrogen-powered data centers. Afterward, a digital twin of 50kW and a prototype of 5kW will be designed and tested.

Research Objectives:

- Investigating the challenges in using hydrogen as an energy storage system for data centers.
- Developing an optimal power electronics system to realize hydrogen-powered data centers.
- Digital twin, HIL, and hardware implementation of the proposed system.

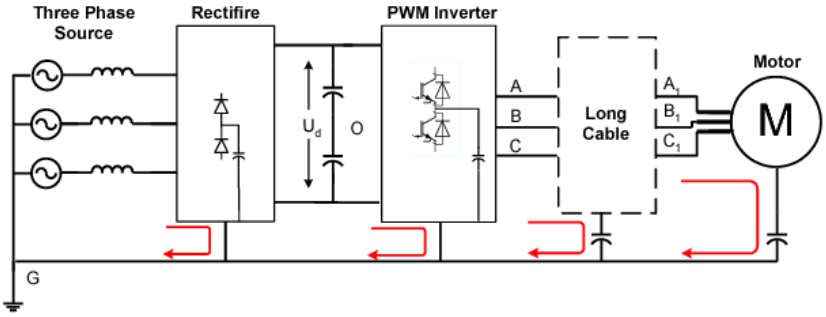
Contact details:

- Supervisor: Dr. Hani Vahedi, H.Vahedi@tudelft.nl
  Prof. Pavol Bauer, P.Bauer@tudelft.nl

TU Delft

COMMON MODE VOLTAGE REDUCTION IN NON-ISOLATED POWER CONVERTERS

Type of project: Master Thesis



Scope:

Common mode voltage is always a matter of concern in non-isolated power converters. It is seen in different applications, such as PV systems, motor drives, EV chargers, and electrolyzers. Such common mode voltage generates a current flow in the ground cable, which targets safety and security directly. Strict standard levels are imposed on the amount of this current, which differs based on the applications. Consequently, non-isolated converters could not find their path into some specific applications, such as EV chargers and electrolyzers. In this project, different software-based strategies will be investigated to reduce the common mode voltage in non-isolated converters, targeting appropriate switching and controller design.

Problem definition:

Designing proper switching and controller algorithms to reduce the common mode voltage in non-isolated converters.

Methodology:

A literature review of common mode voltage in power converters will be performed extensively. Various switching and controller algorithms will be developed and simulated in MATLAB to understand their effect on common mode voltage. Finally, an improved technique will be developed, simulated, and tested practically, showing reduced common mode voltage in non-isolated converters.

Research Objectives:

- Performing a literature review on common mode voltage in power converters.
- developing and designing a switching and or controller algorithm to reduce the common mode voltage in non-isolated power converters..
- simulation and experimental test of the proposed topology in the lab.

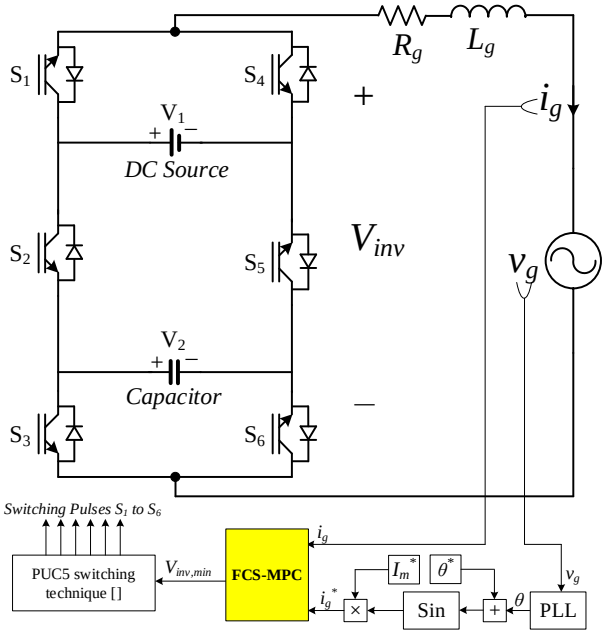
Contact details:

- Supervisor: Dr. Hani Vahedi, H.Vahedi@tudelft.nl
  Prof. Pavol Bauer, P.Bauer@tudelft.nl

TU Delft

Master's Thesis Proposal

ADVANCED CONTROLLER DESIGN FOR PUC5 CONVERTER



Scope:

Multilevel inverters are widely used in industries for higher power applications due to low harmonic pollution and high efficiency. On the other hand, due to their complex structure and having more switches and DC links, their control is a matter of concern. Moreover, not too many advanced controllers have yet been designed on multilevel inverters due to the complexity of those auxiliary capacitors at a higher number of levels and the difficulty in voltage balancing. In this project, the 5-level Packed U-Cell inverter (PUC5) will be investigated to design and implement finite control set (FCS) model predictive control (MPC). The developed technique will be implemented on the real-time simulator and hardware setup.

Problem definition:

Developing advanced controller FCS-MPC algorithms with integrated voltage balancing for the PUC5 inverter.

Methodology:

PUC5 multilevel topology and MPC will be studied thoughtfully. Afterward, FCS-MPC with an integrated voltage balancing technique will be developed for the PUC5 inverter and rectifier modes of operation and simulated in MATLAB or PLECS. Hardware-in-the-loop (HIL) and rapid control prototyping (RCP) will be done using Plecs RT-Box or Opal-RT devices.

Research Objectives:

- Performing a literature review on multilevel inverters and their applications in industry.
- developing and applying an FCS-MPC controller with an integrated voltage balancing on the PUC5 inverter and rectifier.
- simulation and experimental test of the developed algorithm in the lab

Industry relevance/partner:

You will get experience in working with PUC5 commercialized by dcbel (https://www.dcbel.energy/puc5/), and real-time simulation platforms OPAL-RT or Plecs RT-Box.

Contact details:

Hani Vahedi (H.Vahedi@tudelft.nl)
Aleksandra Lekić (A.Lekic@tudelft.nl)

MODELING AND ANALYSIS OF BATTOLYSER ELECTRIC POWER SYSTEM

Scope:

Affordable hydrogen from renewable sources is expected to account for 20% of Europe's energy system by 2050. Electricity is the dominant cost in the levelized cost of hydrogen. Trading power in volatile power markets and producing hydrogen using low-cost power at high efficiency reduces the overall electricity cost the most. The lower the cost of hydrogen, the more economical and faster the energy transition. Battolyser's innovative technology consists of an integrated battery and electrolyzer. It can be charged up to a certain level and then produce hydrogen. On the other side, it can be discharged as a battery and send energy back to the grid. Therefore, it can be considered a bidirectional battery/electrolyzer system. The electrical system is fed from a 400V AC grid and then connected to an AC/DC rectifier to supply DC voltage for the 1MW Battolyser unit, consisting of 4 250kW stacks. This project aims to model the electric power system of a 1MW Battolyser unit connected to the grid, considering its bidirectional power flow. Afterward, different analyses, such as grid reduction, harmonic performance, voltage/current ripple effect, etc., will be analyzed.

Methodology:

A detailed study of the Battolyser technology will be done to learn how it works in connection with the grid. The electrical model of the Battolyser unit is given by the company, and then its connection to the grid will be modeled in Matlab/Python. This includes the grid from a 1MW transformer, bidirectional converters, and the Battolyser stacks. Having the model ready, different analyses will be performed according to the company's needs, such as the voltage/current ripple effect of the Battolyser units, harmonic performance, grid fluctuations, etc. A digital twin of this system will also be created to run in real time.

Research Objectives:

- Understanding the Battolyser hydrogen production system.
- modeling a whole Battolyser electric power system and studying the different conditions on that, such as grid fluctuations, voltage/current ripples, and harmonic performance…
- delivering a digital twin model of the system with real-time operation

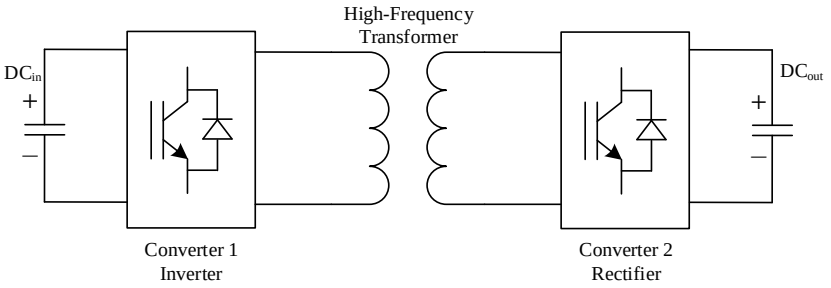
Contact details:

Dr. Hani Vahedi: H.Vahedi@tudelft.nl

Maarten van Heel Maarten@battolysersystems.com

DUAL ACTIVE MULTILEVEL BRIDGE (DAMB) FOR ELECTROLYZER APPLICATIONS

Type of project: Master Thesis



Scope:

Dual active bridges (DAB) are widely used in isolated dc-dc conversion applications. They can also be used as electrolyzer where a controlled DC voltage/current is required as well as for fuel cell applications to deliver the energy from hydrogen to the electric loads. Although many researchers have been working on topology and control of DABs, there is still room to improve such emerging high frequency isolated converters to enable new features and applications.. In this project, the goal is to use multilevel topologies in DAB configuration called DAMB. This combination helps reducing the switching frequency and size of passive components simultaneously which results in lower losses, size and weight of the converter. This can enable us to achieve higher power for electrolyzer applications..

Problem definition:

Developing bidirectional multilevel converter topologies for EV charger applications.

Methodology:

A DAB will be simulated and used as a reference to compare new topologies of DAMB with. Associated switching and controller of the DAMC will be also implemented to reach the highest possible efficiency and power quality. Simulations can be done in MATLAB or PLECS. Hardware-in-the-loop (HIL) and rapid control prototyping (RCP) will be done using Plecs RT-Box or Opal-RT devices.

Research Objectives:

- New multilevel converters will be developed to replace the full bridge module in DAB
- Comparison between DAB and proposed DAMB will be performed considering power losses, size of passive components, component count, etc.
- Digital twin, HIL and hardware setup of the proposed DAMB will be designed and tested.

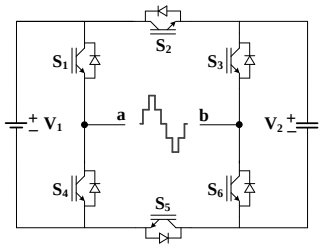
Contact details:

- Ph.D. student: Rohan Shailesh Deshmukh, R.S.Deshmukh@tudelft.nl
- Supervisor: Dr. Hani Vahedi, H.Vahedi@tudelft.nl
  Prof. Pavol Bauer, P.Bauer@tudelft.nl

TU Delft

SINGLE-DC-SOURCE MULTILEVEL CONVERTER TOPOLOGIES FOR SMART BIDIRECTIONAL EV CHARGER

Type of project: Master Thesis



Scope:

Multilevel inverters are promising technologies with inherent features such as low harmonic pollution, high power quality, distributed and lower power losses, etc. However, they need to operate in both rectifier and inverter mode to be used as bidirectional EV chargers. In this project, a new single-dc-source multilevel converter will be developed to work as a bidirectional EV charger featuring V2G and V2H modes. A controller should be developed and integrated into such a smart bidirectional charger to adjust the power level charging the battery or discharge it to the load or grid.

Problem definition:

Developing bidirectional multilevel converter topologies for EV charger applications.

Methodology:

A literature review will be done on multilevel converter topologies to develop a new one according to the project requirements. Simulations can be done in MATLAB or PLECS. Hardware-in-the-loop (HIL) and rapid control prototyping (RCP) will be done using Plecs RT-Box or Opal-RT devices.

Research Objectives:

- Performing a literature review on multilevel converter topologies.
- developing and designing a new multilevel bidirectional converter topology for EV chargers with V2G and V2H capabilities.
- simulation and experimental test of the proposed topology in the lab.

* collaboration with another university. Possible travel support

Contact details:

- Supervisor: Dr. Hani Vahedi, H.Vahedi@tudelft.nl
  Prof. Pavol Bauer, P.Bauer@tudelft.nl

POWER CONVERTER DESIGN FOR HYDROGEN AIRCRAFT

Type of project: Master Thesis

Scope:

Independence from fossil fuels is becoming increasingly important as current times show that access to fossil fuels can become limited. Hydrogen can be of aid here. In aviation particularly, we believe liquid hydrogen is the key to making flight sustainable. AeroDelft is a team of young engineers working on a hydrogen aircraft. With a full tank of just 10kg of liquid hydrogen, it can enjoy nearly three hours of flight, making it travel a distance of nearly 400km. These endurance and range values are unmatched by batteries and conventional fuels. This project aims at the custom design of the aircraft DC-DC and DC-AC converters.

Problem definition:

Designing a DC-DC and a DC-AC converter and associated controller based on the AeroDelft hydrogen aircraft requirements.

Methodology:

A detailed study of the AeroDelft hydrogen aircraft will be done to extract their requirements for those converters. Afterward, the best suitable topology and controller will be simulated in MATLAB or Plecs software. A digital twin implementation will be done, and finally, a lab prototype will be designed and tested.

Research Objectives:

- Understanding the Aerodelft hydrogen aircraft converter requirements.
- Designing DC-DC and DC-AC converters and associated controllers based on the hydrogen aircraft requirements.
- Simulation, digital twin, and practical implementation of the proposed system.

* possible collaboration/internship with AeroDelft

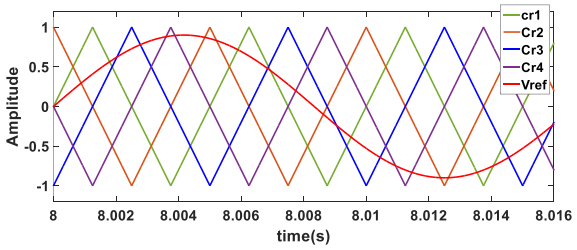
Contact details:

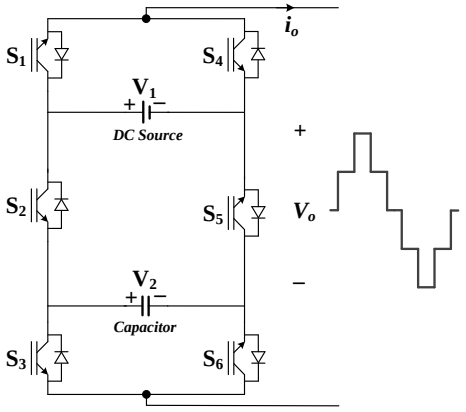
- Supervisor: Dr. Hani Vahedi, H.Vahedi@tudelft.nl
  Prof. Pavol Bauer, P.Bauer@tudelft.nl

TU Delft

VOLTAGE-BALANCING-INTEGRATED SWITCHING ALGORITHM FOR MULTILEVEL INVERTERS

Type of project: Master Thesis





Scope:

Multilevel inverters are widely used in industries for higher power applications due to low harmonic pollution and high efficiency. On the other hand, the phase-shift switching technique is well-known for its harmonic mitigation performance. However, phase-shift switching has not been regularly implemented on multilevel inverters due to complexity at a higher number of levels and difficulty in voltage balancing of the auxiliary capacitors in the configuration. In this project, the 5-level Packed U-Cell inverter (PUC5) will be investigated to design and implement a new switching technique with an integrated voltage balancing algorithm. The developed technique will be implemented on the real-time simulator and hardware setup.

Problem definition:

Developing different switching algorithms with integrated voltage balancing for PUC5 inverter.

Methodology:

A literature review will be done on switching algorithms and multilevel inverters. Afterward, a suitable switching algorithm with an integrated voltage balancing technique will be developed for the PUC5 inverter and simulated in MATLAB or PLECS. Hardware-in-the-loop (HIL) and rapid control prototyping (RCP) will be done using Plecs RT-Box or Opal-RT devices.

Research Objectives:

- Performing a literature review on phase-shift switching algorithms and multilevel inverters.
- developing and applying an improved switching algorithm with an integrated voltage balancing technique on the PUC5 inverter.
- simulation and experimental test of the developed algorithm in the lab.

Contact details:

- Supervisor: Dr. Hani Vahedi, H.Vahedi@tudelft.nl
  Prof. Pavol Bauer, P.Bauer@tudelft.nl

TU Delft

DESIGN AND TEST INTERFACE CARDS FOR REAL-TIME AND DIGITAL TWIN APPLICATIONS

Type of project: Extra Project

Scope:

Digital platforms are widely used in engineering. Opal-RT and Plecs RT-Box are two commonly used real-time simulators in the field of power electronics. Those simulators can be also connected to different microcontroller development boards to exchange analog and digital signals. Two main development boards used at our group are carrying TI and STM32 microcontrollers. In this project, various interface cards will be designed to connect development boards, Plecs RT-Boxes and Opal-RT simulators to implement innovative digital twin ideas.

Problem definition:

Designing interface cards for development boards and real-time simulator devices (TI, STM32, Opal-RT, Plecs RT-Box)

Methodology:

In this project, the pin-out configuration of the existing devices and development boards will be reviewed, and the requirements of the interface cards will be listed. Electronic circuits for isolation and protection of analog/digital signals will be simulated in LTspice. Then the schematics will be designed in Altium Designer. Finally, the PCB layout will be done in Altium and the board will be assembled and then tested practically in the lab.

Research Objectives:

- Designing electronic circuits for isolation, protection, and power supply of analog/digital signals and ICs.
- Designing schematics and then PCB layout of interface cards in Altium Designer
- Assembling interface PCB and testing in the lab

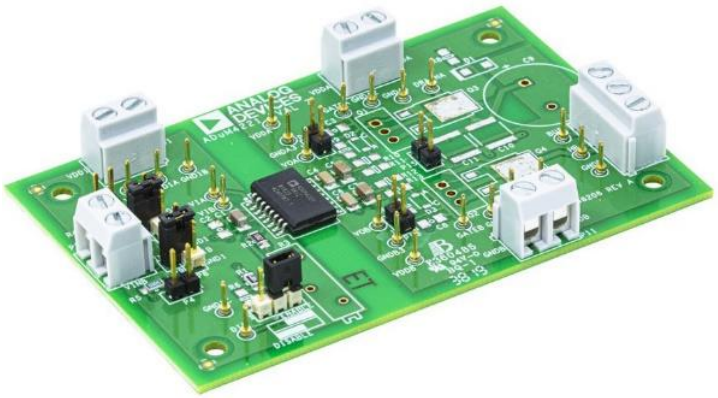
Contact details:

- Ph.D. student: Rohan Shailesh Deshmukh, R.S.Deshmukh@tudelft.nl
- Supervisor: Dr. Hani Vahedi, H.Vahedi@tudelft.nl
  Prof. Pavol Bauer, P.Bauer@tudelft.nl

TU Delft

DESIGN AND TEST A UNIVERSAL AND MODULAR FPGA-BASED GATE DRIVER

Type of project: Extra Project



Scope:

Power electronics converters are widely used and developed in industry. Semiconductor power switches are the key element of those converters. There are different types of power switches with their own characteristics. For example, IGBTs, Si, and SiC MOSFETs have different switching frequency capabilities. Moreover, they have different voltage/current ratings. Deepening into their datasheet, it is seen that many other characteristics are exclusive to each product. Therefore, every switch needs a specific gate driver corresponding to its own characteristics. However, to facilitate research, a universal gate driver with programmable dead-time, gate resistor, and capacitor can be designed in the form of a modular card. It will have 1 input pulse and 2 output pulses as a half-bridge configuration with a programable dead time. That can be attached to any switches in the ESP lab (IGBTs or MOSFETs) and help PhD students design and test their converters faster.

Problem definition:

Designing a universal and modular gate driver with programmable dead-time and adjustable gate resistor.

Methodology:

In this project, an isolated gate driver will be designed for different types of switches (IGBT, MOSFET, SIC). It will use an FPGA for fast signal control and conditioning. The electronic circuit will be first simulated in LTSpice, and the schematic and PCB layout will be done by Altium Designer. The final board will be assembled and tested in the lab.

Research Objectives:

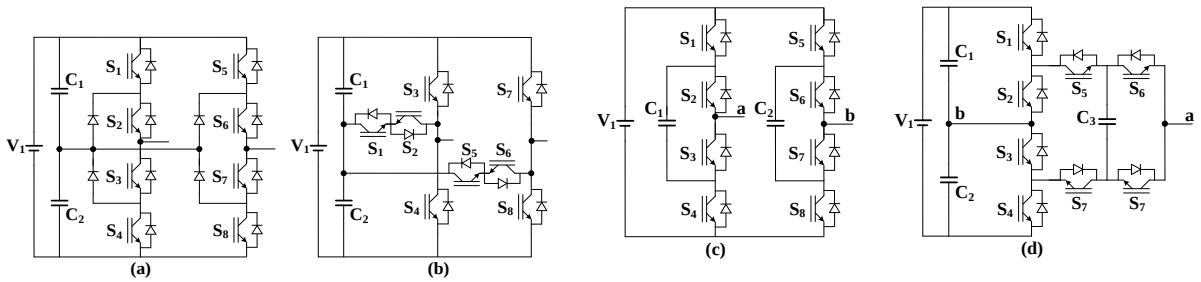
- Designing electronic circuits for isolation, protection, and power supply of gate driver
- Designing schematics and then PCB layout
- Assembling interface PCB and testing in the lab

Contact details:

- Supervisor: Dr. Hani Vahedi, H.Vahedi@tudelft.nl

DESIGN AND TEST DIFFERENT MULTILEVEL CONVERTERS WITH WIDE BANDGAP DEVICES

Type of project: Extra Project



Scope:

Multilevel converters are being developed mainly for high-power applications such as motor drives or electrolyzers. Compared to a conventional full bridge converter, multilevel topologies have more switches and capacitors with different connections in their configuration. Therefore, their hardware design has specific challenges and considerations, such as more number of switches and gate driver circuits, different voltage/current/frequency ratings of switches, and thermal management of the converter. During this project, you will design different popular multilevel converters in Altium Designer and then test them practically at the lab. You will use wide bandgap devices (GaN or SiC) to reach high frequency and high-efficiency performance.

Problem definition:

Designing full PCB of different multilevel inverters to be used for different applications in the lab.

Methodology:

In this project, schematic and PCB layout for different multilevel converters (e.g. , NPC, ANPC, T3, PUC5), including gate driver, snubber, voltage/current sensor, and power switches, will be designed in Altium Designer. The board will be assembled and tested for different grid-connected and islanded applications in the lab.

Research Objectives:

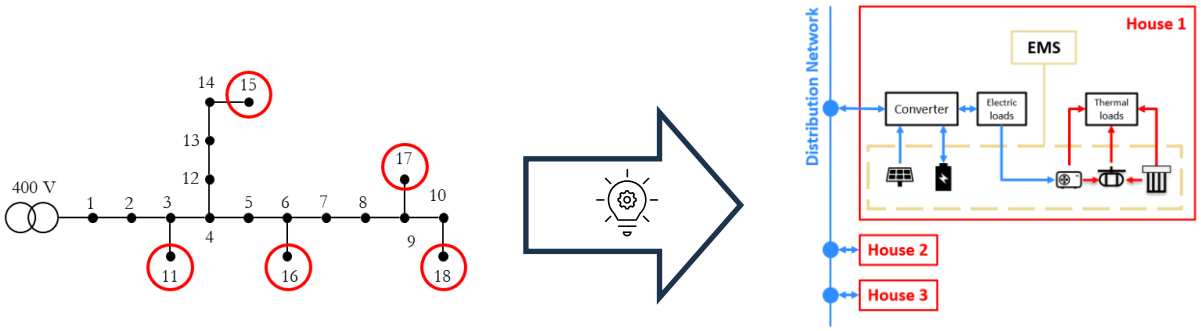
- Studying the characteristics of wide bandgap devices (GaN, SiC)
- Designing electronic circuits for gate drivers, snubbers, and microcontrollers.
- Designing schematics and then PCB layout for electronic and power electronic stages in Altium Designer
- Assembling PCBs and testing in the lab

Contact details:

- Supervisor: Dr. Hani Vahedi, H.Vahedi@tudelft.nl
  Prof. Pavol Bauer, P.Bauer@tudelft.nl

SIZING RESIDENTIAL MULTI-CARRIER SYSTEMS FOR PEAK-SHAVING

Type of project: MSc. thesis



Scope:

The massive deployment of ditributed generation has caused undesired network behaviour. Especifically in low-voltage residential distribution networks, multi-carrier systems can be deployed as an alternative. Nevertheless, the influence of supporting the grid in the sizing of the assets has to be investigated.

Problem definition:

Most residential multi-carrier systems are sized for the soley purpose of meeting the household needs. However, if such systems can support the grid, it can lead to business oportunities and less undesired behaviours. For this reason, insight in how the sizing of the components has to change to meet both requirements would be very valuable.

Methodology:

An evaluation of peak-shaving as an ancillary service at the low-voltage residential distribution networks would allow to determine its impact and benefit for the prosumer and the DSO. Then using models available in Python, the peak-shaving strategy has to be implemented in a test network, in a way that allows an optimization on the size of the components of the multi-carrier system.

Research Objectives:

- Determine the suitability of peak-shaving as an ancillary service for deployment in low-voltage residential distribution networks.
- Propose an optimization problem for the sizing of the components of the multi-carrier system when a peak-shaving strategy is deployed in a test network.
- Evaluate the sizing results with and without deploying the ancillary services.

Contact details:

- PhD candidate: Joel Alpízar-Castillo, J.J.AlpizarCastillo@tudelft.nl
- Supervisor: Laura Ramírez-Elizondo, L.M.RamirezElizondo@tudelft.nl
- Supervisor: Pavol Bauer, P.Bauer@tudelft.nl

CONTROL OF A THREE-PHASE EV AC & DC CHARGING SYSTEM

Type of project: MSc thesis

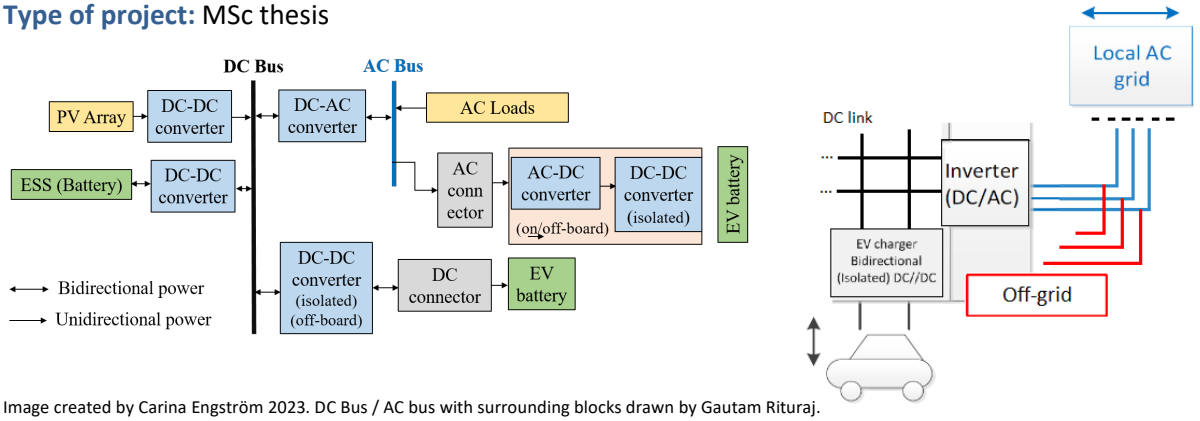


Image created by Carina Engström 2023. DC Bus / AC bus with surrounding blocks drawn by Gautam Rituraj.

Scope:

In this project, the investigation is focused on combining off-grid operation with regular grid-operation of a DC EV charger. Standalone EV charging can provide a seamless charging infrastructure in urban and rural areas where the electrical grid is unreliable or unavailable so that EV adoption can realistically be implemented worldwide. When grid connected, the charger could assist the grid with V2G services to alleviate grid congestion problems.

Problem definition:

A voltage source inverter (VSI) must be able to track its reference voltage or form the reference for the off-grid mode, compensate unbalanced voltage and reject load disturbances. Unbalanced loading is inevitable in this charging system due to various AC loads. Moreover, the islanding detection (when grid-connected) and the transition from and to off-grid mode is an essential component for this systems' full functionality.

Methodology:

Literature review of existing control methods for unbalanced load, islanding detection, and mode transition. Then, implementation of the same on the digital controller. Hardware for testing is available. The stand-alone control has been partially developed and the full two-mode control can be based on this. The control model is developed in Simulink and is further implemented on hardware with C-code.

Research Objectives:

- Develop the control for the unbalanced load (to maintain the output voltage and frequency) for a three-phase inverter, islanding detection scheme and smooth mode transition and its implementation on a digital controller.
- Validation of developed controls in the lab's available hardware of the standalone EV charging system.

Contact details:

- PhD student: Carina Engström, c.b.m.engstrom@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, g.r.chandramouli@tudelft.nl

TU Delft DRIVE2X PRE

EV CHARGER PARTIAL LOAD EFFICIENCY CHARACTERISATION AND IMPROVEMENT

Type of project: MSc thesis

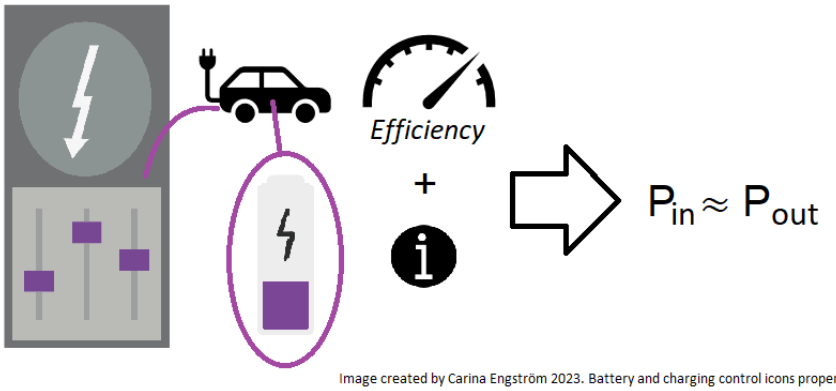


Image created by Carina Engström 2023. Battery and charging control icons property of DCE&S.

Scope:

In this project, the investigation is focused on the all-range efficient operation of a DC EV charger. It is desirable that the EV charging is efficient across the entire load range, which varies depending on, for example, the battery's State of Charge (SoC) to minimise losses and realise EV adoption based on renewable energy only.

Problem definition:

Many converters optimise their efficiency to a nominal operating range. However, care has to be taken for battery recharging so as not to overcharge the cells, especially those close to their full SoC. To achieve this, the output power from the converter is lowered at the end of the charging cycle. This is at the converter's partial load and thus below the nominal operating range.

Methodology:

Literature review on partial load decreased efficiency. As the reasons for the drop in efficiency vary across converter topologies and applications, understanding why and when it happens is required. Measuring on hardware which is available for testing. Simulation of components to detail the causes of loss at partial load.

Research Objectives:

- Characterization of the partial load efficiency.
- Accurate modelling of the causes behind losses during partial load for the converter setup used.
- Suggest improvements to increase the efficiency during partial load conditions.

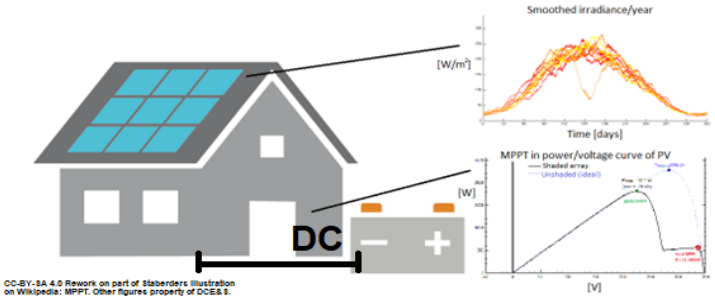
Contact details:

- PhD student: Carina Engström, c.b.m.engstrom@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, g.r.chandramouli@tudelft.nl

TU Delft DRIVE2X

IMPLEMENTATION OF DC BUS CONTROL AND PV MPPT FOR OFF-GRID APPLICATIONS

Type of project: Extra Project



Scope:

Off-grid energy systems can provide renewable electricity where the electrical grid is unreliable or unavailable, ensuring renewable energy access for all. This project aims to implement a DC bus control loop for a Hybrid Energy Storage System (HESS) power module operating in off-grid mode. It will ensure that the system's photovoltaic (PV) panels and the connected battery storage can maintain the electric supply during an outage. Also, connected solar panels need to be managed with Maximum Power Point Tracking (MPPT), including power curtailment and considering partial shading conditions. It will maximise the extracted energy from the photovoltaic (PV) panels and better utilise the renewable energy source for integration in a modular building energy system.

Problem definition:

When no grid is available, the DC bus stabilises voltage and ensures the off-grid power balance. While the concept exists for microgrids, it is novel for EV charging systems where the DC bus targeted in this project is located. MPPT for PV operating under partial shading is challenging, as the PV characteristics include multiple peaks with only one representing the true maximum. Conventional MPPT techniques are suitable for PV systems operating under uniform solar irradiation where the PV curve only has a single peak.

Methodology:

The student will review the literature on DC bus control loops and MPPT algorithms and suggest a few implementation approaches. Then, the method will be implemented in Simulink to test the available models of the HESS system. Further implementation into hardware with C code is a possibility.

Research Objectives:

- Identify the mismatching operating conditions arising from the power modules connected on the DC bus and for PV and adapt the MPPT algorithm
- Maintain a robust system reliant on a stable DC bus
- Maximize energy yield in relation to the energy storage

Contact details:

- PhD student: Carina Engström, c.b.m.engstrom@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, g.r.chandramouli@tudelft.nl

TU Delft

SIMULATION PLATFORM COMPARISON STUDY FOR AN INVERTER BASED POWER GRID

Type of project: <MSc thesis>

Scope:

Based on the model of Inverter-based resources (IBR), this project aims to compare and investigate the differences and advantages of several widely used simulation tools.

Problem definition:

The large-scale installation of IBR has reshaped the conventional power grid. Transitioning from the Root Mean Square (RMS) model of synchronous generators to the Electromagnetic Transient Model (EMT) of power electronics converter resources brings problems to the selection of the proper simulation tools. Simulink and PLECS are typically suitable for converter simulation, especially for switching models. PSCAD is widely accepted by the industrial field for EMT simulation, and Powerfactory has been used for power system level analysis for decades. However, a comparison needs to clarify the difference between simulation tools regarding simulation speed, simulation accuracy, solver configuration, model type, and phenomena timescales. Based on a grid-forming model already built, guidance should be provided to the engineers and researchers to select the most suitable tools for the simulation work.

Methodology:

- The master student will receive a Grid-forming converter model built in Simulink, PLECS, Powerfactory, and PSCAD.
- A short literature review is required to understand the common issues in an IBR system. The basic principles of the solver settings are also investigated.
- Simulation work is conducted to compare the simulation platforms from different perspectives.
- Imperix can conduct an experimental comparison verification based on the project's progress.

Research Objectives:

- Illustrate the basic principles and suitable scenarios of each simulation platform.
- Compare the advantages and drawbacks of each simulation tool.
- Deliver guidance for researchers to select the proper simulation tools.

Contact details:

- PhD student: Fan Yang, F.Y.Yang-1@tudelft.nl
- Supervisor: Dr. Zian Qin, Z.Qin-2@tudelft.nl
- Prof. Pavol Bauer, P.Bauer@tudelft.nl

TU Delft

APPLICATION OF IMC CHARGING SYSTEM IN DELFT BUS SYSTEM

Type of project: MSc thesis

Scope:

Trolleybuses are often considered an outdated solution but this approach is far from the truth. Modern solutions provide new possibilities and greatly increase the attractiveness of trolleybus transport, in particular when trolleybuses are equipped with traction batteries enabling fee catenary driving. This solution is called as IMC (In Motion Charging) – trolleybus equipment with traction batteries, which use overhead catenary as linear charger and runs mainly in the battery mode as standard electric bus.

Problem definition:

Electrification of public transport in Delft based on IMC technologies

Methodology:

- Power and energy consumption simulation in Matlab or similar software
- Analysis of battery degradation, eg. in Open Sesame
- Spatial analysis of bus routes

Research Objectives:

- Choosing routes predestined for IMC electrification and for OPP electrification
- Choosing placement of trolleybus overhead catenary and charging stations
- Preliminary feasibility study of electrification
- Simplified cost – benefits analysis

Contact details:

- Visiting Professor: Mikołaj Bartłomiejczyk, m.b.bartlomiejczyk@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, g.r.chandramouli@tudelft.nl

OPTIMISATION OF IMC CHARGING CORRIDOR

Type of project: MSc thesis

Scope:

Traditional trolleybus operates on a fixed route determined by trolleybus overhead line catenary (OHL), but modern trolleybuses with autonomous battery supply are closer to battery electric buses: they are equipped with a battery that allows them to work without supply from overhead wires. The trolleybus catenary can therefore be considered as a linear charging corridor that allows the battery to be charged on the motion. This solution is often so called In Motion Charging (IMC). Due to the very high costs of building the traction network, the key issue is the optimization of the parameters of the charging corridor in the IMC system.

Problem definition:

Various methods of charging the IMC busses are possible (such as IMC plus, different locations of charging corridor, magnitude of charging power levels) and this significantly affects the size and lifetime of the battery. Hence, optimization of the charging corridor localisation and power level in the IMC, including battery costs and degradation can significantly reduce the total cost of ownership.

Research Objectives:

- On the basis of several case studies to show how placement of IMC charging corridor along the route influences the battery capacitance, degradation process and charging process.

Methodology:

- Energy consumption calculations for the selected bus line (e.g. Matlab)
- Determining variants of the location of the charging corridor
- Calculation of battery load profile and comparison of degradation rate (e.g. Open Sesame)
- Calculation of the current load of the charging corridor

Contact details:

- Visiting Professor: Mikołaj Bartłomiejczyk, m.b.bartlomiejczyk@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, g.r.chandramouli@tudelft.nl

TU Delft

FAST CHARGING STATION FOR IMC ELECTRIC BUSES

Type of project: MSc thesis

Scope:

There are two basic means of trackless electrified urban public transport: trolleybus and battery electric bus. The combination of both solutions – trolleybus traction network and stationary charging - is called IMC technology (In Motion Charging) which allows charging battery vehicle in motion from the trolleybus traction network and go outside traction network with battery mode. In addition, stationary battery charging is also possible, as in battery buses. An important element of this system may be a charging station acting as a range extender (basing charging: trolleybus OHL, supplementary charging: stationary charging).

Problem definition:

The load of the charging station can have significant impact on the local grid due to high peak powers. Analysis of IMC stationary charging station power profiles for selected implementation. Proposing of Storage Energy System usage for peak shaving (Grid Booster).

Methodology:

- Analysis of a selected bus line: presentation of timetables and their daily variability
- Energy consumption calculations of bus line (e.g. Matlab)
- Proposing of algorithm for stationary charging
- Analysis of battery discharge profiles in IMC electric buses - trolleybus
- Determination of charging station load profiles for different operational conditions
- Analysis of Storage Energy System installation in charging station for peak shaving

Research Objectives:

- Determining the optimal stationary charging algorithm
- Setting of optimal system parameters for charging station peak power demand optimisation

---

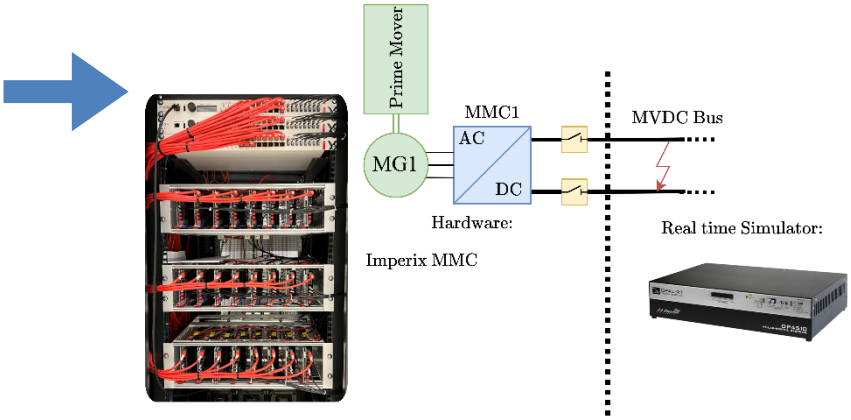
Contact details:

- Visiting Professor: Mikołaj Bartłomiejczyk, m.b.bartlomiejczyk@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, g.r.chandramouli@tudelft.nl

TU Delft

PHIL SIMULATION OF MODULAR MULTILEVEL CONVERTER FOR DC BUS FAULTS

Type of project: <MSc thesis>



Scope:

Design a power hardware in the loop (PHIL) simulation for a modular multilevel converter (MMC) implementing a shipboard MVDC bus. Using this setup, test and reduce the impact of a bus fault on the Naval shipboard power system operation.

Problem definition:

For the electrification of the maritime sector, future vessels are expected to have an MVDC shipboard power system (SPS). Although the DC-SPS has shown significant advantages over AC, it does come with a compromise on protection. State-of-the-art DC circuit breakers (CB) are lossy, expensive, and unable to reach the large current breaking requirements of the SPS. The MMC is an innovative technology that has become one of the favorable converters that act as the interface between AC and DC networks. A significant advantage of MMC is its ability to mitigate and control fault currents, reducing the CB requirements [1]. This property can improve the overall ship survivability, which is crucial for future naval vessels. In this project, you will develop a PHIL setup for the MMC emulating a shipboard DC bus to test and improve the fault mitigation properties of the converter.

Methodology:

The student shall start with a literature study on MMC dynamics, controller design, and DC-SPS architectures. After that, the student is expected to use this knowledge to develop a real-time digital twin (RTDT) model for the MMC in a shipboard DC bus. Then, the student shall develop the interface between RTDT and the lab-scale MMC. Finally, the impact of the bus fault on the SPS operation shall be tested, and improvements will be proposed.

Research Objectives:

- Literature review on DC-SPS architectures, MMC dynamics, and control.
- Design a RTDT model of the MMC in a shipboard bus.
- Develop the interface between the OPAL-RT and Imperix MMC.
- Test the impact of a bus fault on the shipboard bus.

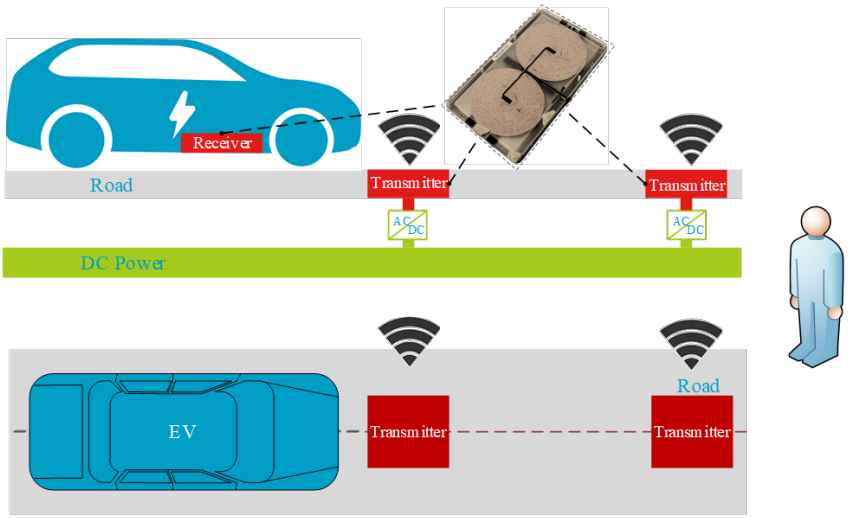
Contact details:

- PhD student: Robin van der Sande, R.P.J.vanderSande@tudelft.nl
- Supervisor: Dr.ir. Aditya Shekhar, A.Shekhar@tudelft.nl
  Prof. Dr. Ir. Pavol Bauer, P.bauer@tudelft.nl

[1] V. Staudt et al., 'Short-circuit protection in DC ship grids based on MMC with full-bridge modules', in ESARS, Mar. 2015, pp. 1–5.

ANALYSIS OF THE ELECTROMAGNETIC FIELD RADIATION OF WIRELESS CHARGING SYSTEMS

Type of project: MSc thesis/Extra project



Scope: As an approach to mitigate the range anxiety and bulky battery packages of EVs, dynamic inductive power transfer (DIPT) for EVs charging attracts lots of attention. As a loosely-coupled power transfer system, leakage field cannot be avoided. For the safety of users, the magnetic radiation has to be considered.

Problem definition: When the DIPT system is energized, a certain amount of magnetic field may be exposed to pedestrians and pose a threat to their health. On one hand, the radiation of a DIPT system should be identified according to the international standards. On the other hand, proper measures should be taken to decrease the radiation, including shielding and coupler design.

Methodology:

- Study of the basic principles of inductive power transfer technology
- Review of relevent EMC international standards
- Finite element modelling of a DIPT charger and human body
- Analysis of EMF radiation exposure at different scenarios
- Shielding method to reduce EMF radiation

Research Objectives:

- Finite element model of IPT charger and human body
- Possible solutions to reduce the radiation of DIPT systems

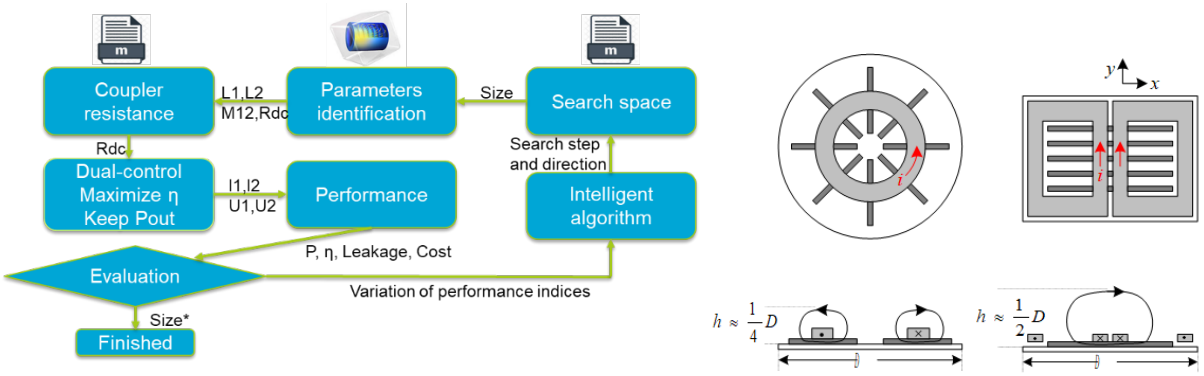
Contact details:

- Supervisor: Dr. Wenli Shi, W.Shi-3@tudelft.nl, LB 02.860
  Prof. Pavol Bauer p.bauer@tudelft.nl, LB 03.600

TU Delft

DEVELOPMENT OF A MOO DESIGN TOOL USING OPEN-SOURCE SOFTWARES FOR WIRELESS POWER TRANSFER SYSTEMS

Type of project: MSc thesis



Scope: As a loosely-coupled power transfer system, special attention should be paid to the power level and the efficiency of the dynamic IPT system, which depend heavily on its operation state, including the lateral misalignment, driving speed, air gap and temperature. Also, the total cost of the system is important to be considered. This research focuses on multi-objective optimization that can yield low cost, high efficiency at high power density.

Problem definition: A thorough MOO program has been developed, using MATLAB and COMSOL. To allow the program accessed by public, open-source software should be used. Meanwhile, effort should be paid to the design of GUI, reasonable frame of data and its visualization functions. Therefore, the experience in coding and data processing is required.

Methodology:

- Study of the basic principles of inductive power transfer technology
- Understand the priciple of MOO designs and the developed program
- Develop new MOO program using Pathon and Elmer.
- Build GUI and data visulization functions for the final MOO design tool

Research Objectives:

- An open-source and user-friendly MOO deisgn tool for wireless power transfer systems

---

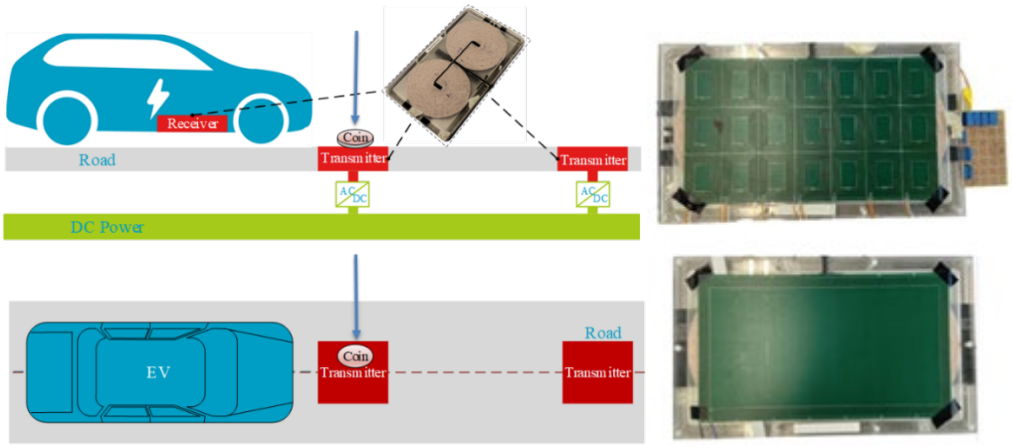
Contact details:

- Supervisor: Dr. Wenli Shi W.Shi-3@tudelft.nl, LB 03.850
  Prof. Pavol Bauer p.bauer@tudelft.nl, LB 03.600

TU Delft

ELECTRIC VEHICLES AND FOREIGN OBJECTS DETECTION FOR DYNAMIC WIRELESS CHARGING SYSTEMS

Type of project: MSc thesis



Scope: As an approach to mitigate the range anxiety and bulky battery packages of EVs, dynamic inductive power transfer (DIPT) for EVs charging attracts lots of attention. Foreign objects like coins and cans may exist on the road, and performances of dynamic IPT system can be affected if these objects are placed on top of transmitters under roads. Besides, detection of EVs is needed to switch on the transmitter only when it is coupled with a receiver.

Problem definition: The detection of EVs and foreign objects can be realized by using auxiliary coil. These auxiliary coils can sense the magnetic field variation by measuring their induced voltage and input impedance. Different architectures of the detection system will be explored. Besides, the digital controller should be built to process the detection signal and determine the operation of transmitters.

Methodology:

- Study of the basic principles of inductive power transfer technology
- Understand how to detect EVs using coil sensors
- Understand how to detect metal and living foreign objects
- Build sensor coils and digital controller to identify EVs and foreign objects

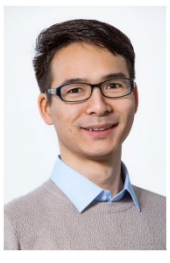
Research Objectives:

- Detection principles for different detection tasks
- Design of coil sensors that is suitable for DIPT applications

---

Contact details:

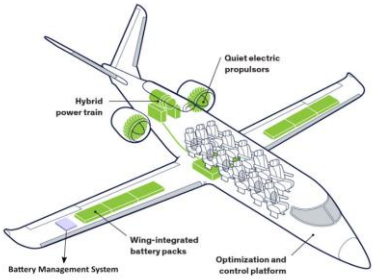
- Supervisor: Dr. Wenli Shi, W.Shi-3@tudelft.nl, LB 02.860
  Prof. Pavol Bauer p.bauer@tudelft.nl, LB 03.600



TU Delft

A RECONFIGURABLE HYBRID HIGH ENERGY-POWER-DENSITY BATTERY PACK

Type of project: MSc thesis



source: Zunum Aero

Scope:

Develop a reconfigurable hybrid battery pack that can realize power and energy capacity maximization, stable output voltage and enhance safety for a large-scale modular battery pack in future electric aircraft.

Problem definition:

Electric aircraft is the key enabler of zero-emission aviation. In future electric aircraft, the large-scale battery pack plays an important role as an energy source. The battery pack should offer both high power density for takeoff and climbing, as well as high energy density for cruising. Besides, for the effective management of a large-scale battery pack, a well-designed and integrated power electronics-enabled hardware-software architecture is required which can automatically configure itself according to the dynamic condition.

Methodology:

A comprehensive literature review regarding the existing reconfigurable battery pack and all-electric aircraft is required first. Next, this thesis is dedicated to designing a hybrid battery pack by combining high-specific-power and high-specific-energy battery types, which is capable of being reconfigured based on real-time conditions at the modular level. The battery pack sizing is integrated with the battery sizing method for all-electric aircraft. Lastly, compared the proposed battery pack design with conventional battery pack.

Research Objectives:

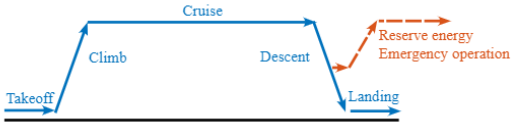
- Evaluate the benefits and disadvantages of a reconfigurable hybrid battery pack when compared to a conventional pack.
- Propose a switching circuit topology and control logic for the battery management system so that the battery pack can dynamically configure itself during operation according to the demand and the battery conditions.
- Evaluate the performance of the proposed reconfigurable modular battery pack via simulation or experiment.

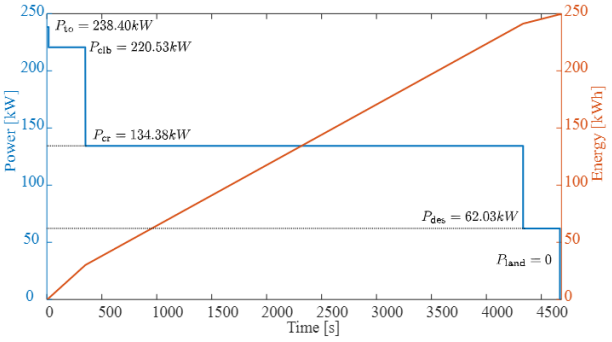
Contact details:

- PhD student: Yawen Liang, Y.Liang-3@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli

BATTERY BEHAVIOR UNDER FLIGHT MISSION-BASED CHARGE-DISCHARGE CYCLES

Type of project: Extra Project





Scope:

This extra project aims at to study battery behavior, including battery capacity degradation and its influence on the second-order RC Thévenin-based electrical cell model (ECM), under standard CC-CV charging and flight mission-based discharging cycles.

Problem definition:

Since 2007, the aviation industry's environmental impact has become an increasing concern, primarily centered on noise and CO_2 emission. To address this, there's been growing interest in electrifying aviation. LIBs are the attractive candidate for near-term small all-electric aircraft (AEA). The AEA feature a unique power profile, marked by high discharge currents during takeoff and climbing phases, followed by moderate power requirements during cruising and descent. However, the majority of battery aging tests are conducted using constant current pulses. Therefore, it is imperative to investigate the impact of this unique power profile of AEA on battery performance and degradation.

Methodology:

First, conduct a literature review focusing on battery modeling, aging, and charging strategies and understand the discharging power profile of AEA. Next, create a schedule file simulating the AEA behavior for the battery tester. Subsequently, execute the schedule file in the lab using the battery tester to observe the battery degradation and performance under this unique charge-discharge cycle.

Research Objectives:

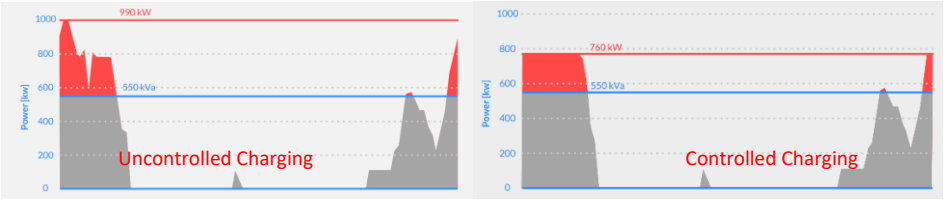
- Generate comprehensive dataset on battery degradation and ECM under the operational conditions of AEA.
- Analyze the dataset to assess the impact of these unique operational cycles on battery performance and degradation over time.

Contact details:

- PhD student: Yawen Liang, Y.Liang-3@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, G.R.ChandraMouli@tudelft.nl

CHARGING SCHEDULING ALGORITHM FOR AIRSIDE MOBILITY IN FUTURE AIRPORT

Type of project: MSc thesis



source: The Mobility House

Scope:

This thesis aims to develop a charging scheduling algorithm that can mitigate the impact on the airport grid due to the electrification of airside mobility (aircraft, ground support equipment, etc.), extend the battery lifetime, minimize flight schedule displacements, increase the use of local renewables, and reduce operating costs.

Problem definition:

Since 2007, the aviation industry's environmental impact has become an increasing concern, primarily centered on noise and CO_2 emission. In this context, the electrification of aviation has emerged as a highly promising solution for curbing fuel consumption and emissions. Nonetheless, the projected demand for charging power in the future is expected to be high, which raises the need for costly upgrades to the electrical grid infrastructure and incurs significant operating costs. Consequently, there is a need to develop charging scheduling algorithms that can minimize the economic cost of upgrading infrastructure while simultaneously reducing the industry's environmental impact.

Methodology:

First, a literature review regarding smart charging is needed. After that, how to mitigate the grid impact, increase the use of local renewables, minimize the flight schedule displacements, and extend the battery lifetime need to be figured out. Next, the uncertainty of PV output, load demand, grid fault, etc., needs to be modeled. Then, develop the charging scheduling algorithm using real-time control and moving horizon control framework to reduce optimization error. Lastly, compare the proposed charging scheduling algorithm with uncontrolled charging.

Research Objectives:

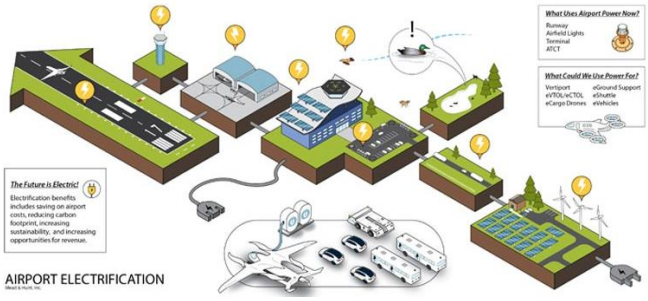
- Quantify the grid impact, battery lifetime, flight schedule displacements, use of local renewables, uncertainty of PV output, load demand, grid fault, etc.
- Develop a charging scheduling algorithm including all the costs (investment, maintenance, energy losses, secondary-life battery, etc.), and revenues (ancillary service such as primary frequency regulation reserve).
- Evaluate the performance of the charging scheduling algorithm in extending the battery lifetime, minimizing flight schedule displacements, increasing the use of local renewables, and reducing operating costs and the impact on the airport grid.

Contact details:

- PhD student: Yawen Liang, Y.Liang-3@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, G.R.ChandraMouli@tudelft.nl

GRID IMPACT ANALYSIS OF FUTURE ELECTRIFIED AIRPORT

Type of project: MSc thesis



source: Mead & Hunt

Scope:

The goal of this thesis is to analyze the impact on the airport grid due to the electrification of airside mobility (aircraft, ground support equipment, etc.), landside mobility, electrified heating system, and other future changes.

Problem definition:

Since 2007, aviation's impact on climate change has been an increasing concern, principally focused on noise emissions and CO2 emissions from the combustion of jet fuel. Airport electrification is very promising for reducing fuel consumption and emissions. However, the adoption of electric airside and landside mobility can result in an excessive increase in power demand that exceeds the current airport grid capacity. Therefore, the grid impact of airport electrification requires further assessment.

Methodology:

First, a literature review regarding the grid impact analysis is needed. After that, changes in the electrified airport, including the future charging power demand of landside and airside mobility, the new added PV system, heat storage system, and other future changes need to be modeled. Next, various scenarios depending on the specific boundary conditions of an airport (geographical, infrastructural, etc.) need to be formulated. Lastly, evaluate the impact of an electrified airport based on the Python simulator in Powerfactory environment, focusing on transformer loading, voltage profile, transmission line loading, and grid congestion. Knowledge and experience with Python and Powerfactory is a plus.

Research Objectives:

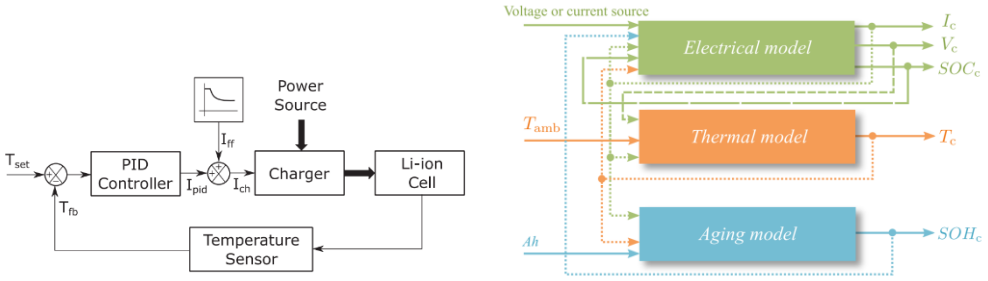
- Estimate changes to the electrified airport, including the future charging power demand of landside and airside mobility, the power profile of new added PV system, heat storage, etc.
- Formulate various scenarios depending on the specific boundary conditions of an airport.
- Evaluate the impact of the electrified airport on the grid using software simulation and assess the performance of the grid under various scenarios.

Contact details:

- PhD student: Yawen Liang, Y.Liang-3@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, G.R.ChandraMouli@tudelft.nl

OPTIMIZATION OF CLOSED-LOOP CHARGING STRATEGY FOR LITHIUM-ION BATTERY

Type of project: MSc thesis



source: [A Closed-Loop Constant-Temperature Constant-Voltage Charging Technique to Reduce Charge Time of Lithium-Ion Batteries]

Scope:

This thesis aims to develop a closed-loop multi-objective optimal charging strategy that considers factors such as charging time, battery aging, and energy loss for lithium-ion battery (LIB) cell based on a complete electro-thermal-aging cell model.

Problem definition:

Since 2007, the aviation industry's environmental impact has become an increasing concern, primarily centered on noise and CO_2 emission. To address this, there's been growing interest in electrifying aviation. LIBs are the attractive candidate for near-term small all-electric aircraft. Therefore, it is thus crucial to study the tradeoff between charging time, battery degradation, and charging efficiency and then develop a optimally health-efficiency conscious closed-loop fast charging protocols.

Methodology:

First, a literature review regarding optimal charging strategy is needed. Next, the electrical, thermal, and ageing behaviour of the battery cell, etc., needs to be understood. After that, how to shorten the charging time, extend the battery lifetime, and improve the charging efficiency need to be figured out. Then, develop a closed-loop optimal charging strategy using a proportional-integral-derivative (PID) controller that adjust the magnitude of charging current in response to the instantaneous battery condition, e.g. cell temperature, voltage.

Research Objectives:

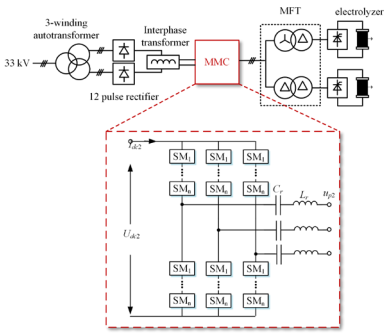
- Develop an optimal charging profile based on a priori knowledge of electro-thermal-aging model via multi-objective optimization that reduces the charging duration, extend the battery lifetime, and improve charging efficiency.
- Propose a closed-loop charging technique using PID controller that adjust the charging current in response to the battery conditions.
- Evaluate the optimal charging strategy performance via experiment validation in the lab.

Contact details:

- PhD student: Yawen Liang, Y.Liang-3@tudelft.nl
- Supervisor: Gautham Ram Chandra Mouli, G.R.ChandraMouli@tudelft.nl

LOCAL PROTECTION STRATEGY FOR CASECADED SOLID STATE TRANSFORMER

Type of project: MSc thesis



Scope:

The primary objective of this project is to develop a comprehensive local protection strategy for the cascaded Solid State Transformer (SST) to mitigate the impact of failures in submodules, electrolyser, DC bus, and other critical components.

Problem definition:

The reliability of Solid State Transformers is crucial for their successful integration into modern power systems. This project focuses on designing a local protection strategy for the cascaded SST to ensure its continued operation and prevent cascading failures in the event of submodule, electrolyser, DC bus, or other critical component failures.

Methodology:

We have identified commonly happened faults in this application, and we have built the close loop control model for the system, so the first step for the student is to understand these faults scenarios and the basic operation of the model. Second, develop advanced protection algorithms and strategies that can detect and respond to failures in real-time. Third, implement the developed protection strategies in simulation environments such as PSCAD/Simulink to assess their effectiveness and fine-tune their parameters. Finally, it is recommended to validate the proposed local protection strategy through real-time simulation (OPAL-RT) studies that simulate various failure scenarios to ensure its reliability and robustness.

Research Objectives:

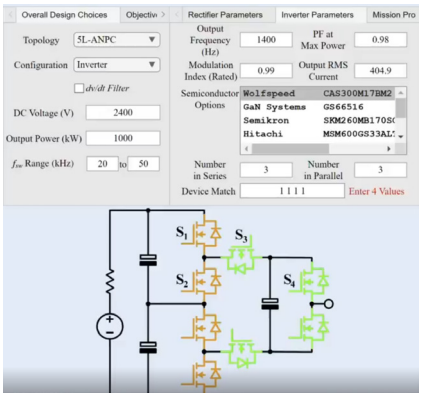
- Gain a deep understanding of the potential failure modes and their consequences in the cascaded Solid State Transformer.
- Develop and implement robust local protection algorithms for early detection and rapid response to failures.
- Design a local protection strategy that prevents cascading failures and ensures the safety and reliability of the system.

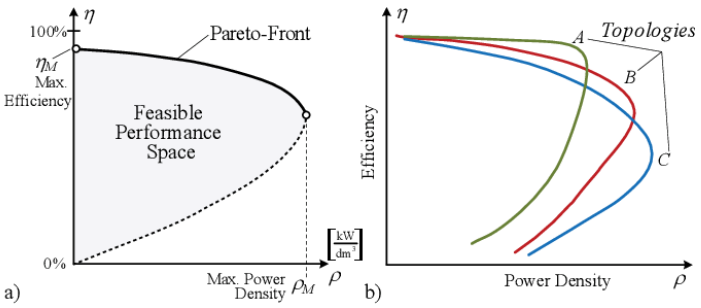
Contact details:

- PhD student: Zhengzhao Li, z.li-20@tudelft.nl
- Supervisor: Zian Qin, z.qin-2@tudelft.nl
  Prof. Dr. Ir. Pavol Bauer, P.bauer@tudelft.nl

MULTI-OBJECTIVE DESIGN OPTIMIZATION TOOL OF SOLID STATE TRANSFORMER

Type of project: MSc thesis





Scope:

The objective of this project is to build an easy to use design optimization tool of solid state transformer.

Problem definition:

Over the past two years, we have designed and compared various topologies for solid state transformers, including modular multilevel converters, modular multilevel resonant converters, and cascaded structures. We have explored different operating frequencies, switch components, and numbers of levels to achieve the lowest loss, smallest size, and lightest weight. This procedure is very time-consuming and tedious. As a result, we aim to develop a multi-objective design optimization software tool. Once we specify the design objectives and constraints (such as power rating, voltage level, THD and EMI constraints, efficiency, power density, and cost), the tool will provide optimized design solutions within minutes.

Methodology:

First, conduct a comprehensive literature review focusing on the design optimization of power converters. Following this, utilize the models previously developed to accurately estimate the losses, size, and weight of the power converters. Subsequently, employ numerical methods in Matlab or Python to automate these calculations. These will be integrated with an optimization method, such as grid search or the Non-dominated Sorting Genetic Algorithm (NSGA), to develop the optimization tool. If it proves to be beneficial and interesting for the master's student, parts of these calculations might be replaced with AI-based methods.

Research Objectives:

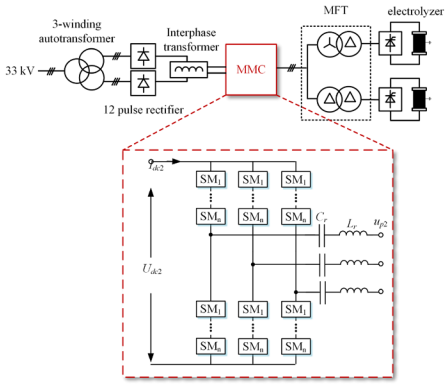
- Gain an understanding of the optimization method of powe converter design
- Build a design optimization tool of solid state transformers
- Validate the effectiveness of the developed tool through simulation/hardware design

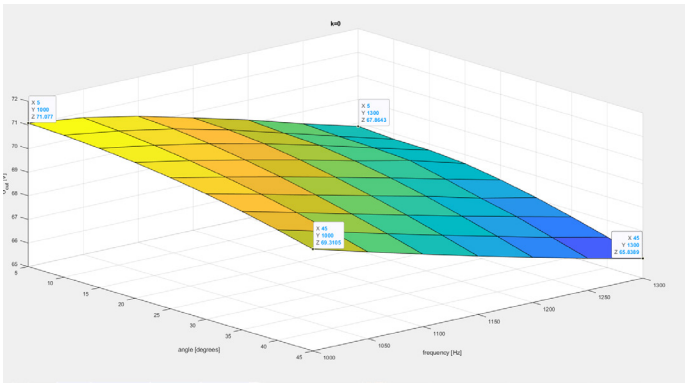
Contact details:

- PhD student: Zhengzhao Li, z.li-20@tudelft.nl
- Supervisor: Zian Qin, z.qin-2@tudelft.nl
  Prof. Dr. Ir. Pavol Bauer, P.bauer@tudelft.nl

OPTIMAL CONTROL OF MODULAR MULTILEVEL RESONANT CONVERTER BASED SOLID STATE TRANSFORMER

Type of project: MSc thesis





Scope:

The objective of this project is to identify the optimal control strategy for the modular multilevel resonant converter. The control variables include frequency and phase shift angle, with the ultimate goal of minimizing power loss.

Problem definition:

Solid State Transformers (SSTs) use medium-frequency transformers to reduce size and weight compared to traditional line frequency transformers. For this project, the modular multilevel resonant converter, similar in working principle to the LLC resonant converter, is selected to decrease switching loss. Control parameters such as phase delay and frequency are adjustable to meet desired voltage and power targets, with an optimal combination of these parameters yielding the lowest system power loss. **A closed-loop control SST model has already been established in Simulink. The project aims to identify this optimal control strategy using advanced methods. If artificial intelligence is foreseen as needed, we have ready-to-use FNN models in python**. The optimal control strategy will be developed and tested using Simulink/PSCAD or the real-time simulator OPAL-RT.

Methodology:

First, conduct a literature review on the optimal control method for power converters. Then adapt existing optimal control method to the solid state transformer in Simulink or other software. Finally, it is expected to build the model in real time simulator.

Research Objectives:

- Gain a deep understanding of the fundamental operating principles of MMR.
- Understand how to design the optimal control strategies with multiple control parameters
- Validate the effectiveness of the developed control algorithms through Simulink or OPAL-RT.

Contact details:

- PhD student: Zhengzhao Li, z.li-20@tudelft.nl
- Supervisor: Zian Qin, z.qin-2@tudelft.nl
  Prof. Dr. Ir. Pavol Bauer, P.bauer@tudelft.nl

ASSESSING ENERGY MANAGEMENT SYSTEM IMPACT ON SYSTEM CONFIGURATION EFFICIENCY IN HEAVY-DUTY ELECTRIC VEHICLE CHARGING STATIONS

Type of project: MSc thesis

Photo from Milence website. The Milence Charging Hubs: A Place to Rest & Recharge. Retrieved from https://milence.com/insight/the-milence-charging-hubs-a-place-to-rest-recharge/

Scope:

Comparative analysis of rule-based and optimization-based energy management systems (EMSs) for heavy-duty electric vehicle (HDEV) charging stations: evaluating the impact on system configuration efficiency.

Problem definition:

The electrification of heavy-duty vehicles is gaining momentum as a crucial step towards achieving sustainable transportation systems. As the deployment of charging infrastructure for HDVs becomes more prevalent, the role of EMS in optimizing the operation of charging stations becomes increasingly important. This thesis proposal aims to compare two EMS approaches: rule-based and optimization-based and to evaluate the extent to which employing a smarter EMS can enhance system configuration efficiency in charging stations for HDEVs.

Methodology:

The methodology for this study involves utilizing an existing model to establish baseline configurations for a HDEV charging station. Subsequently, a rule-based EMS need to be defined to manage the charging station's operation based on a set of predetermined rules and heuristics. In parallel, an optimization-based EMS need to be implemented, employing mathematical models of each element in the charging station. The performance of each EMS will be evaluated by analysing their impact on charging station asset sizes and operational effectiveness. Through a comparative analysis, we will assess the extent to which employing a smarter EMS can enhance system configuration efficiency in HDEV charging stations.

Research Objectives:

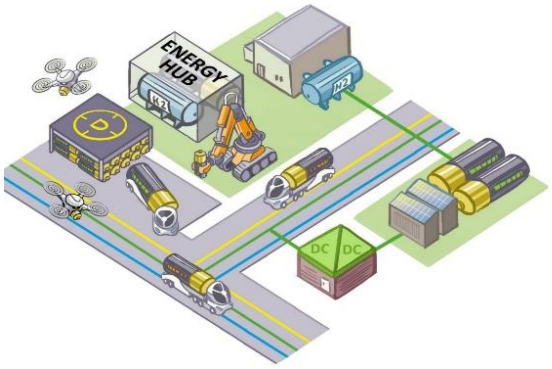
- Develop a rule-based EMS for managing the operation of a HDEV charging station.
- Develop an optimization-based EMS using linear optimization techniques for a HDEV charging station.
- Conduct a sensitivity analysis to evaluate the impact of EMSs on the sizing of assets within the charging station, such as chargers, energy storage systems, and renewable energy sources.

Contact details:

- PhD student: Leila Shams Ashkezari, l.shamsashkezari@tudelft.nl
- Supervisor: Dr. Gautham Ram Chandra Mouli, g.r.chandramouli@tudelft.nl
  Dr. Neil Yorke-Smith, N.Yorke-Smith@tudelft.nl
  Prof. Dr. Pavol Bauer, P.bauer@tudelft.nl

BUILDING THE CHARGING DEMAND CURVE AT A HEAVY DUTY ELECTRIC VEHICLE CHARGING STATION

Type of project: MSc thesis



Scope:

Building the charging demand curve at a heavy-duty electric vehicle (HDEV) charging station and assessing the environmental and grid Impact of electrifying HDEVs.

Problem definition:

The European Commission has set forth a plan to align the European Union with the goal of achieving climate neutrality by 2050, aiming for a substantial 90% reduction in emissions associated with transportation. Within this sector, freight transportation emerges as a substantial contributor to emissions, and its role is anticipated to grow in the coming years. Therefore, the electrification of heavy-duty vehicles stands as a critical measure. Given that HDEVs are currently not in widespread use, this study is designed to predict the charging demand at charging stations for these vehicles and devise strategies to meet this growing energy demand effectively.

Methodology:

The proposed study will begin with an in-depth examination of recent trends in HDEVs electrification, considering the energy demand and charging requirements that have emerged in recent years. Then an algorithm need to be developed to allocate charging stations to HDEVs ,taking into account their battery state of charge and the distance they intend to travel after stopping at the charging station. Additionally, the approximate waiting time for each truck at the charging station needs to be identified as well considering their trip length and EU regulations. Finally, the data will be expanded to cover a one-year period, taking into account seasonal variations, workdays, holidays, and other relevant factors.

Research Objectives:

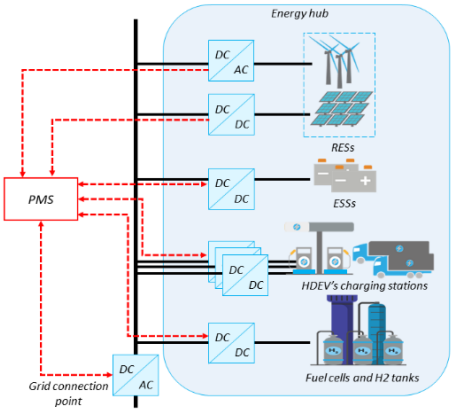
- Conduct a comprehensive literature review on the charging demands of heavy-duty electric vehicles and the chargers available for these vehicles.
- Develop an algorithms to allocate charging stations to trucks based on their battery state of charge, trip length, and EU goals.
- Determine approximate waiting time for each truck at the charging station ensuring compliance with EU regulations.

Contact details:

- PhD student: Leila Shams Ashkezari, l.shamsashkezari@tudelft.nl
- Supervisor: Dr. Gautham Ram Chandra Mouli, g.r.chandramouli@tudelft.nl
  Dr. Neil Yorke-Smith, N.Yorke-Smith@tudelft.nl
  Prof. Dr. Pavol Bauer, P.bauer@tudelft.nl

ENERGY MANAGEMENT SYSTEM FOR AN ENERGY HUB WITH HYDROGEN-TO-POWER OPERATION AS AN ENERGY RESERVE

Type of project: MSc thesis



Scope:

Defining an energy management system (EMS) for a multi-carrier heavy-duty electric vehicle (HDEV) charging station considering hydrogen as a complementary reserve system.

Problem definition:

Meeting the demand of a charging station for HDEVs can require charging rates of several MWs when multiple vehicles are charging concurrently. Uncontrolled charging of HDEVs can strain the power grid, especially in areas with limited grid capacity. To address this challenge, the development of an EMS is crucial to optimize on-site energy sources and energy storage systems. In this multi-carrier charging station hydrogen generation and storage is also considered, leveraging hydrogen as a flexible energy reserve in Hydrogen-to-Power (H2P) mode.

Methodology:

This study will start with a literature review of recent trends in multicarrier electrical systems and HDEV electrification and charging. Then, each element within the EH need to be mathematically modeled, capturing their operational characteristics, constraints, and interactions. Subsequently, a linear optimization model for the EMS will be developed to regulate power and energy flow within the charging station. Finally, a sensitivity analysis will be conducted to evaluate the impact of hydrogen utilization in H2P mode on key performance metrics such as energy efficiency, cost-effectiveness, and system resilience.

Research Objectives:

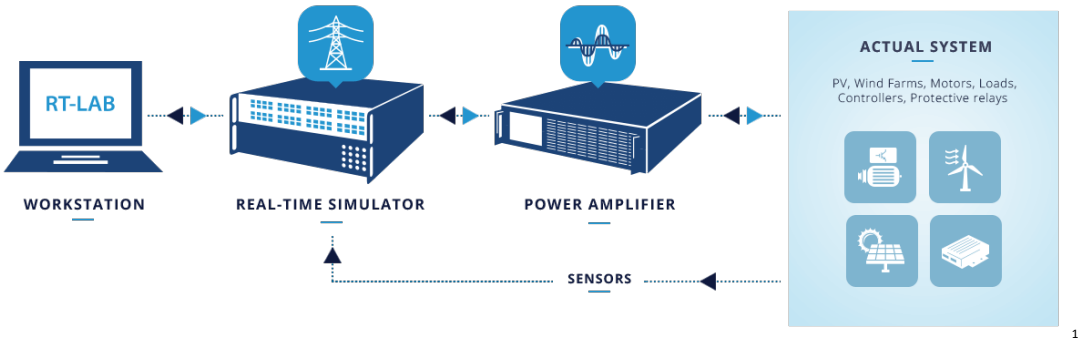
- Conduct a comprehensive literature review on multi-carrier charging station and HDEV electrification and charging stations.
- Development and implementation of an EMS using MILP techniques for optimal energy management within the EH.
- Insights from the sensitivity analysis regarding the role of hydrogen in H2P mode and its impact on EH performance.

Contact details:

- PhD student: Leila Shams Ashkezari, l.shamsashkezari@tudelft.nl
- Supervisor: Dr. Gautham Ram Chandra Mouli, g.r.chandramouli@tudelft.nl
  Dr. Neil Yorke-Smith, N.Yorke-Smith@tudelft.nl
  Prof. Dr. Pavol Bauer, P.bauer@tudelft.nl

COORDINATED CONTROL OF PV GENERATION, ELECTRIC VEHICLES, HEAT PUMPS AND ENERGY STORAGE WITH HARDWARE-IN-THE-LOOP (HIL) SIMULATION

Type of project: MSc Thesis



1

Scope:

The goal of this thesis is the experimental testing of power control of PV generation, flexible loads and energy storage with hardware-in-the-loop (HIL) simulation setup.

Problem definition:

Power control of PV generation, flexible loads such as electric vehicles (EVs) and heat pumps (HPs), and energy storage will play an important role in the future distribution grids. However, most grid-level power control studies remain only on simulations level because of the difficulty of testing in real physical systems. Hardware-in-the-loop (HIL) simulation is a control validation technique, which creates a virtual real-time environment that represents the physical system and realizes behaviour testing without physical prototypes.

Methodology:

In this thesis, the student shall firstly study and understand the power control framework of PV generation, flexible loads, and energy storage. Consequently, the student shall study and understand the experimental setup of the HIL simulation with the use of the OPAL-RT simulator. Finally, the integration of the power control model into the HIL simulation and its testing under various case studies and scenarios are needed. A basic level of knowledge on Python and Matlab environments is highly expected. Previous knowledge on HIL and Opal-RT, while highly recommended, is not a prerequisite.

Research Objectives:

- Study of coordinated power control of flexible loads and energy storage
- Study of the HIL simulation concept, and the experimental HIL setup with use of the Opal-RT simulator
- Experimental lab integration and testing of coordinated power control with HIL simulation

1 https://www.opal-rt.com/

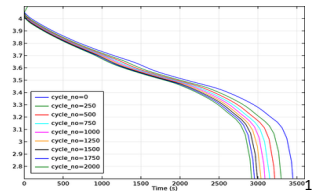
Contact details:

- PhD student: Nikolaos Damianakis, N.Damianakis@tudelft.nl, LB.03.690
- Supervisors: Dr. Gautham Ram Chandra Mouli; Prof. P Bauer

1

COORDINATED CONTROL OF PVS, ELECTRIC VEHICLES, HEAT PUMPS AND ENERGY STORAGE CONSIDERING COMPONENT DEGRADATION

Type of project: MSc thesis



1

Scope:

Coordinated Control in Energy Management Systems is a series of intelligent functionalities to provide power dispatch with flexibility, sustainability, efficiency and low cost. This project aims at developing a coordinated control algorithm focusing on satisfying both customers and power grid needs. However, the continuous operation of components (such as energy storage, EV batteries etc.) leads to degradation, which should be considered and optimized.

Problem definition:

Coordinated Control of RES (e.g PVs), flexible loads (EVs, Heat Pumps) and energy storage can help with distributing the power as well as the energy in a more efficient way. However, even in well-planned scheduling applications, the continuous component operation (such as battery charging/discharging) reduce the lifetime of the components, which is often ignored in related works. Therefore, an algorithm that addresses not only the coordinated control objectives, such as cost minimization, but also optimizes degradation is very significant for the future control applications.

Methodology:

The student is expected to study the state-of-the-art component degradation (especially of energy storage, EV batteries & Heat Pumps) and their integration in coordinated control applications. Then, the work will be focused on modelling, integrating and optimizing the considered degradation in the coordinated control. Finally, the student is expected to do the simulations to compare the developed coordinated control with the one without degradation and also with uncontrolled operation. The platforms, that will be used, are Python & PowerFactory.

Research Objectives:

- Literature study of state-of-the-art degradation in coordinated control applications
- Evaluate the effect of coordinated control operation on component degradation
- Develop the coordinated control algorithm considering also degradation minimization
- Operate the simulations to compare the developed algorithm with the uncontrolled components operation and with coordinated control without considering degradation

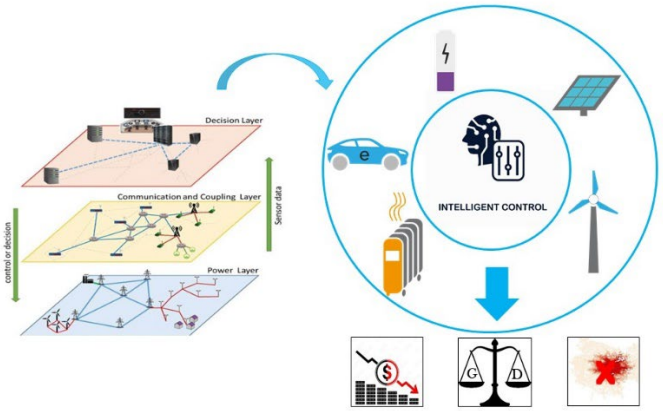
1 https://www.comsol.com/model/1d-lithium-ion-battery-model-for-the-capacity-fade-tutorial-12667

Contact details:

- PhD student: Nikolaos Damianakis, N.Damianakis@tudelft.nl, LB.03.690
- Supervisors: Dr. Gautham Ram Chandra Mouli; Prof. P Bauer

DC TRANSITION INTEGRATION IN COORDINATED CONTROL OF PVS, ELECTRIC VEHICLES, HEAT PUMPS AND ENERGY STORAGE

Type of project: MSc Thesis



Scope:

The goal of this thesis is the integration of grid infrastructure characteristics in power control systems and the investigation of the DC transition effect on optimal power flows and control objectives.

Problem definition:

On the one hand, power control of flexible loads such as electric vehicles (EVs) & heat pumps (HPs) and of energy storage systems (ESSs) will play a key role in energy transition. On the other hand, the vast increase of use of power electronics and inherently DC renewable energy sources (RES) promote DC transition in the grid infrastructure. Most power control works do not consider the grid infrastructure in their models, even though the different components of the AC and DC grids (distribution lines, converters, power sources) can have a significant effect on aspects such as power losses, efficiency, cost, power flows and the decision-making.

Methodology:

In this thesis, the student shall firstly realize an extensive literature review on the characteristics of the different components in AC and DC distribution grids and their integration in power control frameworks. Consequently, the student shall develop and compare AC and DC power control systems that comprise PV generation, EV charging, HP heating & energy storage use (Python environment). Depending on the time management of the project and the interest of the student, the project can also proceed to investigation of power control performance on a hybrid AC-DC distribution grid.

Research Objectives:

- Literature Review and understanding of components of AC and DC grids and their integration in power control frameworks
- Development of power control model in AC and DC grid infrastructures
- Comparison of the performance of the two power control models in terms of minimum cost, EV charging, HP heating, energy storage and PV utilization

---

Contact details:

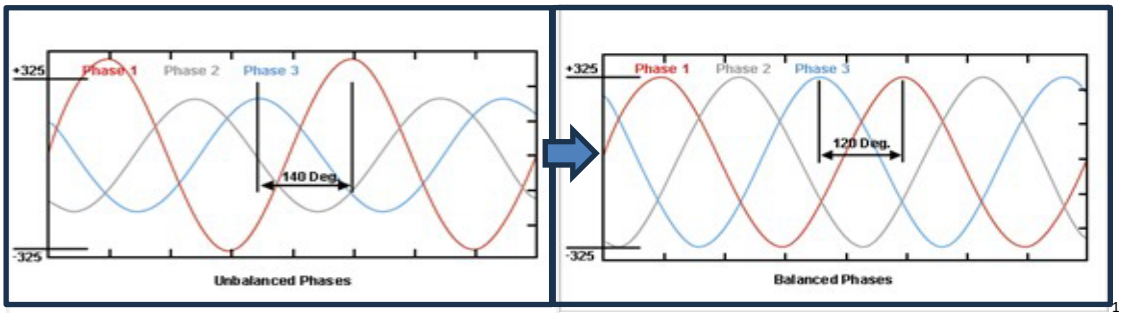
- PhD student: Nikolaos Damianakis, N.Damianakis@tudelft.nl, LB.03.690
- Supervisors: Dr. Gautham Ram Chandra Mouli; Prof. P Bauer

TU Delft

1

DEVELOPMENT AND TESTING OF COORDINATED PHASE CONTROL OF PV GENERATION, ELECTRIC VEHICLES AND HEAT PUMPS FOR PHASE IMBALANCE MITIGATION

Type of project: MSc thesis



1

Scope:

The scope of this thesis is the mitigation of grid phase imbalance with phase control of PV generation, electric vehicles (EVs) and heat pumps (HPs) and its experimental testing with the use of the Zaptec phase-changing charger.

Problem definition:

Phase imbalance is a well-known undesired grid state which can be caused by random single-phase connections of loads in different phases and can result in several negative grid impacts such as thermal losses, decreased efficiency, power quality issues, etc. For example, residential heat pumps (HPs) and a vast number of low rated-power PVs and electric vehicles (EVs) are single-phase connected and can provoke a high impact on grid unbalance which has already been quantified in 6 Dutch LV distribution grids. A development of a phase control model of PVs, EVs, and HPs and its experimental testing are needed.

Methodology:

The student is expected to perform a literature study concerning grid phase imbalance by connections of PVs, EVs, and HPs and its already identified impact on the acquired LV distribution grids. Then, the thesis will focus on the phase control model development. Finally, with the use of the newly installed Zaptec phase-changing charger, the model is expected to be tested in practise with lab experiments. Prior basic knowledge on Python is expected while knowledge on PowerFactory grid simulation tool is also highly recommended.

Research Objectives:

- Study of phase imbalance and its identified impact on the acquired LV distribution grids.
- Study of the experimental use of the Zaptec phase-changing charger
- Development of phase control model of flexible loads
- Experimental testing of the phase control model with the use of the Zaptec charger

1 https://cauk.tv/articles/power-quality-issues-voltage-and-phase-balancing/

Contact details:

- PhD student: Nikolaos Damianakis, N.Damianakis@tudelft.nl, LB.03.690
- Supervisors: Dr. Gautham Ram Chandra Mouli; Prof. P Bauer

MULTIPHYSICS BATTERY DIGITAL TWIN FOR CONTROL

Type of project: MSc thesis

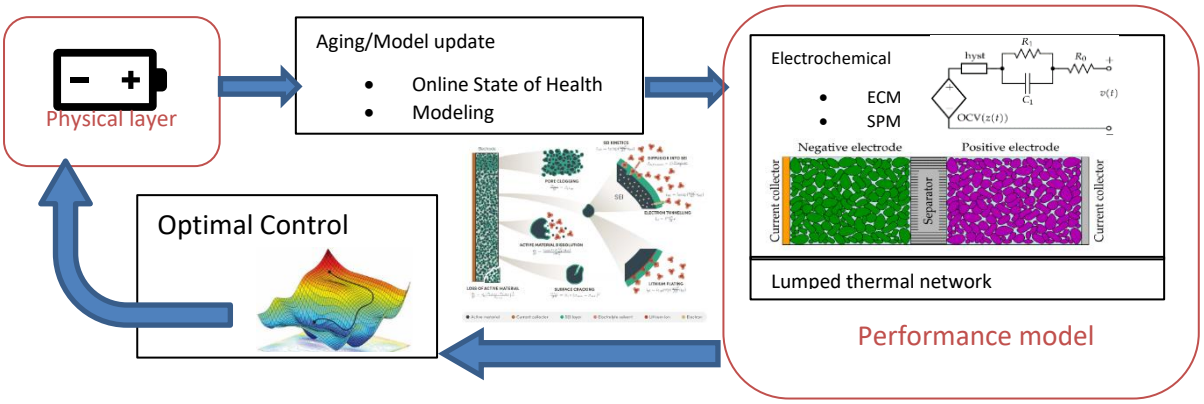


Fig 1: Project workflow

Scope:

Develop algorithms for online state of health estimation

Problem definition:

In the future energy storage devices are expected to play a large role in stationary applications, such as building energy storage or grid support applications. These devices might come from different applications (stationary, mobility, etc.) and manufacturers. Hence, we face the issue of encountering ourselves with many different batteries connecting to the grid, even to the same node. To optimally operate them advanced battery models are used. Once batteries are connected we need to first fit a model to it, but also update that model online to maintain a digital twin which is running in real-time in parallel to the physical battery.

The models and algorithms are encouraged to be developed in Julia/Python/Matlab-Simulink and tested in our lab.

Methodology:

- Perform a literature study on battery modeling and degradation and adaptive control techniques.
- Develop real-time online algorithms that update the models.

Research Objectives:

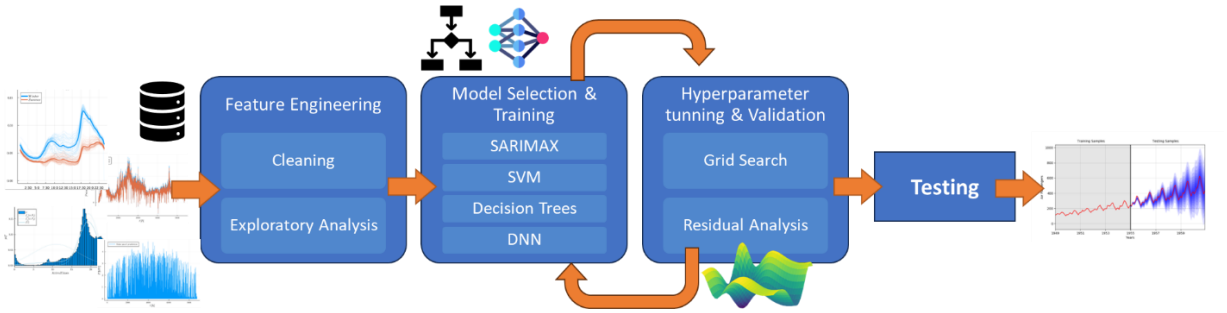
- Literature review.
- Multiphysics control oriented digital twin of a battery pack.
- Develop online parameter estimation algorithms.

Contact details:

- PhD student: Dario Slaifstein, D.A.Slaifstein@tudelft.nl , LB.03.820
- Supervisors: Dr. Gautham Ram Chandra Mouli; Prof. P Bauer

FORECASTING MODULE DEVELOPMENT

Type of project: MSc Thesis / Extra Project/ SIP 2



Scope:

Develop a Forecasting module for internal use of the DCE&S section. The module will include different forecasting methods based on state-space models, filtering and machine learning.

Problem definition:

The integration of renewable energy sources possess a significant challenges for current markets and analytical tools. One the biggest challenge is the integration of uncertainty into decision-making at every time scale (long-term planning, day-ahead and real-time operation). Thus the quantification and modelling of such uncertainties is a key step to develop and deploy future energy systems. This extra project aims to develop a basic open-software module that can be used, in principle, inside the DCE&S section. The models to be implemented will vary from classical methods (autoregressive state-space like SARIMA) to machine learning methods (decision trees or deep learning).

The models and algorithms are encouraged to be developed in Julia/Python and tested in current projects. Strong control, optimization and/or mathematical background are encouraged.

Methodology:

Initially the toolbox has to setup a pipeline for:

1. Data acquisition/Database management.
2. Feature/Data engineering
3. Model tunning/training, testing and validation.
4. Forecast utilization.

Research Objectives:

- Setup a basic and expandable forecasting pipeline.
- Develop module documentation.

Contact details:

- PhD student: Dario Slaifstein, D.A.Slaifstein@tudelft.nl , LB.03.820
- Supervisor:
  Dr. Gautham Ram Chandra Mouli G.R.Chandramouli@tudelft.nl
  Dr. Laura Ramirez Elizondo l.m.ramirezelizondo@tudelft.nl
  Prof. Dr. Ir.Pavol Bauer, P.Bauer@tudelft.nl

TU Delft

REINFORCEMENT LEARNING FOR MULTICARRIER URBAN SYSTEMS

Type of project: MSc thesis

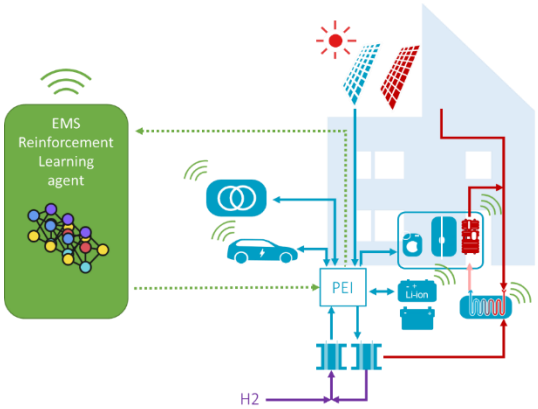


Fig 1: Project overview.

Scope:

Develop energy management system based on continuous time reinforcement learning (RL) algorithms.

Problem definition:

In the future, urban energy systems will be decarbonized. How this will happen is still an open question. It is possible that multiple energy carriers will coexist in the urban environment to fulfil such demand. In this context, the problem of scheduling and controlling the different devices during the day, month and year is non-trivial. Recently, machine learning techniques have acquired a lot of attention due to their speed and performance. The goal of this project is to propose control algorithms based on continuous-time reinforcement learning agents. Special focus should be made on the utilization of different energy storage devices for the different timescales.

The models and algorithms are encouraged to be developed in Julia/Python and tested in our lab. Strong control, optimization and/or mathematical background are encouraged.

Methodology:

- Perform a literature study on reinforcement learning and its application in control setups.
- Build and simulate energy management algorithms based on RL.
- Test the robustness of the algorithms in relevant operation scenarios.

Research Objectives:

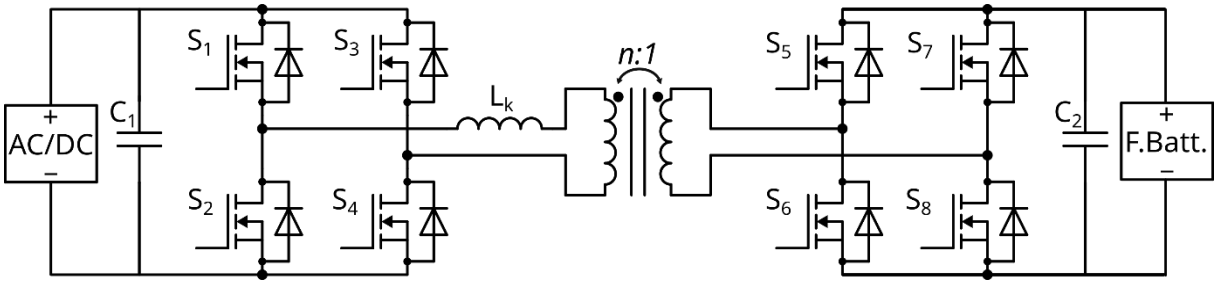
- Literature review.
- Performance of RL algorithms for energy management systems.
- Investigate the impact of incorporating models into the RL framework.

Contact details:

- PhD student: Dario Slaifstein, D.A.Slaifstein@tudelft.nl , LB.03.820
- Supervisors: Dr. Gautham Ram Chandra Mouli; Prof. P Bauer

DESIGN OPTIMISATION FOR A ROBUST DUAL ACTIVE BRIDGE CONVERTER FOR FLOW BATTERY APPLICATION

Type of project: MSc thesis



Scope:

To optimise the design parameters of a DAB converter for CC, CV and CP operating modes of Flow Battery.

Problem definition:

The Flow Battery charge or discharge operation observes a significant voltage variation. The Dual Active Bridge (DAB) converter connected to the Flow Battery to facilitate power transfer has to operate in Constant Current – Constant Voltage (CC-CV) during charging and Constant Power during discharge. The design parameters for the DAB need to be optimised for all three modes to reduce losses. The lower losses lead to lower temperature extremes on the devices, which eventually increases the reliability of the converter.

Methodology:

The student will start with a literature review to build their foundational knowledge on the Dual Active Bridge and the electrical characteristics of the flow battery. Then, an analytical model of the DAB will be created to evaluate the power losses of the converter at different operating points, followed by implementing an optimisation strategy to minimise the losses of the DAB. All of the various operating conditions need to be analysed for optimisation.

Research Objectives:

- Literature review of the DAB and the electrical characteristics of the Flow battery.
- Investigation of power losses as a function of varying voltage of the Flow battery.
- Optimisation of DAB design parameters for better efficiency

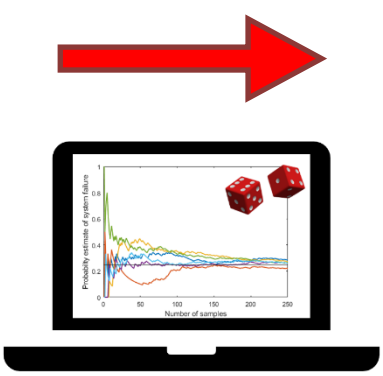
---

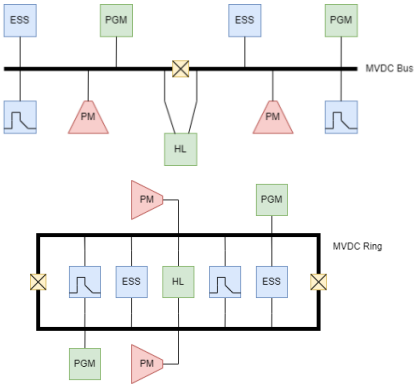
Contact details:

- PhD student: <Sourabh Singh, s.singh-9@tudelft.nl>
- Supervisor: <Aditya Shekhar, A.Shekhar@tudelft.nl>

RELIABILTY COMPARISON OF NAVAL DC SHIPBOARD POWER SYSTEMS

Type of project: <MSc thesis>





Scope:

Evaluate the reliability of different DC shipboard integrated power systems using stochastic simulation in order to maximize the availability of a naval ship.

Problem definition:

The energy transition of the maritime sector imposes the electrification of the ship's power system. Future all-electric ships (AES) need an intelligent shipboard power system (SPS) architecture which connects loads, like the propulsion system, to the power generation modules (PGM). For ship applications, DC SPS has shown significant advantages over AC, like increased efficiency, improved power flow control, reduced SPS weight and size, no synchronization problems, and more.

Though to be used in industry, a DC-AES requires a minimal level of reliability and availability. This requirement is getting even more severe for Navy SPS applications. Following [1], it can be observed that the power system structure significantly affects the ship's reliability. In this project, you will compare different DC-SPS structures in order to maximize the reliability of the naval ship.

Methodology:

The student shall start with a literature study on the DC SPS topologies and reliability evaluation methods. Thereafter, the student is expected to design and validate a stochastic simulation model framework which is then used to compare the reliability of different SPSs. Finally, the student shall improve the SPS to maximise the system's availability while maintaining parameters like cost, space.

Research Objectives:

- Literature review on the different DC SPS topologies and reliability evaluation methods.
- Develop and validate a stochastic simulation model framework for the DC SPSs.
- Determine the optimal power system architecture considering reliability.
- Evaluate the weak spots of the architecture and propose improvements.

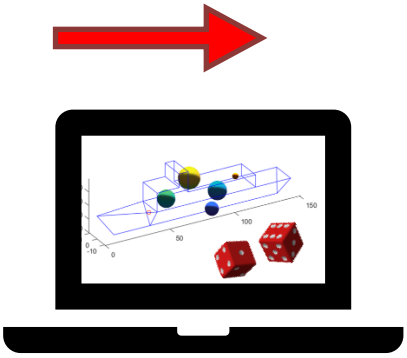
Contact details:

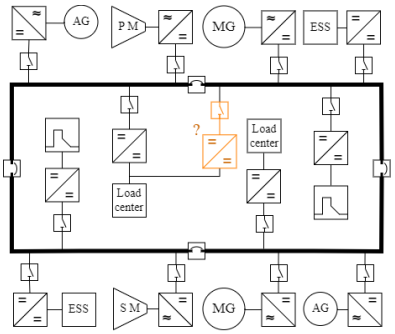
- PhD student: Robin van der Sande, R.P.J.vanderSande@tudelft.nl
- Supervisor: Dr.ir. Aditya Shekhar, A.Shekhar@tudelft.nl
  Prof. Dr. Ir. Pavol Bauer, P.bauer@tudelft.nl

[1] B. Stevens and S. Santoso, "Reliability analysis of a shipboard electrical power distribution system based on breaker-and-a-half topology," 2013 IEEE Electric Ship Technologies Symposium (ESTS), Arlington, VA, USA, 2013, pp. 387-393

SURVIVABILITY ASSESMENT OF DC SHIPBOARD POWER SYSTEMS

Type of project: <MSc thesis>





Scope:

Evaluate the survivability of a DC shipboard power system using stochastic simulation and analyse how methods like redundancy, modularity, and reconfiguration impact the resilience of a vessel.

Problem definition:

The energy transition of the maritime sector imposes the electrification of ship power and propulsion systems. Future all-electric ships (AES) need an intelligent shipboard power system (SPS) which connects loads, like the propulsion system, to the power generation modules (PGM). For ship applications, a DC-SPS has shown significant advantages over AC, like increased efficiency and improved power flow control. However, protecting these DC systems against faults is one of the biggest challenges currently faced in the industry.

To be applied in naval vessels a DC-SPS must secure the supply of power to the critical shipboard loads even under hostile environments. In this project, you will consider the spatial stochastic character of an unanticipated event (flood, fire, or missile impact) and analyse the impact on the performance of the DC-SPS[1]. The probability for availability will then highlight vulnerabilities in the design which can be improved using redundancy, modularity, or reconfiguration.

Methodology:

The student shall start with a literature study on the DC SPS topologies and vulnerability assessment methods. Thereafter, the student is expected to design and implement a stochastic vulnerability assessment model which is used to analyse the survivability of different SPSs. Finally, the student shall improve the DC-SPS using redundancy, modularity, or reconfiguration to improve the system's resilience while maintaining parameters like cost and space.

Research Objectives:

- Literature review on the different DC-SPS topologies and vulnerability assessment methods.
- Develop a stochastic vulnerability assessment model for the DC-SPSs.
- Determine the vulnerabilities of common power system architectures.
- Using redundancy, modularity, or reconfiguration improve the survivability of the DC-SPS.

Contact details:

- PhD student: Robin van der Sande, R.P.J.vanderSande@tudelft.nl
- Supervisor: Dr. Ir. Aditya Shekhar, A.Shekhar@tudelft.nl
  Prof. Dr. Ir. Pavol Bauer, P.bauer@tudelft.nl

[1] Jansen, AC Habben. "A Markov-based vulnerability assessment of distributed ship systems in the early design stage." Delft University of Technology (2020).

TU Delft