Fraunhofer ISIT

Institute for Silicon Technology

Electronic Energy Systems research group

Bachelor’s and Master’s Thesis Catalogue

Supervisor:
Prof. Dr.-Ing. Marco Liserre

Dec. 2022

In collaboration with the Chair of Power Electronics of Kiel University:

www.isit.fraunhofer.de/ees www.pe.tf.uni-kiel.de

Topic

- Renewable Energy Integration
- E-Mobility
- External Cooperation

Renewable Energy Integration

M.Sc. Thesis:

Robust Stability Analysis in P-HIL Tests Under Asymmetrical Faults

Test of Power Converters for Renewable Energy Systems

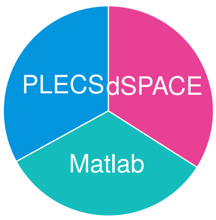
Requirements

Language
English

Theory
Control Theory ★★★★★
Grid-Tied Conv ★★★★★

Related Masters's Course
Gricores ★★★★★
MoCoPec ★★★★★

IT-Skills



Contact

Supervisor:
Dr. Sante Pugliese
sapu@tf.uni-kiel.de
Prof. Marco Liserre

November 14, 2022

Abstract

Power-Hardware-in-the-Loop (P-HIL) is a flexible and effective method to test a power converter under different realistic grid conditions and scenarios, like grid faults. P-HIL consists of a Digital Real-Time Simulator (DRTS), a Power Amplifier (PA), and a Device Under Test (DUT), where the PA is the power interface between the DUT and the real-time simulation. These elements are interfaced together via an Interface Algorithm (IA), which is crucial for the stability of the P-HIL test and the accuracy of the results. Short-circuit scenario can be simulated in the DRTS and the behavior of the DUT can be studied and analyzed in by using Multivariable Control Theory for MIMO systems.

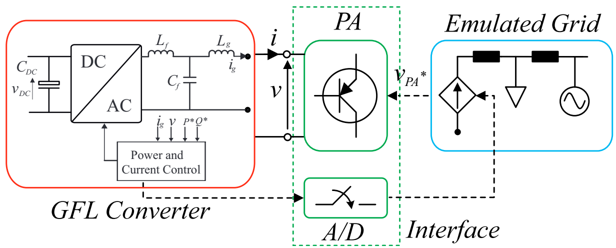


Figure 1: P-HIL scheme for GFL converters testing

Background

Low-Voltage Ride-Through (LVRT) field tests are usually conducted to prove the ability of the converter to ride through faults. Those field tests are expensive and require bulky equipment, while Power-Hardware-in-the-Loop (P-HIL) offers a more cost-effective and flexible alternative. However, the P-HIL must be stable and accurate to get reliable results. The stability of a P-HIL test is directly influenced by its interface algorithm and delays involved in the loop. This work aims to understand the operation of P-HIL under asymmetrical faults, model the uncertainties involved in the loop and study the robustness of the system by using the μ-stability analysis of MIMO systems.

Objectives

- Understand the operation of P-HIL under Asymmetrical Faults.
- Model the uncertainties involved in the loop and study the robustness of the system by using the μ-stability analysis.
- Developing a simulation model in PLECS/MATLAB-Simulink for P-HIL operating in low voltage unbalanced AC grid.
- Developing a Real-Time simulation in RTDS for P-HIL operating in low voltage unbalanced AC grid.

M.Sc. Thesis:

Intelligent Junction Temperature Estimation with Vce Measurement

Artificial Intelligent and Machine Learning

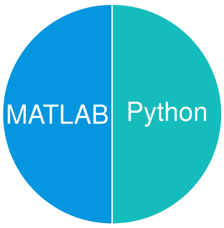
Requirements

Language
English

Theory
Thermal analysis
Semiconductors
Programming

Related Course
DPEC

IT-Skills



Contact

Supervisor:
Jun-Hyung Jung
jj@tf.uni-kiel.de
Joao Victor Matos Farias
jovi@tf.uni-kiel.de
Prof. Marco Liserre

Project

Fraunhofer ISIT@CAU

Fraunhofer ISIT
isit.fraunhofer.de/ees

November 11, 2022

Abstract

Collector-emitter voltage (Vce) is one of the temperature sensitive electrical parameters (TSEPs) used to estimate the junction temperature. Since it is difficult to estimate the accurate temperature using Vce, this thesis will use the machine learning technology to compensate the accuracy. As a first step, Vce and Tj data sets for training the machine must be collected. The collected data sets are used for training based on supervised learning algorithms. The trained machine will be verified through practical experiments.

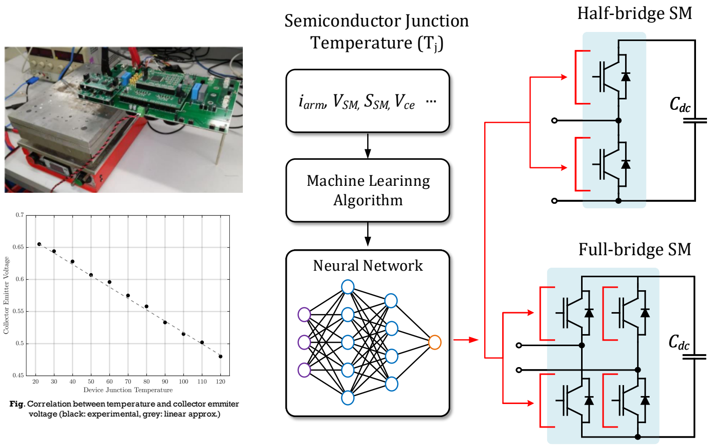


Figure 1: Training Machine learning for junction temperature estimation with TSEP

Background

Monitoring the junction temperature of semiconductors is important for the reliability of power converters. One of the ways to monitor semiconductor thermal conditions is a method using temperature sensitive electrical parameters (TSEPs) and collector-emitter voltage (Vce) is a representative TSEP. Although it is possible to estimate the junction temperature using Vce, it is difficult to guarantee enough accuracy under various conditions. To compensate the accuracy, machine learning can be used, and it can be trained using the collected data sets of Vce and Junction temperature. It is good opportunity to understand the machine learning that can be used for the power electronics applications.

Objectives

- Understanding thermal behavior of semiconductors and supervised learning.
- Experiment for collecting the junction temperature data sets.
- Training the machine for the junction temperature estimation and its verification.

M.Sc. Thesis:

Parameter tuning for a Grid-Forming HVdc system connecting a Wind Power Plant)

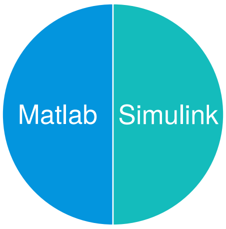
Offshore Wind Integration

Requirements

Language
English

Theory
HVdc systems ★★★☆☆
Converter control ★★★☆☆
Small signal modelling ★★★★☆
Stability analysis ★★★★★

IT-Skills



Contact

Anuradha Mudalige
am@tf.uni-kiel.de
Prof. Marco Liserre

Project

WinGrid
https://www.wingrid.org/

November 11, 2022

Abstract

Offshore Wind Power Plants (WPP) connected through HVdc systems have gained increased research attention. HVdc converter stations are conventionally controlled based on Grid Following mode. This thesis, instead, aims to propose an optimal parameter tuning process for an HVdc connected WPP for providing inertial response to the onshore grid by incorporating an onshore converter station operating in Grid Forming mode. Related courses are MoCoPEC (Modelling and Control of Power Electronics Converters) and RES (Renewable Energy Systems)

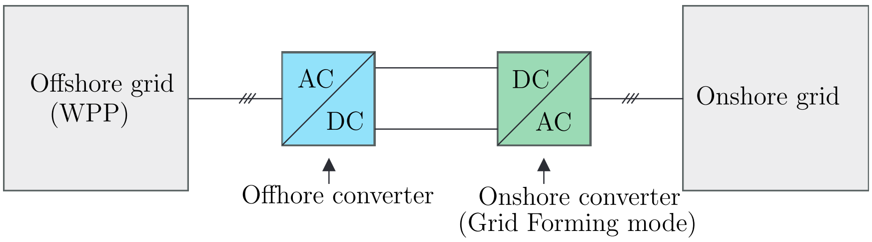


Figure 1: HVdc connected Wind Power Plant system

Background

Grid Forming inverters have shown to exhibit several advantages compared to Grid Following inverters in providing grid services such as frequency regulation. In this thesis, a WPP connected via an HVdc system having an onshore converter station operating as a synchronverter is to be modelled and analyzed in the view of providing inertial response to the power system. Results of the model shall be used to propose an optimal parameter tuning process considering the dc link dynamics and stability margin of the overall system.

Objectives

- Small signal modelling of the proposed system.
- Small signal stability analysis.
- Development of a methodical parameter tuning process.

B.Sc. Thesis:

MMC submodule dc Capacitor Voltage Observation

Artificial Intelligent and Machine Learning

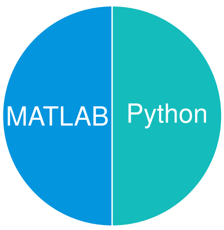
Requirements

Language
English

Theory
Power converter ★★★★☆
Programming ★★★☆☆

Related Course
Principles of Power Electronics ★★★★☆

IT-Skills



Contact

Supervisor:
Jun-Hyung Jung
jj@tf.uni-kiel.de
Prof. Marco Liserre

Project

AC2DC Increasing transmission capacity in the distribution grid with existing AC connection as DC links

November 11, 2022

Abstract

The main objective of this thesis work is to replace voltage sensors of submodules used in modular multilevel converters by using machine learning (ML). Reinforcement learning (RL), which is a subclass of ML, will be trained to predict and estimate dc capacitor voltage of SMs. After establishing Environment to train a RL agent, training will be carried out various conditions and performance of the trained result will be analyzed and evaluated.

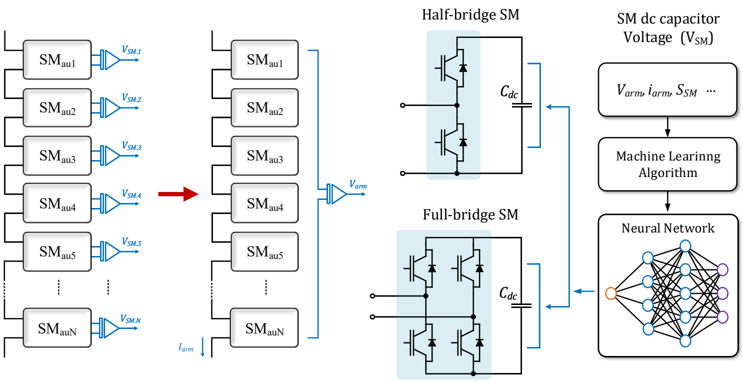


Figure 1: Training Machine learning for SM voltage observation

Background

MMC integrated in Offshore Windpark is a fairly complex system because it consists of many semiconductors and submodules (SMs). One of the important issues in this system is the guarantee of reliability. The factor that lowers the reliability of the system is the failure of the components in the SM, such as a voltage sensor. By replacing numerous voltage sensors with such an observer, it is possible to prevent deterioration of reliability due to failure and reduce manufacturing costs. Machine learning, which getting popular recently, shows strong performance in prediction and estimation. This thesis work will be helpful for understanding basic operating principles of machine learning and power converters.

Objectives

- Understanding converter behaviour and reinforcement learning
- Training the machine with the environment including MMCs.
- Verification of the trained agent for observing the SM voltage.

B.Sc. Thesis:

Thermal Modeling of Modular Multilevel Converter (MMC)

Highly Reliable MMC Integrated in Offshore Windpark

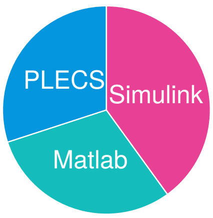
Requirements

Language
English, German

Theory
Multilevel Converters ★★★★☆
Power Devices ★★★★☆
Grids ★★☆☆☆

Related Courses:
MOCOPEC

IT-Skills



Contact

Mahyar Hassanifar
mha@tf.uni-kiel.de

Supervisors:
Mahyar Hassanifar
Dr. Marius Langwasser
Prof. Marco Liserre

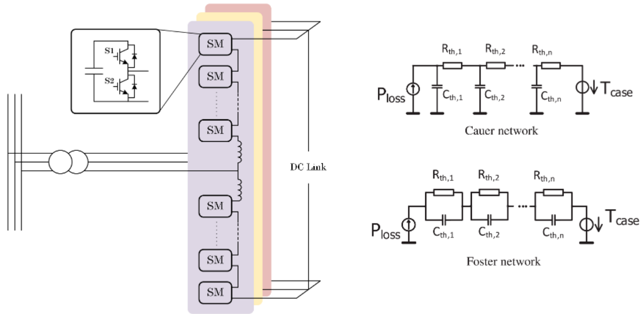
Project

SmartGYsum
smartgysum.eu/

November 23, 2022

Abstract

A modular multilevel converter (MMC) is one of the preferred choices for high-power and high-voltage applications, which makes it as a suitable solution to fulfill the industry's expectations. So, besides functionality, its safe and reliable operation should be considered. Since the temperature profile is directly related to the lifetime of the component and high temperature is very destructive for switches, controlling the temperature of switches can increase the reliability of an MMC-based system. In MMC, a high number of semiconductor switches are used. Hence, it is impossible to observe the temperature of individual switches. Therefore, to control the temperature of components, a model should be provided. The goal of this B.Sc. thesis is to analyze and compare the existing model, as well as to reach the optimum thermal model for MMC.



Background

MMC benefited from high modularity. The high modularity of MMC provides important features such as a very high number of redundant switching states. With the help of redundant switching states, the controller can generate a proper switching command to regulate the voltage of capacitors. Besides, the high number of switching states provides high potential for multi-objective management of switches, such as thermal balancing. With effective thermal management, thermal strain of components can be reduced, which results in longer lifetimes and maintenance intervals, as well as a greater capability for overloading. Consequently, the operating costs of the system can be significantly reduced. The system should be modeled properly to have effective thermal management, which will be done during this thesis.

Objectives

- Analyze and compare the existing models
- Develop a new model or modify the existing models to have more realistic model
- Analyze and compare the models in different type of MMC (e.g., half-bridge, full-bridge, and hybrid)

Fraunhofer ISIT

B.Sc. Thesis:

A Thermal Balancing Control for Hybrid MMC

Offshore Windpark Integration

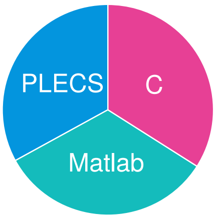
Requirements

Language
English/German

Theory
Multilevel Converters ★★★★☆
Active Thermal Control ★★★★☆
IGBT Power Modules ★★★☆☆

Related Courses
PoSSGRES ★★★★☆
Leistungselektronik Grundlagen ★★★★☆

IT-Skills



Contact

Supervisor:
João Victor Matos Farias
jovi@tf.uni-kiel.de

Dr. Marius Langwasser
mlan@tf.uni-kiel.de

Prof. Marco Liserre

Project

AC2DC: Increasing transmission capacity in the distribution grid with existing AC connections as DC links

ISIT@CAU

Fraunhofer ISIT

November 11, 2022

Abstract

The hybrid modular multilevel converter (HMMC) is employing the unipolar and bipolar submodule (SM) topologies, combining the advantages of both. However, due the different degree of freedom of each SM, different thermal stress can be experienced by the power semiconductors. Therefore, this thesis studies a thermal balancing control for the power semiconductors of the HMMC.

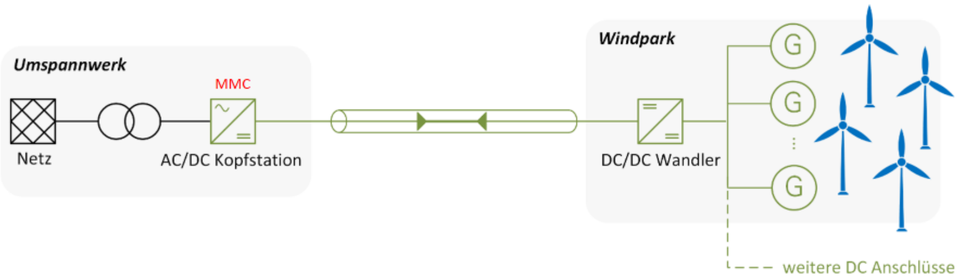


Figure 1: Three-phase topology of HMMC.

Background

The MMC-based on bipolar SM can ensure a dc fault blocking capability due the presence of SM capable of producing reverse biased voltage during the dc fault. Aiming to reduce the cost and to increase the converter efficiency, the converter can present both unipolar and bipolar SM topologies. However, the power devices in a unipolar topology could experience different thermal stress compared to a bipolar topology. Therefore, it is important to ensure a balancing thermal behavior between the power devices in both topologies, avoiding the device failures due to the thermal over-stress. This thesis study will be a great opportunity to improve your understanding of MMCs, which is a core technology in MV grids for offshore windpark integration.

Objectives

- Improvement of the student skills about active thermal control and offshore wind integration
- Impressive hands-on skills and experience with real laboratory measurement
- Analysis of hybrid MMC topologies;
- Proposal of a thermal balance control for hybrid MMC.

M.Sc. Thesis:

Analysis and Modeling of Fault in the AC Valves of MMC

Highly Reliable MMC Integrated in Offshore Windpark

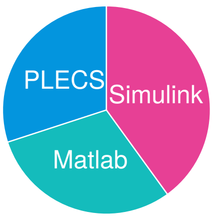
Requirements

Language
English

Theory
Multilevel Converters ★★★★☆
Power Devices ★★★★☆
Grids ★★☆☆☆

Related Courses:
MOCOPEC

IT-Skills



Contact

Mahyar Hassanifar
mha@tf.uni-kiel.de

Supervisor:
Mahyar Hassanifar
Dr. Marius Langwasser
Prof. Marco Liserre

Project

SmartGYsum
smartgysum.eu/

November 23, 2022

Abstract

In recent decades, multilevel converters and, on top of them, the modular multilevel converter (MMC) have been widely used in industrial high-voltage high-power applications. One of the critical issues in grid-connected MMC-based systems is faults on the AC-side valve of the MMC. In this regard, it is crucial to find methods to degrade and mitigate the effect of the AC-valve fault. Therefore, as a first step to achieving this goal, this thesis will aim at developing an accurate model for an MMC under an AC fault condition.

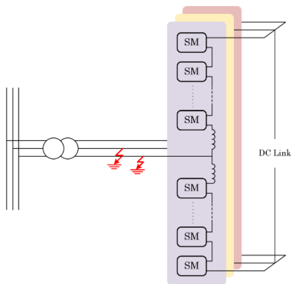


Figure 1: Phase to ground fault in the valves of MMC

Background

MMC is one of the appropriate systems to use in the high-power high voltage applications. One of the undesired circumstances in the MMC is the AC-valve fault. The phase to ground fault in the MMC AC terminals is very harmful to MMC, and its characteristics are very different from those of grid side AC fault. For instance, it can cause a large current in the MMC and other issues to the functionality of a system. Since the inrush current caused by AC-valve fault significantly affects the semiconductor-based components, it is critical to analyze the transient condition of fault. The best approach to analyze the post-fault condition is modeling the MMC. Among the several MMC structures, half-bridge and full-bridge MMC are widely adopted by industry. Therefore, during this thesis, new models will be developed and investigated for the AC-valve fault in half-bridge and full-bridge MMC after reviewing and comparing the current models.

Objectives

- Analyze and compare the possibility and effect of symmetric and asymmetric AC-valve fault
- Review and analyze the effects of faults on different possible MMC topologies (i.e., half-bridge, full-bridge, and Hybrid)
- Developing an accurate AC fault Model for the MMC

Fraunhofer ISIT

M.Sc. Thesis:

Modulation Strategy for Highly Reliable MMCs in MVdc Grids

Highly Reliable MMC Integrated in Offshore Windpark

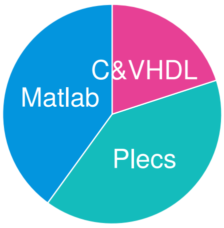
Requirements

Language
English

Theory
Power Electronics ★★★★★
Semiconductors ★★★☆☆

Related Master Course
DPEC ★★★★★

IT-Skills



Contact

Supervisor:
Jun-Hyung Jung
jj@tf.uni-kiel.de
Joao Victor Matos Farias
jovi@tf.uni-kiel.de
Prof. Marco Liserre

Project

AC2DC Increasing transmission capacity in the distribution grid with existing AC connection as DC links

November 11, 2022

Abstract

A new active thermal control (ATC) with modulations suitable for modular multi-level converters (MMCs) applicable to medium-voltage (MV) applications will be developed in this thesis. ATC is performed by adjusting the modulation according to the monitored thermal condition. While managing the thermal stresses, balance of the submodule (SM) dc capacitor voltage should be also considered in the ATC. The developed new ATC will be verified in simulation and experiment.

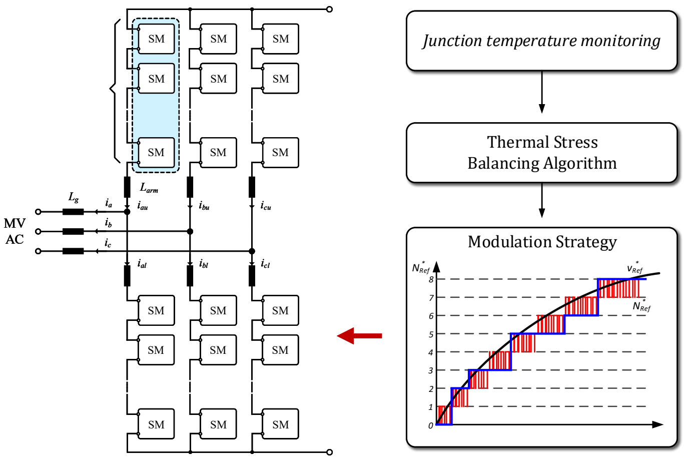


Figure 1: Modulation-based ATC strategy for MMCs

Background

A medium-voltage dc network is an emerging technology in the future energy distribution system, and modular multilevel converters will be a promising topology to support the MV dc network. Since the MMC is composed of a large number of semiconductors and converter modules, many studies have been done to ensure high reliability. The ATC is an effective method to improve reliability by managing the thermal stresses on the semiconductors and modules. This thesis study will be a great opportunity to improve your understanding of MMCs, which is a core technology in MV grids to integrate highly reliable offshore windpark.

Objectives

- Understanding modulations and controllers for MMCs
- Understanding thermal behavior of semiconductors and modulations for MMCs.
- Development of modulation-based active thermal control for full-bridge SM MMCs
- Practical verification with simulation and experiment.

M.Sc. Thesis:

Control of active distribution network with consideration of communication delays

Control of smart grids

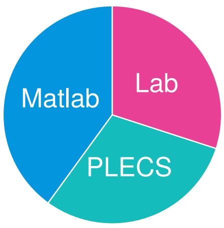
Requirements

Language
English/German

Theory
Grid modeling: ★★★★☆
Control design: ★★★★★

Related classes
GriCoRES ★★★★☆
RES ★★★★★

IT-Skills



Contact

Supervisor:
Federico Cecati
fc@tf.uni-kiel.de
Prof. Marco Liserre

Project

DFG-SPP 1984 Priority Program:
https://www.spp1984.de/

In collaboration with:
Fraunhofer ISIT

November 23, 2022

Abstract

Communication between different resources in active distribution networks is fundamental to achieve effective voltage and frequency regulation and proper power sharing. However, the communication links are naturally affected by delays and/or packet losses, which can have a significant impact on the grid stability. Mathematical tools to study the grid stability under delays and to design robust controllers are thus requested. This thesis is associated to a large research project involving 17 European universities, and is carried out in collaboration with Fraunhofer ISIT.

Background

The use of the communication network allows different strategies for the system-level control. With centralized control strategy, a global controller exchanges control set-points and measurements with the converters in the grid, as in Figure 1. With distributed control strategy, the information are instead exchanged between nearby converters, as shown in Figure 1.

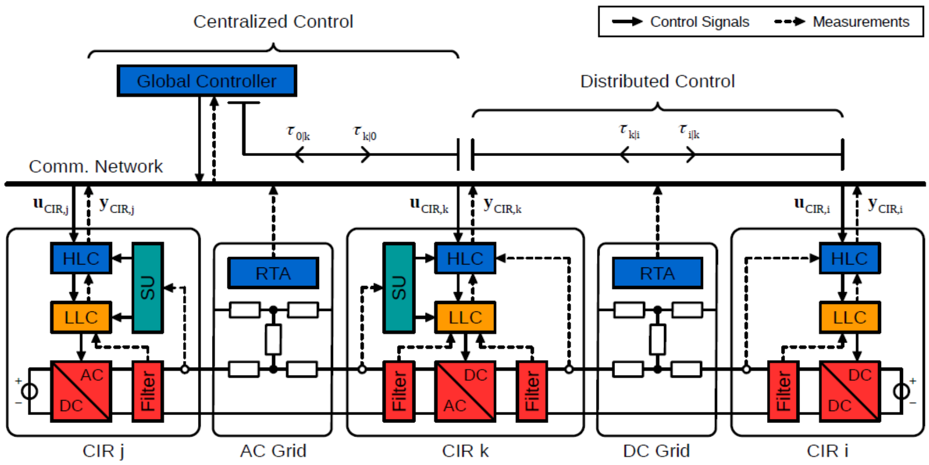


Figure 1: Conceptual schematic of distributed and centralized control in a active distribution network.

Objectives

- Modeling of power converters and converter-dominated grids
- Modeling of system-level control, with the consideration of communication delays
- Design of a system-level with high robustness with respect to communication delays

Fraunhofer ISIT

M.Sc. Thesis:

Intelligent Fault Diagnosis for Modular Multilevel Converters

Artificial Intelligent and Machine Learning

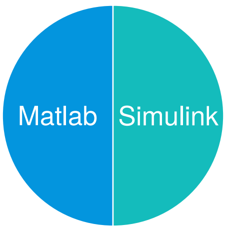
Requirements

Language
English

Theory
Power Electronics ★★★★★
Programming ★★★★★

Related Course
DPEC ★★★★★

IT-Skills



Contact

Supervisor:
Jun-Hyung Jung
jj@tf.uni-kiel.de
Prof. Marco Liserre

Project

AC2DC Increasing transmission capacity in the distribution grid with existing AC connection as DC links

November 11, 2022

Abstract

Since modular multilevel converters (MMCs), which are a promising topology for medium- and high-voltage applications, are composed of numerous semiconductors, it is one of the major issues to detect and localize faulty switches quickly and accurately. To achieve this mission, reinforcement learning, a subclass of machine learning, will be studied and applied in this thesis. Reinforcement learning can learn features of the environment, which is MMC in this case, in real-time by connecting the machine directly. For an effective training process, designing and providing an environment that includes various conditions is necessary. In addition, research on the effects of hyper-parameters on training the machine will be done to achieve precise learning results.

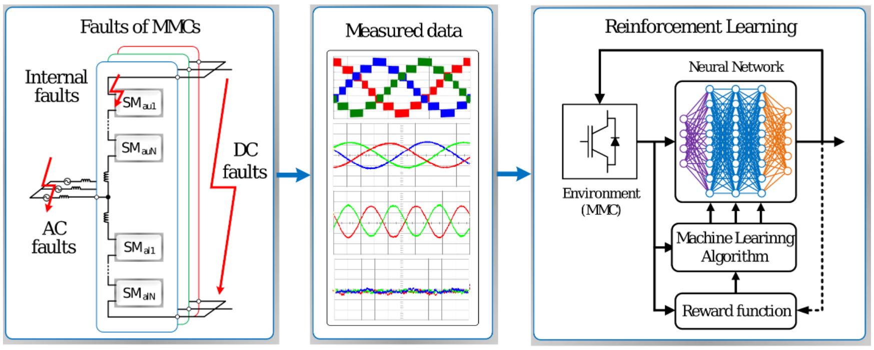


Figure 1: Fault diagnosis for MMCs with machine learning

Background

In power electronics converters, failure in semiconductors and related devices is the most dominant. When this failure occurs, it deteriorates the performance of the converter and leads to critical destruction. For this reason, fast and accurate fault diagnosis of semiconductors is important for ensuring high reliability of the converter. Machine learning technologies are getting popular in recent and many studies have been done for power electronics. The machine learning can be trained so as to diagnose faults with specific patterns of variables. It is good opportunity to understand the machine learning that can be used for the power electronics applications.

Objectives

- Understanding modular multilevel converters and reinforcement learning
- Training the machine with the environment including MMCs
- Simulation verification the trained machine for the fault diagnosis

E-Mobility

MSc. Thesis:

Junction temperature estimation of SiC Power MOSFET in Inverter Operation

Thermal modelling for Electromobility

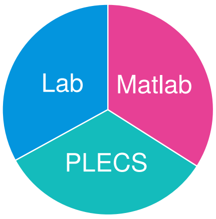
Requirements

Language
English/German

Theory
Power Electronics ★★★★★
Thermal analysis ★★★★★

Relevant Courses
DPEC ★★★★★
Electric Drives ★★★★★

IT-Skills



Contact

Karthik Debbadi
kde@tf.uni-kiel.de

Supervisor:
Prof. Marco Liserre

Project

PE-Region Platform - Interreg
`https://www.pe-regionplatform.eu/en_GB/`

November 11, 2022

Abstract

There are multiple challenges to match the existing Si technology when it comes to cost and realiability simultaneously with SiC/GaN technology. Junction temperature estimation of the power semiconductor provides useful information for condition monitoring and lifetime estimation for the system. The focus of this thesis is to estimate the junction temperature of the power semiconductor inside the power module and validate with experimental work.

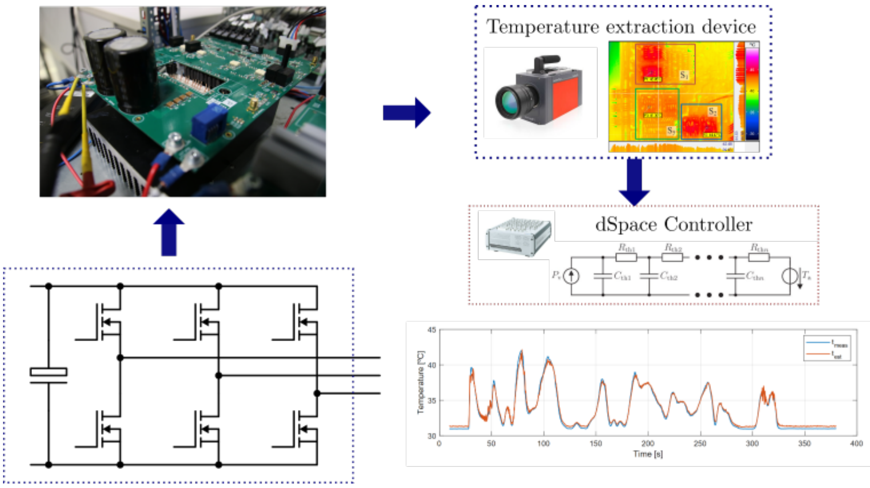


Figure 1: System level view of inverter and the thermal monitoring concept

Background

As e-mobility becomes more mainstream, there will be challenges to reduce cost and improve reliability of the electric drive train in these applications. It is vital to know the junction temperature of the power semiconductor as it acts as a predictor for the reliability and lifetime analysis of the system for a given mission profile. In this work, an infrared (IR) based temperature measurement system is used to characterize the thermal impedance and for experimental validation.

Objectives

- Thermal characterisation of SiC power module
- Implementation of algorithm to estimate the junction temperature in dSpace controller
- Experimental validation of the junction temperature estimation

Fraunhofer ISIT

B.Sc. Thesis:

Thermal Characterization of Lithium Ion Battery Packs

Thermal Design for E-Mobility

Requirements

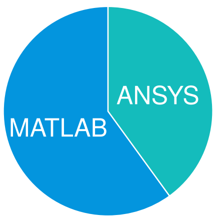
Language
English

Theory
Li-ion Batteries ★★★☆☆
Thermal Measurement ★★★★☆
Thermal Modeling ★★★★☆

Lab Work
Battery Tests ★★★★☆
Thermal Camera ★★★★☆

Relevant Courses:
Battery Technologies

IT-Skills



Contact

Supervisors:
Dr.-Ing. Hamzeh Beiranvand
hab@tf.uni-kiel.de
Prof. Marco Liserre

Project

BAEW: Laboratory for Reliable Battery-based Energy Conversion
Project website link

November 11, 2022

Abstract

Fully electric vehicle (EV), which are powered by lithium Ion (Li-ion) batteries, are substituting the fossil-based vehicles, gradually. One of the problems of EVs is the long charging time. When charging batteries at high currents to achieve fast charging, the battery pack maximum current is limited by thermal issues. Therefore, thermal design and characterization are the key to obtain reliable fast charging for automotive industry. The objective of this thesis is to familiarize you with fundamentals of thermal characterization and testing both in the laboratory and CAD simulation tools.

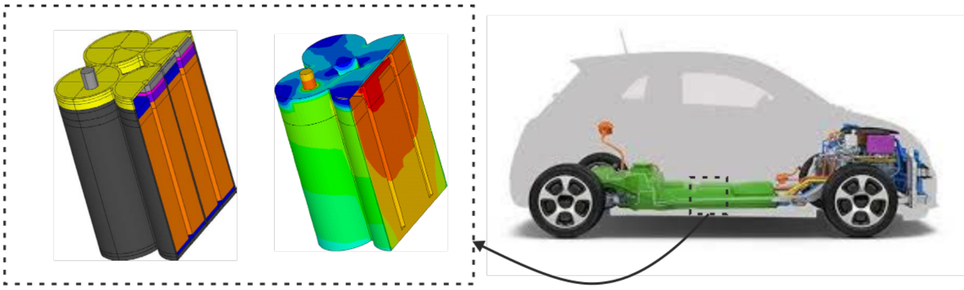


Figure 1: Battery Temperature Characterization for EVs (Source: National laboratory of the U.S. Department of Energy).

Background

Thermal stresses put firm limitation and constraints on the Li-ion battery pack performance. Moreover, their normal operation is impacted greatly by the surrounding temperature. The thesis is recommended for those students who want to join the e-mobility industry and follow their interest on batteries there.

Objectives

After you successfully completed this thesis, you will be able to:

- **High power testing of Li-ion batteries to reach thermal limits**
- **Thermal characterization of Li-ion batteries using thermal camera**
- **Thermal simulation in CAD software**

BSc. Thesis:

Implementation of a Thermal Observer on a Microprocessor

Power Electronics Reliability

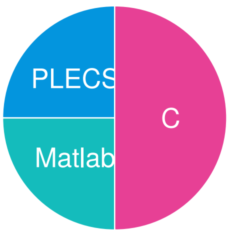
Requirements

Language
English/German

Theory
Microprocessor
Programming: ★★★★★
Reliability: ★★★★☆

Connected Course
Microcontroller and FPGA Technique

IT-Skills



Supervisor:
Johannes Kuprat
jk@tf.uni-kiel.de
Prof. Marco Liserre

November 11, 2022

Abstract

The reliability of power electronic systems is of utmost importance for a save operation of the electrical grid. Assessing the junction temperature of power semiconductors is essential for the reliability assessment. This thesis will focus on the implementation of a thermal observer on a microprocessor.

Background

Thermal observers are a combination of a thermal estimator with a temperature measurement for the correction of the estimation. They provide zero phase lag, low noise as well as the correct temperature, combining the advantages of estimators and temperature measurement. For the implementation in industrial systems the integration of thermal observers in a microprocessor is needed. This Bachelor's thesis will provide the possibility to learn the basics on thermal monitoring of power semiconductors and to acquire of the ability to implement these approaches in a real system.

Objectives

- Basic understanding of thermal observers and their characterization.
- Realization of a thermal observer on a Microprocessor.

Fraunhofer ISIT

BSc. Thesis:

Modelling and Analysis of Switching Behavior of SiC Power MOSFET

Range Extension for Electromobility

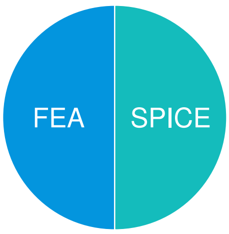
Requirements

Language
English/German

Theory
Power MOSFET ★★★★☆

Relevant Courses
Power Electronics ★★★☆☆

IT-Skills



Contact

Karthik Debbadi
kde@tf.uni-kiel.de

Supervisor:
Prof. Marco Liserre

Project

PE-Region Platform - Interreg
https://www.pe-regionplatform.eu/en_GB/

November 11, 2022

Abstract

With the rise of electric vehicles (EV), the latest power semiconductor technology such as Silicon Carbide (SiC) plays a major role in improving the range and life of the EV. Recently Tesla as built SiC based motordrive and onboard charger to extend the range of the EV. Most of the automobile manufacturers are investigating to incorporate SiC based technology into the drivetrain. For reliable operation of the technology, it is important to model the power semiconductor as close to reality as possible. For this, understanding the switching behavior of SiC power MOSFET is imperative. The focus of this thesis is to model the parasitics elements (capacitances, inductances) inside the half bridge based on SiC power MOSFET and compare the results with experiments on an existing hardware.

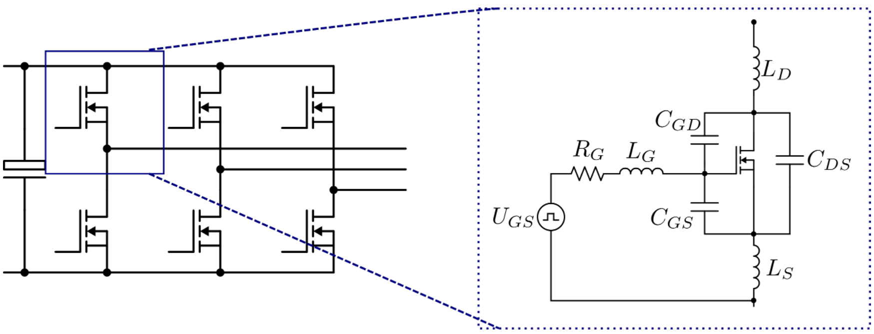


Figure 1: System level view of electric drive system with active gate driver concept

Background

As e-mobility becomes more mainstream, there will be challenges to reduce cost and improve reliability of the electric drive train in these applications. This leads to use of high speed and high frequency motor and inverter to reduce the volume and cost of the system. Due to the current theoretical limitations already reached by use of Si technology, new WBG technology such as SiC/GaN based power switch-based inverters are being researched. Due to fast switching action of these devices, new challenges arise in reliable operation of the power converter switching resulting in system failure. Accurate modelling of the parasitics elements around the MOSFET will give insights into the operation of device under different loading conditions. These insights are useful for proper design of the power converter.

Objectives

- Understanding the switching behavior of SiC power MOSFET
- Finite Element Modelling the power device (power module) in Ansys and simulation of switching behavior
- Comparison of existing experimental results with simulation results

Fraunhofer ISIT

PE 25th anniversary

M.Sc. Thesis:

Advanced Charging Strategies for Lithium Ion Batteries

Fast Charging for E-Mobility

Requirements

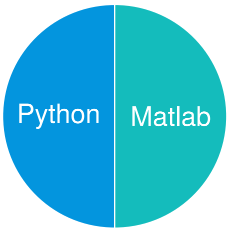
Language
English

Theory
Li-ion Battery ★★★☆☆
Battery Impedance ★★★★☆
Charging Strategies ★★★★☆

Lab Work:
Battery Tests ★★★★☆

Relevant Courses:
Battery Technologies

IT-Skills



Contact

Supervisors:
Dr.-Ing. Hamzeh Beiranvand
hab@tf.uni-kiel.de
Prof. Marco Liserre

Project

BAEW: Laboratory for Reliable Battery-based Energy Conversion
Project website link

November 11, 2022

Abstract

Fast charging of Li-ion batteries impact negatively on the battery lifetime. Battery impedance, which is usually measured using Electrochemical Impedance Spectroscopy (EIS) techiques, can be used to detect the origins of the battery lifetime degradation. Therefore, EIS techniques can be used to design the battery charging strategy. Experiments using Arbin battery tester and Gamry 5000 EIS device in the laboratory are envisaged in the frame of this master thesis.

Figure 1: High-power battery testing system at the chair of power electronics

Background

Battery Testing is a common task in e-mobility industry to implement high reliability battery packs. This thesis topic is designed to develop your competences in battery testing and charging strategies based on the measured impedance and hence ease your way in the e-mobility industry.

Objectives

After you successfully completed this thesis, you will be able to:

- Test Lithium ion battery testing
- Do battery experiments using cell tester, climate chamber and EIS
- Develop charging strategies to improve the battery lifetime and performance
- Data and analysis and feature extraction for batteries
- Understand battery packs used in EVs and e-mobility industry

M.Sc. Thesis:

Design of Medium-Voltage Medium-Frequency Transformer

Fast Charging Station for E-Mobility

Requirements

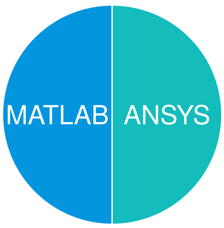
Language
English

Theory
Magnetic ★★★★★
Transformers ★★★★☆
Thermal Design ★★★★☆
DC-DC converters ★★★☆☆

Laboratory
Transformers ★★★★★

Relevant Courses:
DPEC
MOCOPEC

IT-Skills



Contact

Supervisors:
Dr.-Ing. Hamzeh Beiranvand
hab@tf.uni-kiel.de
Prof. Marco Liserre

Project

DFG: MVDC Fast Charging Station

Internship

Yes

November 24, 2022

Abstract

E-mobility industry is ramping up in development where fast charging stations are playing a central role. Galvanic isolation between electric vehicles (EVs) and the upstream grid is mandatory for safety purposes which is realized by medium frequency transformers (MFTs). This thesis targets the design optimization of medium voltage (MV) multiwinding MFTs to achieve high efficiency and power density. In the other word, energy losses and volume are minimized which are critical for e-mobility industry.

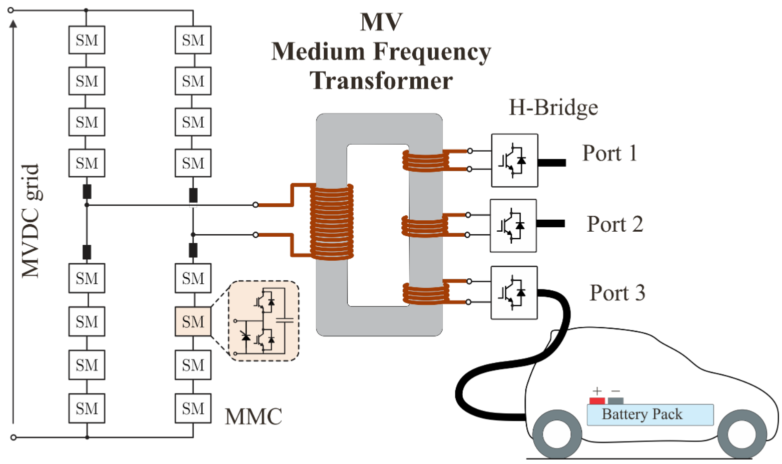


Figure 1: Medium-voltage medium-frequency transformer as the isolation stage of the fast charging stations.

Background

To achieve extremely fast charging speeds, integration to MV grid is a necessity. Therefore, in this thesis MVDC based fast charging stations are exploited where MFT is the key component. The project includes optimization of the MFT core shape and the windings configuration. If you are interested to join E-Mobility industry, this thesis is a perfect starting point where you will learn industrial software beside research and develop your competences.

Objectives

After you successfully completed this thesis, you will be able to:

- 3D CAD design of transformers using ANSYS
- Static and transient analysis of the fast charging station
- Power losses and thermal analysis
- Building experimental prototypes

M.Sc. Thesis:

Multiport Medium Voltage Fast Charging Station

Fast Charging Station for E-Mobility

Requirements

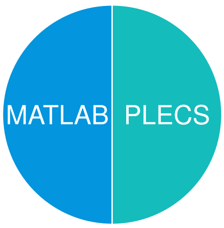
Language
English

Theory
Transformers ★★★★★
Multilevel converters ★★★★☆
DC-DC converters ★★★☆☆

Laboratory
Transformers ★★★★★
Medium voltage ★★★★★

Relevant Courses:
DPEC
MOCOPEC

IT-Skills



Contact

Supervisors:
M.Sc. Sattar Bazyar
sab@tf.uni-kiel.de
Dr.-Ing. Hamzeh Beiranvand
hab@tf.uni-kiel.de
Prof. Marco Liserre

Project

DFG: MVDC Fast Charging Station

November 24, 2022

Abstract

Due to environmental problems caused by fossil fuel burning in the transportation sections, the trend has been toward using the electrical vehicle (EV). The industrial development of EVs has required the necessity to increase the power of the fast charging station (FCS) to reduce the charging duration. In this thesis, optimization design of a new configuration of FCS will be investigated. This FCS is based on modular multilevel converter (MMC) and medium-frequency transformer. Using the MMC can provide the opportunity to connect the FCS to medium-voltage DC (MVDC) grid, and medium-frequency transformer (MFT) is an interesting candidate to reduce the size and cost of the FCS.

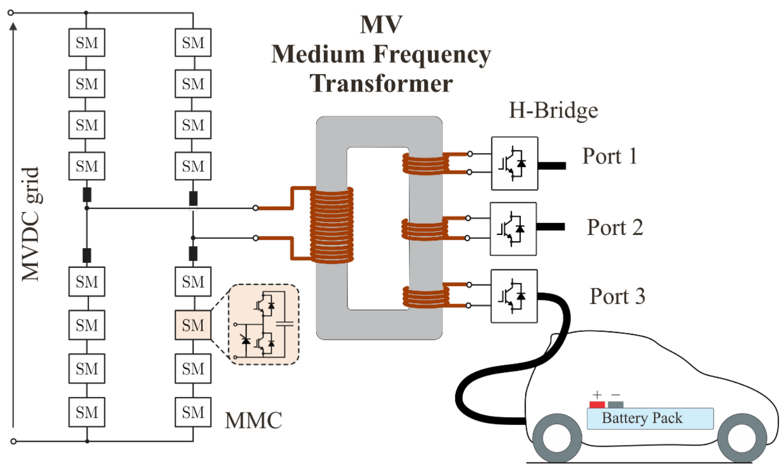


Figure 1: Medium-voltage medium-frequency transformer as the isolation stage of the fast charging stations.

Background

The most common configurations of fast charging station (FCS) have been connected to a low voltage grid and use low-frequency transformer, which causes limitations in space, flexibility, and charging duration. Using the medium-voltage (MV) FCS can be a significant development to charge the electrical vehicles in a short time. In addition, the possibility of using a medium-frequency transformer (MFT) instead of low-frequency transformer can reduce the volume, weight, and loss of the FCS.

Objectives

After you successfully completed this thesis, you will be able to:

- Design of modular multilevel converter (MMC)
- Design of medium-frequency transformer (MFT)
- Power losses analysis

M.Sc. Thesis:

Multiwinding Planar Transformer Parasitic Parameter Optimization

Cooperation with Company

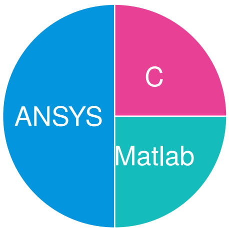
Requirements

Language
English/German

Theory
FEM ★★★★☆
Parasitic components ★★★★★
Multiwinding ★★★★★

Related Courses
DPEC

IT-Skills



Contact

Supervisor:
Fabian Groon
fagr@tf.uni-kiel.de
Hamzeh Beiranvand
hab@tf.uni-kiel.de
Prof. Marco Liserre

Project

ZIM Project with Company
Reese + Thies
Link for informations on company

November 11, 2022

Abstract

Planar transformers are highly important in high frequency applications, where power density is crucial, like electric vehicles, due to the lower and better control of the parasitic components. Multiwinding transformer face the problem that the control of parasitic components is complex, due to coupled magnetic leakage energy. This thesis tries to optimize the parasitic parameters in a multiwinding planar transformer.

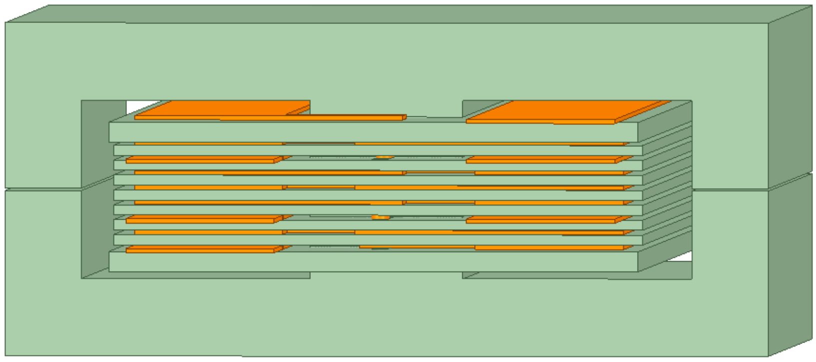


Figure 1: 3D-Model of a planar transformer in ANSYS

Background

Control of parasitic components in transformer is important to decrease the overall losses and to decrease the voltage spikes. The control of parasitic components in multiwinding transformer is more difficult than in non multiwinding transformers. Interleaving the windings in non multiwinding transformers usually lowers the leakage inductance, but this does not apply for multiwinding transformer. Finite element-based design is carried out to find the optimal parameter design with measurements in the lab of parasitic parameters.

Objectives

- Analytic approach for parasitic parameter optimization
- FEM design and optimization of multiwinding planar transformer
- Measurements of a planar transformer in the lab

Fraunhofer
ISIT

MSc. Thesis:

Comparative Analysis of DC/DC Converters for MW Charging Stations

Future Charging Station for electromobility

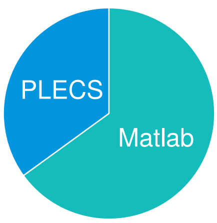
Requirements

Language
English

Theory
Power Converters ★★★★☆
Magnetics ★★★★☆
Power semiconductors ★★★★★

Related Master's Course
DPEC ★★★☆☆

Skills



Contact

Supervisor:
Thiago Pereira
tp@tf.uni-kiel.de
Prof. Marco Liserre

Project

Cooperation with ISIT@CAU
`www.isit.fraunhofer.de/ees`

Fraunhofer
ISIT

November 11, 2022

Abstract

The expansion of DC fast-charging network will enable a sustainable revolution by offering end-user a versatile choice to charge EVs for longer journeys. In this context, DC/DC Converters play a significant role in the design and operation of EV charging stations. In a power range of 25 kW to 100 kW using mostly SiC power devices, the comparison should further analyze the potential of large-scale isolated DC/DC converters using different devices.

Background

The existing electric power system is facing a transition phase from a centralized configuration toward a distributed architecture. Energy storage systems and renewable energy systems such as PV arrays can be incorporated into the FCS architecture to minimize the grid impacts due to MW charging. In this scenario, isolated multiport converters are used to establish the multisource integration.

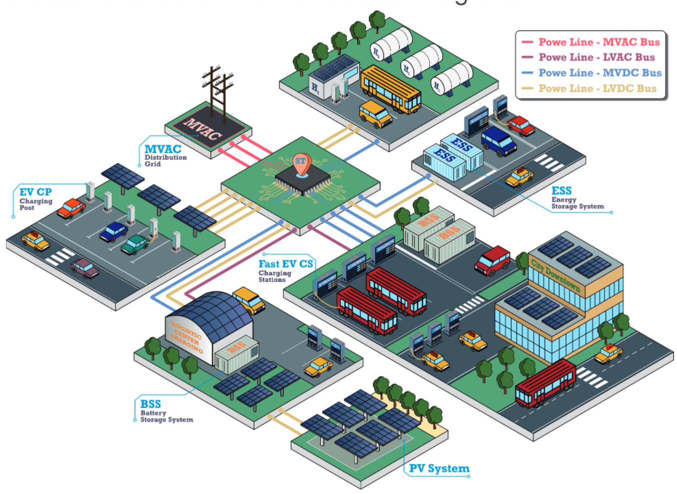


Figure 1: SST architecture considering the multiples EV charging stations and storage systems.

Objectives

The student will have to perform a comparative analysis of dc/dc converter for MegaWatt Charging Stations, considering the following objectives.

- Cluster the main topologies of isolated dc/dc converters
- Assessment of the isolated DC-DC Converter in terms of efficiency and cost
- Definition of the best interconnection among the converter in terms of number of modules, switching frequency, voltage and power level
- As an outcome, the student will acquire a solid knowledge of Isolated DC/DC Converter and analysis of power converters.

M.Sc. Thesis:

Kalman-Filter based Thermal Digital Twin of Power Semiconductors

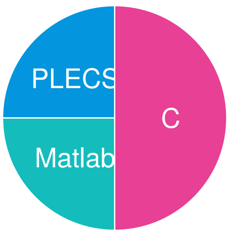
Digital Twin

Requirements

Language
English/German

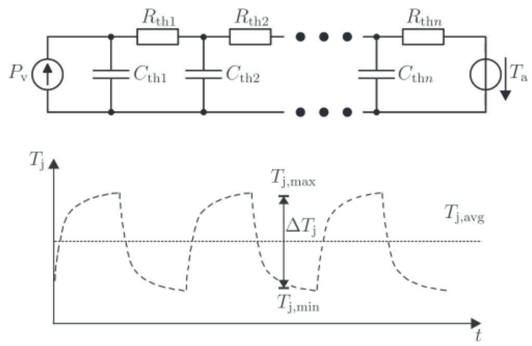
Theory
Digital Twins: ★★★★★
Reliability: ★★★★☆

IT-Skills



Abstract

The reliability of power electronic systems is of utmost importance for a save operation of the electrical grid. Assessing the junction temperature of power semiconductors and the thermal characteristics is essential for the reliability assessment. This thesis will focus on the design and realization of thermal digital twin which is based on a dual extended Kalman filter.



$$\hat{\boldsymbol{x}}_{k|k-1} = f(\hat{\boldsymbol{x}}_{k-1|k-1}, \boldsymbol{u}_k)$$
$$\boldsymbol{P}_{k|k-1} = \boldsymbol{F}_k \boldsymbol{P}_{k-1|k-1} \boldsymbol{F}_k^\top + \boldsymbol{Q}_k$$

$$\tilde{\boldsymbol{y}}_k = \boldsymbol{z}_k - h(\hat{\boldsymbol{x}}_{k|k-1})$$
$$\boldsymbol{S}_k = \boldsymbol{H}_k \boldsymbol{P}_{k|k-1} \boldsymbol{H}_k^\top + \boldsymbol{R}_k$$
$$\boldsymbol{K}_k = \boldsymbol{P}_{k|k-1} \boldsymbol{H}_k^\top \boldsymbol{S}_k^{-1}$$
$$\hat{\boldsymbol{x}}_{k|k} = \hat{\boldsymbol{x}}_{k|k-1} + \boldsymbol{K}_k \tilde{\boldsymbol{y}}_k$$
$$\boldsymbol{P}_{k|k} = (\boldsymbol{I} - \boldsymbol{K}_k \boldsymbol{H}_k) \boldsymbol{P}_{k|k-1}$$

Contact

Supervisor:
Johannes Kuprat
jk@tf.uni-kiel.de
Prof. Marco Liserre

November 18, 2022

Background

A digital twin consists of a real time simulation of the system and an optimization algorithm which is fitting the underlying model to optimally represent the physical system based on measurements on it. So, a digital twin can be seen as an observer with adaptive model, realizing the advantages of an observer, such as zero phase lag and noise filtering, as well as giving the possibility for condition monitoring of the system. The thermal behavior of power semiconductors is of high interest, because it is directly linked to their reliability and allows condition monitoring.

Objectives

- Design of a Dual Extended Kalman filter to realize a thermal digital twin.
- Tuning and testing in simulation.
- Implementation on a real time system in the laboratory.

MSc. Thesis:

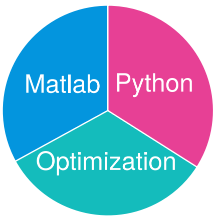
Optimal Design and Machine Learning based Power Management for an EV Charging Station with Energy Storage System

Requirements

Language
English

Theory
Power Converters ★★☆☆☆
Optimization ★★★★☆
Machine learning ★★★★☆

IT-Skills



Contact

Dr.-Ing Qian Xun
Dr.-Ing Junhyung Jung

Supervisor:
Prof. Marco Liserre

Project

ISIT@CAU

November 24, 2022

Abstract

The solid state transformer accomplishes integration to a medium-voltage grid and isolation to the charging ports without the use of a low frequency transformer. This thesis will focus on the quad active bridge (QAB) converter to integrate the utility grid, battery energy storage system (BESS), and two charging ports, as shown in Fig. 1. In the thesis, the mathematical models of the BESS, the QAB converter with multiwinding transformer (MWT), and the charged EVs should be established. The suitable optimization tool and machine learning method will be studied to design the sizing of the BESS and determine the power flow in the converter according to the charging time and the charging capacity of EVs.

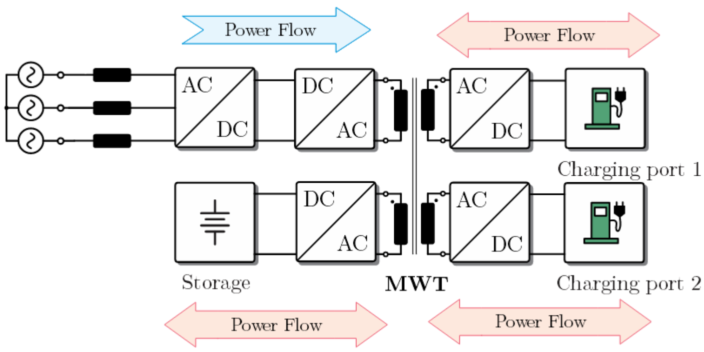


Figure 1: System configuration

Background

The application of EVs in the smart grid has shown a significant option to reduce carbon emission. However, due to the limited battery capacity, managing the charging and discharging process of EVs as a distributed power supply is a challenging task. The EV battery charging management system plays a main role in coordinating the charging and discharging mechanism to efficiently realize a secure, efficient, and reliable power system. More recently, there has been an increasing interest in data-driven approaches in EV charging modeling.

Objectives

- Outline the state of the art of EV charging stations, specifications and requirements of current charging stations
- Modelling of QAB based EV charging station, the power demand of the charged EVs, electricity prices over time, and the BESS
- Optimal sizing of BESS according to the charging demand
- Machine learning based power flow management between each port

Fraunhofer ISIT

MSc. Thesis:

P-HIL for Battery Lifetime Evaluation in E-Vehicles

Electromobility

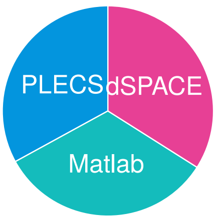
Requirements

Language
English

Theory
Batteries ★★★★★
Electric Drives ★★★★☆

Related Masters's Course
Batteries Technology ★★★★★
Electric Drives ★★★☆☆
MoCoPec ★★★☆☆

IT-Skills



Contact

Supervisor:
Dr. Sante Pugliese
sapu@tf.uni-kiel.de
Prof. Marco Liserre

November 14, 2022

Abstract

Ride safety and the handling capabilities of a car are contrasting goals when designing its suspension system. Mechatronic suspensions can ease this conflict by employing controlled force actuators between the wheels and the chassis. The actuators must be supplied, so harvesting and storaging the dissipated energy by the mechanical system becomes essential to achieve high efficiency. Road profile and suspension control tuning can have an impact on the storage system lifetime. Optimization of the actuator control parameters which take in account for both ride safety/handling and battery lifetime is essential in future e-vehicles.

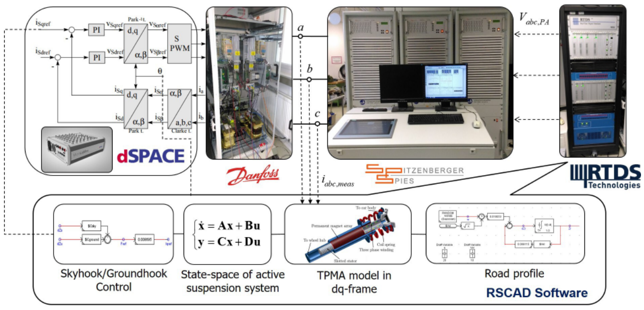


Figure 1: P-HIL active suspension setup

Background

The goal of this work is to investigate the impact of active suspension systems on the lifetime of the e-vehicle battery when driving in different road conditions. The hardware validation would need the realization of a laboratory quarter-car test rig, which is wasteful if the focus is on power electronics. Power hardware in the loop (P-HIL) simulation offers the possibility to connect a real-time simulation of the road profile, of mechanical and electrical components of a car with the hardware under test (HUT) through a power interface. Implementation of a P-HIL test bench with dSPACE real-time simulator is essential requirement for achieving the main goal.

Objectives

- Analysis on the impact of the road profile and suspension tuning on the battery lifetime;
- Implementation of a mechatronic suspension and its control in dSPACE real-time simulator.
- Implementation of a P-HIL test bench for testing the DC/AC power converter and for characterization of the battery lifetime.

External Cooperation

M.Sc. Thesis:

Condition monitoring using high frequency injection

Interdisciplinary research with the Chair of Microwave Engineering

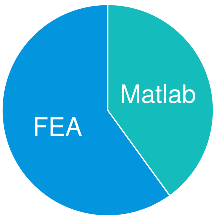
Requirements

Language
English/German

Theory
Component reliability: ★★★★☆
Wave theory: ★★★☆☆
Packaging technology: ★★☆☆☆

Related courses
Design of Power Elec.: ★★★★☆

IT-Skills



Contact

Supervisor:
Yoann Pascal, PhD
yoann.pascal@isit.fraunhofer.de
Dr.-Ing Frank Daschner
fd@tf.uni-kiel.de
Prof. Marco Liserre

Project

ISIT@CAU
isit.fraunhofer.de/ees

Fraunhofer ISIT

November 11, 2022

Abstract

Thermal cycling has been identified as the main cause for ageing in power electronics. Monitoring the state of health (SoH) of the system enables failure prediction and active maintenance strategies to increase lifetime and reduce repair- and downtime- costs.
The response under micro-wave excitation has been little investigated, although it showed great promises for SoH estimation.
This thesis will therefore investigate how measuring the impedance and S parameters of a power module online can help estimate its state of health.

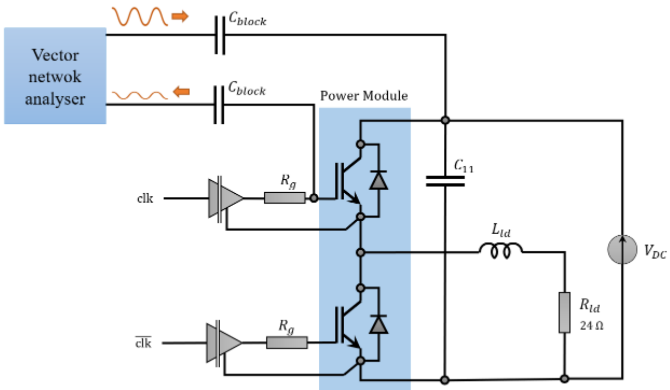


Figure 1: System overview: vector network analyser connected to a power module for online measurements

Background

Power electronics components and systems have limited lifetime and are prone to failure. In the meantime, power electronics is investing fields with increasing availability requirements, and where failures can induce very high costs (exploitation loss, repair costs, induced degradation or destruction of other sub-systems, etc.), and even be life critical.
As a matter of facts, fields such as renewables, heavy duty e-mobility, aerospace, industry, etc. require high availability power systems.

Objectives

- Modelling (CST-Microwave Studio) of a power module
- Simulation of the effect of ageing on the S-parameters of a power module
- Experimental validation: power converter testing and S-parameter measurements

M.Sc. Thesis:

Machine Learning Techniques for Battery Parameter Estimation

Collaboration with Department of Computer Science

Requirements

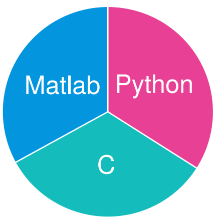
Language
English

Theory
Li-ion Batteries ★★★☆☆
Machine Learning ★★★★☆
Parameter Estimation ★★★★☆

Lab Work
Battery Tests ★★☆☆☆

Relevant Courses:
Battery Technologies

IT-Skills



Contact

Supervisors:
Dr.-Ing. Hamzeh Beiranvand
hab@tf.uni-kiel.de
Prof. Olaf Landsiedel
Prof. Marco Liserre

Project

BAEW: Laboratory for Reliable Battery-based Energy Conversion
Project website link

November 11, 2022

Abstract

Lithium Ion (Li-ion) batteries has became the main technology for electric vehicles and in larger scale e-mobility. Li-ion will also play a key role in energy transition. State Schleswig-Holstein (SH) hosts many small and large industries related to battery products and the presence of Northvolt will make SH a pioneer for Li-ion batteries. To perfectly exploit Li-ion batteries, precise estimation of battery performance parameters such as state of charge (SOC) and state of health (SOH) are inevitable. Machine learning could benefit from the physical models and also enormous data collected during battery operation locally or in a cloud system to solve this challenging problem. Therefore, the aim of this thesis is to bridge the gap between batteries and machine learning methods for industrial applications.

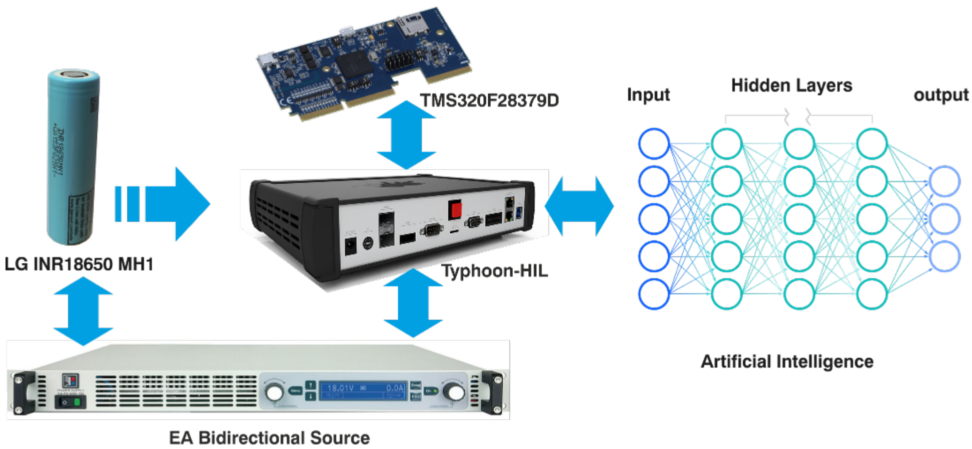


Figure 1: Laboratory setup for battery testing at the chair of power electronics.

Background

There is an growing interest in the e-mobility industry to utilize artificial intelligence and machine learning techniques to improve the performance of their products. I would highly recommends this thesis for the students who are interested in battery technologies and machine learning and want to follow this topic in industry or academia.

Objectives

After you successfully completed this thesis, you will be able to:

- Battery testing using HIL
- Implementing machine learning techniques for battery parameter estimation
- Optimize the training of machine learning mehtods

MSc. Thesis:

Advanced FPGA-based gate drive with controllable slope

Collaboration with Danfoss Drives A/S

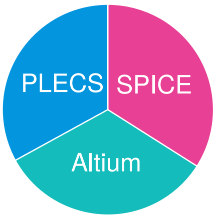
Requirements

Language
English/German

Theory
Power Electronics ★★★★☆
Thermal analysis ★★★☆☆

Relevant Courses
DPEC ★★★★★
Electric Drives ★★★☆☆

IT-Skills



Contact

Karthik Debbadi
kde@tf.uni-kiel.de
Radu Dan Lazar
Danfoss Drives A/S

Supervisor:
Prof. Marco Liserre

Project

PE-Region Platform - Interreg
https://www.pe-regionplatform.eu/en_GB/

November 24, 2022

Abstract

The traditional gate-drives are relatively simple (see figure). The turn on/off slope is controlled by means of the gate resistor R_g (or resistors) and the gate-emitter capacitance C_{GE} (Miller effect). The turn on gate time τ is a function of gate resistor and gate-emitter capacitance. An alternative to the circuit could be using an FPGA to control the charging/discharging gate-emitter capacity (and inherently the turn on/off times) or even the turn on/off profiles. This can give the possibility for an easy change of the power module to another brand (if pin compatible) without changing the layout. Moreover, it can offer the possibility of changing the slope according to the system conditions like motor cable length. Today the gate-driver is fixed "tuned" for the specified motor cable for the drive (fx. 150m for shielded cable). If the system is having a short motor cable (fx. 5m) the turn on/off time could be readjusted and consequently the inverter nonlinearities reduced. The consequence is getting an optimized system with reduced harmonics and losses.

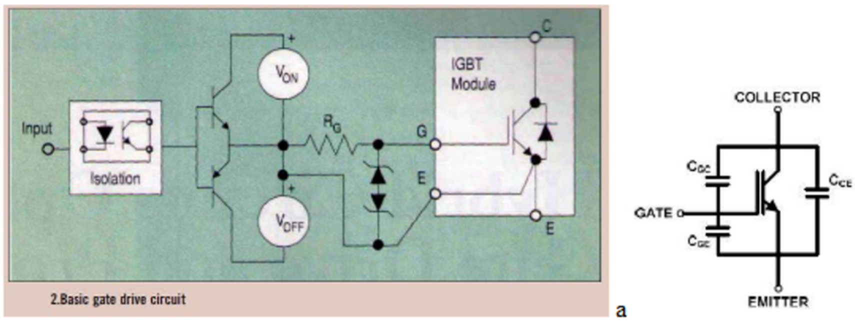


Figure 1: Standard (simple) gate drive and the Power switch model

Objectives

The main objective of this project is to design such gate drive and implement in a FPGA the necessary control. Detailed objectives:

- Model the switch
- Design the gate driver
- Proof of concept by simulation
- Proof of concept in the lab (experimental validation)

M.Sc. Thesis:

Multiwinding Planar Transformer Parasitic Parameter Optimization

Cooperation with Company

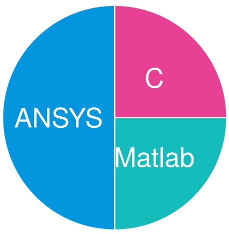
Requirements

Language
English/German

Theory
FEM ★★★★☆
Parasitic components ★★★★★
Multiwinding ★★★★★

Related Courses
DPEC

IT-Skills



Contact

Supervisor:
Fabian Groon
fagr@tf.uni-kiel.de
Hamzeh Beiranvand
hab@tf.uni-kiel.de
Prof. Marco Liserre

Project

ZIM Project with Company
Reese + Thies
Link for informations on company

November 11, 2022

Abstract

Planar transformers are highly important in high frequency applications, where power density is crucial, like electric vehicles, due to the lower and better control of the parasitic components. Multiwinding transformer face the problem that the control of parasitic components is complex, due to coupled magnetic leakage energy. This thesis tries to optimize the parasitic parameters in a multiwinding planar transformer.

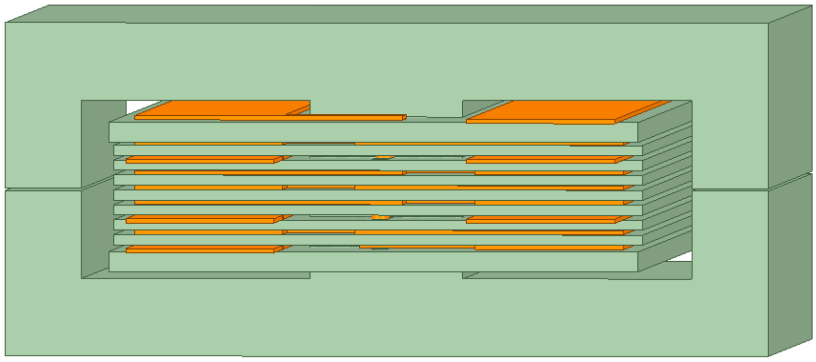


Figure 1: 3D-Model of a planar transformer in ANSYS

Background

Control of parasitic components in transformer is important to decrease the overall losses and to decrease the voltage spikes. The control of parasitic components in multiwinding transformer is more difficult than in non multiwinding transformers. Interleaving the windings in non multiwinding transformers usually lowers the leakage inductance, but this does not apply for multiwinding transformer. Finite element-based design is carried out to find the optimal parameter design with measurements in the lab of parasitic parameters.

Objectives

- Analytic approach for parasitic parameter optimization
- FEM design and optimization of multiwinding planar transformer
- Measurements of a planar transformer in the lab

MSc. Thesis:

Lifetime estimation of power electronics based on field mission profile

Collaboration with Nüwiel

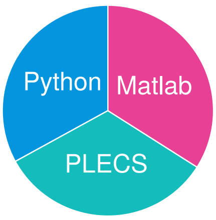
Requirements

Language
English/German

Theory
Power Electronics ★★★★☆
Thermal analysis ★★★☆☆

Relevant Courses
DPEC ★★★★★
Electric Drives ★★★☆☆

IT-Skills



Contact

Karthik Debbadi
kde@tf.uni-kiel.de
Lorenz Hopfmüller
Nüwiel

Supervisor:
Prof. Marco Liserre

November 24, 2022

Abstract

As e-mobility becomes more mainstream, there will be challenges to improve the reliability and reduce cost of the electric drive train in the applications. It is important to perform reliability studies based on the mission profiles to estimate the lifetime. Temperature swing is one of the crucial contributor to the ageing in the power electronics used in these applications and inturn to the reliability. Based on the mission profiles, it is vital to define the thermal profile to perform accelerated ageging tests to provide reasonable estimate for the lifetime of the application power electronics.

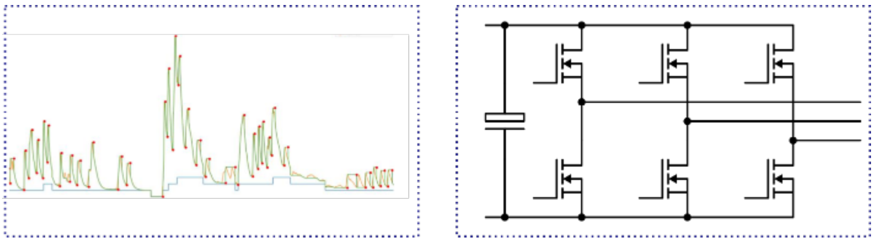


Figure 1: Field Mission profile and 3-phase inverter

Background

NÜWIEL is an award-winning Hamburg based start-up developing electric transportation solutions for last mile logistics. NÜWIEL vision is to improve air quality in big cities and reduce negative impact of traffic emissions on cities, environment and public health by providing an alternative mobility: intelligent electric bike trailers. By improving the lifetime of the power electronics, it could lead to better utilization of the system, overall improvement in reliability and possible cost savings.

Objectives

- Research power electronics aging effects (thermal load, thermal cycling,...)
- Extract mission profiles from field log data
- Create scientifically based model for estimating field lifetime
- Define accelerated test cycles for ensuring the desired reliability

Fraunhofer ISIT

M.Sc. Thesis:

Parallel-Connected Converter for High Power Variable Frequency Drives

Cooperation with Danfoss Drives

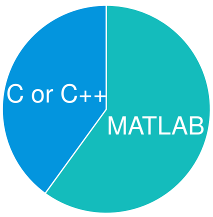
Requirements

Language
English

Theory
Power converter ★★★★★
Electric machine ★★☆☆☆

Master Course
DPEC ★★★★☆

IT-Skills



Contact

Supervisor:
Jun-Hyung Jung
jj@tf.uni-kiel.de
Prof. Marco Liserre

Project

Cooperation with Danfoss Drives

November 24, 2022

Abstract

The main scope of this thesis is to design, develop, and implement three-phase parallel-connected inverters for high power drives. The main focus will be the minimization of losses in the overall inverter system by suppressing the circulating current with a special modulation scheme, control algorithm and coupled inductor design.

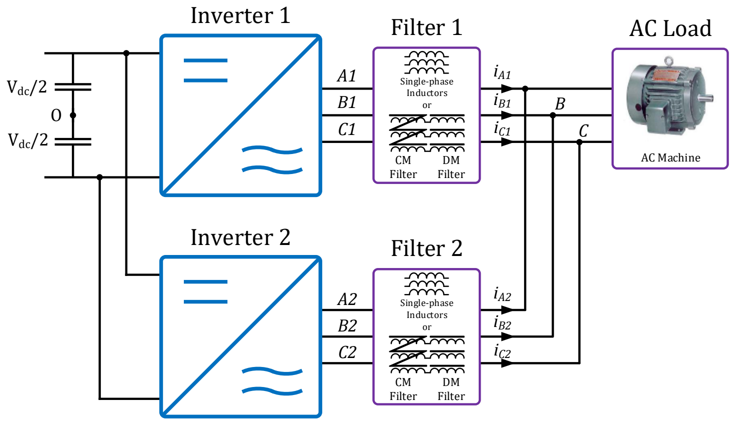


Figure 1: Parallel Connected Inverter for high-power ac machine

Background

Parallel-connected VFDs modules for realizing high power drive have several advantages, such as low current ripple, modularity, improved thermal management, increased power capability, redundancy, easy maintenance etc. The parallel connected voltage source inverters (VSIs) have common dc-link, ac sides are connected through inductors, and the common-point is connected to load. The parallel connected VSIs should be operated ideally using the modulating reference signals having same frequency, phase, amplitude, and uniform modulation. However, the parallel connected VSIs are conventionally modulated using interleaved carrier signals to reduce the ac side harmonic distortion and line current ripple. This interleaving of carrier signals introduces an instantaneous common-mode (CM) voltage difference between the VSIs. Due to this CM voltage difference, a circulating current flows between the VSIs. This circulating current flow is restricted using common-mode inductors, coupled inductors, or integrated inductors.

Objectives

- Design the inductor effective in reducing the circulating current.
- Implement suitable modulation strategy and control systems, which minimizes the overall losses in the drive system.