Advanced Mechatronic
Systems Group

Advanced Mechatronic Systems Group (AMS)

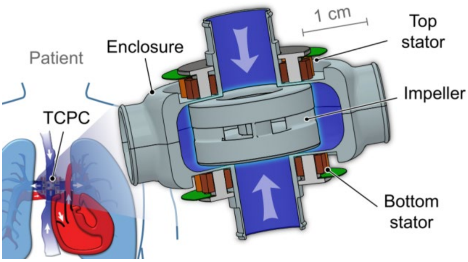
FS 2025

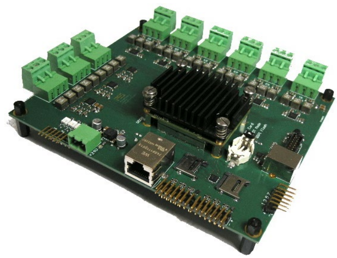
Bachelor Projects
Semester Projects
Master Theses

www.pes.ee.ethz.ch/education
www.ams.ee.ethz.ch/education (as of 2025)

Bachelor Project / Semester Project / Master Thesis FS 2025

Design and Realization of an Ultra-Compact Motor Inverter for Implantable Artificial Hearts





Novel total artificial hearts (TAH) or ventricular assist devices (VAD), i.e., blood pumps, can be implanted in conjunction with a transcutaneous energy transfer system (TET). This creates the need for an ultra-compact implantable motor inverter with high efficiency. The main challenges are the size constraints for pediatric applications as well as the strict limit on allowable heating of tissue inside of the human body.

Most of the current mechanical circulatory support systems use a percutaneous driveline and place the motor inverter outside of the human body. The use of a TET eliminates the driveline and the associated risks for infections but makes it necessary to place the motor inverter inside of the body. Magnetically levitated TAHs or VADs use multiple sensors and an increased number of individually controlled motor phases. This further accentuates the need of an implantable inverter system to reduce the number percutaneous drive lines. In addition, such a system poses high requirements regarding functional safety and EMI compliance. In the scope of this thesis, the lower size limits for multiphase inverters including output filters and control circuitry are explored. Then, an optimal prototype is designed, commissioned, and characterized regarding power loss and EMI compliance. ■

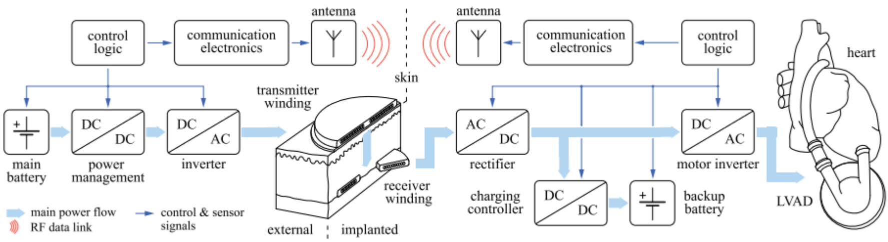
Type of Work: 20% FEM & circuit simulation / 50% hardware realization / 20% measurements / 10% report & documentation

Prerequisites: Lectures in power electronic systems / interest in hardware design / initial hardware experience is a plus

Contact: Andreas Horat, ETL H 14, horat@ams.ee.ethz.ch

Bachelor Project / Semester Project / Master Thesis FS 2025

Realization and Characterization of a Transcutaneous Energy Transfer System



Percutaneous drivelines are the major cause for infections after implanting a mechanical circulatory support system (e.g., a ventricular assist device or a total artificial heart). Inductive power transfer systems are a promising alternative. The main challenges are the heating of the tissue and the limited allowed power dissipation for implanted power electronics.

There are currently no commercially available transcutaneous energy transfer (TET) systems. Based on the work previously done at the Power Electronic Systems Laboratory of ETH Zürich, the goal is to develop an improved TET system utilizing the latest (semiconductor) technologies to reduce power losses and mechanical dimensions. The project starts with thoroughly understanding the previously developed TET system and the current state of research. Based on that, an improved system will be designed using multi-objective optimization based on MATLAB and 2D/3D FEM simulations. Based on this optimization, a hardware prototype is designed and built. Finally, you will verify the performance of the developed system including measurements of power losses and tissue heating. ■

Type of Work: 30% FEM & circuit simulation / 40% hardware realization / 20% measurements / 10% report & documentation

Prerequisites: Lectures in power electronic systems / interest in hardware design / initial hardware experience is a plus

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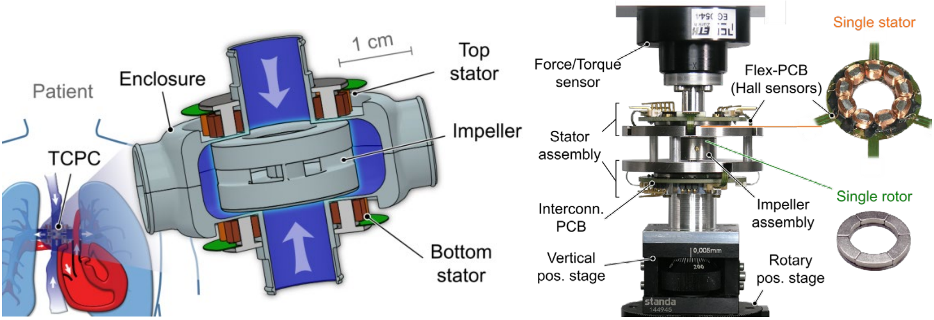
Advanced Mechatronic Systems Group

Bachelor Project / Semester Project FS 2025

Design and Realization of an Acceleration Test Stand for Magnetically Levitated Blood Pumps



Total artificial hearts (TAH) or ventricular assist devices (VAD) for pediatric applications are exposed to high accelerations due to patient movements. For the magnetically levitated system currently under development at ETH Zurich, an acceleration test bench to emulate the acceleration/force profiles acting on the TAH/VAD during operation is needed.

Total artificial hearts (TAH) or ventricular assist devices (VAD) for pediatric application are exposed to high accelerations because of patient movements. While conventional mechanically supported systems are inherently immune to these disturbances, this is not the case for magnetically levitated rotary blood pumps (RBPs). The magnetically levitated RBP currently under development at ETH Zurich must therefore be tested under realistic acceleration profiles. These profiles will be provided by the project partner from the Medical University of Vienna.

A testbench for the magnetically levitated RBP should be designed, which is capable of emulating these acceleration profiles. After building the testbench, it should be verified using commercially available acceleration sensors. ■

Type of Work: 10% Research of state of the art / 40% investigation of acceleration data / 30% hardware realization / 10% measurements / 10% report & documentation

Prerequisites: Initial hardware experience is a plus

Contact: Andreas Horat, ETL H 14, horat@ams.ee.ethz.ch

Semester Project / Master Thesis FS 2025

Commissioning and Further Development of the ShuttlePump

An electric drive system for the ShuttlePump, a new concept for an artificial implantable heart, was developed during the last years. The fully manufactured pump prototype is now available for completing the commissioning and the detailed assessment of the electric and hydrodynamic properties.

The Shuttle pump is a novel linear-rotary blood pump. This total artificial heart works with a piston, which pumps in linear direction and opens and closes the valves by rotating the piston. The tubular linear actuator is paired with a modified rotary actuator using only a fraction of the usual permanent magnets.
An eddy current based position sensor is used to measure the linear and rotational position. A functional prototype of the drive system was designed and built during a previous PhD thesis. Based on this prototype, multiple final pump demonstrators were manufactured. The goal of this project is to fully commission these demonstrators at ETH Zurich and afterwards assess the hydrodynamic performance in collaboration with the Medical University of Vienna. ■

Type of Work: 10% Documentation study / 80% hardware commissioning and measurements / 10% report & documentation

Prerequisites: Experience in power electronics and electric machines / VLSI 1 and embedded software is a plus

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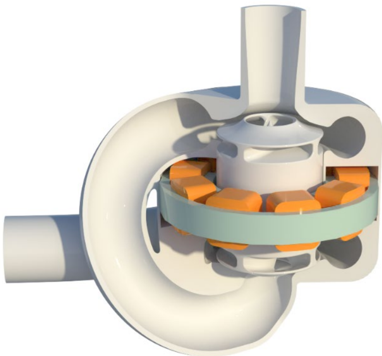
Advanced Mechatronic Systems Group

Bachelor Project / Semester Project / Master Thesis FS 2025

Commissioning and Characterization of an Electric Machine for a Two-Stage Rotary Blood Pump



A novel award winning dual-stage pump is developed at the Medical University of Vienna and at ETH Zurich, where the focus is on the development of a corresponding miniature electric motor. The task of this semester thesis is the characterization of the electric motor which will later be used in the two-stage pump.

A suitable miniature machine has already been designed and partially manufactured. The scope of this thesis is to complete the mechanical design of the electric machine and adapt an existing motor testbench to incorporate the new machine. Then, the machine is characterized in detail using high-resolution torque and force sensors. An existing converter is repurposed and adapted to drive this machine. In a second step, a sensor system for the measurement of the radial and rotational rotor position is designed, built, and experimentally evaluated. Optionally, a sensorless control algorithm shall be implemented. ■

Type of Work: 20% Embedded software / 10% hardware realization (CAD/ECAD) / 60% measurements / 10% report & documentation

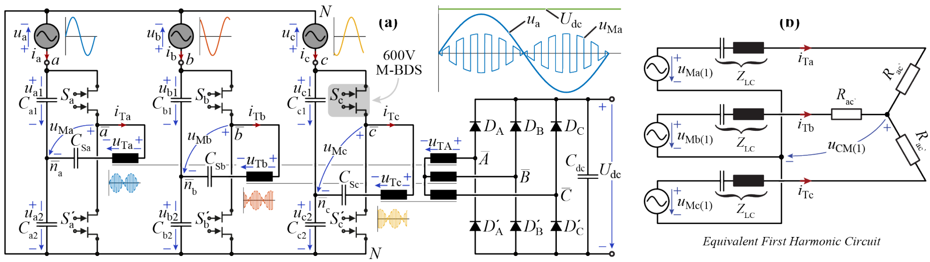
Prerequisites: Experience or lecture in power electronics and electric machines / VLSI 1 and embedded software is a plus

Contact: Andreas Horat, ETL H 14, horat@ams.ee.ethz.ch

Advanced Mechatronic Systems Group

Bachelor Project / Semester Project / Master Thesis FS 2025

Design of a Single-Stage Isolated Natural Ohmic Mains Behavior Fixed Voltage Transfer Ratio Three-Phase Rectifier



In the above converter topology, the series-resonant compensation of the transformer leakage inductance and operation of the system at the resonance frequency results in a load-independent dc output voltage, directly defined by the grid voltage amplitude, and natural ohmic mains behavior, i.e., sinusoidal input currents, without any closed-loop control.

Circuit simulation and mathematical analysis demonstrate that this isolated Y-rectifier with a DCX-like operation (iYRx), maintains a constant output voltage with a fixed voltage ratio relative to the three-phase grid voltage input. Unlike conventional designs, it achieves this with a three-phase grid input, sustaining natural ohmic mains behavior without requiring active control. This simplicity promises a robust design; however, preliminary investigations reveal a significant sensitivity to asymmetries in the transformer leakage inductances caused by manufacturing imperfections. To address this, transformers will be designed and fabricated with precisely tuned leakage inductances using low-variability manufacturing techniques, such as PCB windings. These transformers will then be integrated into either an existing or newly developed hardware design, depending on the project timeline. Finally, system commissioning will enable measurements and waveform captures to validate the iYRx's operating principles. ■

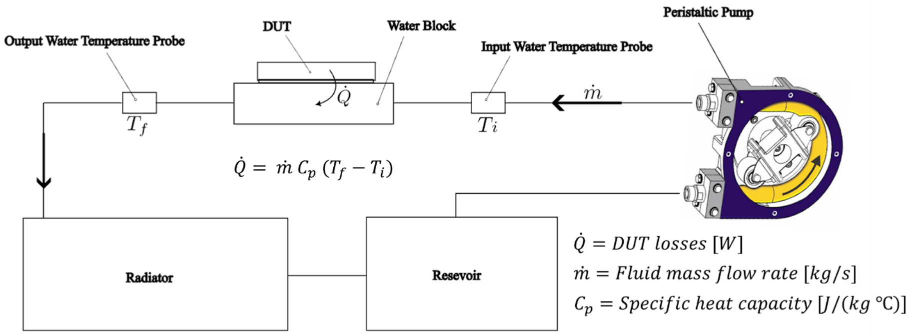
Type of Work: 20% Transformer analysis and design / 45% hardware & software realization / 20% measurements / 15% report & documentation

Prerequisites: Lectures in power electronic systems / interest in hardware design / initial hardware experience is a plus

Contact: Sven Weihe, ETL H18.1, weihe@ams.ee.ethz.ch

Bachelor Project / Semester Project / Master Project FS 2025

Development of a MATLAB Integrated Automated Calorimetric Switch Loss Measurement Setup



Calorimetric measurement methods are necessary to accurately characterize the switching losses of fast-switching SiC or GaN transistors. In this project, you will design and build a fully automated test stand using a proposed calorimetric method that significantly reduces the measurement time.

The above approach has been validated, but to enhance usability, the setup should be upgraded with new PCBs, including a logic board with a microcontroller to provide gate signals and driver supply voltages to a swappable daughter card carrying the power transistors under test in a half-bridge configuration. Testing new power transistors will then require only a new daughter card. Additionally, an existing temperature measurement board should be improved for robustness against electromagnetic interference caused by the high-frequency switching of the half-bridge transistors. A MATLAB software will enable automated measurements by controlling the hardware to adjust gate signals, reconfigure the circuit with relays, manage supply voltage/current to the half-bridge, and capture temperature and current data to evaluate switching losses of the device under test. ■

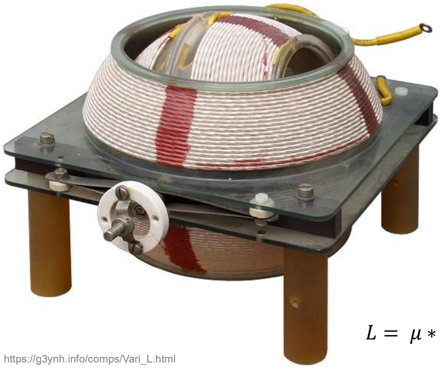
Type of Work: 10% Error analysis and operating principal investigation / 55% hardware & software realization / 20% measurements / 15% report & documentation

Prerequisites: Lectures in power electronic systems / interest in hardware design / initial hardware experience is a plus

Contact: Sven Weihe, ETL H18.1, weihe@ams.ee.ethz.ch

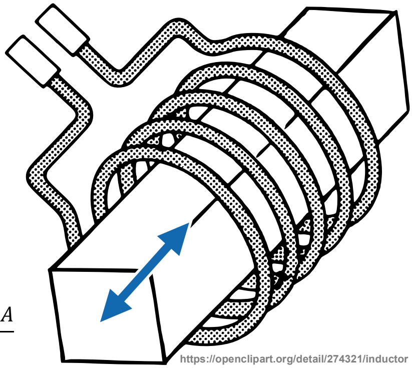
Bachelor Project / Semester Project FS 2025

Design and Construction of a Remotely Controlled Variable Power Inductor



https://g3ynh.info/comps/Vari_L.html

$$L = \mu * \mu_0 * \frac{N^2 * A}{l}$$



https://openclipart.org/detail/274321/inductor

Accurate soft-switching loss measurements require a wide range of inductances to evaluate switching losses at various turn-on currents. Using a discrete set of inductances is inefficient and time-consuming, making a high-current variometer with mechanically adjustable inductance a more desirable solution especially when considering the possibility of remote adjustment via a MATLAB script.

In this project first the means of constructing a variable inductor are to be investigated based on the two principles shown above. In the first the magnetic coupling between two series connected spherical windings can be adjusted to vary the inductance while in the second the magnetic core is moved linearly in and out of the coil to vary the inductance. Given the targeted specifications of the variable inductor, FEM simulations should be used to evaluate the best solution and facilitate the design of the variable inductor. To enable integration into an automated switch-loss measurement setup, mechanical adjustment should be precisely controlled, ideally in a closed-loop system with real-time position feedback, using a servo or stepper motor interfaced with a microcontroller, allowing a fine-tuned selection of the inductance from a MATLAB script. ■

Type of Work: 20% Research & FEM simulations / 60% hardware realization / 5% measurements / 15% report & documentation

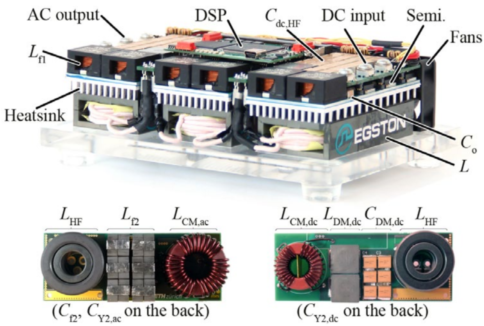
Prerequisites: Lectures in power electronic systems / interest in hardware design / initial hardware experience is a plus

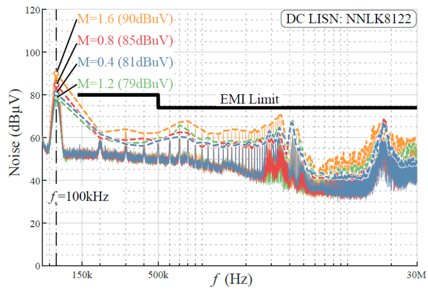
Contact: Sven Weihe, ETL H18.1, weihe@ams.ee.ethz.ch

Advanced Mechatronic Systems Group

Semester Project / Master Thesis FS 2025

Design and Testing of a Hybrid EMI Input Filter for a Three-Phase Inverter





In this project, you will design and characterize a hybrid EMI filter topology. This involves first understanding the underlying theory and then implementing a promising hybrid EMI input filter concept for a three-phase inverter. Ultimately, the goal is to develop and test the EMI filter and evaluate the performance by comparing it to measurement results from other filter topologies.

Electromagnetic compatibility (EMC) is essential in any power electronic converter. To comply with international standards, electromagnetic interference (EMI) mitigation is crucial. EMI filters attenuate unwanted high-frequency noise emission at the input and/or output ports to acceptable levels and thus prevent disruption of other nearby devices. EMI filters can be built with passive components only or can also feature active components. In this project, you will first familiarize yourself with EMI filter theory (modeling, measurement methods, standards), and then you will implement a promising hybrid filter concept, featuring both active and passive components. Finally, you will test your filter with an existing inverter and compare your results with previous measurement results featuring various filter topologies. ■

Type of Work: 20% Literature review & circuit simulation / 30% hardware design & commissioning / 40% measurements / 10% report & documentation

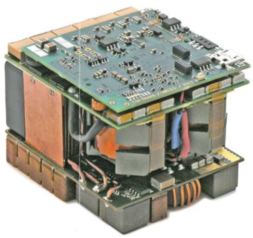
Prerequisites: Lecture in design of power electronic systems / interest in hardware design and characterization / initial hardware experience is a plus

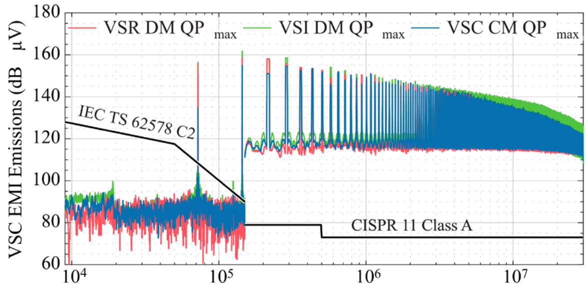
Contact: Rahel Herzog, ETL H 17, herzog@ams.ee.ethz.ch

Advanced Mechatronic Systems Group

Semester Project / Master Thesis FS 2025

Design and Testing of Ultra-Compact EMI Filters for Variable Speed Drives





In this project, you will optimize and characterize EMI filters for Variable Speed Drives (VSDs). This involves first understanding the underlying theory and then identifying optimal EMI filter concepts for three-phase VSDs, including novel concepts. Finally, the goal is to develop and test an EMI filter for an ultra-compact VSD demonstrator.

Electromagnetic interference (EMI) filters are essential components in any power electronic converter, which attenuate unwanted high-frequency noise emissions from the input and/or output ports to very low levels according to applicable international standards, thereby preventing disruption of other nearby devices. Designing EMI filters is not a trivial task; especially when optimizing for gravimetric or volumetric power density without compromising efficiency and attenuation performance. Further, EMI filters can be built with passive components only and/or feature active components.

In this project, you will first familiarize yourself with EMI filter theory (modeling, measurement methods, standards), and then you will optimize various EMI filter concepts for a three-phase VSD, targeting minimum size and losses. Finally, you will design and build a representative test setup and experimentally characterize selected filter variants. ■

Type of Work: 30% Literature review, circuit simulation / 30% hardware design and commissioning a test setup / 30% design and characterization of EMI filter prototypes / 10% report & documentation

Prerequisites: Lecture in power electronic systems / interest in software / initial hardware experience is a plus

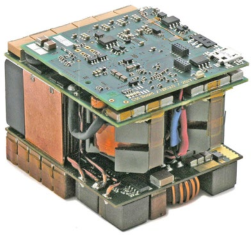
Contact:

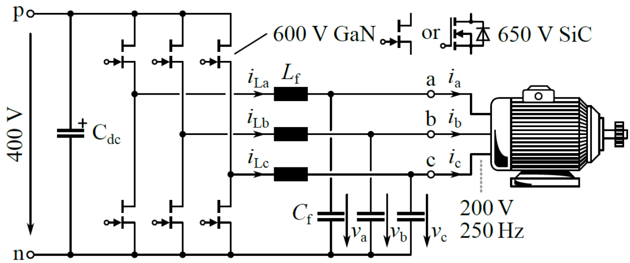
Luc Imperiali, ETL H 18.1, imperiali@ams.ee.ethz.ch
Rahel Herzog, ETL H 17, herzog@ams.ee.ethz.ch

Advanced Mechatronic Systems Group

Master Thesis FS 2025

Design and Realization of an Ultra-Compact Variable Speed Drive Demonstrator





In this project, you will design, realize, and commission an ultra-compact Variable Speed Drive (VSD) demonstrator. By leveraging a multi-objective optimization approach in MATLAB, focusing on efficiency and reduced material usage, the goal is to develop a highly integrated ultra-compact VSD with minimum environmental footprint.

In the modern industrial landscape, the demand for efficiency, precision, and compactness in machinery and equipment is ever-increasing. This trend is further amplified by the growing need for devices with a low embodied carbon footprint, driven by the global goal of achieving net-zero greenhouse gas emissions by 2050.Variable speed drives (VSDs) have emerged as a critical technology in this context, as 45% of all electric energy used worldwide is transformed into mechanical work by electrical motors. Designing an ultra-compact VSD comes with significant challenges, as they must be highly integrated and very efficient at the same time. An ultra-compact design of a VSD, however, could reduce the material usage during the manufacturing phase, contributing to a lower carbon footprint and environmental impact. First, you will familiarize yourself with three-phase VSDs and the existing optimization framework in MATLAB, in particular also with the modeling of environmental impacts. Then, you will consider cutting-edge techniques for ultra-compact realizations to design, construct, and commission a 2.5 kW demonstrator system. ■

Type of Work: 10% Literature review, circuit simulation / 50% hardware considerations and optimization / 30% hardware realization and testing / 10% report & documentation

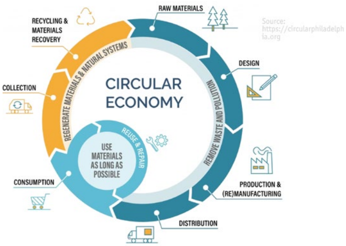
Prerequisites: Lectures in power electronic systems / interest in hardware design / initial hardware experience is a plus

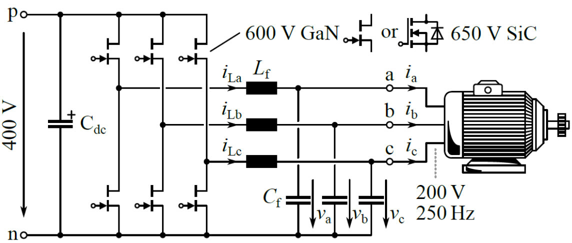
Contact: Luc Imperiali, ETL H18.1, imperiali@ams.ee.ethz.ch

Advanced Mechatronic
Systems Group

Master Thesis FS 2025

Design and Realization of a Circular Economy Compatible 2.5 kW Variable Speed Drive





To achieve net-zero greenhouse gas emissions by 2050 and address resource limitations, future power electronic converters must align with circular economy principles. These designs should enable easy repair, reuse, and recycling at the end of life. In this project you will focus on these aspects when designing and realizing a modular 2.5 kW variable speed drive (VSD).

With the aim of achieving net-zero greenhouse gas emissions by 2050 and recognizing the finite availability of natural resources, future power electronic converter designs must be compatible with a circular economy. To achieve this goal, future converters must be designed for ease of repair, (partial) reuse, and/or recycling at the end of life. Disassembling of electronic components is a challenge, thus it is of key importance that the end-of-life is already considered in the design phase. In contrast to today's often highly integrated power converters stands a fully modular approach which enhances repairability, as defective submodules and/or components can easily be replaced, and further ensures straightforward disassembly, such that certain long-living components can be reused again. In this project, you will familiarize yourself with circular economy concepts and the repairability, reusability and recyclability of power electronic converters. You will then study what criteria for modularization, e.g., functional, lifetime, component values, etc. is most suitable to design such a circular economy friendly converter. Then you will design and realize a 2.5 kW VSD prototype to experimentally verify your findings. ■

Type of Work: 10% Literature review, circuit simulation / 40% hardware considerations and optimization / 40% hardware realization / 10% report & documentation

Prerequisites: Lectures in power electronic systems / interest in hardware design / initial hardware experience is a plus

Contact: Luc Imperiali, ETL H18.1, imperiali@ams.ee.ethz.ch

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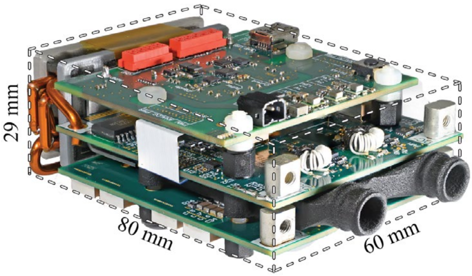
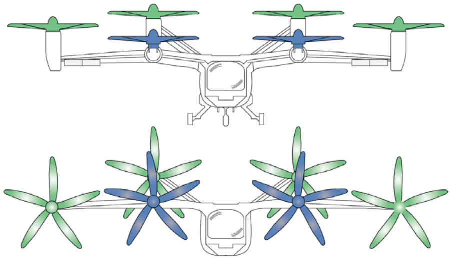
Bachelor Project / Semester Project / Master Thesis FS 2025

Design and Realization of a Lightweight Cryogenic DC-DC Converter for Airborne Applications





This thesis investigates the gravimetric power density limits of a buck-boost dc-dc converter at cryogenic temperatures through multi-objective optimization. Initially, the behavior of power electronic components at cryogenic temperatures is studied and then implemented in a multi-objective optimization framework. Finally, a 15 kW prototype shall be built to validate the results.

Due to stringent weight requirements, future all-electric aircraft may utilize a hybrid electric propulsion system. A hydrogen fuel cell (FC) provides high energy density and a battery the peak power for take-off and climbing. As the FC and the battery voltages vary in large overlapping ranges, a dc-dc converter with buck-boost capability is needed. Liquid hydrogen is stored at cryogenic temperatures, which allows to cool parts of the powertrain accordingly. For example, the conductivity of copper increases by about a factor of 10 at 77 K, reducing conduction losses in, e.g., magnetic components, and hence enables potentially smaller, lighter, and more efficient converter systems.

In this thesis, you will clarify the limits of gravimetric power density of a cryogenic buck-boost dc-dc converter by means of a multi-objective optimization (MOO). First, you will familiarize yourself with cryogenic power electronics and an MOO framework. Based on the optimization results, you will design and realize a 15 kW buck-boost dc-dc converter to experimentally verify your findings in a cryogenic environment. ■

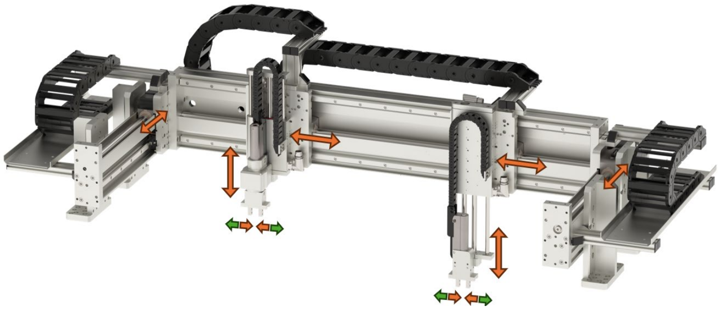
Type of Work: 20% Literature review, circuit simulation / 20% multi-objective optimization (MATLAB) / 50% hardware design and realization / 10% report & documentation

Prerequisites: Lectures in power electronic systems / interest in hardware design / initial hardware experience is a plus

Contact: Luc Imperiali, ETL H18.1, imperiali@ams.ee.ethz.ch

Bachelorarbeit / Semesterarbeit / Masterarbeit FS 2025

Systemanalyse mit Linearmotoren



In industriellen Mehrachsensystemen können mechanische Kopplungen und begrenzte Steifigkeiten zu unerwünschtem Betriebsverhalten führen. Es soll ein Systemanalyse-Tool entwickelt werden, das mithilfe der integrierten Servomotoren automatisierte Messungen durchführen sowie positionsabhängige mechanische Kopplungen und Schwingneigungen ermitteln, analysieren und visualisieren kann.

In industriellen Applikationen werden häufig Mehrachsensysteme eingesetzt. Durch die mechanischen Verbindungen und deren begrenzte Steifigkeit können die Aktions- und Reaktionskräfte der Motoren zu unerwünschten Kopplungen zwischen den Achsen und zu mechanischen Schwingungen im System führen. Zur Systemanalyse bietet es sich an, gleich die im System verbauten Servomotoren mit integrierter Positionserfassung zu verwenden (in der vorliegenden Arbeit hauptsächlich Linearmotoren). Dazu müssen diese geeignet angeregt und die resultierenden Bewegungen gemessen und analysiert werden.

In dieser Arbeit soll ein Tool entwickelt werden, mit dem bei einem Mehrachssystem eine Systemanalyse durchgeführt werden kann. Im Zentrum steht die Ermittlung der Schwingneigung des mechanischen Aufbaus als auch die mechanische Kopplung zwischen den Achsen. Das Tool soll in einem vorliegenden Aufbau Messungen bei verschiedenen Positionen und Frequenzen automatisiert durchführen können und die analysierten Daten geeignet visualisieren.

Die Arbeit wird in Zusammenarbeit mit der Firma NTI AG (www.LinMot.com) in Spreitenbach durchgeführt. ■

Type of Work: 55% Softwareentwicklung (LabView) / 45% Systemanalyse und Messtechnik / 10% Dokumentation

Prerequisites: Interesse an Hardwareentwicklung und Antriebstechnik

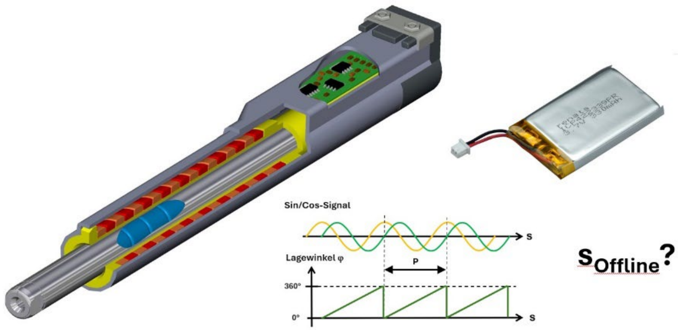
Contact: Dr. Daniel Ausderau, LinMot, daniel.ausderau@linmot.com

Advanced Mechatronic Systems Group

LinMot®

Bachelorarbeit / Semesterarbeit FS 2025

Absolute Positionssensorik für Linearmotoren



Um die absolute Position bei Linearmotoren im ausgeschalteten Zustand auch bei Bewegung aktuell halten zu können, soll eine integrierbare Lösung mit Akku und Ultra-Low-Power-Sensorik für eine lange Betriebszeit realisiert werden. Vorgängig sind verschiedene Schaltungskonzepte zu evaluieren.

Wird bei permanenterregten Synchronlinearmotoren das periodische Erregerfeld für die Positionserfassung verwendet (sin/cos-Auswertung), fehlt beim Einschalten die Information der absoluten Position, was jeweils eine Initialisierungsbewegung erfordert.

In dieser Arbeit soll die Positionserfassung eines Linearmotors so erweitert werden, dass die absolute Position auch bei stromlosem Motor sowohl im Stillstand als auch passiv bewegt aktuell gehalten wird. Dies soll mit einem elektrischen Speicher (Akku) und einer Ultra-Low-Power-Sensorik realisiert werden. Die Betriebszeit ist dabei zu maximieren (mehrere Monate). Dafür ist eine integrierbare Hardware inkl. der nötigen Software zu entwickeln und zu realisieren. Vorgängig sind verschiedene Schaltungskonzepte zu entwerfen und zu evaluieren. Die erweiterte Positionserfassung soll schliesslich mit dem Motor in Betrieb genommen und verifiziert werden.

Die Arbeit wird in Zusammenarbeit mit der Firma NTI AG (www.LinMot.com) in Spreitenbach durchgeführt. ■

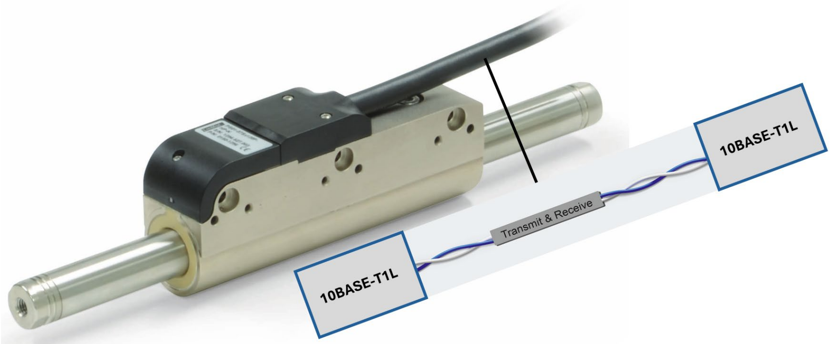
Type of Work: 75% Hardware / 15% Software / 10% Dokumentation

Prerequisites: Interesse an Hardwareentwicklung und Antriebstechnik

Contact: Dr. Daniel Ausderau, LinMot, daniel.ausderau@linmot.com

Bachelorarbeit / Semesterarbeit FS 2025

Single-Pair-Ethernet-Echtzeitkommunikation für ein Servomotorsystem



Ein Servoantriebssystem soll durch Single-Pair-Ethernet (≥10 Mbit/s) modernisiert werden, wobei das bestehende Motorkabel genutzt wird. Dazu wird eine neue Motorsensorik mit Ethernet-Schnittstelle und Echtzeitkommunikation entwickelt und deren Funktion und Robustheit bei betriebenem Motor verifiziert.

Im Rahmen der Digitalisierung von Sensorsystemen soll bei einem bestehenden Servoantriebssystem ein sin/cos-Positionssignal durch eine zuverlässige Single-Pair-Ethernet-Echtzeitkommunikation von mindestens 10 Mbit ersetzt werden. Dabei soll dasselbe Motorkabel verwendet werden können.

In dieser Arbeit soll eine neue Motorsensorik entwickelt werden, welche die Positionssignale via Single-Pair-Ethernet über die Signalleitung eines bestehenden hybriden Motorkabels überträgt. Die Arbeit umfasst die Realisierung einer neuen Motorelektronik mit Ethernetschnittstelle sowie die Entwicklung der Mikrocontroller-Software zur Aufbereitung und Kommunikation der Signale in Echtzeit. Die Funktion und Robustheit der Kommunikation ist für verschiedene Betriebsmodi und Kabellängen des Motors zu zeigen.

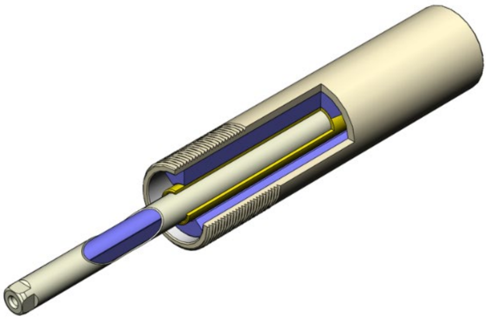
Die Arbeit wird in Zusammenarbeit mit der Firma NTI AG (www.LinMot.com) in Spreitenbach durchgeführt. ■

Type of Work: 45% Hardware / 45% Software / 10% Dokumentation

Prerequisites: Interesse an Echtzeitsystemen und Antriebstechnik

Contact: Dr. Daniel Ausderau, LinMot, daniel.ausderau@linmot.com

Magnettester für magnetische Federn



Magnetische Konstantkraft-Federn können über einen definierten Hub eine konstante magnetische Kraft aufbringen. In dieser Arbeit ist ein automatisierter Magnettester zu entwickeln, mit welchem Feder-Magnete schnell und mit hoher Reproduzierbarkeit ausgemessen und qualifiziert werden können.

Magnetische Federn mit einer über den Hubbereich konstanten Rückstellkraft sind hervorragend geeignet, in dynamischen Linearmotorsystemen die Gewichtskraft passiv zu kompensieren oder applikationsbedingte passive Vorspannkräfte zu erzeugen. Unterschiedlich stark und/oder inhomogen magnetisierte Magnete führen zu Abweichungen im Konstantkraftbereich. In dieser Arbeit ist ein Magnettester zur Qualifikation von Federmagneten zu realisieren. Zur Messung ist eine Antriebseinheit vorgesehen, mit welcher ein Magnet kontrolliert durch eine Messeinheit bewegt werden kann. Die Arbeit umfasst Konzept und Entwicklung einer geeigneten Messeinheit mit integrierter Sensorik sowie Design und Implementation der Software. Eine intuitiv bedienbare Testsoftware soll PC-basiert in der grafischen Programmiersprache LabView von NI implementiert werden. Der Tester ist aufzubauen, in Betrieb zu nehmen und seine Funktionsweise durch Testreihen zu verifizieren.

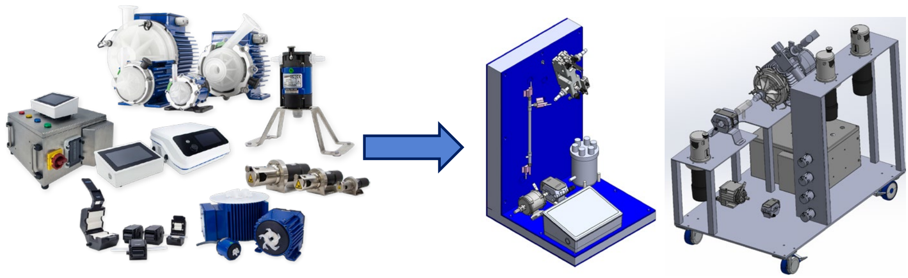
Die Arbeit wird in Zusammenarbeit mit der Firma NTI AG (www.LinMot.com) in Spreitenbach durchgeführt. ■

Type of Work: 35% Hardware / 55% Software / 10% Dokumentation

Prerequisites: Interesse an Messtechnik, Mechatronik und LabView-Programmierung

Contact: Dr. Daniel Ausderau, LinMot, daniel.ausderau@linmot.com

Design and Optimization of a Modular System for Lab-Scale Filtration Processes in Bioprocessing



Levitronix provides essential bioprocessing components like magnetically levitated pumps, flow sensors, and viscometers that can be used in many biotechnological applications. This project focuses on designing a modular system that allows to flexibly combine the components for various laboratory applications.

Levitronix specializes in critical bioprocessing technologies, producing components like levitated centrifugal pumps, flow sensors, and pinch valves for applications such as tangential flow filtration, cell culture perfusion, and vaccine production. These components are crucial for high-performance biotechnological laboratory systems.

This project aims at developing a modular system that securely and precisely positions various components, such as sensors, actuators, and filters, tailored to each specific application. The system shall enhance ease of use, installation, and operation in laboratory environments.

Using rapid prototyping through SolidWorks and 3D printing, the design will undergo iterative improvements to be production-ready and compatible with injection molding processes. Key design goals include production feasibility for manufacturing, laboratory compatibility with compact and easy-to-clean structures, and optimized fluid dynamics that reduce fluid volume and eliminate dead zones or high-shear areas. ■

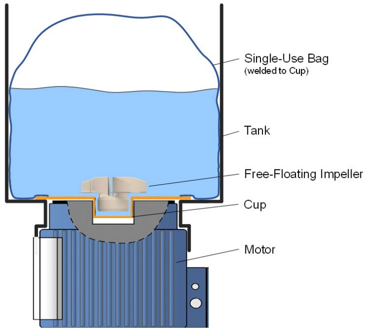
Type of Work: 40% CAD modeling & simulation / 30% prototyping (3D-printing) / 20% testing and validation / 10% report & documentation

Prerequisites: Basic knowledge of CAD software (e.g., SolidWorks) / interest in mechanical design for life sciences / prior experience with 3D printing is a plus

Contact: Dr. Patrick Romann, Levitronix, patrick.romann@levitronix.com

Bachelor Project / Semester Project / Master Thesis FS 2025

Fluid Dynamic Simulation and Optimization of a Bearingless Bottom Agitator for Bioreactors



Magnetically supported bottom mixers offer great practical advantages for bioreactors, but it must be shown that the mixing tasks can be performed equivalently to the stirring rods used to date. This is to be demonstrated in this work by means of CFD simulations and measurements.

Bioreactors for cell cultivation and vaccine production are typically equipped with mechanically supported stirring bars. These stirring rods require a lot of space and handling during cultivation is very time-consuming.

A novel method is the use of magnetically mounted bottom stirrers, which are to be investigated in this work. The use of such drives would offer enormous advantages in terms of flexibility and space management. However, it must first be shown that the mixing efficiency is at least on par with state-of-art technology. This is to be demonstrated in this work by means of CFD simulations and mixing time measurements.

The final aim of the work is to analyze to what extent the design of the mixer (diameter, height, geometry, placement) and reactor tanks (diameter, height, shape) have an influence on performance and to derive design specifications accordingly. ■

Type of Work: 60% simulation / 30% measurements / 10% report & documentation

Prerequisites: Interest in simulation, fluid dynamics, mechatronics, and practical lab work

Contact: Dr. Daniel Steinert, Levitronix, steinert@levitronix.com

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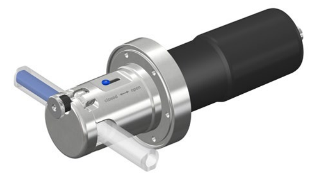
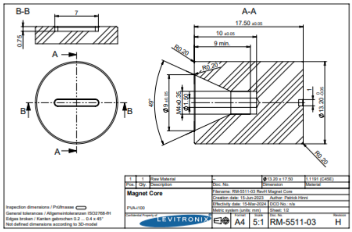
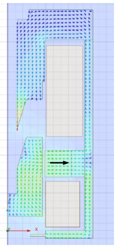
Bachelor Project / Semester Project / Master Thesis FS 2025

Design and Optimization of a Bistable Pinch Valve System with a Dual-Slot







Levitronix provides essential bioprocessing components such as magnetically levitated pumps, flow sensors, and pinch valves, which are used in various biotechnological applications. This project focuses on the design and optimization of a bistable pinch valve system with a dual tube slot.

Levitronix specializes in critical bioprocessing technologies, producing components like levitated centrifugal pumps, flow sensors, and pinch valves for applications such as tangential flow filtration, cell culture perfusion, and vaccine production. These components are crucial for high-performance biotechnological laboratory systems.

This project aims at developing a bistable solenoid dual slot pinch valve, enabling further miniaturization based on an existing valve. The pinch valve system shall operate as a 3/2-way valve, replacing two valves in a Y-configuration tube setup.

This will require a completely new bistable actuator design and a specialized concept for accommodating two tubes in the closure mechanism. The actuator is to be designed and optimized using magnetostatic simulations. Subsequently, the actuator and the closure mechanism are to be designed in SolidWorks and manufactured using a combination of 3D-printed or machined parts.

In the final step, the valve will be assembled, the simulation results verified, and its functionality tested in a fluid circuit.

Type of Work: 30% Simulation / 30% CAD-modeling / 30% testing and validation / 10% report & documentation

Prerequisites: Basic knowledge of CAD software (e.g., SolidWorks) / interest in mechanical design for life sciences / interest in simulation

Contact: Peter Mayr, Levitronix, mayr@levitronix.com

Master Thesis FS 2025

Development of the Auxiliary Drive Train System for Mobile Applications (EHS and xPTOs)

Electrification of mobile machinery and trucks requires electrohydraulic systems (EHS) and xPTOs for auxiliary functions. In this project, you will model, simulate, and finally propose the auxiliary drive train. All components must be modeled and the main focus will be on the E-motor and drive. The implementation of the auxiliary power train tool is in Matlab/Simulink.

The CO_2 emission target is recently driving a trend towards electrification of heavy mobile machinery, buses, and trucks (off-highway), where electrohydraulic systems (EHS) and xPTOs are needed for the auxiliary functions. The aim of this thesis is to develop an auxiliary drive train tool for the above-mentioned application and to propose and design a suitable efficient auxiliary drive train system.

Each component in the auxiliary drive train will be modeled in Matab/Simulink and the overall auxiliary drivetrain simulation must be performed. For the electrical machine and drive components, FEM calculation is required to estimate the losses and efficiency for all relevant torque-speed operating points. It is also possible to verify the results of the model in a hardware test bench. Finally, you will propose different auxiliary drive train systems for EHS and xPTOs. Recent methodology such as machine learning algorithms can be implemented when necessary.

The master thesis is carried out in the Advanced Technology team of Bucher Hydraulics AG in CH-6345 Neuheim. ■

Type of Work: 40% Modeling and drive concept (Matlab/Simulink) / 40% software calculation (FEM/Python) / 10% hardware / 10% documentation

Prerequisites: Lectures in power electronic systems and/or electric machines

Contact: Dr.-Ing. Ahamed Bilal Asaf-Ali, Bucher Hydraulics AG, ahamedbilal.asafali@bucherhydraulics.com

Master Thesis FS 2025

Development of Control Concept for an Electrically Excited Synchronous Machine

In this master thesis, field-oriented control (FOC) of an electrically excited synchronous machine (EESM) for mobile applications will be developed in Matlab/Simulink.

Bucher Hydraulics provides auxiliary systems such as electrohydraulic systems (EHS) and xPTOs with a matching motor drive (Bucher Mobile Drives, BMD) product. The application of the BMD is for the electrification of heavy mobile machinery and off-highway vehicles.
In this project, first you will first carry out a literature review to understand the electromagnetic energy conversion principle and field-oriented control (FOC) of electrically excited synchronous machine (EESMs). The electrical parameters of the synchronous machine are estimated either analytically or using FEM simulations of an EESM. The control concept and the drive topology will be explained in detail. The dq-modelling and FOC of the EESM will be implemented in Matlab/Simulink. The expected model outputs are voltage, current, power, losses, power factor for the entire torque-speed plane. The thesis result provides incite knowledge about drive concept and operating characteristics of the electrohydraulic system. Finally, a proposal will be made to implement the model into the BMD software.
The master thesis is carried out in the Advanced Technology team of Bucher Hydraulics AG in CH-6345 Neuheim. ■

Type of Work: 40% Modeling and drive concept (Matlab/Simulink) / 40% software calculation (analytical/FEM) / 10% hardware / 10% documentation

Prerequisites: Lectures in power electronic systems and/or electric machines

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Advanced Mechatronic Systems Group

BUCHER hydraulics

Master Thesis FS 2025

Optimizing the Drive System Components of Electrohydraulic Systems for Mobile Applications

Electrification of mobile machinery and trucks requires electrohydraulic systems (EHS) for auxiliary functions. In this project, you will simulate, design, and finally realize different components of future EHS power trains, focusing mainly on the motor design and sizing, and then implement an EHS power train configuration tool.

Meeting CO_2 emission targets drives a trend towards electrification of mobile machinery, buses, and trucks, where then electrohydraulic systems (EHS) are needed for auxiliary functions. The aim of this thesis is to extend a drive configurator tool to propose/design suitable components (motors and drives) for such future EHS applications.

To minimize overall losses, it is first important to calculate the performance of the electric machine and the motor drive in terms of power, torque, power factor, and efficiency for all relevant torque-speed operating points of the hydraulic application. Accordingly, Matlab/Simulink models of the drive system must be developed to include data from motor FEM simulations, and the overall model will be experimentally verified with a real application. Based on the results, you will develop a configurator tool for future drive systems for EHS applications using Python, possibly utilizing machine learning algorithms.

The master thesis is carried out in the Advanced Technology team of Bucher Hydraulics AG in CH-6345 Neuheim. ■

Type of Work: 40% Modeling and drive concept (Matlab/Simulink) / 40% software development (Python) / 10% hardware / 10% documentation

Prerequisites: Lectures in power electronic systems and/or electric machines

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