Chair of High-Power Converter Systems

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Master Thesis

Test, validation and operation of Three Level T-Type IGBT based VSI for predictive controllers of electric motors

Background and preface:

Sensor- und sensorless control of electric machines play nowadays very important roles in the different automation areas, in the industry as well as in the automotive fields. Within the scope of the improvement of the whole control concept of a modern control strategy some interface- and control-circuits have to be fully designed and fabricated. These electronic circuits have to be simulated and the PCBs' layouts have to be implemented purpose utilizing them in the control of AC motors, additionally and according to the desired requirements and simulation results some drafts must be validated, enhanced and implemented. The current implemented Inverter must be operated and validated first, then a new improved concept for the design of the next generation must be developed. Due to the high burden of the calculations in real time the current system should be upgraded to a 64 based architecture, this step is an important enhancement for the whole work and will be discussed in details focusing on the concept and the design of additional interface PCBs and signal conditioning circuits as well.

Keywords:

PCB-Design, Bootstrap, Induction Motor, PMSM, Current/Voltage measurements, states space representation, IGBT based 3L-NPC-VSI, active and inactive topologies of 3L inverters, signal conditioning circuits, Space Voltage Vectors, sensorless, model based software development, switching losses, embedded software, control/experimental techniques for electric motors, Test and Validation, Hardware enhancements.

Duties and tasks:

- Test, validation and operation of the already implemented 3L-PCB (Version II); a complete validation process must be done and the board has to be tested and integrated into the test bench,
- Test of three Phase rectifier board up to 20 A. and 1000 V. including the smoothing capacitor and taking into account the protection needed between the inverter and converter board,
- Implementation and test of the Inverter-Boards (NPC, T-Type),
- Test and validation of the hardware-components using 3-phase star/delta connected RL-Load and Motors,
- Comparison of the test results with the simulation results while calculating the switching losses of the inverter,
- Investigation of the balance of the two voltages of the DC-Link Capacitors,
- Literature research on the topic sensorless control of nonlinear motors focusing on Model Predictive Control for three phase induction and PMSM motors,
- Preparing the Load Motor and including the step load's behavior into the control loop and finalizing any needed PCBs or interface circuits,
- Identification of motor's parameters under certain Test conditions using the 3L-inverter,

- Literature research on the topic: the use of 3L-IGBT-based Voltage Source inverters (VSI) for sensor and sensorless control of electric motors for high frequency control strategies focusing on the reduction of the losses in an active or inactive way,
- Extension and improvement of the current design of the PCB for 3L-VSI including the needed connectors for the driver and measurement-circuits for interfacing the MCU-Board inclusive the bill of materials for the PCB assembly, a robust and tunable signal conditioning and measurement circuit is an important enhancement of the new 3L-VSI,
- Test and Validation of the whole system while accessing the currents and voltages measurement channels through interfacing them to the microcontroller-/processor-/Real Time-Board,
- Experimental Surveys for improving the different hardware components of the test bench using MCU STM32F7 or Real-Time Systems,
- Remedy the errors in the design while manufacturing the PCB till the finalization of the PCBs and integration and operation into the control loop of the test bench.

Qualifications and prerequisites:

- Good Knowledge of or rather experience in PCB-Design.
- Good Knowledge of or rather experience in simulation of electric/electronic circuits using LT-spice/Simulink.
- Good Knowledge of the topic control of electric machines using power electronics.
- Good Knowledge of design of driver-, interface- and measurement-circuits.
- Good Knowledge of design and simulation using MATLAB/SIMULINK.
- Good knowledge of or rather experience in the topic control of electric machines using power electronics.
- Good knowledge of or rather experience in microcontroller applications and embedded programming using c-language.

Start and duration:

SS-2023 for six months.

Contact and additional information:

Contact person:

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Sensorless-MPC-Lab on researchgate:

https://www.researchgate.net/lab/Ahmed-Ibrahim-Solimans-Sensorless-MPC-Lab-Ahmed-Ibrahim-Soliman

Related IEEE Publications:

- Direct Sensorless Model Predictive Control of Induction Motor Based on Extended Kalman Filter for Three-Level NPC Inverter.
  https://ieeexplore.ieee.org/document/9008024

- Enhanced Sensorless Model Predictive Control of Induction Motor Based on Extended Kalman Filter
  https://ieeexplore.ieee.org/document/8980031

- Flexible Test Bench Arrangement and Particular Implementation of Three Level IGBT Based VSI for Self-sensing Model Predictive Control of Induction Motor
  https://ieeexplore.ieee.org/document/9265822