University of Stuttgart
Institute of Robust Power Semiconductor Systems

M.Sc. Swapnil Sunil Roge
Room 1.443, Pfaffenwaldring 47
70569 Stuttgart
swapnil-sunil.roge@ilh.uni-stuttgart.de
+49 711 685 68893

05.09.2023

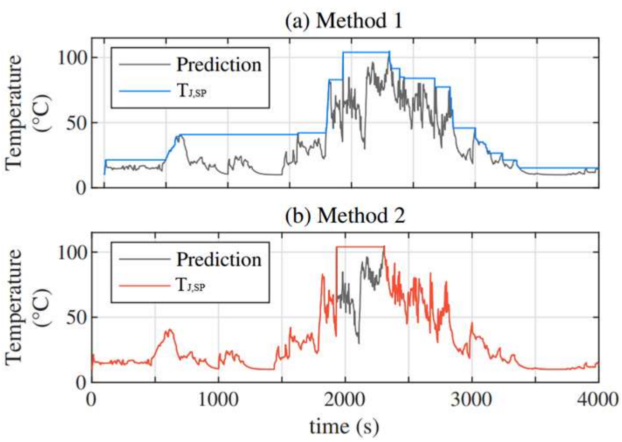
Research Project or Master Thesis

Power Electronics

Development of Temperature Controller for Optimization of SiC MOSFET-based Inverter over Selectable Target Variables

SiC MOSFETs have emerged as a promising solution for high-power applications. However, their long-term reliability can be compromised when subjected to temperature fluctuations, which are common in many real-world operating environments. Rapid temperature cycling can induce degradation in these devices both at the semiconductor level (e.g. deep traps, interfacial stress, oxide failure, etc.) and the package level (e.g. cracks, delamination, bond-wire lift-off, etc.). This result into non-ideal behaviour in the electrical (e.g. R_{ON}, V_{TH}, I_{GSS}, R_{DSS}, etc.) and thermal characteristics (e.g. R_{TH}) of the device. As a result, it is important to tackle the temperature-induced degradation and thus increase the lifetime of the SiC MOSFETs.

This work primarily focuses on implementing an efficient thermal management system based on a predictive temperature controller and smoothing algorithm to reduce the magnitude of temperature fluctuations and thus extend the SiC MOSFET module lifespan to be used in a 3-phase inverter (B6 bridge topology).



Example of the predictive control strategy used in [1]. (a) denotes the case where the $T_{J,SP}$ is chosen to optimse for the MOSFET lifetime, while (b) denotes the case where the inverter efficiency is optimised.

Tasks and Goals:

- Familiarization and state-of-the-art literature research for
  - different temperature sensitive electrical parameters (TSEPs) for SiC MOSFETs.
  - temperature control systems
- Determination of the setpoint MOSFET junction temperature ($T_{J,SP}$) from a given predicted temperature fluctuation profile, based on different target variables, such as range, service life, robustness and energy efficiency.
- MATLAB/Simulink-based implementation of the temperature controller, which translates the $T_{J,SP}$ value into the appropriate SiC MOSFET TSEPs and other inverter parameters (e.g. dead-time, switching frequency, etc.) and thus regulate the actual junction temperature of the MOSFET ($T_{J,actual}$) .
- Experimental verification and evaluation of the temperature and smoothing control.
- Written thesis and presentation.

Expected Qualifications:

- Experience of MATLAB and Simulink.
- Knowledge of B6-bridge inverter topology.

Optional (Preferable) Qualifications:

- Attended the RPSS1 and the RPSS2 courses offered by the ILH.
- Experience with dSPACE equipments.

[1] A. Chu et al., "LETSCOPE: Lifecycle Extensions Through Software-Defined Predictive Control of Power Electronics," IEEE EUROCON 2023 - 20th International Conference on Smart Technologies, Torino, Italy, 2023, pp. 665-670, doi: 10.1109/EUROCON56442.2023.10199076.