Design of a photovoltaic inverter

Degree programme: BSc in Electrical Engineering and Information Technology
Specialisation: Electric Mobility
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Development of a 10 kW inverter for off-grid solar systems, designed to convert 400 V DC into 230 V AC using next-generation semiconductor technology. The project aims to deliver a cost-effective and efficient solution for reliable electricity access in areas without a power grid.

Problem Statement

Access to electricity is essential for safety, health, and quality of life. However, in many remote or unstable regions, connection to the public grid is not possible, requiring self-sufficient energy systems to generate and store power locally.

Objective and Concept

The goal of this thesis is to design an inverter that converts 400 V DC, supplied by a photovoltaic system with a 48 V battery, into 230 V AC for typical household use. The design must combine high performance with low cost, leveraging advanced semiconductors and an optimal control strategy.
Two inverter topologies were evaluated: a symmetrical H-bridge and a totem-pole design. Modern semiconductor materials, such as Silicon Carbide (SiC), were considered to enhance switching speed, reduce losses, and minimize passive components like filters and heat sinks. The aim was to achieve a balanced solution in terms of efficiency and cost.

Implementation

Simulations were conducted to evaluate switching behavior, losses, and filter requirements, with the design optimized to keep semiconductor junction temperatures within safe limits. An automated workflow was developed to explore component combinations near thermal constraints, identifying the most efficient and cost-effective setup. Based on these results, the final topology and components were defined, and the complete inverter including PCB layout, control logic, and software was implemented. Initial measurements confirmed the design choices.

Outcome

The result is a 10 kW inverter design optimized for off-grid applications. It integrates advanced switching devices, efficient filtering, and thermal management to ensure a balance between cost, performance, and reliability.

Conclusion

An appropriate topology and advanced semiconductors could help optimize and renew off-grid systems, with potential for future refinement and broader deployment.

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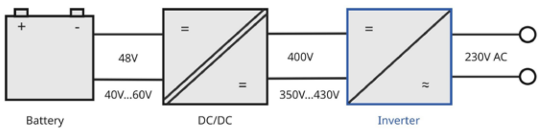
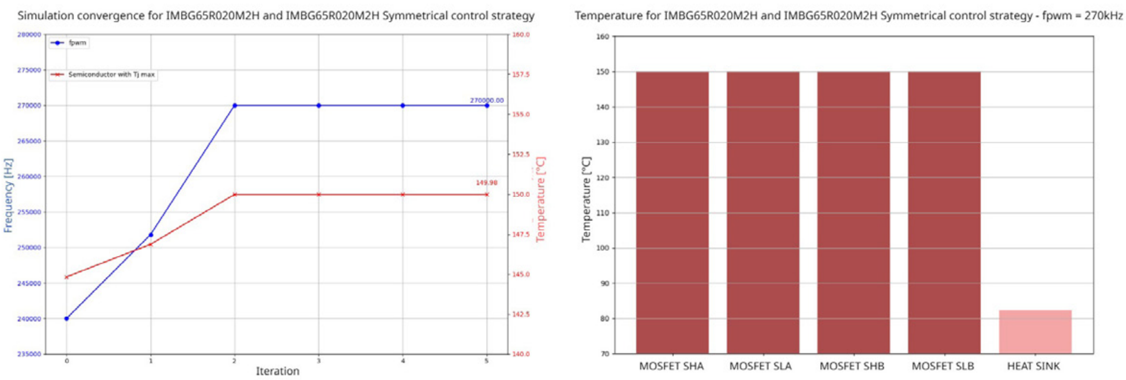


Overall system overview and inverter contextualization



Simulation results showing switching frequency and achieved temperature limits