Master Thesis: Development of a Scalable Monitoring System for Voltage and Temperature Diagnostics in Hydrogen Electrolyzer Stacks

Research Field: Embedded Systems and Energy Systems Engineering

Hydrogen is expected to play a central role in both the German National Hydrogen Strategy and the EU Hydrogen Strategy. Water electrolysis enables the production of green hydrogen using renewable electricity and is increasingly deployed in industrial and energy applications. Electrolyzer stacks consist of multiple electrochemical cells connected in series, whose efficiency, reliability, and lifetime strongly depend on their electrical and thermal operating conditions. Monitoring the voltage and temperature of individual cells provides essential information about the electrochemical state of the stack. It enables the detection of operational imbalances, degradation processes, or abnormal thermal behavior. Continuous monitoring supports early fault detection and predictive maintenance, thereby contributing to safe and efficient electrolyzer operation. However, existing monitoring approaches are often based on laboratory-scale prototypes, which are limited in scalability.

In the current prototype system developed by H&S, voltage and temperature measurements are implemented through separate printed circuit boards, controlled by an Arduino-based data acquisition system. While this architecture is suitable for experimental setups, monitoring systems with several dozen cells would require numerous individual boards and controllers, increasing hardware costs, wiring complexity, and system integration effort.

This thesis aims to develop a modular monitoring system capable of measuring both voltage and temperature across electrolyzer cells using a unified hardware architecture. A single PCB design should integrate the required measurement channels and enable scalable monitoring of stacks with up to 400 cells. Data acquisition will be implemented using an industrial-grade embedded platform, such as an STM32 microcontroller, Digital Signal Processor or FPGA-based system, providing high-resolution analog-to-digital conversion and sampling rates. The acquired measurement data will be transmitted to a host computer via an appropriate communication interface and evaluated to assess the operational condition of the electrolyzer stack. Experimental validation can be performed using available laboratory infrastructure and measurement equipment.

Work plan:

- Literature review on electrolyzer monitoring, stack diagnostics, and measurement systems
- Analysis of the existing prototype and definition of system requirements
- Development of a modular PCB integrating voltage and temperature measurement channels
- Implementation of embedded data acquisition and communication architecture
- Experimental validation of the monitoring system and evaluation of measurement data
- Documentation of the results

Prerequisites:

- The candidate should be well-versed in embedded systems
- High affinity to research and development using hardware components
- Interest in working with real product development for the hydrogen industry

Contact:

The thesis will be executed at H&S Hard- and Software Technologies and will be jointly supervised by the Institute for Energy Systems, Energy Efficiency and Energy Economics.

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