Design and implementation of a dynamic system for monitoring and managing the life cycle of Li-Ion batteries

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Abstract*. The goal of this thesis is to design and implement an external, non-invasive monitoring system for lithium-ion batteries. The device is primarily intended for use in light electric vehicles, such as electric bicycles and scooters, but it can also be applied to common rechargeable power tools. The main function of the developed system is to reliably estimate the battery's State of Health (SOH) directly during a standard charging cycle, thereby eliminating the need for time-consuming full-discharge tests.*
The system is built using modern hardware components. At its core is an ESP32 microcontroller with a touchscreen display, which works in conjunction with a precision power monitor and other supporting modules. The overall solution includes a custom-designed printed circuit board, a custom-made 3D-printed mechanical enclosure, and firmware programmed in the C language.
The proposed algorithm for estimating SOH works by measuring the electrical energy supplied over time, which is then combined with a capacity calculation based on changes in state of charge (SOC). Experimental validation of the developed system in practice demonstrated its high accuracy and reliability. Measurement deviations were less than 5% compared to reference values from a precision laboratory charger. The result is a fully functional device that simplifies and streamlines battery condition diagnostics.

Keywords. Li-Ion battery, State of Health, SOH, battery monitoring, ESP32, Energy integration, Light electric vehicles.

Acknowledgments

This work was supported by KEGA through the Teaching and Development of methodology for the use of microcontrollers in automation using practical examples and laboratory exercises for engineering students, under Grant 024STU-4/2024.

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