Abstract

The increasing integration of renewable energy sources, distributed generation, and electric mobility has made battery energy storage systems essential to modern power networks. Lithium-ion batteries, although widely adopted for their high energy density and efficiency, present safety and reliability challenges, particularly due to hidden internal faults that may lead to thermal runaway. This thesis develops a framework for online internal resistance-based diagnostics and smart fault management in battery-integrated energy systems.

A Battery Test Environment prototype was designed to capture resistance variations during charge and discharge cycling. Experimental results demonstrate that sudden deviations in internal resistance, extracted through short idle-time open-circuit voltage measurements.

To support system-level protection, a Genetic Algorithm-based relay coordination strategy was developed by optimizing time multiplier and plug setting multipliers to ensure selectivity under high penetration of distributed generation, with emphasis on battery-based storage systems.

A Hybrid Power Factor Selection Algorithm (HPFSA) was implemented on a microcontroller-based energy management platform to adapt control strategies under frequency deviations.

The thesis also presents a conceptual framework for integrating diagnostic and control outputs within an Advanced Metering Infrastructure to enable coordinated fault management.