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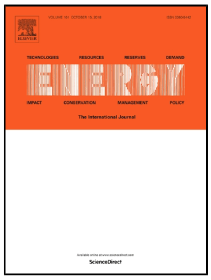

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Lithium-Ion Battery Modeling and Parameter Identification Based on Fractional Theory

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Hilghts:

A fractional-order equivalent circuit model of lithium-ion battery is established.
A MCPSO based parameter identification is conducted.
The model accuracy and robustness are verified by experiments.
The accuracy of proposed SOC estimator is discussed.

Abstract: To effectively use and manage lithium-ion batteries and accurately estimate battery states such as state of charge and state of health, battery models with good robustness, accuracy and low-complexity need to be established. So the models can be embedded in microprocessors and provide accurate results in real-time. Firstly, this paper analyzes the electrochemical impedance spectrogram of lithium-ion battery, and adopts impedance elements with fractional order characteristics such as constant phase element and Warburg element to improve the second-order RC integer equivalent circuit model based on the fractional calculus theory. Secondly, a fractional-order equivalent circuit model of lithium-ion battery is established, which can accurately describe the electrochemical processes such as charge transfer reaction, double-layer effect, mass transfer and diffusion of lithium-ion battery. Thirdly, based on the mixed-swarm-based cooperative particle swarm optimization, parameter identification of the fractional-order equivalent circuit model is conducted using the federal city driving schedule experimental data in the time domain. The simulation results show that the model has higher accuracy and better robustness against different driving conditions, different SOC ranges and different temperatures than the second-order RC equivalent circuit model. The SOC estimation accuracy based on the fractional-order equivalent circuit model of lithium-ion battery is validated.

Key words: lithium-ion battery; fractional-order model; parameter identification; particle swarm algorithm; electric vehicle

1 Introduction

Lithium-ion batteries are widely used in pure electric vehicles and hybrid vehicles because of their high specific energy, long life, and low self-discharge rate. [1] In order to use lithium-ion batteries safely and effectively, an accurate and low-complexity model is needed to describe the dynamic and static characteristics inside the battery.[2] An accurate lithium-ion battery model not only effectively improves the accuracy of state of charge (SOC) and state of health (SOH) estimation, but also enhances the simulation effectiveness when formulating the vehicle control strategy. The