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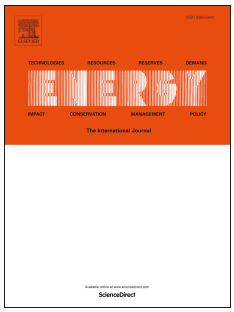

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Data-based fractional differential models for non-linear dynamic modeling of a Lithium-ion battery

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Abstract

This paper presents a battery model with non-integer order derivatives for modeling the dynamics of a lithium-ion battery over a large operating range. The non-integer or fractional differential model includes a constant phase element term to approximate the non-linear dynamical behavior of the battery. The proposed fractional differential model is an amalgamation of electrochemical impedance spectroscopy experimental data and standard 1-resistor-capacitor electrical circuit model. The standard least squares-based state-variable filter identification method used for continuous-time system identification is used to estimate the model parameters and the fractional derivative coefficients of the proposed fractional differential model. For application of modeling fractional differential order battery dynamics, the continuous-time least squares-based state-variable filter parameter estimation approach is extended to an instrumental variable method to be robust to (non-white) noise perturbed output measurement. The model accuracy and model performance are validated on experimental data obtained from a lithium-ion battery and confirm that the proposed fractional differential model is able to accurately capture the battery dynamics over broad operating range. In comparison, the fractional differential model shows significant improvement on

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