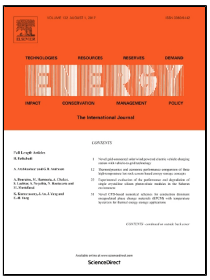
Accepted Manuscript



A Unified Modeling Framework for Lithium-ion Batteries: An Artificial Neural Network Based Thermal Coupled Equivalent Circuit Model Approach

Qian-Kun Wang, Yi-Jun He, Jia-Ni Shen, Zi-Feng Ma, Guo-Bin Zhong

PII:	S0360-5442(17)31210-0
DOI:	10.1016/j.energy.2017.07.035
Reference:	EGY 11223
To appear in:	*Energy*
Received Date:	10 February 2017
Revised Date:	04 July 2017
Accepted Date:	07 July 2017

Please cite this article as: Qian-Kun Wang, Yi-Jun He, Jia-Ni Shen, Zi-Feng Ma, Guo-Bin Zhong, A Unified Modeling Framework for Lithium-ion Batteries: An Artificial Neural Network Based Thermal Coupled Equivalent Circuit Model Approach, *Energy* (2017), doi: 10.1016/j.energy.2017.07.035

A Unified Modeling Framework for Lithium-ion Batteries: An Artificial Neural Network Based Thermal Coupled Equivalent Circuit Model Approach

Qian-Kun Wang[a], Yi-Jun He[a,*], Jia-Ni Shen[a], Zi-Feng Ma[a,b], Guo-Bin Zhong[c]

[a]Dept. of Chemical Engineering, Shanghai Electrochemical Energy Devices Research Center, Shanghai Jiao Tong University, Shanghai 200240, China

[b]Sinopoly Battery Research Center, Shanghai 200241, China

[c]Electric Power Research Institute of Guangdong Power Grid Co., Ltd., Guangzhou 510080, China

Abstract

The thermal coupled equivalent circuit model provides a vital role not only in accurate and reliable state monitoring, but also in effective thermal management of lithium-ion batteries. However, it lacks appropriate modeling strategies for including both the temperature and state of charge effects into the thermal coupled equivalent circuit model. In this study, a unified artificial neural network based thermal coupled equivalent circuit model approach is proposed to accurately and reliably capture the electrical and thermal dynamics of lithium-ion batteries. Both reversible and irreversible heat generation mechanisms are introduced in the thermal model. The quantitative relationship between circuit parameters and temperature/state of charge in equivalent circuit model is modeled by artificial neural network. Both electrical and thermal related parameters are simultaneously identified by means of least square strategy with l_1-norm penalty on output weights in artificial neural network and positive constraints on circuit parameters. The effectiveness of the proposed artificial neural network based thermal coupled equivalent circuit model approach is validated by the experimental constant current discharge, pulse current discharge test and hybrid pulse power characterization test of a commercial large-format pouch-type lithium-ion battery. It implies that the proposed hybrid modeling strategy can provide a general framework for the inclusion of other effects such as health state and current into battery models and can be easily extended to more complicated models such as first-principle electrochemical-thermal model.

Keywords: lithium-ion batteries, equivalent circuit model, thermal model, artificial neural network, state of charge, temperature

*Corresponding author. E-mail addresses: heyijun@sjtu.edu.cn (Y. He).