Online State of Charge estimation for lithium-ion battery cell using a combined RLS-NLS method

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1 Introduction

Lithium-ion (Li-ion) batteries are essential in many applications, and efficient state of charge (SOC) estimation is required. This work proposes a simple online method of estimating the parameters and SOC of an equivalent electrical model of Li-ion batteries by combining the Non-Linear Least Square (NLS) and Recursive Least Square (RLS) techniques.

2 Battery model

A first-order equivalent electrical model with a hysteresis voltage, as shown in Fig.1, is considered in this study. A voltage source and an RC network are typically found in this type of model. The open circuit voltage (OCV) is denoted by VOC and includes two parts. The first part, $VOC(SOC)$, represents the average equilibrium OCV as a function of the SOC. The second part V_h, is the hysteresis voltage which captures the hysteresis behaviour of the OCV curves. The ohmic resistance R_s, the polarization resistance R_c and capacitance C_d are the remaining parameters, and the terminal voltage V_B and the load current i_B the circuit variables [1]. The input and output profiles of the Li-ion Battery model are shown in Fig. 2.

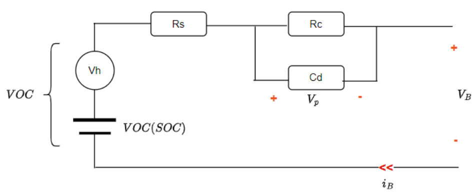

Figure 1: First-order RC model of Li-ion battery [1]

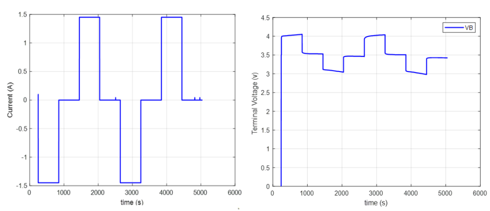

Figure 2: Current and terminal voltage of battery cell

3 Online estimation SOC using RLS-NLS

The idea of the method is to decompose the parameter estimation in two parts: (a) the estimation of the parameters of the RC network represented by an autoregressive exogenous model (ARX) using a standard RLS procedure and (b) the NLS estimation of the hysteresis and SOC. The RLS method is first used for the online identification of battery parameters, namely R_s, R_c and C_d. Then, a combination of RLS and NLS is employed, with RLS recursively obtaining battery model parameters for NLS. Finally, the battery SOC is identified by using the continuously updated model parameters.

The new Panasonic NCR18650BD-Improved Li-ion battery cell, with 2.9Ah/3.6V at 25°C, is used for collecting current and voltage data. The setup involves a DC load and a power supply, connected via NODE-RED and MATLAB software. Experimental outcomes (Fig. 3) validate the real-time SOC estimation efficiency. SOC measurement employs the Coulomb Counting method.

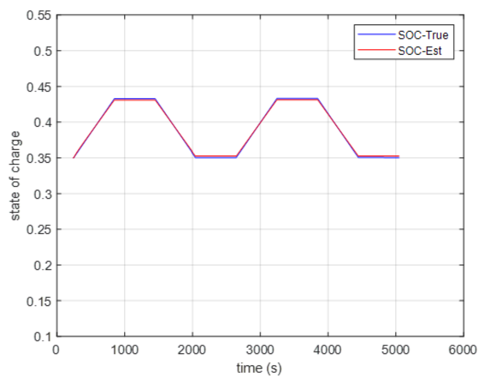

Figure 3: Real and estimated SOC

References

[1] Kim, T., Wang, Y., Fang, H., Sahinoglu, Z., Wada, T., Hara, S., Qiao, W. (2015). Model-Based Condition Monitoring for Lithium-ion Batteries. Journal of Power Sources, 295, 16-27.