Hybrid low-dimensional limiting state of charge estimator for multi-cell lithium-ion batteries

Mira Khalil*[1,2], Romain Postoyan[1], Stéphane Rael[2], and Dragan Nešić[3]

[1]Centre de Recherche en Automatique de Nancy – Université de Lorraine - CRAN CNRS UMR 7039 – France

[2]Groupe de Recherche en Energie Electrique de Nancy – Université de Lorraine - GREEN – France

[3]University of Melbourne – Australie

Résumé

The state of charge (SOC) of lithium-ion batteries needs to be accurately estimated for safety and reliability purposes. For battery packs made of a large number of cells, it is not always feasible to to duplicate SOC estimation algorithms developed for single cells due to limited computational resources. An alternative consists of only estimating the minimum and maximum SOCs of the battery pack. Given these quantities, we can ensure that the SOCs of all the cells are within the operating limits. The problem is that the limiting cells, i.e., the cells having the minimum and maximum SOCs, cannot be directly determined based solely on the available measurements. Moreover, these limiting cells may change with time. In this seminar, we present a low-dimensional hybrid estimator of the minimum (maximum) SOC, whose convergence is analytically guaranteed. We consider for this purpose a battery consisting of cells interconnected in series, which we model by electric equivalent circuit models. We then present the hybrid estimator, which runs an observer designed for a single cell at any time instant, selected by a switching-like logic mechanism. We establish a practical exponential stability property for the estimation error on the minimum (maximum) SOC thereby guaranteeing the ability of the hybrid scheme to generate accurate estimates of the minimum (maximum) SOC. Finally, we give a numerical example to showcase the relevance of the proposed estimation approach.

Mots-Clés: Batteries, hybrid dynamical systems, nonlinear estimation, Lyapunov stability

*Intervenant