Observer design for multi-cell lithium-ion batteries

Ph.D.

Supervisors

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Location

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Description

Electrochemical batteries are ubiquitous in our daily lives, whether in our computers or our cell phones. Among the different technologies available, lithium-ion batteries offer many advantages in terms of energy mass, power mass and low self-discharge. In addition, they do not have a memory effect. On the other hand, they require a management system (BMS) for safety reasons, but also to prevent premature aging.

The BMS plays a key role on the battery performance and lifespan. It requires for this purpose to have access to accurate data on the current state of the battery. The problem is that little information about the internal variables is directly accessible through measurements, typically the current, the voltage and possibly the temperature. To access the battery states (state of charge, state of health, functioning state), a mathematical model of the battery dynamics is usually developed, based on which an observer is designed to estimate the non-measurable internal variables. Different approaches have been developed for this purpose [1], in particular by CRAN and GREEN, whose main originality is to exploit local electrochemical models and then to build non-linear observers with convergence and robustness guarantees [2-4].

However, it appears that most of these approaches are dedicated to the state estimation of a single lithium-ion cell. However, in practice, batteries are most often composed of multiple cells associated in series and/or in parallel. For implementation reasons, single-cell approaches cannot simply be duplicated when many cells are interconnected. It is therefore necessary to develop estimation tools, that are easy to implement, adapted to multi-cell batteries and which generate guaranteed data.

The objective of this PhD thesis is to develop methodological tools with low computational requirements for the state estimation of multi-cell lithium-ion batteries. The results obtained will be validated in Matlab Simulink interfaced with dSPACE using experimental data.

References

[1] Y. Wang, J. Tian, Z. Sun, L. Wang, R. Xu, M. Li, Z. Chen. (2020). A comprehensive review of battery modeling and state estimation approaches for advanced battery management systems. *Renewable and Sustainable Energy Reviews*, *131*, 110015.

[2] P.G. Blondel, R. Postoyan, S. Raël, S. Benjamin, P. Desprez. (2018). Nonlinear circle-criterion observer design for an electrochemical battery model. *IEEE Transactions on Control Systems Technology*, *27*(2), 889-897.

[3] P.G. Blondel, R. Postoyan, S. Raël, S. Benjamin, P. Desprez. (2017). Observer design for an electrochemical model of lithium ion batteries based on a polytopic approach. *IFAC-PapersOnLine*, *50*(1), 8127-8132.

[4] E. Planté, R. Postoyan, S. Raël, Y. Jebroun, S. Benjamin, D. Monier Reyes, Multiple active material Lithium-ion batteries: finite-dimensional modeling and constrained state estimation, 2021.

Profile

Candidates must have a M.Sc. in control engineering/theory, applied mathematics or electrical engineering. Expertise in Matlab is expected.

Do not hesitate to contact Romain Postoyan (romain.postoyan@univ-lorraine.fr) and Stéphane Raël (stéphane.rael@univ-lorraine.fr) for any question.