Modeling and estimation of lithium-ion batteries with flat output current voltage

Master project

Advisors

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Location

This SAFT Master project will take place at CRAN, UMR CNRS 7039 : 2 avenue de la forêt de Haye, 54516 Vandœuvre-lès-Nancy, France

Duration

5 to 6 months, starting date between February 1 and March 31 2021

Funding

924€/month gross

Keywords

Control engineering, batteries, modeling, observer, estimation, Lyapunov stability, Matlab-Simulink

Context

The global economic demand for electrochemical storage batteries is increasing today. This growth is mainly due to the emergence of hybrid and electric vehicles (Hybrid-Electric Vehicle, Plug-in Hybrid Electric Vehicle and Battery-Electric Vehicle) on the one hand, and the energy storage market related to renewable energies and power grid management on the other.

SAFT is particularly present in this context as a precursor of the deployment of lithium batteries. SAFT produces, among others, lithium-ion batteries in Poitiers, Nersac and Bordeaux. This SAFT M.Sc. project will take place at CRAN in Vandœuvre-lès-Nancy.

Topic

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

The BMS plays a key role in the performance and lifespan of the battery, and it is essential to supply the BMS with accurate data on the current state of the battery. The problem is that little information about battery 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, including some by CRAN, GREEN and SAFT, based on local electrochemical models and implementing a nonlinear observer [1,2,3].

However, most of these approaches are a priori not well suited for lithium-ion cell technologies with flat open circuit voltage (OCV) versus state of charge curves (quasi-constant OCV curve), and therefore pose a major problem for the observability of the induced model [4,5]. Batteries with flat OCVs might play an important role in electric vehicles in the future. To overcome this observability problem and to favor the spreading of batteries with flat OCVs in a near future, our idea is to temporarily exploit additional measurements, such as the charge state given by coulometry. This type of measurement becomes inaccurate after a while, so the question is when not to trust it anymore.

Plan

- Literature review on state-of-charge estimation of flat OCV lithium-ion cells.
- Mathematical modeling and simulation with Matlab-Simulink.
- Observer synthesis and simulation on Matlab-Simulink.

References

[1] P. Blondel, et al., IEEE Transactions on Control Systems Technology 27 (2) (2019) 889-897; doi: 10.1109/TCST.2017.2782787

[2] P. Blondel, et al., 20th World Congress of the International Federation of Automatic Control (IFAC 2017) 50 (1) 8127-8132, Toulouse, (2017); doi: 10.1016/j.ifacol.2017.08.1252

[3] E. Planté, et al., Submitted to IEEE Transactions on Control Systems Technology, 2021

[4] S. Torai, et al., Journal of Power Sources 306 (2016), https://doi.org/10.1016/j.jpowsour.2015.11.070

[5] M. Berecibar, et al., Energy 103 (2016), https://doi.org/10.1016/j.energy.2016.02.163

Profile

This is a Master project for a student in control or electrical engineering. Matlab skills and good knowledge of the English language are expected.

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for more information.