Simulink® Modeling of an Intelligent Battery System towards Sustainable Electronics

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***Abstract*—This paper presents a battery system simulation flow for simulating a battery array, demonstrates its characteristics, its mode of operation and the its implementation. The IntellBatt system is built with a management system which performs its management activities by protecting the battery from operating outside its safe operating area, monitoring its state, calculating data, reporting the data and controlling its environment (modifying the temperature). Related prior work has focused on a battery model system which adapts to the current profile of the device, while this research focuses on the deployment of smarter batteries to self-manage lifetime.**

This paper presents the following: (1) Modeling of an intelligent battery (IntellBatt) using Simulink®. (2) Implementation of a cell selection algorithm. (3) Design of a permanent emergency system and/or cell shut down by a system safety manager. (4) Complete system design and implementation in Simulink® [1].

The basic architecture, consists of the battery discharge management, the current flow management and the battery state management modules. The proposed architecture involves a cell array, a cell switching circuit (CSC), a Battery Cell Array Manager (BCAM) and a System Safety Manager (SSM) [2], [3]. The battery cell discharges to the load based on the direction of the switching circuit which in turn receives and executes instructions from the BCAM and the SSM. The SSM supersedes the BCAM so that SSM instructions can shut down the CSC to ensure safety in the entire system.

The first step in the flow is to determine the various devices and components and ensure specifications are met. The next step is the design and creation of each subsystem. The Battery Cell Array subsystem is created and tested first; if it passes the tests based on the required specifications and type of battery cell that is being emulated, the flow proceeds to the next stage, otherwise the design is iteratively modified until all required specs are met. This process is followed for the CSC, BCAM and SSM and finally the entire subsystem is integrated and tests are performed via simulation to ensure the system's functionality: to switch between each battery cell whenever the BCAM determines that the threshold has been met based on the state of battery, voltage, and current flowing in the system. Also the SSM is tested by inputting an unacceptable battery state to ensure that it indeed overrides the decision of the BCAM to ensure the safety of the entire system.

The completed Simulink® model of the system is shown in Fig. 1.

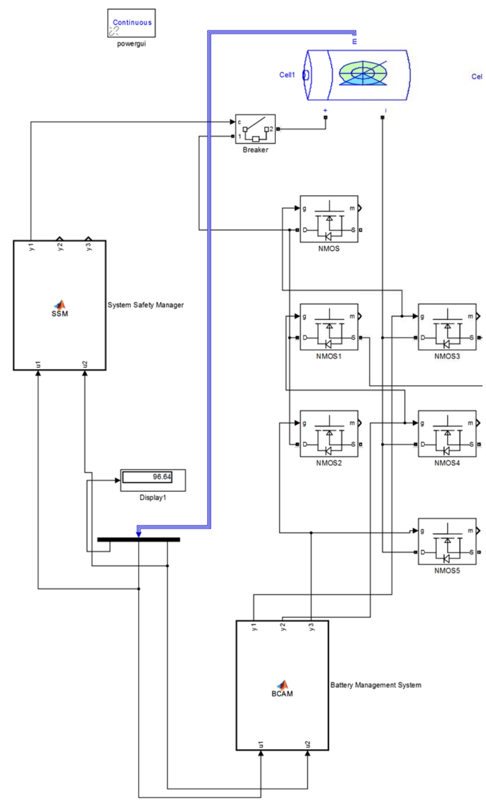

Fig. 1. Complete system Simulink® description.

The system was used to perform an analysis on the model based on [4], and demonstrated savings of $29.01 per ton of CO_2 emitted while the amount of CO_2 emissions when utilizing fully electric powered vehicles is zero.

References

[1] S. P. Mohanty, *Nanoelectronic Mixed-Signal System Design*. McGraw-Hill Education, 2015, no. 9780071825719 and 0071825711.
[2] S. K. Mandal, R. N. Mahapatra, P. Bhojwani, and S. P. Mohanty, "IntellBatt: Toward a Smarter Battery," *IEEE Computer*, vol. 43, no. 3, pp. 67–71, 2010.
[3] S. K. Mandal, P. Bhojwani, S. P. Mohanty, and R. N. Mahapatra, "IntellBatt: Towards Smarter Battery Design," in *Proceedings of the 45th Design Automation Conference (DAC)*, 2008, pp. 872–877.
[4] R. W. Wies, R. A. Johnson, A. N. Agrawal, and T. J. Chubb, "Simulink model for economic analysis and environmental impacts of a pv with diesel-battery system for remote villages," *IEEE Transactions on Power Systems*, vol. 20, no. 2, pp. 692–700, May 2005.