Simulink® Modeling of an Intelligent Battery System towards Sustainable Electronics

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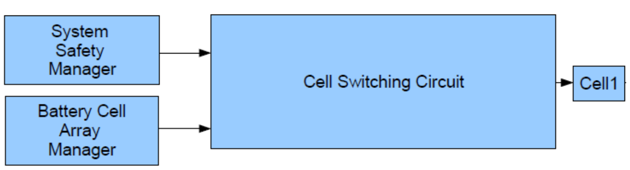
Introduction

- Battery driven systems are everywhere.
- The increasing trend to move from wired devices to wireless is the motivation for the design of smart and intelligent methods of using available energy in the battery.
- The importance of Simulink® based models is that they allows us to model hierarchical subsystems with predefined library blocks and simulate the dynamic behavior of the system.
- This paper presents the following:
- ✓ Simulink® based modelling of an intelligent battery system.
- ✓ Implementation of a cell selection algorithm.
- ✓ Design of a permanent emergency system by a system safety manager.
- ✓ Complete system design in Simulink® [1].

Major Contributions

- Simulink® Modeling of an intelligent battery system is done for the purpose of illustrating its viability.
- The framework is developed in Simulink® which is used to model the intelligent battery system.
- The algorithm was designed considering the temperature of the cells, the current, the voltage and state of charge and discharge.
- The total savings of the cost was tracked using data available from major EV manufacturers, including GM (Chevy Volt), and Tesla (Model S).

INTELLIGENT BATTERY ARCHITECTURE



- The four major components are;
- ✓ Cell array
- ✓ Cell switching circuit (CSC)
- ✓ Battery Cell Array Manager (BCAM)
- ✓ System Safety Manager (SSM)
- A high capacity battery is broken down into cells which have a certain voltage and supply current to the switching circuit.
- The cell switching circuit switches between the various cells based on instructions from the BCAM and/or SSM.
- The BCAM, intelligently changes the load of the circuit to the cell based on the threshold set in the algorithm, which includes, temperature, current flow, voltage capacity, and state of charge & discharge.
- The SSM permanently disconnects the load from the cells whenever there is a situation that can cause harm to the circuit and/or used in high temperature, voltage fluctuation and high cell discharge rate.

Simulation Framework Design

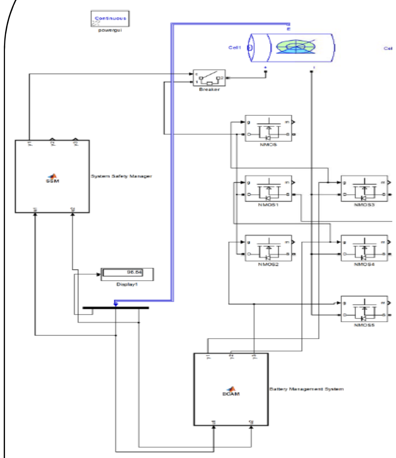
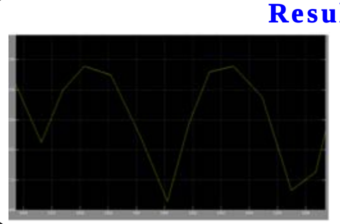


Fig. 1. Complete system Simulink® description.

Cell Selector Algorithm
Input: Load Current, I
Voltage/State of Charge (for Individual Cells), V
Output: g1, g2, g3
1. Assign threshold for I and V to g1, g2 & g3
2. While I = and or < (assigned threshold)
   g1, g2 and g3 = 0(gate opens)
   else g1, g2 and g3 = 1(gate closed)
3. While V/SoC = and or < (assigned threshold)
   g1, g2 and g3 = 0(gate opens)
   else g1, g2 and g3 = 1(gate closed)
4. End

- ✓ 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.
- ✓ Based on the required specification, algorithm and input, the battery cell, CSC, BCAM and SSM are tested.
- ✓ The system switches between each cell whenever the BCAM determines that the threshold has been met based on the state of battery, voltage, and current flowing in the system.

Results



Simulation results for the cell selector algorithm which transfers the load from one cell to another due to threshold being attained.
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Conclusions

- The system was used to perform an analysis on the model based on [2], and demonstrated savings of $29.01 per ton of CO_2 emitted while the amount of CO emissions when utilizing fully electric powered vehicle is zero.
- The proposed implementation gives opportunities to mimic real time situations and delivers a smart energy utilization along with efficient management strategy.
- Future research involves recharge management and introduction of solar charging system/panel to obtain a realistic approach.

References

[1] S. P. Mohanty, *Nanoelectronic Mixed-Signal System Design*. McGraw-Hill Education, 2015. no. 9780071825719 and 0071825711.
[2] R. W. Wies et al, “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.

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