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Toolbox Streamlines BMS Design, Testing And Algorithm Deployment

MathWorks, maker of MATLAB and Simulink, and NXP Semiconductors are collaborating on model-based design for battery management system (BMS) development. MathWorks Simscape Battery enables engineers to model, develop, and validate BMS applications and NXP's Model-Based-Design Toolbox (MBDT) helps automate C code generation from Simulink for NXP Battery Cell controllers, and also supports NXP's software solution, the BMS SDK components.

BMSs are crucial for electric vehicles (EVs) as they ensure the optimal performance, durability, and safety of the battery packs that power these vehicles. The BMS design process increasingly relies on modeling and simulation to fine-tune algorithms tailored to the EVs' specific battery cell types and battery pack configuration. These are the algorithms that perform tasks such as state-of-charge calculation, cell balancing, thermal management, and others.

Model-based design enables the efficient design of the BMS algorithms, providing a means to test them in simulation for different scenarios, such as driving habits, environmental conditions, and fault occurrences. The MBDT for BMS makes it easy for engineers to transition directly from Simulink models to running and testing their BMS algorithms on an NXP processor. This capability simplifies the BMS development process and accelerates the prototyping and testing phases.

The Model-Based Design Toolbox bridges the gap between theoretical design and practical application. As Tony Lennon, Simscape product family marketing manager at MathWorks, observed, microcontroller companies have different ways of optimizing code to run on their processors. "For example, they may have mathematics libraries that are unique to their microcontroller. There are also I/O and memory allocation considerations specific to their micro."

Typically, these differences would require system developers to learn those hardware-specific requirements and manually make changes in the C code they've generated from Simulink. However, the blocks provided by NXP eliminate this step. As a result, engineers can directly implement their Simulink BMS models onto NXP processors with little to no manual coding, thereby preserving the integrity and efficiency of their original algorithms and saving development time. According to Lennon, when modeled properly in Simulink, the code generated for the NXP microcontrollers is as optimized "as handwritten code a software programmer would write".

In addition, the Model-Based Design Toolbox features integrated input/output (IO) connectivity, automating the process of determining what I/Os are connected to one another and memory allocations. These are the types of tasks a "hardware engineer would normally take care of when they're working with the software engineers," he said.

This functionality allows engineers to perform dynamic, real-world testing on their BMS systems, providing immediate feedback from early hardware prototypes and insights into system performance under various conditions. This level of testing is critical for ensuring the reliability and safety of BMS solutions in real-world scenarios.

The figure below shows the application development flow for developing BMS control algorithms using model-based design in the MathWorks environment. As Danielle Chu, Simscape Battery product manager at MathWorks, explained, "At any stage, engineers can use MathWorks tools like Simulink and Simscape Battery to design the BMS algorithms and the battery plant model to run the closed-loop simulation to test aspects of BMS performance." These are things like "state-of-charge estimation, cell balancing and the power limits". And "does my thermal management run as expected? For example, does it kick on the cooling system to lower the temperature [as needed]?" said Chu.

She added that in electric vehicles, there are expectations governing how the vehicle acts when certain faults occur in the battery system. Designers need to know how the BMS responds.

"Modeling tools enable engineers to do the fault analysis, which is critical for engineers to ensure the battery management system design is robust against a variety of scenarios, especially under fault conditions and at any stage of the development process," said Chu.

These tools also enable engineers to do tolerance studies in the early stages of development. "For example, in a battery pack, if one cell goes into thermal runaway, can the system stop the rest of the cells from going into thermal runaway with the right insulation material? These types of tolerance studies can be done with simulation during battery pack development," she said.

Given the energy levels involved in EV battery systems, it's not only faster to run such tests in a simulation environment, it's also safer. Chu added that the tools automatically generate the C code for the BMS algorithm which can be used to run hardware-in-the-loop simulation for further testing of the BMS algorithms.

Lars Reger, CTO at NXP Semiconductors, commented on his company's part in developing the Model-Based Design Toolbox. "We're excited to collaborate with MathWorks to support automotive engineers in developing the next generation of BMS solutions," said Reger. "Simplifying direct testing with tools like MBDT on NXP processors offers a broad range of benefits, including faster design iterations that allow engineers to identify and fix issues upfront in the design process and reduce time to market."

"By enabling engineers to go directly from creating BMS algorithms in Simulink to running them on an NXP processor, we're simplifying and accelerating the development process," said Jim Tung, MathWorks fellow. "The growth of the EV market demands more efficient, reliable, and safer battery systems, and tools like MBDT that streamline and enhance the engineering process will be critical. Reducing development times, facilitating easier testing, and accelerating market entry will be differentiators in this competitive market."

For more information, see the NXP Hardware Support from Simulink page and the NXP Support Package BMS page.

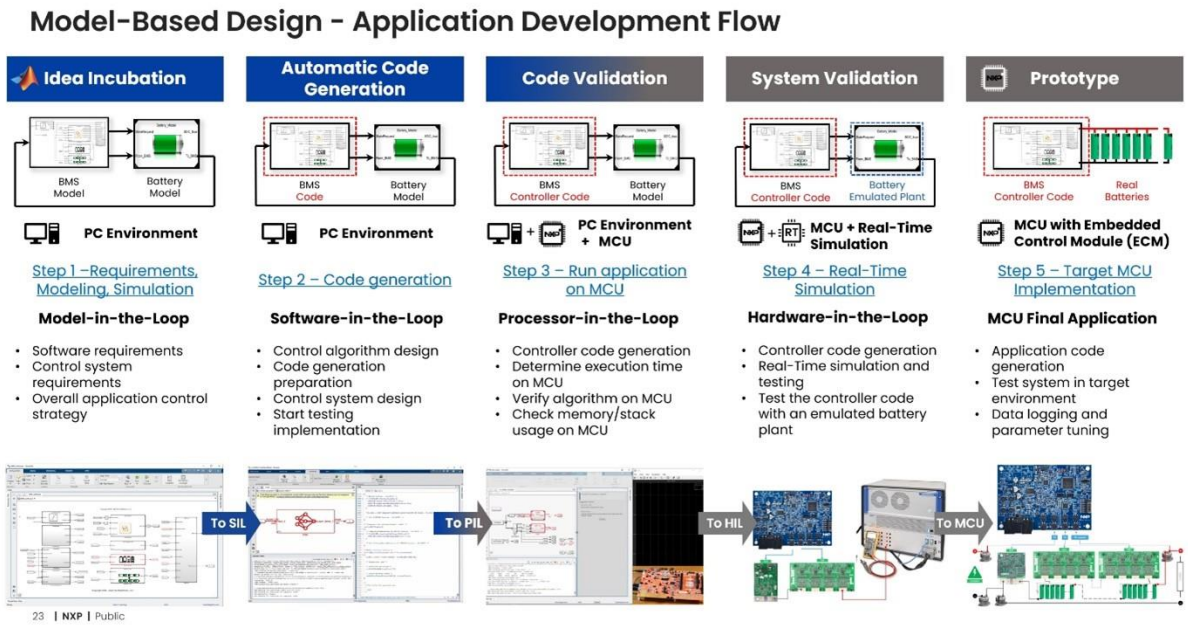

Figure. Schematic of the workflow for high-voltage battery management system design using the Model-Based Design Toolbox.