MAXEYE TECHNOLOGIES

White Paper

Battery Management System
(BMS) HIL Testing

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Contents

Introduction

Ever increasing in usage of HEV/EV demands high energy storage in rechargeable batteries to drive motors, the voltage for such batteries in the range of 200-600V or even exceeds. Today's increased energy capacity of batteries comes at a cost of increased risk. To maintain the battery pack at a safe and optimal state, the Battery Management System is becoming more complex. BMS is to monitor the battery key operational parameters such as voltage, current and internal temperature along with ambient temperature during charging and discharging.

The main objectives of the BMS is,

- To protect the battery cells from abuse and damage
- Monitor and control the charging and discharging process of the battery
- Ensure that the energy of the battery is optimized to power the product
- Extends the electric range as well as the battery life as long as possible
- Make sure the battery is always ready to be used

The BMS serves many purposes in battery applications such as monitoring the state of charge (SOC) and state of health (SOH). It also mitigates several risks associated with high voltage battery packs such as cell over voltage or overheating. The BMS system provides inputs to the protection devices so that the monitoring circuits could generate alarms and even disconnect the battery form load or charger, if any of the parameters exceed the values set by the safety zone. In reality the deviations of capacity, self-discharge rate, internal resistance, operating temperature, and manufacturing quality can create significant differences in cell behavior. This type of parameter uncertainty often limits the battery operating range and the BMS plays a central role in balancing the cells. Cell balancing is a method of compensating the weaker cells by equalizing the charge on all cells in a battery pack to extend the overall battery life and maintaining optimal battery performance.

Objective

In-vehicle testing of Battery Management System with large set of battery packs is expensive, time consuming, energy inefficient to charge/discharge and present safety hazards.

One pathway to lower development cost of BMS is the use of HIL techniques, which offers lower cost and higher reproducibility of the test scenario's with a virtual test bench. This generates a new set of trade-offs between model fidelity and complexity. The battery model needs to simulate the behaviors of tens or hundreds of individual cells and it must run in real time with limited processing power. The test system should be capable of executing battery models in real-time, performing flexible, safe and reproducible test to meet the BMS functional, safety, performance requirements.

Challenges

The test system needs to accurately simulate the battery cell stack voltages in real-time & the required sensors to the BMS along with the fault simulations.

MaxEye Solution

Hardware-in-the-loop (HIL) test platform based on NI PXI with Real-Time Controller, Communication, Input/output modules, NI LabVIEW, NI VeriStand software and simulation environment includes Battery Cell Simulator to simulate a cell advanced-chemistry, fault simulations, temperature simulations & shunt sensor simulation for hybrid and electric-vehicle applications.

MaxEye BMS HIL automated test system software is based on NI LabVIEW to manage the test system, NI VeriStand to run the cell/pack models in real-time on RT engine. The software provides the configuration and execution of tests, custom stimulus profiles as well as manual control. Then we acquire measure and process the digital & analog outputs, read CAN messages from the BMS to validate against the simulated parameters. The test system also validates the state of charge (SOC), State of Health (SOH) from the BMS.

BMS HIL System Architecture

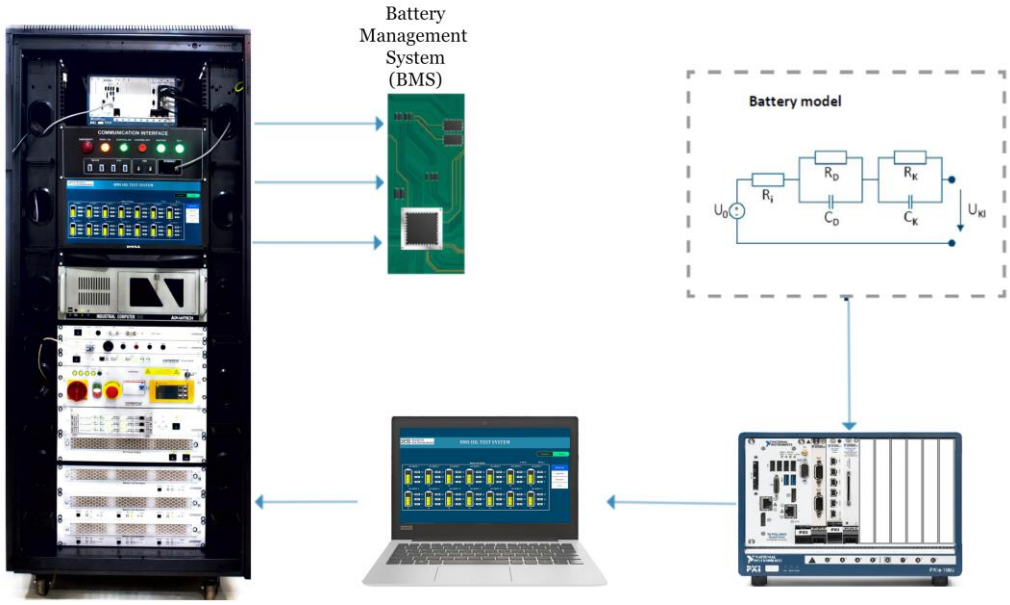

Fig1: BMS HIL Test System Architecture

Battery Model

To simulate the battery model for real-time systems, Equivalent Circuit Model (EMC) is widely adopted as it is the better approach to make a right balance between accuracy and complexity of the model to execute it in real-time processor. Fig2. Below shows the thevinen's equivalent circuit battery model having voltage source with series internal resistance, parallel resistor-capacitor networks.

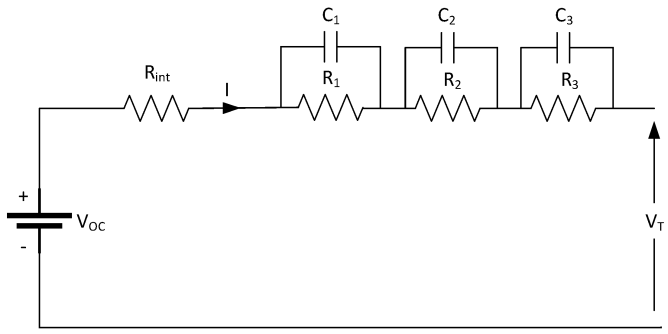

Fig2: Thevinen's Equivalent Circuit 3-RC Model

MaxEye offers custom battery model development that is flexible enough to change the battery parameters that include battery internal resistance, capacity, aging characteristics, thermal properties, initial SOC, voltage and battery initial temperature along with input charge/discharge current profiles for the battery. The battery model supports development of multi cell configuration for series or parallel connection as per the specification.

HIL System Hardware

Battery Cell Simulator

Battery Cell Simulator (BCS) allows testing of Battery Management System on cell-level with high-precision and more dynamics. The electrical emulation of such virtual battery cells puts into the position to achieve safe, reproducible and full automated testing of BMS. The Battery Cell Simulator is the core of a BMS test system. BCS system can scale up to 200cells with voltage range up to 1000V.

Key Features:

- 1-200 cells
- 0.01-8 V
- Accuracy +/- 0.5 mV
- Nominal Current 0-4.9 A
- Accuracy +/- 2 mA
- Passive & Active Balancing
- µA Current Measurement
- Supports CAN/EtherCAT communication

Fault Simulation Unit

Failure Simulation Unit (FSU) is used to extend the failure simulation of the Battery Cell Simulation (BCS). It supports the short, open and reverse polarity of a cell. BCS is connected to the FSU then to the BMS to simulate the fault condition for each specific cell.

Temperature Simulation Unit

Efficiency, reliability and safety of modern lithium ion batteries for electric vehicle drives strongly depend on the Battery Management System (BMS) as their electronic control unit. As an overheated battery is a high safety risk, monitoring and controlling of the temperature has become very important. For development, validation and test of the

control algorithms of the BMS, a high-precision temperature simulation in the voltage area of the battery is required. This is achieved by the temperature simulation unit.

Temperature simulation unit supports both NTC/PTC simulations to simulate characteristic curves of NTC/PTC resistors at a value range of 0 Ohm... 8.1 MOhm at a resolution of 1 Ohm.

Key Features:

- NTC/PTC Simulation
- 0 Ohm .. 8.1 MOhm
- Resolution 1 Ohm
- Accuracy +/- 1 %
- Operation in high voltage area upto 1kv
- Fault injection on temperature simulation
- Communication via CAN bus

Isolation Resistance Emulation

Isolation resistance emulation module supports testing of the isolation between the battery and vehicle chassis in high voltage area. This module supports emulation of isolation resistance between DC+, PE, and DC-.

Key Features:

- 20 kΩ.. 65 MΩ
- Resolution 1 kOhm
- Accuracy +/- 1 %
- Voltage upto 1kv
- Communication via CAN bus

HIL System Software

MaxEye BMS HIL Test Automation Software supports Manual & Auto mode. In manual mode, the BMS tested with or without battery model & drive profiles. In Auto-mode, the tool supports test case creation, configuration & execution as well custom report generation with data logging capabilities. The software GUI shows the emulation of battery cell voltage, current & temperature in real time, graphical view of input/output, parameters of the battery and BMS, error information.

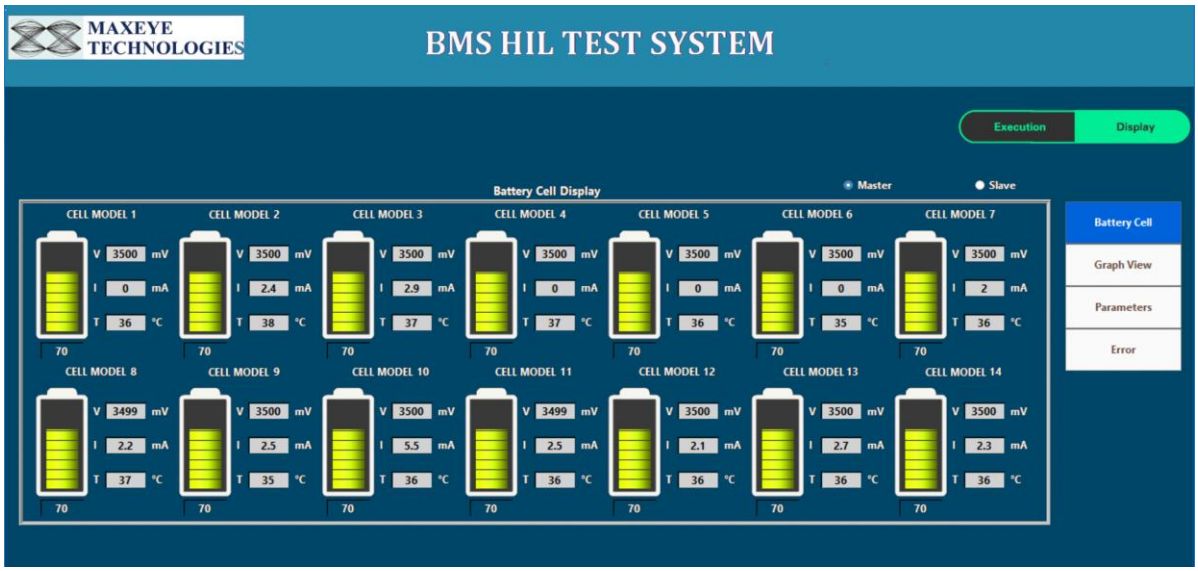

Fig3: BMS HIL System Graphical User Interface (GUI)

Conclusion

Our BMS HIL test solution is a flexible, cost effective, safe and reproducible test platform that eliminates the risks associated with testing real batteries from electric or hybrid vehicles. It provides a testing environment that encompasses cell stack voltages, current, temperature and fault simulations. In addition, using NI PXI system increases hardware reliability and reduces development time.

By using LabVIEW & Veristand Tools, we quickly implemented the user interface configuration and easily integrated the battery model. With NI Teststand, we can configure multiple test cases derived for BMS functional, safety & performance evaluation for readable, concise test automation scenarios.

About MaxEye Technologies

MAXEYE Technologies founded in 2011, is a privately held company based in Bengaluru and Chennai, India, Silver Alliance Partner of National Instruments. We are a Test and Measurement company, specialized in providing turnkey solutions, products and consulting services. We have strong expertise in providing Test and Measurement solutions for Automotive Infotainment, ADAS, EV, IOT devices testing and ATE Development.

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