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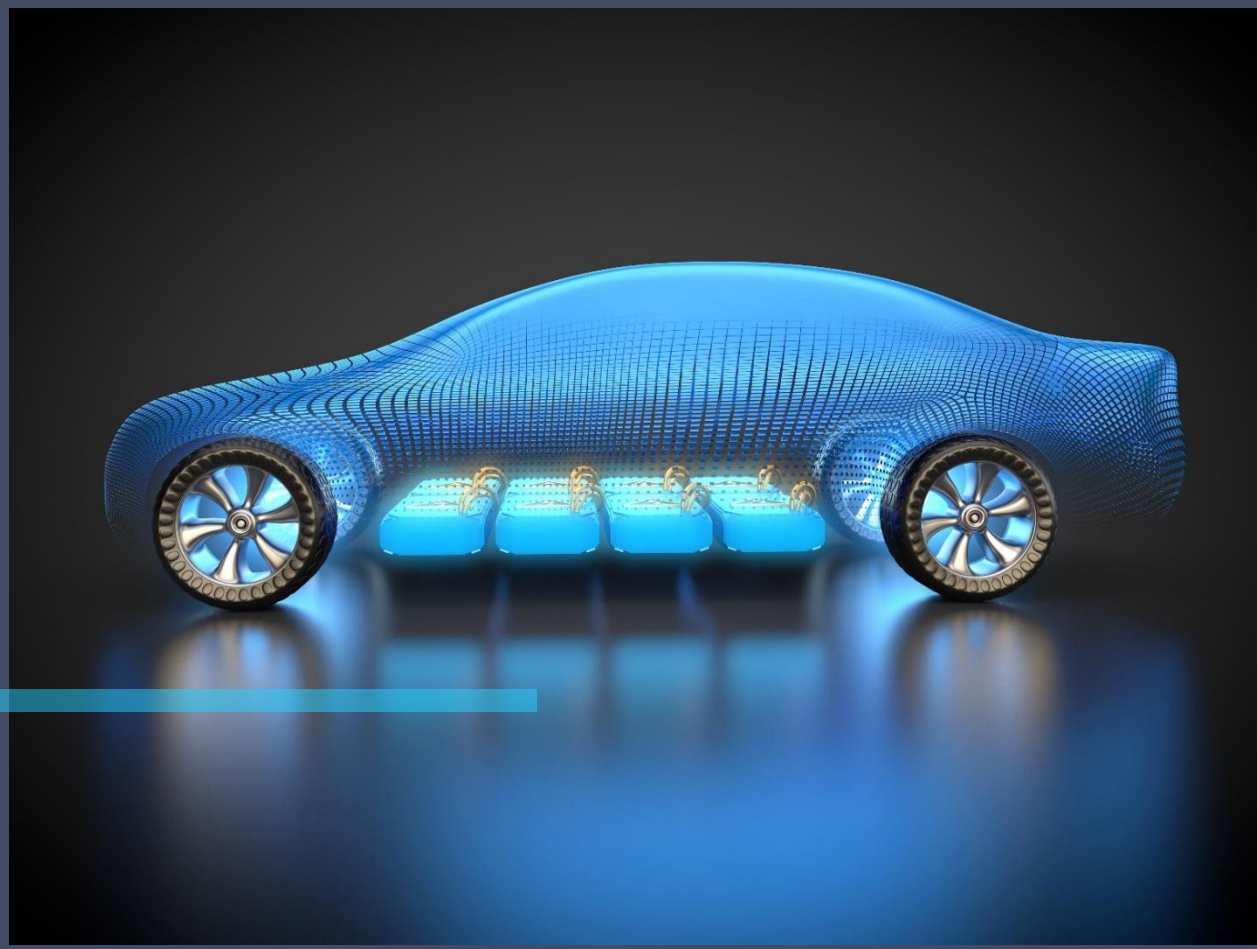
Battery Management System



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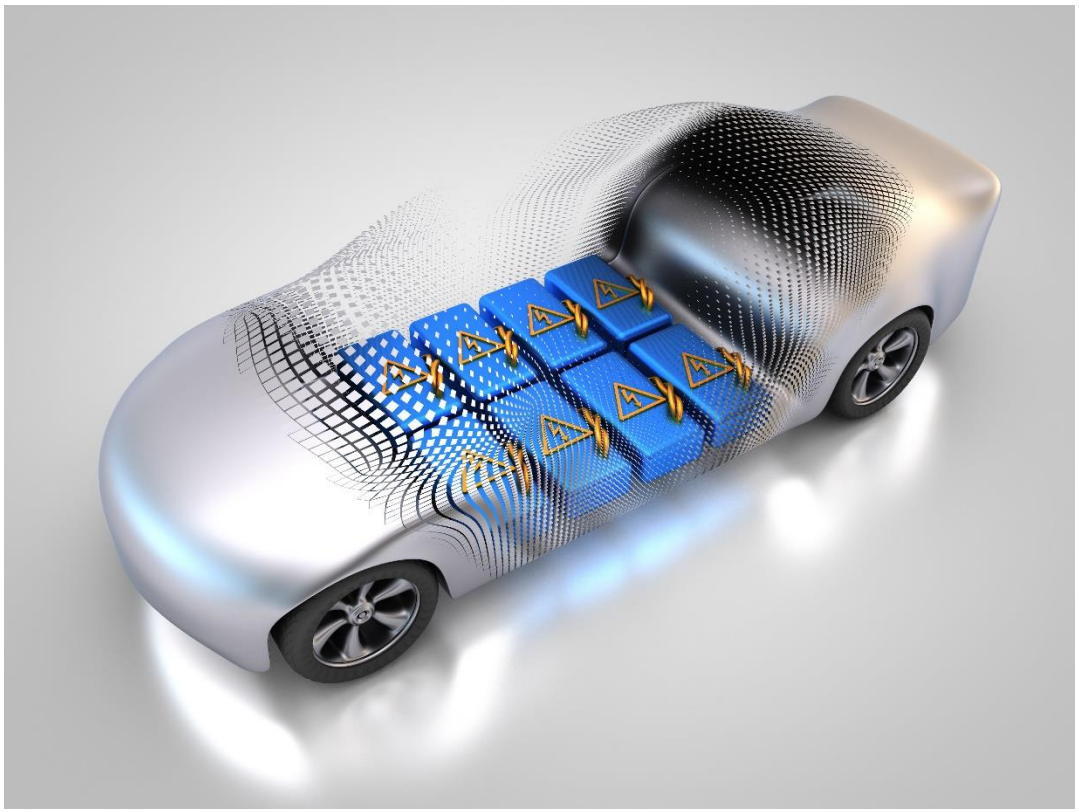
Battery Management System

Trends

- International Energy Organization (IEA) forecasts, the global number of EVs on the road will reach 125 million by 2030
- Global battery management system market size is estimated to grow from USD 5.2 billion in 2019 to USD 12.6 billion by 2024, at a CAGR of 19.5%
- Modular topology segment of the BMS market is expected to grow at the highest rate
- Intelligent BMS solutions to improve asset health & user experience over the lifecycle of the EV



Opportunities & Challenges

- Modular battery packs/ BMS solution for different use cases
- Scalable to multi-battery type
- Standardization & compliance
- Reliability: Battery life and warranty
- Structural Safety design for batteries
- Efficient energy management across both HV and LV
- BMS would also play an important role in full lifecycle considerations of EV batteries, tracking and maintaining accurate health predictions of the battery

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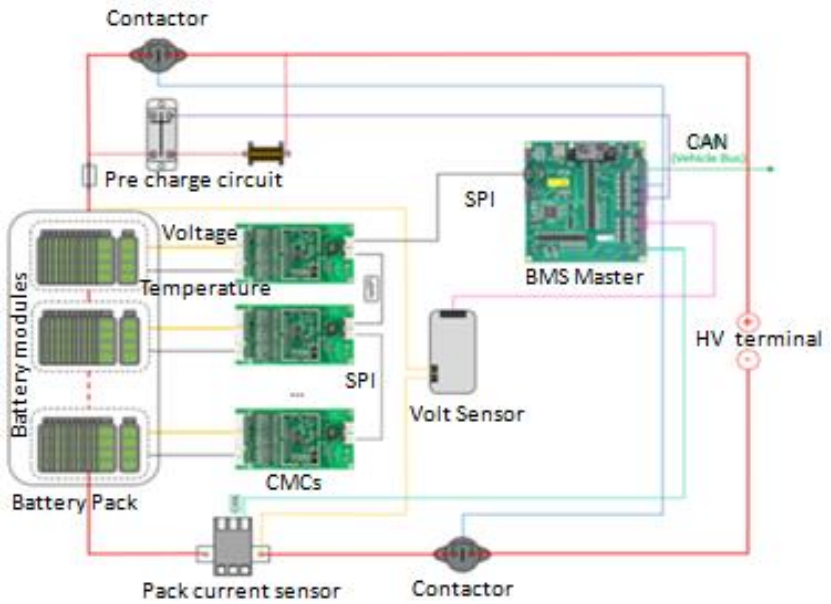
BMS Solution – High Level Specifications

Attribute	Specification
Architecture	Master- slave architecture
Master-slave communication	Isolated SPI
Voltage range	48V – 800 V
Battery chemistries	Configurable for Li-Ion NMC or LFP
No of channels per slave	15 channels
Connectivity interfaces	Wi-Fi, Bluetooth, LTE/3G/2G, and GPS
Vehicle communication	4x CAN, 1x BroadR Reach Ethernet (CAN FD supported)
Charging support	ChaDeMo and CCS-1&2 compatible
Balancing	Passive Balancing
Safety	Supports HVIL diagnostics and isolation monitoring

HW Architecture



BMS Master

BMS Slave

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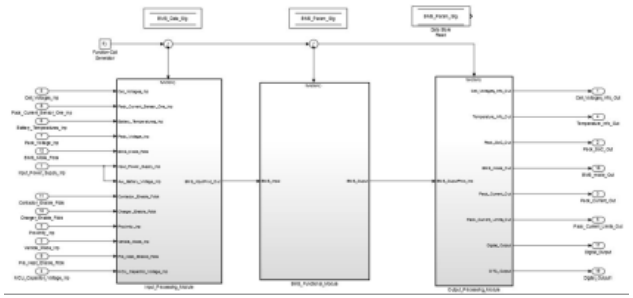
BMS Solution – Features & Benefits

BMS Features

- Cell and pack parameter monitoring
- State estimation (SoC, SoH)
- Passive cell balancing
- Thermal management
- Diagnostics
- Fault management and derating
- Pre charge control
- HVIL monitoring
- Isolation resistance monitoring



BMS MATLAB/Simulink Model

User Interface

01

Modular Scalable Architecture

- Supports multiple EV segments
- MHEV of 48V to PHEVS
- BEVs: 300-400V | Trucks & CVs: 800V Multiple chemistries
- Configurable for NMC, LFP
- Post characterization for other chemistries

02

Safety & Reliability

- Supports HVIL diagnostics and Isolation Monitoring
- Ring topology-based Isolated SPI interface with CMCs leading to a more robust fault-tolerant H/W architecture

03

User Convenience

- LTE, 3G, 2G, Wi-Fi & Bluetooth – Connectivity + specific use cases for tracking, asset health & cybersecurity
- Configurable MATLAB/Simulink models along with UI to enable easy desktop & HiLS-based validation

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Services in BMS & Battery Pack

Design & Engineering – SW, HW, Validation

- Battery Management System
- BMS & Battery Plant models- SW/HW
- Battery Sizing
- Battery Cell and Module layout
- Control system for Fuel Cell
- Cell Balancing
- BMS Master/Slave Hardware and Software
- HILS Validation
- HW control & Power Electronics
- Integration of 3rd party components
- Design optimization for BoM cost
- Prototype development

BMS

Battery Pack

Frames/ Enclosures

Cooling system

SOLUTION ACCELERATOR

Scalable BMS HW/SW Design

Design & Engineering – Mechanical

Battery Pack

- Battery module structure design
- Bus bar design & optimization
- External interface components package
- Joints design
- Virtual Validation - Structural, Crash & Safety

Thermal Management System

- Cooling plate design
- TIM Selection
- Thermal system integration
- CFD – Flow & Thermal simulation

Frames/Enclosures

- Battery Frames structure design
- Structural & durability simulation

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BMS & Battery Pack Work Samples

Model-based development of BMS features for Li-Ion battery pack

Development of BMS models for the following features: SOC, SOH estimation, Capacity estimation, Resistance estimation, Max current/power, Balancing, Thermal management, Fault management - 300V, 90kWH Li-Ion NMC battery pack

HILS and test automation for battery energy control module

Design and development of Test Automation Framework for the Automated tests for BECM ECU.

Software development for 250kW battery pack, mixed-signal MCU with 40AIs and 45 DIs, RS232 communication

Design & development of control firmware, monitoring application and automated test equipment for L-cell battery systems

HV traction battery pack design

Design & develop a high power capacity Lithium-Ion Battery (102KWh) pack for complete electric vehicle applications

Thermal system and frame structure design

The designed thermal system, modular frame, and ingress protection design for the battery pack for fully electric vehicle application

Module stack and Busbar design

Designed modular stack, unique Busbar, and module structure for the battery pack

Why Tata Elxsi

Complete end-to-end ecosystem

- Concept & requirement engineering
- Embedded – H/W & S/W
- Mechanical – Simulation led design
- HILS validation & prototyping
- Standards & compliance

Accelerators

- BMS h/w & s/w design
- Test case database covering SW qualification, system integration, and qualification testing
- eMobility HILS – VaaS