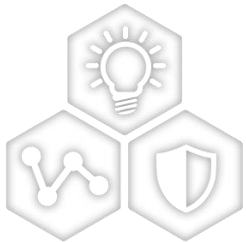


Microchip's Battery Management Solutions



A Leading Provider of Smart, Connected and Secure Embedded Control Solutions



SMART | CONNECTED | SECURE

BMS Objective(s)

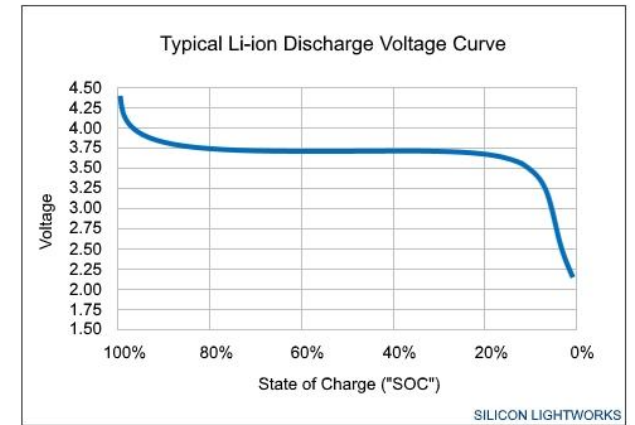
- **BMS Primary objective:**
 - Maximize system reliability and safety by avoiding unexpected power-loss and 'end-of-life' situations in *dynamically loaded battery* systems.
 - Key system attributes centered around determining battery capacity, i.e. **SOC (State Of Charge)** relative to capacity of a new cell!!!
 - Capacity Calculation Methods
 - Voltage Measurement
 - Coulomb Counting
 - Ohmic Measurement
 - LPR (Large Pulse Response)



Battery Management Systems Monitoring

Capacity Monitoring Techniques

- **Voltage Measurement – Voltage-to-Capacity Correlation!!!**
 - Battery terminal voltage measurement to determine capacity of battery. (simplest but least reliable method)
- **Coulomb-Counting – Integrate Current Over Time!!!**
 - *Carefully and Constantly* track battery current (in/out) over time from a known point, i.e. starting from empty or full.
- **Ohmic Measurement – Internal Imp.-to-Capacity Correlation!!!**
 - Internal Resistance increases as battery discharges. (most precise method)
 - Large-Pulse-Response Method (aka: Transient Response Analysis)





Battery Management Systems

Balancing

Cell Balancing

- **Cell Balancing Primary Objective:**

- All cells in a series pack should have the same voltage and SOC
 - Maximizes performance, efficiency, and life of all cells in pack
 - Overheated/Overcharged lithium cells are prone to accelerated degradation – reduced life.
 - Lithium cells can catch fire or explode if voltage exceeds limits by only a few hundred millivolts – SAFETY ISSUE!!!

- **Cell Balancing Methods**

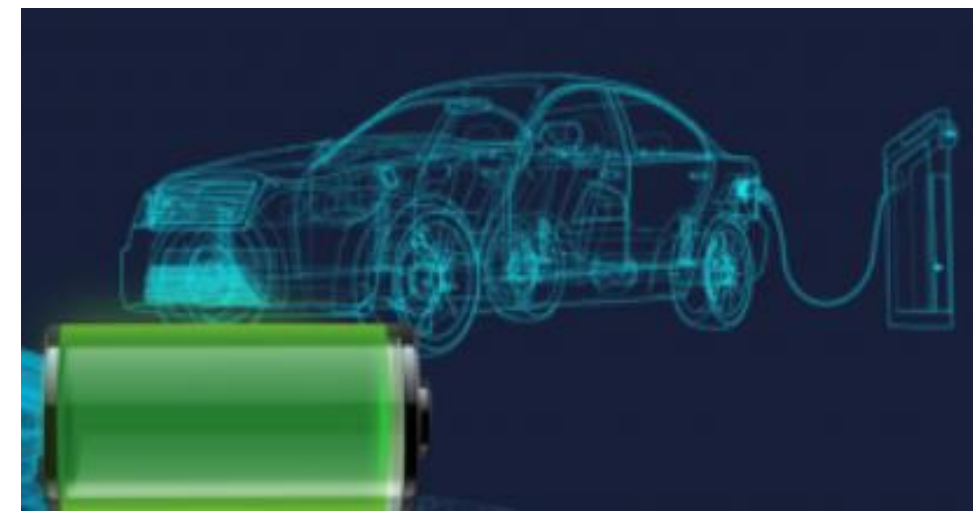
- **Passive**

- Cells with excess voltage (charge) are discharged to the level of the other cells – energy lost through resistive heat dissipation!!!

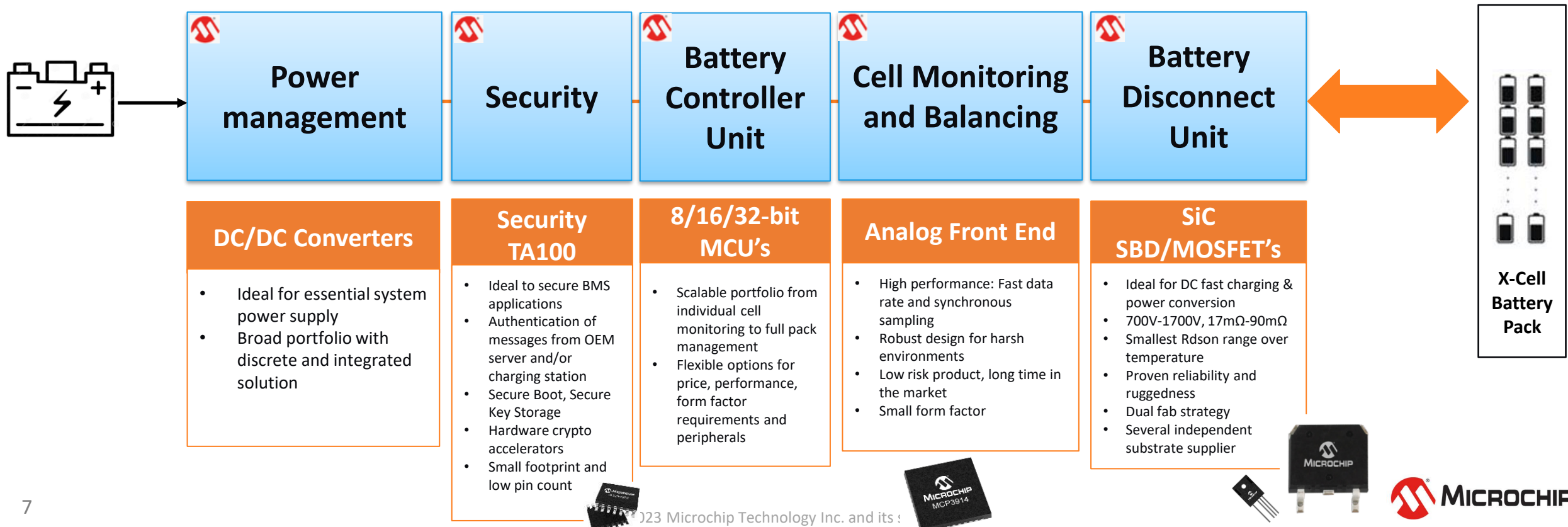
- **Active**

- Stronger cells are used to charge weaker cells to equalize their potentials – less energy wasted through heat dissipation!!!

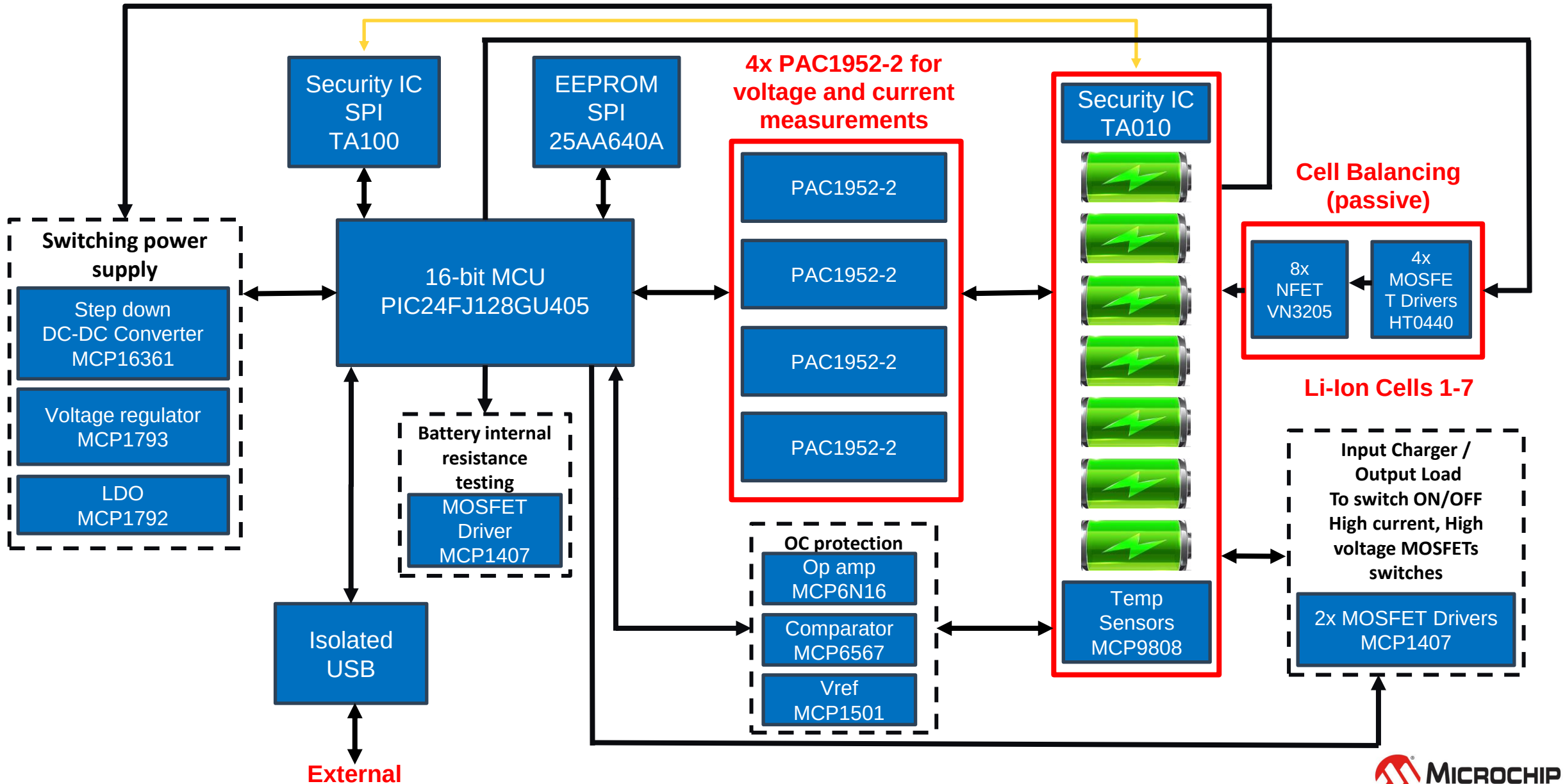
Battery Management Systems



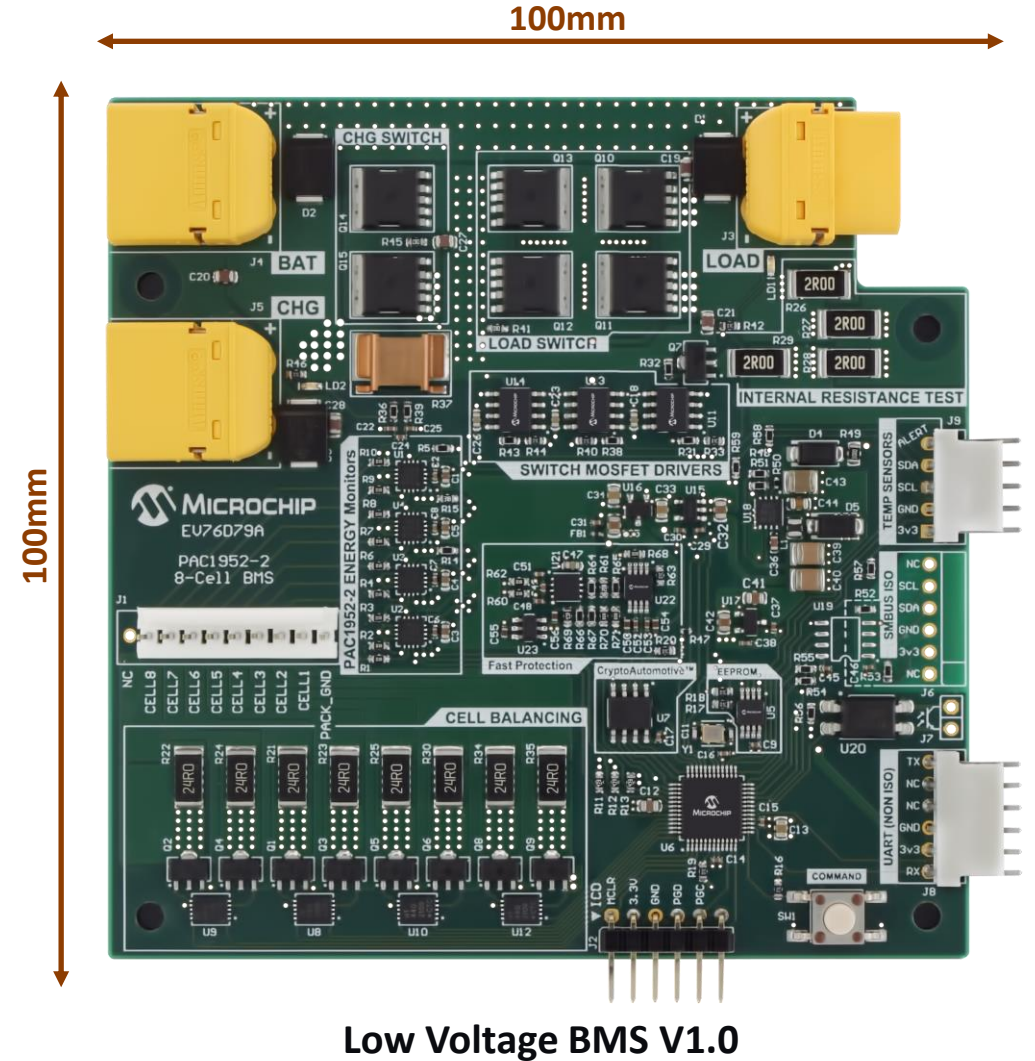
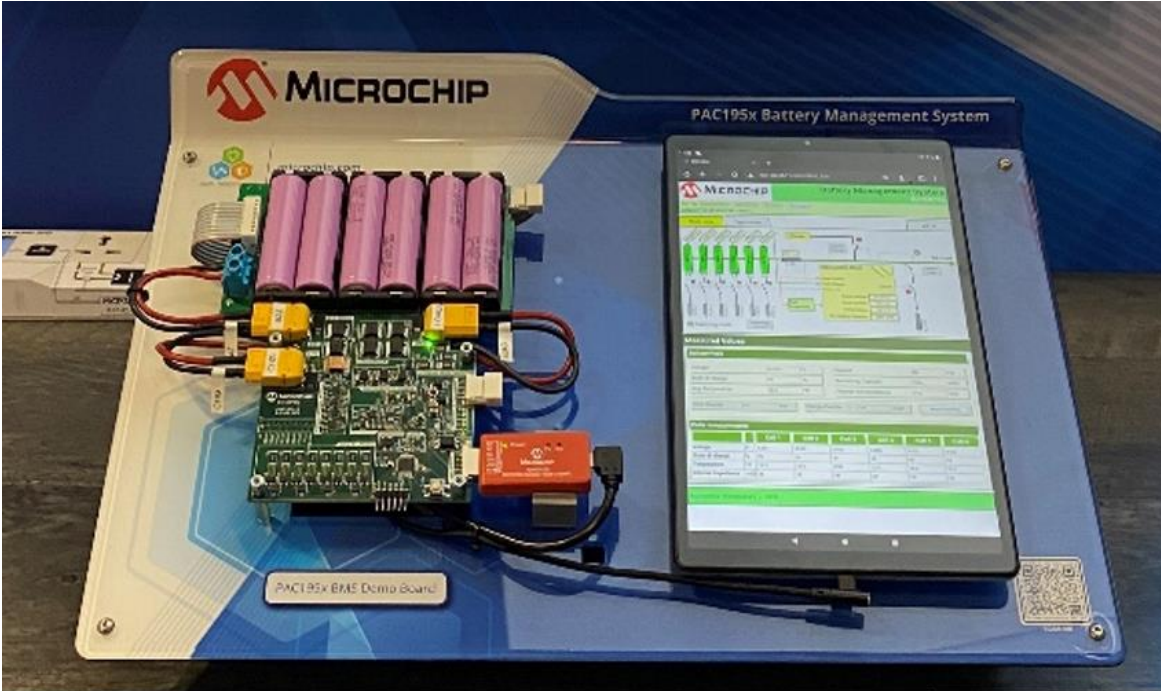
Major Functions



Low Voltage BMS V1.0 - Block Diagram



Low Voltage BMS V1.0 - EVB



Low Voltage BMS V1.0 Spec.

- **Specifications and features**

- **Support for monitoring a stack of up to 7 Li-Ion (or 8 LiFePo4) cells in series**
- **State-of-charge determination using:**
 - Coulomb-counting table
 - Voltage-to-state-of-charge table
 - Impedance measurement
- **Passive cell-balancing using a network of discrete MOSFETs and resistors:**
 - HT0440K6 (Dual, High Voltage, Isolated MOSFET Driver)
 - VN3205 (N-Channel enhancement-Mode Vertical DMOS FET)
- **1m Ω shunt for max. current of up to +/-100A**
 - (1 or 10mA precision on 16-bit, according to the customer requirements)
- **On-board Secure Crypto Authentication devices:**
 - TA100 (Trust Anchor External HSM)
 - TA010 (EDSA sign and HMAC operations with Common Criteria JIL High secure key storage)
- **Very fast short-circuit protection** (less than 25 μ s response time)
- **Undervoltage, overvoltage, overcurrent, under-temperature and over-temperature protection**
 - MCP9808 ($\pm 0.5^{\circ}\text{C}$ Max. Accuracy Digital Temp. Sensor)
 - PAC1952-2 (dual power monitor and energy monitor)
- **Low current consumption in sleep mode** (less than 100 μ A)

Low Voltage BMS V1.0 system Spec Table

<u>System specifications</u>	
Voltage Channels (how many cells)	7 Li-Ion cells (more could be stacked)
Supply V range	Max. 32V
Cell input voltage range	0-32V (optional $\pm 16V$)
PAC measurement error (from -40°C to +125°C)	Voltage: $\pm 0.2\%$, Current: $\pm 0.3\%$
Total Measurement error (from -40°C to +125°C)	$\pm 1.3\%$ (with 1% shunt tolerance), no calibration, better than $\pm 0.5\%$ with calibration
Functional safety (ASIL)	TBD
Isolated communication speed	15MBPS
Communication isolation	Opto-couplers
CRC bit	Optional
Integrated balancing	Passive
Coulomb counter count	$\pm 32.768Ah$ (16-bit for now, could be extended to 32-bit if needed)
Total power consumption (W or A)	TBD
Temp sensor accuracy	$\pm 1^\circ C$ from -40°C to +125°C
communication speed?	Full report every 0.5 seconds
<u>AFE</u>	
Resolution	16-bit
Sampling rate	1ksps
Relative current measurement error	$\pm 1.3\%$ (with 1% shunt tolerance), no calibration, better than $\pm 0.5\%$ with calibration
Package	N/A for now - discrete solution

Customer engagement

- Low Voltage 32V Battery Management System Demonstration Application (<https://www.microchip.com/en-us/tools-resources/reference-designs/low-voltage-32v-battery-management-system-demonstration-application>)

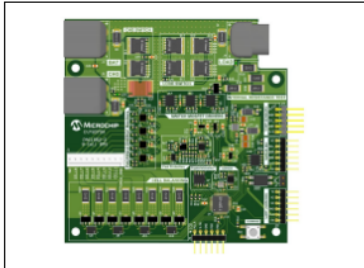
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Tools and Resources / Reference Designs

Overview Key Features Product and Tools



Low Voltage 32V Battery Management System Demonstration Application

Consumer Sustainability Industrial Power Conversion Power Supply

Battery Management

Design Benefits:

- Support for monitoring a stack of up to 7 Li-Ion (or 8 LiFePo4) cells in series
- Demonstrate modular expandable solution to cover wide range of voltage range and applications.
- State-of-charge determination using coulomb-counting table and voltage-to-state-of-charge table.
- Passive cell-balancing using a network of discrete MOSFETs and resistors.

[Read more](#)

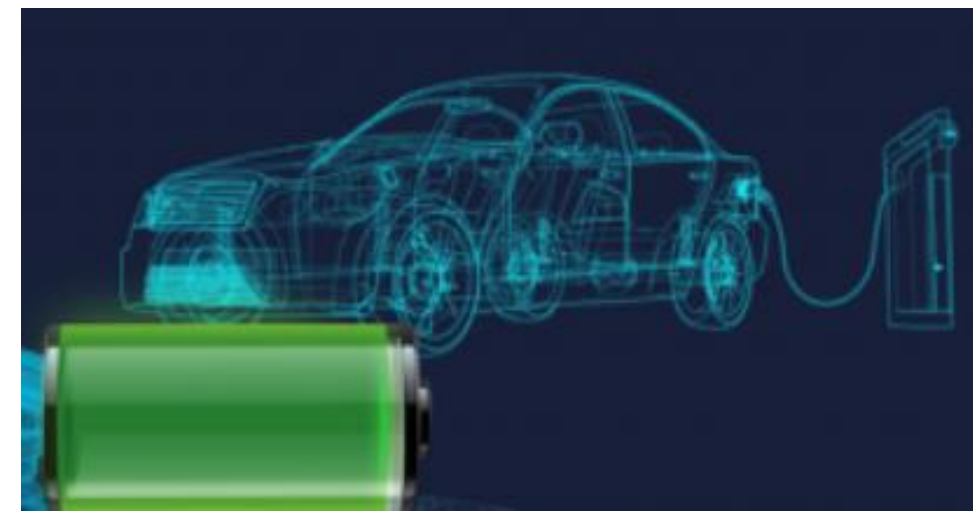
High Voltage BMS (V2.0) Under Development

Modular BMS Specification – V2.0 Advantages

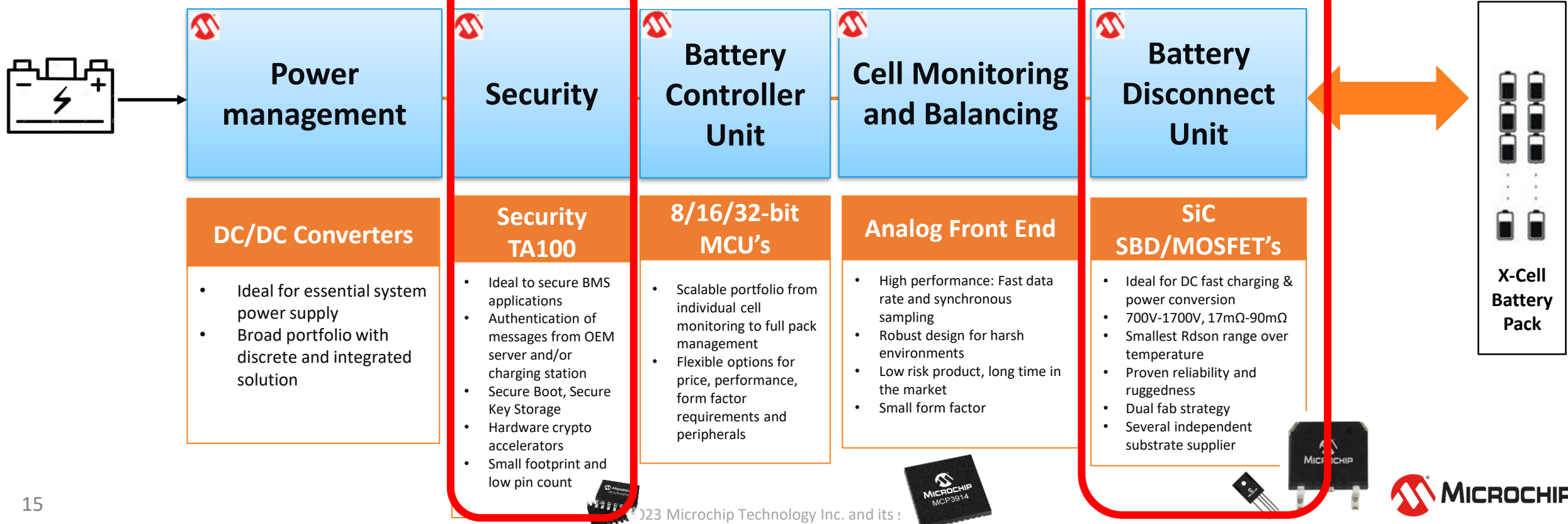
- **Advantages**
 - Flexibility in designing a battery pack with “any number of cells or configuration” “Any monitoring and balancing algo. (TBD)”
 - Current/voltage requirements changes:
 - Modify just one board (HVHC) adding the necessary number of Voltage Expanders.
 - Adding/removing an external interface type or protocol:
 - It requires the redesign of just one board (Main BMS).

Please reach out to iman.chalabi@microchip.com for access to high voltage V2.0 design file

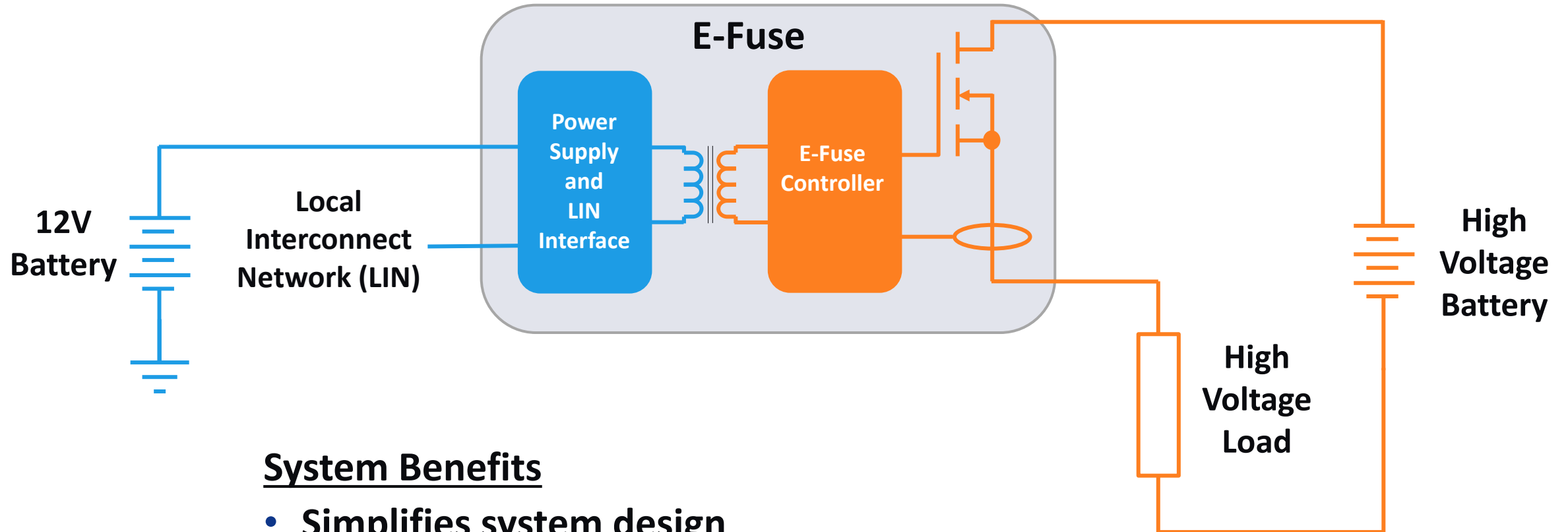
Battery Management Systems



Major Functions



High Voltage E-Fuse Reference Design



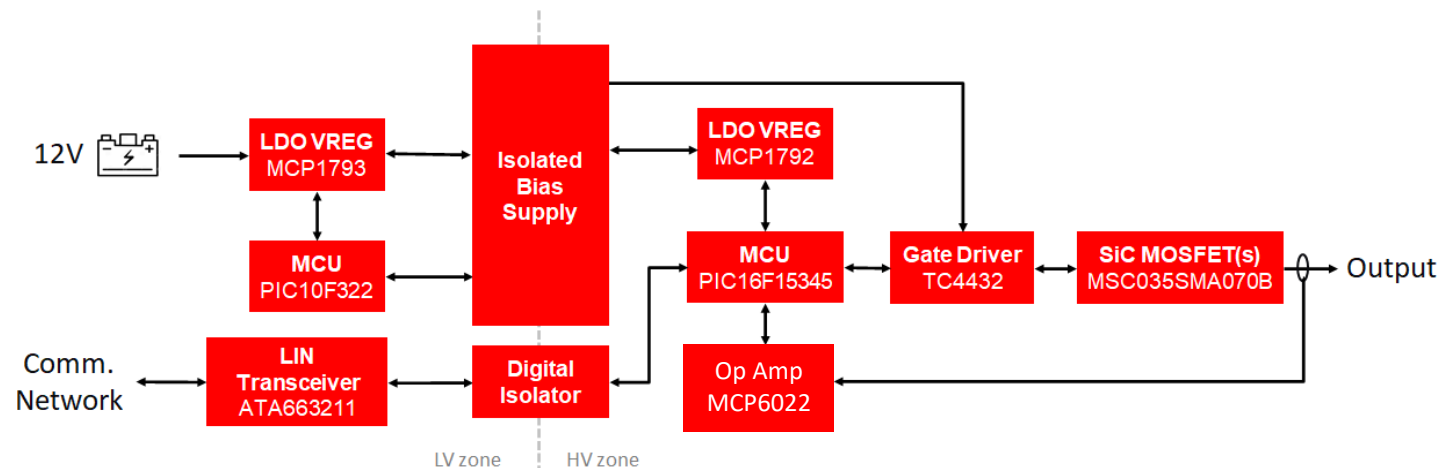
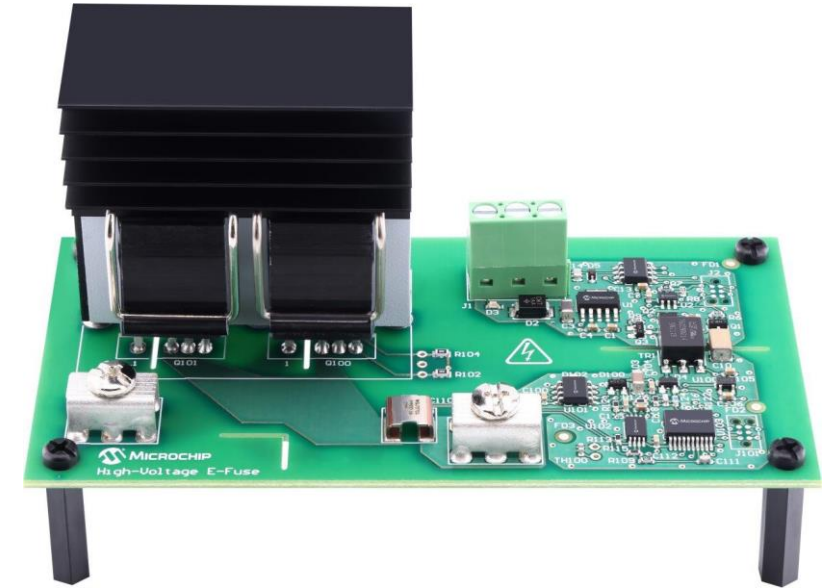
System Benefits

- Simplifies system design
- Fast response time
- Configurable trip profile
- Protection and diagnostics

E-Fuse Technology Demonstrator

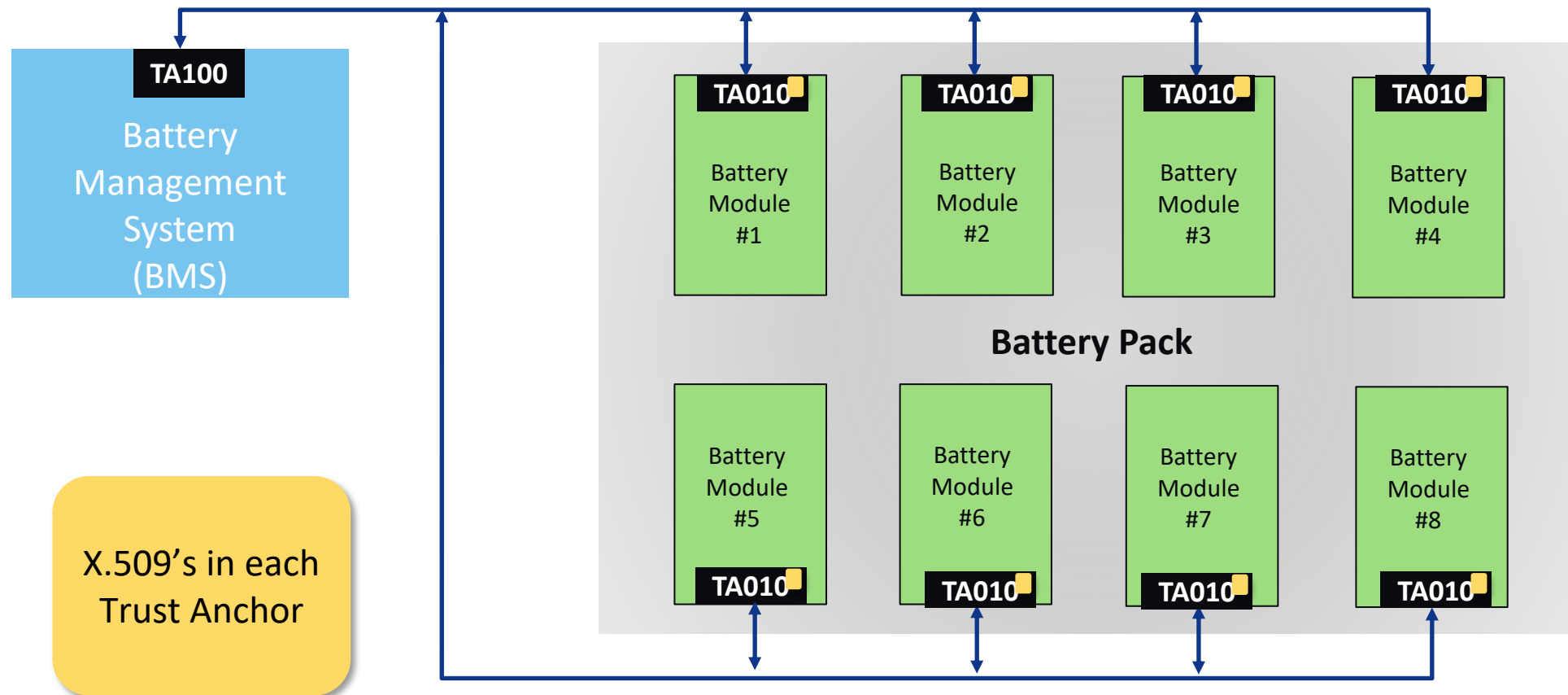
Specifications

- High voltage solid-state relay with over-current protection
- Configurable trip profile
- LIN comm. interface for configurability and diagnostics
- High-side or low-side drive configuration
- Short-circuit withstand time of 10 μ s
- 30A rated current
- Low voltage operating voltage range: 9V to 16V
- High voltage operating voltage range : 200V to 900V
- Operating temperature range: -40°C to 85°C
- Automotive applications
- E-Fuse landing page: www.microchip.com/E-Fuse



System Architecture of Battery Authentication

Microchip's HW security solution using Trust Anchor secure elements



Battery Management System : Security and Authentication (TA100)

- **BMS to gateway to cloud communication**
 - Secure Boot
 - Secure FW Update
 - TLS cloud session establishment
 - Provided signed health status
 - Message authentication
 - X.509 certificates
 - Verify manufacturing source of module



Battery Management System : Security and Authentication (TA010)

- Individual battery modules transmit status to BMS gateway (wired or wireless)
 - Authenticate each module via X.509 certificates
 - Verify manufacturing source of module
 - Simplified security use case



Thank you
