Challenges of Battery Management Systems (BMS) in Electric and Hybrid Vehicles

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Battery Management

• What does a BMS do?
• Technical challenges
  • Accuracy, Capacity & Safety
  • Long term drift
  • Isolation
  • Common mode rejection
  • ISO26262
What Does a BMS Do?

• Basic Functionality
  • Accurately measure individual cell voltages
  • Balance cells during charge
  • Report data back to host

• Advanced Functionality
  • Measure and report SOC, SOH
  • Balance cells during operation
Not as Easy as it Looks
**Voltage Measurement Accuracy: Capacity**

**Li Ion**

**Usable Energy**
- **70%**
- **NOW 60%**
- **NOW 68%**

**Charged**
- **90%**
- **85%**
- **89%**

**Discharged**
- **20%**
- **25%**
- **21%**

**5% ERROR MARGIN**

**1% ERROR MARGIN**
Voltage Measurement Accuracy: Safety

- Primary measurement is typically checked with a second measurement.
- Secondary measurement accuracy sets system error budget.
- Measurements disagree: something is wrong but **system is safe**.
- Measurements both drift in the same direction: **undetected double fault**.
- Both measurements drift strongly positive: **system is unsafe**.
What Makes a Reference Drift?

- Estimated Long Term Drift
- Typical Humidity Sensitivity
- Typical Board Assembly Shift
- Datasheet Temperature Drift
- Datasheet 25C Accuracy
Isolated Communication

• HV battery stack is isolated from the chassis for safety
• Control Module is typically grounded to chassis
• Isolated communication is required between the two domains
Common Mode Rejection: Analog Front End

- Resistance in wiring and adjacent cells causes common mode noise
- AFE circuitry must reject this noise while making precise cell measurements
- AFE circuitry must survive CM faults in the most severe cases
Common Mode Rejection: Communication

- Data errors are just as damaging as analog measurement errors
- CM noise sources affect the data path as well as the AFE path
- Both data integrity checking and effective CMRR are required
ISO 26262

• A measurement IC is considered a “Safety Element out of Context”: SEooC
  • A SEooC does not have an ASIL rating
  • It is designed to help the battery pack reach an ASIL rating, i.e. “Engineered for ISO26262 Compliant Systems”

• The design starts with a Safety Goal
  • e.g., “each individual battery cell within the battery pack shall not be overcharged”

• The design incorporates features to reach the Safety Goal, e.g.:
  • Redundant measurement circuit – each cell voltage can be measured 2 ways
  • Calibration circuit – the accuracy of the cell readings can be determined
  • Self checking circuits – stuck bits are detectable

• The design and manufacturing processes are ISO26262 compliant
Supply Chain Challenges

• Lack of standardization
  • Communication protocols
  • Isolation requirements
  • Safety requirements (which ASIL level?)

• BEV is an emerging market
  • Component needs are constantly evolving
  • Different manufacturers have different requirements

• Best Practice = State of the Art = Do The Right Thing