Introduction to Infineon's Battery Management Systems for Automotive Applications

Mahmoud Ismail
Feb 2022
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Introduction to BMS
Battery management systems protect the battery, calculate its state and optimize its performance

A deep dive into BMS functions

**Battery protection**
- Over/Under voltage
- Inrush current
- Short circuit
- Thermal management

**Cell monitoring and balancing (CMB)**
- Current monitoring
- Voltage monitoring
- Temperature
- Cell balancing

**Battery monitoring and control (BMC)**
- Fuel gauging
- State of health
- Cell temperature
- Cell balancing
- SOTA

**Security**
- Authentication
- Encryption

**Logging**
- Data storage
- Voltage regulators

**Regulators**
- PMICs

**Communication**
- Wired
- Wireless

Key functionalities:
- Monitor
- Battery state calculation
- Performance optimization
- Protection
Types and Trends in Automotive BMS
Battery management systems can be distinguished by voltage classes: 12 V, 48 V and 400/800 V

- AFE: analog front end
- COMM: communication (LIN/CAN)
- CS: current sense
- GD: gate driver
- Iso comm: isolated communication
- MCU: microcontroller
- PS: power supply
- Switch: disconnect relay or solid state switch

<table>
<thead>
<tr>
<th>Voltage Class</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 V</td>
<td>All Cars</td>
</tr>
<tr>
<td>48 V</td>
<td>E2Ws</td>
</tr>
<tr>
<td>400/800 V</td>
<td>MHEV, FHEV, PHEV, BEV</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power Range</th>
<th>Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2 kW</td>
<td>Lead acid, Lithium ion</td>
</tr>
<tr>
<td>5–15 kW</td>
<td>12V—48V, 400/800V Battery</td>
</tr>
<tr>
<td>20–25 kW</td>
<td>48V Battery, 400/800V Battery</td>
</tr>
<tr>
<td>&gt; 25 kW</td>
<td>400/800V Battery</td>
</tr>
<tr>
<td>&gt; 50 kW</td>
<td>400/800V Battery</td>
</tr>
</tbody>
</table>

2022-02-25
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Battery management systems can be distinguished by voltage classes: 12 V, 48 V and 400/800 V

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Lead acid</th>
<th>Lithium ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASIL B</td>
<td>(ASIL C for thermal runaway)</td>
<td></td>
</tr>
<tr>
<td>Functions</td>
<td>Start stop, power distribution</td>
<td></td>
</tr>
<tr>
<td>Trends</td>
<td>Expected ban of lead acid in favor of lithium ion batteries (not confirmed)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Voltage</th>
<th>12 V</th>
<th>48 V</th>
<th>400/800 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMS</td>
<td>E2W</td>
<td>MHEV</td>
<td>HV BMS for BEV, PHEV &amp; FHEV</td>
</tr>
<tr>
<td>ASIL</td>
<td>SIL – ASIL B</td>
<td>ASIL B to ASIL D</td>
<td>ASIL D</td>
</tr>
<tr>
<td>Functions</td>
<td>Start stop, regenerative breaking, torque boost, electric drive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trends</td>
<td>E2Ws to largely replace ICE 2 Ws in India and South East Asia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MHEV will not withstand long term due to aggressive low CO₂ targets</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Trends**
  - E2Ws to largely replace ICE 2 Ws in India and South East Asia
  - MHEV will not withstand long term due to aggressive low CO₂ targets

**Diagrams:**
- 12 V system
- 48 V system
- 400/800 V system

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High Voltage BMS
Infineon one stop shop for high voltage BMS products

**List of products**

- **Cell Monitoring and Balancing:**
  - TLE9012DQU
- **Current Sensing**
  - TLE4972
  - PSoc™ HV PA
- **Pack Monitoring**
  - PSoc™ HV PA
- **Isolated pre-regulator:**
  - AUIR2085
- **Isolated-UART Transceiver/Receiver**
  - TLE9015DQU
- **Microcontroller**
  - AURIX™
- **PMIC**
  - TLF35585
- **Smart Switches**
  - PROFET™
  - HITFET™
Cell Monitoring and Balancing with **TLE9012DQU**
Cell voltage monitoring and balancing is a device that senses and balances the voltages of the individual battery cells.

- A lithium-ion battery cell is characterized by a low voltage and very flat state of charge curve (especially within the safe operating regions of 20-80% SoC).
- The cells are always on (Cell nominal voltage > 3 V).
- The cells are located in harsh environments.
- Cells in series are prone to imbalancement.

![Diagram](image-url)
BMS IC application requires highest accuracy in a harsh & unique environment

Tier1s & OEMs around the world had problems with their previous BMS developments. Resulting in:
- Large and expensive external BOM (for filtering, protection circuits, robust communication, etc.)
- Higher than expected CSC board failure rates (mainly due to EOS)

Infineon addresses all this topics by maximizing robustness & performance for the TLE9012DQU.
- The TLE9012DQU is build in Infineon's leading automotive smart power technology (SPT9) using a 90 V/130 nm technology node
- Chosen device architecture and concepts are focusing on optimizing robustness & performance for our customers
- Early engagement with lead customer(s) for joined system evaluation & testing to increase confidence in the device robustness & performance
TLE9012DQU a unique combination of high performance, highest application robustness & lowest PPM rates for lowest system cost

**BMS IC offering**

**High Performance ADCs**
- **Highest intrinsic accuracy** enabled by true 16-Bit ENOB DS-ADCs
- **Highest** relative device to device and channel to channel **accuracy** with excellent repeatability

**Application Robustness**
- **Best performance under noise:**
  - Passed 200mA BCI test
  - Passed random **plugging test** with 4.5V / cell without any additional external protection components
  - Passed **8kV gun test** without any additional external protection components

**Lowest PPM rates**
- Infineon's full development & production lifecycle **design for stress methodology enables industry leading PPM rates** for latent defects
- Productive DfS compliant devices achieve already <0.1PPM

**Lowest system cost**
- Highest accuracies to maximize battery pack usage
- High application robustness for the **leanest BOM around the BMS IC** (no large filter, chokes or protection circuits needed)
- **Small & lean TQFP-48 pin package** to achieve competitive device pricing
Key benefits

- Balancing & monitoring for up to 12 cells in series
- Robust Infineon 90V/130nm automotive technology supports hot plugging and enables digital features
- Dedicated 16-bit delta-sigma ADC per cell enabling synced & filtered measurements
  - Several built-in digital filtering (down to 70Hz cut-off)
  - Long running ADC mode with adaptive sample times for up to ~92ms (<10Hz cut-off) averaging.
- Secondary ADC with same filter characteristics for a synced cell voltage plausibility as advanced End-to-End safety mechanism
- 13th DS-ADC with the same filter characteristics for synced block voltage measurements
- Compatible with Infineon complex device driver for TC3xx
- 5 NTC channels + additionally 4 GPIOs to connect e.g. an external EEPROM
- UART & robust capacitive coupled interface for daisy chain & ring mode communication
- Supporting up to ASIL-D BMS safety applications
- Small package (TQFP-48) & high feature integration for a lean external BOM

Block diagram

Click here for Datasheet and Product page
Current Sensing
Current sensing is used to accurately estimate the different states of cells with lithium ion based chemistries.

- A very flat state of charge curve (especially within the safe operating regions of 20-80% SoC)

- Current sense is needed for advanced SoC measurements such as Coulomb count

- Additionally current sensing is needed for monitoring further critical events such as over current detection (OCD)
Current sensing with two different set of sensors

Shunt Based Solution (with Pack Monitoring)

- Precise analog measurements with 2x Delta-Sigma ADCs and 4x hardware digital processing channels
- Optimized for battery V, I and T measurements
- ISO 26262 for ASIL-C compliance
- Analog diagnostics, E2E protection of data, ECC for memories, Window watchdog with challenge/response
- Iso-UART, CAN-FD and Serial communication interfaces
- MCU with a fault subsystem and for diagnostics
- Compact QFN packages

Hall Based Solutions

- Stray field suppression through **differential voltage measurement** of 2 Hall probes/cell
- No saturation, no hysteresis, high linearity
- Low dependency on temperature and lifetime
- Sensor comes in small SMD packages
Shunt Based Current Sensing
with PSoC HVPA
Shunt based current sensing with PSoC HVPA 144k
IBS Application Overview

High Precision Analog

High Voltage Subsystem

Functional Safety

Integrated MCU

One-chip Solution

PSoc HV PA (IBS)

12V LDO

HV Div

NTC

12V Pb Acid Battery

12V

Analog Front End

Voltage Channel

Current Channel

Temperature Channel

Diagnostic Channel

Arm

Cotex M0+

(w/MPU)

128k Code Flash & Data Flash

LIN PHY

PSoc HV PA
## High Precision Analog

<table>
<thead>
<tr>
<th>Current</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>› Measurement range: +/-1500 A</td>
<td>› Measurement range: 3.6 V – 28 V</td>
</tr>
<tr>
<td>› Measurement accuracy up to 0.3%</td>
<td>› Measurement accuracy up to 0.15%</td>
</tr>
<tr>
<td>› Automatic Gain Control</td>
<td></td>
</tr>
</tbody>
</table>

### Temperature

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>› Internal temperature sensor Measurement accuracy: +/-2°C (-40 to +125°C)</td>
<td></td>
</tr>
<tr>
<td>› External temp sensor Measurement accuracy <em>(Vtemp)</em>: +/-1%</td>
<td></td>
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</table>

### Diagnostics

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>› Open Shunt detection</td>
<td></td>
</tr>
<tr>
<td>› Vref comparison (primary and secondary)</td>
<td></td>
</tr>
<tr>
<td>› Channel cross-checks</td>
<td></td>
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</tbody>
</table>
High Voltage Subsystem

LDO
- VBAT (12 V) supply
- 42 V Tolerant
- 3.3 V output, 30 mA supply

LIN PHY
- LIN 2.2 A / ISO 17987 compliant

HV Sense
- Integrated HV dividers

HV Subsystem
Functional Safety: A Holistic System-level Approach

- ISO 26262 Safety-Element-Out-of-Context product
- Supports safety critical applications up to ASIL-B
- Software is developed according to ISO 26262
- Supplemented by safety documents

PSoc 4 HV PA Offers Safety Hardware and Collaterals
Software support for HVPA-144K
AutoPDL 1.0

IFX AutoMiddleware

Low-level drivers (AutoPDL 1.0)

- Analog
  - HVSS
  - PACSS
- Digital
  - TCPWM
  - SYSCLK
  - SYSINT
  - SYSLIB
  - SYSPM
  - SYSRESET
- SYSTICK
- SYSWDT
- CPU
- GPIO
- SYSFLT
- Memory
  - DMA
  - FLASH
- Comm
  - UART
  - I2C
  - LIN

Application layer

- LIN stack
- LIN bootloader
- Customer middleware

Sample IFX SW support (SDL)**
Sample IFX SW support (code example)**

Tools

- Compilers (IAR)
- IDE (IAR)
- Debugger / Programmer* (IAR)

*IFX tools (Auto Flash Utility, MiniProg4) without warranty supports for early development stage
**Sample without warranty for evaluation and reference to customers

Microcontroller (Hardware)

- HVPA-144K

Headers
PSoc 4 HV PA: Preferred Solution for IBS

**High Precision Analog**
- Precise analog measurements with 2x Delta-Sigma ADCs and 4x hardware digital processing channels
- Optimized for battery V, I and T measurements

**Functional Safety**
- ISO 26262 for ASIL-B compliance
- Analog diagnostics, ECC for memories, Window watchdog

**One-Chip Solution**
- Operates directly off the 12 V battery, Integrated LIN PHY
- Integrated MCU
- Compact QFN package
Getting started: Evaluation and Demo

CYHVPA-128K-32-001: Evaluation board available now

CYHVPA-DEMO-001: Solution demo available now
PSOC 4 HV PA 144k | CY8C41x7-HVPA
Precision Analog

Applications
Intelligent battery monitoring and management systems

Features
32-Bit MCU Subsystem
- 48-MHz Arm® Cortex®-M0+ CPU with DMA controller
- Up to 128KB Code Flash, 8KB Data Flash and 8KB SRAM, with ECC
Precision Analog Channel Subsystem
- Two 16-bit Precision ΔΣ analog-to-digital converters (ADC)
- Current Channel with automatic Gain, Voltage Channel with High-Voltage input divider
- Temperature and diagnostic channels
- Digital filtering, accumulators, and threshold comparisons on all channels
Programmable Digital Subsystem
- Four 16-bit timer/counter/pulse-width modulation (TCPWM) blocks
- One independent Local Interconnect Network (LIN) block
- One serial communication blocks (SCB) that are configurable as I²C, SPI, UART or LIN Slave
High Voltage Subsystem
- Operates directly off 12 V battery (tolerant up to 42 V), Integrated LIN Transceiver
ASIL-B Compliant
Packages
- 32-pin Wetable Flank QFN
I/O Subsystem
- GPIOs (up to 11)

Collateral
Datasheet: Contact Sales
Hall Based Current Sensing with TLE497x
Current sensing based on HALL effect
Differential sensing key for core-less sensing

### Core-less sensing
- Hall element
- Conductor
- Sensor chip (without package)
- Sensing structure

### Core-based sensing
- Conductor
- Field probe Hall mono-cell
- Field concentrator

- Stray field suppression **through differential voltage measurement** of 2 Hall probes/cell
- No saturation, no hysteresis, high linearity
- Low dependency on temperature and lifetime
- Sensor comes in small SMD packages

- Risk of saturation in case of over currents
- Hysteresis in case of PWM
- Non-linearity due to iron core
- Bulky package
Product summary TLE4972 – Infineon current sensor optimized for drives

Product features

› Measurement range **0 to 31 mT** (0A to > 1 kA) enabling large measurement range
› Fast overcurrent detection output **OCD**
› **Analog output**
› High bandwidth (typ. 210 kHz) for fast measurement
› **3.3 V** supply voltage
› High accuracy over temperature & lifetime
› Intrinsic stray-field robustness through differential measurement
› Automotive grade qualified
› **ISO26262** complaint development
  – Component rating: ASIL B

Block diagram & packages
TLE4972 family: designed to enable flexibility

Output modes are programmable

- Semi differential
- Fully differential
- Single – ended

Overcurrent thresholds are programmable

Programming options
- 3 Output modes
- OCD1 64 Thresholds
- OCD1 8 Deglitch Timings
- OCD2 64 thresholds
- OCD2 16 Deglitch Timings

Sensitivity ranges are programmable

- S1: ±39 mV/mT, ±31 mT FS
- S2: ±47 mV/mT, ±26 mT FS
- S3: ±62 mV/mT, ±19 mT FS
- S4: ±93 mV/mT, ±13 mT FS
- S5: ±124 mV/mT, ±10 mT FS
- S6: ±186 mV/mT, ±6.5 mT FS
Two package variants are offered to enable different implementations and to cover a wide measurement range.

- TLE4972 on PCB:
  - Lateral Insertion:
    - S – Bend
    - Straight

- TLE4972 with Bus-Bar:
  - Lateral Insertion:
    - S – Bend
  - Vertical Insertion:
    - Through hole sensor implementation

- Sensing structure:
  - Up to 2 kA
  - < 500 A
  - 500 A
  - 2 kA
Design-In tools

### PCB for current < 500 A
- TLE4972 EVAL STD PCB
  - Measurement range 191 A
    - Multilayer PCB (2x140 µm Cu)
    - Lateral sensing structure: 45°S-bend

- TLE4972 EVAL INLAY
  - Measurement range 421 A
    - Thick copper-inlay (1 mm Cu)
    - Lateral sensing structure: 45°S-bend

### Bus-bar for currents 500 A – 2 kA
- TLE4972 EVAL LAT BAR
  - Measurement range 543 A
    - Bus bar dimension: 2x14 mm
    - Lateral sensing structure: S-bend

- TLE4972 EVAL VER BAR
  - Measurement range 843 A
    - Bus bar dimension: 2x14 mm
    - Vertical sensing structure
Key features and benefits of TLE4972

- It's an accurate current sensor family for automotive use, particularly in electric vehicles.
- It has two programmable product variants that cover a wide measurement range up to 2 kA.
- It offers fast overcurrent detection for inverter and battery main switch applications.
- It is an ISO 26262 compliant device of safety requirements up to ASIL B.

- High performance at minimal space.
- Ideal for platform designs.
- Less external components reduce cost.
- Reduces design risk.
Isolated Communication with TLE9015DQU
Battery communication transfers the sensing and controlling values between the control units and the monitoring devices.

The different monitoring modules are on different voltage levels.

The different monitoring devices share different local grounds.

The high voltage battery must be at all time isolated.

The monitoring devices must communicate with a 12 V controlling unit.
TLE9015DQU a UART to iso UART transceiver IC

Key benefits

› Two UART ports for serial communication to host microcontroller
› Two iso UART ports for daisy chain communication inside battery pack
› Fully transparent communication scheme from µC to sensing IC (TLE9012DQU)
› Ring mode topology compatible (only 1 device needed)
› Supporting up to 2 Mbit/s
› High robustness against external noise
› General purpose error pin
› Two external fault inputs with internal latching
› Error output pin to trigger external microcontroller
› Internal supply monitoring
› AEC-Q100 qualified
Battery Monitoring and Controlling
Battery monitoring and controlling unit performs all the necessary calculation and controlling protocols

**Battery State Calculation**
- State of Charge (SoC)
- State of Health (SoH)
- Depth of Discharge (DoD)
- State of Power (SoP)
- State of Safety (SoS)
- etc.

**House Keeping**
- Run battery state machine
- Communicated with other car ECUs or charges
- Log battery status & history
- etc.

**Controlling**
- During charging and/or discharging
- Toggling battery disconnects
- Extending battery life
- etc.
PSoC™ Automotive, TRAVEO™ & AURIX™ architectures meet a broad set of application requirements and provide a strong roadmap.
Infineon offers different MCU solutions for battery management systems

<table>
<thead>
<tr>
<th>TRAVEO™ T2G</th>
<th>AURIX™ TC3xx</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cores</strong></td>
<td><strong>Cores</strong></td>
</tr>
<tr>
<td>Up to dual core Arm® Cortex™ M7</td>
<td>Tricore based core up to 6 CPUs</td>
</tr>
<tr>
<td><strong>Qualification</strong></td>
<td><strong>Qualification</strong></td>
</tr>
<tr>
<td>AEC-Q100 up to Grade 1 ($T_a \leq 125 , ^\circ C$)</td>
<td>AEC-Q100 up to Grade 0 ($T_a \leq 150 , ^\circ C$)</td>
</tr>
<tr>
<td><strong>Functional Safety</strong></td>
<td><strong>Functional Safety</strong></td>
</tr>
<tr>
<td>ISO26262 ASIL-B</td>
<td>ISO26262 ASIL-D</td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td><strong>Memory</strong></td>
</tr>
<tr>
<td>Up to 8-MB Flash, 1-MB SRAM</td>
<td>Up to 16-MB Flash, 6.6-MB SRAM</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td><strong>Security</strong></td>
</tr>
<tr>
<td>HSM EVITA Full</td>
<td>HSM EVITA Full</td>
</tr>
</tbody>
</table>

Depending on requirements, customer can choose between Infineon's TRAVEO and AURIX family as a battery main control for 48 V and HV Battery Management Systems.
OPTIREG™ PMIC: The #1 power supply solution for AURIX™ microcontroller family

OPTIREG™ PMIC: THE AURIX™ supply

- #1 Functional Safety supply for AURIX™
- > 20 Mpcs already shipped worldwide
- > 300 projects secured at all major OEMs
- > 30 different applications (xEV, Chassis, Safety, ADAS, Body)

General Purpose AURIX™ TC2x/3x PMICs

TLF35584 & TLF35585
- Scalable general purpose PMIC for AURIX™ TC2x/3x
- ISO26262 compliant, supporting ASIL D classified automotive systems
- Extended performance by using TLF11251, improving supply efficiency by up to 25%
Battery Disconnect Solutions
Solutions for battery disconnects

**Mechanical Disconnect**

- Wide range of high and low side smart disconnects
- Support multi channels per device
- High current outputs
- Controllable voltage regulators for relay armature control

**Solid State Disconnect**

- CoolMOS™ S7A
- CoolSiC™

- Applicable to 400 V & 800 V vehicle network
- Same constructed space as melting fuse
- Functional Safety according to ASIL-C
- Cost optimized system solution
- Selective, arcing-free switch-off in case of failure
- Flexible system integration
**eFuse** have faster response and longer lifetime than mechanical switches.

**HV eFuse and HV eDisconnect switch**

---

**Application**

- Central eFuse for auxiliaries
- Main relay or pyro-fuse replacement

**State of the art**

- **Main difficulties:**
  - Space, weight, reliability, mechanical vibrations
  - Maintenance costs, accessibility
  - Reaction time

**Success Factors**

- **CoolMOS™ S7A**
  - QDPAK TSC
  - Best-in-class $R_{on}$ x A x cost
  - Lowest $R_{on}$ in a SMD package

- **Customer support**
  - Thermal simulations
  - Circuit design

---

*First point for snubber dimensioning*
eFuse and eDisconnect
Reliable and maintenance-free protection of the HV boardnet

**Applicable to 400 V & 800 V vehicle network**
- Scalable to different current and voltage classes
- OBD capability

**Same constructed space as melting fuse**
- Maintenance free
- No accessibility required
- No openings for maintenance needed

**Functional Safety according to ASIL-C**
- Integrated current and temperature measurement
- Enables high availability supply with state-of-health indication and pre-warning

**Cost optimized system solution**
- Can be integrated into available system components
- Dedicated chip set
- No current stress integral degradation

**Flexible system integration**
- Variable cooling strategy
- Scalable technology

**Selective, arcing-free switch-off in case of failure**
- Minimized failure propagation into vehicle network
- Reset possible via OBD command
eFuse Reference Design
Top Side Cooling (TSC) vs. Bottom Side Cooling (BSC)

Top-Side Cooling (TSC)

- Implementation w/o significant thermal requirements to base PCB
- Tightly coupled local thermal capacitance and increased aperture Area to high-Rth TIM
- Best possible Rth and Cth performance and enables full utilization of Power Device
- Advanced Assembly Process

Bottom-Side Cooling (BSC)

- High Performance Power PCB required
- PCB as Rth / Cth bottleneck
- Isolation Coordination strategy critical (PCB internal/external isolation)
- Standard PCB assembly flow, simple system integration
Complementary technologies enabling HV eFuse & eDisconnect

<table>
<thead>
<tr>
<th>power</th>
<th>driving</th>
<th>sensing</th>
<th>control</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoolMOS™ S7A</td>
<td>EiceDRIVER™</td>
<td>XENSIV™</td>
<td>AURIX™</td>
</tr>
</tbody>
</table>

- **CoolMOS™ S7A**
  - 10 mΩ BiC
  - 800 A pulse current
  - High power SMD
  - Kelvin Source

- **Power Technologies**
  - 600V-800V N-Channel Automotive MOSFET
  - 650-1700V Silicon Carbide MOSFET

- **Driving Technologies**
  - Safe operation
  - High efficiency
  - Lower system size & weight

- **Sensing Technologies**
  - Magnetic sensing solution with ultra-low insertion resistance
  - Galvanic insulation
  - Analog measurement w/ high speed overcurrent detection

- **Control Technologies**
  - Scalable
  - Safe/ secure
  - Broad connectivity

---

We have a broad and high quality product spectrum to enable eFuse & eDisconnect
Thermal Runaway Detection with KP2xx
Thermal runaway (TR) a growing concern around safety of electric vehicles

**Thermal Runaway challenge** – Prevent TR or give passengers enough time to safely leave their car

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Description</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Early Warning</td>
<td>Mechanical, electrical, thermal abuse start internal chemical reactions</td>
<td>Warn the passenger of the coming fault: CO₂ sensor for overcharging detection? Crash detection sensor?</td>
</tr>
<tr>
<td>Intrinsic Safety</td>
<td>Avoid TR and/or Propagation</td>
<td>Improve material properties at cell and pack level</td>
</tr>
<tr>
<td>Extend Time for Escaping</td>
<td>Propagation of TR cannot be stopped</td>
<td>Pressure sensor for accurate, fast and reliable detection of thermal runaway</td>
</tr>
</tbody>
</table>
Pressure sensor reliably detects beginning thermal runaway independent of position inside battery pack

GTR20 Thermal Propagation Regulation: The vehicle shall provide an advance warning indication to allow egress or 5 minutes prior to the presence of a hazardous situation inside the passenger compartment caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway such as fire, explosion or smoke.

Barometric Pressure Sensor for Thermal Runaway detection can be placed inside battery pack housing or inside central control box (BMS)

→ Pressure sensor triggers a warning signal for the driver/passengers to meet requirements of GTR20

→ Pressure sensor detects a cell opening very reliable and avoids any false alarm
Absolute Pressure Measurement within Battery Pack

Two options for pressure increase detection with the absolute pressure sensor

Option 1

\[ \Delta p' = \frac{p_2}{p_1} \]

ECU pressure sensor (BAP)

Option 2

\[ p = \frac{p_2}{p_1} \]

\[ \Delta p = p_2 - p_1 \]

Overview of the pressure sensors for BMS application

<table>
<thead>
<tr>
<th>60 kPa</th>
<th>165 kPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>KP236N6165</td>
<td>-40 ( \rightarrow ) 125°C ( 0.2 \rightarrow 4.8 \text{ V} )</td>
</tr>
<tr>
<td>KP253</td>
<td>-40 ( \rightarrow ) 125°C</td>
</tr>
<tr>
<td>KP256</td>
<td>-40 ( \rightarrow ) 125°C</td>
</tr>
</tbody>
</table>

Analog

Digital
Full BMS Evaluation Solutions
Fast and easy evaluation of HV BMS with evaluation kits

2 Aurix boards with PMICs and CAN & UART interface
Evaluation board

**TLE9012DQU**
Li-ion monitoring and balancing IC evaluation board

- Connection LED for easy debugging
- Easy connection to BMS transceiver IC TLE9015DQU
- Additional devices in the daisy chain
- Cables included for fast set up
- Wide supply range up to 75 V input voltage
- Integrated optional resistor divider for use with DC supply
- Integrated dummy resistors for temperature measurement emulation

**TLE9015DQU**
iso UART transceiver IC evaluation board

- Easy connection to monitoring devices in the daisy chain
- Cables included for fast set up
- Ring mode support
- Wide supply range up to 75 V input voltage
- Available footprint for monitoring and balancing IC TLE9012DQU integration

User manual and evaluation software available
## Fast and easy evaluation of HV BMS with dedicated software solutions

### Evaluation software
- **Available now**
- **Fast path for hardware evaluation with IFX evaluation boards**
- **Scripting possibility for system emulation**
- **Available**

### Reference software (Livonia, MI)
- **AURIX™ TC3xx**
- **Application Example Software**
- **RTE (AUTOSAR License Required)**
- **BSW (AUTOSAR License Required)**
- **IFX Reference Complex Device driver (iCDD)**
- **Hyper-terminal Software**
- **Windows GUI**
- **Scripting LL driver**

### In Development
- **Available in Q3/2021 (beta now)**
- **CAN interface for beta version**
- **GUI in definition phase for:**
  - COM State Machine Sequence & DMA Link List
  - Device Init Configuration
  - **Available**

### Trial version of Production SW
- **AURIX™ TC3xx**
- **T1 and OEM application software**
- **Common IFX BMS SW Interface**
- **Productive Complex Device drivers (CDD)**
- **MCAL**
- **Availability not yet defined**
- **Complimentary offering**
- **Alpha release quality**
- **Limited functionality**
- **For application software development**
- **Q3 2022**

### Production SW
- **AURIX™ TC3xx**
- **T1 and OEM application software**
- **Common IFX BMS SW Interface**
- **Productive Complex Device drivers (CDD)**
- **MCAL**
- **Availability not yet defined**
- **Paid product**
- **Full functionality released**
- **Full ISO26262 compliant**
- **Qualified to be used in the final customer software**
- **Q4 2022**

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**IFX SW offering**
- **AURIX™ Hyper-terminal Software**
- **Complex Device drivers (CDD)**
- **MCAL**
- **Common IFX BMS SW Interface**
- **T1 and OEM application software**
- **Production SW**
- **Available in Q3/2021 (beta now)**
- **CAN interface for beta version**
- **GUI in definition phase for:**
  - COM State Machine Sequence & DMA Link List
  - Device Init Configuration
  - **Available**
Complex Device Driver for BMS application

Description

› The CDD is a driver component which can be integrated in an Autosar compliant application with or without an OS. Therefore, it cannot act stand-alone.

Key features

› Communication via UART using the AURIX ASCLIN module with the TLE9015DQU
› Configuration data generated through TRESOS configuration.
› Storing the data of each TLE9012DQU device
› CSC functions as described in SOW_CDD_BMS_1_1 chapter 2.3.2
› Implementation using technics of layering and abstract interfaces to be MCU independent
› Safety ASIL-D
  – Safety documentation reduces customers’ effort for safety qualification
  – Safety features based on SEooC according to ISO26262 standard
› MCAL 2.0.0 compatible regarding AUTOSAR 4.4. version and compiler versions
› Validated on AURIX™ 2G, compatible to AURIX™ 3G
Summary
Go greener with Infineon’s full chip offering for high voltage automotive BMS products

Ease of Use: reduce development efforts and fasten time to market

› **One Stop Shop** for BMS: Infineon offers hardware and software for BMS application
› Complete **Infineon chipset** solution including BMS ASIC and MCU
› Complex device driver available for **rapid prototyping** and **mass production** reducing the customer’s development efforts and time to market
› **Enhanced interoperability** with production ready complex device driver designed, developed and qualified for AURIX™ TC38X
› Customer does not need develop low level driver
› Supporting industry standard tool completely automotive quality/functional safety compiler
Part of your life. Part of tomorrow.