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BPS Introduction

Battery thermal runaway event

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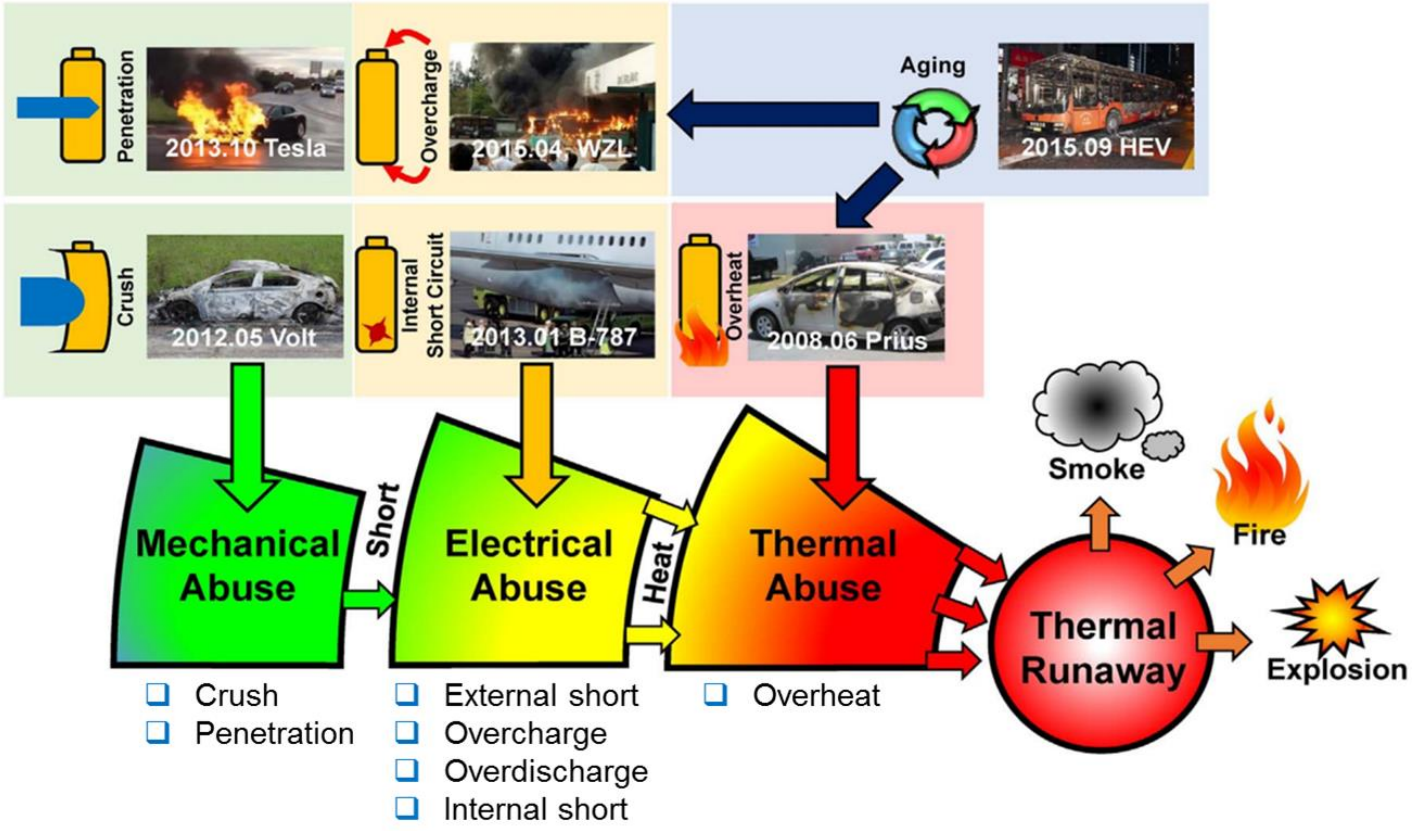
- Thermal runaway is an uncontrolled chain reaction caused by mechanical, electrical, thermal abuses or a combination of abuse.
- Thermal runaway leads to battery uncontrolled self-heating up to 400-1000℃ and easily propagates to other cells which could end with a destructive result like fire or explosion.



Safety legislations for thermal runaway

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*CN MIIT revised the legislation of "Electric vehicles traction battery safety requirements" which will be effective on **Jul 1st 2020**.*

- New mandatory standard defines requirements to protect passengers from battery thermal event (thermal runaway to propagation), which particularly requires OEs to design & implement **a robust and reliable thermal runaway detection system**.

- Implementation requirement:

  New vehicle models start from **2020/07**

  All production vehicle models start from **2021/07**

NEV Global Safety Technical Specification / EVS-GT unanimously approved at the 174th conference of WP.29 in Mar.2018.

- EVS - GTR Phase 1
  - Scheduled for adoption March 2018
  - Amended ECE R 100 adopted end of 2020
- EVS - GTR Phase. 2 / mandatory
  - No ext. fire / explosion / smoke in cabin within 5 minutes after warning
  - Implementation 2020 and beyond
  - China earlier (2020)
  - Status:
    - Adoption end 2021
    - Amended ECE R 100 adopted 2023

xEV fire events during parking

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2016.04.09 PHEV

2016.06.14 PHEV

2016.07.07 BUS

2018.01

2018.08.04 PHEV

2018.08.25

2018.08.31

2018.09

2017.05.01 ***80+*** *Electric Buses Burned Down in a Parking Fire Event, Beijing*

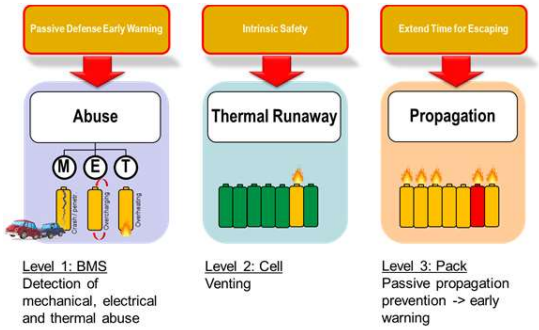
Possible causes of thermal events during parking

1. When the vehicle is parked, thermal management system stops working but hot battery's heat may not be completely dissipated yet;
2. Environmental temperature can reach over 65℃ in summer, which exceeds the operating temperature range of NCM battery;
3. High humidity/water cause short of electrical components.

Thermal runaway detection during parking is essential for safety of life & asset as well as legislation compliance

Application – technology comparison

Smart BPS (Why pressure? Why smart?)
Pressure coupled with voltage is the most reliable, fastest, and most cost effective detection option. ST smart BPS enables BMS wakeup function and low power consumption



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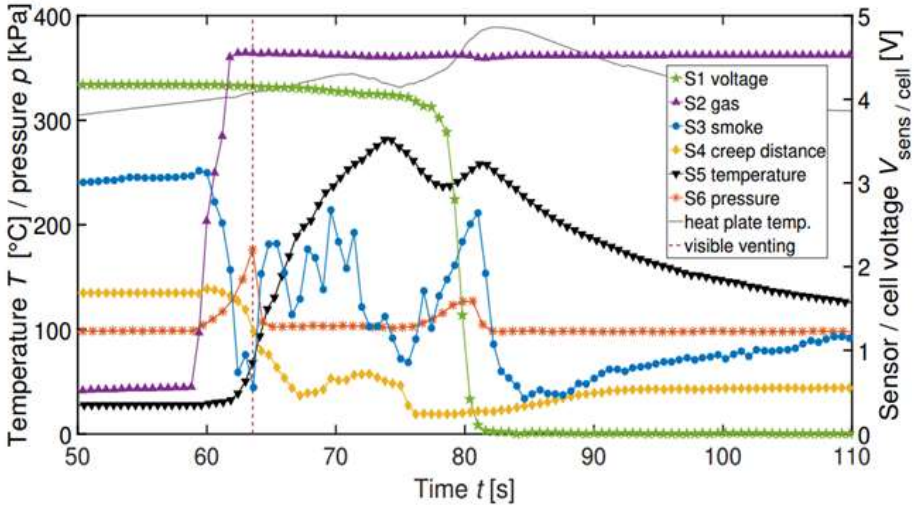
Abuses → Temp. increase → Self heating → Chain reaction → Gas accumulation → Pressure rise → Gas evaporation → Smoke → Fire → Explosion

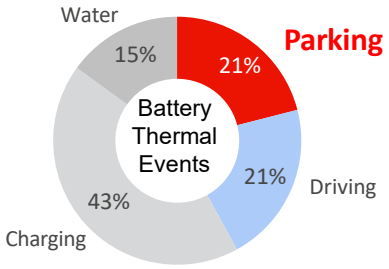
Sensor Selection:

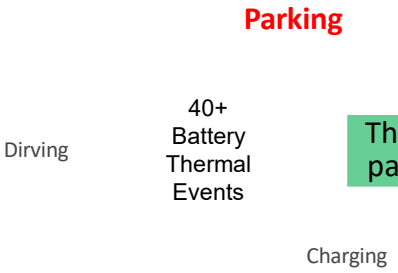
Pressure + Voltage

Technology	Pressure	Gas	Smoke	Temp	Voltage (BMS)
Automotive Grade	+	-	-	+	+
Detection Speed	+	+	-	0	-
Sensor Reliability	+	+	0	0	+
Signal Clarity	0	+	0	0	+
Power Consumption	+	-	0	+	+
Mounting flexibility	+	-	-	-	N/A
System Cost	+	0	0	-	+



Why parking mode of Smart BPS is critical?





Thermal events @ parking: **20~40%***

Key sensor features:

- Sensor detection during parking: **BMS wakeup function**
- 24/7 operation: **low power consumption**

2019 data * https://www.d1ev.com/news/jishu/97394

Application – Churod value proposition

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Churod Smart BPS Value

- Eliminate false warning for thermal runaway with **high reliability**
- Extremely **low power consumption** @ deep sleep mode
- Offer digital communication with **BMU wakeup** function
- **Automotive Grade** Design
- **Easy to mount & no position requirement**
- **Quick response** & warning to single cell thermal runaway
- **Self diagnostics** to ensure safety related function

Sensing solutions	Sensing object	Signal clarity	Response speed	Sensor reliability	Diagnostics	Power consumption	System cost
Pressure sensor	Air pressure inside pack	Good	Immediately at cell venting	High	High (capable for FuSa)	Low to medium	Low
Gas sensor	H2, CO, CH, etc.	Good but just qualitative	Sometimes earlier before cell venting	Low, no automotive grade product	Neutral	High	High
Pressure switch	Air pressure inside pack	Good but just qualitative	Immediately at cell venting	Medium, especially for low range	Poor	Low	Low
Add-on T sensor	Temperature inside pack	Good	Uncertain depends on location and heat transfer	High	Neutral	Depend on quantity	Medium to high due to multi T sensors needed
Software solution w/o add-on sensor	Existing V, T, etc.	Neutral, no function in parking	Uncertain	High	Good	High	No BOM cost

Product specification

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- **Main Specifications**
  - ✓ Supply voltage: 6 ~ 16 VDC, 12 VDC Typ. (directly powered by vehicle lead-acid battery)
  - ✓ Mounting location: inside battery pack
  - ✓ Working Temp. range: -40 ~ 105 degC
  - ✓ Power consumption
    - High power consumption working mode: ≤ 20mA
    - Low power consumption working mode: ≤ 0.2mA *@ 12 VDC & 23 ℃with 1s sampling interval*
    - Deep sleep mode: ≤ 0.02 mA *@ 12 VDC & 23 ℃*
  - ✓ Pressure range
    - 50 ~ 165 kPa abs
  - ✓ Accuracy
    - ±1% FS @ 0~ 85 degC // ±1.5% FS @ -40 & 105 degC
  - ✓ EMC: TBD
  - ✓ Flammability class: UL94 V-0
  - ✓ Software refreshable

How SMART is defined

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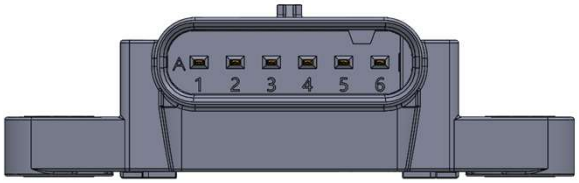
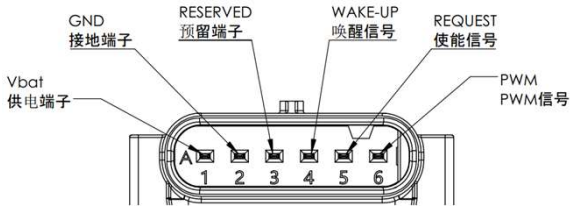
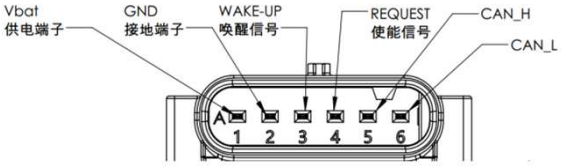
- **BPS working mode**
  - ✓ **High power consumption working mode** to provide pressure signal (when BMS is active)
    - During car driving / charging, BPS should send continuous pressure signal to BMS (decision maker of thermal runaway alarm)
  - ✓ **Low power consumption working mode** to save lead-acid battery energy (when BMS sleeps)
    - During car parking mode, BPS should check battery pack pressure at a set frequency with low power consumption
  - ✓ **Deep sleep mode** to save lead-acid battery energy (when BMS sleeps)
    - No pressure monitor, no communication with BMS.







- **6-PIN Battery Pack Pressure Sensor (BPS)**
  - ✓ Vpwr: directly powered by vehicle lead-acid battery, 6 to 16 VDC, 12 VDC Typ.
  - ✓ GND: ground
  - ✓ Pout: pressure output (PWM / LIN signal)
  - ✓ Wake-up: send warning signal to BMS if detected pressure exceeds threshold in low power consumption working mode
    - An independent wake-up pin is requested by OEMs (important for detection while parked)
  - ✓ Request: BMS send request signal to control BPS working modes
  - ✓ Reserved PIN: CAN H and CAN L - pressure output, firmware configuring

BPS state machine

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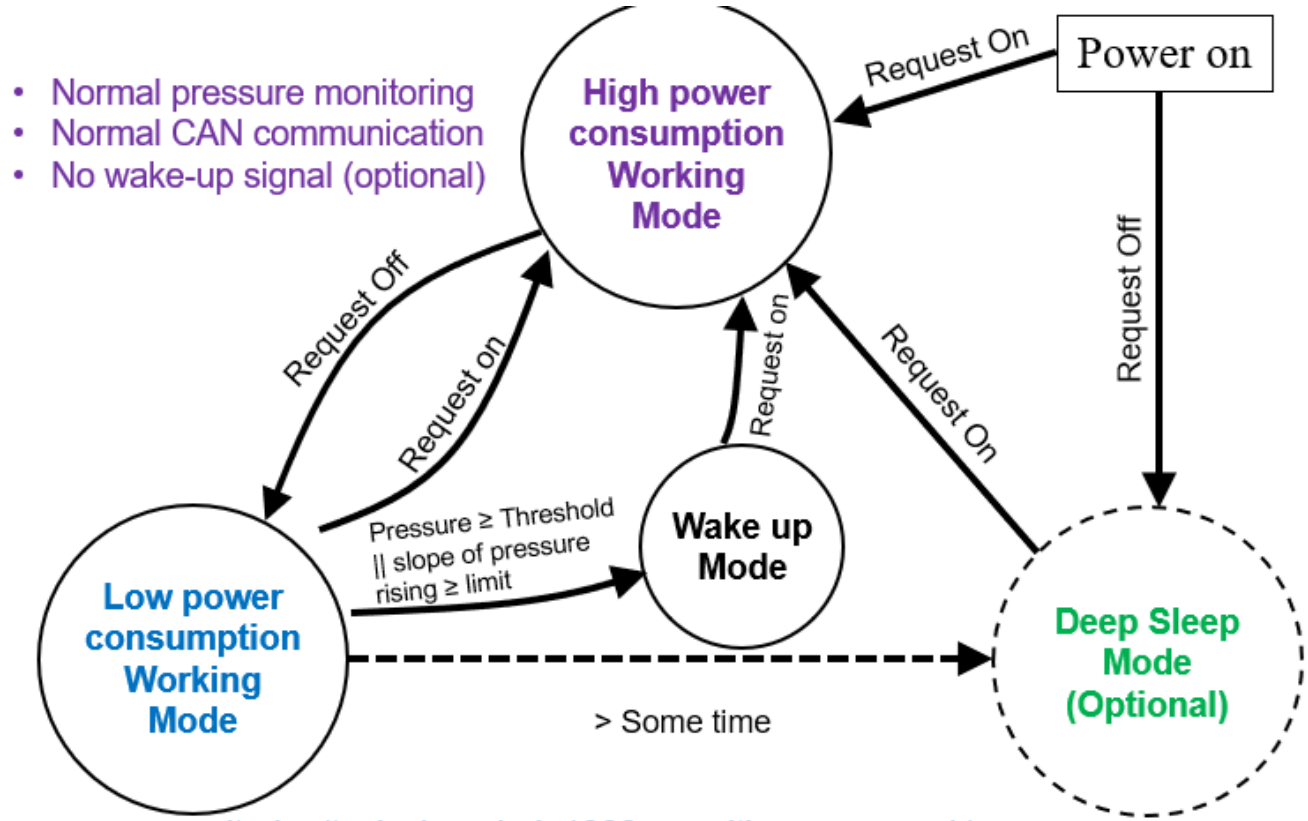
- To realize continuous monitor, low power consumption and wake up BMS.



- Normal pressure monitoring
- Normal CAN communication
- No wake-up signal (optional)

- Low frequency pressure monitoring(typical: period: 1000ms, with xms on work)
- No CAN communication
- Self-check, send wake up signal if Pcheck ≥ Threshold || slope of pressure rising ≥ limit
- Update the baseline of threshold every *2mins(adjustable)*

- No pressure monitoring
- No CAN communication
- No SW execution

Product overview-Product design

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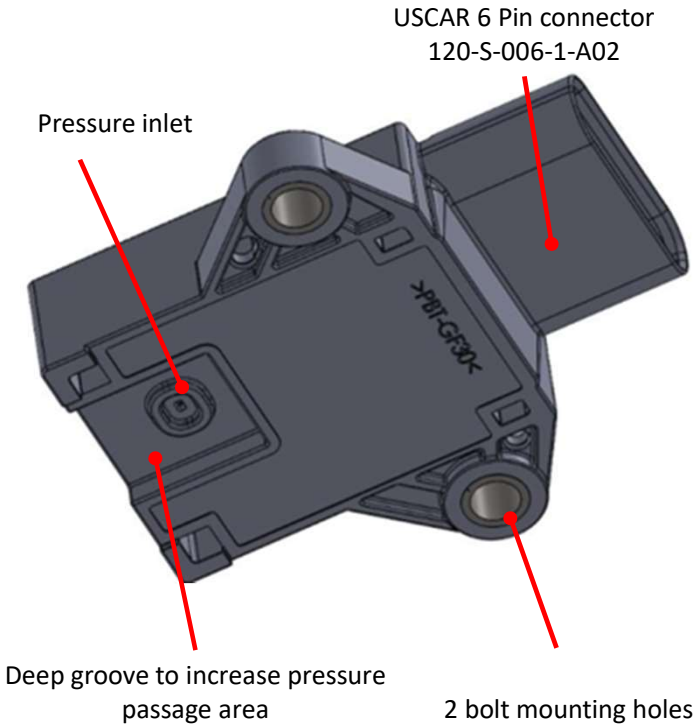

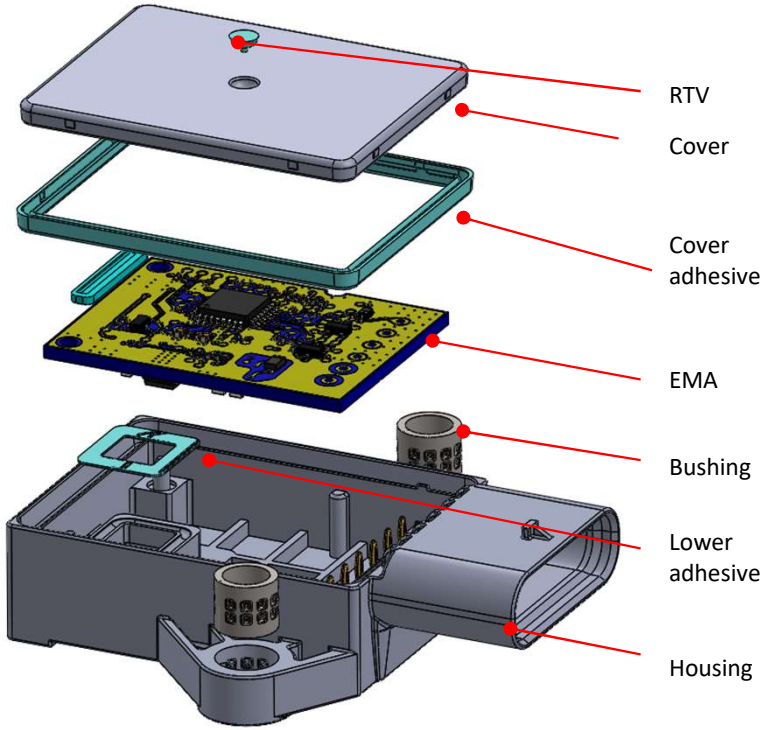

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THANKS

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