中汇瑞德
CHUROD ELECTRONICS

About Churod Sensing

Churod Sensing Technologies (Suzhou) Co., Ltd.

Mar 10, 2022

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- Sensors and Application
- Thermal Runaway Detection Overview
- Churod SMART BPS Technical Review
  - MEMS Sensing Technology Introduction
  - SMART BPS Overview (design overview, working mode, and state machine etc.)

Churod Sensing History

- **2006-2009**
  OEM Manufacturer

- **Jan. 2010**
  CHUROD'S First Plant started production

- **Jun. 2016**
  CHUROD's Third Plant started production

- **2021**
  CHUROD SENSING TECHNOLOGIES is founded

2006

2010

2016

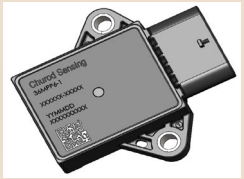
2021

2009

2014

2020

2021



- **Oct. 2009**
  CHUROD launched the brand

- **Jun. 2014**
  CHUROD's Second Plant started production

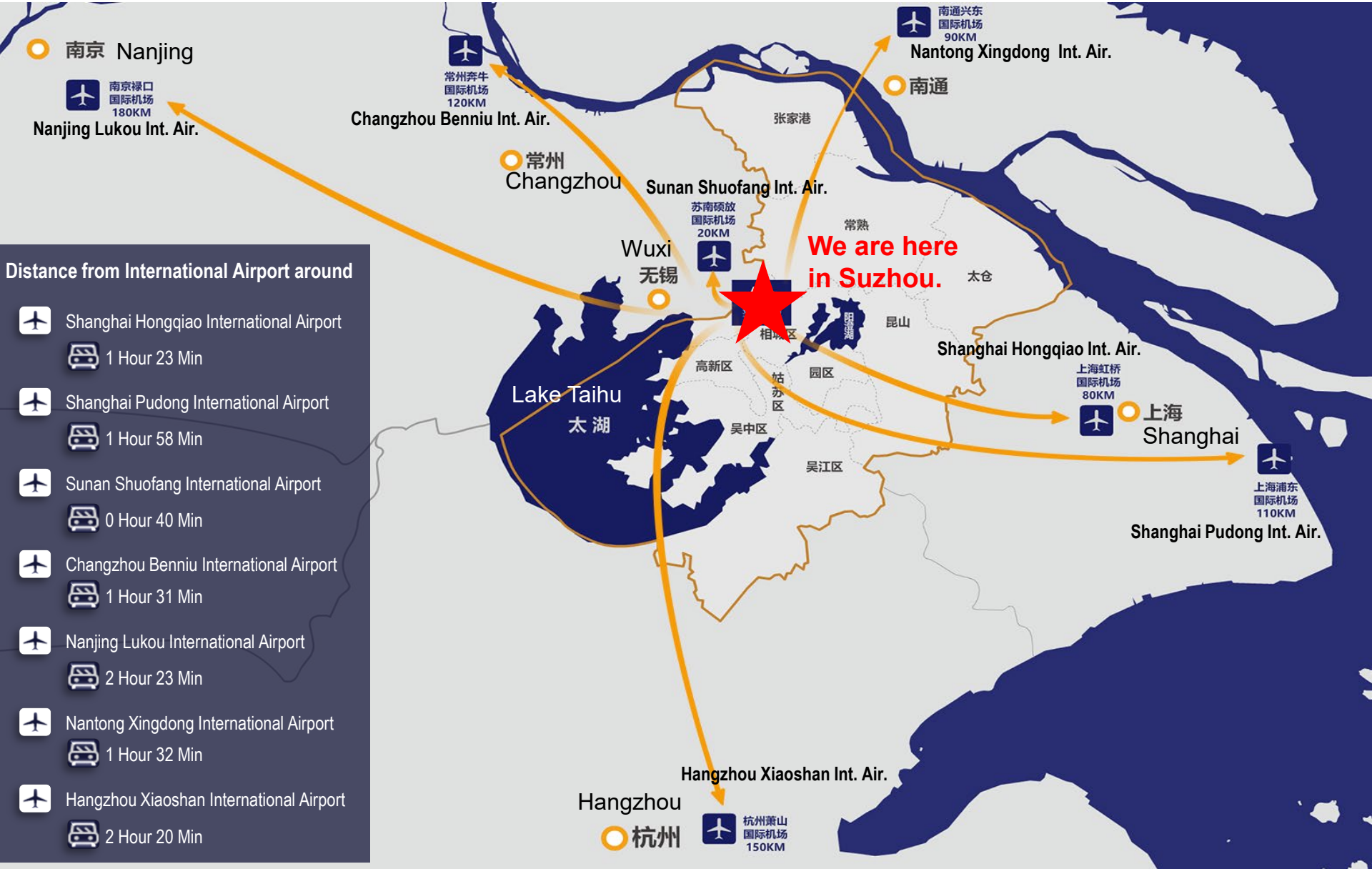
- **Oct. 2021**
  CHUROD's Fourth Plant started construction

- **2021**
  CHUROD SENSING acquired Sensata BPS business

R&D Center and Manufacturing Site

Churod Sensing Technologies located in Suzhou city, JiangSu Province.

Where are we located?



Distance from International Airport around

- Shanghai Hongqiao International Airport
  - 1 Hour 23 Min
- Shanghai Pudong International Airport
  - 1 Hour 58 Min
- Sunan Shuofang International Airport
  - 0 Hour 40 Min
- Changzhou Benniu International Airport
  - 1 Hour 31 Min
- Nanjing Lukou International Airport
  - 2 Hour 23 Min
- Nantong Xingdong International Airport
  - 1 Hour 32 Min
- Hangzhou Xiaoshan International Airport
  - 2 Hour 20 Min

Our Vision

A world leading sensing solution provider to make the world smarter!
传感科技的引领者，让世界更智能！

Our Values

Respect 尊重
Responsibility 负责任
Innovation 创新
Excellence 卓越

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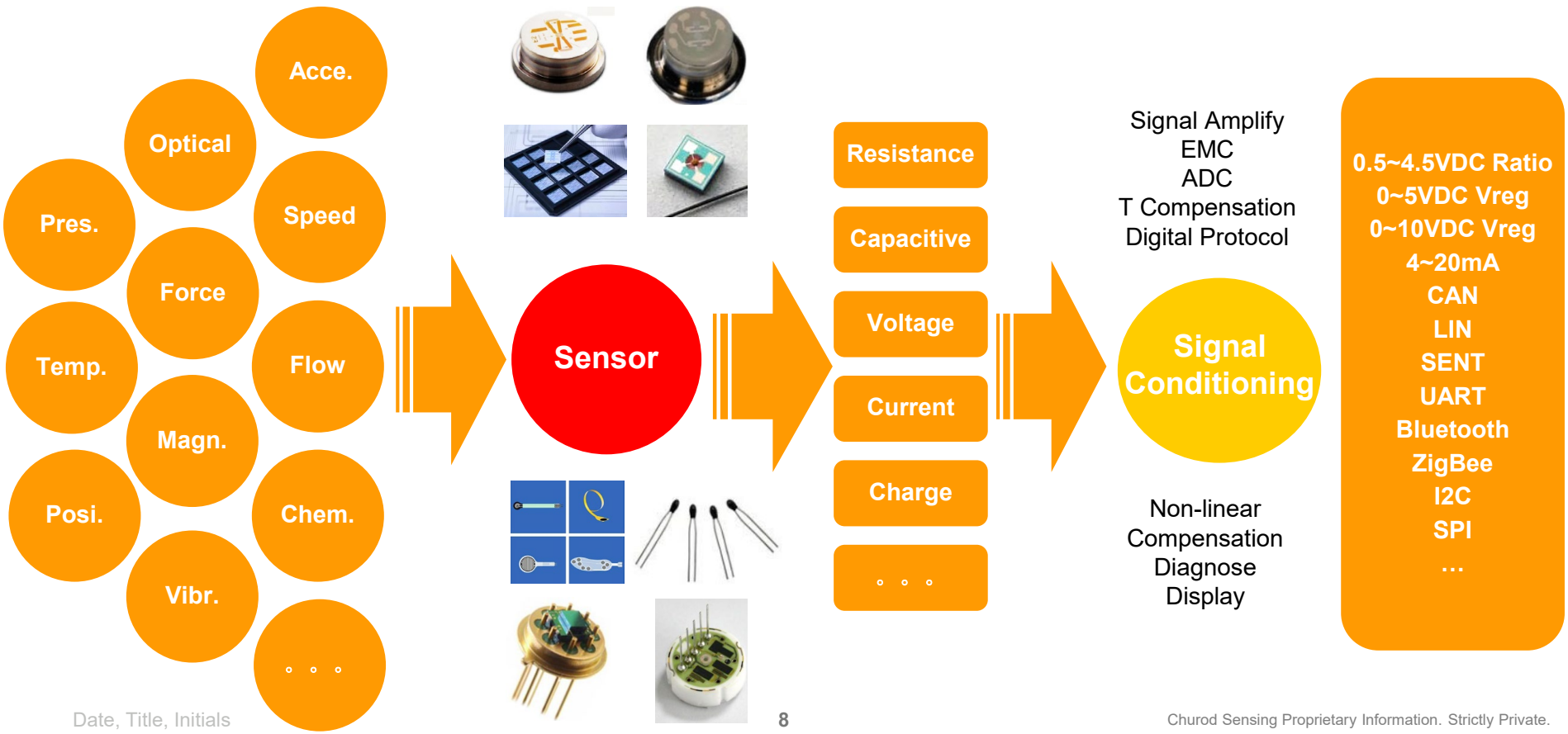
SMART BPS Introduction

Mar 10, 2022

What Is a Sensor or a Transducer?

- The **sensor** is a device that measures the physical quantity (i.e. Heat, light, sound, etc.) into an easily readable signal (voltage, current etc.).

Transducer = Sensor + Signal Conditioning

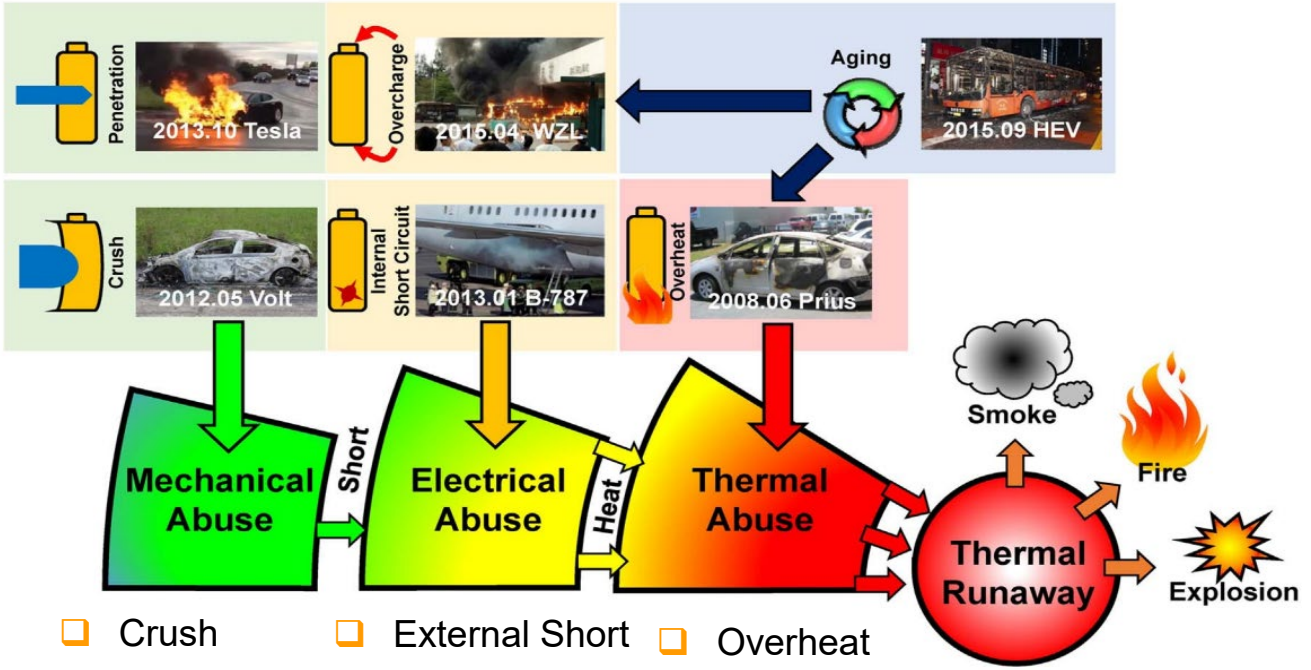


Where Are the Sensor Used?

Sensors are everywhere.

Battery Thermal Runaway Event

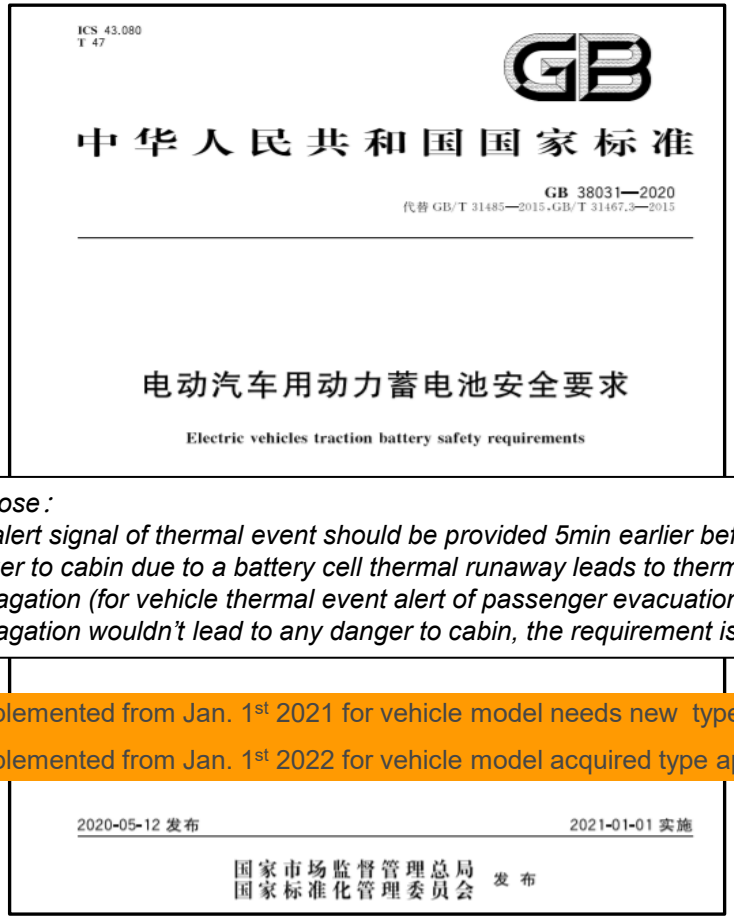
- Thermal runaway is an uncontrolled chain reaction caused by mechanical, electrical, thermal abuses or a combination of abuse.
- Thermal runaway leads to battery uncontrolled self-heating up to 400-1000℃ and easily propagates to other cells which could end with a destructive result like fire or explosion.



- Crush
- Penetration
- External Short
- Overcharge
- Overdischarge
- Internal Short
- Overheat

Safety Legislations for Thermal Runaway

*CN MIIT legislation of "Electric vehicle s traction battery safety requirements" which is effective on **Jan 1st 2021**.*


ICS 43.080
T 47

GB

中华人民共和国国家标准

GB 38031—2020
代替 GB/T 31485—2015,GB/T 31467.3—2015

电动汽车用动力蓄电池安全要求

Electric vehicles traction battery safety requirements

2020-05-12 发布　　2021-01-01 实施

国家市场监督管理总局
国家标准化管理委员会　发布

Purpose :
"An alert signal of thermal event should be provided 5min earlier before any danger to cabin due to a battery cell thermal runaway leads to thermal propagation (for vehicle thermal event alert of passenger evacuation). If thermal propagation wouldn't lead to any danger to cabin, the requirement is met."

- Implemented from Jan. 1st 2021 for vehicle model needs new type approval.
- Implemented from Jan. 1st 2022 for vehicle model acquired type approval.

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

2016.04.09 PHEV

2016.06.14 PHEV

2016.07.07 BUS

2018.01

2019.05

2018.08.04 PHEV

2018.08.25

2018.08.31

2018.09

2019.05.22

*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.

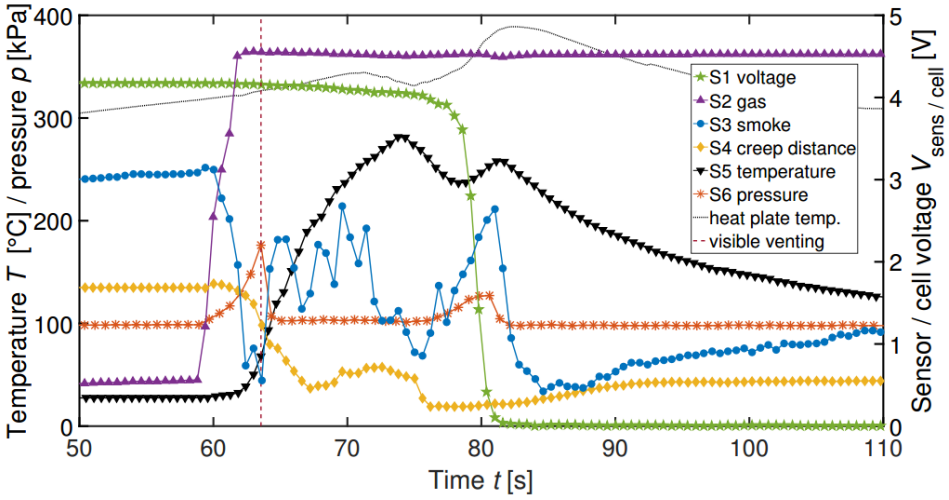
Thermal runaway detection during parking is essential for safety of life & asset as well as legislation compliance

Thermal Runaway Process & Detection

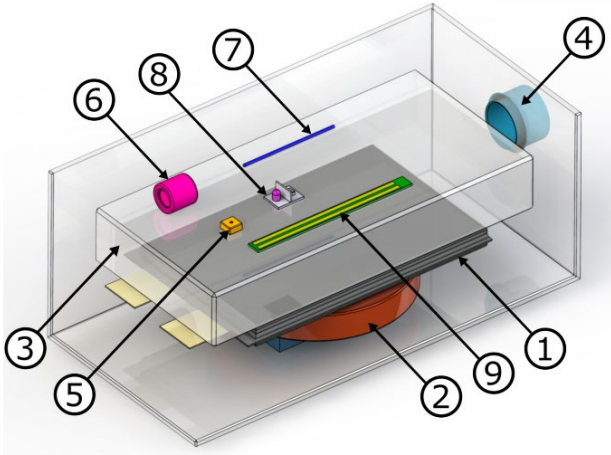
Temperature, Pressure, Gas etc Can Be Measured as Signal to Indicate Thermal Runaway/ Which One is Fast, Most Reliable and Low Cost?

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

Data source: Batteries, 27 March 2018



Sensor	Detection Speed	Signal Clarity	Sensor Feasibility
S1 voltage	-	+	+
S2 gas	+	+	-
S3 smoke	-	0	0
S4 creep distance	-	-	+
S5 temperature	0	0	0
S6 pressure	+	-	+
S7 force	+	-	0



1. Battery cell
2. Heat plate
4. Vent opening
5. Pressure sensor
6. Gas sensor
7. Temp. sensor
8. Smoke detector
9. Creep distance sensor

Conclusions:

- Gas, Pressure, Smoke, and force have shown to react the fastest. And pressure sensing is the one with highest feasibility.
- Signal clarity can be addressed by software algorithm.
- Pressure measurement does not depend on position within battery, because pressure travels with the speed of sound.

Detection Option Comparison

- **Why current BMS (voltage, current & temperature) is not sufficient for thermal runaway detection?**
  - ✓ BMS with low confidence level to detect thermal runaway if no additional sensing
  - ✓ High probability of cell signal lost since CMU or harness might be damaged in early stage due to high temperature venting
  - ✓ BMS can't achieve 24/7 operation especially in parking due to power consumption

- **Sensing technologies comparison**

Sensor type	Qualified Auto grade	Detecting speed	Reliability	Signal clarity	Power consumption	Diagnostics	Flexibility[2]	System cost
Pressure	+	+	+	0	+	+	+	+
Gas	–	+	–	+	–	0	0	0
Smoke	–	–	–	0	0	0	0	0
T (point)	+	0[1]	+	0	+	+	–	0
T (cable)	–	+	0	+	+	0	–	–

Note1: T(point) is position sensitive
Note2: Including flexibility for mounting location/position and the flexibility to adapt different cells, modules and packs

Pack pressure is the best add-on signal for thermal runaway detection (<u>well recognized by most OEMs</u>)

Pressure (coupled with V/T from BMS) is the most reliable, easy-to-use and cost effective system solution

Churod Smart Solution – More than a Pressure Sensor

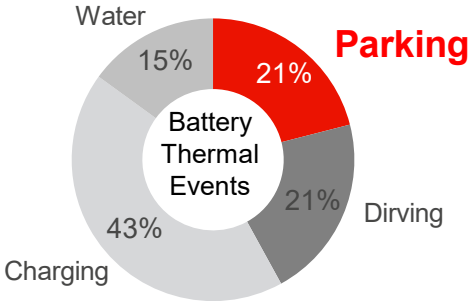
- Churod Smart BPS enables parking mode with BMS wakeup function and low power consumption.

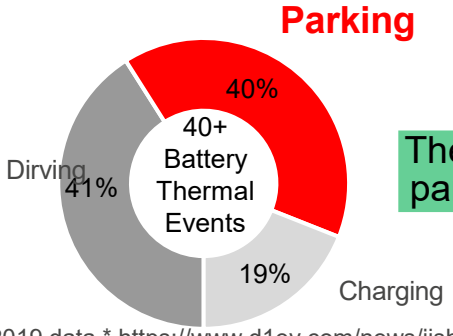
Churod's Value

- Eliminate false warning and miss warning for thermal runaway with **high reliability**
- Extremely **low power consumption** during parking (<0.2mA)
- 24/7 operation, And offer **wakeup BMU** function during parking
- **Automotive Grade** Design
- **Easy to mount,** and independent from mounting position
- **Quick response** & warning to thermal propagation within 10s
- Help Customer to **reduce system cost**

Churod Sensing Smart Battery Pressure Sensor Solution

Why parking mode of Smart BPS is critical?





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

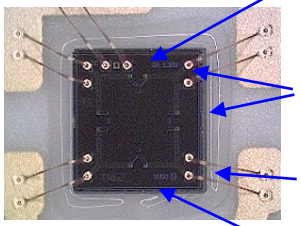
Key sensor features:

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

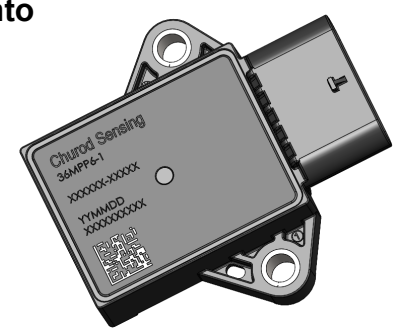
* China EV Battery Safety Summit, August 2018

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

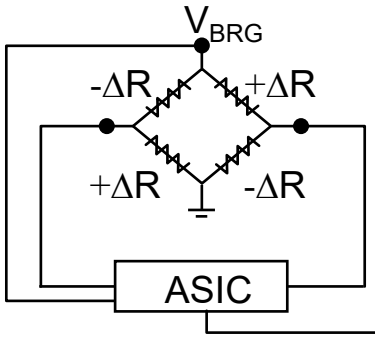
Sensing Technology



Sense Element



- Pressure across diaphragm results in tensile stress in center, compressive stress at edge
- Strain-sensitive piezo resistors are implanted in silicon substrate and connected in a full bridge configuration
- Applied pressure results in a bridge imbalance that is amplified and compensated in signal conditioning electronics
- MCU is used for logic control for different working mode and alarm strategy.



FORCE / PRESSURE

MECHANICAL DEFLECTION/ STRESS

SILICONE PIEZORESISTIVE EFFECT

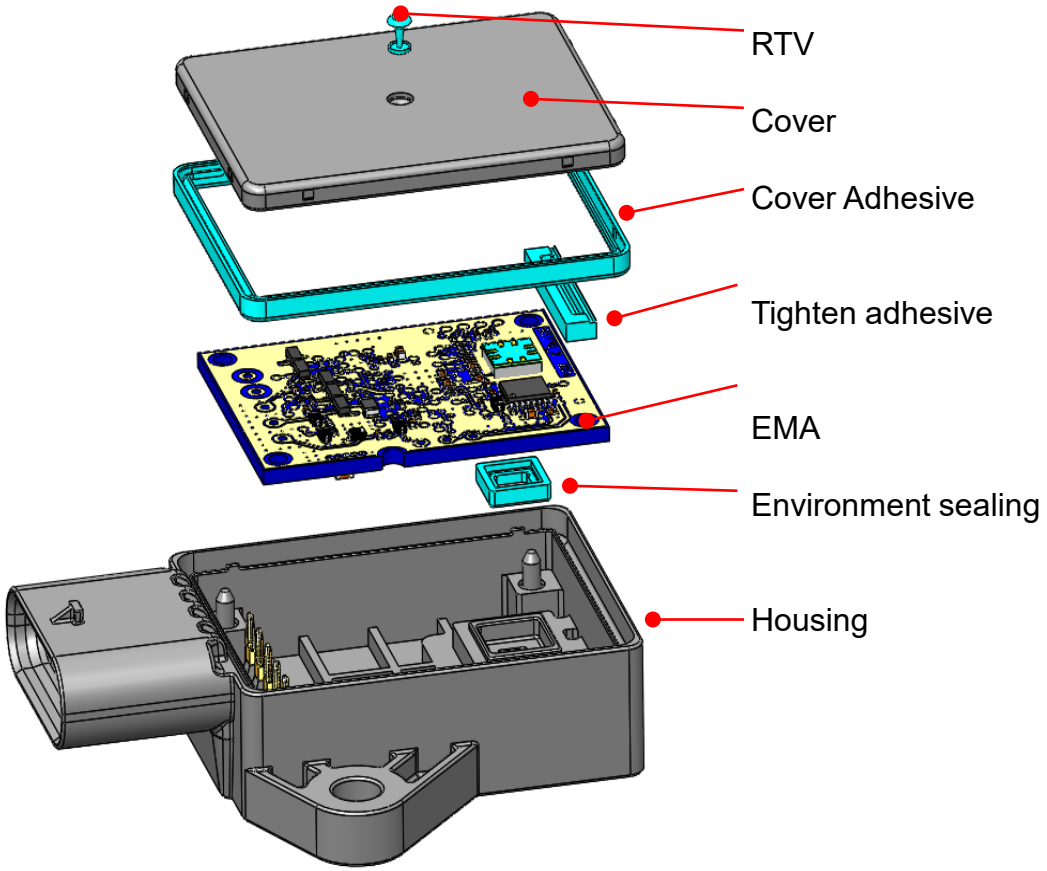
CONDITIONING ELECTRONICS

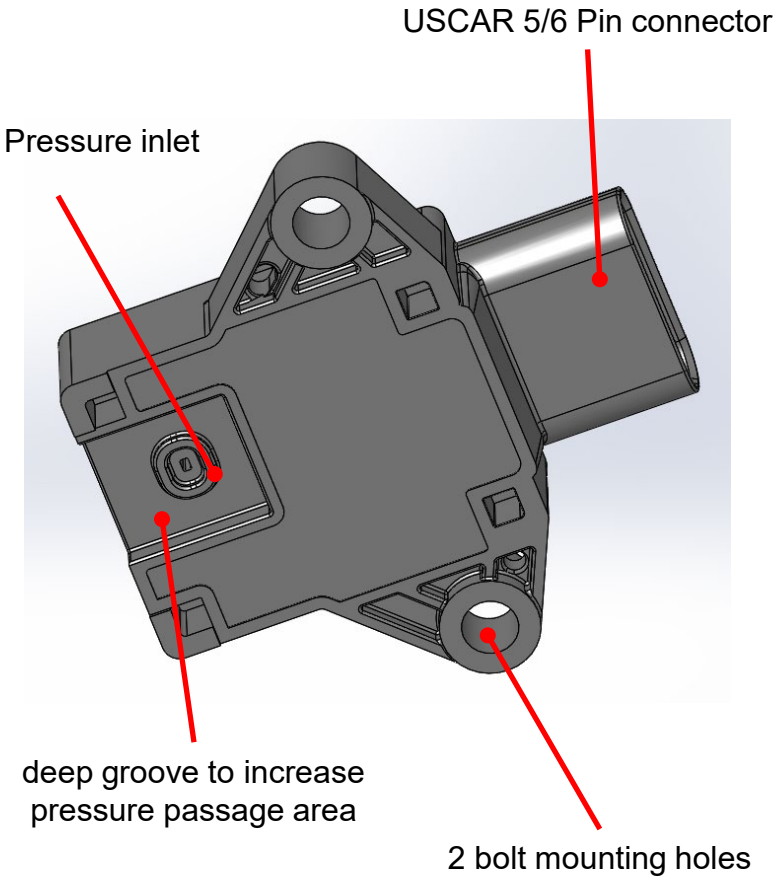
MCU
For Logic control

PWM signal
CAN/LIN transceiver

PWM/CAN/LIN/ Analog OUTPUT PROPORTIONAL TO MECH. INPUT

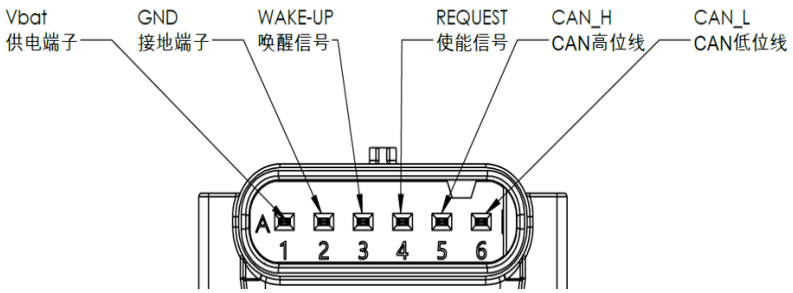
Product Overview

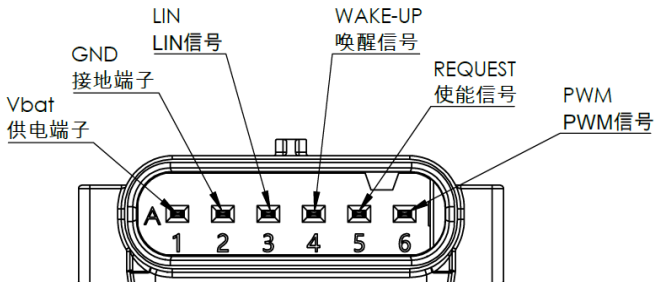




SMART BPS Working Mode and E-Interface

The specifications shall prevail

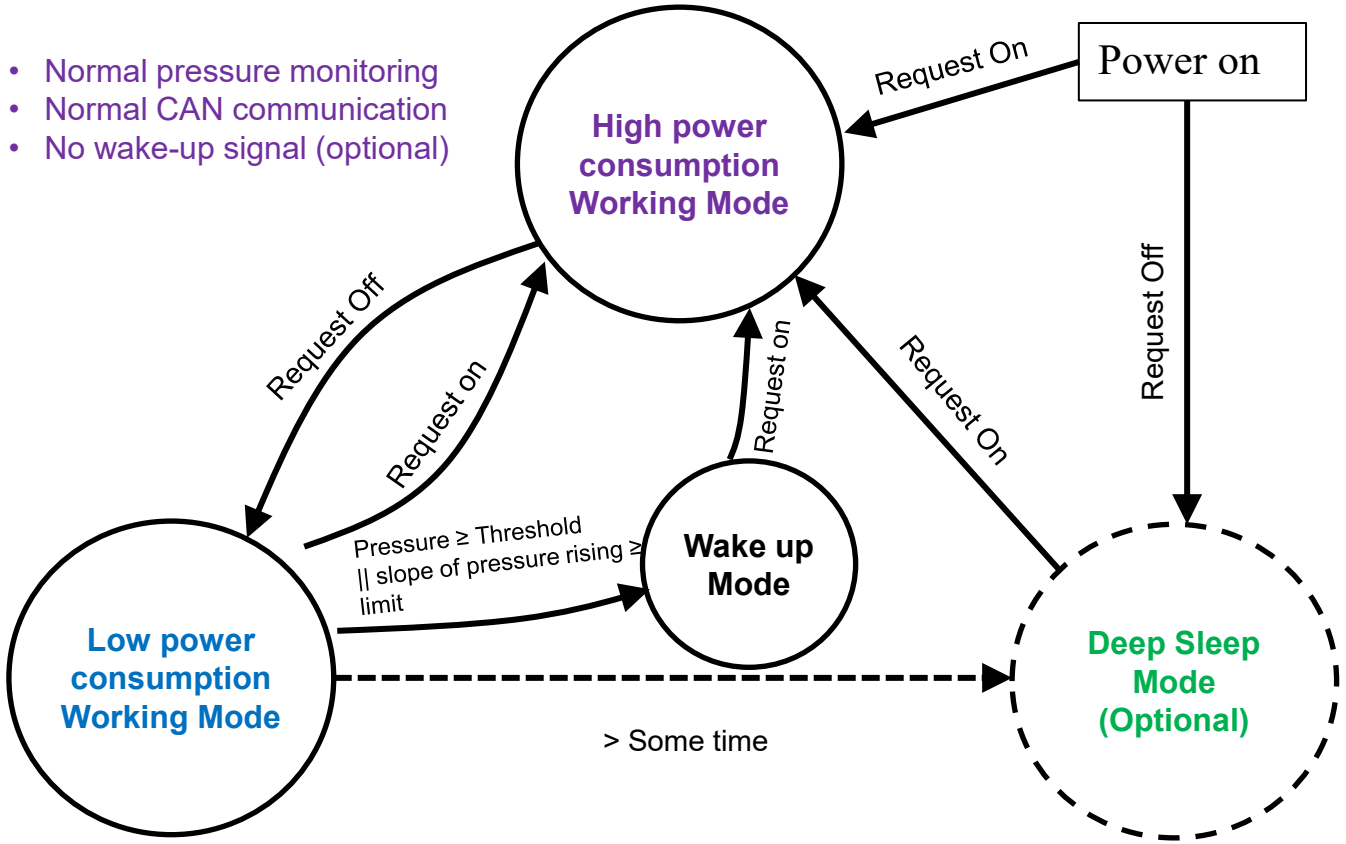




- **BPS Working Mode**
  - ✓ High power consumption working mode to provide pressure signal (when BMS is active)
    - During car driving / charging, BPS should send continuous pressure signal to BMS.
  - ✓ Low power consumption working mode to save lead-acid battery energy (when BMS sleeps)
    - During car parking, BPS should check battery pack pressure at a set frequency with low power consumption
- **BPS E-interface**
  - ✓ Vpwr: directly powered by vehicle lead-acid battery, 6 to 16 VDC, 12 VDC Typ.
  - ✓ GND: ground
  - ✓ Wake-up: send warning signal to BMS if detected pressure exceeds setting conditions in low power consumption working mode
  - ✓ Request: BMS send request signal to control BPS working modes

SMART BPS State Machine

The specifications shall prevail



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

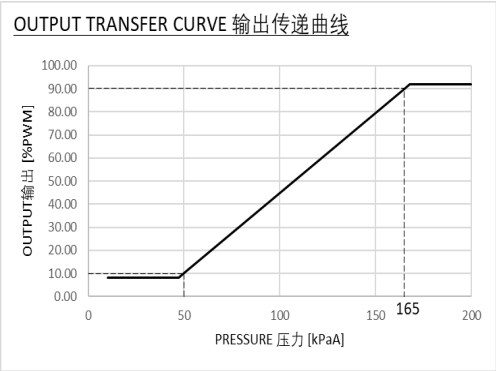
- Low frequency pressure monitoring(period: 1000ms, with xxms on work)
- No CAN communication
- Self-check, send wake up signal if Pcheck ≥ Threshold || slope of pressure rising ≥ limit
- Update the baseline of threshold every *x mins*

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

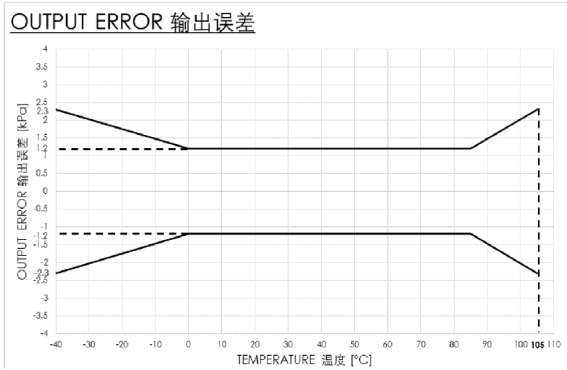
Product Key Features

The specifications shall prevail

BPS	CAN Version	PWM Version
Vcc	6~16VDC (Typ. 12VDC）	6~16VDC (Typ. 12VDC）
Operating Pressure Range	50~165kPa(A)	50~165kPa(A)
Proof Pressure	400kPa(A)	400kPa(A)
Operation Temperature Range	-40 - 105ºC	-40 - 105ºC
Power Consumption in Low Power Consumption working Mode (23° C, 12V)	< 0.2mA	<0.2mA
Power Consumption in High Power Consumption Working Mode (23° C, 12V)	35mA	16mA
Pressure refresh rate	120s	120s
Accuracy (Over life)	2% (-40℃~105℃）	2% (-40℃~105℃）



PWM BPS Transfer Curve



BPS Error Bond

Target Customers

Battery Pack Suppliers：

Key OEMs Globally：

Power Storage Companies：

Thanks！