



# Battery Management Systems Role in Thermal Runaway Prevention/Mitigation

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# BATTERY MANAGEMENT SYSTEMS ROLE IN THERMAL RUNAWAY PREVENTION/MITIGATION

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# PURPOSE OF BMS

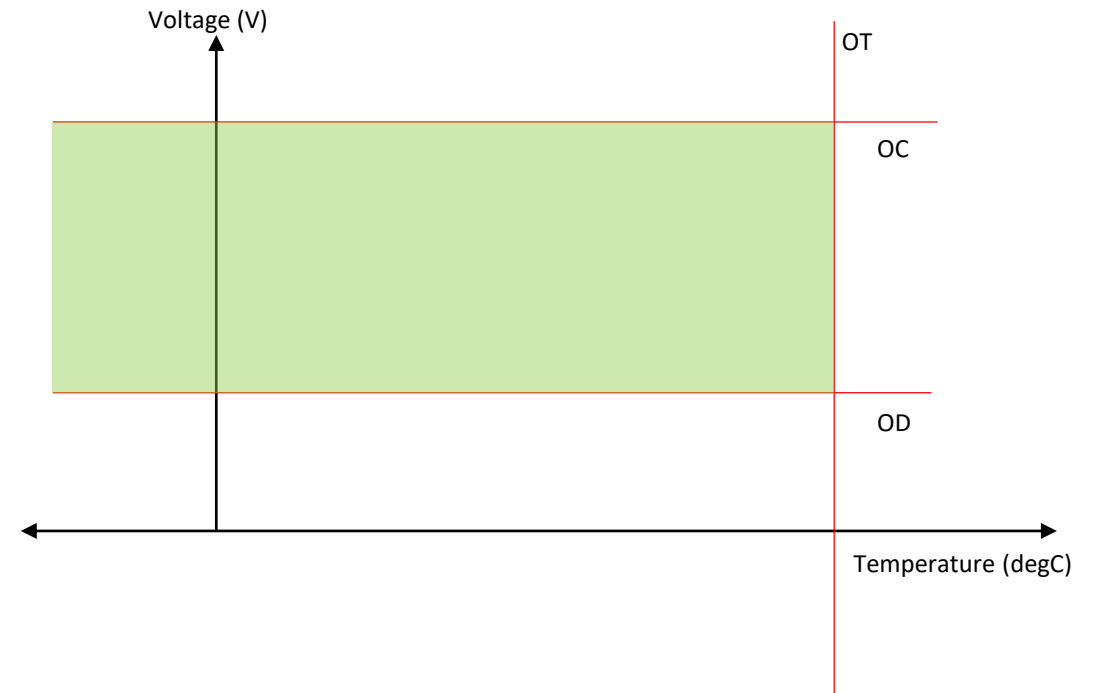
- BMS undertake a number of functions
  - State of charge/health calculation
  - Available capacity optimization (balancing)
  - Status communications
  - Charger control

Most fundamental is to protect the battery from harm.

# SAFE OPERATING AREA

- Battery Management Systems prevent battery failures due to operation outside of safe operating area.

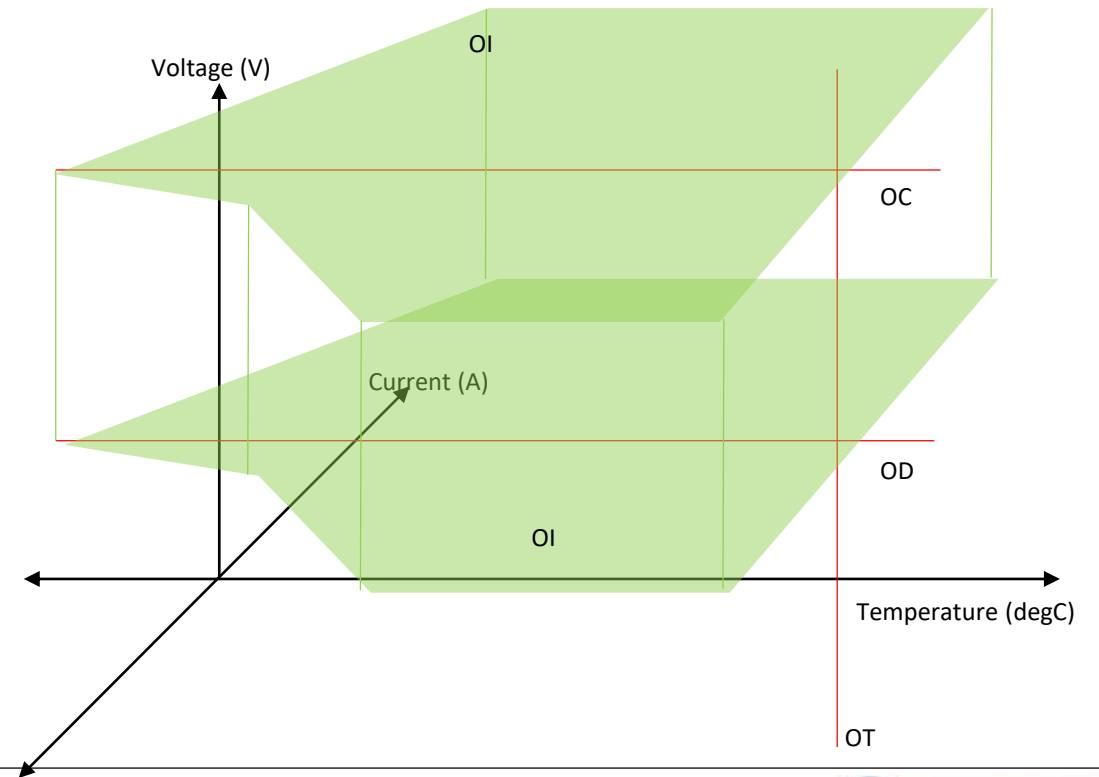
- Over charge (OC)
- Over discharge (OD)
- Over temperature (OT)



# SAFE OPERATING AREA

- Battery Management Systems prevent battery failures due to operation outside of safe operating area.

- Over charge (OC)
- Over discharge (OD)
- Over temperature (OT)
- Over Current (OI)



# EFFECTIVENESS OF THIS APPROACH

- BMS is ensuring a safe envelope of operation
- BMS is preventing failure due to abuse
- But do other mechanisms for failure exist?

# KEY ASSUMPTIONS

- All cells in the pack are created equal
- Cells do not contain quality issues
- Mechanical means prevent cell damage from external events e.g. vehicle impact
- Battery assembly process (cell welding) does not damage cells

# IS THIS ENOUGH?

A Nissan LEAF caught fire in North Texas – cause currently unknown

Fred Lambert - Sep. 4th 2015 11:08 am ET @FredLambert



## Porsche catches fire while charging

PUBLISHED: 16 MAR 2019 AT 10:55

WRITER: ONLINE REPORTERS



The Porsche Cayenne catches fire as firefighters reach the house on Friday. (Photo from @TheRescueNews Facebook)

## Electric car catches fire and explodes in Île-Bizard garage



No one was injured and Montreal firefighters are investigating

CBC News - Posted: Jul 27, 2019 7:09 AM ET | Last Updated: July 27



The explosion blew the front of the garage clean across the street. (Mattheu Daniel Wagner/Radio-Canada)

## Feuerwehr löscht brennenden E-Golf

Kniffliger Einsatz für die Feuerwehr: Im Industriegebiet Triangel brannte am Donnerstagmorgen ein E-Golf mit Hochvoltbatterie. Um das Fahrzeug zu löschen, zeigten sich die Brandschützer kreativ.



Einsatz in Triangel: Die Feuerwehr musste einen brennenden E-Golf löschen. Quelle: Tim Schulze



# CAN WE DO MORE?

- LIBRIS Faraday project is looking at methods which can suppress, contain, manage or prevent thermal runaway.
- Now assumption changes, original BMS safety functions are still maintained but we augment them with new functionality
- Assume a single cell can fail, can we contain this event?
- What is the BMS role in this scenario?

# BMS IN FAILURE DETECTION/MITIGATION

- BMS will have to detect failure of cell(s).
- Assuming we have a mitigation method, BMS will have to activate the mitigation.
- This will have to occur before the failure cascades to a point where the mitigation is no longer effective.

# DETECTION OF CELL FAILURE

- Typical BMS will know
  - cell voltage – measured across parallel connected cell groups
  - some cell temperatures

# QUICK ASIDE!

How many cell temperature measurements does a BMS need?

Answer – minimum of 2 (to allow redundant sensor check)

OR

2 per cell

How well do you understand the thermal properties of the battery?

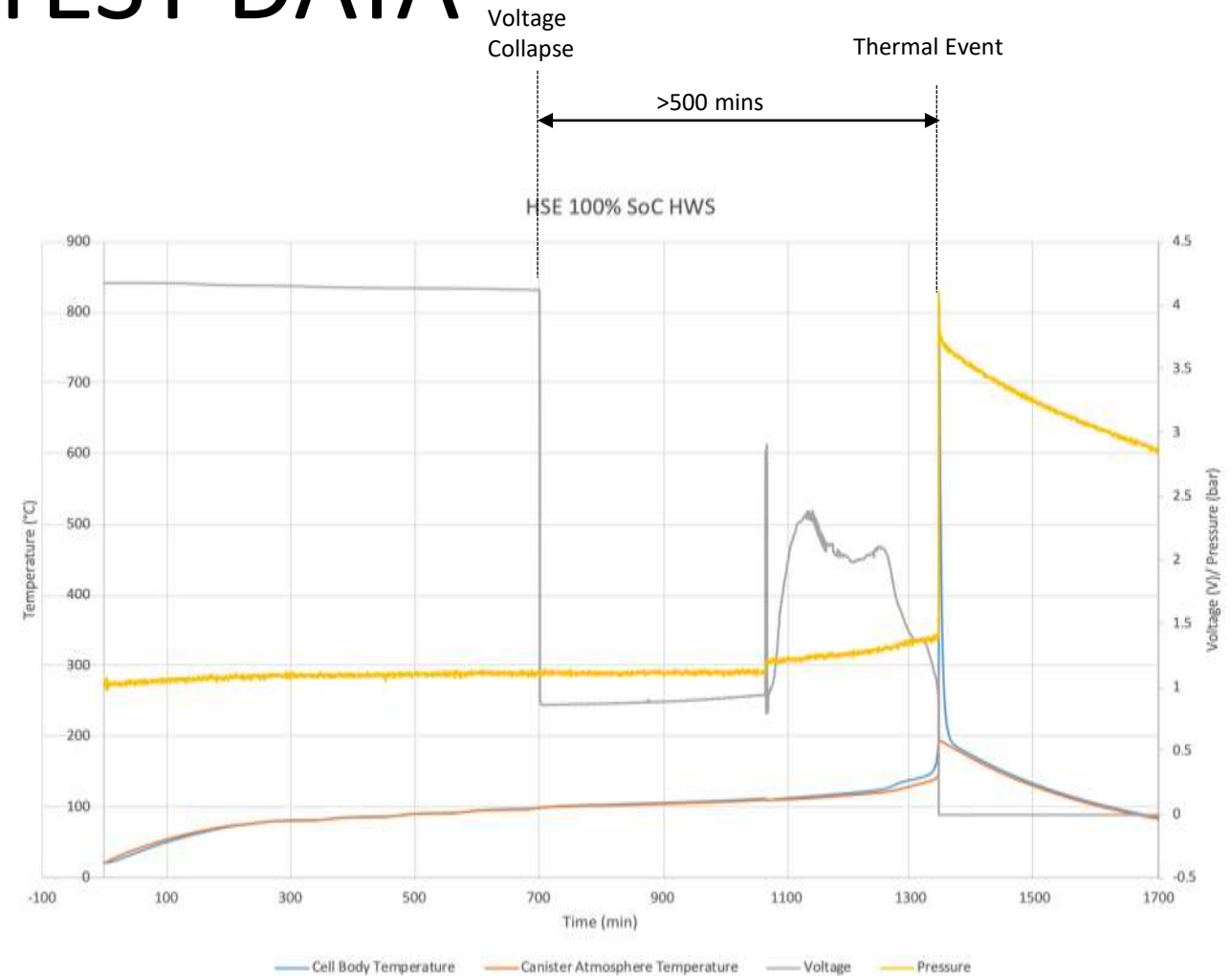
# DETECTION OF CELL FAILURE

- Typical BMS will know
  - cell voltage – measured across parallel cell group
  - some cell temperatures – usually not cost effective to measure all cells
  - battery current

Is this sufficient or do we need other measurements, and what is the cost associated with these?

# SINGLE CELL FAILURE TEST DATA

- From single cell test data we have significant time from voltage collapse to thermal event.
- But how representative is this?
- Will the voltage drop significantly when connected to 60+ parallel cells?



# LIBRIS NOW LOOKING AT BROADER PICTURE

- Testing single cell failures when connected in a pack arrangement
- Evaluating alternative sensing methods
  - Gas – venting occurs prior to thermal event, gas spreads so less sensors to provide coverage and some compositions (CO<sub>2</sub>, CO) widely supported
- Solution – likely to be a combined ‘finger print’ of measurements which indicate failure which will lead to thermal runaway with high certainty.

# MAJOR RISK – FALSE DETECTION

- Could ‘brick’ a battery erroneously through mitigation material release inside the battery.
- Will be as important to ensure we don’t false detect as it is to detect.
- Problem likely to be complicated by battery design and cell variations (form, chemistry, parallel connections) and lack of data so solution will need tuning to each application.



# APPLICABILITY

- Automotive – particularly to help meet Chinese regulations for 5 minute warning to occupants prior to loss of containment.
- Aerospace, Marine, Rail – containment in redundant packs, inhibiting structural damage to vessel.
- Static Batteries – containment to prevent damage to infrastructure, adjacent buildings.

# FUTURE

Hopefully next year will be back reporting how well we can detect and mitigate cell failures prior to thermal runaway.

For more information please contact : [info@ptech.co](mailto:info@ptech.co)