Battery Pack Safety Testing and System-level Integration

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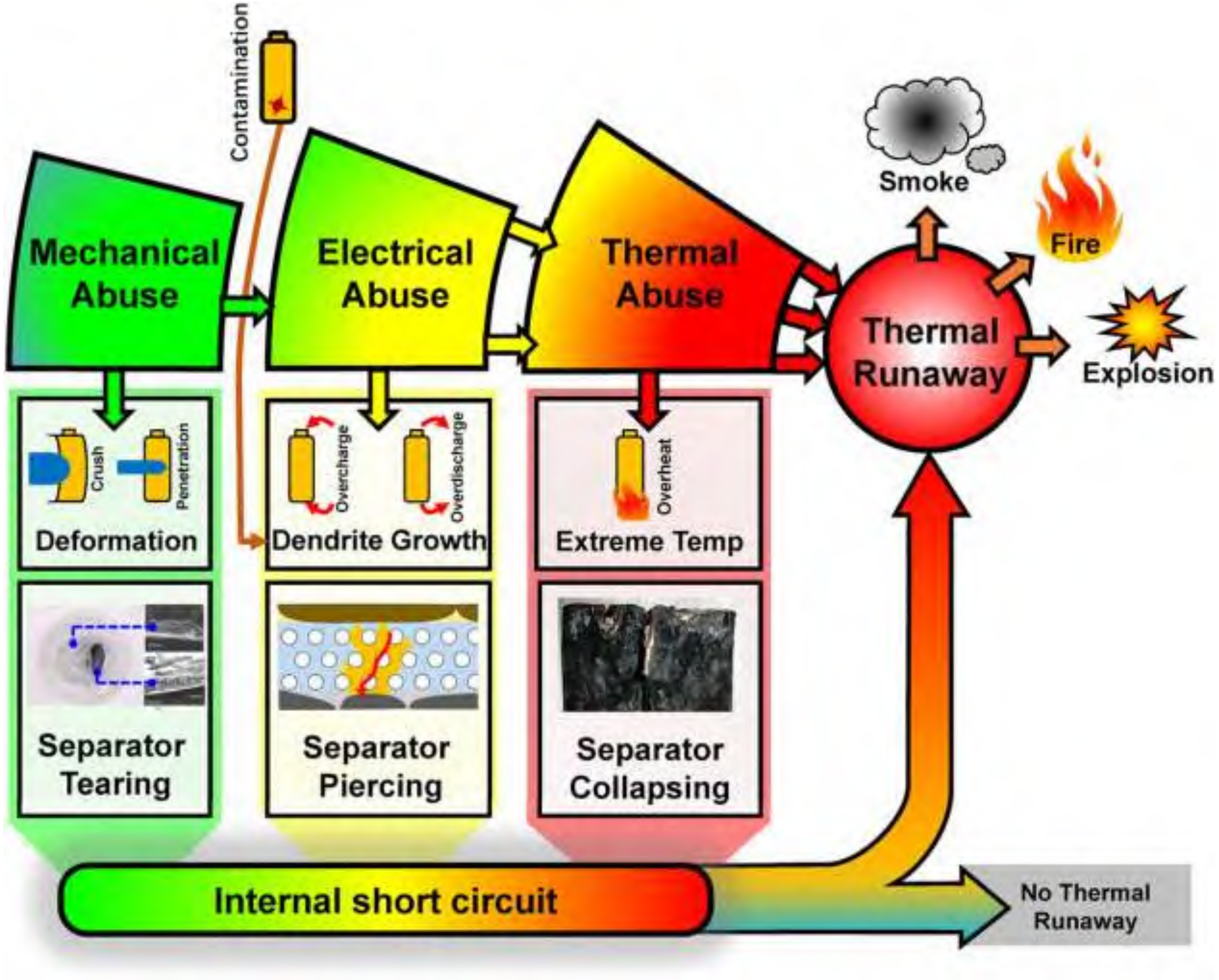
Fire and explosion hazard due to LIB thermal runaway is a major concern

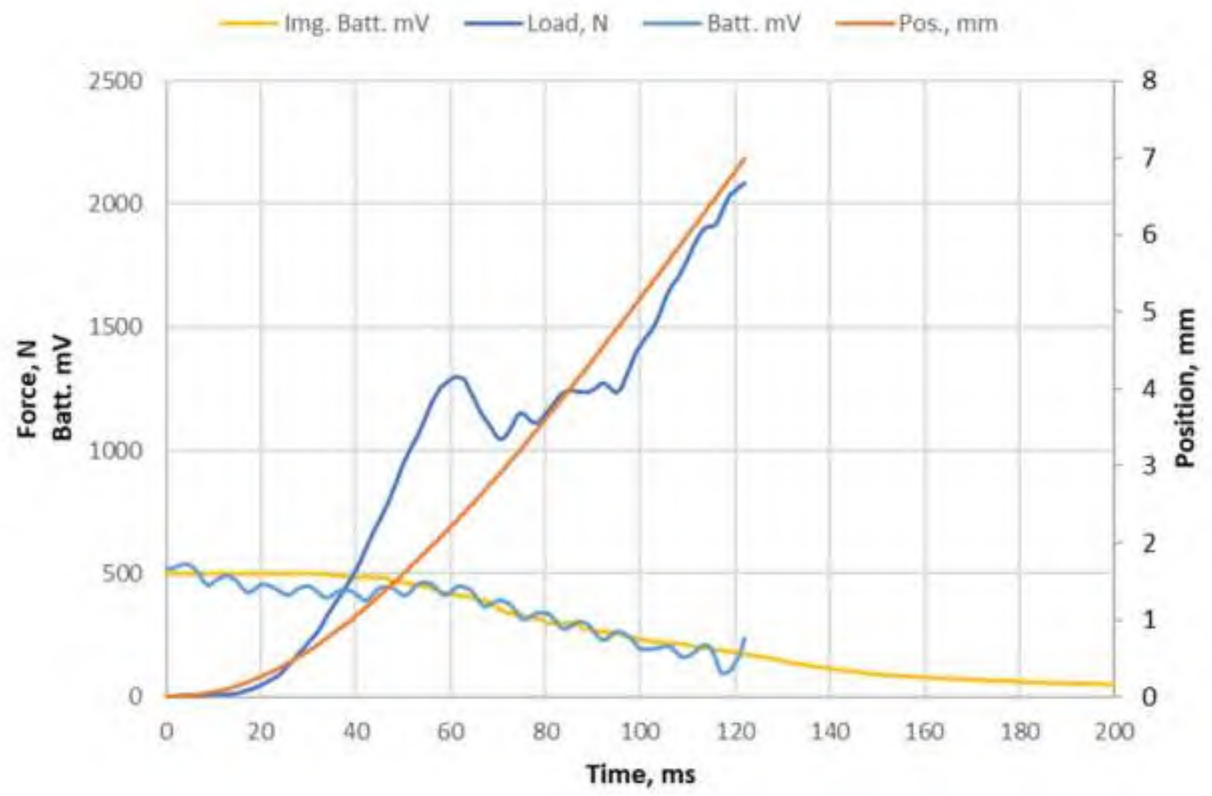


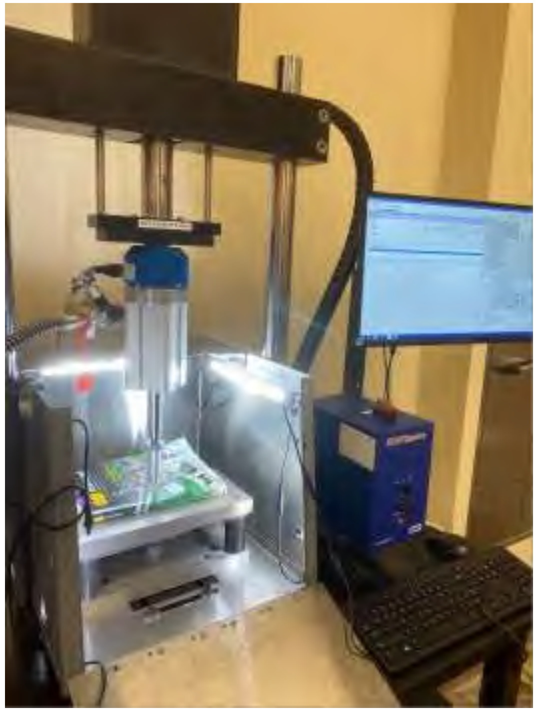
X Feng et al, Energy Storage Materials 10 (January 1, 2018): 246–67.

Tesla Megapack Fire, Geelong, Australia, July 2021

E-bike fire set a grocery store in blaze, NYC, Mar 2023

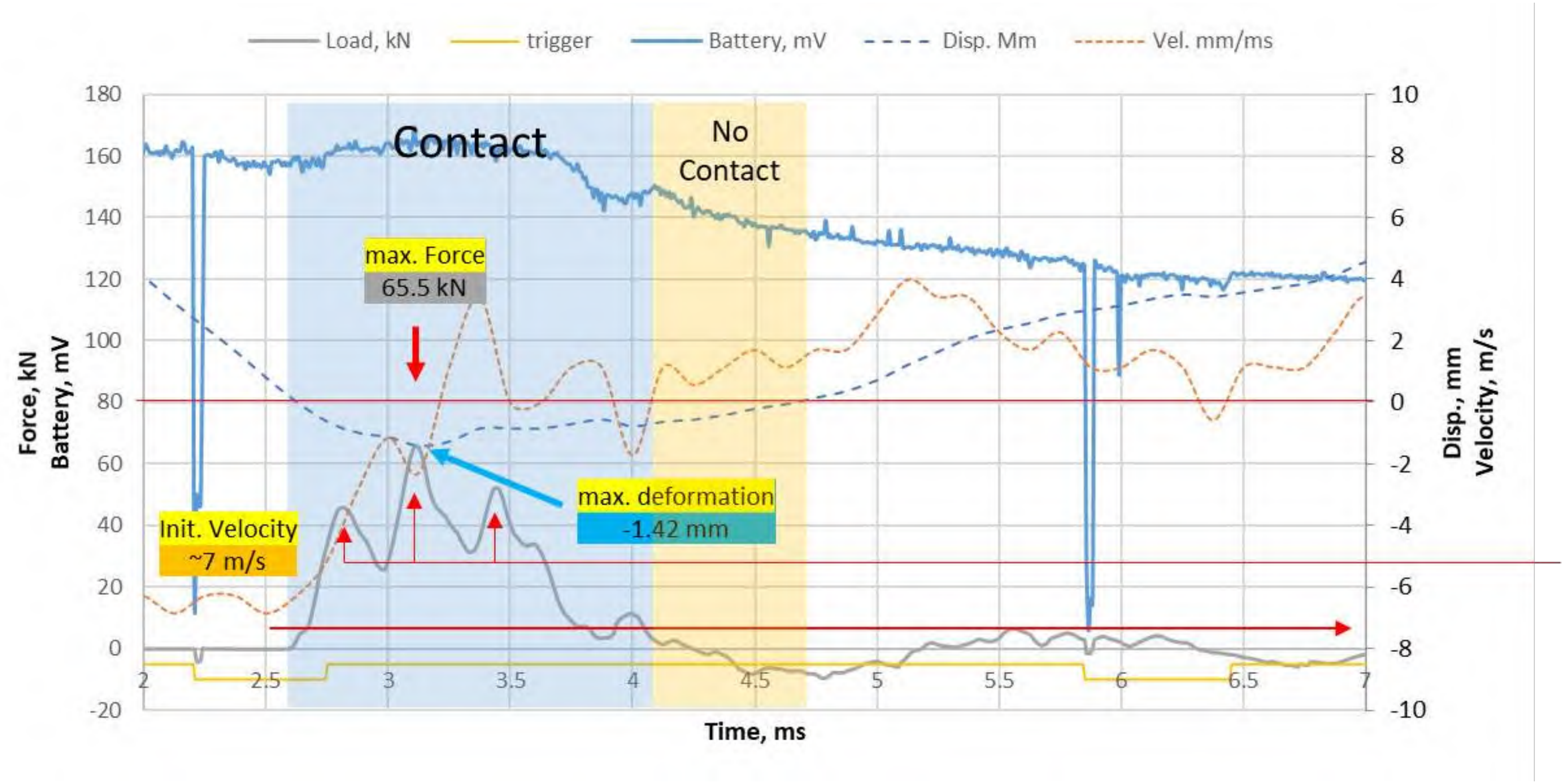
Penetration resistance of large LIB pouch cell with a 6-mm dia. ball-end punch



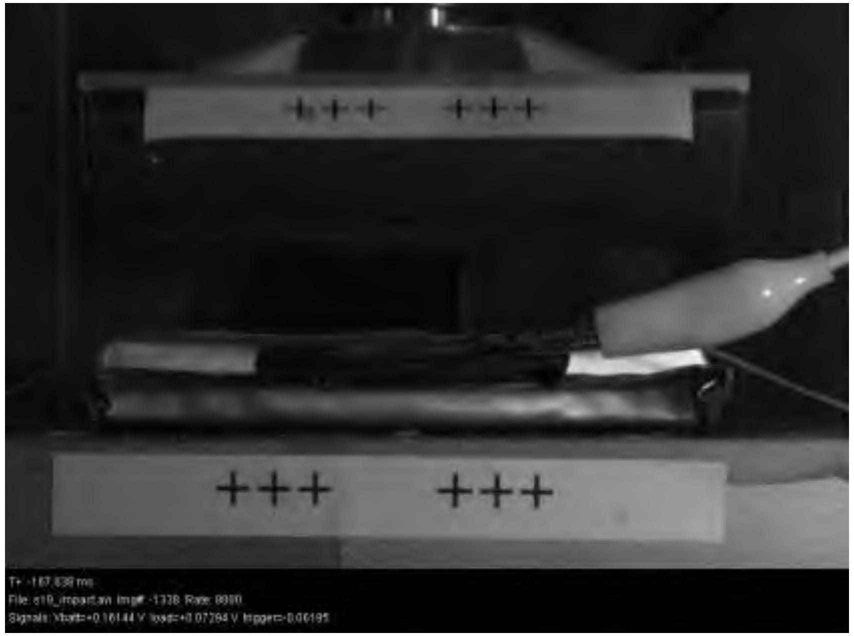


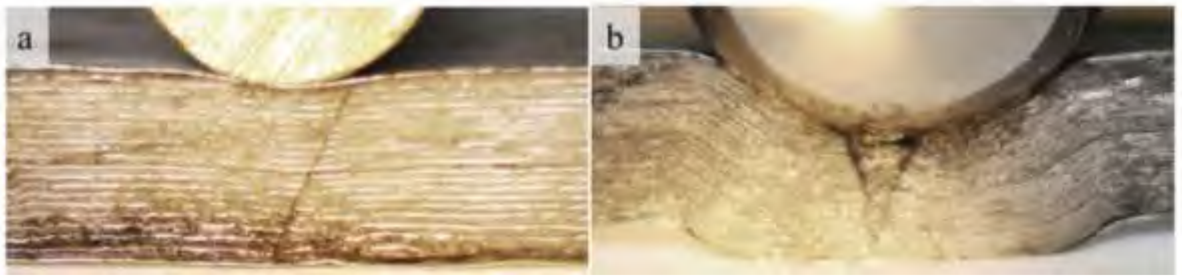
Large pouch cell under testing

Impact testing on LIB pouch cells with detailed mechanical response measurements



Impact testing on LIB pouch cells with detailed mechanical response measurements

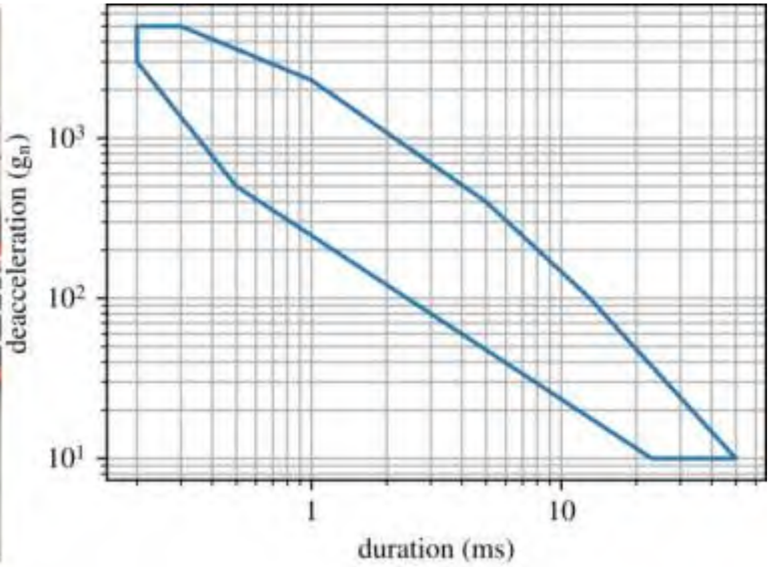




Shock And Vibration Testing Capabilities

- Accelerated shock test system that can generate upto 5,000 g_n of de-acceleration and pulse times from 0.2 ms to 150 ms.
- Gravity shock test systems for testing full-scale battery components.
- 1-DOF vibration shake table for full-scale vibration testing of battery components.
- Substantial instrumentation for vibration and shock monitoring.

Accelerated Shock Test System



Gravity Shock Test System

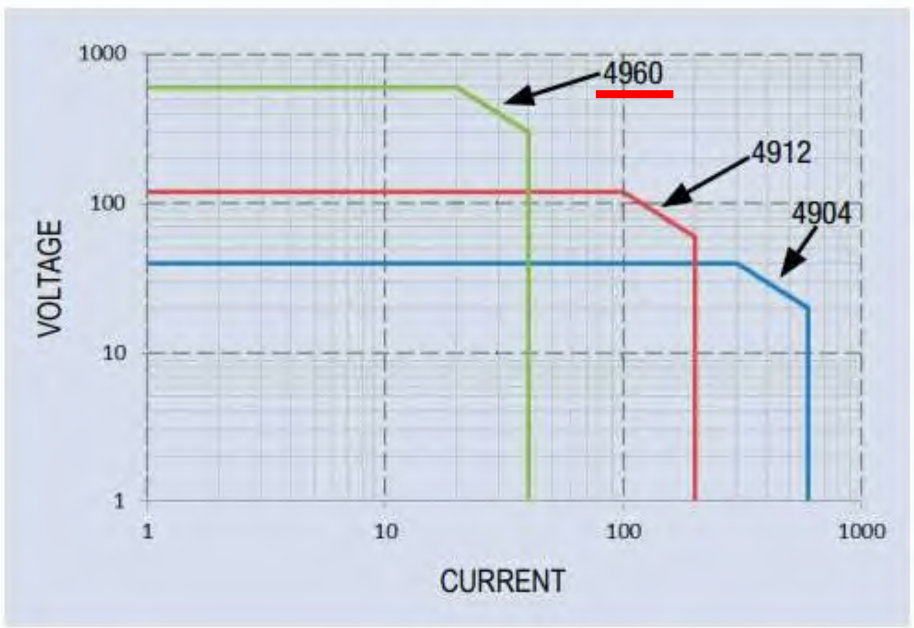
Vibration Table

High-Voltage Battery Pack Testing Capabilities

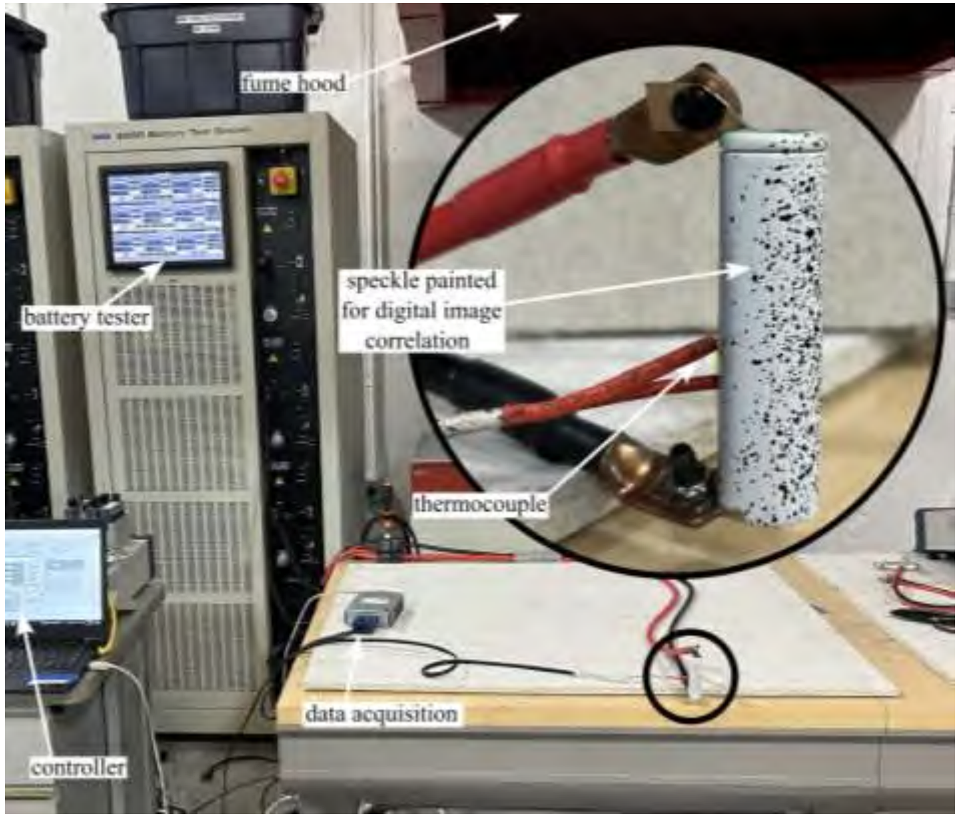
High-Voltage Battery Pack Testing Capabilities

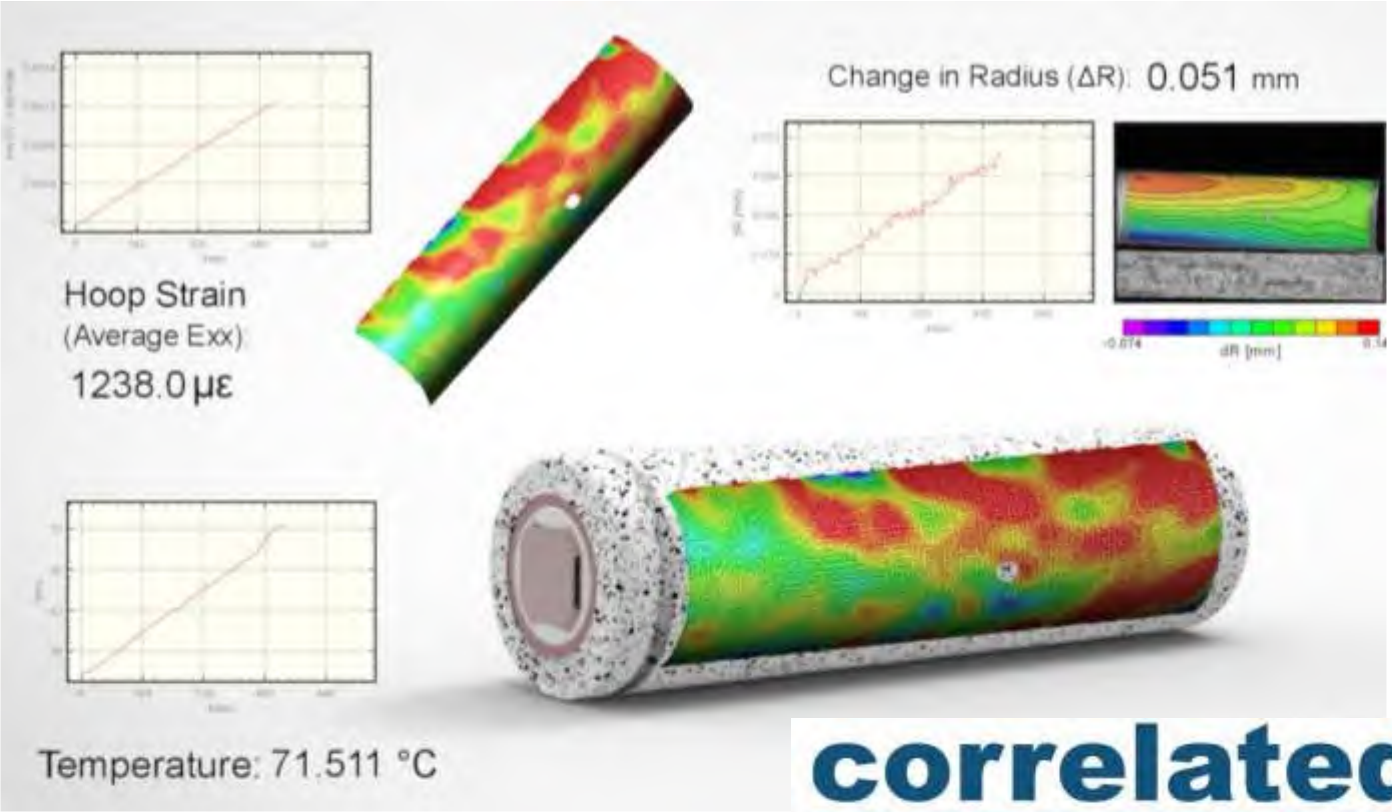
Recently acquired battery pack test system,

- 108 kW Maximum test power (All three cabinets required).
- 9 channels at 12 kW per channel.
- Power module maximums of 600 V and 360 A.
- Can be coupled with shock and vibration testing.



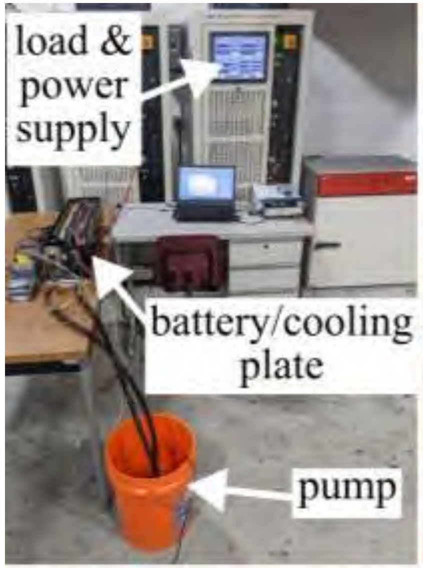
Strain-based Cell Failure Investigations

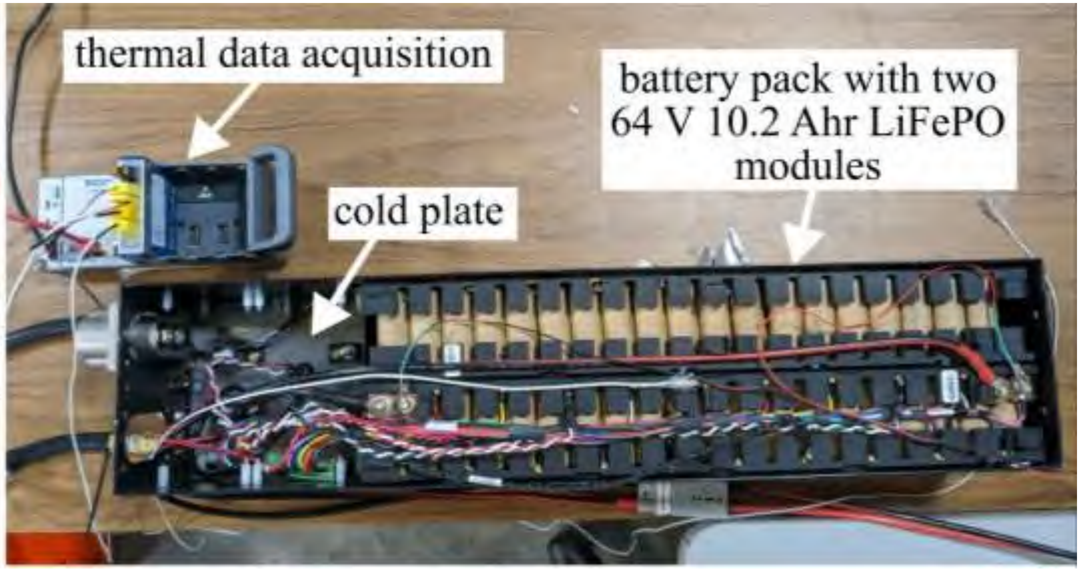


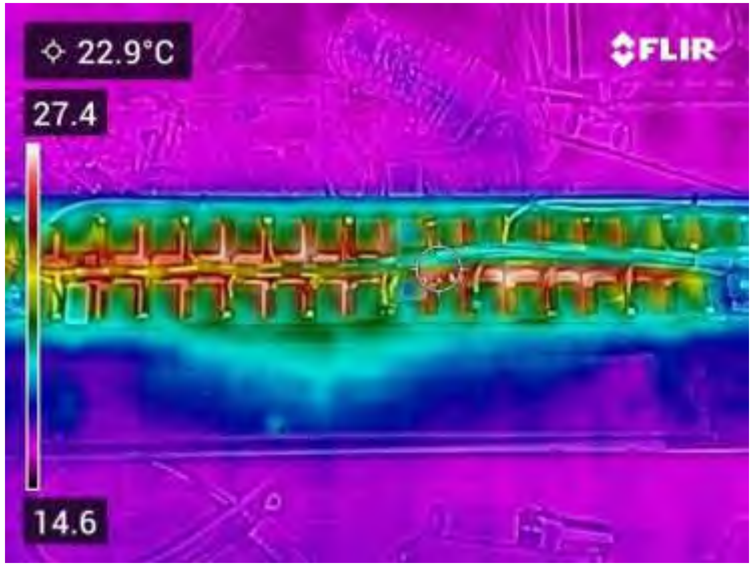


correlated SOLUTIONS

Full-scale Battery Pack Testing





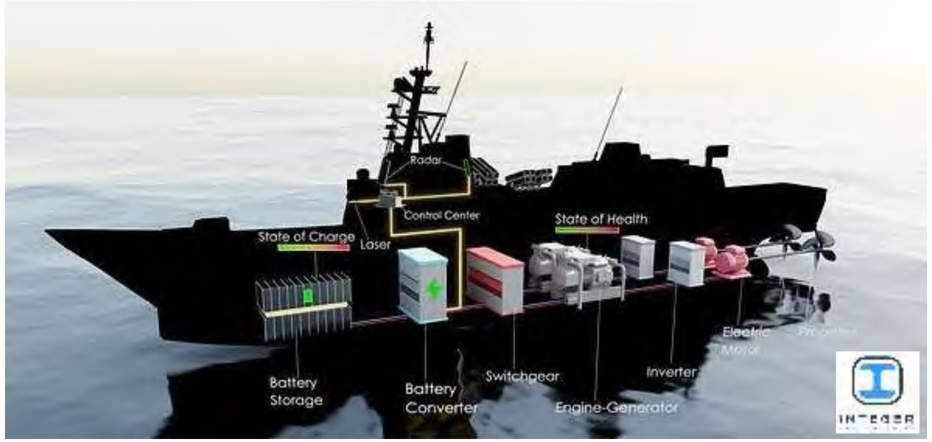


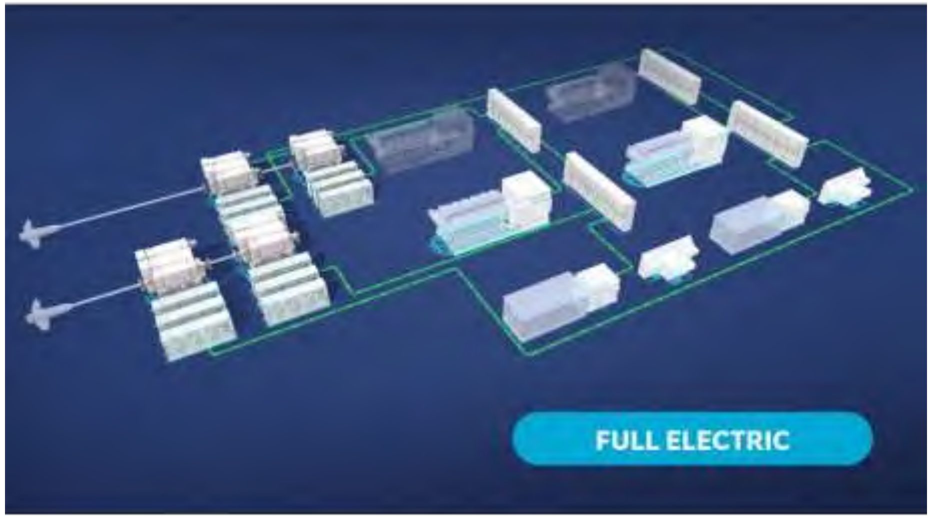
Liquid cooled Li-Iron Phosphate Battery Pack

Pack is two 64 V 10.2 Ahr modules

Battery Integration into Naval Systems

- USC is developing a digital twin test bed for naval propulsion at University of South Carolina.
- System includes the integration of large battery packs into a coupled electro-thermal system.
- Also developing electro-thermal battery emulators for system-level testing.





[1]

[1]"Solutions - Naval Electric Power & Propulsion." *GE Power Conversion*, https://www.gepowerconversion.com/product-solutions/Naval-Electric-Power-Propulsion.

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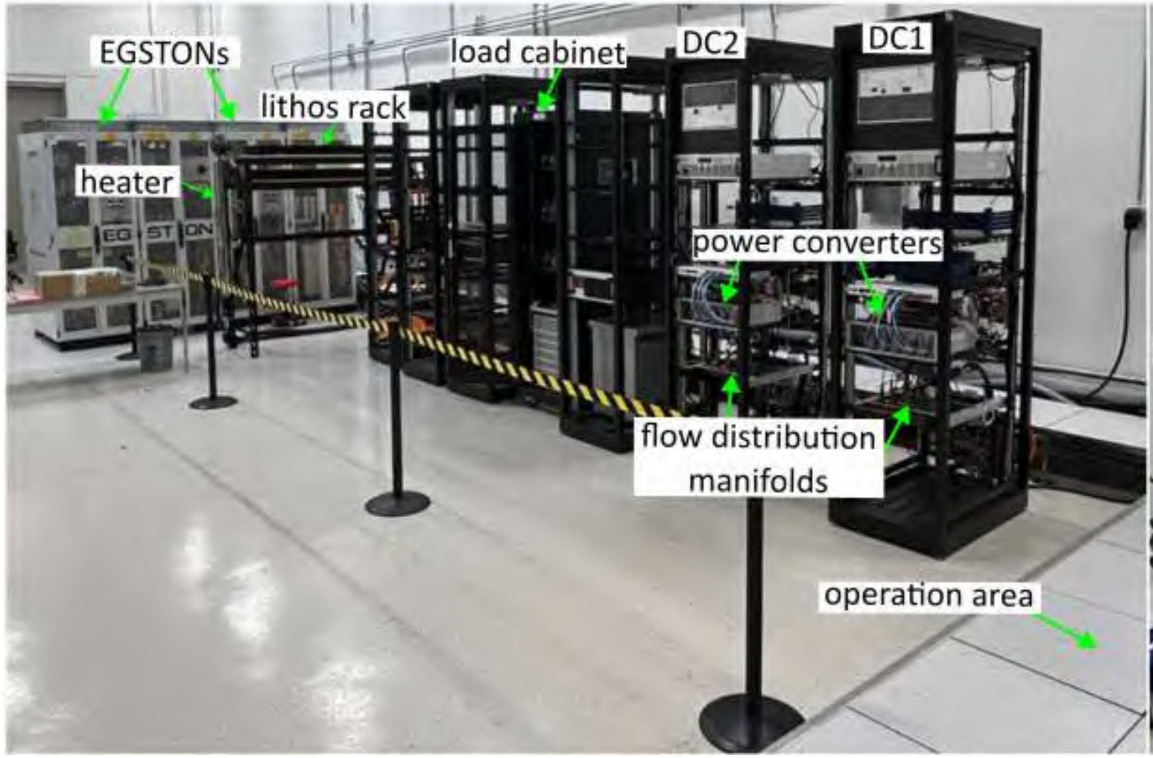
South Carolina Energy and Power Testbed for Engineering Research (SCEPTER)



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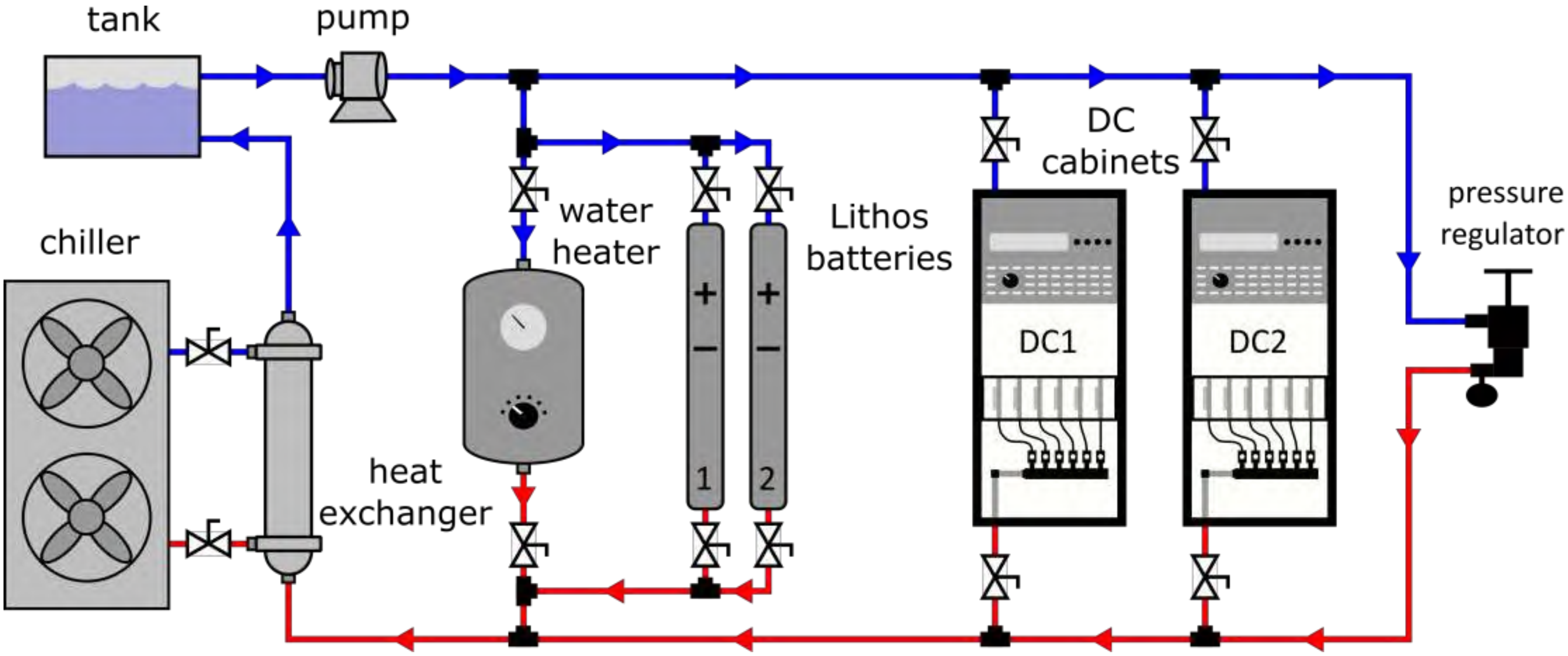
Electro-Thermal Testbed



Electro-Thermal Battery Emulator

Safety:

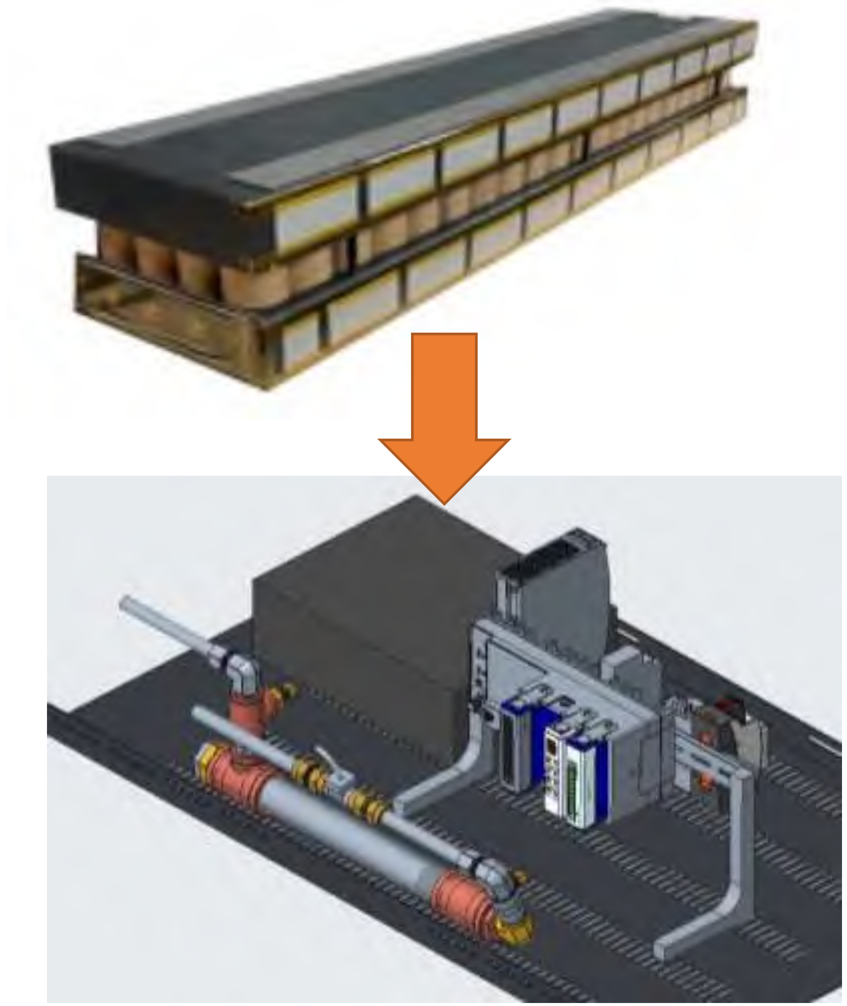
- Enable safe exploration of energy storage under extreme conditions

Scalability:

- Emulate characteristics of large battery at all system connections -- electrical terminals and fluid ports -- based on actual behavior of a single cell of the type used in the battery

Parity:

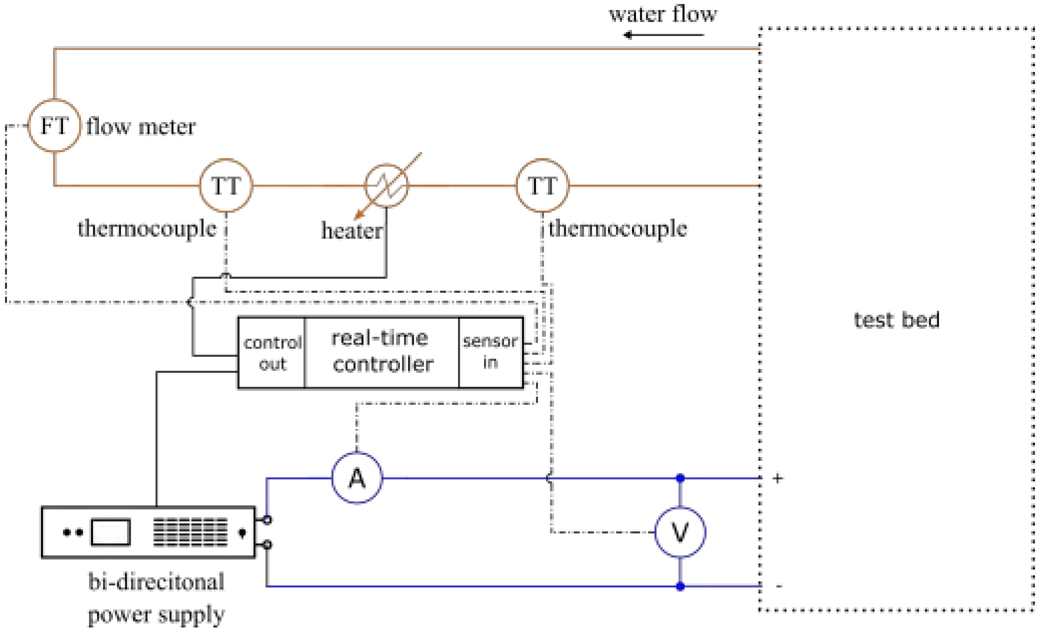
- Investigate equivalent thermal and electrical coupling effects



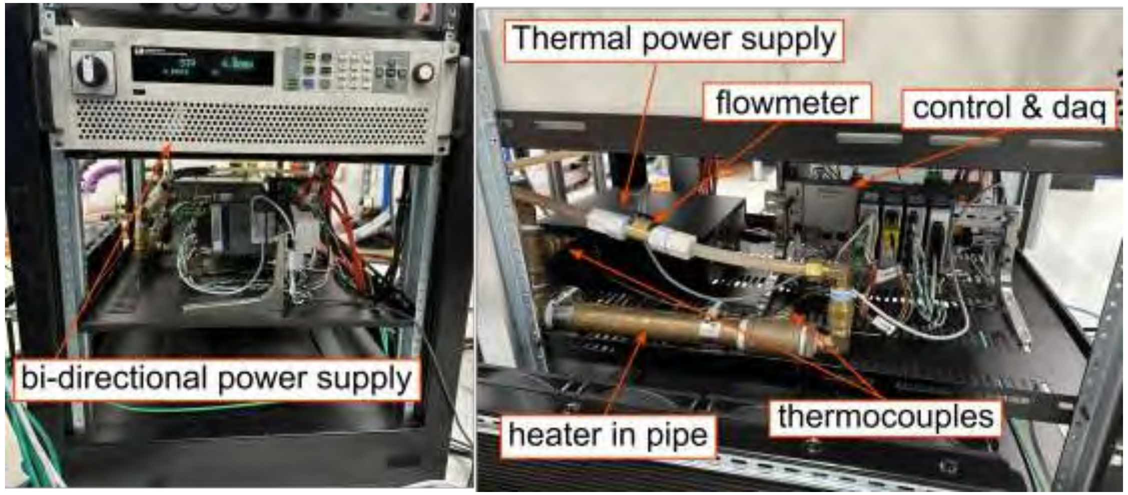
Emulator Hardware

- Implements Battery model on cRIO 9054 controller
- Electrical emulation through a bidirectional power supply
- Thermal Emulation through a heater

hardware diagram:

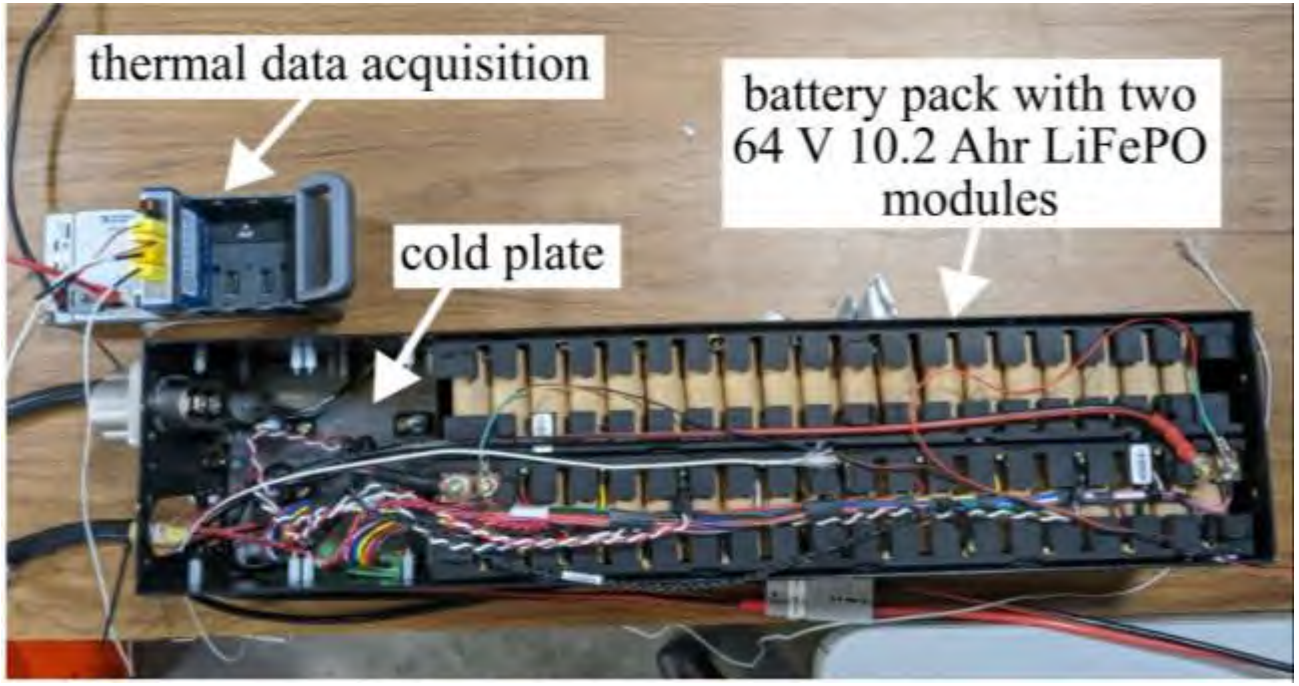


Physical setup:

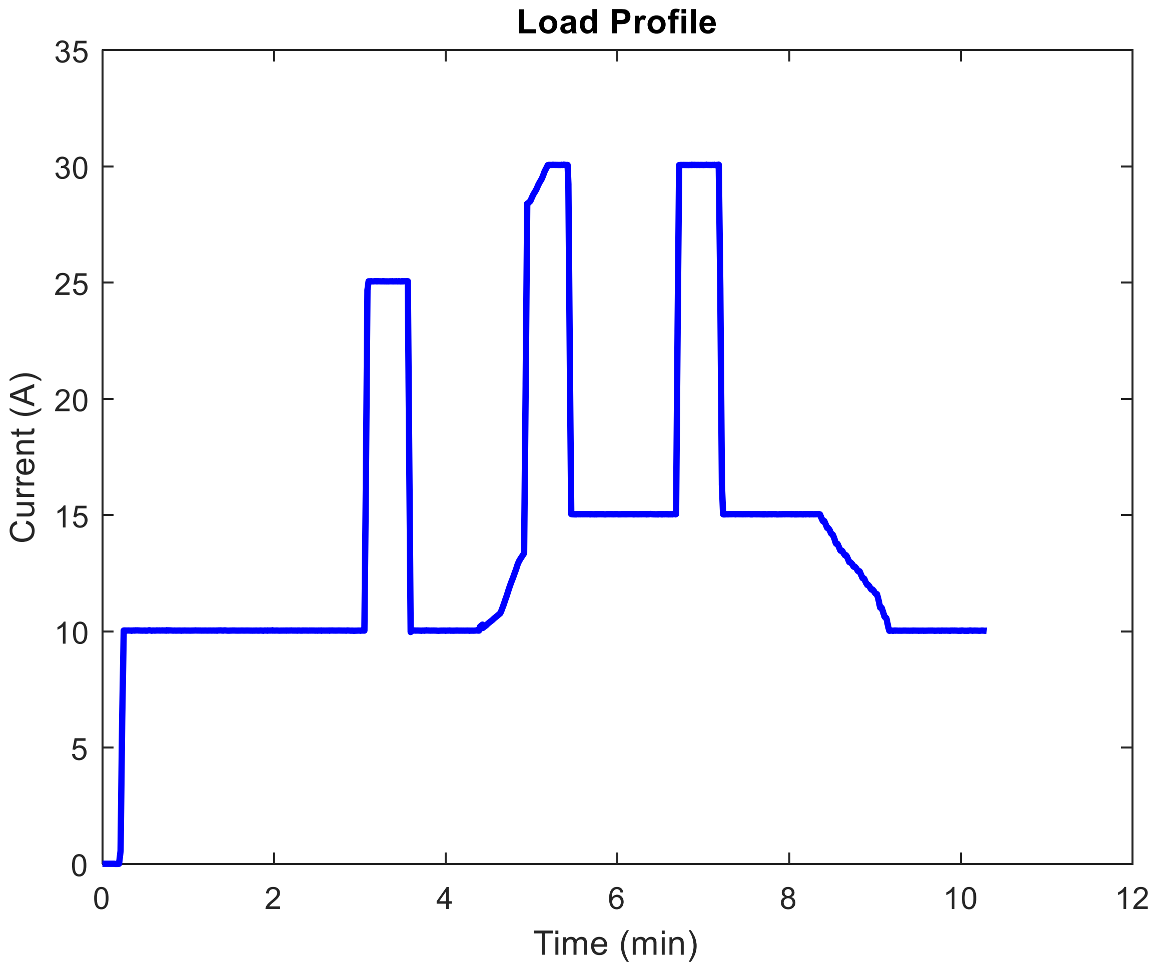


Electro-thermal Battery Pack Emulation

- Li-Iron Phosphate Battery
- 20 Cells in series
- 4 Cells in Parallel
- SoC set to 100%
- SoH approximately 60%
- Liquid cooled

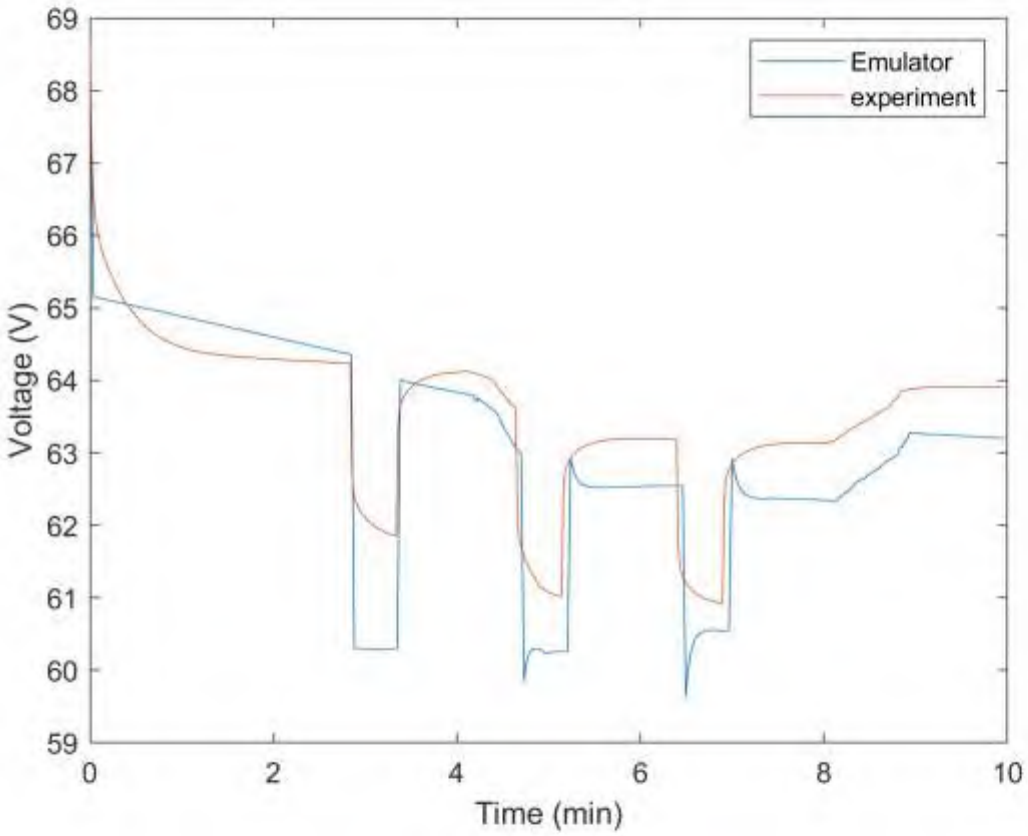


2.5C Pulse Load

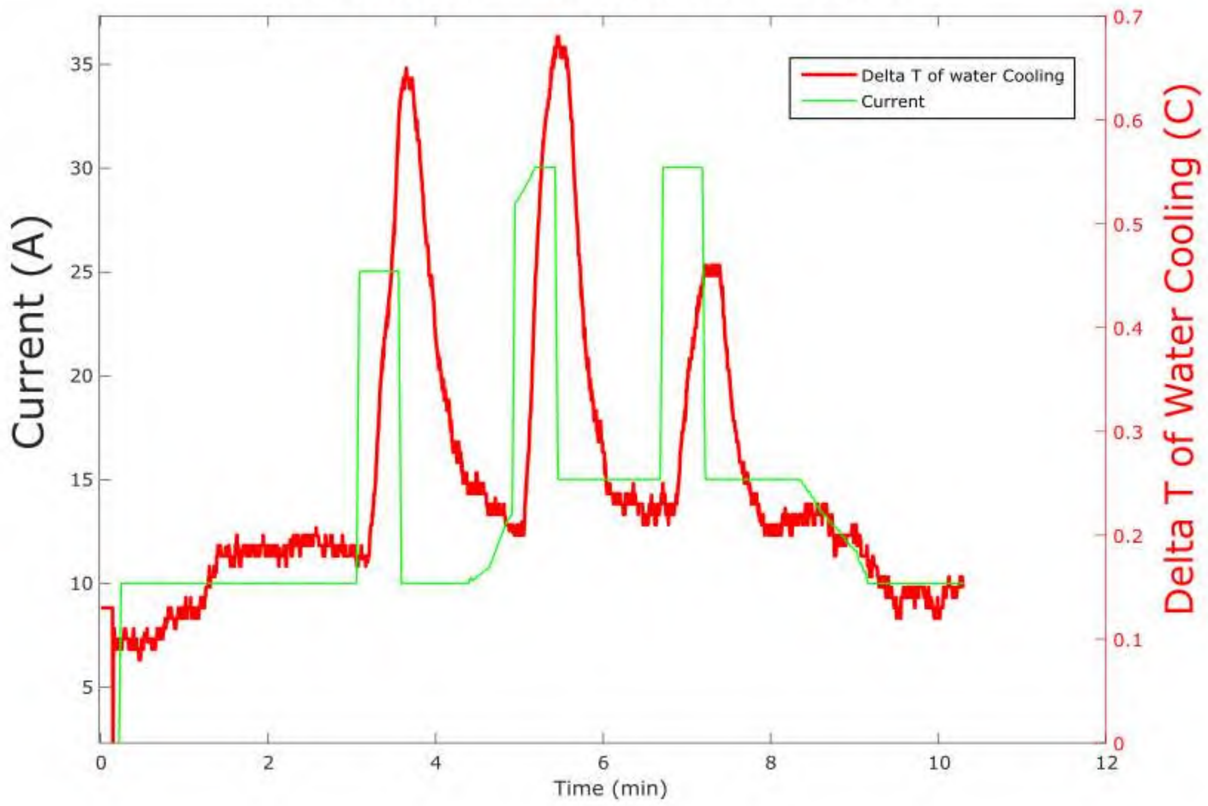


Electro-thermal Load Profile Results

Voltage Response



Temperature Response



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Thank You For Your Time and Attention

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