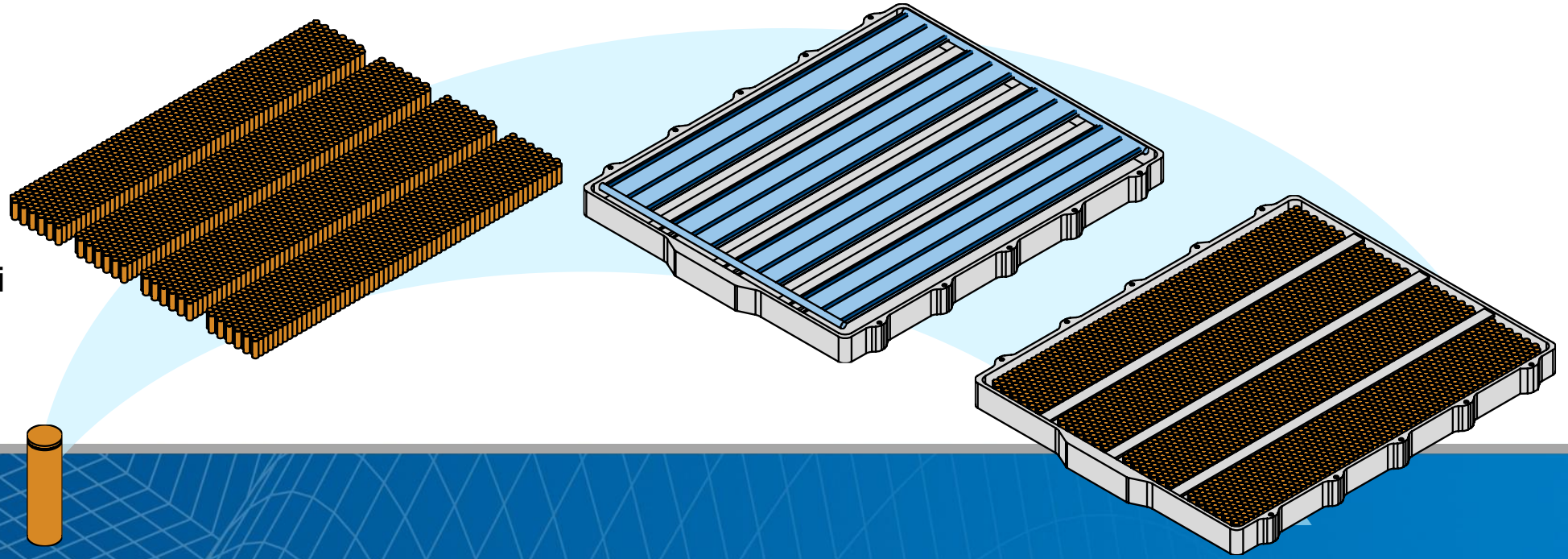
From Cell to Pack: Battery Modeling with Simscape



By Lorenzo Nicoletti

12.11.2026

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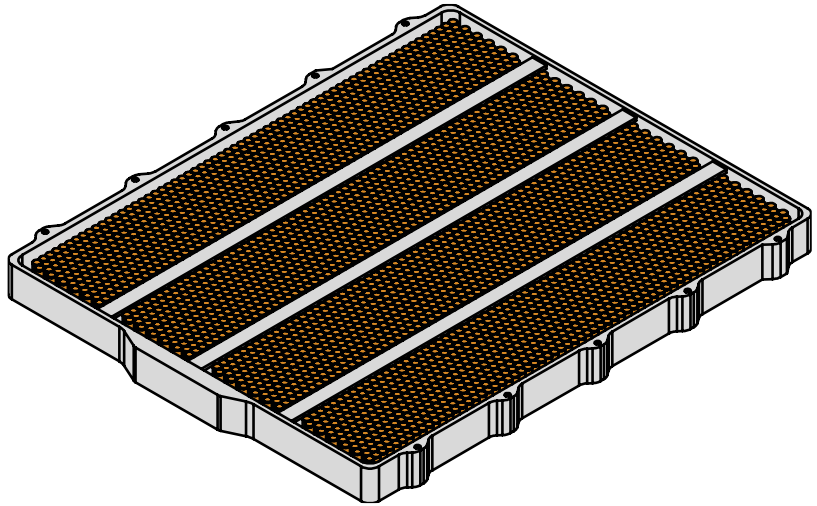
Why Explore Electrothermal Pack Modeling?

The importance of temperature monitoring for Li-Io packs

- Battery Electric Vehicle (BEV) sales are steadily rising
- Li-Io battery is the heart of a BEV
  - Energy storage
  - Expensive component
- The Li-Io battery performance is highly influenced by its temperature



Resistance increase
Capacity reduction





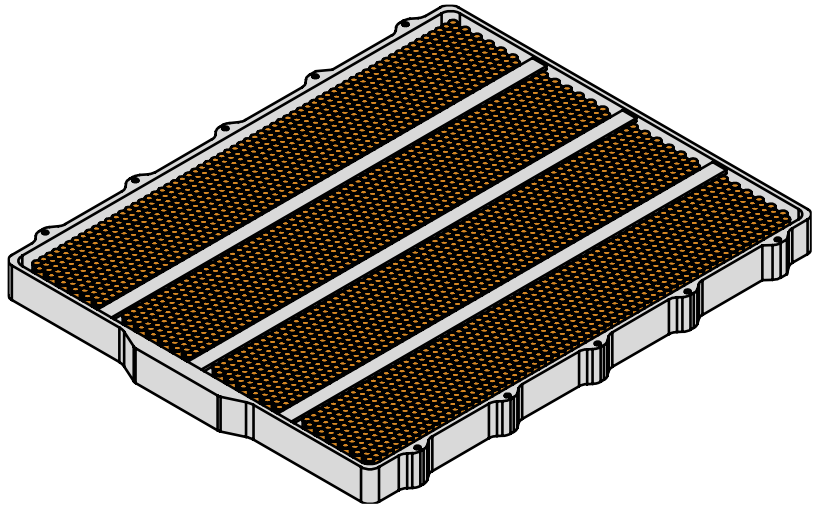
Cell Aging
Thermal Runaway

Why Explore Electrothermal Pack Modeling?

The importance of temperature monitoring for Li-Io packs



Resistance increase
Capacity reduction





Cell Aging
Thermal Runaway

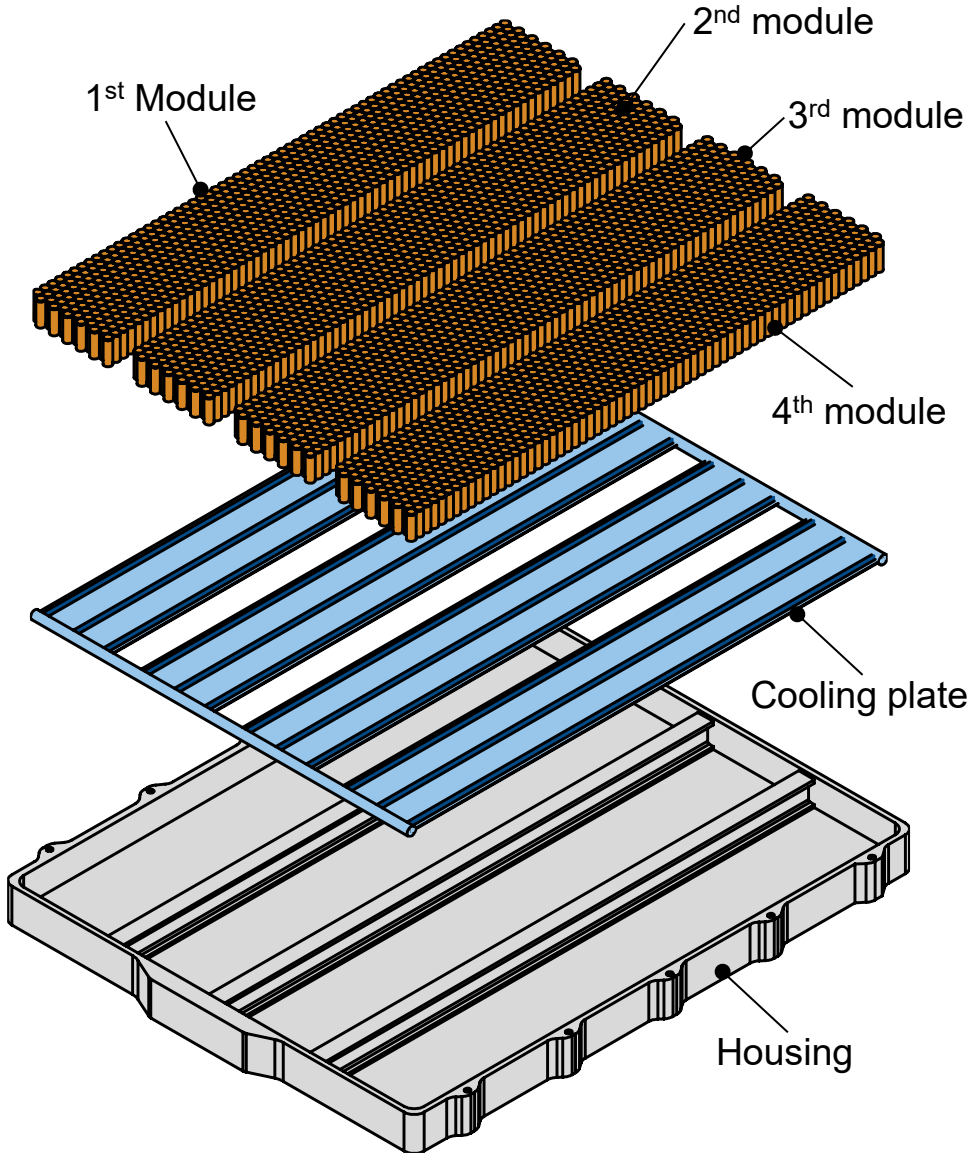
- The battery must operate in a safe temperature window
- Electrothermal simulation is a powerful for analyzing the battery behavior
- Creating detailed electrothermal models is a challenging task

The Pack We Will Build Today

Using Simscape Battery

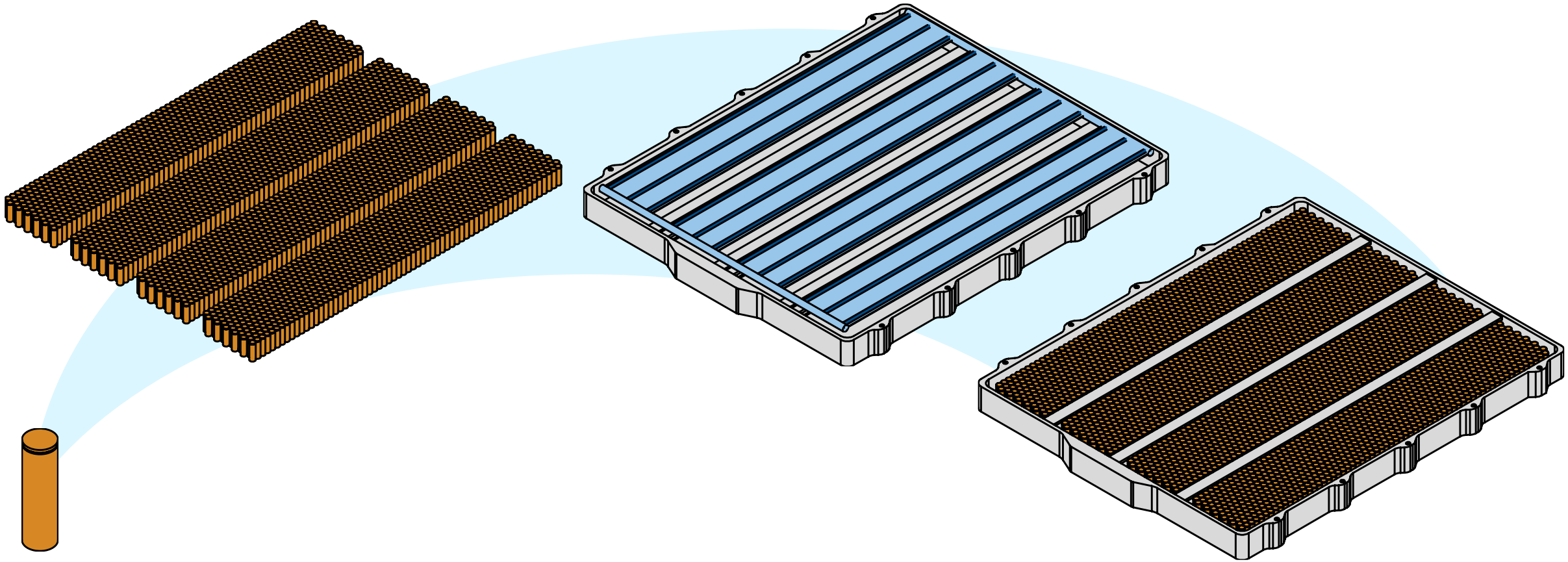
The thermal and electrical modeling will be applied on a previously-sized battery pack

1. 3072 cylindrical cells (21700 format)
2. Electrical scheme 96s32p
3. Cell are disposed in 4 modules
4. Installed energy: 50 kWh

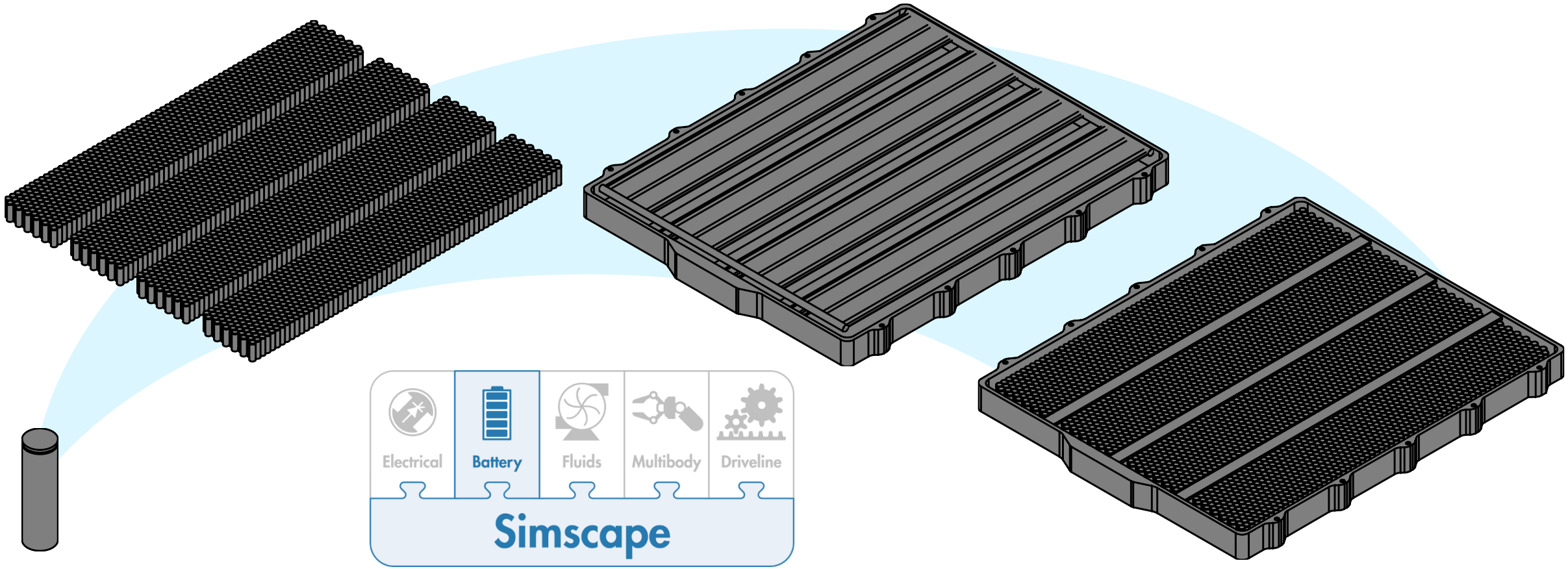


From Cell to Pack: Simulate Behavior during Charge Scenario

Agenda



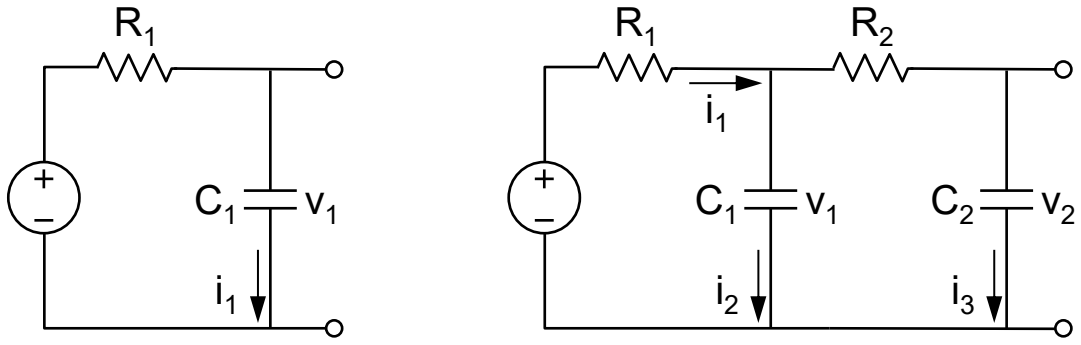
Step 1: Introduction to Simscape and Simscape Battery



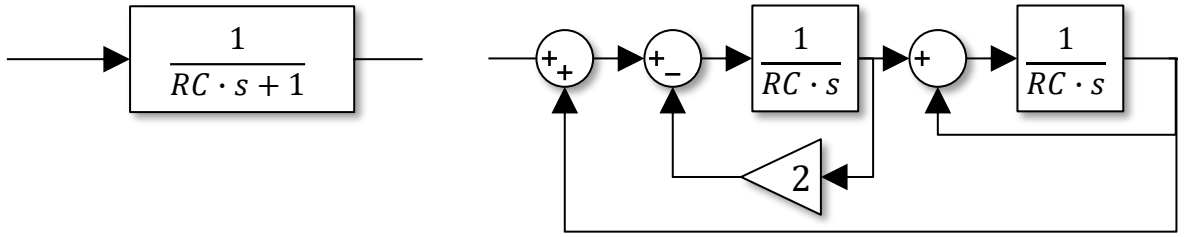
Simscape Helps You To Rapidly Describe Physical Systems

Comparison with Simulink

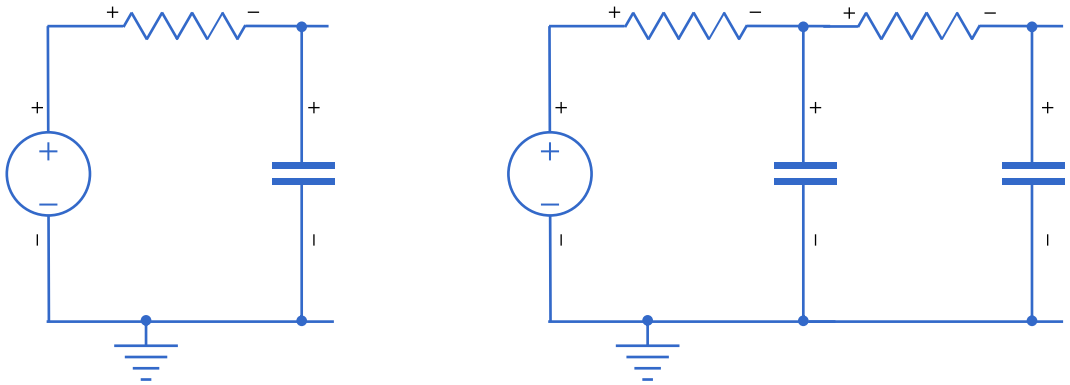
- Simulink uses signal-based modeling
  - Signals
  - Clear Inputs and Outputs
- Simscape enables bidirectional flows of energy between components
  - Connections
  - No signal direction
- The system equations in Simscape are:
  - Formulated automatically
  - Solved simultaneously
  - Cover multiple physical domains



Simulink: Inputs & outputs



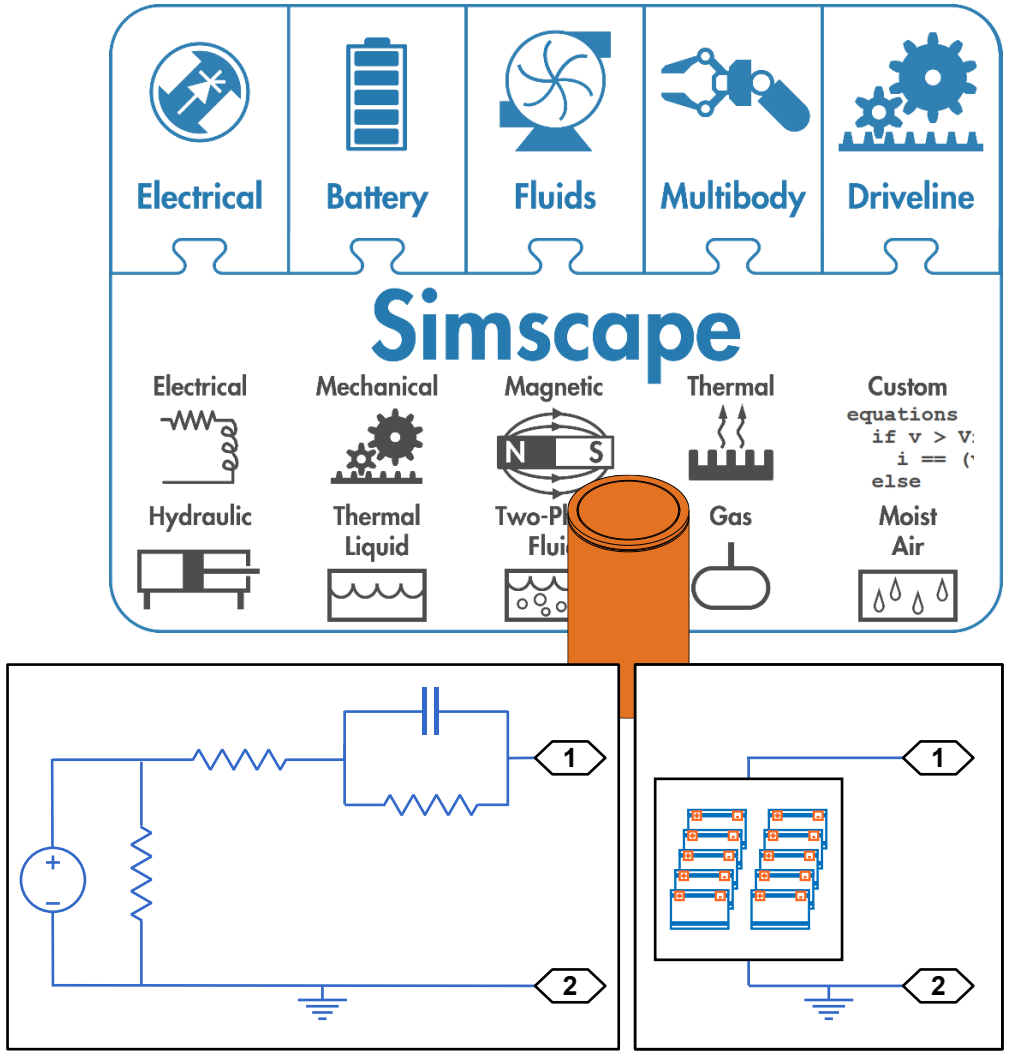
Simscape: Physical Networks



With Simscape You Can Model Model Different Physical Systems

Key Features

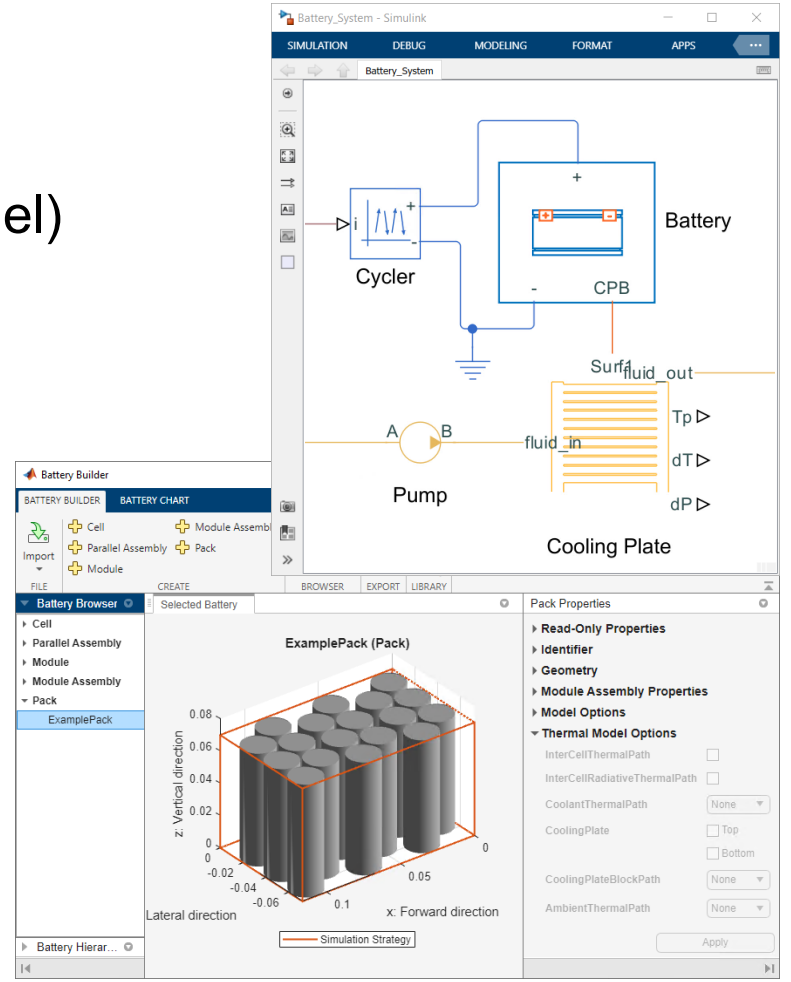
- Foundation physical modeling blocks in different physical domains
  - Mechanical, electrical, hydraulic …
  - Custom components with Simscape language
- Specialized libraries available
  - Battery, Electrical, Driveline, Multibody …
- Support for C-code generation



Simscape Battery Is The Dedicated Tool For Battery Simulation

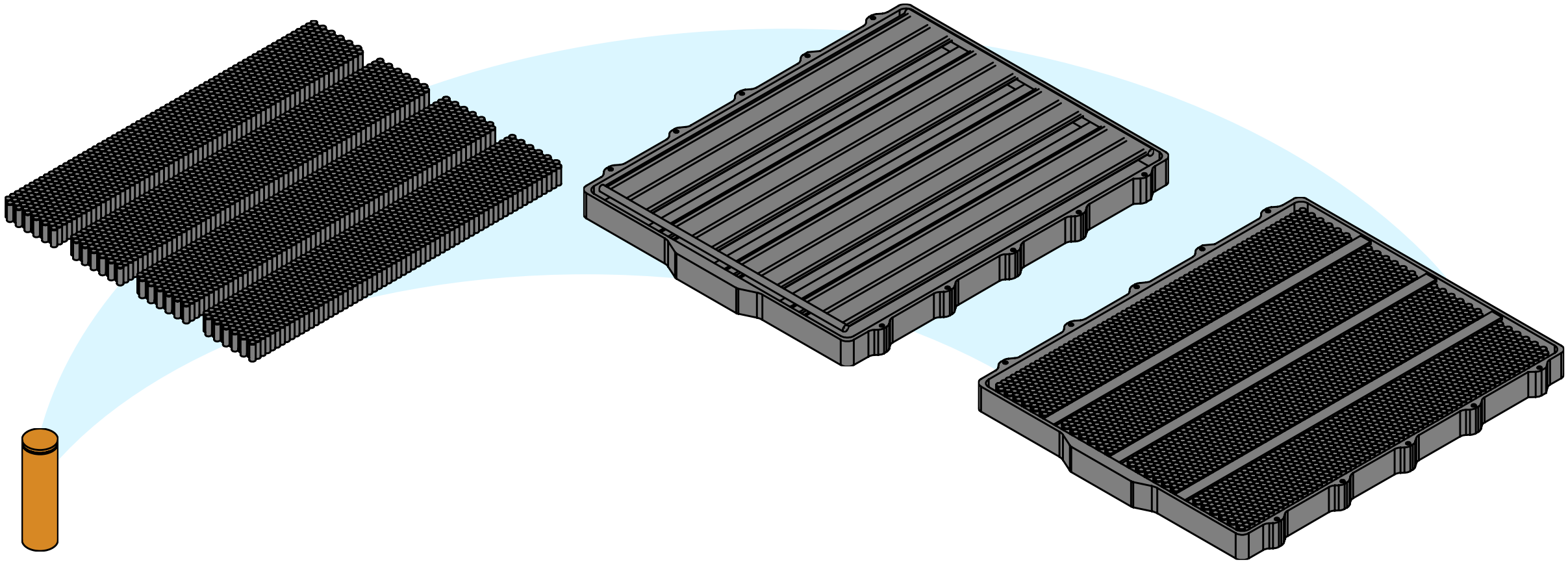
Key Features

- Battery Pack Builder (MATLAB API, App)
  - Automatically assemble cell models into battery pack
  - Define electrical and thermal connections (series, parallel)
- Cooling plate models
  - Includes edge, parallel channel, and U-shaped channel
- Battery management algorithms
  - Charge/discharge
  - SOC, SOH, SOE
  - Cell balancing
  - Thermal management



Step 2: Select A Cell Model

Understanding the cell models in Simscape Battery



First, You Can Select A Cell Model To Build Your Battery

Pick the right model based on your need

Click on the ? symbol to see the block documentation



Today's Example







Capabilities	Battery (Table-Based)	Battery Eq. Circuit	Battery Single Particle	DFN
RC parameters	SOC/T dependent	SOC/T dependent	None	None
Number of RC blocks	5	3	None	None
Electrochemical model	No	No	Yes	Yes
Hysteresis Model	No	Yes	No	No
Possibility to Inject Faults	No	Yes	Yes	No
Source Code Available?	No	Yes	Yes	Yes

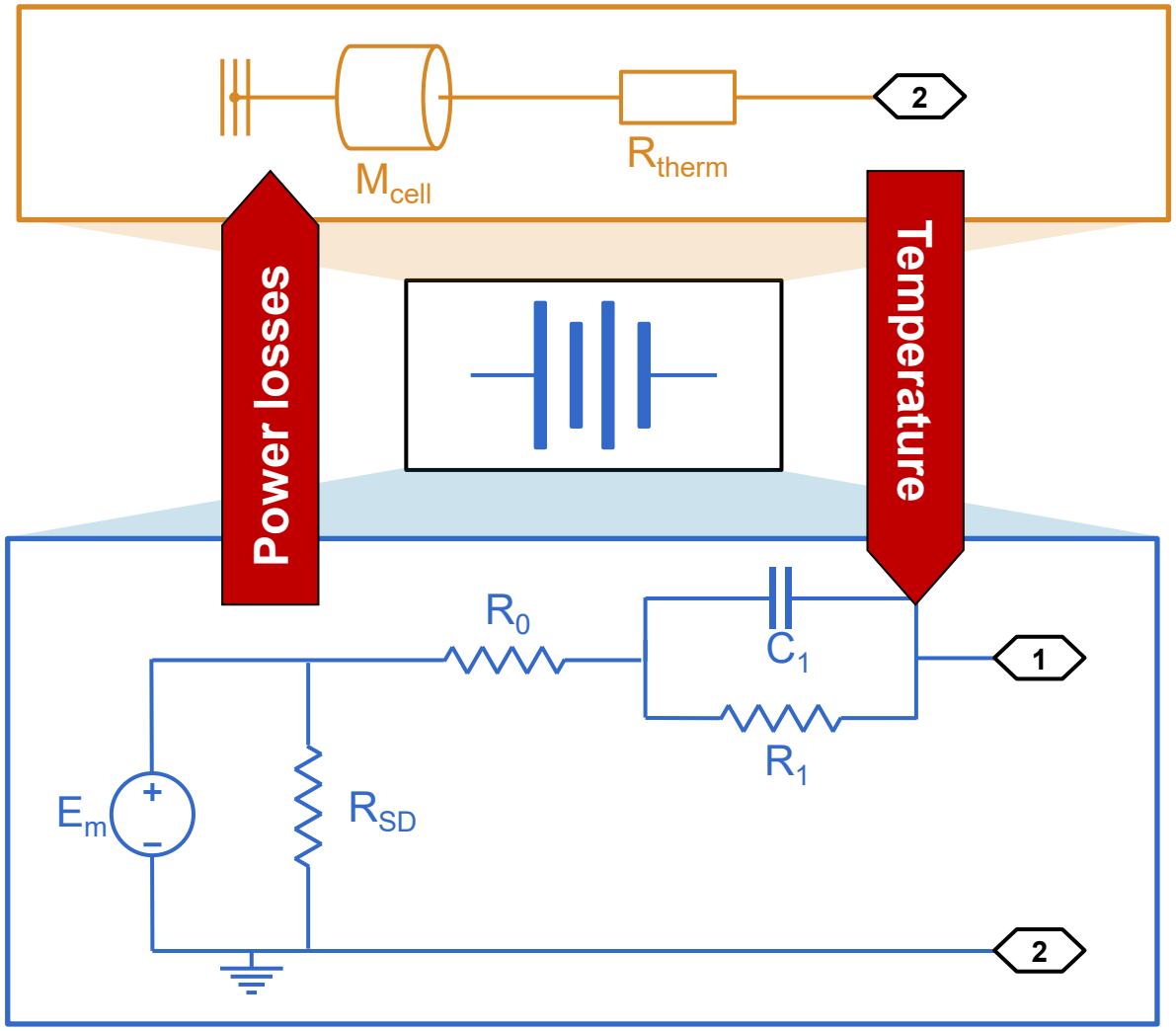
Implementation

We select the Battery Equivalent Circuit Block

The Battery Equivalent Circuit Block Is A Multi-Physics Model

Battery Equivalent Circuit

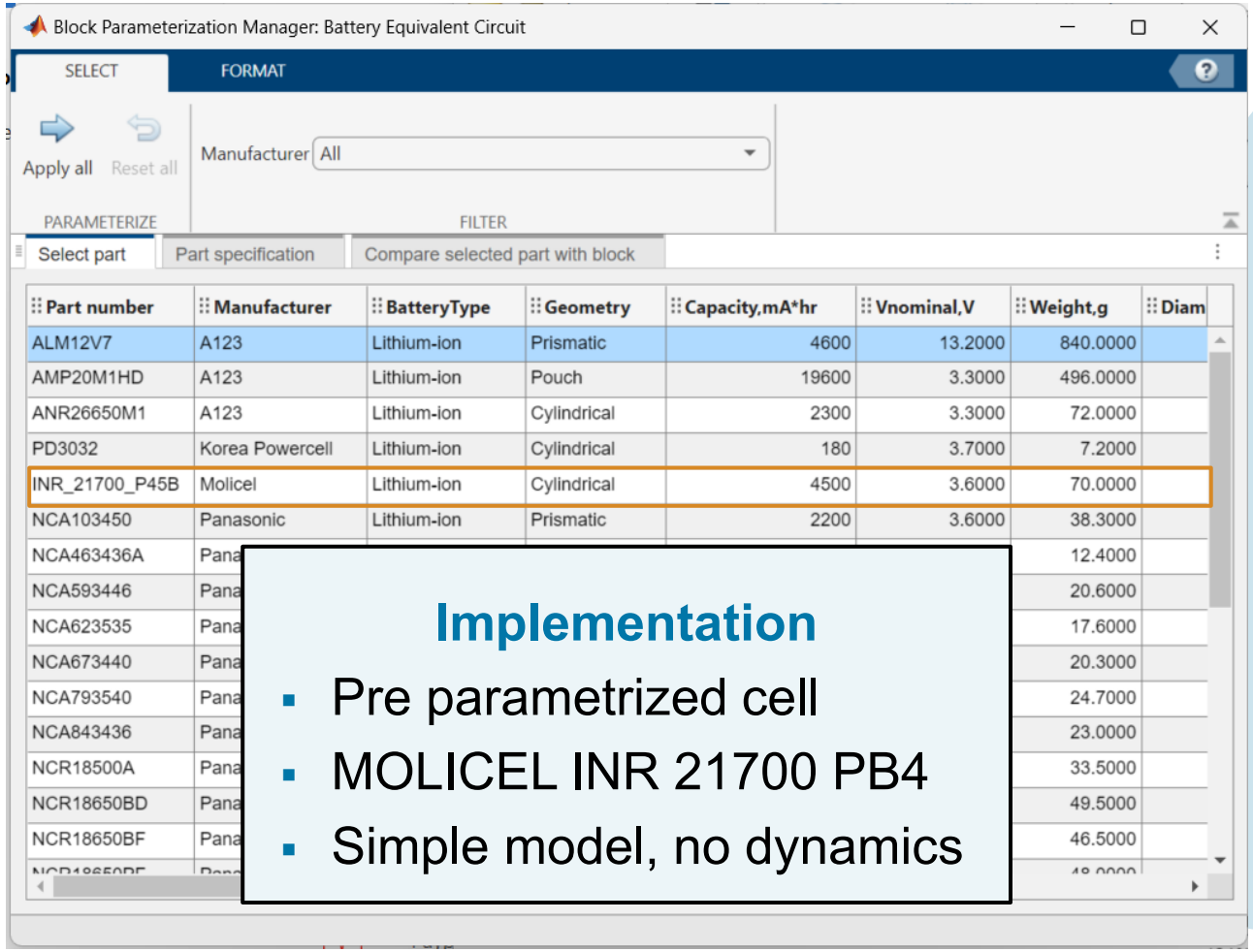
- Multi-domain physical model
- Electrical cell model
  - Cell described with up to 3 RC circuit
  - Different levels of detail available
  - Hysteresis model available
- Thermal lumped cell model
  - Cell as lumped thermal mass
  - Irreversible heat from power losses
  - Includes reversible heat generation
- Simulate faults

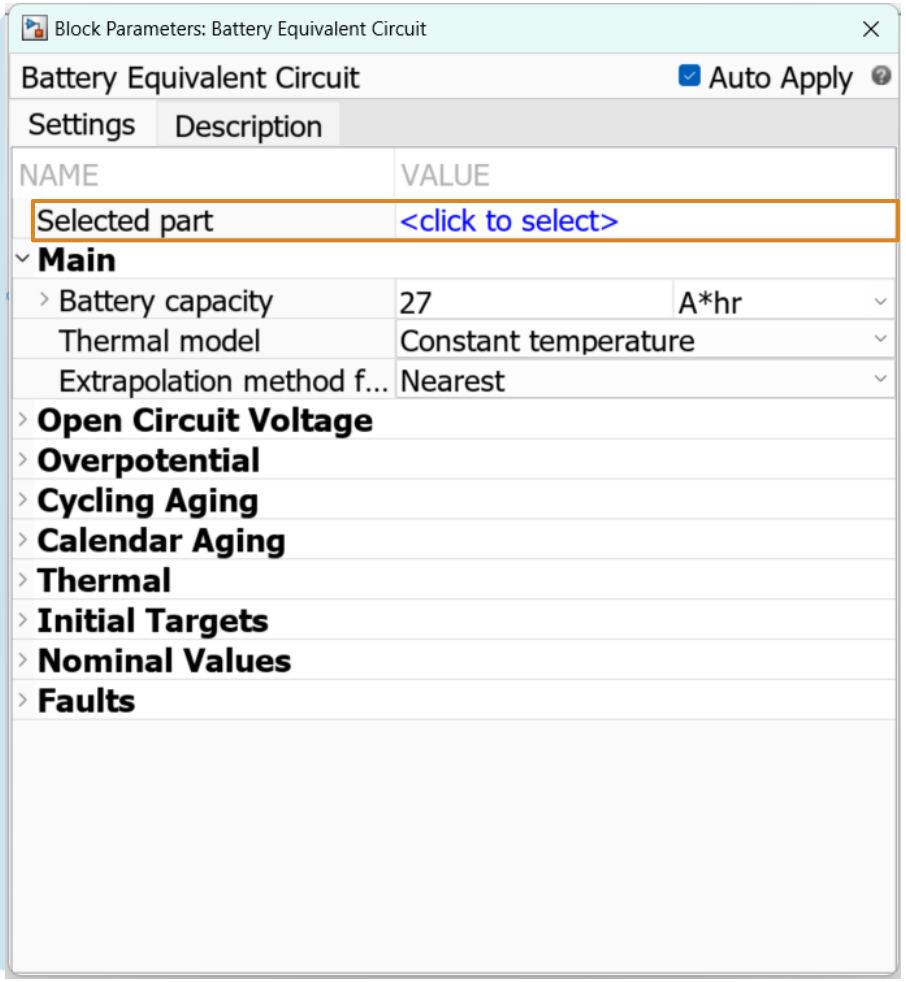


» Battery Equivalent Circuit

Parametrize Your Cell Model with One Click

Using the Block Parametrization Manager

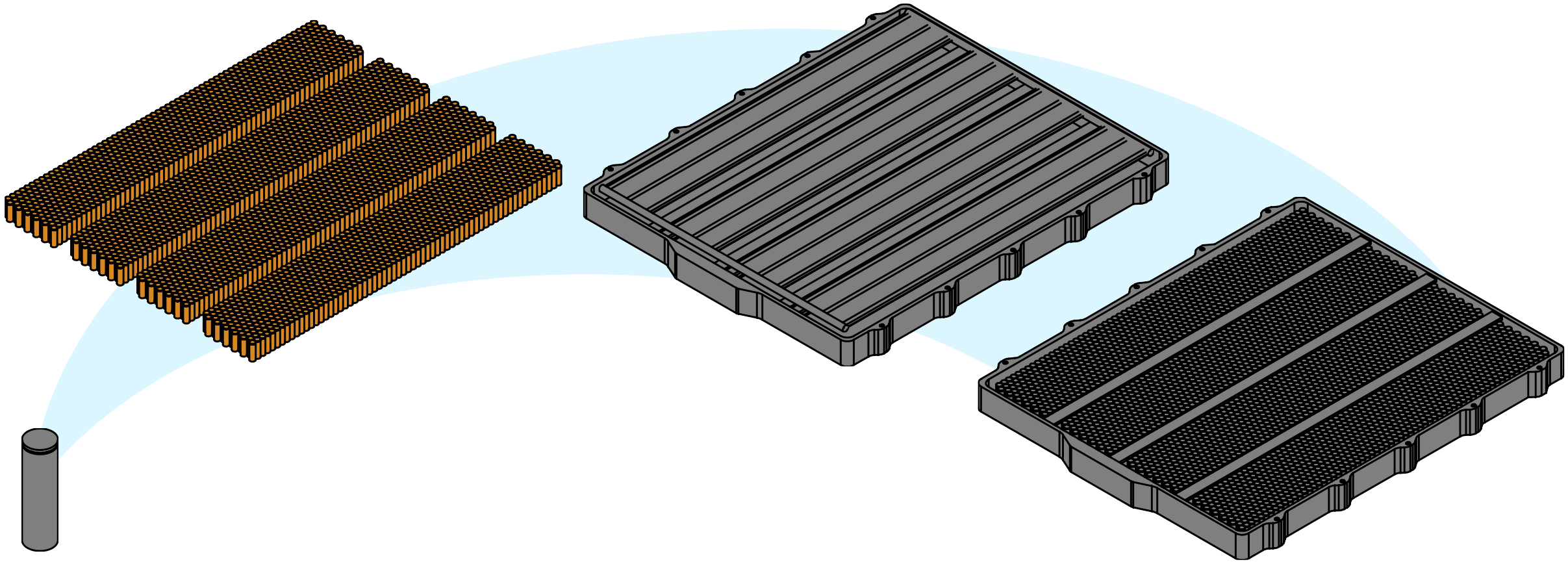




» List of Pre-Parametrized Components

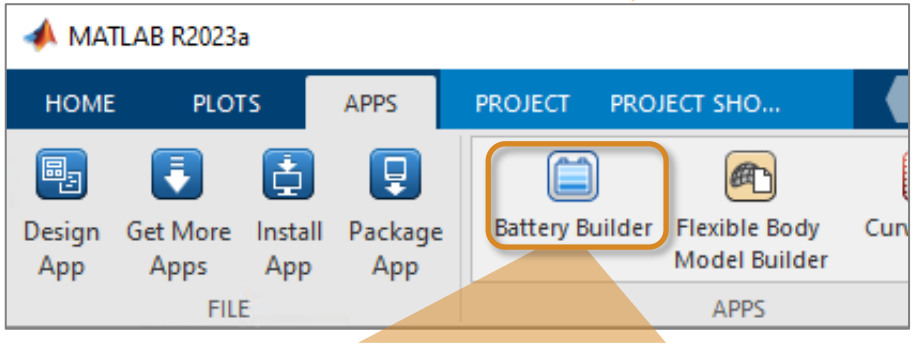
Step 3: Build The Battery Pack

Going from cell to pack



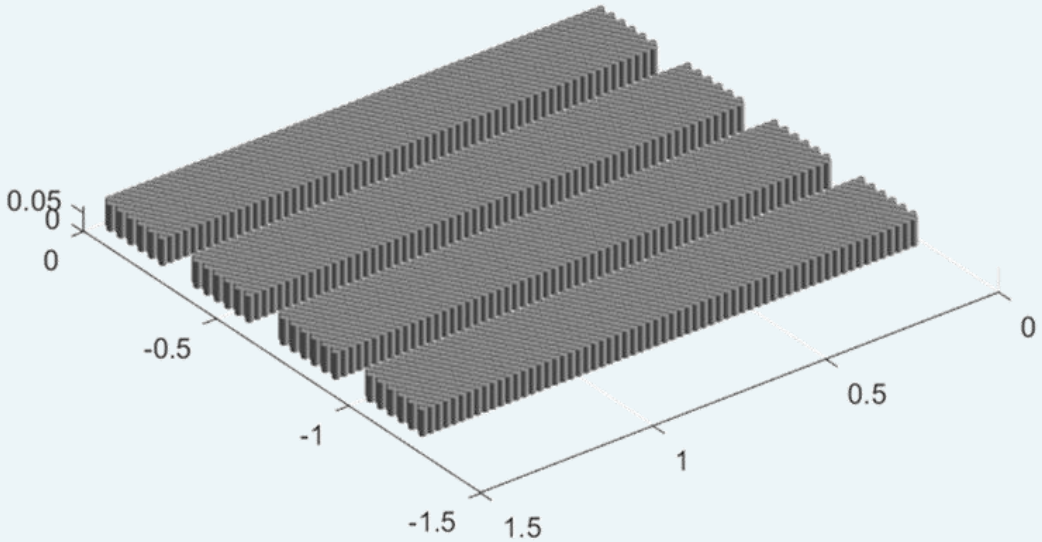
Building A Battery Pack Within Few Minutes

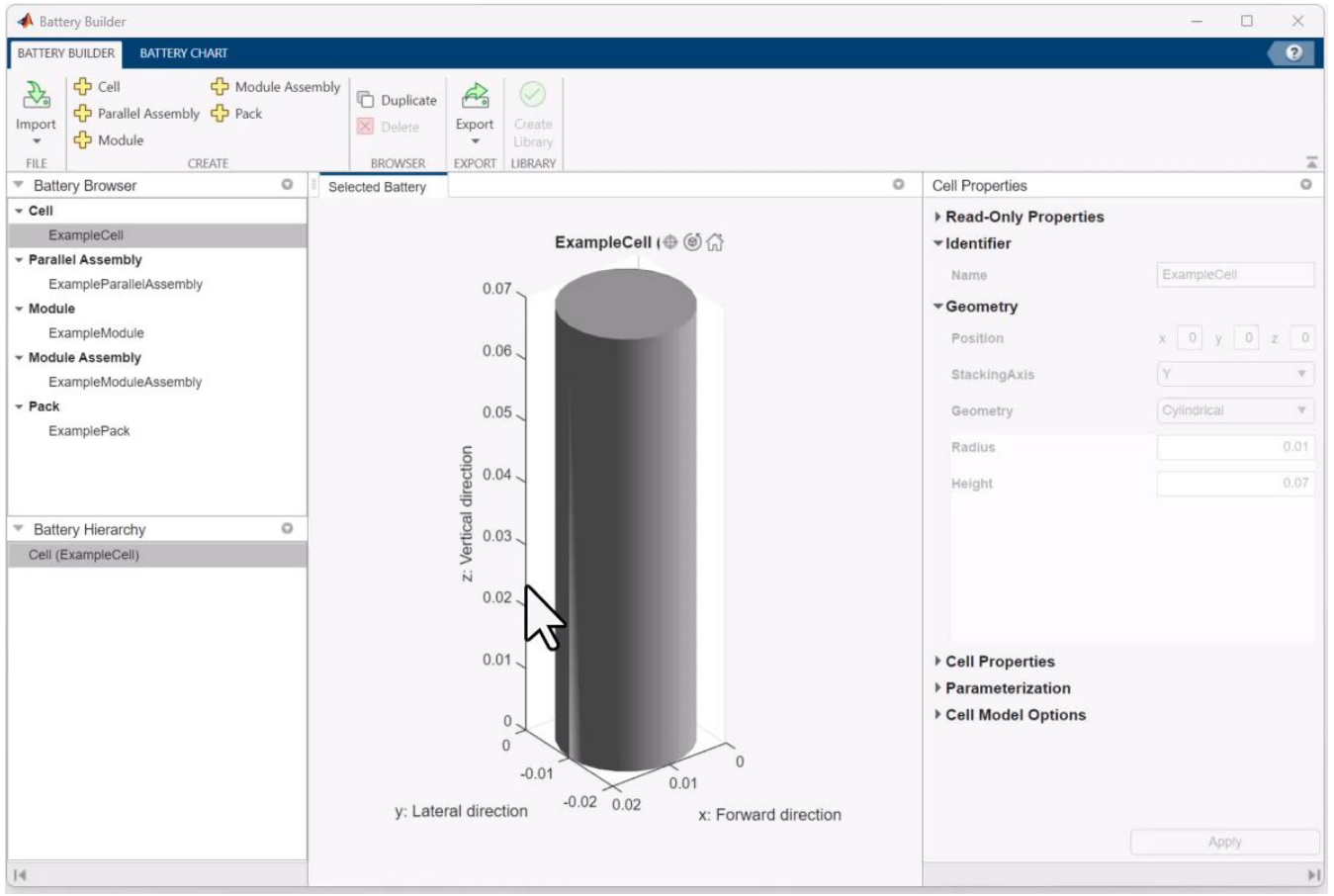
with the Battery Builder App



Implementation

- 3072 cells disposed on four modules
- Electrical scheme 96s32p



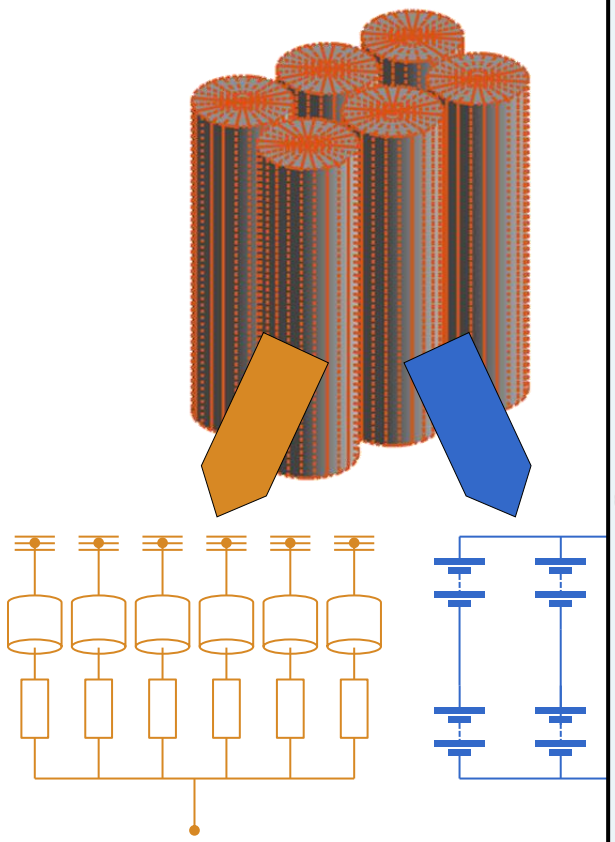


» Battery Builder

Find The Tradeoff Between Calculation Speed & Precision

Choosing the right model fidelity for the pack

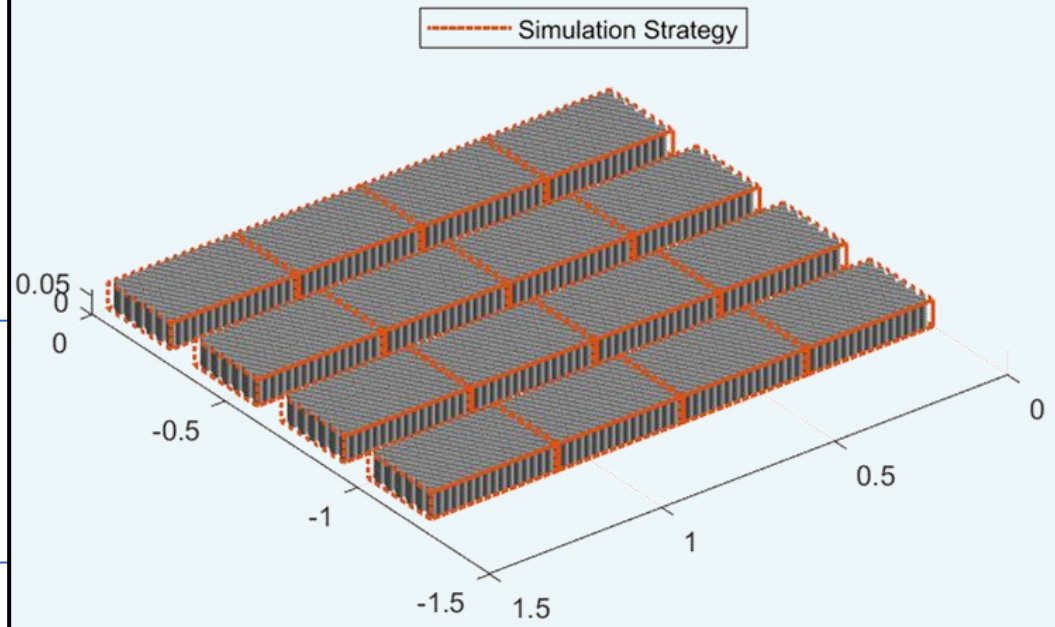
Detailed



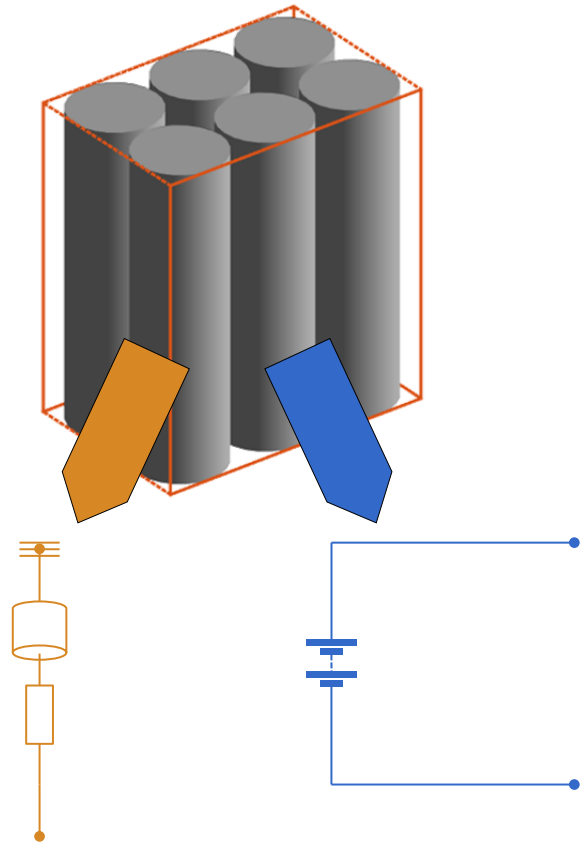
Grouped

Implementation

Selected a *Grouped* model resolution by dividing each module in four cell groups.



Lumped



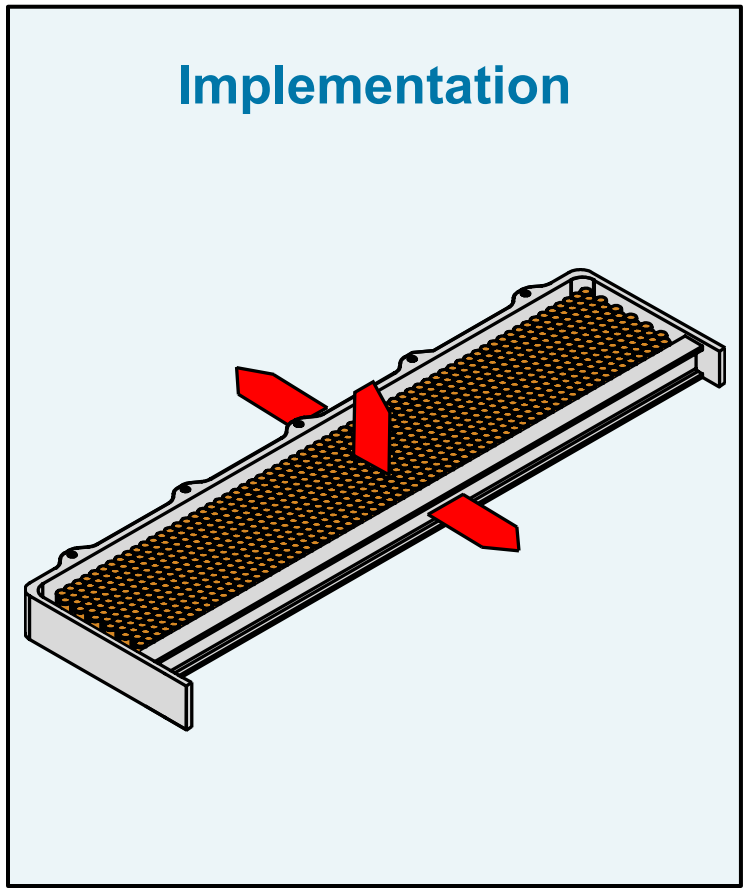
» More to Model Resolution

Set Up The Battery's Thermal Paths With The Battery Builder

Using thermal paths

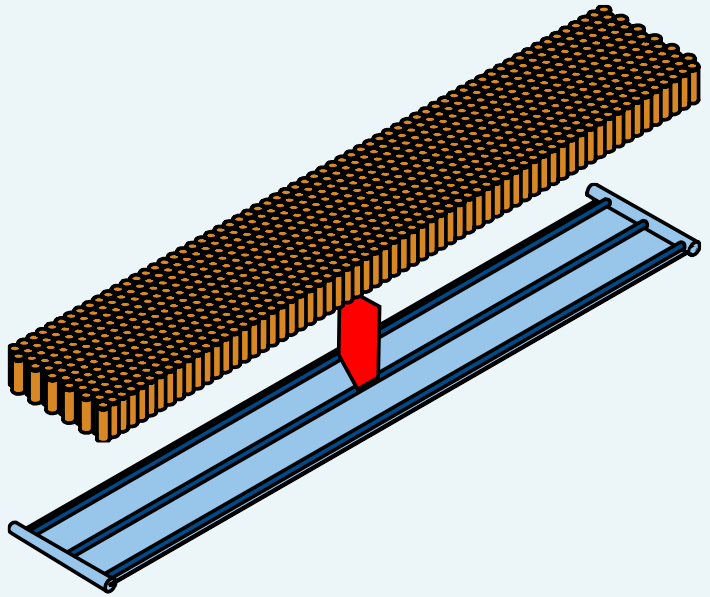
Path to ambient

Implementation

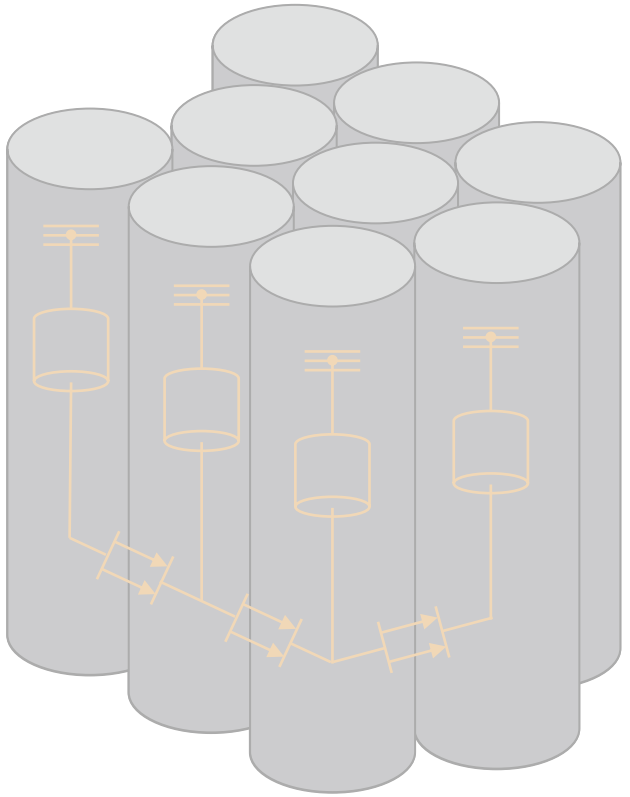


Path to cooling plate

Implementation

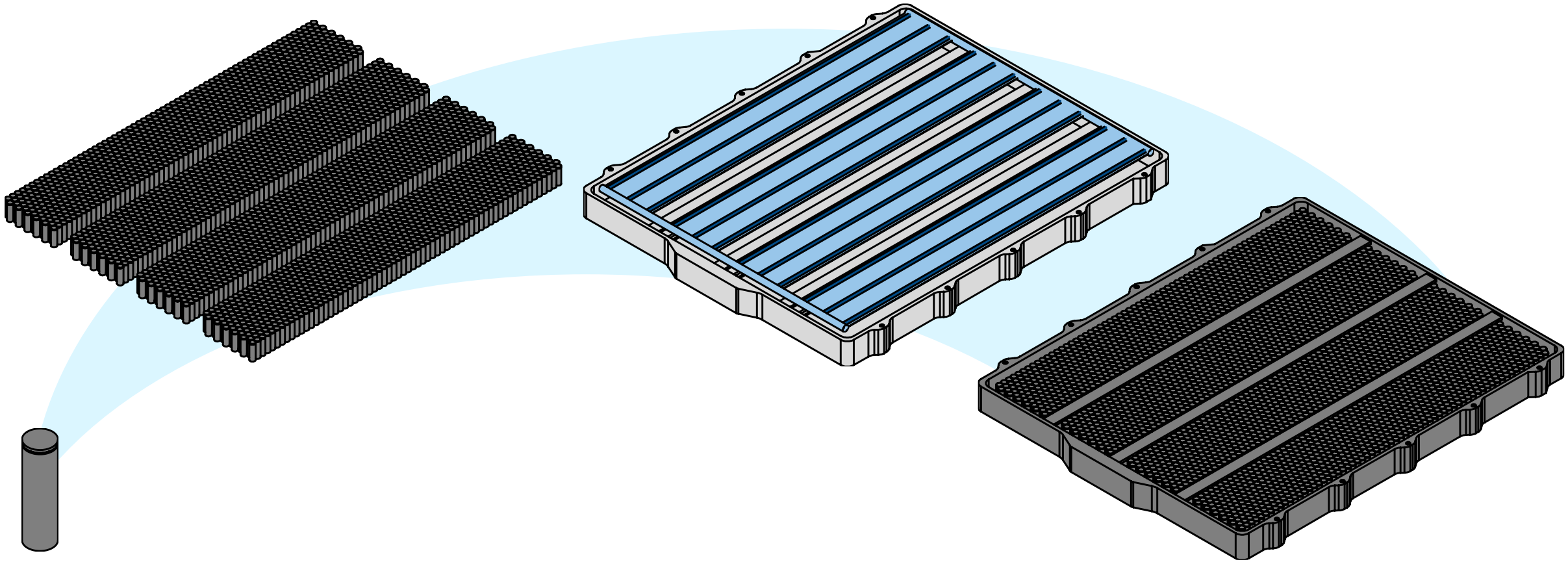


Inter cell path



Step 4: Build The Cooling Plate

Sizing the liquid cooling system



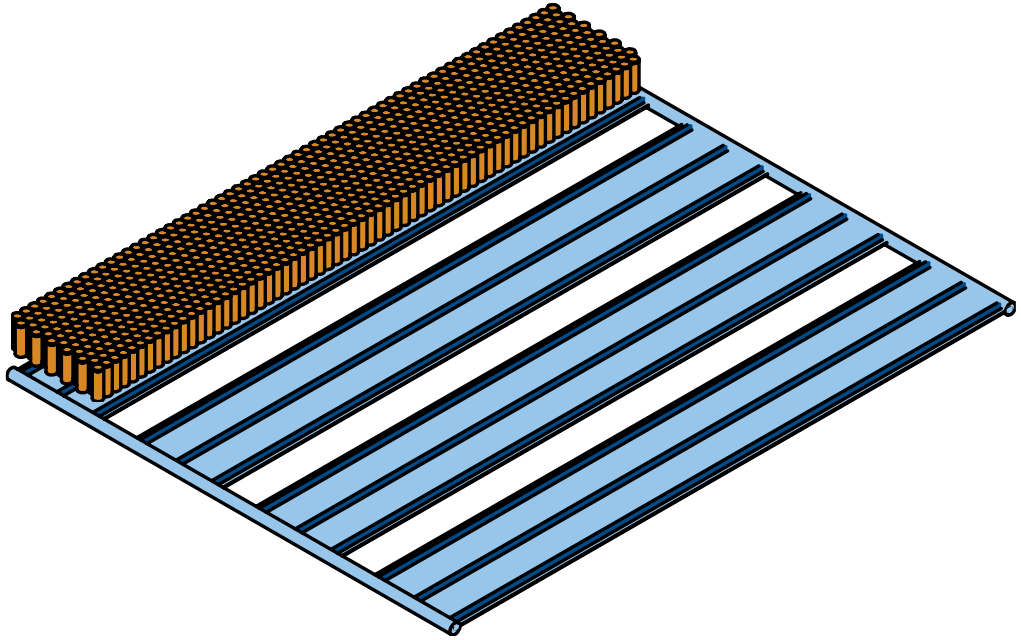
The Simscape Battery Library Contains Several Plate Model

Alternatively, you can create your own model with Simscape

- The cooling plate blocks model the heat transfer between battery, liquid cooling system, and environment
- Different cooling plate topologies
  - Edge, parallel channel, U-shaped channel
  - Single- and double-sided plates
- Adjust model fidelity

Implementation

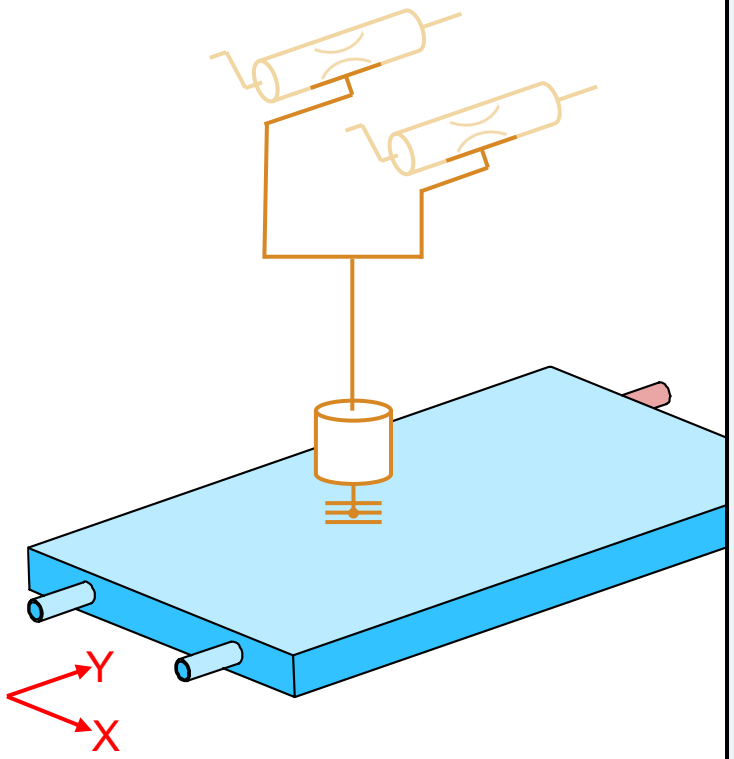
- Parallel channels plate
- Three channels per module (12 total)
- Coolant flow along the module length



Find The Tradeoff Between Calculation Speed & Precision

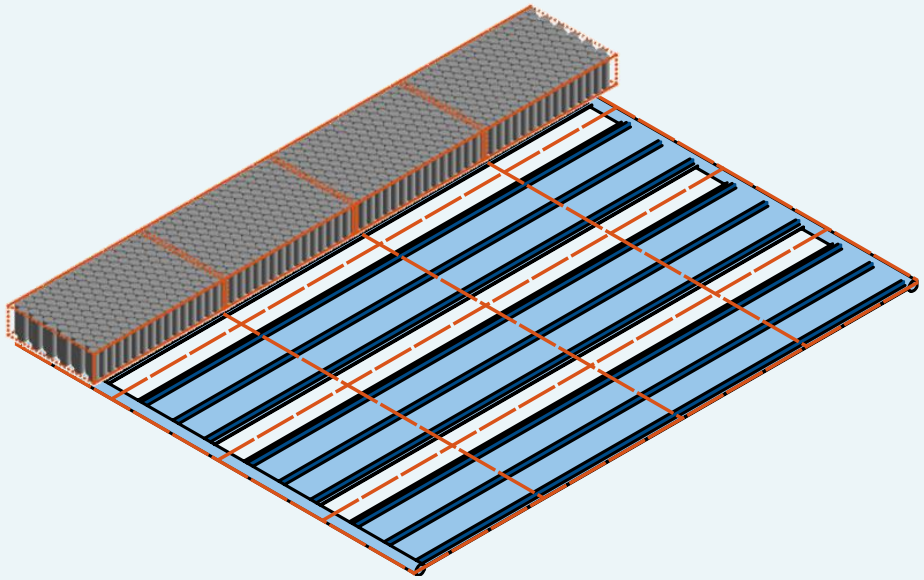
Choosing the right model fidelity for the plate

Lumped plate

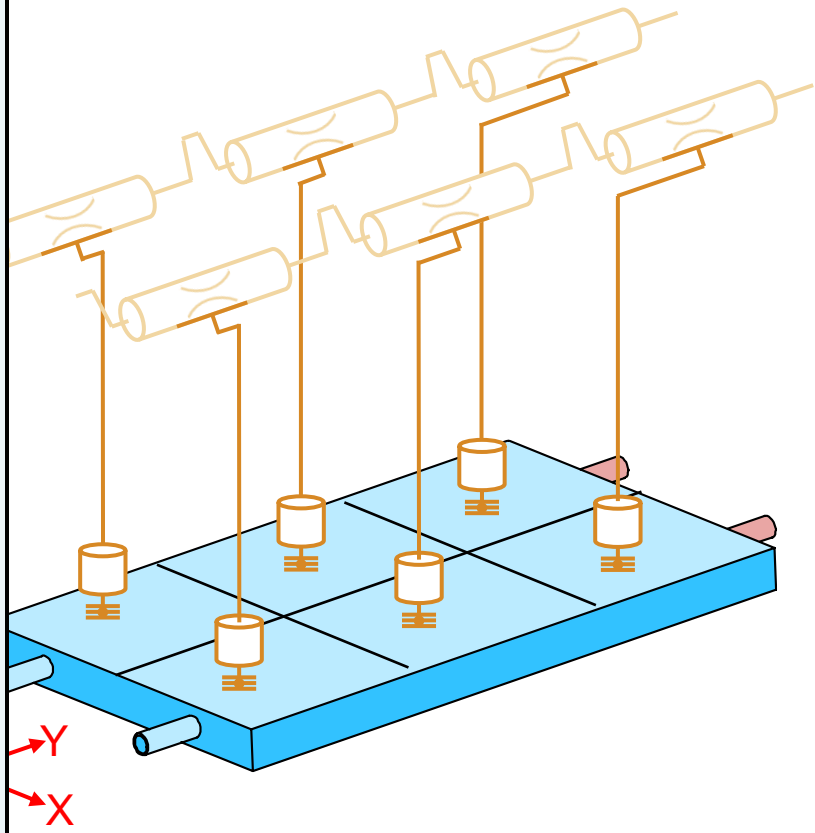


Implementation

The plate was discretized in a 4 by 4 layout as shown below:

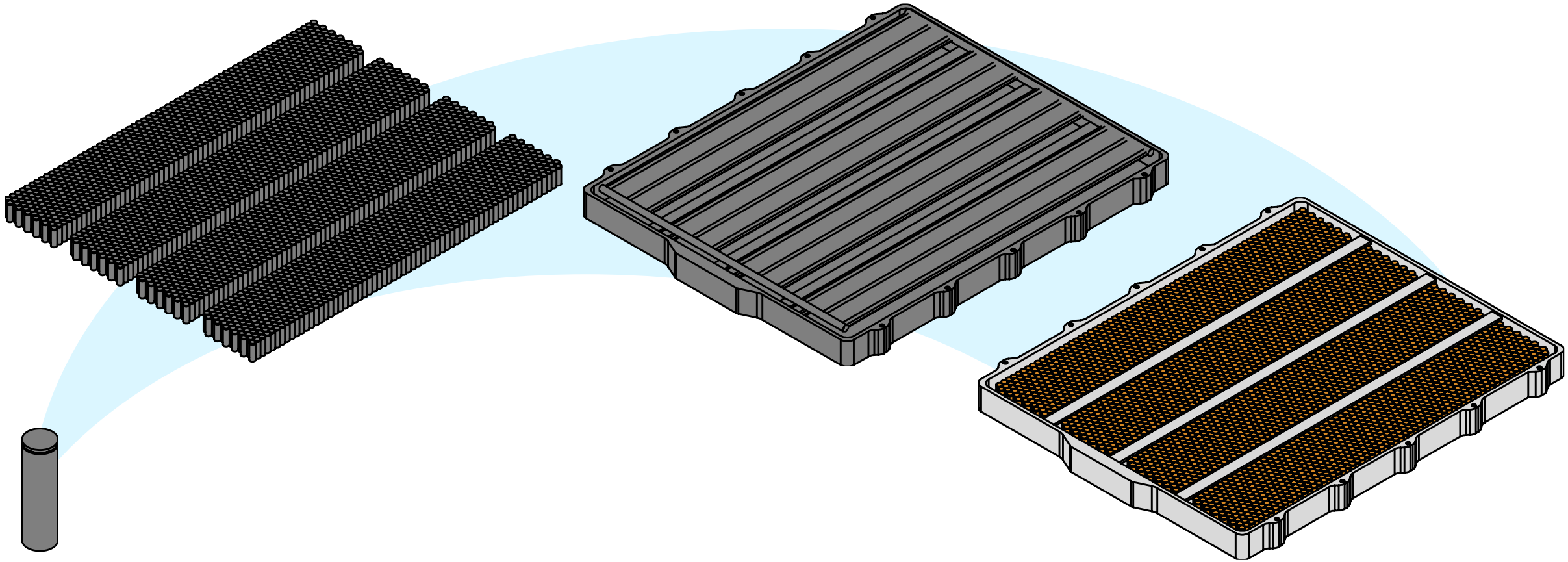


Discretized along X & Y



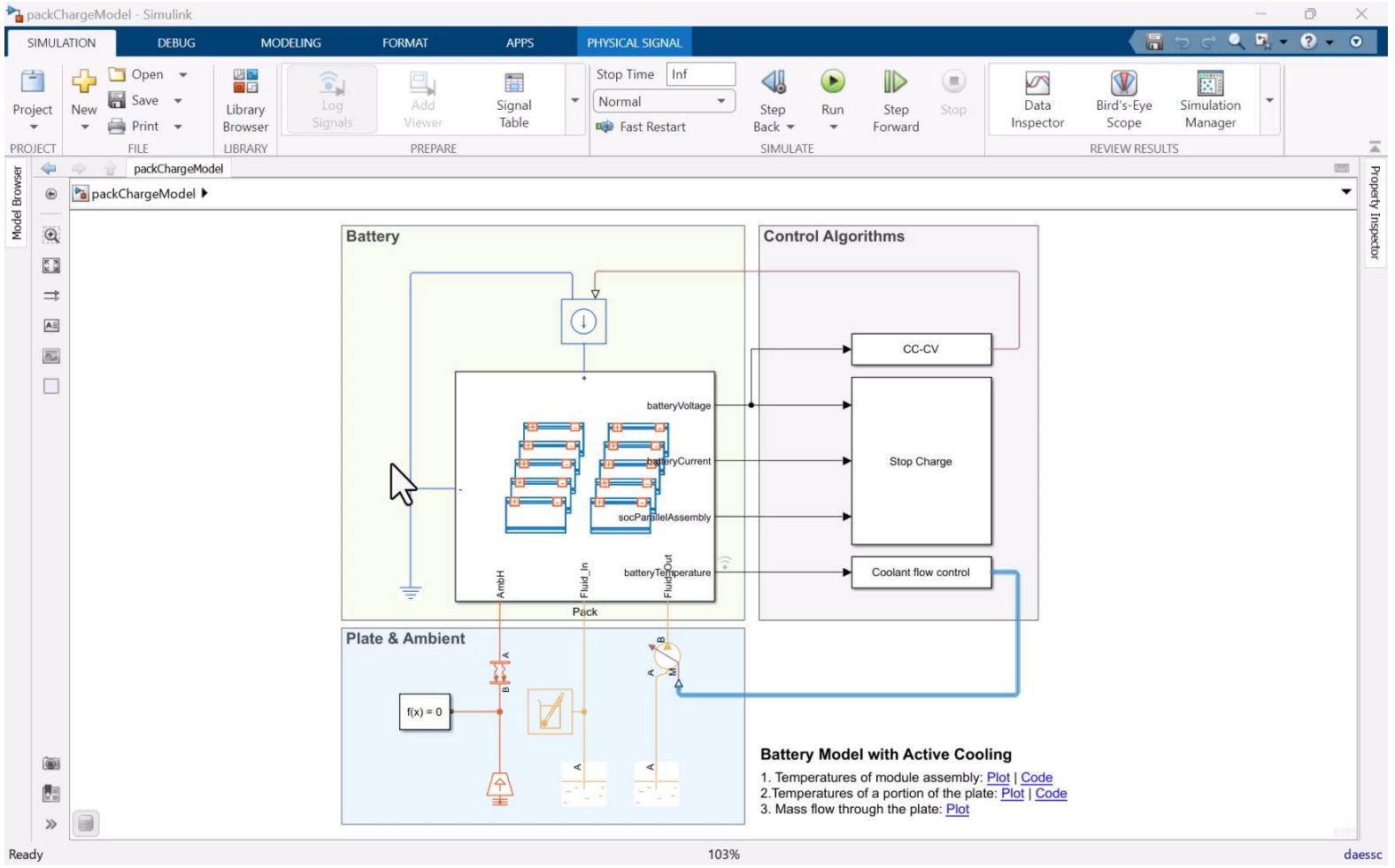
Step 5: Simulate Full Pack with BMS

Understanding the full battery model

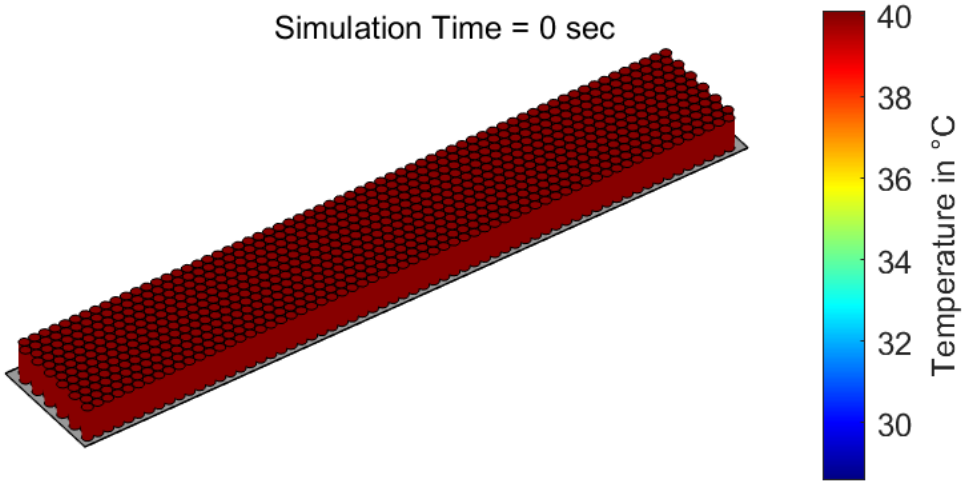


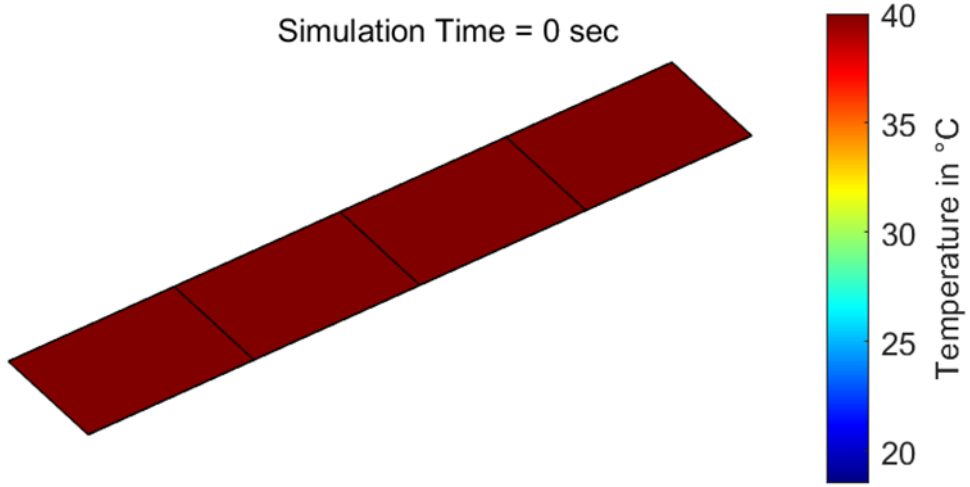
Perform CC-CV Charging with Temperature Control

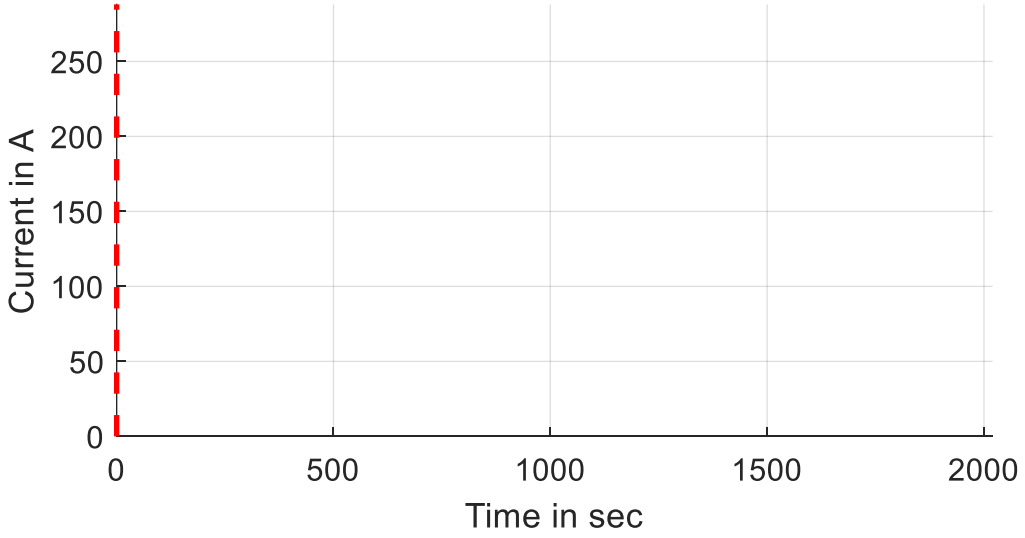
Combing Simscape Battery with Simulink BMS Algorithms

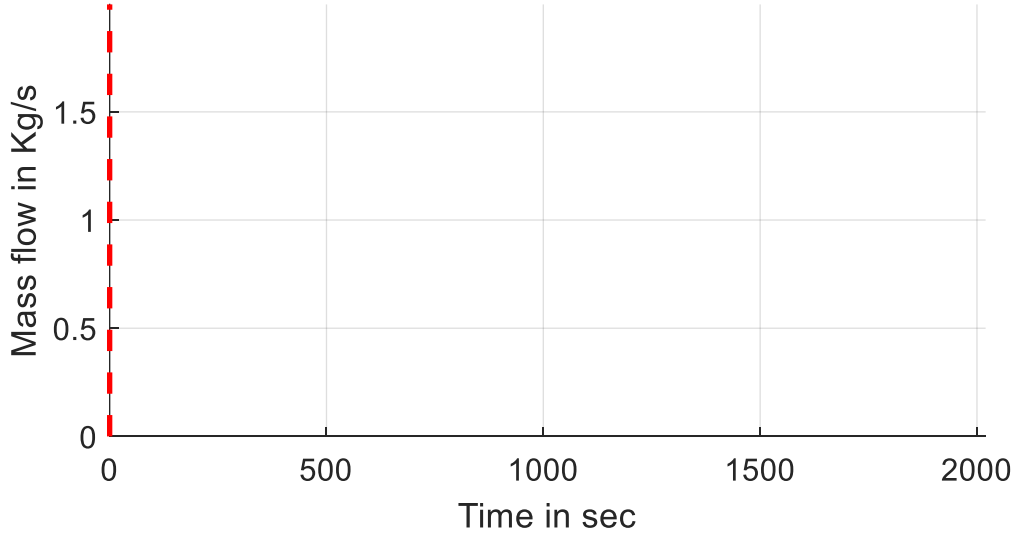


Analyze Results: Visualize Temperature over Time

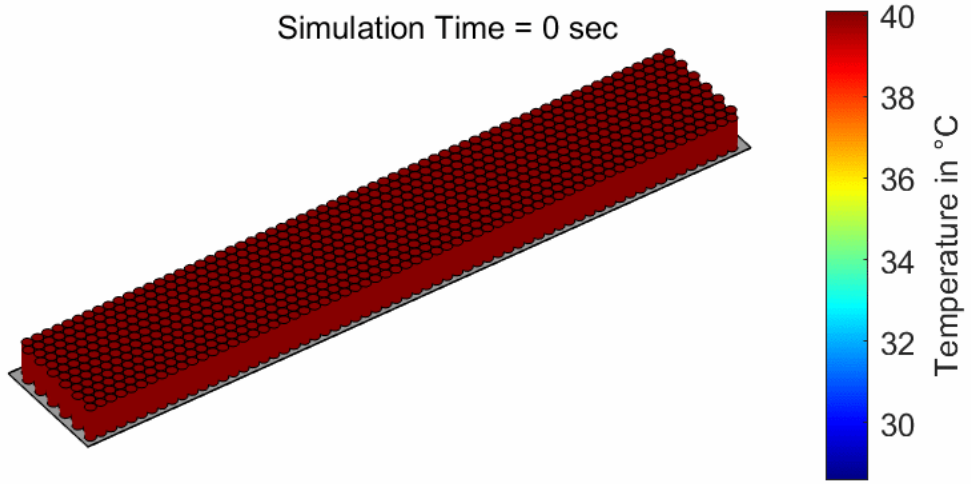


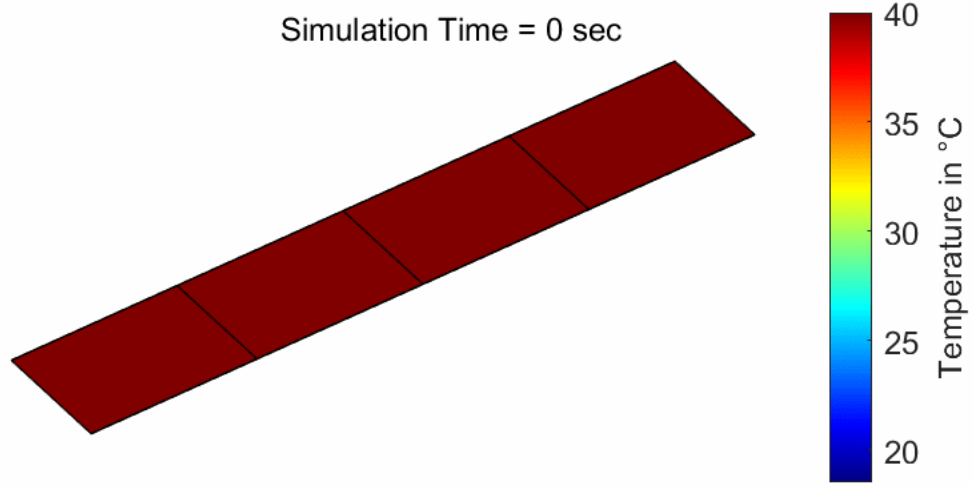


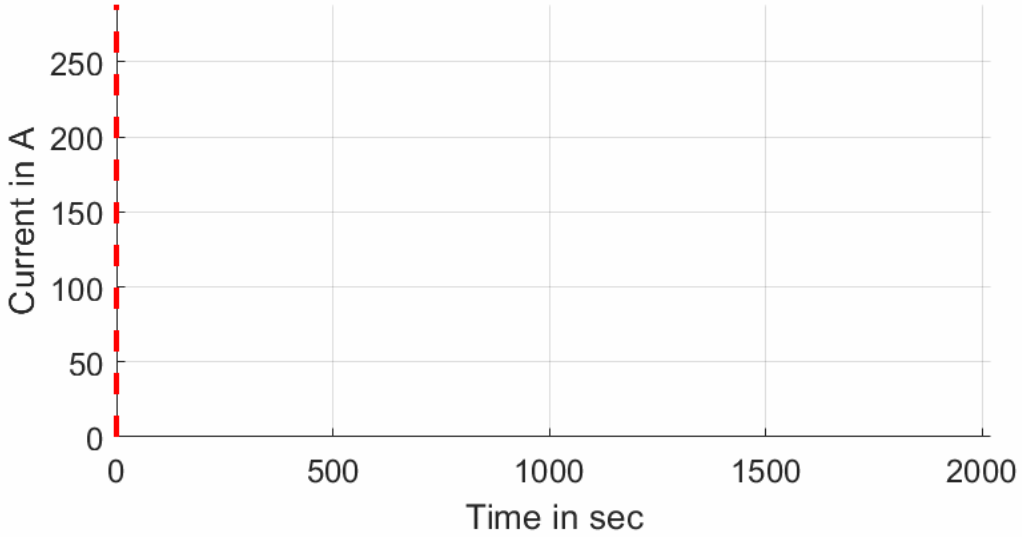


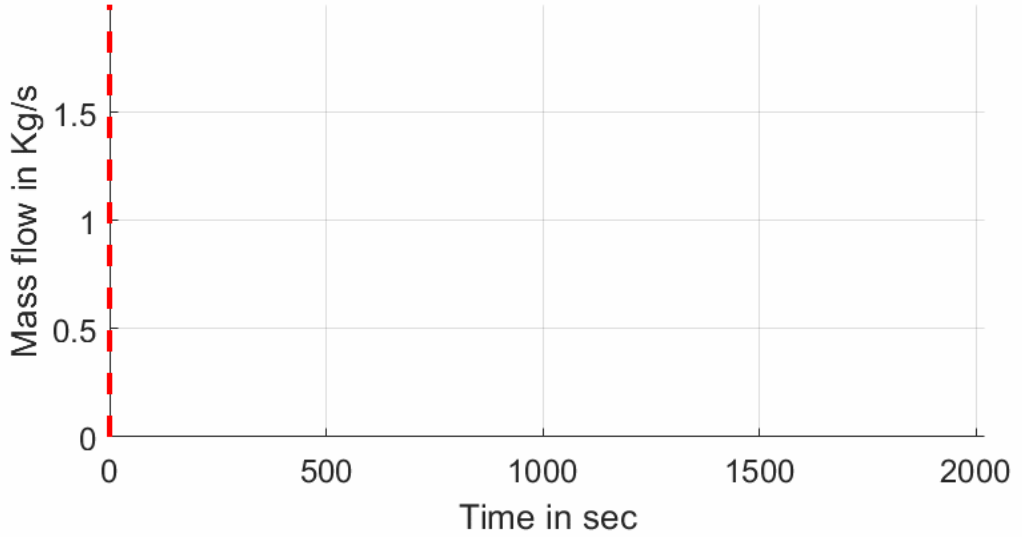


Analyze Results: Visualize Temperature over Time



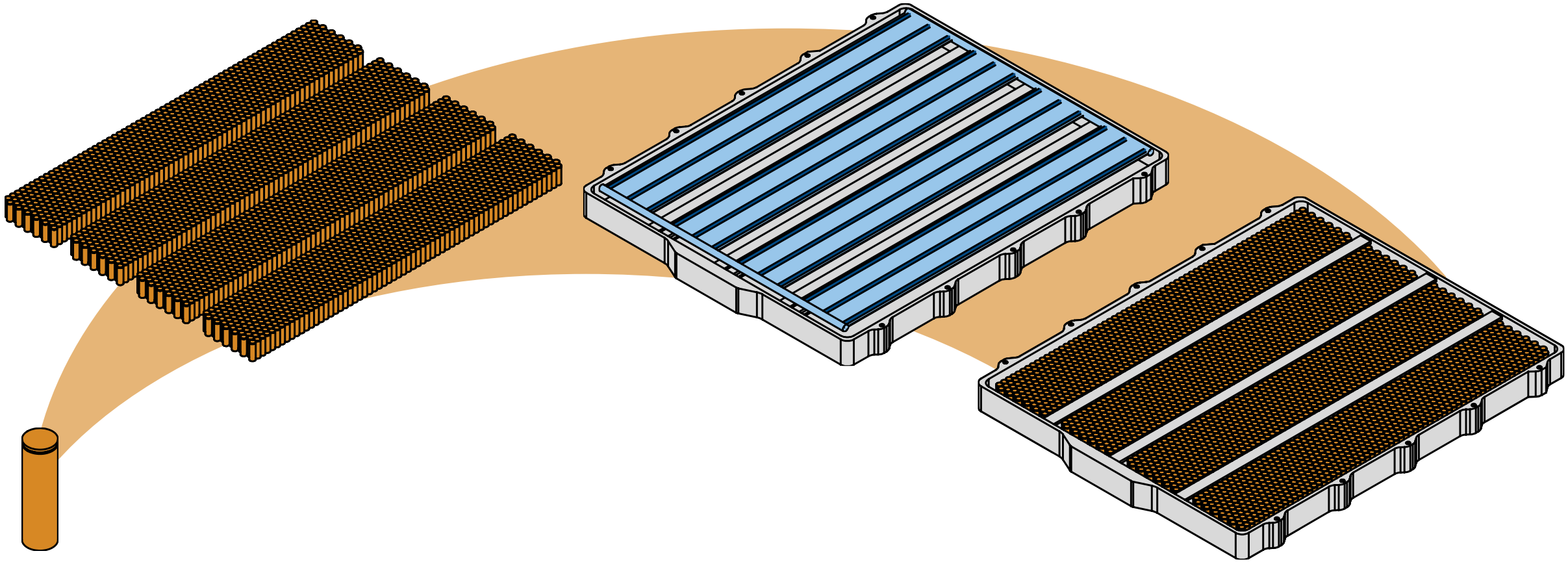






Outlook

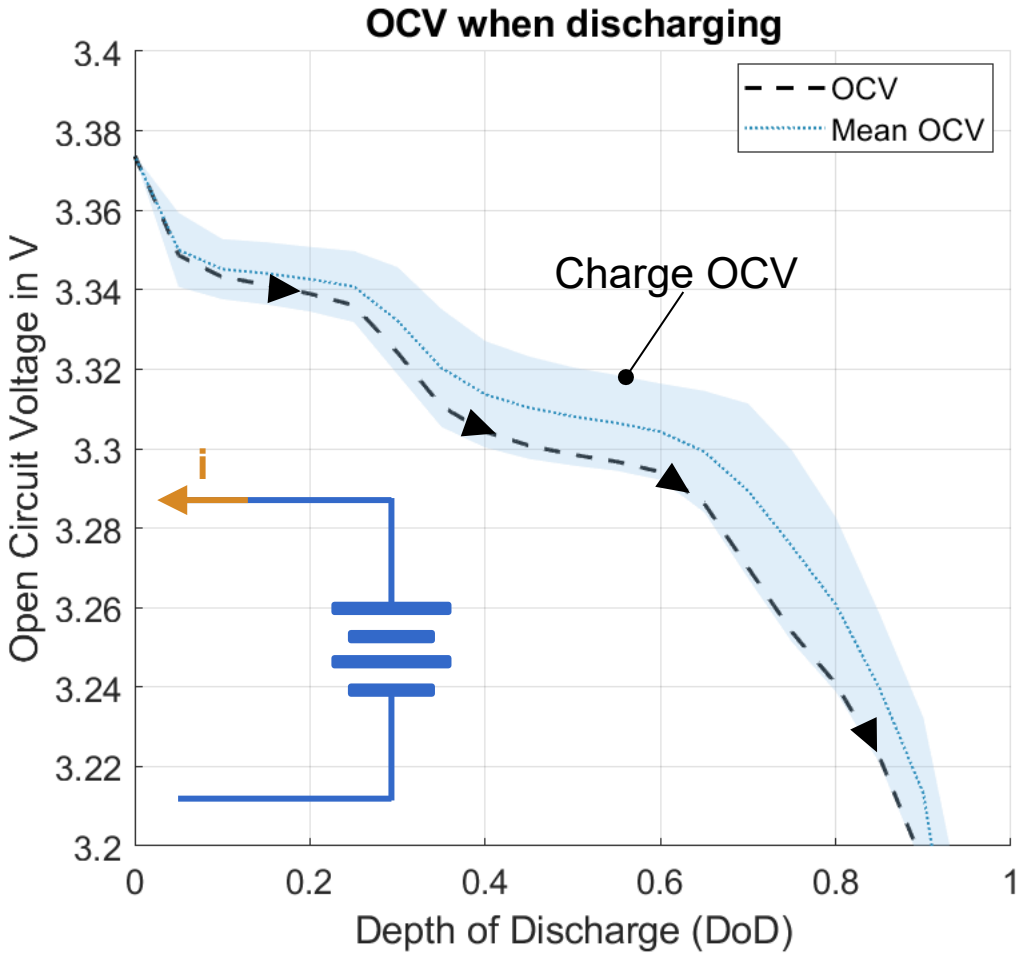
Examples and Resources

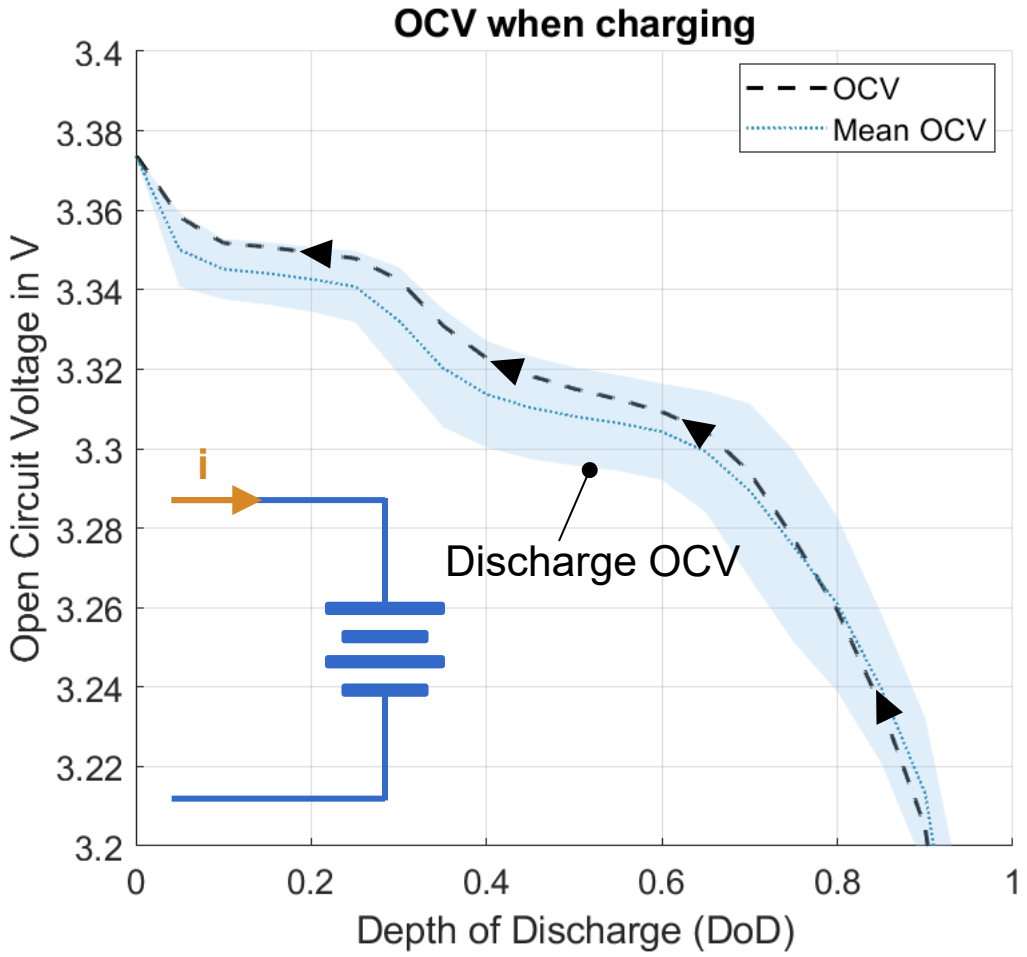


Featured Examples

Model Voltage Hysteresis in Battery

Over 40 different shipping examples available on the documentation page

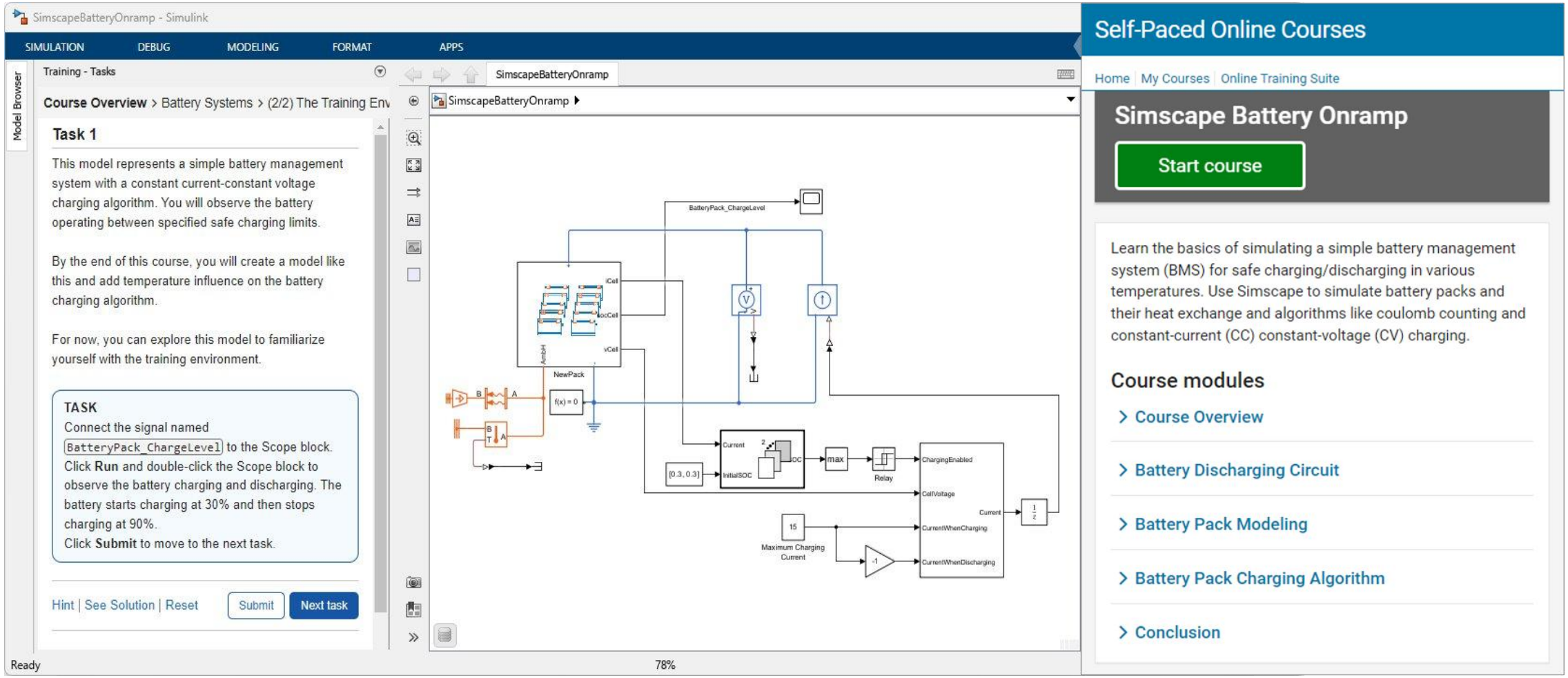




» Model Voltage Hysteresis in Battery

Onramp and Trainings:

Simscape Battery Onramp Now Available



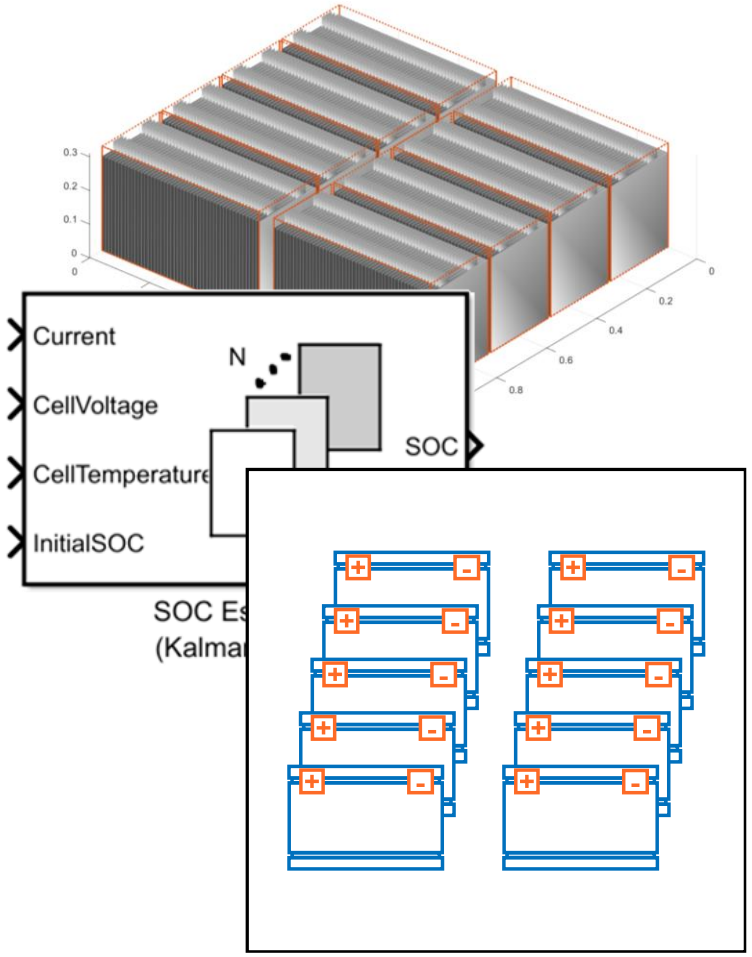
» Simscape Battery Onramp

Onramp and Training

New Instructor-Led Training

After this two-day training you will be able to:

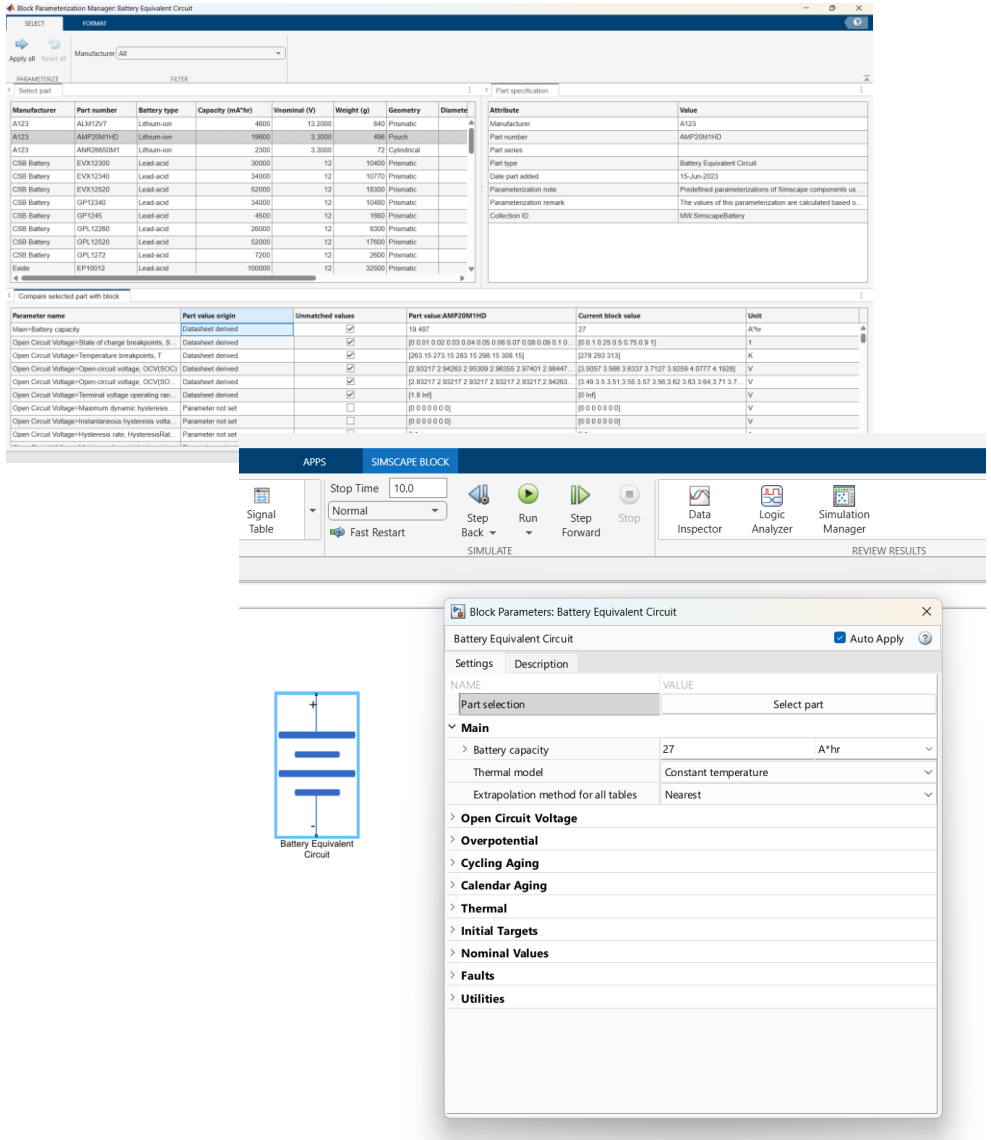
- Model a cell unit including thermal and fading characteristics
- Perform cell characterization
- Construct battery packs and attach cooling plates
- Estimate State-Of-Charge and State-Of-Health
- Design the key functionalities of a battery management system including supervisory control, cell balancing, and fault diagnosis



» Battery Modeling and Algorithm Development with Simulink

Supporting Material

- Block Parameterization Manager for the Battery Equivalent Circuit block in Simscape
- Manufacturers list (R2026a): A123, CSB Battery, Exide, Korea Powercell, Molicel, Panasonic, Sanyo, Tenergy, Valence
- See the Simscape Battery Part Manufacturer information here: [Simscape Battery Part Collection]

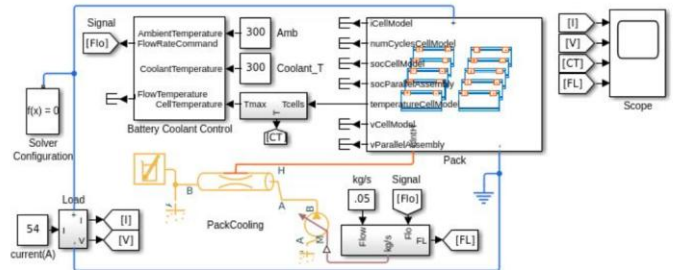


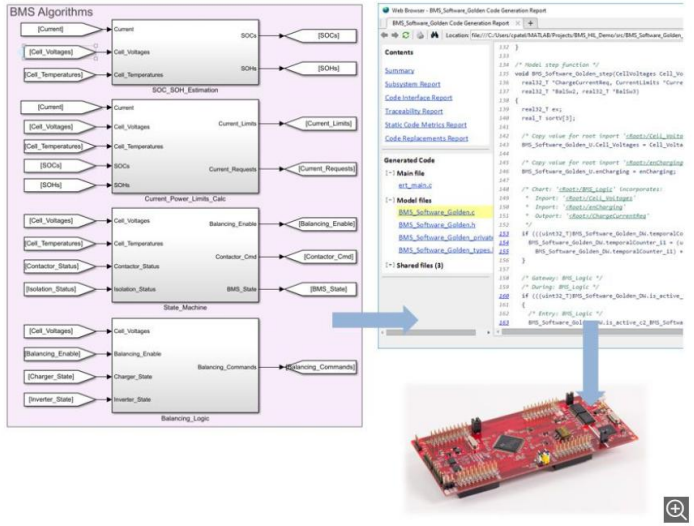
Supporting Material

- Technical Articles suggesting that the Simscape family of tools are well validated and tested:
  - Driving Formula SAE Success with Model-Based Design (shown during Webinar)
  - ResearchGate: Modeling, validation and simulation of electric vehicles using MATLAB
  - ResearchGate: The Development of a MATLAB/Simulink-SCADA/EMS-Integrated Framework for Microgrid Pre-Validation
- Battery Systems Development Workflow:
  - Developing Battery Systems with Simulink and Simscape

Battery Thermal Management System

Engineers can use MATLAB and Simulink to design a battery thermal management system to regulate battery pack temperature within specifications and ensure it delivers optimal performance for a variety of operating conditions.





Automatically generated BMS production code from BMS algorithms modeled in Simulink. The code is deployed to a Texas Instruments C2000 microcontroller.

Summary

What did we learn today?

- Key take-away:
  - Simscape Battery is a powerful tool for electrothermal simulation of battery packs.
  - Easily generate battery packs with the Battery Builder
  - Tune model fidelity based on your needs.

- Topics discussed:
  1. Electrothermal modeling of an automotive battery pack
  2. Coupling with a liquid cooling system
  3. Analysis of pack temperature change during a charge scenario

Thank You For Your Attention!

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