

Simscape™ Battery™ Release Notes



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Simscape™ Battery™ Release Notes

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R2022b

Introducing Simscape Battery: Design and simulate battery and energy storage systems	1-2
Battery Pack Model Builder: Create and evaluate different pack architectures	1-2
Battery Management System: Implement control strategies using controllers, estimators, monitors, and balancers	1-3
Thermal Management: Simulate battery cooling systems for modules or packs	1-4
Deployment and Hardware-in-the-Loop Simulation: Implement interfaces and workflows for real time simulation	1-4
Featured Examples	1-5

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New Features

Introducing Simscape Battery: Design and simulate battery and energy storage systems

Simscape™ Battery™ provides design tools and parameterized models for designing battery systems. You can create digital twins, run virtual tests of battery pack architectures, design battery management systems, and evaluate battery system behavior across normal and fault conditions. Battery Pack Model Builder is a design tool that lets you interactively evaluate different battery pack architectures. The tool automates the creation of simulation models that match the desired pack topology and includes cooling plate connections so electrical and thermal responses can be evaluated.

Parameterized models of battery packs and battery management systems demonstrate operations, including cell balancing and state of charge estimation. You can use these examples to determine cell requirements, perform trade-off analyses and hardware-in-the-loop (HIL) testing, and generate readable and efficient C/C++ code.

To learn how to build your own battery models with Simscape Battery, see the “Get Started with Simscape Battery” category.

Battery Pack Model Builder: Create and evaluate different pack architectures

The Battery Pack Model Builder is a design tool that lets you interactively evaluate different battery pack architectures. The tool automates the creation of simulation models that match the desired pack topology and includes cooling plate connections so that you can evaluate electrical and thermal responses. The MATLAB objects of the Battery Pack Model Builder allow you to define your own battery design specifications, visualize your battery in a 3-D space, customize the modeling resolution during simulation, and generate a Simulink® library that contains your custom generated battery blocks. You can use these blocks to assist with virtual battery design and verification, help develop battery control algorithms using Simulink, explore design sensitivities, and design thermal management strategies.

The “Build a Simple Model of a Battery Pack in MATLAB and Simscape” and “Build Detailed Model of Battery Pack From Cylindrical Cells” examples show how to build simple and detailed models of a battery pack by using the objects and methods in Simscape Battery.

- `Cell` — Create a single electrochemical battery cell. The `Cell` object is the foundational element for the creation of a battery pack system model.
- `CylindricalGeometry` — Define a cylindrical geometry for a battery `Cell` object.
- `PouchGeometry` — Define a pouch geometry for a battery `Cell` object.
- `PrismaticGeometry` — Define a prismatic geometry for a battery `Cell` object.
- `CellModelBlock` — Specify set of conditional parameters for a battery `Cell` object.
- `ParallelAssembly` — Create a battery parallel assembly which represents a number of cells connected electrically in parallel under a specific topological configuration or geometrical arrangement.
- `Module` — Create a battery module which represents a number of battery parallel assemblies connected electrically in series.
- `ModuleAssembly` — Create a battery module assembly which represents a number of `Module` objects connected electrically in series or in parallel.

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- `Pack` — Create a battery pack which represents a number of `ModuleAssembly` objects connected electrically in series or in parallel.
 - `BatteryChart` — Construct a battery chart to visualize a Simscape Battery object.
 - `buildBattery` — Generate custom library blocks from battery objects

Battery Management System: Implement control strategies using controllers, estimators, monitors, and balancers

Simscape Battery includes Simulink blocks that perform typical battery management system (BMS) functions, such as state estimation, battery protection, cell balancing, thermal management, and current management.

Use these blocks to implement estimation algorithms for battery cell state-of-charge and battery cell state-of-health, simulate battery cell balancing algorithms, size the balancing resistors, get and apply battery charging and discharging limits based on the internal states, simulate battery protection algorithms, and much more. These libraries are fully compatible with the custom battery models that you can generate by using the `buildBattery` function.

These examples perform typical battery management system (BMS) functions:

- “Battery Monitoring”
- “Battery Charging and Discharging”
- “Battery State-of-Health Estimation”
- “Battery State-of-Charge Estimation”
- “Battery Passive Cell Balancing”
- “Size Resistor for Battery Passive Cell Balancing”
- “Peak Shaving with Battery Energy Storage System”
- “Protect Battery During Charge and Discharge for Electric Vehicle”

Cell Balancing

- `Passive Cell Balancing` — Implement a passive battery cell balancing algorithm that keeps a similar state-of-charge value in all cells by dissipating the excess charge in a bleed resistor.

Current Management

- `Battery CC-CV` — Implement a constant current (CC), constant voltage (CV) charging algorithm.
- `Battery Charging Current Limit` — Calculate the maximum charging current of a battery.
- `Battery Discharging Current Limit` — Calculate the maximum discharging current of a battery.

Estimators

- `SOC Estimator (Adaptive Kalman Filter)` — Implement an estimator which estimates the state-of-charge and the terminal resistance of a battery by using the Kalman filter algorithms.
- `SOC Estimator (Coulomb Counting)` — Implement an estimator which estimates the state-of-charge of a battery by using the Coulomb counting method.
- `SOC Estimator (Kalman Filter)` — Implement an estimator which estimates the state-of-charge of a battery by using the Kalman filter algorithms.

- SOH Estimator — Implement an estimator that estimates the state-of-health (SOH) of a battery.

Protection

- Battery Current Monitoring — Implement battery overcurrent monitoring.
- Battery Temperature Monitoring — Implement battery temperature monitoring.
- Battery Voltage Monitoring — Implement battery voltage monitoring.
- Fault Qualification — Implement a fault qualification algorithm.

Thermal Management

- Battery Coolant Control — Implement an algorithm for battery coolant control.
- Battery Heater Control — Implement an algorithm for battery heater control.

Cyclers

- Charger — Implement an ideal battery charger.
- Discharger — Implement an ideal battery discharger.
- Cycler — Implement an ideal galvanostat, potentiostat, or a cycler.

Thermal Management: Simulate battery cooling systems for modules or packs

Simscape Battery includes blocks and models of battery cooling systems for simulations of battery thermal management. Use these blocks to add detailed thermal boundary conditions and thermal interfaces to the battery Module or ParallelAssembly blocks:

- Edge Cooling — Model a battery cooling plate with edge cooling.
- Parallel Channels — Model a battery cooling plate with multiple channels and a pair of distributor channels for inlet and outlet flow.
- U-shaped Channels — Model a battery cooling plate with flat channels.

The cooling system blocks in this library are flat cooling plates. These blocks support three main flow configurations: parallel channels, U-shaped rectangular channels, and edge cooling. In the edge cooling configuration, the coolant flows at one end of the flat plate and all the heat from the battery cells is transferred via conduction within the cooling plate material. You can discretize these cooling plates into elements to closely capture temperature spreads resulting from the dynamic interaction with the battery and the coolant flow.

For more information on how to connect a cooling plate to a battery module or parallel assembly, see “Connect a Cooling Plate to a Battery Module and Parallel Assembly”.

Deployment and Hardware-in-the-Loop Simulation: Implement interfaces and workflows for real time simulation

Simscape Battery includes Simscape blocks to connect to real-time hardware inputs and outputs:

- Active Interface — Provide an abstracted active interface between a battery and a cell supervisory circuit.

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- **Passive Interface** — Provide an abstracted passive interface between a battery and a cell supervisory circuit.

When you use these blocks with real-time hardware, you can easily connect your battery simulations to a real-world battery balancing hardware. Use this capability to help design and verify your battery balancing algorithms, to ensure that they work correctly during both regular operation and adequately detect, degraded operation, or ride through faults.

You can develop and test battery balancing strategies by simulating your custom battery blocks with the blocks in the **Battery Management System** library of Simscape Battery. Options on the physical blocks enable you to assume ideal thermal measurements, thermal estimation or state-of-charge estimation algorithms until you have designed and implemented actual thermal measurements or state-of-charge algorithms.

Featured Examples

New examples in this release include:

- “Build a Simple Model of a Battery Module in MATLAB and Simscape” — This example shows how to create and build a Simscape system model of a battery module.
- “Build a Simple Model of a Battery Pack in MATLAB and Simscape” — This example shows how to create and build a Simscape system model of a battery pack.
- “Build Model of Battery Module with Thermal Effects” — This example shows how to create and build a Simscape system model of a battery module with thermal effects.
- “Build Model of Battery Pack with Cell Aging” — This example shows how to create and build a Simscape system model of a battery pack that includes cell aging.
- “Build Model of Battery Pack with Cell Balancing Circuit” — This example shows how to create and build a Simscape system model of a battery pack with cell balancing circuits.
- “Build Model of Battery Pack for Grid Application” — This example shows how to use Simscape Battery to create and build a Simscape system model of a battery pack from prismatic cells for grid applications.
- “Build Model of Hybrid-Cell Battery Pack” — This example shows how to build a Simscape system model of a hybrid-cell battery pack with two sets of cell run-time parameters. The generated battery pack model contains two types of battery modules, each with different battery cell components inside.
- “Build Detailed Model of Battery Pack From Cylindrical Cells” — This example shows how to create and build detailed Simscape system models for various battery designs and configurations based on cylindrical battery cells.
- “Build Detailed Model of Battery Pack From Pouch Cells” — This example shows how to create and build detailed Simscape system models for various battery designs and configurations based on pouch battery cells.
- “Battery Monitoring” — This example shows how to use battery management system blocks to monitor the current and temperature of a battery.
- “Battery Charging and Discharging” — This example shows how to use a constant current and constant voltage algorithm to charge and discharge a battery.
- “Battery State-of-Health Estimation” — This example shows how to estimate the battery internal resistance and state-of-health (SOH) by using an adaptive Kalman filter.
- “Battery State-of-Charge Estimation” — This example shows how to estimate the battery state-of-charge (SOC) by using a Kalman filter.

- “Battery Passive Cell Balancing” — This example shows how to balance a battery with two cells connected in series by using a passive cell balancing algorithm.
- “Thermal Analysis for New and Aged Battery Packs” — This example shows how to evaluate a new and end-of-life (EOL) lithium-ion battery pack.
- “Size Resistor for Battery Passive Cell Balancing” — This example shows how to implement a passive cell balancing for a lithium-ion battery pack.
- “Peak Shaving with Battery Energy Storage System” — This example shows how to model a battery energy storage system (BESS) controller and a battery management system (BMS) with all the necessary functions for the peak shaving.
- “Protect Battery During Charge and Discharge for Electric Vehicle” — This example shows how to efficiently charge and discharge a battery for an electric vehicle (EV) and handle battery faults.