Simulation of Battery Performance and Characteristics in Simulink

Title:

Modeling and Simulation of Battery Performance using MATLAB Simulink

Aim:

To develop a simulation model for analyzing the performance of batteries under various operating conditions using MATLAB Simulink. This includes evaluating State of Charge (SoC), voltage response, current output, and energy flow based on real-world load conditions.

Model Used:

This simulation is based on two files:

1. **Batteries.slx** – The main simulation model.
2. **Batteries_lib.slx** – A custom Simulink library containing reusable battery subsystem components.

The model consists of:

- **Battery Block (Lithium-ion or Lead-Acid):** Models the dynamic behavior of the battery.
- **Load Circuit:** Represents current draw from external systems.
- **Charging/Discharging Controllers:** Control the flow of current depending on load condition.
- **SoC Estimation Module:** Tracks the State of Charge in real time.
- **Measurement and Scope Blocks:** Monitor key parameters (Voltage, Current, SoC, Power).

Toolboxes Used:

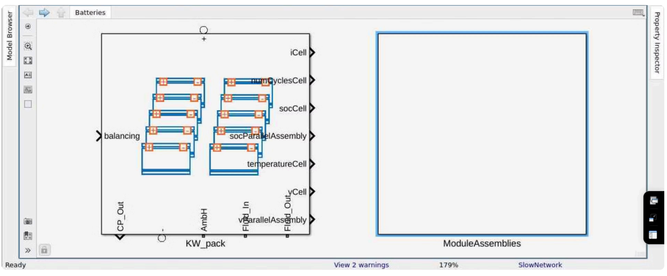
- Simulink
- Simscape
- Simscape Electrical
- Simulink Signal Routing and Math Operations

Working:

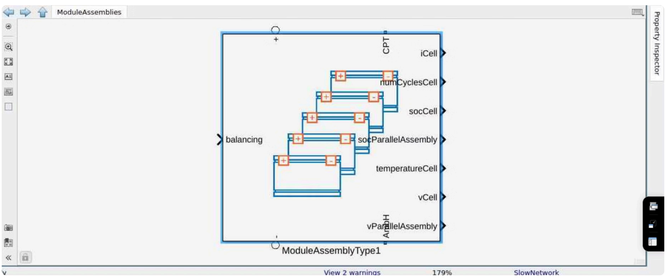
1. **Battery Configuration:**
   - Configured using parameters like nominal voltage, capacity (Ah), internal resistance, and initial SoC.
   - The battery can be charged or discharged depending on the controller signal.
2. **Load Integration:**
   - Load can be a constant resistor or a dynamic function simulating real application demand.
   - Load level determines the rate of battery discharge.
3. **Controller Logic:**
   - Automatically switches between charge and discharge depending on system status.
   - Protects the battery from overcharge and deep discharge.
4. **SoC Calculation:**
   - Tracks remaining charge in the battery using Coulomb counting or integral-based methods.
   - Displayed as a live percentage to observe how fast charge drains or builds.
5. **Monitoring Outputs:**
   - Voltage: Terminal voltage response over time.
   - Current: Drawn from or supplied to the battery.
   - Power: Real-time power consumption or delivery.
   - SoC: Real-time State of Charge tracking.

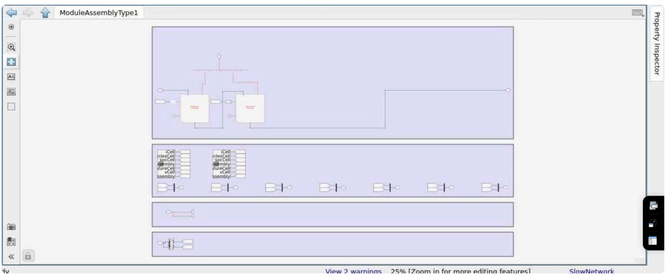
Screenshots (SS):

1. Top-Level Batteries Simulation Model

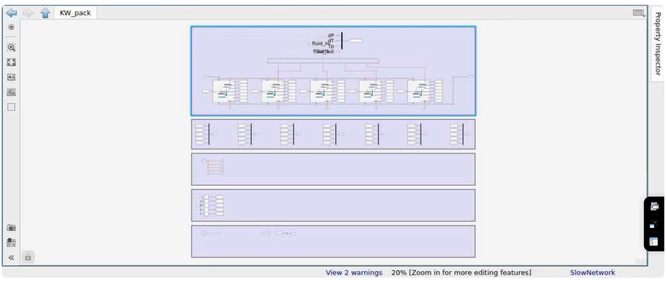


2. Internal View of Custom Battery Subsystem from Batteries_lib.slx





3. Voltage, Current, and SoC Scopes



Conclusion:

The battery simulation using Simulink and the Batteries library offers a robust platform for analyzing battery behavior in both standalone and integrated systems. The model allows dynamic evaluation of how a battery responds to different load profiles, charging rates, and discharge events. By adjusting simulation parameters, this model supports experimentation and understanding of battery limitations, helping guide the design of efficient and safe battery-powered systems for electric vehicles, renewable energy applications, and embedded electronics.