Battery Pack Safety Monitor - Technical Report

1. Introduction

Battery safety monitoring is essential for the reliable operation of battery packs in electric vehicles, energy storage systems, and other applications. This report outlines the development of a Battery Pack Safety Monitor using Simulink with the capability to generate C code for embedded implementation. The system monitors key parameters and ensures the battery operates within safe limits.

2. System Requirements

The system must monitor the following input parameters:

- Individual cell voltages
- Individual cell temperatures
- Total pack current

Fault conditions to be detected include:

- Overvoltage (OV)
- Undervoltage (UV)
- Overcurrent (OC)
- Overtemperature (OT)

The system must generate individual fault flags and an overall safety status ('AllSafe').

3. Design Approach

The design follows a model-based development (MBD) workflow using Simulink. The model includes:

- Signal inputs via Inport blocks
- Threshold comparisons using Relational Operator blocks
- Logic blocks for fault condition evaluation
- Latching logic (optional) using Memory and Switch blocks

- Fault flags as outputs through Outport blocks

Simulink configuration is set for Embedded Coder with 'ert.tlc' system target file to enable C code generation.

4. Model Inputs and Outputs

Inputs:

- CellVoltages [1xN] array
- CellTemperatures [1xN] array
- PackCurrent [scalar]

Outputs:

- OV_Fault (Overvoltage flag)
- UV_Fault (Undervoltage flag)
- OC_Fault (Overcurrent flag)
- OT_Fault (Overtemperature flag)
- AllSafe (Boolean: True if all parameters within limits)

5. Safety Limits

Safety limits are set as follows (configurable via Constant blocks in the model):

- Overvoltage Limit (OV_LIM): 4.2 V
- Undervoltage Limit (UV_LIM): 2.8 V
- Overtemperature Limit (OT_LIM): 60 °C
- Overcurrent Limit (OC_LIM): 100 A

6. Fault Detection Logic

The model uses Relational Operator blocks to compare inputs with safety thresholds. Logical OR blocks are

used to aggregate faults across all cells. An optional latching mechanism ensures faults persist until manually cleared.

Example:

OV_Fault = any(CellVoltages > OV_LIM)

UV_Fault = any(CellVoltages < UV_LIM)

OC_Fault = PackCurrent > OC_LIM

OT_Fault = any(CellTemperatures > OT_LIM)

AllSafe = NOT (OV_Fault OR UV_Fault OR OC_Fault OR OT_Fault)

7. Code Generation

The model is configured for code generation using Simulink Coder with the following settings:

- System target file: ert.tlc
- Language: C
- Code Interface: Model Reference
- Build Action: Generate code only / Build and compile

Output files include:

- BatteryMonitor.c
- BatteryMonitor.h
- BatteryMonitor_data.c
- BatteryMonitor_types.h

8. Simulation and Testing

Test cases were simulated using Signal Builder blocks and 'From Workspace' inputs. Scenarios included:

- Normal operation
- Single fault (e.g., high temp or low voltage)
- Multiple concurrent faults

All outputs were validated via Scope and Display blocks to verify detection logic.

9. Conclusion

The Battery Pack Safety Monitor developed in Simulink provides a reliable model for detecting hazardous conditions in battery systems. With built-in C code generation, it is suitable for integration into embedded systems such as Battery Management Systems (BMS). Future work can include integration with CAN output modules, fault logging, and real-time deployment on microcontrollers.