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Battery Module Enclosure Design

for

5kW Home BESS

Scope : Battery Module Design - Mechanical

Application : Home UPS

Designing a 5kW battery module for a home Battery Energy Storage System (BESS) requires careful attention to critical factors that ensure efficiency, safety, and longevity. This module must securely house and protect the battery cells, manage heat generated during operation, and be compact enough for residential use. Key design considerations include material selection for structural integrity, effective thermal dissipation strategies to prevent overheating, and adherence to safety and regulatory standards.

Mechanical Design - Challenges

The client requested to develop an Enclosure design for battery module with the capacity of 5kW design with low cost. They also needed the design with a scalable module-based approach, allowing for future expansion without major system overhauls.

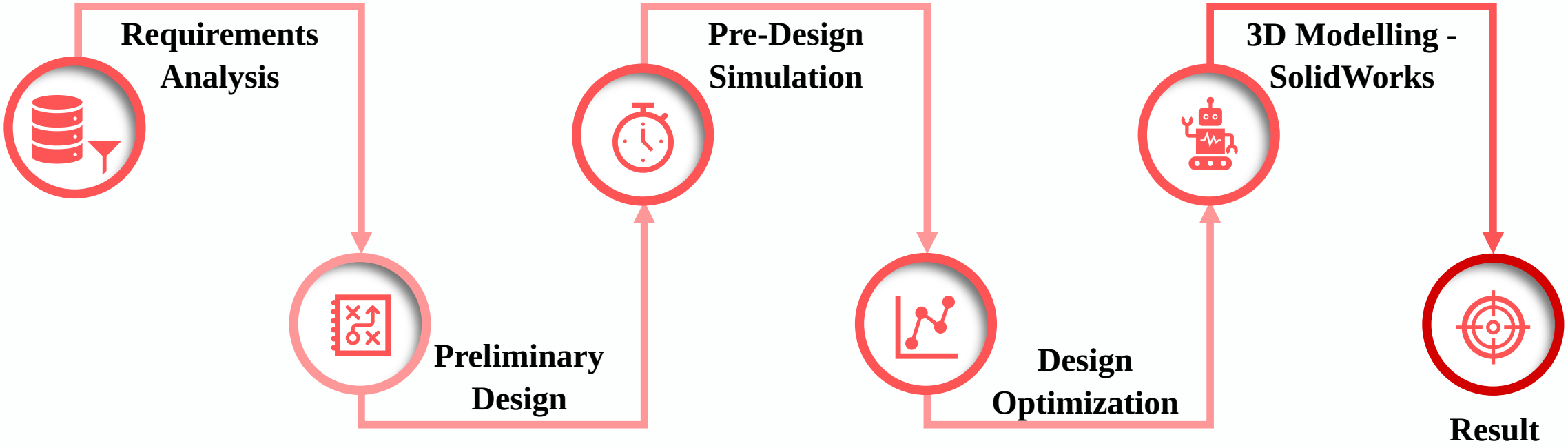
Challenges

- Provision for Accessory Parts – Fan, Connector and Switch
- Optimization of Mounting and Installation
- Thermal Management - Adequate heat dissipation
- EMI considerations
- Size and Form factor constraints
- Material Selection for Durability
- Cost-Effective Solutions

Simulation - Challenges

- Modeling Accuracy
- Computational Complexity
- Material Characterization
- Meshing and Resolution
- Multi-Physics Interactions

Mechanical Design - SoW



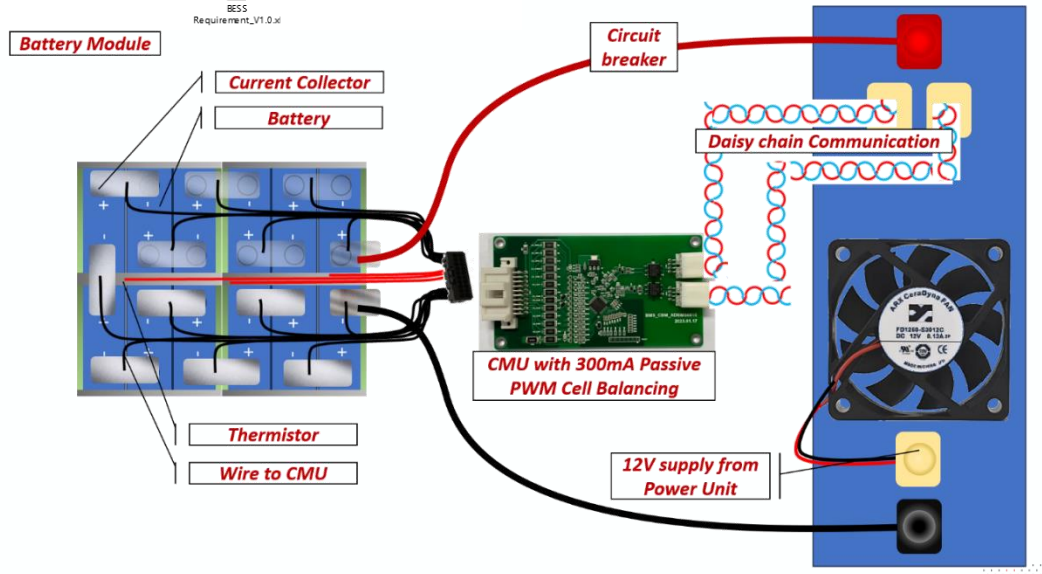
Requirement Analysis

- Requirement Analysis in battery module design is a crucial first step to ensure that the battery system meets the technical, performance, and safety needs of the intended application.
- This stage involves gathering and analyzing all necessary requirements to define the battery module Enclosure's specifications.
- Collaborating with clients is key to understanding the project's specific needs and constraints.

- Defining Use Case (Application): Identify the specific application of the battery pack (e.g., automotive, renewable energy storage, consumer electronics, UPS, peak load shaving). It will be very helpful to arrive all conditions and objectives.
- Derive Design Objectives:
  - Grid Connection: [On/Off grid with frequency]
  - Capacity: [e.g., 50 kWh for Energy Storage Systems]
  - Charging Power: [e.g., 30kW and what charges it?]
  - Discharging Power or time: [e.g., 50kW for 1hr]
  - Voltage Range: [Nominal and maximum voltage values]
  - Current Rating: [Minimum, Nominal and Maximum values]
  - Cycle Life: [Number of charge-discharge cycles]
  - Form factor: [for Enclosure]
  - Space & Weight constraint:
  - Thermal Management: To maintain safe operating temperature limits
  - Safety Features: Overcurrent, overvoltage, and thermal runaway protection
  - Regulatory Compliance: Adherence to industry standards such as CISPR 25, ISO 26262, and UN38.3
  - Additional features: like IP rating
- System Load Profile / Electricity consumption profile: There could be daily, weekly, or seasonal patterns.
- Environmental Conditions:
  - Operating temperature: [Minimum, Nominal and Maximum values]
  - Humidity:
  - mechanical shock/vibration requirements:

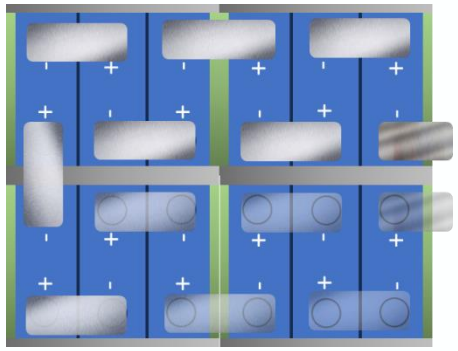
BESS Requirement_V1.0.xl

Parameters and Details

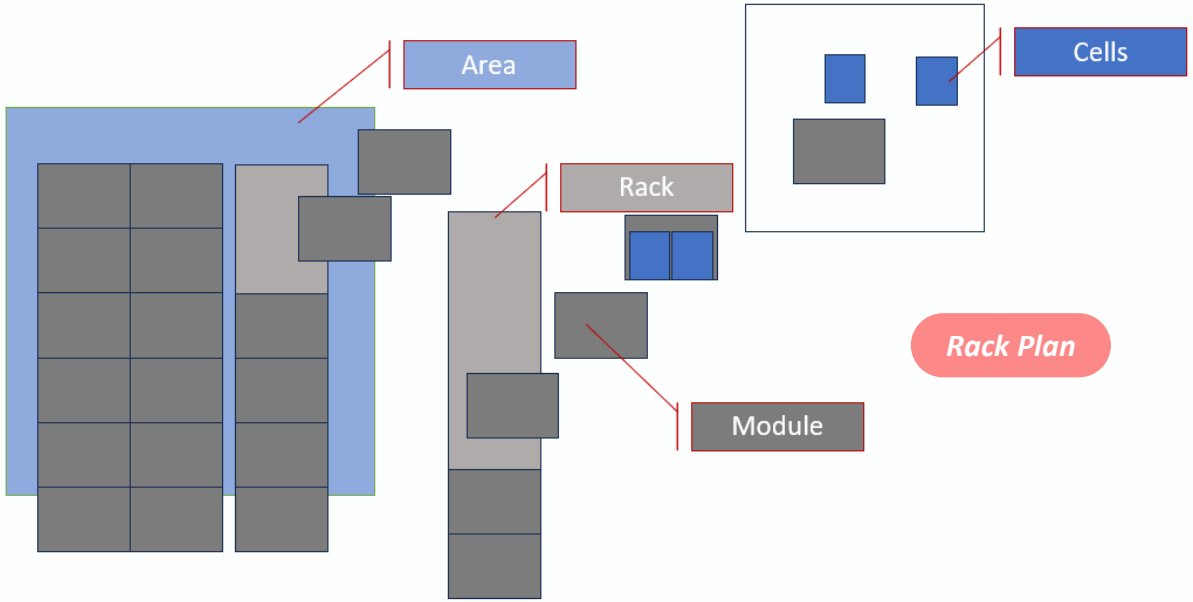


Preliminary Design

- An initial concept design was developed based on space constraints and functional requirements.
- *Material chosen:* Stainless Steel for durability and thermal stability.
- *Cell Layout:* The cell layout was designed by fixing the configuration of battery module as 12S1P (arrived based on the electrical calculations).



Cell Layout



Rack Plan

Concept

Pre-Design Simulation

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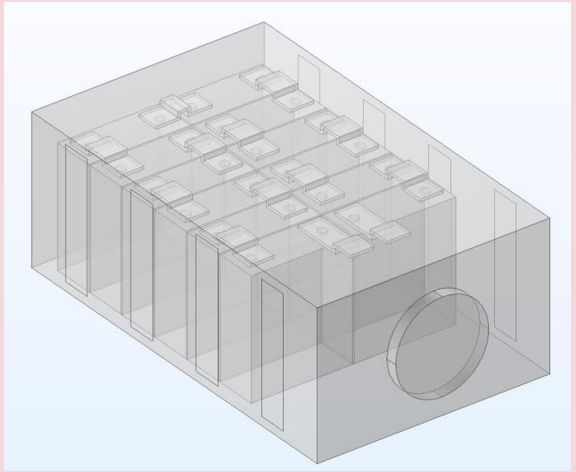
Steps for Every Simulation

Geometry Creation

The model was developed with removing components with negligible or no effects on the simulation.

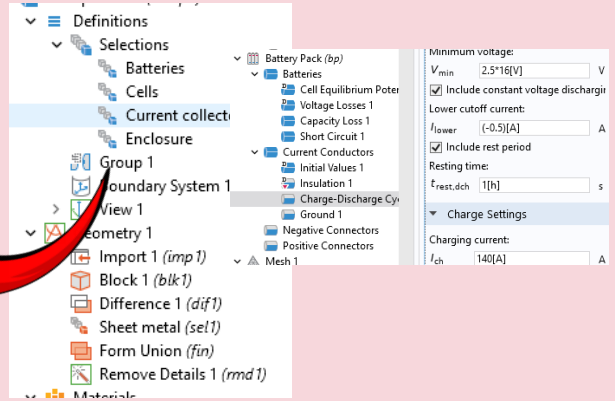


Assign Material

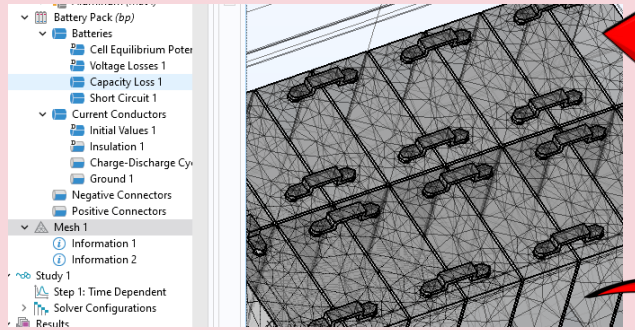
Cu for current collector
Al for enclosure

Defining Boundary condition

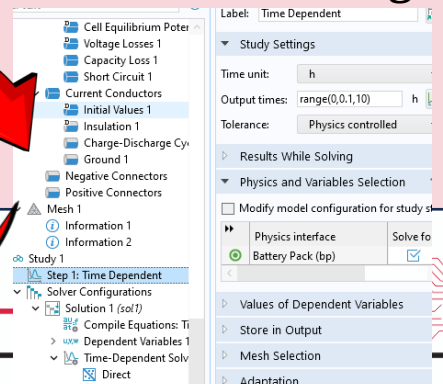
In COMSOL Boundary were created



Assign Mesh



Simulation Setting



Run the Simulation

Pre-Design Simulation

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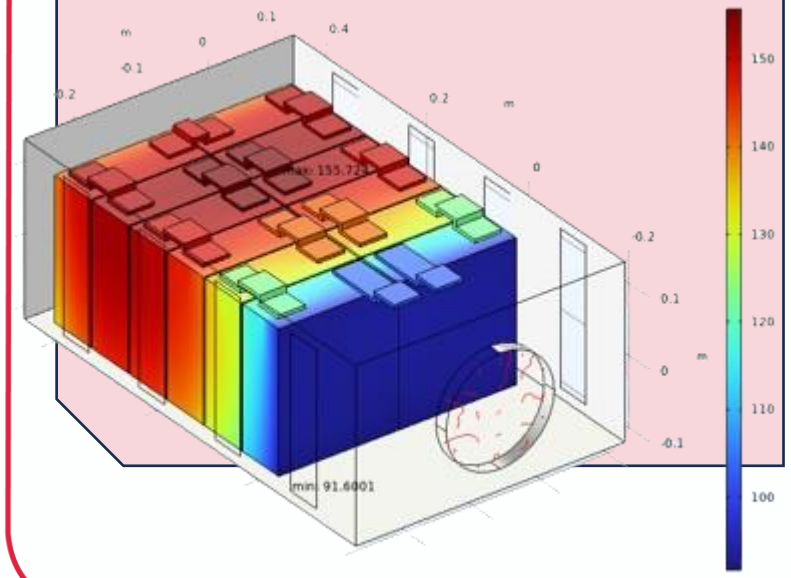
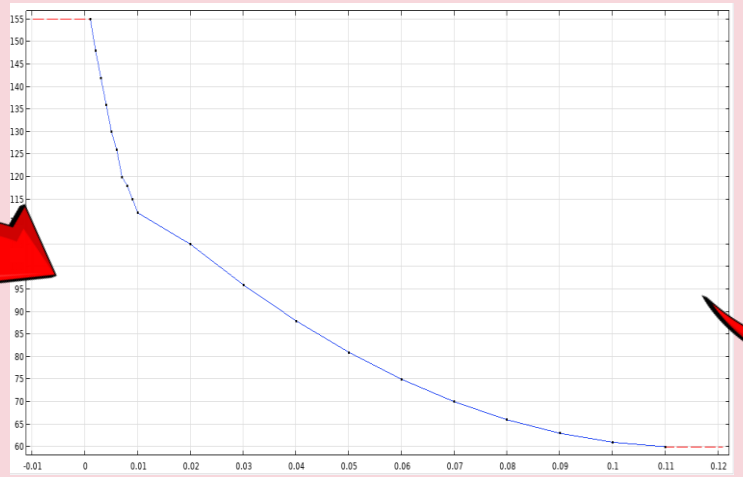
Steady State Thermal Analysis

General thermal analysis to find simulation cost and hotspot

$T_{Max} = 155^0C$

$T_{Min} = 91^0C$

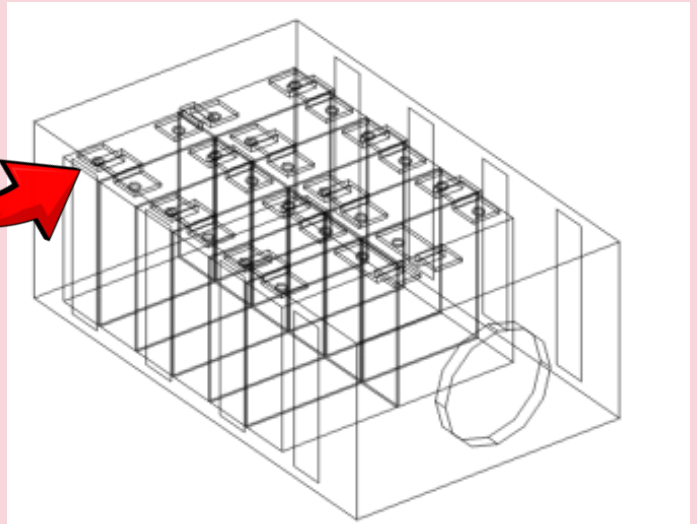




Thermal with Flow

Find optimal flow of air to reduce the maximum temperature

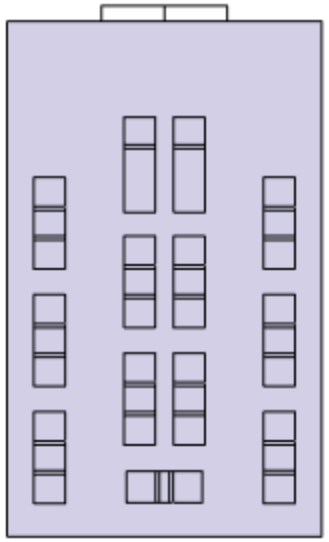
Transient and Thermal

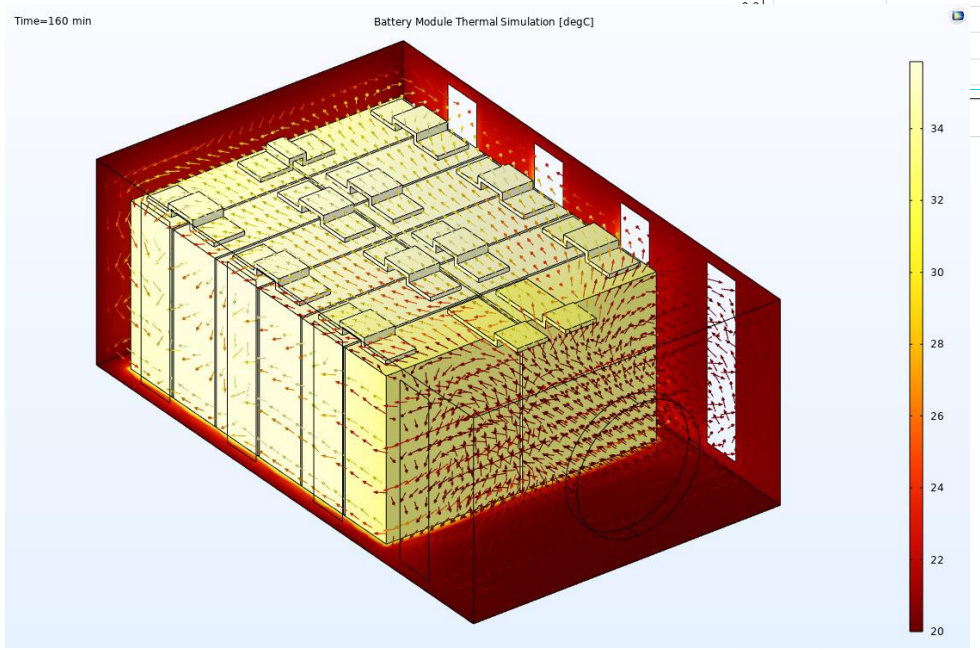


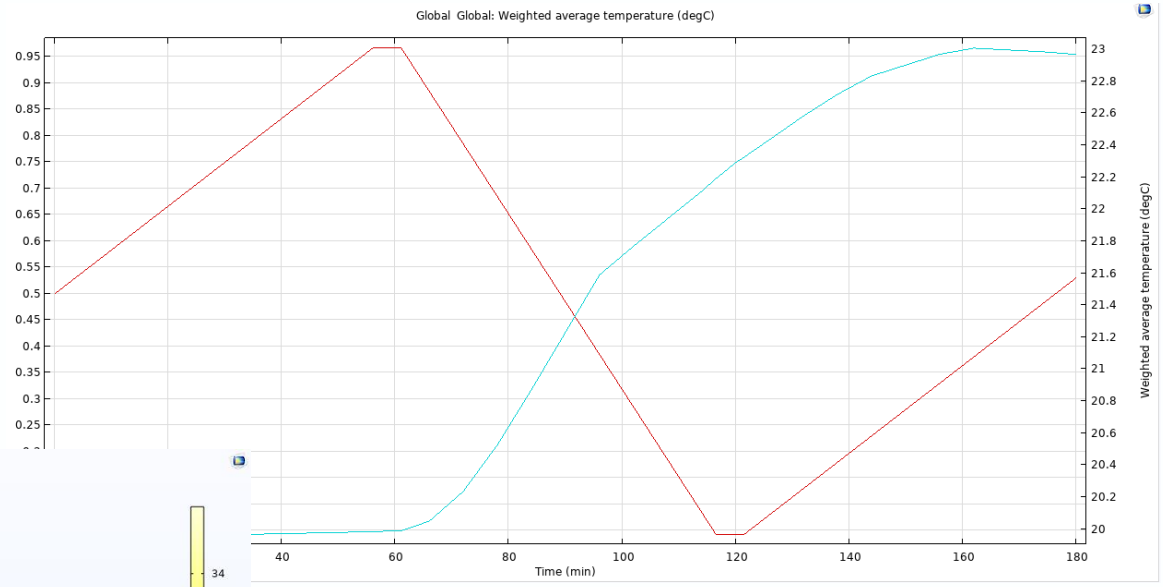
Design Optimization

Transient and Thermal

Based on the result from thermal with flow sweep, the fan with 0.7m/s flow is selected for better cooling.







Based on the simulation outcomes, the fan type, enclosure dimensions, and cell arrangement were finalized to achieve a compact, efficient, and safe battery pack design.

3D Modelling - SolidWorks

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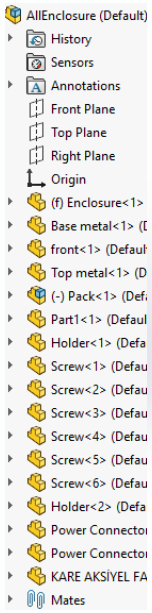
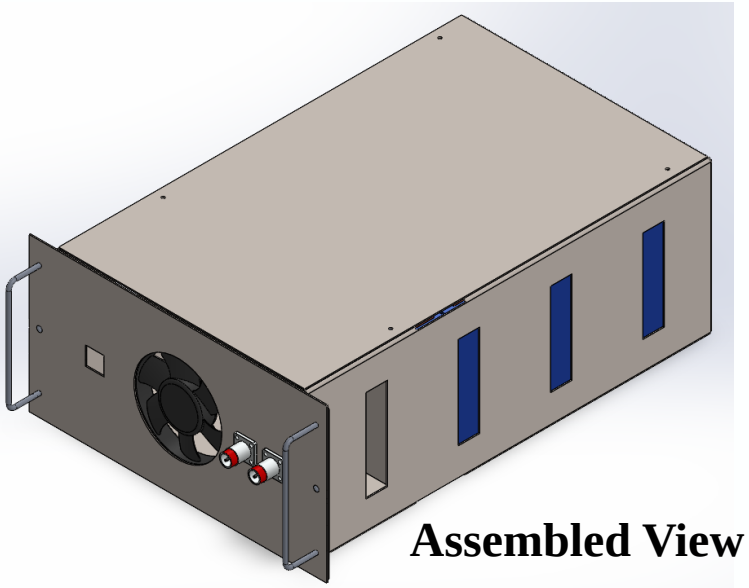
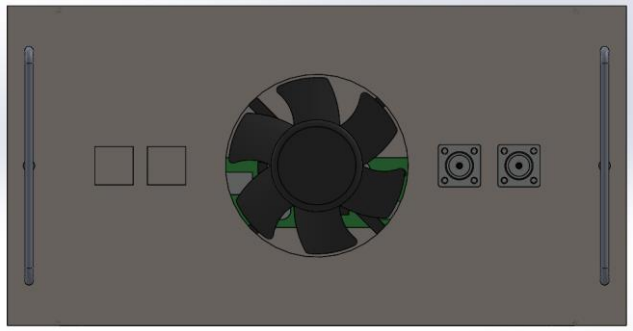
Final Model and Assembly:

The final battery module layout was refined and approved after iterating through simulations, with components fully integrated for electrical and thermal stability in line with industrial storage standards.

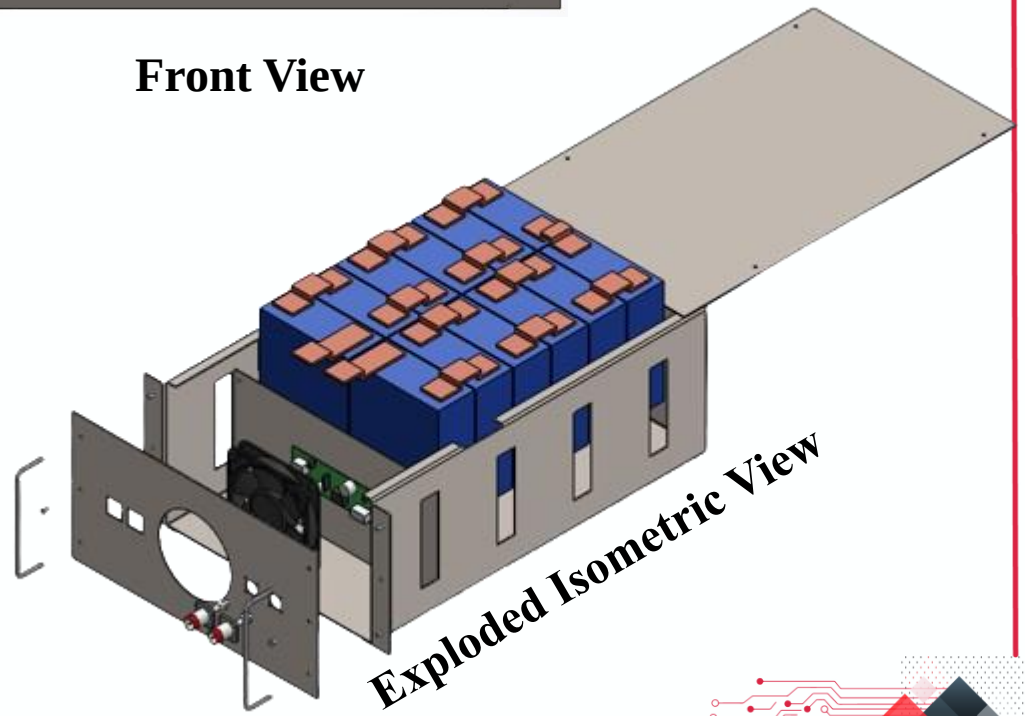




Assembled View



Front View



Exploded Isometric View

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Customer Testimonial

We are delighted to share a testimonial from a satisfied client highlighting the success of our Battery Module Mechanical Design project. The team exceeded expectations by delivering a high-quality, reliable battery module design tailored to our specific requirements. Their expertise in Mechanical design and Simulations ensured optimal performance, all while keeping the project within budget. The project was completed within a challenging timeframe without compromising on accuracy or quality. We highly recommend their exceptional service, attention to detail, and cost-effective solutions for battery module design.

Conclusion

Our commitment to excellence and technical expertise was evident in the successful delivery of customized Battery Module Mechanical Design solutions that met industry standards.

We meticulously designed and simulated the battery module to ensure optimal performance, efficiency, and safety, significantly reducing the need for costly post-production testing.

Our focus remains on providing top-tier Mechanical design services, demonstrating our unmatched proficiency and dedication to delivering exceptional results while maintaining the highest levels of reliability and innovation.