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# ORV3 BBU Module Reference Design (Rev 0.5)



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NOVEMBER 9-10, 2021



# ORV3 Battery Back-up Unit Reference Design (Rev 0.5)

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Design Development Team

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# Agenda



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- Electrical Hardware Design
  - System Level Design Diagram
  - BBU Module Hardware level Design Diagram
- Simplified Functional State Machine Diagrams
  - BBU MCU
  - BMS MCU
  - Shelf MCU
- Electrical Lab Test Results
  - Efficiency, Buck to Boost Transition, Active Voltage Droop, Active Current Share
- Mechanical Design & Airflow Considerations
  - Detailed Mechanical Design Diagrams

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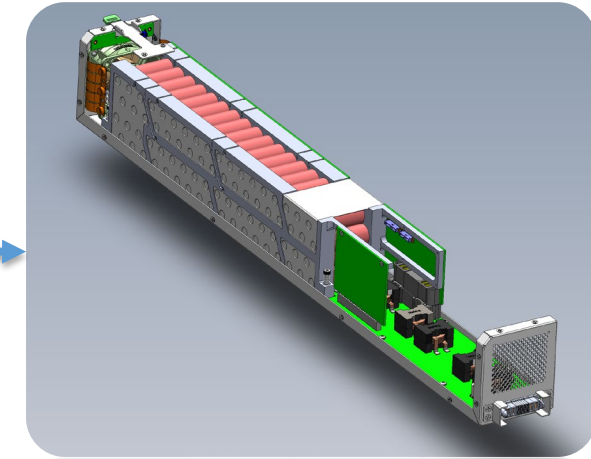


# System Level: Shelf/BBU Module and Test Hardware

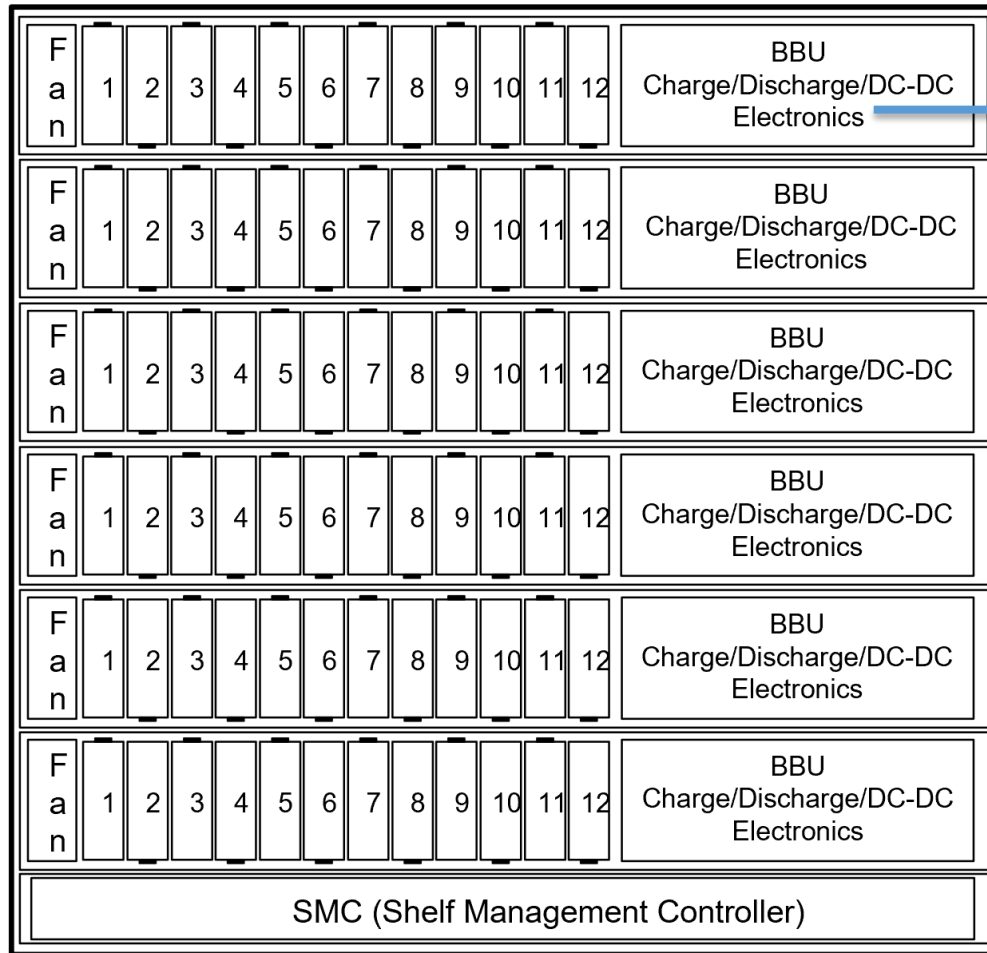


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Battery Backup Module



Battery Back-up Shelf



PWR/GND

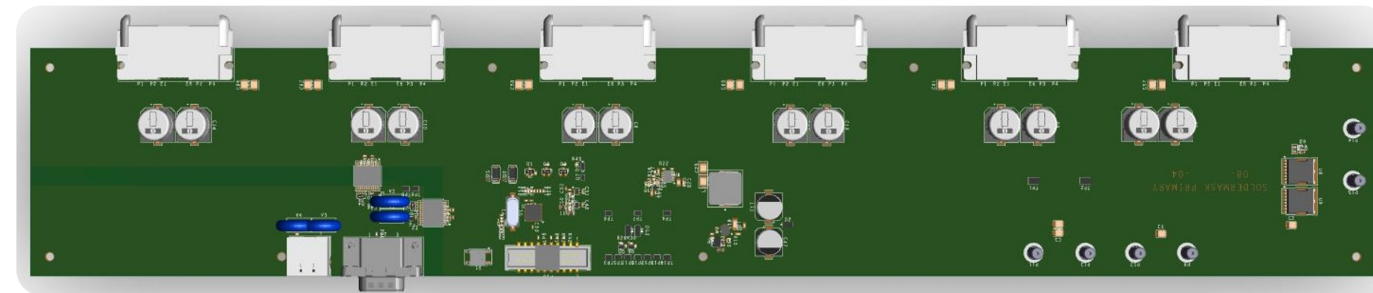
Analog I Share Bus

ModBus System Comms

## Compliance Safety (as applicable)

- UL or an equivalent NRTL for the US with follow-up service (e.g. UL or CSA).
- CB Certificate and test report issued by CSA, UL, VDE, TUV or DEMKO
- CE Marking for EU
- UL1973 (Recog) cRUus
- IEC62133
- 62368-1 (UL/IEC)
- UN38.3

Backplane Test Board + MODBUS Communications Module



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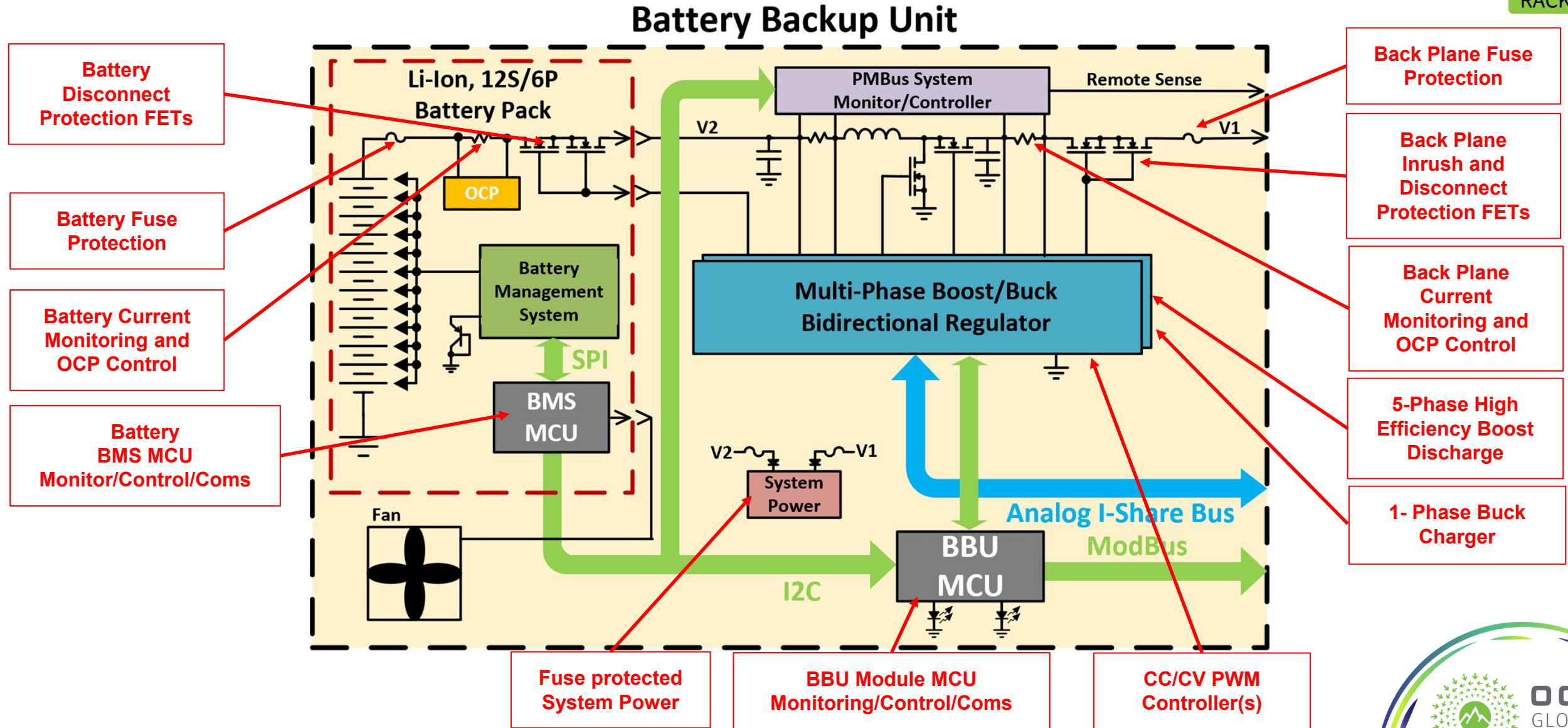




# BBU Module Hardware Diagram



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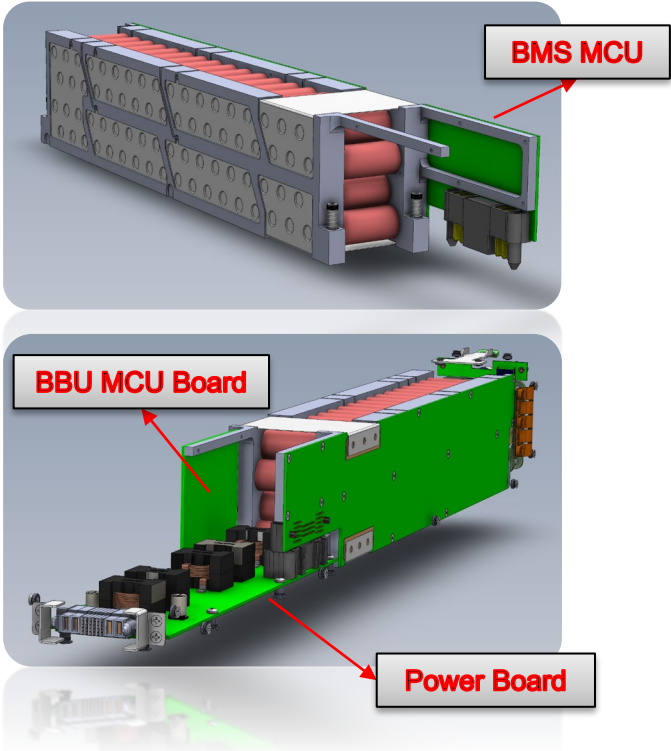
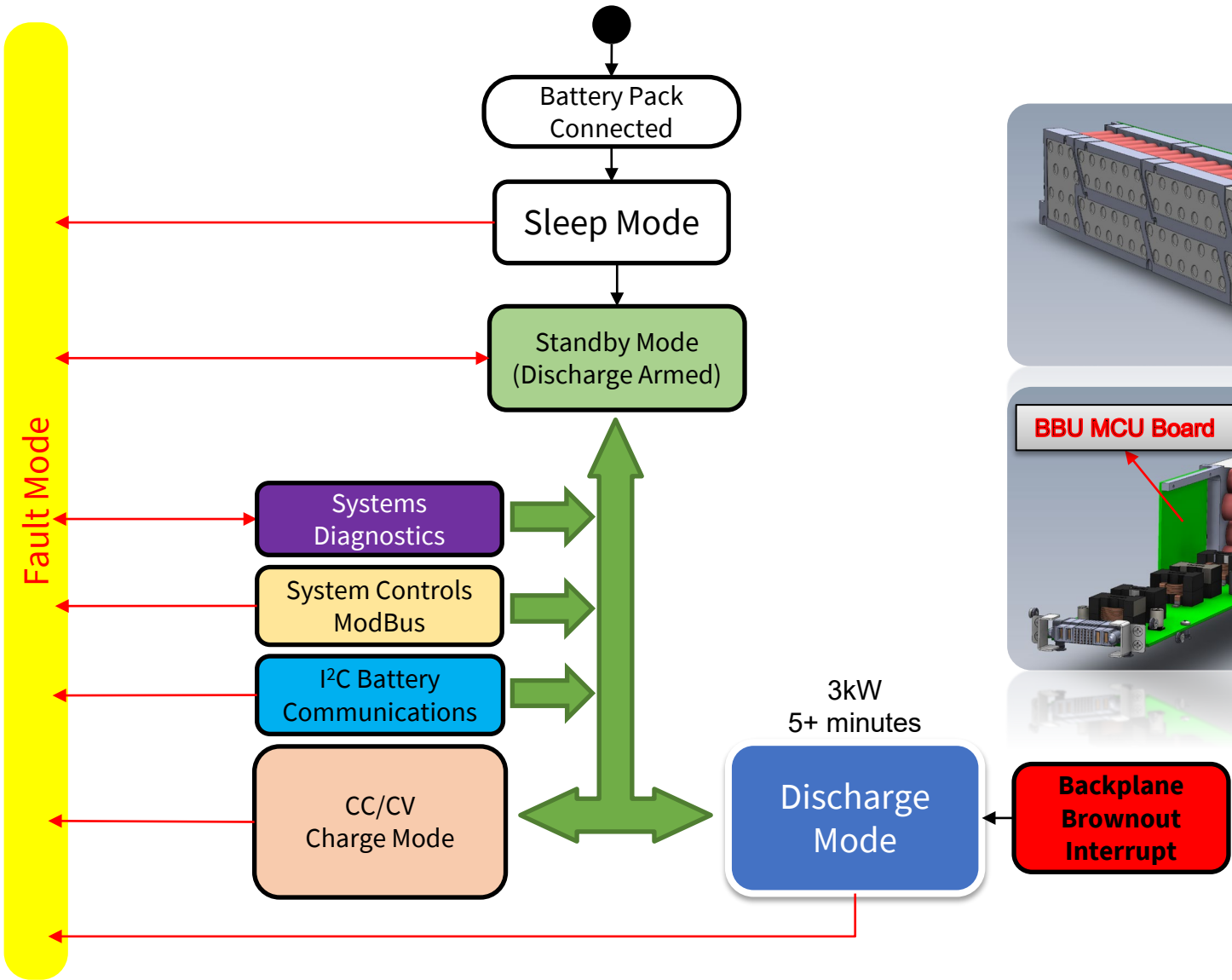
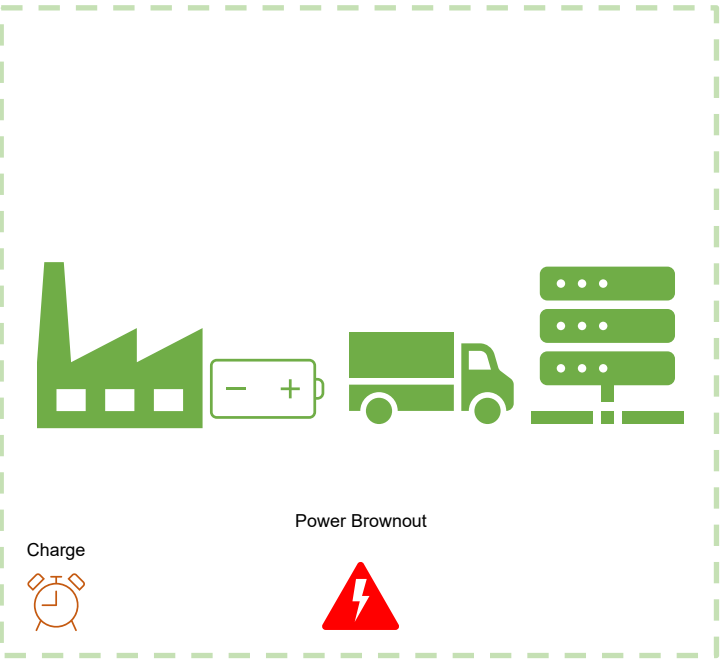
# OCP ORV3 - BBU Spec(0.5) – Firmware System Overview

## Simplified Function Diagram – **BBU MCU**



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BBU Life



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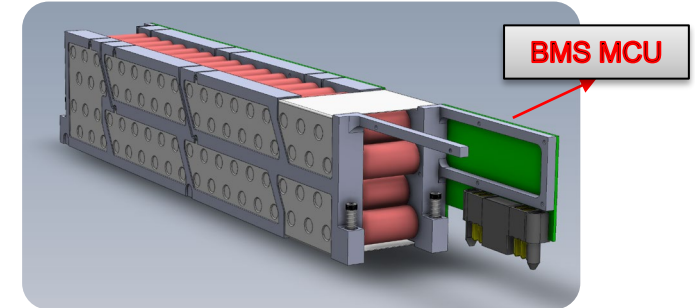
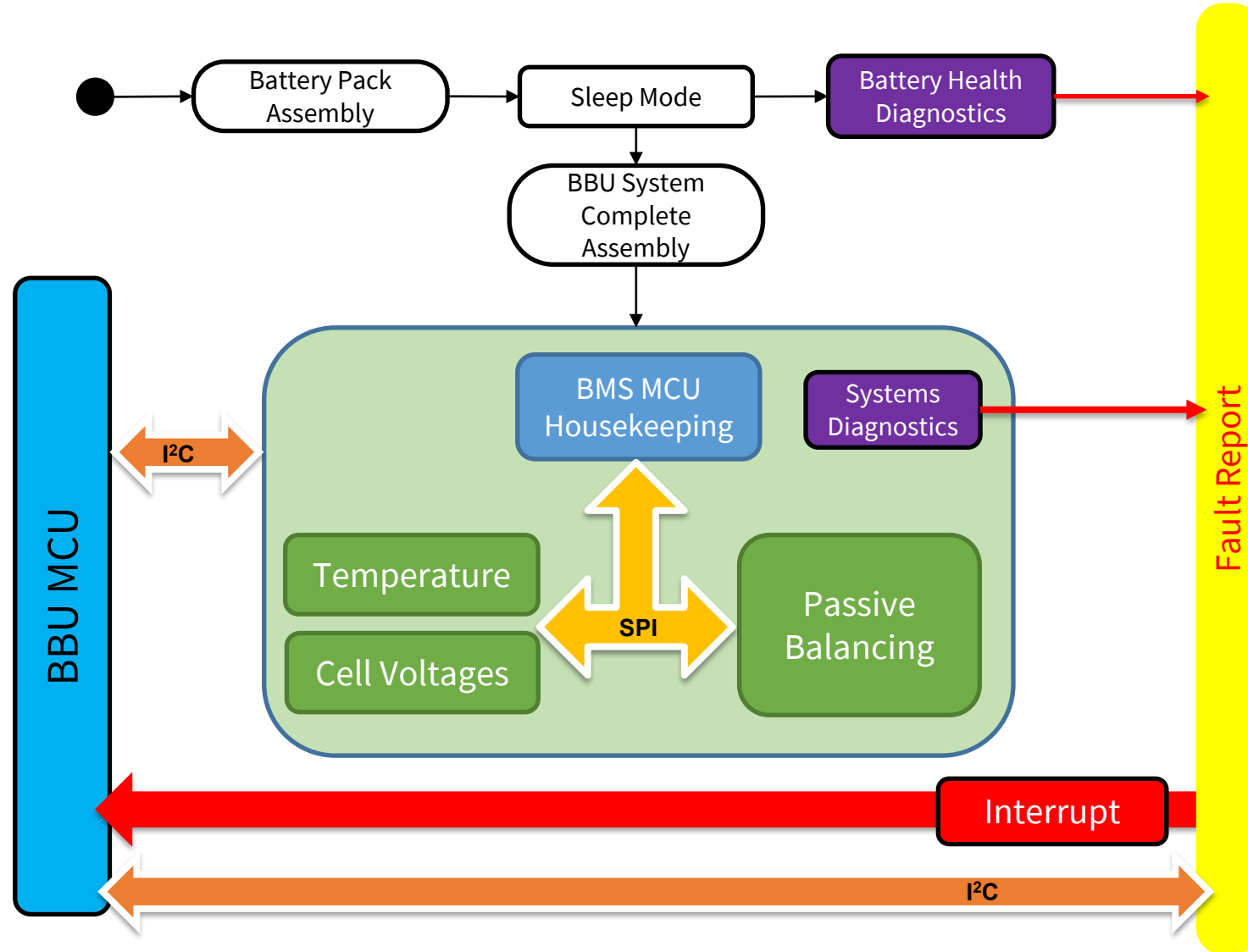


# OCP ORV3 - BBU Spec (0.5) – Firmware System Overview

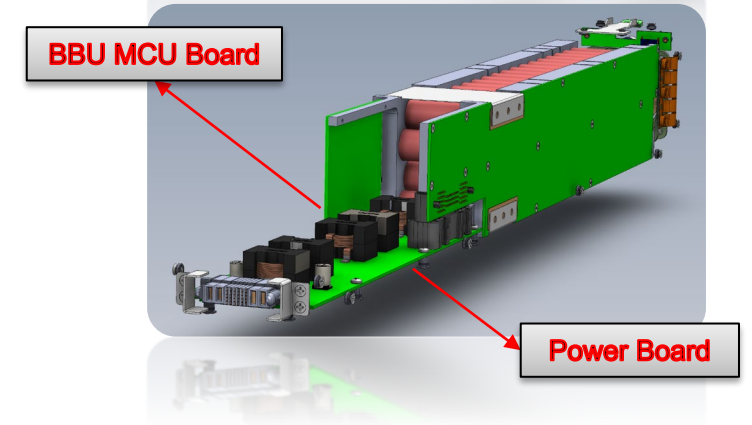
## Simplified Function Diagram - **BMS MCU**



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BMS MCU



BBU MCU Board

Power Board

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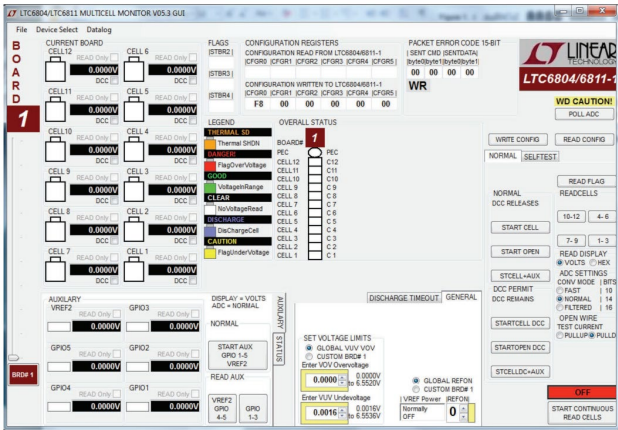
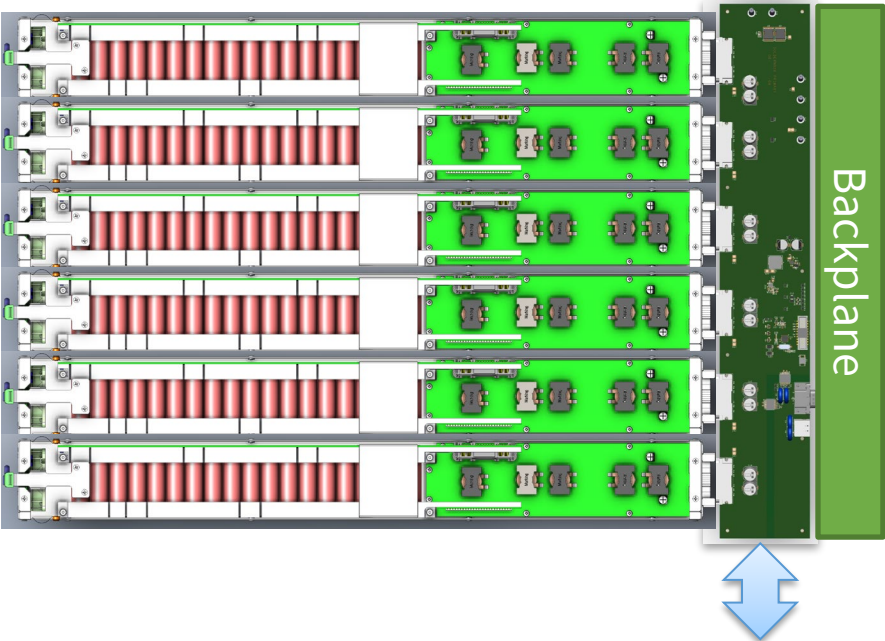


# OCP ORV3 - BBU Spec(0.5) – Firmware System Overview

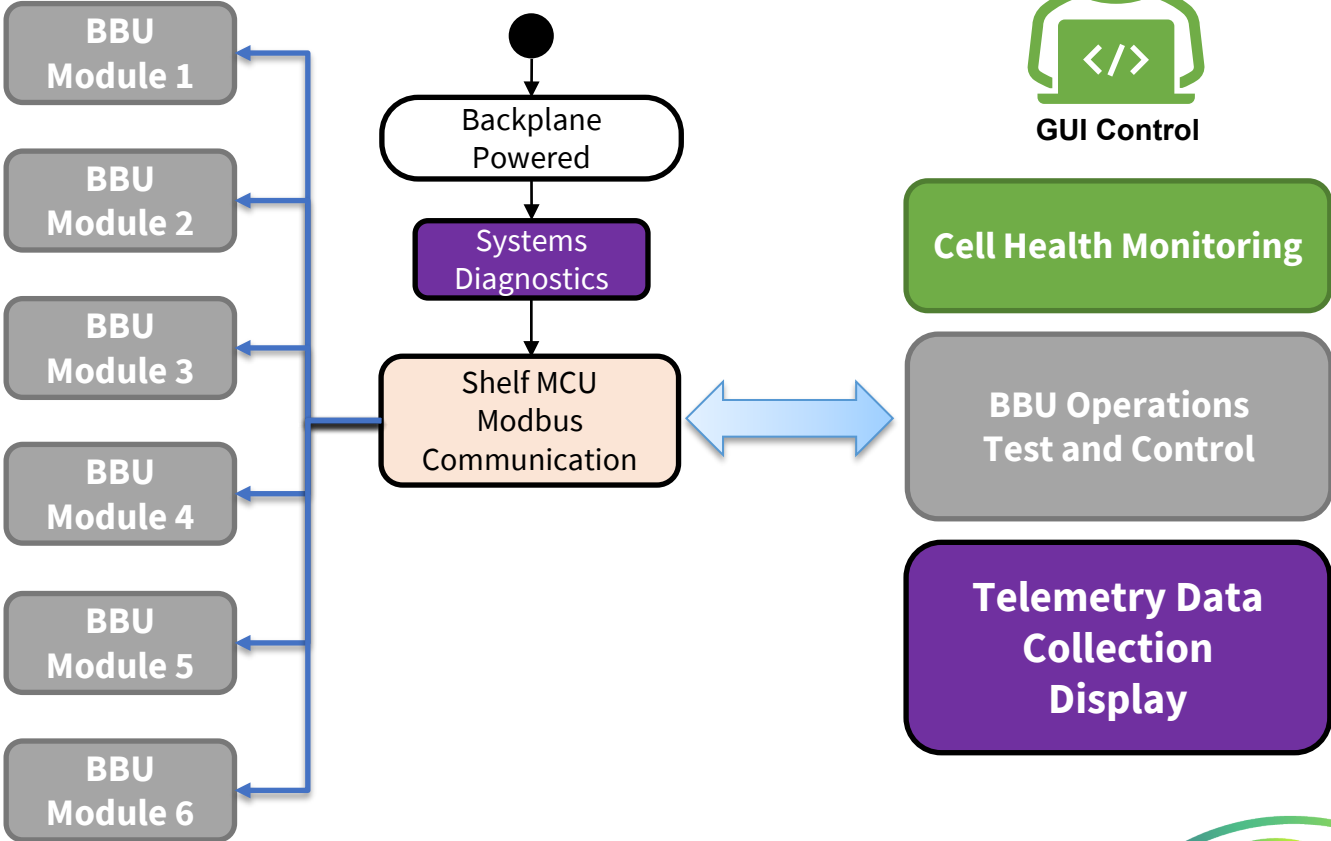
## Simplified Function Diagram – Shelf MCU



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Centralized System Monitoring and Control GUI



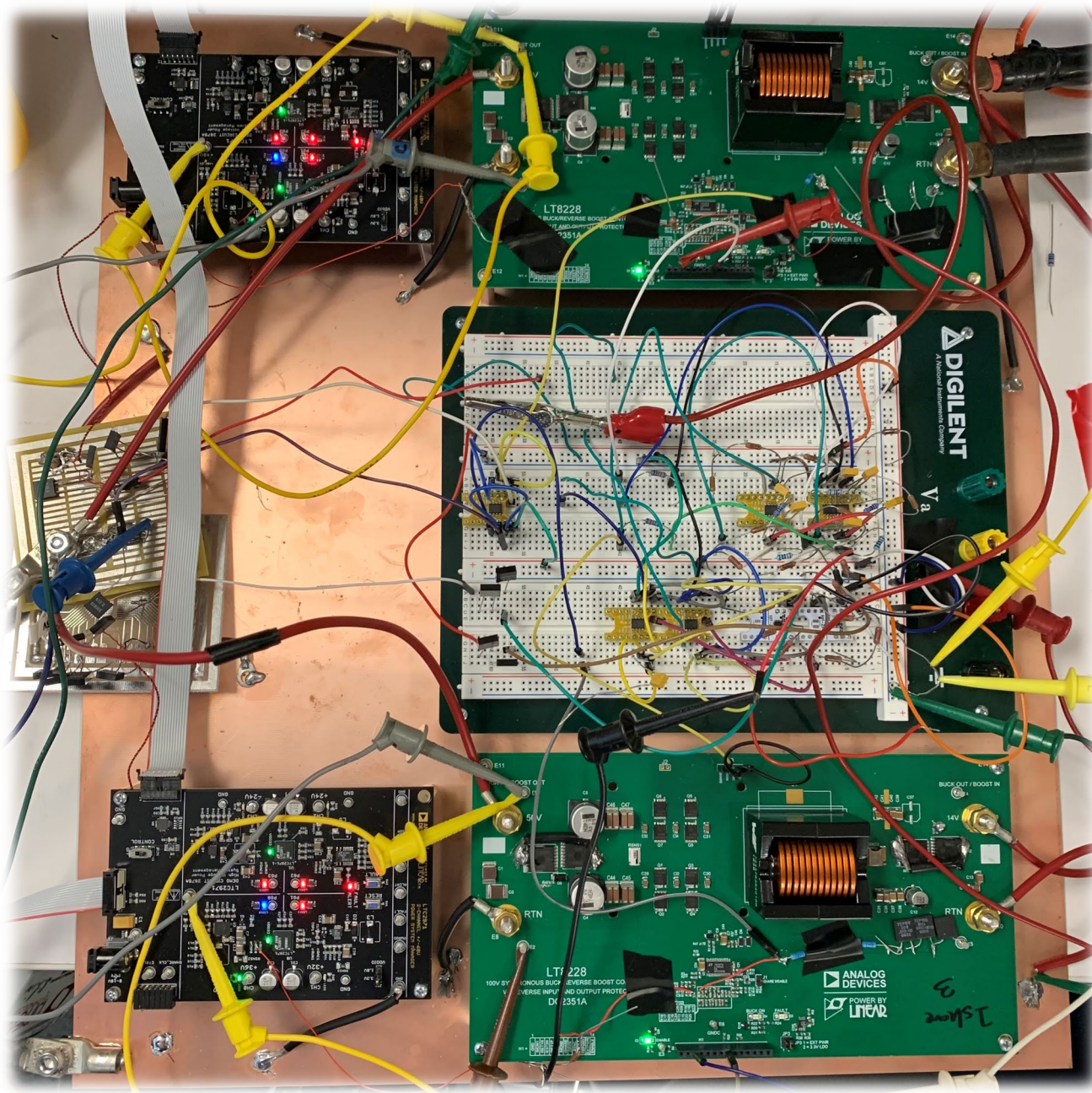
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# Lab Test Results

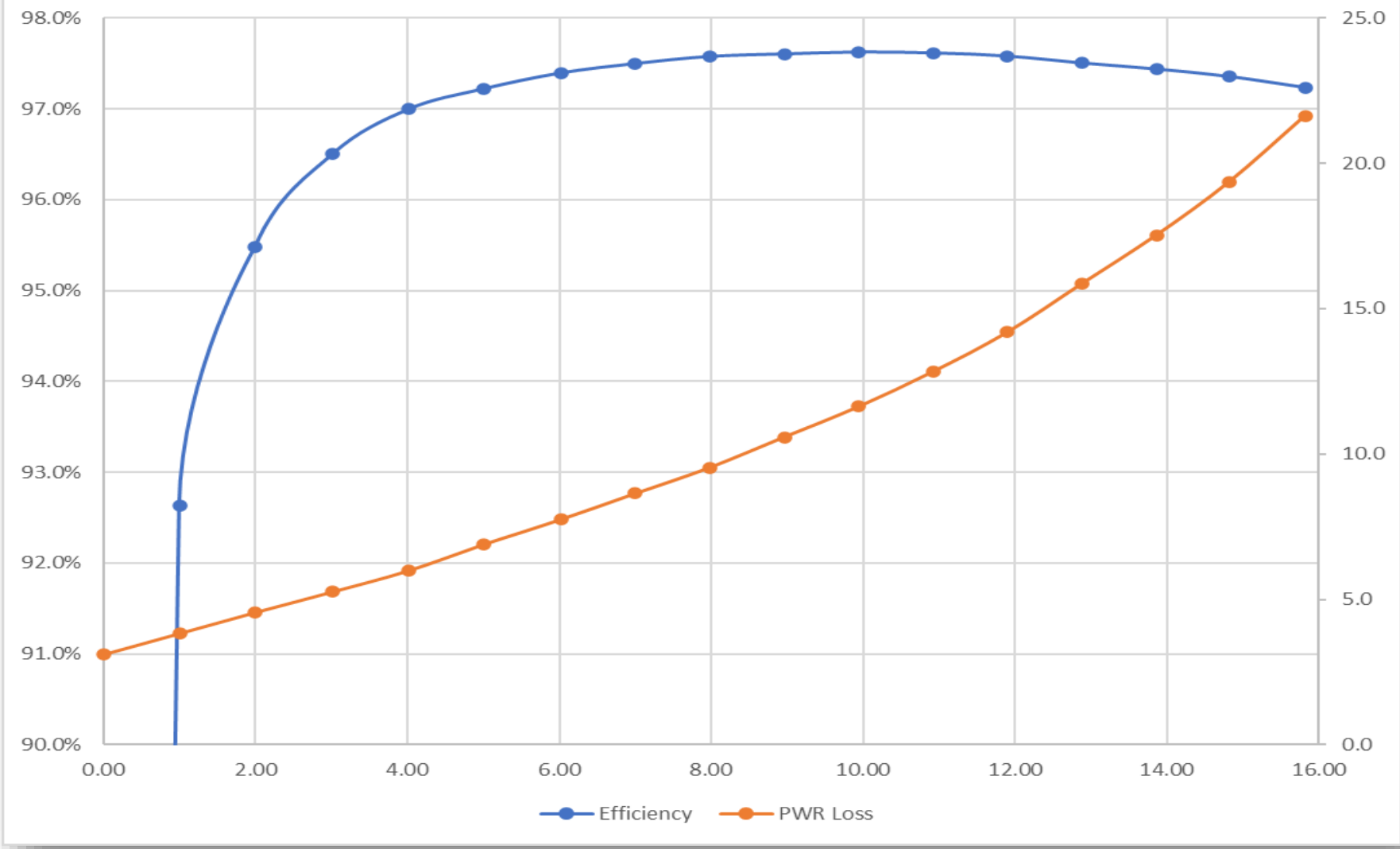
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# LT8228 31V to 48V Boost Conversion Efficiency



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# Buck to Boost mode transition, single phase conversion

## LT8228 Single Phase Switchover Buck to Boost with 16A constant current Load

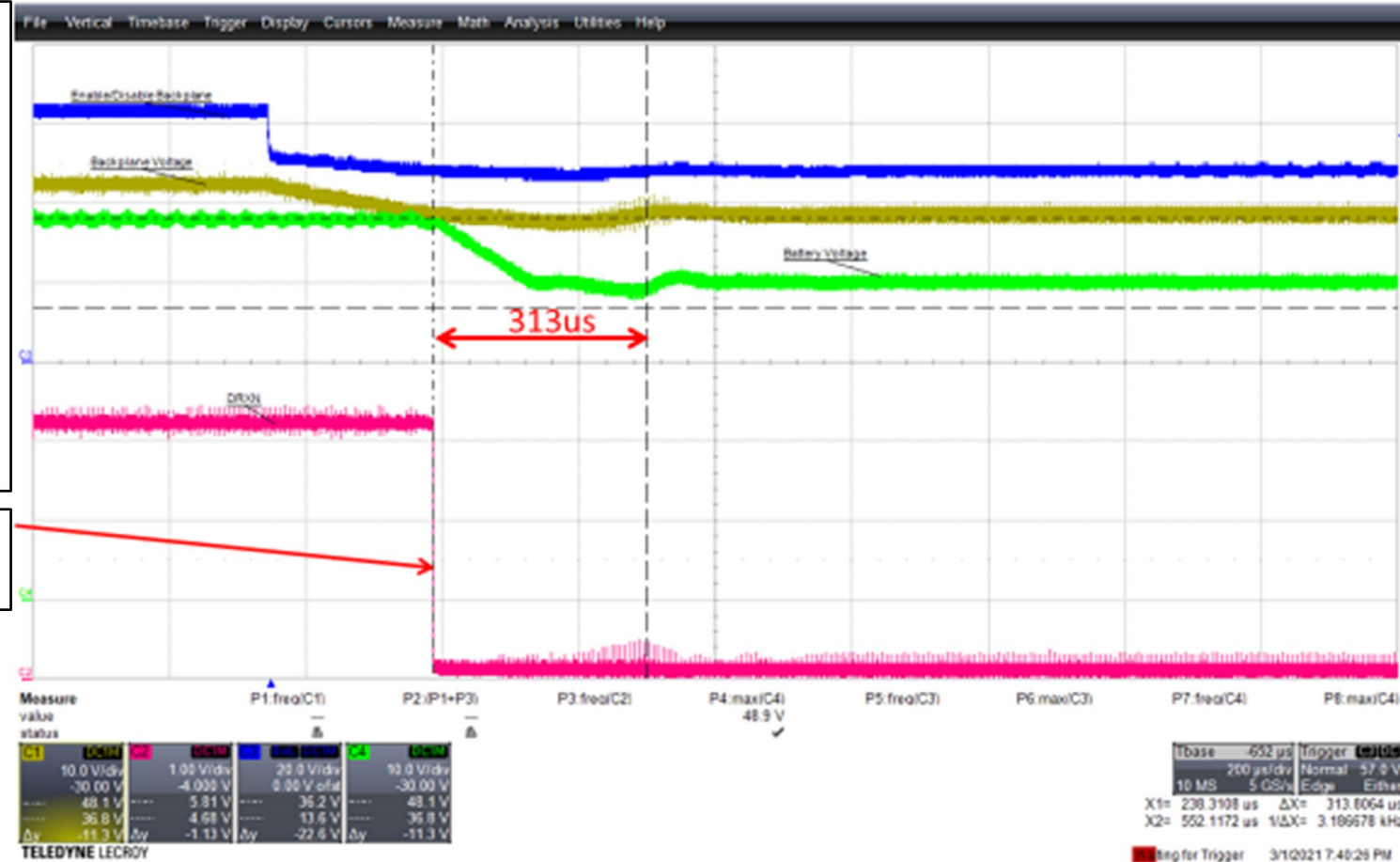
Blue:  
BackPlane Disable (20V/div)

Yellow:  
Back Plane Voltage (10V/div)

Green:  
Battery Voltage (10V/div)

Red:  
DRXN pin (1V/div)

Boost Mode trigger  
(DRXN = low)



LT8228 unmodified demo board (Single Phase)

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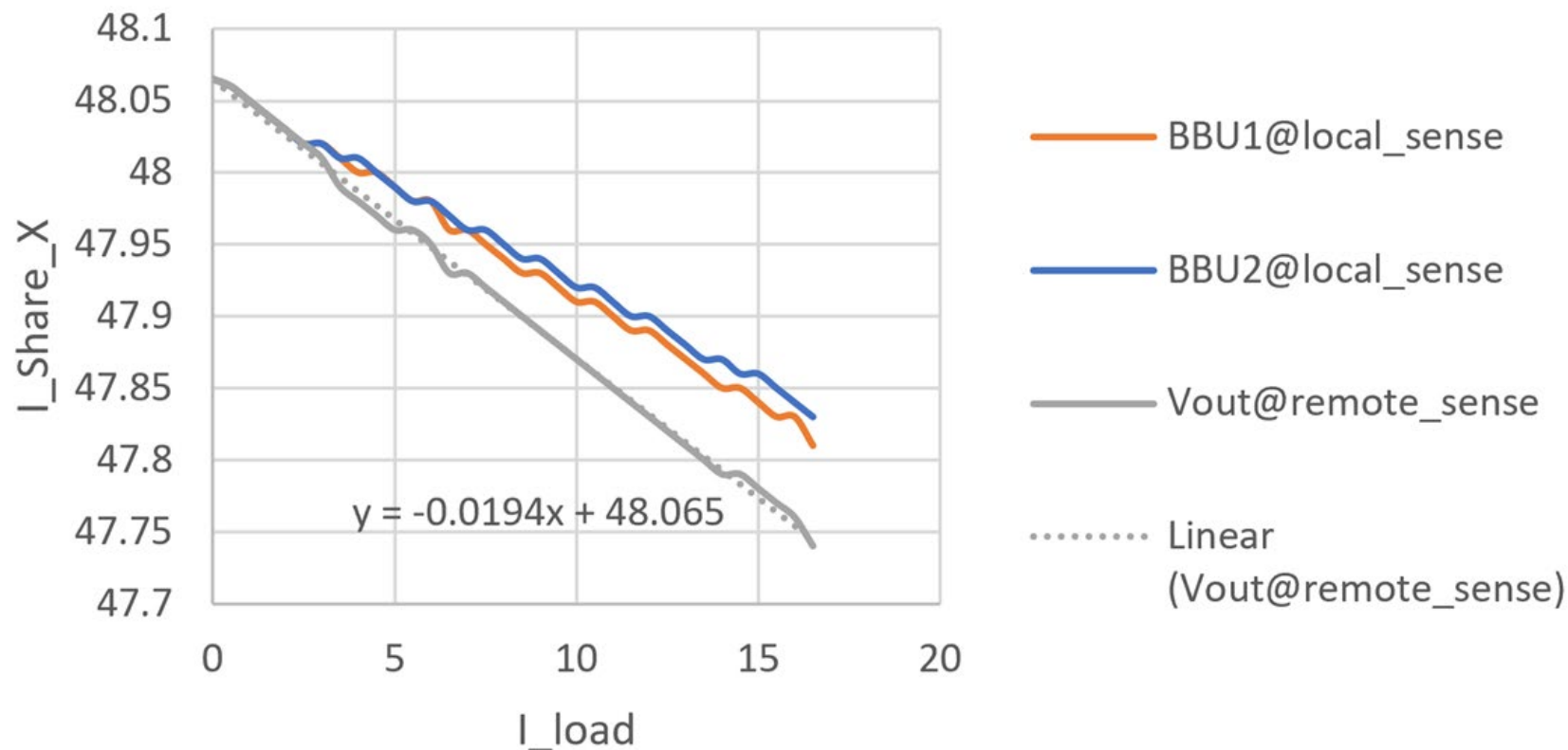


# Active Voltage Droop



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## Vout vs. I\_load (Collected by hand)



## Ideal Voltage Droop under Load

### • Single BBU:

BBU Current		Remote Sense Voltage
0	A	-> 48 V
6.25	A	-> 47.75 V
12.5	A	-> 47.5 V
19.375	A	-> 47.25 V

### • Dual BBU:

Total Current		Remote Sense Voltage
0	A	-> 48 V
6.25	A	-> 47.875 V
12.5	A	-> 47.75 V
19.375	A	-> 47.625 V

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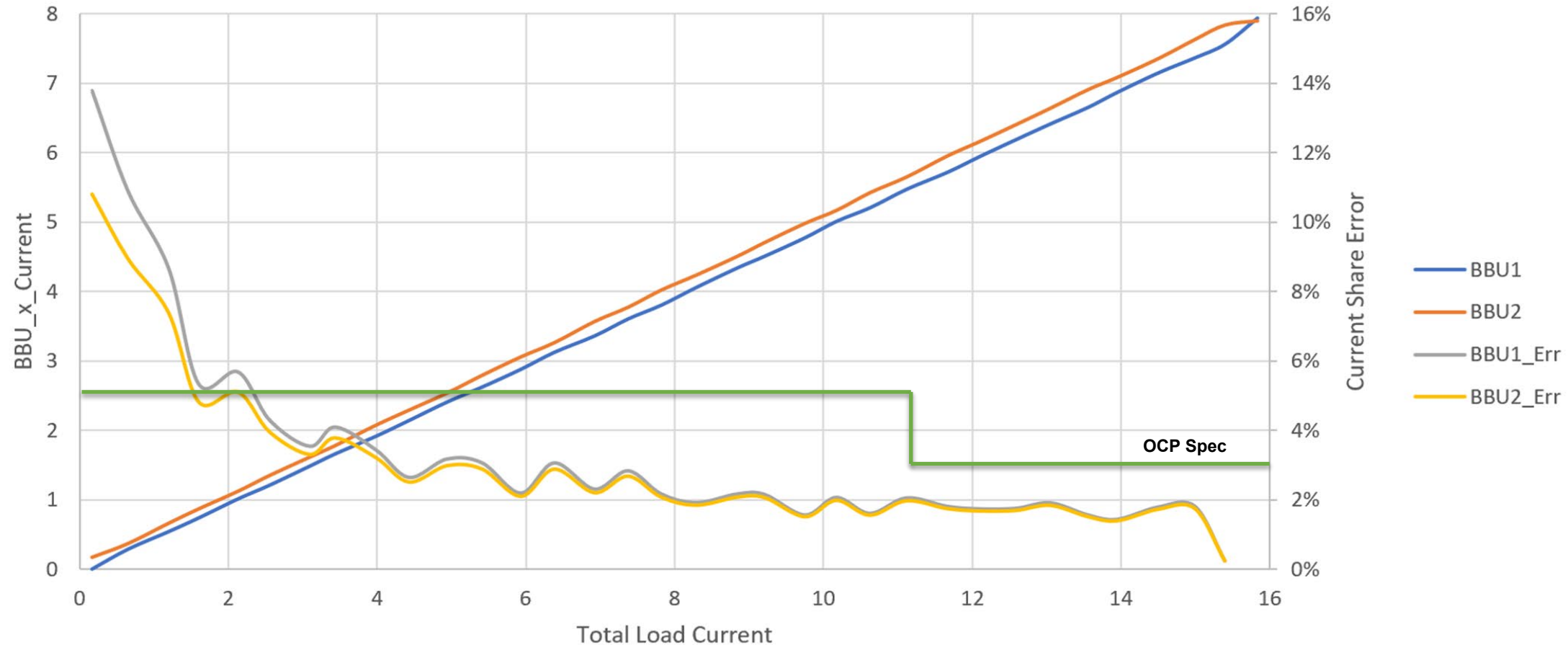




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## Active Current Share between 2 BBU Modules

### BBU Current vs. Load Current



### Analog I-Share Performance

Spec:  $\pm 3\%$  > 90% load,  $\pm 5\%$  > 50% load,  $\pm 5\%$  < 25% load

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# Mechanical Design Summary

OCP BBU ORV3 – rev 0.5

BBU module - compliant with specification  
78.1mm x 87.6mm x 674mm (W x H x L).

## Key features:

### ➤ Main Power Board

- Manages BBU Power Conversion and Delivery
- 5-Ph/3kW Boost Power Conversion
- 1-Ph/0-5A Buck CC/CV Power Conversion
- Backplane Hot-swap/Disconnect/Protection
- Auxiliary Power System Conversion

### ➤ MCU Board

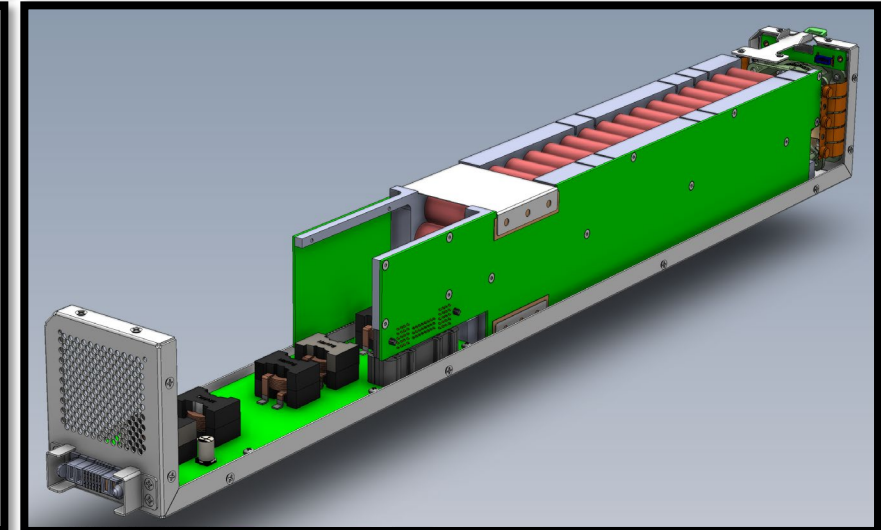
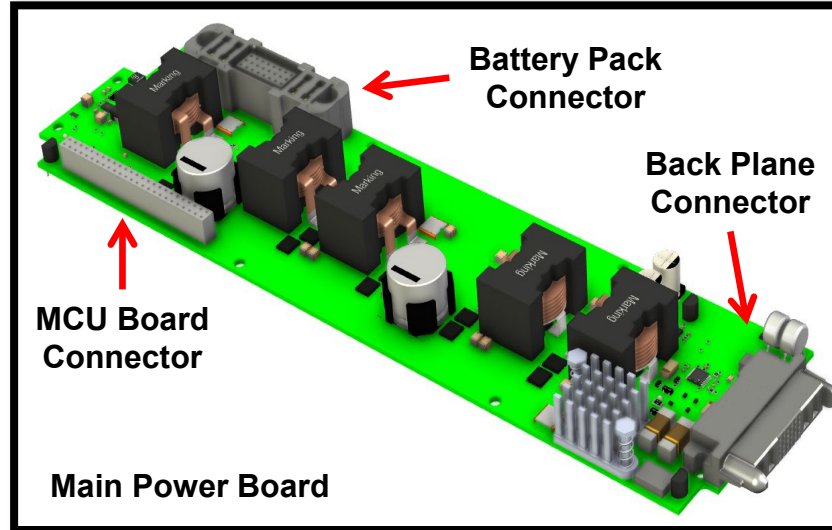
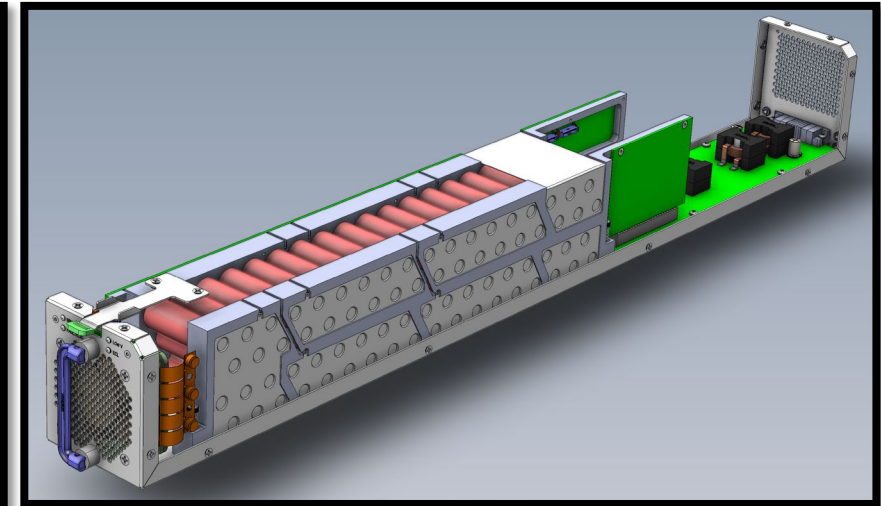
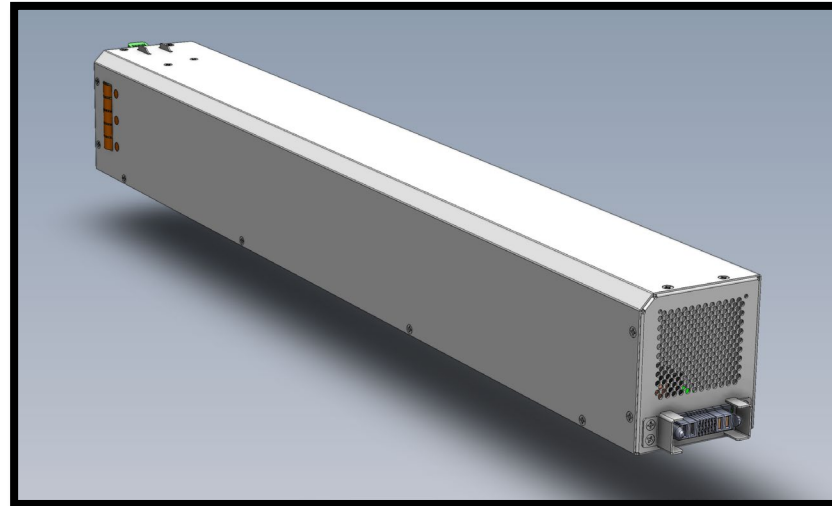
- Manages system level operations (Diagnostics/Faults)
- Housekeeping & timing
- Fault logging + Firmware Backup and EEPROM COMs
- System communications and addressing
- Battery charging algorithm

### ➤ Battery Management System (BMS) Board

- Performs battery pack system SoH & SoC monitoring
- Manages Battery Cell Diagnostics and Telemetry
- Provides system data to the mainboard controller
- Passive cell balancing
- Fan controller

### ➤ LED Board

- User interface diffused LED indicators



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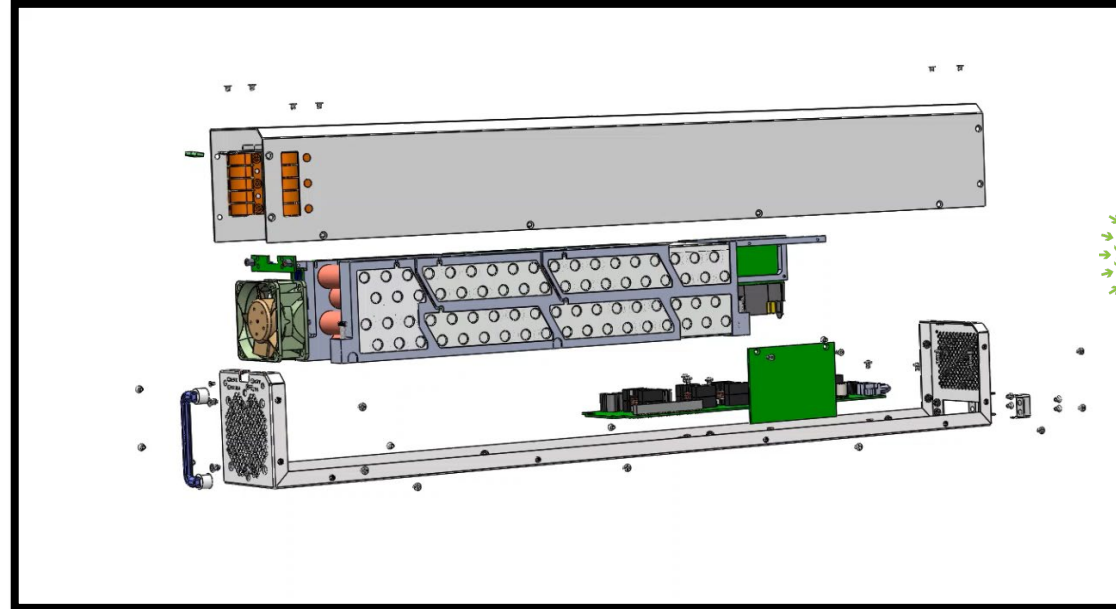
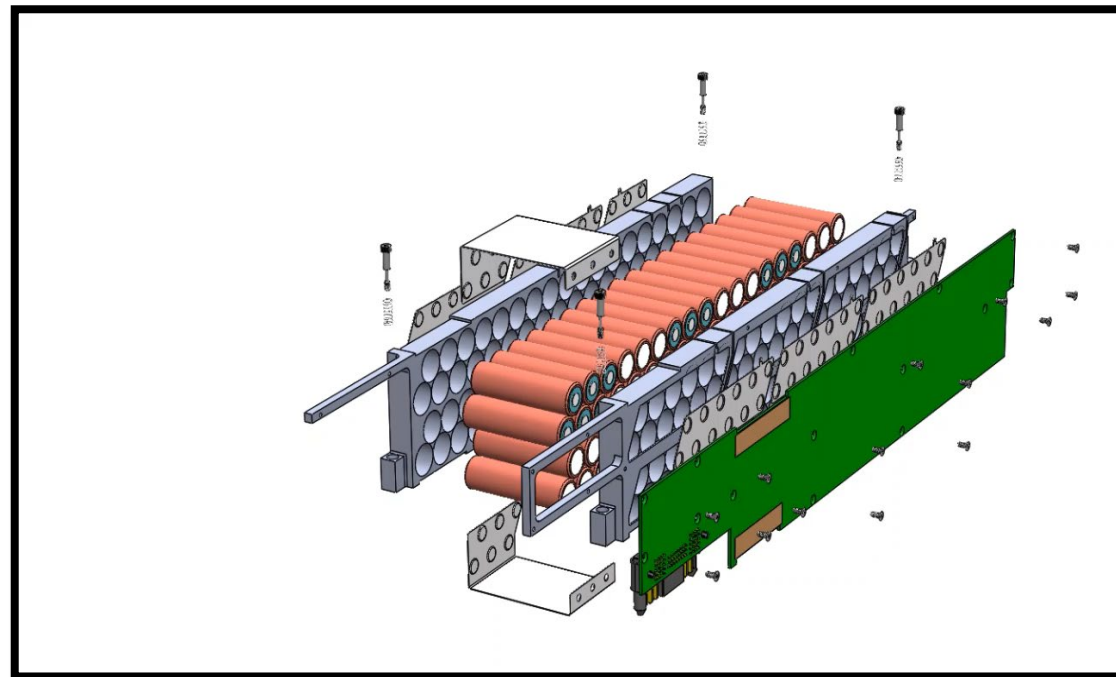
# Mechanical Design Details

## ➤ Battery Pack Assembly

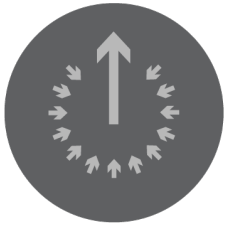
- Carries and aligns 72 x 18650 type Li-ion cells
- 3mm cell to cell spacing for optimal airflow cooling
- Rigid pack construction
- Secure Battery Pack to Chassis mounting system
- Modular sub-assembly design (easy replacement)
- High current(>100A) welded nickel strip/PCB construction
- Compliant with safety requirements
- On board BMS/MCU electronics
- Multi-layer Battery Disconnect Protection

## ▪ Battery Back-up Module

- Meets ORV3-BBU Electrical & Mech. Specifications(0.5)
- Design for manufacturability
- Flexible design for high customizability
- Design for safe transportation & installation
- Accessible programming ports
- Easy Modular disassembly & maintenance
- Low complexity design for easy component sourcing



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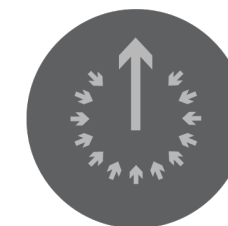
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# Mechanical Design Details



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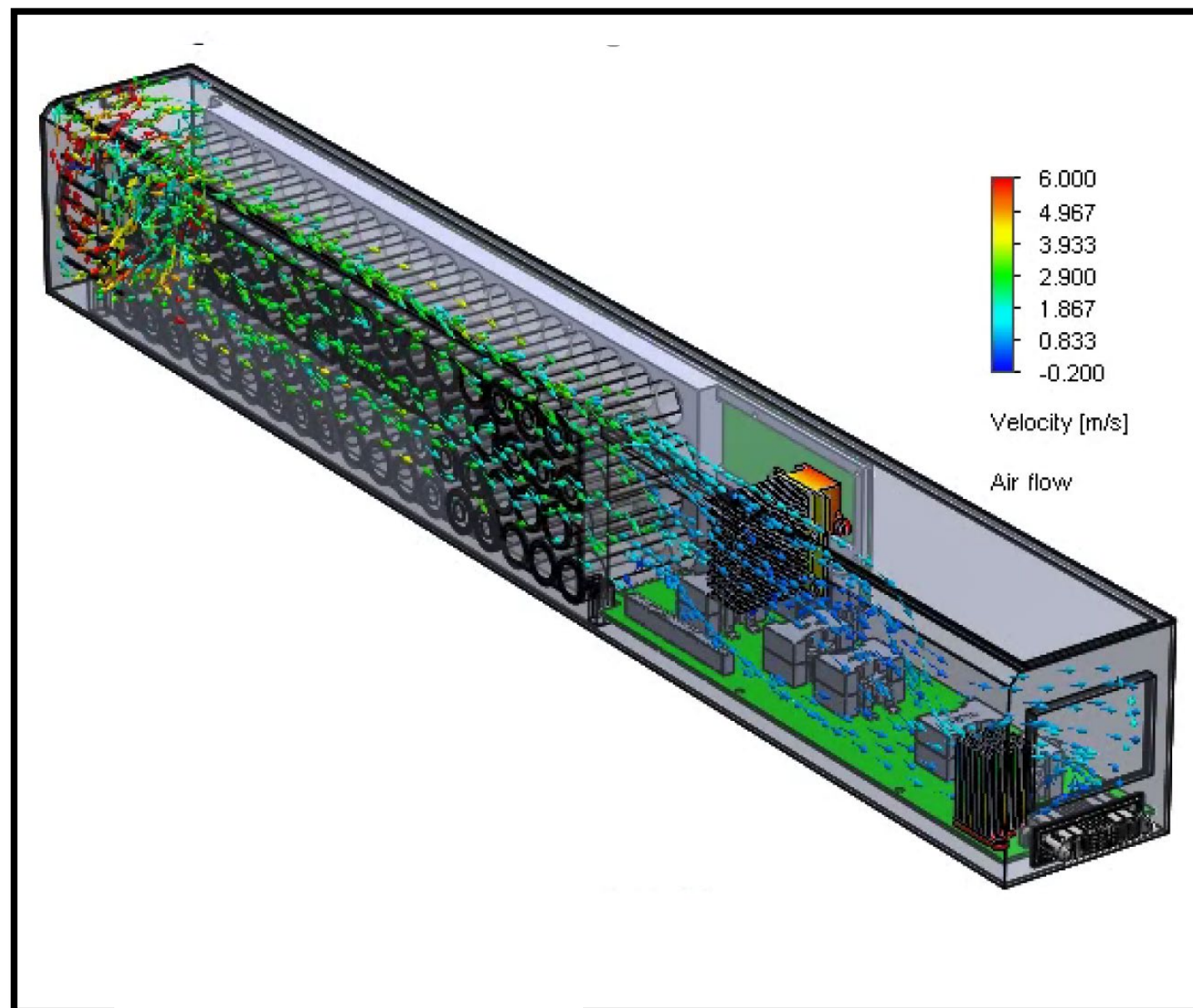
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## Thermal & Airflow:

- Permeable cell spacing to ensure maximum thru pack airflow
- Strategic heatsink placement for protection MOSFET cooling
- Welded wide nickel strip conduction paths for reduced IR losses
- High speed fan with programmable PID/Linear PWM control
- PCB 2oz copper trace design for high current/low loss conduction(>100A)
- Strategic temperature sensor placements for effective systems diagnostics and component OT protection



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# Thank you!



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# Open Discussion



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# Call to Action



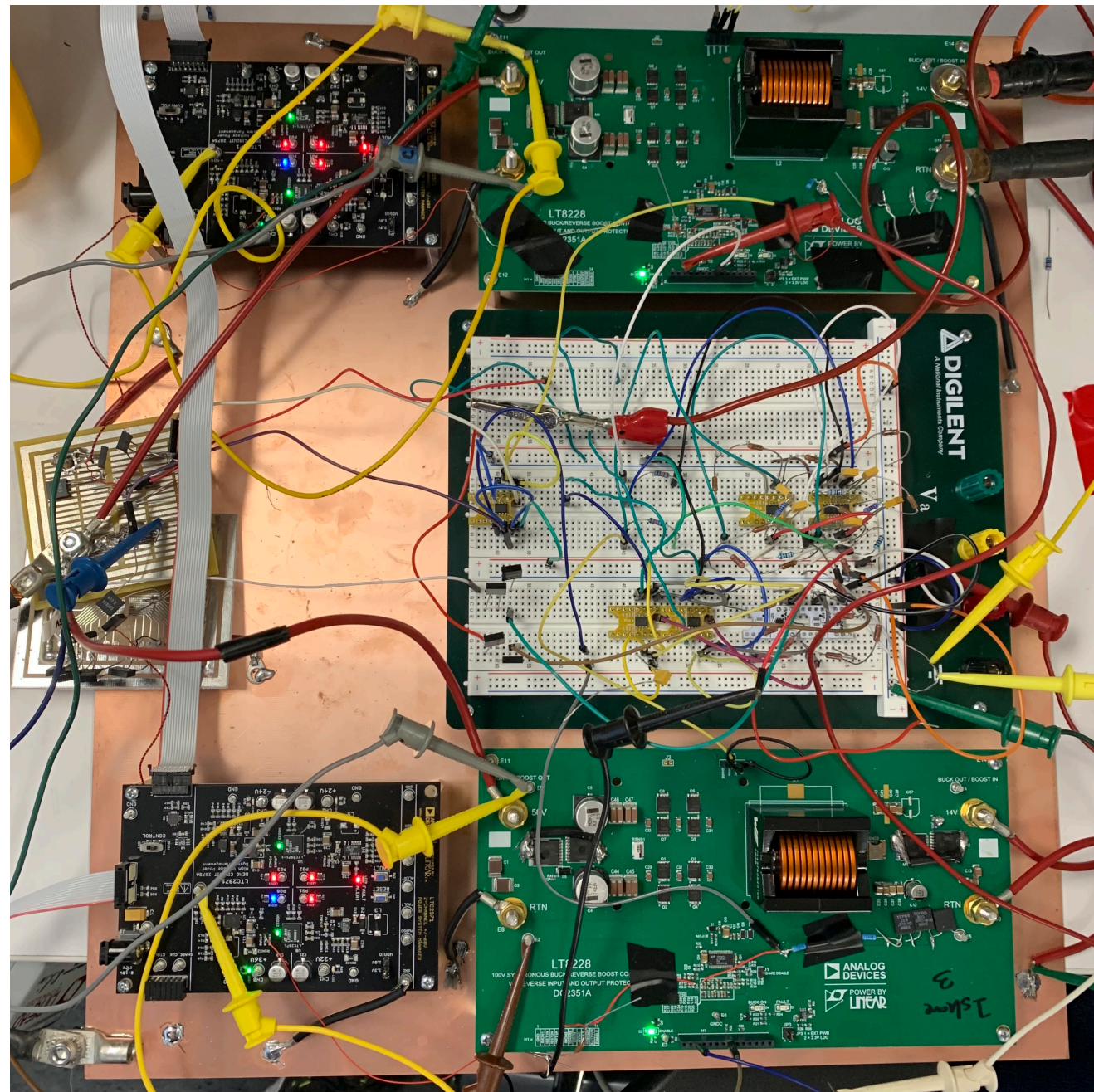
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- Contact us at:
  - [Gary.Sapia@analog.com](mailto:Gary.Sapia@analog.com)
- Demonstration Availability: Currently in prototype building phase
- Link to Contribution: Coming soon
- Where to find additional information: [Gary.Sapia@analog.com](mailto:Gary.Sapia@analog.com)

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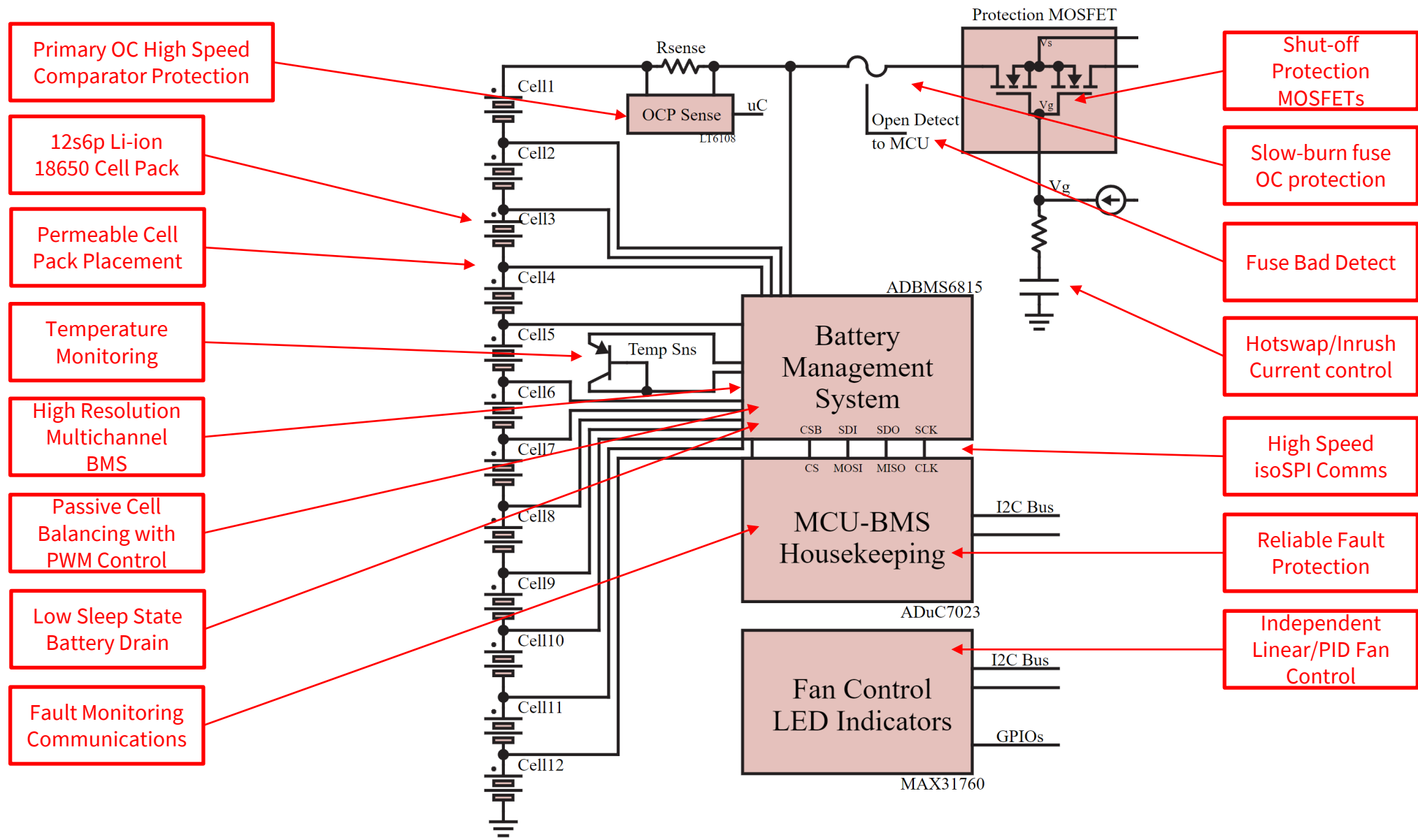




# EE - OCP - BBU ORV3 Spec – Detailed Battery Management System Design



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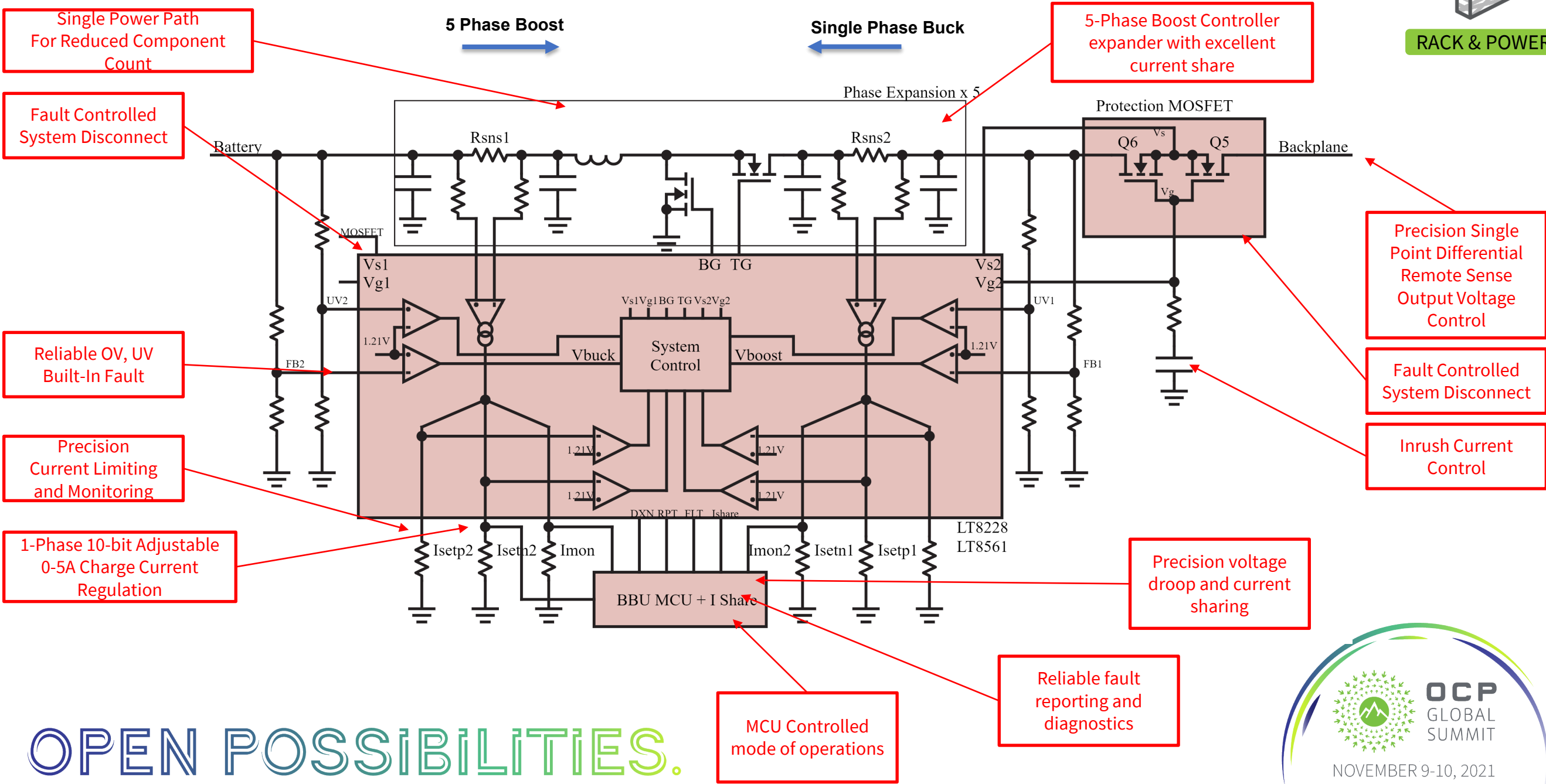




# OCP - BBU ORV3 Spec – Charge/Discharge Power System Design



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