OPEN POSSIBILITIES.

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

Gary Sapia - Director of Datacenter Power - Analog Devices – gary.sapia@analog.com

Design Development Team

Christian Cruz – Senior Product Applications Engineer – Analog Devices
Juan Brizo – Test Engineering Manager – Analog Devices
Vermont Sanchez – Equipment Development Engineer – Analog Devices
Regina Gavino – Senior PCB Layout Engineer – Analog Devices
Fengrui Zuo - Systems Applications Engineer - Analog Devices
Agenda

• 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
System Level: Shelf/BBU Module and Test Hardware

- 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, TÜV or DEMKO
- CE Marking for EU
- UL1973 (Recognized) cRUs
- IEC62133
- 62368-1 (UL/IEC)
- UN38.3

Battery Back-up Shelf

- BBU Charge/Discharge/DC-DC Electronics
- SMC (Shelf Management Controller)

PWR/GND

- Analog I Share Bus
- ModBus System Comms

Open Possibilities.

Battery Backup Module

Backplane Test Board + MODBUS Communications Module

Open Possibilities.
OCP ORV3 - BBU Spec(0.5) – Firmware System Overview
Simplified Function Diagram – BBU MCU

BBU Life
- Charge
- Power Brownout

Fault Mode
- Battery Pack Connected
- Sleep Mode
- Standby Mode (Discharge Armed)

Discharge Mode
- CC/CV Charge Mode
- PC Battery Communications
- System Controls ModBus
- Systems Diagnostics

3kW
5+ minutes

Open Possibilities.

BBU MCU Board
- BMS MCU
- Power Board

Backplane Brownout Interrupt

RACK & POWER
OPEN POSSIBILITIES.
OCP ORV3 - BBU Spec(0.5) – Firmware System Overview
Simplified Function Diagram – Shelf MCU

- Cell Health Monitoring
- Telemetry Data Collection Display
- BBU Operations Test and Control
- GUI Control
- Backplane Powered
- Systems Diagnostics
- Shelf MCU Modbus Communication

BBU Module 1
BBU Module 2
BBU Module 3
BBU Module 4
BBU Module 5
BBU Module 6

Centralized System Monitoring and Control GUI
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)
Active Voltage Droop

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

---

Active Voltage Droop (Collected by hand)

\[ y = -0.0194x + 48.065 \]
Active Current Share between 2 BBU Modules

BBU Current vs. Load Current

Analog I-Share Performance
Spec: ±3% > 90% load, ±5% > 50% load, ±5% < 25% load

OCP Spec
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
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
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
Thank you!
Open Discussion
Call to Action

• Contact us at:
  • 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
EE - OCP - BBU ORV3 Spec – Detailed Battery Management System Design

- 12s6p Li-ion 18650 Cell Pack
- Permeable Cell Pack Placement
- Temperature Monitoring
- High Resolution Multichannel BMS
- Passive Cell Balancing with PWM Control
- Low Sleep State Battery Drain
- Fault Monitoring Communications
- Primary OC High Speed Comparator Protection
- Shut-off Protection MOSFETs
- Slow-burn fuse OC protection
- Fuse Bad Detect
- Hotswap/Inrush Current control
- High Speed isoSPI Comms
- Reliable Fault Protection
- Independent Linear/PID Fan Control
- Fault Monitoring Communications
- Battery Drain
- Communications
- Fault Monitoring
- Communications
OCP - BBU ORV3 Spec – Charge/Discharge Power System Design

- Single Power Path for Reduced Component Count
- Fault Controlled System Disconnect
- Reliable OV, UV Built-In Fault
- Precision Current Limiting and Monitoring
- 1-Phase 10-bit Adjustable 0-5A Charge Current Regulation
- Reliable fault reporting and diagnostics
- MCU Controlled mode of operations
- Precision voltage droop and current sharing