# OCP ORv3 Power
# BBU Concept Proposal

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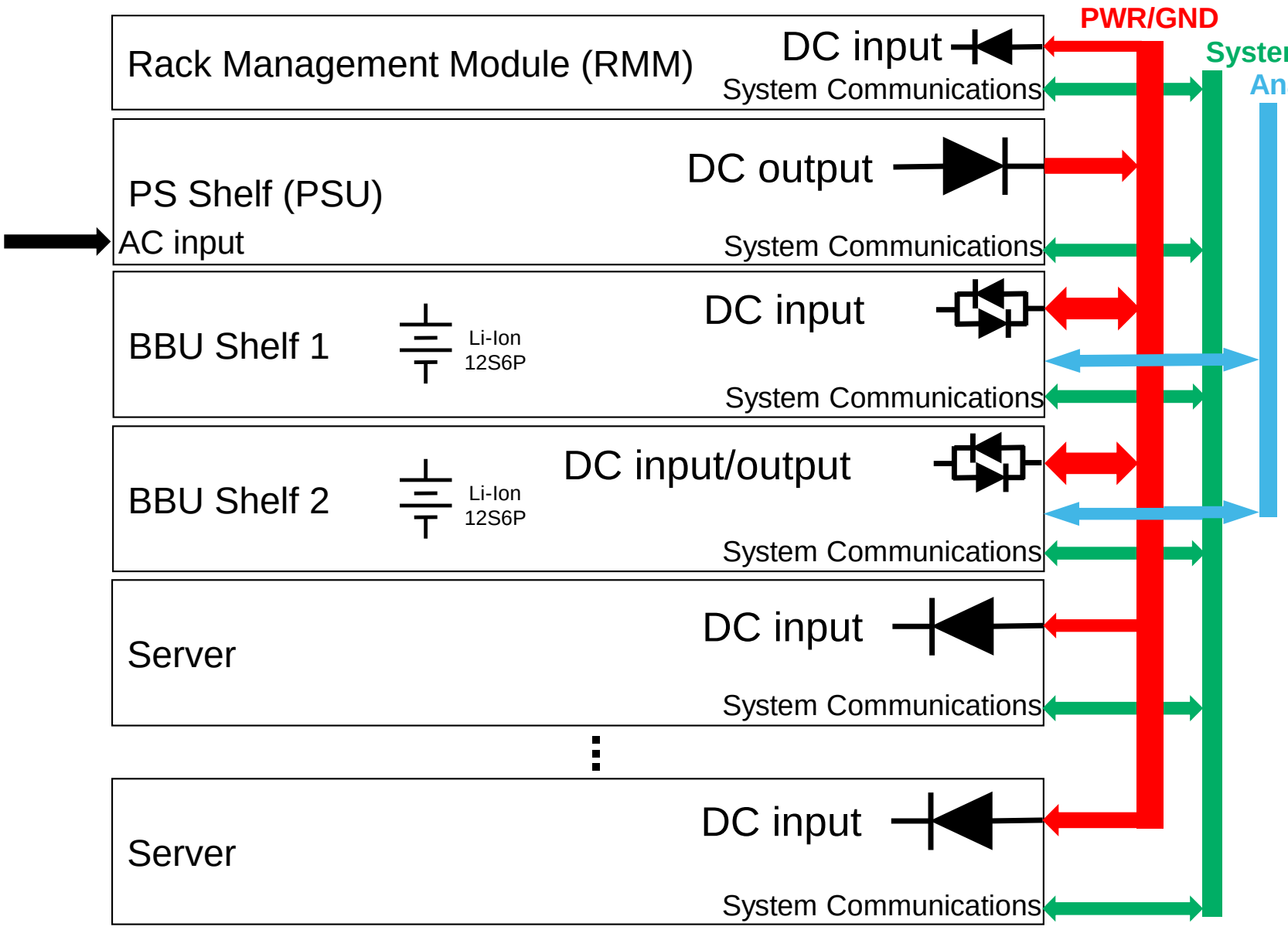
AHEAD OF WHAT'S POSSIBLE™

# Rack Power System Diagram




## System Voltage Requirements

**PSU Output Voltage:**
50V +/-0.25%, Plus 1% Droop
(49.6V – 50.13V)

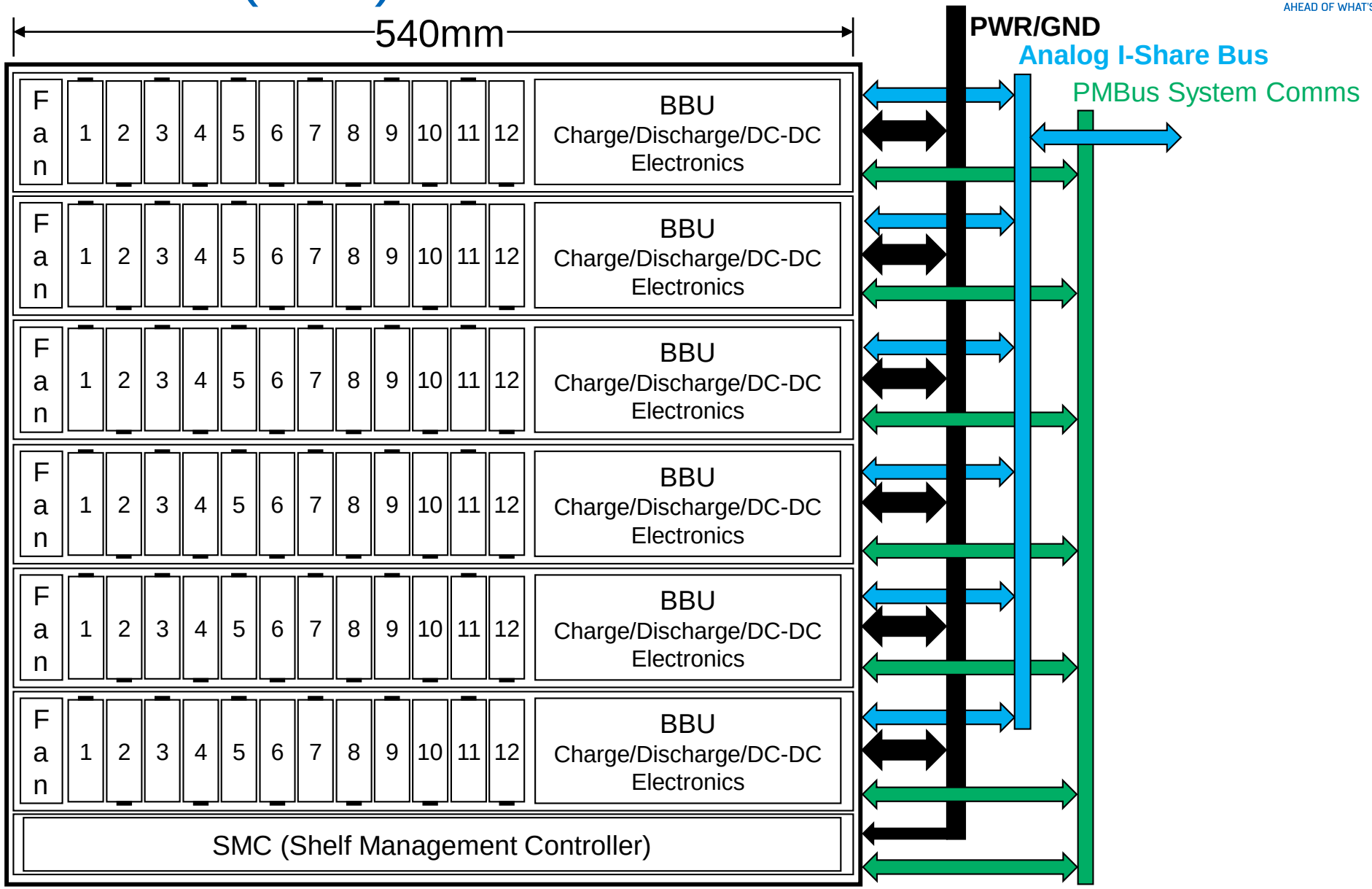
**BBU Voltage:**
Input: 49.6V – 50.13V
Output: 48V +/-0.5%,
(47.76V – 48.24V)

**Battery Voltage:**
36V – 49.2V, 12s6p stackup,
4.1V/cell_max

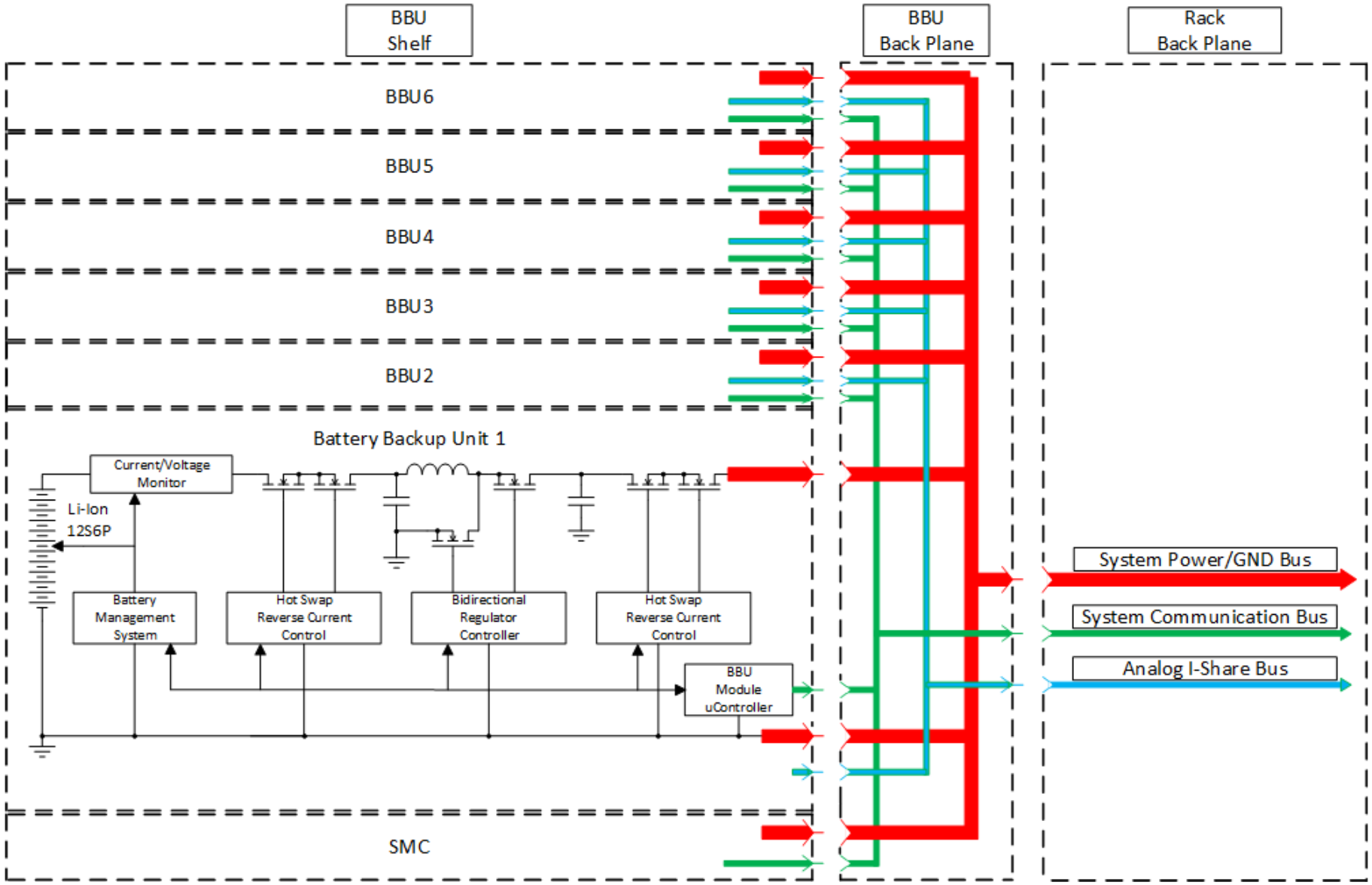
**BusBar Voltage Range:**
Operational: 47.76V – 50.13V
Transitional Limits(<1ms): 40V to 60V

# Battery Shelf: 15kW (N+1) Redundant Modules

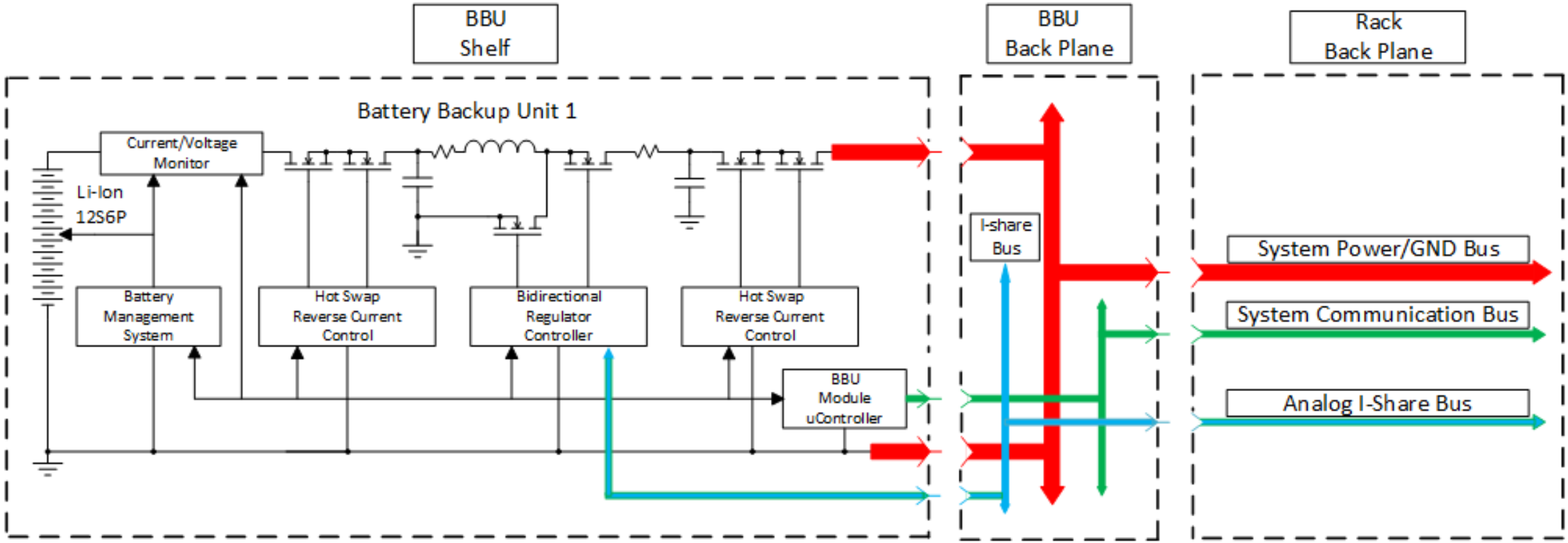
Li-Ion
12s6p
Stack



# BBU Shelf Functional Concept Proposal



# BBU v3 Module Proposal



# BBU Block Description:

## Battery

- Lithium Ion 12s6p (72 cell pack)
  - 18650 VTC4 12AHr
  - 18650 VTC5  15AHr
- Battery size easily fits mechanical requirements.
- Enables efficient boost architecture
- Enables fast switch over to BBU
- Sized to meet system requirements with adequate margin over lifetime.
- Compatible with high performance automotive battery monitors

| Parameter | Spec Requirement | 12s – 6p VTC4 | 12s – 6p VTC5 |
|---|---|---|---|
| Voltage Range Float | 48V | 49.2V | 49.2V |
| Voltage 90% @15A | | 45V | 45V |
| Cell ESR | | 12mohm | 12mohm |
| Pack ESR | | 36mohm | 36mohm |
| Cont. Current | 85A | 120amps | 135amps |
| Ahr | 7 | 12Ahr | 15Ahr |
| Pack Energy | 305Whr (min required) | 514Whr | 617Whr |
| Cycle Life | | 500 | 500 |

# BBU Block Description:

## Busbar side Hot Swap/Reverse Current Controller

- Enables initial battery connection during BBU event
- Controls inrush during BBU Shelf insertion onto a live Busbar
- Controls inrush during BBU Module insertion onto a live Shelf
- Isolates Busbar from BBU Module Fault condition
- Provides Boost output disconnect and short circuit protection
- Reverse current protection, busbar to BBU system, shelf and module
- Provides protection from PSU system over voltage condition
- MOSFET failure detection
- Reverse voltage protection
- Protection for n+1 redundancy

# BBU Block Description:

## Bidirectional Regulator Controller

- 3.3kW boost voltage generation from battery pack input to busbar output
- Buck voltage charging/current control from busbar to battery pack
- Seamless/instant/no-glitch switchover from buck mode to boost mode and back
- Provides CC/CV control for battery charging
- Adjustable discharge control for battery pack SOH testing
- Accurate analog current sharing between phases and BBU modules/shelves
- Adjustable charging current/voltage control
- Switching MOSFETs short circuit detection, protection and reporting
- Bi-Directional Programmable Current Regulation and Monitoring
- Capable of n-phases for operation in high power applications

# BBU Block Description:

## Battery Pack Hot Swap and Reverse Current Control

- Enables initial battery connection during BBU event
- Inrush control from battery pack to DC/DC boost input capacitance
- Over current protection
- Battery pack disconnect for redundant power
- Isolates Battery pack from boost and busbar Fault condition
- Provides Battery pack short circuit protection
- MOSFET failure detection
- Reverse voltage protection
- Protection for n+1 redundancy

# BBU Block Description:

## Battery System Management(BMS) and Voltage/Current Monitor

- Measures Up to 12 Battery Cells in Series
- Low Total Measurement Error over system lifetime
- Manages/Controls/Reports battery functions, i.e. SOC, SOH
- Passive Cell Balancing with Programmable Timer to ease compute time on uController
- Many General Purpose Digital I/O and/or Analog Inputs
  - Temperature, voltage, current or other Sensor Inputs
  - I2C or SPI Communications protocol
- Very low Iq and Supply Current
- Monitor system level failures, open wire, battery failure, degraded measure accuracy, etc.

# BBU Block Description:

## BBU System uController

- Manages battery charging functions
- Reports BBU information to System Management Controller(SMC)
  - Battery SOH, SOC
  - Electronics Health, diagnostics and fault detection
  - Real Time system Telemetry
- Monitors current sharing between BBU modules
- Manages battery charging and discharging algorithm

# BBU Block Description:

## BBU System Communications

- Current sharing
- State of Charge
- Battery Status
- Power Metrics

# OCP BBU v3 Spec Review Summary/Concerns

## Summary

- Battery pack stack - 12s6P
  - Optimal capacity for back up requirement with margin
  - Fastest switchover time due to max charge voltage exceeding BBU boost voltage
  - 18650 VT4/VT5 cells are commonly used and well tested for this application
  - Many vendors support a 12Cell stack with common BMS products
- Non-isolated Bidirectional DC/DC power architecture
  - Simplicity in power conversion
  - Buck mode charge/Boost mode discharge - fewer MOSFETs, higher reliability
  - Single converter block for simplicity, size, and cost benefit
  - Analog current limit bus offers no droop requirement for improved voltage tolerance

## Concerns

- PSU/BBU operational voltages and droop leaves no margin for system tolerances
- Operational voltage ranges don’t include tolerance for load transition variations
- Initial BBU switchover voltage drop dominated by hold up capacitance ESR
  - Need to spec allowable minimum voltage during the switchover
  - Is 40Vmin, <1ms acceptable?