ORV3 Power Shelf Development Update
ORV3 Power Shelf Development Update

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Harry Soin, Senior Director, Advanced Energy
Lam Vu, Director, Lite-on Technologies
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Short recap on ORV3 Spec
Holdup time during overload
Dummy Load-Box
Common ORV3 with PMBus Shelf-Controller (PMC)

by Ralf

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PFC and THD Update
Rectifier and BBU transition

by Harry

BBU and Rectifier transition in fault cases
Current sharing between power shelves

by Lam

OPEN POSSIBILITIES.
Short refresh on ORV3 Spec

**Rectifier:**
- Input voltage range: 180V-305VAC
- Output power: 3000W
- Output voltage: 50V @ AC / 48V @ BBU
- Output current: 60A
- Holdup time: 20ms
- Efficiency: 97.5% pk / 96.5% @ full load
- Current share: Active + Voltage Droop
- Communication: I2C / MOD-Bus
- Size: 73mm x 40mm (1RU) x 520mm

**Shelf:**
- 6 Slots for PSU + 1 Slot for PMC
- Output power: (N+1) = 18000W / 15000W usable
- Output voltage: 50V @ AC / 48V @ BBU
- Output current: 300A nominal
- Output connector: 500A Barklip (BK500)
- Communication: Ethernet via PMC
- Size: 21" x 48mm (1OU) x 787mm
Holdup time during overload

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**Design 2** Requirements:

- 20ms Holdup @ 100% equals 60J
- 13,3ms Holdup @ 150% (9ms + 4ms)

After 10ms Output voltage drops to 48V to wake up Battery Backup Unit.

BBU timing requirement:
- 1ms for detection
- 2-3ms for rampup DC/DC ➔ Minimum 4ms

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OPEN POSSIBILITIES.
Dummy Load Box

**Dummy Load:**
- 8 x 500W TTV Loads (adjustable)
- Hot Swap Controller
- MCU controlled Fan Speed (adjustable)
- Input connector: 100A IT-Gear-Barklip
- Communication: N/A
- Size: 21” x 142mm (3OU) x 787mm
Dummy Load Box

Input 50V/48V

MOSFET x 4

IT-Gear-Barklip to Busbar

ADM1272

Hot Swap Controller

OV, UV, I_Limit

DC

12V

DC

3.3V

MCU

PWM x 8

Driver x 8

PWM x 8
45° Phase-Shifted

TTV Load

500W x 8

PWM

TACH (RPM)

48V Fan x 4

MOSFET x 8

Fan Speed Setting

Load Setting

2 Knobs at the front

50V/48V

45°
Dummy Load Box

Air flow direction

Heatsinks

Heatsink

TTV (Thermal Test Vehicle)

0.12 mm Gap for thermal grease

OPEN POSSIBILITIES.
**Last year:** Step 1 with PMC-Light + I2C-Box + Laptop GUI

**This year:** Step 2
PMC with openBMC & Redfish implementation

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**PMC**

**PMC & GUI (graphical user interface)**

**Step 1 – PC connection via COM controller**

**Step 2 – PMC with openBMC via Ethernet**

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**OPEN POSSIBILITIES.**
For more information & Prototypes

Contact: ralf.pieper@deltawww.com

ORV3 10U Power Shelf
ORV3 3000W Power Supply
ORV3 20U Power Shelf
ORV3 5000W Power Supply
Dummy Load
Advanced Energy
ORV3 3KW Measured Efficiency

* % Load based on 3000W full load; Efficiency measured with fan loss included
* Efficiency measured on PSU that can meet 20msec hold-up on all load conditions
# ORV3 3KW iTHD and PF Measurement Data

**iTHD**

<table>
<thead>
<tr>
<th>Load</th>
<th>iTHD@240 VAC</th>
<th>iTHD@277 VAC</th>
<th>Limit</th>
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</thead>
<tbody>
<tr>
<td>5%</td>
<td>22.271</td>
<td>35.713</td>
<td>15%</td>
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<tr>
<td>10%</td>
<td>4.709</td>
<td>9.712</td>
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<tr>
<td>15%</td>
<td>3.571</td>
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<td>20%</td>
<td>3.196</td>
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<td>10%</td>
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<td>30%</td>
<td>2.789</td>
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<tr>
<td>40%</td>
<td>2.631</td>
<td>2.671</td>
<td>5%</td>
</tr>
<tr>
<td>100%</td>
<td>2.269</td>
<td>2.148</td>
<td>5%</td>
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**PF**

<table>
<thead>
<tr>
<th>Load</th>
<th>PF@240VAC</th>
<th>PF@277VAC</th>
<th>Limit</th>
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</thead>
<tbody>
<tr>
<td>5%</td>
<td>0.7843</td>
<td>0.6876</td>
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<tr>
<td>10%</td>
<td>0.9495</td>
<td>0.9105</td>
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<tr>
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<tr>
<td>20%</td>
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<td>30%</td>
<td>0.9936</td>
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<td>40%</td>
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<tr>
<td>100%</td>
<td>0.9992</td>
<td>0.9987</td>
<td>0.98</td>
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iTHD and PF improvement is work in progress to meet the specs.
ORV3 Rectifier to BBU Transitions Definitions

For the load to transition or share from rectifier to BBU seamlessly, rectifier regulation would drop by 3V and maintain that level at minimum 4msec to trigger BBU to turn on and time to share.

There are two main conditions for rectifier to adjust from 51V to 48V:

Condition 1: During AC loss conditions
- Output will adjust if 66.6% of bulk energy is depleted

Condition 2: Over power/current conditions:
- Average power more than 3.3kW for 10s
- Average power more than 3.6kW for 100ms
- Repetitive pulse power more than the pulse power envelope specified (up to 150% load)
- Single pulse power more than holdup time at the overload condition (up to 150% load)
ORV3 Rectifier adjusts from 51V to 48V – AC Loss @100% load

- AC loss (100% load); time before drop – 11.6msec
- AC loss (100% load); remaining time @48V – 13.9msec

CH1: Ishare; CH2: Vout; CH3: Iout; CH4: AC
ORV3 Rectifier adjusts from 51V to 48V – AC Loss @150% load

**AC loss (150% load); time before drop – 9msec**

**AC loss (150% load); remaining time @48V – 4.8msec**

CH1:Ishare; CH2:Vout; CH3: Iout; CH4:AC

CH1:Ishare; CH2:Vout; CH3: Iout; CH4:AC
ORV3 Rectifier adjusts from 51V to 48V – Output Over Power (Average Overload)

3.6KW average power overload for 100msec
(100% - 140% dynamic load)
Recovers back to 51V after 10sec

3.3kW average power overload for 10sec
(100% - 120% dynamic load)
Recovers back to 51V after 10sec

CH1:Ishare; CH2:Vout; CH3: Iout; CH4:AC

CH1:Ishare; CH2:Vout; CH3: Iout; CH4:AC
ORV3 Rectifier adjusts from 51V to 48V – Output Over Power (Repetitive/Envelope Pulse Overload)

10-110% Step Load (Adjusts to 48V after the step load exceeds specified pulse power envelope; shuts down after persistent overload then recovers after 10sec)

10-110% Step Load (Short step load pulse exceeds specified pulse power envelope, no shutdown after reducing load <5msec, stays at 48V for 10sec before recovering back to 51V)

CH1: Ishare; CH2: Vout; CH3: Iout; CH4: AC

CH1: Ishare; CH2: Vout; CH3: Iout; CH4: AC
ORV3 Rectifier adjusts from 51V to 48V – Output Over Power (Single pulse overload)

100-110% Step load (load exceeds the hold up time for the overload condition adjusts output to 48V then shuts down after a persistent overload then recovers after 10sec)

100-110% Step load (load exceeds the hold up time for the overload condition adjusts output to 48V and reduce load to maintain output at 48V before recovering back to 51V after 10sec)

CH1: Ishare; CH2: Vout; CH3: Iout; CH4: AC
ORV3 Rectifier to BBU transition – AC Loss

<table>
<thead>
<tr>
<th>1PSU: 1BBU 100% load @ AC loss; time before drop 11msec</th>
<th>Time remaining for share between PSU and BBU is 25msec</th>
</tr>
</thead>
</table>

CH1: Vout; CH2: PSU Ishare; CH3: AC; CH4: BBU Ishare

CH1: Vout; CH2: PSU Ishare; CH3: AC; CH4: BBU Ishare
ORV3 Rectifier to BBU Transition – Overload

1PSU: 1BBU Single envelope pulse overload 50% - 115%; PSU adjusted to share load with BBU

Load share between PSU and BBU for 10sec after adjust then PSU adjusted back to 51V

CH1: Vout; CH2: PSU Ishare; CH3: Iout; CH4: BBU Ishare
For more information, please contact: Harry.Soin@aei.com
For more Information & Prototypes

Please contact: Harry.Soin@aei.com
ORV3 Rectifier to BBU Transitions in Fault Cases

Transition between PSU to Battery backup is facilitated by PSU lowering its output voltage into the output voltage range of BBU.

Whenever PSU is about to shutdown, it will bring its output voltage down 3V to allow BBU a chance to support load.

Line loss: reduce output by 3V during holdup time. Holdup time varies linearly with load level.

Overload:

Situation: one input phase is lost, 4 remaining PSUs supply 15kW load and go into overload condition

Maintain output until overload accumulation reaches shutdown timings

Output voltage is reduced by 3V and continues for the next 10mS to allow BBU to pick up the load

Overtemperature: drop output voltage 3V for 20mS before shutdown
Power Transition Between ORV3 PSU Power Shelf and BBS Line Loss

Power Shelf drops output 3V to trigger Battery shelf to start providing power
Power shelf and battery shelf share current by droop mode during transition time

Power Shelf to Battery Shelf

Battery Shelf to Power Shelf

Holdup time

50A/div

50mS/div

OPEN POSSIBILITIES.
ORV3 Rectifier to BBU Transitions in Fault Cases

120% overload on the remaining 4 PSUs

At the end of overload duration, PSUs lower output by 3 V to signal transferring load to Battery Backup

Battery Shelf supports load

One phase of 3-phase input fails causing loss of 2 PSUs
BBU Charging Power Allocation

BBU has programmable max charging current to apportion power between load and battery charging.

Waveform of 2 BBUs in shelf charging batteries (total 6 BBUs in shelf)

- Charging at 5A max
- Charging current change rate: at 50mA/s
- 51V bus voltage
- 0A reference

BBU receives command to charge at 3A max
BBU receives command to charge at 1A max
BBU SOH Testing with Constant Current Discharge

BBU can discharge at constant current during SOH test for precise measurement of battery health status.

Start SOH testing: BBU raises its output voltage to provide constant 30A to load.

Load changes cause output bus change. BBU makes adjustment to continue providing 30A discharge.

Output Voltage 10V/div
More Power in a Rack: Current Sharing Between Power Shelves

Power shelves can share current via both droop and active share bus method to increase power of a rack. Active current share bus can be access thru front analog RJ45 connector. Accuracy between PSUs in different shelves is better than 2%

<table>
<thead>
<tr>
<th></th>
<th>PSU_1</th>
<th>PSU_2</th>
<th>PSU_3</th>
<th>PSU_4</th>
<th>PSU_5</th>
<th>PSU_6</th>
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<tbody>
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<td>61.07</td>
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More Power in a Rack: Current Sharing Between Power Shelves

Without active current share signal, two power shelves can share thru droop with more error between two shelves.

<table>
<thead>
<tr>
<th>Current Sharing with Droop Only</th>
<th>PSU_1</th>
<th>PSU_2</th>
<th>PSU_3</th>
<th>PSU_4</th>
<th>PSU_5</th>
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<tr>
<td>shelf 1</td>
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<td>shelf 1</td>
<td>shelf 2</td>
<td>shelf 1</td>
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<tr>
<td>120A</td>
<td>9.31</td>
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<td>59.87</td>
<td>58.98</td>
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</tbody>
</table>
For more information & Prototypes

Contact: sam.ye@liteon.com

OPEN POSSIBILITIES.
Call to Action

• Get in touch with us to receive latest information about the ORV3 power shelves

• Start testing the ORV3 Power Shelves by yourself! Samples / Prototypes are available!

• Give feedback of your findings to help improving the project in future
Thank you!
Open Discussion
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