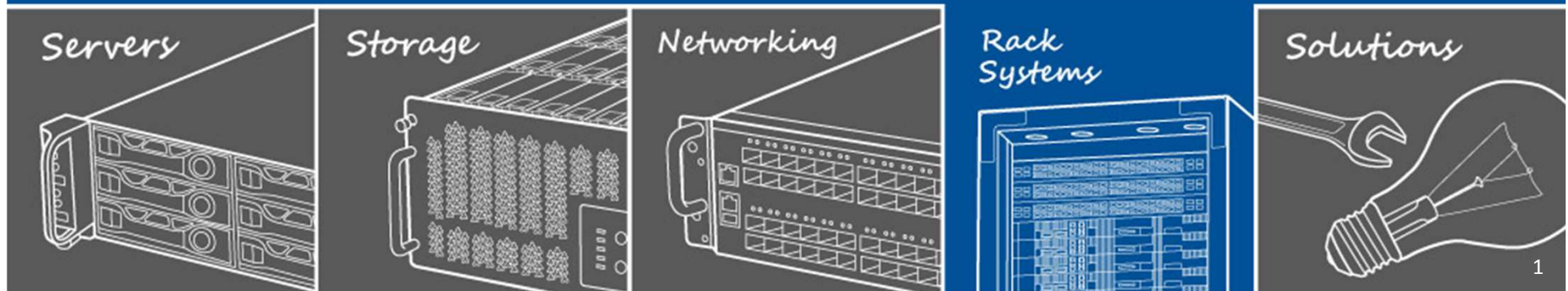


QCT Rack Systems-Power Backup Solution

Prepare by CCBU A2D Power Team
2015/05/06



Rackgo X



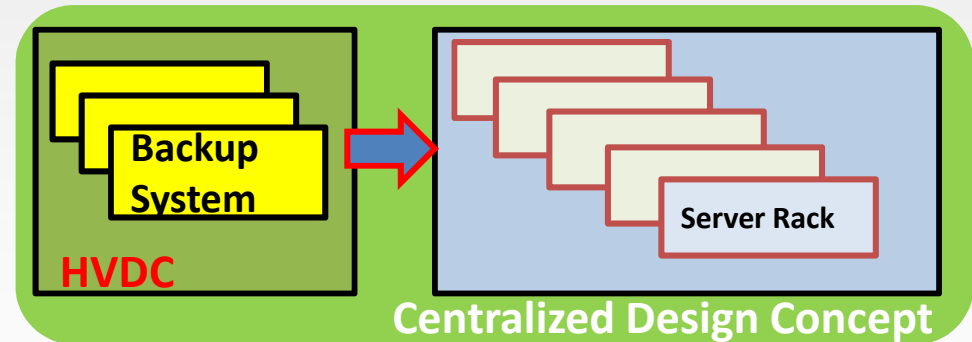
Quanta
www.QuantaQCT.com

- ◆ Rack solution that integrates Quanta's servers, storage and TOR switches inspired by Open Compute Project (OCP) standard
- ◆ Designed for
 - ✓ Capital efficiency
 - ✓ Vanity-free design eliminates excessive features that do not contribute to overall performance
 - ✓ Operational efficiency
 - ✓ Energy efficiency
 - ✓ Cooling efficiency
 - ✓ High serviceability: tool-less repair and cold-aisle operation
 - ✓ Easy maintenance: vanity-free design provides high MTBF
 - ✓ Manageability
 - ✓ High compute & storage density
 - ✓ Scalability
 - ✓ Flexibility
- ◆ Delivering the highest level of efficiency required by hyperscale datacenters such as Facebook

Backup System Deployment Strategy in Data Center

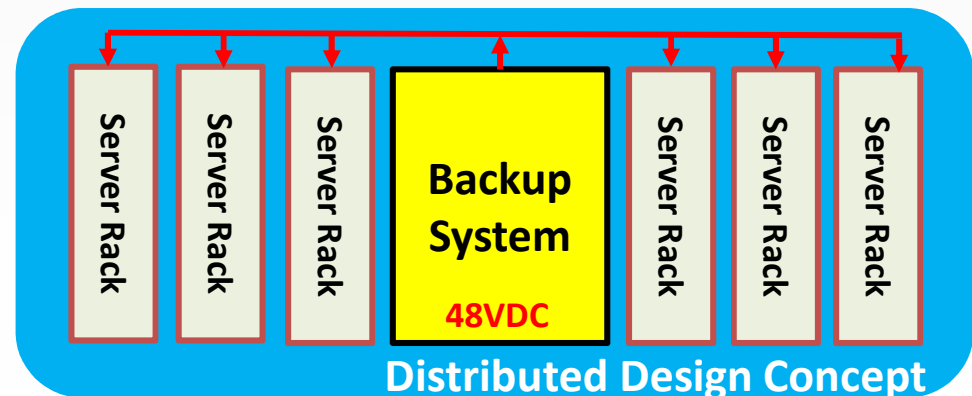
Centralized Design Concept:

- HVDC and traditional AC UPS are suitable for this approach
- Backup system maintenance and management are simplified
- Higher risk level of shut down for backup system



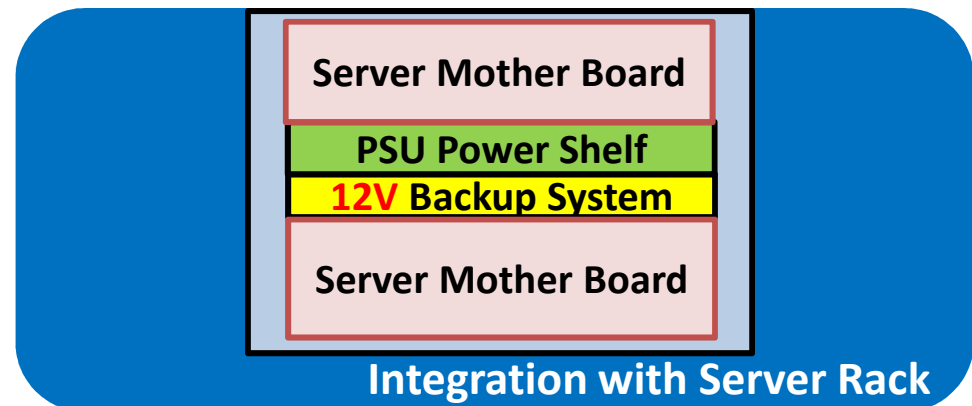
Distributed Design Concept :

- 48VDC and 12VDC are suitable for this approach
- Limits impact of module failure to a enclosure
- High risk level of shut down for backup system



Integration with Server Rack :

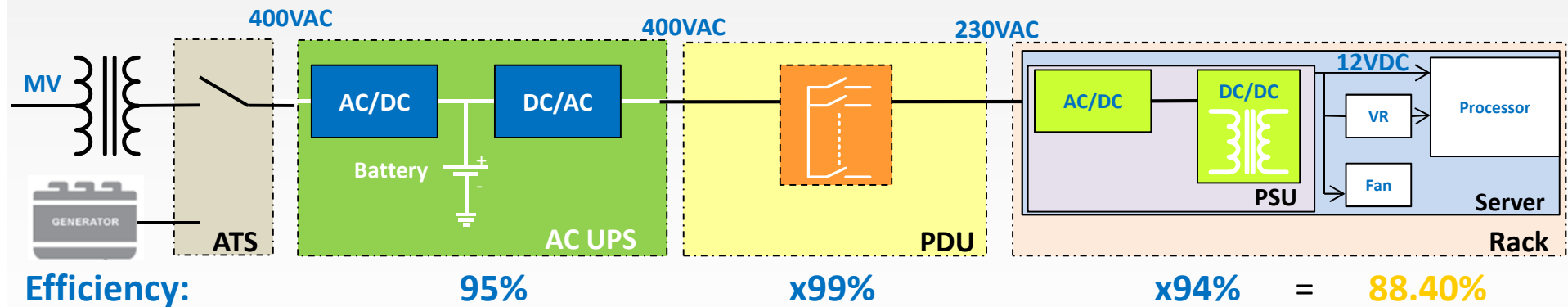
- 48VDC and 12VDC are suitable for this approach
- BBU modularity design for easy maintenance
- Least risk level of shut down for backup system



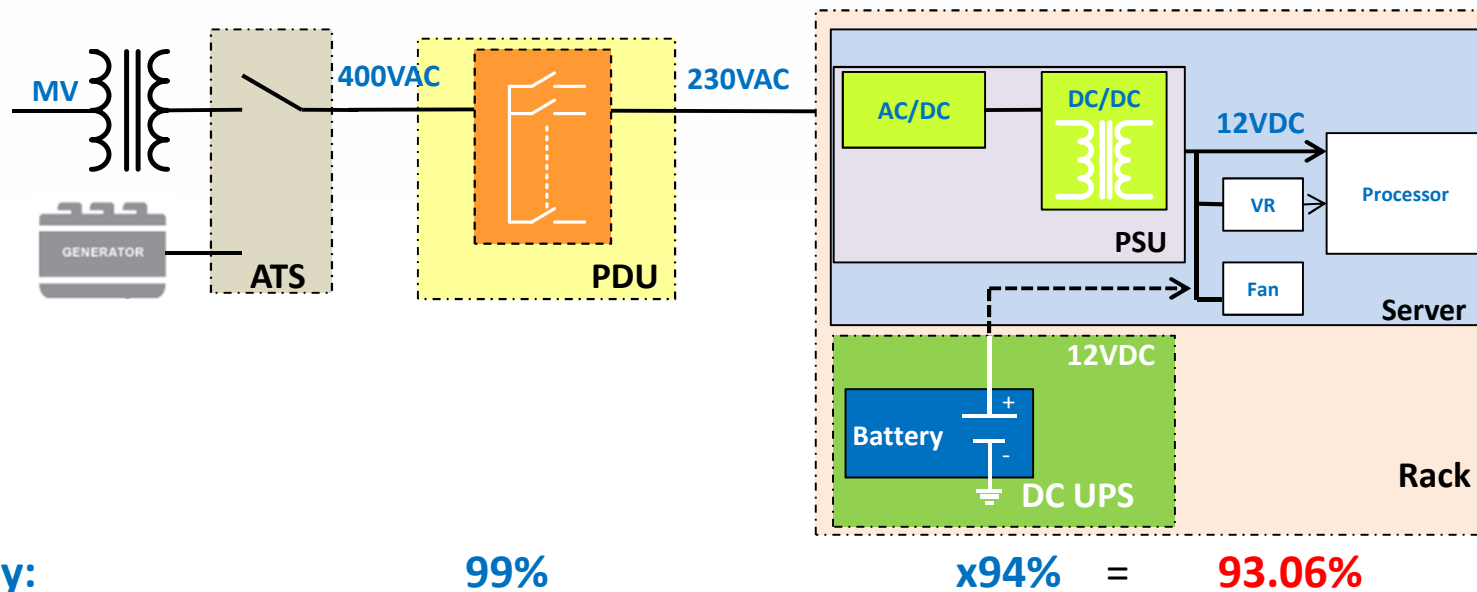
An Improved Power Architecture for High-Efficiency, High-Density, Low-Risk Data Centers

Data Center Power Architecture -An Improved Power Solution

◆ The typical data center power flow



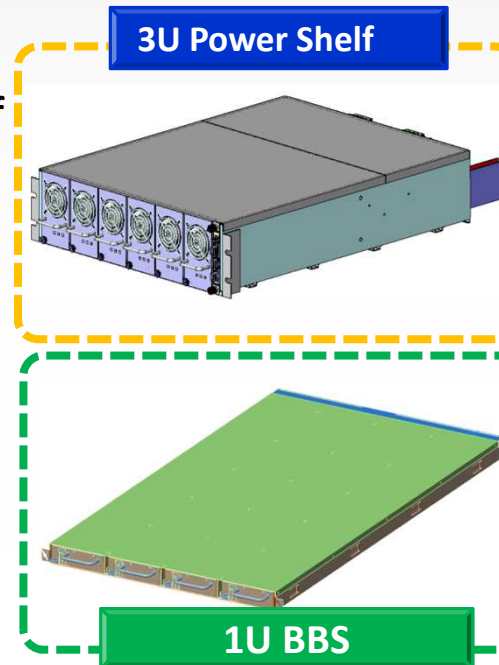
◆ Integrated 12VDC Back-up Solution



Efficiency:

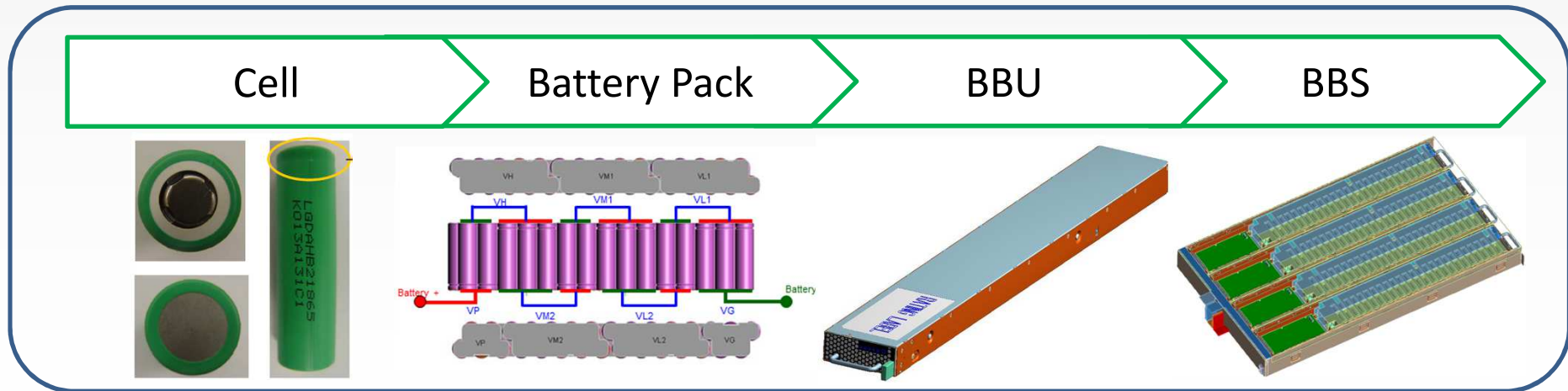
QCT Rack Systems-Power Backup Solution

- ◆ Dual inputs - AC Wye/ Delta three phase source or HVDC
 - ◆ 6 slots for plug in PSU modules
 - PSU – Power Supply module, 12.5V output, 2.5KW max
 - ◆ 1 slots for plug in RMC module
 - ◆ Up to 12.5KW redundant power per shelf
 - ◆ Support Battery Backup System
-
- ◆ 1U High-density modular design
 - ◆ 14KW/12.7VDC high power density Backup solution
 - ◆ High capacity Li-Battery with 3 minutes discharge time
 - ◆ Fully integrated with standard power shelf and bus-bar architecture
 - ◆ Hot-Pluggable BBU module for better serviceability



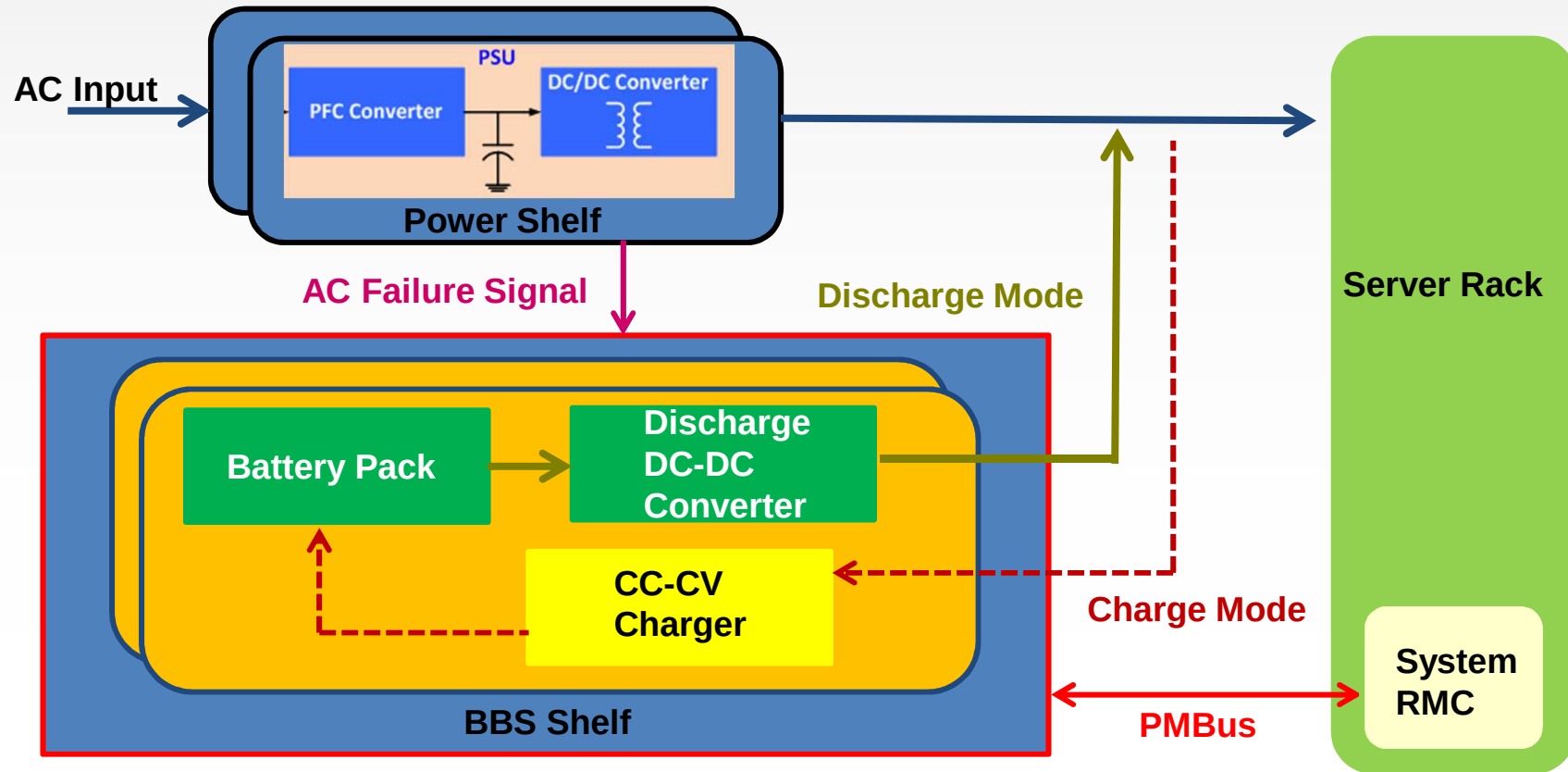
Power Backup Solution – BBU Architecture

- BBU needs high reliability to meet system requirements same as IT device does
(Communication, high efficiency converter and highly accurate capacity prediction algorithm)
- Also it should provide high power discharge capacity

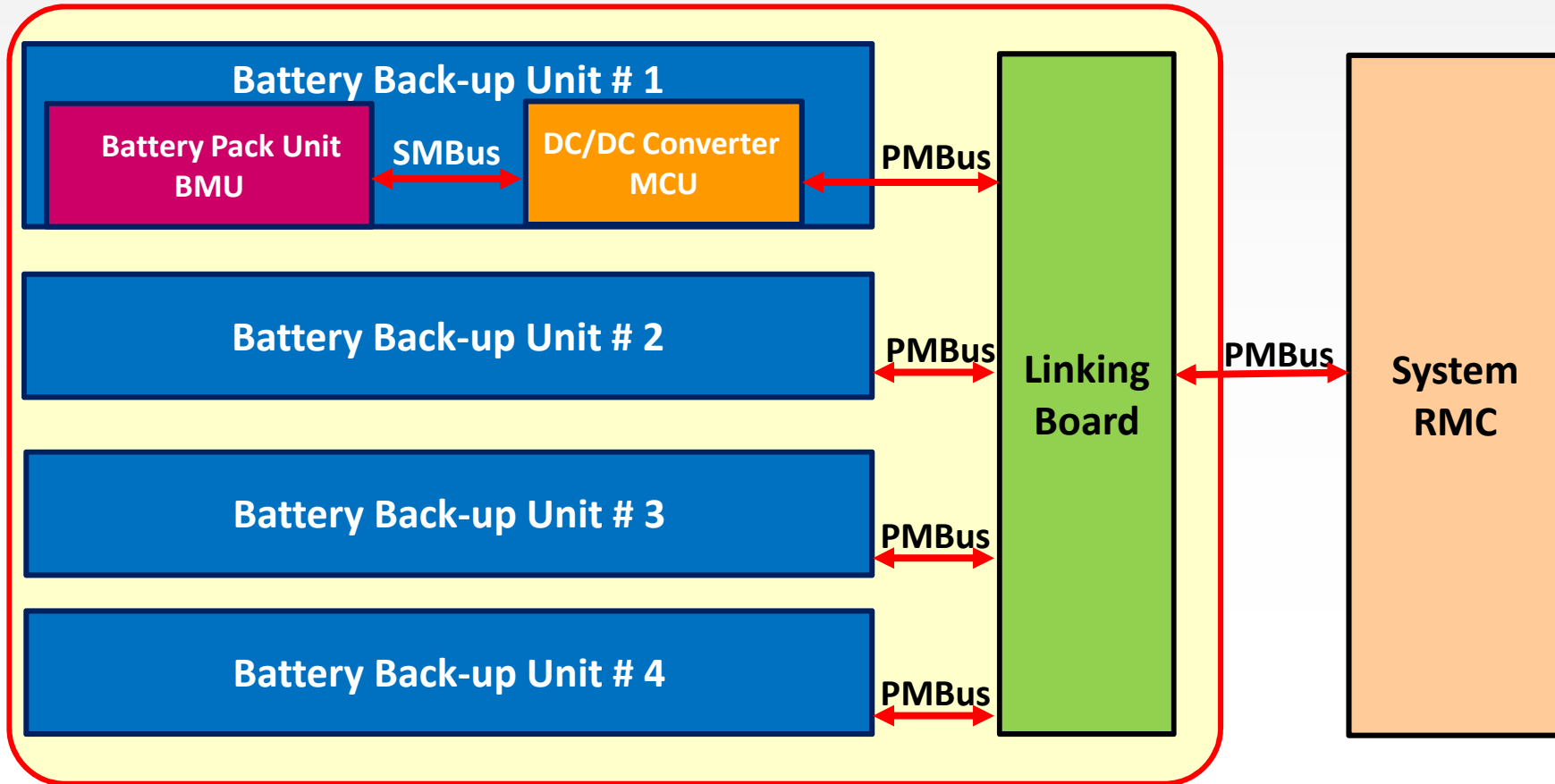


Composition	Cell	Cell Assembly BMU, Fuel Gauge	Charging/ Regulation Converter	1U & 2U ...
Basic Requirement	High drain	OVP,UVP,OTP ,Low IR, Cell balancing	Optimized Heat Flow, BMU-BMS-system communication	Bus-bar configuration
Additional Requirement	Hong battery cell life	High accuracy fuel gauge	High efficiency converter, Hot swap, fire wall	Power Management & Control

Power Backup Solution – BBS Operational Principle



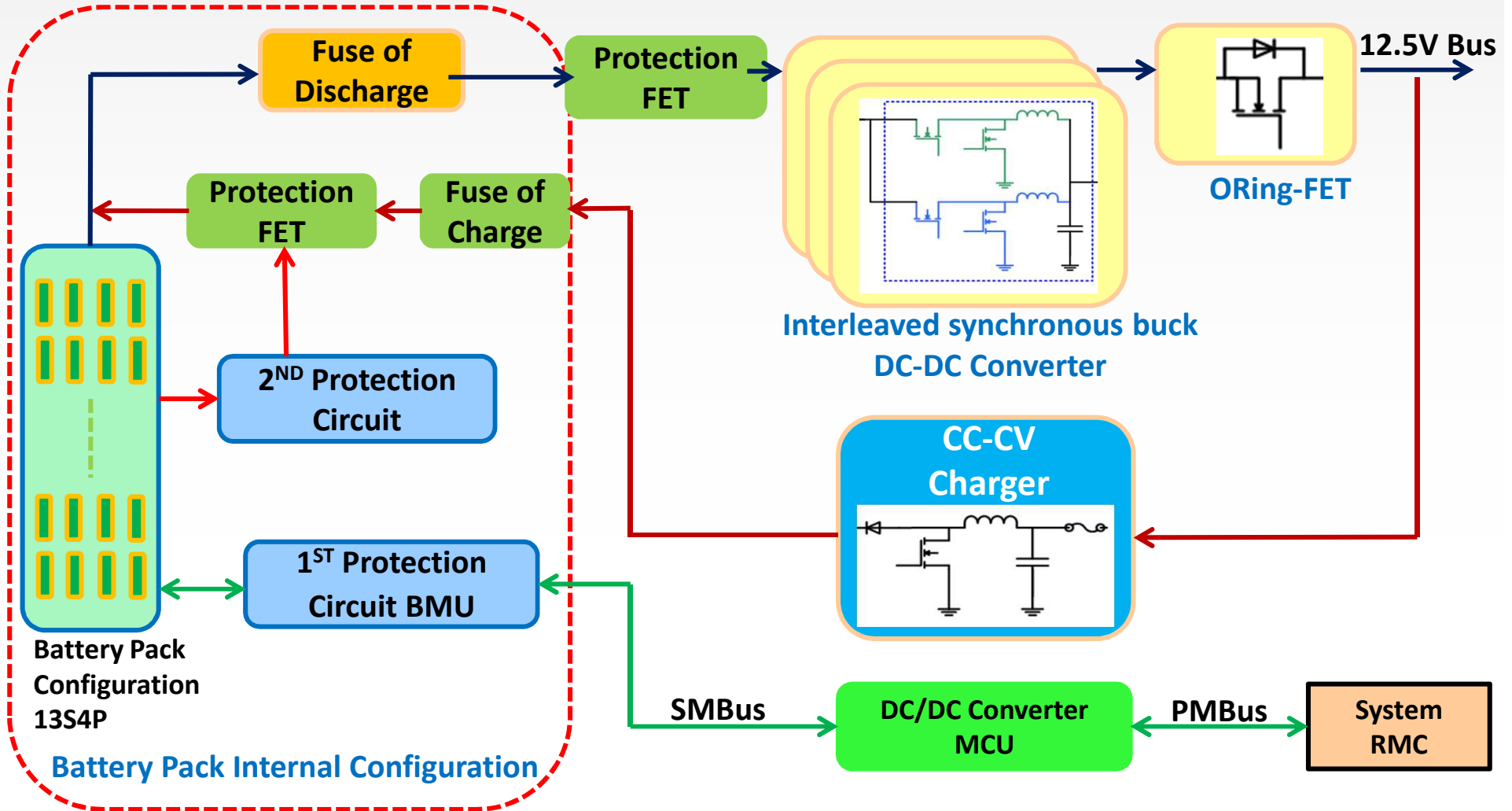
Power Backup Solution – BBS Communication Interface



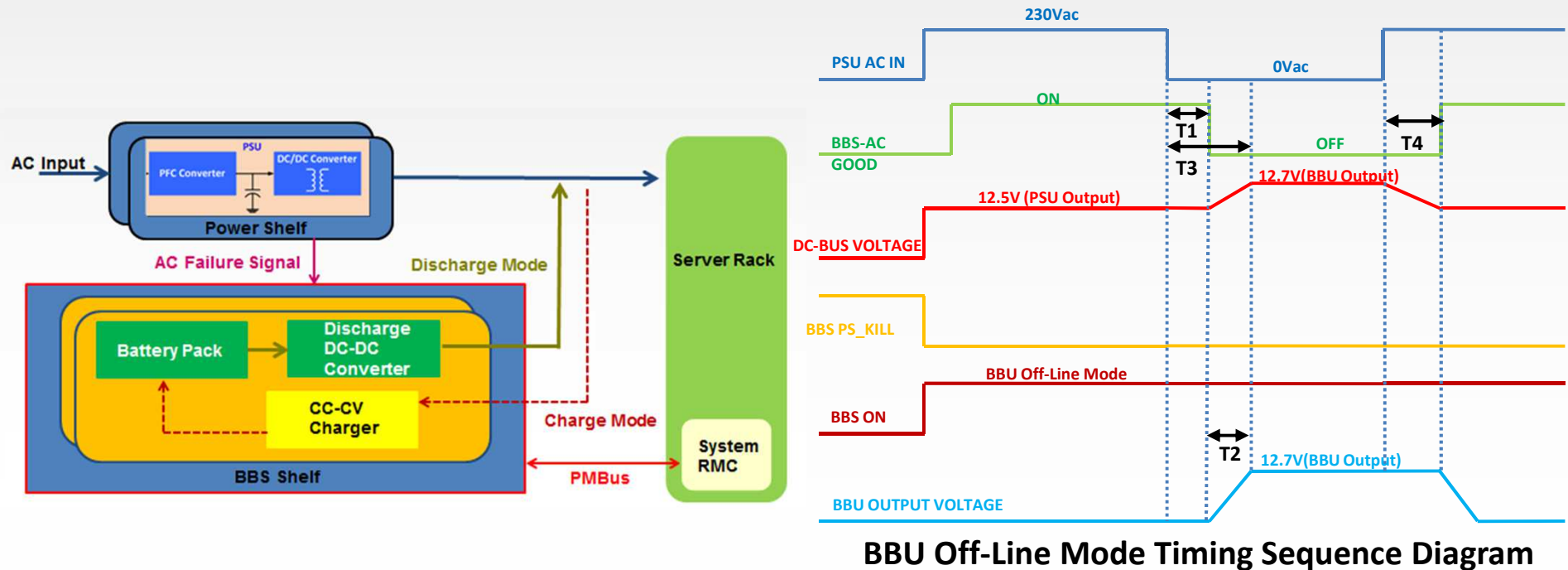
SMBus: System Management Bus

PMBus: Power Management Bus
RMC: Remote Monitor Controller

Power Backup Solution – BBU Functional Block Diagram

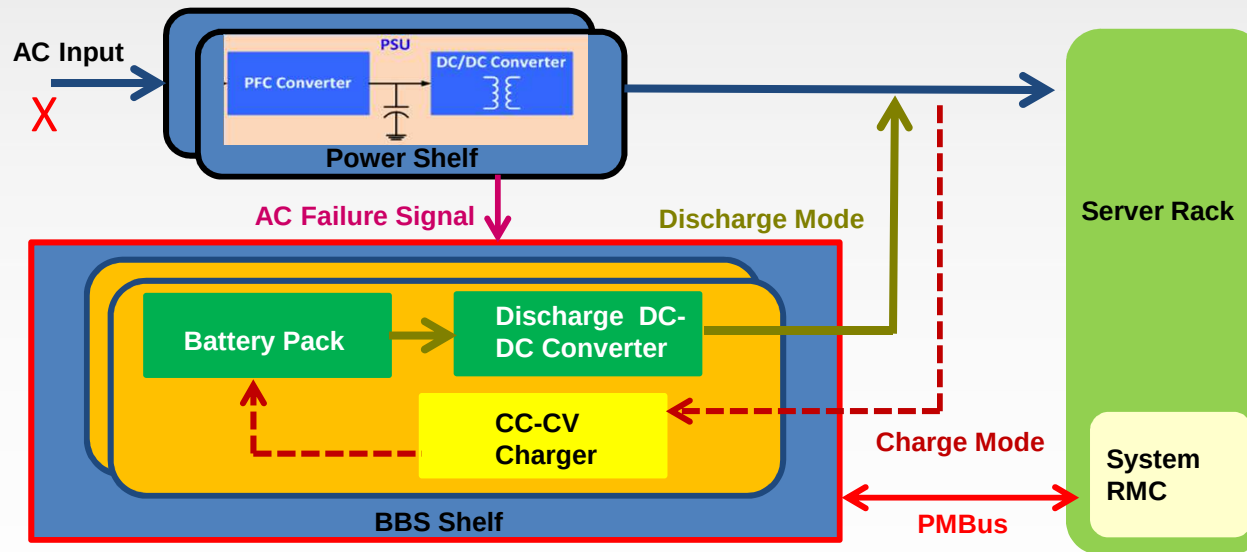
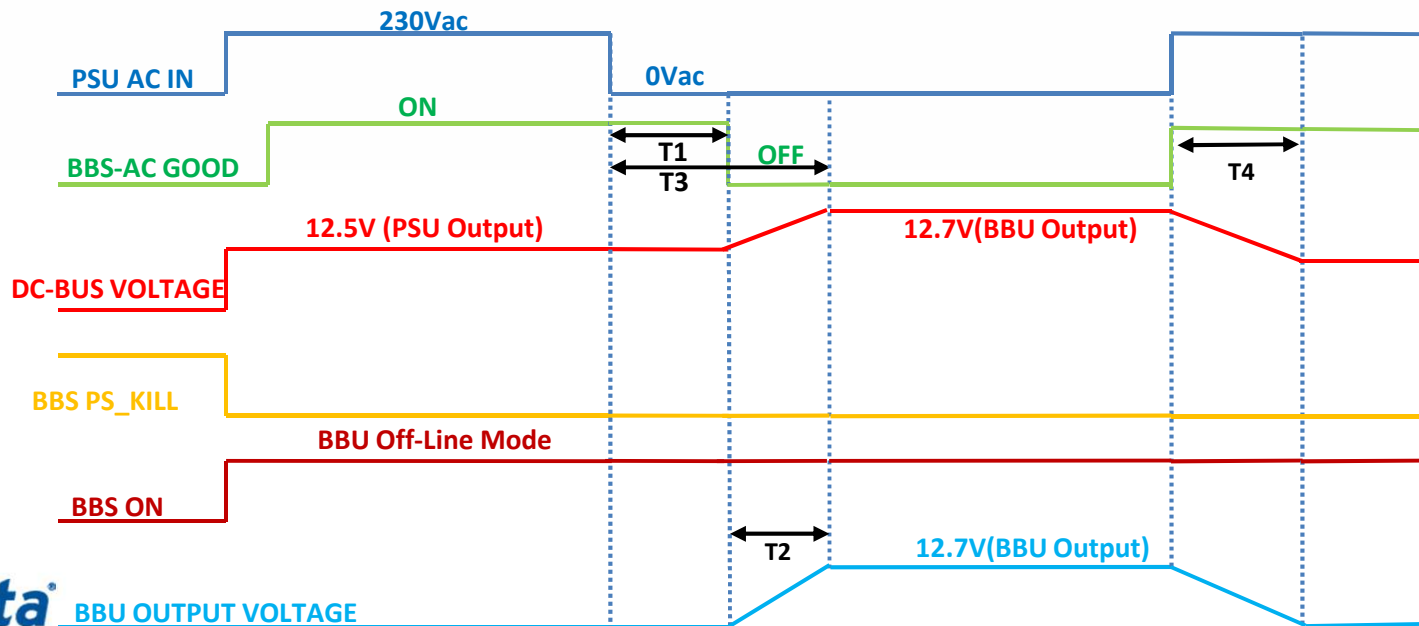


Power Backup Solution – BBS Off-Line Mode Operational Principle

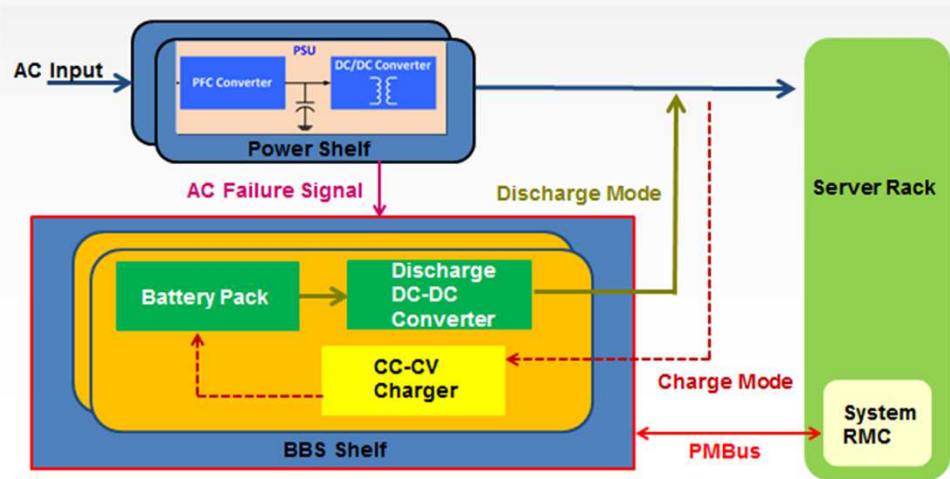
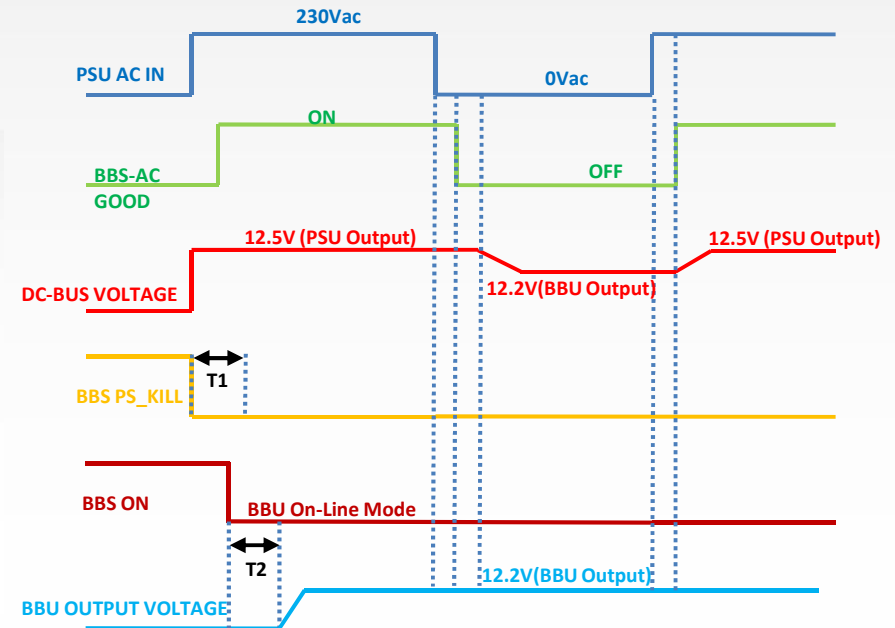


- ❖ Mainly AC-DC PSU is keep in “ON” status ; backup system is keep in “OFF” status at normal condition to achieve higher system efficiency requirement.
- ❖ The backup system will start working at AC-DC PSU loss input power within reasonable switch time.
- ❖ Total efficiency is great than On-Line Mode configuration.
- ❖ Operation and Control method is complex during AC outage.
- ❖ Need to longer hold-up time to cover the output smooth transfer.

Power Backup Solution – BBS Off-Line Mode Operational Principle



Power Backup Solution – BBS On-Line Mode Operational Principle



BBU On-Line Mode Timing Sequence Diagram

- ❖ The backup system will be switched to On-Line Mode automatically once communication loop with BMC is loss .
- ❖ Mainly AC-DC PSU is keep in “ON” status ; backup system is keep in “ON” status too at abnormal condition to achieve higher backup capacity requirement.

Power Backup Solution – BBS Specification

Specification for Discharge Mode:

- ◆ Output Voltage Range : 12.7VDC @ Off-Line Mode control
- ◆ Max. Output Power : 14KW @ 3minimum discharge time
- ◆ Max. Ripple and Noise : < 240mV p-p
- ◆ Dynamic Load Regulation: +/- 5% at $\Delta I=100\%$ condition
- ◆ Current Share Capacity: Active current sharing with +/- 5% accuracy at 20%~100% load
- ◆ Switching time (AC failed to BBS available): 5ms for Off-Line Mode control
- ◆ Protections: Battery Over discharge ; Over Current ; Over Temperature; Under Temperature
- ◆ Ambient Temperature: 10 deg C ~ 35 deg C (max. output power)

Power Backup Solution – BBS Specification

Specification for Charge Loop:

- ◆ Input Voltage Range : 12.5VDC
- ◆ Max. Charge Current : 4A
- ◆ Max. Charge Time : 6 Hours to 90% capacity
- ◆ Protections: Battery Over Voltage ; Over Current ; Over Temperature; Under Temperature

Specification for Others:

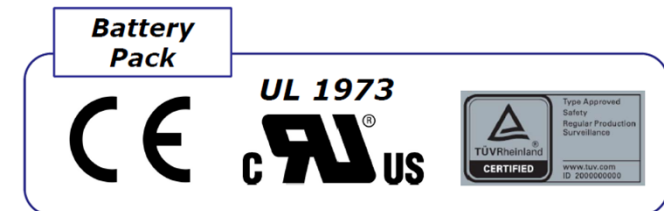
- ◆ Communication interface support PMBus Version 1.2 protocol
- ◆ Radiated/Conducted Emissions meet EN55022/CISPR 22 and FCC Part 15 Class A
- ◆ Safety meet : UN38.3 transport certification. UL 1973.



Battery cell level has qualified by safety UL1642 evaluations

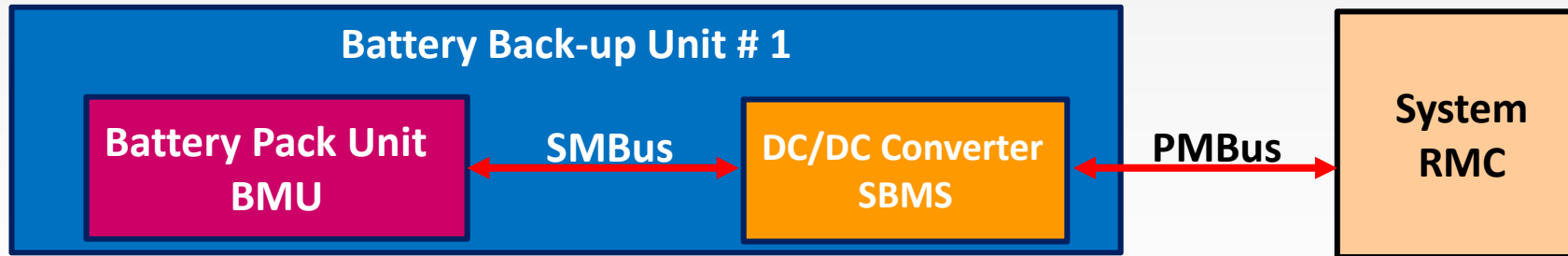


Transport meet UN manual of tests and criteria, part III, subsection 38.3.



Battery pack level has qualified by safety UL1973 evaluations

Smart Battery Manager System (SBMS)



Battery Pack BMU Function

- ◆ Battery Pack Status
- ◆ Cell/Pack Protections
- ◆ Battery Pack Information
- ◆ Remaining Capacity
- ◆ Cell Imbalance Detect
- ◆ Discharge Cycle Count

SBMS Function

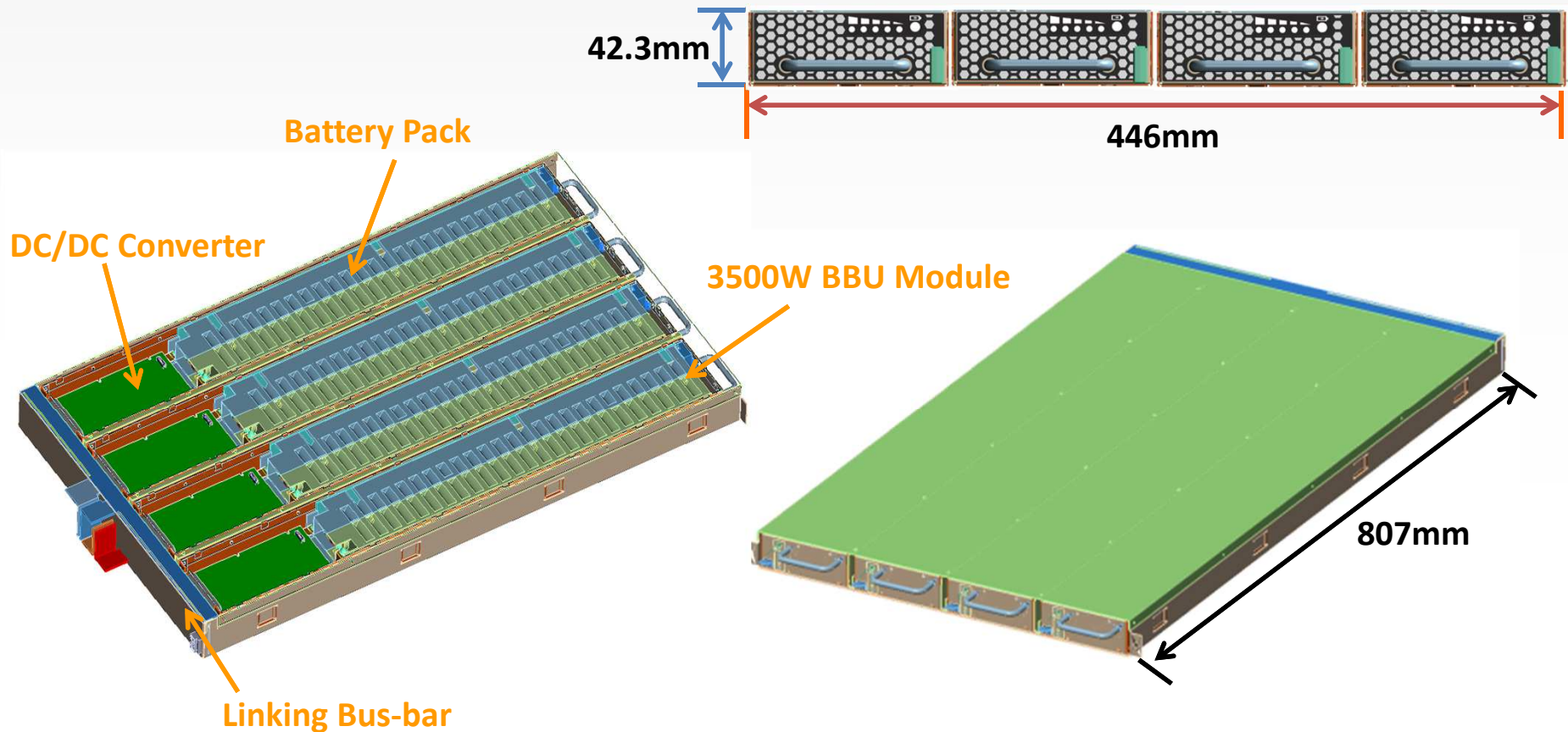
- Battery Back-up Unit Status
- DC/DC Converter Protections
- Discharge/Charging Information
- Charging voltage Compensation
- Battery Life Extension

RMC Function

- On-Line Status Monitor
- Battery Status of Health Check
- Battery firmware bootloader

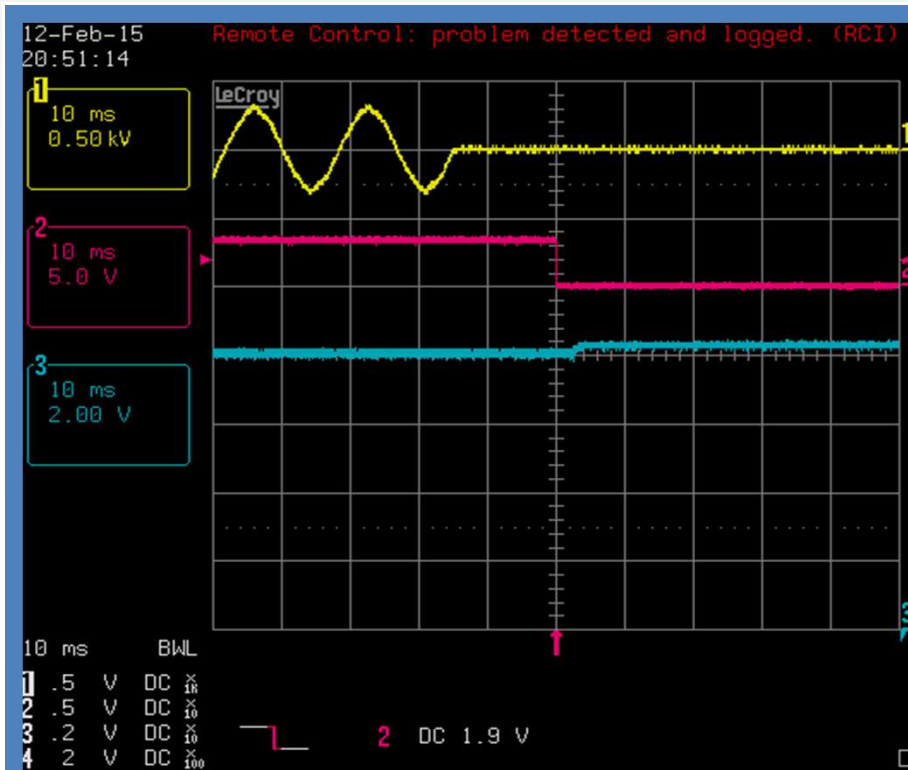
Battery Backup System Dimensions

Dimensions: 446mm(W) x 42.3(H) x 807 mm (L)

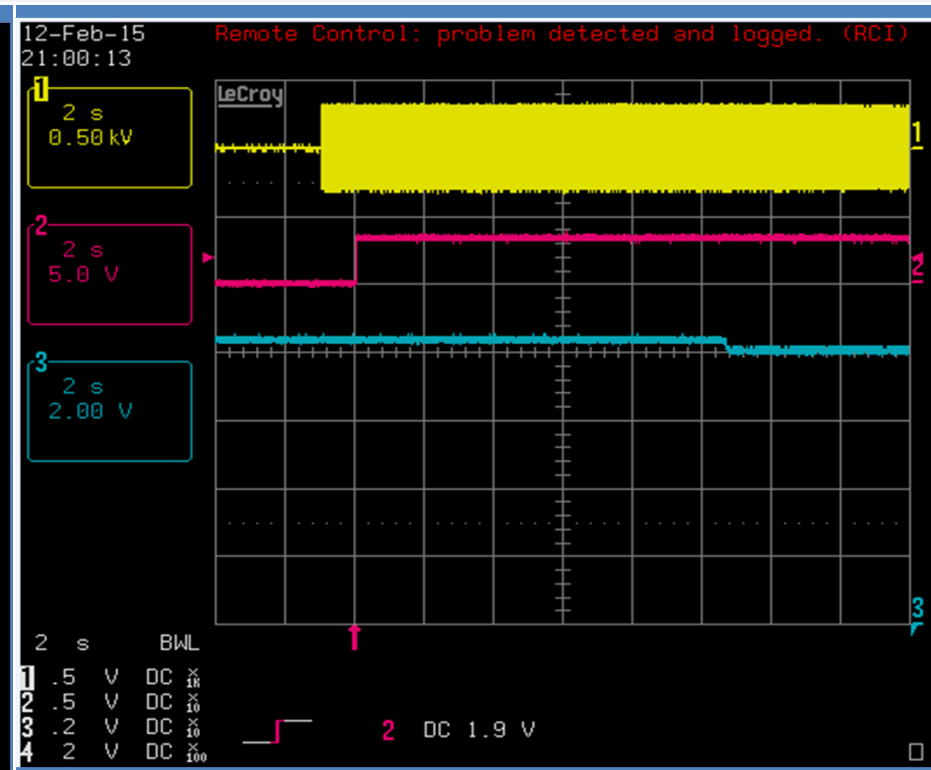


14KW Backup System Dimensions

Functional Test Result – BBU Off-Line Mode Operation

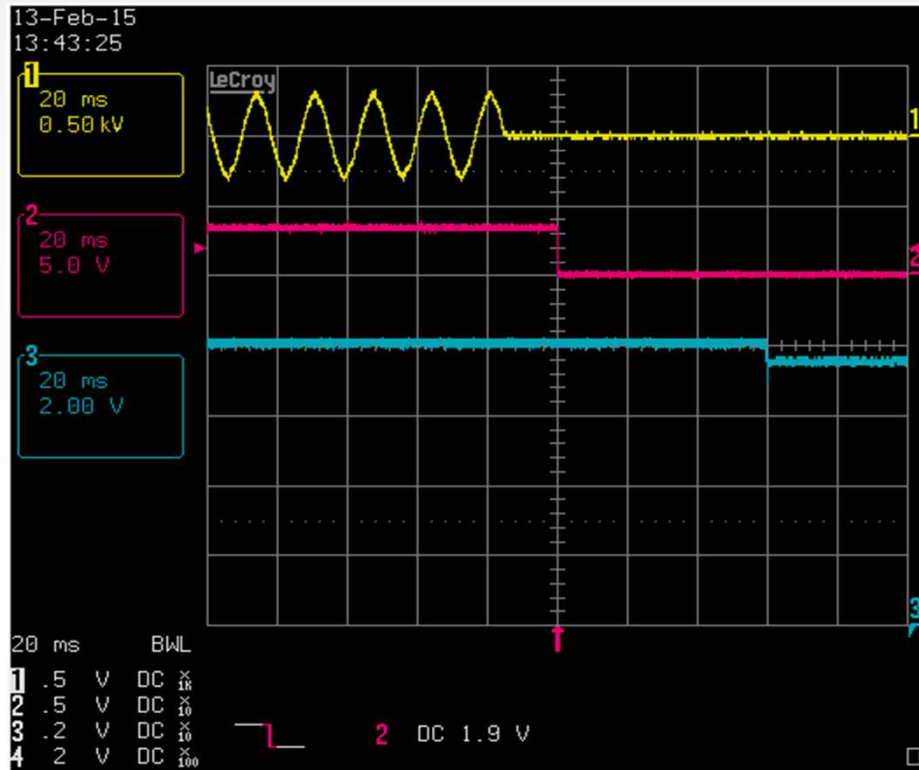


CH1: AC Power ON → AC Power OFF
CH2: AC fail signal
CH3: 12VBUS(offset 4.5V)

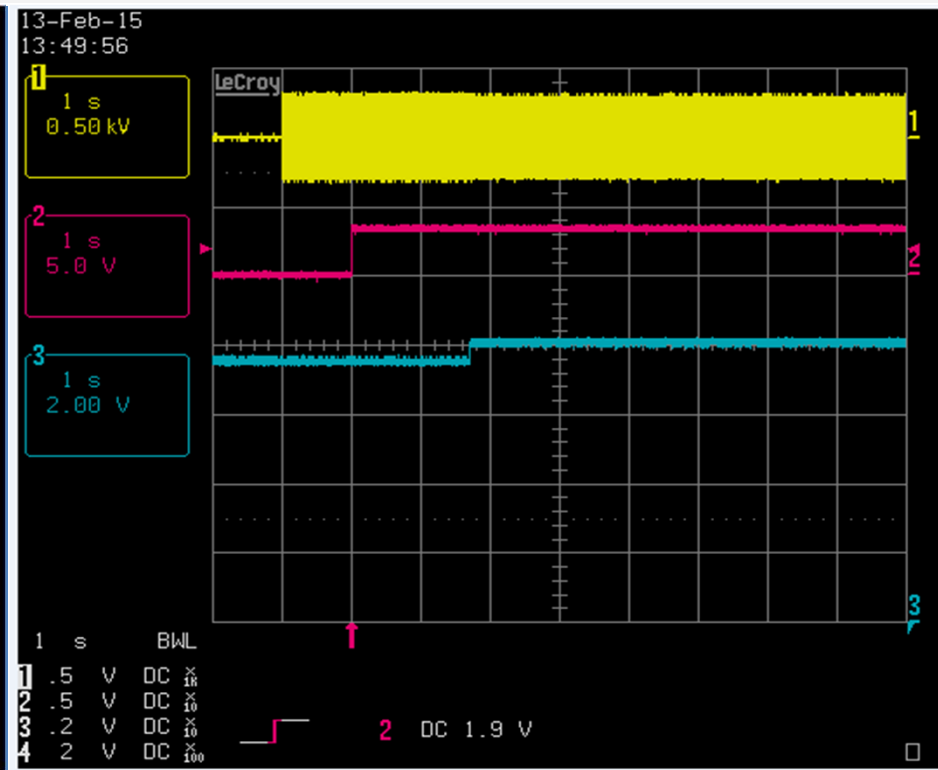


CH1: AC Power OFF → AC Power ON
CH2: AC fail signal
CH3: 12VBUS(offset 4.5V)

Functional Test Result – BBU On-Line Mode Operation



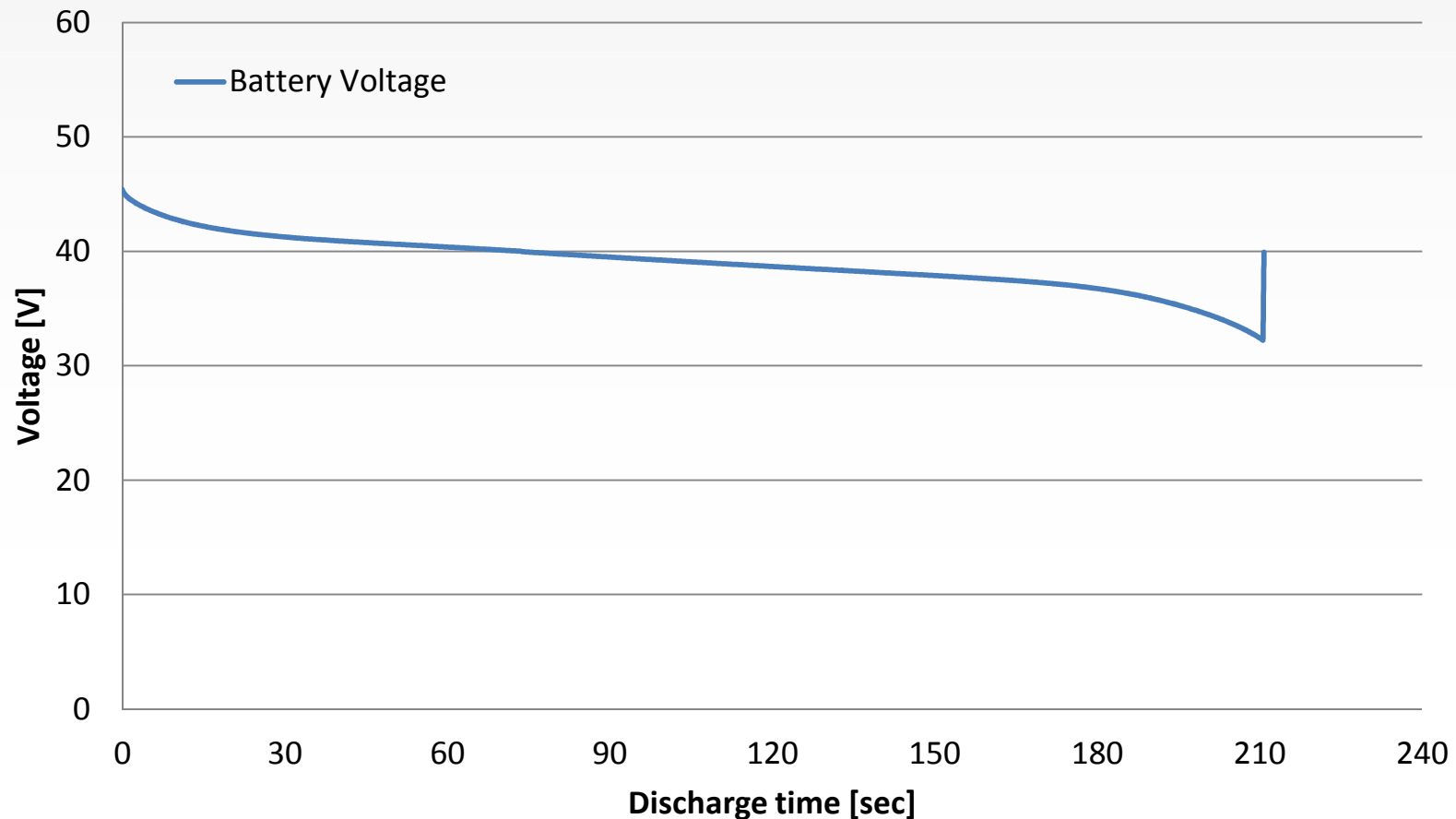
CH1: AC Power ON → AC Power OFF
CH2: AC fail signal
CH3: 12VBUS(offset 4.5V)



CH1: AC Power OFF → AC Power ON
CH2: AC fail signal
CH3: 12VBUS(offset 4.5V)

Functional Test Result – BBU Discharge Time

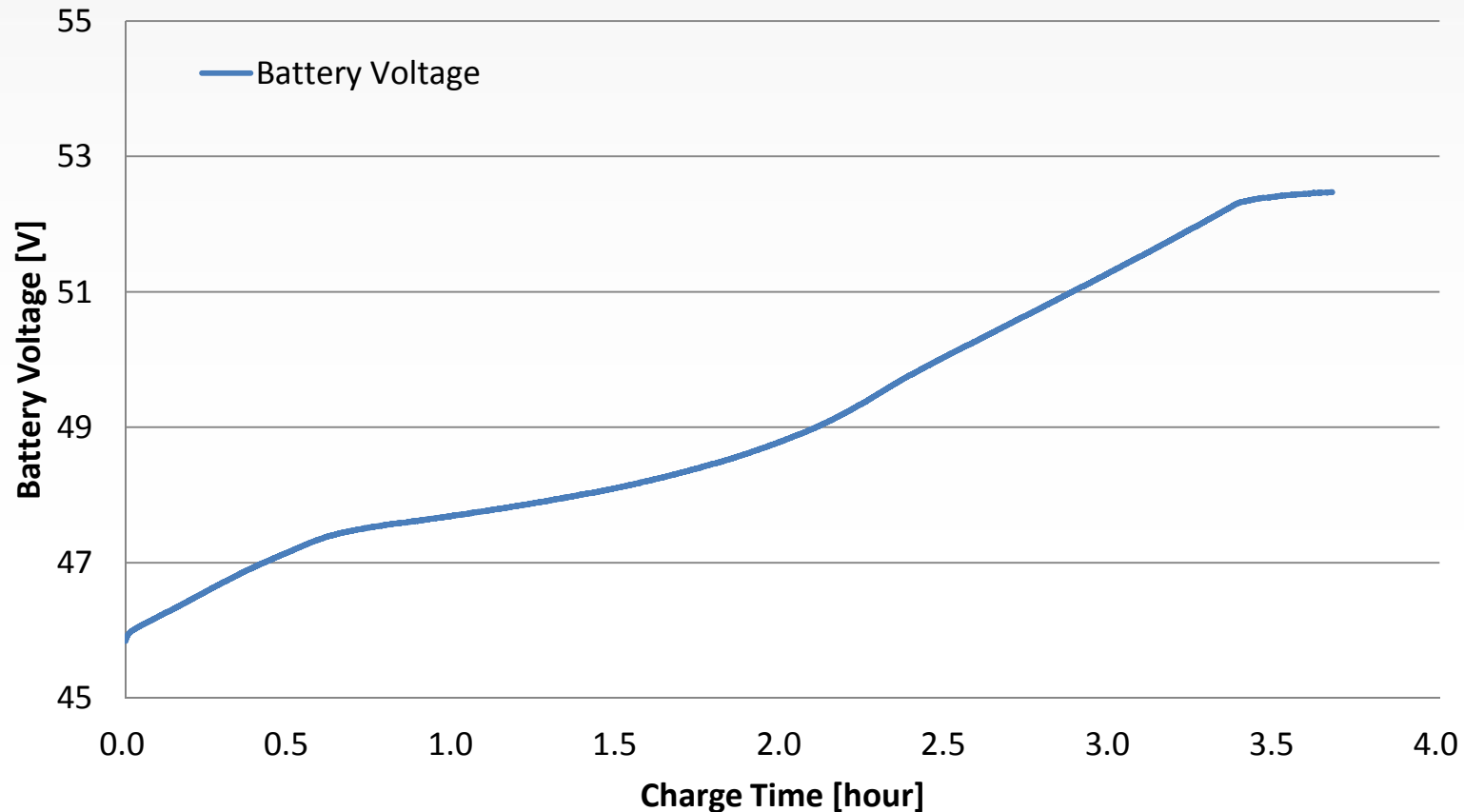
◆ Battery Discharge Time > 180 seconds.



Battery discharge curve @ Off-line mode with discharge power 3500W, Ta=25degC

Functional Test Result – BBU Charge Time

◆ Battery Charge Time < 4 hours.



Battery charge curve @ Off-line mode with charge current 1A, $T_a=25\text{degC}$

Functional Test Result – BBS Current Sharing Accuracy

◆ BBS Current Sharing Accuracy < +/- 5% tolerance

Load setting	Output Load Current	Total Output power	BBU_1			BBU_2			BBU_3			BBU_4		
			Output	Error		Output	Error		Output	Error		Output	Error	
				A	%		A	%		A	%		A	%
20%	233 A	2817 W	59.9A	1.7 A	2.9 %	56.4A	-1.9 A	-3.2 %	58.7A	0.4 A	0.7 %	58.0A	-0.2 A	-0.4 %
30%	347 A	4187 W	88.6A	1.9 A	2.1 %	84.3A	-2.5 A	-2.9 %	87.6A	0.9 A	1.0 %	86.5A	-0.2 A	-0.3 %
40%	462 A	5560 W	117.5A	2.0 A	1.7 %	112.8A	-2.7 A	-2.4 %	116.6A	1.1 A	0.9 %	115.2A	-0.3 A	-0.3 %
50%	582 A	6988 W	148.4A	2.9 A	2.0 %	142.5A	-3.0 A	-2.1 %	146.1A	0.6 A	0.4 %	145.1A	-0.4 A	-0.3 %
60%	697 A	8352 W	177.5A	3.2 A	1.8 %	170.9A	-3.3 A	-1.9 %	174.9A	0.6 A	0.3 %	173.8A	-0.4 A	-0.3 %
70%	817 A	9766 W	207.7A	3.4 A	1.7 %	200.7A	-3.6 A	-1.7 %	204.8A	0.6 A	0.3 %	203.8A	-0.4 A	-0.2 %
80%	932 A	11117 W	236.7A	3.7 A	1.6 %	229.2A	-3.8 A	-1.6 %	233.6A	0.6 A	0.2 %	232.6A	-0.4 A	-0.2 %
90%	1052 A	12516 W	267.1A	4.1 A	1.6 %	258.9A	-4.1 A	-1.6 %	263.6A	0.6 A	0.2 %	262.5A	-0.5 A	-0.2 %
100%	1172 A	13909 W	297.6A	4.6 A	1.6 %	288.5A	-4.5 A	-1.5 %	293.5A	0.5 A	0.2 %	292.4A	-0.6 A	-0.2 %

BBS Current Sharing Accuracy Table

Data Center OCP Architectures Comparison- Backup Power Solution



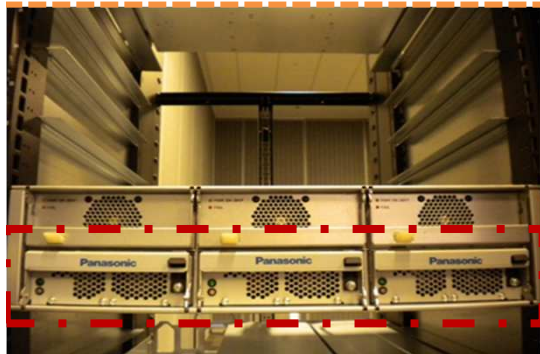
OpenRack V1

- ◆ 56.6KW or 85KW backup power can support six server racks.
- ◆ Battery cabinet provides around 90sec run time.
- ◆ 3x Rectifiers (AC-DC 54Vdc output) can charge batteries and also provide power to networking switch.
- ◆ High rate VRLA Battery



QCT Rackgo M

- Server Power Supply with or without Integrated Battery
- 1600W PSU with Battery Back-up Power
- Battery provides >45 sec run time
- 12x Li-Ion Batteries (6S2P)



OpenRack V2

- 3.6KW backup power @module
- 6.6KW@ power zone
- Support around 90sec run time.
- 2+1 Redundant design
- 52x Li-Ion Batteries (13S4P)
- 32.5~52Vdc output



QCT Rackgo X

- 3.5KW backup power @module
- 14KW@ power zone
- Support around 180sec run time.
- 52x Li-Ion Batteries (13S4P)
- 12.6Vdc output voltage

Q & A