LI-Ion Battery Solution for Datacenter

ESS 2017/Oct

Lithium Ion Battery for High Power UPS

Cell Business and Technology Transfer

Battery cell technology & manufacturing come from Mitsubishi

Press Information

April 18, 2014 No.1792

MHI to Sell Lithium-ion Rechargeable Battery Business Assets, Including Machinery, to Delta Electronics of Taiwan
– Management Resources to be Shifted to Energy Storage System Products –

2014/9/1 MHI to Sell Lithium-ion Rechargeable Battery Business Assets, Including Machinery, to Delta Electronics of Taiwan | Mitsubishi Heavy Industries, Ltd...

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HOME News Release MHI to Sell Lithium-ion Rechargeable Battery Business Assets, Including Machinery, to Delta Electronics of Taiwan

Press Information

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MHI to Sell Lithium-ion Rechargeable Battery Business Assets, Including Machinery, to Delta Electronics of Taiwan
– Management Resources to be Shifted to Energy Storage System Products –

Tokyo, April 18, 2014 - Mitsubishi Heavy Industries, Ltd. (MHI) has concluded an agreement with Delta Electronics, Inc., a leading manufacturer of electronic devices in Taiwan, under which MHI will sell Delta its business assets, including machinery, in lithium-ion rechargeable batteries. As a result MHI will shift its management resources into operations in energy storage system (ESS) products employing lithium-ion rechargeable batteries.

Delta Electronics is the core enterprise of the Taiwan-based Delta Group. The company undertakes operations encompassing a diverse lineup of electronic products including power and thermal management solutions, and as an enterprise of global scale it has approximately 200 facilities worldwide including production, sales and R&D functions.

ESS products today are expected to record sustained market growth ahead as core devices for achieving power network stabilization in tandem with the introduction of wind power, solar power and other renewable energies, and for adjusting power supply vis-à-vis demand in order to save energy.

The lithium-ion rechargeable batteries developed by MHI are light in weight, compact in size and high in reliability. The company boasts an abundant track record in this field, its batteries being widely used in diverse products ranging from electric buses to ESS products, including container-based systems. Following the sale, MHI will focus on expanding the market for ESS products.

Leveraging the new agreement, going forward MHI and Delta Electronics also plan to join forces in pursuing further development of the lithium-ion rechargeable battery business, including ESS products. At the same time, MHI will continue to work toward the realization of an ever more energy-efficient, low-carbon society through expanded adoption of stationary large-capacity ESS's, electric buses, etc.

About Delta Electronics, Inc.
The company founded in 1971, is the global leader in power and thermal management solutions, as well as a major source for industrial automation, data center, ICT components, displays and networks. As an energy-saving solutions provider, Delta's businesses encompass power electronics, energy management and smart green life. Delta is as an enterprise of global scale with approximately 200 facilities worldwide including production, sales and R&D functions.

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MHI: Mitsubishi Heavy Industries, Japan

Energy Storage Device Hierarchy

Battery System Information:

Installed Capability: 1.16MWh(Maximum)

Design Usable Capacity: 928KWh(80%)

System Voltage Range: 739.2VDC ~ 907.2VDC

Operation voltage range:

- Min – 739.2V (3.3V/cell@3Cdischarge_SOC10%)
  Max – 907.2V (4.05V/cell@1C Charge_SOC90%)

Battery storage container content:

- 40ft container
- Lithium battery(1.16MWh)
- BMS(Battery management system)
- FES(Fire extinguishing system)
- Electrical distribution panel
- HVAC
- System controller

Battery Container

Battery Rack

ESS content 28 racks (224S 28 P)
Energy: 1.16MWh (828V- 1400 Ah)

Rack content 16 battery module (224S1P)
Energy: 41.4KWh (828V-50Ah)

Battery module

Module content 14cell (14S1P)
Energy: 2.59KWh (51.8V-50Ah)

Battery Cell

P140 Cell
3.7V, 50Ah

Li-Ion Battery Solution for Datacenter

- Safety design
  Integrated Cell Monitor Unit(CMU)
  Integrated Battery Management Unit(BMU)
  predictability and manageability

- Longer Life

Assumption	VRLA	Li-ion
UPS Load	100%	100%
UPS Service Life	10 years	10 years
batteries refreshed before UPS life	Year 4 & 8	Not required

- Space Saving

- Less Weights

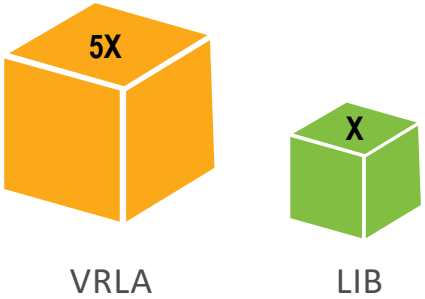
- Cooling cost saving.

- Reduced TCO
  capital cost/operational cost/
  Transportation cost/ Maintenance Cost.
  The li-ion battery solution has a 35% lower 10-year TCO than the VRLA solution.

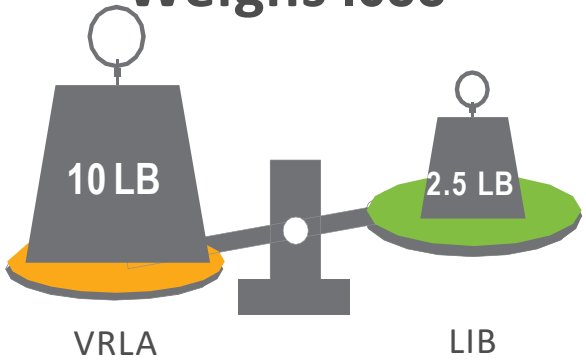
LI-Ion Battery Solution Advantages

LIBs can provide effective performance when compared to valve regulated acid battery (VRLA), savings begin to occur after the first comparable VRLA replacement cycle.

Saves space



Weighs less



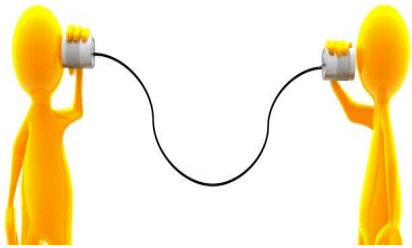
Modular & Scalable

Longer life

Saves cooling

Communication

Modbus / CAN



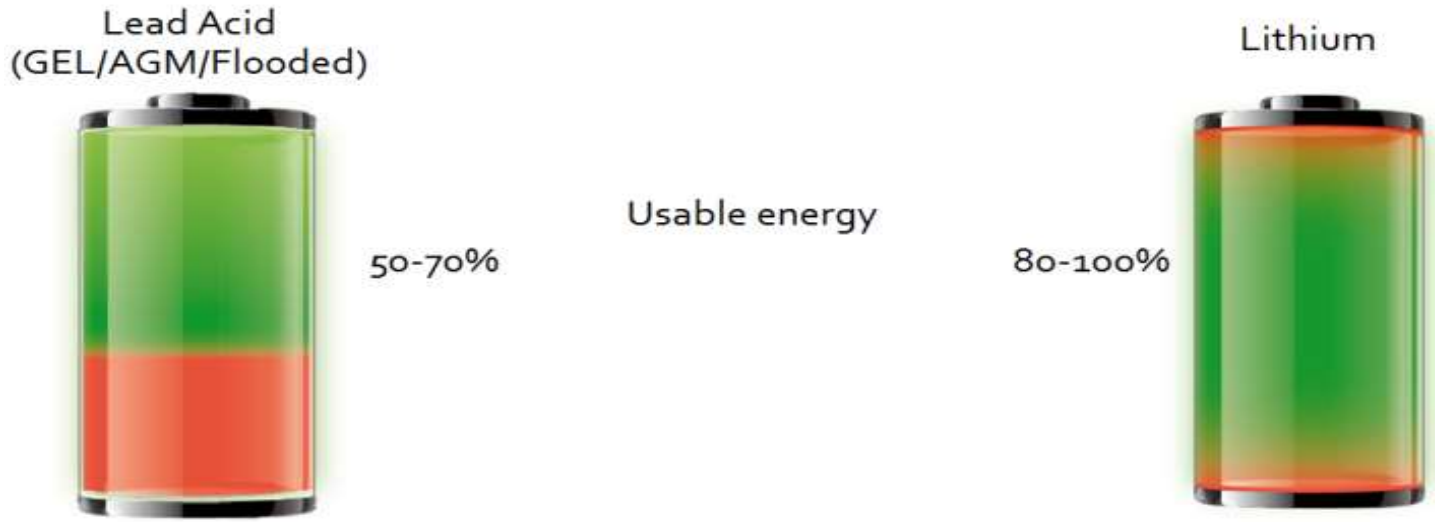
Turn Around Efficiency

Very Little Wasted Energy

Lead acid batteries are less efficient at storing power than lithium ion batteries. Lithium batteries charge at nearly 100% efficiency, compared to the 80% efficiency of most lead acid batteries.

Usable Capacity

Due to DOD limitations, VRLA battery is always designed at 50 - 60% DOD, whereas Li-Ion Battery can go up to 100%



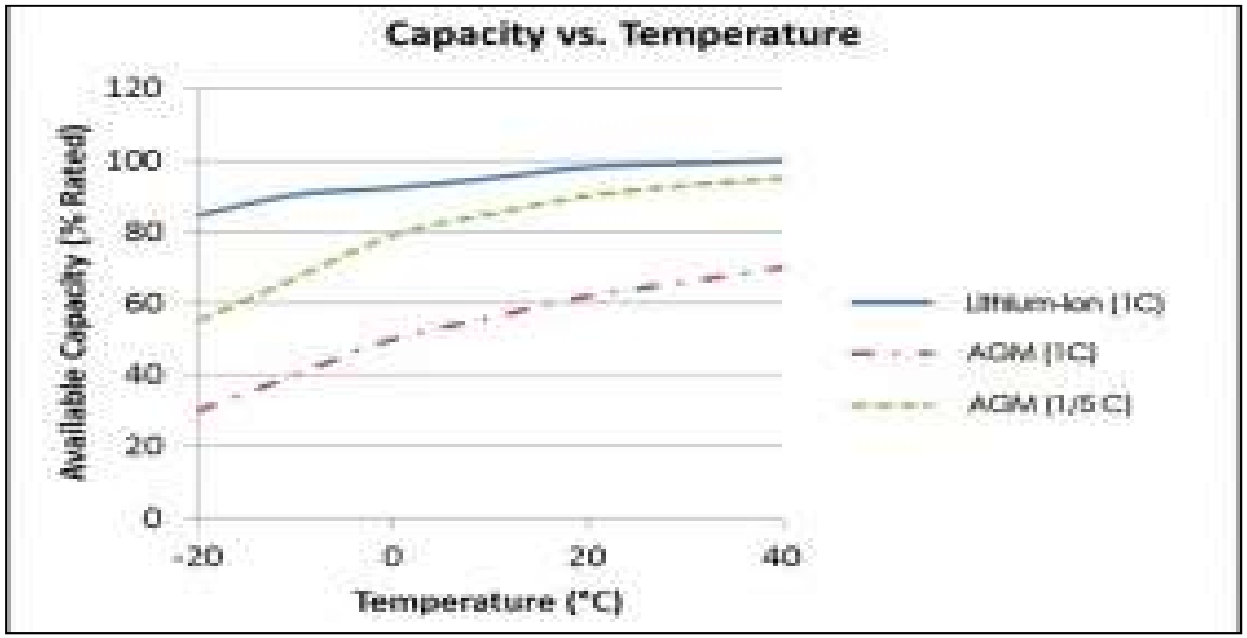
Float Charge

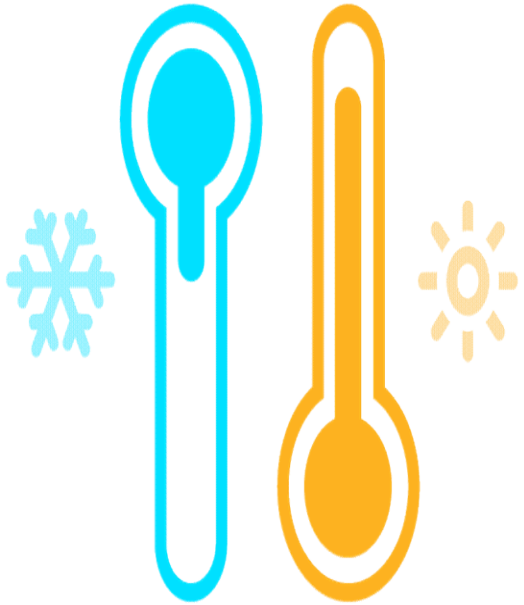
VRLA battery needs Float Charge vs Lithium which cut's off once fully charged

No Cooling Needed

Climate Resistance

- Lead Acid batteries are affected by and need Controlled Temperature environment
- Lithium-ion batteries are much more efficient at wide temperature range -20 to +45˚C.
- At -20˚C, a Lithium battery that delivers a 1C current (one times its capacity), can deliver more than 80% of its energy when the AGM battery will deliver 30% of its capacity. For harsh environments (hot and cold), Lithium-Ion is the technological choice.

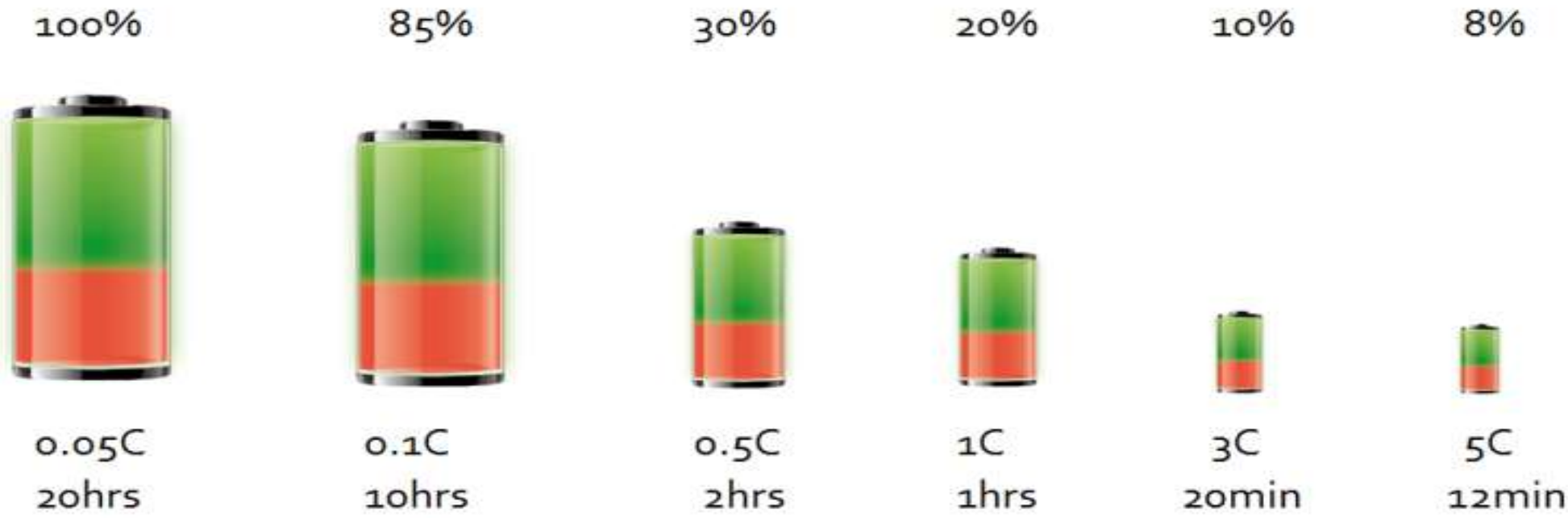




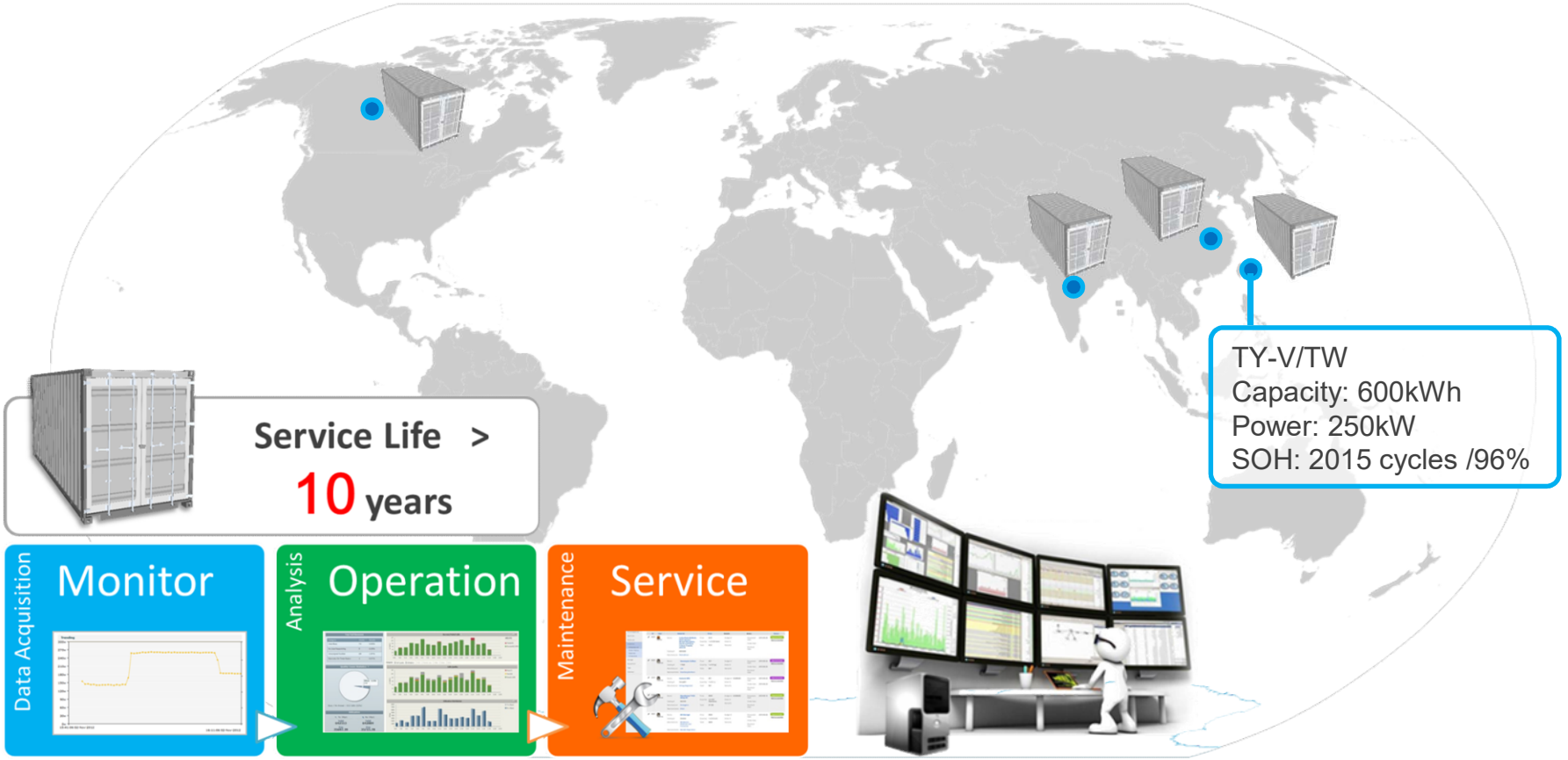
High C rate application

High “C” Rate of the Battery

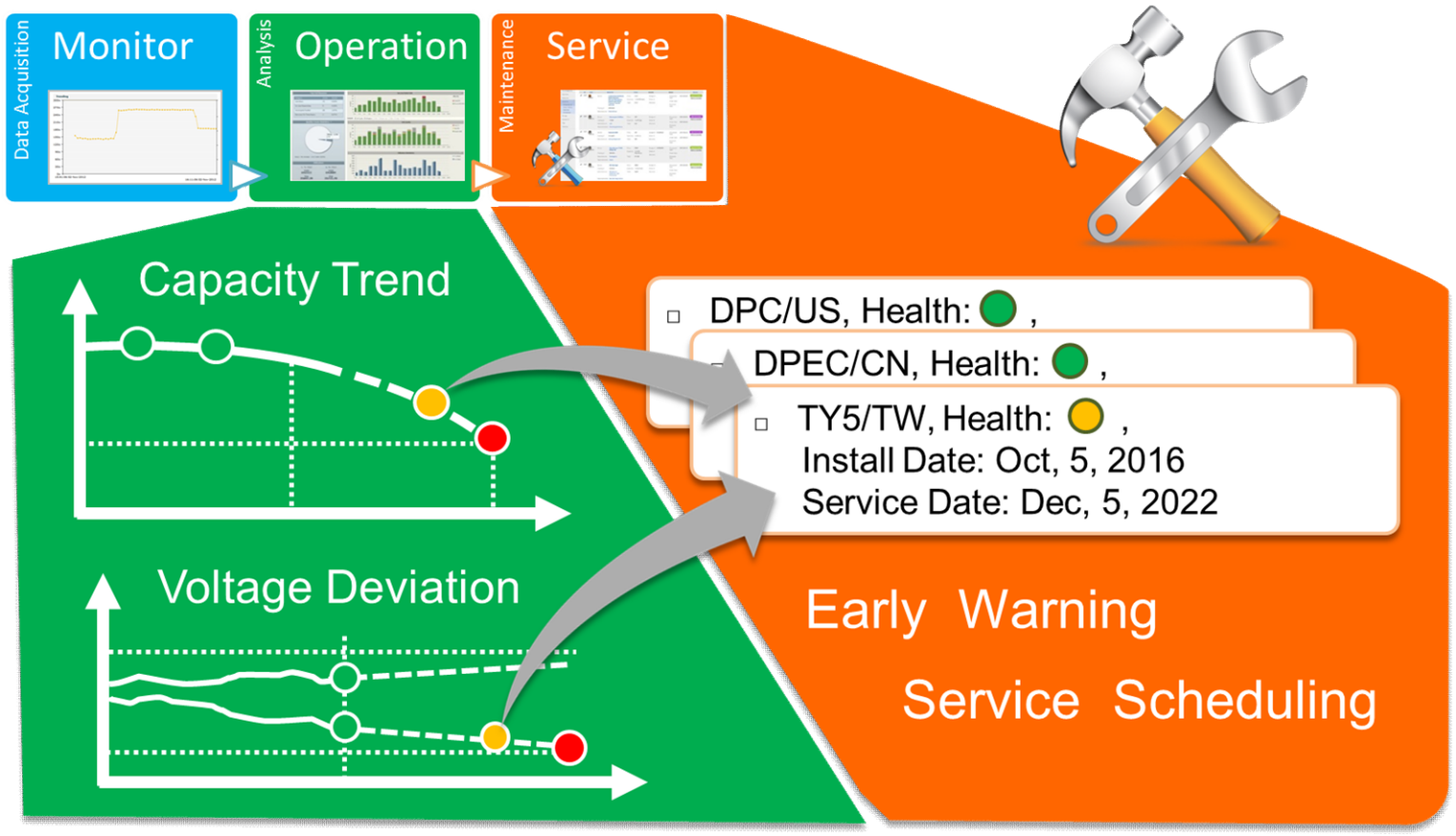
- Lead Acid batteries cannot be used at High C rates since its Cycle Life is affected
- Lithium-ion batteries are much efficient and can be easily used up to 6C continuous



Remote Sensing System



Prediction for Service



Green Eco Friendly Solution

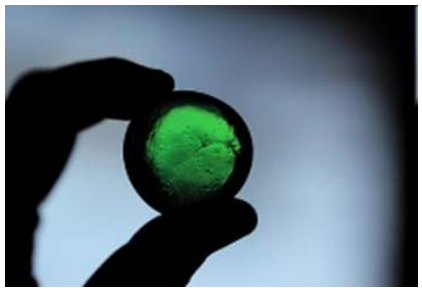
Go Green…

Save Energy….

Save Environment

Fully Recyclable

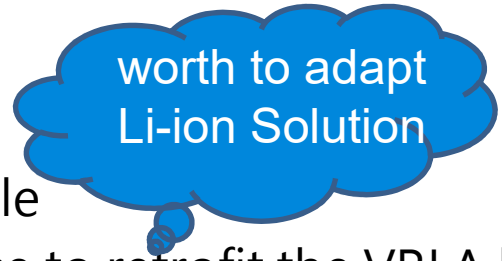
- Lead Free
- Plastic, Copper, Aluminium can all be recycled



Retrofit solution

Retrofit and new UPS applications

There are three possible scenarios when deciding
to retrofit the VRLA batteries or Li-ion Batteries of an existing UPS:



1. The UPS is operating in the early part of its lifecycle
   UPS generally less than 5 years old, it makes sense to retrofit the VRLA batteries with li-ion batteries

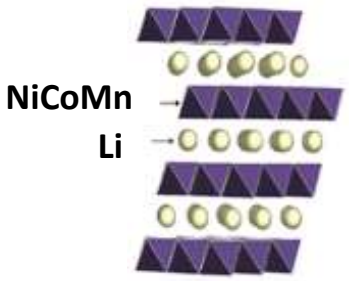
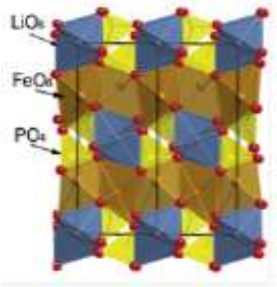
2. The UPS is operating near the middle of its lifecycle
   UPS generally 5-10 years old, it depends to refresh the VRLA batteries or Li-ion batteries.

3. The UPS is operating at the end of its lifecycle
   UPS generally 10 years old, it may makes sense to replace the entire UPS with a new UPS that uses li-ion batteries

NMC v.s. LPF v.s. VRLA

Battery chemistry nature

Delta Battery Chemistry

	($LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$, NMC)	($LiFePO_4$, LFP)
Mineral structure	 **Layer (2D)**	 **Olivine (3D)**
Working voltage	**3.6~3.7 V**	**3.2~3.3 V**
Theoretical capacity	**276 mAh/g**	**170 mAh/g**
Practical capacity	**150~170 mAh/g**	**140~160 mAh/g**
Conductivity	**10^{-3} S/cm**	**10^{-9} S/cm**
Low temp. (-20℃) retention rate	**>70%**	**40~70%**

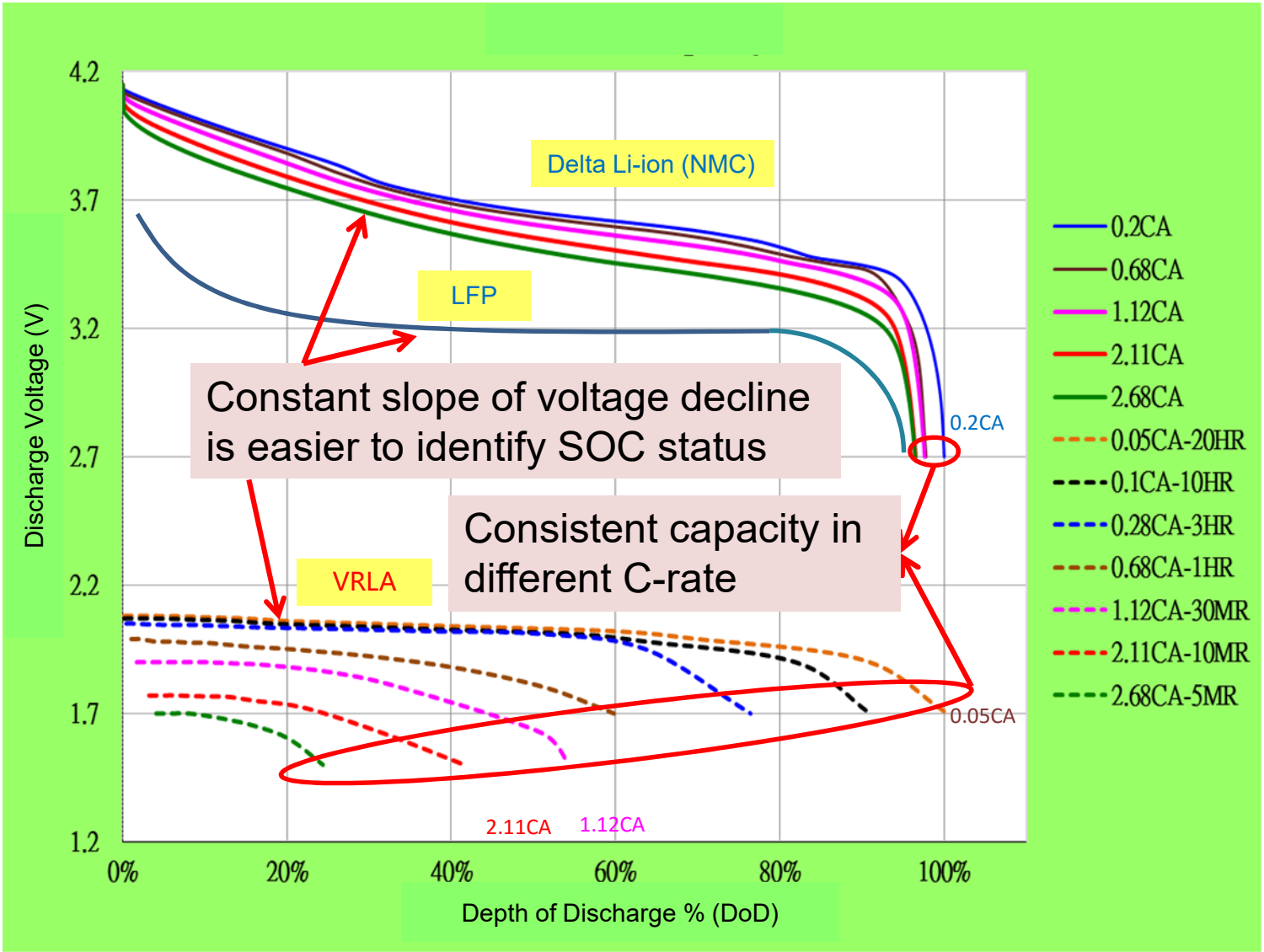
NMC vs LFP vs VRLA (1/2)

	Delta NMC	LFP	VRLA
Nominal Cell Voltage (V)	3.7	3.2	2.0
Energy Density (Wh/Kg)	132	>80	30
Power Density (KW/Kg)	2.78	>0.7	0.3
Cycle life*	>2,000	>1,000	<500
Self discharge rate**	<1%	<5%	>15%
Storage life @90%SOC	>10 years	7~10 years	2~3 years
Round-trip efficiency	>96%	95%	60%
Full charge time from 0% SOC	<0.5 hour	<1 hour	>8 hours

* 100% D.O.D. @25℃, 1C-rate, EOL capacity 80%

** 100% SOC for 1 month rest @25℃

NMC vs LFP vs VRLA (2/2)

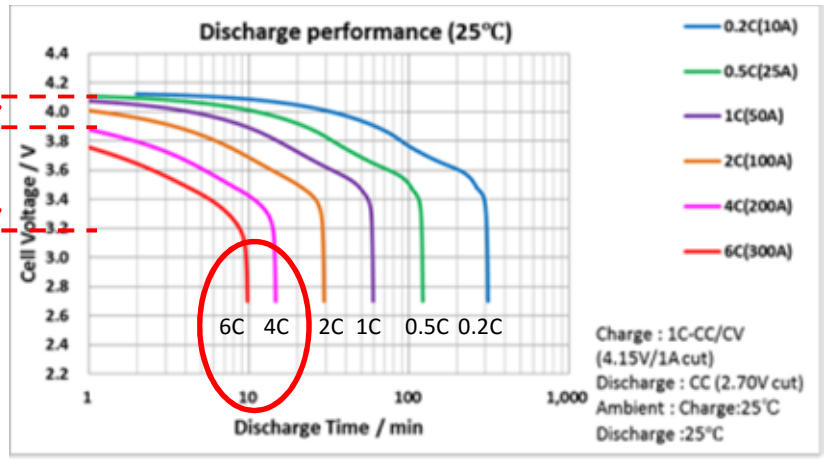


High current discharge capacity

Delta
NMC P-140

Initial voltage drop

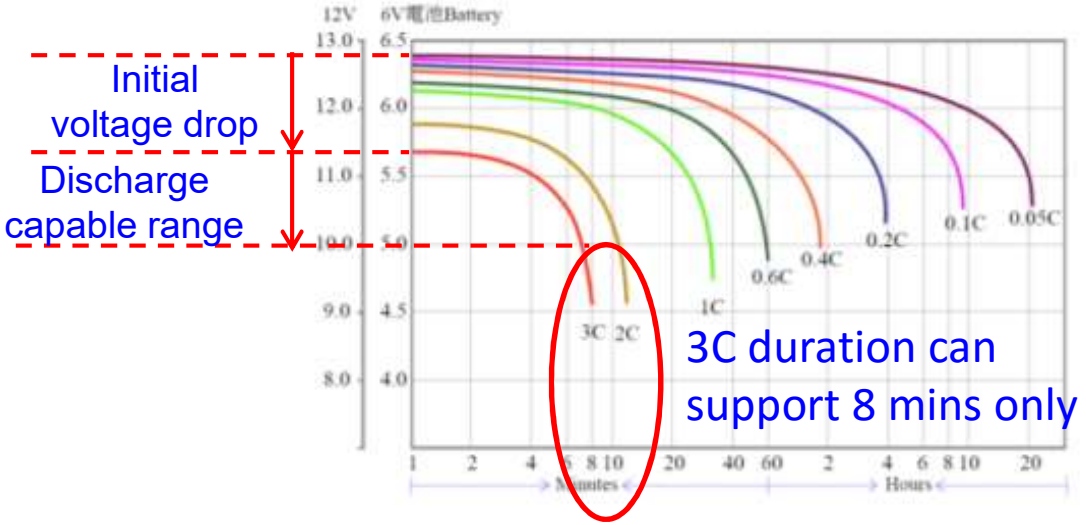
Discharge capable range



VRLA Discharging Characteristics Curves at 25℃

Initial voltage drop

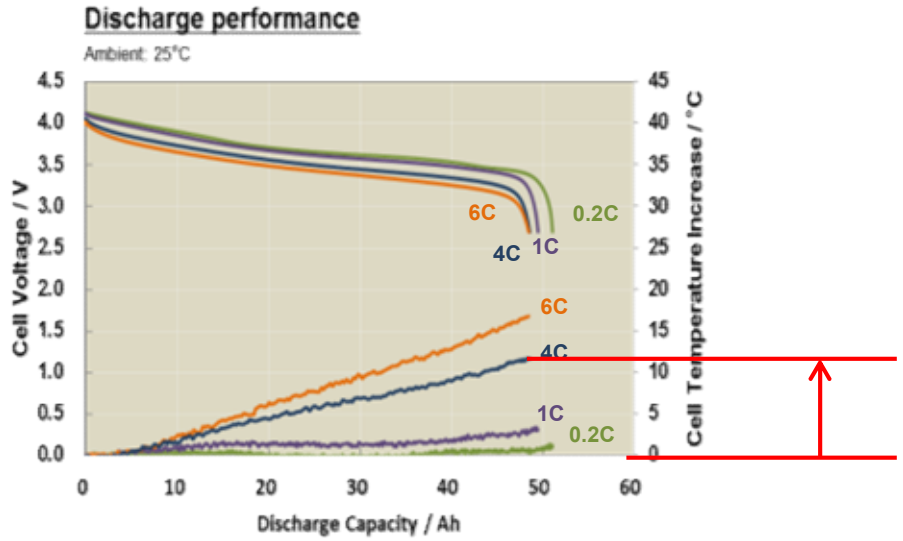
Discharge capable range



- High battery resistance to cause the voltage drop a lot when discharge beginning. It will reduce the backup capacity and even can't deliver enough power.

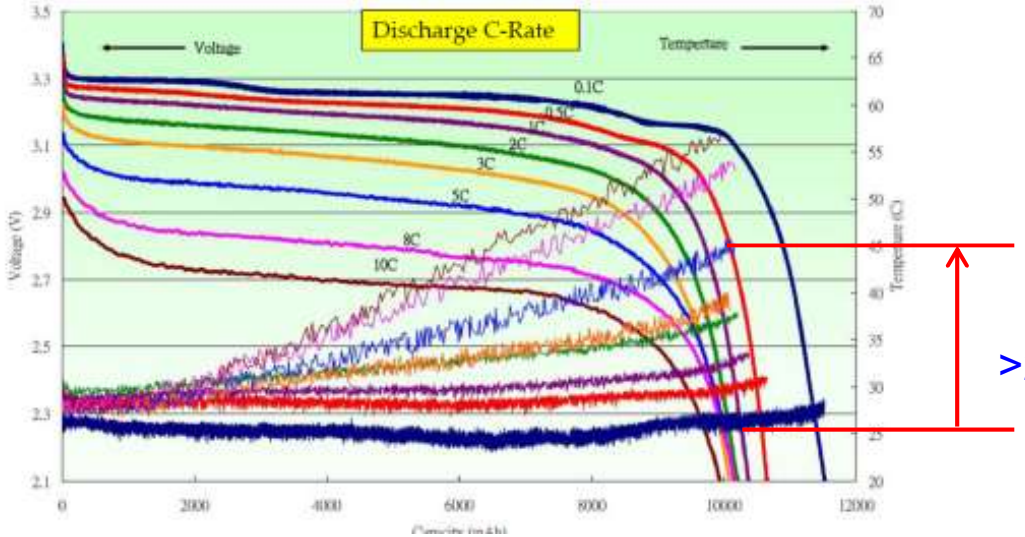
Thermal issue @high current discharge

Delta
NMC P-140



Temp. raised
<13℃ @4C-rate

Cylindrical
LFP



Temp. raised
>20℃ @4C-rate

- Due to the battery internal resistance and form factor design, the generated heat will impact the battery life and operation cost of air conditioning.

Li-Ion Battery Rack System Configuration

Lithium Ion Battery Module

DBSHV50S

High Voltage design applied for high power application

Special Features

High Safety
- Certification: UN38.3, UL1973
- Built-in CMU (Cell management unit) to monitor individual cell voltage, temperature and manage cell balance.
- Built-in isolated CAN Bus among CMUs & BMU for high voltage battery string operation

Easy installation and Service
- Plug-in power bus connection
- High voltage protection during installation and service
- Isolated CAN Bus cable (loop connection or daisy chain) for high voltage battery string.

Flexible Capacity Expansion
- Series Expansion up **to ~900VDC**
- Parallel expansion up to MWh capacity

Excellent Manageability
- A Delta design **BMU (Battery Management Unit)** is provided to manage and protect individual cell of each module

Nominal Voltage	51.8V
Nominal Capacity	50 Ah
Nominal Energy	2.59 KWh
Dimension (mm)	199 (W)x 187 (H)x 543 (L)
Weight	~26Kg
Certifications	UL1973, UN 38.3
Cycle life @ 25° C	10% - 90% SOC*1≥4,000 cycles
Operating Temperature	Charge: 0° C to +45 ° C Discharge: -20° C to +45 ° C
Interface	CAN 2.0B (500kHz)
Discharge Rate	Max. 4C (200A)

*1) SOC is “State of Charge”

Control box Design

Control box

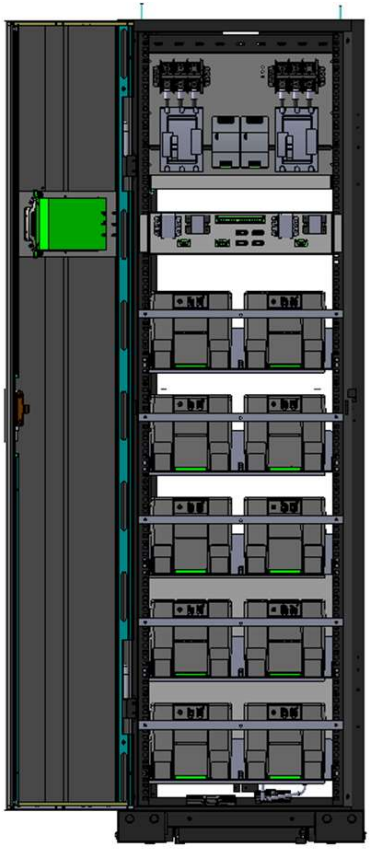
- Integrating Battery management system and protection unit such as Fuse and Relay

Function of Control box

- **Short circuit protection**
- **Pre-charge function**
- **Current measurement**
- **SOC,SOH calculation**
- **Cell balancing**
- **Battery protection**
- **Communication to UPS (RS485,CAN,dry contact)**

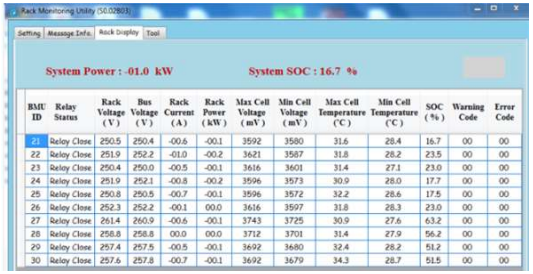
Battery Rack Integration with DPH Series

Lithium – Ion Battery Rack



Battery Rack

- ✓ Li-Ion Battery Rack - 25.9 kWh
- ✓ MCCB & Fuses Inside Battery Cabinet
- ✓ Top Cable Entry
- ✓ Provision for HMI
- ✓ Master BMS
- ✓ Graphical User Interface



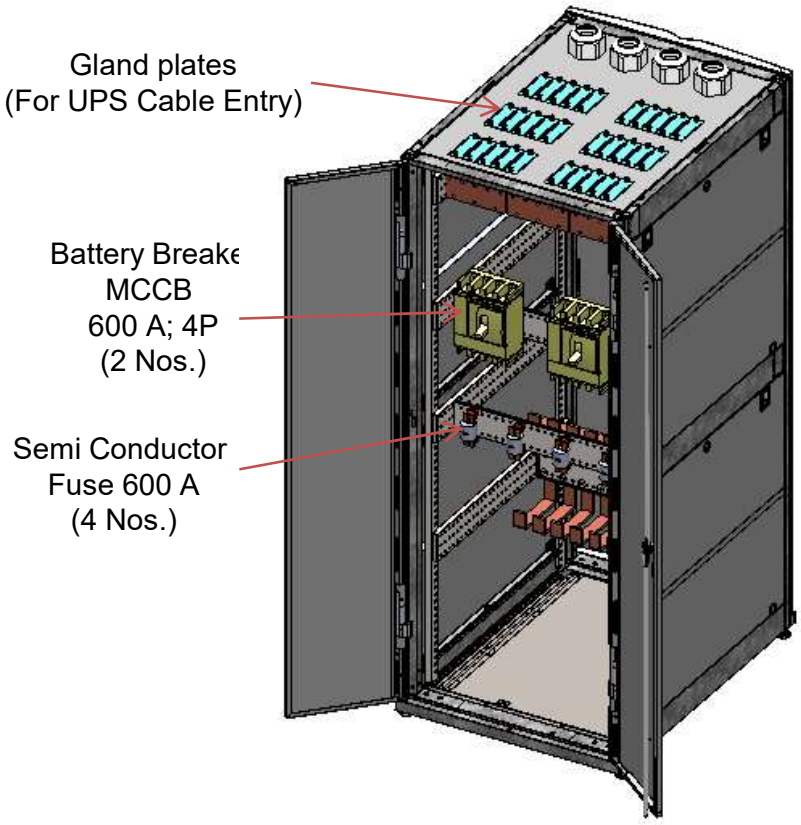
Graphical User Interface

Modular UPS DPH Series

- ✓ Modular UPS with 25kW power modules / 200kW in a rack (400kVA/400kW)
- ✓ Hot Swappable Power Modules, Static By-pass and Controller
- ✓ Controller level redundancy with distributed control architecture
- ✓ Inbuilt redundancy for aux – power supply and cooling fans
- ✓ Flat Efficiency Curve, hitting > 95% @ 30% part load

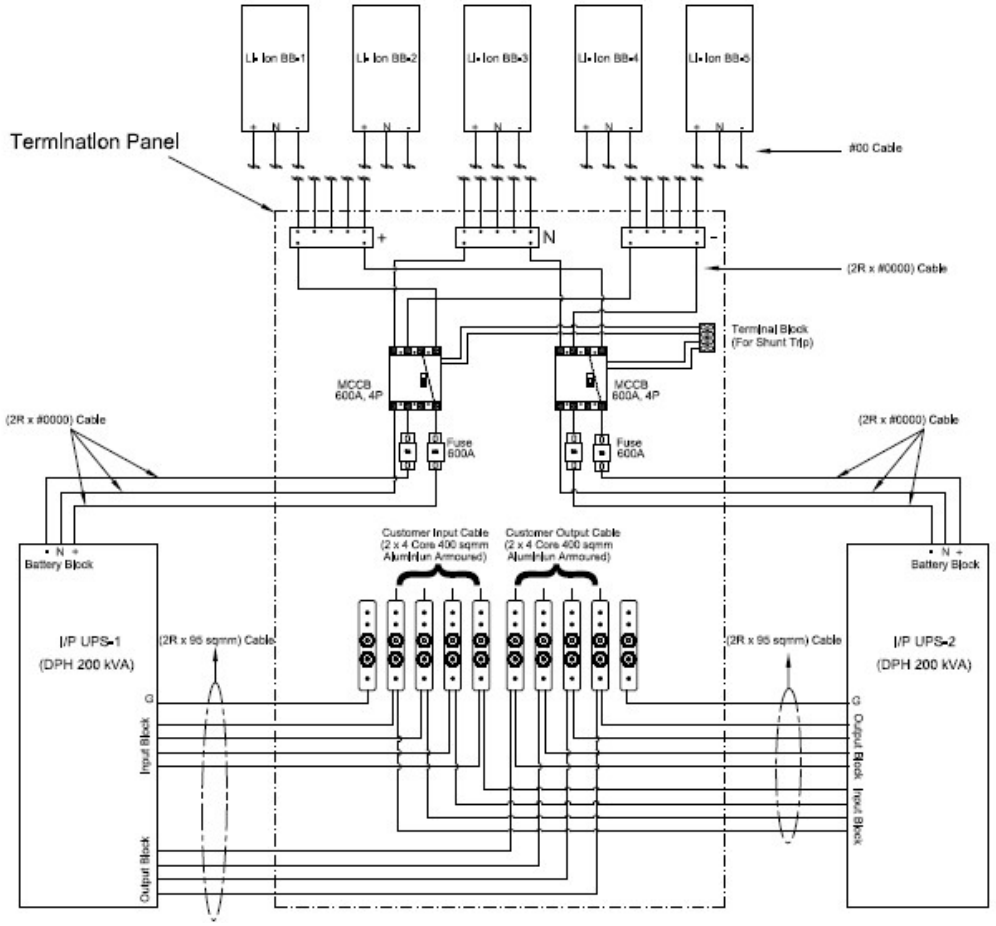
System Configuration with DPH series

UPS Input / Output Panel



Isometric View (Rear)

Schematic



Notes:-

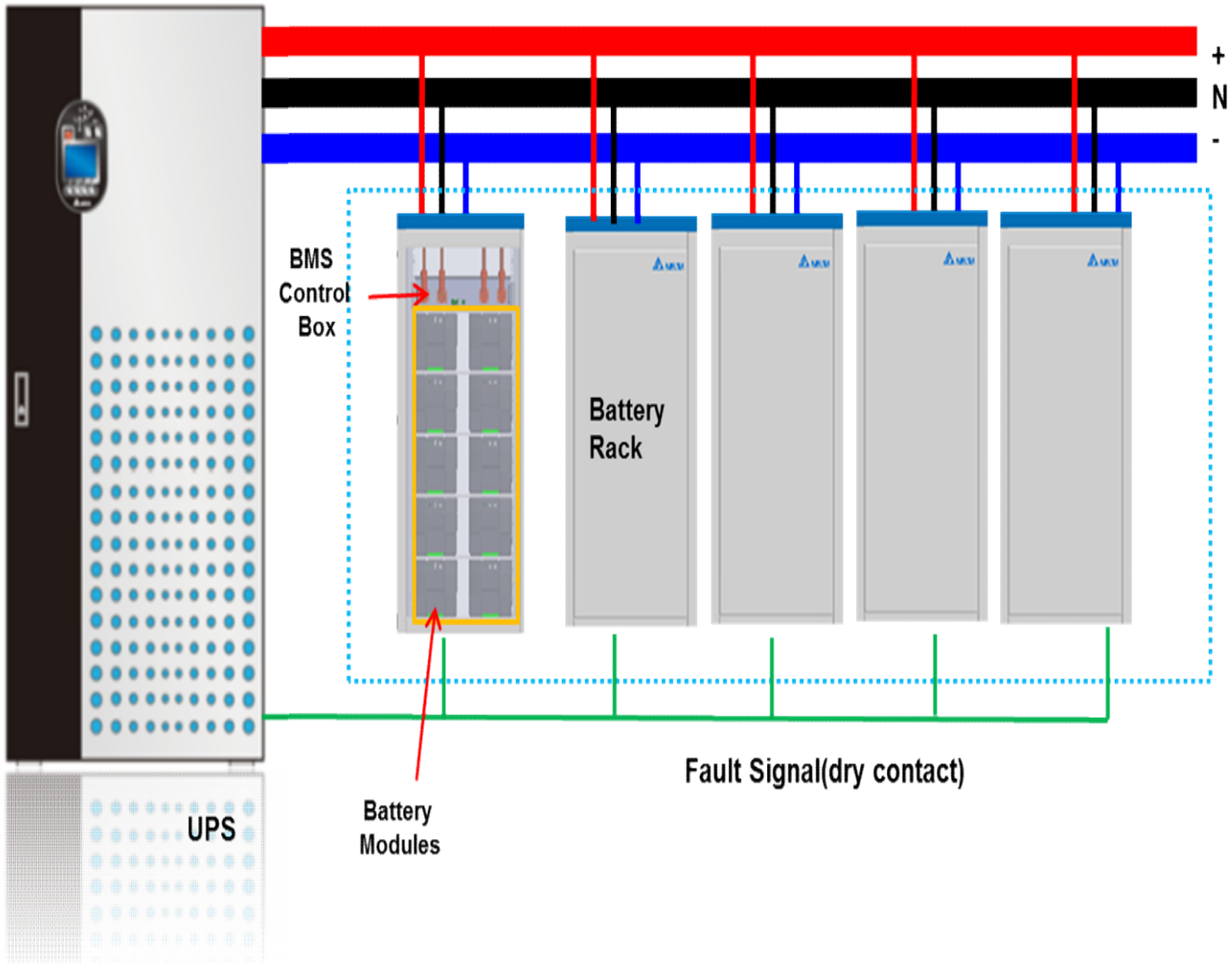
- Overall Size of Termination Panel is 800 (W) x 1090 (D) x 2000 (H), matching to UPS footprint
- All Cable Entry in Termination panel will be from Top.

Typical Configuration & Back Up time

UPS	Power	1 Rack (25.9kWh)	1 Rack (51.8kWh)	2 Rack (77.7kWh)	2 Rack (103.6kWh)	3 Rack (155.4kWh)	4 Rack (207.2kWh)	5 Rack (259kWh)
DPH Series (PF: 0.9) (Eff.: 95%)	100KVA	12	25	37	50	75	100	125
	150KVA	N/A	17	25	33	50	66	83
	200KVA	N/A	12	19	25	37	50	62
DPH II Series (PF: 0.9) (Eff.: 95%)	300KVA	N/A	N/A	12	17	25	33	42
	400KVA	N/A	N/A	N/A	12	19	25	31
	500KVA	N/A	N/A	N/A	10	15	20	25

System Configuration with Unitary DPS

DPS Series
400KVA/360kW
UPS
Unitary Model



Li-Ion Battery
130KWH

UPS + Li-ion Reference Case

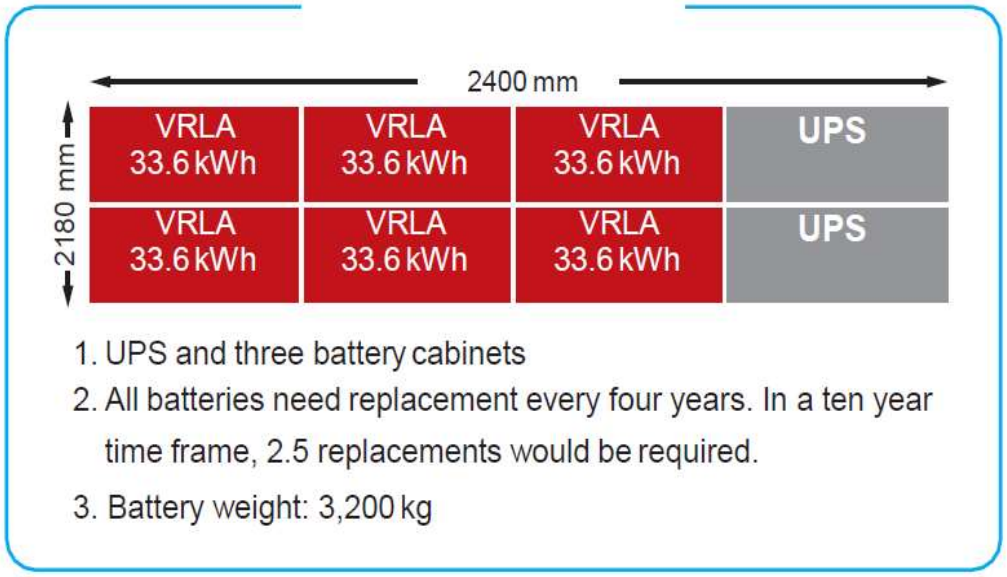
Real Case - USV India

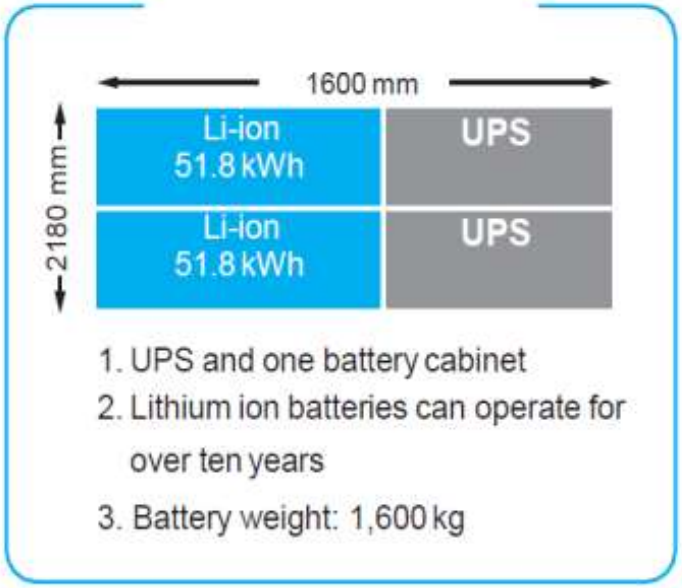
India's 1st Lithium Ion Battery + Modular UPS system

200KVA DPH + 4 Lithium Ion Battery Rack (104kWh) for 30 mins back up

Real Case study of Datacenter

- **IT load: 100kW**
- **Backup time: 30 minutes**
- **Battery redundancy: 1+1 sets**
- **Data center's years of use : 10 years minimum**





- Footprint 33%↓
- Weight 50%↓
- Cycle Life 250%↑
- TCO 10%↓

Benefit to Datacenter PUE

Power Usage Effectiveness

$$PUE = \frac{Total\ Facility\ Energy}{IT\ Equipment\ Energy} = 1 + \frac{Non\ IT\ Facility\ Energy}{IT\ Equipment\ Energy}$$

- Operation temperature range of Li-ion battery is wider than VRLA (-20~+55℃ vs. -15~+45℃)
  - LIB is capable to operate in ambient 35℃ normally without cooling

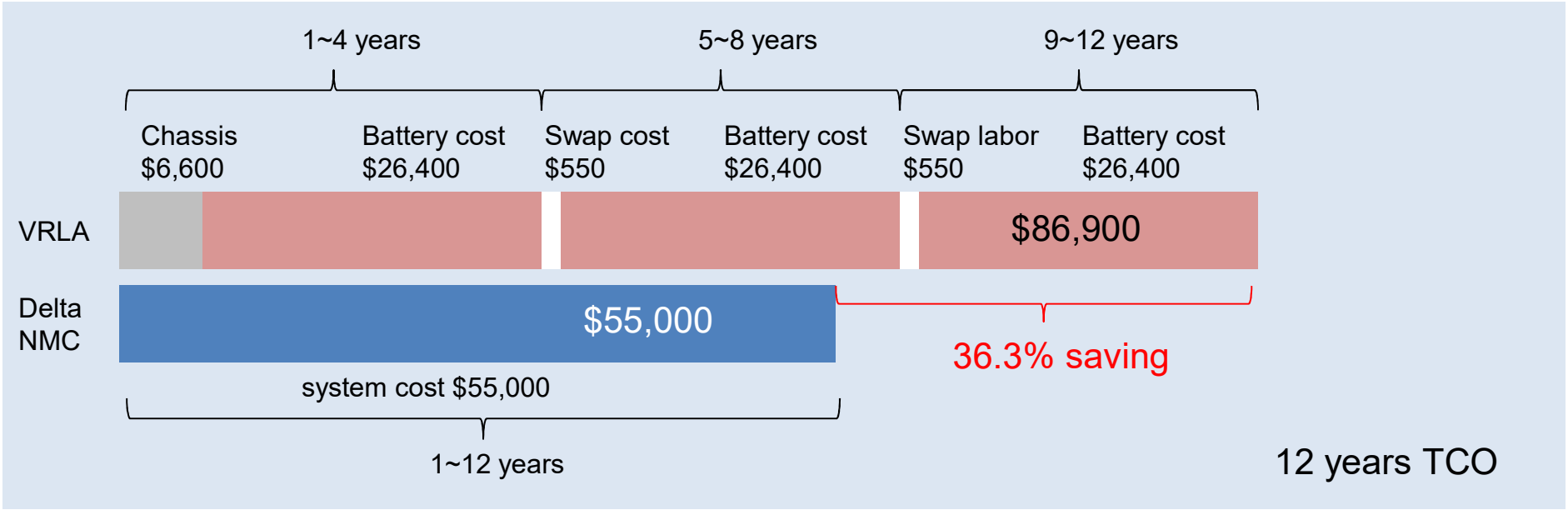
Delta vs. VRLA system configuration

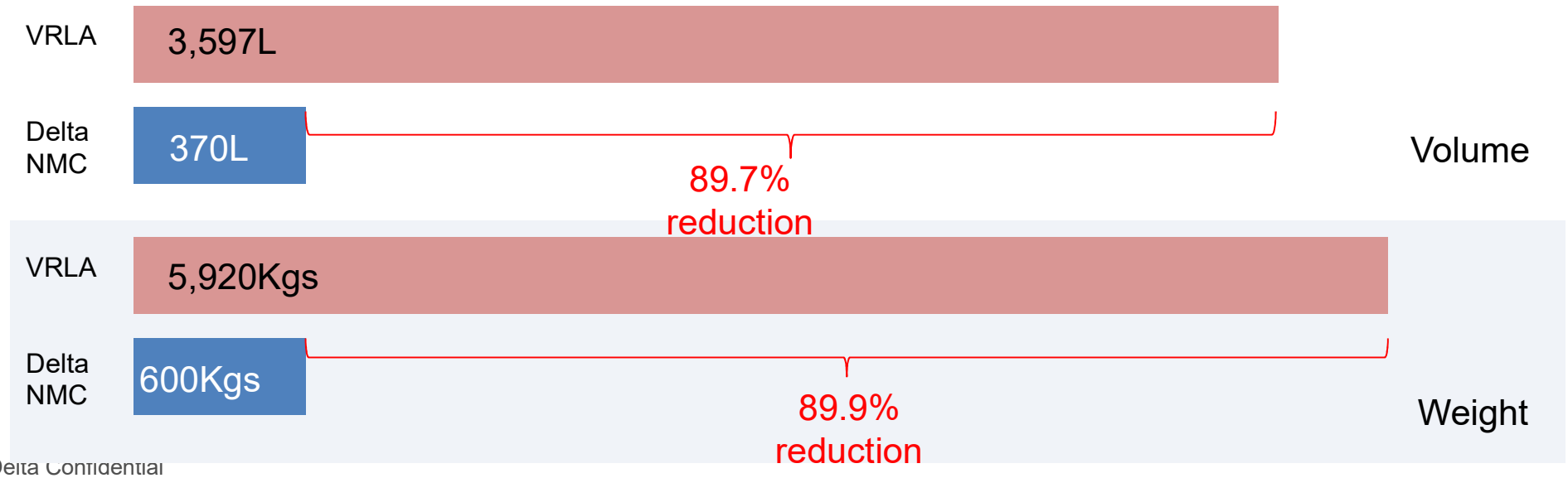
Delta NMC Battery Specification		
Band		Delta
Model		DBS48V50SH
Nominal Voltage	V	51.8
Nominal Capacity	Ah	50
Max. Charge current	A	100
Max. discharge current (30 sec.)	A	500
Float Charging	V	N/A
Weight	Kg	30
Length	mm	730
Width	mm	214
Height	mm	118

VRLA Battery Specification		
Band		Yuasa
Model		NPA115-12I FR
Nominal Voltage	V	12
Nominal Capacity	Ah	120
Max. Charge current	A	30
Max. discharge current (30 sec)	A	360
Float Charging	V	13.65±0.15
Weight	Kg	37
Length	mm	342±3
Width	mm	170±3
Height	mm	213±3

Delta NMC	System Configuration	VRLA
10	Modules of each serial string	40
2	Qty of string	4
20	Qty of module	160
US$55,000	Battery system initial cost	US$33,000
600 Kgs	Total weight of battery modules	5,920 Kgs
370 L	Total volume of battery modules	3,597 L

Total Cost of Ownership Analysis





Design for Safety

Design for Safety

Cell P140	• UL 1642 (Safety) • UN 38.3 (Transportation) • S Mark (UL safety in Japan) • Safety valve
Module DBS48V50S	• Cell Voltage Temp Monitor in each Cell • Thermostat Protection in Cell level • Warning & Error Status (CAN Signal) • HVIL Circuit Design
Cabinet DBC41HV	• Redundant disconnect unit(Relay) in both positive and negative circuit • Fast melting fuse • HVIL protection circuit • Soft start / Pre-charge Circuit

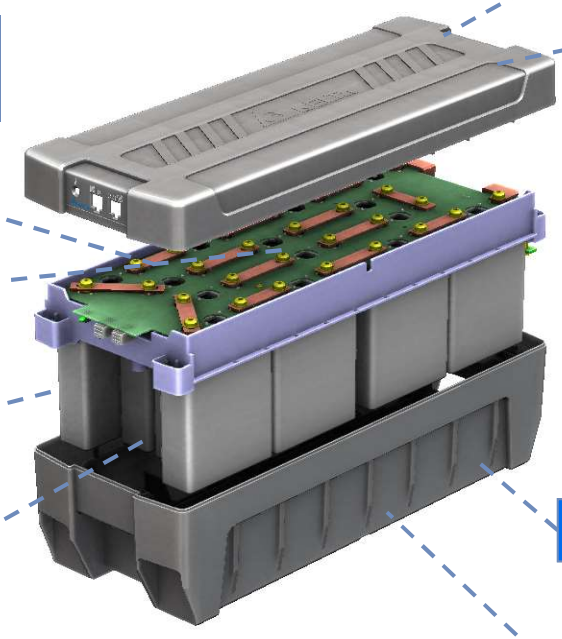
14S1P module test

Test items	Test photos	Test condition	RESULT
Impact test **UL1973**	 	steel ball with diameter 50.8 mm, weight 535g, drop to battery module surface from 1.258m height.	Pass -no damage
Drop test **UL1973**	 	Weighing >7kg, dropped from a minimum height of 10 cm `	Pass -no damage
static force **UL1973**	  	250N for 5s	Pass -no damage

14S1P module test

Test items	Test photos	Test condition	RESULT
Temperature behavior **UL1973**		The charge and discharge cycles are then repeated for a total of 5 complete cycles of charge and discharge	Pass (Not exceed component temperature spec)
Handling **UL1973**	 	3 times the weight of DUT	Pass -no damage
Internal fire **UL1973**	 	heating one internal cell that is centrally located within the DUT until thermal runaway	Pass - no fire propagating from the DUT or explosion of the DUT

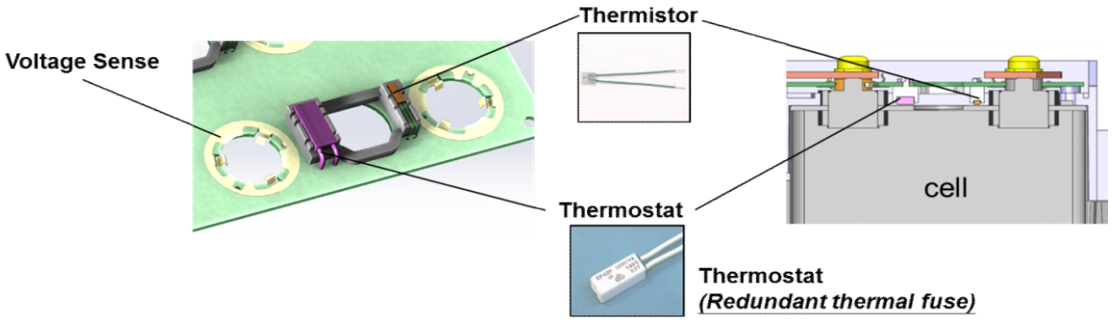
Battery Module Exploded View



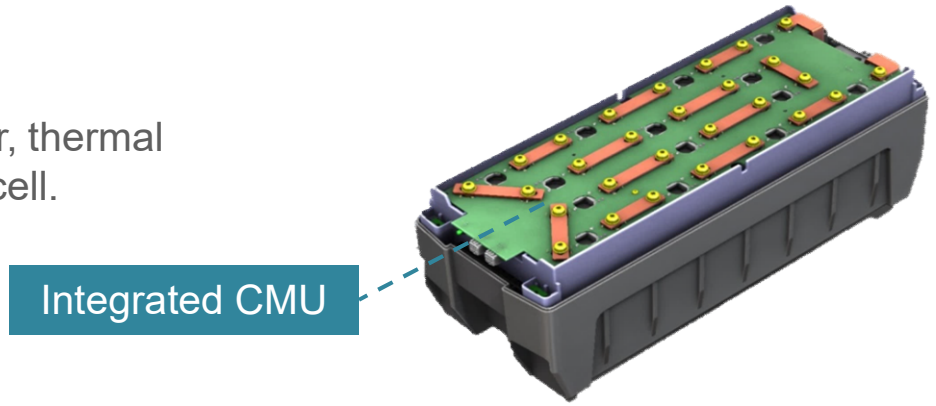
- UL1973 compliant
- Compact Size
- Integrated PCB
  Voltage & Temperature Monitoring
- Redundant Thermal Fuse
- Blind mate connector
- High Portability
- Insulation Enclosure
- Optimal flow path
- Non-flammable Material(5VA)

Battery Module Design

- **Thermostat (Redundant thermal fuse)**
  - Apply redundant thermal fuse to ensure over temperature protection while system failure(thermistor…etc.).



- **Integrated PCB**
  - CMU integrated with Voltage sensor, thermal resistor and thermal fuse for every cell.
  - No flying voltage sense wiring.
  - Compact space usage.



Smarter. Greener. Together.

To learn more about Delta,
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New Product – Under Development

Cell

- High Power / Long life Prismatic Cell
- High Capacity 50Ah Cell
- Nominal Voltage 3.7V

Module

- High Safety Plug-in Design
- Integrated Cell Monitor Unit(CMU)
- Contain 14 Cells in Series(14S1P)

Safety Control Box

- High Power Application Design
- Built-in Safety Breaker(MCCB)
- Dual Relay/Diode Protection Loop
  - Relay protection (Charge)
  - Diode connection (Discharge)
- Meet Isolation Standard(UL 60950) for Power & Control section
- Integrated Battery Management Unit(BMU)

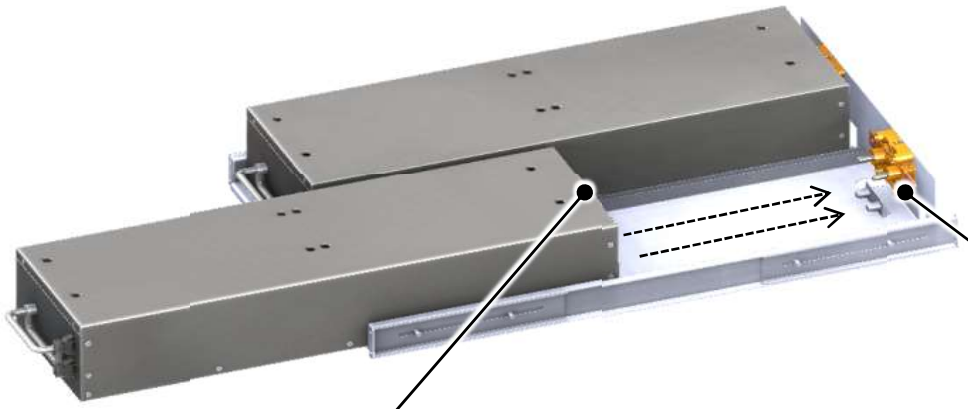
Rack

- Standard 19” Datacenter Rack
- Pre-Installed Series Connection Bus-bar
- Integrate Master BMS w/ Gateway Hub Design for Parallel Communication Connection
- Top Side Connection Access(Power & Signal)
- Front Accessible for Simple Maintenance

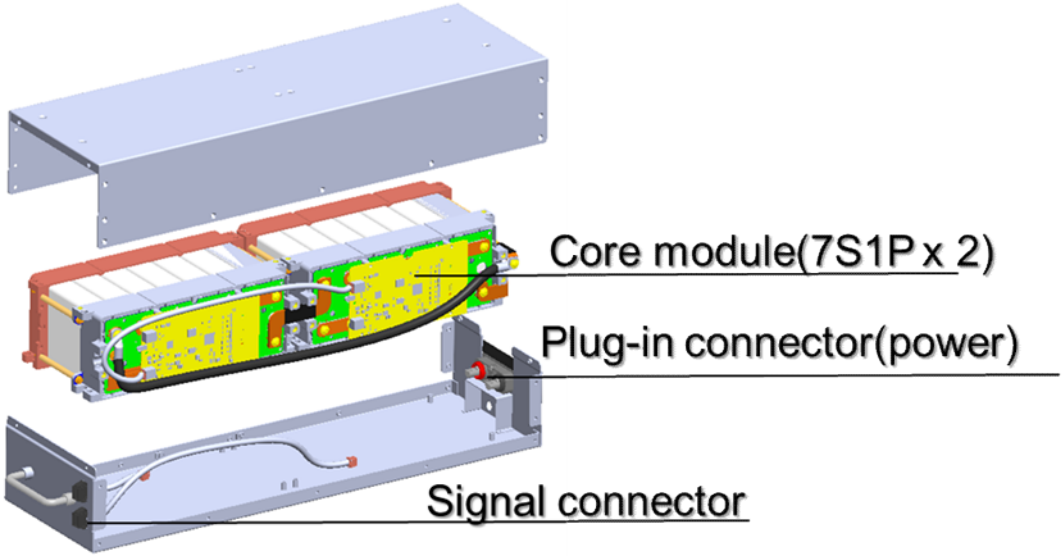
Battery module Design

Battery Module Design

- Plug-in Design
- Standard Rack mount type w/ 3U Height
- Light Weight(29.5Kg) with Handle Bar
- Integrated Cell Monitor Unit(CMU)



Female side



Battery System Outlook & Feature

➢ Design Feature

- **High Energy Density**
  - Max capacity up-to 51.8KWh
- **High Power Output**
  - Continue discharge power up-to 200KW
  - Max peak(30s) power up-to 550KW
- **Standard Data Centre Rack Design**
  - 19” with white color exterior
- **High Safety Design**
  - Isolation zone between high-side & low-side
  - 2 level BMS design(CMU & BMU)
- **Easy installation & Service**
  - Plug-in battery module

*Control box and cable entry can be placed on top side if required.

Highly Reliable Battery System for Mission Critical IT Equipment

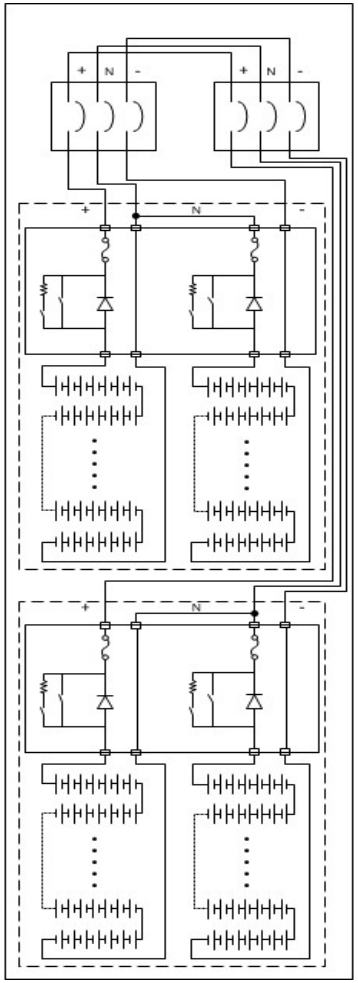
UPS Battery System Specification

➢ Technical Data

Item	Parameter	
Applied Cell type	DELTA P140-1304(50Ah)	
Installation Capacity	25.9KWh	51.8KWh
Nominal Voltage	±259Vdc	
Maximum Voltage	±287Vdc	
Max Charging Power	50KW	100KW
Minimum Voltage	±224Vdc	
Max Discharging Power	100KW(Cont.) 200KW(30s)	200KW(Cont.) 400KW(30s)
Cycle Life*/Design Life*	≧4000Cycles / ≧10years	
Communication Bus	CAN2.0/RS485	
Environment Operation Temperature	Charge: 0°C ~ +45°C Discharge: -20°C ~ +45°C	
Dimension	1090mm(L) x 600mm(W) x 2000mm(H)	
Total Weight	500kg	800kg
Storage humidity	0~95% @ 25°C	
Waterproof level	IP 20 class Function	
Permissible Altitude	≤2000m	
Additional Accessories	• Master BMS • Gateway Hub(Optional) • HMI(Optional)	

➢ Product Outlook

➢ Single-line Diagram



UPS of Data Center (TY5 facility)

50KW + 25.9KWh System for 30 min. , UPS + Li-ion in one Rack

➢ Design Feature

- **High Energy Density**
  - Max capacity 51.8KWh
- **High Power Output**
  - Max discharge power 200KW
- **Dual Battery Loop Design**
  - Top & Bottom independent battery system
  - Support UPS N+1 structure
- **Standard Data Centre Rack Design**
  - 19” with black color exterior
- **High Safety Design**
  - Isolation zone between high-side & low-side
  - Integrate MCCB in main DC BUS line
  - Dual auxiliary power supply(DC & AC)
  - 2 level BMS design(CMU & BMU)
- **Easy installation & Service**
  - Plug-in battery module
  - Top side power & signal connection

✸ Highly Reliable , Space saving for Mission Critical IT Equipment

UPS of Data Center

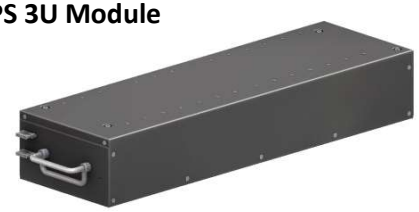
500KW + 51.8KWh System for 10 min.

➢ Design Feature

- **High Energy Density**
  - Max capacity 51.8KWh
- **High Power Output**
  - Max discharge power 200KW
- **Dual Battery Loop Design**
  - Top & Bottom independent battery system
  - Support UPS N+1 structure
- **Standard Data Centre Rack Design**
  - 19” with black color exterior
- **High Safety Design**
  - Isolation zone between high-side & low-side
  - Integrate MCCB in main DC BUS line
  - Dual auxiliary power supply(DC & AC)
  - 2 level BMS design(CMU & BMU)
- **Easy installation & Service**
  - Plug-in battery module
  - Top side power & signal connection

✸ Highly Reliable Battery System for Mission Critical IT Equipment

Battery System Specification

System Component	Cell 	UPS 3U Module 	UPS Battery Cabinet 
Configuration	1S1P	14S1P	70S2P*2
Nominal Capacity	185 Wh	2.59 kWh	51.8 kWh
Nominal Voltage	3.7 Vdc	51.8 Vdc	±259 Vdc
Operation Voltage Range	2.7 Vdc – 4.15 Vdc	44.8 Vdc - 57.4 Vdc	±224 Vdc - ±287 Vdc
Output Power	1.1 KW	12.5 KW	250 KW
Dimensions	166.6mm(H)x110.1mm(W)x38.2mm(D)	690mm(D)x214mm(W)x121mm(H)	1090mm(L) x 600mm(W) x 2000mm(H)
Weight	1.4 Kg	28.5 Kg	800 Kg

➢ **Back-up Time(in minuets)**

UPS	Power	1 Rack (25.9kWh)	1 Rack (51.8kWh)	2 Rack (77.7kWh)	2 Rack (103.6kWh)	3 Rack (155.4kWh)	4 Rack (207.2kWh)	5 Rack (259kWh)
DPH Series (PF: 0.9) (Eff.: 95%)	**100KVA**	12	25	37	50	75	100	125
	150KVA	N/A	17	25	33	50	66	83
	200KVA	N/A	12	19	25	37	50	62
DPH II Series (PF: 0.9) (Eff.: 95%)	**300KVA**	N/A	N/A	12	17	25	33	42
	400KVA	N/A	N/A	N/A	12	19	25	31
	500KVA	N/A	N/A	N/A	10	15	20	25