ENERGY
BACKUP

UP Battery Range

Installation & Operating Instructions

Technical Manual

FZSoNick

GREEN & SAFE SALT BATTERY

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1 GENERAL INFORMATION

1.1 Introduction

The FZSonick UP battery range is a group of batteries designed for energy backup applications. Each module of this range is a complete battery system, assembled with Sodium-Metal Chloride cells arranged in strings according to Table 1:

UP Battery Model	110UP80	125UP80	220UP40	250UP40
Nominal Voltage [Vdc]	110	125	220	250
Charge Voltage Range [Vdc]	121.0 - 160	135.1 - 160	243.2 - 300	270.2 - 300
Min Voltage [Vdc]	88	100	180	200
Nominal Capacity (C4)	80Ah 8.5kWh	80Ah 9.6kWh	40Ah 8.6kWh	40Ah 9.6kWh
Cells	88	100	90	100
Configuration	44S 2P	50S 2P	90S 1P	100S 1P

Table 1: Battery Model configuration

A battery module is an assembly of a Battery Management System (BMS) and the relevant Battery pack.

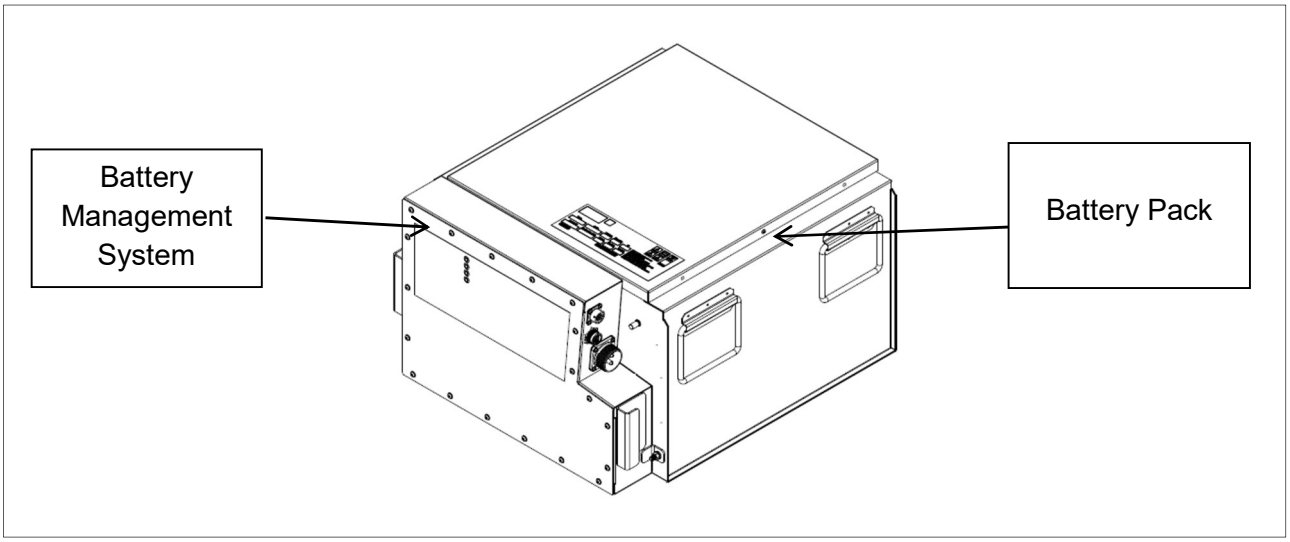


Figure 1

The BMS manages all the battery functions and ensures a reliable and safe operation.

The battery pack is provided with internal electric heaters, to achieve and maintain the internal working temperature of 265°C. The thermal insulation of the battery pack is such that, with an internal temperature of 265°C, the surface temperature of the enclosure is just 10 to 15°C above the environment.

1.2 Purpose

This manual provides information required to install and operate the FZSoNick UP batteries.
Anyone involved in handling, installing or using the FZSoNick UP Batteries must read and understand this manual.

1.3 Related Publications

Publication Name	Publication Number
Battery safety data sheet	20231204_PSDS FZSonick Batterie_IT 20231204_PSDS FZSonick Batterie_EN 20231204_PSDS FZSonick Batterie_DE 20231204_PSDS FZSonick Batterie_ES 20231204_PSDS FZSonick Batterie_FR 20231204_PSDS FZSonick Batterie_PT
Monitoring Software Manual	SMC Monitor300 V2X User Manual
Battery ModBus Protocol	TI_UP ModBus protocol rev 01
Battery CanOpen Protocol	250UP40 CANopen Protocol rev 1.1

Table A

2 SAFETY

2.1 Battery Safety

This manual contains important instructions that should be followed during installation and operation of the FZSonick Battery Module.
The battery is designed to operate safely and to protect personnel from danger. Because it is an industrial product, however, the battery may cause risk to personnel, equipment or facilities if not handled properly.
The hazardous materials found in the battery are sealed inside the battery's case. Under normal operating conditions, this design is intended to help protect the user from the risk of injury.

If multiple layers of the battery are breached or the battery ruptures, extra care must be taken. Refer to the Battery Safety Data Sheet (SDS) for instructions on how to manage these extreme conditions.

The following guidelines should be followed when handling and operating the battery under normal circumstances.

This battery should only be installed and operated by qualified personnel.
If you have any questions regarding safety for this product, please refer to section 5.11 of this manual

Unlike traditional batteries, this Sodium Metal Chloride battery can be charged or discharged only when the internal temperature reaches the operative value. Whenever the internal temperature is below, the battery acts as a passive device.
Before use, be sure to fully understand the battery functionality described in this manual

2.2 Warnings

A battery can present a risk of electrical shock. The following precautions should be observed when working on batteries and energy storage systems:

- Remove watches, jewelry, rings and other metal objects.
- Use tools with insulated handles

High voltages may be present within this unit even when it does not appear to be Operational. Observe all cautions and warnings in this document.

As for Electromagnetic compatibility (EMC) the battery is tested and certified for general industrial applications.

In a domestic environment, this product may cause radio interference

In case the current drawn by the inverter from the battery presents a prevalent half wave variable profile the user shall consult the battery supplier to apply appropriate filters to mitigate it, otherwise the warranty is void.

As an example this situation has been found in three-phase inverters with capacitor midpoint topology and unbalanced loads.

2.3 Site conditions caution

Install and operate the battery in an indoor or enclosed environment only in an ambient temperature range of -20°C to +60°C. Install it in a clean environment, free from conductive contaminates, flammable liquids or gases.
The installation site must have a properly rated and tested grounding system.

Ventilation for outgassing or cooling is not required. Each FZSonick Battery module will dissipate average of 115 Watts of heat under normal operation, which may affect room or cabinet ventilation design.

The installation site should be clear of obstructions. The installation team should understand the route that personnel and equipment will take when moving the batteries into position.

DO NOT open or damage sealed batteries.
For additional information, refer to the battery Safety Data Sheet (SDS).

2.4 Safety Precautions

To prevent damages to the batteries and personal injuries, following safety instructions need to be followed all the times:

- Do not install the battery if you notice physical damage
- Do not place the battery upside down, on a side or with the BMS facing down
- Do not pack the battery when it is hot
- Do not expose the battery to temperatures above 90°C (194°F) or below -40°C (40°F)
- Do not allow metal objects to rest on the battery
- Remove rings or metal wristbands when working with the battery
- Use insulated tools to install the battery
- Use all the handles when handling the battery

2.5 Required Safety Equipment

The following safety equipment should be available on site. Check local safety codes and standards to determine if additional equipment is required.

- Safety rated eye protection
- Hearing protection
- Electrically insulated gloves
- Flame-retardant clothing (8 cal/cm2)
- Electrically insulated/impact resistant footwear
- Electrically insulated tools

Verify the requirement with the AHJ (Authority Having Jurisdiction) to determine if additional equipment is required.

3 HANDLING PROCEDURES

3.1 Unpacking and Inspections

FZSoNick carefully tests and inspects the battery before shipment. Upon receiving a shipment of batteries, open the wooden crate box and check the battery and hardware against the packing list. Report any damage immediately to the carrier if the shipment shows signs of damage in transit. Also notify your FZSoNick customer service representative.

3.2 Handling

The use of certified non-conductive tools is highly recommended.
High energy batteries should always be handled carefully to avoid the possibility of creating a short circuit. In some circumstances, when in operation, the battery surface may be hot.
Battery handles are for hand carrying only, do not sling from the handles. Use an appropriate battery lifting harness for hoisting the battery. The battery lifting handles are to be used to remove the battery from its original packaging and to securely place the battery in its operating location. Always use all handles when handling the battery.
Never push the battery by applying force to the Battery Management System front panel.
Personnel should inspect the nearby environment where batteries will be handled to identify and eliminate all potential sources of electrical and physical damage to the batteries. Avoid conditions that could result in short-circuits, overheating, puncture or crush.
During cool down period is possible to handle the battery (maximum tilting 30°) if battery internal temperature is >200°C, typically within 12h from battery switch off. Shipping is possible only when the battery internal temperature is <90°C, typically after 72h from battery switch off.
When the battery is cold (all internal materials are in a solid state), a temporary placement with angles greater than 30° is allowed. In any case, never place the battery on its power terminals, upside down, with the front cover facing down or on its sides.

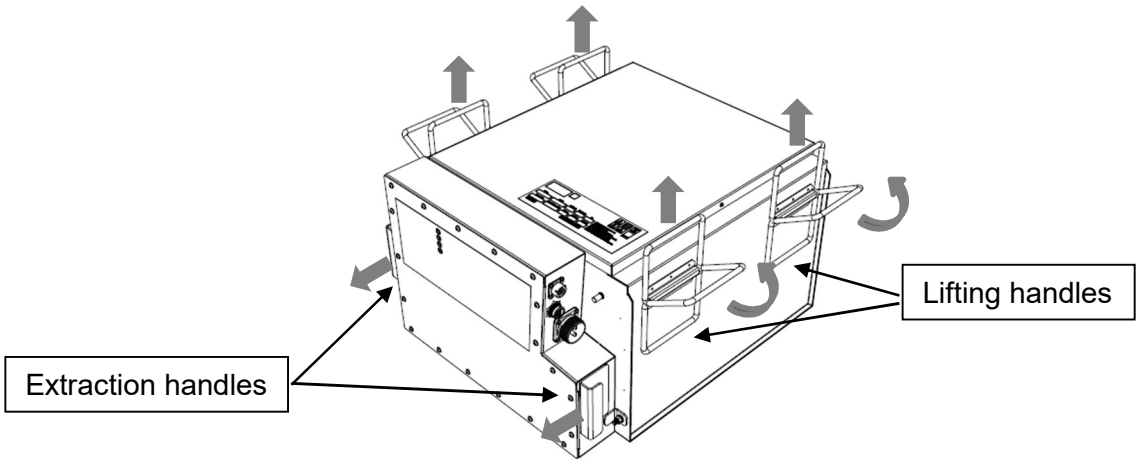


Figure 2

3.3 Storage

The best environment to store the FZSoNick battery system is a cool, dry, and well-ventilated location, in a properly identified warehouse area.
The battery can be stored for any length of time in the cold state without changing its characteristics or state of charge.

The battery cells have an extremely high resistance in the cold state and even a very low current can damage the cell when cold. Do not try to disassemble the battery management system (BMS) and apply any load or perform any measurement using the internal terminals of the battery.
The storage conditions should be temperature between –40°C and +60°C, Relative Humidity (non-condensing) max 90%

3.4 Battery Return and Disposal

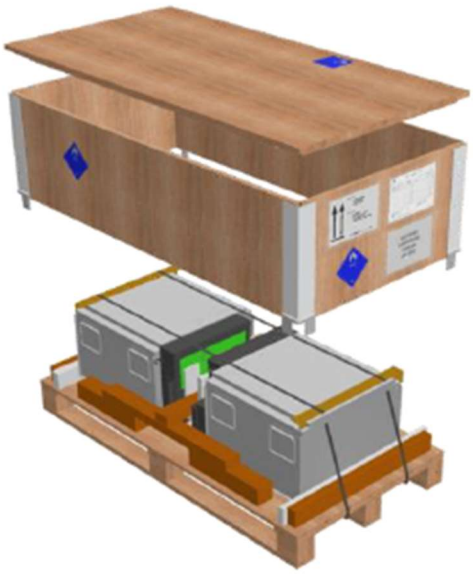
A Sodium Metal Chloride battery must be transported cold and, if possible, discharged.
Do not burn or dispose of the battery. End of life or defective batteries are to be returned to FZSoNick, where recycling and/or disposal of the different parts will be performed.
Notify FZSoNick customer service prior to returning the battery.

As soon as the battery power connector is unplugged, the internal temperature starts to decrease. The minimum cool down period since the power plug disconnection to allow the transportation is 72 hours for the complete solidification of the internal materials.

3.5 Packaging

The battery is shipped cold and completely discharged in a wooden crate fixed with straps to avoid any risk of uncontrolled movement or drops and surrounded by a protective foam cushion (fig.3, dimensions in mm).

In case of battery return, battery should be packed in the original wooden box, only when turned off and cold. Battery with a heavily damaged external case should be wrapped with polyethylene sheets before of the packing, to avoid the risk of release of material or odors.
The package should include the relevant safety information for the transport: please contact FZSoNick for the details.



1425 x 735

1200 x 800

Figure 3

3.6 Transportation

Anyone who is engaged in shipping Sodium Metal Chloride batteries must comply with all the rules and regulations listed below.

UN number:	3292 “Batteries or cells containing sodium”
Class:	4.3 “Water reactive substances” In contact with water produces flammable gas
Packing group:	II Materials of medium danger
Packing instructions:	433 For air shipment P408 For road shipment IMDG For sea shipment
Kemler nr:	Not Identified
ERG:	4W
Particular caution:	Protect from humidity and water Handle with care

Table B

Transport classification conforming to the following specific regulations:

For road or rail transport	ADR/RID (SDR)
For air transport	IATA
For sea transport	IMDG

Table C

Use ADR vehicles only if the gross weight for each transport unit is > 333 kg.
During air transport: use only cargo flight.

Conforming to the regulations, the batteries are transported:

- at ambient temperature with the sodium at the solid state, typically after 72h from battery switch off.
- labeled and packed conforming to international rules (ADR, IATA, IMDG)
- not charged.

4 BATTERY INSTALLATION

4.1 Tools and Hardware Required

- Insulated 13mm socket and a torque wrench 5-10Nm (3 -7Ft-Lbs. or 10 - 88 in-Lbs.);
- Insulated wrench set;
- Multi-meter.

4.2 Battery Layout and Mounting Orientation

An FZSoNick battery, when active, contains some materials in a liquid form. Even though the battery is fully sealed, for best performance the maximum permanent inclination, when installed, is 30 degrees.
During handling when the battery is cold (all internal materials are in a solid state) a temporary placement, with angles greater than 30° is allowed.
In any case, never place the battery on its power terminals or upside down or with the front cover facing down or in its sides.
The battery must stand on a flat mechanical support that has to cover at least 50% of the battery footprint .Provide adequate shelf loading capacity, ensure that there is sufficient aisle space and avoid short-circuits between the battery connector terminals and the shelf's metal parts.

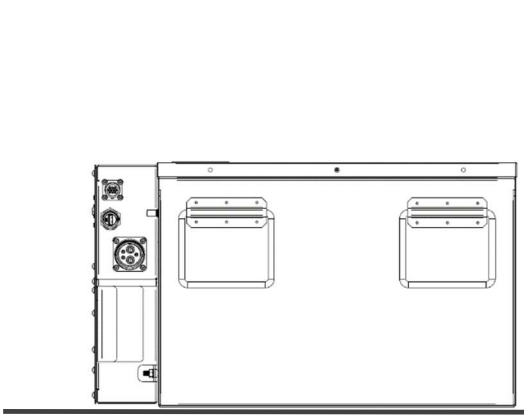


Figure 4A

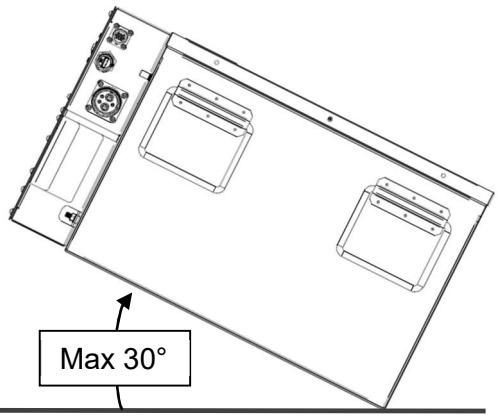


Figure 4B

The battery must be properly locked to the shelf, ensuring complete mechanical stability.
Fixing points are indicated in the following picture:

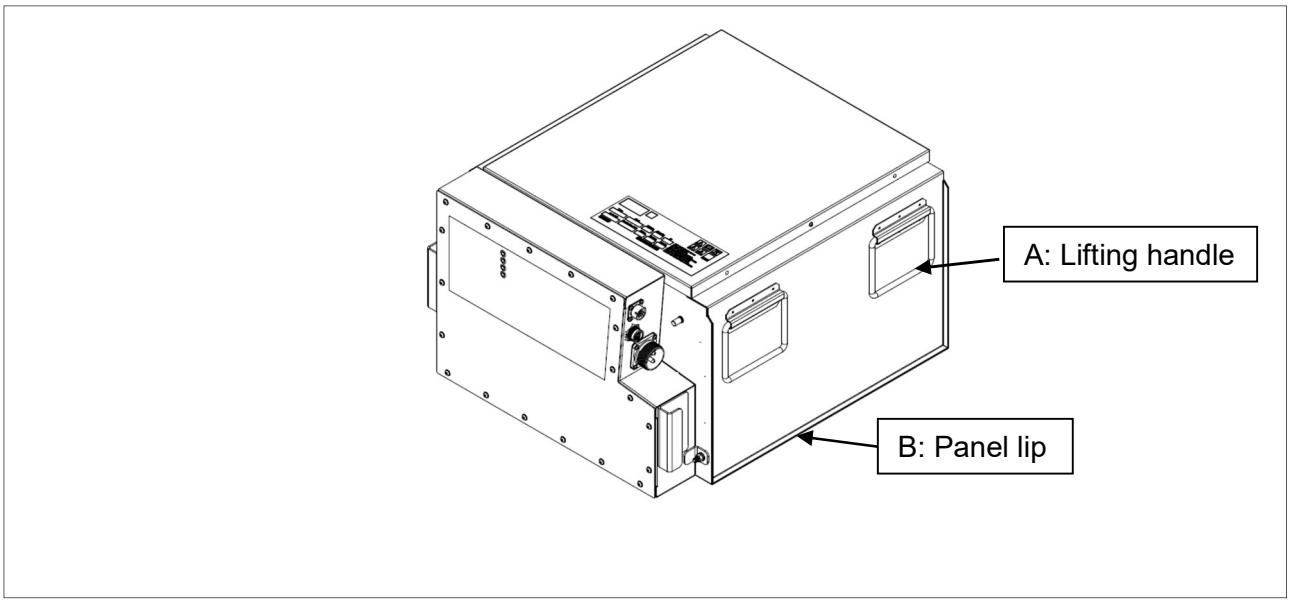


Figure 5

Point	Item	Suggested operation
A	Lifting handles	Fasten to the structure by means of ties
B	Lateral panels lip	Lock to the structure by means of clamps

Table D

Never drill, weld or modify battery surface to lock it to structure

4.3 Battery Front Panel

The battery power terminals and interface ports are located in the battery management system of the battery as indicated in the fig.6. All the connections of the battery are described in the Table E.

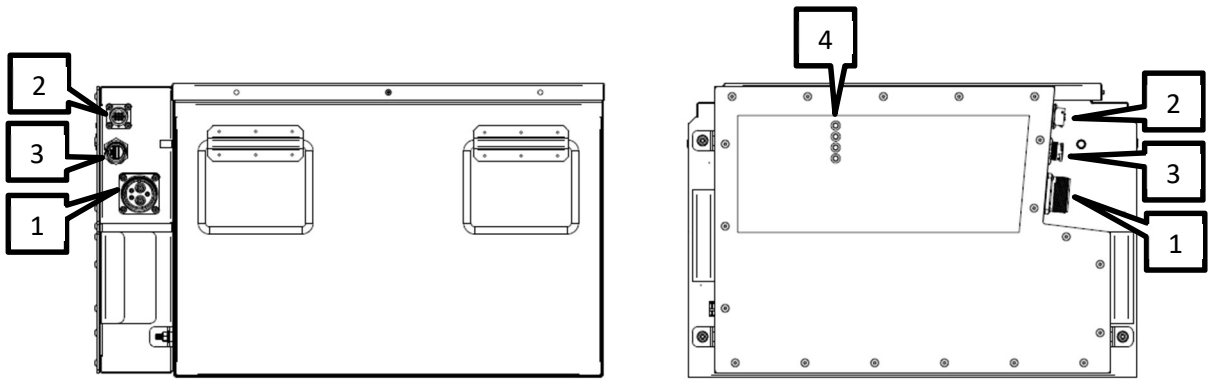


Figure 6

Item	Description	Function	Type
1	Power connector, J1BS	Battery power terminals connection to the DC Bus	MS3102 to MIL-DTL 5015 Series I
2	Data Connector, J2BS	Communication. Alarm contacts. EPO input	MS3110 to MIL-C-26482 Series I
3	USB, J3BS	Service port	USB Type A
4	HMI	Battery status display	LED

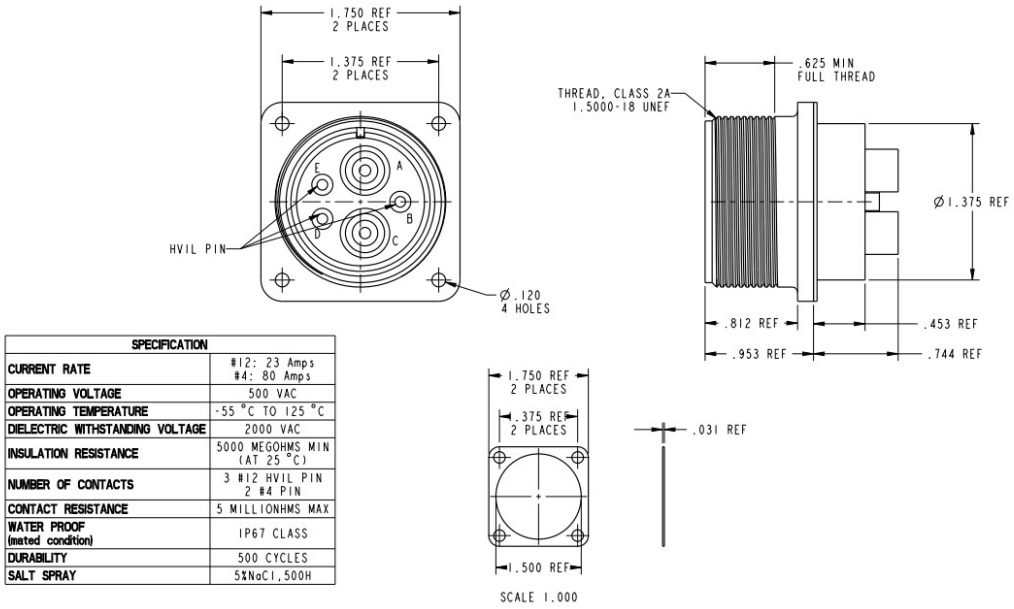
Table E

The IP rating of the battery is guarantee only if all the plugs are properly screwed in.

4.4 Power Cable Connection

Do not connect batteries in series. Parallel connection is allowed.
Each SMC battery is to be considered as VDC battery system.

Power cable connector is identified with the name J1BS (label A, section 6.3.2).
It includes the power connection of the battery, the emergency load disconnect input and the shutdown input pins as indicated in the table D and figure 5.



SPECIFICATION	
CURRENT RATE	#12: 23 Amps #4: 80 Amps
OPERATING VOLTAGE	500 VAC
OPERATING TEMPERATURE	-55 °C TO 125 °C
DIELECTRIC WITHSTANDING VOLTAGE	2000 VAC
INSULATION RESISTANCE	5000 MEGOHMS MIN (AT 25 °C)
NUMBER OF CONTACTS	3 #12 HVIL PIN 2 #4 PIN
CONTACT RESISTANCE	5 MILLIONHMS MAX
WATER PROOF (mated condition)	IP67 CLASS
DURABILITY	500 CYCLES
SALT SPRAY	5%NaCl,500H

Figure 5

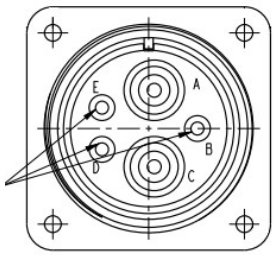
Identification	Contact function	Contact	Contact size AWG	Contact type- P/N	Connector P/N
J1BS 	Battery positive terminal	A	4		ACC02A24-12P(072)(SP)
	safe disconnection	B	12	HVIL	
	Battery Negative terminal	C	4		
	external booster power supply (-)	D	12	HVIL	
	external booster power supply (+)	E	12	HVIL	

Table D

4.5 Data Cable Connection

Data cable connector is identified with the name J2BS (label B, section 6.3.3)
It includes the CANbus and MODBUS connections with the pin out indicated in the table E and figure 6.

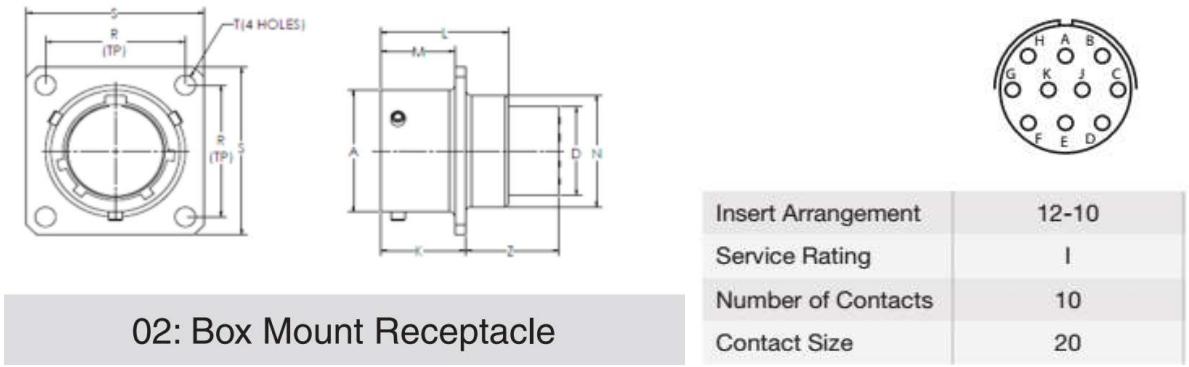


Figure 6

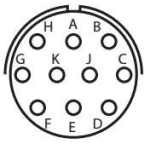
Identification	Connector function	Contact function	ID	Contact size AWG	Connector P/N
J2BS  12-10 I 10 20	Battery network connection	CAN L	A	To suit 0.5 mm^2 cable	LPT02SE-12-10P(072)
		CAN H	B		
		MODBUS+	C		
		MODBUS –	D		
		ALARM DRY CONTACT- NC	E		
		ALARM DRY CONTACT- COM	F		
		REMOTE POWER OFF +5Vdc	G		
		REMOTE POWER OFF GND	H		
		ALARM DRY CONTACT- NO	K		
		GND	J		

Table E

4.6 USB receptacle to allow connection for service operation

The USB receptacle to allow connection for service operation is identified with the name J3BS (label C, section 5.3.4)

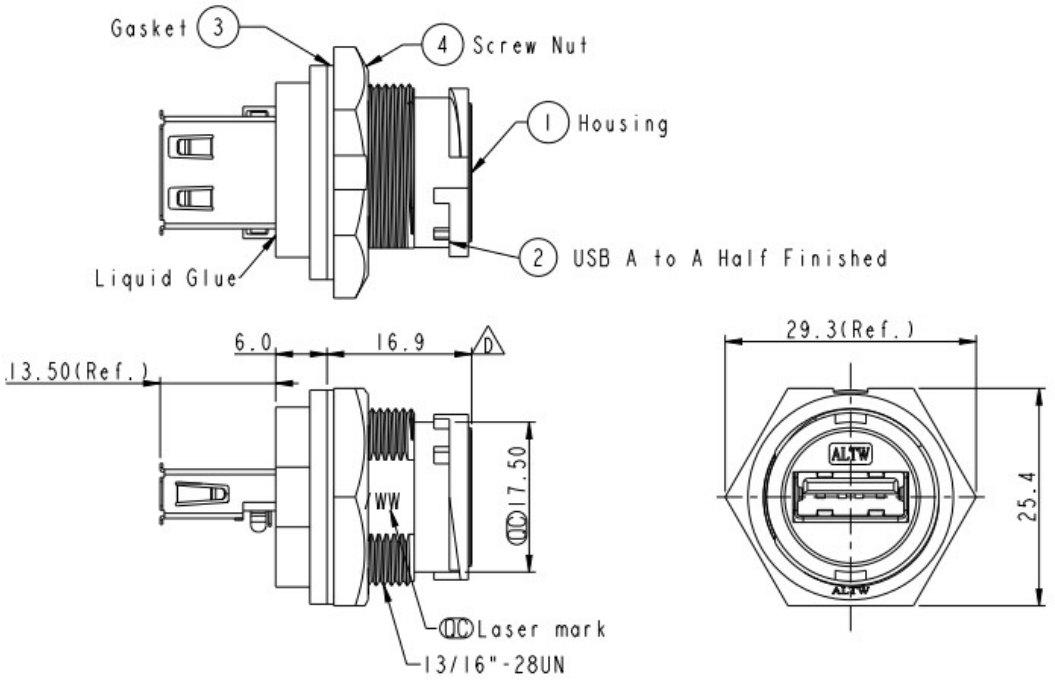


Fig.7, J3BS connector

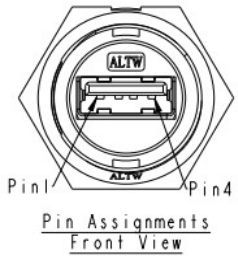
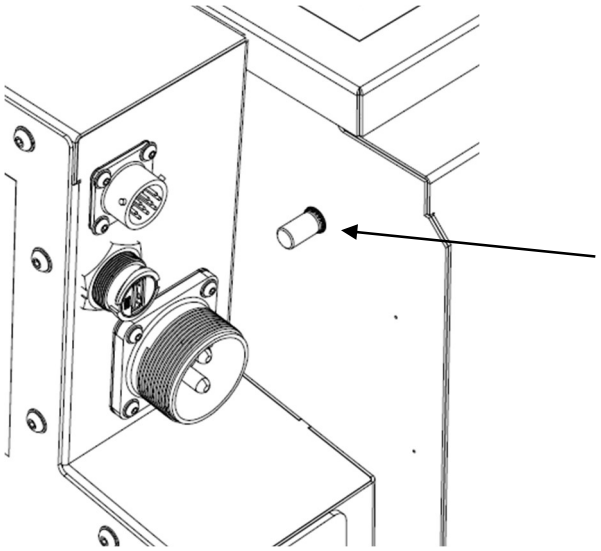
Identification	Connector function	Contact function	ID	Contact size AWG	Connector P/N
J3BS  Pin Assignments Front View	Service Operation	USB	1		UA-20PMFJ-NC7001
			2		
			3		
			4		

Table F

4.7 Ground connection

The UP battery is equipped with a ground connection located on the front side of battery pack close to the BMS connectors (Fig.8)



Ground Connection	
Diameter	Length
M8	16 mm

Fig.8, Ground Connection

4.8 Battery activation

1) Connect J1BS and ground wire. Data connection (J2BS) in not mandatory.
2) Set the DC power supply at the charge voltage indicated in table 1. No current limitation is needed however, with the factory setting, a minimum current supply per battery is necessary to ensure the shortest charging time. Please refer to table 1.
3) Turn on the DC power supply
4) If the battery internal temperature is below 265°C (509°F) the warm up phase is started, (see section 5.1 of this manual) till the target temperature is achieved. At this point the battery main contactor is closed, connecting the battery pack to the DC power supply.
5) Now the battery is electrochemically operative and, if it is not in the full state of charge, the built-in battery charger turns on and the charging phase starts. (See section 5.2 of this manual).
6) A discharge is always possible, even if the battery is in charge mode (see section 5.4 of this manual).

When an SMC battery is off, it is always necessary to connect it to a powered DC bus to turn it on again, for any SOC and any internal temperature condition.

If the voltage at the terminals of the battery power connector exceed the maximum specified limit for the battery, an alarm is issued and, depending on the voltage level, the battery may be permanently damaged. Do not connect the battery to a power source where the voltage or voltage spikes may exceed the maximum allowable battery voltage.

Battery must be activated and charged using a constant voltage power source.

4.9 Battery in parallel operation

In order to achieve the required level of energy two or more battery modules can be connected in parallel.
Parallel power connection is defined such that all the positive battery terminals (pin A of the J1BS connector) are connected to the same rectifier positive terminal and all the negative battery terminals (pin C of the J1BS connector) are connected to the same rectifier negative terminal.
Wire lengths should be the same for all modules to have even discharge between them.

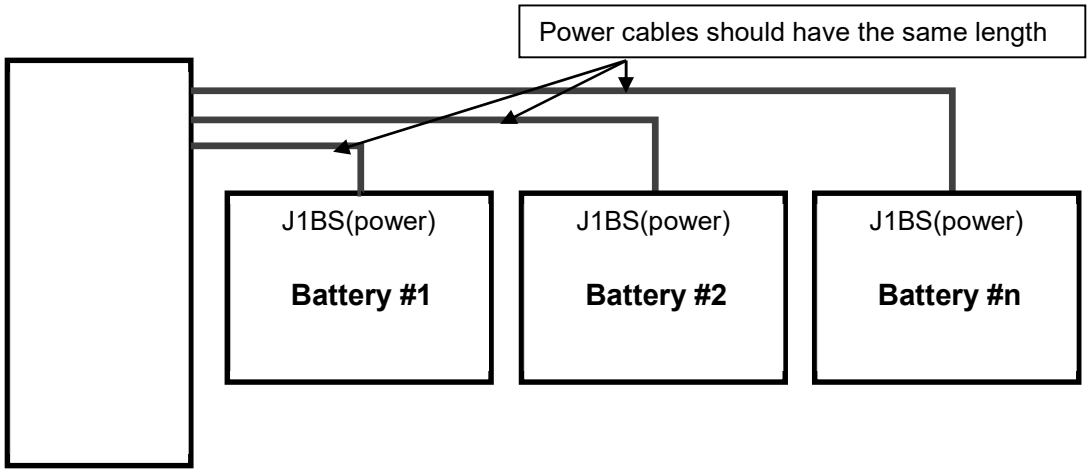


Figure 10a

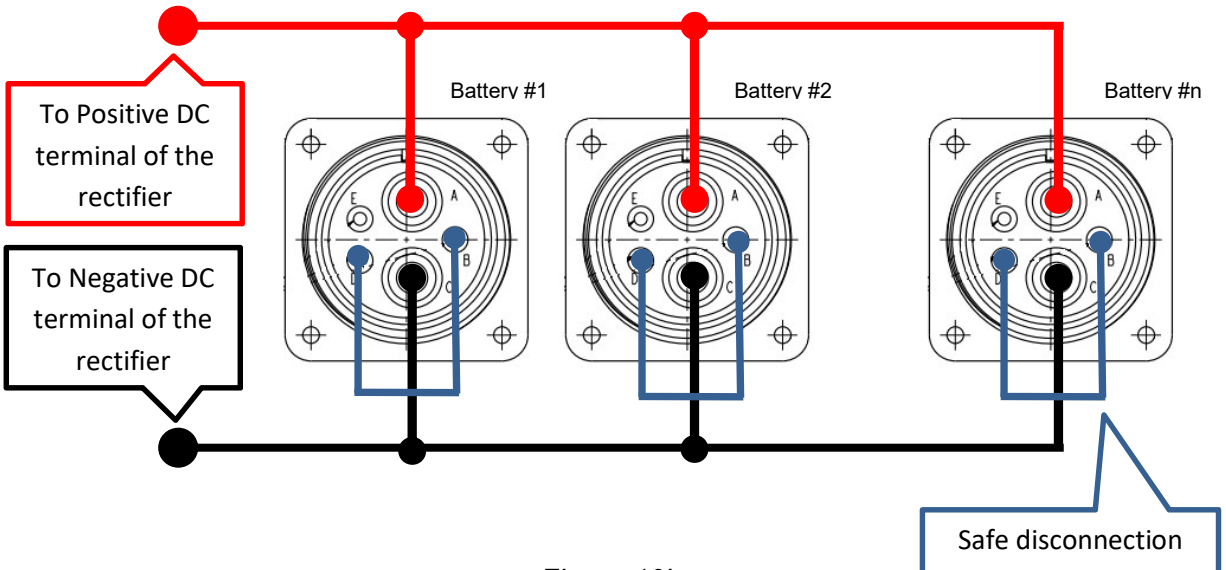


Figure 10b

Safe disconnection jumper is necessary to activate the battery.
FZSonick standard wiring already include this jumper, located in the connector plug.

4.9.1 Parallel charge

When the batteries are connected to the same DC rail, all their positive terminals are at the same potential and all their negative terminals are at the same potential.
Since the BMS is equipped with a charge regulator, all of them have the same voltage input but they individually manage the charge phase of the relative battery pack.
Battery charger is designed to work permanently connected to a constant voltage source and it regulates the voltage and the current as a function of the SOC: when in parallel, if the batteries have different SOCs, the system tends to an even situation thanks to the individual regulation.
Due to the voltage levels and the BMS circuit design, current circulation between batteries is not possible during a charge phase, as shown in figure 11.

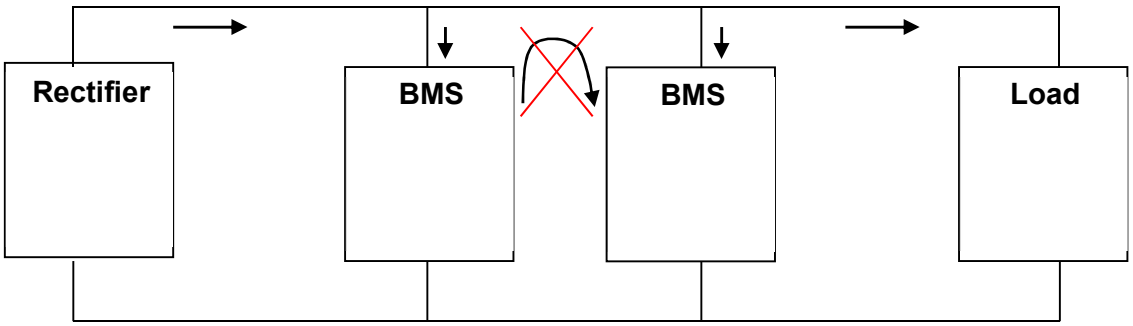


Figure 11

4.9.2 Parallel discharge

When the DC bus voltage becomes lower than the battery voltage, the battery immediately enters in discharge phase. Due to the BMS design there is no delay in the power delivery.
In a discharge phase with a parallel connection, individual battery current may be slightly different due to different internal resistances or to the presence of different connection residences and so, at the end of the discharge, batteries could show slightly different final SOCs. This uneven situation is recovered during the subsequent charge, thanks to the individual charger topology.
With a given load power, current circulation between batteries during a discharge is impossible due to the level of internal resistance and the presence of the internal charge regulator. Even if a battery disconnects before the other of the parallel, that battery cannot enter the charge phase, due to the low voltage applied to the charger input.

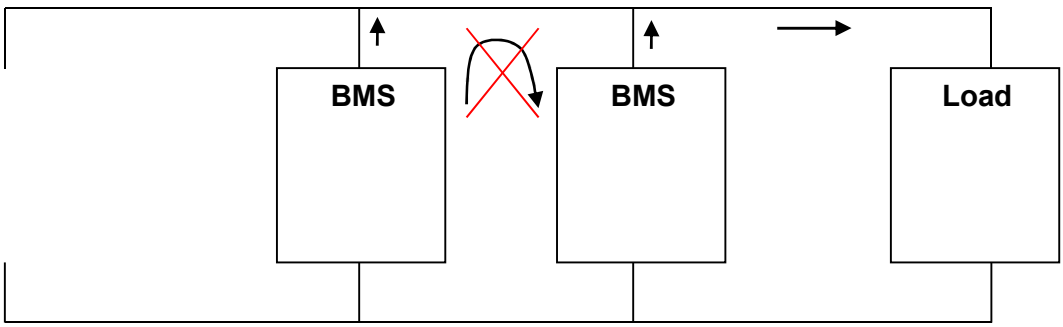


Figure 12

Maximum number of batteries that can be connected in the same data chain is 64 with the RS485.

5 BATTERY IN OPERATION

5.1 Battery Warm-Up

The FZSoNick battery needs to be warm up before it starts to deliver energy since it operates between 265° and 350°C (509-662°F).
The BMS performs the warm-up process automatically as soon as the battery is connected to a powered DC BUS. When the battery is in the warm-up state both green and blue LEDs will blink.
Starting from room temperature, this process takes >12 hours. A graph of the process is included in the appendix I section. Power consumption during this process is indicated in the Table J.

Elapsed Time (h)	Temperature (°C)	Power consumption (W)
0	25	380
7	160	380
12	260	380
>12	265	115

Table J

Power consumption values in the first three lines in Table J are during the warm-up phase of operation. Whenever the battery SOC is lower than 100%, the battery will automatically Start the charge cycle after the warm-up condition. After the charge cycle the Power consumption of the battery remains constant. The exact value is affected by ambient temperature. See Appendix for details.

5.2 Battery Charging

The BMS of the battery is equipped with an integrated charge regulator, basically a DCDC step-down (Buck) converter. A specific battery accepts any voltage in the range indicated in table 1 , and regulates the charging current and the charging voltage of each string to the optimal levels. Recharge current is limited by the BMS, therefore there is no need to limit the current at the rectifier level. To charge the battery, a simple DC power supply can be used. In any case the BMS is fully compatible with most of the rectifiers or UPS available in the industrial market.

If the BMS detects the SOC of the battery is below 100%, the charge phase is automatically started. This is indicated by the blue LED which will turn solid on.

Battery recharge time depends on the current availability and the initial SOC. If the full current is available, a complete charge takes approximately 12hrs. More charging information is included in the appendix II section.

If the available current is below the value indicated in table 1, during the first part of the charge process, the DC Bus voltage could decrease below the minimum value. A warning could be issued by the BMS. Besides the factory setting, lower current settings are available on request.

5.3 Floating

When a fully charged battery is connected to the DC bus (with only green led solid on) the internal charge regulators are switched off. In this condition the Battery “float” current is the sum of two main parts.
The first one is due to the power consumption of the electronics controller and the second is due to the power consumption used to compensate for the heat losses.
The first component of the float current is constant over the battery status while the second depends on battery working conditions. (i.e. ambient temperature).
The average float power consumption at 25°C is 115W; more detailed information is available in the appendix III section of this manual.

5.4 Discharging and Rated Capacity

A discharge is always possible in case the battery is in float or charge state, when the green LED is on solid. When the battery is performing a warm-up or is an alarm condition a discharge is not possible (green LED blinking).
In case the battery goes into discharge, the yellow LED turns on solid and, when the state of charge of the battery is under 12,5% of its nominal capacity value this LED turns to a blinking indication.
The rated capacity of FZSoNick battery are reported in Table 1. At higher rates the capacity is lower than nominal because of the internal resistance losses; at lower rates the useful capacity is lower due to the fact that some power is needed to maintain the battery at the internally working temperature and this power is drawn from the battery itself. The discharge performance is not significantly affected by temperature variations, especially compared with other battery technologies. Even if the outside ambient temperature varies greatly, its internal temperature will remain within the operative range and then the capacity and life are not affected.
Detailed information is available in the appendix IV section of this manual.

Discharge test is not mandatory: battery after charge is ready to use

5.5 Battery Cool Down

The battery is kept at its operating temperature with the internal heaters, controlled by the BMS and it is insulated with special insulation material to limit both the thermal losses and the temperature gradients inside the battery. If the battery is operative (ON-LINE), the thermal management of the BMS keeps the internal temperature at a minimum of 265°C.

As soon as the battery is turned off, the BMS is powered off and so the heating elements: the internal temperature starts to decrease with a typical behavior (see appendix V section for details).
If the battery is removed from the DC bus by an external circuit breaker (Power connector still plugged) , the battery starts to use its own energy to keep the internal temperature. After a number of hours, depending on the SOC, the battery turns off (when it’s SOC=0%) and the temperature starts to decrease.

During cool down period is possible to handle the battery if battery internal temperature is >200°C, typically within 12h from battery switch off. Shipping is possible only when the battery internal temperature is <90°C, typically after 72h from battery switch off.

When the battery is cold (all internal materials are in a solid state), a temporary placement with angles greater than 30° is allowed. In any case, never place the battery on its power terminals, upside down, with the front cover facing down or on its sides.

5.6 Battery Internal Resistance

The internal battery resistance varies depending on the different states of charge and model. Average value are reported in the following tables, see appendix VI section for details.

UP Battery Range	110UP80	125UP80	220UP40	250UP40
Typical Internal Resistance [mOhm]	193	219	788	875
Cells in series **Strings in Parallel**	44 2	50 2	90 1	100 1

5.7 Maintenance Free

The FZSoNick Sodium Metal Chloride battery does not require any maintenance.
The battery is designed and manufactured without user serviceable parts.
User interface provides battery statuses and operation data.

6 TECHNICAL INFORMATION

6.1 FZSoNick Battery Description

The battery's primary function is to store electrical energy and to supply it to an external load when needed. The battery management system also provides secondary functions that are essential to achieve the required service life duration.

6.1.1 BMS Functions

Main functions of the integrated Battery Management System (BMS) are:

- Battery Thermal Management: battery needs to be warm before to receive or deliver energy. The thermal management of the BMS performs the warm-up process automatically as soon as it is powered.
- Battery Charge Process: the BMS is equipped with a charge controller which is able to regulate the charging parameters (voltage and current) in order to obtain the best charging performance.
- Battery Power/Energy Output Checks: the BMS calculates the battery SOC to provide a reliable and safe operation and to avoid overcharge or over discharge.
- Battery Operating Conditions Checks: the BMS continuously measures all the battery parameters such as voltages, currents, temperatures, insulation levels providing a continuous monitoring of the operating conditions.
- Redundant Control: the controller is equipped with a safety redundant microprocessor for safe operations.
- Battery communication: the BMS has various communication capability using different communication ports: USB, RS485 or CAN Bus .

6.2 Battery Specification

BATTERY TYPE	110UP80	125UP80	220UP40	250UP40
Nominal Voltage [V dc]	110	125	220	250
Charge Voltage Range [V dc]	121.0 - 160	135.1 - 160	243.2 - 300	270.2 - 300
Vmin [V dc]	88	100	180	200
Nominal Capacity (C4)	80Ah / 8.6kWh	80Ah / 9.6kWh	40Ah / 8.6kWh	40Ah / 9.6kWh
Max Discharge Current (1')	120 A	120 A	60 A	60 A
Max Discharge Current (1h)	60 A	60 A	30 A	30 A
Power Fuse Rating	150 A	150 A	100 A	100 A
Thermal Dissipation at 25ºC	110 W	110 W	110 W	110 W
Warm-up time at commissioning	<13 h	<13 h	<13 h	<13 h
Recharge time from 0% to 100% SOC	<13 h	<13 h	<13 h	<13 h
Recharge time from 0% to 90% SOC	<8 h	<8 h	<8 h	<8 h
Recharge Current (internally regulated)	16 A	16 A	8 A	8 A
System Communication Port / Protocol	RS485/Modbus RTU and CAN/CanOpen			
HMI	4 LEDs			
Local Access Interface	USB			
IP RATING	IP55			
F [mm/ in.]	500 / 19.7			
H [mm/ in.]	322 / 12.7			
D [mm/ in.]	522 /20.6	560 /22.0	522 /20.6	560 /22.0
WEIGHT [kg / lb]	113 / 249	120 / 264	114 / 251	120 / 264
Operating temperature range with full performance	-20°C / +60°C -4°F / +140°F continuous			
Storage Temperature Range	-40 /+ 60°C (-40 / 140°F)			
Cell Pack Shelf life with no degradation	20 years			
Battery Expected Service Life	20 years			

Table K

6.3 Battery Labels

The FZSoNick battery has three visible labels located as in the Figure 14:

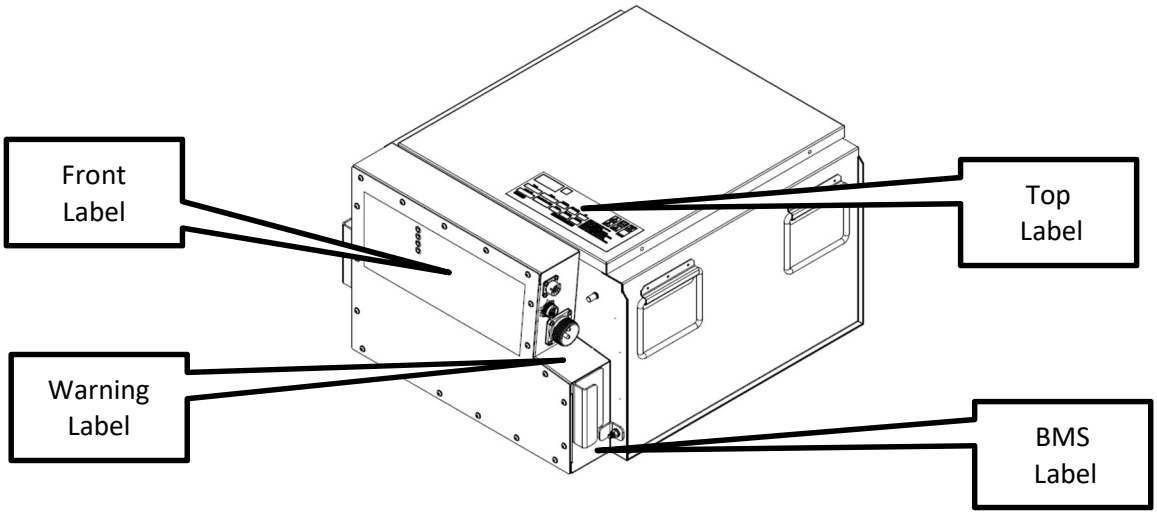


Figure 14

6.3.1 Front Label

The label in Fig.15 contains battery technical information, the LED explanation legend and the interface ports indications.

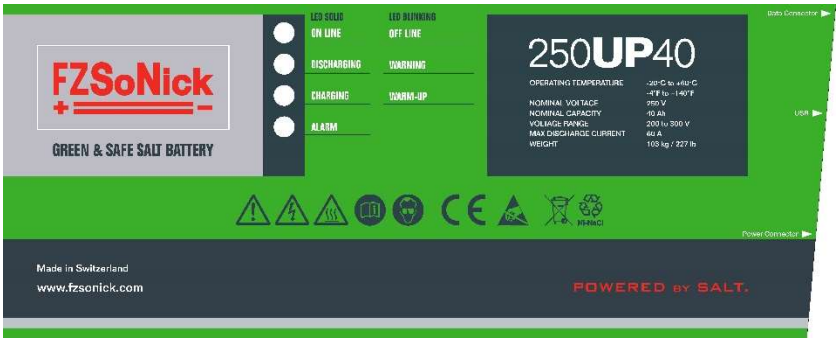


Figure 15

6.3.2 Side BMS Label

The label in Fig.16 contains the BMS serial number

Figure 16

6.3.3 Top Label

The label in Fig.17 contains battery technical information, the production date and the battery serial number.

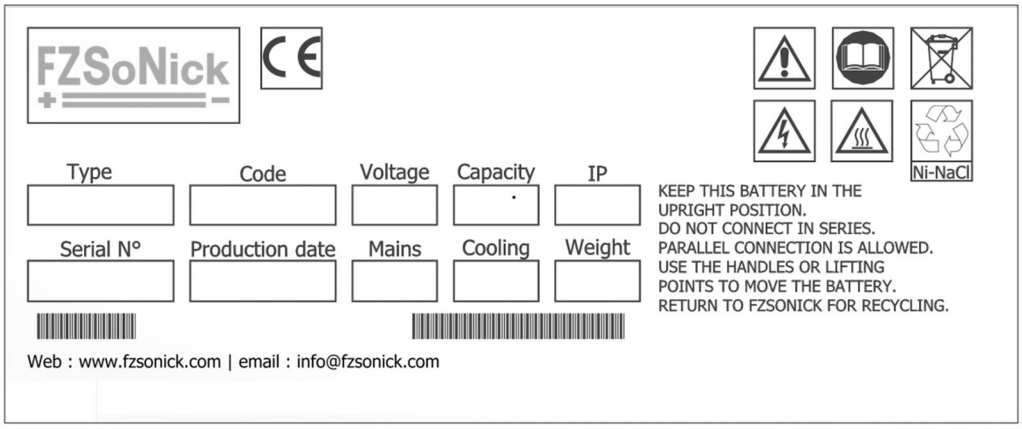


Figure 17

6.3.4 Warning Label

Symbol	Description
	Keep the battery in the upright position. Do not connect in series two or more batteries. Parallel connection is allowed.
	Hazardous voltage risk of electric shock. Authorized personnel only.
	The battery surface may be hot.
	The battery is an electrostatic-sensitive device, pay attention during its manipulation.
	Observe operating instructions and display it visibly in the vicinity of the battery. Work on batteries only after instruction by qualified staff.
	Wear eyes protection and protective clothing when working with batteries. Observe accident prevention regulations.

6.4 Battery Alarms

Battery management system issues warnings or alarms depending on the battery working conditions or to the presence of internal faults. Depending on the criticality of the situation, the Amber LED begins to blink (warning) or the Red LED become solid (Alarm). Alarm code is visible via SMC Monitor as indicated in the Table below:

Alarm Code	Descr String	ALARM TYPE	Description
0	Tam	RECOVERABLE	Ambient Temperature is low - Environmental Temperature Low
2	TaM2	RECOVERABLE	Ambient Temperature is too high - Environmental Temperature High
3	Tbm	RECOVERABLE	Battery Temperature is low - Min Battery Temperature
4	TbM1	WARNING	Battery Temperature is high -Max Battery Temperature
5	TbM2	RECOVERABLE	Battery Temperature is too high - Max Battery Temperature
7	VBm2	RECOVERABLE	Too Low Voltage on DC BUS - Min Bus Voltage
9	VBM2	RECOVERABLE	Too High Voltage on DC BUS - Max Bus Voltage
10	IDM1	WARNING	Discharge Current is High - Max Discharge Current
11	IDM2	RECOVERABLE	Discharge Current is Too High - Max Discharge Current
15	HTRE	RECOVERABLE	Warm Up Fault - Hater Error
16	TCPE	UNRECOVERABLE	Thermocouple is not reliable - Thermocouple Error
17	STRE	RECOVERABLE	Voltage measurement circuit fails - Max Measurement Error on String Voltage
18	CM E	RECOVERABLE	Current measurement circuit fails - String Current Measurement Error
19	HWFL	RECOVERABLE	BMS hardware fails - Internal Can Bus Communication Error
20	HWEM	RECOVERABLE	BMS HW protection is activated - Westinghouse Security
21	ThM	RECOVERABLE	Heatsink temperature too High - Max Heatsink Temperature
22	vsm1	WARNING	String Voltage Low - Min String Voltage
23	vsm2	UNRECOVERABLE	String Voltage Too Low - Min String Voltage
25	vsM2	RECOVERABLE	String Voltage Too High - Max String Voltage
27	iCM2	UNRECOVERABLE	String Charge Current Too High - Max Charge String Current
28	iDM1	WARNING	String Discharge Current ì High - Max Discharge String Current
29	iDM2	RECOVERABLE	String Discharge Current Too High - Max Discharge String Current
30	MID1	WARNING	String voltages unbalance warning - Max Midpoint Unbalance
31	MID2	RECOVERABLE	String voltages unbalance alarm - Max Midpoint Unbalance
32	BLPW	WARNING	Charging power is not available - Bus Voltage Low
33	CCBF	WARNING	Charger Circuit not working - Battery Charger Error
42	HTFS	UNRECOVERABLE	Heaters Fuse Blown
43	DATA	UNRECOVERABLE	Parameter out of range
44	LMPW	WARNING	String voltages unbalance warning
45	LMPA	UNRECOVERABLE	String voltages unbalance alarm
49	TOCW	WARNING	TOC is less than 100% from 2.5 days
50	TOCA	RECOVERABLE	TOC is less than 100% from 3.5 days

- Tripping of mechanism that provides electrical isolation:
  On battery side, the electrical insulation is provided by insulation materials that compose the battery case. On BMS side, the insulation is guaranteed by the isolated cables that went from the battery pack and by distances for busbar that went from battery pack. The ISO circuit (ref. MPS board diagram page 9) disconnects the battery terminals from the BUS terminals in the event that the electrical insulation is completely or partially damaged.

- Failure of normal power supply to BMS (2 cases):
  - If the external power supply is active, the BMS turns off the CCB, opens the main switches and the electronics continue to be powered.
  - If the external power is off, the BMS turns off the CCB, opens the main switches and shuts down because the energy in the cell pack is not allowed to be used under alarm conditions. In both cases the battery is made safe by opening the main switches and therefore ensuring the isolation of the cell pack.

- Activation of any automatic safety actions (2 cases):
  - If the external power supply is active, the BMS turns off the CCB, opens the main switches and the electronics continue to be powered.
  - If the external power is off, the BMS turns off the CCB, opens the main switches and shuts down because the energy in the cell pack is not allowed to be used under alarm conditions. In both cases the battery is made safe by opening the main switches and therefore ensuring the isolation of the cell pack.

- Balancing the batteries as necessary:
  At the string level, balancing is not necessary because there is only one string in the 250UP40 battery. At the battery level, if there are two or more batteries in parallel, it is not necessary to balance them through a specific procedure because each battery has its own BMS which charges one battery independently of the other

- Isolating batteries in case of damage/incorrect operation/maintenance (2 cases):
  - If the external power supply is active, the BMS turns off the CCB, opens the main switches and the electronics continue to be powered.
  - If the external power is off, the BMS turns off the CCB, opens the main switches and shuts down because the energy in the cell pack is not allowed to be used under alarm conditions. In both cases the battery is made safe by opening the main switches and therefore ensuring the isolation of the cell pack.

- Emergency shutdown (2 cases):
  - If the external power supply is active, the BMS turns off the CCB, opens the main switches and the electronics continue to be powered.
  - If the external power is off, the BMS turns off the CCB, opens the main switches and shuts down because the energy in the cell pack is not allowed to be used under alarm conditions. In both cases the battery is made safe by opening the main switches and therefore ensuring the isolation of the cell pack.

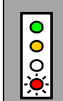
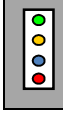
6.5 Service Life Definition

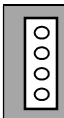
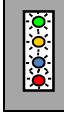
The service life of a FZSoNick battery is the period of useful service under the conditions defined in the battery specification expressed as the period elapsed between the start of life and the time where the ampere-hour maximum capacity has fallen to 80% of the rated capacity. Even if the battery goes below 80%, its rated capacity will not drop abruptly and suddenly like other battery technologies.

6.6 Extended Outages

Extended outages don't have any consequences on the battery health. In case of a prolonged discharge, the battery disconnects itself from the load when its energy is expended and, if the main DC supply doesn't come back, the internal temperature will start to decrease. When cold the battery is completely inactive and can stand in such condition for a period of time which is virtually infinite. As soon as the mains return the battery starts the warm up procedure (if needed).

6.7 Light Emitting Diodes (LED's) Explanation

LED COLOUR		INDICATION	NOTE / ACTION
	SOLID *GREEN*	Battery ready to operate, connected to the DC bus	The battery is fully charged State of Charge (SOC) =100%
	BLINKING *GREEN* BLINKING *BLUE*	Battery is warming up, not connected to the DC bus	Temperature is below operational. Charging or discharging is not allowed
	SOLID *GREEN* SOLID *BLUE*	Battery under charge, connected to the DC bus	Battery SOC is < 100% Discharging is allowed
	SOLID *GREEN* SOLID *YELLOW*	Battery is discharging	
	SOLID *GREEN* BLINKING *YELLOW*	Battery is discharging	Warning Active
	SOLID *GREEN* SOLID *YELLOW* SOLID *BLUE*	Battery is discharging. Direct charge is allowed	
	SOLID *GREEN* BLINKING *YELLOW* SOLID *BLUE*	Battery is charging. Discharge is allowed	Warning Active
	SOLID *GREEN* BLINKING *RED*	A warning occurred during the float (idle) condition	Check float (idle) conditions/parameters
	SOLID *GREEN* SOLID *BLUE* BLINKING *RED*	A warning occurred while the battery was charging	Check charge conditions/parameters
	SOLID *GREEN* SOLID *YELLOW* BLINKING *RED*	A warning occurred while the battery was discharging	Check discharge conditions/parameters
	BLINKING *GREEN* SOLID *RED*	Alarm status – the battery is not connected to the DC bus	The battery was disconnected because of a major issue. Charging or discharging is not allowed
	SOLID *GREEN* SOLID *YELLOW* SOLID *BLUE* SOLID *RED*	Battery is preforming the Start-up process	The BMS is pre-charging internal circuits

	NO LED ON	the BMS is not powered-up	Check if DC bus is up otherwise, the BMS has to be serviced/repaired
	BLINKING GREEN BLINKING YELLOW BLINKING BLUE BLINKING RED	Recessed contacts open	Check Power connection insertion

6.8 Safe Technology

Each battery is made of sodium metal chloride cells in series and parallel. A single cell is composed by a fully sealed prismatic steel case which contains the active materials and the cell separator. The cells are electrically connected by brazed/welded rigid inter-cell connectors and the resulting cell pack is contained into a stainless steel (inner) box together with 3 heating elements and the temperature probes.
The inner box is surrounded by the thermal insulation complex which is composed by a number of micro-porous silica panels with the appropriate thickness to provide the right level of insulation, minimizing the thermal losses.
The outer stainless steel battery box contains the inner box and the thermal insulation barrier and provides the adequate mechanical strength and a sealed construction.
All of the active materials are safely and permanently contained within the battery, which has zero spillage and cannot leak or outgas in normal operation.

6.9 Battery Protection

Each battery has its own electrical, thermal and mechanical protection built-in.

6.9.1 Electrical Protection

Electrical protections are considered as primary security.
FZSoNick battery is protected against short circuit or prolonged current overload (current above nominal will open the positive leg) by the Battery Management System's (BMS) ability to disconnect the battery . Battery is also provided with internal fusible link protection, that will open the negative leg if an over current situation, in the remote case of non-intervention by the BMS, occurs.

6.9.2 Battery Thermal Protection

Thermal protection devices are used to prevent battery overheating situations. The following is a list of the thermal protections built in each battery:

- To maintain the battery internal temperature between 265 and 350 °C (509-662°F), heaters activated by a closed-loop temperature control system, are managed by the BMS.
- The BMS will temporarily disconnect the battery path should its internal temperature exceed 350°C (662°F).
- The BMS will cut power to the battery heaters should the battery temperature be above 350°C (662°F).

6.9.3 Mechanical Protection

Batteries are packed with a double stainless steel case and cells are hermetically sealed with metal cases which fully enclose the active materials and which are so constructed and closed to prevent the release of the active materials under normal conditions.

6.9.4 Reliability

A battery failure in a multi-battery installation will not cause the battery backup system to fail nor will it cause the other batteries to malfunction. The defective battery will take itself off-line from the other batteries. Power to the load will not be compromised with the only effect being a reduction in the backup time.

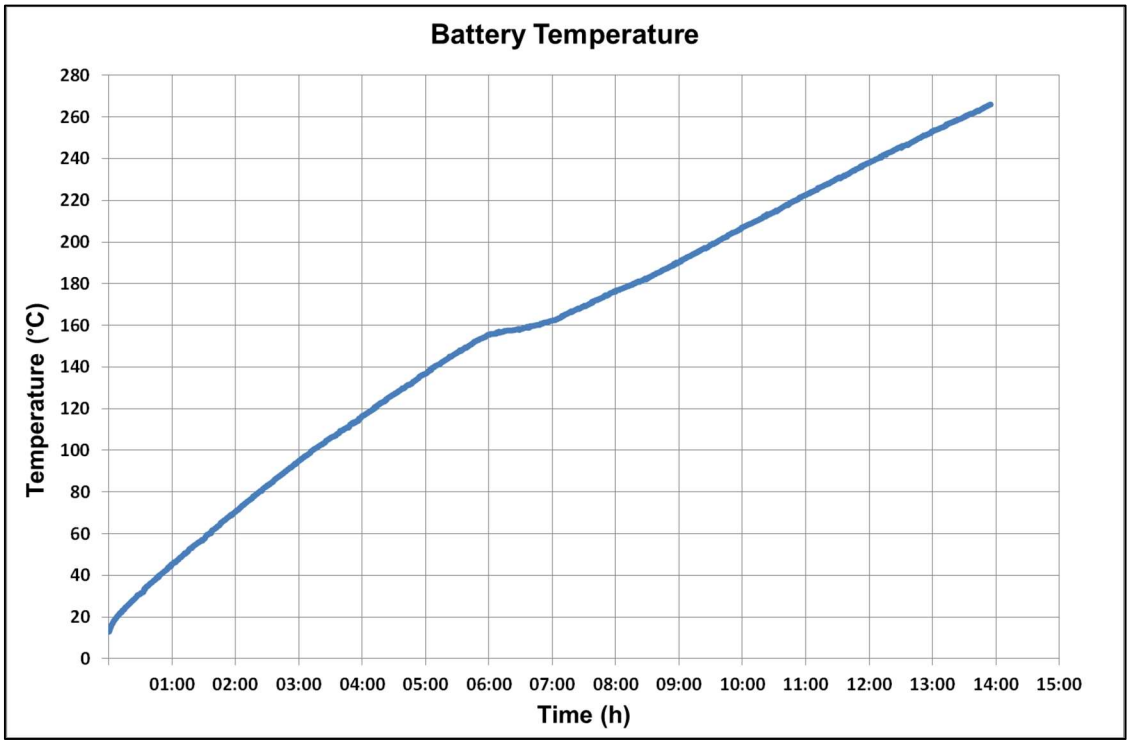
6.10 Technical Assistance

For technical assistance or any questions concerning FZSoNick or any of its products, contact FZSoNick customer support.

APPENDIX

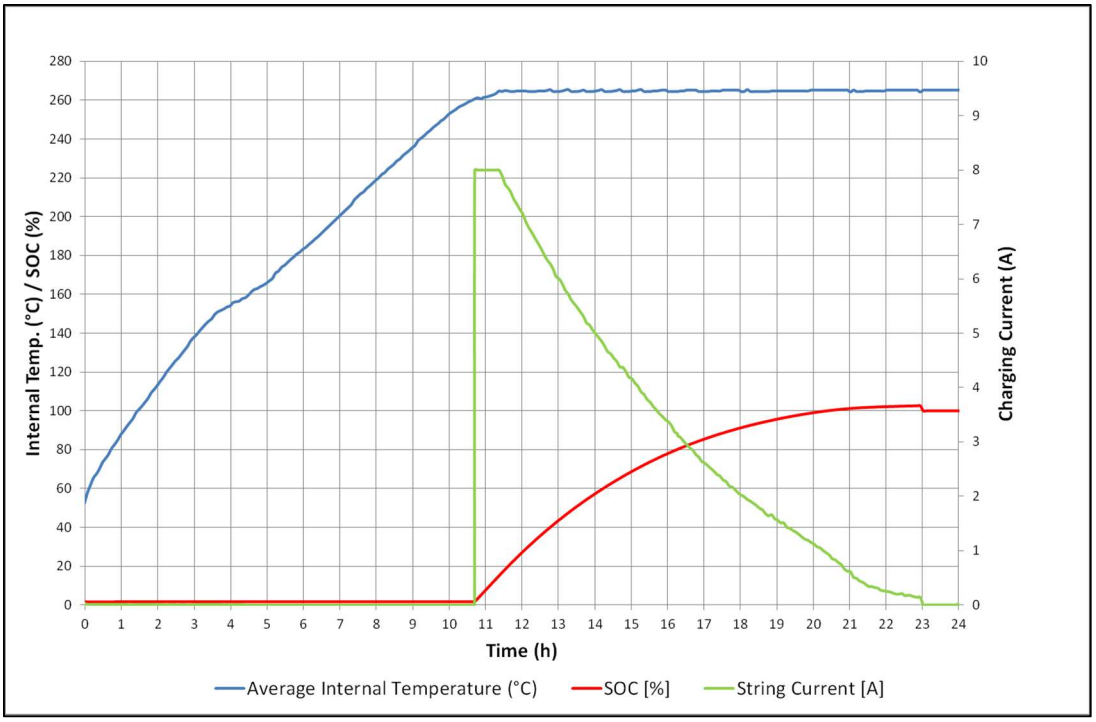
I - Warm Up Process

The graph below shows the internal temperature evolution of a battery during the warm-up process

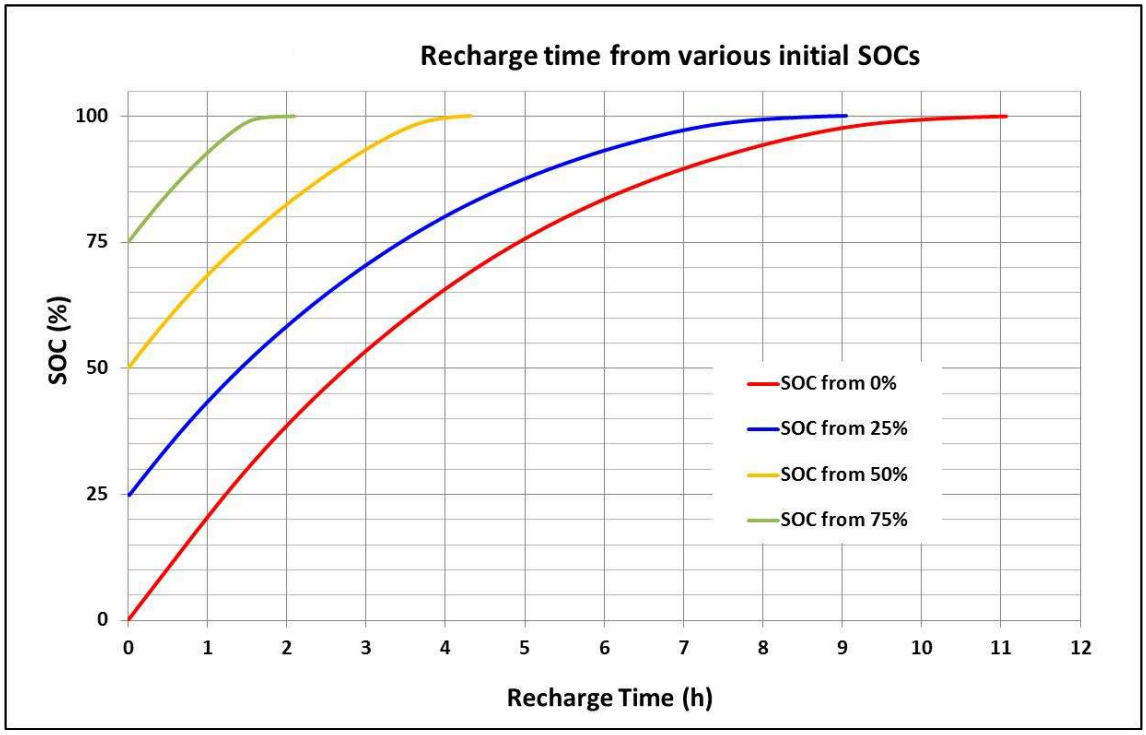


II - Battery Recharge

The battery can be recharged using a constant voltage DC power supply. Excess of charging capacity is not a concern because internal battery circuitry automatically limits the charging current (8A or 16A depending on the battery model) to ensure the safe and optimum operation of the battery.



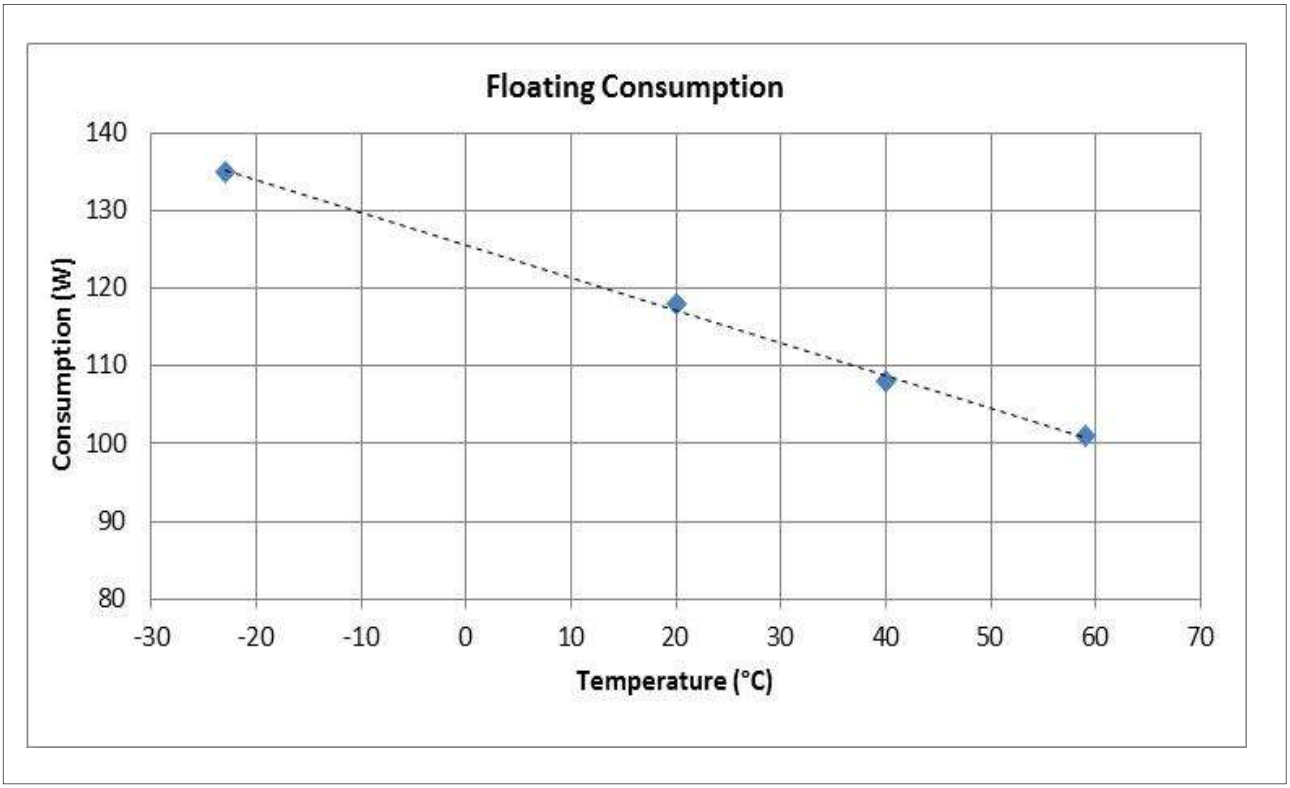
The graph below shows the recharge time for various initial states of charge. These results can be obtained when the recharge power required by the battery (standard setting) is fully available from the rectifier.



Recharge time [h] [-20 + 60°C; -4 ÷ +140°F]				
Final SOC (%) / Initial SOC (%)	**25**	**50**	**75**	**100**
0	1.2	2.7	5	<12
25		1.4	3.4	9
50			1.4	4.2
75				2
100				

III - Battery Floating

The float power consumption of the battery depends on the temperature of the ambient where the battery is installed. This behavior is mainly due to the variations of the heat power requirements with the temperature. The graph below shows the power consumption at different ambient temperatures.

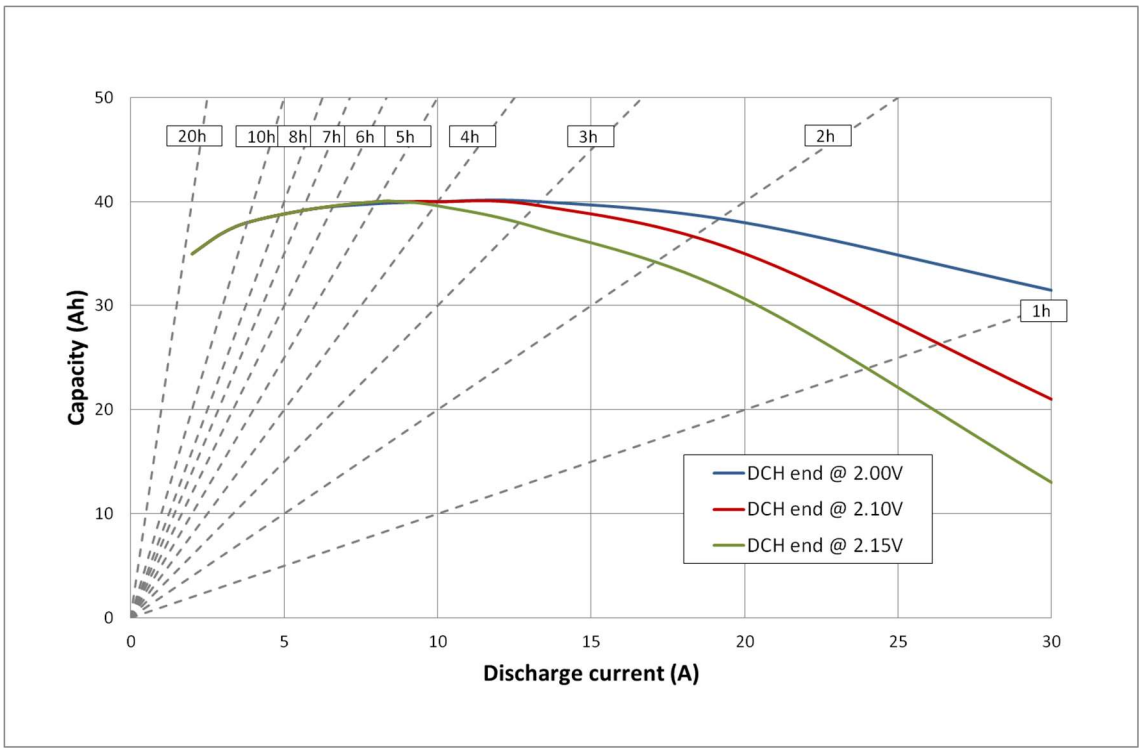


IV - Battery Performance

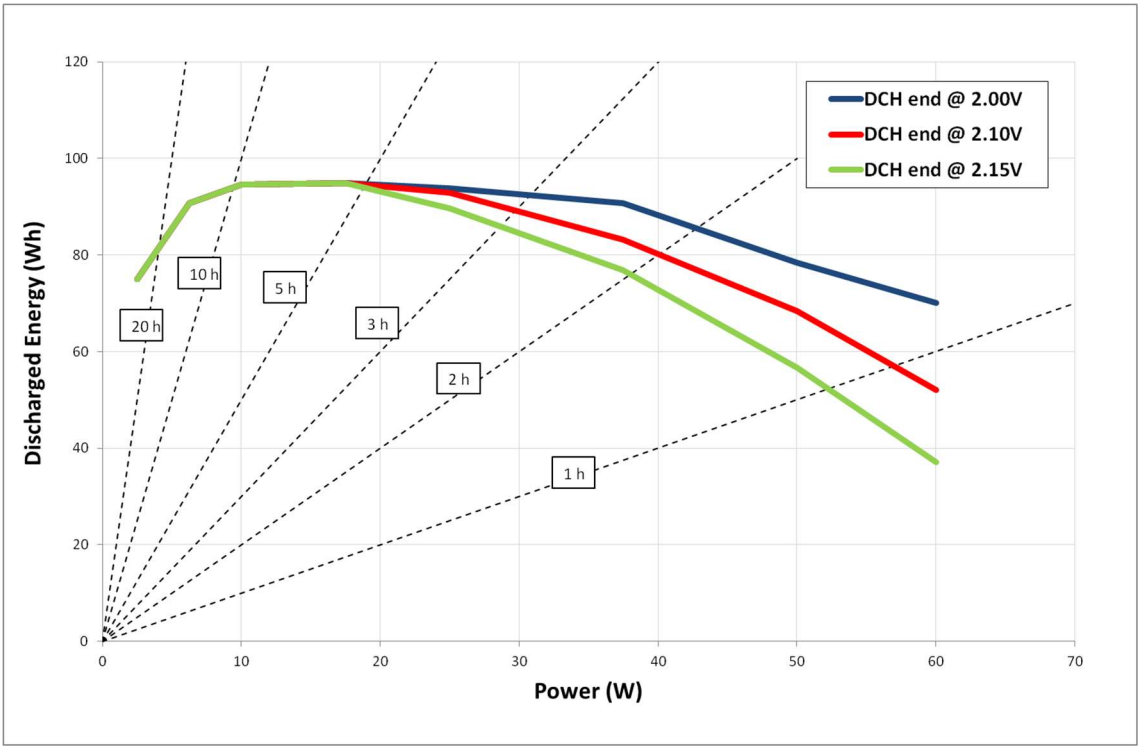
Following tables show the capacity and energy at different final voltage levels when the battery is discharged with a constant current or constant power load.

During a discharge at low temperatures, the internal heaters will consume more energy than at higher ambient temperatures, but the capacity or energy reduction is minimal. During operation at high temperatures, capacity or energy is not affected.

- **Capacity / Current:** Cell discharge behavior: CONSTANT CURRENT

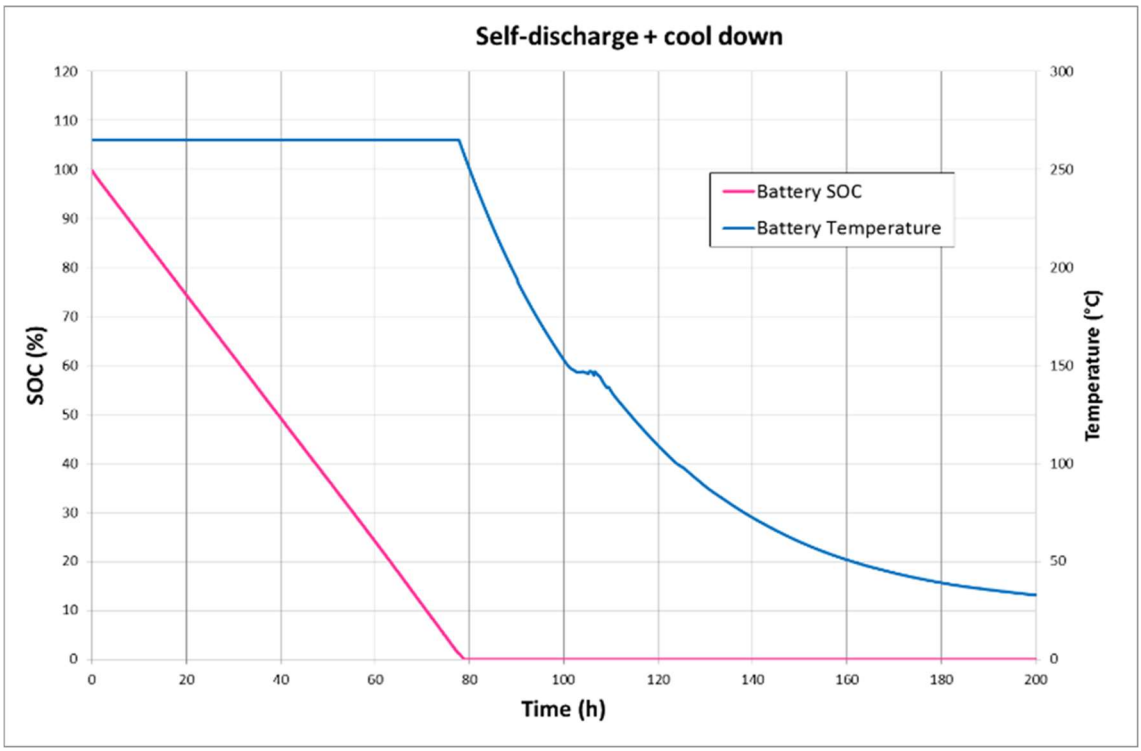


- **Power / Energy: Cell discharge behavior: CONSTANT POWER**



V - Battery Cool Down

The graph below shows the internal temperature evolution of a battery module during the cool down process.



APPLICATION NOTES

A. Battery main features

Sodium-Metal Chloride Batteries belong to the molten-salt battery category. This technology has high specific and gravimetric capacity, with cells operating at relatively high temperatures (260-350°C) enclosed in a thermally insulated case.
The ambient operating temperature range of the battery extends about from -20°C to +60°C, without any power de-rating.
Energy performance is excellent, while the internal cell resistance gives an optimal discharge rate between 1 and 8 hours.
Typical cell failure mode is low-dissipation internal short-circuit, therefore guaranteeing battery overall performance with this unique graceful degradation feature.
A sealed steel cell case provides for zero ambient emissions and allows the battery installation in any closed environment.

B. Electrical differences with other battery types

The main differences between a conventional room-temperature battery (e.g. Lead-Acid) and a Sodium-Metal Chloride Battery are following:

1) Sodium-Metal Chloride Batteries can exchange energy only when their internal temperature reaches the minimum operating temperature of about 260°C.
2) A Warm-Up time shall pass before the battery could be brought into operation
3) All batteries have an integral charger and shall be connected only to a Constant-Voltage DC Bus when charging
4) Maximum DC Bus voltage limits shall be respected at all times, in order to avoid damaging internal control electronics
5) Sodium-Metal Chloride Batteries cannot be series-connected

The BMS includes the power electronics circuits to control the resistive heaters and the charge process and by a microprocessor that supervises the complete operation of the battery.
The resistive heaters will be switched on and off by power Mosfets with a PWM control at about 300Hz.
Integrated step-down (Buck) DC/DC converter charge regulators have a switching frequency of 45 kHz (one for each cell string).
Default, maximum charging current of each string is 8 A. Charge Current can be programmed for lower levels.
The external source (charger, rectifier or bi-directional inverter) should provide a stable voltage working as voltage generator and should include a soft start function to avoid overvoltage peaks that could damage the battery electronics**.**
When a battery is switched on, the BMS shows a capacitive load and then the internal power supply starts and powers up the micro-controller with a load of about 10 watts.

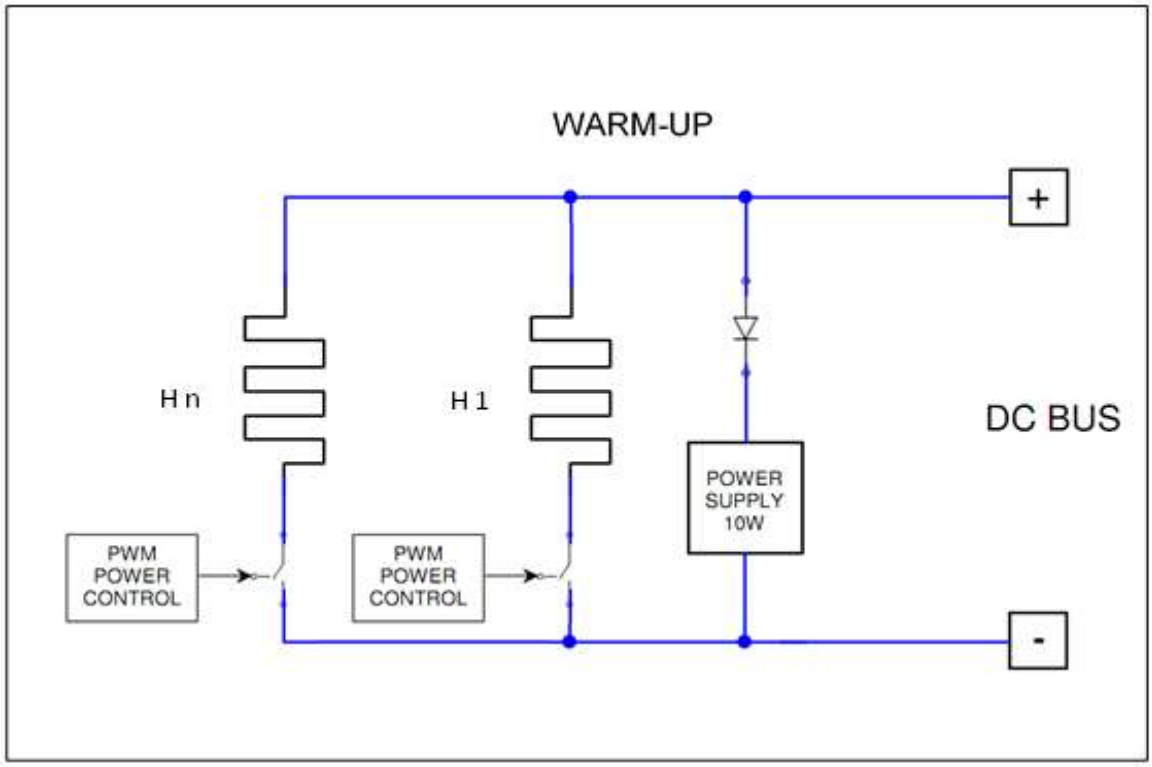
If a BMS is plugged to an already powered DC BUS the resonance of the capacitive load with the inductance of the bus could lead to an overvoltage dangerous for the electronic circuits. The DC bus must show a low inductance and/or the system must be equipped with a Surge Protective Device capable to limit the overvoltage**.**

C. Warm-up

As soon as the battery is connected to a constant-voltage DC Bus within the specified range, it starts warming its cells from ambient temperature to 260°C. Throughout this phase, the battery is a switched-resistive load, consisting of a PWM-controlled heater, with a switching frequency of 310 Hz

The power source must provide a stable voltage in presence of a switched load.

- During the 12-13h warm-up period, the battery draws a constant power from the DC Bus. Due to internal cell structure, no charge can be exchanged with the cells during warm-up, therefore all circuits are disconnected by holding the battery contactor open (Main Switch)
- From a user point of view, even low currents cannot be drawn from the battery during warm-up: if the DC Bus is switched off, its voltage is not held by the battery and drops to zero
- If power is removed during the warm-up process, the battery begins to cool down at a rate between 5°C/h and 2°C/h (in the temperature ranges 250...150°C and 150...50°C respectively). Warm-up resumes as soon as DC Bus power is restored.
- Being the battery a switched resistive load, no excess power can be dumped into the battery. If for any reason this is attempted, DC Bus voltage will rise possibly to dangerous voltages for the BMS electronics
- Maximum Vbus voltage is specified in Table 1 and can never be exceeded even for short transients. Compliance to this limit should be verified by the System Integrator
- If for any reason Vbus voltage exceeds the maximum allowed, the battery could be permanently damaged and will need to be shipped back to the manufacturer



D. Charge

- The battery closes the Main Switch and turns on its internal charger as soon as it reaches the operating temperature
- During charge the power source must work as voltage generator and keep the voltage within the specified limits (Vbus_min...Vbus_max) in presence of a variable load : A CC/CV charge profile is applied until all the cells are brought to an EOC (End-Of-Charge) condition.
- The charge process is always managed by the internal DC/DC: the current of each string is controlled and slowly reduced to keep a maximum current/maximum voltage control and the absorbed power tapers down in time from Pcharge_max to Stand-by power
- If the DC BUS voltage will decrease below Vmin the charge will stop, if the DC BUS voltage will further decrease below the battery open circuit voltage,the battery will switch to Discharge condition.
- For this reason, during the charge, NO excess power can be dumped into the battery. If this is attempted for any reason, DC Bus voltage will rise to possibly dangerous voltages for the BMS electronics
- The minimum current before the detection of the complete charge could be low as 0,2 A.per string
- During the charge process the BMS will also control the heaters with the power necessary to keep the battery temperature at the heating set point.

To charge the battery the power source (rectifier, power supply or bi-directional inverter) must work as voltage generator and provide a stable voltage in presence of a variable load .See section H for the maximum acceptable ripple

E. Stand-by / floating mode

- after charge current has dropped under a set value, the EOC condition is reached: the internal charger is turned off and the battery goes into the “Stand-by” (or “Float”) state
- when in this state, the battery draws only “Stand-by Power” from the DC Bus. The BMS will control the heaters with the power necessary to keep the battery temperature at the heating set point. The power request depends on the ambient temperature
- in this condition the battery can instantly deliver power and hold the DC Bus through its output diode, supplying all bus loads until its energy is over
- in this condition the battery cannot instantly absorb charge power.
- Its internal power circuits have to be steered and a current ramp will begin within hundreds of milliseconds from the DC Bus being restored

The power source must provide a stable voltage in presence of a switched load. .See section H for the maximum acceptable ripple

F. Discharge

- the battery can instantly deliver power and hold the DC Bus through its output diode, supplying all bus loads until its energy is over.
- the BMS includes an electronic fuse that protects the battery from any overcurrent abuse
- As soon the voltage on the bus recover, the battery will be set back in charge mode
- The discharge will be terminated if then battery is discharged, or the maximum current , maximum temperature or minimum voltage limits are exceed

G. Overvoltage protection

The maximum Vbus voltage can never be exceeded even for short transients.

The charger/rectifier should provide a stable voltage working as voltage generator and in presence of transients should react fast enough to avoid overvoltage peaks on the DC bus that could damage the battery. The system must be equipped with a Surge Protective Device capable to limit the overvoltage on DC bus.

If the BMS detects a voltage higher than V Max the main switch will be open to protect the cells but in any case some electronic circuits of the BMS will remain connected to the DC bus and can be damaged by the overvoltage

	V MAX [Vdc]			
Time [msec]	110UP80	125UP80	220UP40	250UP40
1000	154	175	308	350
100	165	190	335	380
30	180	204	360	410
10	194	220	385	440

Special care must be taken in systems where it is not possible to prevent energy sourge to be dumped in the DC bus.

Examples of such systems are some UPS/PCS applications where capacitive / inductive energy surges are dumped into the standard Lead Acid batteries.
Such system must be equipped with a convenient Surge Protective Device to prevent overvoltages.
Clamp Peak/Sustained power ratings shall be determined after a careful evaluation of the worst-case energy surges that may be expected during the operational life of the system.

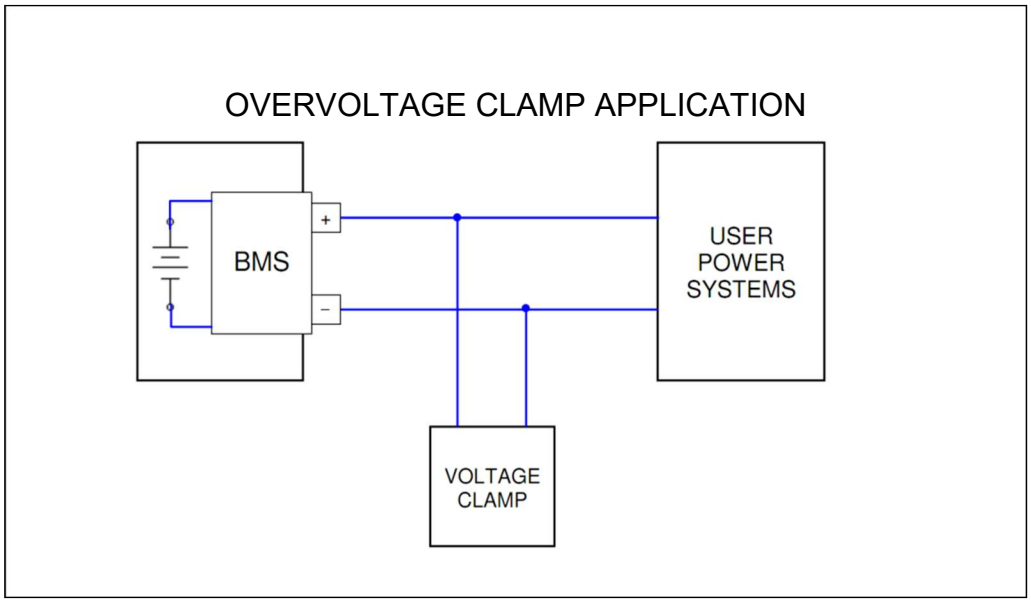
H. Ripple

High ripples on the DC BUS generated by the power electronics could damage the BMS

The maximum acceptable ripples is

Frequency range	V rms
50-300 Hz	**2% V nominal**
10-40 kHz	**2% V nominal**

In order to limit the ripple a capacitor pack must be installed as close as possible to the battery module



Capacitor sizing shall be determined after a careful evaluation of the worst-case that may be expected and/or real measurements of the system.

NOTE:
In case the current drawn by the inverter from the battery presents a prevalent half wave variable profile the user shall consult the battery supplier to apply appropriate filters to mitigate it, otherwise the warranty is void.

As an example this situation has been found in three-phase inverters with capacitor midpoint topology and unbalanced loads.

Title	Issue Date	Revision
I&O – UP Range HV	2023/12/12	December 2023

FZSoNick

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