

Technical Report No.: 64.280.25.60378.01

Date: 2025-10-20

Client: Shanghai PYTES Energy Co., Ltd.
No. 3492 Jinqian Road, Fengxian District, 201406 Shanghai, PEOPLE'S
REPUBLIC OF CHINA

Manufacturer: Shanghai PYTES Energy Co., Ltd.
No. 3492 Jinqian Road, Fengxian District, 201406 Shanghai, PEOPLE'S
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Factory: Shanghai PYTES Energy Co., Ltd.
No. 3492 Jinqian Road, Fengxian District, 201406 Shanghai, PEOPLE'S
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Test object: Product: Rechargeable Li-ion Battery System

Model: HV48100 SE BMU-3, HV48100 SE BMU-4,
HV48100 SE BMU-5, HV48100 SE BMU-6,
HV48100 SE BMU-7, HV48100 SE BMU-8,
HV48100 SE BMU-9, HV48100 SE BMU-10,
HV48100 SE BMU-11, HV48100 SE BMU-12,
HV48100 SE BMU-13, HV48100 SE BMU-14,
HV48100 SE BMU-15

Trade mark: **Pytes**

Test specification: Annex H of UL 60730-1:2016 & CAN/CSA E60730-1:2015/A1:2017-11 (Class B
control)

Purpose of
examination: Testing and evaluation according to the test specification.

Test result: The test results show that the presented product is in compliance with the above
listed test specifications.

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1. Description of the test object

1.1 Picture(s)

HV48100 SE BMU-15:



Remark: This is the largest Rechargeable Li-ion Battery System model: HV48100 SE BMU-15. The other models are based on this model to reduce battery modules in series.

BCU board: HV48100-SE-BCU-V02

BMU board: HV48100-SE-BMU-V03

1.2 Function

Manufacturer's specification for intended use:

- according to the user manual or installation instructions.

1.3 Consideration of the foreseeable use

- ☐ Not applicable
- ☒ Covered through the applied standard
- ☐ Covered by the following comment
- ☐ Covered by attached risk analysis

1.4 Technical Data

1. The Rechargeable Li-ion Battery Systems, model: HV48100 SE BMU-3, HV48100 SE BMU-4, HV48100 SE BMU-5, HV48100 SE BMU-6, HV48100 SE BMU-7, HV48100 SE BMU-8, HV48100 SE BMU-9, HV48100 SE BMU-10, HV48100 SE BMU-11, HV48100 SE BMU-12, HV48100 SE BMU-13, HV48100 SE BMU-14, HV48100 SE BMU-15 are used in industrial application.
 2. Model: HV48100 SE BMU-3, HV48100 SE BMU-4, HV48100 SE BMU-5, HV48100 SE BMU-6, HV48100 SE BMU-7, HV48100 SE BMU-8, HV48100 SE BMU-9, HV48100 SE BMU-10, HV48100 SE BMU-11, HV48100 SE BMU-12, HV48100 SE BMU-13, HV48100 SE BMU-14, HV48100 SE BMU-15 respectively consist of 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 Rechargeable Li-ion Battery Modules (model: HV48100 SE BMU) connected in series with the HV box (model: HV48100 SE BCU).
 3. The maximum operating voltage of the Rechargeable Li-ion Battery System is 855 Vd.c. and the battery system is for indoor use.
 4. The Rechargeable Li-ion Battery System is isolated from an Overvoltage category III supply source (such as from an Overvoltage category III PCS) through an isolated transformer or protected in a manner that prevents transient overvoltage conditions, Overvoltage Category II is applied.
- Additionally, details information of the batteries and its component cell are shown in following table:

Product name	Rechargeable Prismatic Lithium-ion Cell	Rechargeable Li-ion Battery Module	Rechargeable Li-ion Battery System
Type/model		HV48100 SE BMU	HV48100 SE BMU-3 HV48100 SE BMU-4 HV48100 SE BMU-5 HV48100 SE BMU-6 HV48100 SE BMU-7 HV48100 SE BMU-8 HV48100 SE BMU-9 HV48100 SE BMU-10 HV48100 SE BMU-11 HV48100 SE BMU-12 HV48100 SE BMU-13 HV48100 SE BMU-14 HV48100 SE BMU-15

Nominal voltage	3.2 Vd.c.	51.2 Vd.c.	HV48100 SE BMU-3: 153.6 Vd.c. HV48100 SE BMU-4: 204.8 Vd.c. HV48100 SE BMU-5: 256 Vd.c. HV48100 SE BMU-6: 307.2 Vd.c. HV48100 SE BMU-7: 358.4 Vd.c. HV48100 SE BMU-8: 409.6 Vd.c. HV48100 SE BMU-9: 460.8 Vd.c. HV48100 SE BMU-10: 512 Vd.c. HV48100 SE BMU-11: 563.2 Vd.c. HV48100 SE BMU-12: 614.4 Vd.c. HV48100 SE BMU-13: 665.6 Vd.c. HV48100 SE BMU-14: 716.8 Vd.c. HV48100 SE BMU-15: 768 Vd.c.
Rated capacity	100 Ah	100 Ah	100 Ah
Recommended charging voltage by manufacturer	3.65 V	57.6 V	HV48100 SE BMU-3: 171 V HV48100 SE BMU-4: 228 V HV48100 SE BMU-5: 285 V HV48100 SE BMU-6: 342 V HV48100 SE BMU-7: 399 V HV48100 SE BMU-8: 456 V HV48100 SE BMU-9: 513 V HV48100 SE BMU-10: 570 V HV48100 SE BMU-11: 627 V HV48100 SE BMU-12: 684 V HV48100 SE BMU-13: 741 V HV48100 SE BMU-14: 798 V HV48100 SE BMU-15: 855 V or any cell reaches 3.6 V
Recommended charging current by manufacturer	50 A	50 A	50 A
Maximum continuous charging current	100 A	50 A	50 A
Recommended discharging current by manufacturer	50 A	50 A	50 A
Maximum continuous discharging current	150 A	50 A	50 A
Discharging cut off voltage	2.5 V	45.5 V or any cell reaches 2.8 V	HV48100 SE BMU-3: 136.5 V HV48100 SE BMU-4: 182 V HV48100 SE BMU-5: 227.5 V HV48100 SE BMU-6: 273 V HV48100 SE BMU-7: 318.5 V HV48100 SE BMU-8: 364 V

			HV48100 SE BMU-9: 409.5 V HV48100 SE BMU-10: 455 V HV48100 SE BMU-11: 500.5 V HV48100 SE BMU-12: 546 V HV48100 SE BMU-13: 591.5 V HV48100 SE BMU-14: 637 V HV48100 SE BMU-15: 682.5 V or any cell reaches 2.8 V
Operating ambient temperature	-	-	0 °C to 30 °C
Standard charging method by manufacturer	Charge at constant current 50 A until the voltage reaches 3.65 V, then charge at 3.65 V till charge current is 5 A	Charge at constant current 50 A until the voltage reaches 57.6 V or any cell reaches 3.6 V	Charge at constant current 50 A until voltage reaches (HV48100 SE BMU-3: 171 V, HV48100 SE BMU-4: 228 V, HV48100 SE BMU-5: 285 V, HV48100 SE BMU-6: 342 V, HV48100 SE BMU-7: 399 V, HV48100 SE BMU-8: 456 V, HV48100 SE BMU-9: 513 V, HV48100 SE BMU-10: 570 V, HV48100 SE BMU-11: 627 V, HV48100 SE BMU-12: 684 V, HV48100 SE BMU-13: 741 V, HV48100 SE BMU-14: 798 V, HV48100 SE BMU-15: 855 V) or any cell reaches 3.6 V
Dimension	(52.3±1) mm x (148.4±1) mm x (119±1) mm	WxDxH: 484 mm×530 mm×140 mm	HV48100 SE BMU-3: 484 mm×530 mm×560 mm HV48100 SE BMU-4: 484 mm×530 mm×700 mm HV48100 SE BMU-5: 484 mm×530 mm×840 mm HV48100 SE BMU-6: 484 mm×530 mm×980 mm HV48100 SE BMU-7: 484 mm×530 mm×1120 mm HV48100 SE BMU-8: 484 mm×530 mm×1260 mm HV48100 SE BMU-9: 968 mm×530 mm×700 mm HV48100 SE BMU-10: 968 mm×530 mm×840 mm HV48100 SE BMU-11: 968 mm×530 mm×840 mm HV48100 SE BMU-12: 968 mm×530 mm×980 mm HV48100 SE BMU-13: 968 mm×530 mm×980 mm HV48100 SE BMU-14:

			968 mm×530 mm×1120 mm HV48100 SE BMU-15: 968 mm×530 mm×1120 mm
Weight	(1.93±0.15) kg	Approx. 45.16 kg	HV48100 SE BMU-3: 149.08 kg HV48100 SE BMU-4: 194.24 kg HV48100 SE BMU-5: 239.40 kg HV48100 SE BMU-6: 284.56 kg HV48100 SE BMU-7: 329.72 kg HV48100 SE BMU-8: 374.88 kg HV48100 SE BMU-9: 420.04 kg HV48100 SE BMU-10: 465.20 kg HV48100 SE BMU-11: 510.36 kg HV48100 SE BMU-12: 555.52 kg HV48100 SE BMU-13: 600.68 kg HV48100 SE BMU-14: 645.84 kg HV48100 SE BMU-15: 691.00 kg
Configuration	-	(8S)2S	HV48100 SE BMU-3: ((8S)2S)3S HV48100 SE BMU-4: ((8S)2S)4S HV48100 SE BMU-5: ((8S)2S)5S HV48100 SE BMU-6: ((8S)2S)6S HV48100 SE BMU-7: ((8S)2S)7S HV48100 SE BMU-8: ((8S)2S)8S HV48100 SE BMU-9: ((8S)2S)9S HV48100 SE BMU-10: ((8S)2S)10S HV48100 SE BMU-11: ((8S)2S)11S HV48100 SE BMU-12: ((8S)2S)12S HV48100 SE BMU-13: ((8S)2S)13S HV48100 SE BMU-14: ((8S)2S)14S HV48100 SE BMU-15: ((8S)2S)15S
Max. short circuit current declared by manufacturer	-	-	2200 A
Duration at max. short circuit current declared by manufacturer	-	-	8 ms

1.5 The information for BMS system

Battery model no.	BMS model no.	BMS manufacturer	HW version	SW version	MCU information
HV48100 SE BMU-3 HV48100 SE BMU-4 HV48100 SE BMU-5 HV48100 SE BMU-6 HV48100 SE BMU-7 HV48100 SE BMU-8 HV48100 SE BMU-9 HV48100 SE BMU-10 HV48100 SE BMU-11 HV48100 SE BMU-12 HV48100 SE BMU-13 HV48100 SE BMU-14 HV48100 SE BMU-15	BCU board	Shanghai PYTES Energy Co., Ltd.	HV48100-SE- BCU-V02	PSBCUL- 16S-400- V1.01.001	MCU1 on BCU: Model: GD32F427ZGT 6 (IC1, Gigadevice Semiconductor), MCU2 on BCU: Model: APM32F072CB T6 (U18, Geehy)
	BMU board		HV48100-SE- BMU-V03	PSBMUSE- 16S-RP1- V1.01. 001.T16	Model: GD32F307VCT 6 (U10, Gigadevice Semiconductor)

2. Order

2.1 Date of Purchase Order, Customer's Reference

2023-06-05, 2025-07-01

2.2 Test Sample(s)

- Reception date(s): 2023-08-16, 2023-08-28, 2025-07-21
- Location(s) of reception: PS: Battery department, Guangzhou
- Condition of test sample(s): Engineering samples

2.3 Testing

- Testing date(s): 2023-08-31 to 2024-06-05, 2025-07-21 to 2025-10-19
- Location(s) of testing: TÜV SÜD New Energy Testing and Certification (Guangdong) Co., Ltd.
North-1/F, 2/F & Unit 301-3/F, TÜV SÜD Testing Center, D1, No. 63 Chuangqi Road, Shilou Town, Panyu District, Guangzhou, Guangdong, China

3. Test Results

Decision rule according to ILAC-G8:09/2019 clause 4.2.1 Binary statement for simple acceptance rule or IEC Guide 115:2023, clause 4.3.3 Simple acceptance was applied.

3.1 Test Object

According to the hazard analysis and risk assessment and UL 1973:2022, CAN/UL 1973:2022, the battery management system (BMS) should comply with the functional safety requirements of Annex H of UL 60730-1:2016 & CAN/CSA E60730-1:2015/A1:2017-11.

The safety functions in the BMS system including:

Safety function	Class of control function	Parameters
Voltage protection	Class B	Over voltage protection value: 3.6V/cell, 3s; Under voltage protection value: 2.8V/cell, 3s
Current protection	Class B	Charge overcurrent protection value: 55A, 20s; Discharge overcurrent protection value: 100A, 20s
Temperature protection	Class B	Charge mode: Over temperature protection value: 57°C, 4s; Under temperature protection value: 0°C, 4s; Discharge mode: Over temperature protection value: 57°C, 4s; Under temperature protection value: -18°C, 4s

3.2 Scope

Scope of this report is the evaluation of the safety functions listed in Test object. All of them fulfil the class B control requirements of Annex H of Annex H of UL 60730-1:2016 & CAN/CSA E60730-1:2015/A1:2017-11.

3.3 Results

3.3.1 Functional Safety Management and Lifecycle Audit

Shanghai PYTES Energy Co., Ltd. describes the project, the planned activities and responsibilities for managing the functional safety by a safety plan. The safety plan covers the measures to avoid failures during hardware and software development.

Result:

The specified measures to avoid systematic failures were reviewed during the project. The measures to avoid systematic failures are suitable for a Class B control development according to Annex H of UL 60730-1:2016 & CAN/CSA E60730-1:2015/A1:2017-11.

3.3.2 Architecture

BMS architecture is shown in Figure 1.

Figure 1 BMS architecture

1. Cell overvoltage and undervoltage protection:

The safety function is implemented by turning off Contactor (+) and Contactor (-). The 16 cells' voltages are measured by BMS sampling circuit diagram → AFE → MCU on BMU → MCU1 on BCU and if MCU1 on BCU find it is overvoltage or undervoltage, it will turn off Contactor (+) and Contactor (-). In case of if any of the contactor in single fault, MCU1 on BCU will control to turn off the other contactor. If the communication of MCU1 on BCU in single fault, MCU2 on BCU will control to turn off Contactor (+) and Contactor (-). See Figure 2 block diagram.

Figure 2 Cell overvoltage and undervoltage protection block diagram

The safety function is realized by a single channel with periodic self-test structure. The total voltage of battery is measured by BMS sampling circuit diagram → AFE → MCU1 on BCU. If MCU1 on BCU find it is overcharge or undervoltage, MCU1 on BCU will control to turn off Contactor (+) and Contactor (-). MCU1 on BCU also compare the sum of cells' voltage and the total voltage of battery.

2. Cell overcurrent protection:

The safety function is implemented by turning off Contactor (+) and Contactor (-). The cells' current is measured by shunt → ADC → MCU1 on BCU and if MCU1 on BCU find the overcurrent, MCU1 on BCU will turning off Contactor (+) and Contactor (-).

In case of any of the contactor in single fault, MCU1 on BCU will control to turn off the other contactor. If the communication of MCU1 on BCU in single fault, MCU2 on BCU will control to turn off Contactor (+) and Contactor (-). See Figure 3 block diagram.

Figure 3 Cell overcurrent protection block diagram

The safety function is realized by a single channel with periodic self-test structure. The cells' current is also measured by hall → AFE → MCU1 on BCU. If the difference of current measured by shunt and hall > 5A, MCU1 on BCU will control to turn off Contactor (+) and Contactor (-).

3. Cell over and under temperature protection:

The safety function is implemented by turning off Contactor (+) and Contactor (-). The cells' temperature is measured by 6 NTCs → AFE → MCU on BMU → MCU1 on BCU and if the MCU1 on BCU find it is over or under temperature, MCU1 on BCU will turn off Contactor (+) and Contactor (-).

In case of any of contactor in single fault, MCU1 on BCU will control to turn off the other contactor. If the communication of MCU1 on BCU in single fault, MCU2 on BCU will control to turn off Contactor (+) and Contactor (-). See Figure 4 block diagram.

Figure 4 Cell over and under temperature protection block diagram

The safety function is realized by a single channel with periodic self-test structure. The diagnostic of over and under temperature protection circuit is realized by comparing the temperatures from 6 NTCs by MCU1 on BCU. MCU1 on BCU will control to turn off Contactor (+) and Contactor (-).

Result:

The architecture described above is suitable for realization of the safety functions overvoltage, undervoltage, overcurrent, overtemperature and undertemperature for Class B control of Annex H of UL 60730-1:2016 & CAN/CSA E60730-1:2015/A1:2017-11.

3.3.3 Software

The software implemented is responsible for the execution of the safety function and support of diagnostics.

Result:

The reliability of the safety function and the effective of diagnostics above were tested during fault injection test. The tests were performed without objections.

3.3.4 Fault Injection Test

Shanghai PYTES Energy Co., Ltd. performed a fault injection test which simulated the typical faults according to fault modes defined by Annex H of UL 60730-1:2016 & CAN/CSA E60730-1:2015/A1:2017-11. The test also covered the diagnostic software to check the effectiveness of the implemented measures.

Result:

The fault injection test was performed without objections.

3.3.5 Safety and environmental testing

The battery safety was tested in accordance with UL 1973:2022, CAN/UL 1973:2022 and the regulations related to the standard. The battery was also tested for environmental testing.

Result:

The tests have passed without objections and are documented by test reports.

3.3.6 EMC testing

The strength of the design versus electromagnetic immunity was tested.

Result:

The tests are passed without objections and are documented by test reports.

3.3.7 Manual

The product manual includes the necessary information for system integrators

4. Test History

Project no.	Revision	Date	Author	Modification / Description
64.280.25.60378.01	00	2025-10-20	Nic Wang, Ava Deng	Initial

5. Documentation

No.	Title	Document number / ID	Rev.	Date
[D1]	Hazard analysis and risk assessment	PYTES-HV48100 SE-000	V1.0	2024-12-13
[D2]	Safety Requirement Specification	PYTES-HV48100 SE-001	V1.0	2025-01-03
[D3]	Safety Plan	PYTES-HV48100 SE-002	V1.0	2025-02-05
[D4]	Verification & Validation Plan	PYTES-HV48100 SE-003	V1.0	2025-03-02
[D5]	System safety design	PYTES-HV48100 SE-004	V1.0	2025-04-07
[D6]	System software design	PYTES-HV48100 SE-Software security design	V1.0	2025-05-10
[D7]	Component FMEA	Component FMEA	A0	2023-09-05

[D8]	User manual	LiFePO4 Energy Storage Battery-HV48100-SE User Manual	01	2025-06-23
		HV48100 SE Commercial & Industrial Solution	V2	-
[D9]	Impact analysis report	PYTES-HV48100 SE-Impact analysis report	V1.0	2025-07-23

6. Summary

The safety functions of BMS in battery model HV48100 SE BMU-3, HV48100 SE BMU-4, HV48100 SE BMU-5, HV48100 SE BMU-6, HV48100 SE BMU-7, HV48100 SE BMU-8, HV48100 SE BMU-9, HV48100 SE BMU-10, HV48100 SE BMU-11, HV48100 SE BMU-12, HV48100 SE BMU-13, HV48100 SE BMU-14, HV48100 SE BMU-15 are suitable for Class B control according to Annex H of UL 60730-1:2016 & CAN/CSA E60730-1:2015/A1:2017-11.

TÜV SÜD New Energy Testing (Guangdong) Co., Ltd.

Tested by: Nic Wang / Project Handler
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Supervised by: Ava Deng / Project Handler
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Approved by: Vitta Wang / Designated Reviewer
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