

Technical Report No.: 64.280.24.60585.02

Dated: 2025-07-02

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 REPUBLIC OF CHINA

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

Test object: Product: Rechargeable Li-ion Battery
Model: V10, V10α, V12, V12α

Trade mark:



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

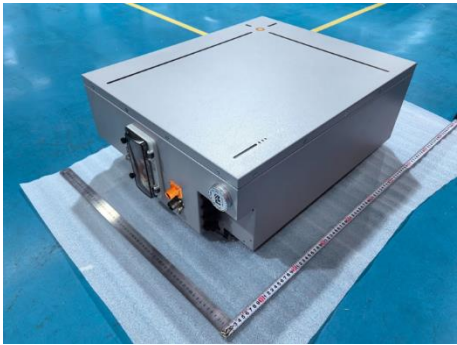
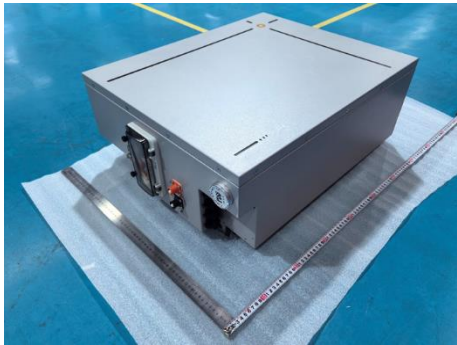
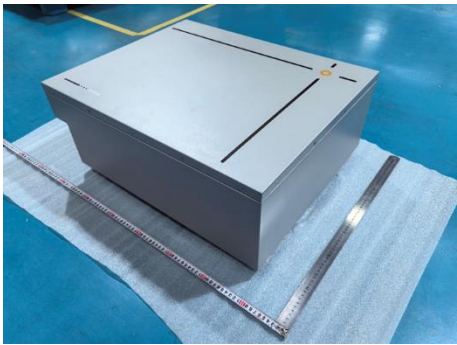
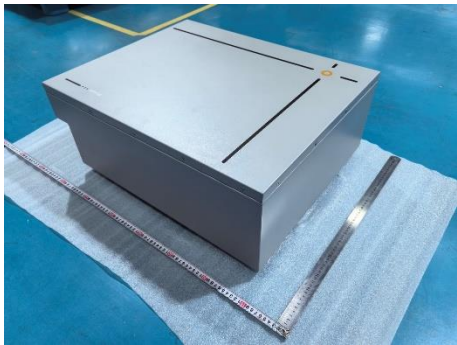
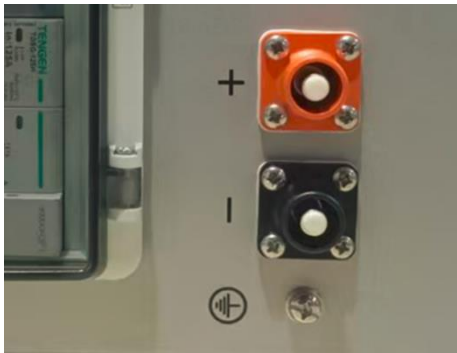
Purpose of examination: Testing and evaluation according to the test specification

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

Any use for advertising purposes must be granted in writing. This technical report may only be quoted in full. This report is the result of a single examination of the object in question. It does not imply a general statement regarding the quality of products from regular production. For further details please see Testing, Certification, Validation and Verification Regulations, chapter A-3.3.

1. Description of the test subject

1.1 Picture(s)

Pictures of the product:	
V10, V12:	V10α, V12α:
	
	
	



Top view of MCU board, model: V10-MCU-V3

Bottom view of MCU board, model: V10-MCU-V3



Top view of PWR board, model: V10-PWR-V5

Bottom view of PWR board, model: V10-PWR-V5



Top view of LIMIT_CHG board, model: V10-LIMIT_CHG-V03

Bottom view of LIMIT_CHG board, model: V10-LIMIT_CHG-V03

Top view of SHUNT board, model: DYDD-SHUNT-V3

Bottom view of SHUNT board, model: DYDD-SHUNT-V3

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

The Rechargeable Li-ion Batteries, models no. V10, V10 α , V12, V12 α are used in industrial application. The Rechargeable Li-ion Batteries, models no. V10, V10 α , V12, V12 α , which consist of cell, model no. 230, connected in 16S. The cell has been approved with UL 1973:2022 certification.

The difference between V10 and V12, as well as V10 α and V12 α is the rated capacity, V10/V10 α is 200Ah and V12/V12 α is 230Ah, all other features are identical.

The sole difference between V10 and V10 α , as well as between V12 and V12 α , is in the battery connectors; all other features are identical. V10 α /V12 α use battery connector, model: C10-730189, V10/V12 use battery connector, model: BPC 250 FT B.

The external communication mode for Rechargeable Li-ion Battery, models: V10, V10 α , V12, V12 α are CAN and RS485.

The Rechargeable Li-ion Batteries, models no. V10, V10 α , V12, V12 α , have current-limited circuit, V10-LIMIT_CHG_V03. In the charging state: when the total voltage is more than 56.5V, or the single voltage is more than 3.55V, or the SOC is equal to 100%, or the temperature is more than 55 °C; Also, If the current exceeds 5A, the charging current limited mode will be triggered after one minute. Once the current drops to below 10A, the battery will keep in charging

at this current until a protective condition is triggered. Finally, the charging current-limited MOSFET will operate for this protection state.

Additionally, details information of the batteries and the component cell are shown in following table:

Item	Specification	
Product name	Rechargeable Li-ion Cell	Rechargeable Li-ion Battery
Type/model	230	V10, V10α, V12, V12α
Nominal voltage	3.2Vd.c.	51.2Vd.c.
Rated capacity	230Ah	V10, V10α: 200Ah V12, V12α: 230Ah
Charging voltage declared by manufacturer	3.65V	56.8V
Upper limit charging voltage	3.65V	-
Charging current declared by manufacturer	115A	100A
Maximum continuous charging current	460A	150A
Discharging current declared by manufacturer	115A	100A
Maximum continuous discharging current	690A	150A
Discharge Cut-Off Voltage	2.5V (T>0°C), 2.0V (T≤0°C)	47.5V
Standard charging temperature range	-10°C to 65°C	-
Standard discharge temperature range	-35°C to 65°C	-
Operating ambient temperature range	-	0°C to 25°C
Standard charging method by manufacturer	Charge at constant current 115A until voltage reaches 3.65V, then charge at constant voltage 3.65V till charge current is 11.5A	Charge at constant current 100A until voltage reaches 56.8V, then charge at constant voltage 56.8V till charge current is 9.2A
Dimension	L×W×H: (173.93±0.5)mm x (53.85±0.5)mm x (207.2±0.5)mm	L×W×H: (671.1±2.0)mm x (260.0±2.0)mm x (520.0±2.0)mm
Weight	(4.140 ± 0.124)kg	(98.6±0.5)kg
Configuration	-	16S

1.5 The information for BMS system

Battery model no.	BMS model no.	BMS manufacturer	HW version	SW version	MCU information
V10, V10α,	V10_BMS_V1	Shanghai PYTES Energy Co.,	MCU board: V10-MCU-V3	SPBMS16SE V1.12.1	GigaDevice)

V12, V12α		Ltd.	PWR board: V10-PWR-V5	-	-
			LIMIT_CHG board: V10-LIMIT_CHG-V03	-	-
			SHUNT board:	-	-

2. Order

2.1 Date of Purchase Order, Customer's Reference

2024-08-14, 2025-05-08

2.2 Test Sample(s)

- Reception date(s): 2025-02-10, 2025-05-14
- Location(s) of reception: PS: Battery department, Guangzhou
- Condition of test sample(s): Engineering samples

2.3 Testing

- Testing date(s): 2025-02-11 to 2025-03-14, 2025-05-14 to 2025-07-01
- Location(s) of testing: TÜV SÜD New Energy Testing (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 511447, 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 CAN/UL 1973:2022, the battery management system (BMS) should comply with the functional safety requirements of Annex H of UL 60730-1 & CAN/CSA E60730-1.

The safety functions in the BMS system including:

Safety function	Class of control function	Parameters
Voltage protection	Class B	Charge mode: When charging voltage >56.5V or any cell reaches 3.55V, the battery will turn off charge MOS (Q100, Q106, Q108, Q118, Q119, Q125,

		Q127, Q133, Q380, Q381 operate), and the battery will be limited to charge at constant current 10A until the battery reaches over-voltage value: 3650mV+0/-96mV protection (Q380, Q381 operate), respond time: 4s±2s Discharge mode Under voltage protection value: 2900mV±96mV, respond time: 4s±2s
Current protection	Class B	Charge overcurrent protection value: 205A±5A, respond time: 15s±8s Discharge overcurrent protection value: 205A±5A, respond time: 15s±8s
Temperature protection	Class B	Charge mode: Over temperature protection value: 58°C±2°C, respond time: 6s±2s Under temperature protection value: 0°C±2°C, respond time: 6s±2s Discharge mode: Over temperature protection value: 58°C±2°C, respond time: 6s±2s Under temperature protection value: -20°C±2°C, respond time: 6s±2s

3.2 Scope

Scope of this report is the evaluation of the safety functions listed in Test object. All of them comply with the functional safety requirements 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 for a Class B control development according to Annex H of UL 60730-1 & CAN/CSA E60730-1.

3.3.2 Architecture

BMS architecture is shown in Figure 1.

1. Cell overvoltage and undervoltage protection:

The safety function is implemented by turning off the charge, discharge and current limit MOSFET and circuit breaker (with shunt release). The cell voltages are measured by BMS sampling circuit diagram → AFE(U7) → MCU(U304).

In charge mode, if MCU find the battery voltage $\geq 56.5V$ or any cell reaches $3.55V$, it will turn off the charge MOSFET and turn on the current-limit MOSFET, until the cell is overvoltage, MCU will turn off the current-limit MOSFET. In case of the charge or current-limit MOSFET is in fault, MCU will turn off the circuit breaker (with shunt release).

In discharge mode, if MCU find the cell is undervoltage, MCU will turn off the discharge MOSFET. In case of the discharge MOSFET is in fault, MCU will turn off the circuit breaker (with shunt release). 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. BMS also sample the total voltage of battery → IC(U327) → MCU(U304). The diagnostic of voltage sampling fault protection circuit is to compare the sum of cells' voltage and the total voltage of

battery. If MCU finds that voltage difference between them is more than 3V, MCU will find the voltage sampling in fault and turned off the charge and discharge MOSFET.

2. Cell overcurrent protection:

The safety function is implemented by turning off the charge, discharge and current limit MOSFET. The cells' current is measured by current sampling resistance on BMS main board → IC(U327) → MCU(U304). If MCU find it is charging or discharging overcurrent, it will turn off the charge and discharge MOSFET.

In case of the charge or discharge MOSFET is in fault, MCU will turn off the circuit breaker+shunt release. See Figure 3 block diagram.

Figure 3 Cell overcurrent charge and discharge protection block diagram

The safety function is realized by a single channel with periodic self-test structure. BMS also sample the current of battery by shunt resistor on SHUNT board → IC(U21) → MCU(U304). The diagnostic of current sampling fault protection circuit is to compare the current of current sampling resistance and shunt resistor. If the MCU finds that difference between them is more than 2A, it will find current sampling is in fault and turn off the charge and discharge MOSFET.

3. Cell over and under temperature protection:

The safety function is implemented by turning off the charge and discharge MOSFET. The cell temperature is measured by 8NTCs → AFE(U7) → MCU(U304) and if the MCU find it is over or under temperature, it will turn off the charge and discharge MOSFET.

In case of the charge or discharge MOSFET is in fault, MCU will turn off the circuit breaker+shunt release. 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 temperature sampling fault protection circuit is to compare the temperature from all 8 NTCs. If the max. and min. temperature difference between 8NTCs exceeds 10 degrees, the MCU will find temperature sampling is in fault and turn off the charge and discharge MOSFET.

Result:

The architecture described above is suitable for realization of the safety functions overvoltage, undervoltage, overcurrent, overtemperature and under temperature for Class B control of Annex H of UL 60730-1.

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 & CAN/CSA E60730-1. 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 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
64.280.24.60585.01	00	2025-04-02	Zoe Zhu	Initial.
64.280.24.60585.02	00	2025-07-02	Zoe Zhu	This report based original report 64.280.24.60585.01 to make following changes: 1) Add the new models V12 and V12α, 2) updated the (description of intended use) and parameters. All tests can be covered by original report.

5. Documentation

No.	Title	Document number / ID	Rev.	Date
[D1]	Hazard analysis and risk assessment	PYTES-V10/V12-000	V1.0	2024-06-03
[D2]	Safety Requirement Specification	PYTES-V10/V12-001	V1.0	2024-06-18
[D3]	Safety Plan	PYTES-V10/V12-002	V1.0	2024-06-27
[D4]	Verification & Validation Plan	PYTES-V10/V12-003	V1.0	2024-09-05
[D5]	System safety design	PYTES-V10/V12-004	V1.0	2024-09-20
[D6]	System software design	PYTES-V10-Software security design	V3.0	2025-03-18
[D7]	Component FMEA	PYTES-V10/V10α-DFMEA	V1.0	2024-11-21
[D8]	User manual	PYTES V10/V12 Series LFP Battery User Manual	Version 1.0	2024-09-20
		V10,V12 Datasheet	-	-
[D9]	Impact analysis report	PYTES-V10/V12-Impact analysis report	V1.0	2025-07-01



6 Summary

The safety functions of BMS in battery system model no. V10, V10α, V12, V12α 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: Zoe Zhu / Project Handler
printed name, function & signature

Approved by: Zoey Liu / Designated Reviewer
printed name, function & signature



--- End of Report ---