Test Report **Report No.: CQES240900088501**
Date: 2024-09-20

Applicant:	Ningbo AUX Solar Technology Co., Ltd. No.17 Fenglin Road, Cicheng Town, Jiangbei District, Ningbo, Zhejiang, China
Test item:	Rechargeable Lithium-ion Battery System
Model:	ABL-T05H-H02, ABL-T10H-H02, ABL-T15H-H02, ABL-T20H-H02, ABL-T25H-H02
Manufacturer:	Same as applicant
Factory:	Zhejiang LeapEnergy Technology Co., Ltd. No.888 Xinrong Road, Sumeng Town, Wucheng District, Jinhua, Zhejiang, China
Test specifications / Test standard:	Regulation (EU) 2023/1542, Article 12 and Annex V
Purpose of examination:	Testing according to the test specification and applicant's requirement.
Test result:	See below report for details.
Remark:	1. The test results presented in this report relate only to the object tested. 2. This report was based on Test Report No. CQES240900085501, dated 2024-09-19, with following changes and/or additions: - Change the applicant and manufacturer - Update model No.: ABL-T05H-H02, ABL-T10H-H02, ABL-T15H-H02, ABL-T20H-H02, ABL-T25H-H02.

Ryan Hu
Report Reviewer
Safety Laboratory

Hanson Wei
Project Engineer

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1. General product description:

Test item description:	Rechargeable Lithium-ion Battery System				
Model:	ABL-T05H-H02	ABL-T10H-H02	ABL-T15H-H02	ABL-T20H-H02	ABL-T25H-H02
Number of Modules:	1	2	3	4	5
Nominal voltage:	102.4 V	204.8 V	307.2 V	409.6 V	512.0 V
Max. charge voltage:	115.2 V	230.4 V	345.6 V	460.8 V	576.0 V
End of discharge voltage:	86.4 V	172.8 V	259.2 V	345.6 V	432.0 V
Rated capacity:	52 Ah				
Model of battery pack:	ABL-P05H-H02				
Rated voltage of battery pack:	102.4 V				
Rated capacity of battery pack:	52 Ah				
Upper charge voltage of battery pack:	115.2 V				
Maximum charge current of battery pack:	32 A				
Discharge cut-off voltage of battery pack:	86.4 V				
Maximum discharge current of battery pack:	32 A				
Cell Configuration:	1P32S				
Operation Ambient range:	Charging: -10 ~ 50 ºC Discharging: -10 ~ 50 ºC				
Model of cell:	IFP28148115A-52Ah				
Rated voltage of cell:	3.2 V				
Rated capacity of cell:	52 Ah				

2. Test description:

Possible test case verdicts:	
- test case does not apply to the test object:	N/A (Not Applicable)
- test object does meet the requirement:	P (Pass)
- test object does not meet the requirement:	F (Fail)
Testing:	
Date of receipt of test item:	Original: 2024-09-06
Date (s) of performance of tests:	Original: 2024-09-10 to 2024-09-18
Ambient temperature:	20 ºC ± 5 ºC
Testing Laboratory:	SGS-CEC New Energy Technology (Chongqing) Co., Ltd.
Testing location/ address:	Building 13 & 14, No. 1839, Ranjun Road, Shuangfu Street, Jiangjin District, Chongqing, China

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Remark:

Thermal shock and cycling test result is cited form Report No.: RZUN2023-6556 and Report No.: RZUN2023-6556-M1, issued by CVC Testing Technology Co., Ltd.
External short circuit protection test result is cited form Report No.: RZUN2023-6556 and Report No.: RZUN2023-6556-M1, issued by CVC Testing Technology Co., Ltd.
Overcharge protection test result is cited form Report No.: SHES240701477901, issued by SGS-CSTC Standards Technical Services (Shanghai) Co., Ltd.
Over-temperature protection test result is cited form Report No.: SHES240701477901, issued by SGS-CSTC Standards Technical Services (Shanghai) Co., Ltd.
Mechanical damage by external forces test result is cited form Report No.: SHES240701477901, issued by SGS-CSTC Standards Technical Services (Shanghai) Co., Ltd.
Internal short circuit test result is cited form Report No.: 085-282260450-000, issued by. TUV SUD New Energy Testing (Guangdong) Co., Ltd.
Thermal abuse test result is cited form Report No.: 085-282260450-000, issued by TUV SUD New Energy Testing (Guangdong) Co., Ltd.

All test data were copied from original report CQES240900085501, dated 2024-09-19. After compare, no additional test was considered necessary.

Unless otherwise specified, all tests were performed on representative Model H02-05, due to all the 5 models of battery system have the same high voltage box and basic battery pack (model ABL-P05H-H02), the only difference is the number of the battery pack, models ABL-T05H-H02, ABL-T10H-H02, ABL-T15H-H02, ABL-T20H-H02, ABL-T25H-H02 have 1, 2, 3, 4, 5 basic battery packs respectively.

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3. Test result summary:

Regulation (EU) 2023/1542, Article 12 and Annex V			
Items	**Requirement + Test**	**Result - Remark**	**Verdict**
1	Thermal shock and cycling	See table 4.1	P
2	External short circuit protection	See table 4.2	P
3	Overcharge protection	See table 4.3	P
4	Over-discharge protection	See table 4.4	P
5	Over-temperature protection	See table 4.5	P
6	Thermal propagation protection	See table 4.6	P
7	Mechanical damage by external forces	See table 4.7	P
8	Internal short circuit	See table 4.8	P
9	Thermal abuse	See table 4.9	P
10	Fire test	See table 4.10	P
11	Emission of gases	See table 4.11	P

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4. Test procedure and result

4.1 Thermal shock and cycling

This test shall be designed to evaluate changes in the integrity of the battery arising from expansion and contraction of cell components upon exposure to extreme and sudden changes in temperature, and potential consequences of such changes. During a thermal shock, the battery shall be exposed to two temperature limits and held at each temperature limit for a specified period.

4.1	TABLE: Thermal shock and cycling				P
Sample No.	OCV before test (V dc)	Mass before test (kg)	OCV after test (V dc)	Mass after test (kg)	Results
b1#	106.60	44.31	106.28	44.31	A
b2#	106.50	44.33	106.17	44.33	A
b3#	107.10	44.29	106.77	44.29	A
b4#	106.51	44.30	106.08	44.30	A

Supplementary information:
A – No fire or Explosion
B – Fire
C – Explosion
D – No leakage, no venting, no disassembly and no rupture
E – Other (Please explain):___

4.2 External short circuit protection

This test shall evaluate the safety performance of a battery when applying an external short circuit. The test can evaluate the activation of the overcurrent protection device or the ability of cells to withstand the current without reaching a hazardous situation (e.g. thermal runaway, explosion, fire). The main risk factors are heat generation at cell level and electrical arcing, which can damage circuitry or lead to reduced isolation resistance.

4.2	TABLE: External short-circuit protection				P
Sample No.	Ambient	OCV at start of test (V dc)	Resistance of Circuit (mΩ)	Maximum Case Temperature (°C)	Results
b1#	57	106.60	<100	57.2	A, E
b2#	57	106.50	<100	56.7	A, E
b3#	57	107.10	<100	56.6	A, E
b4#	57	106.51	<100	57.0	A, E

Supplementary information:
A – No fire or Explosion
B – Fire
C – Explosion
D – The test was completed after 6 h
E – The test was completed after the cell casing cooled to 20% of the maximum temperature rise
F – Other (Please explain):___

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4.3 Overcharge protection

This test shall evaluate the safety performance of a battery in overcharge situations. The main safety risks during overcharge are the decomposition of the electrolyte, cathode and anode breakdown, exothermic decomposition of the solid electrolyte interphase (SEI) layer, separator degradation, and lithium plating, which can lead to self-heating of the battery and thermal runaway. The factors affecting the outcome of the test shall, as a minimum, include, the charging rate and the finally reached state of charge. The protection can be ensured either by voltage control (interruption after reaching the limit charging voltage) or current control (interruption after exceeding maximum charging current).

4.3	TABLE: Overcharge protection					P
Sample No.	**OCV at start of test for Cell/Cell Blocks, (V dc)**	**Maximum Charging Current, (A)**	**Max. Charging Voltage, (V dc)**	**Max. Voltage of Cell/Cell Blocks, (V dc)**	**Results**	
5#	2.714 to 2.733 (Cell)	32	115.2	3.65	A, D, F	
			Charge Voltage Applied Battery System: 1)			
			Whole	**Part**		
			128.48 Vdc	--		

Supplementary information:

1. The exceeded voltage can be applied to only a part of the system such as the cell(s) in the battery system per Figure 6 of IEC 62619, if it is difficult to do it in using the whole battery system.

Results:
A - No Fire or Explosion
B – Fire
C - Explosion
D - The voltage of the measured cells or cell blocks did not exceed the upper limit charging voltage
E - The voltage of the measured cells or cell blocks did exceed the upper limit charging voltage
F - All function of battery system did operate as intended during the test.
G - All function of battery system did not operate as intended during the test.
H - Other (Please explain):

4.4 Over-discharge protection

This test shall evaluate the safety performance of a battery in over-discharge situations. Safety risks during over- discharge include polarity reversal leading to oxidation of the anode current collector (Copper) and to plating on the cathode side. Even minor over-discharge can cause dendrite formation and ultimately short-circuiting.

4.4	TABLE: Over-discharge protection				P
Sample No.	OCV at start of test, (V dc)	Max. Discharging Current, (A)	Min. Discharging Voltage, (V dc)	Results	
M1	106.800	32.001	94.772	A, D, F	

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Supplementary information: Results: A – No fire or Explosion B – Fire C – Explosion D –Over-discharge sensing function of BMU did operate and then charging stopped E –Over-discharge sensing function of BMU did not operate and then charging stopped F – All function of battery system did operate as intended during the test. G – All function of battery system did not operate as intended during the test. H – Other (Please explain): ____

4.5 Over-temperature protection

This test shall evaluate the effect of temperature control failure or failure of other features for protection against internal overheating during operation.

4.5	TABLE: Over-temperature protection		P
Model No.	OCV at start(SOC 50%) of test, V dc	Maximum Charging Current, A	Measured Maximum Charging Voltage, V dc
5#	103.021	32	115.2
Maximum Specified Temperature of Battery System, °C		Maximum Measured Cell Case Temperature, °C	Results
50		55	A, D, F
Supplementary information: Results: A – No fire or Explosion B – Fire C – Explosion D – Temperature sensing function of BMU did operate and then charging stopped E – Temperature sensing function of BMU did not operate and then charging stopped F – All function of battery system did operate as intended during the test. G – All function of battery system did not operate as intended during the test. H – Other (Please explain): ____			

4.6 Thermal propagation protection

This test shall evaluate the safety performance of a battery in thermal propagation situations. A thermal runaway in one cell can cause a cascading reaction throughout the entire battery which can be composed of numerous cells. It can lead to severe consequences including a significant gas release. The test shall take into account the tests that are under development for transport applications by ISO and the UN Global Technical Regulation.

4.6	TABLE: Thermal propagation protection				P
Sample No.	OCV of Battery System Before Test, (V dc)	OCV of Target Cell Before Test, (V dc)	Maximum Cell Case Temperature, (°C)	Maximum DUT Enclosure Temperature, (°C)	Results
M2	106.252	3.337	267.5	81.0	A

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Method of cell failure 1)	Location of target cell	Area for fire protection (m^2)
1	Cell 8	--

Supplementary information:
1) Refer to 7.3.3 Propagation test of Standard IEC 62619:2022 for testing, external heaters were used to initiate thermal runaway.
Results:
A – No fire external to DUT enclosure or area for fire protection or no battery case rupture
B – Fire external to DUT enclosure or area for fire protection
C – Explosion
D – Battery case rupture
E – Other (Please explain): __

4.7 Mechanical damage by external forces

These tests shall simulate one or more situations in which a battery is accidentally exposed to mechanical stresses and remains operational for the purpose for which it was designed. The criteria to simulate these situations should reflect real life uses.

4.7	TABLE: Mechanical damage by external forces		P
Sample No.	Product weight, (kg)	Drop Height, (cm)	Results
5#	59	5	A

Supplementary information:
Results:
A – No fire or Explosion
B – Fire
C – Explosion
D –All function of battery system did operate as intended during the test.
E –All function of battery system did not operate as intended during the test.
F –Other (Please explain): ____

4.8 Internal short-circuit

This test shall evaluate the safety performance of a battery in internal short-circuit situations. The occurrence of internal short circuits, one of the main concerns for battery manufacturers, potentially leads to venting, thermal runaway, and sparking which can ignite the electrolyte vapours escaping from the cell. The generation of such internal short circuits can be triggered by manufacturing imperfections, the presence of impurities in the cells or dendritic growth of lithium, and is the cause of most in-field safety incidents. Multiple internal short circuit scenarios are possible (e.g. electrical contact of cathode/anode, aluminium current collector/copper current collector, aluminium current collector/anode) each with a different contact resistance.

4.8	TABLE: Internal short-circuit			P
Sample No.	OCV at start of test, (V dc)	Particle location 1)	Maximum applied pressure, (N)	Results
IFP2814811A-52Ah	3.348	1	400	A, E
IFP2814811A-52Ah	3.345	1	400	A, E
IFP2814811A-	3.344	1	400	A, E

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52Ah				
IFP2814811A-52Ah	3.350	1	400	A, E
IFP2814811A-52Ah	3.345	1	400	A, E

Supplementary information:
1) Identify one of the following:
1: Nickel particle inserted between positive and negative (active material) coated area.
2: Nickel particle inserted between positive aluminium foil and negative active material coated area.

Results:
A – No fire or explosion
B – Fire
C – Explosion
D – Test concluded when 50 mV voltage drop occurred prior to reaching force limit
E – Test concluded when 800/400 N pressure was reached and 50 mV voltage drop was not achieved
F – Test was concluded when fire or explosion occurred
G – Other (Please explain): __

4.9 Thermal abuse

During this test, the battery shall be exposed to elevated temperatures (in IEC 62619 the temperature is 85 °C) which can trigger exothermal decomposition reactions and lead to a thermal runaway in the cell.

4.9	TABLE: Thermal abuse	P
Sample No.	Test temperature, (°C)	Results
IFP2814811A-52Ah	85	A
IFP2814811A-52Ah	85	A
IFP2814811A-52Ah	85	A

Supplementary information:
Results:
A - No fire or Explosion
B - Fire
C - Explosion
D - Other (Please explain): _

4.10 Fire test

The risk of explosion shall be assessed by exposing the battery to fire.

4.10	TABLE: Fire test	P
Sample No.	OCV at start of test, (Vdc)	Results
M3	106.918	A

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Supplementary information: Reference test method: UN ECE R-100: Annex 9E Fire resistance. Results: A - No fire or Explosion B - Fire C - Explosion D - Other (Please explain): _

4.11 Emission of gases

Batteries can contain significant amounts of potentially hazardous materials, for example highly flammable electrolytes, corrosive and toxic components. If exposed to certain conditions, the integrity of the battery could be compromised, resulting in the release of hazardous gases. Therefore, it is important to identify emissions of gases from substances released from the battery during tests: the risk of toxic gases emitted from non-aqueous electrolytes shall be properly taken into account for all safety parameters listed in points 4.1 to 4.10.

4.11	TABLE: Emission of gases	P
Test	Emission of gases results	
4.1 Thermal shock and cycling	No emission of gases	
4.2 External short circuit protection	No emission of gases	
4.3 Overcharge protection	No emission of gases	
4.4 Over-discharge protection	No emission of gases	
4.5 Over-temperature protection	No emission of gases	
4.6 Thermal propagation protection	Gas emission observed. Gas emission is caused by the deliberately forced thermal runaway.	
4.7 Mechanical damage by external forces	No emission of gases	
4.8 Internal short circuit	No emission of gases	
4.9 Thermal abuse	No emission of gases	
4.10 Fire test	Gas emission observed. Gas emission is caused by deliberate external fire.	
Supplementary information: --		

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5. Photo documentation

Overall External View of Battery model: ABL-T05H-H02

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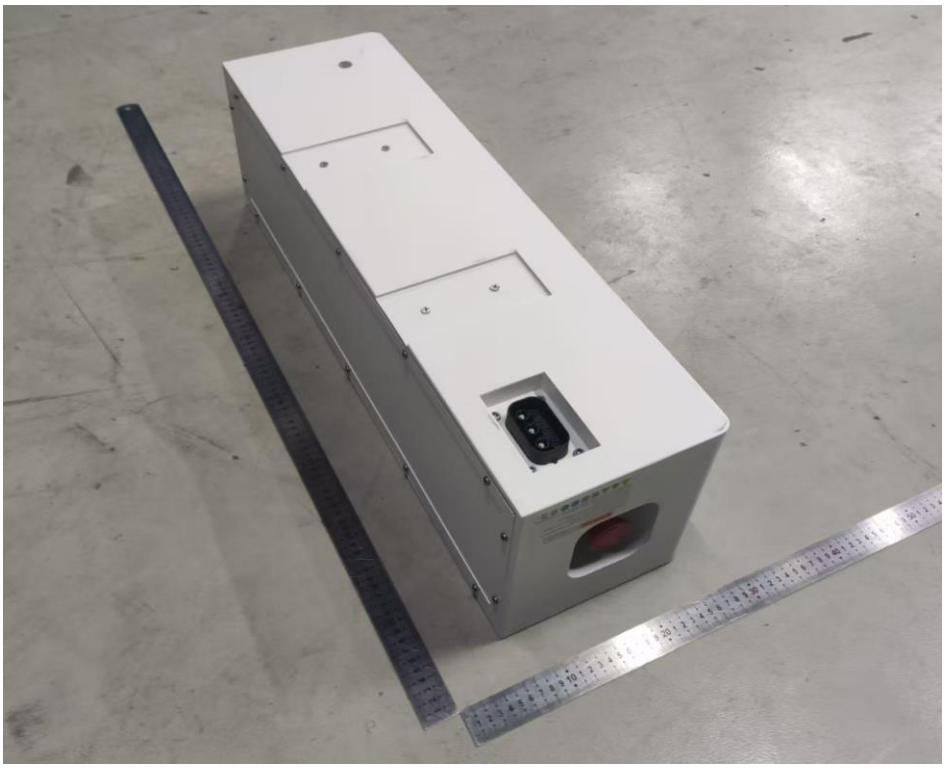
View of High-voltage Box



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Connectors on High-voltage Box

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Internal view of High-voltage Box

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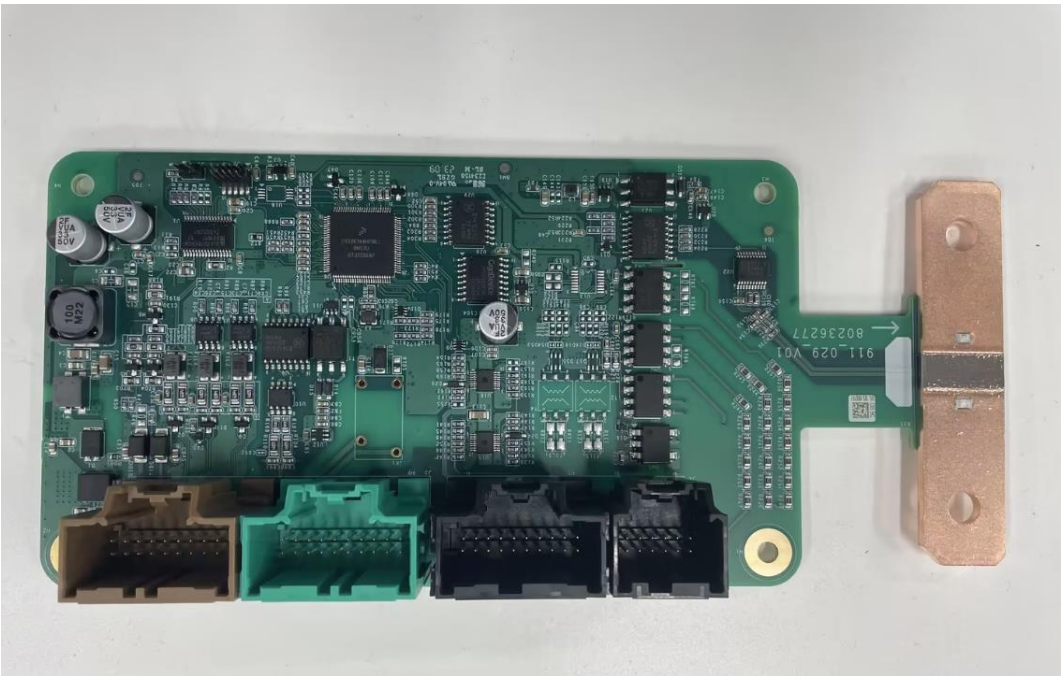
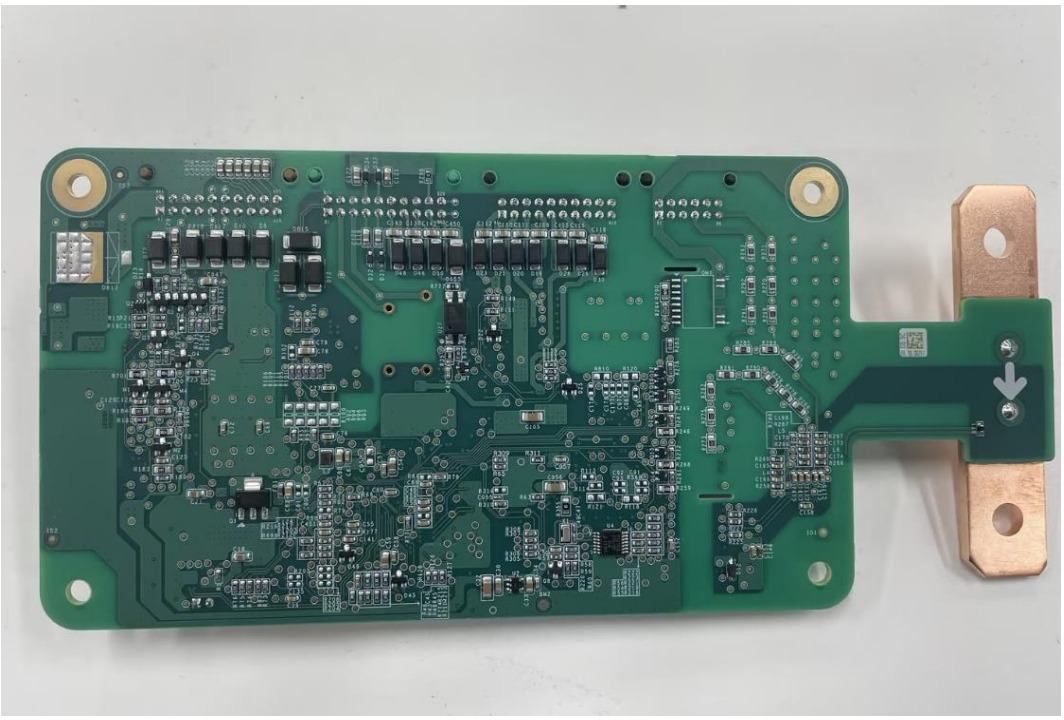
PCBA of BMU





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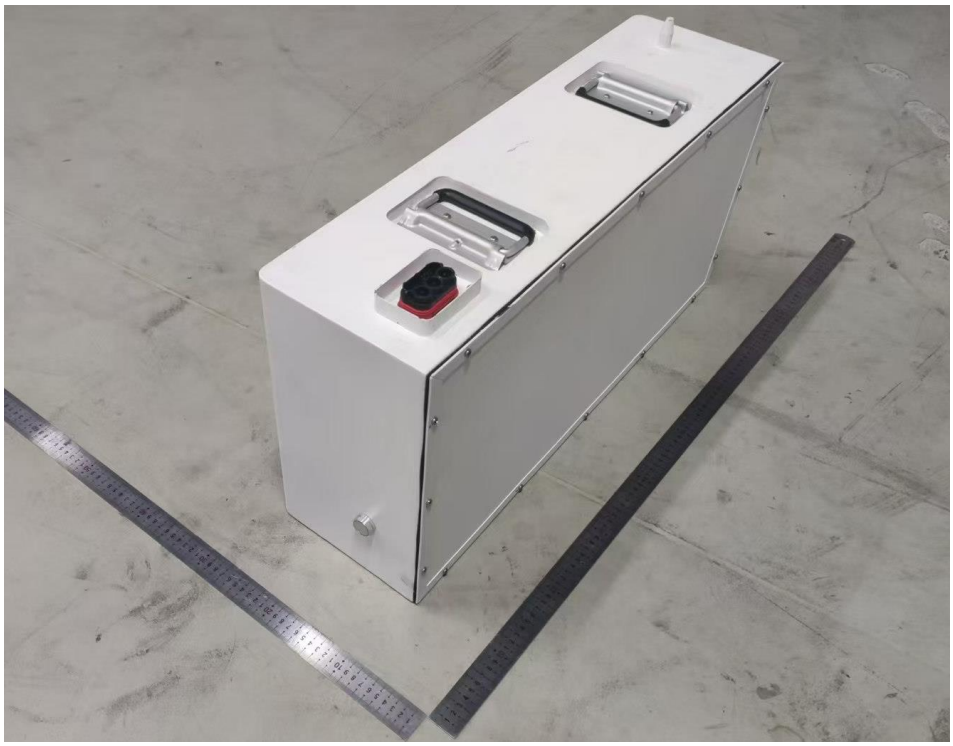
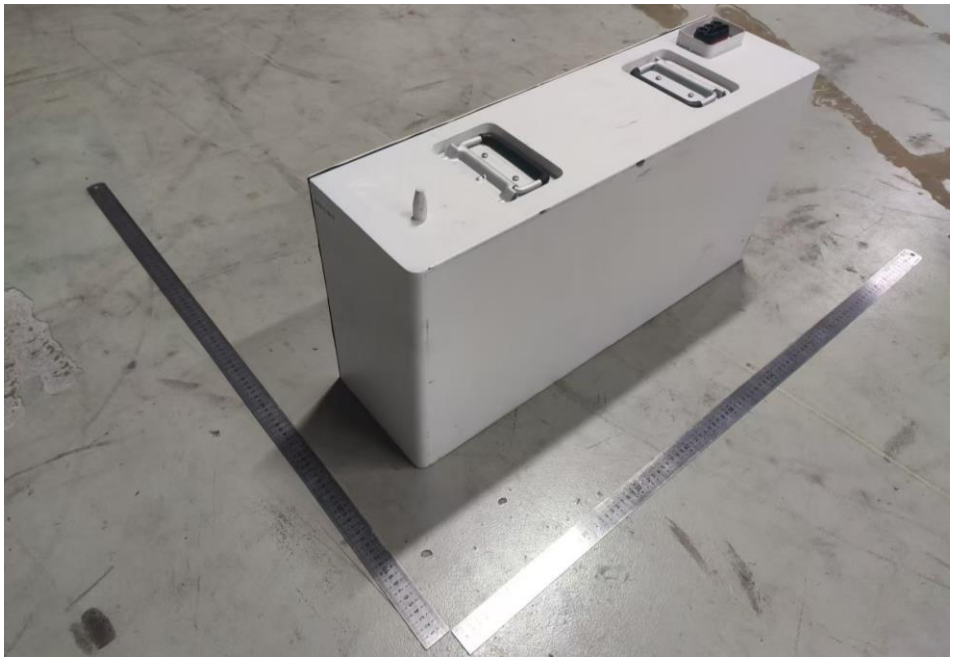
View of Battery Pack





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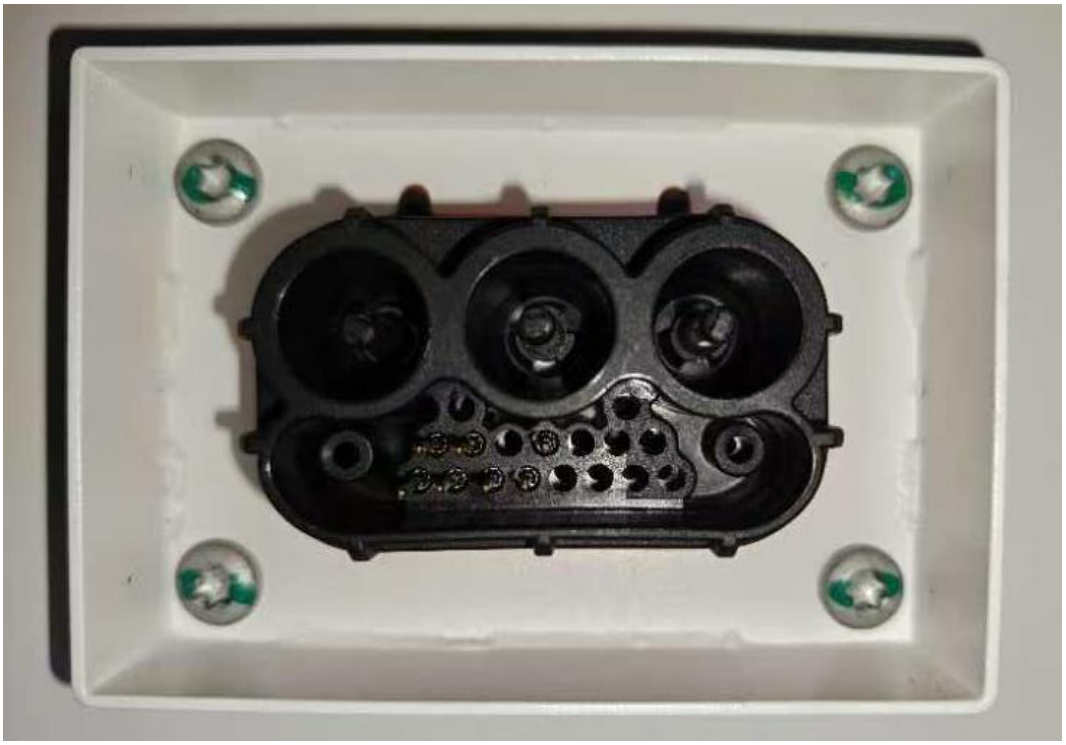
Connectors on Battery Pack



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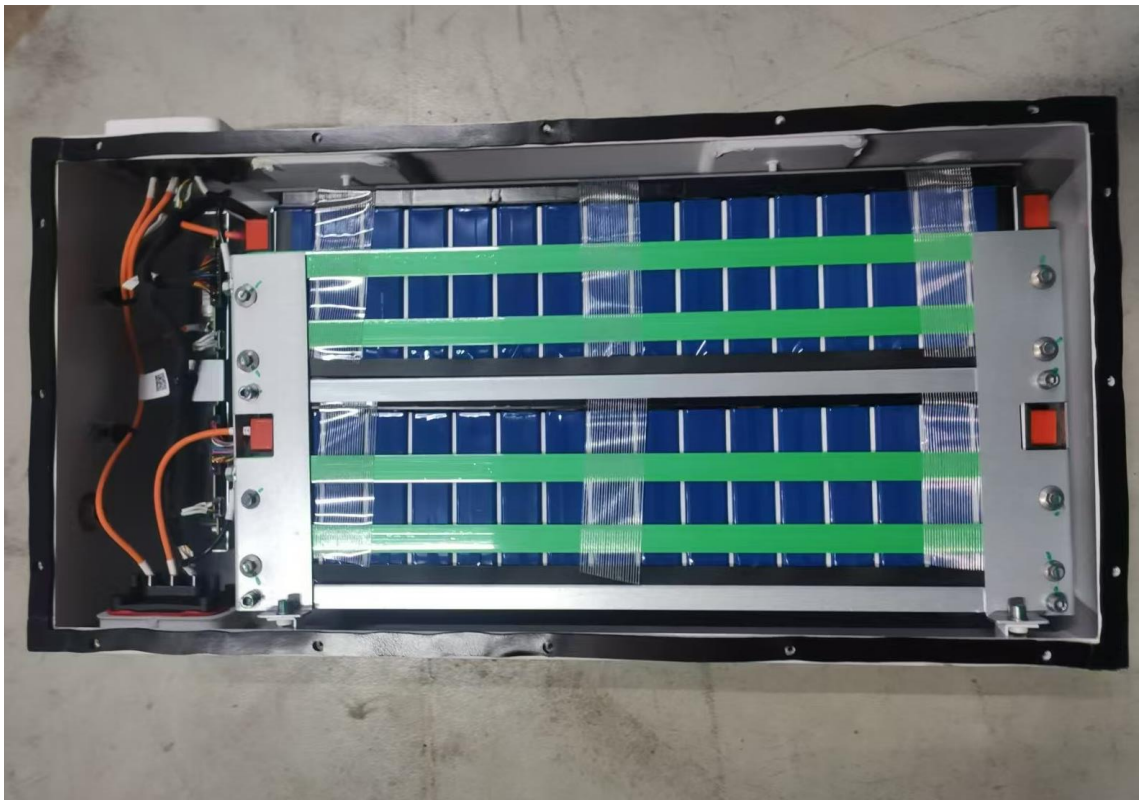
Internal View of Battery Pack



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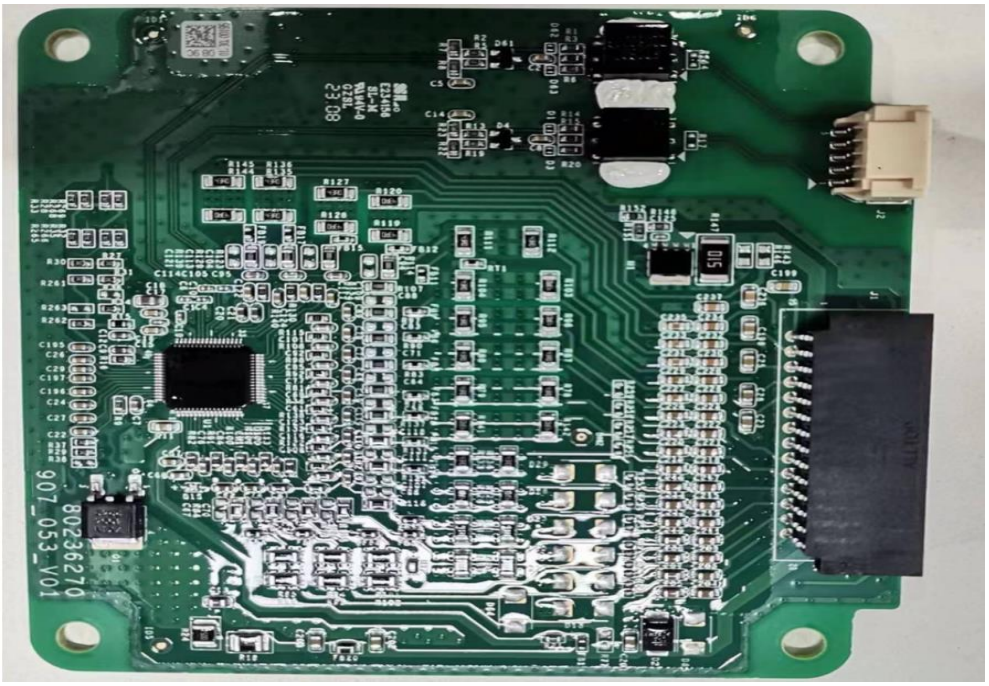
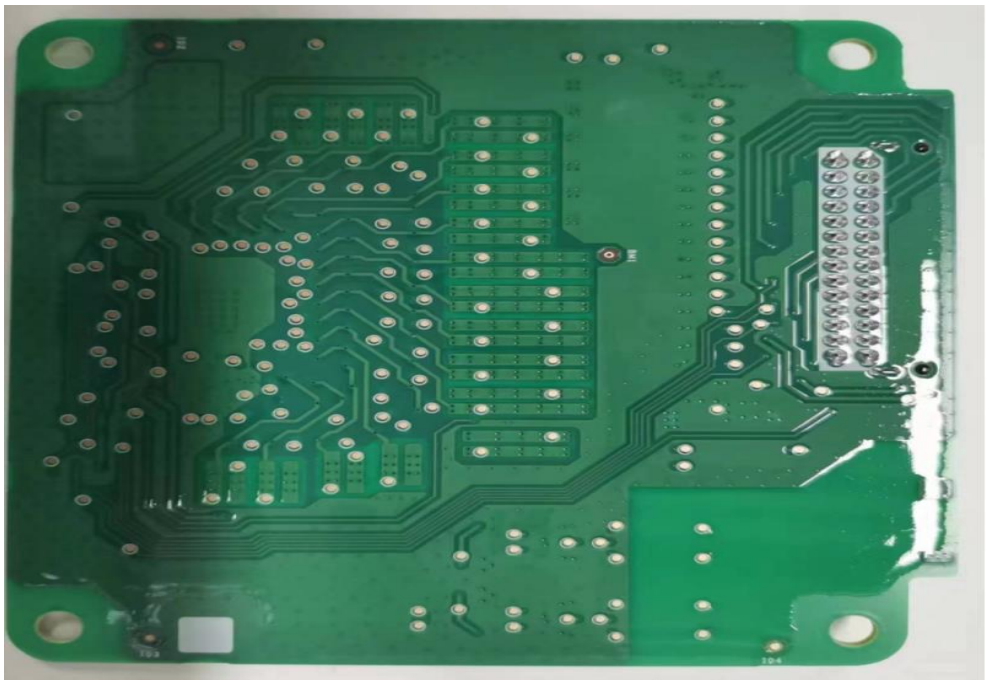
PCBA of BSU





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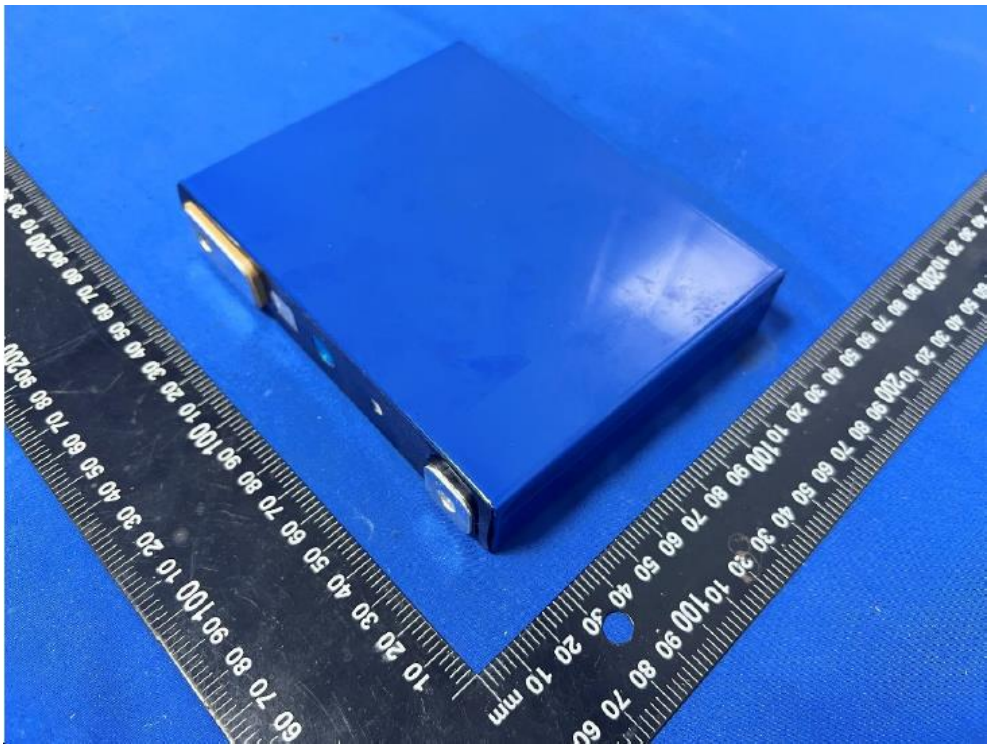
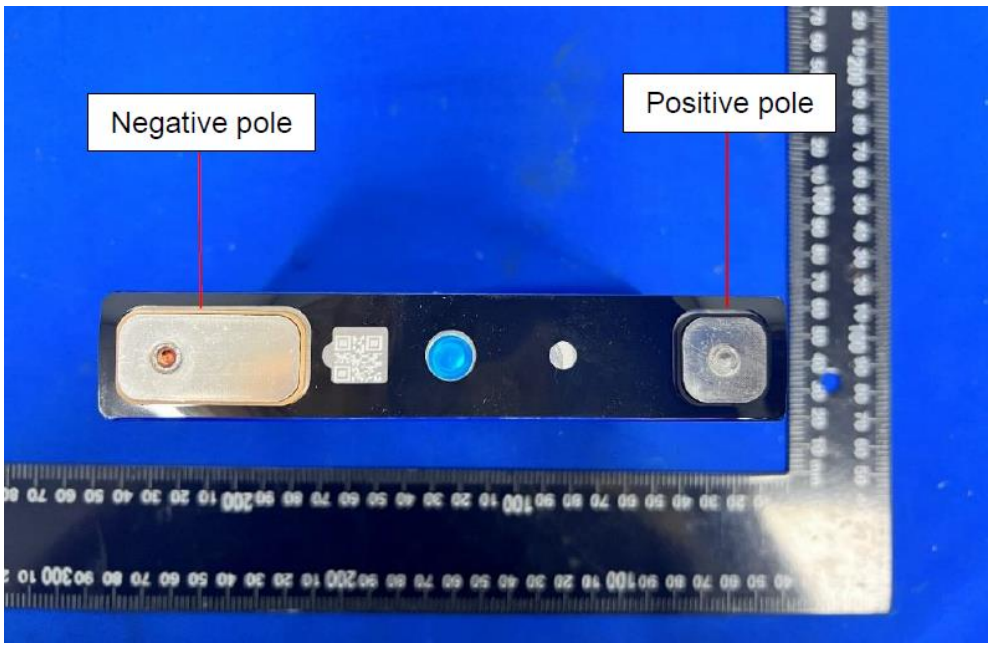
Cell





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NOTES TO THIS TEST REPORT

1. The following language(s) of marking(s) and instruction sheets were submitted during the test application:
   - English
   - Throughout this report a comma is used as the decimal separator.

   According to the standard, instruction sheets and other texts required by the standard should be written in the official language(s) of the country in which the product is to be sold. The applicant should ensure that the product in future production fulfils the receptive standard requirements.

- - - End of Report - - -

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