Model	M32	Spec. No.	PBRI-M32-D06-02	Version	B

PRODUCT SPECIFICATION

Prismatic Lithium Cell

Model：M32

Draft	Product Design Review	Quality Review	Sales Review	Approved
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May, 2022

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Revision History

Revision No.	Date	Description	Approved
A	August 11th, 2019	First Edition	Steve Li
B	May 15th ,2022	Update packaging method	Steve Li

Definition of Terminology

Terminology	Definition
Product	The "product" in this specification refers to the M32 rechargeable prismatic lithium-ion cell produced.
Customer	Refers to the buyer in the "Product Sales Contract ".
Ambient temperature	The ambient temperature where the cell is located.
Cell temperature	The temperature of the cell measured by the temperature sensor connected to the cell.
Magnification(C)	The ratio of the charge or discharge current to the cell's rated capacity value. For example, if the cell capacity is 166Ah, when the charge or discharge current is 166A, the charge or discharge rate is 1C.
State of charge(SOC)	Under no-load conditions, the ratio of the cell capacity state and the rated capacity measured in ampere hours or watt hours. For example, if the capacity is 166Ah as 100% SOC, when the capacity is 0Ah, the SOC is 0%.
Cycle(Cycle)	The cell is charged and discharged in a cycle according to the prescribed charging and discharging standards. The cycle includes short-term normal charging or a combination of regenerative charging and discharging processes. Sometimes during the charging process, there is only normal charging and no regenerative charging. Discharge can be formed by combining some partial discharges.
Standard charge	The charging mode described in clause 3.5 of this specification.
Standard discharge	The discharge mode described in clause 3.6 of this specification.
Open circuit voltage(OCV)	The voltage of the cell measured when no load is connected.
DC Resistance(DCR)	The ratio of the voltage change of the cell to the corresponding current change under working conditions, the test method is as described in section 3.8.3.9 of this specification.
Cell Management System(BMS)	An effective tracking and control system used by customers to detect and record product operating parameters throughout the service period. Its tracking and recording parameters include but are not limited to voltage, current, temperature, etc., to control the operation of the product and ensure that the product's operating environment and operating conditions meet the requirements of this specification.
Module	Lithium-ion batteries are combined in series and parallel, and are the intermediate products of batteries and packs formed by adding single cell monitoring and management devices.
Pulse current	The current or voltage pulses that appear repeatedly in cycles are called pulse currents. The pulse currents appear either in the same direction or in alternating positive and negative directions.
Compression force	When the module is assembled, the cell can withstand the safety margin of the compressive force.

Continued table:

Model	M32	Spec. No.	PBRI-M32-D06-02	Version	B

Units of measurement	“V” (Volt)　Volt (V)，Voltage unit “A” (Ampere)　Current(A)，Current unit “Ah” (Ampere-Hour)　Current -hour(Ah)，Load unit “Wh” (Watt-Hour)　Watt-hour (Wh)，Energy unit “Ω” (Ohm)　Ohm (Ω)，Resistance unit “mΩ”(Milliohm)　Milliohm (mΩ)，Resistance unit “°C” (degree Celsius)　Celsius (°C)，Temperature unit “mm” (millimeter)　millimeter (mm)，Length unit “s” (second)　second (s)，Time unit “Hz” (Hertz)　Hertz (Hz)，Frequency unit

Model	M32	Spec. No.	PBRI-M32-D06-02	Version	B

1. Basic Information

1.1. Scope of application

This product specification has been prepared to specify the rechargeable lithium-ion cell to be supplied to customer.

1.2. Product Description: Prismatic lithium cell
1.3. Product Model: M32

2. Cell Specifications

2.1. Basic Specifications

Items		Standards	Remarks
Capacity (min.)		166.0Ah	1/3C，25±2℃，2.5-4.35V
Energy (min.)		620.8Wh	1/3C，25±2℃，2.5-4.35V
Internal Resistance		≤0.3mΩ	25℃，AC, 1kHz, 30%SOC
Nominal Voltage		3.74V	1/3C，2.50-4.35V
Cell Weight		2465±35g	/
Maximum charging voltage（U_{max}）		4.35V	/
Minimum discharge voltage（U_{min}）		2.8V	35℃<T≤55℃
		2.5V	10℃<T≤35℃
		2.1V	-30℃<T≤10℃
Standard Charge/Discharge Current		55.3A	1/3C
Cycling	25℃ Standard Cycle	1800 cycle	0.5C/1.0C，2%-97%DOD，capacity retention≥80%
	25℃ Fast charging cycle	1000 cycle	FC/1.0C，2%-97%DOD，capacity retention≥80%
	45℃ Standard Cycle	1400 cycle	0.5C/1.0C，2%-97%DOD，capacity retention≥80%
Dimensions	Height 1	112.9±0.4mm	See Figure 1
	Height 2	110.2±0.4mm	See Figure 1
	Width 1	194.3±0.3mm	See Figure 1
	Thickness	50.7±0.3mm	30%SOC, the maximum thickness under 300kgf compresive force, See Figure 1
Energy density	mass energy density	≥251Wh/kg	/
	Volume energy density	≥572Wh/L	/
Storage Temperature*	One Year	0-25℃	Shipping SOC status
	Three Months	0-45℃	
	One Month	0-60℃	

2.2. Product Specifications

2.2.1. Dimensions and Weight

Number	Item		Standard	Test method chapter
1	Dimension	Height 1	112.9±0.4mm	3.8.1
		Height 2	110.2±0.4mm	
		Width 1	194.3±0.3mm	
		Thickness	50.7±0.3mm	
2	Weight	Including insulating film	2465±35g	3.8.2

2.2.1. Electrical performance

Number	Item		Standard	Test method chapter
1	Capacity	1/3C Capacity	≥166.0Ah	3.8.3.1
		1C Capacity	≥163.0Ah	3.8.3.2
2	Energy	1/3C Energy	≥620.8Wh	3.8.3.1
		1C Energy	≥603.1Wh	3.8.3.2
3	Discharge Capacity Retention according to temperature	-30℃	≥80%	3.8.3.3
		-20℃	≥82%	3.8.3.4
		-10℃	≥83%	3.8.3.5
		0℃	≥87%	3.8.3.6
		10℃	≥92%	3.8.3.7
		55℃	≥100%	3.8.3.8
4	DCR	25℃，50%SOC，1C，10sec	≤0.60mΩ	3.8.3.9
5	Cycle	25℃ Standard Cycle	1800 cycle capacity retention≥80%	0.5C/1.0C，2%-97%DOD
		25℃ Fast charging cycle	1000 cycle capacity retention≥80%	10%-80%SOC@20min
		45℃ Standard Cycle	1400 cycle capacity retention≥80%	0.5C/1.0C，2%-97%DOD
6	Capacity retention and recovery	25℃，28 days	capacity recovery≥99%	3.8.3.13
			capacity retension≥96%	
		45℃，28 days	capacity recovery≥98%	3.8.3.14
			capacity retension≥94%	

2.2.2. Safety performance

Number	Item	Standard	Test method
1	Over-Discharge	No fire, No explosion	3.8.4.1
2	Over-Charge	No fire, No explosion	3.8.4.2
3	Crush	No fire, No explosion	3.8.4.3
4	External Short Circuit Test	No fire, No explosion	3.8.4.4
5	Hot Box	No fire, No explosion	3.8.4.5
6	Temperature cycle	No fire, No explosion	3.8.4.6

2.3. Outline Dimensions

See the attachment (Fig.1).

2.4. Appearance

The cell has no obvious scratches, cracks, rust stains, discoloration, or electrolyte leakage, which have a bad appearance that affects the commercial value of the cell.

3. Standard Test Condition

3.1. Environment Condition

Unless otherwise specified, all tests stated in this specification are conducted at 25±5℃, the relative humidity is under 65%RH, and the atmospheric pressure is 86kPa ~ 106kPa. The room temperature mentioned in this specification refers to 25±2℃.

3.2. Measuring Equipment

The accuracy of measuring instruments and meters shall meet the following requirements:

（1）Voltage measuring device: ±0.1%；

（2）Current measuring device: ±0.1%；

（3）Temperature measuring device: ±0.5℃；

（4）Dimension measuring device: ±0.01mm；

（5）Weight measuring device: ±0.1g.

3.3. Test fixture assembly

The single cell needs to be fixed with an expansion clamp. The plywood is made of aluminum plate and needs to cover the large surface of the battery. Each surface of the plywood needs to be covered with an insulating film with a thickness of no less than 0.1mm. The fixture tooling is shown in the figure below

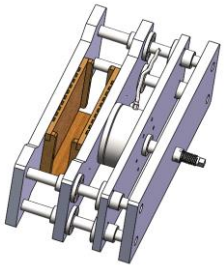


Fig. 1 Cell expansion clamp

3.4. Fixture tools assembly

The cell (~ 30% SOC) coated with rubber frame(material: rubber, thickness: 0.9mm) and top patch was placed in the middle of the expansion clamp, and the pre tightening force of the cell is 3000±200N.

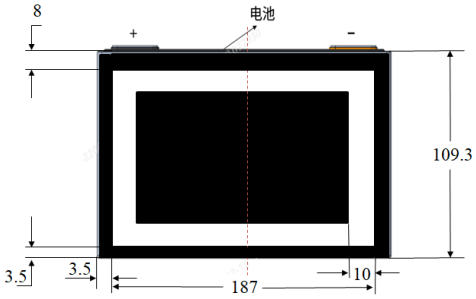


Fig.2 Installation diagram of rubber frame of cell

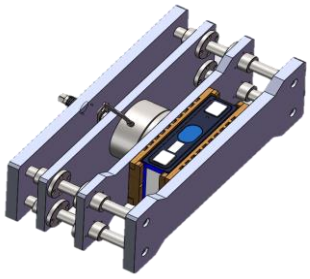


Fig.3 Installation diagram of cell expansion clamp

3.5. Standard charging mode

The standard charging mode means charge with 55.3A CC-CV to 4.35V, 8.3A cut-off at 25±2 ℃, rest 30min.

3.6. Standard discharging mode

The standard discharging mode means discharge with 55.3A to 2.8V at 25 ℃, rest 30min.

3.7. Capacity and energy calibration

The capacity calibration is to charge the cell according to (3.5) standard charging mode and discharge according to (3.6) standard discharging mode under the ambient temperature of 25±2℃. Repeat the standard charging mode and standard discharging mode for three times. The average discharge capacity is discharge capacity of 1/3C rate, the recorded discharge capacity is the calibrated capacity C_0, and the average discharge energy is discharge energy of 1/3C rate. Record the discharge energy as the calibration energy E_0.

3.8. Test Method

3.8.1. Dimensions

Test equipment: Caliper (Length/Width/Height); Plat thickness gauge (Thickness*)

Test method:

a) Use calipers to measure the length, width and height of the cell;

b) Use the plate thickness gauge to measure the thickness of the cell, maintain 10sec under 300kgf pressure.

* The thickness of the cell will increase as the SOC increases, and it will increase as the use time increases. The thickness here indicates the thickness of the cell at the time of delivery (SOC~30% at the time of shipment).

3.8.2. Weight

Test equipment: Electronic Scale

Use electronic scale to measure the weight of cell.

3.8.3. Electrical property

3.8.3.1. 1/3C discharge capacity and energy

At 25±2℃, the cell is fully charged according to the standard charging method (3.5), and then discharged according to the standard dicharging method (3.6). The discharge capacity and discharge energy are recorded. The average discharge capacity of three times is 1/3C discharge capacity, and the average discharge energy of three times is 1/3C discharge energy.

3.8.3.2. 1 C discharge capacity and energy

At 25±2℃, the cell is fully charged according to the standard charging method (3.5), and then discharged to 2.5V at the constant current of 163.0A, and then the cell is stored for 30min .The discharge capacity and discharge energy are recorded. The average discharge capacity of three times is 1C discharge capacity, and the average discharge energy of three times is 1C discharge energy.

3.8.3.3. -30℃ Capacity retention

At 25±2℃, install the test fixture to the cell according to the method in 3.4, the cell is tested according to 3.7 chapter, the cell is fully charged according to the standard charging method (3.5), and then the cell is stored at -30±2℃ for 6h, discharged to 2.1V with a current of 55.3A. The discharge capacity(C_1) is capacity retention，and C_1/C_0 is recorded as capacity retention rate at -30℃.

3.8.3.4. -20℃ Capacity retention

At 25±2℃, install the test fixture to the cell according to the method in 3.4, the cell is tested according to 3.7 chapter, the cell is fully charged according to the standard charging method (3.5), and then the cell is stored at -20±2℃ rest for 6h, discharged to 2.1V with a current of 55.3A. The discharge capacity(C_2) is capacity retention，and C_2/C_0 is recorded as capacity retention rate at -20℃.

3.8.3.5. -10℃ Capacity retention

At 25±2℃, install the test fixture to the cell according to the method in 3.4, the cell is tested according to 3.7 chapter, the cell is fully charged according to the standard charging method (3.5), and then the cell is stored at -10±2℃ rest for 6h, discharged to 2.1V with a current of 55.3A. The discharge capacity(C_3) is capacity retention，and C_3/C_0 is recorded as capacity retention rate at -10℃.

3.8.3.6. 0℃ Capacity retention

At 25±2℃, install the test fixture to the cell according to the method in 3.4, the cell is tested according to 3.7chapter, the cell is fully charged according to the standard charging method (3.5), and then the cell is stored at 0±2℃ for 6h, discharged to 2.1V with current of 55.3A. The discharge capacity(C_4) is capacity retention，and C_4/C_0 is recorded as capacity retention rate at 0℃.

3.8.3.7. 10℃ Capacity retention

At 25±2℃, install the test fixture to the cell according to the method in 3.4, the cell is tested according to 3.7 chapter, the cell is fully charged according to the standard charging method (3.5), and then the cell is stored at 10±2℃ for 6h, discharged to 2.1V with a current of 55.3A. The discharge capacity(C_5) is capacity retention，and C_5/C_0 is recorded as capacity retention rate at 25±2℃.

3.8.3.8. 55℃ Capacity retention

At 25±2℃, install the test fixture to the cell according to the method in 3.4, the cell is tested according to 3.7 chapter, the cell is fully charged according to the standard charging method (3.5), and then the cell is stored at 55±2℃ for 3h, discharged to 2.8V with a current of 55.3A. The discharge capacity(C_6) is capacity retention，and C_6/C_0 is recorded as capacity retention rate at 55℃.

3.8.3.9. Internal Resistance

a） At 25±2℃, the shipping cell is tested with AC 1kHz.

b） At 25±2℃, the capacity of the cell is calibrated (3.7 capacity calibration and energy calibration), then the cell is charged according to the standard charging method (3.5), then discharged for 90min with a current of 55.3A (adjust the SOC to 50%), rest for 1h, the voltage is recorded as V_1, and then discharged for 10sec with 166.0A. The end voltage is recorded as V_2, DCR = （ V_1-V_2 ）*1000/166.0 mΩ.

3.8.3.10. 25℃ Standard cycle

Fix fixture before test: At room temperature, the cell with 30%SOC is clamped with fixture according to the method in 3.4.

Capacity test before cycle: At 25±2℃, the cell is discharged to 2.5V with 55.3A, rest 10min, then fully charged according to standard charging method (3.5), and then discharged according to standard discharge method (3.6), the discharge capacity is recorded as C_0.

Cycle test: at 25±2℃;

a) The cell is charged with a constant current of 83.0A to 4.30V, and then switched to constant voltage charged, 8.3A cut-off; rest 30min;

b) Discharged with 83.0A to 3.18V, rest 30min;

c) Repeat a)-b) for 1800 cycles.

Capacity test after cycle: At 25± 2℃, the cell is discharged to 2.5V with 55.3A , rest 30min, then fully charged according to the standard charging method (3.5), then discharged according to the standard discharge method (3.6), record the discharge capacity as C_7, the capacity retention rate = $C_7/C_0 \times 100\%$.

3.8.3.11. 45℃ Standard cycle

Fix fixture before test: At room temperature, the cell with 30%SOC is clamped with fixture according to the method in 3.4.

Capacity test before cycle: At 25±2℃, the cell is discharged to 2.5V with 55.3A, rest 10min, then fully charged according to standard charging method (3.5), and then discharged according to standard discharge method (3.6), the discharge capacity is recorded as C_0.

Cycle test: at 45±2℃;

a) The cell is charged with a constant current of 83.0A to 4.30V, and then switched to constant voltage charged, 8.3A cut-off; rest 30min;

b) Discharged with 83.0A to 3.18V, rest 30min;

c) Repeat a)-b) for 1400 cycles.

Capacity test after cycle: At 45± 2℃, the cell is discharged to 2.5V with 55.3A , rest 30min, then fully charged according to the standard charging method (3.5), then discharged according to the standard discharge method (3.6), record the discharge capacity as C_8, the capacity retention rate = $C_8/C_0 \times 100\%$.

3.8.3.12. 25℃ Fast charging cycle

Fix fixture before test: At room temperature, the cell with 30%SOC is clamped with fixture according to the method in 3.4.

Capacity test before cycle: At 25±2℃, the cell is discharged to 2.5V with 55.3A, rest 10min, then fully charged according to standard charging method (3.5), and then discharged according to standard discharge method (3.6), the discharge capacity is recorded as C_0.

Cycle test: at 25±2℃;

1） Charge from 2% SOC to 97% SOC according to the fast charging strategy, rest 1h, discharge to 2% SOC, and rest 1h;

2） Repeat the above cycle for 1000 times.

3.8.3.13.25℃ Capacity retention and recovery

At 25±2℃, the cell is clamped with fixture according to the method in 3.4, the capacity of the cell is calibrated (3.7 capacity calibration and energy calibration), then the cell is charged according to the standard charging method (3.5), and then the cell is stored at 25±2℃ for 28 days, then discharged according to the standard discharge method (3.6) (record the discharge capacity as C_9), then charged according to the standard charging method (3.5), and then discharged with the standard discharge method (3.6) (record the discharge capacity as C_{10}). Capacity retention rate = $C_9/C_0 \times 100\%$, Capacity recovery rate = $C_{10}/C_0 \times 100\%$.

3.8.3.14.45℃ Capacity retention and recovery

At 25±2℃, the test fixture is installed according to the method of 3.4, the capacity of the cell is calibrated (3.7 capacity calibration and energy calibration), and then the cell is charged according to the standard charging method (3.5), and then the cell is stored at 45±2℃ for 28 days, then rest 6h at 25±2℃, then discharged according to the standard discharge method (3.6) (record the discharge capacity as C_{11}), then charged according to the standard charging method (3.5) , and then discharged with the standard discharge method (3.6) (record the discharge capacity as C_{12}). Capacity retention rate = $C_{11}/C_0 \times 100\%$, Capacity recovery rate = $C_{12}/C_0 \times 100\%$.

3.8.4. Safety Performance

3.8.4.1. Over-discharge

At 25±2℃, then fully charged according to the standard charging method (3.5), and then the cell is discharged with 163.0A for 90 min at 25±2℃ under safety test environment, observed for 1 hour. (Referred to GB 38031-2020 safety requirements for batteries of electric vehicles)

Judgment criteria: no fire, no explosion.

3.8.4.2. Over-charge

At 25±2℃, then fully charged according to the standard charging method (3.5). and then the cell is charged to 4.785V or 115%SOC with 163.0A , observed for 1h. (Referred to GB 38031-2020 safety requirements for batteries of electric vehicles)

Judgment criteria: no fire, no explosion.

3.8.4.3. Crush

At 25±2℃, the cell is fully charged according to the standard charging method (3.5). The test shall be carried out at 25±2℃ under safety test environment temperature in the following conditions:

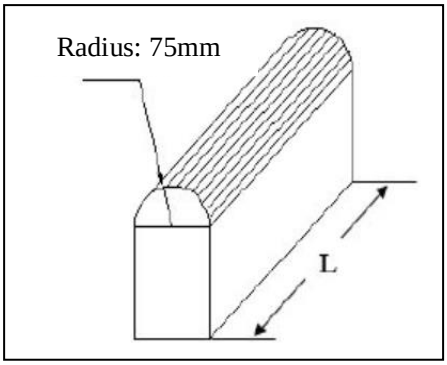
a) Extrusion direction: the pressure is perpendicular to the electrode plate of the cell, or the same direction as the cell which is most vulnerable to extrusion in the vehicle layout;

b) The form of extruded plate: a semi cylinder with a radius of 75mm, and the length (L) of the semi cylinder is larger than the size of the cell (see the figure below);

c) Extrusion speed: no more than 2mm/s;

d) Extrusion degree: stop extrusion when voltage reaches 0V or deformation reaches 15%, or extrusion force reaches 100kN or 1000 times weight of test object;

e) Keep for 10min. Observe for 1h. (Referred to GB 38031-2020 safety requirements for batteries for electric vehicles).



Judgment criteria: no fire, no explosion.

3.8.4.4. External short circuit

At 25±2℃, then fully charged according to the standard charging method (3.5). The anode and cathode of the cell are short circuit externally for 10min at 25±5℃, the resistance value of the external shall be less than 5mΩ, observed for 1h. (Referred to GB 38031-2020 safety requirements for batteries of electric vehicles)

Judgment criteria: no fire, no explosion.

3.8.4.5. Hot Box

At 25±2℃, then fully charged according to the standard charging method (3.5). Put the cell into the hot box, and the temperature of the hot box will rise to 130℃±2℃ at the rate of 5℃/min, and then stop heating after keeping this temperature for 30 min, observed for 1h. (Referred to GB 38031-2020 safety requirements for batteries of electric vehicles)

Judgment criteria: no fire, no explosion.

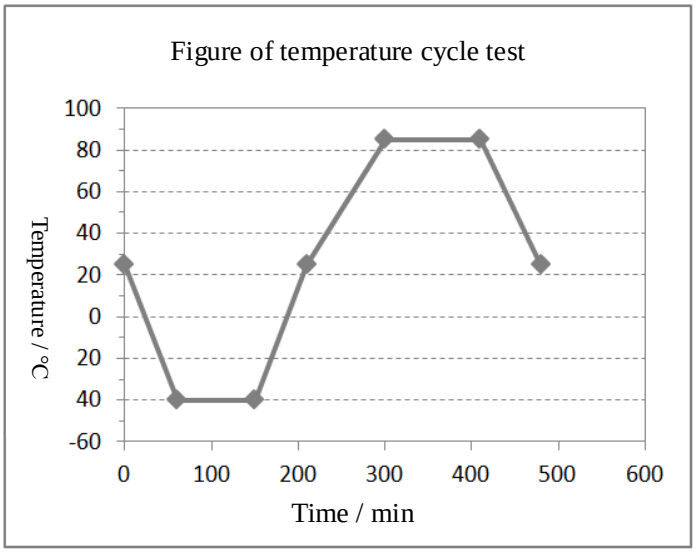
3.8.4.6. Temperature cycle

At 25±2℃, then fully charged according to the standard charging method (3.5). Put the cell into the hot box. The temperature of the hot box is adjusted according to the table below for 5 cycle times. (Referred to GB 38031-2020 safety requirements for batteries of electric vehicles)

Judgment criteria: no fire, no explosion.

Temperature(℃)	Time increment(min)	Total time(min)	Temperature changing rate(℃/min)
25	0	0	0
-40	60	60	13/12
-40	90	150	0
25	60	210	13/12
85	90	300	2/3
85	110	410	0
25	70	480	6/7

Figure of temperature cycle test



4. Suggestion of BMS design parameters

The following data are the reference performance of M32, it can used as reference for BMS design. The actual use is subject to the usage mode and conditions agreed by both sides.

4.1. Electrical performance data

4.1.1. SOC-OCV

At 25±2℃, the capacity of the cell is calibrated (3.7 capacity calibration and energy calibration). Then, the cell is charged according to the standard charging method (3.5), then discharged with 55.3.0A with a discharge capacity of 10%×C_0. Rest 60min and repeat discharged for 10 times. The voltage after each rest time is recorded as the OCV corresponding to the SOC in discharged.

At 25±2℃, the capacity of the cell is calibrated (3.7 capacity calibration and energy calibration). Then, the cell is charged with 55.3A with a capacity of 10%×C_0. Rest for 60min and recharged for 10 times. The voltage after each rest time is recorded as the OCV corresponding to the SOC in charged.

Temperature	OCV (V)											
	SOC %	100	90	80	70	60	50	40	30	20	10	0
25℃	Charge	4.322	4.190	4.082	3.966	3.858	3.739	3.681	3.646	3.606	3.512	3.343
	Discharge	4.322	4.180	4.069	3.953	3.844	3.724	3.669	3.633	3.577	3.492	3.321

4.1.2. Recommended charging

Normal charging (10~ 45℃): The cell is charged with a constant current of 55.3A to 4.30V, and then switched to constant voltage charged, 8.3A cut-off.

Fast charging ：（25℃,10%-80%SOC@20min）：The cell is charged according to the fast charging strategy.

4.1.3. Pulse discharge and charging power

Temperature	Mode	Maximum power（W）				
		Time(s)			Time(s)	
40℃	Discharge	10sec	3000	2800	2300	2000
		30sec	2300	2000	1800	1600
	Charge	10sec	600	2000	2100	2300
		30sec	400	1800	2000	2100
25℃	Discharge	10sec	2300	2000	1900	1700
		30sec	2100	1800	1700	1500
	Charge	10sec	500	1800	2000	2200
		30sec	300	1500	1800	2000
-5℃	Discharge	10sec	1500	1000	800	700
		30sec	1200	800	600	500
	Charge	10sec	200	600	800	900
		30sec	100	300	400	500
-20℃	Discharge	10sec	1200	900	500	300
		30sec	800	500	300	200

4.1.4. DCR

Temperature	Method	DCR（mΩ）				
		Time (s)	90% SOC	50% SOC	30% SOC	20% SOC
40℃	Discharge	10sec	0.46	0.48	0.50	0.54
		30sec	0.58	0.55	0.58	0.62
	Charge	10sec	0.55	0.53	0.55	0.57
		30sec	0.82	0.78	0.70	0.72
25℃	Discharge	10sec	0.50	0.48	0.47	0.51
		30sec	0.63	0.58	0.59	0.65
	Charge	10sec	0.55	0.56	0.60	0.73
		30sec	0.88	0.82	0.75	0.79
0℃	Discharge	10sec	1.282	1.209	1.256	1.516
		30sec	2.177	1.998	2.109	2.617
	Charge	10sec	1.334	1.227	1.180	1.206
		30sec	2.334	2.211	1.927	2.035
-20℃	Discharge	10sec	3.830	3.602	4.267	5.974
		30sec	24.263	21.576	21.068	20.787

4.1.5. Charging capacity at different temperatures

After standard discharged, the cell shall be stored for 4h at the corresponding temperature in the following table, and then charged to 4.35V at the constant current and voltage corresponding to the table until the current is reduced to 8.3A (0.05C). The measured capacity is the charging capacity at the corresponding temperature and current.

Charge rate	Temperature(℃)	Charge capacity(Ah)
1/3C（55.3A）	45	172
	25	170
	10	169
	5	168

4.1.6. Discharge capacity at different temperatures

After standard charged, the cell is stored for 6h at the corresponding temperature in the following table, and then discharged to 2.8/2.5/2.1V with 55.3.0A . The measured capacity is the discharging capacity at the corresponding temperature and current.

Discharge rate	Temperature（℃）	Discharge capacity（Ah）	Discharge Voltage（V）
1/3C（55.3A）	45	172	2.8
	25	170	2.5
	0	160	2.1
	-10	157	2.1
	-20	150	2.1

4.2. Cell safety operation limit

4.2.1. Current limit

4.2.1.1. Discharge operation current limit：

Temperature（℃）	Discharge operation current limit		
	Pulse current limit		Continuous current limit
	$I_{max\text{-}peak}$ (A)	Time (sec)	$I_{max\text{-}peak}$ (A)
52	0	-	0
50	600	150	330
40	600	150	330
35	600	150	330
30	600	150	330
25	600	150	330
20	600	150	330
15	600	150	300
10	600	150	300
5	350	150	300
0	350	150	300
-5	350	150	210
-10	350	150	210
-15	170	150	100
-20	170	150	100
-25	130	150	60
-30	85	150	40
-32	0	-	0

Remark: The above $I_{max\text{-}peak}$ and $I_{max\text{-}continuous}$ refer to the maximum allowable current of the cell at 50% SOC.

4.2.1.2. Charge operation current limit：

Temperature（℃）	Discharge operation current limit		
	Pulse current limit		Continuous current limit
	$I_{max\text{-}peak}$ (A)	Time (sec)	$I_{max\text{-}peak}$ (A)
52	0	-	0
50	500	30	83
40	500	30	350
35	500	30	350
30	500	30	415
25	500	30	415
20	415	30	300
15	332	30	212
10	332	30	132
5	166	30	83
0	80	30	33
-5	30	30	16
-10	0	/	0

4.2.1.3. Safety current limit：

If the current exceeds $I_{max\text{-}safety}$ between 0msec and 200msec, the cell will not trigger a safety event (EUCAR hazard level≤HL3: Cell leakage and electrolyte loss < 50%), but the cell cannot continue to be charged and discharged, and it must be replaced.

It will seriously accelerate the cell decay when used between the operating current limit and the safe current limit, but no safety event will occur.

When no temperature is specified, the safe limit current can be determined by linear interpolation between two adjacent conditions in the table below.

Temperature（℃）	Safety current limit			
	Discharge		Charge	
	$I_{max\text{-}safety}$（A）	Maximum allowable time（msec）	$I_{max\text{-}safety}$（A）	Maximum allowable time（msec）
55	0	200	0	200
50	800	200	600	200
40	800	200	600	200
35	800	200	600	200
30	800	200	600	200
25	800	200	600	200
20	800	200	500	200
15	800	200	400	200
10	800	200	400	200
5	500	200	250	200
0	500	200	160	200
-5	500	200	100	200
-10	340	200	80	200
-15	340	200	60	200
-20	260	200	40	200
-25	170	200	20	200
-30	0	200	10	200

4.2.2. Voltage limit：

Charge & discharge voltage limit			
Type	Item	Value	Remark
Safety limit	Charge voltage	4.35V	When the voltage is above 4.35V, the sustainable charging time must be less than 2000msec. When the charging voltage is above 4.35V, cannot guarantee the safe performance of the cell. If the voltage exceeds the safety limit voltage, please discharge immediately to bring it to the safety limit.
	Discharge voltage	2.0V	When the voltage is less than 2.0V, the sustainable charging time must be less than 2000msec. When the charging voltage is less than 1.8V, cannot guarantee the safe performance of the cell. If the voltage exceeds the safety limit voltage, please charge immediately with constant current and constant voltage (the charge current is not more than 55.3A, and the charge voltage is not more than 4.3V, the cut-off current is not less than 8.3A) to bring it to the safety limit.
Operation limit	Charge voltage	4.30V	Charging is not allowed when T>55℃.
	Discharge voltage	2.1V	When 35℃＜T≤55℃， the discharging cut-off voltage is 2.8V； When 10℃＜T≤35℃， the discharging cut-off voltage is 2.5V； When -30℃≤T≤10℃， the discharging cut-off voltage is 2.1V.

4.2.3. Temperature limit：

Temperature limit for safety operation			
Type	Item	Value	Remark
Safety limit	Maximum safe temperature	60℃	If the using temperature of the cell exceeds the maximum safe temperature, it will cause irreversible permanent damage to the cell. The usage should not be above than the maximum safe temperature.
	Minimum safe temperature	-40℃	If the using temperature of the cell exceeds the minimum safe temperature, it will cause irreversible permanent damage to the cell, and the usage should not be lower than the minimum safe temperature.
Operation limit	Maximum operate temperature	55℃	If the usage temperature of the cell exceeds the maximum operate temperature, the power needs to be reduced to 0.
	Recommended operate temperature range	10~45℃	Recommended temperature range of the cell.
	Minimum operate temperature	-30℃	If the usage temperature of the cell exceeds the minimum operate temperature, the power needs to be reduced to 0.

5. Suggestions on module design parameters

5.1. Cell direction

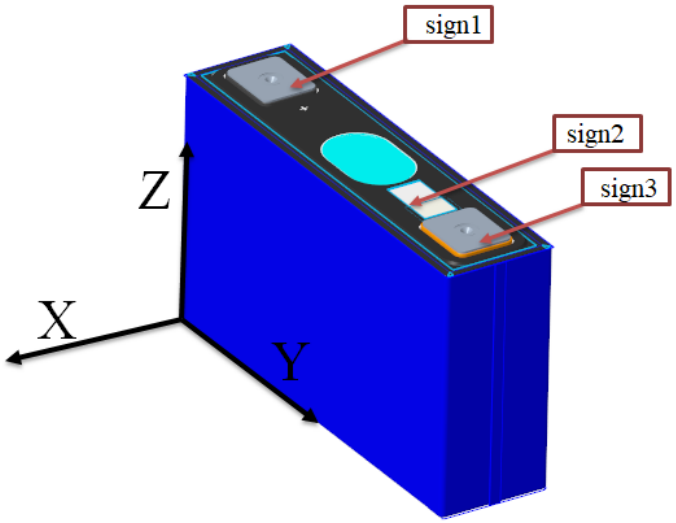


Fig.4 Schematic diagram of cell

5.2. Compression force of cell

When the module is assembled, the cell can bear the safe boundary of compression force.
Test conditions:

—Compression area:194.3mm*110.3mm（L*H）
—Compression area:1.0mm/sec
—Compression direction: X direction
—Cell SOC：100%

Item		Unit	Cell status @30%SOC
Module airless gel	Compressive force @BOL	N	Max. 3000
	Relaxation force @BOL		Max. 1500

It can be seen from the above table that the compression force of the cell should not exceed 20kN, otherwise the cell may be damaged.

5.3. Expansion force of cell

5.3.1. Test conditions：

The initial preload of the battery is：3000N±200N

Charge/Discharge conditions

- Charging: Charge from 2% SOC to 97% SOC according to the fast charging strategy, rest 1h.

- Discharge: Discharge to 2%SOC with 1C. Rest 1h.

According to the charge & discharge conditions, the cell is cycled for 1000 times, and the expansion force before and after the cycle is recorded.

5.4. Thermal parameters

Test method: Reference standard: GB / T 10295-2008, ASTM E1269-2011

Mean value of thermal conductivity	Thermal conductivity (W/mK)	
	Y/Z	X
	25~26W/mK	5~7 W/mK
Mean heat capacity	Heat capacity (kJ/(kg·K))	
	0.9~1.2 kJ/(kg·K)	

5.5. Recommended temperature acquisition points (distribution of cell temperature field)

When collecting the temperature of the cell surface, it is recommended to arrange the temperature collection points at the marks 1, 2 and 3 in Figure 4.

6. Cell operation instructions and precautions

6.1. Long term storage

The cell should be used as soon as possible to avoid the loss of usable capacity due to self-discharge after charged. The cell needs to be stored in low SOC if it must be stored. The recommended storage conditions are: 30% ±10% SOC, 0~25℃ and ≤60%RH.

6.2. Transportation

The products shall be packed in boxes with no more than 30% SOC. During transportation, violent vibration, impact or extrusion shall be prevented, and sun and rain shall be avoided. It is suitable for transportation of vehicles, trains, ships, airplanes, etc.

6.3. Operating instructions

- Reverse charging is prohibited. Connect the anode and cathode of the cell correctly. Reverse charging is strictly prohibited.
- It is forbidden to over discharge. In the normal use, in order to prevent the occurrence of over discharge, the cell should be regularly charged to maintain the voltage above 2.5V.
- It is forbidden to immerse the cell in water. When it is not used, it should be placed in a cool and dry environment.
- It is forbidden to put the cell beside the hot and high temperature source, such as fire, heater, etc.
- Please use the special charger for lithium ion cell when charging.
- It is strictly forbidden to reverse the anode and cathode poles of the cell during use.
- It is forbidden to throw the cell on fire or heat the cell.
- It is forbidden to directly connect the anode and cathode of the cell with metal.
- It is forbidden to transport or store cells together with metals such as hairpins and necklaces.
- It is forbidden to knock or throw, step on or bend the cell.
- It is forbidden to directly weld the cell.
- It is forbidden to pierce the cell with nails or other sharp tools.
- Do not use the cell in extremely hot environment, such as in the vehicle in direct sunlight or hot weather.
- It is forbidden to use it in places with strong static electricity and strong magnetic field.
- In case of cell leakage and electrolyte splashing on the skin or clothes, the affected area should be cleaned immediately with flowing water.
- If the cell has peculiar smell, heat, discoloration, deformation, or any abnormality in the process of use, storage and charging, it shall not be used.

6.4. Others

Any matters not involved in this specification should be confirmed with the both parties.

Model	M32	Spec. No.	PBRI-M32-D06-02	Version	B

8. Attachment

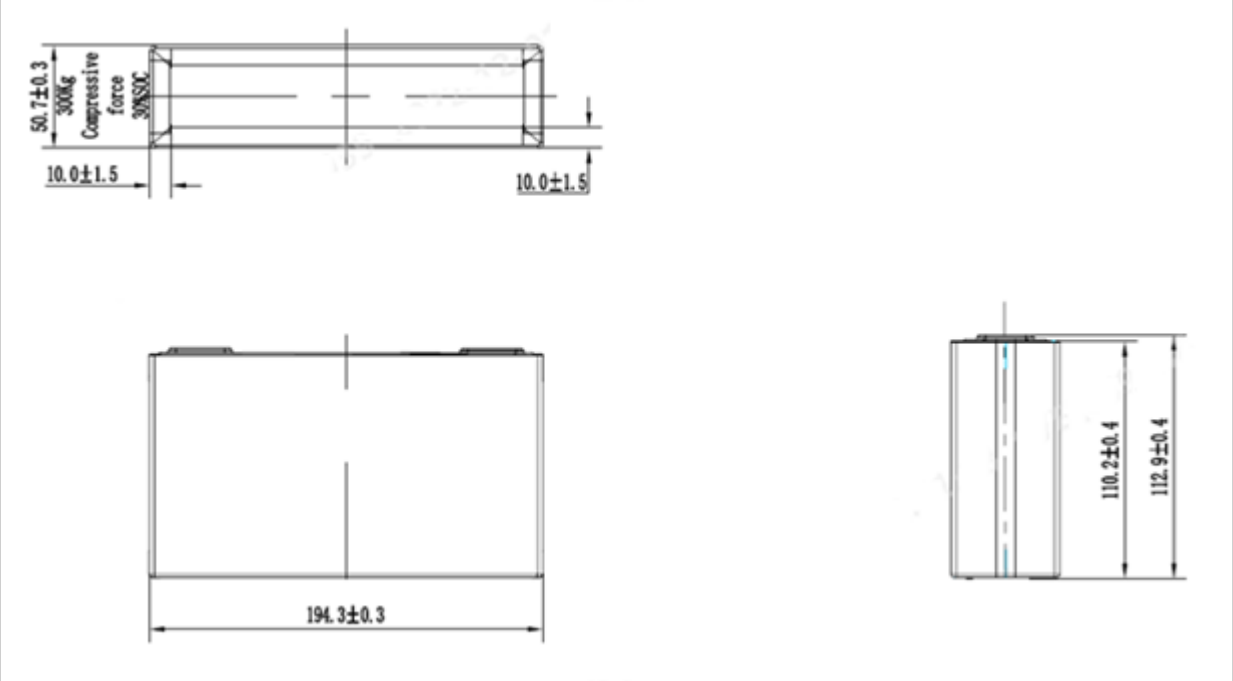


Figure 1: M32 cell drawing