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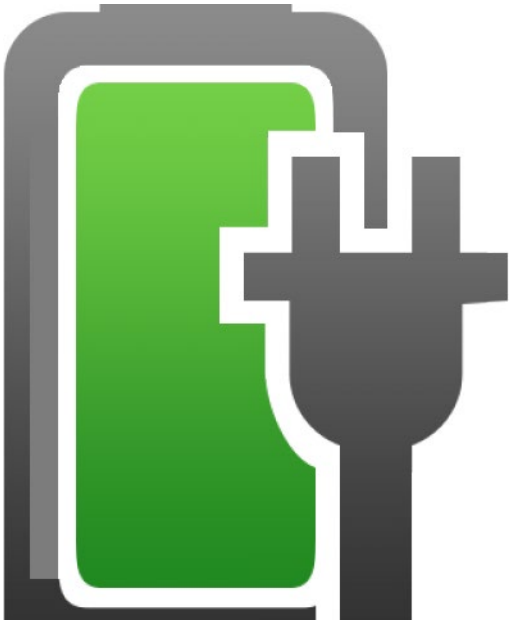
IN COOPERATION WITH NGI®

NS81000 Battery simulation

Battery Simulation Software Manual



Offizieller Partner von NGI: Service und Vertrieb direkt durch ET System electronic GmbH.
Official partner of NGI: Service and sales directly through ET System electronic GmbH.

ET System electronic GmbH
www.et-system.de

Hauptstraße 119 – 121
D – 68804 Altlußheim

Vertrieb Kontakt: **Tel.: +49 (0)6205 / 394 80**
Sales contact: **info@et-system.de**

Contents

1 Software Introduction

1.1 Brief Introduction

NS81000 battery simulator software with N35200 series programmable bi-directional DC power supply can accurately simulate the battery characteristic curve, to meet the user's needs for different types of battery simulation, and improve the test efficiency.
NS81000 has 7 standard battery model libraries, users only need to select the corresponding battery type, configure the basic capacity and protection parameters, the software can quickly generate the corresponding type of battery characteristic curve; and there are 2 types of custom battery characteristic curve, engineers can be based on the actual measurement of the battery curve data, import the data into the software and carry out simulation.
Battery types: LiFePO4 battery, Ternary lithium battery, Lead-acid battery, Ni-MH battery, LTO, ICO, IMO.

1.2 Supported Devices

NGI N35200 series wide range high power bidirectional programmable DC power supply with battery simulation function are supported by this software.

1.3 Communication Interface

Including LAN, RS232, CAN, RS485.

1.4 Preparation

1.4.1 Hardware Preparation

Battery simulation device: N35200 series;
Charging device: power supplies with rated voltage, current, and power exceeding that of battery simulation devices, e.g., N38300;
Load device: loads with rated voltage, current, and power exceeding that of battery simulation devices, e.g., N69200;

1.4.2 System Condition

To make better use of the system performance, the following computer configuration is recommended:

- CPU: 2.0G, dual-core and above
- Memory: 4G and above
- Hard disk: 80G and above
- Port: Ethernet port
- Operating system: Microsoft Windows 7 and above

1.4.3 Device Wiring

The N35200 series is equipped with LAN as standard and supports connection to a computer via a network cable to form a battery simulator.
When simulating the battery charging state, the N35200 is connected to a charging device (e.g. N38300); when simulating the battery discharging state, the N35200 is connected to a discharging device (e.g. N69200);

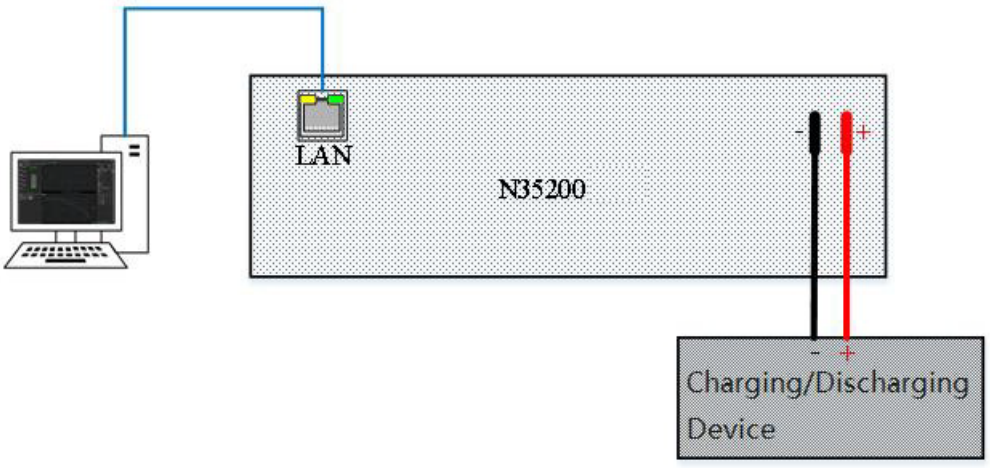


Figure 1 Device Wiring

2 Application Software Installation & Configuration

2.1 Installation & Uninstallation

2.1.1 Installation

1) Find the installation program "NS81000_Full_setup.exe" from the USB flash drive in accessory bag.
2) Make double-click on the file and begin installation.

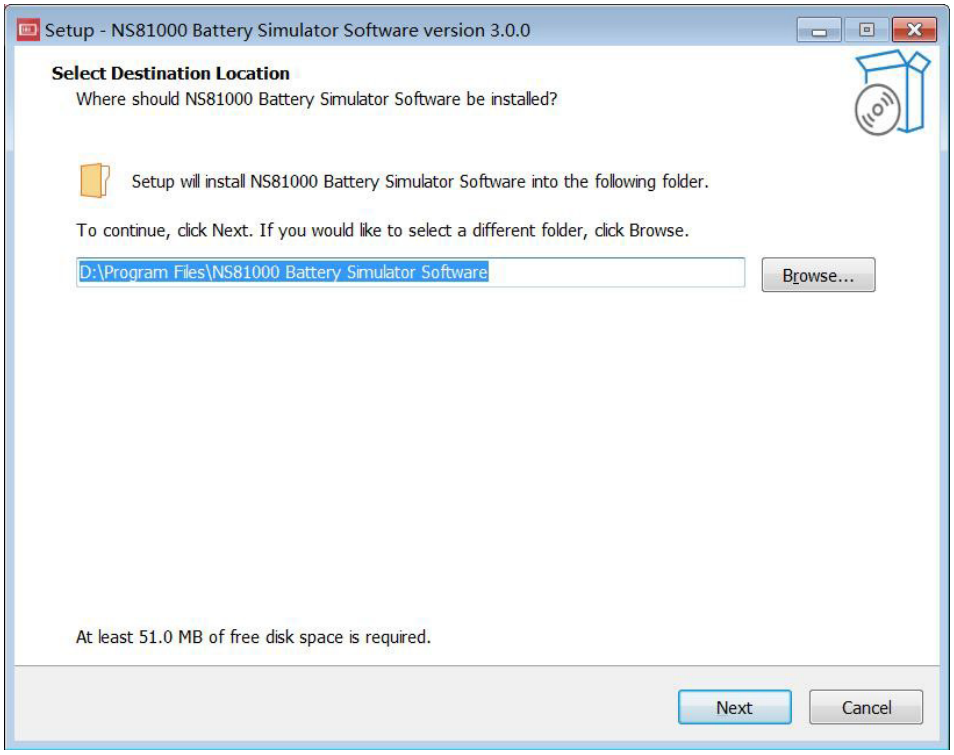


Figure 2 Program Installation

3) Click Next as prompted until the installation is completed. The software will automatically create a shortcut on the desktop.

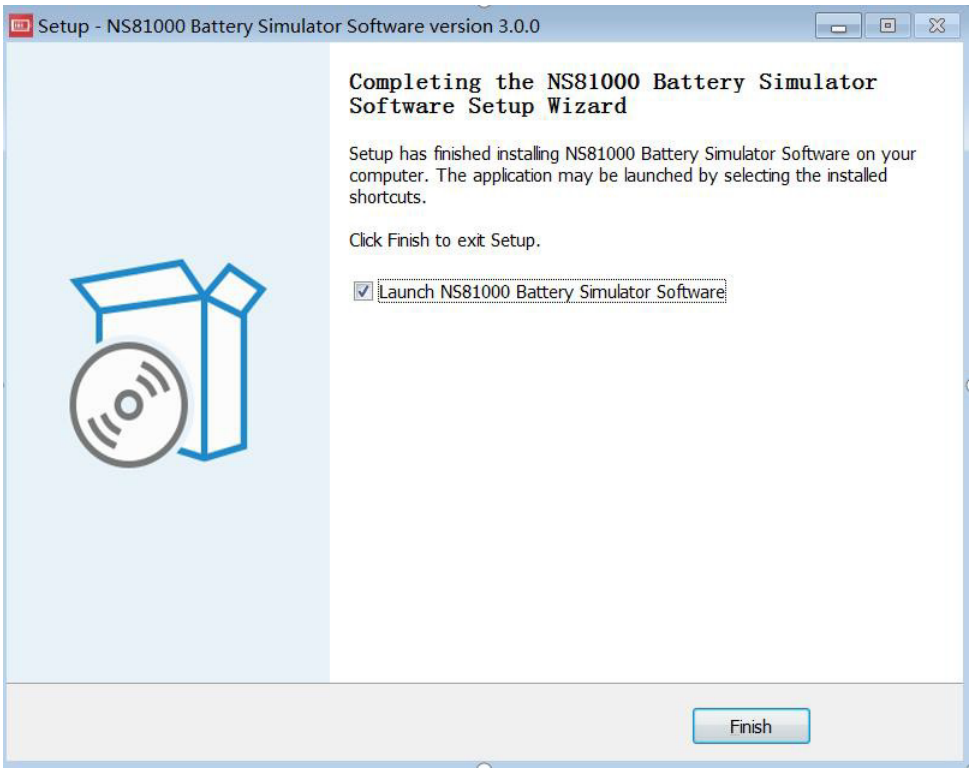


Figure 3 Installation Completed

2.1.2 Uninstallation

Methods for uninstallation:
Method 1: Program uninstallation can be completed through **Uninstall Program** in **Control Panel** of the operating system, or by right-clicking the shortcut and selecting uninstall.
Method 2: Find the setup program in your computer disk and delete.

2.2 PC Connection

2.2.1 Port Connection

N35200 LAN port, can be connected to the computer through the network cable to achieve the master computer communication.
Operation steps:
1. Open the programme on the computer
2. Set IP address (the same network segment as the IP address of the power supply)
3. Click Detect to start connecting with N35200

4. When the device receives the correct communication command, it enters the remote control mode.

2.2.2 Disabling operating system standby mode

■ Windows 7 settings

Click **Start**→Click **Control Panel**→Click **Power Options**→Click **Change Computer Sleep Time**.

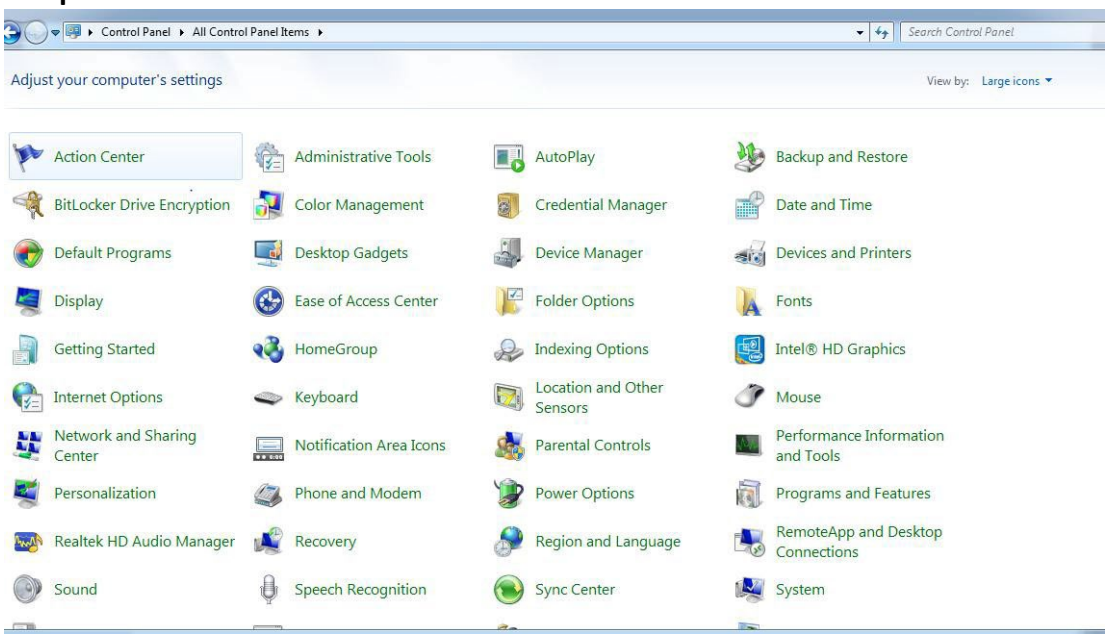


Figure 4 Windows 7 settings

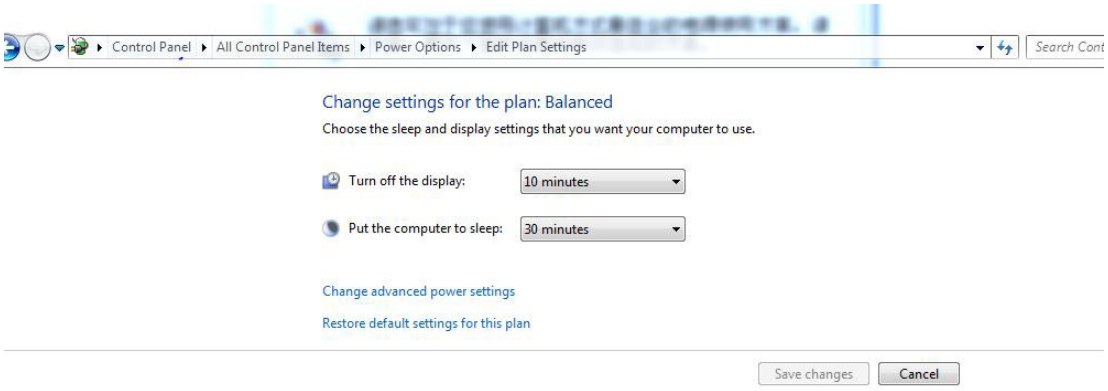


Figure 5 Windows 7 settings

Set **Turn off the display** and **Put the computer to sleep** to Never.

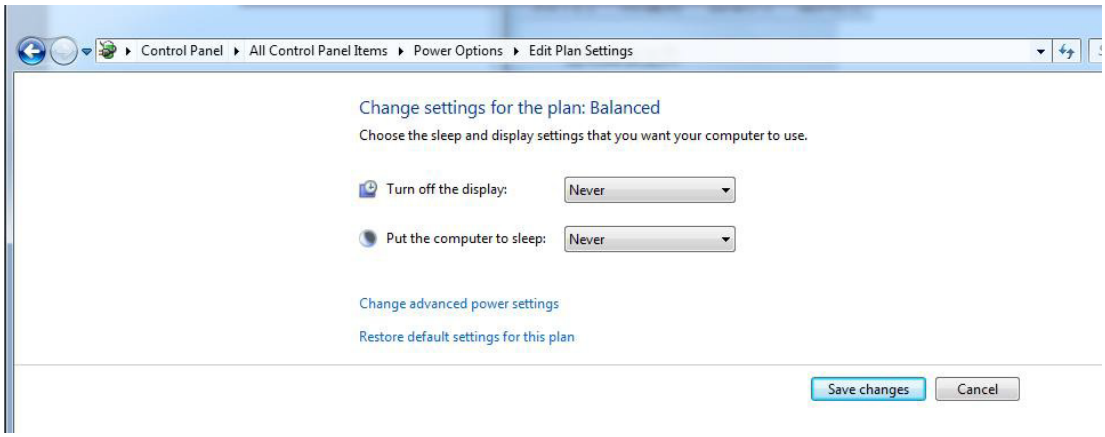


Figure 6 Windows 7 settings

■ Windows 10 settings

Click **Start**→Click **Settings**.

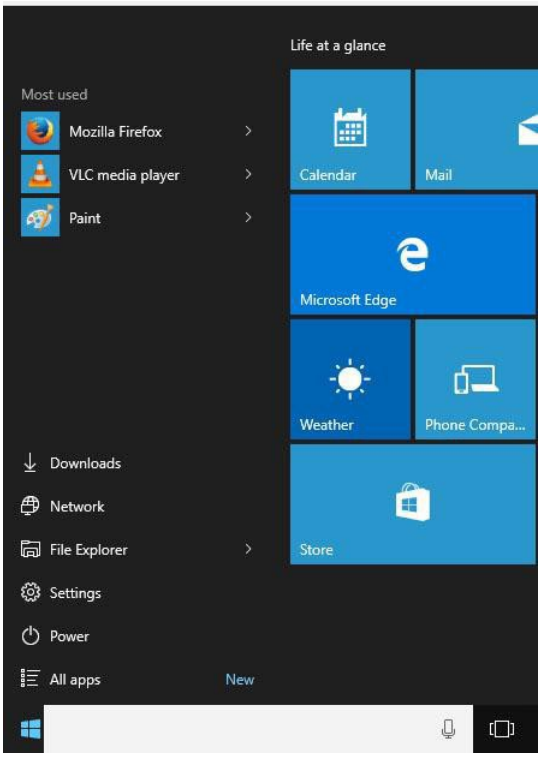


Figure 7 Windows 10 settings

Click **System**.

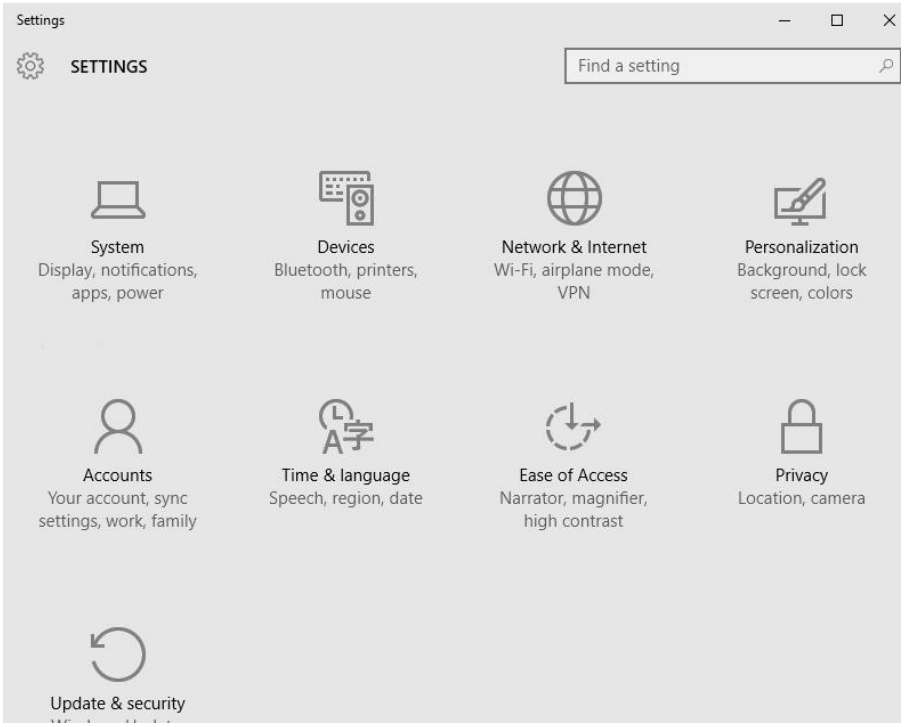


Figure 8 Windows 10 settings

Click **Power & sleep**.

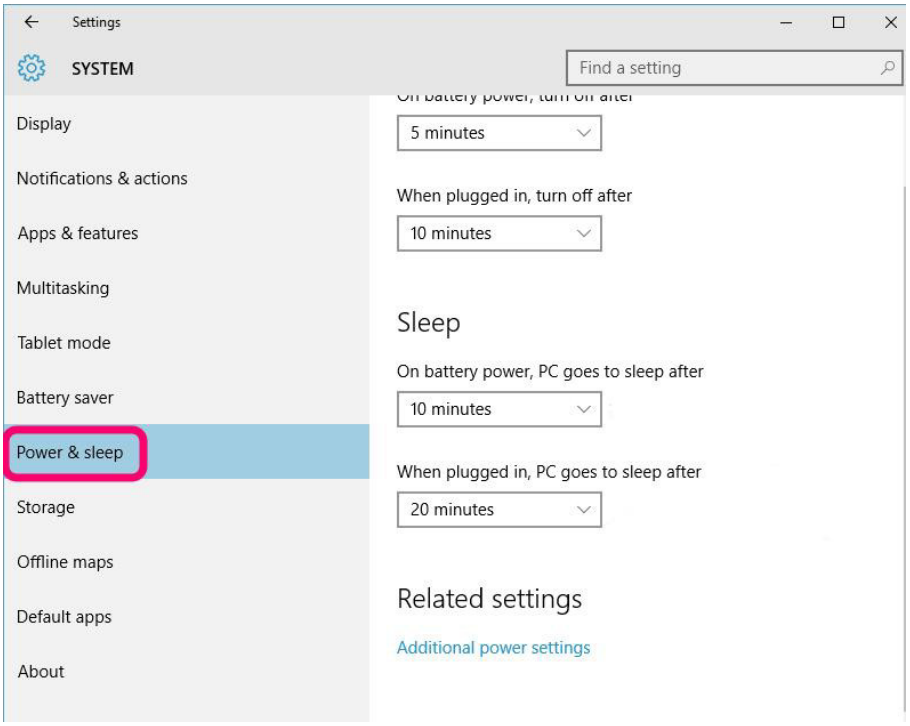


Figure 9 Windows 10 settings

Select **Never** for both options under **Sleep**.

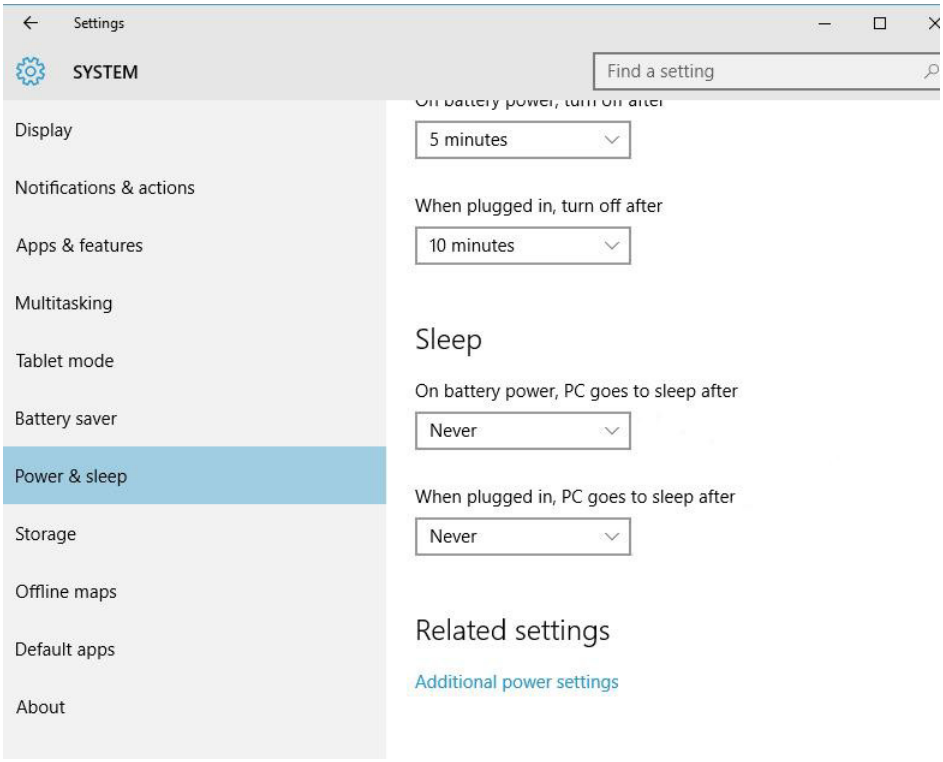


Figure 10 Windows 10 settings

2.2.3 Network IP Address Setting

The default IP of LAN port is 192.168.0.XXX (range from 0 to 255). Before operation, the computer IP should be assigned to the same network segment of the device. But IP addresses should be different.

■ Windows 7 Setting

Click **Start**→Click **Control Panel**→Click **Network and Sharing Center**.

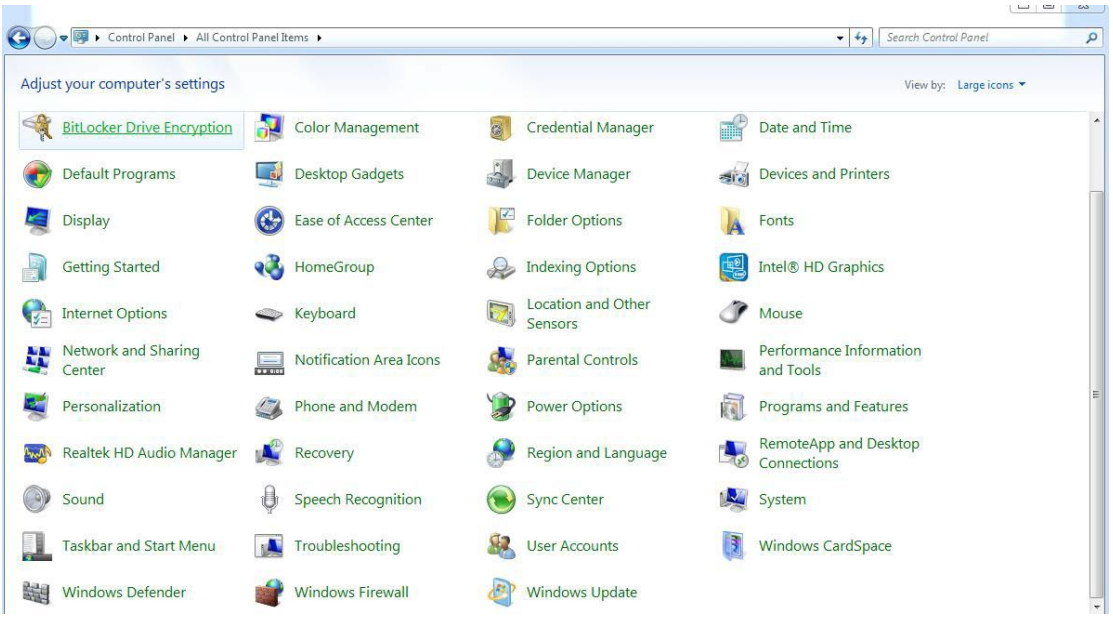


Figure 11 Network IP Address Setting

Click **Change adapter settings**.

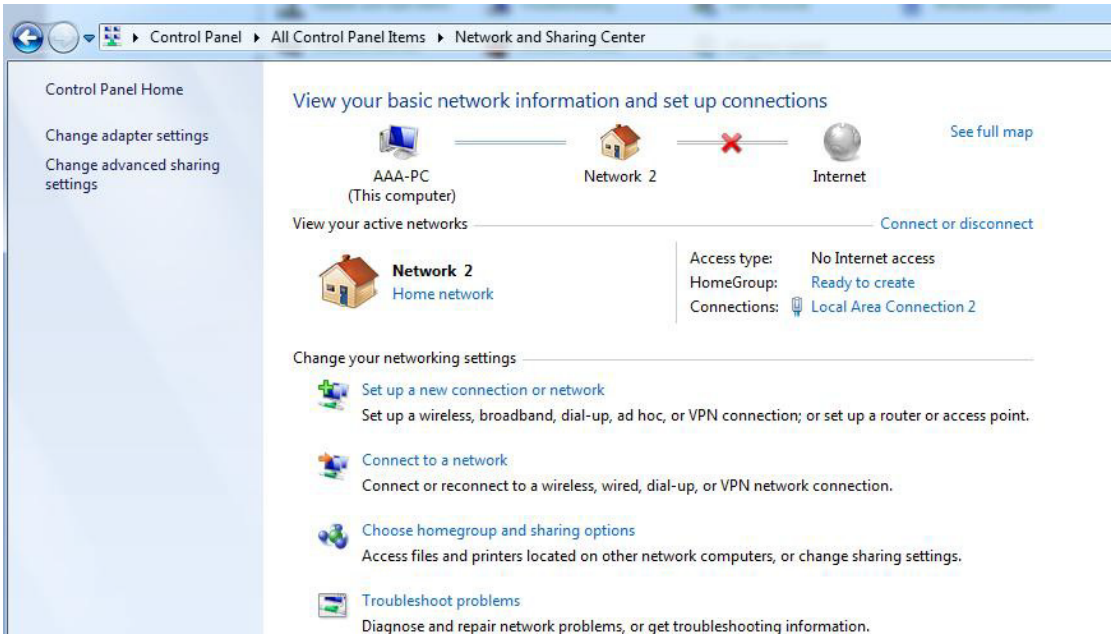


Figure 12 Network IP Address Setting

Select the network→Right click and choose **Properties**.

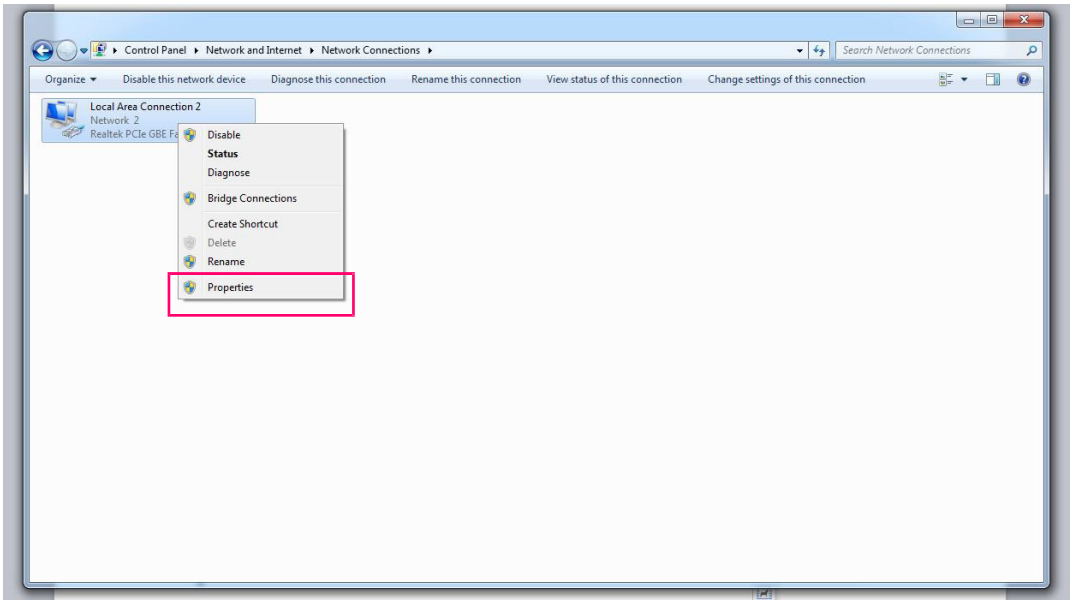


Figure 13 Network IP Address Setting

Click Internet Protocol Version 4(TCP/IPv4) and fill the below information and press **OK**.

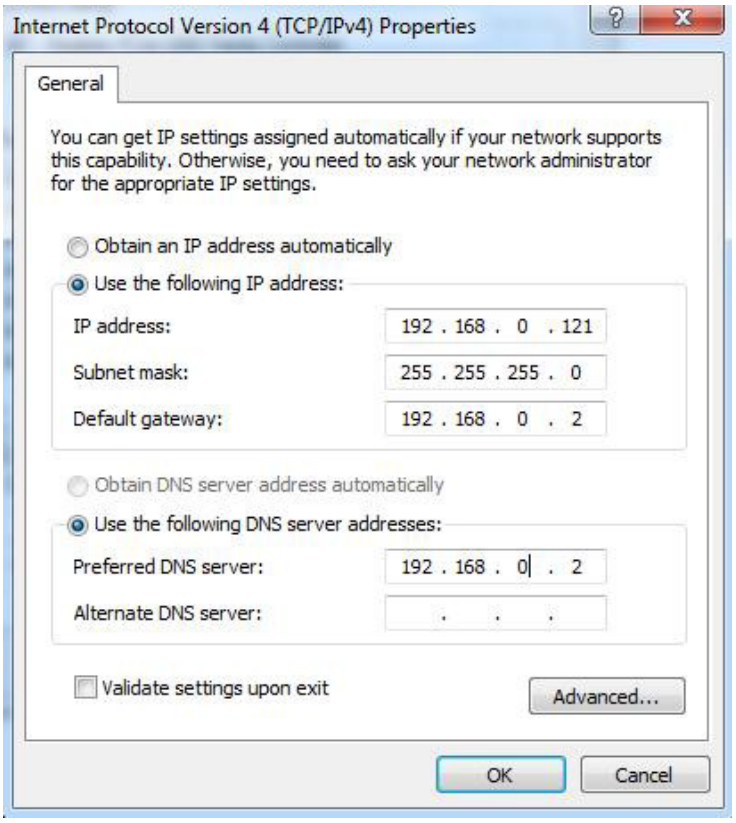


Figure 14 Network IP Address Setting

Click **Start**→Input **cmd**.

Input ping 192.168.0.123(default IP) and check if device and PC can communicate properly.

Figure 15 Run Command

If communicating properly, the below information will be reverted.

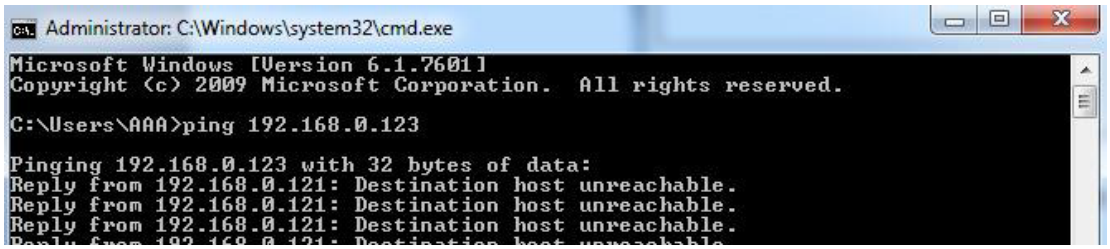


Figure 16 Communication Test

■ Windows 10 Setting

Click **Start**→Click **Set**→Click **Network & Internet**.

Figure 17 Network IP Address Setting

Click **Change adapter options**.

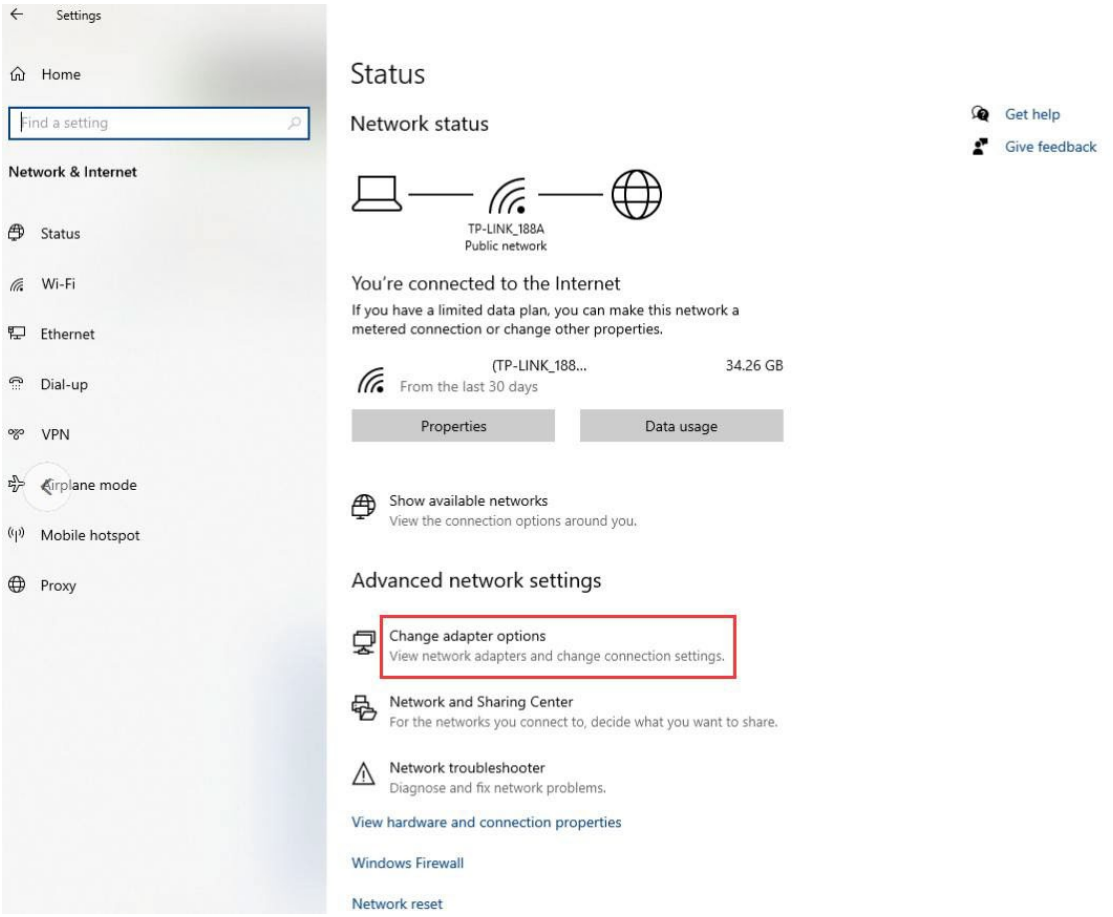


Figure 18 Network IP Address Setting

Select the network→Right click and choose **Properties**.

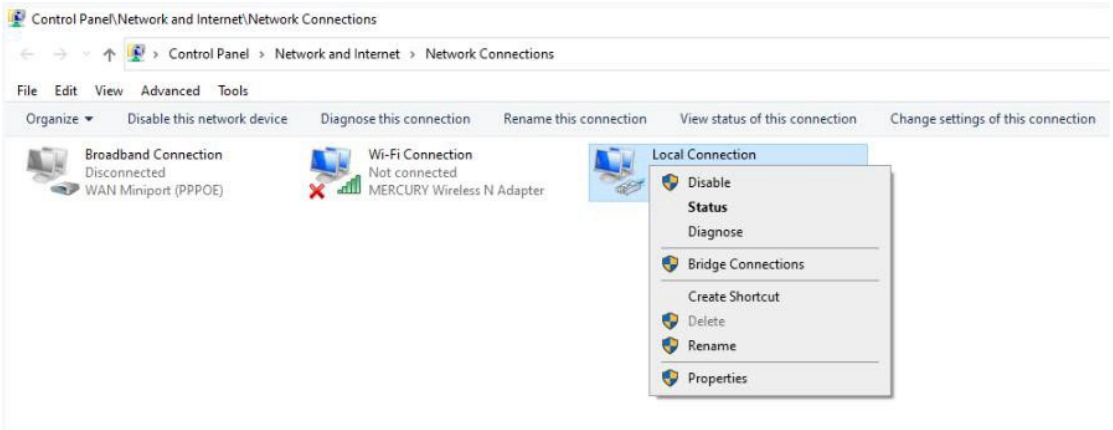


Figure 19 Network IP Address Setting

Click Internet Protocol Version 4(TCP/IPv4) and fill the below information and press **OK**.

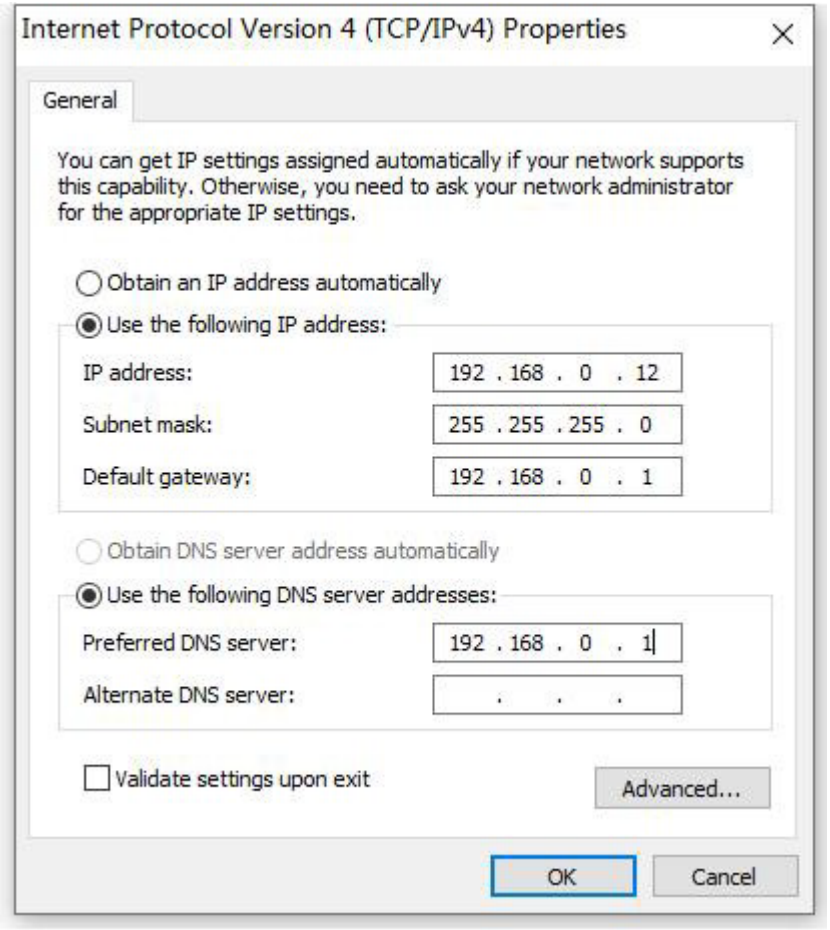


Figure 20 Network IP Address Setting

Click **Start**→Input **cmd**.

Input ping 192.168.0.123(default IP) and check if the device and PC can communicate properly.

Figure 21 Run Command

If communicating properly, the below information will be reverted.

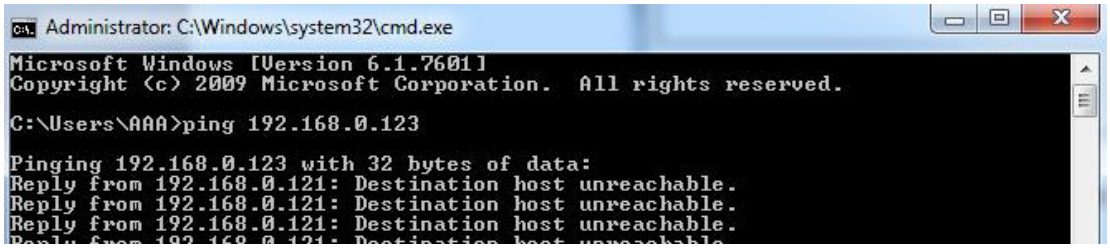


Figure 22 Communication Test

3 Software Operation

3.1 Menu

After the application software is successfully installed, a shortcut icon will be generated on the desktop. Please click the shortcut to enter the menu.

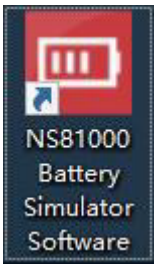


Figure 23 Shortcut

Figure 24 Application Software Interface

The main interface is mainly divided into the following parts:

1. Toolbar: connect, historical data, custom curve, import, export, parameter configuration, etc;

2. Test Data: display various battery parameters during charging and discharging;

3. Test Info: display operation status, alarm prompts and other information;

4. Battery pack Info: display the relationship curve between VOC, RES and SOC of the

battery pack;

5. Test Data Curve: Real-time display of voltage, current, and SOC changes over time during testing;

6. Battery Status: prompts the status of the device;

7. Battery configuration: type selection, specification configuration;

8. Test configuration: battery test cycle / termination conditions;

9. Device Operation: including refresh configuration, ON, pause, stop.

3.1.1 Parameter Configuration

Open NS81000 and select [Parameter Config], then set device IP address which should be keep consistent with master computer IP, click [Connect].

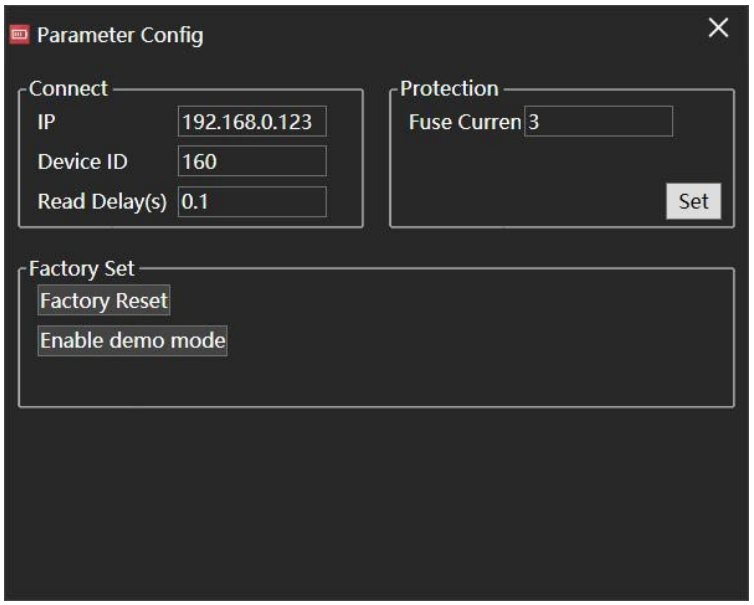


Figure 25 System Configuration

IP: Configure IP address (it needs to be kept in the same network segment with the PC to be connected successfully);

Device ID: configure device ID, default 160;

Read delay: device read delay, default 0.1s;

Fuse Current: if operating current exceeds this threshold, device will be automatically OFF and alarm prompts. Range 0 to the maximum value of protection current (105% of current rating), 0 for no restriction.

3.2 Connect/Disconnect

Open NS81000 and select [Connect]. After successfully connecting, the "Connect" in the toolbar will change to "Disconnect" , and the test information will indicate that the device is connected, and the battery status will be displayed as "Ready".

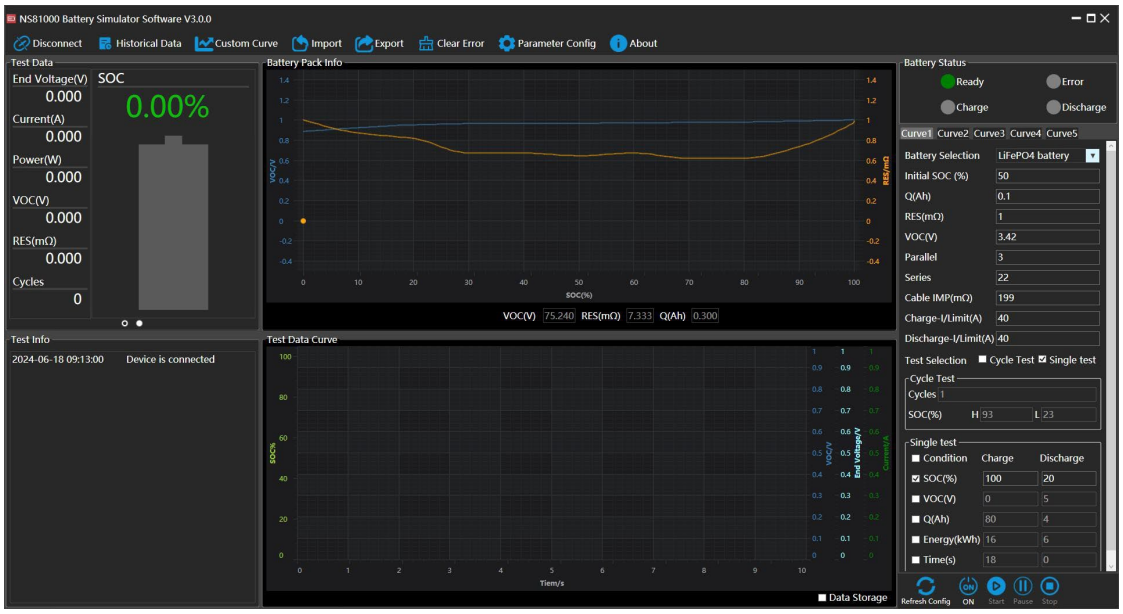


Figure 26 Successful connection

There are four status lights in the battery status, a green light indicates that it has occurred, and a grey light indicates that it has not occurred.

Figure 27 Battery status

- Operation Status Light: when there is no fault and in ON status, light for green.
- Error Status Light: When there is a device failure (programming configuration error, self-test failure, EEPROM), parameter configuration error (battery pack VOC overrun), alarm (OVP, OCP, OTP), illegal operation, (no update) light for red;

- Charging Status Light: when charging, light for green.
- Discharging Status Light: when discharging, light for green.

NOTE

When the error status is on, users can clear alarm by clicking [Clear Error] on the toolbar.

3.3 Battery Configuration

3.3.1 Battery Selection

Battery simulation software built-in seven types of battery models, users only need to select the type of battery, configure the series and parallel parameters, then the characteristics of different types of battery modules with different capacity curve can be simulated.

Battery simulation software supports 5 groups of test cases, and the selected test cases support snapshot data import and export.

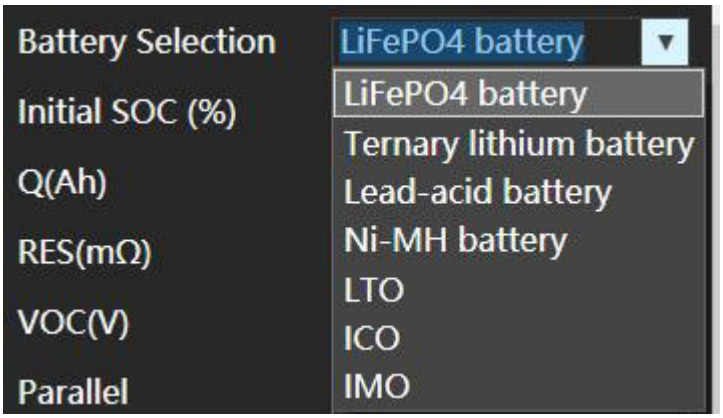


Figure 28 Battery types

NOTE

Custom curves need to be enabled to be displayed in Battery Selection.

3.3.2 Battery Parameter

First select the battery type, then configure the battery pack related parameters. The battery pack parameters include initial SOC%, single cell capacity, single cell VOC, single cell RES, parallel, series, cable impedance, charging current limit and discharging current limit.

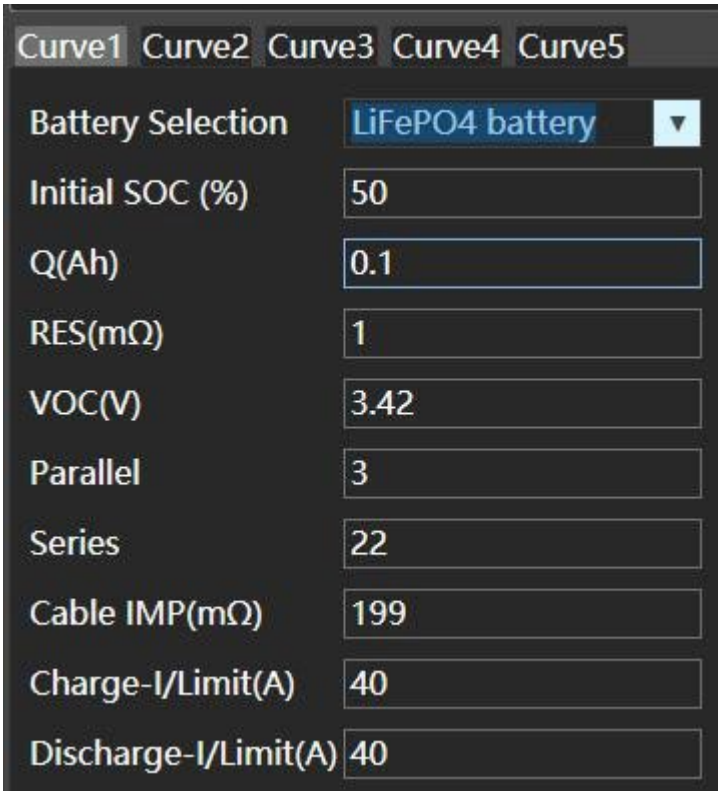


Figure 29 Battery parameters

- Battery Selection: supports 7 standard batteries + two custom batteries;
- Initial SOC: Initial value of single/whole SOC before starting the test, standard battery range 0~100%;
- Capacity: capacity of single cell, range 0.01~5000Ah;
- RES: equivalent internal resistance of single cell, take the average of the range, range 0~1000mΩ;
- VOC: open circuit voltage of single cell at full charge, range 0.1V~equipment rating;
- Parallel: number of single cells in series within the battery pack, range

1~500;

- Series: number of single cells connected in series in the battery pack, range 1~500;
- Cable impedance: total impedance of the battery pack connecting cable, range 0~1000mΩ;
- Charging current limit: specifies that the current will not exceed the limit value during the charging test, range 1% rated value ~ set rated value;
- Discharge current limit: stipulates that the current during discharge test will not exceed the limit value, range 1% rated value to set the rated value.

3.3.3 Custom Curve

In order to meet the needs of different customers, NS81000, in addition to the simulation of seven standard battery curves, also provides a custom battery curve simulation. Users can edit the parameters of the curve in the [Custom Curve] interface, or import the custom curve through the .csv file, and click [Send] to make the curve take effect after editing.

NS81000 supports two custom curves, each with 200 data points, and each data point contains SOC1, VOC, SOC2, RES. If enabled, the edited custom curve will be added to the battery selection list, otherwise, it will not be displayed in the battery selection. In the case of dual SOC enable, VOC is paired with SOC1 and RES is paired with SOC2; otherwise, both VOC and RES are paired with SOC1, at which time SOC2 is disabled and meaningless.

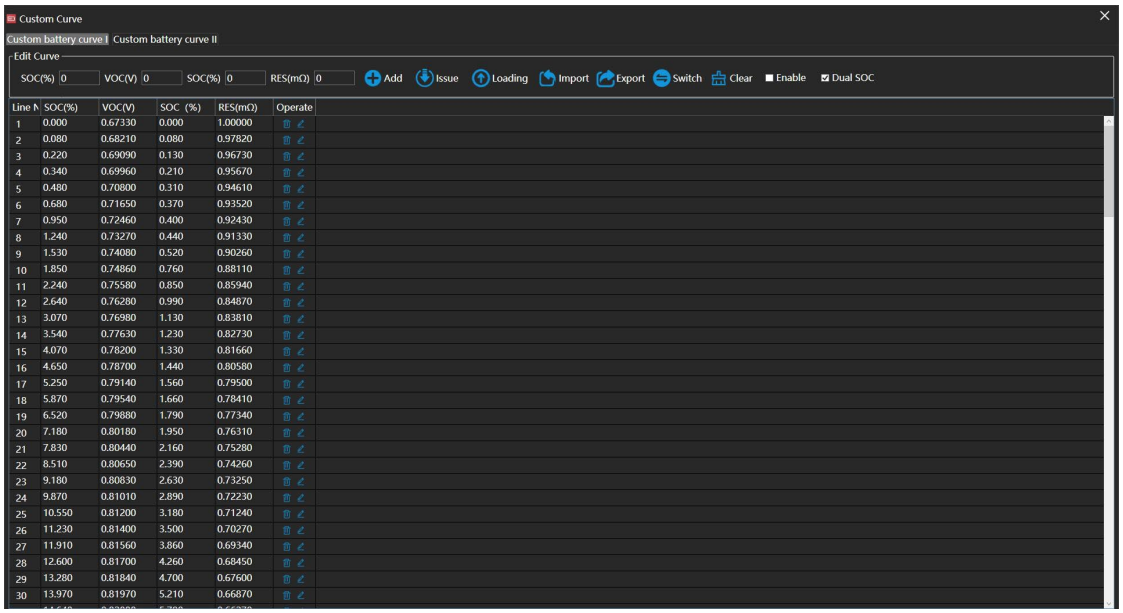


Figure 30 Custom curve editing interface

Click [Switch], the interface will switch from the custom curve editing interface to the custom curve simulation curve interface.

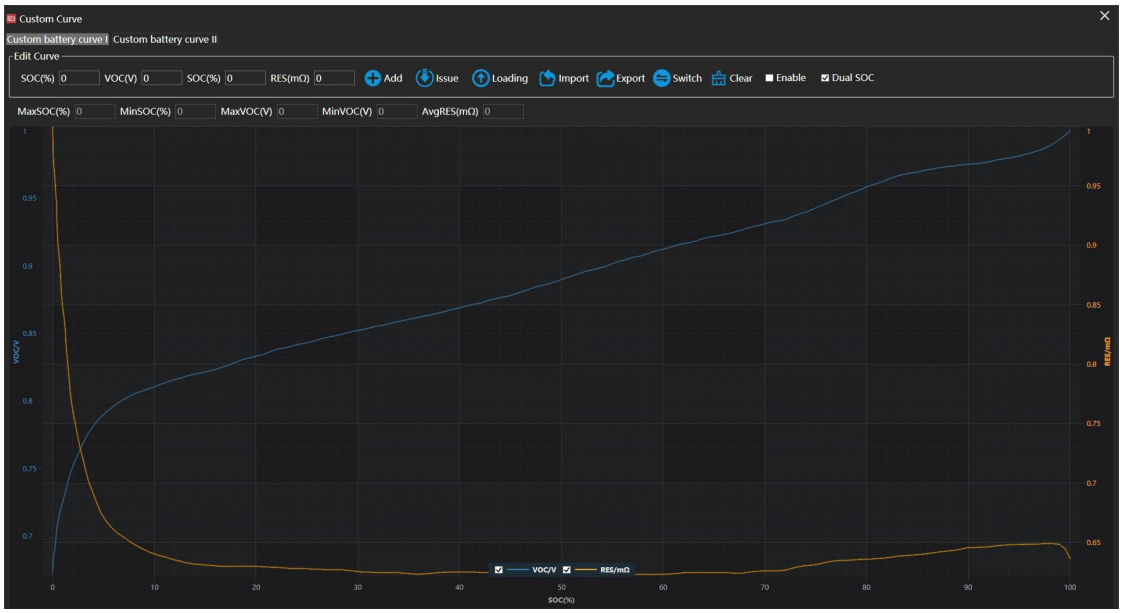


Figure 31 Custom curve analogue curve

NS81000 supports importing and exporting curve data, and provides custom curve editing .csv file in the installation package, which is convenient for users to edit quickly, as shown in the figure.

	A	B	C	D
1	Dual SOC			
2	TRUE			
3	SOC(%)	VOC(V)	SOC(%)	RES(mOHM)
4	0	0.6733	0	1
5	0.08	0.6821	0.08	0.9782
6	0.22	0.6909	0.13	0.9673
7	0.34	0.6996	0.21	0.9567
8	0.48	0.708	0.31	0.9461
9	0.68	0.7165	0.37	0.9352
10	0.95	0.7246	0.4	0.9243
11	1.24	0.7327	0.44	0.9133
12	1.53	0.7408	0.52	0.9026
13	1.85	0.7486	0.76	0.8811
14	2.24	0.7558	0.85	0.8594
15	2.64	0.7628	0.99	0.8487

Figure 32 Custom curve editing file

The custom curve editing file is used to edit the curve of single cell, users can use EXCEL to open it, fill in SOC1, VOC, SOC2, RES, and then click [Import] in the curve

editing interface to import the custom curve data into the software quickly, and pay attention to the editing of .csv file:

- VOC and SOC must be positively correlated;
- Missing data and blank lines are not allowed;
- Custom curves support up to 200 points.

3.4 Test Configuration

NS81000 performs a single test by default, users need to set the charge/discharge termination conditions (SOC, VOC, capacity, energy, time), and the test stops when any of the conditions are reached.

For cycle test, users need to select [Cycle Test], and then set the cycles, SOC H, SOC L. Charging to H or discharging to L will be counted as one cycle. Every time change the above parameters, users need to click [Refresh Configuration] to take effect.

3.4.1 Test Conditions

Test selection

Enable 1: Cyclic test, automatic recovery to initial value when low value is touched during discharge, automatic recovery to initial value when high value is touched during charging. Each high/low limit is counted as one cycle until the cycle count is full.

Enable 2: Single test, charging and discharging are set separately. The simulation is terminated when either condition is reached (it will not be automatically OFF), and the simulation is terminated when the battery is full/discharged when none of the termination conditions are enabled.

Cycle test conditions

Configure the three parameters of cycles, SOC high value and SOC low value. The battery SOC cycles between the set SOC H and SOC L. The range can be set from 0-100%, but note that SOC H should be greater than the set value of SOC L.

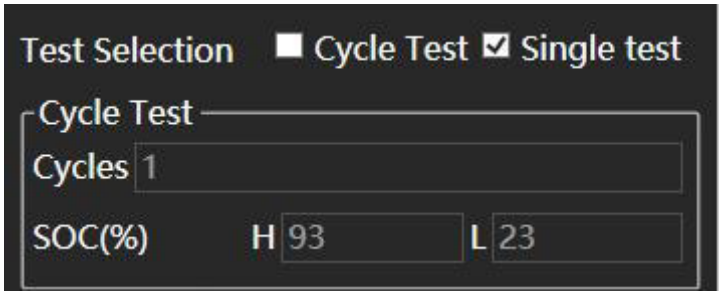


Figure 33 Cycle test

Single test conditions

- SOC: charging until the set value (if the set value is higher than the effective range of SOC, then it will reach the upper limit of the effective range) or discharging until the set value (if the set value is lower than the effective range of SOC, then it will reach the lower limit of the effective range), the range is 0~100%.
- VOC: range 0~setting rated value, same logic as SOC;
- Capacity: range 0~5000Ah;
- Energy: range 0~1000kW;
- Time: range 0~5184000 (60 days).

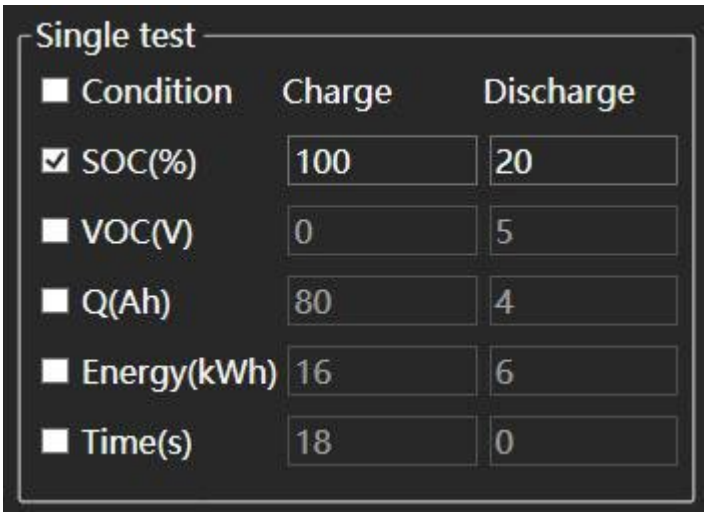


Figure 34 Single test conditions

3.4.2 Test Operation Buttons

- Refresh Config: Send the set parameters to the slave computer. This button is grey and unavailable when the device is outputting;
- ON: switch on/off the power output;
- Start: start to simulate the battery characteristics, if only ON without clicking start, the device is only used as an ordinary bi-directional power supply and does not simulate the battery;
- Pause: suspend the simulation, at this time the SOC, VOC will not change, but the voltage and current are still in line with the battery law, click "Start" again to resume the simulation;
- Stop: end the simulation, users can click the [Start] again, but the SOC will return to the initial value.

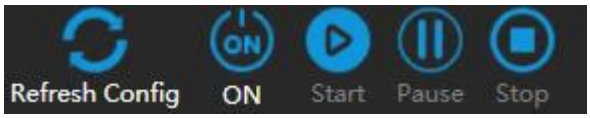


Figure 35 Operation buttons

3.5 Start Test

After the battery configuration is completed, click "Refresh Configuration", the battery pack information will be updated according to the set value. Battery pack information curve will show the relationship between voltage, internal resistance and SOC during charging and discharging. The VOC, RES and capacity at the bottom of the graph represent the voltage, internal resistance and capacity of the battery pack after series-parallel connection.

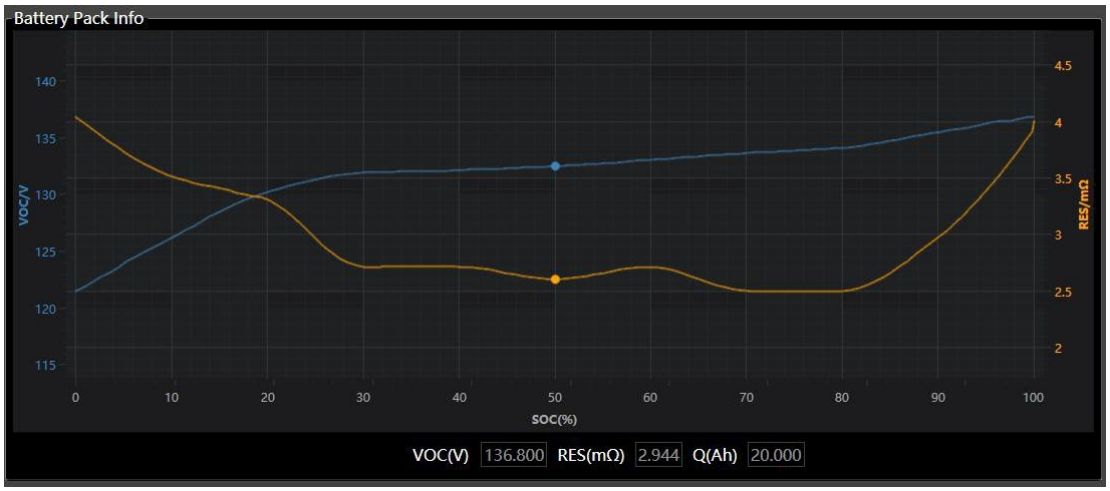
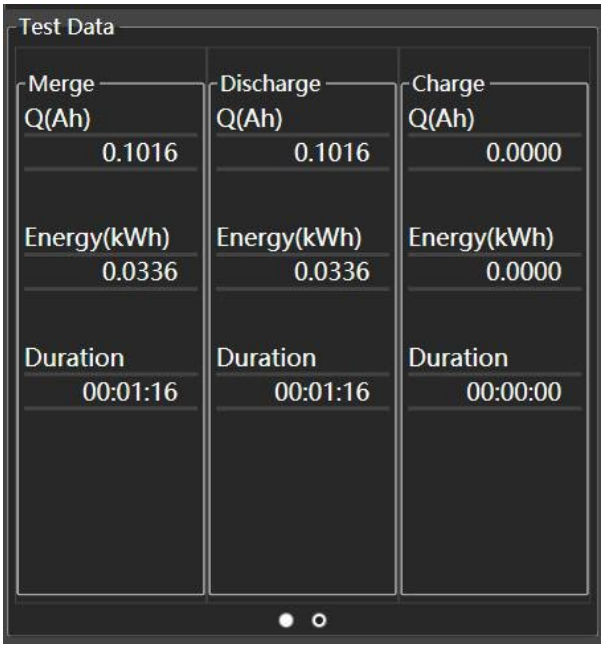


Figure 36 Battery Pack Info

After refreshing the configuration and clicking [ON], the battery simulator starts to operate, and the test data displays the measured SOC, terminal voltage, current, power, VOC and RES, and records the capacity, energy and duration of charging and discharging.



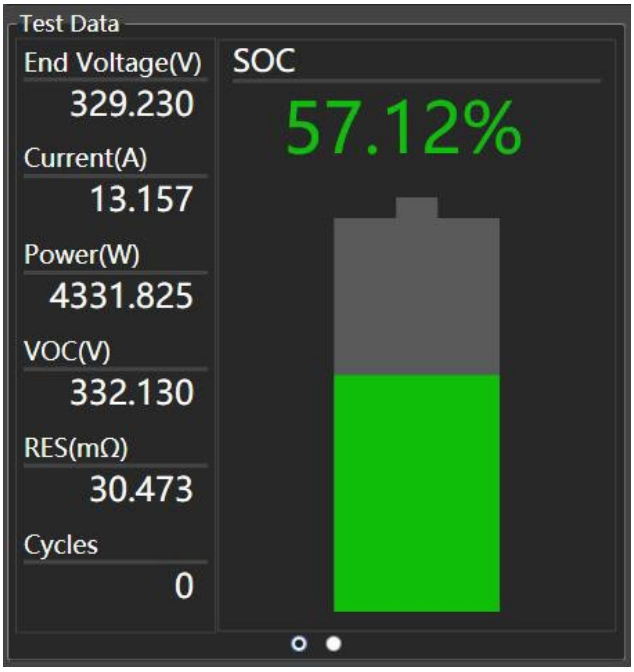


Figure 37 Test Data

After the device is turned on, click [Start] to test. When the external voltage is higher than the simulated battery voltage, it will automatically enter the charging mode, and the battery status shows "Charging"; when the external voltage is lower than the simulated battery voltage or no voltage at all, it will switch to the discharging mode, and the battery status shows "Discharging". Measurement data graph will show the change curve of SOC, terminal voltage and current with time during charging and discharging process, and checking "Data Save" will save the measurement data to the default folder, which can be viewed in the historical data.

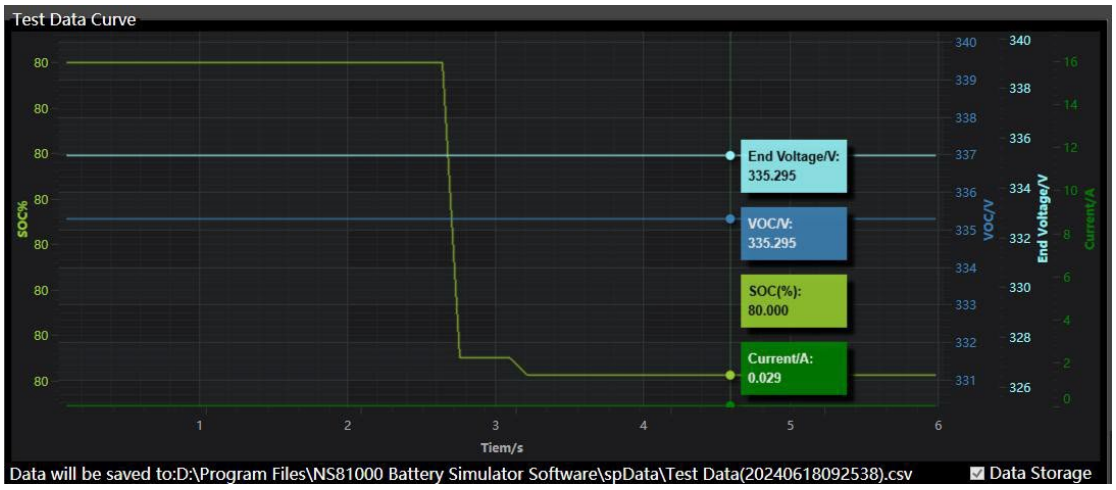


Figure 38 Test Data Curve

Measurement data on the top left of the interface will also reflect the change of SOC during battery charging and discharging as well as terminal voltage, current, power, VOC, RES, and cycle times in real time.

3.6 History Data

After running the software or testing, click [Historical Data] in the toolbar to view the historical measurement data curve.

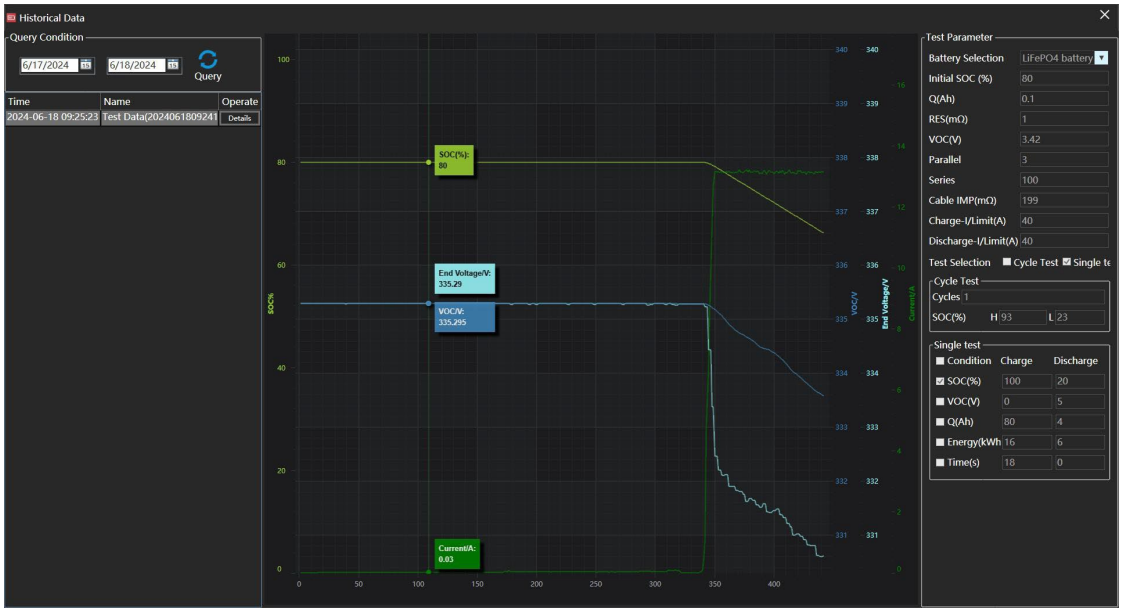


Figure 39 History data

NOTE

Data logging is only initiated manually.

Each history can be viewed in detail, including battery configuration and test configuration, plus measured SOC, terminal voltage, current, power, VOC, capacity, energy and time.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Battery model	Initial SOC(	Cable Imp	Q(AH)	RES(mOHM	VOC(V)	Parallel	Series	I-Limit+(A	I-Limit-(A)	SOC(H(%)	SOC(L(%)
2	2	80	199	0.1	1	3.42	3	100	40	40	93	23
3	SysTime	TestVolt(V)	TestVOC(V	TestCur(A)	TestSOC(%	TestPower	TestCapac	TestEnergy(kWh)				
4	2024-6-18 09:24	335.2946	335.2946	0.0072	80	2.4262	0	0				
5	2024-6-18 09:24	335.2946	335.2946	0.0069	80	2.3231	0	0				
6	2024-6-18 09:24	335.2946	335.2946	0.0071	80	2.3908	0	0				
7	2024-06-18 09:24:2(	335.2946	335.2946	0.0067	80	2.2501	0	0				
8	2024-6-18 09:24	335.2946	335.2946	0.0072	80	2.4055	0	0				
9	2024-6-18 09:24	335.2946	335.2946	0.0071	80	2.3753	0	0				
10	2024-6-18 09:24	335.2946	335.2946	0.0071	80	2.3769	0	0				
11	2024-6-18 09:24	335.2946	335.2946	0.0069	80	2.3087	0	0				
12	2024-6-18 09:24	335.2946	335.2946	0.007	80	2.3401	0	0				
13	2024-6-18 09:24	335.2946	335.2946	0.0068	80	2.2772	0	0				
14	2024-6-18 09:24	335.2946	335.2946	0.0065	80	2.1887	0	0				
15	2024-6-18 09:24	335.2946	335.2946	0.0067	80	2.2378	0	0				
16	2024-6-18 09:24	335.2946	335.2946	0.0067	80	2.2488	0	0				
17	2024-6-18 09:24	335.2946	335.2946	0.0064	80	2.1451	0	0				
18	2024-6-18 09:24	335.2946	335.2946	0.0064	80	2.1456	0	0				
19	2024-6-18 09:24	335.2946	335.2946	0.0219	80	7.3573	0	0				
20	2024-6-18 09:24	335.2946	335.2946	0.0214	80	7.1741	0	0				
21	2024-6-18 09:24	335.2946	335.2946	0.0263	80	8.8287	0	0				
22	2024-6-18 09:24	335.2946	335.2946	0.0288	80	9.6435	0	0				
23	2024-6-18 09:24	335.2946	335.2946	0.0289	80	9.6883	0	0				
24	2024-06-18 09:24:2:	335.2946	335.2946	0.0295	80	9.8941	0	0				
25	2024-6-18 09:24	335.2946	335.2946	0.03	80	10.0563	0	0				
26	2024-6-18 09:24	335.2946	335.2946	0.03	80	10.0722	0	0				
27	2024-6-18 09:24	335.2946	335.2946	0.0302	80	10.1115	0	0				
28	2024-6-18 09:24	335.2946	335.2946	0.0294	80	9.8564	0	0				

Figure 40 Detailed Historical data

4 Battery Model and Control

For batteries, it is first necessary to build its equivalent circuit model for the simulation of batteries. A commonly used equivalent circuit model for batteries is the internal resistance model, where R0 represents the internal resistance of the battery, VOC represents the open circuit voltage, and Vt represents the terminal voltage. By building the internal resistance model, the information such as current, voltage and charge state of the battery can be accurately simulated.

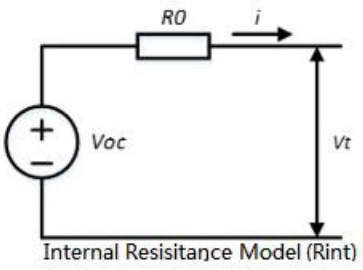


Figure 41 Internal resistance model

4.1 Battery Curve Model

Battery types: LiFePO4 battery, Ternary lithium battery, Lead-acid battery, Ni-MH battery, LTO, ICO, IMO.

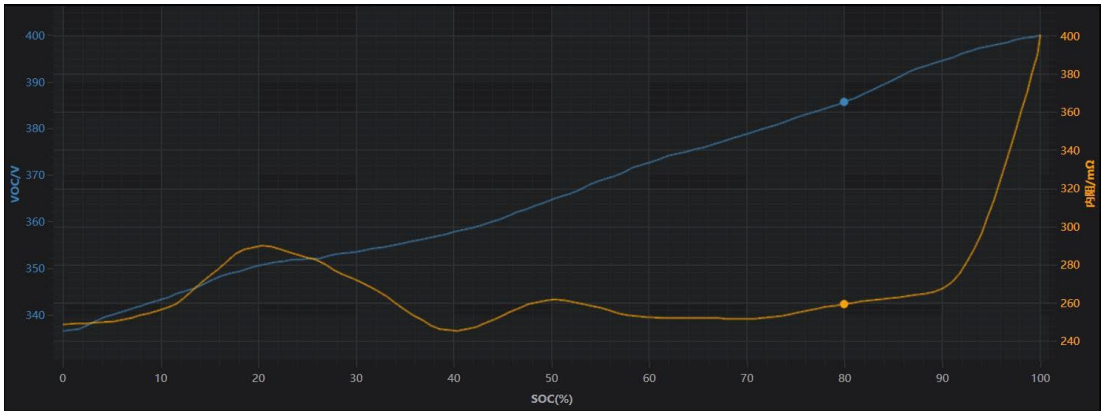


Figure 42 Ternary lithium battery curve model

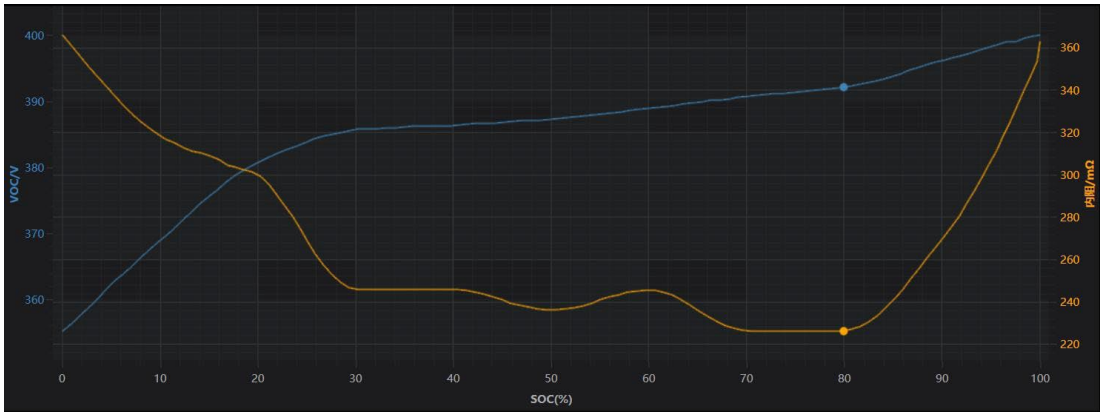


Figure 43 LiFePO4 battery curve model

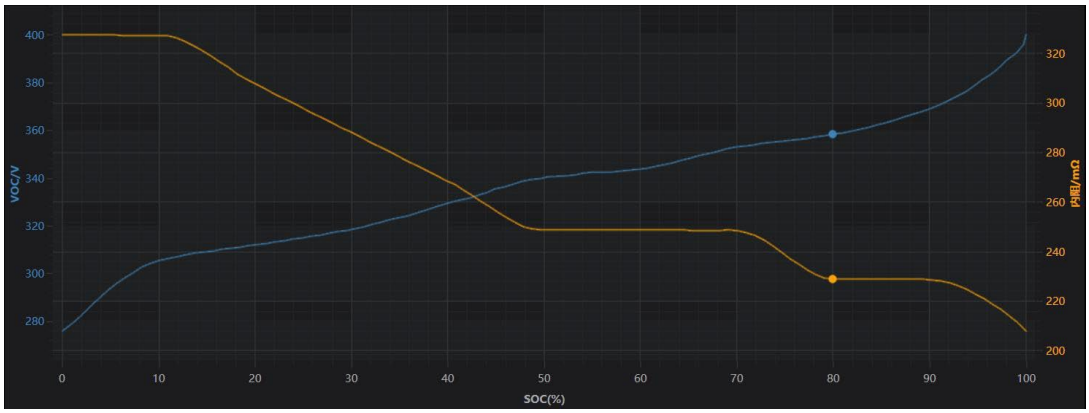


Figure 44 LTO curve model

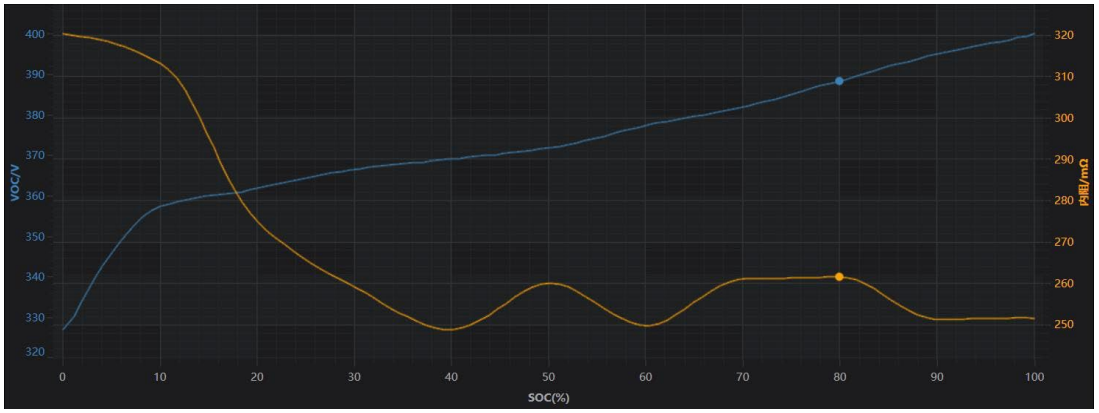


Figure 45 ICO curve model

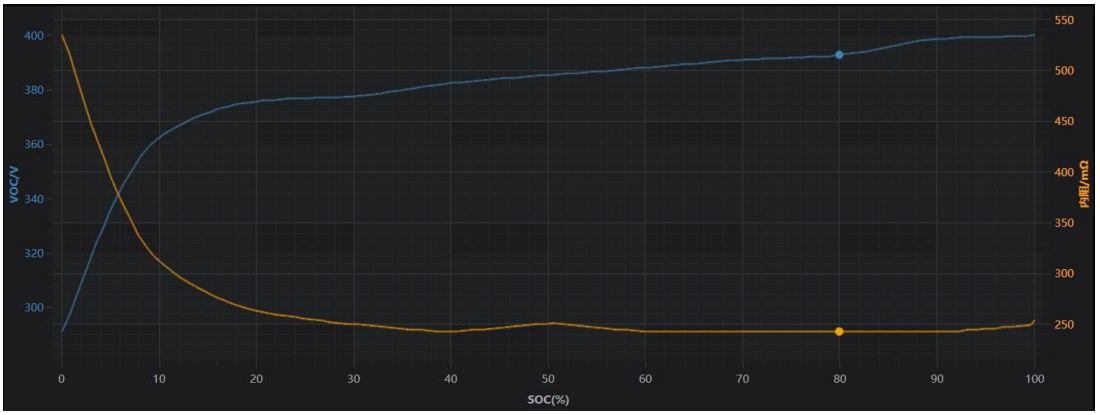


Figure 46 IMO curve model

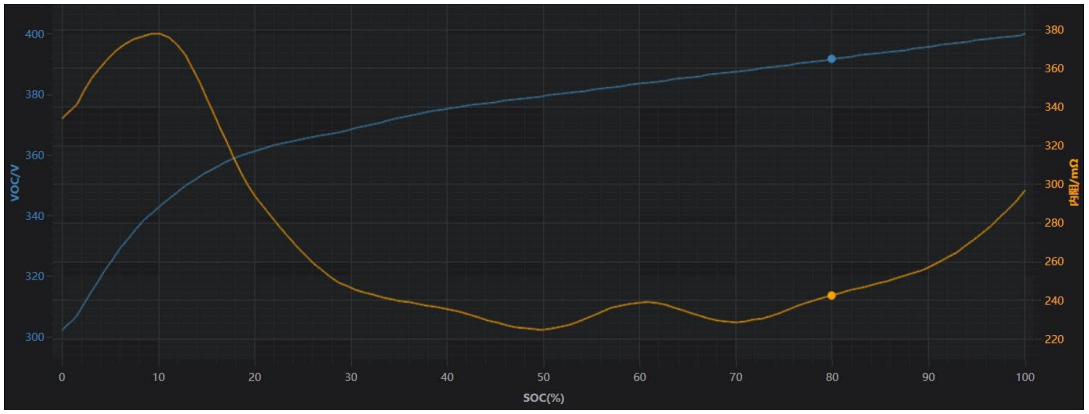


Figure 47 Ni-MH battery curve model

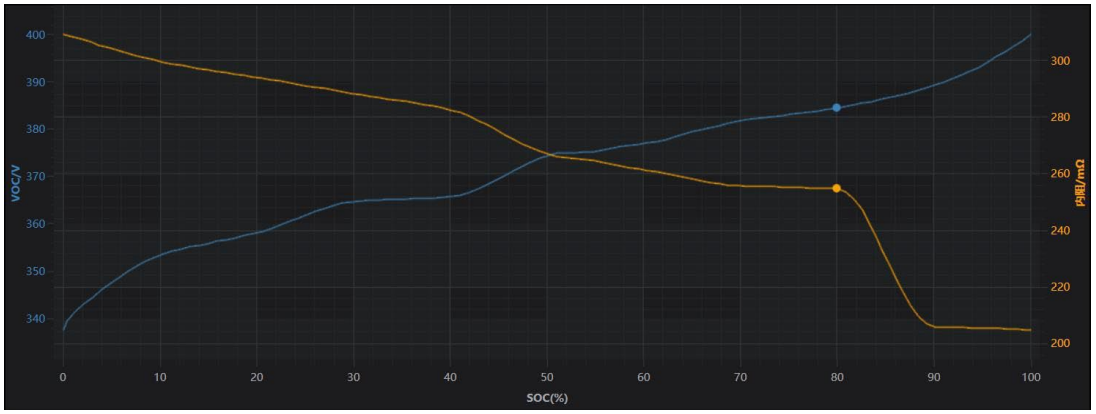


Figure 48 Lead-acid battery curve model

4.2 Battery Pack Model

For everyday use, there are single batteries as well as battery packs, and the NS81000 can be set to simulate real battery packs with the number of batteries connected in series and parallel.

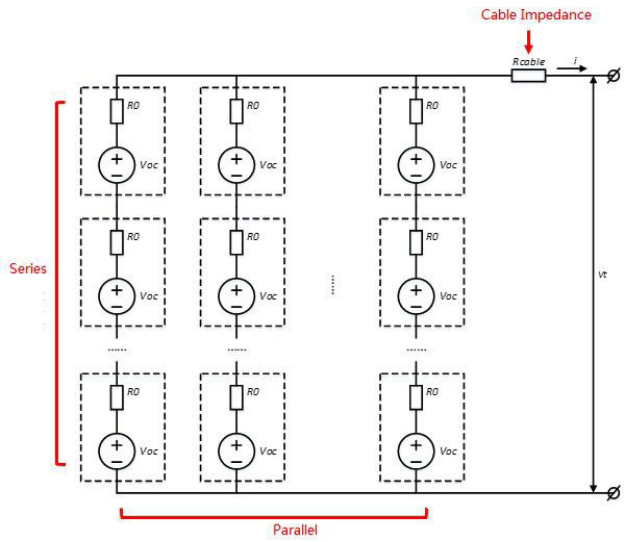
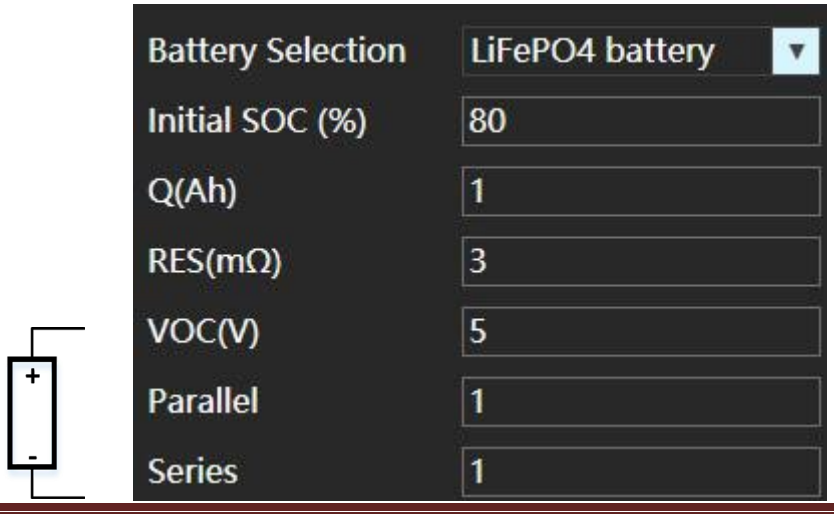


Figure 49 Battery pack model

The series connection of a single cell will increase the overall voltage and the parallel connection of a single cell will increase the overall current. A single battery with capacity = 1Ah, RES = 3mΩ, and VOC = 5V is used as an example to describe the overall battery when connected in series and parallel. When there is one battery in the circuit, the simulation curve is as follows:



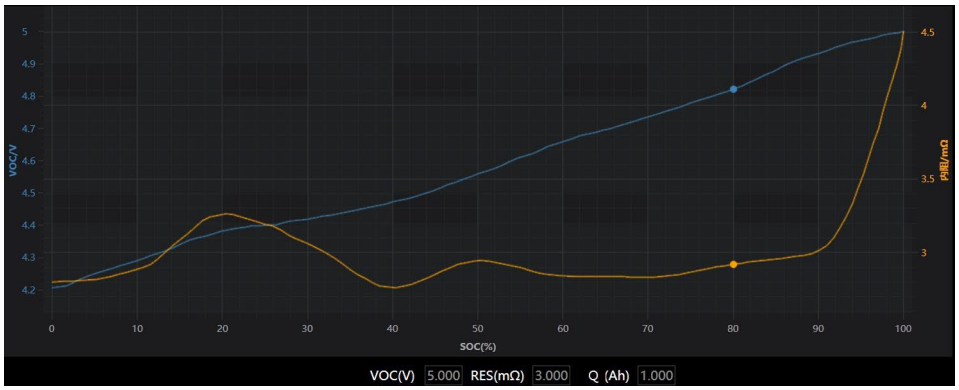
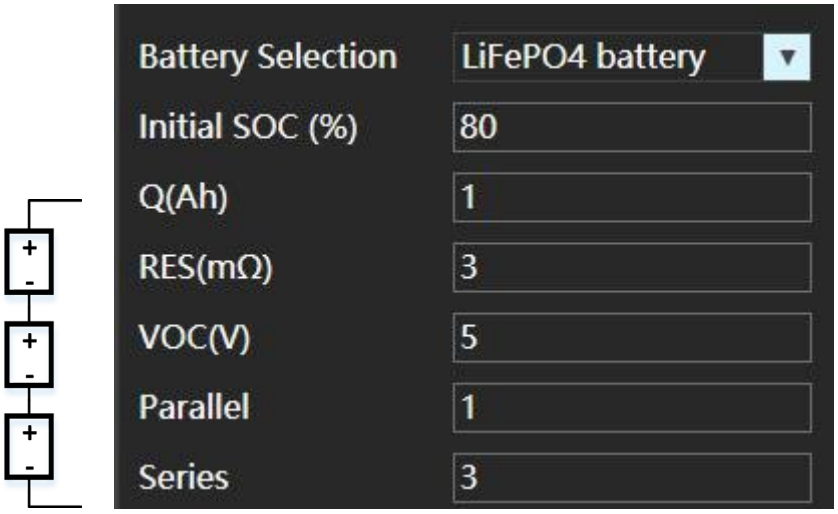


Figure 50 Simulation curve 1

When there are three batteries in series in the circuit, capacity = 1Ah, RES = 9mΩ, VOC = 15V, the simulation curve is as follows:



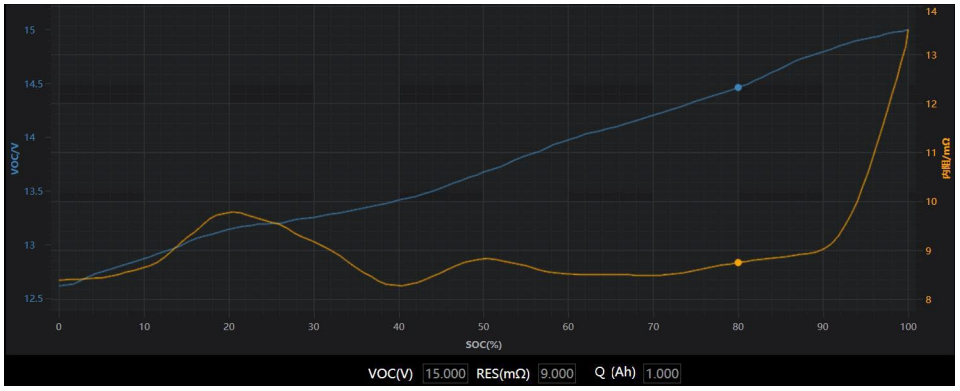


Figure 51 Simulation curve 2

When there are six batteries in the circuit, three of which are connected in series and two series resistors are connected in parallel, the capacity = 2Ah, RES =

4.5mΩ and VOC = 15V simulation curves are as follows:

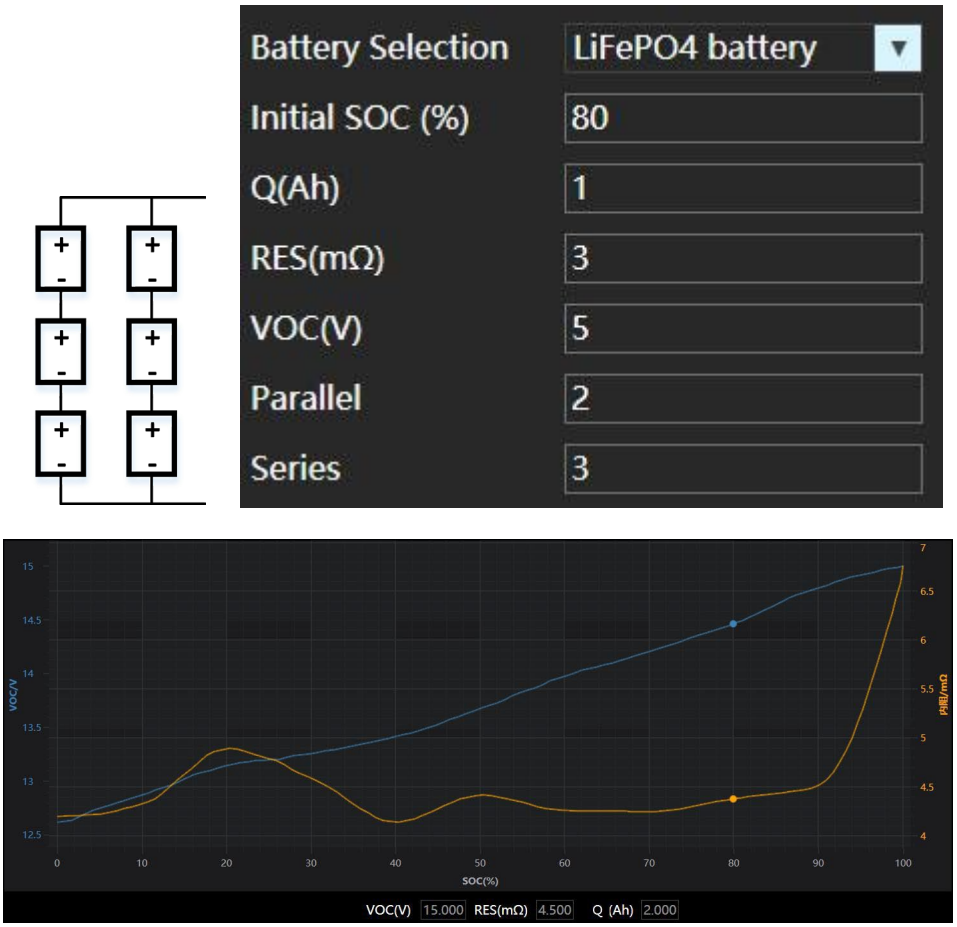


Figure 52 Simulation curve 3

4.3 Battery Control

After the model is built, the battery needs to be controlled. Battery characteristic curves include SOC-RES and SOC-VOC relationships, which have an important impact on the performance analysis and control of the battery. The battery built-in algorithm always controls around the following relationships:

$$Vt = Voc - Ro \times i$$

Table 1

Notation	Definition
Vt	Terminal voltage
VOC	Open circuit voltage
R0	Battery internal resistance

i	Terminal Current

The simulator estimates the remaining capacity (SOC) of the battery by measuring parameters such as voltage and current. Then, based on the SOC, the VOC and RES are checked, and then the control voltage and control current are calculated, so as to achieve the results always in line with the battery law.