

## 7.2.2 BMS Automatic Calibration

The battery system SoC calibration is an automatic process. This calibration occurs during completely fully charged or discharged state as long as the predefined calibration conditions are met.

The SOC calibration is the third step of SOC estimation, which is explained in the following steps.

SOC estimation includes three steps, SOC initialization, SOC calculation, and SOC calibration. The main method is based on the Ah integration method, supplemented by the full-fill calibration method.

- **SOC Initialization**

BMS initially sets the battery module's SOC to 50%. The actual SOC is uncertain because the battery will self-discharge during transportation and storage.

BMS records SOC in EEPROM after BMS restarts and then BMS will read SOC value from EEPROM. After the software is updated, the SOC maintains the value before the upgrade.

- **SOC Calculation**

Calculate SOC using Ah Integral method, the integral formula is as follows:

$$SOC = SOC_0 - \frac{1}{C_N} \int_0^t \eta I d\tau$$

SOC<sub>0</sub> is the SOC at the initial moment, η is the charge and discharge efficiency, C<sub>N</sub> is the total capacity of the battery, I is the charge and discharge current, the specified charge current is negative, and the discharge current is positive.

- **SOC Calibration**

Due to current acquisition errors and data calculation errors, the Ah integral will produce accumulative error, so the SOC needs to be calibrated to eliminate the accumulative error.

### SOC Calibration Method

(1) Fully charge calibration method

**Full-charge standard:** when the system triggers the high voltage warning of the single cell or the high voltage of the total voltage.

**Calibration result:** BMS automatically calibrates the SOC to 100%, the calibration speed is (100%-current SOC)/180s, that is, the SOC calibration is completed within the next 180s.

(2) Full discharge calibration method

**Full discharge standard:** when the system triggers a single cell low warning or a total voltage low warning.

**Calibration result:** BMS automatically calibrates the SOC to 0%, and the calibration speed is (current SOC)/180s, that is, the SOC calibration is completed within the next 180s.

### SOC Calibration Frequency

The SOC calibration frequency is determined by the following factors.

(1) Tolerance to SOC errors, which depends on the SOC operating window and the operating

mode of the energy storage system;

(2) The accumulative error of SOC, which depends on the current collection accuracy, clock accuracy, and battery state;

(3) Daily charge and discharge power, the greater the daily charge and discharge power of the battery pack, the greater the accumulated error;

(4) Whether the SOC calibration meet the conditions for the battery pack to perform self-calibration, for example, the battery pack is fully charged.