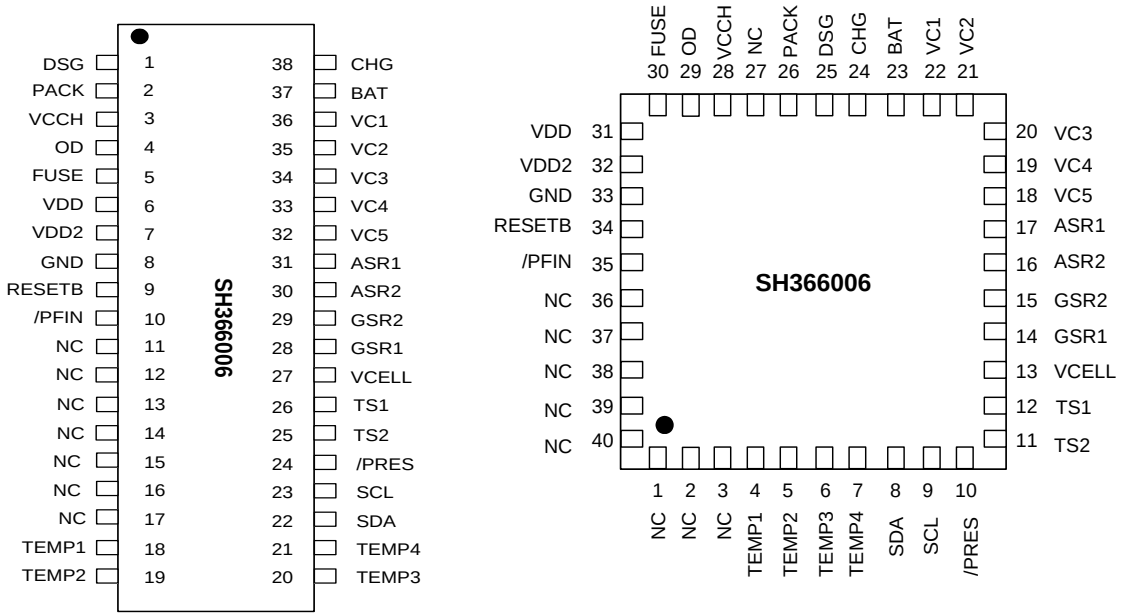
1. Features

- Flexible Configuration for 2, 3, and 4 series Li-Ion or Li-Polymer Cells
- Advanced Accurate Fusion Gauge Algorithm for Remaining Capacity Calculation
- Compatible with the Smart Battery Specification SBS V1.1 with High-speed 400 kHz Programming option
- Programmable Protection Features on Voltage, Current and Temperature
- Supports Internal and External Cell Balance
- N-CH High Side Protection FET Drive
- Low Power Modes: Sleep and Shutdown
- Sophisticated Charge Algorithm JEITA
- Four Stages Charge Mode Function
- Support Turbo Mode (Intel DBPT2.0)
- Supports SHA-1 Authentication
- 38-Pin TSSOP package/40-Pin QFN package

2. Pin Assignment



TSSOP38 **QFN40**

Fig.1 Pin Assignment

3. Terminal Functions

Pin(TSSOP38)	Pin(QFN40)	Terminal	IO	Description
1	25	DSG	O	High Side N-CH Discharge MOSFET Drive
2	26	PACK	I	Pack Input Voltage Sense Input. It Also Serves As Wake Up Pin
3	28	VCCH	P	Positive Device Supply Input
4	29	OD	O	Precharge Control Pin
5	30	FUSE	O	Blow Fuse Signal Output
6	31	VDD	P	3V Regulator Output
7	32	VDD2	P	1.8V Regulator Output
8	33	GND	P	Ground
9	34	RESETB	I	Reset
10	35	/PFIN	I	FUSE Blow Detection Input
11~17	1-3, 27, 36-40	NC	NC	NC
18	4	TEMP1	O	Temperature1 Input Control Pin
19	5	TEMP2	O	Temperature2 Input Control Pin
20	6	TEMP3	O	Temperature3 Input Control Pin
21	7	TEMP4	O	Temperature4 Input Control Pin
22	8	SDA	I/O	SMBus Data Line
23	9	SCL	I/O	SMBus Clock Line
24	10	/PRES	I/O	System Present Detection Pin
25	11	TS2	I	Temperature Sensor 2 Input
26	12	TS1	I	Temperature Sensor 1 Input
27	13	VCELL	I	Internal Cell Voltage Output
28	14	GSR1	I	Coulomb Counter Differential Input, Connect To One Side of the Sense Resistor
29	15	GSR2	I	Coulomb Counter Differential Input, Connect To One Side of the Sense Resistor
30	16	ASR2	I	Short Circuit and Overload Detection Input, Connect To One Side of the Sense Resistor
31	17	ASR1	I	Short Circuit and Overload Detection Input, Connect To One Side of the Sense Resistor
32	18	VC5	I	Cell Voltage Sense Input and Cell Balancing Input For the Negative Voltage of the Bottom Cell In Cell Stack
33	19	VC4	I	Cell Voltage Sense Input and Cell Balancing Input For the Positive Voltage of the Lowest Cell and the Negative Voltage of the Second Lowest Cell In Cell Stack
34	20	VC3	I	Cell Voltage Sense Input and Cell Balancing Input for the Positive Voltage of the Second Lowest Cell and the Negative Voltage of the Second Highest Cell In Cell Stack
35	21	VC2	I	Cell Voltage Sense Input and Cell Balancing Input for the Positive Voltage of the Highest Cell and the Negative Voltage of the Lowest Cell in Cell Stack
36	22	VC1	I	Cell Voltage Sense Input and Cell Balancing Input for the Positive Voltage of the Highest Cell In Cell Stack
37	23	BAT	P	BAT Power Supply
38	24	CHG	O	High Side N-CH Charge FET Gate Drive

Table.1 Terminal Description

4. Introduction

SH366006 SBS-compliant gas gauge and protection IC is a single IC solution designed for battery-pack or in-system installation. SH366006 measures and maintains an accurate record of available charge in Li-Ion or Li-polymer batteries with the integrated high performance analog peripherals. It monitors capacity charge, battery voltage, and other critical parameters of battery pack and reports these to the system host controller through a serial communication bus. The SH366006 also supports short-circuit protection and overload protection with the help of the integrated analog front-end (AFE). The requested *ChargingVoltage()* and *ChargingCurrent()* vary for different status depending on voltage, current, temperature and aging life etc. In addition, its implemented Advanced Fusion Gauge algorithm calculates the remaining capacity by analyzing voltage, current, temperature and other relevant parameters in each stage of every cycle.

5. Function Description

5.1 System Present Operation

When SH366006 detects the battery is inserted into the system via a low state on the PRES pin, the SH366006 enters normal operating mode and sets the *[PRES]* bit in *BatteryStatus()*. The charge and discharge FETs turn on within 1 second. When the pack is removed from the system and the PRES input is high, the SH366006 enters the battery-removed-state and turn off the charge and discharge FETs. If *[NR]* in *Operation Cfg B* is set, the PRES input can be left floating but the system is always being inserted.

SH366006 measures individual cell voltage, pack voltage, temperature, and current. SH366006 also monitors the amount of charge input or removed from a rechargeable battery and estimates battery self-discharge.

5.2 Measurement

SH366006 detects the sense resistor voltage for current measurement, coulomb counting and Remaining Capacity updating once per second. Pack voltage, each cell voltage, Cell Temperature and FET Temperature are also monitored by the SH366006 once per second. The battery pack can be set as 2-cell, 3-cell or 4-cell by configuring bit 9-8 in *Operation Cfg A*.

5.3 Gas Gauging

SH366006 implements the Advanced Fusion Gauge Algorithm combining with Coulomb Counting and Open Circuit Cell Voltage Measurement, to get the smart battery gas gauging, according to the current cell voltages, pack voltage, temperature and current.

In charge or discharge mode, SH366006 updates the remaining capacity based on Coulomb Counting every second. And in charge, discharge or relaxation mode, when some conditions are met, the SH366006 adjusts the capacity in the battery pack, according to the measured voltage, current, Cell Temperature and other relevant data. And the SH366006 automatically compensates for aging, temperature and discharge rate to make an accurate state of charge (SOC).

RemainingCapacity () (RC) represents the remaining capacity in the battery pack. The SH366006 computes RC in units of either mAh or cWh depending on the configuration of *BatteryMode()*. The SH366006 can adjust RC during charge, discharge and relaxation modes.

FullChargeCapacity() (FCC) represents the maximum available capacity of battery pack. SH366006 computes FCC in units of either mAh or cWh depending on the configuration of *BatteryMode()* . The SH366006 can adjust FCC during charge, discharge and relaxation modes.

5.4 JEITA Temperature Ranges

SH366006 follows the JEITA guidelines, which specify that *ChargingVoltage()* and *ChargingCurrent()* depend on the temperature ranges .There are four temperature ranges in which charging is allowed and they are defined as:

• JT1 – JT2: Low charging temperature range (JT1 < Temperature ≤ JT2)

• JT2 – JT3: Standard charging temperature range (JT2 <Temperature ≤ JT3)

• JT3 – JT4: High charging temperature range (JT3< Temperature ≤ JT4)

• JT5 – JT6: Recommended charging temperature range (JT5< Temperature ≤ JT6)

The temperature ranges set in data flash should adhere to the following format:

JT1 ≤ JT2 ≤ JT5 ≤ JT6 ≤ JT3 ≤ JT4

• JT1: Lower bound of low charging temperature range, in ℃.

• JT2: Upper bound of low charging temperature range and lower bound of standard charging temperature range low, in ℃.

• JT5: Upper bound of standard charging temperature range low and lower bound of recommended charging temperature range, in ℃

• JT6: Upper bound of recommended charging temperature range and lower bound of standard charging temperature range high, in ℃

• JT3: Upper bound of standard charging temperature range high and lower bound of high charging temperature range, in ℃.

• JT4: Upper bound of high charging temperature range, in ℃.

SH366006 implements hysteresis (*Temp Hys*) for the temperature ranges above, using the DF variable .The hysteresis should be used before switching temperature ranges. The active temperature range is indicated using a set of flags. Since hysteresis is implemented for the temperature ranges, determining the active temperature range depends on the previous state, in addition to the actual temperature. These flags reside in a status register called *TempRange()*.

Flag	JEITA *Temperature Range*	Charging Mode
UT	*Temperature() ≤ JT1*	Charge Suspend or Charge Inhibit
LT	*JT1 < Temperature() ≤ JT2*	Low Temp Charge
STL	*JT2 < Temperature() ≤ JT5*	Standard Temp Charge Low
RT	*JT5 < Temperature() ≤ JT6*	Recommeded Temp Charge
STH	*JT6 < Temperature() ≤ JT3*	Standard Temp Charge High
HT	*JT3 < Temperature() ≤ JT4*	High Temp Charge or Charge Inhibit
OT	*JT4 < Temperature()*	Charge Suspend or Charge Inhibit

Table.2 Temperature Ranges in SH366006

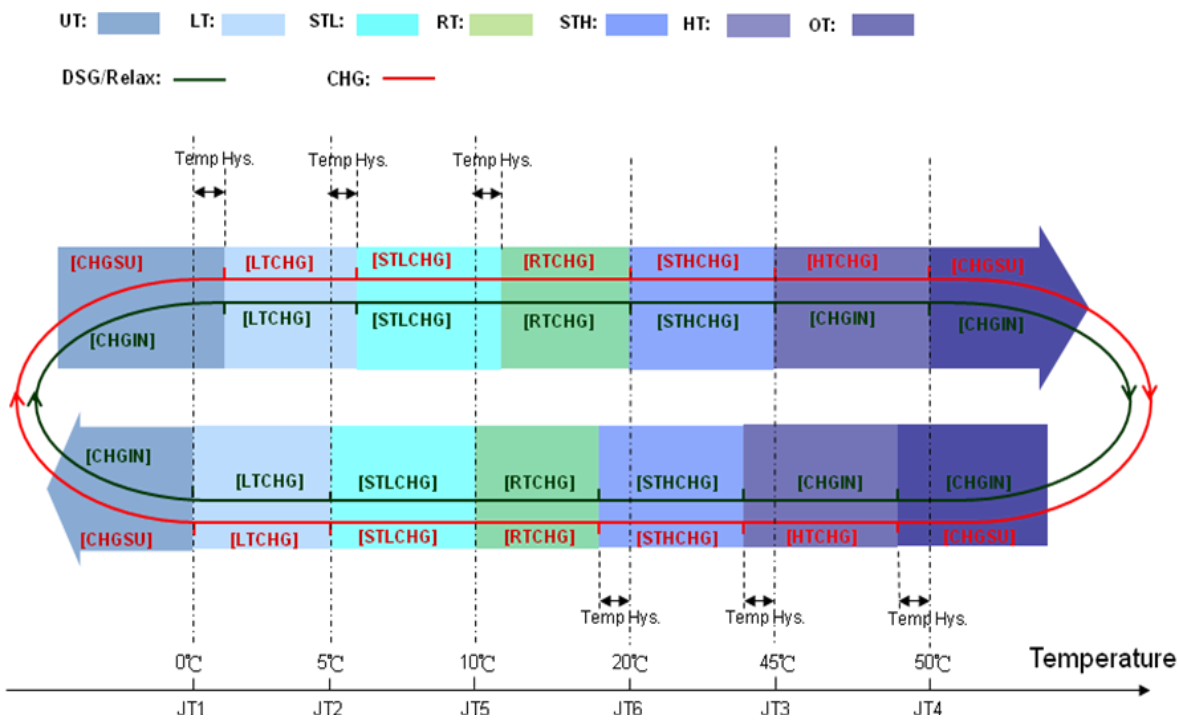


Fig.2 JEITA Temperature Range Switch and Flags

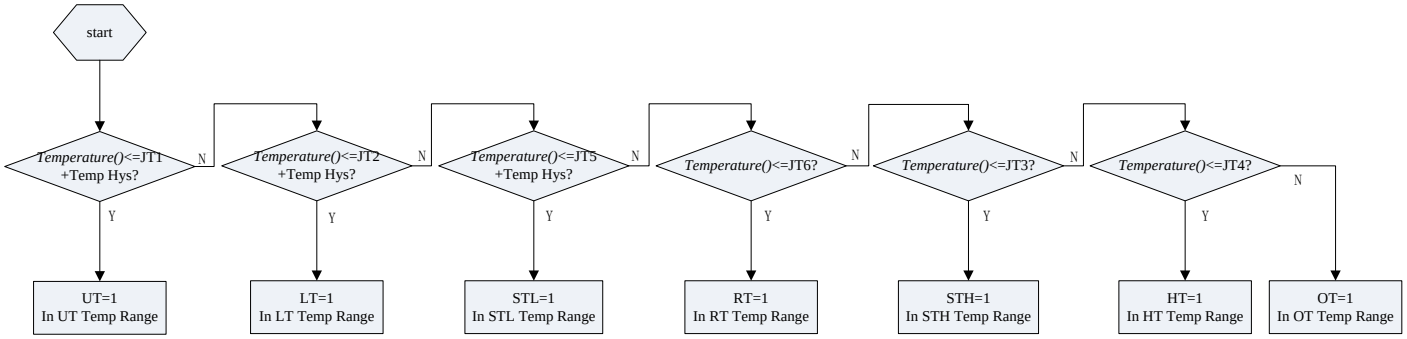


Fig.3 JEITA Temperature Range definition (temperature rise direction)

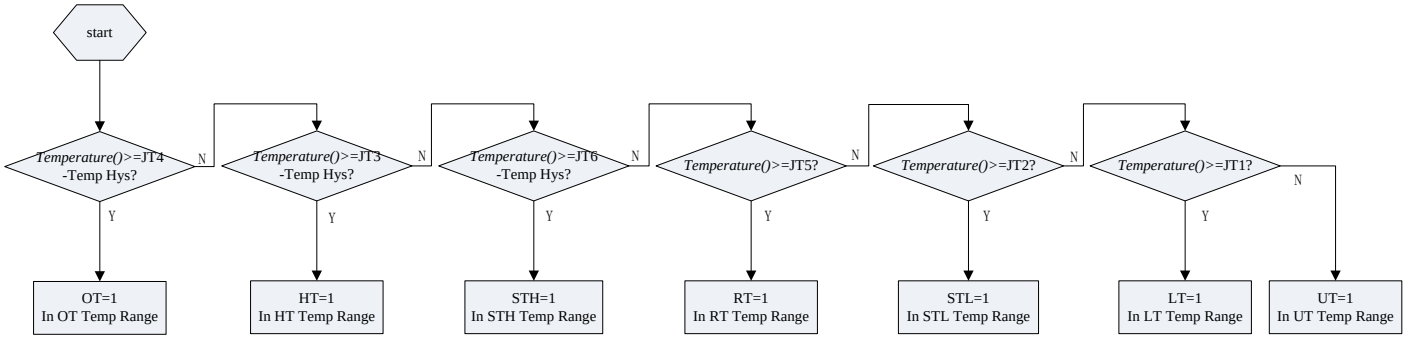


Fig.4 JEITA Temperature Range definition (temperature drop direction)

5.5 Charge Control

SH366006 can report the appropriate *ChargingCurrent()* needed for the constant charging current and the *ChargingVoltage()* needed for constant charging voltage per charging algorithm to a smart charger using *ChargingCurrent()* and *ChargingVoltage()* functions. The actual *ChargingStatus()* of SH366006 is indicated with flags and can be read out with *ChargingStatus()* function.

5.5.1 Charging and Temperature Ranges

SH366006 requests different *ChargingCurrent()* and *ChargingVoltage()* for each of the temperature ranges through *ChargingVoltage()* and *ChargingCurrent()* commands.

Condition	Cell Voltage Range
CellMaxVolt < *Cell Voltage Threshold 1 or* CellMinVolt<*Precharge Start Voltage*	*ChargingStatus()[PV] = 1*
Cell Voltage Threshold 1 < CellMaxVolt < *Cell Voltage Threshold 2*	*ChargingStatus()[LV] = 1*
Cell Voltage Threshold 2 < CellMaxVolt < *Cell Voltage Threshold 3*	*ChargingStatus()[MV] = 1*
Cell Voltage Threshold 3 < CellMaxVolt	*ChargingStatus()[HV] = 1*

Table.3 Cell Voltage Ranges in SH366006

Additionally, the *ChargingCurrent()* can be set differently depending on the cell voltage. Four ranges of cell voltage are defined using three cell voltage thresholds: *Cell Voltage Threshold 1*, *Cell Voltage Threshold 2* and *Cell Voltage Threshold 3*. During *ChargingCurrent()* is set to the appropriate value when cell voltage increases and crosses one of the cell voltage thresholds. However, if cell voltage decreases below the threshold *ChargingCurrent()* is not set back to the previous value unless discharge or relax state is detected. In addition, *Cell Voltage Thresh Hys* is used to make sure that voltage ranges transitions are not affected by slight fluctuations, avoiding the situation frequent variation.

Temp Range	Cell Voltage Range	*ChargingVoltage()*	*ChargingCurrent()*
UT	-	0	0
LT	PV	*LT Chg Voltage*	*Pre-chg Current*
	LV		*LT Chg Current 1*
	MV		*LT Chg Current 2*
	HV		*LT Chg Current 3*
STL	PV	*STL Chg Voltage*	*Pre-chg Current*
	LV		*STL Chg Current 1*
	MV		*STL Chg Current 2*
	HV		*STL Chg Current 3*
RT	PV	*RT Chg Voltage*	*Pre-chg Current*
	LV		*RT Chg Current 1*
	MV		*RT Chg Current 2*
	HV		*RT Chg Current 3*
STH	PV	*STH Chg Voltage*	*Pre-chg Current*
	LV		*STH Chg Current 1*
	MV		*STH Chg Current 2*
	HV		*STH Chg Current 3*
HT	PV	*HT Chg Voltage*	*Pre-chg Current*
	LV		*HT Chg Current 1*
	MV		*HT Chg Current 2*
	HV		*HT Chg Current 3*
OT	-	0	0

Table.4 *ChargingVoltage()* and *ChargingCurrent()* based on Temperature Range and Cell Voltage Range

Low Temperature Charging

SH366006 enters this mode when the Temperature function reports a temperature in the LT range (*JT1* ≤ Temperature < *JT2*). In this mode, the *[LT]* flag in *ChargingStatus()* is set, *ChargingVoltage()* is set to *LT Chg Voltage*, and *ChargingCurrent()* is set to *LT Chg Current 1*, *LT Chg Current 2*, or *LT Chg Current 3* depending on the active cell voltage range. The DataFlash values for low temperature charging should be set to low current values similar to Precharge mode. SH366006 leaves this mode and clears the *[LT]* flag as long as the Temperature goes below *JT1* or above *JT2*.

Standard Temperature Charging Low

SH366006 enters this mode when the Temperature function reports a temperature in the STL range (*JT2* ≤ Temperature < *JT5*). In this mode the *[STL]* flag in *ChargingStatus()* is set, *ChargingVoltage()* is set to *STL Chg Voltage*, and *ChargingCurrent()* is set to *STL Chg Current 1*, *STL Chg Current 2*, or *STL Chg Current 3* depending on the active cell voltage range. SH366006 leaves this mode and clears the *[STL]* flag as long as the Temperature goes below *JT2* or above *JT5*.

Recommended Temperature Charging

SH366006 enters this mode when the Temperature function reports a temperature in the RT range (*JT5* ≤ Temperature < *JT6*). In this mode the *[RT]* flag in *ChargingStatus()* is set, *ChargingVoltage()* is set to *RT Chg Voltage*, and *ChargingCurrent()* is set to *RT Chg Current 1*, *RT Chg Current 2*, or *RT Chg Current 3* depending on the active cell voltage range. SH366006 leaves this mode and clears the *[RT]* flag as long as the Temperature goes below *JT5* or above *JT6*.

Standard Temperature Charging High

SH366006 enters this mode when the Temperature function reports a temperature in the STH range (*JT6* ≤ Temperature < *JT3*). In this mode the *[STH]* flag in *ChargingStatus()* is set, *ChargingVoltage()* is set to *STH Chg Voltage*, and *ChargingCurrent()* is set to *STH Chg Current 1*, *STH Chg Current 2* or *STH Chg Current 3* depending on the active cell voltage. SH366006 leaves this mode and clears the *[STH]* flag as long as the Temperature goes below *JT6 – Temp Hys* or above *JT3*.

High Temperature Charging

SH366006 enters this mode when the Temperature function reports a temperature in the HT range (*JT3* ≤ Temperature < *JT4*). In CHG state, the *[HT]* flag in *ChargingStatus()* is set, *ChargingVoltage()* is set to *HT Chg Voltage*, and the *ChargingCurrent()* is set to *HT Chg Current 1*、*HT Chg Current 2*、or *HT Chg Current 3* depending on the active cell voltage. And in DSG/Relax state, the [CHGIN] flag in *ChargingStatus()* is set, *ChargingVoltage()* and *ChargingCurrent()* is set to 0. SH366006 leaves this mode and clears the *[HT]* flag as long as the Temperature goes below *JT3 – Temp Hys* or above *JT4*.

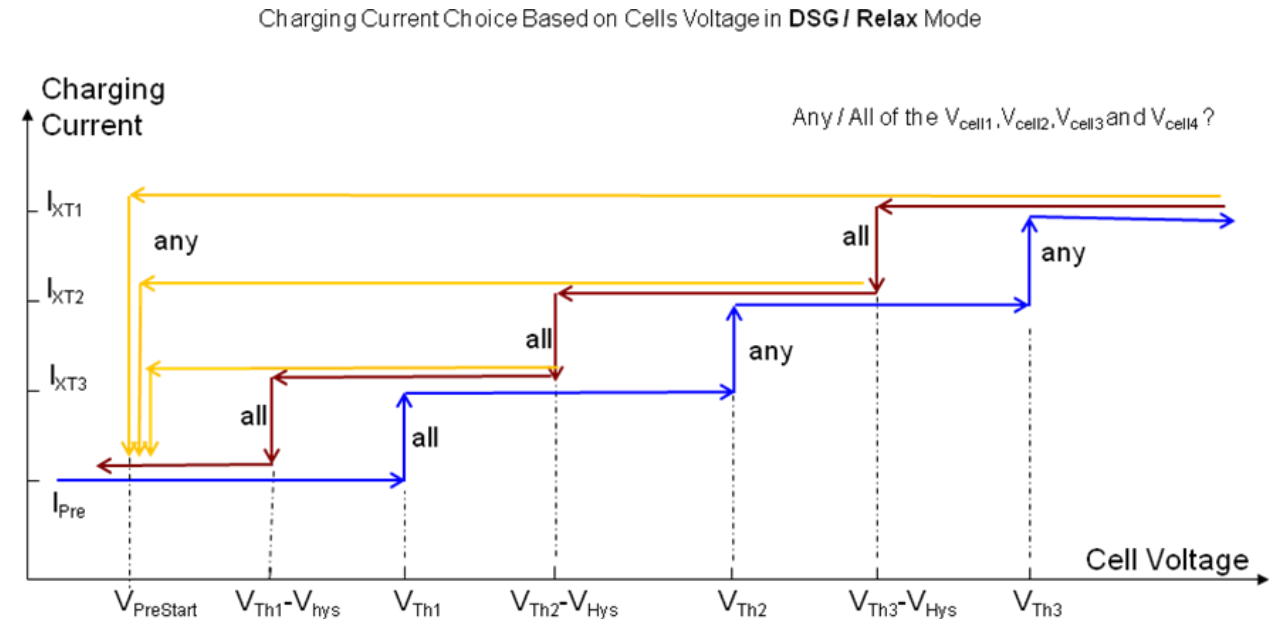


Fig.5 Charging current switch depending on cell voltage in DSG or Relax Mode, I_{XT1}- LT/RT/ST/HT Chg Current1, I_{XT2}- LT/RT/ST/HT Chg Current2, I_{XT3}- LT/RT/ST/HT Chg Current3, I_{pre}- Pre-chg Current, $V_{PreStart}$-Pre-chg Start Voltage, V_{TH1}/ V_{TH2}/ V_{TH3}-Cell Voltage Threshold1/2/3, V_{HYS}- Cell Voltage Thresh Hys.

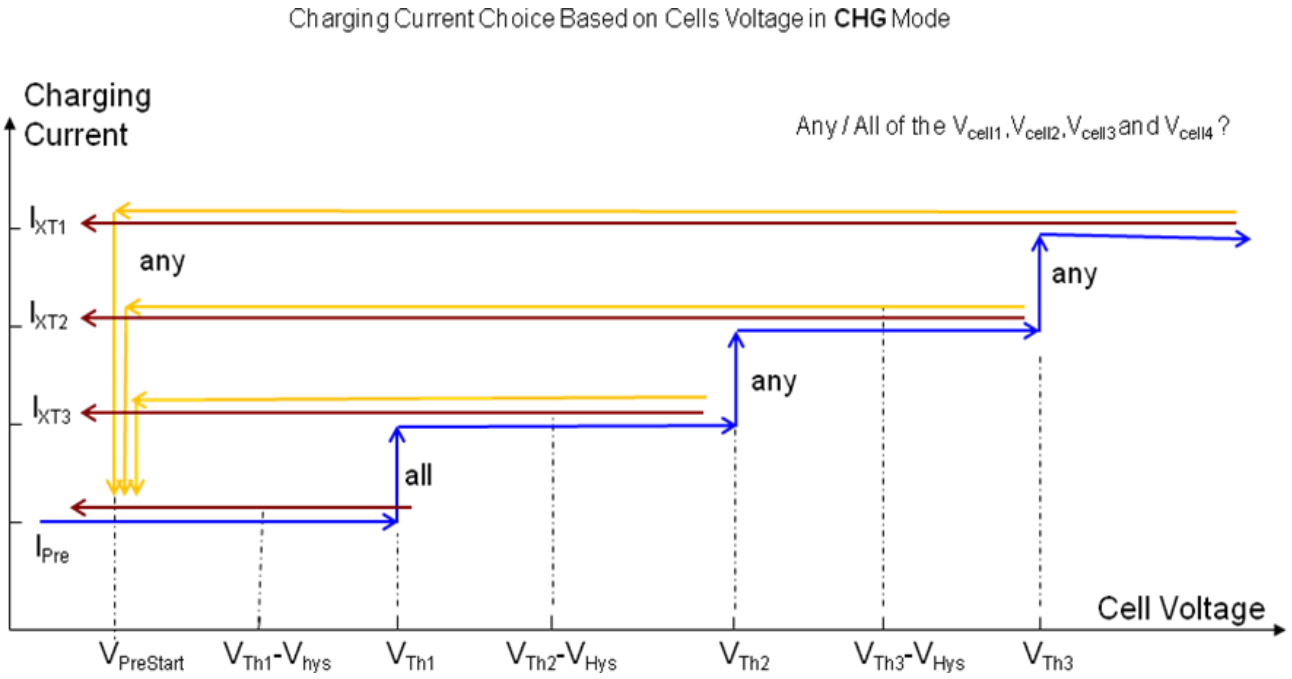


Fig.6 Charging current switch depending on cell voltage in CHG Mode, I_{XT1}- LT/RT/ST/HT Chg Current1, I_{XT2}- LT/RT/ST/HT Chg Current2, I_{XT3}- LT/RT/ST/HT Chg Current3, I_{pre}- Pre-chg Current, $V_{PreStart}$-Pre-chg Start Voltage, V_{TH1}/ V_{TH2}/ V_{TH3}-Cell Voltage Threshold1/2/3, V_{HYS}- Cell Voltage Thresh Hys.

5.5.2 Precharge Mode

SH366006 enters Precharge mode if all cell voltage goes *Cell Voltage Threshold 1- Cell Voltage Thresh Hys* in non-charging mode or any cell voltage goes blow *Precharge Start Voltage*, and Charge Inhibit Mode(CHGIN=0) and Charge Suspend Mode(CHGSU=0) isn't entered at this time.

Depending on the setting of the [PRECHG] bit in *Operation Cfg A*, PCHG FET can be enabled or disabled in precharge mode. If the PCHG FET is disabled, the precharge current should be provided by CHG FET.

In Precharge mode, the *[PV]* flag in *ChargingStatus()* is set and *ChargingCurrent()* is set to *Pre-chg Curren*t. SH366006 exits Precharge mode with clearing the *[PV]* flag only if all cell voltages reach or rise above *Cell Voltage Threshold 1*. Precharge mode can also exit if charge suspend mode or inhabit mode is entered.

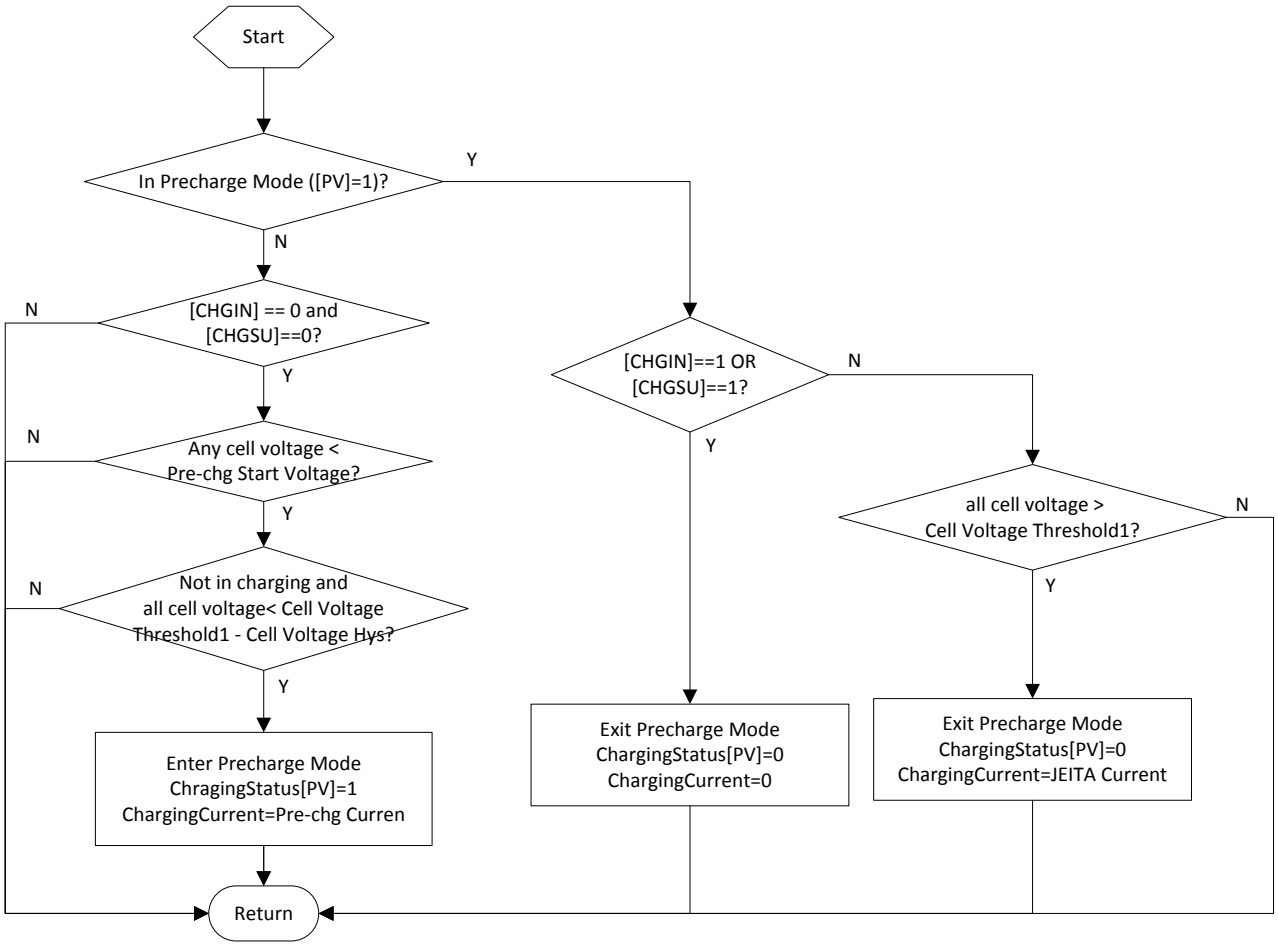


Fig.7 Precharge Mode Entrance and Exit

5.5.3 Charge Inhibit Mode

In discharge mode or relaxation mode (*[DSG]* = 1), SH366006 goes into charge inhibit mode and sets the *ChargingCurrent()* and *ChargingVoltage()* values to 0 to inhibit charging if *Temperature()* < *JT1* limit , or *Temperature()* > JT3 limit. In charge inhibit mode, the *[CHGIN]* flag in *ChargingStatus()* is set and the CHG FET is also turned off if the *[CHGIN]* bit in *Operation Cfg B* is set.

SH366006 allows charging to resume when Temperature ≥ *JT2+ Temp Hys* AND Temperature ≤ *JT3 - Temp Hys*. When it occurs, the FETs can return to their previous states at the same time with *[CHGIN]* flag being cleared.

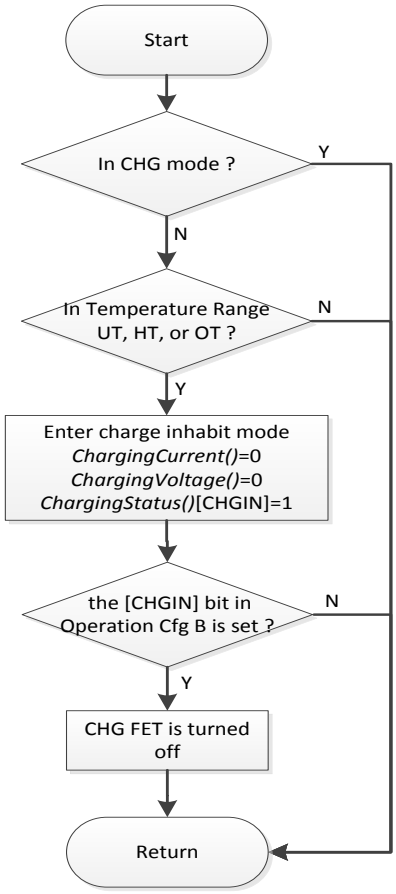


Fig.8 Charge Inhabit Mode Entrance

5.5.4 Charge Suspend Mode

In CHG mode, SH366006 suspends charging if Temperature < *JT1*, OR Temperature > *JT4*. In charge suspend mode, the *[CHGSU]* flag in *ChargingStatus()* is set and *ChargingCurrent()* is set to 0. The CHG FET is turned off if the *[CHGSU]* bit in the *Operation Cfg B* register is set.

SH366006 resumes charging if Temperature ≥ *JT1+ Temp Hys*, AND Temperature ≤ *JT4 - Temp Hys*. When it occurs, SH366006 clears the *[CHGSU]* status flag and sets *ChargingCurrent()* according to the appropriate charging mode, and the CHG FET return to their previous state. SH366006 can also exit the charge suspend mode with clearing the *[CHGSU]* flag when some protection conditions are detected or CHG mode exit is detected.

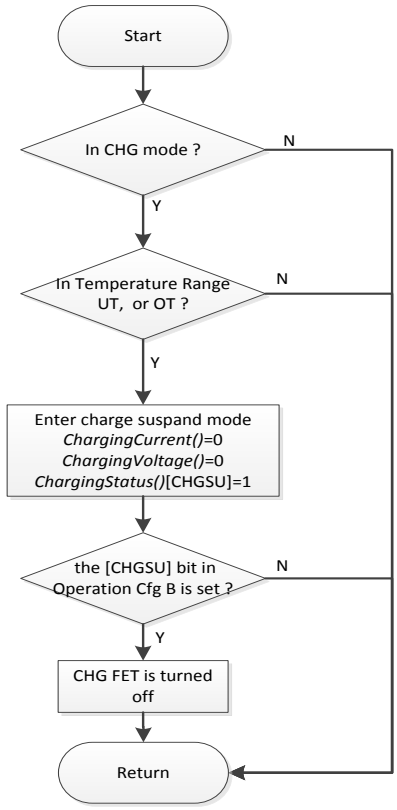


Fig.9 Charge Suspend Mode Entrance

5.5.5 Primary Charge Termination

In charge mode, SH366006 determines charge termination after detecting Taper Condition as follow:

1) *AverageCurrent()* < Taper Current during Two Taper Windows, and

2) The accumulated coulomb ≥ 0.25mAh*2 during the same Two Taper Windows, and

3) *Max cell voltage1…4 + Taper Voltage ≥ ChargingVoltage() / number of cells in series* during the same Two Taper Windows

Upon entering charge termination status, *[FC]* and *[TCA]* flags are set, *ChargingCurrent()* is set to 0 and *[MCHG]* flag in *ChargingStatus()* is set. Additionally, SH366006 has the following actions at charge temination based on the flags settings:

- If *Operation Cfg B[CHGFET]* = 1, the CHG FET is turned off , *ChargingVoltage()* and *ChargingCurrent()* are set to zero.
- If *Operation Cfg B[CHGFET]* = 0, the CHG FET Keeps on, *ChargingCurrent()* is set to *MChg Current*.
- If *Operation Cfg B[CSYNC]* = 1, *RemainingCapacity() = FullChargeCapacity()*.
- If *Operation Cfg C[RSOCL]* = 1, *RelativeStateOfCharge()* and *RemainingCapacity()* are held at 99% until charge termination occurs. Only on entering charge termination is 100% displayed.
- If *Operation Cfg C[RSOCL]* = 0, *RelativeStateOfCharge()* and *RemainingCapacity()* are not held at 99% until charge termination occurs. Fractions of % greater than 99% are rounded up to display 100%.

After charging temination occuring, when *RelativeStateOfCharge()* is equal to or below *TCA Clear%*, the *[TCA]* flag is allowed to be clear and the CHG FET is allowed to be on.

5.5.6 Charging Loss Compensation

The SH366006 can modify *ChargingVoltage()* and *ChargingCurrent()* to compensate losses caused by the FETs, the fuse, and the sense resistor by measuring the cell voltages directly and adjusting *ChargingCurrent()* and *ChargingVoltage()* accordingly.

In CONSTANT CURRENT mode, the SH366006 can increase the *ChargingVoltage()* value to compensate the drop losses. This feature can be enabled by setting *Operation Cfg A[CCC]* = 1 and configuring the *CCC Current Threshold*.

The SH366006 enters charging loss compensation function if *Current()* > *CCC Current Threshold* and *Voltage()* < Charging alogrithm voltage. In this function, the *[CCC]* flag in *ChargingStatus()* is set and *ChargingVoltage()* is set to Charging algorithm voltage + (*PackVoltage()* – *Voltage()*). At this time, if *PackVoltage()* – *Voltage()* > *CCC Voltage Threshold*, *ChargingVoltage()* is limited to Charging algorithm voltage + *CCC Voltage Threshold.*

5.5.7 Four Stages Mode

SH366006 optimizes *ChargingVoltage()* and *ChargingCurrent()* according to the battery lifespan additionally based on CyclCount or SOH if enabled by setting either *[FSMCC]* or *[FSMSOH]* in *Operation Cfg A* register. This helps to reduce the *ChargingVoltage()* and *ChargingCurrent()* as the battery pack ages in order to increase the longevity of the battery pack. For the additional optimization, Nomal Mode, Lifespan Mode 1, Lifspan Mode 2 and Lifespan Mode 3 are defined by different used age of the battery pack.

Nomal Mode:

Normal Mode(the *[NM]* flag is set in *OperationStatus()*) is the initial mode of the system, and the *ChargingVoltage()* and *ChargingCurrent()* follow cell standard charge voltage and current of JEITA, indicated that there is no capacity loss in this mode.

Lifespan Mode 1:

When SH366006 detects CycleCount > *LS1 Set CycleCount*(default=50)(if enabled by setting *[FSMCC]*) or SOH < *LS1 Set SOH* (default=95%)(if enabled by setting *[FSMSOH]*), SH366006 fixes in Lifespan Mode 1 (the *[LS1]* flag is set in *OperationStatus()*) and *ChargingVoltage()* is reduced by *CV Degrade Threshold 1*(default=10mV/cell). At the same time, *ChargingCurrent()* also can be reduced by *CC Degrade Threshold 1*(default=10%) when the *[DCC]* flag in *Operation Cfg A* is set.

Lifespan Mode 2:

When SH366006 detects CycleCount > *LS2 Set CycleCount*(default=150)(if enabled by setting *[FSMCC]*) or SOH < *LS2 Set SOH* (default=80%)(if enabled by setting *[FSMSOH]*), SH366006 fixes in Lifespan Mode 2 (the *[LS2]* flag is set in *OperationStatus()*) and *ChargingVoltage()* is reduced by *CV Degrade Threshold 2*(default=50mV/cell). At the same time, *ChargingCurrent()* also can be reduced by *CC Degrade Threshold 2*(default=20%) when the *[DCC]* flag in *Operation Cfg A* is set.

Lifespan Mode 3:

When SH366006 detects CycleCount > *LS3 Set CycleCount*(default=350)(if enabled by setting *[FSMCC]*) or SOH < *LS3 Set SOH* (default=60%)(if enabled by setting *[FSMSOH]*), SH366006 fixes in Lifespan Mode 3 (the *[LS3]* flag is set in *OperationStatus()*) and *ChargingVoltage()* is reduced by *CV Degrade Threshold 3*(default=120mV/cell). At the same time, *ChargingCurrent()* also can be reduced by *CC Degrade Threshold 3*(default=40%) when the *[DCC]* flag in *Operation Cfg A* is set.

Note, Only CyclCount condition or SOH condition can be used at a time. *[FSMCC]* and *[FSMSOH]* must not be enabled together.

The following table shows how ChargingVoltage() and ChargingCurrent are degraded at different temperature and different mode in charge mode or discharge/relax mode:

DSG&Relaxing Mode			Normal Mode	Lifespan Mode 1	Lifespan Mode 2	Lifespan Mode 3
UT	*Charging Voltage()*		0	0	0	0
	Charging Current()	[DCC] = 0	0	0	0	0
		[DCC] = 1	0	0	0	0
LT	*Charging Voltage()*		*LTChargeVoltage*	*LTChargeVoltage-(CV Degrade Threshold 1** cell number)	*LTChargeVoltage-(CV Degrade Threshold 2** cell number)	*LTChargeVoltage-(CV Degrade Threshold 3** cell number)
	Charging Current()	[DCC] = 0	*LTChargeCurrent*	*LTChargeCurrent*	*LTChargeCurrent*	*LTChargeCurrent*
		[DCC] = 1	*LTChargeCurrent*	*LTChargeCurrent**(1-*CC Degrade Thresold 1*)	*LTChargeCurrent**(1-*CC Degrade Thresold 2*)	*LTChargeCurrent**(1-*CC Degrade Thresold 3*)
STL	*Charging Voltage()*		*STLChargeVoltage*	*STLChargeVoltage-(CV Degrade Threshold 1** cell number)	*STLChargeVoltage-(CV Degrade Threshold 2** cell number)	*STLChargeVoltage-(CV Degrade Threshold 3** cell number)
	Charging Current()	[DCC] = 0	*STLChargeCurrent*	*STLChargeCurrent*	*STLChargeCurrent*	*STLChargeCurrent*
		[DCC] = 1	*STLChargeCurrent*	*STLChargeCurrent**(1-*CC Degrade Thresold 1*)	*STLChargeCurrent**(1-*CC Degrade Thresold 2*)	*STLChargeCurrent**(1-*CC Degrade Thresold 3*)
RT	*Charging Voltage()*		*RTChargeVoltage*	*RTChargeVoltage-(CV Degrade Threshold 1** cell number)	*RTChargeVoltage-(CV Degrade Threshold 2** cell number)	*RTChargeVoltage-(CV Degrade Threshold 3** cell number)
	Charging Current()	[DCC] = 0	*RTChargeCurrent*	*RTChargeCurrent*	*RTChargeCurrent*	*RTChargeCurrent*
		[DCC] = 1	*RTChargeCurrent*	*RTChargeCurrent**(1-*CC Degrade Thresold 1*)	*RTChargeCurrent**(1-*CC Degrade Thresold 2*)	*RTChargeCurrent**(1-*CC Degrade Thresold 3*)
STH	*Charging Voltage()*		*STHChargeVoltage*	*STHChargeVoltage-(CV Degrade Threshold 1** cell number)	*STHChargeVoltage-(CV Degrade Threshold 2** cell number)	*STHChargeVoltage-(CV Degrade Threshold 3** cell number)
	Charging Current()	[DCC] = 0	*STHChargeCurrent*	*STHChargeCurrent*	*STHChargeCurrent*	*STHChargeCurrent*
		[DCC] = 1	*STHChargeCurrent*	*STHChargeCurrent**(1-*CC Degrade Thresold 1*)	*STHChargeCurrent**(1-*CC Degrade Thresold 2*)	*STHChargeCurrent**(1-*CC Degrade Thresold 3*)
HT	*Charging Voltage()*		0	0	0	0
	Charging Current()	[DCC] = 0	0	0	0	0
		[DCC] = 1	0	0	0	0
OT	*Charging Voltage()*		0	0	0	0
	Charging Current()	[DCC] = 0	0	0	0	0
		[DCC] = 1	0	0	0	0

Table.5 *ChargingVoltage()* and *ChargingCurrent()* (DSG & Relaxing Mode)

CHG Mode			Normal Mode	Lifespan Mode 1	Lifespan Mode 2	Lifespan Mode 3
UT	*Charging Voltage()*		0	0	0	0
	Charging Current()	[DCC] = 0	0	0	0	0
		[DCC] = 1	0	0	0	0
LT	*Charging Voltage()*		LTChargeVoltage	*LTChargeVoltage-(CV Degrade Threshold 1** cell number)	*LTChargeVoltage-(CV Degrade Threshold 2** cell number)	*LTChargeVoltage-(CV Degrade Threshold 3** cell number)
	Charging Current()	[DCC] = 0	LTChargeCurrent	*LTChargeCurrent*	*LTChargeCurrent*	*LTChargeCurrent*
		[DCC] = 1	LTChargeCurrent	*LTChargeCurrent**(1-*CC Degrade Thresold 1)*	*LTChargeCurrent**(1-*CC Degrade Thresold 2)*	*LTChargeCurrent**(1-*CC Degrade Thresold 3)*
STL	*Charging Voltage()*		STLChargeVoltage	*STLChargeVoltage-(CV Degrade Threshold 1** cell number)	*STLChargeVoltage-(CV Degrade Threshold 2** cell number)	*STLChargeVoltage-(CV Degrade Threshold 3** cell number)
	Charging Current()	[DCC] = 0	STLChargeCurrent	*STLChargeCurrent*	*STLChargeCurrent*	*STLChargeCurrent*
		[DCC] = 1	STLChargeCurrent	*STLChargeCurrent**(1-*CC Degrade Thresold 1)*	*STLChargeCurrent**(1-*CC Degrade Thresold 2)*	*STLChargeCurrent**(1-*CC Degrade Thresold 3)*
RT	*Charging Voltage()*		RTChargeVoltage	*RTChargeVoltage-(CV Degrade Threshold 1** cell number)	*RTChargeVoltage-(CV Degrade Threshold 2** cell number)	*RTChargeVoltage-(CV Degrade Threshold 3** cell number)
	Charging Current()	[DCC] = 0	RTChargeCurrent	*RTChargeCurrent*	*RTChargeCurrent*	*RTChargeCurrent*
		[DCC] = 1	RTChargeCurrent	*RTChargeCurrent**(1-*CC Degrade Thresold 1)*	*RTChargeCurrent**(1-*CC Degrade Thresold 2)*	*RTChargeCurrent**(1-*CC Degrade Thresold 3)*
STH	*Charging Voltage()*		STHChargeVoltage	*STHChargeVoltage-(CV Degrade Threshold 1** cell number)	*STHChargeVoltage-(CV Degrade Threshold 2** cell number)	*STHChargeVoltage-(CV Degrade Threshold 3** cell number)
	Charging Current()	[DCC] = 0	STHChargeCurrent	*STHChargeCurrent*	*STHChargeCurrent*	*STHChargeCurrent*
		[DCC] = 1	STHChargeCurrent	*STHChargeCurrent**(1-*CC Degrade Thresold 1)*	*STHChargeCurrent**(1-*CC Degrade Thresold 2)*	*STHChargeCurrent**(1-*CC Degrade Thresold 3)*
HT	*Charging Voltage()*		HTChargeVoltage	*HTChargeVoltage-(CV Degrade Threshold 1** cell number)	*HTChargeVoltage-(CV Degrade Threshold 2** cell number)	*HTChargeVoltage-(CV Degrade Threshold 3** cell number)
	Charging Current()	[DCC] = 0	HTChargeCurrent	*HTChargeCurrent*	*HTChargeCurrent*	*HTChargeCurrent*
		[DCC] = 1	HTChargeCurrent	*HTChargeCurrent**(1-*CC Degrade Thresold 1)*	*HTChargeCurrent**(1-*CC Degrade Thresold 2)*	*HTChargeCurrent**(1-*CC Degrade Thresold 3)*
OT	*Charging Voltage()*		0	0	0	0
	Charging Current()	[DCC] = 0	0	0	0	0
		[DCC] = 1	0	0	0	0

Table.5 *ChargingVoltage()* and *ChargingCurrent()* (Continue, CHG Mode)

5.5.8 Cell Balancing

SH366006 supports cell charge balancing. Under the condition that none of 1st or 2nd level safety protection occurs, when the cells capacity differences exist during charging, balance process starts. The cell balancing algorithm is described as follows:

- Find the lowest capacity cell, and then detect the differences, dQ, to all the other cells.
- These differences must be bypassed through turning on the integrated bypass FETs in the SH366006 during each calculated cell bypass time.
- The bypass time is calculated based on *MinCellDeviation*, as time=dQ x *MinCellDeviation*.

MinCellDeviation is defined as the conversion factor for each cell balance time calculation in unit of mAh, before balance process starts. If *Min Cell Deviation* is set to 0, cell balancing is disabled and all bypass FETs stay OFF..

The bypass time needed for each cell is calculated as: Min Cell Deviation = R / (duty_cycle * Rating_Voltage) * 3.6 s/mAh

Where:

R = internal bypass FET resistance of 200 (type) of SH366006 + 2 series input filter resistors, Rc. For example: if input filter Rc value is 100ohm, R = 200 + 2 x Rc = 400.

Rating_Voltage = 3.7V

duty_cycle = 0.6typ.

Using default values, the formula calculates the default value for Min Cell Deviation:

Min Cell Deviation = (200 + (2 x Rc)) / (0.6 * 3.7V) * 3.6 s/mAh = 648 s/mAh, and 700s/mAh is effective as the rounding process in this function.

Name	Description
MinCellDeviation	Min Cell Deviation Threshold
Cell Imbalance Fail Voltage	Cell Imbalance Fail Voltage Threshold
Cell Imbalance Time	Time Delay of Serious Imbalance
Cell Imbalance Current	Serious Imbalance Min Current
Battery Rest Time	Battery Rest Time for Serious Imbalance

Table.6 Cell Charge Balance

5.5.9 Charging Faults

The SH366006 can report charging faults by setting the *BatteryStatus()* register.

Discharge and Charge Alarms

The SH366006 enables *[TCA]*, *[FC]*, *[TDA*, *[FD]*, *[OCA]* and *[OTA]* flags in *BatteryStatus()* to be set or cleared on the following conditions. Here is a summary of these conditions of the various flags

Flag	Set Condition	Clear Condition
TCA	*SafetyStatus()[SCC],[COV],[OCC1],[OCC2],[OTC], [OC], [OCPC], [OTF], [UTC], [PTO]* or *[CTO]* = 1 OR	any of these conditions do not meet and RSOC ≤ *TCA Clear %*
	Any *PFStatus()* = 1 OR	
	OperationStatus()[PRES] = 0 OR	
	Primary Charge Termination	
FC	Primary Charge Termination	RSOC ≤ *TCA Clear %*
TDA	*SafetyStatus()[AOCD],[SCD],[CUV],[OCD1], [OCD2], [OTD], [OTF],*or *[UTD]* = 1 OR	any of these conditions do not meet and RSOC ≥ *TDA Clear %* and *Min Cell Voltage 1…4 ≥ TDA Clear Volt*
	Any *PFStatus()* = 1 OR	
	OperationStatus()[PRES] = 0 OR	
	RSOC ≤ *TDA Set %* OR	
	Min Cell Voltage 1…4 ≤ TDA Set Volt Threshold	
FD	*SafetyStatus()[CUV]* = 1 OR	any of these conditions do not meet and RSOC ≥ *FD Clear %*
	PFStatus()[SUV] = 1 OR	
	RSOC ≤ *FD Set %*	
OCA	*SafetyStatus()[OC]* = 1 and in CHARGE mode	Overcharge recover or in non-charge mode
OTA	*SafetyStatus()[OTC],[OTD],*or *[OTF]* =1 OR	any of these conditions do not meet
	PFStatus()[SOTC], or *[SOTF]* = 1	

Table.7 Discharge and Charge Alarms

5.6 1st level Protection

SH366006 supports a wide range of battery and system protection which can be easily configured via the integrated data flash. In protection the CHG or DSG FET is turned off to prevent battery from damage. The 1st protecting includes voltage, current and temperature protection. All protection items can be enabled or disabled under *Protection Cfg A & B*. When the protections and permanent fails are triggered, the *BatteryStatus() [TCA] [TDA] [FD] [OCA] [OTA]* is set according to the type of safety protections.

5.6.1 Voltage Protection

Overvoltage Protection (COV)

SH366006 can detect cell overvoltage to protect battery cells from the potential damage. If the overvoltage maintain over a period of *COV Time*, SH366006 goes into overvoltage condition and turns off the CHG FET.

To follow JEITA guidelines, the cell overvoltage thresholds vary from the *Temperature Range*s.

The SH366006 will indicate cell overvoltage condition by setting the *[COV]* flag in *SafetyStatus()* when any CellVoltage4…1 reaches the cell overvoltage limit (*LT COV Threshold*, *STL COV Threshold*, *RT COV Threshold*, *STH COV Threshold* or *HT COV Threshold*, according to the current Temperature Range) and stays above the threshold for period of *COV Time*. Under the overvoltage condition, charging is disabled (CHG FET and PCHG FET are off), *ChargingCurrent()* and *ChargingVoltage()* are set to zero, *[COV]* flag in *SafetyStatus(),[XCHG]* flag in *OperationStatus()* and *[TCA]* flag in *BatteryStatus()* are set.

SH366006 can recover from the condition if all *CellVoltages4…1* decrease to COV Recovery limit (*LT COV Recovery*, *STL COV Recovery*, *RT COV Recovery*, *STH COV Recovery* or *HT COV Recovery*).On recovery, the *[COV]* flag, *[XCHG]* flag and *[TCA]* flag are cleared, *ChargingCurrent()* and *ChargingVoltage()* should be set back to the appropriate values per the charging algorithm if no other protection occurs.

In the Overvoltage Protection, the CHG FET should keep on during discharging (*Current()* ≤ *- Dsg Current Threshold*) period for avoiding its body diode overheating.

Undervoltage Protection (CUV)

SH366006 can detect cell under-voltage to protect battery cells from the potential damage.

SH366006 will indicate the cell under-voltage condition by setting the *[CUV]*, *[XDSG]*, *[FD]*, *[TDA]* if when any CellVoltage4...1 decreases to *CUV Threshold* and stays below *CUV Threshold* limit for *CUV Time*. Under this condition, discharging is disabled (DSG FET is off) and *ChargingCurrent()* is set according to JEITA.

SH366006 will recover from the cell under-voltage condition if all CellVoltages4...1 reach up to *CUV Recovery* limit over 1s only in CHG mode when *[CUVRC]* flag is set in *Operation Cfg A*, or if all CellVoltages4...1 reach up to *CUV Recovery* limit over 1s when *Operation Cfg A[CUVRC] = 0*. On recovery, the *[CUV]* flag in *Safety Status()*, the *[FD]*, *[TDA]* flag in *BatteryStatus()* and the *[XDSG]* flag in *OperationStatus()* are all reset, also *Charging Current()* and *Charging Voltage()* should be set back to appropriate value per the charging algorithm.

In the Under-voltage Protection, the DSG FET should keep on during charging period for avoiding its body diode overheating.

5.6.2 Temperature Protection

SH366006 provides over-temperature protection for both cell temperature and FET temperature and under-temperature protection for cell temperature, with its corresponding alarm and FET off operation.

For temperature reporting, SH366006 default support a maximum of four external thermistors. Unused temperature sensors must be disabled by clearing the corresponding flag in *Operation Cfg* C*[TS4] [TS3] [TS2] [TS1]*.

Each of the external thermistors can be set up individually as a source for cell temperature or FET temperature reporting. Setting the corresponding flag to 1 in *Operation Cfg C[TS4M] [TS3M] [TS2M] [TS1M]* configures that temperature sensor to report for FET temperature. Clearing the corresponding flag sets that temperature sensor to report for cell temperature. The *Operation Cfg A [FTEMP]* enables users to use the maximal (set to 0) or the average (set to 1) of the source temperature sensors for FET temperature reporting.

The *Operation Cfg A[CTEMP1] [CTEMP0]* enables users to define which temperature sensor's output is displayed by the *SBS Temperature()* command (a setting of 1, 0 allows the temperature sensor with the lowest temperature to be displayed, while a setting of 0, 1 displays an average of all the sensors, and a setting of 0, 0 displays the temperature sensor with the highest temperature). Cell temperature protections will work automatically such that for the under temperature check, only the min cell temperature will be used, while for over temperature check only the max cell temperature will be used.

The *Temperature()* command returns the cell temperature measurement. The extended command *DAStatus2()* also returns the temperature measurement from the external thermistors TS1, TS2, TS3, and TS4, and the cell and FET temperatures.

Charge Overtemperature Protection

If Max Cell Temp reaches up to *Over Temp Chg* during charging for *OTC Time* in CHG mode, Charge Overtemperature protection occurs and *[OTC]* in *SafetyStatus()* is set. At the same time, CHG or PCHG FET(if used) is turned off , the *[XCHG]* flag in *OperationStatus()* is set and the *ChargingCurrent()* and *ChargingVoltage()* are set to zero if *[OTFET]* flag in *Operation Cfg B* is on, also *[TCA]* and *[OTA]* in *BatteryStatus()* are set as well.

The SH366006 can recover from an *[OTC]* condition, if Max Cell Temp ≤ *OT Chg Recovery*. On recovery, *[OTC]* in *SafetyStatus()* and *[TCA] [OTA] in BatteryStatus()* are reset, *ChargingCurrent()* and *ChargingVoltage()* are set back to their appropriate value per charging algorithm, and CHG/PCHG FET is allowed to be on again.

Under the [OTC] condition,CHG FET keeps on during discharge (*Current()* ≤ - *Dsg Current Threshold*) for avoiding its body diode overheating.

Discharge Overtemperature Protection

if Max Cell Temp reaches up to *Over Temp Dsg* for *OTD Time* in DSG or Relax mode, Discharge Overtemperature protection occurs and *[OTD]* in *SafetyStatus()* is set. At the same time, DSG FET is turned off and the *[XDSG]* flag is set if *[OTFET]* flag in *Operation Cfg B* is on, also *[TDA]* and *[OTA]* flags are set as well

The SH366006 can recover from an *[OTD]* condition, if Max Cell Temp ≤ *OT Dsg Recovery*. On recovery, *[OTD]* in *SafetyStatus()*and *[TDA] [OTA]*in *BatteryStatus()* are reset, and DSG FET is allowed to on again.

Under the *[OTD]* condition, DSG FET keeps on during charging (*Current()* ≥ *Chg Current Threshold*) for avoiding its body diode overheating.

FET Overtemperature Protection

If the FET Temperature in *DAStatus2()* ≥*OTF Temp Threshold for OTF Time*, FET Overtemperature protection occurs, *[OTF]* in *SafetyStatus()* is set. At same time, CHG/DSG FETs are turned off and the *[XCHG] [XDSG]* are set if *[OTFET]* flag in *Operation Cfg B* is on, also *[TCA][TDA] [OTA]* in *BatteryStatus()* are set and *ChargingCurrent()* and *ChargingVoltage()* are set to zero.

To exit FET Overtemperature protection, it must be met that the FET Temperature in *DAStatus2()* < *OTF Recovery Temp* for 1s. When exit, *[OTF]* in *SafetyStatus()* and *[TCA][TDA][OTA]* in *BatteryStatus()* are reset, CHG/DSG FETs are allowed back to be on, *ChargingCurrent()* and *ChargingVoltage()* are set to the appropriate value per the charging algorithm.

Charge Undertemperature Protection

If Min Cell Temp < *Under Temp Chg* during charging for *UTC Time* in CHG mode, Charge Undertemperature protection occurs and *[UTC]* in *SafetyStatus()* is set. At the same time, CHG or PCHG FET(if used) is turned off , also *[XCHG]* in *OperationStatus()* is set and *ChargingCurrent()* and *ChargingVoltage()* are set to zero as well.

The SH366006 can recover from an *[UTC]* condition, if Min Cell Temp ≥ *UT Chg Recovery*. On recovery, *[UTC]* in *SafetyStatus()* and *[XCHG] in OperationStatus()* are reset, *ChargingCurrent()* and *ChargingVoltage()* are set back to their appropriate value per charging algorithm, and CHG/PCHG FET is allowed to be on again.

Under the [UTC] condition,CHG FET keeps on during discharge (*Current()* ≤ - *Dsg Current Threshold*) for avoiding its body diode overheating.

Discharge Undertemperature Protection

if Min Cell Temp < *Undedr Temp Dsg* for *OTD Time* in DSG or Relax mode, Discharge Undertemperature protection occurs and *[UTD]* in *SafetyStatus()* is set. At the same time, DSG FET is turned off, also *[XDSG]* flag is set as well

The SH366006 can recover from an [UTD] condition, if Min Cell Temp ≤*UT Dsg Recovery*. On recovery, *[UTD]* in *SafetyStatus()*and *[XDSG] in OperationStatus()* are reset, and DSG FET is allowed to on again.

Under the [UTD] condition, DSG FET keeps on during charging (*Current()* ≥ *Chg Current Threshold*) for avoiding its body diode overheating.

5.6.3 Current Protection

SH366006 provides four current protections: pre-charge overcurrent protection, charge overcurrent protection, discharge overcurrent protection and discharge overloaded protection.

Pre-charge Overcurrent Protection(OCPC)

Pre-Charge Overcurrent Protection occurs when *Current( )* is greater than or equal to *OC PreChg* for over *OC PreChg Time* in precharge mode. In this condition, the *[OCPC]* in *SafetyStatus()* is set, *ChargingCurrent()* and *ChargingVoltage()* are set to zero, also CHG or PCHG (if used) FET is turned off.

It can make SH366006 exit the *[OCPC]* condition and return to normal state with clearing *[OCPC]* flag that *AverageCurrent* <*OC PreChg* for *OC PreChg Recovery Time* or the exit of Prechg Mode.

When the charging-fault recovery conditions are detected, the CHG or PCHG (if used) FET is allowed back to be on, also *ChargingCurrent()* and *ChargingVoltage()* are set to the appropriate value per the charging algorithm.

Under the *[OCPC]* condition, CHG FET should keep on during discharging (Current ≤ *-Chg Current Threshold*) for avoiding its body diode overheating.

Charge Overcurrent Protection (OCC1/OCC2)

The charge overcurrent protection requires the charge current to be greater than or equal to a programmed *OCC1 Threshold* for a period greater than *OCC1 Time* to be enabled. In this condition, the *[OCC1]*, *[XCHG]* and *[TCA]* flags are set, *ChargingCurrent()* and *ChargingVoltage()* are set to zero, also CHG or PCHG (if used) FET is turned off .

The charge overcurrent protection requires the charge current to be greater than or equal to a programmed *OCC2 Threshold* for a period greater than *OCC2 Time* to be enabled. In this condition, the *[OCC2]*, *[XCHG]* and *[TCA]* flags are set, *ChargingCurrent()* and *ChargingVoltage()* are set to zero, also CHG or PCHG (if used) FET is turned off.

The SH366006 can recover from the OCC condition, if *Current()* ≤ *OCC Recovery* for *OCC Recovery Time.* On recovery, *[OCC1]*[*OCC2]* in *SafetyStatus()*and *[XCHG] in OperationStatus()* are reset, the *ChargingCurrent()* and *ChargingVoltage()* are set back to their appropriate value per charging algorithm, and CHG/PCHG FET is allowed to be on again.

Under the *[OCC1]* or *[OCC2]* condition, CHG FET should keep on during discharging (*Current()* ≤ *-Dsg Current Threshold*) for avoiding its body diode overheating.

Discharge Overcurrent Protection (OCD1/OCD2)

The discharge overcurrent protection requires the discharge current to be lower than or equal to a programmed *OCD1 Threshold* for a period greater than *OCD1 Time* to be enabled. In this condition, the *[OCD1]*, *[XDSG]*and *[TDA]* flags are set, also DSG FET is turned off.

The discharge overcurrent protection requires the discharge current to be lower than or equal to a programmed *OCD2 Threshold* for a period greater than *OCD2 Time* to be enabled. In this condition, the *[OCD2]*, *[XDSG]*and *[TDA]* flags are set, also DSG FET is turned off.

The SH366006 can recover from the OCD condition, if *Current()*≥ *OCD Recovery* for *OCD Recovery Time.* On recovery, *[OCD1]*[*OCD2]* in *SafetyStatus()*and *[XDSG] in OperationStatus()* are reset, and DSG FET is allowed to be on again.

Under the *[OCD1]* or *[OCD2]* condition, DSG FET should keep on during charging (*Current()* ≥ *Chg Current Threshold*) for avoiding its body diode overheating.

Discharge Overloaded Protection (AOCD)

When the AFE detects the discharge current(negative value) to be lower than or equal to the *AFE OC Dsg* for *AFE OC DSG Time*, the charge and discharge FETs are turned off, the AFECurrent_Fault timer starts counting from 0, *[AOCD]* and *[XCHG]* flags are set. CHG FET is turned on when current is high than *AFE OC Dsg.*

The SH366006 can recover from the AOCD condition, if *AverageCurrent()* ≥ -100mA and AFECurrent_Fault timer count to *AOCD Recovery Time* from the start of the protection. Then the DSG FET is allowed to be turned on, and the *[AOCD]* and *[XDSG]* flags are reset.

5.6.4 Short-Circuit Protection

SH366006 charge and discharge short-circuit protections are controlled by the AFE. These protections can recover by two ways depend on *[NR]* status.

Charge Short-Circuit Protection (SCC)

When Charging Current exceeds the current for the delay time based on *AFE SC Chg Cfg*, the SH366006 goes into Charge Short-Circuit protection, all FETs are turned off, the internal AFECurrent_Fault timer starts counting from 0, *[SCC]* and *[XCHG]* are set, and the *ChargingCurrent()* and *ChargingVoltage()* are set to 0.

The SH366006 can recover from the SCC condition, if *AverageCurrent()*≤ 5mA and AFECurrent_Fault timer count to *SCC Recovery Time* from the start of the protection. Then the CHG and PCHG(if use) FETs return to the previous state, the *[SCC]* and *[XCHG]* are reset, and *ChargingCurrent()* and *ChargingVoltage()* are set to the appropriate values per the charging algorithm.

However, in this protection the CHG FET should keep on during discharge (*Current()* ≤ *- Dsg Current Threshold*) if *SafetyStatus()[SCC]* =1 for avoiding its body diode overheating.

Discharge Short-Circuit Protection

When Discharging Current exceeds the current for the delay time based on AFE SC Dsg Cfg, the SH366006 goes into Discharge Short-Circuit protection, all FETs are turned off, the internal AFECurrent_Fault timer starts counting from 0, and the *[SCD]* and *[XDSG]* flags are set.

The SH366006 can recover from the SCD condition, if *AverageCurrent()* ≥ -5mA and AFECurrent_Fault timer count to *SCD Recovery Time* from the start of the protection. Then the DSG FET is allowed to be turned on, and the *[SCD]* and *[XDSG]* flags are reset.

However, in this protection the DSG FET should keep on during charge (*Current()* ≥ *Chg Current Threshold*) if *SafetyStatus()[SCD]*=1 for avoiding its body diode overheating.

5.6.5 Timeout Function

SH366006 charge time and pre-charge time are limited by charge and pre-charge time out functions for avoiding deep overcharge state.

Charge Timeout Function (CTO)

In charge mode, when *Current()* > *CTO Charge Thershold*, the CTO timer begins to count from zero. If *Current()* < *CTO Suspend Threshold*, the CTO timer stops counting, otherwise it keeps counting. When the CTO timer counts to *CTO Time*, SH366006 triggers CTO protection , the C-FET is turned off, the *ChargingCurrent()* and *ChargingVoltage()* are set to zero, and the *[CTO]*, *[XCHG]* and *[TCA]* flags are set.

The charge timeout protection can exit individually by two ways depend on *[NR]* bit configuration:

Firstly, when *[NR]* = 0 (removable Battery Mode), removing and reinserting the pack can make SH366006 recover from charge timeout protection with clearing *[CTO]* flag.

Secondly,when *[NR]* = 1 (Non-removable Battery Mode), it can make SH366006 recover from charge timeout protection with clearing *[CTO]* that the discharge mode is detected and discharged by *CTO Revery.*

When a charge timeout recovery condition is detected, then the CHG FET is allowed to be turned on, *[XCHG][TCA]* flags are reset, and *ChargingCurrent()* and *ChargingVoltage()* are set to the appropriate value per the charging algorithm.

The CTO timer is reset also throuth these two ways above.

Pre-charge Timeout Function (PTO)

In Precharge mode, when *Current() > PTO Charge Thershold*, the PTO timer begins to count from zero. If *Current() < PTO Suspend Threshold*, the PTO timer stops counting, otherwise it keeps counting. When the PTO timer counts to *PTO Time*, SH366006 triggers PTO protection , the CHG or PCHG (if used) FET is turned off, the *ChargingCurrent()* and *ChargingVoltage()* are set to zero, and the *[PTO]*, *[XCHG]* and *[TCA]* flags are set.

The precharge timeout protection can exit individually by two ways depend on *[NR]* bit configuration:

Firstly, when *[NR]* = 0 (removable Battery Mode), removing and reinserting the pack can make SH366006 recover from precharge timeout protection with clearing *[PTO]* flag.

Secondly,when *[NR]* = 1 (Non-removable Battery Mode), it can make SH366006 recover from precharge timeout protection with clearing *[PTO]* that the discharge mode is detected and discharged by *PTO Revery.*

When a charge timeout recovery condition is detected, then the CHG or PCHG (if used) FET is allowed to be turned on, *[XCHG] [TCA]* flags are reset, and *ChargingCurrent()* and *ChargingVoltage()* are set to the appropriate value per the charging algorithm.

The PTO timer is reset also throuth these two ways above.

5.6.6 AFE Watchdog

The AFE automatically turns off the CHG FET and DSG FET, if it does not receive the 32 KHz frequency on the WDF pin from SH366006. When the internal interrupt is triggered by AFE, the SH366006 reads the STATUS register of the AFE. If the *[WDF]* is set, the *[WDF]* in *SafetyStatus()* is set as well, and then periodic verification on the AFE RAM is undertaken. If the verification is failure the FETs will be turned off. However, the verification will continue once a second. If the periodic verification is passed, then *[WDF]* in *SafetyStatus()* will be cleared, and the FETs will return to normal operation.

5.6.7 Overcharge Protection

The SH366006 goes into overcharge protection if battery pack capacity is charged to exceed *FullChargeCapacity()* for *OC Capacity Threshold*, CHG FET is turned off, the *ChargingCurrent()* and *ChargingVoltage()* are set to zero, and *[TCA]*, *[OCA]* flags in *BatteryStatus()*, *[XCHG]* flag in *OperationStatus()* and *[OC]* flag in *SafetyStatus()* are set.

When *[NR]* = 0, the SH366006 recovers from overcharge protection if battery pack is removed and reinserted.

When *[NR]* = 1, the SH366006 recovers from overcharge protecion if continuous amount of discharge ≥ *OC Capacity Recovery* or if *RelativeStateOfCharge()* ≤ *OC RSOC Recovery*.

On recovery, CHG FET is turned on, *[TCA]* and *[OCA]* flags in *BatteryStatus()*, *[XCHG]* flag in *OperationStatus()* and *[OC]* flag in *SafetyStatus()* are cleared.

5.7 2nd Level Protection

SH366006 provides 2nd level protection which disables charge and discharge function permanently by permanently turning off CHG/DSG FETs, some of them blow the fuse in primary circuit additionally, when the system is under dangerous conditions, such as serious overvoltage, overcurrent or overtemperature, etc.

5.7.1 2nd Level Protection Introduction

SH366006 can permanently disable the use of battery pack and report a 2nd level protection by setting the appropriate flag in the *PFStatus()* function if the monitored value reaches or rises above the protection threshold for a period of max alert duration. The 2nd level protection checks, except for IFC and DFF, can be enabled and disabled individually by configuring the appropriate bit *PF Enable Cfg A* and *PF Enable Cfg B*. All 2nd level protection checks, except for IFC and DFF, are disabled until *ManufacturingStatus()[PF_EN]* is set.

On the first occasion of a permanent failure, the *PFStatus()* value is stored in *PF Flags 1* and *PF Flags 2*. When any NEW cause of a permanent failure is set in *PFStatus()* function, the NEW cause is added to *PF Flags 1* register but not the *PF Flags 2*.

When the *PFStatus()* register changes from 0x00 to indicate a permanent failure, then the following actions are taken in sequence.:

a. CHG, DSG, and PCHG FETs are turned OFF.

b. The *[TCA]*, *[TDA]* in *BatteryStatus()* and *[PF]*, *[XCHG]*, *[XDSG]* flags in *OperationStatus()* are set.

c. The *ChargingCurrent()* and *ChargingVoltage()* are set to 0.

d. Data Flash write access is then disabled, but the data flash can be read.

e. The FUSE pin is driven and latched high then the fuse will be blown (if related configuration in *Fuse Blow Cfg A* or *Fuse Blow Cfg B* is set).

5.7.2 2nd Level Protection Status

The SH366006 detects work environment such as current, voltage, temperature and clock, etc and provides protection such as Safety Undervoltage Protection (SUV), Safety Overvoltage Protection (SOV), Cell Imbalance Fault (CIM), Safety Overcurrent Protection (SOCC & SOCD), Safety Overtemperature Protection (SOTC & SOTF), FET Fault Protection (CFETF & DFETF), 2nd Level Protection IC Input (PFIN), AFE Failure Protection (AFEC & AFER), Flash Failure (DFF & IFC), TS Sensor Failure (TS1, TS2, TS3, TS4) and other permanent failure (ISD/TDD/OWB), etc.

Safety Undervoltage Protection (SUV)

SOV protection occurs if the min cell voltage is lower than or equal to *SUV Threshold* for over *SUV Time*. Under the SUV protection, *[SUV]* in *PFStatus()* is set.

If the *[SUV]* bit in *PF Enable Cfg A* is cleared, this function is disabled.

Note: If one cell voltage is lower than *SUV Voltage Threshold*, when SH366006 wakes up from shutdown state (min cell voltage < *shutdown voltage* for more than *shutdown time*) by a charger, it keeps C-FET off for avoiding charging to fill the voltage bank. If all cell voltages are higher than *SUV Voltage Threshold*, C-FET off will be relieved for other functions control after POR.

Safety Overvoltage Protection (SOV)

SOV protection occurs if the max cell voltage is higher than or equal to *SOV Threshold* for over *SOV Time*. Under the SOV protection, *[SOV]* in *PFStatus()* is set.

If the *[SOV]* bit in *PF Enable Cfg A* is cleared, this function is disabled.

Safety Charge Overcurrent Protection (SOCC)

SOCC protection occurs if charging current reaches or exceeds the *SOC Chg* Threshold for over *SOC Chg Time*. Under the SOCC protection, *[SOCC]* in *PFStatus()* is set.

If the *[SOCC]* bit in *PF Enable Cfg A* is cleared, this function is disabled.

Safety Discharge Overcurrent Protection (SOCD)

SOCD protection occurs if the discharging current reaches or exceeds the *SOC Dsg* Threshold for over *SOC Dsg Time*. Under the SOCD protection, *[SOCD]* in *PFStatus()* is set.

If the *[SOCD]* bit in *PF Enable Cfg A* is cleared, this function is disabled.

Safety Cell Overtemperature Protection (SOTC)

SOTC protection occurs if Max Cell Temp reaches or exceeds the *SOTC Threshold* for over *SOTC Time*. Under the SOTC protection, *[SOTC]* in *PFStatus()* is set.

If the *[SOTC]* bit in *PF Enable Cfg A* is cleared, this function is disabled.

Safety FET Overtemperature Protection (SOTF)

SOTF protection occurs if the FET Temperature in *DAStatus2()* reaches or exceeds *SOTF Threshold* for *SOTF Time*. Under the SOTF protection, *[SOTF]* in *PFStatus()* is set.

If the *[SOTF]* bit in *PF Enable Cfg A* is cleared, this function is disabled.

Charge FET Fault Protection (CFETF)

CFETF protection occurs if SH366006 detects the CHG FET off but still detects a continues current ≥ *CFET Fail Current* exist for *CFET Fail Time*. Under the CFETF protection, *[CFETF]* in *PFStatus()* is set.

If the *[CFETF]* bit in *PF Enable Cfg B* is cleared, this function is disabled.

Discharge FET Fault Protection (DFETF)

DFETF protection occurs if SH366006 detects the DSG FET off but still detects a continues current ≤ - *DFET Fail Current* exist for *DFET Fail Time*. Under the DFETF protection, *[DFETF]* in *PFStatus()* is set.

If the *[DFETF]* bit in *PF Enable Cfg B* is cleared, this function is disabled.

2nd Level Protection IC Input (PFIN)

The PFIN input of SH366006 can be used to determine the state of an external protection device. PFIN protection occurs if the PFIN pin is driven low for over *PFIN Detect Time*. Under the PFIN protection, *[PFIN]* in *PFStatus()* is set.

If the *[PFIN]* bit in *PF Enable Cfg B* is cleared, this function is disabled.

AFE Communication Fault Protection (AFEC)

SH366006 periodically validates its read and write communications with the AFE. If either a read or write verify fails, an internal AFE_Fail_Counter starts. If the AFE_Fail_Counter reaches *AFE Fail Limit*, SH366006 reports an *[AFEC]* permanent failure. Under the AFEC protection, *[AFEC]* in *PFStatus()* is set.

If the *[AFEC]* bit in *PF Enable Cfg B* is cleared, this feature is disabled.

AFE Register Failure Protection (AFER)

An *[AFER]* fault can also be declared if, after a full reset, the initial gain and offset values read from the AFE cannot be verified and the max difference between two readings is fixed at 20. Under the AFER protection, *[AFER]* in *PFStatus()* is set.

If the *[AFER]* bit in *PF Enable Cfg B* is cleared, this feature is disabled.

Instruction Flash Checksum Failure (IFC)

IFC protection occurs when the Instruction Flash checksum verify erroneous after a reset. Under the IFC protection, *[IFC]* in *PFStatus()* is set.

DataFlash Failure (DFF)

SH366006 detects whether the data flash operates correctly every read or write operation. DFF protection occurs when the dataflash write/erase operation fails. Under the DFF protection, *[DFF]* in *PFStatus()* is set.

Chemical Fuse Permanent Fail (FUSE)

FUSE protection occurs if SH366006 detects *PFStatus()* ≠ 0 and |*Current()*| continuous ≥ *FUSE Fail Current* for *FUSE Fail Time* after *Fuse Blow Timeout* expired. Under the FUSE protection, *[FUSE]* in *PFStatus()* is set .

If the *[FUSE]* bit in *PF Enable Cfg B* is cleared, this feature is disabled.

Internal Short Detection (ISD)

To detect Internal Short Detection, SH366006 records the two OCVs ($OCV1_{celli}$ and $OCV2_{celli}$, i=1, 2, 3, 4) and Temperatures (T1 and T2) when Min cell Voltage > *ISD OCV Threshold* before and after ISD Delta Time.

When (Min(T1,T2)<5degC and |T1-T2|<5degC) OR (Min(T1,T2)≥5degC), the fusion gauge detects the following two conditions and sets [ISD] in PF Flags to indicate the ISD permanent failure occurrence if there are both satisfied.

1) (Max ΔV/Δt)>*ISD Delta Voltage*(default=35mV/hr), Δt = *ISD Delta Time*(default=0.5h).

For example, during the last 0.5h, at least one cell voltage must vary over 17.5mV considering circuit accuracy.

2) (Max ΔV/*ISD Delta Time*-MinΔV/ *ISD Delta Time*) >*ISD Voltage Threshold* [mV].

It means that if the Delta voltage difference for different cells in the last *ISD Delta Time* exceeds *ISD Voltage Threshold*, internal short is identified. Under the ISD permanent failure, *[ISD]* in *PFStatus()* is set.

If the *[ISD]* bit in *PF Enable Cfg A* is cleared, this function is disabled.

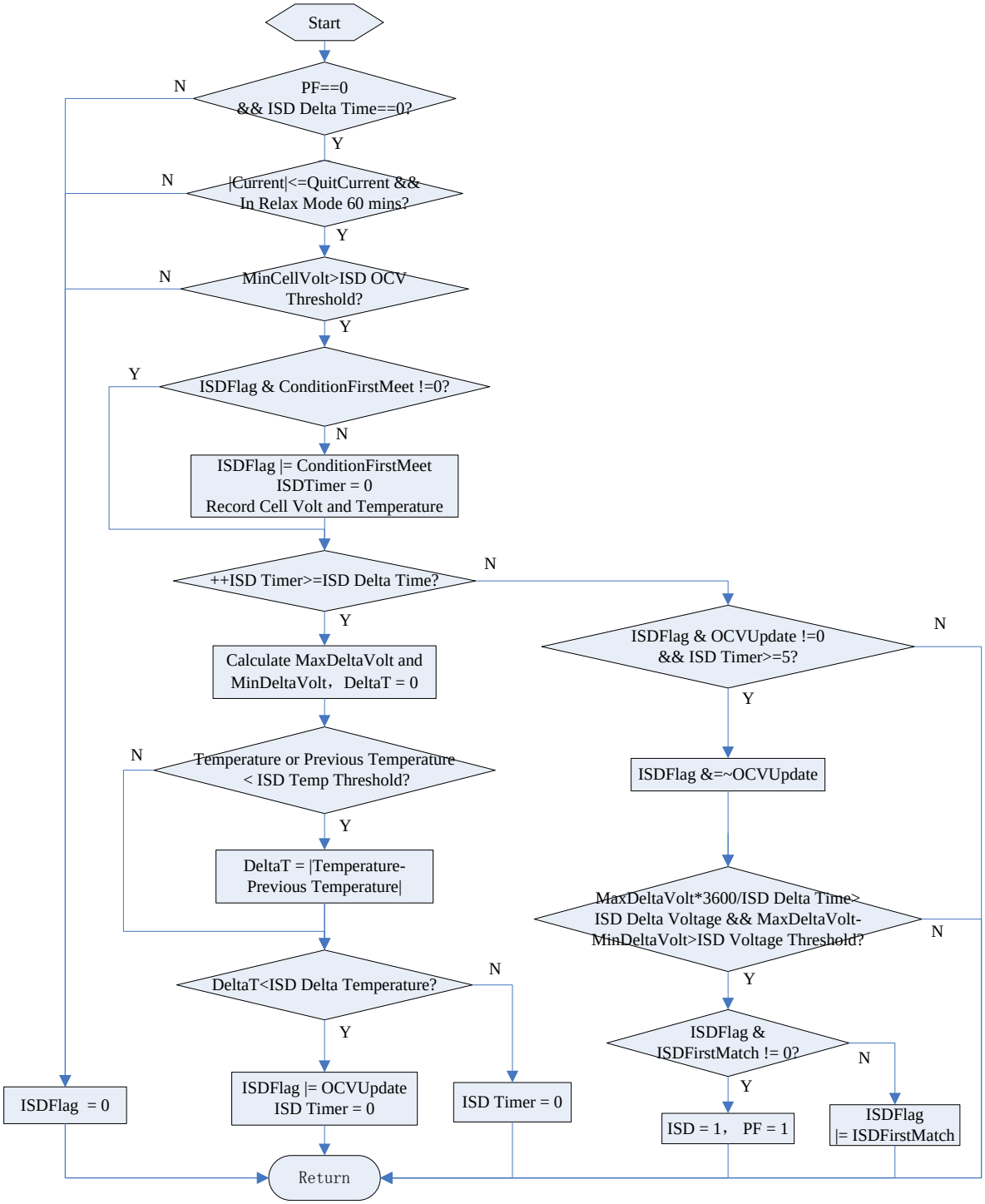


Fig.10 Internal Short Detection Entrance

Tab Disconnection Detection (TDD)

To detect Tab Disconnection Detection(TDD) condition when *CellTemperature() > TDD Temp Threshold* (default=0degC) , the Gas Gauge has capacity to detect the passed charge during CHG/DSG-Relax cycle and disable the pack charging/discharging to avoid over charge risk.

Take a 2 series-2 parallel cell block for example, after a discharge or charge procedure, the Gas Gauge detects the passed charge (PC) and two OCV values in the two relax modes before and after the procedure. When disconnection occur, a very large gap between the OCV values of different cell block in relax mode could be exist. The SOC (SOC1, 2 of different cell block before and after discharge/charge) which can be found in OCV-SOC table could be used to calculate the actual passed charge of each cell block (PC1: cell block1, PC2: cell block2). If PC>*TDD Percent Threshold* (default=37%)**Design Capacity* and Max (PC1, PC2)>*TDD Multiple Factor* (default=15, means 1.5 times)*Min (PC1, PC2), Sh366006 responds the Tab Disconnection Detection (TDD) permanent failure and the *[TDD]* flag in *PFStatus()* is set.

If the *[TDD]* bit in *PF Enable Cfg A* is cleared, this function is disabled.

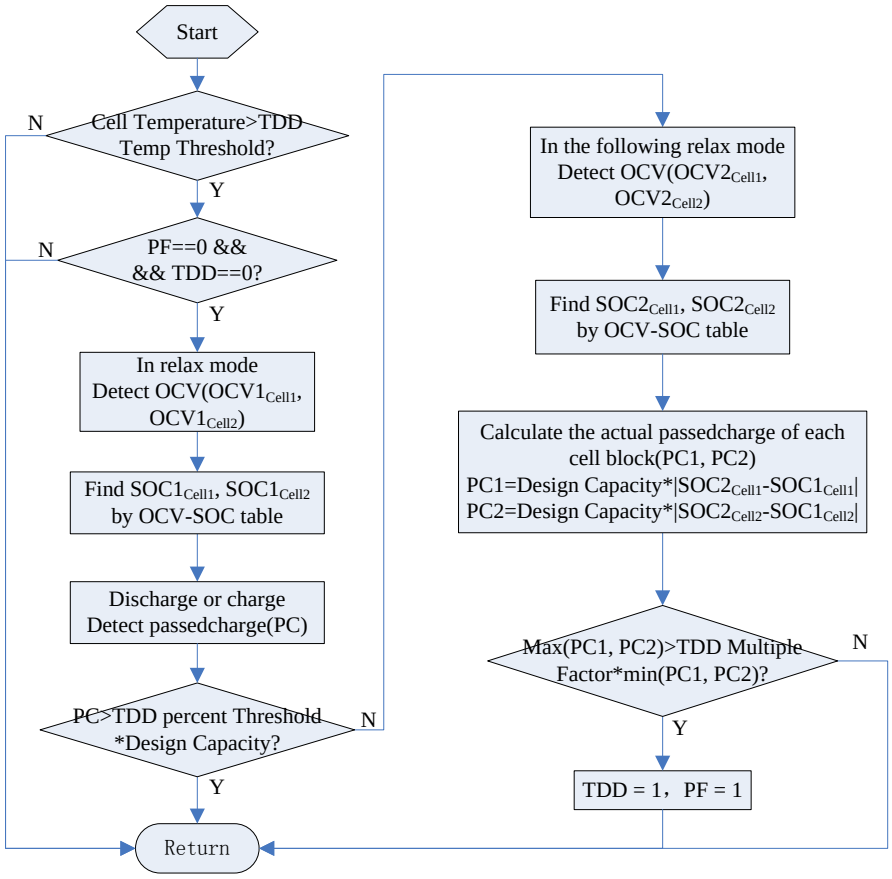


Fig.11 Tab Disconnection Detection Entrance

Old Weak Battery (OWB)

OWB protection occurs if *Total Usage Time* of the Lifetime Data > *OWB Time* and SOH (FCC/*Design Capacity*) < *OWB SOH Threshold*. Under the OWB protection, *[OWB]* in *PFStatus()* is set.

If the *[OWB]* bit in *PF Enable Cfg A* is cleared, this function is disabled.

Thermistor Failure (TS1, TS2, TS3, TS4)

In case of Thermistor Failure, the thermal resistor could be disconnected to the system or short-circuit exist, the SH366006 should be respond a permanent failure for the Thermistor Failure when TSx(which is TS1, TS2, TS3 or TS4) Temperature ≥130degC or ≤ -50degC for *Thermistor Error Time*. In the Thermistor Failure permanent failure, *[TSx]* (which is TS1, TS2, TS3 or TS4) in *PFStatus()* is set.

If the *[TSx]* (x=1~4) bit in *PF Enable Cfg B* is cleared, the related TSx (x=1~4) thermistor failure is disabled.

Cell Imbalance Fault (CIM)

Under the condition that max cell voltage is higher than or equal to *Cell Imbalance Check Voltage*, SH366006 starts cell imbalance fault detection when *Current()* is less than or equal to *Cell Imbalance Current* for *Battery Rest Time period*. When the cell voltage deviation exceeds *Cell Imbalance Fail Voltage* and lasts longer than *Cell Imbalance Time*, CIM Protection occurs. In CIM permanent failure, *[CIM]* in *PFStatus()* is set.

If the *[CIM]* bit in *PF Enable Cfg A* is cleared, this function is disabled.

5.7.3 2nd Level Protection Clearance

SH366006 permanent failure can be cleared by sending the *PF Data Reset subcommand (0x0029)* through *ManufacturerAccess()* in unsealed mode.

After sending this subcommand, All *PF Data* except for *PF Flags 2* and *PFStatus()* flags are cleared and the system returns to previous state.

5.7.4 Fuse Blow Function

The FUSE pin is drived high if configured for specific failures in *Fuse Blow Cfg A* and *Fuse Blow Cfg B* and Voltage() is above Min Blow Fuse Voltage or there is a CHG FET (CFETF) Or DSG FET (DFETF) failure. The FUSE pin will remain asserted until the *Fuse Blow Time* expired.

5.7.5 PF Data Recorder

When a permanent fail occurs, the PF Data Recorder logs the pack information for permanent fail analysis.This information is writen to data flash before data flash updating are disabled.

- PF Status 1
- PF Status 2
- Cell1 Voltage/Cell2 Voltage/Cell3 Voltage/Cell4 Voltage
- Pack Voltage
- *Current()*
- TS1, TS2, TS3, TS4 temperature in DAStatus2

5.8 Lifetime Data Collection

Useful for analysis, the SH366006 has extensive capabilities for logging events over the life of the pack. The Lifetime Data Collection is enabled by setting *ManufactureStatus[LF_EN]* = 1. The data is collected in RAM and only written to DF under the following conditions to avoid wear out of the data flash:

• Every 10 hours if RAM content is different from flash.

• In permanent fail, before data flash updates are disabled.

• A reset counter increments. The lifetime RAM data is reset; therefore, only the reset counters are updated to data flash.

• Before scheduled shutdown.

• Before low voltage shutdown and the voltage is above the *Flash Update OK Voltage*

The Lifetime Data stops collecting under following conditions:

• After permanent fail.

• Lifetime Data Collection is disabled by setting *ManufactureStatus [LF_EN]* = 0.

Total usage timer starts when Lifetime Data is enabled.

• Voltage

– Max Cell Voltage each cell

– Min Cell Voltage each cell

• Current

– Max charge current

– Max discharge current

• Temperature

– Max Cell Temp

– Min Cell Temp

– Max FET Temp

• Safety events that trigger the SafetyStatus()

– Number of safety events

– CycleCount at last safety event(s)

5.9 Security

There are three levels of secured operation within SH366006 and they are Full Access, Unsealed and Sealed.

5.9.1 Access Authority

In different secure mode SMBus has different access authority. Details are listed below:

Security	Standard SBS	Extended SBS	DataFlash
Full Access	All	All	All
Unsealed	All	Limited	All
Sealed	All	Limited	Forbidden

5.9.2 Full Access or Unsealed to Sealed

The Seal Device command instructs the SH366006 to Sealed Mode and sets the *[SS]* flag.

In Sealed Mode, SBS functions have access to battery information, but not to partial subcommand in *ManufacturerAccess()* and data flash. Once in sealed mode, the part can never permanently return to Unsealed or Full Access modes.

5.9.3 Sealed to Unsealed

Once the Unseal Device is commanded, the SH366006 goes into Unsealed Mode and clears the *[SS]* flag.

In Unsealed Mode all data, SBS, and DF have read/write access.

Unsealing must be a 2-step-command performed by writing key1 and key2 of the *UnSealKey()* to *ManufacturerAccess()*. For an example, if the *UnsealKey()* is 0x56781234, key1 is 0x5678 and key2 is 0x1234. Then *ManufacturerAccess()* should supply 0x7856 and 0x3412 to unseal the part.

A reset or the *ManufacturerAccess()* seal device command will bring the SH366006 back to sealed mode.

The unseal key can be read and changed via the extended SBS block command *UnSealKey()* when in Full Access Mode.

5.9.4 Unsealed to Full Access

Once the Full Access Device is commanded, the SH366006 goes into Full Access Mode and allows full access to all SBS commands and DataFlash.

Changing from Unsealed to Full Access must be performed by writing key1 and key2 of the *FullAccessKey()* to *ManufacturerAccess()*.

A reset or the ManufacturerAccess seal device command will bring the SH366006 back to sealed mode.

The full access key can be read and changed via the extended SBS block command *FullAccessKey()* when in Full Access Mode.

The SH366006 is shipped by Sinowealth in Full Access Mode by default. Only in this mode, the SH366006 can enter Boot ROM by command.

5.10 SMBus Communication

The SH366006 uses SMBus v1.1 with Master Mode and packet error checking (PEC) options per the SBS specification where the data format follows CRC8 calculation. The SH366006 uses the address 0x16 by default on SMB for communication.

5.11 Standard SBS Commands

The SH366006 SBS command set meets the SBD v1.1 specification. Smart battery host acquires battery information by sending corresponding commands to SH366006. The SBData commands are listed below.

SBS Command	Access			Name	Format	Byte	Min	Max	Default	Unit
	SE	US	FA							
0x00	R/W	R/W	R/W	*ManufacturerAccess*	Hex	2	0x0000	0xffff	-	hex
0x01	R/W	R/W	R/W	*RemainingCapacityAlarm*	Unsigned int	2	0	65535	-	mAh or cWh
0x02	R/W	R/W	R/W	*RemainingTimeAlarm*	Unsigned int	2	0	65535	-	min
0x03	R/W	R/W	R/W	*BatteryMode*	Hex	2	0x0000	0xffff	-	hex
0x04	R/W	R/W	R/W	*AtRate*	Signed int	2	-32768	32767	-	mA or cW
0x05	R	R	R	*AtRateTimeToFull*	Unsigned int	2	0	65535	-	min
0x06	R	R	R	*AtRateTimeToEmpty*	Unsigned int	2	0	65535	-	min
0x07	R	R	R	*AtRateOK*	Unsigned int	2	0	65535	-	-
0x08	R	R	R	*Temperature*	Unsigned int	2	0	65535	-	0.1°K
0x09	R	R	R	*Voltage*	Unsigned int	2	0	20000	-	mV
0x0A	R	R	R	*Current*	Unsigned int	2	-32768	32767	-	mA
0x0B	R	R	R	*AverageCurrent*	Unsigned int	2	-32768	32767	-	mA
0x0C	R	R	R	*MaxError*	Unsigned int	2	0	100	-	%
0x0D	R	R	R	*RelativeStateOfCharge*	Unsigned int	1	0	100	-	%
0x0E	R	R	R	*AbsoluteStateOfCharge*	Unsigned int	1	0	100	-	%
0x0F	R	R	R	*RemainingCapacity*	Unsigned int	2	0	65535	-	mAh or cWh
0x10	R	R	R	*FullChargeCapacity*	Unsigned int	2	0	65535	-	mAh or cWh
0x11	R	R	R	*RunTimeToEmpty*	Unsigned int	2	0	65535	-	min
0x12	R	R	R	*AverageTimeToEmpty*	Unsigned int	2	0	65535	-	min
0x13	R	R	R	*AverageTimeToFull*	Unsigned int	2	0	65535	-	min
0x14	R	R	R	*ChargingCurrent*	Unsigned int	2	0	65535	-	mA
0x15	R	R	R	*ChargingVoltage*	Unsigned int	2	0	65535	-	mV
0x16	R	R	R	*BatteryStatus*	Unsigned int	2	0x0000	0xffff	-	hex
0x17	R	R/W	R/W	*CycleCount*	Unsigned int	2	0	65535	-	-
0x18	R	R/W	R/W	*DesignCapacity*	Unsigned int	2	0	65535	-	mAh or cWh
0x19	R	R/W	R/W	*DesignVoltage*	Unsigned int	2	700	16000	14400	mV
0x1A	R	R/W	R/W	*SpecificationInfo*	Unsigned int	2	0x0000	0xffff	0x0031	hex
0x1B	R	R/W	R/W	*ManufactureDate*	Unsigned int	2	0	65535	0	-
0x1C	R	R/W	R/W	*SerialNumber*	Hex	2	0x0000	0xffff	0x0001	hex
0x1D	R	R	R	*Real RemainingCapacity*	Unsigned int	2	0	65535	-	mAh or cWh
0x1E	R	R	R	*Real FullChargeCapacity*	Unsigned int	2	0	65535	-	mAh or cWh
0x20	R	R	R	*ManufacturerName*	String	15+1	-	-	Sinowealth	ASCII
0x21	R	R	R	*DeviceName*	String	15+1	-	-	SH366006	ASCII
0x22	R	R	R	*DeviceChemistry*	String	4+1	-	-	LION	ASCII
0x23	R	R	R	*ManufacturerData*	Block	-	-	-	-	ASCII
0x2F	R/W	R/W	R/W	*Authenticate*	Block	20+1	-	-	-	ASCII
0x3C	R	R	R	*CellVoltage4*	Unsigned int	2	0	65535	-	mV
0x3D	R	R	R	*CellVoltage3*	Unsigned int	2	0	65535	-	mV
0x3E	R	R	R	*CellVoltage2*	Unsigned int	2	0	65535	-	mV
0x3F	R	R	R	*CellVoltage1*	Unsigned int	2	0	65535	-	mV

Table.8 SBData List

5.11.1 *ManufacturerAccess (0x00) and ManufacturerBlockAccess (0x44)*

There are two methold of reading and writing data in the Manufacturer Access System (MAC).

One method is through *ManufacturerBlockAccess()* command. The MAC command is sent via *ManufacturerBlockAccess()* by the SMBus block protocol. The result is returned on *ManufacturerBlockAccess()* via an SMBus block read.

Example: Send a MAC Permanent Failure subcommand to enable all permanent failure check via *ManufacturerBlockAccess()*.

1. With Permanent Failure Detection disabled, send Permanent Failure (0x0024) to *ManufacturerBlockAccess()*.

   a) SMBus block write. Command = 0x44. Data = 24 00 (data must be sent in little endian)

2. Permanent Failure Detection is enabled, and *ManufacturerStatus()[PF_EN]* = 1.

Example: Read Chemical ID (0x0006) via *ManufacturerBlockAccess()*.

1. Send Chemical ID subcommand to *ManufacturerBlockAccess()*.

   a) SMBus block write. Command = 0x44. Data sent = 06 00 (data must be sent in little endian)

2. Read the result from *ManufacturerBlockAccess()*.

   a) SMBus block read. Command = 0x44. Data read = 06 00 51 50 (each data entity is returned in little endian).

   b) The first 2 bytes, “06 00”, is the MAC command.

   c) The second 2 bytes, “51 50”, is the Chemical ID returning in little endian. Then Chemical ID is 0x5051.

The other method is through *ManufacturerAccess()* and ManufacturerData(). The MAC commands is sent via *ManufacturerAccess()* by an SMBus write word protocol, and the result is returned on *ManufacturerData()* via an SMBus block read. Note that the result reading from *ManufacturerData()* includes the MAC command.

Example: Send a MAC Permanent Failure subcommand to enable all permanent failure check via *ManufacturerAccess()*.

1. With Permanent Failure Detection disabled, send Permanent Failure (0x0024) to *ManufacturerAccess()*.

   a) SMBus word write. Command = 0x00. Data = 0024 (Data to address 0x00 is not little endian.)

2. Permanent Failure Detection is enabled, and *ManufacturerStatus()[PF_EN]* = 1.

Example: Read Chemical ID (0x0006) via ManufacturerAccess().

1. Send Chemical ID subcommand to ManufacturerAccess().

   a) SMBus word write. Command = 0x00. Data sent = 0006 (data to address 0x00 is not little endian.)

2. Read the result from *ManufacturerData()*.

   a) SMBus block read. Command = 0x23. Data read = 51 50 (each data entity is returned in little endian.)

   b) Then Chemical ID is 0x5051.

The *ManufacturerAccess()* and *ManufacturerBlockAccess()* are interchangeable. The result can be read from *ManufacturerData()* or *ManufacturerBlockAccess()*, regardless of how the MAC command is sent.

Sub Command	Name	Access	Format	Data Read on 0x44 or ox23	Data Read on 0x2F	Available in SEALED Mode	Type	Unit
0x0001	Device Type	R	Block	Yes	-	Yes	Hex	-
0x0002	Firmware Version	R	Block	Yes	-	Yes	Hex	-
0x0003	Hardware Version	R	Block	Yes	-	Yes	Hex	-
0x0004	IF CheckSum	R	Block	Yes	-	Yes	Hex	-
0x0005	Static DF Checksum	R	Block	Yes	-	Yes	Hex	-
0x0006	Chemistry ID	R	Block	Yes	-	Yes	Hex	-
0x0008	Cell Para Checksum	R	Block	Yes	-	Yes	Hex	-
0x0009	All DF Checksum	R	Block	Yes	-	Yes	Hex	-
0x0010	Shutdown	W	-	-	-	Yes	Hex	-
0x0011	Sleep Command	W	-	-	-	-	Hex	-
0x001d	Fuse Toggle	W	-	-	-	-	Hex	-
0x001e	PCHG FET Toggle	W	-	-	-	-	Hex	-
0x001f	CHG FET Toggle	W	-	-	-	-	Hex	-
0x0020	DSG FET Toggle	W	-	-	-	-	Hex	-
0x0022	FET Control	W	-	-	-	-	Hex	-
0x0023	Lifetime Data Collection	W	-	-	-	-	Hex	-
0x0024	Permanent Failure Detection	W	-	-	-	-	Hex	-
0x0026	Fuse Control	W	-	-	-	-	Hex	-
0x0028	Lifetime Data Reset	W	-	-	-	-	Hex	-
0x0029	PF Data Reset	W	-	-	-	-	Hex	-
0x0030	Seal Device	W	-	-	-	-	Hex	-
0x0035	Security Keys	R/W	Block	Yes	-	-	Hex	-
0x0037	Authentication Key	R/W	Block	-	Yes	-	Hex	-
0x0040	Calibration Mode	W	-	-	-	-	Hex	-
0x0041	Device Reset	W	-	-	-	-	Hex	-
0x0051	SafetyStatus	R	Block	Yes	-	Yes	Mixed	Mixed
0x0053	PFStatus	R	Block	Yes	-	Yes	Mixed	Mixed
0x0054	OperationStatus	R	Block	Yes	-	Yes	Mixed	Mixed
0x0055	ChargingStatus	R	Block	Yes	-	Yes	Mixed	Mixed
0x0057	ManufacturingStatus	R	Block	Yes	-	Yes	Mixed	Mixed
0x0058	AFE Data	R	Block	Yes	-	Yes	Hex	-
0x0060	Liftime Data Block 1	R	Block	Yes	-	Yes	Mixed	Mixed
0x0061	Liftime Data Block 2	R	Block	Yes	-	Yes	Mixed	Mixed
0x0062	Liftime Data Block 3	R	Block	Yes	-	Yes	Mixed	Mixed
0x0070	ManufacturerInfo	R	Block	Yes	-	Yes	Hex	-
0x0071	DAStatus1	R	Block	Yes	-	Yes	Mixed	Mixed
0x0072	DAStatus2	R	Block	Yes	-	Yes	Mixed	Mixed

Table.9 ManufacturerAccess subcommand

1) *ManufactureAccess () 0x0000 Default*

A read word on this command returns the *OperationStatus()* data.

2) *ManufactureAccess () 0x0001 Device Type*

The SH366006 can be checked for the IC part number. The device type returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: aa AA.

3) *ManufactureAccess () 0x0002 Firmware Version*

The SH366006 can be checked for the firmware version. The firmware version returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*.

4) *ManufactureAccess () 0x0003 Hardware Version*

The SH366006 can be checked for the hardware version. The hardware version returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*.

5) *ManufactureAccess () 0x0004 IF Checksum*

The SH366006 can return the instruction flash checksum. The instruction flash checksum returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*.

6) *ManufactureAccess () 0x0005 Static DF Checksum*

The SH366006 can return the static data flash checksum which is calculated by all static data flash parameters. The static DF checksum returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*.

7) *ManufactureAccess () 0x0006 Chemical ID*

This command returns the chemical ID of the OCV tables used in the gauging algorithm. The chemical ID returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*.

8) *ManufactureAccess () 0x0008 Cell Para Checksum*

The SH366006 can return the cell parameters checksum which is calculated by all cell related parameters. The cell para checksum returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*.

9) *ManufactureAccess () 0x0009 All DF Checksum*

The SH366006 can return the all data flash checksum which is calculated by all data flash parameters. The all DF checksum returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*.

10) *ManufactureAccess () 0x0010 Shutdown Command*

Sending this command instructs the SH366006 to verify and enter ShutDown Mode.

11) *ManufactureAccess () 0x0011 Sleep Command*

Sending this command instructs the SH366006 to verify and enter Sleep Mode.

12) *ManufactureAccess () 0x001D Fuse Toggle*

This command manually activates or deactivates the FUSE output. If the *OperationStatus()[FUSE]* = 0 indicates the FUSE output is low, sending this command toggles the FUSE output to be high and the *OperationStatus()[FUSE]* = 1 and vice versa.

13) *ManufactureAccess () 0x001E PCHG FET Toggle*

This command manually turns on or off the Precharge MOSFET. If the *ManufacturingStatus()[PCHG_T]* = 0, sending this command will turn on the Precharge MOSFET and the *ManufacturingStatus()[PCHG_T]* = 1 and vice versa. This command is only enabled when the *ManufacturingStatus()[FET_EN]* = 0, indicating an FW FET Control is not active and manual control is allowed. A reset will clear *ManufacturingStatus()[PCHG_T]* and turn off the Precharge MOSFET.

14) *ManufactureAccess () 0x001F CHG FET Toggle*

This command manually turns on or off the Charge MOSFET. If the *ManufacturingStatus()[CHG_T]* = 0, sending this command will turn on the Charge MOSFET and the *ManufacturingStatus()[CHG_T]* = 1 and vice versa. This command is only enabled when the *ManufacturingStatus()[FET_EN]* = 0, indicating an FW FET Control is not active and manual control is allowed. A reset will clear *ManufacturingStatus()[CHG_T]* and turn off the Charge MOSFET.

15) *ManufactureAccess () 0x0020 DSG FET Toggle*

This command manually turns on or off the Discharge MOSFET. If the *ManufacturingStatus()[DSG_T]* = 0, sending this command will turn on the Discharge MOSFET and the *ManufacturingStatus()[DSG_T]* = 1 and vice versa. This command is only enabled when the *ManufacturingStatus()[FET_EN]* = 0, indicating an FW FET Control is not active and manual control is allowed. A reset will clear *ManufacturingStatus()[DSG_T]* and turn off the Discharge MOSFET.

16) *ManufactureAccess () 0x0022 FET Control*

This command disables or enables the control of Precharge, Charge and Discharge MOSFETs by the firmware. The initial setting is loaded from *Init Mfg Status[FET_EN]*. If the *ManufacturingStatus()[FET_EN]* = 0, sending this command allows the firmware to control all mosfets and the *ManufacturingStatus()[FET_EN]* = 1 and vice versa.

In UNSEALED mode, the *ManufacturingStatus()[FET_EN]* status is copied to *Init Mfg Status[FET_EN]* when the command is received. The SH366006 remains on its latest FET Control status prior to a reset.

17) *ManufactureAccess () 0x0023 Lifetime Data Collection*

This command disables or enables Lifetime Data Collection fuction. The initial setting is loaded from *Init Mfg Status[LF_EN]*. If the *ManufacturingStatus()[LF_EN]* = 0, sending this command starts the Lifetime Data Collection and the *ManufacturingStatus()[LF_EN]* = 1 and vice versa.

In UNSEALED mode, the *ManufacturingStatus()[LF_EN]* flag is copied to *Init Mfg Status[LF_EN]* when this command is received. The SH366006 remains on its latest Lifetime Data Collection setting prior to a reset.

18) *ManufactureAccess () 0x0024 Permanent Failure Detection*

This command disables or enables Permanent Failure Detection.The initial setting is loaded from *Init Mfg Status[PF_EN]*. If the *ManufacturingStatus()[PF_EN]* = 0, sending this command enables Permanent Failure Detection and the *ManufacturingStatus()[PF_EN]* = 1 and vice versa.

In UNSEALED mode, *ManufacturingStatus()[PF_EN]* flag is copied to *Init Mfg Status[PF_EN]* when this command is received. The SH366006 remains on its PF Detecton enable or disable setting prior to a reset.

19) *ManufactureAccess () 0x0026 Fuse Control*

This command disables or enables firmware-based fuse activation. The initial setting is loaded from *Init Mfg Status[FUSE_EN]*. If the *ManufacturingStatus()[FUSE_EN]* = 0, sending this command allows the firmware to control the FUSE output and the *ManufacturingStatus() [FUSE_EN]* = 1 and vice versa.

In UNSEALED mode, the *ManufacturingStatus()[FUSE_EN]* status is copied to *Init Mfg Status[FUSE_EN]* when the command is received. The SH366006 remains on its latest Fuse Control setting prior to a reset.

20) *ManufactureAccess () 0x0028 Lifetime Data Reset*

Sending this command resets the Lifetime Data in data flash.

21) *ManufactureAccess () 0x0029 Permanent Fail Data Reset*

Sending this command resets the Permanent Fail Data in data flash.

22) *ManufactureAccess () 0x0030 Seal Device*

Sending this command instructs the SH366006 into Seal Mode. When SH366006 is sealed, the *OperationStatus()[FAS] = 1 and [SS] = 1* and disable partial SBS commands and access to data flash

23) *ManufactureAccess () 0x0035 Security Keys*

This is a read or write command for 2-word UNSEAL and FULL ACCESS Keys.

Security Keys can be read from *ManufacturerData()* or *ManufacturerBlockAccess()*. SH366006 must be in FULL ACCESS mode for security keys to read. The keys are returned in the following format: aaAAbbBBccCCddDD, defined as follow:

Value	Description	Default
AAaa	First word of the UNSEAL key	0x5678
BBbb	Second word of the UNSEAL key	0x1234
CCcc	First word of the FULL ACCESS key	0xCDEF
DDdd	Second word of the FULL ACCESS key	0x90AB

It is highly recommended to change the UNSEAL and FULL ACCESS keys from default.

The keys can only be changed through the *ManufacturerBlockAccess().*

Example: Change UNSEAL key to 0x695A, 0xA596, and leave the FULL ACCESS as default.

Send an SMBus block write with Command = 0x44.

Data = MAC command + New UNSEAL key + New FULL ACCESS KEY = 35 00 5A 69 96 A5 EF CD AB 90

24) *ManufactureAccess () 0x0037 Authentication Key*

This command can enable the update of the authentication key into SH366006. SH366006 must be in FULL ACCESS mode for the authentication key to update.

There are two methold to update a new authentication key:

a. Send the *AuthenticationKey()* + the new 128-bit authentication key to *ManufacturerBlockAccess()*.

b. Send the *AuthenticationKey()* to *ManufacturerAccess()*, then send the 128-bit authentication key to *Authentication()*.

There is no direct read access to the authentication key. After writing the new authentication key to SH366006, SH366006 will generate an all-zero challenge and provide the corresponding response for verification.

There are also two methold to verify the new authentication key:

a. Read the response from *ManufacturerBlockAccess()* after updating the new authentication key.

b. Read the response from *Authentication()* after updating the new authentication key.

25) *ManufactureAccess () 0x0040 Calibration Mode*

This command instructs the SH366006 into calibration mode.

26) *ManufactureAccess () 0x0041 Device Reset*

This command resets the SH366006.

27) *ManufactureAccess () 0x0051 SafetyStatus*

This command returns the *SafetyStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***SafetyStatus(0x51)*** in **Section 5.12.2.**

28) *ManufactureAccess () 0x0053 PFStatus*

This command returns the *PFStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***PFStatus(0x53)*** in **Section 5.12.3**.

29) *ManufactureAccess () 0x0054 OperationStatus*

This command returns the *OperationStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***OperationStatus(0x54)*** in **Section 5.12.4**.

30) *ManufactureAccess () 0x0055 ChargingStatus*

This command returns the *ChargingStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***ChargingStatus(0x55)*** in **Section 5.12.5**.

31) *ManufactureAccess () 0x0057 ManufacturingStatus*

This command returns the *ManufacturingStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***ManufacturingStatus(0x57)*** in **Section 5.12.6**.

32) *ManufactureAccess () 0x0058 AFE Data*

This command returns the AFE Data on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***AFE Data(0x58)*** in **Section 5.12.7**.

33) *ManufactureAccess () 0x0060 Liftime Data Block 1*

This command returns the first block of Lifetime Data on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***Liftime Data Block 1(0x60)*** in **Section 5.12.15**.

34) *ManufactureAccess () 0x0061 Liftime Data Block 2*

This command returns the second block of Lifetime Data on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***Liftime Data Block 2(0x61)*** in **Section 5.12.16**.

35) *ManufactureAccess () 0x0062 Liftime Data Block 3*

This command returns the third block of Lifetime Data on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***Liftime Data Block 3(0x62)*** in **Section 5.12.17**.

36) *ManufactureAccess () 0x0070 ManufacturerInfo*

This command returns the manufacturer information on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***ManufacturerInfo(0x70)*** in **Section 5.12.18**.

37) *ManufactureAccess () 0x0071 DAStatus1*

This command returns the Cell Voltages, PackVoltage, Power and AveragePower on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***DAStatus1(0x71)*** in **Section 5.12.19**.

38) *ManufactureAccess () 0x0072 DAStatus2*

This command returns the TS1 Temperature, TS2 Temperature, TS3 Temperature, TS4 Temperature, Cell Temperature and FET Temperature on *ManufacturerBlockAccess()* or *ManufacturerData()*. For a description of each bit flag, see the ***DAStatus2(0x72)*** in **Section 5.12.20**.

5.11.2 *RemainingCapacityAlarm (0x01)*

This read/ write function sets or gets a low-capacity alarm threshold value. If *RemainingCapacity()* < *RemainingCapacityAlarm*, *[RCA]* flag is set and the SH366006 sends AlarmWarning message to SMBUS host. If *RemainingCapacityAlarm* is set to 0, alarm is disabled.

5.11.3 RemainingTimeAlarm (0x02)

This read or write function sets or gets the RemainingTimeAlarm time threshold. If *AverageTimeToEmpty()*< *RemainingTimeAlarm*, [RTA] flag is set and SH366006 sends AlarmWarning message to SMBus host. If *RemainingTimeAlarm* = 0, this alarm is disabled.

5.11.4 BatteryMode (0x03)

This read or write function selects the various battery operational modes and reports the battery's capabilities, modes, and flags minor conditions requiring attention.

This command can be divided into High Byte and Low Byte. High Byte is Read/Write, Low Byte is Read Only.

Battery Mode	Bits	Format	Allowable Values
INTERAL_CHARGE_CONTROLLER(ICC)	0	Read Only	Always be 1
PRIMARY_BATTERY_SUPPORT(PBS)	1	Read Only	Always be 0
Reserved	2-6	-	Always be 0
CONDITION_FLAG (CF)	7	Read Only	0:System OK 1:Capacity error correction requested
CHARGE_CONTROLLER_ENABLED(CC)	8	R/W	Always be 0
PRIMARY_BATTERY(PB)	9	R/W	Always be 0
Reserved	10-12	-	Always be 0
ALARM_MODE(AM)	13	R/W	Reserved
CHARGE_MODE(ChgM)	14	R/W	Reserved
CAPACITY_MODE(CapM)	15	R/W	0:Reports in mAh/mA 1:Reports in cWh/cW

Table.10 Battery Mode Table

INTERNAL_CHARGE_CONTROLLER — This flag indicates if internal charge controller function is supported (1)or not (0). But there is no internal charge controller in SH366006.

PRIMARY_BATTERY_SUPPORT — Primary battery supported (1) or not (0) by SH366006.This flag is fixed to 0.

CONDITION_FLAG —Capacity error correction requested flag. This flag is set if MaxError > CF MaxError Limit and cleared after capacity error correction being done.

CHARGE_CONTROLLER_ENABLED —Enable or disable internal charge controller. This flag is not used by the SH366006 and should be set to 0.

PRIMARY_BATTERY — Sets the role of the battery pack. This flag is not used by the SH366006 and should be set to 0.

CAPACITY_MODE —Sets the units used for capacity information and internal calculation. When it clears the SH366006 reports in mA or mAh and when it sets the SH366006 reports in cW or cWh. This change affects several commands such as *RemainingCapacityAlarm(), AtRate(), RemainingCapacity(), FullChargeCapacity()* and *DesignCapacity()*.

The following functions are recalculated within 1 second after *[CAPACITY_MODE]* changes: *RemainingTimeAlarm(), AtRateTimeToEmpty(), AtRateOK(), RunTimeToEmpty(), AverageTimeToEmpty(),* and *BatteryStatus()*.

5.11.5 *AtRate* (0x04)

This read- or write-word function is the first half of a two-function call set used to set the *AtRate()* value used in calculations made by the *AtRateTimeToFull()*, *AtRateTimeToEmpty()* and *AtRateOK()* functions. The *AtRate()* units are in either mA or cW.

AtRateTimeToFull(): Returns the predicted time to full-charge at the *AtRate()* value in minutes.

AtRateTimeToEmpty(): Returns the predicted operating time at the *AtRate()* value in minutes.

AtRateOK(): Returns a Boolean value that predicts the battery's ability to supply the *AtRate()* value of additional discharge energy (current or power) for 10 seconds.

5.11.6 AtRateTimeToFull (0x05)

This read-word function returns the predicted remaining time to fully charge the battery at the *AtRate()* value in minutes. A value of 65,535 indicates that the *AtRate()* = 0.

5.11.7 AtRateTimeToEmpty (0x06)

This read-word function returns the predicted remaining operating time in minutes with a range of 0 to 65534, if the battery is discharged at the *AtRate()* value. A value of 65,535 indicates that *AtRate()* = 0.

5.11.8 AtRateOK (0x07)

This read-word function returns a Boolean value that indicates whether or not the battery can deliver the *AtRate()* value of energy for 10 seconds. If *AtRate()* function returns 0, *AtRateOK()* always returns TRUE.

5.11.9. Temperature (0x08)

This read-word function returns an unsigned integer value of the temperature in units of 0.1°K.

5.11.10 Voltage (0x09)

This read-word function returns the sum of the individual cell voltage measurements in mV.

5.11.11 Current (0x0A)

This read-word function returns the measured current being supplied (or accepted) by the battery in mA.

5.11.12 AverageCurrent (0x0B)

This read-word function returns a one-minute rolling average of the current being supplied (or accepted) through the battery terminals in mA. *AverageCurrent()* is calculated by a rolling IIR filtered average of Current function data with a period of 14.5s.

5.11.13 MaxError (0x0C)

This read-word function returns the expected margin of error in the state-of-charge calculation, in %. The actual RelativeStateOfCharge is between 50%~60% when MaxError = 10% and RelativeStateOfCharge = 50%.

5.11.14 RelativeStateOfCharge (0x0D)

This read-word function returns the predicted remaining battery capacity expressed as a percentage of *RealFullChargeCapacity* in %.

5.11.15 AbsoluteStateOfCharge (0x0E)

This read-word function returns the predicted remaining battery capacity of *DesignCapacity* expressed in %.

5.11.16 RemainingCapacity (0x0F)

This read-word function returns the predicted equivalent charge or energy remaining in the battery (also defined as *Ideal RemainingCapacity*). *RemainingCapacity() = RelativeStateOfCharge() * FullChargeCapacity()*. This value reports in either mAh or cWh depending on the setting of *[CAPACITY_MODE]* flag.

5.11.17 FullChargeCapacity (0x10)

This read-word function returns the predicted equivalent pack capacity which is the FCC simulated at 25℃ with 0.2C current (also defined as *Ideal FullChargeCapacity*). When *CycleCount()* < 10 , if the calculated *FullChargeCapacity()* is lower than *DesignCapacity(), FullChargeCapacity()* is equal to *DesignCapacity()*. This value reports in either mAh or cWh depending on setting of *[CAPACITY_MODE]* flag.

5.11.18 RunTimeToEmpty (0x11)

This read-word function returns the predicted remaining battery life at the present rate of discharge, in minutes. This value is 65535 when the current is positive or zero.

5.11.19 AverageTimeToEmpty (0x12)

This read-word function returns the predicted remaining battery life, in minutes, based upon AverageCurrent. The value is 65,535 when the average current is positive or zero.

5.11.20 AverageTimeToFull (0x13)

This read-word function returns the predicted remaining time until the battery reaches full charge, in minutes, based on AverageCurrent. The value is 65,535 when the average current is negative or zero.

5.11.21 ChargingCurrent (0x14)

This read-word function returns the desired charging rate, in mA.

5.11.22 ChargingVoltage (0x15)

This read-word function returns the desired charging voltage, in mV.

5.11.23 *BatteryStatus* (0x16)

This read-word function returns the status of the SH366006-based battery.

Name	Bits	Set	Clear
OVERCHARGEALARM (OCA)	15	RemCap≥ (FCC+ Over Charge Capacity)	RSOC≤FC Clear% or the battery pack is removed and re-inserted or Average ≤ 0 and RemCap ≤ FCC-2 when NR=1
TERMINATECHARGEALARM (TCA)	14	1.2nd protect alarm appears 2.The charge termination conditions are fulfilled 3. Charging overcurrent or short-circuit appears. 4. Charging current is dectected greater than Current Detected Threshold when FC is set. 5. Charge overtemperature appears. 6. Overvoltage appears. 7.The battery pack is removed	All these conditions are inconformity or the battery pack is removed and re-inserted
Reserved	13	0 fixed	
OVERTEMPALARM (OTA)	12	1st/2nd overtemperature appears	All these conditions are inconformity or the battery pack is removed and re-inserted
TERMINATE DISCHARGEALARM (TDA)	11	1.2nd protection alarm appears 2.The battery pack is removed 3. Discharge overcurrent or short-circuit appears. 4. Discharge overtemperature appears. 5. Undervoltage alarm appears. 6.RSOC ≤ *TDA Set%* 7.Voltage ≤ *TDA Set Volt Threshold* over *TDA Set Volt Time* period	All these conditions are inconformity or the battery pack is removed and re-inserted
REMAININGCAPACITYALARM (RCA)	9	*RemainingCapacity()*< *RemainingCapacityAlarm()*	*RemainingCapacity()*≥ *RemainingCapacityAlarm()* Or *Current()* ≥ *Chg Current Threshold*
REMAININGTIMEALARM (RTA)	8	AverageTimeToEmpty( ) <RemainingTimeAlarm( )	*AverageTimeToEmpty()*≥ *RemainingTimeAlarm()*
INITIALIZED (INT)	7	Initialized is done	Not initialized yet
DISCHARGING (DSG)	6	Discharging status	Charging status
FULLYCHARGED (FC)	5	Battery pack is fully charged	RSOC ≤ *FCC clear%*
FULLYDISCHARGED (FD)	4	VCELLmin ≤ CUVThreshold or RSOC ≤ *FD Set %*	VCELLmin > *CUV Recovery* and RSOC≥*FD Clear %*
Reserved	3-0	0000B fixed	

Table.11 Battery Status Table

5.11.24 CycleCount (0x17)

This read-word function returns the number of cycles the battery has experienced. One cycle count is accumulated discharge of *CC Percentage * DesignCapacity()*.

5.11.25 DesignCapacity (0x18)

This read-word function returns the theoretical capacity of the battery pack which is expressed in either current (mAh) or power (cWh) depending on the setting of *[CAPACITY_MODE]* bit.

5.11.26 DesignVoltage (0x19)

This read-word function returns the theoretical voltage of the battery pack, in mV.

5.11.27 SpecificationInfo (0x1A)

This read-word function returns the version number of the Smart Battery Specification that the battery pack supports. The version SH366006 supported is spec1.1 which includes PEC but without current or voltage amplification.

Field	Bits	Allowable values
SpecID_L	0-3	Spec1.0 = 0x0 Spec1.1 = 0x1
SpecID_H	4-7	Spec1.0 = 0x1 Spec1.1 without PEC = 0x2 Spec1.1 with PEC =0x3
Vscale	8-11	0-3(True value is Return×10^ Vscale)
IPScale	12-15	0-3(True value is Return×10^ Vscale)

Table.12 SpecificationInfo Table

5.11.28 ManufactureDate (0x1B)

This read/write-word function returns the date the pack was manufactured. The date is packed in the following fashion:

(year-1980) x 512 + month x 32 + day

Field	Bits	Allowable Values
Day	0-4	1-31(Absolute Date)
Month	5-8	1-12(Absolute Date)
Year	9-15	0-127(Relative to 1980)

Table.13 ManufactureDate Table

5.11.29 SerialNumber (0x1C)

This read/write-word function is used to return the serial number.

5.11.30 RealRemainingCapacity (0x1D)

This read-word function returns the predicted charge or energy remaining in the battery. This value is expressed in either charge (mAh) or energy (cWh), depending on the setting of *[CAPACITY_MODE]* flag.

5.11.31 RealFullChargeCapacity (0x1F)

This read-word function returns the predicted pack capacity when it is fully charged. This value is expressed in either charge (mAh) or power (cWh) depending on setting of *[CAPACITY_MODE]* flag.

5.11.32 ManufacturerName (0x20)

This read-block function returns a character string containing the battery manufacturer's name.

5.11.33 *DeviceName (0x21)*

This read-block function returns a character string that contains the battery name.

5.11.34 DeviceChemistry (0x22)

This read-block function returns a character string that contains the battery chemistry which is fixed by LION in SH366006.

Chemistry	Abbreviations
Plumbic Acid	PbAc
Lithium-ion	LION
Nickel-Cadmium	NiCd
Ni-Mh	NiMH
Nickel-Zinc	NiZn
Rechargeable Alkalinity Manganese Battery	RAM
Zinc-Air	ZnAr

Table.14 Device Chemistry Table

5.11.35 ManufacturerData (0x23)

This read-block function returns the SH366006 internal data.

5.11.36 Authenticate (0x2F)

This read/write-block function allows the host to authenticate the SH366006-based battery using a SHA-1 authentication transform with a length of 20 data bytes + 1 length byte.

5.11.37 CellVoltage4..1(0x3C..0x3F)

These read-word functions return the calculated individual cell voltages, in mV. CellVoltage1 corresponds to the bottom most series cell element, while CellVoltage4 corresponds to the top most series cell element.

5.12 Extended SBS Commands

The SH366006 extended SBS command set meets the SBD V1.1 specification. Smart battery host acquires battery information by sending corresponding commands to the SH366006. The SBData commands are listed below.

SBS Command	Access			Name	Format	Byte	Min	Max	Default	Unit
	SE	US	FA							
0x44	R/W	R/W	R/W	*ManufacturerBlockAccess*	-	-	-	-	-	-
0x47~0x48	R/W	R/W	R/W	*FirmwareUpdateFunction*	-	-	-	-	-	-
0x49	R	R	R	*FUVersion*	Hex	2	0	0xffff	0x0003	-
0x4F	R	R	R	*StateOfHealth*	Unsigned int	1	0	100	-	%
0x51	R	R	R	*SafetyStatus*	Block	4	-	-	-	-
0x53	R	R	R	*PFStatus*	Block	4	-	-	-	-
0x54	R	R	R	*OperationStatus*	Block	2	-	-	-	-
0x55	R	R	R	*ChargingStatus*	Block	3	-	-	-	-
0x57	R	R	R	*ManufacturingStatus*	Block	2	-	-	-	-
0x58	R	R	R	*AFEData*	Block	11	-	-	-	-
0x59	R	R	R	*MaxPeakPower*	Signed int	2	-32767	0	-	cW
0x5A	R	R	R	*SusPeakPower*	Signed int	2	-32767	0	-	cW
0x5B	R/W	R/W	R/W	*PackResistance*	Unsigned int	2	0	65535	-	mΩ
0x5C	R/W	R/W	R/W	*SysResistance*	Unsigned int	2	0	65535	-	mΩ
0x5D	R/W	R/W	R/W	*MinSysVoltage*	Unsigned int	2	0	65535	-	mV
0x5E	R	R	R	*MPPCurrent*	Signed int	2	-32767	0	-	mA
0x5F	R	R	R	*SPPCurrent*	Signed int	2	-32767	0	-	mA
0x60	R	R	R	*LiftimeDataBlock1*	Block	30	-	-	-	-
0x61	R	R	R	*LiftimeDataBlock2*	Block	32	-	-	-	-
0x62	R	R	R	*LiftimeDataBlock3*	Block	12	-	-	-	-
0x65	R	R	R	*GaugeUpdateIndex*	Hex	2	0	0xffff	-	
0x66	R	R	R	*GaugeUpdateStatus*	Hex	2	0	0xffff	-	-
0x67	R	R	R	*QmaxStatus*	Hex	2	0	0xffff	-	-
0x68	R	R	R	*FusionModelStatus*	Hex	2	0	0xffff	-	-
0x70	R/W	R/W	R/W	*ManufacturerInfo*	String	32+1	-	-	-	
0x71	R	R	R	*DAStatus1*	Block	14	-	-	-	-
0x72	R	R	R	*DAStatus2*	Block	12	-	-	-	-
0x77	-	R/W	R/W	*DataFlashSubClassID*	Hex	2	0x0000	0xffff	-	
0x78	-	R/W	R/W	*DataFlashSubClassPage1*	Hex	32	-	-	-	
0x79	-	R/W	R/W	*DataFlashSubClassPage2*	Hex	32	-	-	-	
0x7A	-	R/W	R/W	*DataFlashSubClassPage3*	Hex	32	-	-	-	
0x7B	-	R/W	R/W	*DataFlashSubClassPage4*	Hex	32	-	-	-	
0x7C	-	R/W	R/W	*DataFlashSubClassPage5*	Hex	32	-	-	-	
0x7D	-	R/W	R/W	*DataFlashSubClassPage6*	Hex	32	-	-	-	
0x7E	-	R/W	R/W	*DataFlashSubClassPage7*	Hex	32	-	-	-	
0x7F	-	R/W	R/W	*DataFlashSubClassPage8*	Hex	32	-	-	-	

Table.15 Extended SBS Commands

5.12.1 FirmwareUpdateFunction (0x47~0x48)

This command 0x47 and 0x48 are used for Firmware Update Function to update SH366006 firmware. Each definition is shown in "*SH366006 Communication Specification for Huawei V0.1*".

5.12.2 FUVersion(0x49)

This read-word function returns the FU program version in hex data format with its default value 0x0003.

5.12.3 StateOfHealth(SOH) (0x4F)

This read word function returns the state of health of the battery. SOH = *FullChargeCapacity() / DesignCapacity()*. *FullChargeCapacity()* should be calculated with the standard conditions including the 25℃ temperature and a standard load such as 0.2C.

5.12.4 *SafetyStatus (0x51)*

This read block function returns the status of the 1st level protect.

Name	Bits	Description
RSVD	15-14	Reserved
OTD	13	Discharge overtemperature flag 0 = Normal 1 = SH366006 in the discharge overtemperature condition
OTC	12	Charge overtemperature flag 0 = Normal 1 = SH366006 in the charge overtemperature condition
RSVD	11	Reseved
SCD	10	AFE discharge short-circuit flag 0 = Normal 1 = SH366006 in the discharge short-circuit condition
RSVD	9	Reseved
SCC	8	AFE charge short-circuit flag 0 = Normal 1 = SH366006 in the charge short-circuit condition
RSVD	7	Reseved
AOCD	6	AFE overload flag 0 = Normal 1 = SH366006 in the discharge overload condition
OCD2	5	Discharge overcurrent 2 flag 0 = Normal 1 = SH366006 in the discharge overcurrent 2 condition
OCD1	4	Discharge overcurrent 1 flag 0 = Normal 1 = SH366006 in the discharge overcurrent 1 condition
OCC2	3	Charge overcurrent 2 flag 0 = Normal 1 = SH366006 in the charge overcurrent 2 condition
OCC1	2	Charge overcurrent 1 flag 0 = Normal 1 = SH366006 in the charge overcurrent 1 condition
COV	1	Cell overvoltage flag 0 = Normal 1 = SH366006 in the cell overvoltage condition
CUV	0	Cell undervoltage flag 0 = Normal 1 = SH366006 in the cell undervoltage condition

Table.16 SafetyStatus Table

Name	Bits	Description
RSVD	31-28	Reserved
UTD	27	Discharge undertemperature flag 0 = Normal 1 = SH366006 in the discharge undertemperature condition
UTC	26	Charge undertemperature flag 0 = Normal 1 = SH366006 in the charge undertemperature condition
OCPC	25	Pre-charge overcurrent flag 0 = Normal 1 = SH366006 in the pre-charge overcurrent condition
RSVD	24-23	Reserved
OC	22	Overcharge protection flag 0 = Normal 1 = SH366006 in the overcharge protection condition
RSVD	21	Reserved
CTO	20	Charge timeout flag 0 = Normal 1 = SH366006 in the charge timeout condition
RSVD	19	Reserved
PTO	18	Preharge timeout flag 0 = Normal 1 = SH366006 in the precharge timeout condition
WDF	17	AFE WDT flag 0 = Normal 1 = SH366006 in the AFE watchdog condition
OTF	16	FET overtemperature flag 0 = Normal 1 = SH366006 in the FET overtemperature condition

Table.16 SafetyStatus Table Continued

5.12.5 *PFStatus (0x53)*

The permanent failure status register indicates the source of the SH366006 permanent-failure condition.

Name	Bits	Description
RSVD	15~12	Reserved
CIM	11	Cell-Imbalance permanent failure flag 0 = Normal 1 = SH366006 detects the Cell-Imbalance permanent failure
OWB	10	Old weak battery permanent failure flag 0 = Normal 1 = SH366006 detects the Old Weak Battery permanent failure
ISD	9	Internal short detection permanent failure flag 0 = Normal 1 = SH366006 detects the Internal Short Detection permanent failure
RSVD	8	Reserved
TDD	7	Tab disconnection detection permanent failure flag 0 = Normal 1 = SH366006 detects the Tab Disconnection Detection permanent failure
SOTF	6	Safety FET Overtemperature permanent failure flag 0 = Normal 1 = SH366006 detects the Safety FET Overtemperature permanent failure
RSVD	5	Reserved
SOTC	4	Safety Cell Overtemperature permanent failure flag 0 = Normal 1 = SH366006 detects the Safety Cell Overtemperature permanent failure
SOCD	3	Discharge safety overcurrent permanent failure flag 0 = Normal 1 = SH366006 detects the Discharge Safety Overcurrent permanent failure
SOCC	2	Charge safety overcurrent permanent failure flag 0 = Normal 1 = SH366006 detects the Charge Safety-Overcurrent permanent failure
SOV	1	Safety Overvoltage permanent failure flag 0 = Normal 1 = SH366006 detects the Safety Overvoltage permanent failure
SUV	0	Safety Undervoltage Permanent failure flag 0 = Normal 1 = SH366006 detects the Safety Undervoltage permanent failure

Table.17 PFStatus Table

Name	Bits	Description
TS4	31	TS4 Thermistor failure permanent failure flag 0 = Normal 1 = SH366006 detects the TS4 Thermistor Failure permanent failure
TS3	30	TS3 Thermistor failure permanent failure flag 0 = Normal 1 = SH366006 detects the TS3 Thermistor Failure permanent failure
TS2	29	TS2 Thermistor failure permanent failure flag 0 = Normal 1 = SH366006 detects the TS2 Thermistor Failure permanent failure
TS1	28	TS1 Thermistor failure permanent failure flag 0 = Normal 1 = SH366006 detects the TS1 Thermistor Failure permanent failure
RSVD	27	Reserved
DFF	26	Dataflash Fault permanent failure flag 0 = Normal 1 = SH366006 detects the Dataflash Fault permanent failure
RSVD	25	Reserved
IFC	24	Instruction Flash Checksum failure flag 0 = Normal 1 = SH366006 detects the Instruction Flash Checksum failure
RSVD	23	Reserved
PFIN	22	External Input Indication of permanent failure flag 0 = Normal 1 = SH366006 detects the External Input Indication of permanent failure
AFEC	21	AFE Communications permanent failure flag 0 = Normal 1 = SH366006 detects the AFE Communications permanent failure
AFER	20	AFE Register failure flag 0 = Normal 1 = SH366006 detects the AFE Communications permanent failure
FUSE	19	Chemical Fuse failure flag 0 = Normal 1 = SH366006 detects the Chemical Fuse failure
RSVD	18	Reserved
DFETF	17	Discharge-FET-Failure permanent failure flag 0 = Normal 1 = SH366006 detects the Discharge-FET-Failure permanent failure
CFETF	16	Charge-FET-Failure permanent failure flag 0 = Normal 1 = SH366006 detects the Charge-FET-Failure permanent failure

Table.17 PFStatus Table Continued

5.12.6 OperationStatus (0x54)

This read-word function returns the current operating status of the SH366006.

Name	Bits	Description
FAS	15	Full Access mode flag 0 = Not in Full Access mode 1 = Full access security mode
SS	14	Sealed mode flag 0 = not in Sealed mode 1 = Sealed mode
PF	13	Permanent failure flag 0 = Normal 1 = SH366006 in the permanent failure condition
DUE	12	Data Update Error flag 0 = Data update success 1 = Data update failure
LS3	11	Four Stages Mode 0= System in other Lifespan Mode 1= System in Lifespan Mode 3
LS2	10	Four Stages Mode 0= System in other Lifespan Mode 1= System in Lifespan Mode 2
LS1	9	Four Stages Mode 0= System in other Lifespan Mode 1= System in Lifespan Mode 1
NM	8	Four Stages Mode 0= System in other Lifespan Mode 1= System in Normal Mode
WAKE	7	WAKE mode flag 0 = Not in WAKE mode 1 = WAKE mode
FUSE	6	Fuse Status 0 = Inactive 1= Active
XDSG	5	Discharge fault flag 0 = Normal 1 = Discharge fault
XCHG	4	Charge fault flag 0 = Normal 1 = Charge fault
PCHG	3	Pre-Charge FET Control 0 = Turn OFF Pre-Charge FET 1 = Turn ON Pre-Charge FET
CHG	2	Charge FET Control 0 = Turn OFF CHG FET. CHG FET doesn't turn off in discharge mode to protect the FET body diode. 1 = Turn ON CHG FET
DSG	1	Discharge FET Control 0 = Turn OFF DSG FET. DSG FET doesn't turn of in charge mode to protect the FET body diode. 1 = Turn ON DSG FET
PRES	0	System present flag 0 = System is not present 1 = System is present (battery inserted).

Table.18 Operation Status Table

5.12.7 ChargingStatus (0x55)

This command returns the *ChargingStatus()* and Temperature Range flags.

Name	Bits	Description
RSVD	23-20	Reserved
CB	19	Cell Balance flag 0 = Normal 1 = Cell balancing in progress
CCC	18	Charging loss compensation flag 0 = Normal 1 = Enter charging loss compensation function
RSVD	17-15	Reserved
MCHG	14	Maintenance charge flag 0 = Maintenance charging conditions do not exist 1 = Maintenance charging conditions exist
CHGSU	13	Charge suspend flag 0 = Normal 1 = Charging suspend conditions exist
CHGIN	12	Charge disable flag 0 = Normal 1 = Charging disabled
HV	11	High Voltage Region flag 0 = Inactive 1 = Active
MV	10	Mid Voltage Region flag 0 = Inactive 1 = Active
LV	9	Low Voltage Region flag 0 = Inactive 1 = Active
PV	8	Precharge Voltage Region flag 0 = Inactive 1 = Active
RSVD	7	Reserved
OT	6	Overtemperature Region flag 0 = Inactive 1 = Active
HT	5	High Temperature Region flag 0 = Inactive 1 = Active
STH	4	Standard Temperature High Region flag 0 = Inactive 1 = Active
RT	3	Recommended Temperature Region flag 0 = Inactive 1 = Active
STL	2	Standard Temperature Low Region flag 0 = Inactive 1 = Active
LT	1	Low Temperature Region flag 0 = Inactive 1 = Active
UT	0	Undertemperature Region flag 0 = Inactive 1 = Active

Table.19 ChargingStatus and Temperature Range Table

5.12.8 ManufacturingStatus (0x57)

This command returns the *ManufacturingStatus()* of SH366006.

Name	Bits	Description
RSVD	15-9	Reserved
FUSE_EN	8	Fuse action 0 = Disabled 1 = Enabled
RSVD	7	Reserved
PF_EN	6	Permanent Failure 0 = Disabled 1 = Enabled
LF_EN	5	Lifetime Data Collection 0 = Disabled 1 = Enabled
FET_EN	4	All FET Control action 0 = Disabled 1 = Enabled
RSVD	3	Reserved
DSG_T	2	DSG FET Manual Control Test 0 = Deactivated 1 = Activated
CHG_T	1	CHG FET Manual Control Test 0 = Deactivated 1 = Activated
PCHG_T	0	PCHG FET Manual Control Test 0 = Deactivated 1 = Activated

Table.20 ManufacturingStatus Table

5.12.9 *AFEData (0x58)*

This read-block function returns the AFE status.

Name	Bytes	Description
RSVD	11	String Length Byte
SH366006	10	Internal AFE_Fail_Counter low byte
	9	Internal AFE_Fail_Counter high byte
AFE Data	8	0
	7	AFE SCD
	6	AFE SCC
	5	AFE OLT
	4	AFE OLV
	3	0
	2	AFE Function
	1	AFE Output
	0	AFE Status

Table.21 AFEData Table

5.12.10 *MaxPeakPower* (0x59)

This read-word function will compute and return the maximum instantaneous peak output power of the battery pack in cW, which is available for up to 10ms,given the external resiatance and required minimum voltage of the voltage regulator. The *MaxPeakPower* value is expected to be negative and has to be updated at least once every second.

5.12.11 *SusPeakPower* (0x5a)

This read-word function will compute and return the sustained peak output power of the battery pack in cW, which is available for up to 10s, given the external resiatance and required minimum voltage of the voltage regulator. The *SusPeakPower* value is expected to be negative and has to be updated at least once every second.

5.12.12 *PackResistance* (0x5b)

This function.reports the total non-cell pack resistance value in mOhm, to account for the resistance due to cell interconnet, sense resistance,FET,fuse,connector,and other impedances between the cells and output of battery pack. The cell internal resistance should NOT be included. *PackResistance* is set at time of pack manufacture. Writes to this value will have no change to the value during normal operation. This value is usually determined by the battery pack manufacturer,and set at time of pack manufacture.

5.12.13 *SysResistance* (0x5c)

This function is to write the total resistance value in mOhm into gas gauge to account for the resistances due to the resistance of power/group metal, sense resistor, FET,and other parasitic resistance on the system main board. *SysResistance* is initialized to a default value upon removal or insertion of a battery pack. Writes with this function will overwrite the default value.

5.12.14 *MinSysVoltage* (0x5d)

This function is to write the required minimum system input voltage in mV into the gas gauge. The system regulator will still operate normally if its input voltage is at this level. *MinSysVoltage* is initialized to the default value. Write with this function will overwrite the default value.

5.12.15 *MPPCurrent* (0x5e)

This read-word function will compute and return the maximum instantaneous peak current of the battery pack in mA, which is available for up to 10ms,given the external resistance and required minimum voltage of the voltage regulator. The *MPPCurrent* value is expected to be negative and has to be updated at least once every second.

5.12.16 *SPPCurrent*(0x5f)

This read-word function will compute and return the sustained peak current of the battery pack in mA, which is available for up to 10s, given the external resistance and required minimum voltage of the voltage regulator. The *SPPCurrent* value is expected to be negative and has to be updated at least once every second.

5.12.17 Lifetime Data Block 1 (0x60)

This command returns the first block of Lifetime Data with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMNNOOPPQQ.

Value	Description	Unit
AAaa	Cell1 Max Voltage	mV
BBbb	Cell2 Max Voltage	mV
CCcc	Cell3 Max Voltage	mV
DDdd	Cell4 Max Voltage	mV
EEee	Cell1 Min Voltage	mV
FFff	Cell2 Min Voltage	mV
GGgg	Cell3 Min Voltage	mV
HHhh	Cell4 Min Voltage	mV
IIii	Max Delta Cell Voltage	mV
JJjj	Max Charge Current	mA
KKkk	Max Discharge Current	mA
LLll	Max Avg Dsg Current	mA
MMmm	Max Avg Dsg Power	cW
NN	Max Cell Temperature	℃
OO	Min Cell Temperature	℃
PP	Max Delta Cell Temp	℃
QQ	Max FET Temperature	℃

Table.22 Lifetime Data Block 1 Table

5.12.18 LifetimeDataBlock2 (0x61)

This command returns the second block of Lifetime Data with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description	Unit
AAaa	No. Of COV Events	-
BBbb	Last COV Event	-
CCcc	No. Of CUV Events	-
DDdd	Last CUV Event	-
EEee	No. Of OCD1 Events	-
FFff	Last OCD1 Event	-
GGgg	No. Of OCD2 Events	-
HHhh	Last OCD2 Event	-
IIii	No. Of OCC1 Events	-
JJjj	Last OCC1 Event	-
KKkk	No. Of OCC2 Events	-
LLll	Last OCC2 Event	-
MMmm	No. Of AOCD Events	-
NNnn	Last AOCD Event	-
OOoo	No. Of SCD Events	-
PPpp	Last SCD Event	-

Table.23 Lifetime Data Block 2 Table

5.12.19 LifetimeDataBlock3 (0x62)

This command returns the third block of Lifetime Data with the following format:

AaAAbbBBccCCddDDeeEEffFFggGGhhHHIIJJkkKK.

Value	Description	Unit
AAaa	No. Of SCC Events	-
BBbb	Last SCC Event	-
CCcc	No. Of OTC Events	-
DDdd	Last OTC Event	-
EEee	No. Of OTD Events	-
FFff	Last OTD Event	-
GGgg	No. Of OTF Events	-
HHhh	Last OTF Event	-
II	No. of Partial Resets	-
JJ	No. of Full Resets	-
KKkk	No. of WDT resets	-

Table.24 Lifetime Data Block 3 Table

5.12.20 GaugeUpdateIndex (0x65)

Fusion gauge updates pack capacity periodicity. This variable indicates moment of capacity updated.

5.12.21 GaugeUpdateStatus (0x66)

Fusion gauge takes many filters in capacity updating algorithm. This variable indicates filter status in last capacity updating.

5.12.22 QmaxStatus (0x67)

This variable indicates Qmax updating status. =0 is OK, other is error number.

5.12.23 FusionModelStatus (0x68)

This variable indicates fusion model updating status. =0 is OK, other is error number.

5.12.24 ManufacturerInfo (0x70)

This read-block function returns the data stored in Manuf. Info.

5.12.25 DAStatus1 (0x71)

This command returns 16 bytes of data which include the cell voltages, pack voltage, average voltage, currents and average current. The data vlaues in the following format: aaAAbbBBccCCddDDeeEEffFFggGG where:

Value	Description	Unit
AAaa	Cell 1 Voltage	mV
BBbb	Cell 2 Voltage	mV
CCcc	Cell 3 Voltage	mV
DDdd	Cell 4 Voltage	mV
EEee	Pack Voltage	mV
FFff	Power	cW
GGgg	Average Power	cW

Table.25 DA Status 1 Table

5.12.26 *DAStatus2* (0x72)

This command returns 12 bytes of temperature data which include the TS1, TS2, TS3, TS4, Cell Temperature and FET Temperature. The data values in the following format: aaAAbbBBccCCddDDeeEEffFF where:

Value	Description	Unit
AAaa	TS1 Temperature	0.1°K
BBbb	TS2 Temperature	0.1°K
CCcc	TS3 Temperature	0.1°K
DDdd	TS4 Temperature	0.1°K
EEee	Cell Temperature	0.1°K
FFff	FET Temperature	0.1°K

Table.26 DA Status 2 Table

5.12.27 DataFlashSubClassID (0x77)

This write word function set the SH366006 DataFlash subclass, where data can be accessed by following DataFlashSubClassID commands.

5.12.28 DataFlashSubClassPage1..8(0x78..0x7F)

These commands are used to access the consecutive 32-byte pages of each subclass, where data can be accessed by following DataFlashSubClassID commands. DataFlashSubClassPage1 gets byte 0 to 31 of the subclass, DataFlashSubClassPage2 get bytes 32 to 63, and so on.

5.13 SMBus Timing Sequence

SBData1.1 supports 4 communication formats: Word Write, Word Read, Block Write and Block Read.

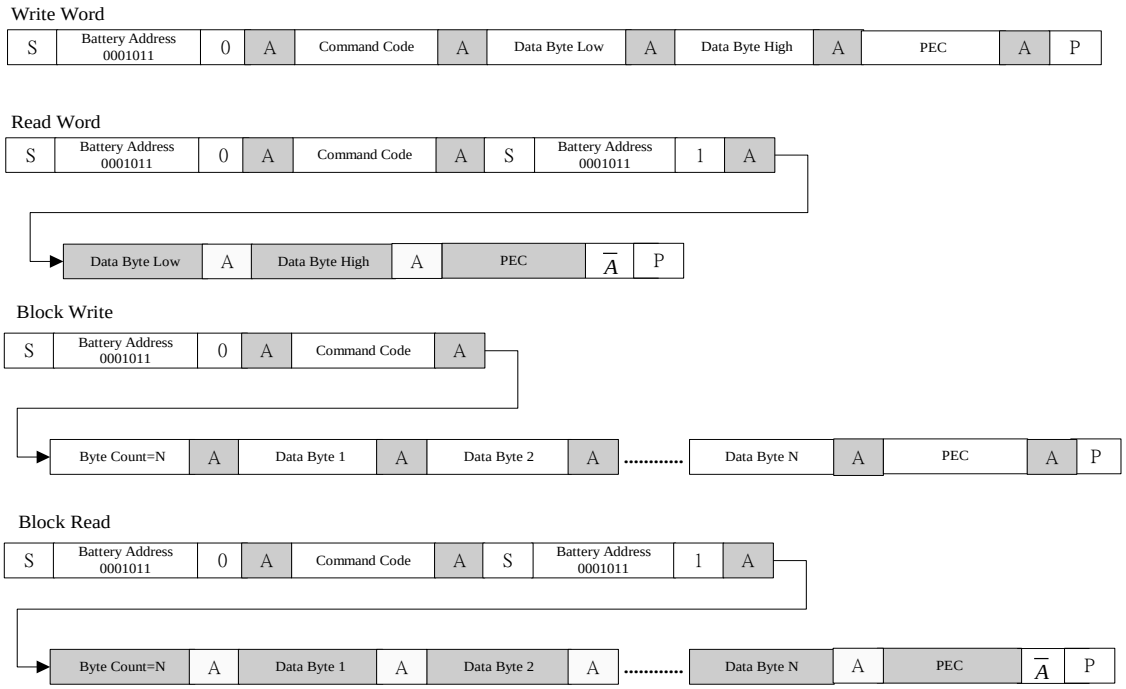


Fig.12 SMBus Communication Flow

6. Data Flash

This part is DataFlash operating instruction, including Read/Write DataFlash, single parameter configuration.

6.1 Accessing Data Flash

DataFlash can be updated when battery pack voltage is higher than *Flash Update OK Voltage* or charger voltage is higher than *Charger Present* but this parameter is unable to be modified when *PFStatus()* is set.

In different security modes, the data flash access authority conditions change.

SECURITY MODE	DATA FLASH ACCESS
Full Access	R/W
Unsealed	R/W
Sealed	N/A

Table.27 DataFlash Access

The SH366006 data flash is organized into subclasses and can be accessed by subclasses where each data flash variable is assigned a unique offset within its numbered subclass.

Each subclass can be addressed individually by using the *DataFlashSubClassID* command and the data within each subclass is accessed by using the *DataFlashSubClassPage1...8* commands.

A subclass can hold up to 256 bytes of data, but subclass data can only be read within 32 byte long data blocks.

Reading DataFlash

To read the DataFlash of SH366006, SubClassID, length of the subclass and Variable Offset are required.

Take the reading procedure of *FC Clear%* for example. This parameter is in subclass Decimal 36(offset=6, byte length=1, subclass length=7).

Step1: Write Subclass ID to the SH366006

– SMB Slave Address (0x16)

– SMB CMD 0x77 with 0x0024 (Decimal 36) as data

Step2: Read Subclass

– SMB Slave Address (0x16)

– SMB CMD 0x78 Receive 1(subclass length=7) + 7 Bytes Data from SH366006

Step3: Read the offset 6+1(subclass length) byte in received data, which is *FC Clear%*

Writing DataFlash

To write the DataFlash of SH366006, SubClassID, length of the subclass and Variable Offset are required.

Take modifying *Device Name* for example, this parameter is in subclass Decimal 48(offset=47, byte length=15, subclass length=63).

Step1: Write Subclass ID to the SH366006

– SMB Slave Address (0x16)

– SMB CMD 0x77 with 0x0030 (Decimal 48) as data

Step2: Read Subclass

– SMB Slave Address (0x16)

– SMB CMD 0x79 Receive 1(string length=31) + 31 Bytes Data from SH366006

Step3: Read the offset 47 - 62(notice received data include string length) bytes in received data, which are the *Device Name* Data.

Step4: Write Subclass ID to the SH366006

– SMB Slave Address (0x16)

– SMB CMD 0x77 with 0x0030 (Decimal 48) as data

Step5: Write Subclass data to the SH366006

– SMB Slave Address (0x16)

– SMB CMD 0x78 Write the original data.

– SMB CMD 0x79 Write 1(string length=31) + 31 Bytes Data (including the offset 47 - 62 data) to SH366006. Then the *Device Name* is update successful.

6.2 1st Level Safety

The SH366006 supports a series of 1st protection of voltage, current, temperature, etc.

6.2.1 Voltage (Subclass 0)

***LT COV Threshold* (Offset 0):** low temperature range overvoltage protect threshold

When the SH366006 is operating in the low temperature range, it sets the [*COV]* flag in *SafetyStatus()* if any CellVoltage4..1 is equal to or higher than the *LT COV Threshold* for *COV Time*.

***LT COV Recovery* (Offset 2):** low temperature range overvoltage recovery threshold

When the SH366006 is operating in the low temperature range, it recovers from cell over voltage condition if all cell voltages are equal to or lower than the *LT COV Recovery* for a period of 1s.

***STL COV Threshold* (Offset 4):** standard temperature range low overvoltage protect threshold

When the SH366006 is operating in the standard temperature range low, it sets the *[COV]* flag in *SafetyStatus()* if any CellVoltage4..1 is equal to or higher than the *STL COV Threshold* for *COV Time*.

***STL COV Recovery* (Offset 6):** standard temperature range low overvoltage recovery threshold

When the SH366006 is operating in the standard temperature range low, it recovers from cell over voltage condition if all cell voltages are equal to or lower than the *STL COV Recovery* for a period of 1s.

***RT COV Threshold* (Offset 8):** recommended temperature range overvoltage protect threshold

When the SH366006 is operating in the recommended temperature range, it sets the *[COV]* flag in *SafetyStatus()* if any CellVoltage4..1 is equal to or higher than the *RT COV Threshold* for *COV Time*.

***RT COV Recovery* (Offset 10):** recommended temperature range overvoltage recovery threshold

When the SH366006 is operating in the recommended temperature range, it recovers from cell over voltage condition if all cell voltages are equal to or lower than the *RT COV Recovery* for a period of 1s.

***STH COV Threshold* (Offset 12):** standard temperature range high overvoltage protect threshold

When the SH366006 is operating in the standard temperature range high, it sets the *[COV]* flag in *SafetyStatus()* if any CellVoltage4..1 is equal to or higher than the *STH COV Threshold* for *COV Time*.

***STH COV Recovery* (Offset 14):** standard temperature range high overvoltage recovery threshold

When the SH366006 is operating in the standard temperature range high, it recovers from cell over voltage condition if all cell voltages are equal to or lower than the *STH COV Recovery* for a period of 1s.

***HT COV Threshold* (Offset 16):** high temperature range overvoltage protect threshold

When the SH366006 is operating in the high temperature range, it sets the *[COV]* flag in *SafetyStatus()* if any CellVoltage4..1 is equal to or higher than the *HT COV Threshold* for *COV Time*.

***HT COV Recovery* (Offset 18):** high temperature range overvoltage recovery threshold

When the SH366006 is operating in the high temperature range, it recovers from cell over voltage condition if all cell voltages are equal to or lower than the *HT COV Recovery* for a period of 1s.

***COV Time* (Offset 20):** overvoltage protect time threshold

SH366006 enter overvoltage protect state when any cell voltage is equal to or higher than *HT/STH/RT/STL/LT COV Threshold* for *COV Time*.

***CUV Threshold* (Offset 21):** undervoltage protect threshold

***CUV Time* (Offset 23):** undervoltage protect time threshold

SH366006 enter undervoltage protect state when any cell voltage is equal to or lower than *CUV Threshold* for *CUV Time*.

***CUV Recovery* (Offset 24):** undervoltage recovery threshold

The SH366006 recovers from cell under voltage condition, if all CellVoltage4..1 is higher than the *CUV Recovery* for a period of 1s.

6.2.2 Current (Subclass 1)

***OCC1 Threshold* (Offset 0):** over current 1 protection threshold in charging condition

***OCC1 Time* (Offset 2):** over current 1 protection time threshold in charging condition

The SH366006 sets the *SafetyStatus()[OCC1]* if charge current is equal to or higher than the *OCC1 T*hreshold for *OCC1 Time.*

***OCC2 Thresholde* (Offset 3):** over current 2 protection threshold in charging condition

***OCC2 Time* (Offset 5):** over current 2 protection time threshold in charging condition

The SH366006 sets the *SafetyStatus()[OCC2]* if charge current is equal to or higher than the *OCC2 T*hreshold for *OCC2 Time.*

***OCC Recovery* (Offset 6):** charge over current protection recovery threshold

***OCC Recovery Time* (Offset 8):** charge over current protection recovery time threshold

SH366006 can recover from charge over current condition if current is equal to or lower than the *OCC Recovery* for *OCC Recovery Time*.

***OCD1 Threshold* (Offset 9):** over current 1 protection threshold in discharging condition

***OCD1 Time* (Offset 11):** over current 1 protection time threshold in discharging condition

The SH366006 sets the *SafetyStatus()[OCD1]* if discharge current is equal to or higher than the *OCD1 T*hreshold for *OCD1 Time.*

***OCD2 Threshold* (Offset 12):** over current 2 protection threshold in discharging condition

***OCD2 Time* (Offset 14):** over current 2 protection time threshold in discharging condition

The SH366006 sets the *SafetyStatus()[OCD2]* if discharge current is equal to or higher than the *OCD2 T*hreshold for *OCD2 Time.*

***OCD Recovery* (Offset 15):** discharge over current protection recovery threshold

***OCD Recovery Time* (Offset 17):** discharge over current protection recovery time threshold

SH366006 can recover from discharge over current condition if current is equal to or higher than the *OCD Recovery* for *OCD Recovery Time*.

***AFE OC Dsg* (Offset 18):** AFE discharging over current threshold

AFE Overcurrent Dsg configures the AFE discharging over current threshold.

Name	Bits	Description			
AFE OLV	4-0	Discharging over current threshold			
		00000: 0.050V	00001: 0.055V	00010: 0.060V	00011: 0.065V
		00100: 0.070V	00101: 0.075V	00110: 0.080V	00111: 0.085V
		01000: 0.090V	01001: 0.095V	01010: 0.100V	01011: 0.105V
		01100: 0.110V	01101: 0.115V	01110: 0.120V	01111: 0.125V
		10000: 0.130V	10001: 0.135V	10010: 0.140V	10011: 0.145V
		10100: 0.150V	10101: 0.155V	10110: 0.160V	10111: 0.165V
		11000: 0.170V	11001: 0.175V	11010: 0.180V	11011: 0.185V
		11100: 0.190V	11101: 0.195V	11110: 0.200V	11111: 0.205V

Table.28 AFE OLV Register

***AFE OC Dsg Time* (Offset 19):** AFE discharging over current delay threshold

AFE Overcurrent Dsg Time configures the AFE discharging over current delay threshold.

Name	Bits	Description			
AFE OLT	3-0	discharging over current delay			
		0000: 1ms	0001: 3ms	0010: 5ms	0011: 7ms
		0100: 9ms	0101: 11ms	0110: 13ms	0111: 15ms
		1000: 17ms	1001: 19ms	1010: 21ms	1011: 23ms
		1100: 25ms	1101: 27ms	1110: 29ms	1111: 31ms

Table.29 AFE OLT Register

***AFE SC Chg Cfg* (Offset 20):** AFE short circuit charging configuration

AFE Short-Circuit Chg configures the AFE short circuit charging threshold and delay.

Name	Bits	Description			
AFE SCC	7-4	short circuit charging delay			
		0000: 0μs	0001: 61μs	0010: 122μs	0011: 183μs
		0100: 244μs	0101305μs	0110: 366μs	0111: 427μs
		1000: 488μs	1001: 549μs	1010: 610μs	1011: 671μs
		1100: 732μs	1101: 791μs	1110: 854μs	1111: 915μs
	3-0	short circuit charging threshold			
		0000: 0.100V	0001: 0.125V	0010: 0.150V	0011: 0.175V
		0100: 0.200V	0101: 0.225V	0110: 0.250V	0111: 0.275V
		1000: 0.300V	1001: 0.325V	1010: 0.350V	1011: 0.375V
		1100: 0.400V	1101: 0.425V	1110: 0.450V	1111: 0.475V

Table.30 AFE SCC Register

***AFE SC Dsg Cfg* (Offset 21):** AFE short circuit discharging configuration

AFE Short-Circuit Discharge Cfg configures the AFE short circuit discharging threshold and delay.

Name	Bits	Description			
AFE SCD	7-4	short circuit discharging delay			
		0000: 0μs	0001: 61μs	0010: 122μs	0011: 183μs
		0100: 244μs	0101305μs	0110: 366μs	0111: 427μs
		1000: 488μs	1001: 549μs	1010: 610μs	1011: 671μs
		1100: 732μs	1101: 791μs	1110: 854μs	1111: 915μs
	3-0	short circuit discharging threshold			
		0000: 0.100V	0001: 0.125V	0010: 0.150V	0011: 0.175V
		0100: 0.200V	0101: 0.225V	0110: 0.250V	0111: 0.275V
		1000: 0.300V	1001: 0.325V	1010: 0.350V	1011: 0.375V
		1100: 0.400V	1101: 0.425V	1110: 0.450V	1111: 0.475V

Table.31 AFE SCD Register

***AOCD Recovery Time* (Offset 22):** AFE discharge over current protection recovery time threshold

SH366006 can recover from an AOCD condition if current is equal to or higher than the *-100mA* for *AOCD Recovery Time*.

***SCC Recovery Time* (Offset 23):** AFE charge short circuit protection recovery time threshold

SH366006 can recover from a SCC condition if current is equal to or lower than the *5mA* for *SCC Recovery Time*.

***SCD Recovery Time* (Offset 24):** AFE discharge short circuit protection recovery time threshold

SH366006 can recover from a SCD condition if current is equal to or higher than the *-5mA* for *SCD Recovery Time*.

6.2.3 Temperature (Subclass 2)

***Over Temp Chg* (Offset 0):** Over temperature charge protect threshold

***OTC Time* (Offset 2):** Over temperature charge protect time threshold

The SH366006 sets the *[OTC]* in *SafetyStatus()* if Max Cell Temp is equal to or higher than the *Over Temp Chg* threshold for *OTC Time*.

***OT Chg Recovery* (Offset 3):** Over temperature charge recovery threshold

The SH366006 recovers from over temperature charge condition, if Max Cell Temp is equal to or lower than the *OT Chg Recovery* level for a period of 1s.

***Over Temp Dsg* (Offset 5):** Over temperature discharge protect threshold

***OTD Time* (Offset 7):** Over temperature discharge protect time threshold

The SH366006 sets the *[OTD]* in *SafetyStatus()* if Max Cell Temp is equal to or higher than the *Over Temp Dsg* threshold for *OTD Time*.

***OT Dsg Recovery* (Offset 8):** Over temperature discharge recovery threshold

The SH366006 recovers from over temperature discharge condition, if Max Cell Temp is equal to or lower than the *OT Dsg Recovery* level for a period of 1s.

***OTF Temp Threshold* (Offset 10):** FET over temperature protect threshold

***OTF Time* (Offset 12):** FET over temperature protect time threshold

The SH366006 sets the [*OTF]* in *SafetyStatus()* if FET Temperature value is equal to or higher than the *OTF Temp Threshold* for *OTF Time*.

***OTF Recovery Temp* (Offset 13):** Over temperature discharge recovery threshold

The SH366006 recovers from FET over temperature condition, if the FET Temperature reports a temperature equal to or lower than the *OTF Recovery Temp* for a period of 1s.

***Under Temp Chg* (Offset 15):** Under temperature charge protect threshold

***UTC Time* (Offset 17):** Undr temperature charge protect time threshold

The SH366006 sets the *[UTC]* in *SafetyStatus()* if Min Cell Temp is lower than the *Under Temp Chg* threshold for *UTC Time*.

***UT Chg Recovery* (Offset 18):** Under temperature charge recovery threshold

The SH366006 recovers from under temperature charge condition, if t Min Cell Temp is equal to or higher than the *UT Chg Recovery* level for a period of 1s.

***Under Temp Dsg* (Offset 20):** Under temperature discharge protect threshold

***UTD Time* (Offset 22):** Under temperature discharge protect time threshold

The SH366006 sets the [*UTD]* in *SafetyStatus()* if Min Cell Temp is lower than the *Under Temp Dsg* threshold for *UTD Time*.

***UT Dsg Recovery* (Offset 23):** Under temperature discharge recovery threshold

The SH366006 recovers from under temperature discharge condition, if Min Cell Temp is equal to or higher than the *UT Dsg Recovery* level for a period of 1s.

6.2.4 Pre-chg Current (Subclass 3)

***OC PreChg* (offset 0):** over current protection threshold in pre-charging condition

When *Current( ) > OC PreChg* for over *OC PreChg Time*, SH366006 enter Pre-Charge Over Current Protection.

***OC PreChg Time* (offset 2):** over current protection time threshold in pre-charging condition

When *Current( ) > OC PreChg* for over *OC PreChg Time*, SH366006 enter Pre-Charge Over Current Protection.

***OC PreChg Recovery Time* (offset 3):** over current protection recovery time in pre-charging condition

When Average *Current( )* ≤ *OC PreChg* and AFECurrent_Fault timer count to *OC PreChg Recovery Time* from the start of the protection, SH366006 exit the Pre-CHG Current Protection.

6.2.5 Time Out (Subclass 4)

***PTO Charge Threshold*(offset 0):** precharge timeout current threshold

PTO timer begins to count from zero when current is higher than *PTO Charge Threshold* in precharge mode.

***PTO Suspend Threshold* (offset 2):** precharge timeout suspend current threshold

In the process of PTO timer counting, when current is equal to or lower than *PTO Suspend Threshold*, the timer stop counting.

***PTO Time* (offset 4):** precharge timeout delay threshold

SH366006 triggers PTO protection and turns off C-FET to interrupt charging current when the PTO Timer counts to *PTO Time*, more details please refer to Precharge Timeout function description.

***PTO Recovery* (offset 6):** precharge timeout protection recovery threshold

SH366006 can recover form PTO protection when discharged by an amount of *PTO Recovery* .

***CTO Charge Threshold*(offset 8):** charge timeout current threshold

CTO timer begins to count from zero when current is higher than *CTO Charge Threshold* in charge mode.

***CTO Suspend Threshold* (offset 10):** charge timeout suspend current threshold

In the process of CTO timer counting, when current is equal to or lower than *CTO Suspend Threshold*, the timer stop counting.

***CTO Time* (offset 12):** charge timeout delay threshold

SH366006 triggers CTO protection and turns off C-FET to interrupt charging current when the CTO Timer counts to *CTO Time*, more details please refer to Charge Timeout function description.

***CTO Recovery* (offset 14):** charge timeout protection recovery threshold

SH366006 can recover form CTO protection when discharged by an amount of *CTO Recovery* .

6.2.6 Overcharge (Subclass 5)

***OC Capacity Threshold* (Offset 0):** Over Charge Capacity Threshold

The SH366006 goes into overcharge protecion and sets *[OC]* flag in *SafetyStatus()* if the internal counted remaining capacity exceeds 99%**FullChargeCapacity()* + *OC Capacity Threshold*.

***OC Capacity Recovery* (Offset 2):** Over Charge Capacity Recovery Threshold

***OC RSOC Recovery* (Offset 4):** Over Charge RSOC Recovery Threshold

When *[NR]* = 0, the SH366006 recovers from overcharge protection if battery pack is removed and reinserted. When *[NR]* = 1, the SH366006 recovers from overcharge protecion if continuous amount of discharge ≥ *OC Capacity Recovery* or if *RelativeStateOfCharge()* ≤ *OC RSOC Recovery*.

6.3 2nd Level Safety

The SH366006 supports a series of 2nd protection of voltage, current, temperature, MOSFET failure, etc.

6.3.1 Voltage (Subclass 16)

***SOV Threshold* (Offset 0):** Safety over voltage threshold

***SOV Time* (Offset 2):** Safety over voltage time threshold

When any CellVoltage4..1 is equal to or higher than the *SOV Threshold* for a period of SOV *Time*, the SH366006 goes into safety overvoltage condition, *[SOV]* in *PFStatus()* is set.

***SUV Threshold* (Offset 3):** Safety undervoltage threshold

***SUV Time* (Offset 5):** Safety undervoltage time threshold

When any cell voltage falls below *SUV threshold* for *SUV Time*, SH366006 goes into safety undervoltage condition, *[SUV]* in *PFStatus()* is set.

***Cell Imbalace Check Voltage* (Offset 6):** Cell Imbalance Check Voltage Threshold

The max cell voltage must be higher than or equal to *Cell Imbalance Check Voltage* before SH366006 starts detecting cell imbalance.

***Cell Imbalance Current* (Offset 8):** Cell Imbalance Check Current Threshold

The battery pack current must be below or equal the *Cell Imbalance Current* limit for *Cell Imbalance Time* before SH366006 starts detecting cell imbalance.

***Cell Imbalance Fail Voltage* (Offset 10):** Cell Imbalance Fail Voltage Threshold

***Cell Imbalance Time* (Offset 11):** Cell Imbalance Time Threshold

If the measured voltage difference between cells is higher than the *Cell Imbalance Fail Voltage* threshold for a period of *Cell Imbalance Time limit*, SH366006 goes into cell imbalance condition, *[CIM]* in *PFStatus()* is set

***Battery Rest Time* (Offset 12):** Battery Rest Time

The battery current must be below or equal *Cell Imbalance Current* limit for at least Battery Rest Time period before SH366006 starts detecting cell imbalance.

***PFIN Detect Time* (Offset 14):** PFIN Detect Time

If PFIN pin logic low for a period of *PFIN detect time*, *[PFIN]* in *PFStatus()* is set.

6.3.2 Current (Subclass 17)

***SOC Chg* (Offset 0):** 2nd over current charge threshold

***SOC Chg Time* (Offset 2):** 2nd over current charge time threshold

If the charge current is equal to or higher than the *SOC Chg threshold* for a period of *SOC Chg Time*, *[SOCC]* in *PFStatus()* is set.

***SOC Dsg* (Offset 3):** 2nd over current discharge threshold

***SOC Dsg Time* (Offset 5):** 2nd over current discharge time threshold

If the discharge current is equal to or higher than the *SOC Dsg threshold* for a period of *SOC Dsg Time*, *[SOCD]* in PFStatus() is set

6.3.3 Temperature (Subclass 18)

***SOTC Threshold* (Offset 0):** 2nd cell overtemperature threshold

***SOTC Time* (Offset 2):** 2nd cell overtemperature time threshold

If Max Cell Temp is equal to or higher than the *SOTC Threshold* for a time period of *SOTC Time*, SH366006 goes into SOTC condition, *[SOTC]* in *PFStatus()* is set

***SOTF Threshold* (Offset 3):** 2nd FET overtemperature threshold

***SOTF Time* (Offset 5):** 2nd FET overtemperature time threshold

If the FET temperature in *DASatus2()* is equal to or higher than the *SOTF Threshold* for a time period of *SOTFTime*, SH366006 goes into SOTF condition, *[SOTF]* in *PFStatus()* is set.

***Thermistor Error Time* (Offset 6):** Thermistor Fail Detect Time

If the TSx (x=1~4) Thermistor is open-circuit or short-circuit for *Thermistor Error Time*, SH366006 goes into Thermistor Permanent Failure Protection and *[TSx]*(x=1~4) in *PFStatus()* is set.

6.3.4 FET Verification (Subclass 19)

CFET Fail Current **(Offset 0)**: CFET Fail Current Threshold

CFET Fail Time **(Offset 2):** CFET Fail Time Threshold

If SH366006 tries to turn off CHG FET and charge current is equal to or higher than *CFET Fail Current* for a time period of *CFET Fail Time* the SH366006 goes into *[CFETF]* condition, *[CFETF]* in *PFStatus()* is set,

DFET Fail Current **(Offset 3)**: DFET Fail Current Threshold

DFET Fail Time **(Offset 5):** DFET Fail Time Threshold

If SH366006 tries to turn off DSG FET and the discharge current is equal to or lower than the *–DFET Fail Current* for a time period of *DFET Fail Time*, SH366006 goes into *[DFETF]* condition, *[DFETF]* in *PFStatus()* is set

6.3.5 AFE Verification (Subclass 20)

AFE Fail Limit **(Offset 0):** AFE Fail Counter Threshold

If the AFE_Fail_Counter reaches *AFE Fail Limit*, SH366006 reports a *[AFEC]* permanent failure and [AFEC] in *PFStatus()* is set.

6.3.6 Internal Short Detection (Subclass 21)

ISD OCV Threshold **(offset 0):** Internal Short Detection OCV Threshold

When Min Cell OCV > *ISD OCV Threshold*, Internal Short Detection permanent failure can be detected.

ISD Delta Voltage **(offset 2):** Internal Short Detection Delta Voltage Threshold

To detect Internal Short Detection permanent failure, at least one cell voltage must vary over *ISD Delta Voltage* in the last *ISD Delta Time*.

ISD Voltage Threshold **(offset 4):** Internal Short Detection Voltage Threshold

To detect Internal Short Detection permanent failure, cell voltages shift differences must be greater than this value in the last *ISD Delta Time*.

ISD Delta Time **(offset 6):** Internal Short Detection Delta Time Threshold

To detect Internal Short Detection permanent failure, at least one cell voltage must vary over *ISD Delta Voltage Threshold* in the last *ISD Delta Time*.

6.3.7 Tab Disconnection Detection (Subclass 22)

TDD Percent Threshold **(offset 0):**

To detect Tab Disconnection Detection permanent failure, more than this percent (default=37) of *Design Capacity* charge must be passed during the last charge/discharge procedure.

TDD Temp Threshold **(offset 1):** Tab Disconnection Detection Temperature Threshold

To detect Tab Disconnection Detection permanent failure, *Temperature()* must be greater than this value.

TDD Multiply Factor **(offset 3):** Tab Disconnection Detection Multiply Factor

To detect Tab Disconnection Detection permanent failure, the calculated passed charge, PC1 and PC2 (PC3, PC4 could be exist) must be satisfied the condition: Max (PC1, PC2, PC3, PC4) > TDD Multiple Factor (default=15, means 1.5 times)* Min (PC1, PC2, PC3, PC4).

6.3.8 Old Weak Battery (Subclass 23)

OWB SOH Threshold **(offset 0):** Old Weak Batteries SOH Threshold

To detect *Old Weak Battery* permanent failure in charge starting, SOH must be lower than this value.

OWB Time **(offset 1):** Old Weak Batteries Protection trip Delay Time Threshold

To detect *Old Weak Battery* permanent failure, battery age must be greater than this value.

6.3.9 Chemical Fuse (Subclass 24)

***FUSE Fail Current* (offset 0):** Chemical Fuse Permanent Fail Current Threshold

***FUSE Fail Time* (offset 2):** Chemical Fuse Protection trip Delay Time Threshold

FUSE permanent failure occurs if SH366006 detects FUSE pin=high and |*Current()*| continuous ≥ *FUSE Fail Current* for *FUSE Fail Time*.

6.4 Charge Control

The charge control of SH366006 is comprised by Charge Inhabit, Charge Suspended, Precharge, Low Temperature Charge, Standard Temperature Charge Low, Recommend Temperature Charge, Standard Temperature Charge High, High Temperature Charge, Charge Termination, and Balance, etc.

6.4.1 Charge Temperature Cfg (Subclass 34)

Notice: DF parameters updating of this subclass must be through all data flash writing by using SH366006 PC.

***JT1* (Offset 0):** the lower bound of the low temperature charging range

When Temperature is below the *JT1* threshold, then *[UT]* flag in *TempRange()* is set and charging is inhibited(Relax or DSG Mode) or suspended(CHG Mode), *[CHGIN]* or *[CHGSU]* flag in *ChargingStatus()* is set, and *ChargingCurrent()* and *ChargingVoltage()* are set to zero.

***JT2* (Offset 2):** the upper bound of the low temperature charging range and the lower bound of standard temperature charging range low

When Temperature is between *JT1* and *JT2*, *[LT]* flag in *TempRange()* is set, *ChargingVoltage()* is set to *LT Chg Voltage* and *ChargingCurrent()* is set to *LT Chg Current 1*, *LT Chg Current 2*, or *LT Chg Current 3* depending on cell voltage

***JT5* (Offset 4):** the upper bound of the standard temperature charging range low and the lower bound of recommended temperature charging range

When Temperature is between *JT2* and *JT5*, *[STL]* flag in *TempRange()* is set, *ChargingVoltage()* is set to *STL Chg Voltage* and *ChargingCurrent()* is set to *STL Chg Current 1*, *STL Chg Current 2*, or *STL Chg Current 3* depending on cell voltage

***JT6* (Offset 6):** the upper bound of the recommended temperature charging range and the lower bound of the standard temperature charging range high

When Temperature is between *JT5* and *JT6*, *[RT]* flag in *TempRange()* is set, *ChargingVoltage()* is set to *RT Chg Voltage* and *ChargingCurrent()* is set to *RT Chg Current 1*, *RT Chg Current 2*, or *RT Chg Current 3* depending on cell voltage

***JT3* (Offset 8):** the upper bound of the standard temperature charging range high, and the lower bound of high temperature charging range

When Temperature is between *JT6* and *JT3*, *[STH]* flag in *TempRange()* is set, *ChargingVoltage()* is set to *STH Chg Voltage* and *ChargingCurrent()* is set to *STH Chg Current 1*, *STH Chg Current 2*, or *STH Chg Current 3* depending on cell voltage. If Temperature is greater than *JT3* and charging did not start (*[DSG]* = 1), then charging is inhibited from starting.

***JT4* (Offset 10):** the upper bound of the high temperature charging range

When Temperature is between *JT3* and *JT4*, *[HT]* flag in *TempRange()* is set, *ChargingVoltage()* is set to *HT Chg Voltage* and *ChargingCurrent()* is set to *HT Chg Current 1*, *HT Chg Current 2*, or *HT Chg Current 3*, depending on cell voltage. If Temperature is greater than *JT4* then [*[TR5]*] flag in *TempRange()* is set. If SH366006 is in charge mode (*[DSG]* = 0), then charging is suspended, *[CHGSU]* flag in *ChargingStatus()* is set, and *ChargingCurrent()* and *ChargingVoltage()* are set to 0.

***Temp Hys* (Offset 12):** temperature hysteresis

When in charge inhibit mode, the Temperature rises above *JT1* + *Temp Hys* or falls below *JT3*–*Temp Hys* charging is allowed to be resumed and *[CHGIN]* in *ChargingStatus()* is cleared.

***LT Chg Voltage* (Offset 14):** Low temperature charge voltage value

SH366006 sets *ChargingVoltage()* to the *LT Chg Voltage* value when Temperature in is the low temperature charging range (*[LT]* = 1).

***LT Chg Current 1* (Offset 16):** Low temperature charge current value 1

SH366006 sets *ChargingCurrent()* to the *LT Chg Current 1* value when Temperature is in the low temperature charging range (*[LT]* = 1) and CellMaxVolt is in the LV range.

***LT Chg Current 2* (Offset 18): l**ow temperature charge current value 2

SH366006 sets *ChargingCurrent()* to the *LT Chg Current 2* value when Temperature is in the low temperature charging range (*[LT]* = 1) and CellMaxVolt is in the MV range.

***LT Chg Current 3* (Offset 20):** low temperature charge current value 3

SH366006 sets *ChargingCurrent()* to the *LT Chg Current 3* value when Temperature is in the low temperature charging range (*[LT]* = 1) and CellMaxVolt is in the HV range.

***STL Chg Voltage* (Offset 22):** standard temperature low charge voltage value

SH366006 sets *ChargingVoltage()* to the *STL Chg Voltage* when Temperature is in the standard temperature charging range low (*[STL]* = 1).

***STL Chg Current 1* (Offset 24):** standard temperature low charge current value 1

SH366006 sets *ChargingCurrent()* to the *STL Chg Current 1* value when Temperature is in the standard temperature charging range low (*[STL]* = 1) and CellMaxVolt is in the LV range.

***STL Chg Current 2* (Offset 26):** standard temperature low charge current value 2

SH366006 sets *ChargingCurrent()* to the *STL Chg Current 2* value when Temperature is in the standard temperature charging range low (*[STL]* = 1) and CellMaxVolt is in the MV range.

***STL Chg Current 3* (Offset 28):** standard temperature low charge current value 3

SH366006 sets *ChargingCurrent()* to the *STL Chg Current 3* value when Temperature is in the standard temperature charging range low (*[STL]* = 1) and CellMaxVolt is in the MV range.

***RT Chg Voltage* (Offset 30):** recommended temperature charge voltage value

SH366006 sets *ChargingVoltage()* to the *RT Chg Voltage* value when Temperature is in the recommended temperature charging range (*[RT]* = 1).

***RT Chg Current 1* (Offset 32):** recommended temperature charge current value 1

SH366006 sets *ChargingCurrent()* to the *RT Chg Current 1* value when Temperature is in the recommended temperature charging range (*[RT]* = 1) and CellMaxVolt is in the LV range.

***RT Chg Current 2* (Offset 34):** recommended temperature charge current value 2

SH366006 sets *ChargingCurrent()* to the *RT Chg Current 2* value when Temperature is in the recommended temperature charging range (*[RT]* = 1) and CellMaxVolt is in the MV range.

***RT Chg Current 3* (Offset 36):** recommended temperature charge current value 3

SH366006 sets *ChargingCurrent()* to the *RT Chg Current 3* value when Temperature is in the recommended temperature charging range (*[RT]* = 1) and CellMaxVolt is in the HV range.

***STH Chg Voltage* (Offset 38):** standard temperature high charge voltage value

SH366006 sets *ChargingVoltage()* to the *STH Chg Voltage* value when Temperature is in the standard temperature charging range high (*[STH]* = 1).

***STH Chg Current 1* (Offset 40):** standard temperature high charge current value 1

SH366006 sets *ChargingCurrent()* to the *STH Chg Current 1* value when Temperature is in the standard temperature charging range high (*[STH]* = 1) and CellMaxVolt is in the LV range.

***STH Chg Current 2* (Offset 42):** standard temperature high charge current value 2

SH366006 sets *ChargingCurrent()* to the *STH Chg Current 2* value when Temperature is in the standard temperature charging range high (*[STH]* = 1) and CellMaxVolt is in the LV range.

***STH Chg Current 3* (Offset 44):** standard temperature high charge current value 3

SH366006 sets *ChargingCurrent()* to the *STH Chg Current 3* value when Temperature is in the standard temperature charging range high (*[STH]* = 1) and CellMaxVolt is in the HV range.

***HT Chg Voltage* (Offset 46):** high temperature charge voltage value

SH366006 sets *ChargingVoltage()* to the *HT Chg Voltage* value when Temperature is in the high temperature charging range (*[HT]* = 1).

***HT Chg Current 1* (Offset 48):** high temperature charge current value 1

SH366006 sets *ChargingCurrent()* to the *HT Chg Current 1* value when Temperature is in the high temperature charging range (*[HT]* = 1) and CellMaxVolt is in the LV range.

***HT Chg Current 2* (Offset 50):** high temperature charge current value 2

SH366006 sets *ChargingCurrent()* to the *HT Chg Current 2* value when Temperature is in the high temperature charging range (*[HT]* = 1) and CellMaxVolt is in the MV range.

***HT Chg Current 3* (Offset 52):** high temperature charge current value 3

SH366006 sets *ChargingCurrent()* to the *HT Chg Current 3* value when Temperature is in the high temperature charging range (*[HT]* = 1) and CellMaxVolt is in the HV range.

***Pre-chg Current* (Offset 54):** Pre-charge Current Value

SH366006 sets the *ChargingCurrent()* to the *Pre-chg Current* value, when in precharge mode.

***Mchg Current* (Offset 56):** Maintenance Charge Current Value

SH366006 sets the *ChargingCurrent()* to the *Mchg Current* value, when in maintenance charge mode.

***Prechg Start Voltage* (Offset 58):** Precharge Start Voltage Threshold

SH366006 enters precharge mode and sets the *[PV]* flag in *ChargingStatus()* if any CellVoltage4..1 drops below the *Prechg Start Voltage* threshold.

***Cell Voltage Threshold 1* (Offset 60):** Cell Voltage Range Threshold 1

SH366006 is in precharge voltage range (PV) when CellMaxVolt < *Cell Voltage Threshold 1*.

***Cell Voltage Threshold 2* (Offset 62):** Cell Voltage Range Threshold 2

SH366006 is in cell voltage low range (LV) when *Cell Voltage Threshold 1* < CellMaxVolt < *Cell Voltage Threshold 2*.

***Cell Voltage Threshold 3* (Offset 64):** Cell Voltage Range Threshold 3

SH366006 enters cell voltage medium range (MV) when *Cell Voltage Threshold 2* < CellMaxVolt <*Cell Voltage Threshold 3*.

SH366006 enters cell voltage high range (HV) when CellMaxVolt >*Cell Voltage Threshold 3*.

***Cell Voltage Thresh Hys* (Offset 66):** Cell Voltage Range Threshold Hysteresis

Cell Voltage Thresh Hys is used to make sure that transitions between cell voltage ranges are not affected by small transients. For example, if the current cell voltage range is [MV] and cell voltage goes above *Cell Voltage Threshold 3* then [HV] is entered. Cell voltage has to fall below *Cell Voltage Threshold 3 – Cell Voltage Thresh Hys* for the SH366006 to go back to MV range in non-charging.

***LS1 Set CycleCount*(offset 68):** LS1 Set Cycle Count Threshold

***LS2 Set CycleCount*(offset 70):** LS2 Set Cycle Count Threshold

***LS3 Set CycleCount*(offset 72):** LS3 Set Cycle Count Threshold

***LS1 Set SOH*(offset 74):** LS1 Set SOH Threshold

When SH366006 detects *CycleCount()* > *LS1 Set CycleCount*(default=50)(if enabled by setting *[FSMCC]*) or SOH < *LS1 Set SOH* (default=95%)(if enabled by setting *[FSMSOH]*), SH366006 fixes in Lifespan Mode 1.

***LS2 Set SOH*(offset 75):** LS2 Set SOH Threshold

When SH366006 detects *CycleCount()* > *LS2 Set CycleCount*(default=150)(if enabled by setting *[FSMCC]*) or SOH < *LS2 Set SOH* (default=80%)(if enabled by setting *[FSMSOH]*), SH366006 fixes in Lifespan Mode 2.

***LS3 Set SOH*(offset 76):** LS3 Set SOH Threshold

When SH366006 detects *CycleCount()* > *LS3 Set CycleCount*(default=350)(if enabled by setting *[FSMCC]*) or SOH < *LS3 Set SOH* (default=60%)(if enabled by setting *[FSMSOH]*), SH366006 fixes in Lifespan Mode 3.

***CC Degrade Threshold 1*(offset 77):** Charging Current degrade threshold in Lifespan Mode 1

When enters Lifespan Mode 1, *ChargingCurrent() also* can be reduced by *CC Degrade Threshold 1*(default=10%) if the *[DCC]* flag in *Operation Cfg A* is set.

***CC Degrade Threshold 2*(offset 78):** Charging Current degrade threshold in Lifespan Mode 2

When enters Lifespan Mode 2, *ChargingCurrent() also* can be reduced by *CC Degrade Threshold 2*(default=20%) if the *[DCC]* flag in *Operation Cfg A* is set.

***CC Degrade Threshold 3*(offset 79):** Charging Current degrade threshold in Lifespan Mode 3

When enters Lifespan Mode 3, *ChargingCurrent() also* can be reduced by *CC Degrade Threshold 3*(default=40%) if the *[DCC]* flag in *Operation Cfg A* is set.

***CV Degrade Threshold 1*(offset 80):** Charging Voltage degrade threshold in Lifespan Mode 1

When enters Lifespan Mode 1, *ChargingVoltage()* is reduced by *CV Degrade Threshold 1*(default=10mV/cell).

***CV Degrade Threshold 2*(offset 82):** Charging Voltage degrade threshold in Lifespan Mode 2

When enters Lifespan Mode 2, *ChargingVoltage()* is reduced by *CV Degrade Threshold 2*(default=50mV/cell).

***CV Degrade Threshold 3*(offset 84):** Charging Voltage degrade threshold in Lifespan Mode 3

When enters Lifespan Mode 3, *ChargingVoltage()* is reduced by *CV Degrade Threshold 3*(default=120mV/cell).

***CCC Current Threshold*(offset 86):** Charging Loss Compensation Current Threshold

In constant current charge mode, if *Current()* is higher than *CCC Current Threshold*, SH366006 enters to Charging Loss Compensation function, more details please refer to Charging Loss Comppensation function description.

Loss Compensation

***CCC Voltage Threshold*(offset 88):** Charging Loss Compensation Voltage Limit Threshold

In Charging Loss Compensation function , max *ChargingVoltage()* increase limit, more details please refer to Charging Loss Comppensation function description.

6.4.2 Termination Cfg (Subclass 36)

***Taper Current* (Offset 0):** Charge Termination Current Threshold

***Taper Voltage* (Offset 2):** Charge Termination Voltage Threshold

***Taper Current Window* (Offset 4):** Charge Termination Time Threshold

If battery Current falls below Taper Current for 2 consecutive *Taper Current Window* periods during charging and *Max cell voltage1...4 + Taper Voltage* ≥ *ChargingVoltage() / number of cells in series*, the SH366006 recognizes valid primary charge termination.

***TCA Clear %* (Offset 5):** TCA Flag Clear Threshold

[TCA] in *BatteryStatus()* is cleared, if *RelativeStateOfCharge()* sinks below *TCA Clear %*.

***FC Clear %* (Offset 6):** FC Flag Clear Threshold

[FC] in *BatteryStatus()* is cleared if *RelativeStateOfCharge()* sinks below *FC Clear %*.

6.4.3 Cell Balancing Cfg (Subclass 37)

***MinCellDeviation* (Offset 0):** Min Cell Deviation Threshold

The SH366006 supports cell charge balancing. When the cells capacity differences exist during charging, balance process starts. The cell balancing algorithm is described as follows:

(a) Find the lowest capacity cell, and then detect the differences, dQ, between all the other cells.

(b) These differences must be bypassed through turning on the integrated bypass FETs in the SH366006 during each calculated cell bypass time.

(c) The bypass time is calculated based on *MincellDeviation*, as time=dQ x *MincellDeviation*.

MinCellDeviation is defined as the conversion factor for each cell balance time calculation in unit of mAh, before balance process starts. If *MinCellDeviation* is set to 0, cell balancing is disabled.

6.5 SBS Configuration

SBS Configuration includes SBData v1.1 standard data and SBS sub-configuration.

6.5.1 Data (Subclass 48)

***Rem Cap Alarm* (Offset 0):** Remaining Capacity Alarm

The default value of *RemainingCapacityAlarm()* is stored in this variable and copied to the SBS value on SH366006 initialization.

***Rem Energy Alarm* (Offset 2):** Remaining Energy Alarm

The default value of *RemainingEnergyAlarm()* is stored in this variable.

***Rem Time Alarm* (Offset 4):** Remaining Time Alarm

The default value of *RemainingTimeAlarm()* is stored in this variable and copied to the SBS value on SH366006 initialization.

***Init Battery Mode* (Offset 6):** Initial Battery Mode

The default value of *BatteryMode()* is stored in this variable and copied to the SBS value on SH366006 initialization.

***Init Mfg Status* (Offset 8):** Initial Manufacturing Status

The default value of *ManufacturingStatus()* is stored in this variable and copied to the SBS value on SH366006 initialization.

***Design Voltage* (Offset 10):** Design Voltage Value

The default value of *DesignVoltage()* is stored in this variable and copied to the SBS value on SH366006 initialization.

***Spec Info* (Offset 12):** Specification Information

The default value of *SpecificationInfo()* is stored in this variable and copied to the SBS value on SH366006 initialization

***Manuf Date* (Offset 14):** Manufacturer Date

The default value of ManufacturerDate() is stored in this variable and copied to the SBS value on SH366006 initialization.

***Ser. Num.* (Offset 16):** Serial Number

The default value of *SerialNumber()* is stored in this variable and copied to the SBS value on SH366006 initialization.

Cycle Count (Offset 18): Cycle Count Value

The default value of *CycleCount()* is stored in this variable and copied to the SBS value on SH366006 initialization. When SBS value changes this value is also updated.

***CC Percentage* (Offset 20):** Single Cycle Count Percentage Threshold

The cycle count function counts the accumulated discharge of *CC Percentage * DesginCapacity()* value in single one cycle.

***CF Max Error Limit* (Offset 21):** Relearning Threshold

If *MaxError()* function value is greater than this limit, *CONDITION_FLAG* is set.

***Design Capacity* (Offset 22):** Design Capacity Value

If *CAPACITY_MODE* is set to 0, the *DesignCapacity()* function reports this value.

***Design Energy* (Offset 24):** Design Energy Value

If CAPACITY_MODE is set to 1, the *DesignCapacity()* function reports this value.

Device Chemistry (Offset 26): Device Chemistry Element

The *DeviceChemistry()* function returns a string stored in this value. The maximum text length is 4 characters.

***Manuf Name* (Offset 31):** Manufacturer Name

The *ManufacturerName()* function returns a string stored in this value. The maximum text length is 15 characters.

***Device Name* (Offset 47):** Device Name

The *DeviceName()* function returns a string stored in this value. The maximum text length is 15 characters.

6.5.2 Sub-Configuration (Subclass 49)

TDA Set % (Offset 0): TDA Set Capacity Threshold

SH366006 sets *[TDA]* flag in *BatteryStatus()* if the *RelativeStateOfCharge()* reaches or falls below this value.

TDA Clear % (Offset 1): TDA Clear Capacity Threshold

SH366006 clears *[TDA]* flag in *BatteryStatus()* if the *RelativeStateOfCharge()* reaches or rises above this value.

FD Set % (Offset 2): FD Set Capacity Threshold

SH366006 sets *[FD]* flag in *BatteryStatus()* if the *RelativeStateOfCharge()* reaches or falls below this value.

FD Clear % (Offset 3): FD Clear Capacity Threshold

SH366006 clears *[FD]* flag in *BatteryStatus()* if the *RelativeStateOfCharge()* reaches or rises above this value.

***TDA Set Volt Threshold* (Offset 4):** TDA Set Volt Threshold

The SH366006 sets *[TDA]* flag in *BatteryStatus()* if Voltage is equal to or lower than *TDA Set Volt Threshold*.

***TDA Clear Volt* (Offset 6):** TDA Clear Volt Threshold

SH366006 clears *[TDA]* flag in *BatteryStatus()* if Voltage is equal to or above than *TDA Clear Volt*.

6.5.3 DBPT Cfg (Subclass 51)

***SPP Max C Rate*(offset 0):**

This value specifies the maximal discharge current for 10s. (defined for Turbo Mode).

***MPP Max C Rate*(offset 1):**

This value specifies the maximal discharge current for 10ms. (defined for Turbo Mode).

***Pack Resistance*(offset 2):**

Pack-side resistance value accessed using ***PackResistance***. (defined for Turbo Mode).

***System Resistance*(offset 4):**

System side resistance value accessed using ***SystemResistance***. (defined for Turbo Mode).

6.6 Lifetimes

6.6.1 Lifetime Data (Subclass 52)

***Total Usage Time* (Offset 0):** Firmware total run time

***Cell 1 Max Voltage* (Offset 2):** Maximum reported cell voltage 1

***Cell 2 Max Voltage* (Offset 4):** Maximum reported cell voltage 2

***Cell 3 Max Voltage* (Offset 6):** Maximum reported cell voltage 3

***Cell 4 Max Voltage* (Offset 8):** Maximum reported cell voltage 4

***Cell 1 Min Voltage* (Offset 10):** Minimum reported cell voltage 1

***Cell 2 Min Voltage* (Offset 12):** Minimum reported cell voltage 2

***Cell 3 Min Voltage* (Offset 14):** Minimum reported cell voltage 3

***Cell 4 Min Voltage* (Offset 16):** Minimum reported cell voltage 4

***Max Delta Cell Voltage* (Offset 18):** Minimum reported delta Cell Voltage

***Max Charge Current* (Offset 20):** Maximum reported *Current()* in charge direction

***Max Discharge Current* (Offset 22):** Maximum reported *Current()* in discharge direction

***Max Avg Dsg Current* (Offset 24):** Maximum reported *AverageCurrent()* in charge direction

***Max Avg Dsg Power* (Offset 26):** Maximum reported AveargePowe in discharge direction in *DAStatus1()*.

***Max Temp Cell* (Offset 28):** Maximum reported cell temperature

***Min Temp Cell* (Offset 29):** Minimum reported cell temperature

***Max Delta Cell Temp* (Offset 30):** Maximum reported temperature delta for TSx inputs configured as cell temperature

***Max Temp FET* (Offset 31):** Maximum reported FET temperature

***No Of COV Events* (Offset 32):** Total number of *SafetyStatus()[COV]* events

***Last COV Event* (Offset 34):** Last *SafetyStatus()[COV]* event in *CycleCount()* cycles

***No Of CUV Events* (Offset 36):** Total number of *SafetyStatus()[CUV]* events

***Last CUV Event* (Offset 38):** Last *SafetyStatus()[CUV]* event in *CycleCount()* cycles

***No Of OCD1 Events* (Offset 40):** Total number of *SafetyStatus()[OCD1]* events

***Last OCD1 Event* (Offset 42):** Last *SafetyStatus()[OCD1]* event in *CycleCount()* cycles

***No Of OCD2 Events* (Offset 44):** Total number of *SafetyStatus()[OCD2]* events

***Last OCD2 Event* (Offset 46):** Last *SafetyStatus()[OCD2]* event in *CycleCount()* cycles

***No Of OCC1 Events* (Offset 48):** Total number of *SafetyStatus()[OCC1]* events

***Last OCC1 Event* (Offset 50):** Last *SafetyStatus()[OCC1]* event in *CycleCount()* cycles

***No Of OCC2 Events* (Offset 52):** Total number of *SafetyStatus()[OCC2]* events

***Last OCC2 Event* (Offset 54):** Last *SafetyStatus()[OCC2]* event in *CycleCount()* cycles

***No Of AOLD Events* (Offset 56):** Total number of *SafetyStatus()[AOLD]* events

***Last AOLD Event* (Offset 58):** Last *SafetyStatus()[AOLD]* event in *CycleCount()* cycles

***No Of SCD Events* (Offset 60):** Total number of *SafetyStatus()[SCD]* events

***Last SCD Event* (Offset 62):** Last *SafetyStatus()[SCD]* event in *CycleCount()* cycles

***No Of SCC Events* (Offset 64):** Total number of *SafetyStatus()[SCC]* events

***Last SCC Event* (Offset 66):** Last *SafetyStatus()[SCC]* event in *CycleCount()* cycles

***No Of OTC Events* (Offset 68):** Total number of *SafetyStatus()[OTC]* events

***Last OTC Event* (Offset 70):** Last *SafetyStatus()[OTC]* event in *CycleCount()* cycles

***No Of OTD Events* (Offset 72):** Total number of *SafetyStatus()[OTD]* events

***Last OTD Event* (Offset 74):** Last *SafetyStatus()[OTD]* event in *CycleCount()* cycles

***No Of OTF Events* (Offset 76):** Total number of *SafetyStatus()[OTF]* events

***Last OTF Event* (Offset 78):** Last *SafetyStatus()[OTF]* event in *CycleCount()* cycles

6.7 System Data

6.7.1 Manufacturer Info (Subclass 58)

***Manuf. Info* (Offset 0):** Manufacturer Information

The *ManufacturerInfo()* function returns the string stored in this variable. The maximum text length is 32 characters.

6.8 Configuration

The parameters that need configuration in different applications are listed below:

6.8.1 Registers (Subclass 64)

***Operation Cfg A* (Offset 0):** Operation Configure Register A

***Operation Cfg B* (Offset 2):** Operation Configure Register B

***Operation Cfg C* (Offset 4):** Operation Configure Register C

These registers enable, disable or configure various features of SH366006.

Name	Bits	Description
IATAEN	15	IATA Function 0 - Disabled 1 - Enabled
FTEMP	14	FET temperature protection source 0 - MAX (default) 1 - Average
DCC	13	*ChargingCurrent()* degrades with *ChargingVoltage()* 0 - Disabled 1 - Enabled
FSMSOH	12	Four Stages Mode switch based on SOH 0 - Disabled 1 - Enabled
FSMCC	11	Four Stages Mode switch based on CycleCout 0 - Disabled 1 - Enabled
ISS	10	In-system SLEEP mode 0 - Disabled 1 - Enabled
CC1:CC0	9-8	Configure the SH366006 for the number of series cells in the battery stack. 0,0 - 2 cell 0,1 - 2 cell 1,0 - 3 cell 1,1 - 4 cell (default)
CTEMP1: CTEMP0	7	Defines which temperature sensor's output is displayed by the SBS Temperature() command 0, 0 - Maximum temperature 0, 1 - Average temperature 1, 0 - Minimum temperature 1, 1 - Not used
SLEEP	5	Enables the SH366006 to enter Sleep mode if SMBus lines are low. 0 - SH366006 never enters Sleep mode 1 - SH366006 enters Sleep mode under normal Sleep entry criteria (default)
RSVD	4-3	Reserved
CUVRC	2	Require charge to recover CUV protection 0 - Disabled 1 - Enabled
CCC	1	Enables charging loss compensation 0 - Disabled 1 - Enabled
PRECHG	0	Enables or disables the use of PCHG or CHG FET in Precharge modes. 0 - PCHG(triggered by OD) 1 - CHG(triggered by CHG)

Table.32 Operation Cfg A Register

Name	Bits	Description
RSVD	15-13	Reserved
NCSMB	12	Enables fast SMBUS mode. 0 - Normal(default) 1 - fast SMBUS
SLEEPCHG	11	Enables the CHG FET during sleep 0 - CHG FET off during sleep (default) 1 – CHG FET remains on during sleep
CSYNC	10	Enables the SH366006 to write RemainingCapacity = *FullChargeCapacity* when a valid charge termination is detected. 0 - RemainingCapacity is not modified on valid primary charge termination 1 - RemainingCapacity is written up to equal *FullChargeCapacity* on valid primary charge termination. (default)
RSVD	9-8	Reserved
CHGSU	7	Enables SH366006 to turn off CHG FET (and PCHG FET) in charge suspend mode. 0 - No FET change in Charge Suspend mode. (default) 1 - CHG FET and PCHG FET (if used) keep off in Charge Suspend mode.
OTFET	6	Enables or disables FET actions from reacting to an overtemperature fault. 0 - There is NO FET action when an overtemperature condition is detected. 1 - When *[OTC]* flag is set, the CHG FET is turned off. When *[OTD]* flag is set, the DSG FET is turned off. When *[OTF]* flag is set, the CHG/DSG FET are turned off.
CHGFET	5	Enables or disables the CHG FET from reacting to a valid charge termination. 0 - CHG FET stays on at charge termination. 1 - CHG FET is turned off at charge termination.
CHGIN	4	Enable the CHG FET and PCHG FET (if used) to turn off in charge inhibit mode. 0 - No FET change in charge-inhibit mode. 1 - Charge and PCHG FET, if used, turn off in charge-inhibit mode.
NR	3	Configures the SH366006 in removable or non-removable battery mode. 0 - Removable battery mode. 1 - Non-removable battery mode.
RSVD	2-0	Reserved

Table.33 Operation Cfg B Register

Name	Bits	Description
TS4M	15	TS4 Mode Select Bit 0 - Cell temperature (default) 1 - FET temperature
TS3M	14	TS3 Mode Select Bit 0 - Cell temperature (default) 1 - FET temperature
TS2M	13	TS2 Mode Select Bit 0 - Cell temperature (default) 1 - FET temperature
TS1M	12	TS1 Mode Select Bit 0 - Cell temperature (default) 1 - FET temperature
TS4	11	Enable TS4 Sensor 0 - Disables TS4 1 - Enalbes TS4(default)
TS3	10	Enable TS3 Sensor 0 - Disables TS3 1 - Enalbes TS3(default)
TS2	9	Enable TS2 Sensor 0 - Disables TS2 1 - Enalbes TS2(default)
TS1	8	Enable TS1 Sensor 0 - Disables TS1 1 - Enalbes TS1(default)
RSVD	7-1	Reserved
RSOCL	0	Configures the RelativeStateOfCharge display during charge termination. 0- *RelativeStateOfCharge()* is not locked. RSOC=RC/FCC. 1- *RelativeStateOfCharge()* is locked at 99% not changed to 100% until primary charge termination.

Table.34 Operation Cfg C Register

Protection Cfg A (Offset 6): Protection Configure Register A

All protection items can be enabled or disabled under Protection Configuration register.

Name	Bits	Description
RSVD	15-14	Reserved
OTD	13	Over temperature in discharge 0 - Disabled 1 - Enabled
OTC	12	Over temperature in charge 0 - Disabled 1 - Enabled
RSVD	11-6	Reserved
OCD2	5	Over current 2 in discharge 0 - Disabled 1 - Enabled
OCD1	4	Over current 1 in discharge 0 - Disabled 1 - Enabled
OCC2	3	Over current 2 in charge 0 - Disabled 1 - Enabled
OCC1	2	Over current 1 in charge 0 - Disabled 1 - Enabled
COV	1	Cell over voltage 0 - Disabled 1 - Enabled
CUV	0	Cell under voltage 0 - Disabled 1 - Enabled

Table.35 Protection Cfg A Register

Protection Cfg B (Offset 8): Protection Configure Register B

All protection items can be enabled or disabled under Protection Configuration register.

Name	Bits	Description
RSVD	15~11	Reserved
UTD	10	Under temperature in discharge 0 - Disabled 1 - Enabled
UTC	9	Under temperature in charge 0 - Disabled 1 - Enabled
OCPC	8	Over current in Precharge 0 - Disabled 1 - Enabled
RSVD	7	Reserved
OC	6	Overcharge protection 0 - Disabled 1 - Enabled
RSVD	5	Reserved
CTO	4	Charge timeout 0 - Disabled 1 - Enabled
RSVD	3	Reserved
PTO	2	Precharge timeout 0 - Disabled 1 - Enabled
RSVD	1	Reserved
OTF	0	FET over temperature 0 - Disabled 1 - Enabled

Table.36 Protection Cfg B Register

PF Enable Cfg A (Offset 10): Permanent Failure Enable Configure Register A

All permanent failure can be enabled or disabled under PF Enable Configuration register.

Name	Bits	Description
RSVD	15~12	Reserved
CIM	11	Cell-Imbalance permanent failure 0 = Disabled(default) 1 = Enabled
OWB	10	Old weak battery permanent failure 0 = Disabled(default) 1 = Enabled
ISD	9	Internal short detection permanent failure 0 = Disabled(default) 1 = Enabled
RSVD	8	Reserved
TDD	7	Tab disconnection detection permanent failure 0 = Disabled(default) 1 = Enabled
SOTF	6	Safety FET Overtemperature permanent failure 0 = Disabled(default) 1 = Enabled
RSVD	5	Reserved
SOTC	4	Safety Cell Overtemperature permanent failure 0 = Disabled(default) 1 = Enabled
SOCD	3	Discharge safety overcurrent permanent failure 0 = Disabled(default) 1 = Enabled
SOCC	2	Charge safety overcurrent permanent failure 0 = Disabled(default) 1 = Enabled
SOV	1	Safety Overvoltage permanent failure flag 0 = Disabled(default) 1 = Enabled
SUV	0	Safety Undervoltage permanent failure 0 = Disabled(default) 1 = Enabled

Table.37 Fuse Blow Cfg A Register

PF Enable Cfg B (Offset 12): Permanent Failure Enable Configure Register B

All permanent failure can be enabled or disabled under PF Enable Configuration register.

Name	Bits	Description
TS4	31	TS4 Thermistor failure permanent failure 0 = Disabled(default) 1 = Enabled
TS3	30	TS3 Thermistor failure permanent failure 0 = Disabled(default) 1 = Enabled
TS2	29	TS2 Thermistor failure permanent failure 0 = Disabled(default) 1 = Enabled
TS1	28	TS1 Thermistor failure permanent failure 0 = Disabled(default) 1 = Enabled
RSVD	23~27	Reserved
PFIN	22	External Input Indication of permanent failure 0 = Disabled(default) 1 = Enabled
AFEC	21	AFE Communications permanent failure 0 = Disabled(default) 1 = Enabled
AFER	20	AFE Register permanent failure 0 = Disabled(default) 1 = Enabled
FUSE	19	Chemical Fuse failure 0 = Disabled(default) 1 = Enabled
RSVD	18	Reserved
DFETF	17	Discharge-FET Failure permanent failure 0 = Disabled(default) 1 = Enabled
CFETF	16	Charge-FET Failure permanent failure 0 = Disabled(default) 1 = Enabled

Table.38 Fuse Blow Cfg B Register

Fuse Blow Cfg A (Offset 14): Fuse Blow Configure Register A

The Fuse blow action for *PFStatus()* bits in the SH366006 permanent-failure condition.

Name	Bits	Description
RSVD	15~12	Reserved
CIM	11	Cell-Imbalance permanent failure 0 = Disabled(default) 1 = Enabled
OWB	10	Old weak battery permanent failure 0 = Disabled(default) 1 = Enabled
ISD	9	Internal short detection permanent failure 0 = Disabled(default) 1 = Enabled
RSVD	8	Reserved
TDD	7	Tab disconnection detection permanent failure 0 = Disabled(default) 1 = Enabled
SOTF	6	Safety FET Overtemperature permanent failure 0 = Disabled(default) 1 = Enabled
RSVD	5	Reserved
SOTC	4	Safety Cell Overtemperature permanent failure 0 = Disabled(default) 1 = Enabled
SOCD	3	Discharge safety overcurrent permanent failure 0 = Disabled(default) 1 = Enabled
SOCC	2	Charge safety overcurrent permanent failure 0 = Disabled(default) 1 = Enabled
SOV	1	Safety Overvoltage permanent failure flag 0 = Disabled(default) 1 = Enabled
SUV	0	Safety Undervoltage permanent failure 0 = Disabled(default) 1 = Enabled

Table.39 Fuse Blow Cfg A Register

Fuse Blow Cfg B (Offset 16): Fuse Blow Configure Register B

The Fuse blow action for *PFStatus()* bits in the SH366006 permanent-failure condition.

Name	Bits	Description
TS4	31	TS4 Thermistor failure permanent failure 0 = Disabled(default) 1 = Enabled
TS3	30	TS3 Thermistor failure permanent failure 0 = Disabled(default) 1 = Enabled
TS2	29	TS2 Thermistor failure permanent failure 0 = Disabled(default) 1 = Enabled
TS1	28	TS1 Thermistor failure permanent failure 0 = Disabled(default) 1 = Enabled
RSVD	27	Reserved
DFF	26	Dataflash Fault permanent failure 0 = Disabled(default) 1 = Enabled
RSVD	25	Reserved
IFC	24	Instruction Flash Checksum failure 0 = Disabled(default) 1 = Enabled
RSVD	23	Reserved
PFIN	22	External Input Indication of permanent failure 0 = Disabled(default) 1 = Enabled
AFEC	21	AFE Communications permanent failure 0 = Disabled(default) 1 = Enabled
AFER	20	AFE Register permanent failure 0 = Disabled(default) 1 = Enabled
FUSE	19	Chemical Fuse failure 0 = Disabled(default) 1 = Enabled
RSVD	18	Reserved
DFETF	17	Discharge-FET Failure permanent failure 0 = Disabled(default) 1 = Enabled
CFETF	16	Charge-FET Failure permanent failure 0 = Disabled(default) 1 = Enabled

Table.40 Fuse Blow Cfg B Register

Min Blow Fuse Voltage **(Offset 18):** Min Blow Fuse Voltage limited

Minimum voltage required to attempt fuse blow, pack based, FET failures bypass this requirement to blow the fuse.

Fuse Blow Time **(Offset 20):** Fuse Blow Time limited

When SH366006 tries to blow the fuse, the fuse is not always blown by some reasons and may cause case melt problem by the heat from the fuse. To avoid over heat and case melt, SH366006 need to have timer function to stop fuse blow action. The supplier needs to decide appropriate timer setting.

6.9 Powers

6.9.1 Power (Subclass 68)

***Flash Update OK Voltage* (Offset 0):** Minimum allowed battery pack voltage for flash update.

If battery pack Voltage is below this threshold no flash update will be enabled. Even so, flash update will be enabled if a charger is detected.

***Shutdown Voltage* (Offset 2):** Shutdown Voltage Threshold

***Shutdown Time* (Offset 4):** Shutdown Time Threshold

The SH366006 goes into Shutdown Mode if any cell voltage is equal to or lower than *Shutdown Voltage* for *Shutdown Time* period but at least 10s counting from the last exit of Shutdown Mode.

***Charger Present* (Offset 5):** Charger Present Voltage Threshold

The SH366006 detects a charger when the voltage at PACK pin of AFE is above this threshold. If a charger is detected, it overrides *Flash Update Ok Voltage* function and enabled flash update.

***Sleep Current* (Offset 7):** Current threshold to enter SLEEP mode.

***Sleep Wait Time* (Offset 9):** Bus low or no communication time to enter SLEEP mode.

***Wake Current Reg* (Offset 10):** Wake Current Register

Wake Current Reg configures the current threshold required to wake the SH366006 from sleep mode by detecting voltage based on the resistances listed below.

Name	Bits	Description
RSVD	7-3	Reserved
IWAKE	2	Enable or disable current wake-up
RSNS1：RSNS0	1-0	Wake Current Threshold 0,0 – 1.4mV 0,1 - 3mV 1, 0 - 6mV 1, 1 - 12mV

Table.41 Wake Current Reg Register

***Term Voltage* (Offset 11):** Termination Voltage for battery discharge.

Its value is the single cell termination voltage * battery cell number. When cell voltage decreases to this value, the *RemainingCapacity()* is set to zero.

6.10 Fusion Gauging

Gas Gauging parameters should be configured different from different application.

6.10.1 Configuration(Subclass 79)

***Load Select* (Offset 0):** This data indicate the kind of current (*Load Mode*=0, Constant Current Mode) or power (*Load Mode*=1, Constant Power Mode) for Gas Gauging calculation. When *Load Select*=3 and *Load Mode*=1, it means *AverageCurrent()* is effective for Gas Gauging in CC Mode.

The current or power for Gas Gauging calculation can be selected from the list below depending on the *Load Select* value.

	Constant Current Mode	Constant Power Mode
0 =	Average I Last Run	Average P Last Run
1 =	Present average discharge current	Present average discharge power
2 =	*Current()*	*Current()* × *Voltage()*
3 =	*AverageCurrent()*	*AverageCurrent()* × *AverageVoltage()*
4 =	*Design Capacity* / 5	*Design Energy* / 5
5 =	*AtRate()* (mA)	*AtRate()* (10 mW)
6 =	*User Rate-mA*	*User Rate-mW*

***Load Mode* (Offset 1):** SH366006 is in Constant Current Mode (CC Mode) if *Load Mode*=0, and in Constant Power (CP Mode) if *Load Mode*=1.

***User Rate-mA* (Offset 2):** It's a value in unit of mA for *Load Select* in CC Mode. And it is also used for Gas Gauging calculation at charging start in CC Mode. Default = 0.5C.

***User Rate-mW* (Offset 4):** It's a value in unit of cW for *Load Select* in CP Mode. And it is also used for Gas Gauging calculation at charging start in CP Mode. Default = 0.5C.

***Reserve Cap-mAh* (Offset 6):** Reserve capacity configuration register in CC Mode

Reserve Cap-mAh determines how much actual remaining capacity exists after reaching *RemainingCapacity()* before *Terminate Voltage* is reached. This register is only used if *Load Mode* is set to 0.

Normal Setting: This register defaults to 0, which disables this function. This is the most common setting for this register. This register is application dependent. This is a specialized function for allowing time for a controlled shutdown after reported Remaining Capacity is reached.

***Reserve Cap-mWh* (Offset 8):** Reserve capacity configuration register in CP Mode.

Reserve Cap mWh determines how much actual remaining capacity exists after reaching *RemainingCapacity()* before *Terminate Voltage* is reached. This register is only used if *Load Mode* is set to 1.

Normal Setting: This register defaults to 0, which basically disables this function. This is the most common setting for this register. This register is application dependent. This is a specialized function for allowing time for a controlled shutdown after reported Remaining Capacity is reached.

6.10.2 Current Thresholds (Subclass 81)

***Dsg Current Threshold* (Offset 0):** Effective Discharge Current Threshold

SH366006 enters discharge mode from relaxation mode or charge mode if *Current()* ≤ (-) *Dsg Current Threshold*

***Chg Current Threshold* (Offset 2):** Effective Charge Current Threshold

SH366006 enters effective charge mode if *Current()* ≥ *Chg Current Threshold*.

***Quit Current* (Offset 4):** Static Current Threshold

***Dsg Relax Time* (Offset 6):** Discharge Relax Mode Time-delay

***Chg Relax Time* (Offset 7):** Charge Relax Mode Time-delay

SH366006 enters relaxation mode from charge mode if *Current()* goes below *Quit Current* for a period of *Chg Relax Time*. The SH366006 also enters relaxation mode from discharge mode if *Current()* goes above (-) *Quit Current* for a period of *Dsg Relax Time*.

6.10.3 State (Subclass 82)

***Qcell0* (Offset 0):** The Maximum Chemical Capacity for Cell 0

***Qcell1* (Offset 2):** The Maximum Chemical Capacity for Cell 1

***Qcell2* (Offset 4):** The Maximum Chemical Capacity for Cell 2

***Qcell3* (Offset 6):** The Maximum Chemical Capacity for Cell 3

SH366006 estimates initial battery pack capacity with Qcell 0…3 after reset.

***FG Status* (Offset 8):** The 1-byte data indicates the status in each running period of the Fusion Gauge Algorithm.

Bit 0=1: The Fusion Gauge Algorithm has run complete at least one cycle after several CHG-Relax-DSG cycles.

Bit 1=1: The first update of Qmax is finished.

Bit 2, 3: Reserved.

Bit 4-7: Set the corresponding bit if the Cell1-4 corresponding parameters have been updated.

More details please refer to Max Error part (5.12).

6.11 PF Status

The data in this class is saved at the time of the PF event.

6.11.1 PF Data(Subclass 96)

***PF Status 1* (Offset 0):** PF Status Record Register 1

All permanent failure flags in the failure sequence are stored in PF Flags 1.

***PF Status 2* (Offset 4):** PF Status Record Register 2

Only the first permanent failure flag in a failure sequence is stored in PF Flags 2 to indicate the cause of the permanent failure.

Cell 1 Voltage(Offset 8): Cell 1 Voltage at the time of PF event

Cell 2 Voltage(Offset 10): Cell 2 Voltage at the time of PF event

Cell 3 Voltage(Offset 12): Cell 3 Voltage at the time of PF event

Cell 4 Voltage(Offset 14): Cell 4 Voltage at the time of PF event

Pack Voltage(Offset 16): Pack Voltage at the time of PF event

Current(Offset 18): Current at the time of PF event

TS1 Temperature(Offset 20): External TS1 temperature at the time of PF event

TS2 Temperature(Offset 22): External TS2 temperature at the time of PF event

TS3 Temperature(Offset 24): External TS3 temperature at the time of PF event

TS4 Temperature(Offset 26): External TS4 temperature at the time of PF event

6.12 Calibration

Various parameters that listed below should be configured different from different application.

6.12.1 Data (Subclass 104)

***CC Gain* (Offset 0):** The Current Scale Factor for the Coulomb Counter

This register is used in current and coulomb counter estimation. Manual modification is not recommended.

***Cell 1 Voltage Gain* (Offset 4):** Cell 1 Voltage Gain

This register is used in cell 1 voltage estimation. Manual modification is not recommended.

***Cell 2 Voltage Gain* (Offset 6):** Cell 2 Voltage Gain

This register is used in cell 2 voltage estimation. Manual modification is not recommended.

***Cell 3 Voltage Gain* (Offset 8):** Cell 3 Voltage Gain

This register is used in cell 3 voltage estimation. Manual modification is not recommended.

***Cell 4 Voltage Gain* (Offset 10):** Cell 4 Voltage Gain

This register is used in cell 4 voltage estimation. Manual modification is not recommended.

***AFE Pack Gain* (Offset 12):** AFE Pack Gain

This register is used in pack voltage estimation. Manual modification is not recommended.

***Board Offset* (Offset 14):** PCB Dependant Coulomb Counter Offset

This register is used in pack current and coulomb counter estimation. Manual modification is not recommended.

***Ext1 Temp Offset* (Offset 16):** TS1 temperature compensation

This register is the temperature sensor offset compensation of the external temperature sensor 1. Manual modification is not recommended.

***Ext2 Temp Offset* (Offset 17):** TS2 temperature compensation

This register is the temperature sensor offset compensation of the external temperature sensor 2. Manual modification is not recommended.

***Ext3 Temp Offset* (Offset 18):** TS3 temperature compensation

This register is the temperature sensor offset compensation of the external temperature sensor 3. Manual modification is not recommended.

***Ext4 Temp Offset* (Offset 19):** TS4 temperature compensation

This register is the temperature sensor offset compensation of the external temperature sensor 4. Manual modification is not recommended.

6.12.2 Current (Subclass 107)

***Deadband* (Offset 0)：** Current Detect Threshold

SBS Current returns 0mA when the current does not exceed this threshold.

CC Deadband Reg (Offset 1)： Coulomb Counter Threshold

The coulomb counter stops when the current does not exceed the threshold which is programmed in CC Deadband Reg. Only these values of 3, 5, 7, and 9 can be set in this register effectively.

Name	Bits	Description
RSVD	7-2	Reserved
CTS1:CTS0	1-0	CC Deadband Current Threshold 0, 0 – 3mA 0, 1 – 5mA 1, 0 – 7mA 1, 1 – 9mA

6.13 IATA

6.13.1 IATA Store (Subclass 108)

***IATA Flag* (Offset 0):** a flag that IATA shutdown is enabled.

***IATA RC* (Offset 1):** IATA RC stores the remaining capacity at the time an IATA shutdown occurs.

***IATA RE* (Offset 3):** IATA RE stores the remaining energy at the time an IATA shutdown occurs.

***IATA FCC*(Offset 5):** IATA RC stores the full charge capacity at the time an IATA shutdown occurs.

***IATA FCE*(Offset 7):** IATA RC stores the full charge energy at the time an IATA shutdown occurs.

When the *[IATAEN]* flag in *Operation Cfg A* is set, if SH366006 receives MAC Shutdown Command(0x0010), SH366006 enters an IATA shutdown procedure. At the same time, IATA Flag is set to 0xFF, store true remaining capacity and full charge capcity in the data flash parameters *IATA RC* and *IATA FCC*, and store ture remaining energy and full charge energy in the data flash parameters *IATA RE* and *IATA FCE*.

Class	Subclass ID	Subclass	Offset	Name	Date Type	Min.	Max.	Default	Units
1st Protect	0	Voltage	0	*LT COV Threshold*	U2	3700	5000	4390	mV
1st Protect	0	Voltage	2	*LT COV Recovery*	U2	0	4400	4200	mV
1st Protect	0	Voltage	4	*STL COV Threshold*	U2	3700	5000	4390	mV
1st Protect	0	Voltage	6	*STL COV Recovery*	U2	0	4400	4200	mV
1st Protect	0	Voltage	8	*RT COV Threshold*	U2	3700	5000	4390	mV
1st Protect	0	Voltage	10	*RT COV Recovery*	U2	0	4400	4200	mV
1st Protect	0	Voltage	12	*STH COV Threshold*	U2	3700	5000	4390	mV
1st Protect	0	Voltage	14	*STH COV Recovery*	U2	0	4400	4200	mV
1st Protect	0	Voltage	16	*HT COV Threshold*	U2	3700	5000	4390	mV
1st Protect	0	Voltage	18	*HT COV Recovery*	U2	0	4400	4200	mV
1st Protect	0	Voltage	20	*COV Time*	U1	0	255	2	s
1st Protect	0	Voltage	21	*CUV Threshold*	U2	0	3500	2850	mV
1st Protect	0	Voltage	23	*CUV Time*	U1	0	255	2	s
1st Protect	0	Voltage	24	*CUV Recovery*	U2	0	3600	3000	mV
1st Protect	1	Current	0	*OCC1 Threshold*	I2	-32767	32767	3500	mA
1st Protect	1	Current	2	*OCC1 Time*	U1	0	255	4	s
1st Protect	1	Current	3	*OCC2 Threshold*	I2	-32767	32767	5000	mA
1st Protect	1	Current	5	*OCC2 Time*	U1	0	255	2	s
1st Protect	1	Current	6	*OCC Recovery*	U2	-32767	32767	-200	mA
1st Protect	1	Current	8	*OCC Recovery Time*	U1	0	255	5	s
1st Protect	1	Current	9	*OCD1 Threshold*	I2	-32767	32767	-6000	mA
1st Protect	1	Current	11	*OCD1 Time*	U1	0	255	6	s
1st Protect	1	Current	12	*OCD2 Threshold*	I2	-32767	32767	-8000	mA
1st Protect	1	Current	14	*OCD2 Time*	U1	0	255	3	s
1st Protect	1	Current	15	*Current Recovery Time*	U1	0	60	30	s
1st Protect	1	Current	17	*OCD Recovery*	I2	-32767	32767	200	mA
1st Protect	1	Current	18	*OCD Recovery Time*	U1	0	255	5	s
1st Protect	1	Current	19	*AFE OC Dsg Time*	U1	0x00	0xff	0x0f	
1st Protect	1	Current	20	*AFE SC Chg Cfg*	U1	0x00	0xff	0xf2	
1st Protect	1	Current	21	*AFE SC Dsg Cfg*	U1	0x00	0xff	0xf2	
1st Protect	1	Current	22	*AOCD Recovery Time*	U1	0	255	5	s
1st Protect	1	Current	23	*SCC Recovery Time*	U1	0	255	5	s
1st Protect	1	Current	24	*SDC Recovery Time*	U1	0	255	5	s
1st Protect	2	Temperature	0	*Over Temp Chg*	U2	0	1200	600	0.1℃
1st Protect	2	Temperature	2	*OTC Time*	U1	0	255	2	s
1st Protect	2	Temperature	3	*OT Chg Recovery*	U2	0	1200	500	0.1℃
1st Protect	2	Temperature	5	*Over Temp Dsg*	U2	0	1200	720	0.1℃
1st Protect	2	Temperature	7	*OTD Time*	U1	0	255	2	s
1st Protect	2	Temperature	8	*OT Dsg Recovery*	U2	0	1200	600	0.1℃
1st Protect	2	Temperature	9	*OTF Temp Threshold*	U2	0	1200	800	0.1℃
1st Protect	2	Temperature	11	*OTF Time*	U1	0	255	2	s
1st Protect	2	Temperature	12	*OTF Recovery Temp*	U2	0	1200	650	0.1℃
1st Protect	2	Temperature	14	*Under Temp Chg*	U2	0	1200	0	0.1℃
1st Protect	2	Temperature	16	*Under Time*	U1	0	255	2	s
1st Protect	2	Temperature	17	*UT Chg Recovery*	U2	0	1200	50	0.1℃
1st Protect	2	Temperature	19	*Under Temp Dsg*	U2	0	1200	0	0.1℃
1st Protect	2	Temperature	21	*Under Time*	U1	0	255	2	s
1st Protect	2	Temperature	22	*UT Dsg Recovery*	U2	0	1200	50	0.1℃
1st Protect	3	Pre-CHG Current	0	*OC PreChg*	U2	0	20000	600	mA

Table.42 DataFlash Configuration

Class	Subclass ID	Subclass	Offset	Name	Date Type	Min.	Max.	Default	Units
1st Protect	3	Pre-CHG Current	2	*OC PreChg Time*	U1	0	60	2	s
1st Protect	3	Pre-CHG Current	3	*OC PreChg Recovery Time*	U1	0	60	8	s
1st Protect	4	Time Out	0	*PTO Charge Threshold*	I2	-32767	32767	2000	mA
1st Protect	4	Time Out	2	*PTO Suspend Threshold*	I2	-32767	32767	1800	mA
1st Protect	4	Time Out	4	*PTO Time*	U2	0	65535	1800	s
1st Protect	4	Time Out	6	*PTO Recovery*	U2	0	65535	2	mAh
1st Protect	4	Time Out	8	*CTO Charge Threshold*	I2	-32767	32767	2500	mA
1st Protect	4	Time Out	10	*CTO Suspend Threshold*	I2	-32767	32767	2000	mA
1st Protect	4	Time Out	12	*CTO Time*	U2	0	65535	54000	s
1st Protect	4	Time Out	14	*CTO Recovery*	U2	0	65535	2	mAh
1st Protect	5	Overcharge	0	*OC Capacity Threshold*	U2	0	65536	300	mAh
1st Protect	5	Overcharge	2	*OC Capacity Recovery*	U2	0	65536	2	mAh
1st Protect	5	Overcharge	4	*OC RSOC Recovery*	U1	0	100	98	%
2nd Protect	16	Voltage	0	*SOV Threshold*	U2	0	5000	4500	mV
2nd Protect	16	Voltage	2	*SOV Time*	U1	0	30	5	s
2nd Protect	16	Voltage	3	*SUV Threshold*	U2	0	3500	1500	mV
2nd Protect	16	Voltage	5	*SUV Time*	U1	0	30	5	s
2nd Protect	16	Voltage	6	*Cell Imbalance Check Voltage*	U2	0	5000	3500	mV
2nd Protect	16	Voltage	8	*Cell Imbalance Current*	U1	0	200	20	mA
2nd Protect	16	Voltage	9	*Cell Imbalance Fail Voltage*	U2	0	5000	500	mV
2nd Protect	16	Voltage	11	*Cell Imbalance Time*	U1	0	30	5	s
2nd Protect	16	Voltage	12	*Battery Rest Time*	U2	0	65535	1800	s
2nd Protect	16	Voltage	14	*PFIN Detect Time*	U1	0	30	0	s
2nd Protect	17	Current	0	*SOC Chg*	I2	-32767	32767	7000	mA
2nd Protect	17	Current	2	*SOC Chg Time*	U1	0	30	0	s
2nd Protect	17	Current	3	*SOC Dsg*	I2	-32767	32767	-9000	mA
2nd Protect	17	Current	5	*SOC Dsg Time*	U1	0	30	0	s
2nd Protect	18	Temperature	0	*SOTC Threshold*	U2	0	1200	800	0.1℃
2nd Protect	18	Temperature	2	*SOTC Time*	U1	0	30	5	S
2nd Protect	18	Temperature	3	*SOTF Threshold*	U2	0	1200	900	0.1℃
2nd Protect	18	Temperature	5	*SOTF Time*	U1	0	30	5	s
2nd Protect	18	Temperature	6	*Thermistor Error Time*	U1	0	30	0	s
2nd Protect	19	FET Verification	0	*CFET Fail Current*	I2	-32767	32767	50	mA
2nd Protect	19	FET Verification	2	*CFET Fail Time*	U1	0	30	5	s
2nd Protect	19	FET Verification	3	*DFET Fail Current*	I2	-32767	32767	-50	mA
2nd Protect	19	FET Verification	5	*DFET Fail Time*	U1	0	30	5	s
2nd Protect	20	AFE Verification	0	*AFE Fail Limit*	U1	0	255	0	-
2nd Protect	21	InternalShort Detection	0	*ISD OCV Threshold*	U2	0	5000	3816	mV
2nd Protect	21	InternalShort Detection	2	*ISD Delta Voltage*	U2	0	1000	20	mV/h
2nd Protect	21	InternalShort Detection	4	*ISD Voltage Threshold*	U2	0	1000	15	mV
2nd Protect	21	InternalShort Detection	6	*ISD Delta Time*	U2	0	65535	3600	s
2nd Protect	22	TabDisconnection Detection	0	*TDD Percent Threshold*	U1	0	100	37	%
2nd Protect	22	TabDisconnection Detection	1	*TDD Temp Threshold*	U2	2331	3981	2731	0.1°K
2nd Protect	22	TabDisconnection Detection	3	*TDD Multiple Factor*	U1	0	100	15	-

Table.42 DataFlash Configuration (continued)

Class	Subclass ID	Subclass	Offset	Name	Date Type	Min.	Max.	Default	Units
2nd Protect	23	OldWeakBattery	0	*OWB SOH Threshold*	U1	0	100	20	%
2nd Protect	23	OldWeakBattery	1	*OWB Time*	U2	0	65535	52600	hour
2nd Protect	24	Fuse Permanent Fail	0	*FUSE Fail Current*	I	-32767	32767	5	mA
2nd Protect	24	Fuse Permanent Fail	2	*FUSE Fail Time*	U1	0	30	5	s
Charge Control	34	Charge Cfg	0	*JT1*	U2	-400	1200	0	0.1℃
Charge Control	34	Charge Cfg	2	*JT2*	U2	-400	1200	50	0.1℃
Charge Control	34	Charge Cfg	4	*JT5*	U2	-400	1200	100	0.1℃
Charge Control	34	Charge Cfg	6	*JT6*	U2	-400	1200	200	0.1℃
Charge Control	34	Charge Cfg	8	*JT3*	U2	-400	1200	450	0.1℃
Charge Control	34	Charge Cfg	10	*JT4*	U2	-400	1200	500	0.1℃
Charge Control	34	Charge Cfg	12	*Temp Hys*	U2	0	100	10	0.1℃
Charge Control	34	Charge Cfg	14	*LT Chg Voltage*	U2	0	20000	13050	mV
Charge Control	34	Charge Cfg	16	*LT Chg Current1*	U2	0	10000	256	mA
Charge Control	34	Charge Cfg	18	*LT Chg Current2*	U2	0	10000	2320	mA
Charge Control	34	Charge Cfg	20	*LT Chg Current3*	U2	0	10000	1450	mA
Charge Control	34	Charge Cfg	22	*STL Chg Voltage*	U2	0	20000	13050	mV
Charge Control	34	Charge Cfg	24	*STL Chg Current1*	U2	0	10000	256	mA
Charge Control	34	Charge Cfg	26	*STL Chg Current2*	U2	0	10000	2320	mA
Charge Control	34	Charge Cfg	28	*STL Chg Current3*	U2	0	10000	1450	mA
Charge Control	34	Charge Cfg	30	*RT Chg Voltage*	U2	0	20000	13050	mV
Charge Control	34	Charge Cfg	32	*RT Chg Current1*	U2	0	10000	256	mA
Charge Control	34	Charge Cfg	34	*RT Chg Current2*	U2	0	10000	2320	mA
Charge Control	34	Charge Cfg	36	*RT Chg Current3*	U2	0	10000	1450	mA
Charge Control	34	Charge Cfg	38	*STH Chg Voltage*	U2	0	20000	13050	mV
Charge Control	34	Charge Cfg	40	*STH Chg Current1*	U2	0	10000	256	mA
Charge Control	34	Charge Cfg	42	*STH Chg Current2*	U2	0	10000	2320	mA
Charge Control	34	Charge Cfg	44	*STH Chg Current3*	U2	0	10000	1450	mA
Charge Control	34	Charge Cfg	46	*HT Chg Voltage*	U2	0	20000	13050	mV
Charge Control	34	Charge Cfg	48	*HT Chg Current1*	U2	0	10000	256	mA
Charge Control	34	Charge Cfg	50	*HT Chg Current2*	U2	0	10000	2320	mA
Charge Control	34	Charge Cfg	52	*HT Chg Current3*	U2	0	10000	1450	mA
Charge Control	34	Charge Cfg	54	*Pre-chg Current*	U2	0	2000	391	mA
Charge Control	34	Charge Cfg	56	*Mchg Current*	U2	0	32767	195	mV
Charge Control	34	Charge Cfg	58	*Precharge Start Voltage*	U2	0	20000	3100	mV
Charge Control	34	Charge Cfg	60	*Cell Voltage Threshold1*	U2	0	5000	3000	mV
Charge Control	34	Charge Cfg	62	*Cell Voltage Threshold2*	U2	0	5000	3900	mV
Charge Control	34	Charge Cfg	64	*Cell Voltage Threshold3*	U2	0	5000	4150	mV
Charge Control	34	Charge Cfg	66	*Cell Voltage Thresh Hys*	U2	0	1000	0	mV
Charge Control	34	Charge Cfg	68	*LS1 Set CycleCount*	U2	0	65535	150	-
Charge Control	34	Charge Cfg	70	*LS2 Set CycleCount*	U2	0	100	95	%
Charge Control	34	Charge Cfg	72	*LS3 Set CycleCount*	U2	0	65535	500	-
Charge Control	34	Charge Cfg	74	*LS1 Set SOH*	U1	0	100	80	%
Charge Control	34	Charge Cfg	75	*LS2 Set SOH*	U1	0	65535	800	-
Charge Control	34	Charge Cfg	76	*LS3 Set SOH*	U1	0	100	60	%
Charge Control	34	Charge Cfg	77	*CC Degrade Threshold 1*	U1	0	65535	10	mV
Charge Control	34	Charge Cfg	78	*CC Degrade Threshold 2*	U1	0	65535	50	mV
Charge Control	34	Charge Cfg	79	*CC Degrade Threshold 3*	U1	0	65535	90	mV
Charge Control	34	Charge Cfg	80	*CV Degrade Threshold 1*	U2	0	100	10	%
Charge Control	34	Charge Cfg	82	*CV Degrade Threshold 2*	U2	0	100	20	%
Charge Control	34	Charge Cfg	84	*CV Degrade Threshold 3*	U2	0	100	40	%

Table.42 DataFlash Configuration (continued)

Class	Subclass ID	Subclass	Offset	Name	Date Type	Min.	Max.	Default	Units
Charge Control	34	Charge Cfg	86	*CCC Current Threshold*	U2	0	65535	3520	mA
Charge Control	34	Charge Cfg	88	*CCC Voltage Threshold*	U2	0	65535	4200	mV
Charge Control	36	Termination Cfg	0	*Taper Current*	I2	0	1000	250	mA
Charge Control	36	Termination Cfg	2	*Taper Voltage*	U2	0	1000	300	mV
Charge Control	36	Termination Cfg	4	*Taper Current Window*	U1	0	240	40	s
Charge Control	36	Termination Cfg	5	*TCA Clear %*	I1	-1	100	95	%
Charge Control	36	Termination Cfg	6	*FC Clear %*	I1	-1	100	95	%
Charge Control	37	Cell Balancing Cfg	0	*Min Cell Deviation*	U2	0	65536	700	s/mAh
SBS Configuration	48	Data	0	*Rem Cap Alarm*	U2	0	700	295	mAh
SBS Configuration	48	Data	2	*Rem Energy Alarm*	U2	0	1000	332	cWh
SBS Configuration	48	Data	4	*Rem Time Alarm*	U2	0	30	10	Min
SBS Configuration	48	Data	6	*Init Battery Mode*	U2	0x0000	0xffff	0x0081	-
SBS Configuration	48	Data	8	*Init Mfg Status*	U2	0x0000	0xffff	0x0000	-
SBS Configuration	48	Data	10	*Design Voltage*	U2	7000	18000	11250	mV
SBS Configuration	48	Data	12	*Spec Info*	U2	0x0000	0xffff	0x0031	
SBS Configuration	48	Data	14	*Manuf Date*	U2	0	65535	2011-12-27	Day+ Mo*32+ (Yr-1980)* 256
SBS Configuration	48	Data	16	*Ser. Num.*	U2	0x0000	0xffff	0x0001	-
SBS Configuration	48	Data	18	*Cycle Count*	U2	0	65535	0	Count
SBS Configuration	48	Data	20	*CC Precentage*	U1	0	100	90	%
SBS Configuration	48	Data	21	*CF MaxError Limit*	U1	0	100	100	%
SBS Configuration	48	Data	22	*Design Capacity*	U2	0	65535	2950	mAh
SBS Configuration	48	Data	24	*Design Energy*	U2	0	65535	3318	cWh
SBS Configuration	48	Data	26	*Device Chemistry*	S5	-	-	LION	-
SBS Configuration	48	Data	31	*Manuf Name*	S16	-	-	Sinowealth	-
SBS Configuration	48	Data	47	*Device Name*	S16	-	-	SH366006	-
SBS Configuration	49	Configuration	0	*TDA Set %*	I1	-1	100	0	%
SBS Configuration	49	Configuration	1	*TDA Clear %*	I1	-1	100	1	%
SBS Configuration	49	Configuration	2	*FD Set %*	I1	-1	100	0	%
SBS Configuration	49	Configuration	3	*FD Clear %*	I1	-1	100	1	%
SBS Configuration	49	Configuration	4	*TDA Set Volt Threshold*	U2	0	16800	9600	mV
SBS Configuration	49	Configuration	6	*TDA Clear Volt*	U2	0	16800	9900	mV
SBS Configuration	51	DBPT Cfg	0	*SPP Max C Rate*	I1	0	-127	-20	0.1CRate
SBS Configuration	51	DBPT Cfg	1	*MPP Max C Rate*	I1	0	-127	-40	0.1CRate
SBS Configuration	51	DBPT Cfg	2	*Pack Resistance*	U2	0	65535	0	$2^{-10}\ \Omega$
SBS Configuration	51	DBPT Cfg	4	*System Resistance*	U2	0	65535	0	$2^{-10}\ \Omega$
Lifetimes	52	Lifetime Data	0	*Total Usage Time*	U2	0	65535	0	mV
Lifetimes	52	Lifetime Data	2	*Cell 1 Max Voltage*	U2	0	32767	0	mV
Lifetimes	52	Lifetime Data	4	*Cell 2 Max Voltage*	U2	0	32767	0	mV
Lifetimes	52	Lifetime Data	6	*Cell 3 Max Voltage*	U2	0	32767	0	mV
Lifetimes	52	Lifetime Data	8	*Cell 4 Max Voltage*	U2	0	32767	0	mV
Lifetimes	52	Lifetime Data	10	*Cell 1 Min Voltage*	U2	0	32767	32767	mV
Lifetimes	52	Lifetime Data	12	*Cell 2 Min Voltage*	U2	0	32767	32767	mV
Lifetimes	52	Lifetime Data	14	*Cell 3 Min Voltage*	U2	0	32767	32767	mV
Lifetimes	52	Lifetime Data	16	*Cell 4 Min Voltage*	U2	0	32767	32767	mV
Lifetimes	52	Lifetime Data	18	*Max Delta Cell Voltage*	U2	0	32767	0	mV
Lifetimes	52	Lifetime Data	20	*Max Charge Current*	U2	0	32767	0	mA
Lifetimes	52	Lifetime Data	22	*Max Discharge Current*	U2	-32767	0	0	mA
Lifetimes	52	Lifetime Data	24	*Max Avg Dsg Current*	U2	-32767	32767	0	mA

Table.42 DataFlash Configuration (continued)

Class	Subclass ID	Subclass	Offset	Name	Date Type	Min.	Max.	Default	Units
Lifetimes	52	Lifetime Data	26	*Max Avg Dsg Power*	U2	-32767	0	0	mA
Lifetimes	52	Lifetime Data	28	*Max Temp Cell*	U1	-128	127	-128	℃
Lifetimes	52	Lifetime Data	29	*Min Temp Cell*	U1	-128	127	127	℃
Lifetimes	52	Lifetime Data	30	*Max Delta Cell Temp*	U1	-128	127	0	℃
Lifetimes	52	Lifetime Data	31	*Max Temp FET*	U1	-128	127	0	℃
Lifetimes	52	Lifetime Data	32	*No Of COV Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	34	*Last COV Event*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	36	*No Of CUV Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	38	*Last CUV Event*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	40	*No Of OCD1 Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	42	*Last OCD1 Event*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	44	*No Of OCD2 Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	46	*Last OCD2 Event*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	48	*No Of OCC1 Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	50	*Last OCC1 Event*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	52	*No Of OCC2 Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	54	*Last OCC2 Event*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	56	*No Of AOLD Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	58	*Last AOLD Event*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	60	*No Of SCD Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	62	*Last SCD Event*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	64	*No Of SCC Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	66	*Last SCC Event*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	68	*No Of OTC Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	70	*Last OTC Event*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	72	*No Of OTD Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	74	*Last OTD Event*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	76	*No Of OTF Events*	U2	0	32767	0	-
Lifetimes	52	Lifetime Data	78	*Last OTF Event*	U2	0	32767	0	-
System Data	58	Manufacturer Info	0	Manuf. Info	S33	-	-	abcdefghijklmnopqrstuvwyzx012345	-
Configuration	64	Registers	0	*Operation Cfg A*	U2	0x0000	0x033b	0x0E21	-
Configuration	64	Registers	2	*Operation Cfg B*	U2	0x0000	0x3eff	0x04F0	-
Configuration	64	Registers	4	*Operation Cfg C*	U2	0x0000	0x0001	0x0001	-
Configuration	64	Registers	6	*Protection Cfg A*	U2	0x0000	0xffff	0x0000	-
Configuration	64	Registers	8	*Protection Cfg B*	U2	0x0000	0xffff	0x0000	-
Configuration	64	Registers	10	*PF Enable Cfg A*	U2	0x0000	0xffff	0x0000	-
Configuration	64	Registers	12	*PF Enable Cfg B*	U2	0x0000	0xffff	0x0000	-
Configuration	64	Registers	14	*Fuse Blow Cfg A*	U2	0x0000	0xffff	0x0000	-
Configuration	64	Registers	16	*Fuse Blow Cfg B*	U2	0x0000	0xffff	0x0000	-
Configuration	64	Registers	18	*Min Blow Fuse Voltage*	U2	0	65535	3500	mV
Configuration	64	Registers	20	*Fuse Blow Time*	U1	0	255	40	s
Power	68	Power	0	*Flash Update OK Voltage*	U2	6000	20000	7000	mV
Power	68	Power	2	*Sleep Current*	U2	0	32767	10	mA
Power	68	Power	4	*Sleep Wait Time*	U1	0	255	5	s
Power	68	Power	5	*Shutdown Voltage*	U2	5000	20000	6500	mV
Power	68	Power	7	*Shutdown Time*	U1	0	240	10	s
Power	68	Power	8	*Charger Present*	U2	0	23000	7000	mV
Power	68	Power	10	*Wake Current Reg*	U1	0x00	0xff	0x02	
Power	68	Power	11	*Term Voltage*	U2	0	65535	9000	mV
Fusion Gauging	79	Configuration	0	*Load Select*	U1	0	255	3	-

Table.42 DataFlash Configuration (continued)

Class	Subclass ID	Subclass	Offset	Name	Date Type	Min.	Max.	Default	Units
Fusion Gauging	79	Configuration	1	*Load Mode*	U1	0	255	1	-
Fusion Gauging	79	Configuration	2	*User-Rate-mA*	U2	2000	9000	2000	mA
Fusion Gauging	79	Configuration	4	*User-Rate-mW*	U2	3000	14000	0	cW
Fusion Gauging	79	Configuration	6	*Reserve Cap-mAh*	U2	0	9000	50	mAh
Fusion Gauging	79	Configuration	8	*Reserve Cap-mWh*	U2	0	14000	56	cWh
Fusion Gauging	79	Configuration	10	*RSOC Adjust*	U1	0	100	11	%
Fusion Gauging	79	Configuration	11	*Voltage Adjust*	U1	0	255	250	mV
Fusion Gauging	81	Current Thresholds	0	*Dsg Current Threshold*	I2	0	2000	50	mA
Fusion Gauging	81	Current Thresholds	2	*Chg Current Threshold*	I2	0	2000	50	mA
Fusion Gauging	81	Current Thresholds	4	*Quit Current*	I2	0	1000	40	mA
Fusion Gauging	81	Current Thresholds	6	*Dsg Relax Time*	U1	0	255	5	s
Fusion Gauging	81	Current Thresholds	7	*Chg Relax Time*	U1	0	255	2	s
Fusion Gauging	82	State	0	*QCell0*	U2	0	32767	2950	mAh
Fusion Gauging	82	State	2	*QCell1*	U2	0	32767	2950	mAh
Fusion Gauging	82	State	4	*QCell2*	U2	0	32767	2950	mAh
Fusion Gauging	82	State	6	*QCell3*	U2	0	32767	2950	mAh
Fusion Gauging	82	State	8	*FG status*	U1	0	255	0	hex
PF Status	96	PF Event Data	0	*PF Status 1*	U4	0	0xffffffff	0	hex
PF Status	96	PF Event Data	4	*PF Status 2*	U4	0	0xffffffff	0	hex
PF Status	96	PF Event Data	8	*Cell 1 Voltage*	U2	0	5000	0	mV
PF Status	96	PF Event Data	10	*Cell 2 Voltage*	U2	0	5000	0	mV
PF Status	96	PF Event Data	12	*Cell 3 Voltage*	U2	0	5000	0	mV
PF Status	96	PF Event Data	14	*Cell 4 Voltage*	U2	0	5000	0	mV
PF Status	96	PF Event Data	16	*Pack Voltage*	*U2*	0	32768	0	mV
PF Status	96	PF Event Data	18	*Current*	I2	-32768	32768	0	mA
PF Status	96	PF Event Data	20	*TS1 Temperature*	U2	-400	1200	0	0.1℃
PF Status	96	PF Event Data	22	*TS2Temperature*	U2	-400	1200	0	0.1℃
PF Status	96	PF Event Data	24	*TS3 Temperature*	U2	-400	1200	0	0.1℃
PF Status	96	PF Event Data	26	*TS4Temperature*	U2	-400	1200	0	0.1℃
Calibrate	104	Data	0	*CC Gain*	F4	0.1	4	0.959106	-
Calibrate	104	Data	4	*Cell 1 Voltage Gain*	U2	0	65535	16574	-
Calibrate	104	Data	6	*Cell 2 Voltage Gain*	U2	0	65535	16558	-
Calibrate	104	Data	8	*Cell 3 Voltage Gain*	U2	0	65535	16552	-
Calibrate	104	Data	10	*Cell 4 Voltage Gain*	U2	0	65535	16543	-
Calibrate	104	Data	12	*AFE Pack Gain*	U2	0	65535	1.030029	uv/cnt
Calibrate	104	Data	14	*Board Offset*	I2	-32767	32767	-2	-
Calibrate	104	Data	16	*Ext1 Temp Offset*	I1	-128	127	0	-
Calibrate	104	Data	17	*Ext2 Temp Offset*	I1	-128	127	0	-
Calibrate	104	Data	18	*Ext3 Temp Offset*	I1	-128	127	0	-
Calibrate	104	Data	19	*Ext4 Temp Offset*	I1	-128	127	0	-
Calibrate	107	Current	0	*Deadband*	U1	0	255	7	mA
Calibrate	107	Current	1	*CC Deadband Reg*	U1	0	3	1	-
IATA	108	IATA Store	0	*IATA Flag*	U1	0	0xff	0	hex
IATA	108	IATA Store	1	*IATA RC*	I2	0	32767	0	mAh
IATA	108	IATA Store	3	*IATA RE*	I2	0	32767	0	cWh
IATA	108	IATA Store	5	*IATA FCC*	I2	0	32767	0	mAh
IATA	108	IATA Store	7	*IATA FCE*	I2	0	32767	0	cWh

Table.42 DataFlash Configuration (continued)

Note: U1 – unsigned char; U2 – unsigned int; U4 – unsigned double word; I1 – signed char; I2 – signed int; F4 – float double word; Sn – string, n bytes.

7. Low Power Consumption Mode

The SH366006 includes two different low power consumption mode, Sleep Mode and ShutDown Mode, based on the working status.

7.1 Sleep Mode

7.1.1 Device Sleep

There are two sleep modes of SH366006 depending on the non-removable and removable system choice. Two states that only DSG FET or both CHG and DSG FETs keep on can be selected in the non-removable sleep mode.

In removable system (*[NR]* = 0), the SH366006 can enter sleep mode with its CHG and DSG FETs being turned off if all the following conditions are satisfied, and exit when any condition is missed. The conditions are that 1) the PRES input is high (*[PRES]* = 0), 2) |*Current()*|≤*Sleep Current*, 3) SMBus is low or no communciation for *Sleep Wait Time*, 4) *[SLEEP]* bit is set, 5) none of *PFStatus()* are set, and 6)No over-current, short-circuit occurs.

In nonremovable system (*[NR]* = 1), the SH366006 can enter sleep mode if all the following conditions are satisfied, and exit when any condition is missed. The conditions are that 1) |*Current()*|≤*Sleep Current*, 2) SMBus is low or no communciation for *Sleep Wait Time*, 3)*[SLEEP]* bit is set, 4)none of PF Status are set, and 5)No over-current, short-circuit occurs. And when SH366006 enters sleep mode, it can choose only DSG FET (*SLEEPCHG* =0) or both CHG/PCHG and DSG FETs (*SLEEPCHG* =1) to be turned on.

In Sleep Mode, the SH366006 measures Voltage, Temperature and Current periodicity and updates RemCap.

NR	SLEEPCHG	Low power consumption State	Conditions to Enter Sleep Mode	Exit Conditions
0	X	CHG and DSG FETs are turned off	1. PRES input is high 2. (|*Current()*|≤*Sleep Current*) 3. No overcurrent, short circuit occurs 4. none of *PFStatus()* are set 5. *SLEEP* is set 6. SMBus is low for *Sleep Wait Time* if *Operation Cfg A [ISS]* = 0 or no communication for *Sleep Wait Time* if *Operation Cfg A [ISS]* = 1 or ManufacturerAccess Sleep command is received	any of these conditions do not meet
1	0	CHG FET and PCHG FET are turned off DSG FET is turned on	1.(|*Current()*|≤*Sleep Current*) 2. No overcurrent, short circuit occurs 3. none of *PFStatus()* are set 4. *SLEEP* is set 5. SMBus is low for *Sleep Wait Time* if *Operation Cfg A [ISS]* = 0 or no communication for *Sleep Wait Time* if *Operation Cfg A [ISS]* = 1 or ManufacturerAccess Sleep command is received	any of these conditions do not meet
1	1	ALL FETs are turned on	1.(|*Current()*|≤Sleep Current) 2. No overcurrent, short circuit occurs 3. none of *PFStatus()* are set 4. *SLEEP* is set 5. SMBus is low for *Sleep Wait Time* if *Operation Cfg A [ISS]* = 0 or no communication for *Sleep Wait Time* if *[ISS]* = 1 or ManufacturerAccess Sleep command is received	any of these conditions do not meet

Table.43 Sleep Mode Table

7.1.2 In System Sleep Mode

The SH366006 provides an option for removable packs (that is, *Operation Cfg B [NR]* = 0) to enter SLEEP mode in-system. When the *Operation Cfg A [ISS]* = 1, the device will enter SLEEP mode even if the *OperationStatus() [PRES]* = 1. This option ignores the PRES pin status only. Additionally, in this option, the SMBus low state is not a condition to enter SLEEP mode (instead, no communication must occur for *Sleep Wait Time* to enter SLEEP). All the other sleep conditions must be met for the device to enter SLEEP mode.

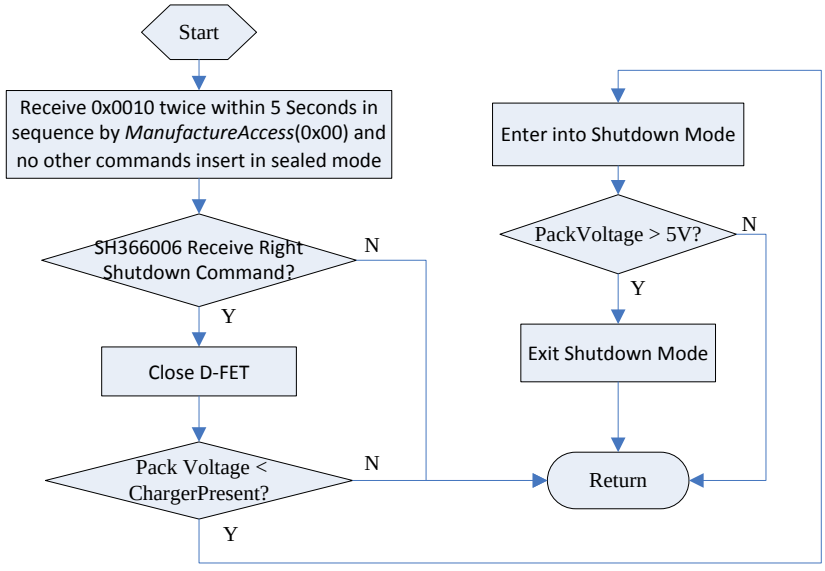
For *[NR]* = 0, the CHG FET and PCHG FET remains on in SLEEP mode if *[SLEEPCHG]* = 1, but if the battery pack is removed from the system, the CHG FET is off because the system present takes higher priority than *[SLEEPCHG]*.

7.2 Shutdown Mode

SH366006 enters Shutdown Mode and cuts down all power supply in demand if any of the following conditions is satisfied.

1) When the SH366006 detects Min cell voltage continuous < *Shutdown Voltage* for *Shutdown Time, turns off DSG FET,* and if *PackVoltage* < *Charger Present*, SH366006 enters shutdown mode.

2) SH366006 receives the shutdown command by *ManufacturerAccess()*. If SH366006 is in SEALED mode, this feature requires the command to be sent twice in sequence by *ManufacturerAccess()* with 5 seconds. The sequence will be cancelled if SH366006 receives other command between twice receiving the shutdown command or total two shutdown command receiving time is over 5 seconds. The shutdown command is defined as: *0x0010*. Flow chart in sealed mode is shown as follow.



Keeping the voltage of Pack$^+$ above 5V for a moment or starting charging can make SH366006 exit Shutdown Mode, with its power recovery and setting *[WAKE]* flag. But *[WAKE]* is cleared immediately with *[INIT]* being set.

Due to IATA regulation, the capacity of batteries shipped by airplane needs to be less than 30%. So, to avoid out of scope of the capacity after resuming from the shutdown mode when the *[IATAEN]* flag in *Operation Cfg A* is set, SH366006 needs to show correct RSOC by keeping the RSOC before entering the shut down mode. Then, on random inspection before air transportation, the RSOC must not exceed 30%.

8. Electrical Characteristics

8.1 Absolute Maximum Rating

Parameter	Min. Value	Max. Value	Units	Note
BAT、VPACK、VC1、VCCH	-0.3	29	V	
CHG	-0.3	29	V	
OD	-0.3	29	V	
DSG	-0.3	29	V	
VC2-VC4	-0.3	29	V	
VC5	-0.3	4	V	
ARS1，ARS2，RS1，RS2	-1	1	V	
VDD，VDD2	-0.3	7	V	
SMBC，SBMD	-0.3	7	V	
Other IO	-0.3	VDD+0.3	V	
Work Temperature	-40	85	C	

8.2 DC Characteristic Ratings

Parameter	Characteristic	Min. Value	Type.	Max. Value	Units	Note
Main Power						
V_{BAT} V_{VPACK}	Operate Voltage	5		25	V	
I_{OP}	Operate Current		300		uA	
I_{SLEEP}	Sleep Current		150		uA	CHG ON，DSG ON
			120		uA	CHG OFF，DSG ON
$I_{SHUTDOWN}$	Shutdown Current		0.1		uA	
LDO						
V_{DD}	LDO Output	-4%	3	2%	V	8.0V < V_{BAT} or V_{VPACK} <25V,I_{LOAD} <25mA, TA = -40 C to 85 C
V_{DD}	LDO Output	-9%	3	2%	V	6.5V < V_{BAT} or V_{VPACK} <8V I_{LOAD} < 25mA, TA = -40 C to 85 C
V_{DD}	LDO Output	-9%	3	2%	V	5.4V < V_{BAT} or V_{VPACK} <6.5V, I_{LOAD} <16mA, TA = -40 C to 85 C
V_{DD}	LDO Output	-2%	3	2%	V	4.5V < V_{BAT} or V_{VPACK} <25V I_{LOAD} < 2mA, TA = -40 C to 85 C
ΔV_{TEMP}	LDO Temperature Stability		±0.2		%	Iout = 2mA, TA = -40 C to 85 C
$\Delta V_{VDDLOAD}$	LDO Load Voltage		7	15	mV	0.1mA< I_{LOAD} <2mA
$\Delta V_{VDDLOAD}$	LDO Load Voltage		40	100	mV	0.1mA< I_{LOAD} <25mA
ΔI_{LINE}	LDO Load Voltage		3	10	mV	5.4V<V_{BAT}<25V, I_{LOAD} = 2mA
Current Detect						
V_{CH}	Current Detect Threshold (including positive and negative current)	1	-	13.8	mV	TA = 25℃
V_{CH_ACR}	Current Detect Accuracy	0.5	1.4	2.6	mV	WAKEN=1，RSNS1:RSNS0=00B，TA = 25℃
		1.8	3.0	4.2	mV	WAKEN=1，RSNS1:RSNS0=01B TA = 25℃
		4.6	6.0	7.4	mV	WAKEN=1，RSNS1:RSNS0 =10B TA = 25℃
		10.2	12.0	13.8	mV	WAKEN=1，RSNS1:RSNS0=11B，TA = 25℃
V_{CH_TCO}	Current Detect Threshold Thermal Drift	-	0.5	0.8	%/℃	
t_{WAKE}	Current Detect Wake Time	-	0.5	1	ms	

8.3 AC Characteristic Ratings

Parameter	Characteristic	Min. Value	Type.	Max. Value	Units	Notes
Main Power						
f_{AD}	ADC Work Frequency		65.535		kHz	
f_{RC}	RC Work Frequency		8.388	±2%	MHz	
SMBus						
f_{SMB}	SMBus Communicate Frequency	10		100	kHz	
t_{BUF}	Idle Time Between Stop and Start-up	4.7			μs	
t_{LOW}	Clock Low-*Voltage Time*	4.7			μs	
t_{HIGH}	Clock High-*Voltage Time*	4.0		50	μs	
$t_{HD: DAT}$	Data Hold Time	300			ns	
$t_{SU: DAT}$	Data Start-up Time	250			ns	
$t_{HD: STA}$	Start Hold Time	4.0			μs	
$t_{SU: STA}$	Start Start-up Time	4.7			μs	
$t_{SU: STO}$	Stop Start-up Time	4.0			μs	
t_R	Clock/Data Raise Time	-	-	1000	ns	(V_{ILMAX} – 0.15V) to (V_{IHMIN}+ 0.15V)
t_F	Clock/Data Fall Time			300	ns	0.9V_{DD} to (V_{ILMAX} – 0.15)
$t_{TIMEOUT}$	Clock Low *Voltage Time*out		25		ms	
GPIO						
V_{IL}	SMBC,SMBD	-0.3		0.8	V	
V_{IH}	SMBC,SMBD	2		6	V	
V_{OH}	Output High Voltage	3.0	-	6.0	V	FUSE，CL = 1nF， V_{BAT} = 4.5~25V
V_{OL1}	SMBD,SMBC	0		0.4	V	I_{OL1}=7mA
V_{OL2}	LED0-LED4	0.8		1.2	V	I_{OL2}=4mA
ADC						
R_{AIN}	ADC Input Resist		2.5		MΩ	ADC Input Resist
V_{AN0},V_{AN1}	AN0,AN1 Input Voltage	0		1	V	
RS1-RS2	Different Input Voltage	-0.2		0.2	V	RS1-RS2, RS2=AGND
MOSFET						
R_{BAL}	VC_n-VC_{n+1} Internal Balance Resist		150	±50%	Ω	VC_n-VC_{n+1}= 2 V
V_{DSGON}	DSG FET On Voltage	7.5	9.4	11	V	V_{DSGON}=V_{DSG}-V_{PACK}， V_{PACK} = 14V，VGS Resist = 10M
V_{CHGON}	CHG FET Turn On Voltage	7.5	9.4	11	V	V_{CHGON}=V_{CHG}-V_{BAT}， V_{BAT} = 14V，VGS Resist =10M
V_{DSGOFF}	DSG FET Switch Off Voltage	-	-	0.2	V	V_{DSGOFF}=V_{DSG}-V_{PACK}， V_{PACK} = 14V
V_{CHGOFF}	DCHG FET Switch Off Voltage	-	-	0.2	V	V_{CHGOFF}=V_{CHG}-V_{BAT}， V_{BAT} = 14V
t_R	CHG Raise Period	-	400	1000	μs	C_L = 4700pF， V_{CHG}: V_{BAT} V_{BAT}+4V
t_R	DSG Raise Time	-	400	1000	μs	C_L = 4700pF， V_{DSG}: V_{PACK} V_{PACK}+4V

AC Characteristic Ratings (continued)

Parameter	Characteristic	Min. Value	Type.	Max. Value	Units	Notes
t_F	CHG Fall Time	-	40	200	μs	C_L = 4700pF，V_{CHG}: V_{CHGON} V_{BAT}+1V
t_F	DSG Fall Time	-	40	200	μs	C_L = 4700pF，V_{DSG}: V_{DSGON} V_{PACK}+1V
t_R	FUSE Raise Time	-	-	10	μs	C_L = 1nF，V_{OH}(Fuse) : 10%~90%

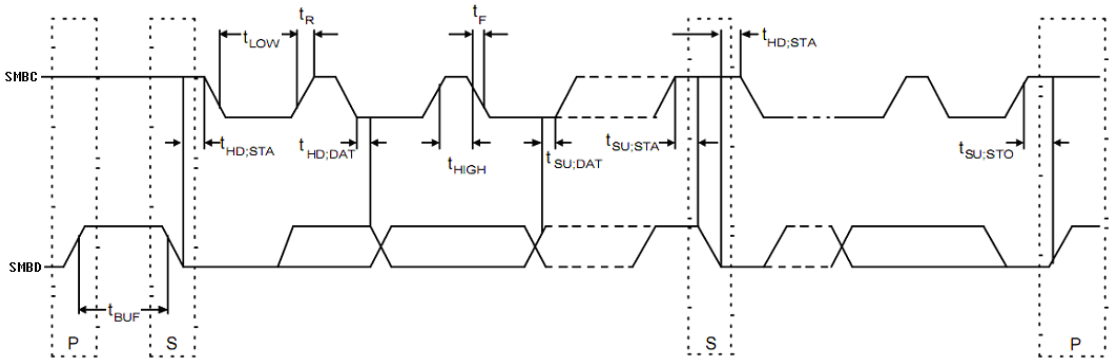
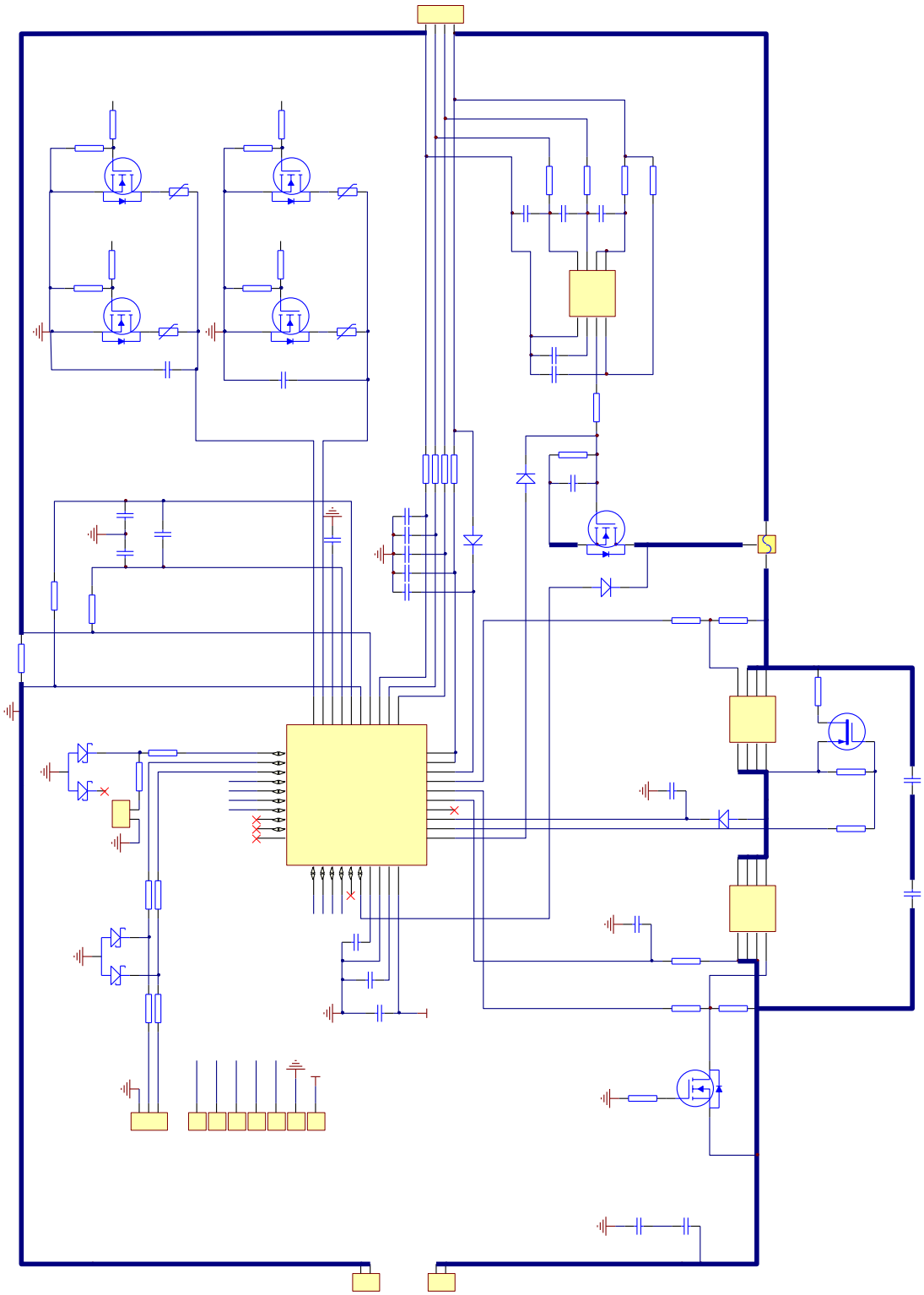


Fig.13 SMBus Communication Flow

9. Reference Circuit

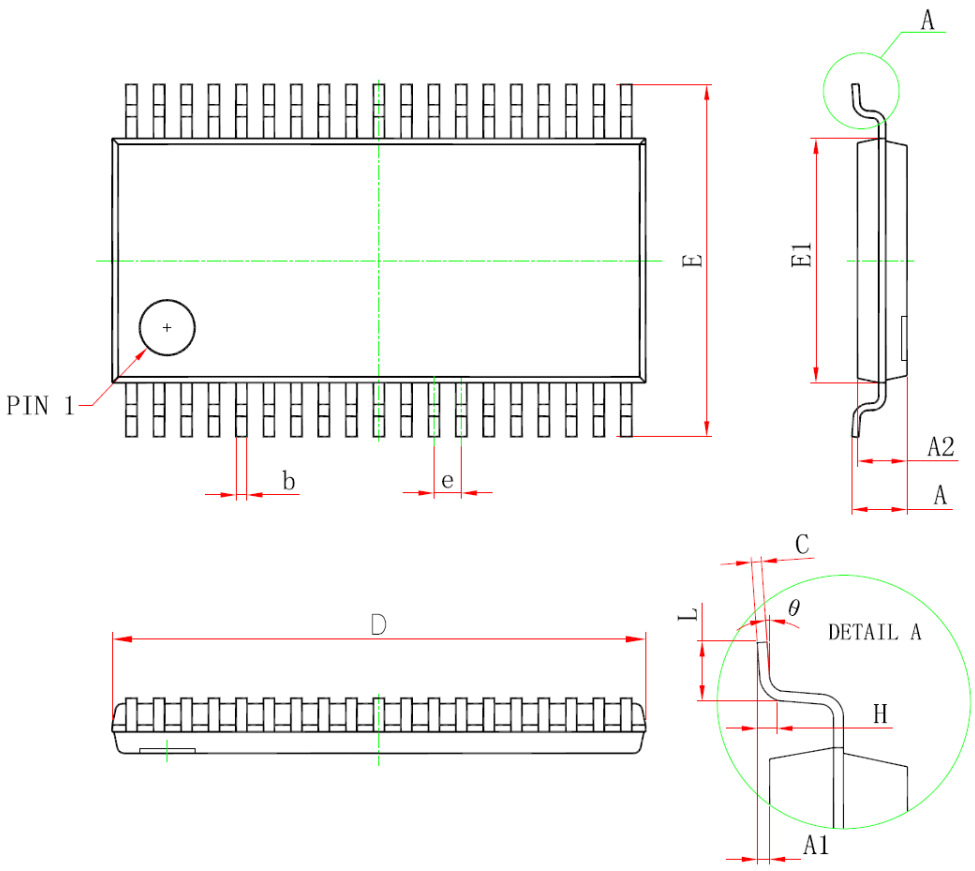


10. Order Information

Product Serial	Package
SH366006X/038XY	TSSOP38，Tape & Reel
SH366006Q/040QY	QFN40，Tape & Reel

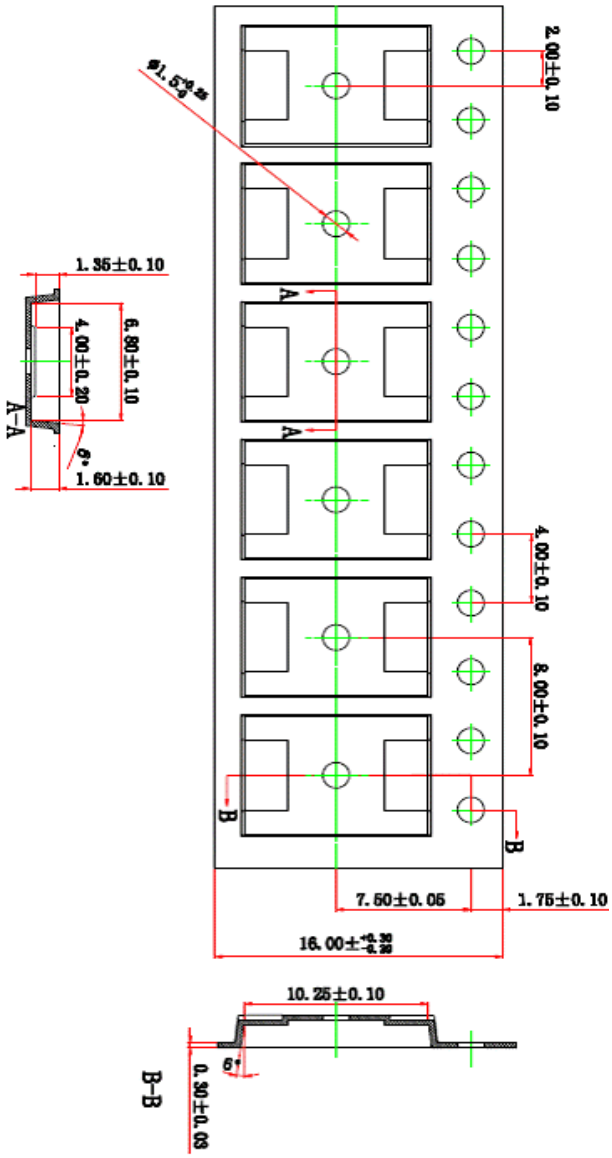
11. Package Information (TSSOP38)

TSSOP 38 Package Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	**Max**	**Min**	**Max**
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.170	0.270	0.007	0.011
c	0.090	0.200	0.004	0.008
D	9.600	9.800	0.378	0.386
E	6.250	6.550	0.246	0.258
E1	4.300	4.500	0.169	0.177
e	0.50 (BSC)		0.020(BSC)	
H	0.25(TYP)		0.01(TYP)	
L	0.500	0.700	0.020	0.028
θ	1°	7°	1°	7°

12. Tap Information (TSSOP38)



Technique Requirement:

Tape carrier should be black.

Mate with 13.30-wide cover tape

Cover tape should be transparent

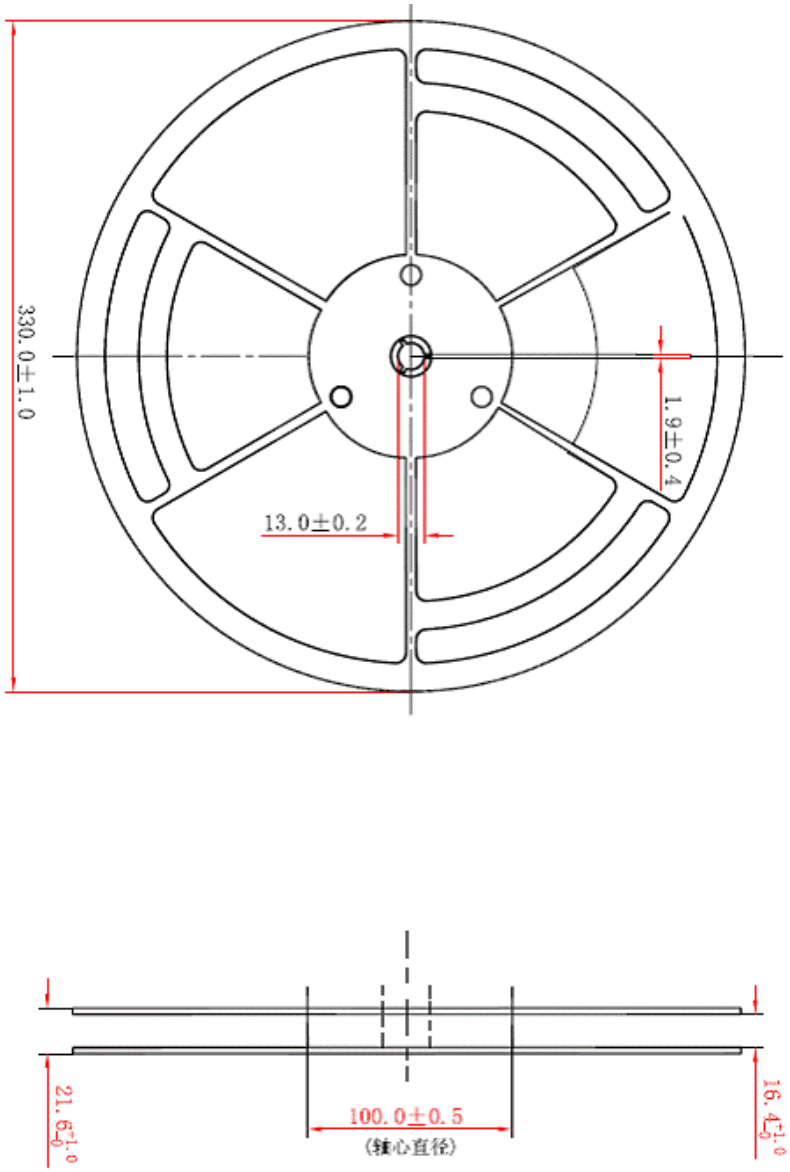
Surface Resistance per unit area is 105~1011 Ohm/SQ

Cumulative tolerance 10 transfer holes spacing is 0.20Max

Tape carrier linear curvature ≤1mm/100mm

All units are mm

View orientation is



Technique Requirement::

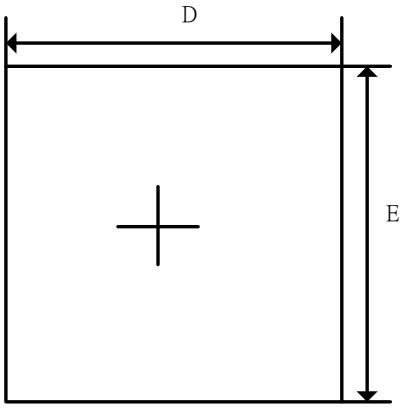
2500 chips are stored each spool

A、B instructs is for reference only which can be adjusted by demand but must meet the tape carrier and braid requirement

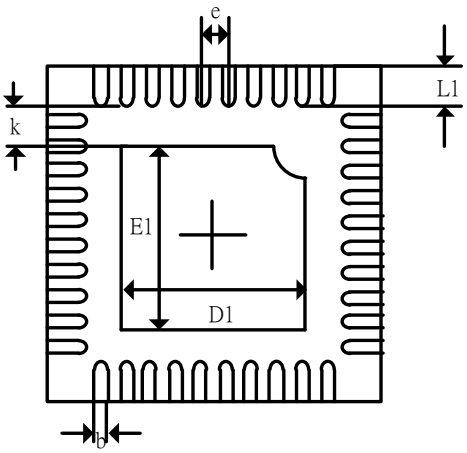
Spool should be blue

13. Package Information (QFN40)

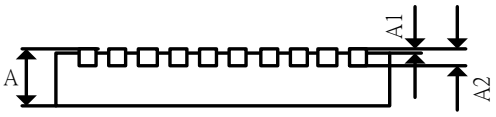
QFN40L (5×5) Outline Dimensionsunit: inches/mm



Top View



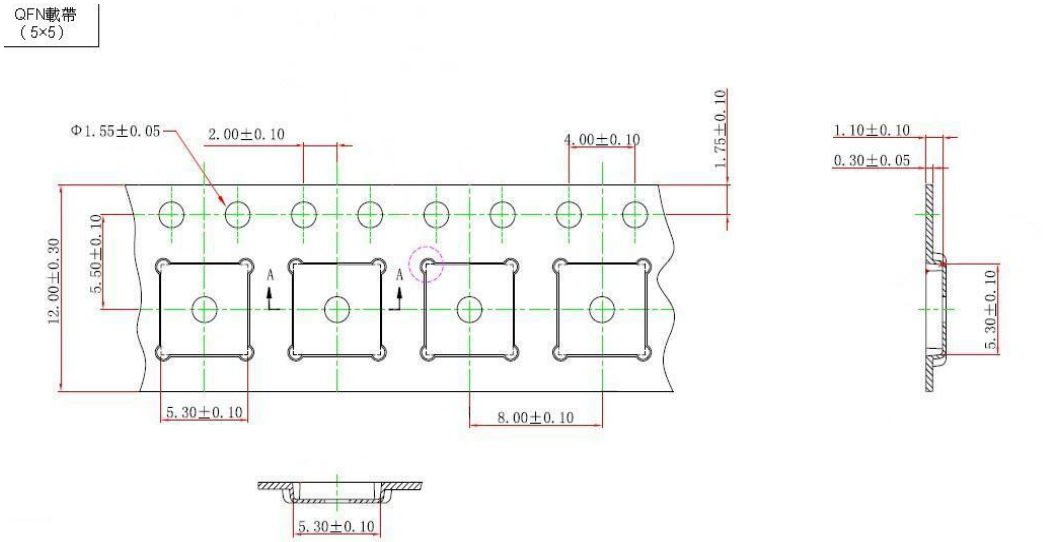
Bottom View

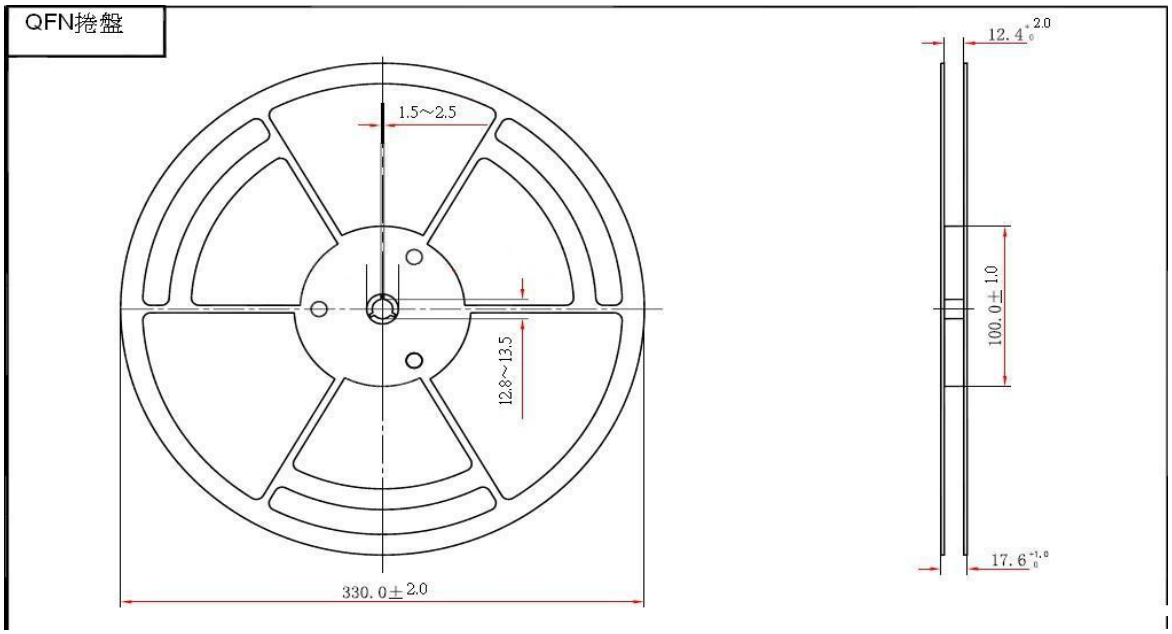


Side View

Symbol	Dimensions in inches		Dimensions in mm	
	MIN	MAX	MIN	MAX
A	0.028	0.031	0.700	0.800
A1	0.000	0.002	0.000	0.050
A2	0.008REF		0.203REF	
D	0.194	0.200	4.924	5.076
E	0.194	0.200	4.924	5.076
D1	0.130	0.138	3.300	3.500
E1	0.130	0.138	3.300	3.500
k	0.008	---	0.200	---
b	0.006	0.010	0.150	0.250
e	0.016TYP		0.400TYP	
L1	0.013	0.019	0.324	0.476

14. Tap Information (QFN40)





15. Product History

SH366006 User Guide Revision		
Version	Content	Date
0.2	1. Add FET Control Function 2. CIM modify 3. Add PF Enable Cfg A/B	2019/04/02
0.1	1. Add XCHG flag 2. Four Stages Mode modify 3. Add Charging Loss Compentation 4. PTO/CTO modify 5. Status Flags modify 6. Calibration modify 7. SBS Command modify 8. DF parameters modify 9. Power Mode modify 10. Reference Circuit modify. etc	2019/01/12
0.1	1. JEITA modify 2. Add Four Stages Mode Function 3. Add Turbo Mode 2.0 4. COV modify 5. Add OCPC Protection 6. Add OCC2/OCD2 Protections 7. Add FUSE permanent failure 8. CFETF/DFETF modify 9. Lifetime data collection modify 10. SOH definition modify 11. Add more temperature sensor 12. Reference Circuit modify. etc	2018/10/12
0.0	Original	2018/09/05