SH366002 SBS Solution User Guide

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1. FEATURES

1. Battery Fusion gauge for 1-Series Li-Ion Applications, providing Voltage, Current and Temperature etc.
2. Advanced Fusion Gauge Algorithm Accurately measures Available Charge
3. TWI and SWI Interface Formats for communication
4. External temperature and Internal temperature detection
5. Support SHA-1 Authentication
6. Low Power Consumption
7. DFN12 Packageok

2. REFERRENCE SCHEMATIC

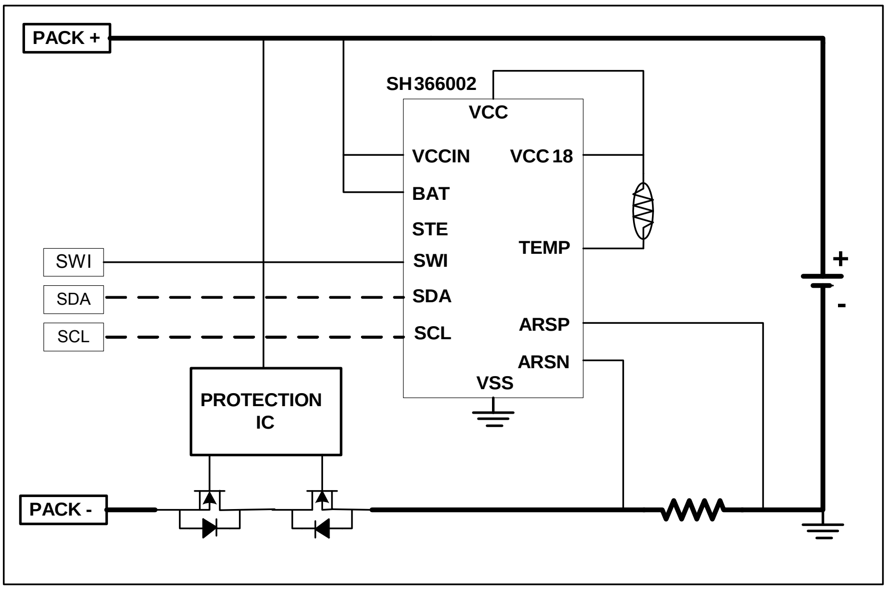


Figure 2.1 Reference Schematic

3. CHIP INFORMATION

Table 3.1 Chip Information

PRODUCTION	PACKAGE	TA	COMMUNICATION FORMAT	TAPE and REEL QUANTITY
SH366002R/012RE	DFN12	-45℃~85℃	TWI&SWI	

Note: SH366002 is shipped in TWI mode.

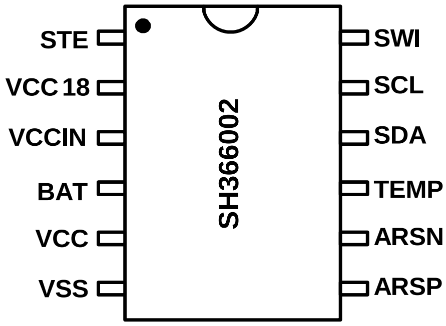


Figure 3.1 PIN Configuration

Table 3.2 Pin Functions

PIN name	No.	Type	Description
STE	1	I/O	SHUTDOWN Enable Output
VCC18	2	P	1.8V output voltage of the internal integrated LDO. Connect a minimum 0.47uF ceramic capacitor
VCCIN	3	P	The input voltage for the internal 1.8V LDO. Connect a 0.1uF ceramic capacitor
BAT	4	IA	Cell-voltage measurement input. ADC input.
VCC	5	P	MCU power input.
VSS	6	P	MCU ground
ARSP	7	IA	CADC differential input. Analog input.
ARSN	8	IA	CADC differential input. Analog input.
TEMP	9	IA	External temperature sense input.
SDA	10	I/O	Slave TWI communications data input line.
SCL	11	I/O	Slave TWI communications clock input line.
SWI	12	I/O	Single wire communication line.

4. GERNERAL DESCRIPTION

The implemented Advanced Fusion Gauge algorithm calculates the remaining capacity by analyzing voltage, current, temperature and other relevant data.

4.1 MEASUREMENT

4.1.1 Gas Gauging

The SH366002 implements Advanced Fusion Gauge algorithm combined with Coulomb Counting and Open Circuit Cell Voltage Measurement, to achieve the smart battery gas gauging, according to currently measured cell voltage, temperature, current, temperature and remaining capacity.

During charge or discharge period, the SH366002 updates the remaining capacity based on Coulomb Counting every second. No matter in any mode(CHG, DSG or Relaxation mode), the SH366002 adjusts the capacity according to the measured voltage, current, temperature and other relevant data as long as it meet some certain conditions. SH366002 automatically compensates for aging, temperature, and discharge rate, providing accurate **State of Charge** (**SOC**) over a wide range of operating conditions.

NominalAvailableCapacity( )(**NAC**) represents the uncompensated remaining capacity of the battery.
FullAvailableCapacity( )(**FAC**) represents the uncompensated full charge capacity of the battery.
RemainCapacity( )(**RC**) represents the compensated remaining capacity of the battery
FullChargeCapacity( )(**FCC**) represents the compensated full charge capacity of the battery

4.1.2 Gauge Related Registers

4.1.2.1 Dsg Current Threshold

This register is used as a threshold to determine if actual discharge current is flowing out of the cell. This threshold should be set low enough to be below any normal application load current but high enough to prevent noise or drift from affecting the measurement.

4.1.2.2 Chg Current Threshold

This register is used as a threshold to determine if actual charge current is flowing into the cell. This threshold should be set low enough to be below any normal charge current but high enough to prevent noise or drift from affecting the measurement.

4.1.2.3 Quit Current, Dsg Relax Time, Chg Relax Time, Quit Relax Time

When the current flowing in or out the battery remains above **Quit Current** for a period greater than **Quit Relax Time**, the system quits relaxation mode. The default value of **Quit Current** should be greater than **Standby Current**.

Either of the following criteria is met to enter Relaxation mode:

1. | **AverageCurrent( )** | < | **Quit Current** | for **Dsg Relax Time**.
2. | **AverageCurrent( )** | < | **Quit Current** | for **Chg Relax Time**.

After about 6 minutes in relaxation mode, SH366002 attempts to take accurate OCV readings with setting **[OCVTAKEN]** in ***Flags()*** to 1. An additional requirement of dV/dt < 4 μV/sec is required for the SH66002 to perform Qmax updates. These updates are used in the Fusion Gauge algorithms. It is critical that the battery voltage be relaxed during OCV readings and that the current is not higher than C/20 when attempting to go into relaxation mode.

4.1.2.4 Discharge Termination Voltage

The value of discharge terminate voltage is set by **Terminate Voltage** and the corresponding Remaining Capacity is 0.

4.2 CHARGE CONTROL

4.2.1 Charge Termination

Charge termination voltage can be specified by users. It is **Charging Voltage** (default) when [JEITA] flag in PackconfigC is set to 0, and is a corresponding JEITAChgVOL when [JEITA] flag in PackconfigC is set to 1.

SH366002 detects charge termination when all the below conditions are satisfied:

1. Pack Voltage >**Selected Charging Voltage - Taper Voltage**;

Selected Charging Voltage= $\begin{cases} \text{Charging Voltage,[JETIA]} = 0 \\ \text{JEITAChgVOL,[JEITA]} = 1 \end{cases}$

2. During two consecutive periods of **Current Taper Window**, the AverageCurrent< **Taper Current**;
3. During the same periods, the accumulated change in capacity ≥ **Min Taper Capacity**.

When this occurs, the ***[CHG]*** bit of ***Flags( )*** is cleared.

If the ***[RMFCC]*** bit of **PackConfiguration** is set, NAC is set equal to FAC as well as RC is set equal to FCC.

If the **TCA Set%** is set as '-1', the parameter is invalid; if as the other value, when the **SOC** is greater than the threshold set in the **TCA Set**%, the ***[CHG]*** bit will be cleared.

If the **TCA Clear%** is set as '-1', the parameter is invalid; if as the other value, when the **SOC** is lower than the threshold set in the **TCA Clear%** , the ***[CHG]*** bit will be set.

If the **FC Set%** is set as '-1', the parameter is invalid, the ***[FC]*** bit will be set only when Charge Termination occurs; if as the other value, when the **SOC** is greater than the threshold set in the **FC Set**%, the ***[FC]*** bit will be set.

If the **FC Clear%** is set as '-1', the parameter is invalid; if as the other value, when the **SOC** is lower than the threshold set in the **FC Clear%** , the ***[FC]*** bit will be cleared.

4.2.2 JEITA Charging Profile

The fusion gauge provides full support for the JEITA charging algorithm, which employs separate constant-current constant-voltage (CCCV) charging parameters depending on the measured *Temperature()*. The allowable charging range is divided into four regions defined by ***T1 Temp***, ***T2 Temp***, ***T3 Temp***, ***T4 Temp***, and ***T5 Temp***, each with its own dedicated *ChargingCurrent()* and *ChargingVoltage()* values.

- If Temperature() < T1 Temp, ChargingCurrent() and ChargingVoltage() are set to 0.
- If T1 Temp ≤ Temperature() ≤ T2 Temp, T1-T2 Chg Current and T1-T2 Chg Voltage are reported.
- If T2 Temp <Temperature() ≤ T3 Temp, T2-T3 Chg Current and T2-T3 Chg Voltage are reported.
- If T3 Temp <Temperature() ≤ T4 Temp, T3-T4 Chg Current and T3-T4 Chg Voltage are reported.
- If T4 Temp <Temperature() ≤ T5 Temp, T4-T5 Chg Current and T4-T5 Chg Voltage are reported.
- If Temperature() > T5 Temp, ChargingCurrent() and ChargingVoltage() are set to 0.

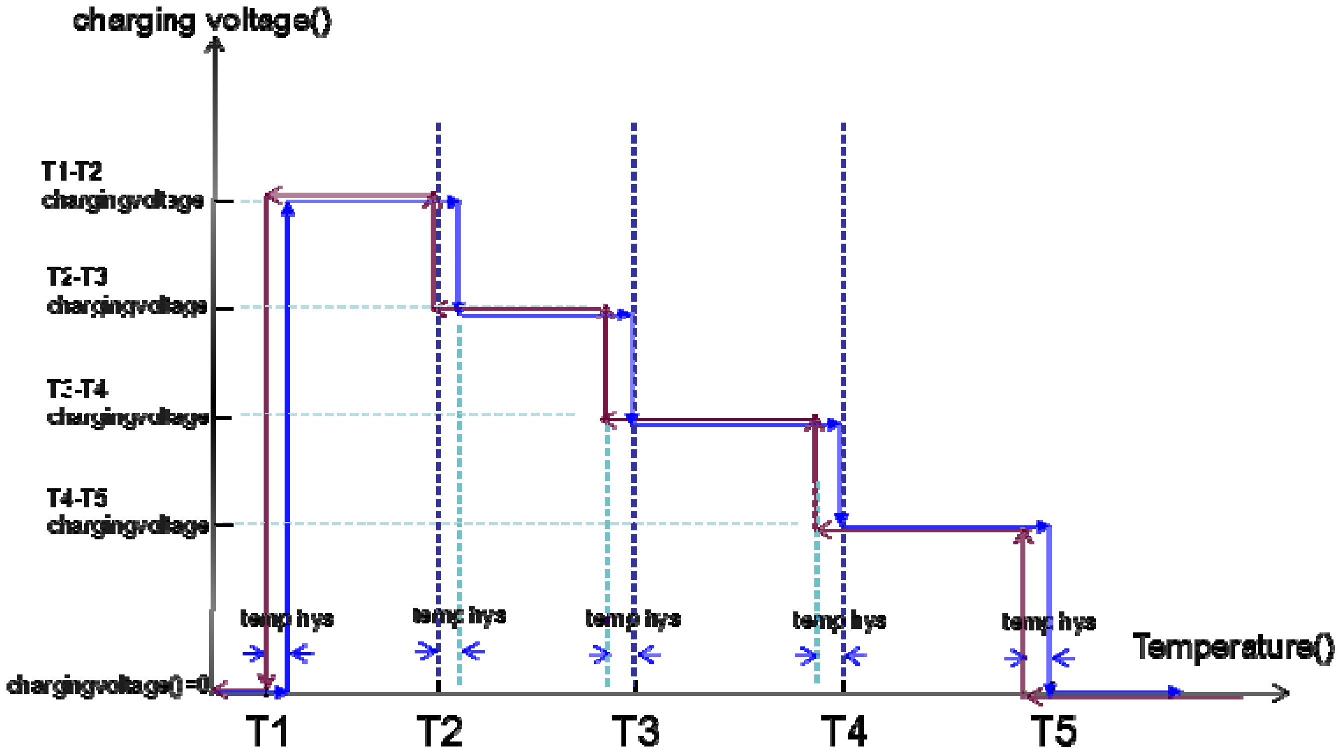


Figure 4.1 JEITA Charging Voltage Profile

(The chargingvoltages in this figure are only show their difference not stand for the default value magnitude.)

Temperature hysteresis (***Temp Hys***) is also applied to movement between various ranges in order to prevent charging parameter oscillation when *Temperature()* continuously changes by a few degrees right on the edge of a temperature boundary. When moving from cooler to warmer temperatures, positive hysteresis is applied to the ***T1 Temp*** and ***T2 Temp*** thresholds. On the contrary, when moving from warmer to cooler temperatures, negative hysteresis is applied to the ***T3 Temp***, ***T4 Temp***, and ***T5 Temp*** thresholds. In order to convert the four-range JEITA profile to a classic, notebook-style three-range version, simply set T4 Temp = T3 Temp.

The diagrams in **Figure 4.1**, *Temperature Hysteresis for Charging Voltage,* and **Figure 4.2**, *Temperature Hysteresis for Charging Current*, illustrate how temperature hysteresis is applied depending on transition direction.

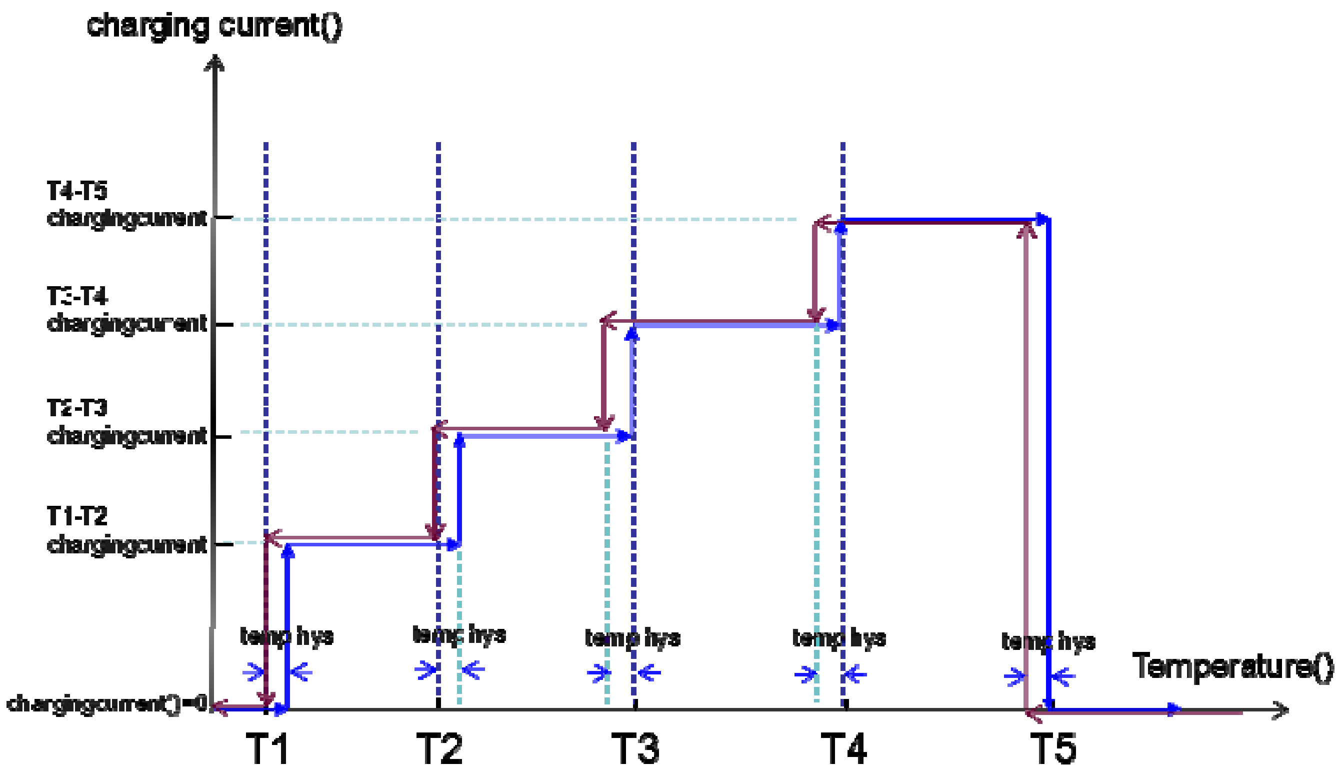


Figure 4.2 Temperature Hysteresis for Charging Current

(The chargingcurrents in this figure are only show their difference not stand for the default value magnitude.)

4.2.3 Charge Suspend

If Temperature*()* < T1 Temp or > T5 Temp during active charging, a charge suspend condition is indicated by setting the *Flags()[CHG_SUS]* bit to 1 and clearing *ChargingCurrent()* and *ChargingVoltage()* to 0.

4.2.4 Charge Inhibit

If Temperature*()* < T1 Temp or > T4 Temp without active charging, a charge inhibit condition is indicated by setting the *Flags()[CHG_INH]* bit to 1 and clearing *ChargingCurrent()* and *ChargingVoltage()* to 0.

4.3 TEMPERATURE MEASUREMENT

The SH366002 measures battery temperature via two ways:

1. When the bit ***[TEMPS]*** of the **PackConfig( )** is set, external Temperature measurement is enabled;
2. When the bit ***[TEMPS]*** of the **PackConfig( )** is cleared, external Temperature measurement is disabled and the temperature will be measured via the on-chip temperature sensor;

If the ***[TEMPS]*** =1, an external 10KΩ thermistor with negative temperature coefficients(for example: 103AT) is necessary to be connected between the VCC and TEMP pins. Additional circuit information is shown in the Reference Schematic.

4.3.1 Charge Over Temperature

If during charging, **Temperature( )** reaches the threshold of **OT Chg** for a period of **OT Chg Time** and **AverageCurrent( )** > **Chg Current Threshold** , then the ***[OTC]*** bit of **Flags( )** is set. When **Temperature( )** falls to **OT Chg Recovery**, the ***[OTC]*** of **Flags( )** is cleared.

If **OT Chg Time**=0, the feature is disabled.

4.3.2 Discharge Over Temperature

If during discharging, **Temperature( )** reaches the threshold of **OT Dsg** for a period of **OT Dsg Time**, and **AverageCurrent( )** ≤ - **Dsg Current Threshold**, then the ***[OTD]*** bit of **Flags( )** is set. When **Temperature( )** falls to **OT Dsg Recovery**, the ***[OTD]*** bit of **Flags( )** is cleared.

If **OT Dsg Time** = 0, the feature is disabled.

4.4 PROTECTION FLAGS

4.4.1 Tab Disconnect Detection

A tab disconnect condition is detected and the *Flags()[TDD]* flag is set when Qmaxcal < TDD Percent * Design Capacity under the Fusion Gauge Qmax update conditions. And *[TDD]* flag is cleared when Qmaxcal > TDD Percent * Design Capacity under the same conditions. The above Qmaxcal is the calculated Qmax duing the current DSG-Relax-CHG-Relax cycle.

An interrupt can be configured to trigger on the (STE or SWI) pin when the tab disconnect condition is detected. Enable/disable of the tab disconnect detection feature is controlled via the ***[TDDEN]*** bit in ***PackConfiguration B***.

The *[TDD]* of ***Flags()*** can be configured to control interrupt pin (STE or SWI) by enabling interrupt mode. See **Section 6.2**, *Interrupt Mode*, for details.

4.4.2 Internal Short Detection

The fusion gauge can indicate detection of an internal battery short by setting the ***[ISDEN***] bit in ***PackConfiguration B.*** If Cell Temperature ≥ 0 degC, the gauge compares the self-discharge current calculated based on the RELAX mode(MinISDTime later in RELAX mode) to the *AverageCurrent* measured in the system. The self-discharge rate is measured at 1 hour intervals. When battery *SelfDischargeCurrent()* is less than ***Design Capacity*** / ***ISD Current*** threshold, the *[ISD]* of *Flags()* is set high.

The *[ISD]* of ***Flags()*** can be configured to control interrupt pin (STE or SWI) by enabling interrupt mode. See **Section 6.2**, *Interrupt Mode*, for details.

4.4.3 STE_fuse Blow Function

Fuse can be blown by STE_fuse Blow Function. This function is enabled and disabled by subcommands 0x0091and 0x0092 respectively in **Control** command (0x00).

When the function is enabled, the fusion gauge detects the cell voltage and triggers STE pin state (set the STE pin low or high according to **Table 4.2**) when cell voltage >*STE_fuse Volt Set* for *STE_fuse Set Time.* The STE pin keeps high for *STE_fuse Blow Time* to blow fuse (fuse blown process) when the '1' state in **Table 4.2** is triggered.

During this process, *Fuseflag*(can be read by sub-command 0x0090) in Dataflash is updated to the following value to indicate the fuse state.

Table 4.1 Fuseflag indicated state

Fuseflag	Condition	Indicated state
0x55	When no obvious current (|current|<STE_fuse Detect CUR) is detected after fuse blown process.	Fuse is blown.
0x05	In fuse blown process	STE pin is on High level process.
0xFF	When higher than STE_fuse Detect CUR current is detected after fuse blown process.	Fuse blown failure.

If STE pin is configured by two or more functions, STE pin responses the prior function in the following order as STE_Fuse Blown Function, Interrupt Mode and Shutdown Mode. STE_fuse Blow Function is prior when enabled.

Table 4.2 STE Pin State under STE Fuse Function Enabled Condition

[STE_PU]	[STE_POL]	The Function Enabled STE Pin not triggered	The Function Enabled STE Pin triggered
0	0	High Impedance	0
0	1	0	High Impedance
1	0	1	0
1	1	0	1

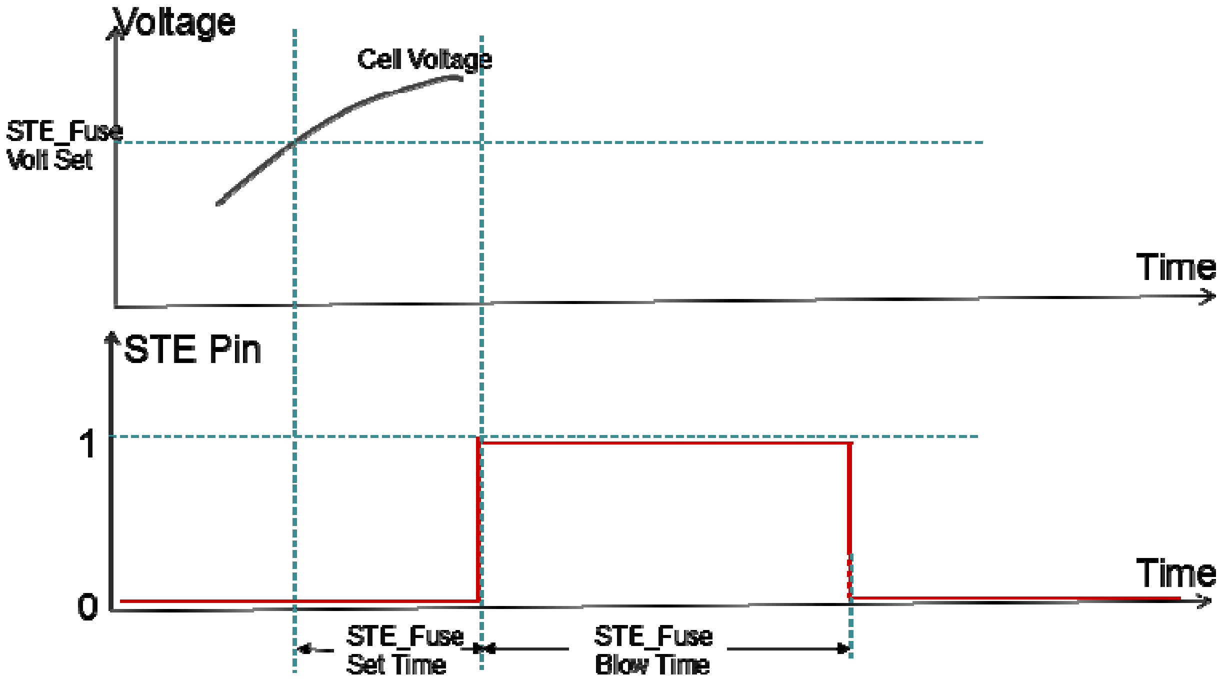


Figure 4.3 STE Pin state under the condition of [STE_PU]=1 and [STE_POL]=1

Note:

If *STE_fuse Blow Time* is set to zero, fuse must be blown (STE pin is set to high) and *Fuseflag* is updated to 0x55 when (voltage >*STE_fuse Volt)* is detected. And also STE pin is set to high to blow fuse when the fusion gauge detected *STE_fuse Blow Time*=0 and *Fuseflag*=0x55*.*

4.4.4 BATLOW/BATHIGH flags

SH366002 detects the cell voltage for low or high voltage alarm. ***[BATLOW]*** flag in ***Flags()*** will be set when lower than *BATLOW Set Threshold* voltage is detected for *BATLOW Set Time* and cleared when cell voltage > *BATLOW Clear Threshold*, and ***[BATHI]*** flag in ***Flags()*** will be set when more than *BATHI Set Threshold* voltage is detected for *BATHI Set Time* and cleared when cell voltage < *BATHI Clear Threshold.*

4.5 TWI /SWI Communication Mode

SH366002 supports TWI Communication mode only (default) or TWI Communication / SWI Communication compatible mode for system communication. SH366002 can respond TWI or SWI signals in same mode (the Communication compatible mode) but not communicate in the two ways at the same time. The compatible mode is non-effective until SH366002 receive some certain commands.

It is important to note that only under the condition of *Pack Configuration* [INTSEL] bit =0 can the communication compatible mode be switch on resulting from that the SWI pin is also used as the respond pin by the Interrupt, SE_Fuse and BTP Function etc.

4.6 ACCESS MODES

The SH366002 provides three security modes: **FULL ACCESS**, **UNSEALED**, and **SEALED**.

Table 4.4 Data Flash Access

SECURITY MODE	DATA FLASH	MANUFACTURER INFORMATION
FULL ACCESS	R/W	R/W
UNSEALED	R/W	R/W
SEALED	NONE	R(A) , R/W(B, C)

The difference between **FULL ACCESS** mode and **UNSEALED** mode is only **FULL ACCESS** mode allows SH366002 to read/write access-mode transition key. In order to avoid conflict, the key must be different from the CNTL DATA shown in **Table 7.2**.

4.6.1 FULL ACCESS / UNSEALED to SEALED

When SEALED-KEY is received via the **Control( )** command, the SH366002 enters **SEALED** mode, setting the ***[SS]*** bit and ***[FAS]*** bit. When in **SEALED** mode, the **UNSEAL** keys can be correctly received, but the system will reenter the **SEALED** mode once a reset occurs.

4.6.2 SEALED to UNSEALED and UNSEALED to FULL ACCESS

Both **Unseal Key** and **Full-Access Key** are stored in data flash in two words. The first word is Key 0 and the second word is Key 1. The order of the keys sent to SH366002 is Key 1 followed by Key 0. For example, if the Unseal Key is 0x56781234, key 1 is 0x1234 and key 0 is 0x5678. Then **Control( )** should supply 0x1234 and then 0x5678, to unseal the part.

5. Lifetime Data Logging Parameters

The Lifetime Data logging function helps development and diagnosis with the fusion gauge. The 0x0021 subcommand needs to be enabled for lifetime data logging functions to be active. The fusion gauge logs the lifetime data as specified in the Lifetime Data and Lifetime Temp Samples data flash subclasses. The data log recordings are controlled by the Lifetime Resolution data flash subclass. The Lifetime Data Logging can be started by setting the 0x0021 subcommand and setting the Update Time register to a non-zero value.

Once the Lifetime Data Logging function is enabled, the measured values are compared to what is already stored in the data flash. If the measured value is higher than the maximum or lower than the minimum value stored in the data flash by more than the Resolution set for at least one parameter, the entire Data Flash Lifetime Registers are updated after at least LTUpdateTime.

LTUpdateTime sets the minimum update time between DF writes. When a new maximum or minimum is detected, a LT Update window of [update time] seconds is enabled and the DF writes occur at the end of this window. Internal to the fusion gauge, there exists a RAM maximum/minimum table in addition to the DF maximum/minimum table. The RAM table is updated independent of the resolution parameters. The DF table is updated only if at least one of the RAM parameters exceeds the DF value by more than resolution associated with it. When DF is updated, the entire RAM table is written to DF. Consequently, it is possible to see a new maximum/minimum value for a certain parameter even if the value of this parameter never exceeds the maximum or minimum value stored in the data flash for this parameter value by the resolution amount.

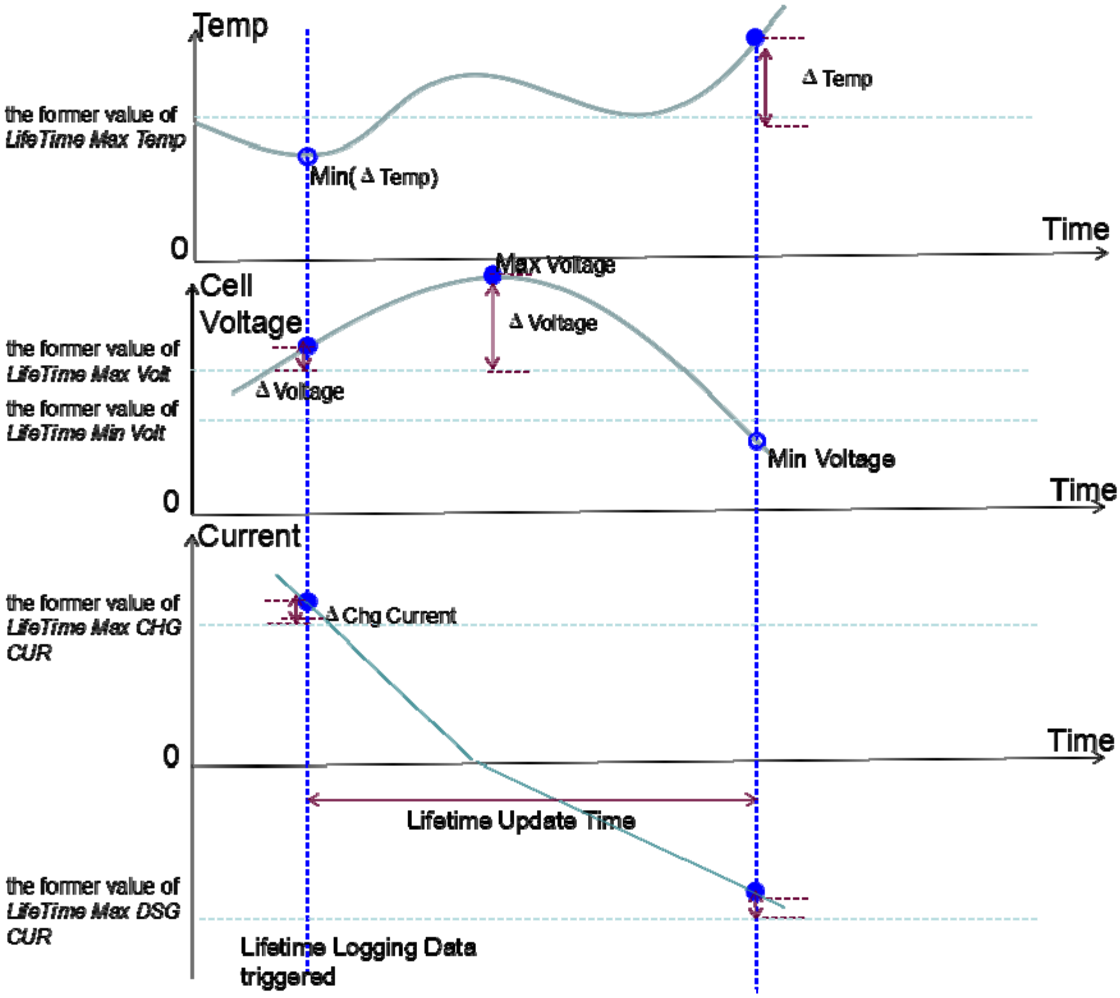


Figure 5.1 Lifetime logging data record example

Take Figure 5.1 for example, when the Life Time Data Logging is enabled, ∆Temp, ∆Voltage, ∆Current are detected every second. The above ∆Temp, ∆Voltage, ∆Current definition and their trigger conditions are listed below.

Definitions	Life Time Logging Data Function trigger condition	Note
∆Temp=Temperature() – the former value of Life Time Max Temp	∆Temp>LifeTime Delta Temp	Temperature()>the former value of Life Time Max Temp
OR ∆Temp= the former value of Life Time Min Temp – Temperature()	∆Temp>LifeTime Delta Temp	Temperature()<the former value of Life Time Min Temp
∆Voltage= Voltage() – the former value of Life Time Max Volt	∆Voltage>LifeTime Delta Volt	Voltage()>the former value of Life Time Max Volt
OR ∆Voltage=the former value of Life Time Max Volt – Voltage()	∆Voltage> LifeTime Delta Volt	Voltage()<the former value of Life Time Min Volt
∆Current= Current() - the former value of Life Time Max CHG CUR	∆Current > LifeTime Delta CUR	Current() > the former value of Life Time Max CHG CUR
∆Current= the former value of Life Time Max DSG CUR - Current()	∆Current > LifeTime Delta CUR	Current() < the former value of Life Time Max DSG CUR

Once any of the above trigger conditions is satisfied, the fusion gauge records all of the max/min Temperature(), Voltage() and Current() during the following *Lifetime Update Time* and updates the max/min values which are higher or lower than the former value to Dataflash at the end of the *Lifetime Update Time*.

As shown in **Figure 5.1**, Lifetime Logging Data triggered if ∆Voltage > LifeTime Delta Volt, and *Lifetime Max Temp*, *Lifetime Max Volt*, *Lifetime Min Volt and Lifetime Max CHG CUR* were updated at the end of the *Lifetime Updete Time.*

The Life Time Data Logging of one or more parameters can be reset or restarted by writing new default (or starting) values to the corresponding data flash registers through SEALED or UNSEALED access as described below. However, when using UNSEALED access, new values take effect only if the device is reset within ***LT Update Time*** after the DF is loaded with new values.

The logged data in ***Lifetime Data*** subclass (subclass ID = 59) can be read and written in both SEALED and UNSEALED modes. However, in SEALED mode, access to this subclass is using a process identical to accessing ***Manufacturer Info Block B***. The *DataFlashBlock()* command code is 4. More detail please refer to the 0x61 command.

The subclasses ***Lifetime Resolution*** (subclass ID = 66) and ***Lifetime Temp Samples*** (subclass ID = 59) that contain settings for lifetime data logging can be configured only in UNSEALED mode using the regular DF access method.

The Lifetime resolution registers contain the parameters which set the limits related to how much a data parameter must exceed the previously logged maximum/minimum value to be updated in the lifetime log. For example, V must exceed MaxV by more than Voltage Resolution to update MaxV in the data flash.

6. System Control Function

The fusion gauge provides system control functions which allows the fusion gauge to enter shutdown mode in order to power-off with the assistance of external circuit or provides interrupt function to the system.

Table 6.1 shows the configurations for STE and SWI pins.

Table 6.1 STE and SWI Pin Functions

TWI Communication Mode:			
	[INTSEL]	STE Pin Function	SWI Pin Function
STE Fuse Function(1) Disabled	0(default)	Interrupt mode(2)	Not used
	1	Shutdown mode	Interrupt Mode
STE Fuse Function Enabled	0	STE Fuse Function Mode	Not used
	1	STE Fuse Function Mode	Interrupt Mode
Compatible Communication Mode:			
	[INTSEL]	STE Pin Function	SWI Pin Function
STE Fuse Function Disabled	0(default)	Interrupt mode(2)	SWI Mode(3)
	1	Shutdown mode	SWI Mode(3)
STE Fuse Function Enabled	0	STE Fuse Function Mode	SWI Mode(3)
	1	STE Fuse Function Mode	SWI Mode(3)

(1) STE Fuse Function can be enabled by subcommand 0x0091 in *Control (0x00)*, and STE Pin only responds STE Fuse Function once it is enabled.

(2) [STE_EN] bit in **PackConfiguration** can be enabled to use [STE] and [SHUTDWN] bits in CONTROL_STATUS() function. The STE pin shutdown function is disabled.

(3) SWI pin is used for communication and SWI Host Interrupt Feature is available.

6.1 shutdown mode

By using **STE** pin, the fusion gauge can be made to power-off through an external circuit. This feature is useful to shutdown the fusion gauge in a deeply discharged battery to protect the battery.

The following bits are used to configure and control **STE** pin:

1. Two **Control Status** bits signals the operation of the **STE** pin:
   [STE] - bit15 -- Status bit indicating the **STE** pin is active. Default is 0.
   [SHUTDOWN] - bit7 -- indicates the shutdown feature is enabled. Default is 1 (enabled)
2. Two ***control()*** sub-commands enable or disable shutdown functionality:
   SET_SHUTDOWN (0x0013) -- enables **STE** pin functionality (sets **SHUTDOWN** status bit)
   CLEAR_SHUTDOWN (0x0014) -- disables **STE** pin functionality (clears **SHUTDOWN** status bit)
3. Two **Data Flash** bits in pack configuration register control the operation of the **STE** pin:
   [STE_PU] - bit3 -- Pull-up enable for **STE** pin when its state is 1.
   [STE_POL] - bit2 -- Polarity for **STE** pin when shutdown is enabled.

By default the **STE** pin is in normal state for all modes of operation. By sending **SET_SHUTDOWN** sub-command or setting ***[STE_EN]*** bit in **PackConfiguration** Register, the ***[SHUTDOWN]*** bit is set and the shutdown feature is enabled.

In the shutdown mode, the STE pin is used to signal external circuit to power-off the fusion gauge. This feature is useful to shutdown the fusion gauge in a deeply discharged battery to protect the battery. By default, the

Shutdown Mode is in normal state. By sending the SET_SHUTDOWN subcommand or setting the ***[STE_EN]*** bit in ***PackConfiguration*** register, the *[SHUTDWN]* bit is set and enables the shutdown feature. When this feature is enabled and *[INTSEL]* is set, the STE pin can be in normal state or shutdown state. The shutdown state can be entered in HIBERNATE mode (only if HIBERNATE mode is enabled due to low cell voltage), all other power modes will default STE pin to normal state. **Table 6.2** shows the STE pin state in normal or shutdown mode. The CLEAR_SHUTDOWN subcommand or clearing ***[STE_EN]*** bit in the ***PackConfiguration*** register can be used to disable shutdown mode.

The STE pin will be high impedance at power-on reset (POR), the *[STE_POL]* does not affect the state of STE pin at POR. Also, *[STE_PU]* configuration changes will only take effect after POR. In addition, the *[INTSEL]* only controls the behavior of the STE pin; it does not affect the function of *[SE]* and *[SHUTDWN]* bits.

Table 6.2 STE Pin State under STE Fuse Function Disabled Condition

		SHUTDOWN Mode [INTSEL] = 1 and ([STE_EN] or [SHUTDOWN] = 1)	
[STE_PU]	**[STE_POL]**	**NORMAL STATE**	**SHUTDOWN STATE**
0	0	High Impedance	0
0	1	0	High Impedance
1	0	1	0
1	1	0	1

STE pin state can be triggered by the following functions but responds the priority in the following order as *STE_Fuse Blown Function*, *Interrupt Mode* and *Shutdown Mode*. More details please refer to **Table 6.1**.

6.2 Interrupt Mode

By utilizing the interrupt mode, the system can be interrupted based on detected fault conditions as specified in **Table 6.5** when the corresponding bit is set in **Interrupt Config**(see **Table 7.11**). The STE or SWI pin can be selected as the interrupt pin by configuring the ***[INTSEL]*** bit. In addition, the pin polarity can be configured according to the system needs as described in **Table 6.3** or **Table 6.4**. More details please refer to **Table 6.1**.

Table 6.3.STE pin state in interrupt Mode ([INTSEL]=0)

[STE_PU]	[INTPOL]	Interrupt Clear	Interrupt Set
0	0	High Impedance	0
0	1	0	High Impedance
1	0	1	0
1	1	0	1

Table 6.4 SWI pin state in interrupt Mode ([INTSEL]=1)

[INTPOL]	Interrupt Clear	Interrupt Set
0	High Impedance	0
1	0	High Impedance

Table 6.5 interrupt condition list

Interrupt condition	***Flags( )*** status bit	Enable condition	Comment
SOC1 Set	[SOC1]	Always	This interrupt is raised when the [SOC1] flag is set.
Battery High	[BATHI]	Always	This interrupt is raised when the [BATHI] flag is set.
Battery Low	[BATLOW]	Always	This interrupt is raised when the [BATLOW] flag is set.
Over Temperature Charge	[OTC]	OT Chg Time≠ 0	This interrupt is raised when the [OTC] flag is set.
Over Temperature Charge	[OTD]	OT Dsg Time≠ 0	This interrupt is raised when the [OTD] flag is set.
Internal Short Detection	[ISD]	[ISDEN]=1 in Pcak Configuration B	This interrupt is raised when the [ISD] flag is set.
Tab Disconnection Detection	[TDD]	[TDDEN]=1 in Pcak Confihuration B	This interrupt is raised when the [TDD] flag is set.
Battery Trip Point (BTP)	[SOC1]	[BTPEN]=1 in **PackConfiguration** C, the BTP interrupt supersedes all other interrupt sources which are unavailable when BTP is active.	This interrupt is raised when RemainingCapacity()⩽ BTPSOC1Set() or RemainingCapacity() ⩾BTPSOC1Clear() during battery discharge or charge, respectively. The interrupt remains asserted until new values are written to both the BTPSOC1Set() and BTPSOC1Clear() registers.

6.3 Battery Trip Point interrupt Function

To provide increased flexibility for capacity-based interrupts to the host, the fusion gauge incorporates a Battery Trip Point (BTP) function that allows the system to dynamically update the traditional ***SOC1 Set Threshold*** and ***SOC1 Clear Threshold*** at runtime using the *BTPSOC1Set()* and *BTPSOC1Clear()* standard commands. These thresholds are used to trigger an interrupt on the SWI pin whenever the set or clear thresholds are crossed following update to the *BTPSOC1Set()* and *BTPSOC1Clear()* values.

Configuration of the interrupt polarity and enable/disable of the feature is provided via the ***PackConfiguration [INTPOL]*** and ***PackConfiguration C [BTP_EN]*** bits, respectively, while initialization values for the interrupt set and clear thresholds are programmed in ***SOC1 Set Threshold*** and ***SOC1 Clear Threshold*** as normal.

When BTP is enabled, the fusion gauge continuously compares *RemainingCapacity()* with the values programmed in *BTPSOC1Set()* and *BTPSOC1Clear()* to determine whether or not it has crossed below the set or above the clear threshold. Once a threshold is crossed, additional conditions are verified to guard against an unintended interrupt trigger. For the BTP set threshold, the direction of current flow is checked to confirm that a discharge event is occurring. If true, the *Flags()[SOC1]* bit is set to 1 and an interrupt asserts on the SWI pin. For the BTP clear threshold, the device again checks the direction of current flow to ensure that a charge event is occurring. Afterwards, an internal variable is examined to determine whether or not a change in the state of *Flags()[SOC1]* has already occurred due to a prior clear threshold crossing. If true, no change is made and a new interrupt will not fire, however, it is implied that a pre-existing interrupt will still be asserted. If false, the current state of *Flags()[SOC1]* is flipped to its opposite value and an interrupt subsequently triggered on the SWI pin. In this way, the correct behavior is guaranteed in cases where the host updates the BTP set and clear thresholds diligently based on SWI interrupts but also when there is a failure to update the thresholds. If, at any time, new values are written to either *BTPSOC1Set()* or *BTPSOC1Clear()* then the *[SOC1]* flag automatically reinitializes to 0 and the SWI pin de-asserts to its default state. The entire functional flow of the BTP feature is illustrated in **Figure 6.1**, *BTP Algorithm Flow*.

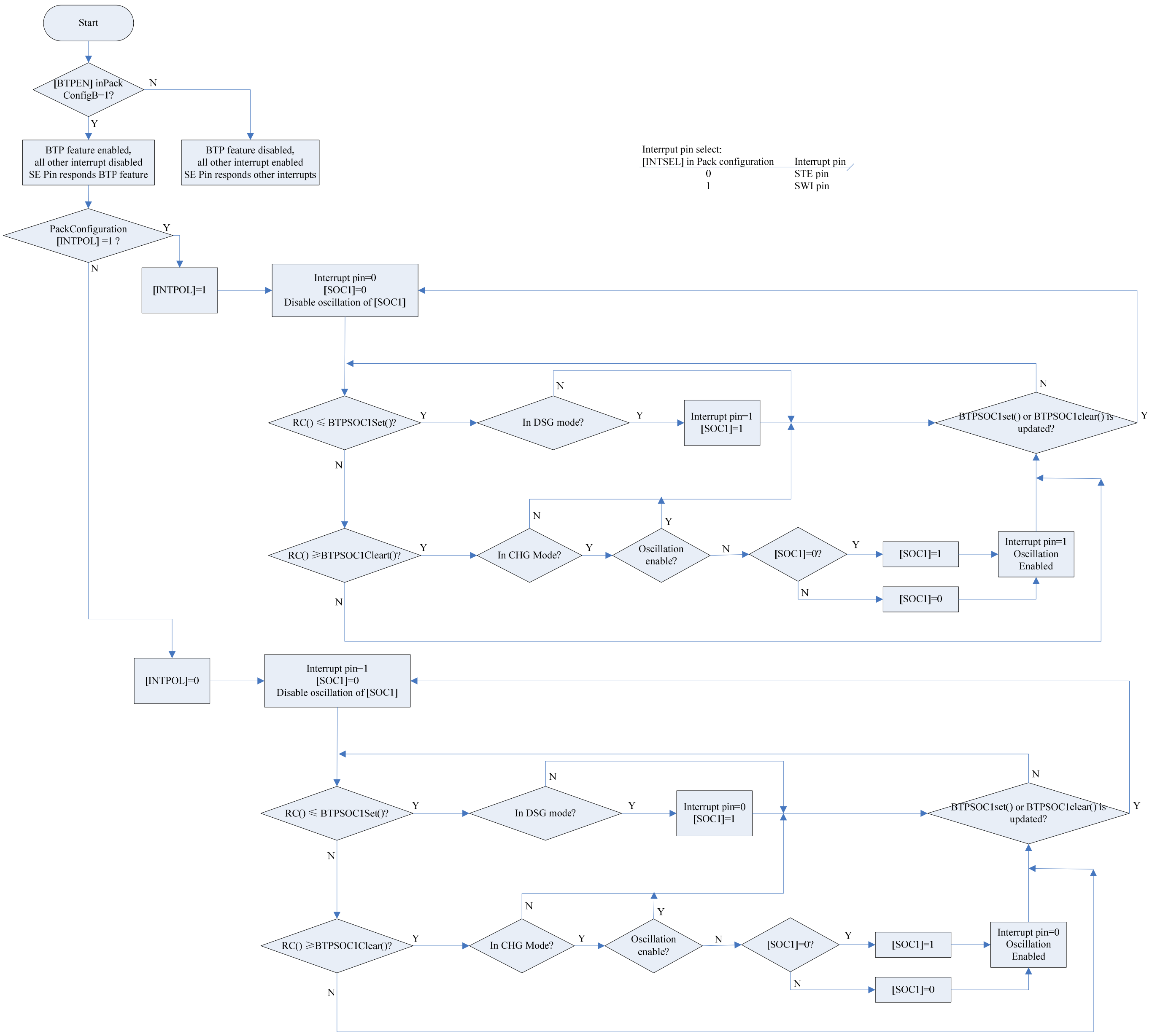


Figure 6.1 BTP Algorithm Flow

In normal usage, the BTP thresholds are continuously updated by the host system at predetermined increments, each time reinitializing the *Flags()[SOC1]* bit to 0 and waiting for the crossing of the next threshold to trigger a new interrupt. If the thresholds are always updated after each interrupt, then it is implied that the crossing of a set or clear threshold always triggers a new interrupt. This is highlighted below in **Figure 6.2**, *BTP Configuration with Multiple Thresholds*.

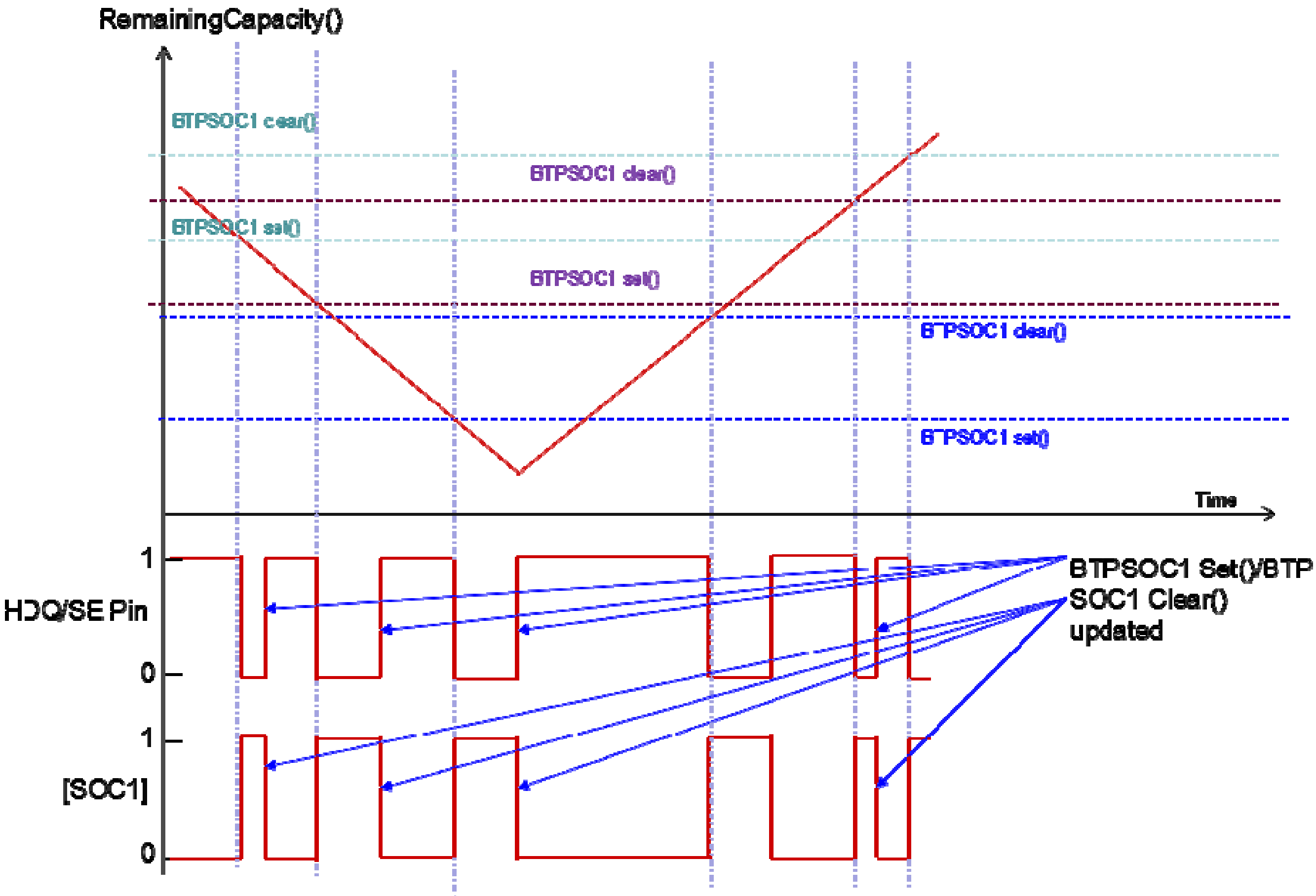


Figure 6.2 **BTP Configuration with Multiple Thresholds([INTPOL]=0)**

However, it is possible that the host may fail to write new thresholds or experience a significant delay in attempting to do so. In this case, there could be an occurrence where the clear threshold is crossed after an interrupt due to a prior set threshold crossing. Thus, the *[SOC1]* bit would experience a change but a new interrupt would not be triggered on SWI. Thus, continued crossings without updates to *BTPSOC1Set()* or *BTPSOC1Clear()* will only result in changes to *Flags()[SOC1]*.

If BTPSOC1 Set() is lower than(default) or equal to BTPSOC1 Clear() the SWI pin state and [SOC1] flag respond according to the **Figure 6.1** and **Figure 6.2**. If BTPSOC1 Set() is higher than BTPSOC1 Clear(), the SWI pin state and [SOC1] flag respond according to the **Figure 6.1** and **Figure 6.2** in non-charging mode, but according to the condition of RC()>BTPSOC1Set() in charging mode.

Note: 1) The interrupt pin is STE pin when [INTSEL] in Pack configuration is set, and SWI pin when cleared.

2) The interrupt pin is default to be pulled up for BTP function.

7. DATA COMMANDS

7.1 STANDARD DATA COMMANDS

The SH366002 uses the following standard commands to enable system reading and writing of battery Information, as indicated in Table 7.1.

Table 7.1 (a) Standard Commands in Normal Mode(default)

Name		COMMAND CODE	UNITS	SEALED ACCESS
Control( )	CNTL	0x00 / 0x01	N/A	R/W
AtRate( )	AR	0x02 / 0x03	mA	R/W
AtRateTimeToEmpty( )	ARTTE	0x04 / 0x05	Minutes	R
Temperature( )	TEMP	0x06 / 0x07	0.1K	R
Voltage( )	VOLT	0x08 / 0x09	mV	R
Flags( )	FLAGS	0x0a / 0x0b	N/A	R
NominalAvailableCapacity( )	NAC	0x0c / 0x0d	mAh	R
FullAvailableCapacity( )	FAC	0x0e / 0x0f	mAh	R
FilteredRC( )	FRC	0x10 / 0x11	mAh	R
FilteredFCC( )	FFCC	0x12 / 0x13	mAh	R
AverageCurrent( )	AI	0x14 / 0x15	mA	R
AverageTimeToEmpty( )	TTE	0x16 / 0x17	Minutes	R
AverageTimeToFull( )	TTF	0x18 / 0x19	Minutes	R
StandbyCurrent( )	SI	0x1a / 0x1b	mA	R
StandbyTimeToEmpty( )	STTE	0x1c / 0x1d	Minutes	R
MaxLoadCurrent( )	MLI	0x1e / 0x1f	mA	R
MaxLoadTimeToEmpty( )	MLTTE	0x20 / 0x21	Minutes	R
AvailableEnergy( )	AE	0x22 / 0x23	10mWh	R
AveragePower( )	AP	0x24 / 0x25	10mW	R
TTEatConstantPower( )	TTECP	0x26 / 0x27	Minutes	R
Internal_Temp( )	INTTEMP	0x28 / 0x29	0.1°K	R
CycleCount( )	CC	0x2a / 0x2b	Counts	R
RelativeStateOfCharge( )	RSOC	0x2c / 0x2d	%	R
StateOfHealth( )	SOH	0x2e / 0x2f	% / num	R
JeitaCHGVOL( )	JCV	0x30/0x31	mV	R
JeitaCHGCUR( )	JCC	0x32/0x33	mA	R
PassedCharge( )	PCHG	0x34 / 0x35	mAh	R
DOD0( )	DOD0	0x36 / 0x37	HEX	R
SelfDischargeCurrent( )	SelfDSGCurrent	0x38/0x39	mA	R

The above standard commands are effective in Normal mode(User Config=0x0000), but in other mode some commands are executed for the other meanings below.

Table 7.1 (b) Standard Commands in User_CFG1 mode

Name	Command	Unit	Sealed access	User Config
Current	0x04/0x05	mA	R	User_CFG1
Time2FullinSec	0x1c/0x1d	S	R	User_CFG1
TermVolt	0x20/0x21	mV	R	User_CFG1
Design Capacity	0x22/0x23	mAh	R	User_CFG1
No action	0x30/0x31	-	-	User_CFG1
FilteredRC	0x32/0x33	mAh	R	User_CFG1
FilteredFCC	0x72/0x73(2)	mAh	R	User_CFG1
Same as in normal mode(1)	0x00-0x63	-	-	User_CFG1

Note:

(1) In User_CFG1 Mode, the commands execute the same actions as those in normal mode except the above commands.

(2) FilteredFCC(0x72/0x73) is belong to extended data command.

Time2FullinSec: This read-only function returns an unsigned integer value of predicted remaining time until the battery reaches full charge, in minutes, based upon **AverageCurrent( )**. A value of 65,535 indicates the battery is not being charged.

TermVolt: Absolute minimum voltage for end of discharge.

FilteredRC: The filtered remaining capacity based on remaining capacity(RC).

FilteredFCC: The filtered full charged capacity based on full charged capacity(FCC).

Table 7.1 (c) Standard Commands in User_CFG2 mode

Name	Command	Unit	Sealed access	User Config
Max load current	0x1e/0x1f	mA	R	User_CFG2
BTPSOC1Set	0x1c/0x1d	%	R	User_CFG2
BTPSOC1Clr	0x20/0x21	%	R	User_CFG2
Full Charged Energy	0x76/0x77(2)	10mWh	R	User_CFG2
Same as in normal mode(1)	0x00-0x63	-	-	User_CFG2

Note:

(1) In User_CFG2 Mode, the commands execute the same actions as those in normal mode except the above commands.

(2)Full Charged Energy(0x76/0x77) is belong to extended data command.

Max load current: This read-only function returns the maximum discharge current that the battery can support for *Max Current Pulse Duration* time without prematurely dropping to empty (that is, 0%).

BTPSOC1Set: Please refer BTP Function for details.

BTPSOC1Clr: Please refer BTP Function for details.

Full Charged Energy: This read-only function returns the full charged energy(ΣFCC*Voltage) in unit of 10mWh.

Table 7.1 (d) Standard Commands in User_CFG3 mode

Name	Command	Unit	Sealed access	User Config
Control()	0x00/0x01	-	R	User_CFG3
Temperature()	0x06/0x07	K	R	User_CFG3
Voltage()	0x08/0x09	mV	R	User_CFG3
Flags()	0x0a/0x0b	-	R	User_CFG3
FullAvailableCapacity()	0x0e/0x0f	mAh	R	User_CFG3
RemainingCapacity()	0x10/0x11	mAh	R	User_CFG3
FullChargeCapacity()	0x12/0x13	mAh	R	User_CFG3
AverageCurrent()	0x14/0x15	mA	R	User_CFG3
InternalTemperature()	0x16/0x17	K	R	User_CFG3
StateOfCharge()	0x20/0x21	%	R	User_CFG3
InstantaneousCurrent Reading()	0x22/0x23	mA	R	User_CFG3
FineQPass()	0x24/0x25	mAh	R	User_CFG3
TrueSOC()	0x74/0x75	%	R	User_CFG3
unfilteredRC()	0x6c/0x6d	mAh	R	User_CFG3
unfilteredFCC()	0x70/0x71	mAh	R	User_CFG3
No Action(1)	Other SBS commands	-	-	User_CFG3

Note:

(1) In User_CFG3 Mode, SH366002 responds no action for other SBS commands except the above mentioned.

(2)TrueSOC(), unfilteredRC() and unfilteredRC() are belong to extended data commands.

InstantaneousCurrentReading(): This read-only function returns the current data(*Current()*) used by the algorithm.

FineQPass(): This read-only function returns passedcharge2 which updates in CHG/DSG mode and clears when Qmax is updated.

TrueSOC(): This read-only function returns TureSOC=RC/filtered FCC.

Table 7.1 (e) Standard Commands in User_CFG4 mode

Name	Command	Unit	Sealed access	User Config
Control()	0x00/0x01	-	R	User_CFG4
Temperature()	0x02/0x03	K	R	User_CFG4
Voltage()	0x04/0x05	mV	R	User_CFG4
Flags()	0x06/0x07	-	R	User_CFG4
NomAvailCapacity()	0x08/0x09	mAh	R	User_CFG4
FullAvailableCapacity()	0x0a/0x0b	mAh	R	User_CFG4
RemainingCapacity()	0x0c/0x0d	mAh	R	User_CFG4
FullChargeCapacity()	0x0e/0x0f	mAh	R	User_CFG4
AverageCurrent()	0x10/0x11	mA	R	User_CFG4
StandbyCurrent()	0x12/0x13	mA	R	User_CFG4
MaxLoadCurrent()	0x14/0x15	mA	R	User_CFG4
AvailablePower()	0x18/0x19	mWh	R	User_CFG4
StateOfCharge()	0x1c/0x1d	%	R	User_CFG4
InternalTemperature()	0x1e/0x1f	K	R	User_CFG4
StateOfHealth()	0x20/0x21	%	R	User_CFG4
unfilteredRC()	0x28/0x29	mAh	R	User_CFG4
unfilteredFCC()	0x2c/0x2d	mAh	R	User_CFG4
No Action(1)	Other SBS commands	-	-	User_CFG4

Note:

(1) In User_CFG4 Mode, SH366002 responds no action for other SBS commands except the above mentioned.

(2) unfilteredRC() and unfilteredRC() are belong to extended data commands.

Table 7.1 (f) Standard Commands in User_CFG5 mode

Name	Command	Unit	Sealed access	User Config
Control()	0x00/0x01	-	R	User_CFG5
Current()	0x04/0x05	K	R	User_CFG5
No Action	0x0c~0x0f	mV	R	User_CFG5
InstantCurrent()	0x14/0x15	mA	R	User_CFG5
NoAction	0x18/0x19	-	R	User_CFG5
RSOC()	0x1a/0x1b	%	R	User_CFG5
PassedEnergy()	0x1c/0x1d	mWh	R	User_CFG5
TermVolt()	0x20/0x21	mV	R	User_CFG5
Qmax()	0x22/0x23	mAh	R	User_CFG5
NoAtcion	0x30/0x31	-	R	User_CFG5
FilteredRC	0x32/0x33	mA	R	User_CFG5

FilteredFCC	0x38/0x39	mAh	R	User_CFG5
NomAvailCapacity()	0x6a/0x6b	mAh	R	User_CFG5
FullAvailCapacity()	0x72/0x73	mAh	R	User_CFG5
AvailablePower()	0x76/0x77	mWh	R	User_CFG5
StandbyCurrent()	0x7a/0x7b	mA	-	User_CFG5
Vcell()	0x7c/0x7d	mV	-	User_CFG5
Qmax()	0x7e/0x7f	mAh	-	User_CFG5
Same as Default	Other Command	-	-	User_CFG5

Note:
(1) In User_CFG5 Mode, SH366002 responds the same as default at the command that doesn't exist in the table above.

7.1.1 Control( ): 0x00/0x01

Issuing a **Control( )** command requires a subsequent 2-byte sub-command, as described in **Table 7.2**.

Table 7.2 Control( ) Sub-commands (Normal Mode)

CNTL FUNCTION	CNTL DATA	SEALED ACCESS	DESCRIPTION
CONTROL_STATUS	0x0000	Yes	Reports the status word
CONFIG_DT	0x0001	Yes	Reports the information in subclass 122 offset 1
CONFIG_SW	0x0002	Yes	Reports the information in subclass 122 offset 3
CONFIG_HW	0x0003	Yes	Reports the information in subclass 122 offset 5
DF_CHECKSUM	0x0004	No	Enables a data flash checksum to be generated and reports on a read
RESET_DATA	0x0005	No	Returns reset data
PREV_MACWRITE	0x0007	No	Returns previous MAC command code
CHEM_ID	0x0008	Yes	Reports the chemical identifier
DF_VERSION	0x000C	Yes	Reports the data flash version on the device
SET_FULLSLEEP	0x0010	No	Set the ***[FULLSLEEP]*** bit in Control Status register to 1
SET_HIBERNATE	0x0011	Yes	Set **CONTROL_STATUS *[HIBERNATE]*** to 1
CLEAR_HIBERNATE	0x0012	Yes	Clear **CONTROL_STATUS *[HIBERNATE]*** to 0
SET_SHUTDOWN	0x0013	Yes	Enables the **STE** pin to change state
CLEAR_SHUTDOWN	0x0014	Yes	Disables the **STE** pin from changing state
SET_SWI INTEN	0x0015	Yes	Set **CONTROL_STATUS *[SWIIntEn]*** to 1
CLEAR_SWI INTEN	0x0016	Yes	Clear **CONTROL_STATUS *[SWIIntEn]*** to 0
SEALED	0x0020	No	Forces the SH366002 into **SEALED** mode
RESET	0x0041	No	Force a full reset of the SH366002

CAL_OFFSET	0x0061	No	Force the SH366002 to perform a zero-current calibration
CAL_CUR	0x0062	No	Force the SH366002 to perform a load-current calibration
CAL_VOL	0x0063	No	Force the SH366002 to perform a voltage calibration
CAL_EXTT	0x0064	No	Force the SH366002 to perform an external-temperature calibration
CAL_INTT	0x0065	No	Force the SH366002 to perform an internal-temperature calibration
EXIT_CAL	0x0080	No	Force the SH366002 to quit calibrate mode
ENTER_CAL	0x0081	No	Force the SH366002 to enter calibrate mode
SEfuseflag	0x0090	Yes	Indicate the STE Fuse flag for the fuse state
STE_Fuse Enable	0x0091	Yes	Enable STE fuse Function
STE_Fuse Disable	0x0092	Yes	Disable STE fuse Function

7.1.1.1 CONTROL_STATUS: 0x0000

Instructs the fusion gauge to return status information to Control addresses 0x00/0x01. The status word includes the following information.

Table 7.3 CONTROL_STATUS Flags

Bit	Name	Description
Bit15	SE	0: STE pin disabled (default) 1: STE pin enabled
Bit14	FAS	0: FULL ACCESS state 1: FULL ACCESS SEALED state.
Bit13	SS	0: UNSEALED state 1: SEALED state,
Bit12	CSV	0: Cleared when writing Data Flash operation (default) 1: Set when Contro()l sends the 0x0004, and returns the DataFlash checksum
Bit11	CCA	0: Coulomb Counter Calibration routine is inactive (default) 1: Coulomb Counter Calibration routine is active
Bit10	BCA	0: Board Calibration routine is inactive (default) 1: Board Calibration routine is active
Bit9	-	Reserved
Bit8	SWIIntEn	0: The SWI interrupt function is inactive (default) 1: The SWI interrupt function is active (see Control() command 0x0015)
Bit7	SHUTDOWN	0: The SHUTDOWN function is disabled (default) 1: The SHUTDOWN function is enabled
Bit6	HIBERNATE	0: The HIBERNATE function is disabled.(default) 1: The HIBERNATE function is enabled. True when set.
Bit5	FULLSLEEP	0: Indicating the SH366002 is not in FULLSLEEP mode. (default) 1: Indicating the SH366002 is in FULLSLEEP mode. True when set.
Bit4	SLEEP	0: in normal state.(default) 1: in sleep state. True when set.

Bit3 ~0	-	Reserved

7.1.1.2 DEVICE_TYPE: 0x0001

The command instructs the fusion gauge to return the device type.

7.1.1.3 FW_VERSION: 0x0002

The command instructs the fusion gauge to return the firmware version.

7.1.1.4 HW_VERSION: 0x0003

The command instructs the fusion gauge to return the hardware version.

7.1.1.5 DF_CHECKSUM: 0x0004

The command instructs the fusion gauge to return the checksum of the data flash memory.

7.1.1.6 RESET_DATA: 0x0005

The command instructs the fusion gauge to return the number of resets (include power on reset and command 0x41 reset).

7.1.1.7 PREV_MACWRITE: 0x0007

The command instructs the fusion gauge to return the previous command written to addresses 0x00/0x01. The value returned is limited to less than 0x0020.

7.1.1.8 CHEM_ID: 0x0008

The command instructs the fusion gauge to return the chemical identifier.

7.1.1.9 DF_VERSION: 0x000C

The command instructs the gas gauge to return the data flash version.

7.1.1.10 SET_FULLSLEEP: 0x0010

The command instructs the gas gauge to set the ***[FULLSLEEP]*** bit in **Control Status** register to 1. This will allow the gauge to enter the **FULLSLEEP** power mode after the transition to **SLEEP** power state is detected. For SWI communication one host message will be dropped. For TWI communications the first message will incur a 6-8 millisecond clock stretch while the oscillator is started and stabilized.

7.1.1.11 SET_HIBERNATE: 0x0011

The command instructs the fusion gauge to force the **CONTROL_STATUS** ***[HIBERNATE]*** bit to 1. This will allow the gauge to enter the **HIBERNATE** power mode after the transition to SLEEP power state is detected. The ***[HIBERNATE]*** bit is automatically cleared upon exiting from **HIBERNATE** mode.

7.1.1.12 CLEAR_HIBERNATE: 0x0012

The command instructs the fusion gauge to force the **CONTROL_STATUS** ***[HIBERNATE]*** bit to 0. This will prevent the gauge from entering the **HIBERNATE** power mode after the transition to **SLEEP** power state is detected. It can also be used to force the gauge out of **HIBERNATE** mode.

7.1.1.13 SET_SHUTDOWN: 0x0013

Sets the **CONTROL_STATUS** ***[SHUTDOWN]*** bit to 1, thereby enabling the **STE** pin to change state.

7.1.1.14 CLEAR_SHUTDOWN: 0x0014

The command disables the **STE** pin from changing state. The **STE** pin is left in a high-impedance state.

7.1.1.15 SET_SWIINTEN: 0x0015

The command instructs the fusion gauge to set the **CONTROL_STATUS** ***[SWIIntEn]*** bit to 1. This will enable the SWI Interrupt
function. When this sub-command is received, the SH366002 will detect any of the interrupt conditions and assert the interrupt at one second intervals until the **CLEAR_SWIINTEN** command is received or the count of 3.

7.1.1.16 CLEAR_SWIINTEN: 0x0016

The command instructs the fusion gauge to set the **CONTROL_STATUS** ***[SWIIntEn]*** bit to 0. This will disable the SWI Interrupt function.

7.1.1.17 SEALED: 0x0020

The command instructs the gas gauge to transition from **UNSEALED** state to **SEALED** state. The gas gauge should always be set to **SEALED** state for use in customer's end equipment.

7.1.1.18 RESET: 0x0041

This command instructs the gas gauge to perform a full reset. This command is only available when the gas gauge is **UNSEALED**.

7.1.1.19 CAL_OFFSET: 0x0061

This command instructs the SH366002 to perform a zero-current calibration when the gas gauge is in calibration mode. This command is only available in **UNSEALED** mode.

7.1.1.20 CAL_CUR: 0x0062

This command instructs the SH366002 to perform a load-current calibration when the gas gauge is in calibration mode. This command is only available in **UNSEALED** mode.

7.1.1.21 CAL_VOL: 0x0063

This command instructs the SH366002 to perform a voltage calibration when the gas gauge is in calibration mode. This command is only available in **UNSEALED** mode.

7.1.1.22 CAL_EXTT: 0x0064

This command instructs the SH366002 to perform an external temperature calibration when the gas gauge is in calibration mode. This command is only available in **UNSEALED** mode.

7.1.1.23 CAL_INTT: 0x0065

This command instructs the SH366002 to perform an internal temperature calibration when the gas gauge is in calibration mode. This command is only available in **UNSEALED** mode.

7.1.1.24 EXIT_CAL: 0x0080

This command forces the SH366002 to exit calibration when the gas gauge is in calibration mode. This command is only available in **UNSEALED** mode.

7.1.1.25 ENTER_CAL: 0x0081

This command instructs the SH366002 to enter calibration mode. The gas gauge will exit calibration mode automatically if no other calibrate sub-command was sent in 5 minutes. This command is only available in **UNSEALED** mode.

7.1.2 AtRate( ): 0x02/0x03

The **AtRate( )** read-/write-word function is the first half of a two-function command call-set used to set the AtRate value used in calculations made by the **AtRateTimeToEmpty( )** function. The **AtRate( )** units are in mA.

The **AtRate( )** value is a signed integer, with negative values interpreted as a discharge current value. The **AtRateTimeToEmpty( )** function returns the predicted operating time at the AtRate value of discharge. The default value for **AtRate( )** is zero and will force **AtRateTimeToEmpty( )** to return 65,535.

7.1.3 AtRateTimeToEmpty( ): 0x04/0x05

This read-only function returns an unsigned integer value of the predicted remaining operating time if the battery is discharged at the **AtRate( )** value in minutes with a range of 0 to 65,534. A value of 65,535 indicates **AtRate( )** ≥ 0. The fusion gauge updates **AtRateTimeToEmpty( )** within 1 s after the system sets the **AtRate( )** value. The fusion gauge automatically updates **AtRateTimeToEmpty( )** based on the **AtRate( )** value every 1s.

7.1.4 Temperature( ): 0x06/0x07

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

7.1.5 Voltage( ): 0x08/0x09

This read-only function returns an unsigned integer value of the measured cell-pack voltage in mV with a range of 0 to 6000 mV.

7.1.6 Flags( ): 0x0a/0x0b

This read-only function returns the contents of the gas-gauge status register, depicting the current operating status.

Table 7.4 Flags Bit Definitions

	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
High Byte	OTC	OTD	-	-	CHG_INH	XCHG	FC	CHG
Low Byte	OCVTAKEN	-	-	-	-	SOC1	SOCF	DSG

OTC = 1	Over-Temperature in Charge condition is detected. True when set
OTD = 1	Over-Temperature in Discharge condition is detected. True when set.
CHG_INH = 1	Charge Inhibit indicates the temperature is outside the range **[T1, T4]** in non-charge mode. True when set.
XCHG = 1	Charge Suspend Alert indicates the temperature is outside the range **[T1, T5]** in charge mode.
FC = 1	Full-charged is detected. FC is set when charge termination is reached and **FC Set%** = -1 (See the Charging and Charge Termination Indication section for details) or State of Charge is larger than **FC Set%** and **FC Set%** is not -1. True when set.
CHG = 1	charging allowed. True when set. When charge termination is reached, or **SOC** is larger than TCA set, or the temperature is outside the range, ***[CHG]*** is cleared, charging prohibited
OCVTAKEN =1	Cleared on entry to relax mode and set to 1 when **OCV** measurement is performed in relax.
SOC1 = 1	**State-of-Charge-Threshold 1** (**SOC1 Set%**) reached. True when set.
SOCF = 1	**State-of-Charge-Threshold Final** (**SOCF Set** %) reached. True when set.
DSG = 1	Discharging detected. True when set.

7.1.7 NominalAvailableCapacity( ): 0x0c/0x0d

This read-only command pair returns the uncompensated battery capacity remaining in unit of mAh.

7.1.8 FullAvailableCapacity( ): 0x0e/0x0f

This read-only command pair returns the uncompensated capacity of the battery when fully charged in unit of mAh.

7.1.9 FilteredRC( ): 0x10/0x11

This read-only command pair returns the compensated battery capacity remaining in unit of mAh.

7.1.10 FilteredFCC( ): 0x12/0x13

This read-only command pair returns the compensated capacity of the battery when fully charged in unit of mAh.

7.1.11 AverageCurrent( ): 0x14/0x15

This read-only command pair returns a signed integer value that is the average current flow through the sense resistor.

7.1.12 AverageTimeToEmpty( ): 0x16/0x17

This read-only function returns an unsigned integer value of the predicted remaining battery life at the present rate of discharge, in minutes. A value of 65,535 indicates battery is not being discharged.

7.1.13 AverageTimeToFull( ): 0x18/0x19

This read-only function returns an unsigned integer value of predicted remaining time until the battery reaches full charge, in minutes, based upon **AverageCurrent( )**. A value of 65,535 indicates the battery is not being charged.

7.1.14 StandbyCurrent( ): 0x1a/0x1b

This read-only function returns a signed integer value of the measured standby current through the sense resistor. The **StandbyCurrent( )** is an adaptive measurement. Initially it reports the standby current programmed in **Initial Standby**, and after spending some time in standby, reports the measured standby current. The current should be above the **Deadband** and less than or equal to 2 x **Initial Standby**.

Each new **StandbyCurrent( )** value is computed by taking approximate 93% weight of the last standby current and approximate 7% of the current measured average current.

7.1.15 StandbyTimeToEmpty( ): 0x1c/0x1d

This read-only function returns an unsigned integer value of the predicted remaining battery life at the standby rate of discharge, in minutes. A value of 65,535 indicates battery is not being discharged.

7.1.16 MaxLoadCurrent( ): 0x1e/0x1f

This read-only function returns a signed integer value, in units of mA, of the maximum load conditions. The **MaxLoadCurrent( )** is an adaptive measurement which is initially reported as the maximum load current programmed in **Initial Max Load Current**. If the measured current is ever greater than **Initial Max Load Current**, then **MaxLoadCurrent( )** updates to the new current. **MaxLoadCurrent( )** is reduced to the average of the previous value and **Initial Max Load Current** whenever the battery is charged to full after a previous discharge to an **SOC** less than 50%. This prevents the reported value from maintaining an unusually high value.

7.1.17 MaxLoadTimeToEmpty( ): 0x20/0x21

This read-only function returns an unsigned integer value of the predicted remaining battery life at the maximum load current discharge rate, in minutes. A value of 65,535 indicates that the battery is not being discharged.

7.1.18 AvailableEnergy( ): 0x22/0x23

This read-only function returns an unsigned integer value of the predicted charge or energy remaining in the battery. The value is reported in units of mWh if the ***[10mW]*** bit in **PackConfiguration** is cleared, and 10mWh if it is set.

7.1.19 AveragePower( ): 0x24/0x25

This read-word function returns an unsigned integer value of the average power of the current discharge. It is negative during discharge and positive during charge. A value of 0 indicates that the battery is not being discharged. The value is reported in units of mW if the ***[10mW]*** bit in **PackConfiguration** is cleared, and 10mW if it is set.

7.1.20 TimeToEmptyAtConstantPower( ): 0x26/0x27

This read-only function returns an unsigned integer value of the predicted remaining operating time if the battery is discharged at the **AveragePower( )** value in minutes. A value of 65,535 indicates **AveragePower( )** = 0.

7.1.21 Internal_Temp( ): 0x28/0x29

This read-only function returns an unsigned integer value of the measured internal temperature of the device in units of 0.1K measured by the fusion gauge.

7.1.22 CycleCount( ): 0x2a/0x2b

This read-only function returns an unsigned integer value of the number of cycles the battery has experienced with a range of 0 to 65,535. One cycle occurs when accumulated discharge ≥**CC Threshold**.

7.1.23 StateOfCharge( ): 0x2c/0x2d

This read-only function returns an unsigned integer value of the predicted remaining battery capacity expressed as a percentage of **FullChargeCapacity( )**, with a range of 0 to 100%.

7.1.24 StateOfHealth( ): 0x2e/0x2f

0x2e **SOH** percentage: this read-only function returns an unsigned integer value, expressed as a percentage of the ratio of predicted **FCC***(25°C, SOH current rate)* over the **DesignCapacity( )**. The **FCC***(25°C, SOH current rate)* is the calculated full charge capacity at 25°C and the **SOH** current rate which is specified in the data flash (State of Health Load). The range of the returned **SOH** percentage is 0x00 to 0x64, indicating 0 to 100% correspondingly.

0x2f **SOH** Status: this read-only function returns 0x00.returns 0.

7.1.25 JeitaCHGVOL( ): 0x30/0x31

This read-only function returns the recommended charging voltage output from the JEITA charging profile. It is updated automatically based on the present temperature range.

7.1.26 JeitaCHGCUR( ): 0x32/0x33

This read-only function returns the recommended charging current output from the JEITA charging profile. It is updated automatically based on the present temperature range.

7.1.27 PassedCharge( ): 0x34/0x35

This signed integer indicates the amount of charge passed through the sense resistor, decrease in charging and increase in discharging.

7.1.28 SelfDischargeCurrent( ): 0x38/0x39

This read-only command pair returns the signed integer value that estimates the battery self-discharge current.

7.2 EXTENDED DATA COMMANDS

Extended commands offer additional functionality beyond the standard set of commands. They are used in the same manner; however unlike standard commands, extended commands are not limited to 2-byte words. The number of command bytes for a given extended command ranges in size from single to multiple bytes, as specified in Table 7.5. For details on the **SEALED** and **UNSEALED** states, see Section **Access Modes**

Table 7.5 Extended Commands

NAME		COMMAND CODE	UNITS	SEALED ACCESS(1) (2)	UNSEALED ACCESS(1) (2)
PackConfig( )	PCR	0x3a / 0x3b	HEX#	R	R
DesignCapacity( )	DCAP	0x3c / 0x3d	mAh	R	R
DataFlashClass( ) (2)	DFCLS	0x3e	N/A	N/A	R/W
DataFlashBlock( ) (2)	DFBLK	0x3f	N/A	R/W	R/W
BlockData( ) / Authenticate( )(3)	A/DF	0x40…0x53	N/A	R/W	R/W

BlockData( ) / AuthenticateCheckSum( ) (3)	ACKS/DFD	0x54	N/A	R/W	R/W
BlockData( )	DFD	0x55…0x5f	N/A	R	R/W
BlockDataCheckSum( )	DFDCKS	0x60	N/A	R/W	R/W
BlockDataControl( )	DFDCNTL	0x61	N/A	N/A	R/W
DeviceNameLength( )	DNAMELEN	0x62	N/A	R	R
DeviceName( )	DNAME	0x63...0x6A	N/A	R	R
Reserved	RSVD	0x6B...0x7f	N/A	R	R

(1) **SEALED** and **UNSEALED** states are entered via commands to **Control( )** 0x00/0x01

(2) In **SEALED** mode, data flash CANNOT be accessed through commands 0x3e and 0x3f.

(3) The **BlockData( )** command area shares functionality for accessing general data flash and for using Authentication.

7.2.1 PackConfig( ): 0x3a/0x3b

SEALED and **UNSEALED** Access: This command returns the value is stored in **PackConfiguration** and is expressed in hex value.

7.2.2 DesignCapacity( ): 0x3c/0x3d

SEALED and **UNSEALED** Access: This command returns the value is stored in **Design Capacity** and is expressed in mAh.

7.2.3 DataFlashClass( ): 0x3e

This command sets the data flash class to be accessed. The class to be accessed should be entered in hexadecimal.

SEALED Access: This command is not available in **SEALED** mode.

7.2.4 DataFlashBlock( ): 0x3f

UNSEALED Access: This command sets the data flash block to be accessed.
Example: writing a 0x00 to **DataFlashBlock( )** specifies access to the first 32 byte block and a 0x01 specifies access to the second 32 byte block, and so on.

SEALED Access: This command directs which data flash block will be accessed by the **BlockData( )** command. Issuing a 0x01, 0x02 or 0x03 instructs the **BlockData( )** command to transfer **Manufacturer Info Block A**, **B**, or **C**, respectively.

7.2.5 BlockData( ): 0x40…0x5f

This command range is used to transfer data for data flash class access. This command range is the 32-byte data block used to access **Manufacturer Info Block A**, **B**, *or* **C**. **Manufacturer Info Block A** is read only for the sealed access. **UNSEALED** access is read/write.

7.2.6 BlockDataChecksum( ): 0x60

The host system should write this value to inform the device that new data is ready for programming into the specified data flash class and block.

UNSEALED Access: This byte contains the checksum on the 32 bytes of block data read or written to data flash. The least-significant byte of the sum of the data bytes written must be complemented ([255 - x] , for x the 8-bit summation of the **BlockData( )** (0x40 to 0x5F) on a byte-by-byte basis.) before being written to 0x60.

SEALED Access: This byte contains the checksum for the 32 bytes of block data written to **Manufacturer Info Block A**, **B**, or **C**. The least-significant byte of the sum of the data bytes written must be complemented ([255 -x] , for x the 8-bit summation of the **BlockData( )** (0x40 to 0x5F) on a byte-by-byte basis.) before being written to 0x60.

7.2.7 BlockDataControl( ): 0x61

UNSEALED Access: This command is used to control data flash access mode. Writing 0x00 to this command enables **BlockData( )** to access general data flash.

SEALED Access: Read Access:0x61 write 0x01, 0x3f write 0x01, 0x02, 0x03, 0x04, and then read the **BlockData( )** (0x40 to 0x5F), **Manufacturer Info Block A**, **B**, **C** and Lifetime LogData return. Write Access: 0x61 write 0x01 ,0x3f write 0x02,0x03,0x04, and then write the **BlockData( )** (0x40 to 0x5F), at last 0x60 write the checksum(0xFF-sum of the block data),**Manufacturer Info Block B**, **C** and Lifetime LogData will be modified. Note: **Manufacturer Info Block C** read/write access is disable in seal mode when **User_CFG1** =1 in **User Config**.

7.2.8 DeviceNameLength( ): 0x62

UNSEALED and **SEALED** Access: This byte contains the length of the **Device Name**.

7.2.9 DeviceName( ): 0x63…0x6A

UNSEALED and **SEALED** Access: This block contains the device name that is programmed in **Device Name**

7.2.10 Reserved: 0x6B - 0x7f

Reserved.

7.3 DATA FLASH DESCRIPTION

7.3.1 Accessing the Data Flash

The SH366002 data flash is a non-volatile memory that contains SH366002 initialization, default, cell status,calibration, configuration, and user information. These information can be accessed by the host. But only Manufacture information can be accessed in **SEALED** mode.

These information data should be optimized and/or fixed during the development and manufacture processes. They will be made into a file and can then be written to multiple battery packs.

Access data flash locations:

1. Send 0x00 to **BlockDataControl( )** (0x61) as a set-up signal;
2. Send the data block No. to **DataFlashClass( )** (0x3e);

3. Send the data block offset to **DataFlashBlock( )** (0x3f) where 0 represents 0~31, 1 represents 32~63, and so on.
4. The correct command address is then given by 0x40 + offset *modulo* 32. For example, to access **Terminate Voltage** in the **Gas Gauging** class. Because the offset is 48, it must reside in the second 32-byte block. Hence, **DataFlashBlock( )** is issued 0x01 to set the block offset, and the offset used to index into the **BlockData( )** memory area is 0x40 + 48 *modulo* 32 = 0x40 + 16 = 0x40 + 0x10 = 0x50.
5. If a new value is written in flash, the new checksum must be sent to **BlockDataCheckSum( )** (0x60) and the next command should not be sent within 120ms.
6. If the block length is over 32 bytes, the whole class can be written or read by repeating step 4 and 5.

Note: Class 224~227 cannot be written separately. All the 4 classes must be written together. Recommend steps are listed below:

1. Send Command 0x0094 to Control(0x00)
2. Wait 200 ms, then send command 0x0095 to Control(0x00), and read Control. If LSB 4 is set, wait 200ms and re-excute step 2. If LSB 5 is set, that means these classed in this chip cannot be written. If LSB 4 is clear, goto step 3
3. Send 0x00 to **BlockDataControl( )** (0x61) as a set-up signal
4. Send 224 to **DataFlashClass( )** (0x3e);
5. Send the data block offset to **DataFlashBlock( )** (0x3f) where 0 represents 0~31, 1 represents 32~63, and so on.
6. Send data buffer to 0x40~0x5F
7. If a new value is written in flash, the new checksum must be sent to **BlockDataCheckSum( )** (0x60) and the next command should not be sent within 250ms.
8. If the block length is over 32 bytes, the whole class can be written or read by repeating step 4 and 5.
9. Write class 225~227
10. Send Command 0x0095 to Control(0x00). Wait 250ms then reset SH366002

7.3.2 Manufacture Information Blocks

The SH366002 contains 96 bytes of user programmable data flash storage: **Manufacturer Info Block A**, **Manufacturer Info Block B**, **Manufacturer Info Block C**. The method for accessing these memory locations is slightly different, depending on whether the device is in **UNSEALED** or **SEALED** mode.

In **UNSEALED** mode, when 0x00 has been written to **BlockDataControl( )**, accessing the Manufacturer Info Blocks is identical to accessing general data flash locations.

Example: for **Block B**, **DataFlashClass( )** is issued 58(0x3A) to set the class, the offset is 32~63, it must reside in the second 32-byte block. Hence, **DataFlashBlock( )** is issued 0x01 to set the block offset, and the **BlockData( )** return the value of *Manufacturer Info Block B*.

When in **SEALED** mode, **BlockDataControl( )** and **DataFlashClass( )** commands are not available. Issuing a 0x01, 0x02, or 0x03 with the **DataFlashBlock( )** command causes the corresponding information block (A, B, or C, respectively) to be transferred to the command space 0x40…0x5f for editing or reading by the system. Upon successful writing of checksum information to **BlockDataChecksum( )**, the modified block is returned to data flash.

Note: **Manufacturer Info Block A** is read-only when in **SEALED** mode.

7.3.3 DATA FLASH SUMMARY

Table 7.6 Data Flash Summary

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Unit	Note
Configuration	2	Safety	0	OT Chg	I2	0	1200	550	0.1°C	Temp Threshold for OTC
Configuration	2	Safety	2	OT Chg Time	U1	0	60	2	s	Time Threshold for OTC. OTC is forbidden when 0.
Configuration	2	Safety	3	OT Chg Recovery	I2	0	1200	500	0.1°C	Temp Threshold for exit OTC
Configuration	2	Safety	5	OT Dsg	I2	0	1200	600	0.1°C	Temp Threshold for OTD
Configuration	2	Safety	7	OT Dsg Time	U1	0	60	2	s	Time Threshold for OTD. OTD is forbidden when 0.
Configuration	2	Safety	8	OT Dsg Recovery	I2	0	1200	550	0.1°C	Temp Threshold for exit OTD
Configuration	34	Charge	0	Charging Current	I2	0	32767	1000	mA	
Configuration	34	Charge	2	Charging Voltage	U2	0	4600	4200	mV	Charge Terminate Voltage
Configuration	36	Charge Termination	2	Taper Current	I2	0	1000	100	mA	Taper Current for Charge Termination
Configuration	36	Charge Termination	4	Min Taper Capacity	U2	0	1000	25	0.01mAh	Min Taper Capacity for Charge Termination
Configuration	36	Charge Termination	6	Taper Voltage	U2	0	1000	100	mV	Taper Voltage for Charge Termination
Configuration	36	Charge Termination	8	Current Taper Window	U1	0	60	40	s	Taper Window for Charge Termination
Configuration	36	Charge Termination	9	TCA Set %	I1	-1	100	99	%	TCA Set threshold
Configuration	36	Charge Termination	10	TCA Clear %	I1	-1	100	95	%	TCA Clear threshold
Configuration	36	Charge Termination	11	FC Set %	I1	-1	100	100	%	FC Set threshold
Configuration	36	Charge Termination	12	FC Clear %	I1	-1	100	98	%	FC Clear threshold
Configuration	39	JEITA	0	JTITA T1 Temp	I1	-128	127	0	°C	
Configuration	39	JEITA	1	JTITA T2 Temp	I1	-128	127	10	°C	
Configuration	39	JEITA	2	JTITA T3 Temp	I1	-128	127	45	°C	
Configuration	39	JEITA	3	JTITA T4 Temp	I1	-128	127	50	°C	

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Unit	Note
Configuration	39	JEITA	4	JTITA T5 Temp	I1	-128	127	60	°C	
Configuration	39	JEITA	5	JTITA TempHys	I1	-128	127	1	°C	
Configuration	39	JEITA	6	JTITA T1-T2 ChgVOL	I2	0	4600	4350	mV	
Configuration	39	JEITA	8	JTITA T2-T3 ChgVOL	I2	0	4600	4350	mV	
Configuration	39	JEITA	10	JTITA T3-T4 ChgVOL	I2	0	4600	4300	mV	
Configuration	39	JEITA	12	JTITA T4-T5 ChgVOL	I2	0	4600	4250	mV	
Configuration	39	JEITA	14	JTITA T1-T2 ChgCUR	U1	0	100	50	mV	
Configuration	39	JEITA	15	JTITA T2-T3 ChgCUR	U1	0	100	80	mV	
Configuration	39	JEITA	16	JTITA T3-T4 ChgCUR	U1	0	100	80	mV	
Configuration	39	JEITA	17	JTITA T4-T5 ChgCUR	U1	0	100	80	mV	
Configuration	121	Data	0	Cycle Count1	I2	0	700	0	mAh	unused
Configuration	121	Data	2	Qmax	I2	0	32767	1000	mAh	maximum chemical capacity
Configuration	121	Data	4	Terminate Voltage	U2	2800	3700	3000	mV	absolute minimum voltage for end of discharge
Configuration	121	Data	6	ReserveCap-mAh	I2	0	9000	0	mAh	
Configuration	121	Data	8	Initial Standby	I1	-128	127	-10	mA	Initial standby current
Configuration	121	Data	9	Initial MaxLoad	I2	-32767	0	-500	mA	Initial Max load current
Configuration	121	Data	11	Load Mode	U1	0	255	0	-	
Configuration	121	Data	12	Update Staus	U1	0	255	0	-	
Configuration	121	Data	15	SeriaNo	U2	0	65535	0	-	
Configuration	121	Data	17	Cycle Count	U2	0	65535	0	count	Cycle Count
Configuration	121	Data	19	CC Threshold	U2	100	32767	900	mAh	Cycle Count Threshold
Configuration	121	Data	21	ReserveCap-mWh	I2	0	14000	0	mWh	
Configuration	121	Data	23	Design Capacity	U2	0	32767	1000	mAh	Design capacity
Configuration	121	Data	25	Design Energy	U2	0	32767	5400	mWh	Design Energy

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Unit	Note
Configuration	121	Data	27	State of Health Load	I2	-400	0	-400	mA	State of Health Load
Configuration	121	Data	29	Device Name	S9	x	x	SH366002	-	Device Name
Configuration	49	Discharge	0	SOC1 Set Threshold	U2	0	1000	150	mAh	State-of-Charge-Threshold 1 Set Threshold
Configuration	49	Discharge	2	SOC1 Clear Threshold	U2	0	1000	175	mAh	State-of-Charge-Threshold 1 Clear Threshold
Configuration	49	Discharge	4	SOCF Set Threshold	U2	0	1000	75	mAh	State-of-Charge-Threshold Final Set Threshold
Configuration	49	Discharge	6	SOCF Clear Threshold	U2	0	1000	100	mAh	State-of-Charge-Threshold Final Clear Threshold
Configuration	49	Discharge	8	BATLOW Set Threshold	U2	0	32767	2500	mV	
Configuration	49	Discharge	10	BATLOW Set Time	U1	0	60	2	s	
Configuration	49	Discharge	11	BATLOW Clear Threshold	U2	0	32767	2600	mV	
Configuration	49	Discharge	13	BATHI Set Threshold	U2	0	32767	4500	mV	
Configuration	49	Discharge	15	BATHI Set Time	U1	0	60	2	s	
Configuration	49	Discharge	16	BATHI Clear Threshold	U2	0	32767	4400	mV	
Configuration	56	Manufacturer Data	0	Pack Lot Code	H2	0	FFFF	0	-	Pack Lot Code
Configuration	56	Manufacturer Data	2	PCB Lot Code	H2	0	FFFF	0	-	PCB Lot Code
Configuration	56	Manufacturer Data	4	Firmware Version	H2	0	FFFF	0	-	Firmware Version
Configuration	56	Manufacturer Data	6	Hardware Revision	H2	0	FFFF	0	-	Hardware Version
Configuration	56	Manufacturer Data	8	Cell Revision	H2	0	FFFF	0	-	Cell Version
Configuration	56	Manufacturer Data	10	DF Config Version	H2	0	FFFF	0	-	Data Flash Configuration Version
System Data	58	Manufacturer Info	0 - 31	Block A [0 - 31]	H1	0	FF	0	-	Manufacture info Block A
System Data	58	Manufacturer Info	32 - 63	Block B [0 - 31]	H1	0	FF	0	-	Manufacture info Block B
System Data	58	Manufacturer Info	64 - 95	Block C [0 - 31]	H1	0	FF	0	-	Manufacture info Block C
System Data	58	Manufacturer Info	96-127	Block D [0 - 31]	H1	0	FF	0	-	Manufacture info Block D
System Data	58	Manufacturer Info	128-159	Block E [0 - 31]	H1	0	FF	0	-	Manufacture info Block E

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Unit	Note
System Data	58	Manufacturer Info	160-191	Block F [0 - 31]	H1	0	FF	0	-	Manufacture info Block F
System Data	48	User Buffer	0-31	User Buffer[0-31]	H1	0	FF	0	-	User Buffer
System Data	59	LifetimeData	0	Lifetime Max Temp	I2	-600	1400	0	0.1℃	
System Data	59	LifetimeData	2	Lifetime Min Temp	I2	-600	1400	500	0.1℃	
System Data	59	LifetimeData	4	Lifetime Max Volt	I2	0	32767	2800	mV	
System Data	59	LifetimeData	6	Lifetime Min Volt	I2	0	32767	5000	mV	
System Data	59	LifetimeData	8	Lifetime Max CHG CUR	I2	-32767	32767	0	mA	
System Data	59	LifetimeData	10	Lifetime Max DSG CUR	I2	-32767	32767	0	mA	
System Data	59	LifetimeData	12	Lifetime FlashCnt	U2	0	65535	0	num	
Configuration	64	Registers	0	Pack Configuration	H2	0	FFFF	A137	-	PackConfiguration
Configuration	64	Registers	2	Pack ConfigB	H1	0	FF	3F	-	
Configuration	64	Registers	3	Pack ConfigC	H1	0	FF	00	-	
Configuration	64	Registers	4	Pack ConfigD	H1	0	FF	00	-	
Configuration	64	Registers	5	Interrupt Config	H2	0	FFFF	0000	-	
Configuration	64	Registers	7	User Config	H2	0	FFFF	0000	-	
System Data	66	LifetimeData	0	Lifetime Delta Temp	U1	0	255	10	0.1℃	
System Data	66	LifetimeData	1	Lifetime Delta Volt	U1	0	255	25	mV	
System Data	66	LifetimeData	2	Lifetime Delta CUR	U1	0	255	100	mA	
System Data	66	LifetimeData	3	Lifetime Update Time	U1	0	255	60	s	
Configuration	68	Power	0	Flash Update OK Voltage	I2	0	4200	2800	mV	Min Voltage for Flash updated
Configuration	68	Power	2	Sleep Current	I2	0	100	10	mA	Sleep Current Threshold
Configuration	68	Power	4	TDD_SOH_Percent	U1	0	100	80	%	
Configuration	68	Power	5	ISDCurrent	I2	0	32767	10	mA	
Configuration	68	Power	7	ISDCurrentFilter	U1	0	255	127	/256	
Configuration	68	Power	8	MinISDTime	U1	0	255	7	hour	

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Unit	Note
Configuration	68	Power	9	Hibernate I	I2	0	700	8	mA	Hibernate Current Threshold
Configuration	68	Power	11	Hibernate V	I2	2400	3000	2550	mV	Hibernate Voltage Threshold
Configuration	68	Power	13	FSWait	U1	0	255	0	S	Fullsleep Enter Delay
Configuration	68	Power	14	STE_FuseVoltage	U2	0	32767	0	mV	
Configuration	68	Power	16	STE_FuseTimeThreshold	U1	0	255	0	s	
Configuration	68	Power	17	STE_FuseBlowTime	U1	0	255	0	s	
Configuration	68	Power	18	STE_FuseFailCurrent	U1	0	255	0	mA	
Gas Gauging	81	Current Thresholds	0	Dsg Current Threshold	I2	0	2000	60	mA	Current Threshold for Discharge
Gas Gauging	81	Current Thresholds	2	Chg Current Threshold	I2	0	2000	75	mA	Current Threshold for Charge
Gas Gauging	81	Current Thresholds	4	Quit Current	I2	0	1000	40	mA	Current Threshold for quitting Relax Mode
Gas Gauging	81	Current Thresholds	6	Dsg Relax Time	U2	0	8191	60	S	Time threshold for transmit from Dsg to Relax
Gas Gauging	81	Current Thresholds	8	Chg Relax Time	U1	0	255	60	S	Time threshold for transmit from Chg to Relax
Gas Gauging	81	Current Thresholds	9	Quit Relax Time	U1	0	63	1	S	Time threshold for quitting Relax
Calibration	104	Data	0	CC Gain	U2	1	65535	8192	num	Coulomb Counter Gain Factor
Calibration	104	Data	2	CC Offset	I2	-32768	32767	0	num	Coulomb Counter Offset Factor
Calibration	104	Data	4	Board Offset	I2	-32768	32767	0	num	Board Offset Factor
Calibration	104	Data	6	Int Temp Offset	I2	-32768	32767	0	0.1°C	Internal temperature offset
Calibration	104	Data	8	Ext Temp Offset	I1	-128	127	0	0.1°C	External temperature offset
Calibration	104	Data	9	Frequent Gain	U2	12288	20480	18022	-	MCU Frequency Adjust
Calibration	104	Data	11	Pack V Gain	U2	0	32767	20299	num	Pack Voltage Gain Factor
Calibration	104	Data	13	Pack V Offset	I2	-32768	32767	0	mV	Pack Voltage Offset Factor
Calibration	107	Current	1	Deadband	U1	0	255	5	mA	Deadband Current Threshold
Security	112	Codes	0	Sealed to Unsealed	H4	0	FFFFFFFF	36720414	-	Unsealed Key

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Unit	Note
Security	112	Codes	4	Unsealed to Full	H4	0	FFFFFFFF	FFFFFFFF	-	Full-Assess Key
Security	112	Codes	8	Authen Key3	H4	0	FFFFFFFF	01234567	-	No.12-15 bits of SHA-1 Authentication key
Security	112	Codes	12	Authen Key2	H4	0	FFFFFFFF	89ABCDEF	-	No.8-11 bits of SHA-1 Authentication key
Security	112	Codes	16	Authen Key1	H4	0	FFFFFFFF	FEDCBA98	-	No.4-7 bits of SHA-1 Authentication key
Security	112	Codes	20	Authen Key0	H4	0	FFFFFFFF	76543210	-	No.0-3 bits of SHA-1 Authentication key
Production	122	Userconfig	1	Config_DT	U2	0	65535	0	-	
Production	122	Userconfig	3	Config_SW	U2	0	65535	0	-	
Production	122	Userconfig	5	Config_HW	U2	0	65535	0	-	
Gauge	123	Algorithm0	0~95	AlgorithmData0~23	Block	-	-	-	-	-
Gauge	224	Algorithm1	0-251	AlgorithmData24~86	Block	-	-	-	-	-
Gauge	225	Algorithm2	0-251	AlgorithmData87~149	Block	-	-	-	-	-
Gauge	226	Algorithm3	0-251	AlgorithmData150~212	Block	-	-	-	-	-
Gauge	227	Algorithm4	0-251	AlgorithmData213~275	Block	-	-	-	-	-

7.3.3.1 Charge Over Temperature Class(Subclass 2)

OT Chg: Temp Threshold for **OTC**. The **OTC** counter begins as soon as **Temperature**≧**OT Chg**. When it exceeds **OT Chg Time**, ***[OTC]*** is set and ***[CHG]*** is cleared.
OT Chg Time: Time Threshold for **OTC**. **OTC** is forbidden when **OT Chg Time** is 0.
OT Chg Recovery: Threshold for exit **OTC**. When **Temperature**≦**OT Chg Recover*y,[OTC]*** is cleared and ***[CHG]*** is set
OT Dsg: Temp Threshold for **OTD**. The **OTD** counter begins as soon as **Temperature**≧**OT Dsg**. When it exceeds **OT Dsg Time**, ***[OTD]*** is set
OT Dsg Time: Time Threshold for **OTD**. **OTD** is forbidden when **OT Dsg** Time is 0.
OT Dsg Recovery: Temp Threshold for exit **OTD**. When **Temperature**≦**OT Dsg Recovery**, ***[OTD]*** is cleared

7.3.3.2 Charge Termination Class(Subclass 34, 36)

Charging Current: Charge current Threshold
Charging Voltage: Charge termination voltage
Taper Voltage: Taper Voltage for Charge Termination
Taper Current: Taper Current for Charge Termination
Min Taper Capacity: Min Taper Capacity for Charge Termination
Current Taper Window: Taper Window for Charge Termination
TCA Set %: TCA Set threshold
TCA Clear %: TCA Clear threshold
FC Set %: FC Set threshold
FC Clear %: FC Clear threshold

See 4.2.1 for more details.

7.3.3.3 JEITA Class(subclass 39)

JTITA T1 Temp: Lowest temperature parameter of JTITA temperature configuration
JTITA T2 Temp: Second lowest temperature parameter of JTITA temperature configuration
JTITA T3 Temp: Normal temperature parameter of JTITA temperature configuration
JTITA T4 Temp: Second highest temperature parameter of JTITA temperature configuration
JTITA T5 Temp: Highest temperature parameter of JTITA temperature configuration
JTITA TempHys: temperature parameter of JEITA temperature configuration
JTITA T1-T2 ChgVOL: Charging Voltage in JEITA T1-T2 temperature
JTITA T2-T3 ChgVOL: Charging Voltage in JEITA T2-T3 temperature
JTITA T3-T4 ChgVOL: Charging Voltage in JEITA T3-T4 temperature
JTITA T4-T5 ChgVOL: Charging Voltage in JEITA T4-T5 temperature
JTITA T1-T2 ChgCUR: Charging Current in JEITA T1-T2 temperature
JTITA T2-T3 ChgCUR: Charging Current in JEITA T2-T3 temperature
JTITA T3-T4 ChgCUR: Charging Current in JEITA T3-T4 temperature
JTITA T4-T5 ChgCUR Charging Current in JEITA T4-T5 temperature

See 4.2.2 for more details.

7.3.3.4 Discharge Termination Class (subclass 49)

SOC1 Set Threshold: State-of-Charge-Threshold 1 Set Threshold. ***[SOC1]*** is set when **NAC**≦**SOC1 Set Threshold**.
SOC1 Clear Threshold: State-of-Charge-Threshold 1 Clear Threshold. ***[SOC1]*** is cleared when **NAC**≧**SOC1 Clear Threshold**.
SOCF Set Threshold: State-of-Charge-Threshold Final Set Threshold. ***[SOCF]*** is set when **NAC**≦**SOCF Set Threshold**.
SOCF Clear Threshold: State-of-Charge-Threshold Final Clear Threshold. ***[SOCF]*** is cleared when **NAC**≧**SOCF Clear Threshold**.
BATLOW Set Threshold: [BATLOW] is set when cell voltage < BATLOW Set Threshold for BATLOW Set Time.
BATLOW Set Time: [BATLOW] is set when cell voltage < BATLOW Set Threshold for BATLOW Set Time.
BATLOW Clear Threshold: [BATLOW] is clear when cell voltage > BATLOW Clear Threshold

BATHI Set Threshold: [BATHI] is set when cell voltage < BATHI Set tThreshold for BATH ISet Time.
BATHI Set Time: [BATHI] is set when cell voltage < BATHI Set Threshold for BATHI Set Time.
BATHI Clear Threshold: [BATHI] is clear when cell voltage > BATHI Clear Threshold

See 4.4.4 for more details.

7.3.3.5 Gas Gauging Class(Subclass 48, 80, 82)

Qmax: the maximum chemical capacity of the battery cell.
Terminate Voltage: absolute minimum voltage for end of discharge.
Reserv Cap-mAh: actual remaining capacity exists after reaching 0 remaining capacity in mAh.
Reserv Cap-mWh: actual remaining capacity exists after reaching 0 remaining capacityin mWh.
Initial Standby: Initial standby current
Initial MaxLoad: Initial Max load current
Cycle Count: Discharge cycles counter
CC Threshold: Cycle Count Threshold. Cycle Count increases by 1 after accumulated coulomb count exceeds it.
Design Capacity: Design Capacity, which can be configured by cell data provided by manufacturer.
Design Energy: Design Energy, which can be configured by cell data provided by manufacturer.
State of Health Load: State of Health Load. Modification by users is not recommended.

7.3.3.6 Configuration Class(Subclass 48, 56, 83)

Device Name: Store the Device Name, the default is the ASCII values for "SH366002”.
Pack Lot Code: Store the pack lot code.
PCB Lot Code: Store the PCB lot code.
Firmware Version: Store the firmware version.
Hardware Revision: Store the hardware version.
Cell Revision: Store the cell version.
DF Config Version: Store the data flash configuration version.
Chem ID: Store the chemical identifier number.

7.3.3.7 Manufacture Class (subclass 58)

Block A [0-31]: Manufacture information Block A
Block B [0-31]: Manufacture information Block B
Block C [0-31]: Manufacture information Block C
Block D [0-31]: Manufacture information Block D
Block E [0-31]: Manufacture information Block E
Block F [0-31]: Manufacture information Block F

7.3.3.8 PackConfiguration (subclass 64)

Pack Configuration:	Some SH366002 pins are configured via the Pack Configuration data flash register, this register can be read and written.
Pack ConfigB:	This register can be used to enable or disable STE fuse function, BTP function, ISD and TDD function.
Pack ConfigC:	This register can be used to enable or disable JEITA function.
Pack ConfigD:	Reserved
Interrupt Config:	This register can be used to enable or disable the following interrupt: TDD, ISD, BATHI, BATLOW, OTC, OTD, SOC1.
User Config:	Fusion gauge Algorithm Configuration.

Table 7.7 Pack Configuration Description

Name	Bit	Description
RESCAP	15	0: No-load rate of compensation is applied to the reserve capacity calculation. 1: load rate of compensation is applied to the reserve capacity calculation. (default)
NormTWI	14	TWI communication frequency control bit 0: Maximum 100KHz (default) 1: Maximum 400KHz
10mWh	13	Power Unit switch control bit 0: Power was calculated by 1mWh unit 1:Power was calculated by 10mWh unit (default)
INTPOL	12	STE Pin state depending on [INTPOL] bit and other bits. More detail please refer to **interrupt mode(6.2)** and **BTP Function(6.3)**.
GNDSEL	11	The ADC ground select control. Default is 0.
IWAKE, **RSNS1**, **RSNS0**	10~8	Current Wake-up Threshold 000/100: Disable 001: Voltage between ASRP~ASRN is +1.4mV or -1.4 mV (default) 101/010: Voltage between ASRP~ASRN is +3.0mV or -3.0 mV 110/011: Voltage between ASRP~ASRN is +6.0mV or -6.0 mV 111: Voltage between ASRP~ASRN is +12.0mV or -12.0 mV
RSVD	7~6	Reserved
SLEEP	5	Sleep mode enable control bit 0: Disabled 1: Enabled (default)
RMFCC	4	Enables the NAC updating to FAC on valid charge termination 0: Disabled 1: Enabled (default)
STE_PU	3	Pull-up enable for STE pin 0: STE output is open-drain. (default) 1: STE output is pull-up
STE_POL	2	Polarity bit for STE pin 0: STE is active low. 1: STE is active high (default)
STE_EN	1	STE function control bit 0: Disable: can be set via PackConfiguration or by sending sub-command CLEAR_SHUTDOWN(0x14) 1: Enabled (default). can be set via PackConfiguration or by sending sub-command SET_SHUTDOWN(0x13). (default)
TEMPS	0	Temperature Measurement control bit 0: Selects internal sensor for temperature measurement. 1: Selects external thermistor for temperature measurement. (default)

Table 7.8 Pack ConfigB

Name	Bit	Description
FuseEN	7	STE fuse Function control bit 0: Disable STE fuse function. (default) 1: Enable STE fuse function.
Reserved	6,5	Reserved
BTPEN	4	BTP Function control bit 0: Disable BTP function. (default) 1: Enable BTP function.
Reserved	3,2	Reserved
ISDEN	1	ISD Function control bit 0: Disable ISD function. (default) 1: Enable ISD function.
TDDEN	0	TDD Function control bit 0: Disable TDD function. (default) 1: Enable TDD function.

Table 7.9 Pack ConfigC

Name	Bit	Description
Reserved	**7-1**	Reserved
JEITA	**0**	JEITA Function control bit 0: Disable JEITA function. 1: Enable JEITA function. (default)

Table 7.10 User Config

Name	Bit3,2,1,0	Description
Normal mode	**0000B**	The fusion gauge is in Sh366002 normal Algorithm Mode. (default)
User_CFG1	**XXX1B**	The fusion gauge is in User_CFG1 Algorithm Mode
User_CFG2	**XX10B**	The fusion gauge is in User_CFG2 Algorithm Mode
User_CFG3	**X100B**	The fusion gauge is in User_CFG3 Algorithm Mode
User_CFG4	**1000B**	The fusion gauge is in User_CFG4 Algorithm Mode

*Note: (1) **X** is 1 or 0.*
(2) User_Config bit15~4 are all zero in any of the three configuration.

Table 7.11 Interrupt Config

Name	Bit	Description
Reserved	15-7	Reserved, 0 fixed.
TDD	6	TDD interrupt control bit 0: Disable TDD interrupt. (default) 1: Enable TDD interrupt.
ISD	5	ISD interrupt control bit 0: Disable ISD interrupt. (default) 1: Enable ISD interrupt.
BATHI	4	BATHI interrupt control bit 0: Disable BATHI interrupt. (default) 1: Enable BATHI interrupt.
BATLOW	3	BATLOW interrupt control bit 0: Disable BATLOW interrupt. (default) 1: Enable BATLOW interrupt.
OTC	2	OTC interrupt control bit 0: Disable OTC interrupt. (default) 1: Enable OTC interrupt.
OTD	1	OTD interrupt control bit 0: Disable OTD interrupt. (default) 1: Enable OTD interrupt.
SOC1	0	SOC1 interrupt control bit 0: Disable SOC1 interrupt. (default) 1: Enable SOC1 interrupt.

7.3.3.9 Power Mode (subclass 68)

Flash Update OK Voltage: Min. voltage for Flash Update. Dataflash could not be modified when cell voltage<Flash Update OK Voltage.
Sleep Current: Sleep Current Threshold. Detailed description is in 8.2
TDD SOH Percent Detailed description is in 4.1.1
ISDCurrent Detailed description is in 4.4.2
ISDCurrentFilter Detailed description is in 4.4.2
MinISDTime Detailed description is in 4.4.2
Hibernate I: Hibernate Current Threshold. Detailed description is in 8.4.
Hibernate V: Hibernate Voltage Threshold. Detailed description is in 8.4.
STE_FuseVoltage Detailed description is in 4.4.3
STE_FuseTimeThreshold Detailed description is in 4.4.3
STE_FuseBlowTime Detailed description is in 4.4.3
STE_FuseFailCurrent Detailed description is in 4.4.3
FS Wait: Fullsleep Enter Delay. Detailed description is in 8.3.

7.3.3.10 Current Thresholds(Subclass 81)

Dsg Current Threshold: Current Threshold for Discharge. Detailed description is in 4.1.2.1.
Chg Current Threshold: Current Threshold for Charge. Detailed description is in 4.1.2.2.
Quit Current, Dsg Relax Time, Chg Relax Time, Quit Relax Time: Detailed description is in 4.1.2.3.

7.3.3.11 Calibration Class(Subclass 104)

The arguments listed below will update automatically after board offset calibration, voltage calibration, temperature calibration and current calibration. Manual modification by user is not necessary

CCGain:	Coulomb Counter Gain Factor.
CC Offset:	Coulomb Counter Offset Factor
Board Offset:	Board Offset Factor
Int Temp Offset:	Internal Temperature Offset Factor.
Ext Temp Offset:	External Temperature Offset Factor.
Pack V Gain:	Pack Voltage Gain Factor
Pack V Offset:	Pack Voltage Offset Factor.

7.3.3.12 Deadband(Subclass107)

Deadband: Deadband Current Threshold. The current is set to zero when **|AverageCurrent( )|** < **Deadband**.

7.3.3.13 Security Codes(Subclass 112)

Sealed to Unsealed:	Unsealed Key. Detailed description is in 4.4.
Unsealed to Full:	Full-Assess Key. Detailed description is in 4.4
Authen Key3:	No.12-15 bits of SHA-1 Authentication key.
Authen Key2:	No.8-11 bits of SHA-1 Authentication key.
Authen Key1:	No.4-7 bits of SHA-1 Authentication key.
Authen Key0:	No.0-3 bits of SHA-1 Authentication key.

7.3.3.14 Userconfig (Subclass 122)

Config_DT: It is a user-configured word.
Config_SW: It is a user-configured word.
Config_HW: It is a user-configured word.

7.3.3.15 Gauge (Algorithm0~4, subclass 123, 224~227)

AlgorithmData are the fusion gauge parameters blocks composed by every four bytes as a single parameter.

7.4 SWI HOST INTERRUPTION FEATURE

The default SH366002 behaves as an SWI slave only device. If the SWI interrupt function is enabled, the SH366002 is capable of mastering and also communicating to a SWI device.

When the **SET_ SWI INTEN** sub-command is received, the SH366002 will detect any of the interrupt conditions and assert the interrupt at one second intervals until the CLEAR_ SWI INTEN command is received or the count of 3 has lapsed.

When over temperature alarm or low capacity alarm occurs, the SWI Interruption is triggered and the SH366002 will send three 0X80 as a signal.

Low Battery Capacity: When ***[SWI INTEN]*** = 1 and ***[SOC1]*** = 1, SWI interrupt starts.

Temperature: When ***[SWI INTEN]*** = 1 and *[OTC]* or ***[OTD]*** = 1, SWI interrupt starts.

8. POWER MODE

The SH366002 has three power modes: **NORMAL**, **SLEEP**, and **HIBERNATE**. In **NORMAL** mode, the SH366002 is fully powered and can execute any allowable task. In **SLEEP** mode the fusion gauge exists in a reduced-power state, periodically taking measurements and performing calculations. Finally, in **HIBERNATE** mode, the fusion gauge is in a very low power state, but can be awaken by communication or certain I/O activity. The relationship between these modes is shown in **Figure 8.1**. Details are described in the sections that follow.

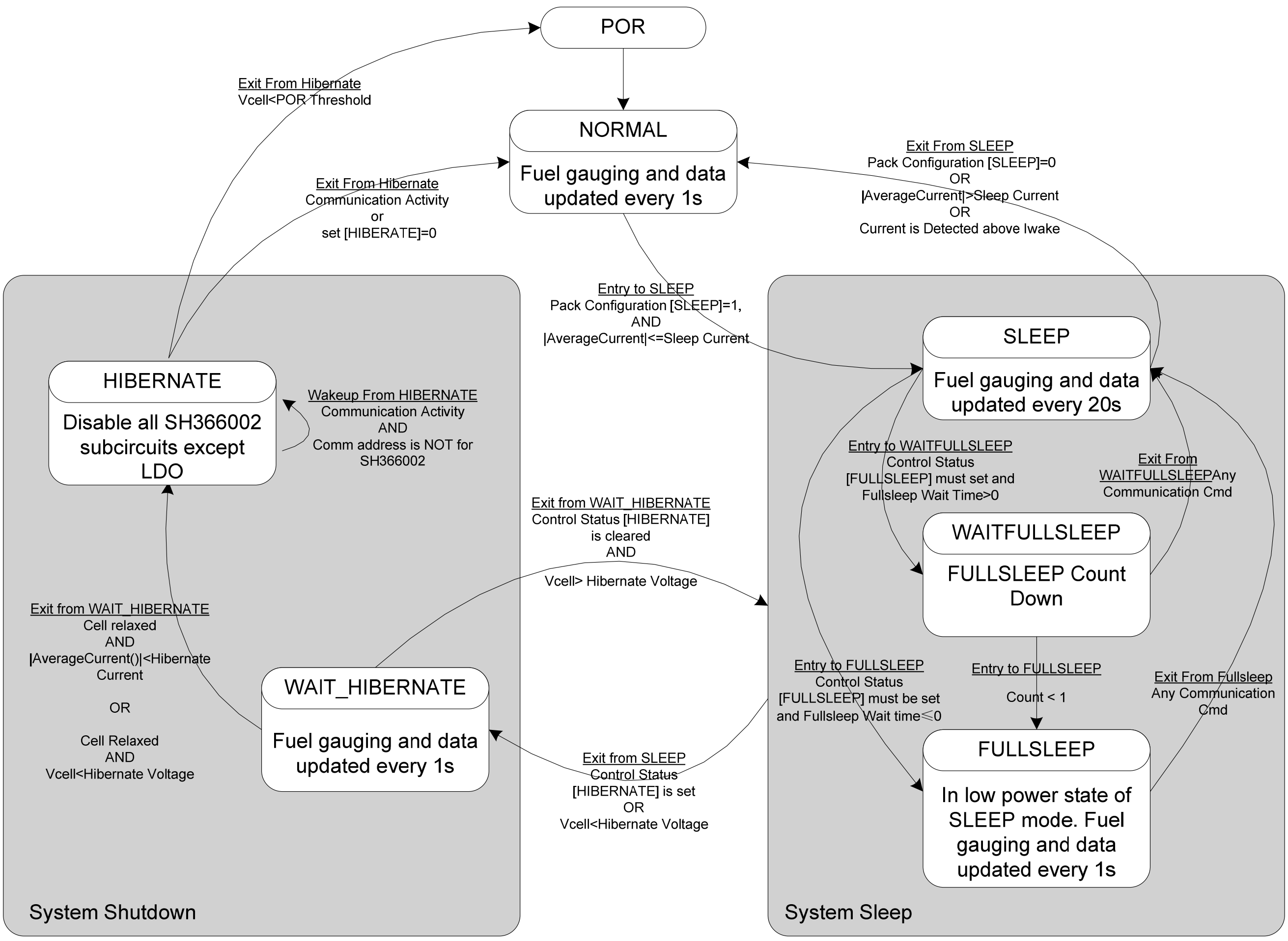


Figure 8.1 Power Mode Diagram

8.1 NORMAL MODE

During this mode, **AverageCurrent( )**, **Voltage( )** and **Temperature( )** measurements are taken every second, and the interface data set is updated. This mode is exited by activating a different power mode.

8.2 SLEEP MODE

SLEEP mode is entered automatically if the feature is enabled (**PackConfiguration *[SLEEP]***) = 1) and **AverageCurrent( )** is below **Sleep Current**. During the **SLEEP** mode, the SH366002 periodically takes data measurements and updates its data set. However, a majority of its time is spent in an idle condition.

The SH366002 exits **SLEEP** if any entry condition is broken, specifically when (1) **AverageCurrent( )** rises above **Sleep Current**, or (2) a current in excess of **IWAKE** through **RSENSE** is detected.

8.3 FULLSLEEP MODE

FULLSLEEP mode is enabled by setting the **PackConfiguration *[FULLSLEEP]*** bit in the Control Status register. **FULLSLEEP** mode is entered automatically when the SH366002 is in **SLEEP** mode and the timer counts down to 0 (**Full Sleep Wait Time** > 0) or immediately (**Full Sleep Wait Time** ≤0).

During **FULLSLEEP** mode, the SH366002 periodically takes data measurements and updates its data set. However, a majority of its time is spent in an idle condition. In this mode, the high frequency oscillator is turned off. The power consumption is further reduced in this mode compared to the **SLEEP** mode.

The gauge exits the **FULLSLEEP** mode when there is any communication activity. While in **FULLSLEEP** mode, the fusion gauge can suspend serial communications as much as 4ms by holding the communication line(s) low. This delay is necessary to correctly process host communication, since the fusion gauge processor is mostly halted in **SLEEP** mode.

8.4 HIBERNATE MODE

HIBERNATE mode should be used when the host system needs to enter a low-power state, and minimal gauge power consumption is required.

1. **HIBERNATE** due to the load current.
2. The ***[HIBERNATE]*** bit of the **CONTROL_STATUS** register must be set.
3. The gauge has taken a valid OCV measurement.
4. The magnitude of the average cell current has fallen below Hibernate Current.
5. No communication.
6. The gauge is already in **SLEEP** or **FULLSLEEP** mode
7. **HIBERNATE** due to the cell voltage.
8. Cell voltage drops below the Hibernate Voltage.
9. A valid OCV measurement has been taken.
10. No communication.
11. The gauge is already in **SLEEP** or **FULLSLEEP**

If the ***[SHUTDOWN]*** bit of **CONTROL _STATUS** is also set, the **STE** pin will be released in the state shown by **Table 7.2**; thereby, allowing an optional external circuit to remove power from the gauge LDO.

Upon exiting **HIBERNATE** mode, the ***[HIBERNATE]*** bit of **CONTROL_STATUS** is cleared. Since any communication activity wakes up the gauge from **HIBERNATE** mode, the host is required to set the ***[HIBERNATE]*** bit of the **CONTROL_STATUS** register to allow gauge to re-enter **HIBERNATE** mode.

To disable the **HIBERNATE** mode, the **Control( )** sub-command **SET_HIBERNATE** should not be used and Hibernate Voltage and Current must be set to 0 in data flash.

9. ELECTRICAL SPECIFICATIONS

9.1 ABSOLUTE MAXIMUM RATINGS

Table 9.1 Absolute Maximum Ratings

Pin	Min Value	Max Value	Units	Note
BAT, VCCIN	-0.3	6.0	V	
VCC, VCC18	-0.3	2.0	V	
ASRP, ASRN	-1	1	V	
SCL, SBMD, SWI	-0.3	6.0	V	
Functional Temperature range	-40	100	°C	

9.2 DC SPECIFICATIONS

(TA=-40 C~85 C, C(VCCIN)=0.47uF,2.35V<=V(VCCIN)<=5.5V;typical values at TA=25 C, V(VCCIN)=V(BAT) =3.6V (unless otherwise noted)

Table 9.2 DC Specification

Parameter	Description	Min Value	Typical Value	Max Value	Units	Note
MainPower						
V_{BAT}, V_{PACK}	Operate Voltage	2.5		5.5	V	T_A=25°C
I_{OP}	Normal operating mode current		120	140	uA	T_A=25°C
I_{IDLE1}	Low-power operating mode current		55	65	uA	T_A=25°C
I_{IDLE2}	Low-power operating mode current		21	26	uA	T_A=25°C
I_{PD}	Hibernate operating mode current		10	15	uA	T_A=25°C
LDO						
V_{CC}	LDO output voltage	1.7	1.85	2	V	2.5V<=VI<=5.5V,I_{OUT}<=6mA
		1.75	-	-	V	2.35V<=VI<2.5V,I_{OUT}<=3mA
ΔV_{CC}	LDO dropout voltage	-	-	200	mV	VI=2.5V,I_{OUT}<=6mA
		-	-	50	mV	VI=2.35V,I_{OUT}<=3mA
ΔV_{TEMP}	LDO output change with temperature		±1		%	VI=3.6V,I_{OUT}=6mA
$\Delta V_{CC(LINE}$	Line regulation	-	80	150	-	2.5V<=VI<=5.5V,I_{OUT}=6mA,T_A=25°C
$\Delta V_{CC(LOAD}$	Load regulation	-	34	50	mV	0.2mA<=I_{OUT}<=3mA,VI=2.35V, T_A=25°C
		-	70	150	mV	3mA<I_{OUT}<=6mA,VI=2.5V, T_A=25°C
I_S	Short circuit current limit			250	mA	Vcc=0V
V_{IR+}	LDO start-up voltage	2.05	2.20	2.30	V	
V_{HYS}	LDO shutdown voltage	2.00	2.10	2.20	V	

Table 9.3 DC Specification(continued)

Parameter	Description	Min Value	Typical Value	Max Value	Units	Note
Wake up						
V_{CH}	Iwake voltage detect threshold	0.5	1.4	2.6	mV	**[IWAKE,RSNS1,RSNS0]** = 001 in PackConfiguration
		1.8	3.0	4.2		**[IWAKE,RSNS1,RSNS0]** = 101/010 in PackConfiguration
		4.6	6.0	7.4		**[IWAKE,RSNS1,RSNS0]** = 110/011 in PackConfiguration
		10.2	12.0	13.8		**[IWAKE,RSNS1,RSNS0]** = 111 in PackConfiguration
V_{CH_TCO}	Current detect temperature drift	-	0.5	0.8	%/℃	
t_{WAKE}	Iwake time threshold	1	5	10	ms	
GPIO						
V_{IL}	SCL,SDA, SWI	-0.3		0.6	V	
V_{IH}	SCL,SDA, SWI	1.2		6	V	
V_{OH}	SCL,SDA, SWI. STE, BAT, TEMP Output voltage high	V_{CC1}-0.5	-	6.0	V	External pull-up resistor connected to V_{CC1}(<6V), V_{VCCIN} =3.6V
V_{OL}	SCL,SDA, SWI STE, BAT, TEMP Output voltage high	-	-	0.4	V	SCL, SDA, SWI, I_{OL} = 7mA, 2.35V=< V_{VCCIN} <=5.5V
		-	-	0.1* V_{VCCIN}	V	STE, BAT, TEMP, I_{OL}=1mA, 2.35V=< V_{VCCIN} <=5.5V
ADC						
NR	Resolution	14		15	Bit	
$R_{VAIN(TS)}$	A/D input resistance(TS)	8	-		MΩ	
$R_{VAIN(BAT)}$	A/D input resistance (BAT)	8	-	-	MΩ	ADC not measuring cell voltage
		-	100	-	KΩ	ADC not measuring cell voltage
V_{VAIN}	A/D input voltage	VSS-0.2	-	1	V	
V_{CAIN}	A/D differential input voltage	-0.125	-	0.125	V	

9.3 AC SPECIFICATIONS

(TA=-40 C~85 C, C(VCCIN)=0.47uF,2.35V<=V(VCCIN)<=5.5V; typical values at TA=25 C, V(VCCIN)=V(BAT) =3.6V (unless otherwise noted)

Table 9.4 AC Specification

Parameter	Description	Min Value	Typical Value	Max Value	Units	Note
MainPower						
f_{LRC}	Operating low frequency	-	32.768	-	KHz	±1.5%(0~60°C) ±2.5%(-20~70°C) ±4.0%(-40~85°C)
f_{HRC}	Operating high frequency	-	4.194	-	MHz	±2.0%(0~60°C) ±3.0%(-20~70°C) ±4.5%(-40~85°C)
TWI(SH366002 as slave**)**						
f_{SMB}	Clock frequency	10		200	KHz	PackConfiguration的***[NormTWI]***=0
		10		400		PackConfiguration的***[NormTWI]***=1
t_{BUF}	Bus free time between stop and start	4.7	-	-	µs	PackConfiguration的***[NormTWI]***=0
		1.3	-	-		PackConfiguration的***[NormTWI]***=1
t_{LOW}	SCL pulse width (low)	4.7	-	-	µs	PackConfiguration的***[NormTWI]***=0
		1.3	-	-		PackConfiguration的***[NormTWI]***=1
t_{HIGH}	SCL pulse width (high)	4.0	-	50	µs	PackConfiguration的***[NormTWI]***=0
		0.6	-	50		PackConfiguration的***[NormTWI]***=1
$t_{HD: DAT}$	Data hold time	300	-	-	ns	PackConfiguration的***[NormTWI]***=0
		0	-	-		PackConfiguration的***[NormTWI]***=1
$t_{SU: DAT}$	Data setup time	250	-	-	ns	PackConfiguration的***[NormTWI]***=0
		100	-	-		PackConfiguration的***[NormTWI]***=1

Table 9.5 AC Specification (continued)

Parameter	Description	Min Value	Typical Value	Max Value	Units	Note
$t_{HD:STA}$	Start hold time	4.0	-	-	μs	PackConfiguration的*[NormTWI]*=0
		0.6	-	-		PackConfiguration的*[NormTWI]*=1
$t_{SU:STA}$	Setup time for start	4.7	-	-	μs	PackConfiguration*[NormTWI]*=0
		0.6	-	-		PackConfiguration*[NormTWI]*=1
$t_{SU:STO}$	Setup time for stop	4.0	-	-	μs	PackConfiguration*[NormTWI]*=0
		0.6	-	-		PackConfiguration*[NormTWI]*=1
t_R	SCL/SDA rise time	-	-	1000	ns	PackConfiguration*[NormTWI]*=0, (V_{ILMAX} - 0.15V) to (V_{IHMIN}+ 0.15V)
		-	-	300		PackConfiguration*[NormTWI]*=1, (V_{ILMAX} - 0.15V) to (V_{IHMIN}+ 0.15V)
t_F	SCL/SDA fall time	-	-	300	ns	(V_{IHMIN}+ 0.15V) to (V_{ILMAX} - 0.15)
$t_{TIMEOUT}$	SCL low timeout	-	25	-	ms	
SWI						
$t_{(CYCH)}$	Cycle time, host to SH366002	190	-	-	μs	
$t_{(CYCD)}$	Cycle time, SH366002 to host	190	205	250	μs	
$t_{(HW1)}$	Host sends 1 to SH366002	0.5	-	50	μs	
$t_{(DW1)}$	SH366002 sends 1 to host	32	-	50	μs	
$t_{(HW0)}$	Host sends 0 to SH366002	86	-	145	μs	
$t_{(DW0)}$	SH366002 sends 0 to host	80	-	145	μs	
$t_{(RSPS)}$	Response time, SH366002 to host	190	-	950	μs	
$t_{(B)}$	Break time	190	-	-	μs	
$t_{(BR)}$	Break recovery time	40	-	-	μs	
$t_{(RISE)}$	SWI line rising time to logic 1 (1.2V)	-	-	950	ns	

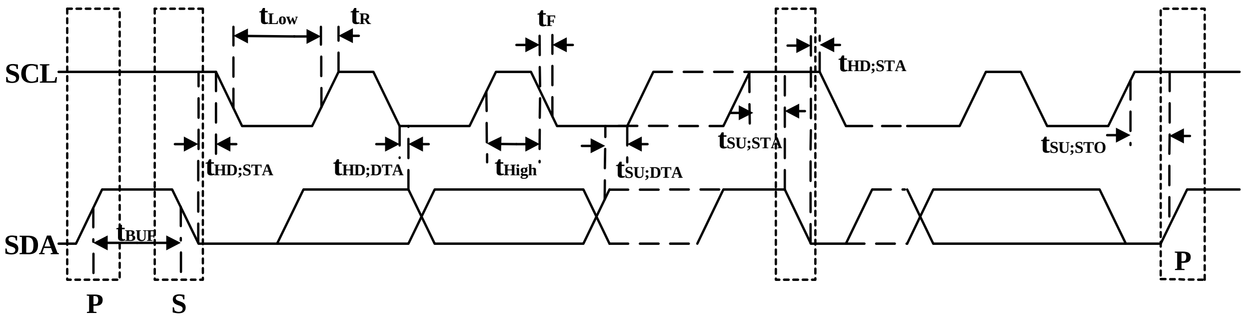


Figure 9.1 TWI InterfaceTiming Diagrams

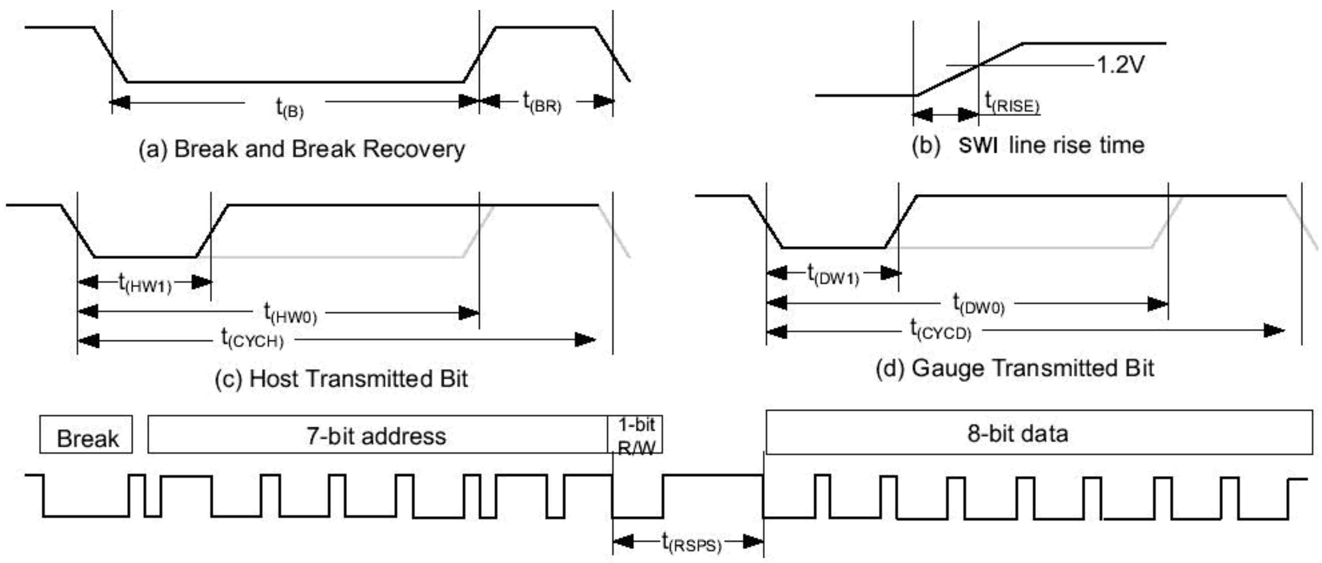
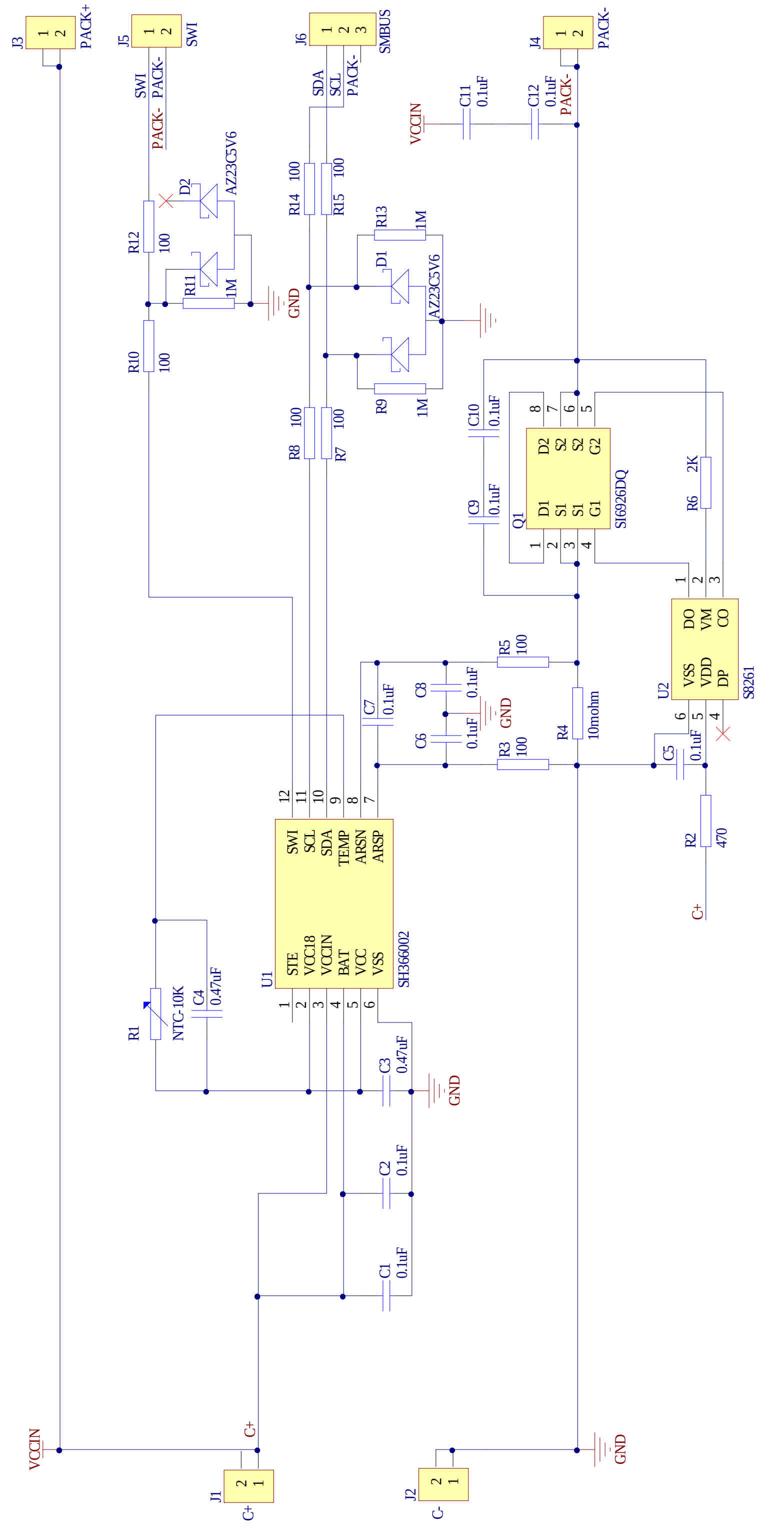


Figure 9.2 SWI Timing Diagrams

10. REFERENCE SCHEMATIC



11. ORDERING INFORMATION

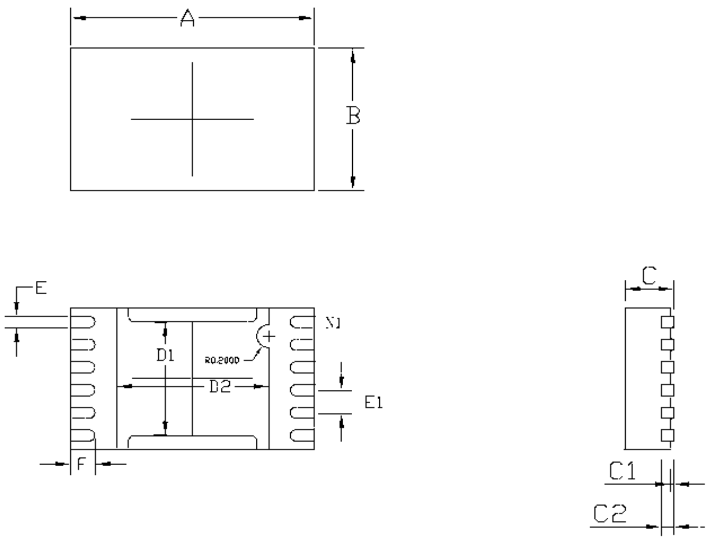
Table 11.1 Ordering information

Part No.	Package
SH366002R/012RE	DFN12

12. PACKAGE INFORMATION

Table 11.2 Package Information

Label Size	Min(mm)	Max(mm)	Label Size	Min(mm)	Max(mm)
A	4.00±0.10		D1	2.00 TYP	
B	2.50±0.10		D2	2.50 TYP	
C	0.70	0.80	E	0.200 TYP	
C1	0~0.050		E1	0.400 TYP	
C2	0.203 TYP		F	0.400 TYP	



Note:

1. Formed lead shall be planar with respect to one another within 0.004 inches.
2. Both package length and width do not include mold flash and burr.

13. Version History

No.	Version	Content	Data
1	0.0		
2	0.1		
3	0.2		
4	0.3	Function modified	2015.03
5	0158	BTP, STE fuse, ISD TDD, BATLOW/HIGH, interrupt, etc.	2016.01-02
6	0159	TWI/SWI, DT, SW, HW, Userconfig subclass, User_CFG3, etc.	2016.08
7	0162	Configuration, block D/E/F etc.	2018.03